National Inventory Report Sweden 2014

Greenhouse Gas Emission Inventories 1990-2012

Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol

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/nir

Cover photo: Jonas Bergström

Preface

According to Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC), parties are required to, on an annual basis, submit national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol. This report is also a submission under the Kyoto Protocol.

This is Sweden's National Inventory Report (NIR) for the year 2014 and it is written in line with the guidelines of the Annotated outline of the National Inventory Report including reporting elements under the Kyoto Protocol. It contains national greenhouse gas emission inventories for the period 1990 to 2012, and descriptions of methods used to produce the estimates. The methods used to calculate the emissions and removals are in accordance with the Revised IPCC 1996 Guidelines for National Greenhouse Gas Inventories and the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. The report is pre-pared in accordance with the Reporting Guidelines, agreed by the UNFCCC at the eighth session of the Conference of the Parties (COP) in New Delhi 2002 and subsequent decisions.

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

Maria Ågren
Director-General, Swedish Environmental Protection Agency

Authors

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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 Intergovernmental Panel on Climate Change (IPCC) och två år senare konstaterade de att antropogen klimatpåverkan utgjorde ett globalt hot och efterfrågade en internationell överenskommelse för att hantera problemet. FN:s generalförsamling inledde förhandlingar om en ramkonvention kring klimatförändringar (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 Kyoto, Japan, 1997. Kyotoprotokollet innebär bindande åtaganden gällande utsläppsmängder för Annex I-parterna, vilket innebär att dessa länders utsläpp av växthusgaser under åren 2008-2012 i medeltal ska vara minst 5 % lägre än under basåret 1990.

Enligt Artikel 4 och 12 i UNFCCC måste Annex I-parterna årligen rapportera sina utsläpp från källor och upptag i sänkor för alla växthusgaser som inte omfattas/kontrolleras av Montrealprotokollet. Rapporteringen ska innefatta utsläppssiffror i ett speciellt format (CRF) och en nationell inventeringsrapport (NIR).

Denna rapport utgör Sveriges NIR 2014. Rapporten omfattar utsläpp till luft av de direkta växthusgaserna CO_2, CH_4, N_2O, HFC, PFC, SF_6 och de indirekta växthusgaserna NO_X, CO, NMVOC och SO_2. Rapporten innehåller information om Sveriges inventering av växthusgaser för alla år från 1990 till 2012, inklusive beskrivningar av metoder, datakällor, osäkerheter, den kvalitetssäkring och kvalitetsstyrning (QA/QC) som görs och en trendanalys.

De data, såsom emissioner, aktivitetsdata och emissionsfaktorer som UNFCCC efterfrågar återfinns i CRF-tabeller tillsammans med denna rapport.

S 2. Sammanfattning av nationella utsläpp och upptag samt trender, inklusive KP-LULUCF

S 2.1 Växthusgaser

Totala utsläpp av växthusgaser i Sverige exklusive LULUCF, uttryckt i koldioxidekvivalenter, var ca 57,6 miljoner ton år 2012 (Tabell S.1), vilket är en minskning med ca 3 miljoner ton jämfört med 2011.

Osäkerheten i skattingen av total nationella utsläppen av västhusgaser exklusive LULUCF (i CO2-equ.) var ± 4,5 %. Utsläppen har minskat med ca 21 %, eller ca 15 miljoner ton, mellan 1990 och 2012.

Nettoupptaget för sektorn Markanvändning, Förändrad markanvändning och Skogsbruk (LULUCF) har beräknats till ca 35 miljoner ton koldioxidekvivalenter 2012 (Tabell S.1). Den årliga förändringen i sänkan är mycket liten i förhållande till poolernas storlekar (levande biomassa, dött organiskt material och markkol). Beräkningarna är på grund av detta behäftade med stora osäkerheter. Osäkerheterna tillsammans med löpande metodutveckling kan ge stora förändringar i rapporterade värden mellan submissionerna.

Utsläppen av koldioxid var ca 46 miljoner ton år 2012 vilket är 20 % lägre jämfört med 1990 (Tabell S.1). Energisektorn, inklusive transporter, står för ca 89 % av de totala koldioxidutsläppen och är därmed den största källan till koldioxidutsläpp i Sverige. Koldioxid står för ca 79 % av de totala utsläppen av växthusgaser.

Metanutsläpp (CH_4) kommer framför allt från jordbruk och avfallsdeponier och var ca 4,8 miljoner ton 2012 räknat som koldioxidekvivalenter (Tabell S.1). Sedan 1990 har utsläppen av metan minskat med 31 %, vilket främst beror på åtgärder inom avfallssektorn och jordbrukssektorn.

År 2012 var de totala utsläppen av lustgas (N_2O) ca 6,2 miljoner ton räknat som koldioxidekvivalenter (Tabell S.1), vilket är en minskning med ca 24 % jämfört med 1990. Utsläpp av lustgas kommer huvudsakligen från jordbrukssektorn (ca 77 %), men också från energiproduktion (16 %), industriprocesser och hantering av avloppsvatten (ca 5 %). Jordbrukssektorn står för den största delen av minskningen.

Totala utsläppen av fluorerade gaser (PFCs, HFCs och SF_6) 2012 var ca 0,9 miljoner ton uttryckt i koldioxidekvivalenter (Tabell S.1). Detta innebär en ökning av utsläppen med 84 % jämfört med 1990. Ökningen beror främst på att ozonförstörande ämnen ersatts av HFCs.'

S 2.2 KP-LULUCF

Sverige rapporterar bokföring enligt artikel 3.3 och 3.4 under Kyoto protokollet. Aktiviteterna under artikel 3.3 i Kyotoprotokollet är obligatoriska för alla parter och när det gäller artikel 3.4 har Sverige valt att bokföra aktiviteten skogsbruk. Sverige valt att bokföra upptag/utsläpp för hela åtagandeperioden (och ej på årsbasis).

Aktiviteterna under artikel 3.3, nybeskogning /återbeskogning (AR) och avskogning (D), är relativt ovanliga i Sverige. Sedan 1990 har AR och D ökat kontinuerligt med ca 10 000 hektar per år. Trenden för AR (nybeskogning /återbeskogning) är en ökande sänka på grund av ökningen av arealen. Trenden för D är ett ökande utsläpp från mark på grund av ökningen av arealen. Utsläpp och upptag i levande biomassa visar ingen trend eftersom dessa är starkt beroende på mängden biomassa på avverkat skogsområde varje år. Det totala utsläppet 2012 för artikel 3.3 har beräknats till 2,5 miljoner ton CO_2-ekvivalenter. Under artikel 3.4 har Sverige valt bokföring av skogsbruk. För denna aktivitet är upptaget ca 39,6 miljoner ton CO_2-ekvivalenter 2012. Rapporteringen under Kyotoprotokollet artikel 3.3 och 3.4 harmonierar med UNFCCC rapporteringen för skogsmark och mark som konverterats till skogsmark (arean).

Tabell S.1. Utsläpp av växthusgaser ämnesvis (Gg CO_2 ekvivalenter)

UTSLÄPP AV VÄXTHUSGASER	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO_2 inkl. netto CO_2 från LULUCF	18 360	21 006	11 552	14 297	13 983	17 024	21 957	22 195	17 966	17 206	13 961	11 128	17 015	12 783	10 192
CO_2 exkl. netto CO_2 från LULUCF	57 141	58 967	54 131	55 064	55 995	56 610	55 771	53 189	53 155	52 025	49 978	46 517	52 279	48 479	45 710
CH_4 inkl. CH_4 från LULUCF	6 972	6 866	6 269	6 235	6 047	5 889	5 917	5 782	5 706	5 465	5 260	5 146	5 045	4 943	4 805
CH_4 exkl. CH_4 från LULUCF	6 971	6 865	6 266	6 232	6 042	5 883	5 911	5 777	5 693	5 462	5 247	5 144	5 044	4 941	4 804
N_2O inkl. N_2O från LULUCF	8 190	7 776	7 330	7 153	7 063	7 006	6 983	6 838	6 841	6 604	6 723	6 558	6 795	6 377	6 290
N_2O exkl. N_2O från LULUCF	8 114	7 717	7 263	7 087	7 000	6 941	6 912	6 756	6 754	6 507	6 612	6 451	6 670	6 270	6 191
HFCs	4	132	568	615	666	710	769	791	819	840	868	870	848	820	775
PFCs	377	343	241	236	261	258	254	257	245	248	225	35	158	183	69
SF_6	107	127	94	111	104	69	81	142	111	151	84	81	72	60	55
Total (inkl. LULUCF)	**34 011**	**36 250**	**26 053**	**28 646**	**28 124**	**30 956**	**35 962**	**36 005**	**31 690**	**30 514**	**27 122**	**23 818**	**29 934**	**25 167**	**22 186**
Total (exkl. LULUCF)	**72 714**	**74 152**	**68 563**	**69 344**	**70 068**	**70 470**	**69 699**	**66 913**	**66 778**	**65 233**	**63 014**	**59 097**	**65 072**	**60 754**	**57 604**

Tabell S.2. Utsläpp av växthusgaser sektorsvis (Gg CO_2 ekvivalenter)

Källor till utsläpp & sinkor	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1. Energy	53 439	55 142	50 191	51 077	51 865	52 846	51 638	49 190	49 101	47 834	46 012	44 226	48 377	44 601	42 141
2. Industrial Processes	6 474	6 745	6 861	6 859	7 008	6 680	7 072	7 012	7 092	7 030	6 778	4 971	6 785	6 349	5 899
3. Solvent and Other Product Use	332	309	278	269	276	292	311	303	299	281	288	284	309	303	303
4. Agriculture	9 046	8 723	8 317	8 268	8 193	8 066	8 106	7 976	7 930	7 890	7 937	7 725	7 803	7 787	7 641
5. LULUCF	-38 703	-37 902	-42 510	-40 698	-41 943	-39 514	-33 737	-30 908	-35 089	-34 719	-35 892	-35 279	-35 138	-35 587	-35 418
6. Waste	3 421	3 233	2 916	2 871	2 726	2 586	2 572	2 431	2 356	2 197	2 000	1 892	1 798	1 716	1 620
7. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)	**34 011**	**36 250**	**26 053**	**28 646**	**28 124**	**30 956**	**35 962**	**36 005**	**31 690**	**30 514**	**27 122**	**23 818**	**29 934**	**25 167**	**22 186**

S 3. Översikt över utsläppsberäkningar och trender sektorsvis, inklusive KP-LULUCF

S 3.1 Växthusgaser

De metoder som använts för att beräkna utsläpp och upptag överensstämmer med 'Revised IPCC 1996 Guidelines for National Greenhouse Gas Inventories' och 'IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories'. Inventeringen och rapporten är framtagen i enlighet med 'Reporting Guidelines', som beslutades av UNFCCC under den åttonde sammankomsten av Conference of the Parties (COP) i New Delhi 2002 och efterföljande beslut.

De sektorer som innefattas av inventeringen och de källor som används för aktivitetsdata och/eller utsläppsdata presenteras i Tabell S.3. Utsläppen är hämtade direkt från dessa datakällor eller beräknade baserat på aktivitetsdata.

Tabell S.3. CRF sektorer och datakällor som används i inventeringen

CRF	Sektor	Primär källa till aktivitetdata/utsläppsdata
1	Energi	
	-Stationär förbränning	Statistiska undersökningar av energiförbrukning
	-Transport	Transportmyndigheter
2	Industriprocesser	Miljörapporter
		Statistiska undersökningar av energiförbrukning
		Direktkontakt med företag
		EU:s utsläppshandelssystem
3	Lösningsmedel och annan Produktanvändning	Nationella data från Produktregistret på Kemikalieinspektionen
		Nationella experter
		Miljörapporter
4	Jordbruk	Officiella statistiska rapporter
		Organisationer och Forskare
5	Förändrad Markanvändning och Skogsbruk	Sveriges lantbruksuniversitet
		Skogsstyrelsen
6	Avfall	Avfall Sverige (fd RVF)
		Skogsindustrierna
		SCB
		Naturvårdsverket
		Miljörapporter

Utsläppen av växthusgaser från energisektorn varierar på grund av temperatur- och nederbördsförhållanden samt det ekonomiska konjunkturläget men trenden för perioden 1990-2012 är minskande utsläpp. Jämfört med 2011 har utsläppen från hela energisektorn under 2012 minskat med 5 %. Utsläppen från energisektorn inklusive transporter var under 2012 ca 42 miljoner ton i koldioxidekvivalenter

(Tabell S.2), vilket är ca 73 % av de totala utsläppen. Det är framförallt utsläppen från el och värmeproduktion och transporter som minskat mellan 2011 och 2012.

Utsläppen från produktion av el och fjärrvärme år 2012 har minskat med ca 5 % (ca 7.7 miljoner ton i koldioxidekvivalenter) jämfört med 1990 (ca 8.0 miljoner ton i koldioxidekvivalenter). Utsläppen från el och fjärrvärme har under 2012 minskat med ca 7 % jämfört med förra året. Några bakomliggande orsaker är minskat behov av uppvärmning på grund av varmt väder, ökad kärnkraftsproduktion och god tillgång på vattenkraft.

Totalt släpper transportsektorn ut 19 miljoner ton, varav nästan 18 miljoner ton i koldioxidekvivalenter utgörs av vägtransporter. Utsläpp från transportsektorn ligger nu på samma nivå som basåret 1990. Utsläppen av växthusgaser från inrikes transporter minskade med ca 6 % under 2012 jämfört med 2011. Ökad andel förnybara bränslen och bränsleeffektivare fordon bidrar till de minskande utsläppen.

Ryggraden i den svenska elproduktionen är kärnkraft och vattenkraft tillsammans med fossila bränslen och en ökande andel förnybar energi. Under 2012 var 57 % av alla bränslen som används för fjärrvärme biomassa, medan avfall stod för 23 %. Sedan 1990 har det skett en stor ökning av användningen av fjärrvärme från 89 PJ (1990) till 188 PJ (2012)

För industriprocesser är koldioxid den dominerande växthusgasen med 82 %, sedan kommer fluorerade växthusgaser med ca 15 %, dikväveoxid med ca 2,5 % och metan med 0,2 %. De totala utsläppen från industriprocesser var knappt 6 miljoner ton koldioxidekvivalenter år 2012 (Tabell S.2), vilket motsvarar ca 10 % av Sveriges totala utsläpp. Utsläppen kommer framför allt från produktion av järn och stål samt mineralindustrin (81 %). Utsläppen från denna sektor minskade med ca 0,45 miljon ton koldioxidekvivalenter eller 7 % mellan 2011 och 2012. Minskningen under 2012 kommer framför allt från produktion av järn och stål som minskade med ca16 % jämfört med året innan. Sedan 1990 har utsläppen från industriprocesser varierat, vilket framför allt beror på att produktionsvolymerna följer den ekonomiska konjunkturen. Utsläppen av växthusgaser under 2012 var ca 9 % lägre än 1990.

Användning av lösningsmedel och andra produkter ger huvudsakligen upphov till utsläpp av flyktiga organiska ämnen (MNVOCs) lustgas (N_2O) och en del koldioxid. 2012 var utsläppen av koldioxid och lustgas drygt 0,3 miljoner ton uttryckt i koldioxidekvivalenter (Tabell S.2), vilket utgör ca 0,5 % av de totala växthusgasutsläppen. Jämfört med 1990 har utsläppen i denna sektor minskat med ca 9 %. Cirka 13 % av koldioxidutsläppen kommer från användningen av färg, även om dessa utsläpp har minskat p.g.a. en övergång till vattenbaserade färger.

Jordbruk är den största källan till utsläpp av lustgas och metan. Utsläpp av metan kommer framför allt från boskapens matsmältningsprocesser och gödselhantering.

År 2012 var de totala utsläppen från jordbrukssektorn ca 7,6 miljoner ton uttryckt i koldioxidekvivalenter (Tabell S.2) varav ca 63 % utgjordes av N_2O och ca 37 % av CH_4. Det är en minskning med drygt 15 % jämfört med 1990. Utsläppen från denna sektor minskade med mindre än 2 % mellan 2011 och 2012 och med drygt 15 % jämfört med 1990. till följd av ett minskande antal djur och även en minskad användning av mineralgödsel. Lustgas kommer framför allt från omvandling av kväve i jorden, vilken påverkas av användning av gödsel och handelsgödsel och odling av kvävefixerande växter. Mer än hälften (ca 57 %) av sektorns utsläpp av lustgas kommer från jordbruksmark.

Nettoupptaget för LULUCF under 2012 uppskattas till drygt 35 CO_2 miljon ton. Nettoupptaget minskade något mellan 2011 till 2012 (Tabell S.2). Den långsiktiga trenden med minskande nettoupptag i levande biomassa beror främst på ökad avverkning.

Avfallsdeponier är den näst största källan till utsläpp av metan. Av avfallssektorns utsläpp under 2012 dominerar metanutsläppen från avfallsdeponier med ca 86 % medan lustgas från avloppsvatten står för 10 % och koldioxidutsläppen från förbränning av farligt avfall står för ca 4 %. 2012 var de totala utsläppen från avfallssektorn drygt 1,6 miljoner ton uttryckt i koldioxidekvivalenter, vilket motsvarar 2,8 % av de totala växthusgasutsläppen (Tabell S.2). Utsläppen från denna sektor har minskat med ca 53 % jämfört med 1990. Utvinning av deponigas, deponiförbud och deponiskatter är huvudorsakerna till utsläppsminskningen.

De totala växthusgasutsläppen i Sverige uppgick 2012 till ca 57,6 miljoner ton koldioxidekvivalenter varav utsläpp icke inkluderade i utsläppshandel stod för 39.4 miljoner ton. Detta innebär att de svenska utsläppen år 2012 var 21% lägre än för basåret.

S 3.2 KP-LULUCF

I och med att aktiviteterna under artikel 3.3 (beskogning och avskogning) är relativt ovanliga är det svårt att uttala sig om skillnader mellan år. Nettoupptag respektive emissioner ligger på ungefär samma nivåer som i tidigare submission.

När det gäller aktiviteten skogsbruk under artikel 3.4 så har nettoinlagringen efter att den minskat lite de sista åren åter uppnått ungefär samma nivå som 1990, drygt 39 miljoner ton koldioxidekvivalenter.

S 4. Översikt av utsläppsberäkningar och trender för indirekta växthusgaser och SO_2

Utsläppen av kväveoxider (NO_X) var ca 132 kton 2012 (Tabell S.4), vilket är en minskning med ca hälften jämfört med 1990 och med 5 % jämfört med 2011. Transportsektorn (främst vägtrafiken) är en sto källa för utsläpp av kväveoxider som bidrar med ca 48 % av de totala utsläppen. Vägtrafikens utsläpp av NO_X har minskat med ca 60 % mellan 1990 och 2012 och även har minskat med ca 5 % mellan 2011 och 2012. De största källorna till utsläpp av kväveoxider är vägtrafik, arbetsmaskiner, sjöfart och el- och värmeproduktion. I tätorter är vägtrafiken den största källan till kväveoxidutsläpp, men införandet av katalysatorer i bilar och den påföljande successivt mer skärpta avgasstandarden har bidragit till en generell minskning av kväveoxidnivåer i tätbebyggda områden. Den ökande användningen av fjärrvärme och NO_X-avgiften i början på 1990-talet har också resulterat i stora minskningar av kväveoxidutsläpp från energisektorn.

Tabell S.4. Utsläpp av indirekta växthusgaser och SO_2 (kton)

Gas	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
NOx	270	246	209	199	191	188	181	176	172	164	156	147	149	139	132
NMVOC	360	277	222	212	205	206	201	198	194	191	187	188	188	189	186
SO_2	105	69	42	41	41	41	37	36	36	32	30	30	32	29	28
CO	1280	1125	816	777	734	719	672	662	623	610	597	596	576	552	546

Utsläppen av kolmonoxid (CO) har minskat från 1280 kton 1990 till 546 kton 2012 (Tabell S.4), en reducering på 57 %. Omkring 95 % av CO-utsläppen kommer från energisektorn varav en tredjedel från transport och en fjärdedel från småskalig värmeproduktion i bostäder.

Utsläpp av flyktiga organiska ämnen (NMVOC) var ca 186 kton 2012 (Tabell S.4), vilket är en minskning med 48 % jämfört med 1990. Utsläppen har minskat något (mindre än 2 %) jämfört med 2011. De huvudsakliga källorna till utsläppen av NMVOC är produkter innehållande lösningsmedel, vägtrafik och vedeldning inom bostadssektorn. Frivilliga miljöstandarder för nya installationer av vedeldningspannor och minskade utsläpp från produkter med lösningsmedel har bidragit till utsläppsminskningen.

Utsläppen av svaveldioxid (SO_2) har minskat från 105 kton 1990 till knappt 28 kton 2012 (Tabell S.4), en reducering på 74 %. Utsläppen har också minskat med mindre än 5 % jämfört med 2011. Minskningen beror framför allt på övergång till lågsvavelhaltiga bränslen, för såväl vägtrafik som uppvärmning. Svavelskatt, som infördes 1991, spelar en stor roll för utvecklingen. Svaveldioxidutsläpp härrör främst från energiproduktion, transporter och industriprocesser. Svaveldioxid från transportsektorn utgör mindre än 4 % av totalen och utsläppen har minskat med 90 % sedan 1990.

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. An Intergovernmental Panel on Climate Change (IPCC) was established in 1988 and two years later they came up with the conclusion that anthropogenic climate change is 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. The long-term goal is to stabilize the amount of greenhouse gases in the atmosphere at a level where harmful anthropogenic climate changes is prevented. The most important addition to the convention was negotiated in 1997 in Kyoto, Japan. The Kyoto protocol involves binding obligations for 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. 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 submission of inventories should including emissions in the Common Reporting Format (CRF) and a National Inventory Report (NIR).

This report constitutes Sweden's NIR 2014 for anthropogenic emissions of direct greenhouse gases CO_2, CH_4, N_2O, HFC, PFC, SF_6 and indirect greenhouse gases NO_X, CO, NMVOC and SO_2. The report contains information on Sweden's inventories of greenhouse gases for all years from 1990 to 2012, including descriptions of methods, data sources, uncertainties, the quality assurance and quality control (QA/QC) activities carried out and a trend analysis.

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

ES 2. Summary of National Emissions and Removal Related Trends, including KP-LULUCF

ES.2.1 GHG inventory

Total greenhouse gas emissions in Sweden excluding LULUCF, expressed in carbon dioxide equivalents, were about 57.6 million tonnes for 2012 (Table ES.1). The emission has decreased by about 3 million tonnes compared to 2011. Emissions have decreased by about 21 % or approximately 15 million tonnes between

1990 and 2012. The overall uncertainty for 2012 GHG emissions (in CO2 equivalents) is calculated to be ±4.5%, excluding LULUCF.

In 2012, the net uptake of the land use, land-use change and forestry (LULUCF) has been estimated to about 35 million tonnes carbon dioxide equivalents (Table ES.1). The annual change of the sink is very small compared to the size of pools (living biomass, dead organic matter and land-based carbon). For this reason, the estimations are associated with significant uncertainties. The uncertainties and change of methods may result in substantial changes on annual values and between different submissions.

Emissions of CO_2 were around 46 million tonnes in 2012 or 20 % lower than in 1990 (Table ES.1). Almost 89 % of total carbon dioxide emissions come from the energy sector, including transport, which is the largest source of carbon dioxide in Sweden. Carbon dioxide's share of the total GHG emissions is approximately 79 %.

Emissions of methane (CH_4) arise mainly from agriculture and landfill sites, and in 2012 were about 4.8 million tonnes CO_2-equivalents (Table ES.1). Since 1990, emissions have decreased about 31 %, primarily due to measures implemented in the waste sector and agriculture.

In 2012, the total emissions of nitrous oxide (N_2O) were around 6.20 million tonnes CO_2-equivalents (Table ES.1), a reduction of about 24 % compared to 1990. Nitrous oxide emissions arise mainly from agriculture sector (about 77 %), but also from energy production (16 %), wastewater handling and industrial processes (about 5 % in total). The agricultural sector accounts for the bulk of the N_2O decline.

Total emissions of fluorinated gases (PFCs, HFCs and SF_6) in 2012 were approximately 0.9 million tonnes expressed in carbon dioxide equivalents (Table ES.1). This corresponds to an increase of about 84 % compared to 1990. The increase is due to the replacement of the ozone-depleting substances by HFCs.

ES.2.2 KP-LULUCF activities

Sweden reports the accounting for Articles 3.3 and 3.4 of the Kyoto Protocol. The accounting under article 3.3 is mandatory and for accounting of activities under article 3.4 Sweden has chosen accounting of Forest Management. For these activities, Sweden has chosen to report the uptake/emission for the entire commitment period but not on an annual basis.

The activities under Article 3.3, afforestation reforestation (AR) and deforestation (D), are relatively uncommon in Sweden, each representing around 10 kha annually in average. The trend for AR (afforestation / reforestation) is an increasing due to increase in acreage. The trend for D is an increasing emission from soils due to the increase in acreage. Emissions and removals in living biomass show no trend as these are highly dependent on the amount of biomass in the deforested area each year. The total emission in 2012 is estimated at 2.5 million tons of CO_2 equivalents. Under Article 3.4, Sweden has chosen accounting of Forest management. For this activity the sink is about 39.6 million tons of CO_2 equivalents in 2012. The reporting under the Kyoto Protocol Articles 3.3 and 3.4 are consistent with the UNFCCC reporting for forest land and land converted to forest land (area).

Table ES.1. Greenhouse gas emissions by gas (Gg CO_2 equivalents)

GREENHOUSE GAS EMISSIONS	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO_2 inkl. netto CO_2 från LULUCF	18 360	21 006	11 552	14 297	13 983	17 024	21 957	22 195	17 966	17 206	13 961	11 128	17 015	12 783	10 192
CO_2 exkl. netto CO_2 från LULUCF	57 141	58 967	54 131	55 064	55 995	56 610	55 771	53 189	53 155	52 025	49 978	46 517	52 279	48 479	45 710
CH_4 inkl. CH_4 från LULUCF	6 972	6 866	6 269	6 235	6 047	5 889	5 917	5 782	5 706	5 465	5 260	5 146	5 045	4 943	4 805
CH_4 exkl. CH_4 från LULUCF	6 971	6 865	6 266	6 232	6 042	5 883	5 911	5 777	5 693	5 462	5 247	5 144	5 044	4 941	4 804
N_2O inkl. N_2O från LULUCF	8 190	7 776	7 330	7 153	7 063	7 006	6 983	6 838	6 841	6 604	6 723	6 558	6 795	6 377	6 290
N_2O exkl. N_2O från LULUCF	8 114	7 717	7 263	7 087	7 000	6 941	6 912	6 756	6 754	6 507	6 612	6 451	6 670	6 270	6 191
HFCs	4	132	568	615	666	710	769	791	819	840	868	870	848	820	775
PFCs	377	343	241	236	261	258	254	257	245	248	225	35	158	183	69
SF_6	107	127	94	111	104	69	81	142	111	151	84	81	72	60	55
Total (inkl. LULUCF)	**34 011**	**36 250**	**26 053**	**28 646**	**28 124**	**30 956**	**35 962**	**36 005**	**31 690**	**30 514**	**27 122**	**23 818**	**29 934**	**25 167**	**22 186**
Total (exkl. LULUCF)	**72 714**	**74 152**	**68 563**	**69 344**	**70 068**	**70 470**	**69 699**	**66 913**	**66 778**	**65 233**	**63 014**	**59 097**	**65 072**	**60 754**	**57 604**

Table ES.2. Greenhouse gas emissions by sector (Gg CO_2 equivalents)

GHG SOURCE & SINK CATEGORIES	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1. Energy	53 439	55 142	50 191	51 077	51 865	52 846	51 638	49 190	49 101	47 834	46 012	44 226	48 377	44 601	42 141
2. Industrial Processes	6 474	6 745	6 861	6 859	7 008	6 680	7 072	7 012	7 092	7 030	6 778	4 971	6 785	6 349	5 899
3. Solvent and Other Product Use	332	309	278	269	276	292	311	303	299	281	288	284	309	303	303
4. Agriculture	9 046	8 723	8 317	8 268	8 193	8 066	8 106	7 976	7 930	7 890	7 937	7 725	7 803	7 787	7 641
5. LULUCF	-38 703	-37 902	-42 510	-40 698	-41 943	-39 514	-33 737	-30 908	-35 089	-34 719	-35 892	-35 279	-35 138	-35 587	-35 418
6. Waste	3 421	3 233	2 916	2 871	2 726	2 586	2 572	2 431	2 356	2 197	2 000	1 892	1 798	1 716	1 620
7. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)	**34 011**	**36 250**	**26 053**	**28 646**	**28 124**	**30 956**	**35 962**	**36 005**	**31 690**	**30 514**	**27 122**	**23 818**	**29 934**	**25 167**	**22 186**

ES 3. Overview of Source and Sink Category Emission Estimates and Trends, including KP-LULUCF

ES.3.1 GHG inventory

The methods used to calculate the emissions and removals are in accordance with the Revised IPCC 1996 Guidelines for National Greenhouse Gas Inventories and the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. The report is prepared in accordance with the Reporting Guidelines, agreed by the UNFCCC at the eighth session of the Conference of the Parties (COP) in New Delhi 2002 and subsequent decisions.

The sectors included in the inventory and the main sources used for activity data and/or emission data are presented in Table ES.3. The emissions are collected directly from these data sources, or calculated based on activity data.

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

CRF	Sector	Main source for activity/emission data
1	Energy	
	-Stationary combustion	Statistical survey on energy consumption
	-Transport	Transport authorities
2	Industrial processes	Environmental reports
		Statistical survey on energy consumption
		Direct contact with companies
		CO_2 Data from the European trading scheme (ETS)
		National data from the Products register at the Swedish Chemicals Agency
3	Solvent and Other Product Use	National data from the Products register at the Swedish Chemicals Agency
		National experts
		Environmental reports
4	Agriculture	Official statistical reports
		Organisations and researchers
5	Land Use, Land Use Change and Forestry	Swedish University of Agricultural Sciences
		Swedish Forest Agency
6	Waste	Swedish Association of Waste Management
		The Swedish Forest Industries Federation
		Statistics Sweden
		Swedish Environmental Protection Agency
		Environmental reports

Greenhouse gas emissions from the energy sector varies due to weather conditions (temperature and precipitation) and conditions related to the economy. However, the trend for the period 1990-2012 is a general decline in emissions. The emission from the energy sector has decreased by about 5 per cent compared to 2011, mainly from the electricity and heat production and transport. Emissions from the energy sector, including transport, were about 42 million tonnes of carbon dioxide equivalents in 2012 (Table ES.2), which corresponds to about 73% of total emissions. It is primarily emissions from electricity and heat production and transport which declined between 2011 and 2012.

Emissions from electricity and heat production in 2012 have decreased by about 5% (about 7.7 million tons of carbon dioxide equivalents) compared to 1990 (8 million tonnes of carbon dioxide equivalents). The decreased emission from electricity and heat production in 2012 compared to 2011 was mainly due to reduced need for heating due to warm weather, increased production of nuclear power and a good supply of hydropower.

The backbone of the Swedish electricity production is hydropower and nuclear power, together with fossil fuels and an increasing share of renewable power. In 2012, about 57% of all fuels used for district heating come from biomass, while waste combustion accounted for 23 %. Since 1990, there has been a large increase in the use of district heating from 89 PJ (1990) to 188 PJ (2012).

Emissions from the transport sector (19 million tonnes of carbon dioxide equivalents, in which about 18 million tonnes of carbon dioxide equivalents) were in 2012 almost down to the same level as the base year 1990. Greenhouse gas emissions from domestic transport decreased by approximately 6 % in 2012 compared to 2011. Increased share of renewable fuels and fuel -efficient vehicles contributes to the decreasing emissions.

Emissions from industrial processes are dominated by carbon dioxide (82 %) followed by fluorinated greenhouse gases (15 %), nitrous oxide with (2.5 %) and methane (0.2 %). The total emission from industrial processes in 2012 was almost 6 million tonnes of carbon dioxide equivalents (Table ES.2), representing approximately 10 % of the national emissions. Iron and steel production and mineral industry are the major sources (81 %) of emissions. Emissions from this sector has decreased by about 0.45 million tonnes of carbon dioxide equivalents, or about 7 % between 2011 and 2012. The decrease in 2012 is mainly due a 16 % decline in iron and steel production compared with the previous year. Since 1990, emissions from this sector have varied, primarily due to fluctuation in production volumes which is influenced by the economic cycles. Greenhouse gas emissions from sector in 2012 were about 9 % lower than 1990.

The use of Solvents and Other products mainly gives rise to emissions of volatile organic substances (NMVOCs), nitrous oxides (N_2O) and some carbon dioxide. In 2012, emissions of carbon dioxide and nitrous oxide were almost 0.3 million tonnes CO_2 equivalents (Table ES.2), which corresponds to about 0.5 % of total greenhouse gas emissions. Compared to 1990, emissions have decreased with about 9 %. Almost 13 % of carbon dioxide emissions arise from paint application, even though these emissions have decreased due to a transition to water-based paints.

Agriculture sector is the largest source of nitrous oxide and methane emissions. In 2012, the aggregated emissions were about 7.6 million tonnes of carbon dioxide equivalents (Table ES.2), of which about 63 % was N_2O and about 37 % CH_4. The emission has decreased by more than about 15 % compared to 1990. The emission has also decreased by less than 2 % between 2011 and 2012.

Methane emissions arise primarily from the digestive processes of cattle and from manure management. The most important reasons for the reduced emissions are reduced livestock keeping activities (decline in animal numbers) and reduced application of N-fertilisers in agriculture. Nitrous oxide emissions originate mainly from transformation of nitrogen that takes place in the ground, which is influenced by the use of manure and commercial fertiliser and the cultivation of nitrogen-fixing crops. More than a half (57 %) of the sector's emission comes from agricultural land.

The net removal for LULUCF in 2012 is estimated to just above 35 million tonnes of CO_2. Net uptake decreased slightly between 2011 and 2012 (Table ES.2). The long-term trend of decreasing net uptake in living biomass is mainly due to an increase in logging.

Emissions from the waste sector in 2012 were dominated by emissions of methane from landfills. Methane gas dominates the total emission from this sector and makes up to 86 %, while nitrous oxide emissions from waste water account for 10 % and carbon dioxide emissions from the incineration of hazardous waste is about 4 %. In 2012, the aggregated emissions from the waste sector were about 1.6 million tonnes CO_2 equivalents (Table ES.2), or 2.8 % of the total GHG emissions. Compared to 1990, emissions in 2012 have decreased by about 53 %. The collection of landfill gas, a ban on landfill deposit for organic material and the introduction of a landfill tax have played a key role for the decrease in emissions.

The total emissions of greenhouse gases in 2012 were about 57.6 million tonnes expressed as carbon dioxide equivalents and the emissions that come from sectors outside the trading system were 39.4 million tonnes. This means that emissions in Sweden in 2012 were 21 % below the base year emissions.

ES.3.2 KP-LULUCF activities

As the activities under Article 3.3 (afforestation and deforestation) are relatively uncommon in Sweden, it is difficult to draw any conclusions on the differences between years. The net uptakes and emissions are approximately at the same levels as in previous years.

Net removals related to Forest management under Article 3.4 decreased during the previous years and reached about the same level as in 1990, more than 39 M tonnes of carbon dioxide equivalents. This is mainly an effect of reduced felling.

ES 4. Overview of Emission Estimates and Trends of Indirect GHGs and SO_2

Emissions of nitrogen oxides (NOx) were about 132 ktonnes in 2012 (Table ES.4), a reduction by about one-half compared to 1990 and by 5 % compared to 2011. Transport sector (mainly road traffic) is a major source for NOx emission which contributes with about 48 % of the total emission. Road traffic emissions of NOx have decreased by 60 % between 1990 and 2012 and by about 5 % between 2011 and 2012. Other important sources of emissions of nitrogen oxides are mobile machinery, maritime transport and electricity and heat production. In urban areas, road traffic is the most significant contributor to emissions of nitrogen oxides, but the introduction of catalytic converters in the late 1980's and the subsequent successively more stringent emission standards have contributed to a general reduction of nitrogen oxide levels in urban areas. The increased use of district heating and the "NO_X charge" of the early 1990s have also resulted in a great reduction of emissions of nitrogen oxides from the energy sector.

Table ES.4. Emissions of indirect greenhouse gases and SO_2 (ktonnes)

Gas	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
NOx	270	246	209	199	191	188	181	176	172	164	156	147	149	139	132
NMVOC	360	277	222	212	205	206	201	198	194	191	187	188	188	189	186
SO_2	105	69	42	41	41	41	37	36	36	32	30	30	32	29	28
CO	1280	1125	816	777	734	719	672	662	623	610	597	596	576	552	546

Emissions of carbon monoxide (CO) have decreased from 1280 ktonnes in 1990 to 546 ktonnes in 2012 (Table ES.4), a reduction of 57 %. About 95 % of emissions come from energy sector of which one-third comes from transport sector and about one-fourth arises from residential heat production.

Emissions of non-methane volatile organic compounds (NMVOC) were 186 ktonnes in 2012 (Table ES.4), a decrease by almost one-half compared to 1990. The emissions in 2012 have decreased slightly (less than 2 %) compared to 2011. The main sources of emissions of NMVOCs are products containing solvents, road traffic and, wood heating in the residential sector. Voluntary environmental standards for new installations of wood-burning boilers and reduced emissions from products containing solvent have contributed to the decrease in emissions.

Emissions of sulphur dioxide (SO_2) have decreased from 105 ktonnes in 1990 to almost 28 ktonnes in 2012 (Table ES.4), a reduction of about 74 %.Moreover, the emissions in 2012 have decreased by less than 5% compared with 2011.Sulphur dioxide emissions derive from the energy, transport and industrial sectors. The reduction is mainly due to a transfer from fuels with high sulphur levels to low-sulphur fuels, both for road traffic and heating. A tax on sulphur, introduced in 1991, has been important in this transition. For this reason, the current sulphur dioxide emission from transport sector is less than 4 % of the total emission. Since 1990, the emission from transport has declined by about 90 %.

Summary in Arabic

ملخص انبعاثات غازات الدفيئة في السويد لعام 2012

مقدمة

إن التغيرات المناخية التي نشهدها في عصرنا الحالي يعود سببها إلى زيادة تراكيز غازات الدفيئة (CO_2, CH_4, N_2O, HFC, PFC, SF_6) في الغلاف الجوي. لقد كانت هذه الغازات موجودة دائما وبشكل طبيعي في الغلاف الجوي ولكن بتراكيز قليلة. اظهرت البيانات والتحاليل الكيميائية للغلاف الجوي في العقدين الماضيين إزدياداً مضطرداً لتراكيز هذه الغازات مقارنةً عما كانت عليه في العقود الاخيرة. وبالرغم من وجود هذه الغازات دائما وبشكل طبيعي في الغلاف الجوي، فإن تراكيز بعضاً منها آخذة في الارتفاع نتيجة لإزدياد النشاط البشري متمثلاً في حرق المشتقات البترولية للحصول على الطاقة ومن خلال النشاطات الزراعية، والذي بدوره يفاقم من حدة ظاهرة الاحتباس الحراري.

ونتيجةً لذلك، وفي عام 1988 انشيء الفريق الحكومي الدولي المعني بتغير المناخ (IPCC) لمتابعة هذه الظاهرة. وبعد ذلك بعامين خرج الفريق بنتيجة مفادها أن التغيرات المناخية هي من صنع الإنسان وهي تمثل تهديداً عالمياً للبشرية. لقد كانت هناك الحاجة إلى اتفاق دولي للتعامل مع هذه المشكلة. لذا بدأت الأمم المتحدة مفاوضات لإنشاء الاتفاقية الإطارية بشأن تغير المناخ (UNFCCC)، والتي دخلت حيز التنفيذ عام 1994. كان الهدف من هذه الاتفاقية هو تحقيق استقرار، وعلى المدى الطويل، لتراكيز غازات الدفيئة في الغلاف الجوي وعند مستوى يمكن فيها تجنب التغيرات المناخية الضارة والتي تنشأ من صنع الإنسان. في عام 1997 وفي كيوتو، اليابان، تم التفاوض لإضافة أكثر البنود أهمية بالنسبة للاتفاقية وهو بروتوكول كيوتو، والذي يشمل على التزامات ملزمة للبلدان المدرجة في المرفق الأول من الاتفاقية لخفض انبعاثات هذه الدول من الغازات المسببة للاحتباس الحراري (غازات الدفيئة) إلى ما لا يقل عن 5٪ خلال 2008-2012 مقارنة مع سنة الأساس 1990.

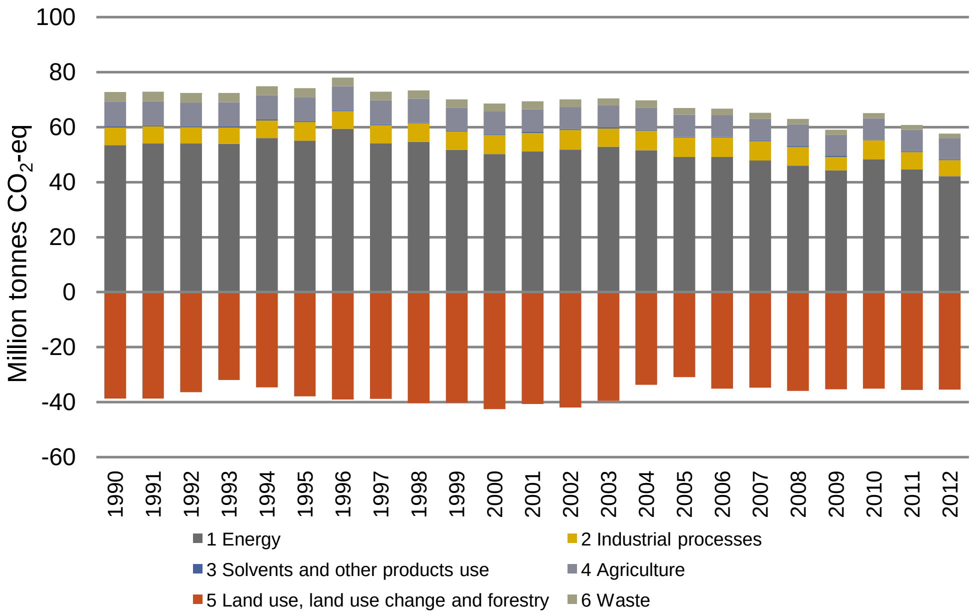
وفقا للمادتين 4 و 12 من اتفاقية الأمم المتحدة الإطارية بشأن تغير المناخ (UNFCCC)، يطلب من الأطراف أن تقدم سنويا قوائم الجرد الوطنية للانبعاثات البشرية المصدر بحسب مصادرها وعمليات إزاحتها بواسطة المصارف لجميع غازات الدفيئة غير الخاضعة لبروتوكول مونتريال. وينبغي أيضاً تقديم قوائم الجرد بما في ذلك الانبعاثات في نموذج الإبلاغ الموحد (CRF) وتقرير الجرد الوطني (NIR) National Inventory Report.

يشكل هذا التقرير (NIR submission 2014) جرداً لأنبعاثات غازات الدفيئة المباشرة (CO_2, CH_4, N_2O, HFC, PFC, SF_6) في الغلاف الجوي وغير المباشرة (NMVOC، NOx، CO، SO_2) الناتجة من النشاطات البشرية في السويد لعام 2012 بلإضافة إلى معلومات عن قوائم الجرد لغازات الاحتباس الحراري لجميع السنوات من 1990 إلى 2012، بما في ذلك وصفا للطرق التحليل و معلومات أخرى متعلقة.

نظرة عامة على **تقديرات انبعاثات غازات الدفيئة المباشرة واتجاهاتها**

قوائم جرد غازات الدفيئة

بلغ مجموع انبعاثات غازات الدفيئة في السويد لعام 2012 ما يقارب 57,6 مليون طن مكافيءمحسوبة بما يعادلها من ثاني أكسيد الكربون، منخفضاً بنحو 3 ملايين طنا مقارنةً بعام 2012. وتراجعت الانبعاثات بنسبة حوالي 21٪ أو ما يقرب من 15 مليون طن بين عامي 1990 و 2012. وفي عام 2012، تم تقدير صافي امتصاص غاز ثاني أكسيد الكربون بواسطة الغابات والاراضي الحرجية بحوالي 35 مليون طن مكافئ ثاني أكسيد الكربون (أنظر إلى الجداول 1 و 2).



الرسم البياني: مقادير الانبعاثات الصادرة من القطاعات المختلفة ما عدا قطاع تغيير إستخدام الأراضي والحراجة (LULUCF).

GREENHOUSE GAS EMISSIONS	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO_2 inkl. netto CO_2 från LULUCF	18 360	21 006	11 552	14 297	13 983	17 024	21 957	22 195	17 966	17 206	13 961	11 128	17 015	12 783	10 192
CO_2 exkl. netto CO_2 från LULUCF	57 141	58 967	54 131	55 064	55 995	56 610	55 771	53 189	53 155	52 025	49 978	46 517	52 279	48 479	45 710
CH_4 inkl. CH_4 från LULUCF	6 972	6 866	6 269	6 235	6 047	5 889	5 917	5 782	5 706	5 465	5 260	5 146	5 045	4 943	4 805
CH_4 exkl. CH_4 från LULUCF	6 971	6 865	6 266	6 232	6 042	5 883	5 911	5 777	5 693	5 462	5 247	5 144	5 044	4 941	4 804
N_2O inkl. N_2O från LULUCF	8 190	7 776	7 330	7 153	7 063	7 006	6 983	6 838	6 841	6 604	6 723	6 558	6 795	6 377	6 290
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HFCs	4	132	568	615	666	710	769	791	819	840	868	870	848	820	775
PFCs	377	343	241	236	261	258	254	257	245	248	225	35	158	183	69
SF_6	107	127	94	111	104	69	81	142	111	151	84	81	72	60	55
Total (inkl. LULUCF)	**34 011**	**36 250**	**26 053**	**28 646**	**28 124**	**30 956**	**35 962**	**36 005**	**31 690**	**30 514**	**27 122**	**23 818**	**29 934**	**25 167**	**22 186**
Total (exkl. LULUCF)	**72 714**	**74 152**	**68 563**	**69 344**	**70 068**	**70 470**	**69 699**	**66 913**	**66 778**	**65 233**	**63 014**	**59 097**	**65 072**	**60 754**	**57 604**

1- ألجدول يبين مقادير الانبعاثات والازاله لغازات الدفيئة المختلفة في السويد.

GHG SOURCE & SINK CATEGORIES	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1. Energy	53 439	55 142	50 191	51 077	51 865	52 846	51 638	49 190	49 101	47 834	46 012	44 226	48 377	44 601	42 141
2. Industrial Processes	6 474	6 745	6 861	6 859	7 008	6 680	7 072	7 012	7 092	7 030	6 778	4 971	6 785	6 349	5 899
3. Solvent and Other Product Use	332	309	278	269	276	292	311	303	299	281	288	284	309	303	303
4. Agriculture	9 046	8 723	8 317	8 268	8 193	8 066	8 106	7 976	7 930	7 890	7 937	7 725	7 803	7 787	7 641
5. LULUCF	-38 703	-37 902	-42 510	-40 698	-41 943	-39 514	-33 737	-30 908	-35 089	-34 719	-35 892	-35 279	-35 138	-35 587	-35 418
6. Waste	3 421	3 233	2 916	2 871	2 726	2 586	2 572	2 431	2 356	2 197	2 000	1 892	1 798	1 716	1 620
7. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)	**34 011**	**36 250**	**26 053**	**28 646**	**28 124**	**30 956**	**35 962**	**36 005**	**31 690**	**30 514**	**27 122**	**23 818**	**29 934**	**25 167**	**22 186**

2- ألجدول يبين مقادير الانبعاثات والازاله الصادرة من القطاعات المختلفة في السويد

غاز ثاني أكسيد الكربون (CO_2)

بلغت انبعاثات CO_2 حوالي 46 مليون طن في عام 2012، منخفضاً بما يقارب 20٪ مقارنةً بعام 1990 .ويستحوذ قطاع الطاقة، بما في ذلك قطاع النقل، على حوالي 89٪ من إجمالي الانبعاثات، لذا يعتبر هذا القطاع المصدر ألاكبر لغاز ثاني أكسيد الكربون في السويد. ويمثل هذا الغاز حوالي 79 بالمئه من الانبعاثات الإجمالية لغازات الدفيئة.

غاز الميثان (CH_4)

ينبعث غاز الميثان (CH_4) بشكل أساسي من النشاطات الزراعية ومواقع مكبات النفايات حيث يتكون غاز الميثان خلال عمليات الهضم للحيوانات المجترة وعمليات التخمر لروث هذه الحيوانات في المزارع. أما في قطاع النفايات فيتكون الميثان نتيجة تخمر النفايات العضوية. كان مجمل الإنبعاث في عام 2012 بحوالي 5 مليون طن مكافيء محسوبة بما يعادلها من ثاني أكسيد الكربون، منخفضاً حوالي 31٪ مقارنة مع عام 1990، ويرجع هذا الأنخفاض في المقام الأول إلى التدابير المنفذة في قطاع النفايات والزراعة والتي تحد من تكون الميثان من هذين القطاعين.

أكسيد النيتروز (N_2O)

في عام 2012، بلغت انبعاثات أكسيد النيتروز (N_2O) حوالي 6.2 مليون طن مكافيء محسوبة بما يعادلها من ثاني أكسيد الكربون، منخفضاً بنسبة 24٪ مقارنة مع عام 1990. ينشأ هذا الغاز أساسا من قطاع الزراعة وخصوصاً من تخمر روث حيوانات المزارع ومن خلال إنبعاث هذا الغاز من السماد العضوي وغير العضوي المستعمل لتحسين مستوى ألمحاصيل الزراعية. كما يتكون هذا الغاز خلال عمليات إحتراق الوقود المتعلقة في إنتاج الطاقة ومن خلال معالجة مياه الصرف الصحي والعمليات الصناعية. ويمثل القطاع الزراعي الجزء الأكبر من الانخفاض وذلك للتدابير المنفذة في القطاع للحد من إنبعاث هذا الغاز.

غازات الكربون المشبعة بالفلور

بلغ مجموع الانبعاثات من الغازات المفلورة (مركبات الكربون المشبعة بالفلور، ومركب سادس فلوريد الكبريت، SF_6) في عام 2012 ما يقرب من مليون طن مكافيء محسوبة بما يعادلها من ثاني أكسيد الكربون. ويتوافق هذا مع زيادة قدرها حوالي 84٪ مقارنة بعام 1990. وتعزى هذه الزيادة إلى الاستعاضة عن المواد المستنفدة للأوزون من مركبات الكربون المشبعه بالكلور والفلور. القطاع الوحيد المسؤول عن هذه الانبعاثات هو قطاع الصناعة حيث تدخل مركبات الكربون المشبعة بالفلور في العديد من الصناعات مثل الاسفنج والمطاط الصناعي.

نظرة عامة على **تقديرات الانبعاثات والإزالة لغازات الدفيئة من القطاعات المختلفة**

قطاع الطاقة

تتأثر كميات الانبعاثات الناجمة من قطاع الطاقة بمعدل درجات الحرارة السنوية (شتاء بارد أو معتدل نسبياً) و معدل هطول الأمطار (وهذا يؤثر على معدل إنتاج الطاقة الكهرومائية) وحالة الاقتصاد (معدل الانتاج الصناعي وتأثره بالإنتعاش أو الركود). عموماً فإن اتجاه كميات الانبعاثات من قطاع الطاقه للفترة 1990-2012 يشير إلى إنخفاضً مستمر. في عام 2012 انخفضت انبعاثات الغازات المسببة للاحتباس الحراري مقارنة بعام 2011 وذلك لتناقص الانبعاثات الناجمة عن إنتاج الطاقة والنقل. لقد بلغ مجموع انبعاثات غازات الدفيئة من قطاع الطاقة بما في ذلك النقل لعام 2011 حوالي 42 مليون طن مكافيء محسوبة بما يعادلها من ثاني أكسيد الكربون.وهذا ما يعادل 73٪ من إجمالي الانبعاثات. وأصبحت كميات الانبعاثات الصادرة من قطاع المواصلات (حركة المرور على الطرق) عام 2012 تعادل تقريباً مستويات الانبعاثات الصادرة عن هذا القطاع لعام 1990.

انخفضت انبعاثات ثاني أكسيد الكربون من إنتاج الكهرباء وطاقة التدفئة في عام 2012 بنحو 7٪ مقارنةً مع عام 2011 ويرجع هذا إلى الاعتماد بشكلٍ أكبر على الطاقة الكهرمائية والطاقة النووية (نظراً لعدم إنتاج أية انبعاثات من هذه المصادر) وهذا أدى بدوره إلى قلة استخدام الوقود الأحفوري.

قطاع الصناعة

يعتبر ثاني أكسيد الكربون أبرز غازات الدفيئة الذي ينبعث من قطاع الصناعة (حوالي 82٪) تليه الغازات المفلورة (بنسبة 15٪)، وأكسيد النيتروز وغاز والميثان بنسبٍ ضئيلة.

معظم هذه الانبعاثات من هذا القطاع تصدر أساسا من العمليات الصناعية المتعلقة من إنتاج الحديد والصلب والمعادن في السويد. قدرت الانبعاثات الإجمالية من هذا القطاع في عام 2012 ما يقرب من 6 ملايين طن مكافيء محسوبة بما يعادلها من ثاني أكسيد. الكربون، مما يجعل هذا القطاع يمثل ما يقرب من 10٪ من اجمالى الانبعاثات الوطنيه. وقد انخفضت الانبعاثات الكلية من هذا القطاع بين عامي 2011 و 2012 بحوالي 0.45 مليون طن مكافئ ثاني أكسيد الكربون أو حوالي 7٪. وسبب هذا الإنخفاض هو التراجع في إنتاج الصلب والحديد والذي أدى بدوره إلى إنخفاض الانبعاثات بحوالي 16% مقارنةً بالعام 2011 .منذ عام 1990 وكميات الانبعاثات من قطاع الصناعة في تذبذب وذلك نتيجة لتذبذب حجم الإنتاج والذي يتأثر بحالة الاقتصاد العالمي. بقي القول أن انبعاثات غازات الدفيئه من هذا القطاع عام 2012، كانت أقل بمستوى 9٪ مقارنةً بعام 1990.

قطاع المذيبات واستخدام والمنتجات

يصدر عن هذا القطاع انبعاثات المركبات العضوية المتطايرة (NMVOC) وغاز واكسيد النيتروز وغاز ثاني أكسيد الكربون. في عام 2012 بلغ مجموع الانبعاثات حوالي 0.3 مليون طن مكافيء محسوبة بما يعادلها من ثاني أكسيد الكربون. وهذه الكمية تعادل حوالي 0.5٪ من إجمالي انبعاثات غازات الدفيئة في السويد. وبالمقارنة مع عام 1990، انخفضت الانبعاثات

بحوالي 9٪. والسبب الرئيسي يعود إلى إستخدام الدهانات التي ترتكز على الماء في تركيبها بدلاً عن التي على الزيتية منها.

قطاع الزراعة

قطاع الزراعة هو أكبر مصدر لانبعاثات غاز الميثان وغاز أكسيد النيتروز. في عام 2012، بلغ مجموع انبعاثات هذا القطاع حوالي 7.6 مليون طن مكافيء محسوبة بما يعادلها من ثاني أكسيد الكربون. ويشكل أكسيد النيتروز وغاز الميثان 63٪ و 37٪ على التوالي لهذا القطاع. انخفضت الانبعاثات لعام 2012 بنسبة حوالي 15٪ مقارنة بعام 1990 وذلك لاينخفاض عدد المواشي في السويد وقلة إستخدام الأسمدة الصناعية. ينشأ غاز الميثان أساسا من خلال عمليات الهضم وكذلك خلال عمليات التخمر لروث الماشية. أما انبعاثات أكسيد النيتروز فتنشأ أساسا من تبخر هذا الغاز نتيجة لإستخدام الأسمدة العضوية والتجارية وزراعة المحاصيل المثبتة للنيتروجين. ويأتي أكثر من نصف (57٪) هذه الانبعاثات من الأراضي الزراعية.

قطاع تغيير إستخدام الأراضي والحراجة (LULUCF)

تتميز السويد باحتوائها على مساحات واسعة من الغابات والاحراج. في عام 2012 قدر صافي إزالة ثاني أكسيد الكربون (بواسطة إمتصاص الأشجار لغاز ثاني أكسيد الكربون) من قطاع تغيير استخدام الأراضي والحراجة (LULUCF) بحوالي 35 مليون طن. وقد قل صافي الإزالة قليلا عام 2012مقارنةً مع 2011.

قطاع النفايات

يهيمن غاز الميثان على الغازات الاخرى التي تصدر عنقطاع النفايات حيث بلغت انبعاثات الميثان في عام 2012 بنحو 86٪ من إجمالي انبعاثات هذا القطاع. في حين بلغت انبعاثات أكسيد النيتروز من مياه الصرف الصحي حوالي 10٪ وانبعاثات ثاني أكسيد الكربون الناتجة عن حرق النفايات نحو 4٪. وفي عام 2012 كانت مجموع الانبعاثات من هذا قطاع ما يقرب من 1.6 مليون طن مكافيء محسوبة بما يعادلها من ثاني أكسيد الكربون. وتشكل هذه الكمية حوالي 2.8٪ من إجمالي انبعاثات غازات الدفيئة الوطنية. بالمقارنة مع عام 1990 فقد انخفضت الانبعاثات بنحو 53٪ وذلك نتيجة لجمع غاز الميثان من مكبات النفايات حيث يتكون هذا الغاز خلال عمليات التخمر للنفايات العضوية . وقد لعبت مجموعة من القوانين المحلية من الحد من انبعاثات الميثان من النفايات، كفرض حظراً على التخلص مباشراةً من النفايات العضوية في المكبات. كما أن فرض ضريبة على طمر النفايات كان له دورا رئيسيا في إنخفاض الانبعاثات بشكل كبير.

نظرة عامة على **تقديرات انبعاثات غازات الدفيئة الغير المباشرة واتجاهاتها**

أكاسيد النيتروجين (NOx)

قدرت كميات انبعاثات أكاسيد النيتروجين في السويد عام بحوالي 132 كيلو طن (أنظر إلى الجدول 3) وبتناقص بحوالي النصف مقارنة بعام 1990. كما انخفضت انبعاثات أكاسيد النيتروجين من حركة المرور على الطرق بنسبة 60٪ بين عامي 1990 و 2012 وبنسبة حوالي 5٪ بين عامي 2011 و 2012. تعتبر حركة المرور على الطرق في المدن والمركبات الكبيرة المتنقلة بين المدن والنقل البحري والإنتاج الكهرباء والتدفئة من أكبر مصادر انبعاثات أكاسيد النيتروجين. ونظراً لأن حركة المرور على الطرق هي المساهم الأكبر لهذه الانبعاثات فقد أدخلت في أواخر عام 1980 تعديلات على المركبات المتنقلة وما رافقها من معايير أكثر صرامة للحد من هذه الانبعاثات حيث أسهمت هذه الاجراءت إلى خفض عام لمستويات أكسيد النيتروجين في السويد. وقد أدت زيادة استخدام التدفئة المركزية المعتمدة على الوقود في أوائل تسعينات القرن الماضي إلى سن قانون يعرف "بضريبة انبعاثات أكاسيد النيتروجين" ونتيجة لهذا فقد إنخفضت انبعاثات أكاسيد النيتروجين من قطاع الطاقة بشكل كبير.

أول أكسيد الكربون (CO)

يتكون غاز أول أكسيد الكربون من خلال عمليات حرق الوقود الاحفوري والعضوي في قطاع الطاقة مثل صناعة الكهرباء والتدفئة وكذلك أثناء عملية الإحتراق في محركات المركبات. انخفضت انبعاثات أول أكسيد الكربون من 1280 كيلو طن في 1990 إلى 546 كيلو طن في عام 2012 بمقدار 57٪. ينتج هذا القطاع حصة الأسد من مجموع إنبعاثات أول أكسيد الكربون بحوالي 95٪. ويمثل قطاع النقل والمواصلات الذي ينضوي تحت قطع الطاقة ما نسبة حوالي 40% من هذه الانبعاثات.

المركبات العضوية المتطايرة (NMVOC)

قدرت كميات انبعاثات المركبات العضوية المتطايرة عام 2012 بحوالي 186 كيلو طن، بانخفاض مقداره النصف مقارنة بعام 1990. تعتبر وسائل النقل على الطرق المساهم الرئيسي في انبعاثات المركبات العضوية المتطايرة. كما أن احتراق الحطب للتدفئة في القطاع السكني وكذلك استخدام المذيبات في المنتجات الصناعية ينشأ عنهما انبعاث المركبات العضوية المتطايرة بنسبٍ متفاوتة. وقد أسهمت المعايير البيئية الغير إلزامية المتبعه في تقنيات مواقد الحطب الجديدة من خفض هذه الانبعاثات بشكل محسوس.

ثاني أكسيد الكبريت (SO_2)

انخفضت انبعاثات ثاني أكسيد الكبريت من 105 كيلو طن في عام 1990 إلى ما يقرب من 28 كيلو طن في عام 2012 أي بنسبة 74٪ تقريبا. ينبعث ثاني أكسيد الكبريت قطاعات الطاقة والنقل والصناعة. ويعود هذا الانخفاض أساسا إلى إستخدام لأنواع الوقود المنخفضة الكبريت سواء وقود المركبات أو وقود التدفئة. كما أن فرض ضريبة على الوقود الذي يحتوي على نسبٍ عالية من الكبريت عام 1991 ساهم في الحد من هذه الانبعاثات.

Gas	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
NOx	270	246	209	199	191	188	181	176	172	164	156	147	149	139	132
NMVOC	360	277	222	212	205	206	201	198	194	191	187	188	188	189	186
SO_2	105	69	42	41	41	41	37	36	36	32	30	30	32	29	28
CO	1280	1125	816	777	734	719	672	662	623	610	597	596	576	552	546

3- ألجدول يبين مقادير انبعاثات غازات الدفيئة الغير المباشرة الصادرة من القطاعات المختلفة في السويد.

PART 1: ANNUAL INVENTORY SUBMISSION 2013

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 Parties, through the secretariat, should include emissions in the Common Reporting Format (CRF) and a National Inventory Report (NIR).

This report constitutes Sweden's NIR for submission 2014. The report contains information on Sweden's inventories for all years from 1990 to 2012 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 and greenhouse gas (GHG) inventories. 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 (OA/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 other than as the result of anthropogenic emissions of greenhouse gases.

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 (compounds of hydrogen, fluorine and carbon). HFCs are used instead of the ozone layer depleting CFCs (freons) in refrigerators and other applications, and their use is on the increase.

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 still 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 thousands of years to come.

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

In consequence of 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. A decade later UNFCCC had 188 member states (including EU as a part). The long-term goal 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 was negotiated in 1997 in Kyoto, Japan. The Kyoto protocol involves binding obligations for the Annex I countries (including all EU member states and other industrialized countries). Together the emissions of greenhouse gases in these countries should be at least 5 % lower during 2008-2012 compared to the base year 1990 (for fluorinated greenhouse gases it is allowed to use 1995 as a base year).

In the spring of 2002 Sweden, together with the other EU member states, ratified the Kyoto protocol and the 16th of February 2005 it came into force. EU and its member states uses a paragraph in the Kyoto protocol which gives them the right to, instead of national emission objective, have a joint EU objectives of a decrease in emissions with 8 %. Within EU the 8 % is shared among the member states in accordance with the burden sharing agreement[1]. For Sweden the agreement involves an allowed increase in emissions of 4 %. Sweden has chosen to go beyond the EU target. Reduced Climate Impact is one of the 16 Swedish Environmental Quality Objectives and is supported by long and short-term emissions targets. In 2009, Sweden adopted a vision that in 2050 the country will have no net emissions of greenhouse gases in the atmosphere. A comprehensive reduction strategy is set out to 2020.

2008–2012: Swedish greenhouse gas emissions will decrease by four per cent in comparison with 1990.

2020: Greenhouse gas emissions in Sweden (this applies to activities outside the emissions trading scheme) will decrease by 40 per cent in comparison with 1990.

2050: The vision for Sweden in 2050 is not to have any net emissions of greenhouse gases into the atmosphere.

The objective also involves that Sweden should encourage the global work to aim at the objective to stabilize the concentration of greenhouse gases in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

1.1.2 Greenhouse gas inventories

The inventory covers anthropogenic emissions of direct greenhouse gases CO_2, CH_4, N_2O, HFC, PFC, SF_6 and indirect greenhouse gases NO_X, CO, NMVOC and SO_2. Inadirect means that they do not contribute directly to the greenhouse effect, but that their presence in the atmosphere may influence climate in different ways. Ozone (O_3) is also a greenhouse gas but, since it is formed by the chemical reactions of nitrogen oxides, hydrocarbons and/or carbon monoxide, a separate report is not necessary.

The obligations of the Kyoto protocol have led to an increased need for international supervision of the emissions reported by the parties. The Kyoto protocol therefore contains rules for how emissions should be estimated, reported and reviewed. Emissions of the direct greenhouse gases CO_2, N_2O, CH_4, HFCs, PFCs and SF_6 are calculated as CO_2 equivalents and added to produce a total. Together with the direct greenhouse gases, also the emissions of $NO_{X,}$ CO, NMVOC and SO_2 are reported to UNFCCC. These gases are not included in the obligations of the Kyoto protocol. When a method used to estimate emissions is improved, a need to recalculate the whole time series may arise in order to maintain consistency. This means that data presented can be changed in the next submission.

[1] 2002/358/EC

1.1.3 Supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

Sweden provides supplementary information under Article 7 of the Kyoto Protocol for the Land Use, Land-Use Change and Forestry sector. The inventory for Kyoto protocol activities encompass emissions/ removals originating from the activities Afforestation and Reforestation (AR), Deforestation (D) and Forest management (FM) under article 3.3 and 3.4 under the Kyoto protocol, respectively. FM covers a major part of the Swedish land area whereas ARD are quite uncommon in Sweden.

To a large extent the KP-reporting of FM and AR harmonize with the UNFCCC-reporting of Forest land and land converted to Forest land. Small discrepancies occur regarding the accumulation of reported land areas as described in section 11.

In addition to the reporting of carbon pool changes, direct N_2O emissions from N fertilization and emissions from forest fires are reported under FM. Forest fires – both natural and wildfires – are uncommon and, this far, has not been registered on AR-land.

N_2O emissions from disturbance associated with land use conversion from Forest land to Cropland are reported under D.

1.1.4 Sweden’s commitment under the Kyoto Protocol and the EU Burden Sharing Decision

Under Sweden’s commitment for the first commitment period of the Kyoto Protocol (2008–12) and EU burden sharing, greenhouse gas emissions in Sweden, excluding LULUCF, are not to exceed the country’s assigned amount, which was 104% of base-year emissions as an average for the years 2008–12 when assigned amount units (AAUs) were allocated.The base year is 1990 for all emissions except fluorinated greenhouse gases, for which it is 1995. Baseyear’s emissions, when the assigned amount was determined, were 72.2 million tonnes carbon dioxide equivalents. This means that Sweden’s assigned amount of emissions was set at 75 million tonnes per year, as an average for 2008–12, taking no account of flexibilities. In addition, Sweden can claim credit for a carbon sink of 2.13 million tonnes per year (Removal Units (RMU)), according to article 3.3 and 3.4 in the Kyoto Protocol. This means that Sweden’s emissions of greenhouse gases will be allowed to comprise a maximum of 77.13 million tonnes per year on average for 2008-2012. Of these emission allowances, an average of approximately 22.4 million tonnes per year has been allocated within the EU emissions trading scheme.

Sweden’s total greenhouse gas emissions in 2012 were 57.6 million tonnes of carbon dioxide equivalents, see Table 1.1. The allocation for the trading sector was 22.7 million tonnes in 2012 and the emissions of the trading sector amounted to 18.2 million tonnes in 2012. The emissions from sectors outside the trading scheme were 39.4 million tonnes carbon dioxide equivalents. This means that the total emissions in Sweden in 2012 were around 21% below the assigned amount, including the net effect of allocation to the EU ETS and the carbon sink. This implies that Sweden will meet its commitment. The national surplus of Assigned Amount Units and Removal Units was around 13 million tonnes in 2008, 2009 and 2011; 11 million tonnes in 2010 and 15 million tonnes in 2012. Note that these figures are preliminary until the final calculations on target fulfilment will be made.

Table 1.1. Preliminary table on Sweden's greenhouse gas emissions in relation to the Kyoto Protocol and EU ETS

Mt CO_2-eq (subm 2014)	2008	2009	2010	2011	2012
Non EU ETS Emissions	43.3§	41.8	42.8	41.6	39.4
EU ETS Verified emissions	20.1	17.5	22.7	19.8	18.2
Allowances EU ETS	20.8	22.1	23.5	22.7	22.7
Total emissions	63.4	59.3	66.5	61.4	57.6
Total emissions incl. net effect of EU ETS	64.1	63.9	66.3	64.3	62.2
Assigned amount incl. LULUCF	77.13	77.13	77.13	77.13	77.13
Emissions incl. effect of EU ETS and LULUCF relative to assigned amount	17%	17%	14%	17%	21%

* Aviation was included in the ETS during 2012, but has not been taken into account in this table.

1.1.5 National emission targets

For the period 2008-2012, Sweden has set a national target of reducing greenhouse gas emissions with at least 4% compared with the 1990 level (Govt. Bill 2001/02:55). This target will be achieved, since the mean level for 2008-2012 is 15% below the 1990 level.

The Swedish milestone target for the environmental quality objective Reduced Climate Impact[2], as defined in the Riksdag's climate policy decision of June 2009 (Govt. Bill 2008/09:162), calls for emissions from activities not included in the EU ETS to be reduced by 40%, or around 20 million tonnes carbon dioxide equivalents between 1990 and 2020. One-third of this reduction, or roughly 6.7 million tonnes carbon dioxide equivalents, can be achieved by means of investments in emission reductions in other countries.

Preliminary projections indicate that this target will be met. An in-depth evaluation of progress towards it will be undertaken as part of the Checkpoint 2015 appraisal of climate policy.

2 http://www.government.se/sb/d/5775/a/217993.

1.2 Institutional arrangements

Under Article 5 of the Kyoto Protocol each party in Annex 1 has 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 national system is to be designed in compliance with UNFCCC decision 20/CP.7. Under the terms of Decision No. 280/2004/EC of the European Parliament and of the Council, the national system has to be in place by the end of 2005. 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.

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 fulfills all quality criteria, i.e. is transparent, accurate, consistent, comparable and complete.

The KP-reporting of LULUCF uses the same institutional arrangements, national system and corresponding QA/QC procedures as for the UNFCCC reporting.

1.2.1 Legal arrangements

Ordinance (2005:626) Concerning Climate Reporting provides the basis for the Swedish national system and describes the roles and responsibilities of the government agencies in the context of climate reporting. Through this, sufficient capacity for timely performance is ensured.

There are legislations in Sweden which is not primarily intended to apply to climate reporting but indirectly supports the work by providing a basis for the estimation of greenhouse gas emissions and removals. Under Chapter 26 Section 19 of the Environmental Code (1998:808), there is an obligation for annual environmental reports to be submitted for certain environmentally hazardous activities so that government agencies can undertake supervision.

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

Sections 6-19 of the Ordinance (2005:626) Concerning Climate Reporting describe the tasks of the government agencies in the context of the yearly inventory and reporting activity. The illustration in Figure 1.1 and Table 1.2 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 or conducting a national peer review (red). In addition to what is described in the Ordinance, the Swedish Environmental Protection Agency (Swedish EPA) engages the SMED consortium as consultants with expert skills to conduct the inventory and reporting in the area of climate change.

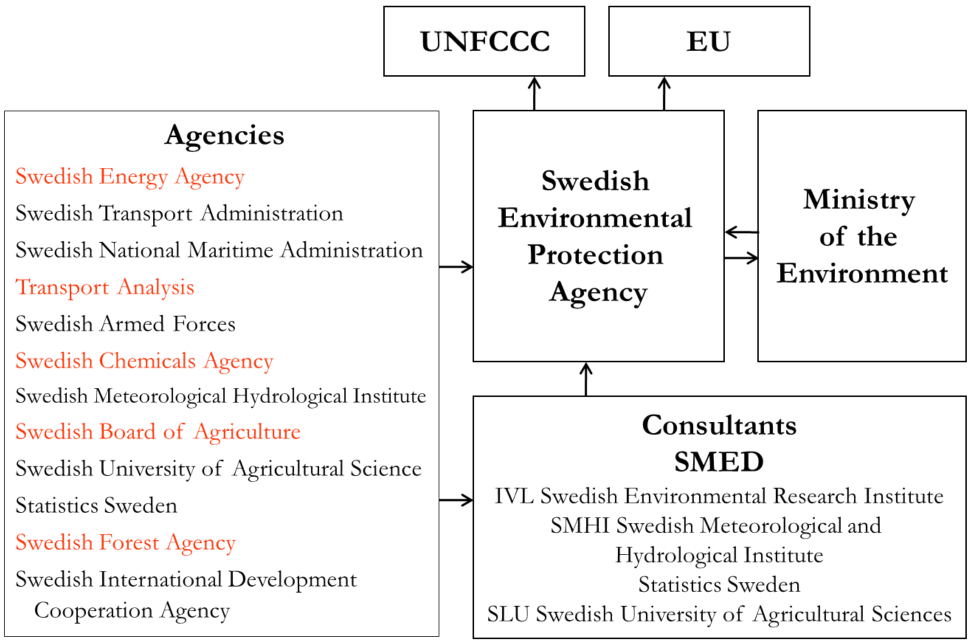

Figure 1.1. The Swedish national system

1.2.2.1 SINGLE NATIONAL ENTITY

The Swedish Ministry of Environment 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:
Ms. Nilla Thomson
M.climate@regeringskansliet.se

Responsible for reporting to EU and UN:
Ms. Agnes von Gersdorff
agnes.von-gersdorff@regeringskansliet.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 reporting system and also for the final quality control and quality assurance of the inventory.

The Swedish EPA sends the inventory to Ministry of the Environment and – on behalf of the Ministry of Environment – submits the inventory to the EU and to the UNFCCC. Finally, the Swedish EPA is responsible for national publication of the greenhouse gas inventory.

The National inventory compiler at the Swedish EPA is Mr. Lars Westermark.

1.2.2.3 AGENCIES RESPONSIBILITIES

Agencies responsibilities according to Ordinance (2005:626) Concerning Climate Reporting is described in Table 1.2 below.

Table 1.2. Agencies responsibilities according to Ordinance (2005:626) Concerning Climate Reporting

Sector	Data and documentation provided by	Peer review conducted by	Other responsibilities
Energy	Swedish Energy Agency the Swedish Transport Administration, the Swedish Transport Agency, the National Maritime Administration the Swedish Armed Forces	Swedish Energy Agency (energy sector excluding transports) Transport Analysis (transports)	The Swedish Energy Agency also assists the Swedish EPA in the work of developing documentation concerning flexible mechanisms and emissions projections as well as extracts from and information about changes to the national register.
Industrial Processes	Swedish Chemicals Agency (fluorinated greenhouse gases)	The Swedish EPA (CO_2, CH_4 and N_2O) Swedish Chemicals Agency (fluorinated greenhouse gases)	
Solvents and Other Product Use	Swedish Chemicals Agency	Swedish Chemicals Agency	
Agriculture	Swedish Board of Agriculture	Swedish Board of	

	Statistics Sweden	Agriculture	
Land Use, Land-Use Change And Forestry Sector	Swedish University of Agricultural Sciences, Statistics Sweden, the Swedish Forest Agency, the Swedish Meteorological and Hydrological Institute (SMHI) and the Swedish Board of Agriculture	Swedish Forest Agency Swedish Board of Agriculture (agriculture related parts)	
Waste		Swedish EPA	
Reporting relating to efforts in developing countries			The Swedish International Development Cooperation Agency (Sida) is responsible for presenting documentation to the Swedish EPA.

1.2.2.4 THE SMED CONSORTIUM

The Swedish EPA engages consultants with expert skills to conduct the inventory and reporting 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 procurement had been completed, a framework contract was signed with the consortium Swedish Environmental Emissions Data (SMED)[3], 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 runs for nine years and thus covers the whole first commitment period under the Kyoto Protocol.

SMED receives data and documentation from responsible authorities as described above and produces most of the data and documentation in the Swedish inventory. 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. The Swedish Meteorological and Hydrological Institute is main responsible for production of gridded emission data. Statistics Sweden is main responsible for the energy sector, the agriculture 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 sector, the solvents and other products use sector and also parts of the waste sector and energy sector.

On behalf of the Swedish EPA, SMED also conducts development projects necessary for improving the inventory.

[3] http://www.smed.se/

1.3 Inventory planning, preparation and management

The present Swedish greenhouse gas inventory and KP-LULUCF inventory was compiled according to the recommendations for inventories set out in the UNFCCC reporting guidelines according to Decision 18/CP.8, the Common Reporting Format (CRF), Decision 13/CP.9, the new CRF for the Land Use Change and Forestry Sector, the IPCC 1996 Guidelines for National Greenhouse Gas Inventories, which specify the reporting obligations according to Articles 4 and 12 of the UNFCCC (IPCC Guidelines, 1996) as well as the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC GPG, 2000) and the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC GPG-LULUCF, 2003).

It could 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

In order to fulfill the obligations of reporting to the UNFCCC and the EU, the Swedish EPA has set up a quality system as part of the national system. The structure of the quality system follows the PDCA cycle (Plan, Do, Check, Act) illustrated in Figure 1.2 below. 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.

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 plan[4]. The QA/QC plan also includes a scheduled time frame describing the different stages of the 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.

[4] Swedish EPA, National Greenhouse Gas and Air Pollutants Inventory System in Sweden

Figure 1.2. Structure of the quality system

The responsibilities of the Swedish EPA and the other government agencies for the quality system are described in Ordinance (2005:626) Concerning Climate Reporting. Under Section 3, 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 manual including several appendices.[5] It is updated annually and lists all quality control steps that must be undertaken during inventory work (Tier 1 and where appropriate Tier 2). It also includes descriptions of roles and responsibilities, of databases and models, work manuals for each CRF 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.

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

The illustration in Figure 1.3 below shows a process description of the annual Swedish inventory.

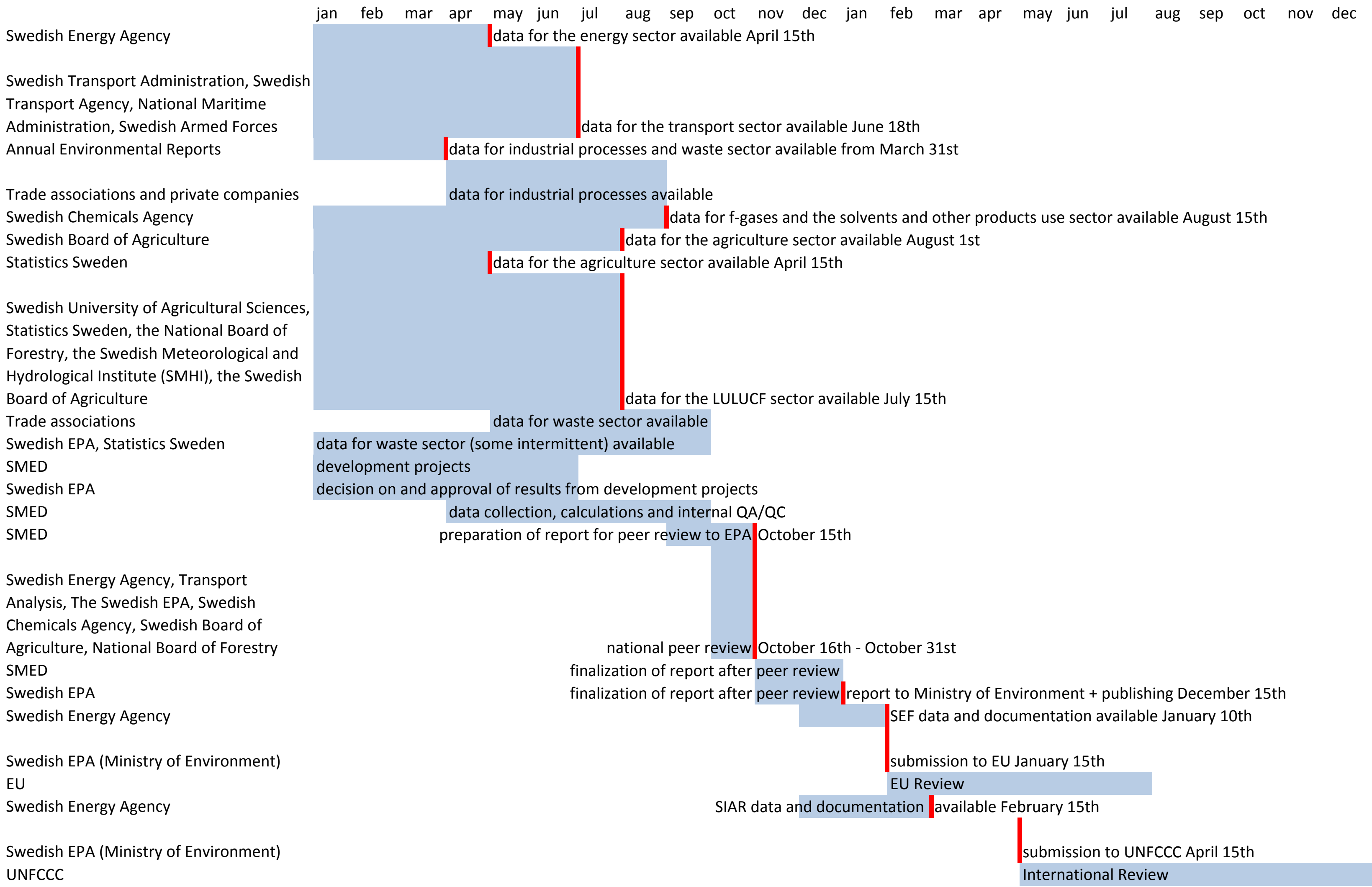

Figure 1.3. Overview of inventory planning, preparation and management

1.3.2 Training, awareness and skills

To meet quality criteria in the IPCC and UNFCCC guidelines, experts from different government agencies are participating in the inventory according to SFS 2005:626. By involving these agencies, it is ensured that the best expertise available in the country is involved.

Skills on the part of SMED 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.

1.3.3 Inventory planning (PLAN)

Planning of the inventory for 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 coming year are set 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

Priorities are distributed to SMED approximately in October.

Based on the priorities and on detailed information in the list on suggestions on improvements (see section 1.3.5.5 below), SMED compiles a list of suggested development projects for the coming years. The list of suggested development projects is discussed between SMED and the Swedish EPA. During the winter the Swedish EPA decides on what projects should be performed.

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. The Swedish EPA each year contacts responsible authorities and discusses needs for updates.

1.3.4 Inventory preparation (DO)

SMED gather data and information from various government agencies, organizations and companies over the period from April to August with the aim of being able to carry out emission calculations. 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 peer review process.

1.3.4.1 ENERGY- STATIONARY COMBUSTION

Energy industries: Data from quarterly fuel statistics, 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, a sample survey conducted by Statistics Sweden. In some cases data from the industrial energy statistics or ETS is used as a complement. All data is at plant level and by fuel type.

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 emission factors provided by the Swedish Energy Agency and 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 National Road Administration, the National Rail Administration, the Civil Aviation Administration 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 in refineries and chemical industries, activity data and CO_2 emissions from ETS are used for 2005 and later. In earlier years, data was collected through personal contacts with the facilities. Activity data and CO_2 emissions from hydrogen production in oil refineries are taken from ETS and reported under CRF 1B2a1 in line with 2006 IPCC Guidelines. For non-CO_2 emissions, 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 National Road Administration.

Transmission- and distribution losses of natural gas and gas works gas are, since submission 2014, estimated using a national method described in section 3.3.2.2. Estimated leakage of gas works gas is taken from environmental reports.

Fugitive emissions from leakage and venting of natural gas, biogas and gas works gas in transmission and distribution activities are mainly estimated using information from national companies.

1.3.4.4 INDUSTRIAL PROCESSES

The reported data for industrial processes is mainly based on information from environmental reports. According to Swedish environmental legislation, operators performing environmentally hazardous activities that require a permit by law are required to compile and send an annual environmental report to their supervisory authority. The County Administrative Boards audit the data from the operators' environmental reports.

The data in the environmental reports refer to emissions derived from plant specific measurements or estimates such as mass balances. The use of default emission factors is limited.

In some cases, when there are a large number of smaller companies within a specific sector, and all the environmental reports are not available, a combination of information available from environmental reports and production statistics at national level is used to estimate national emissions. Emission factors used are usually derived nationally based on available information from some facilities in a specific sector, and applied to the national level. The use of default emission factors is limited.

Emissions of fluorinated greenhouse gases are estimated based on national import and export statistics from the Swedish Chemicals Agency.

1.3.4.5 SOLVENT AND OTHER PRODUCT USE

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

1.3.4.6 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.

1.3.4.7 LAND USE, LAND USE CHANGE AND FORESTRY

Estimates presented in the LULUCF sector are mainly based on data from the SLU. The SLU provides data from the National Forest Inventory, and from the Swedish Forest Soil Inventory but the Swedish Environmental Protection Agency is responsible for the national soil inventory. The two inventories are integrated and use the same infra-structure for the field sampling.

1.3.4.8 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, provides estimates of deposited organic fractions of industrial waste.

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

1.3.5 QA/QC procedures and extensive review of GHG inventory and KP-LULUCF inventory (CHECK)

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 8.1 in IPCC Good Practice Guidance (2000), have been carried out as follows:

- Transcription errors in data input
- Calculations are made correctly
- Units and conversion factors are correct
- Integrity of database files
- Consistency in data between source categories
- Correct movement of inventory data between processing steps
- Recalculations, checked and documented
- Completeness check
- Comparison of last submission's estimates to previous estimates
- Documentation of changes that may influence uncertainty estimates

In addition, source specific Tier 2 QC procedures are carried out for several categories (Table 1.3).

All QC measures performed are documented by SMED in QC checklists for each CRF code or group of codes. After completion of the initial compilation of the inventory, a QC-team within SMED reviews all QC checklists. In addition, the project management team performs checks of submission data using the functionality of the CRF Reporter (i.e. checks of completeness, time-series consistency and recalculation explanations).

Table 1.3. Source specific Tier 2 QC procedures carried out in the inventory

CRF		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.
1.B	Fugitive emissions and flaring of CO_2 CH_4 and N_2O	Measured emissions from flaring are checked to assure that the quality is sufficiently high. Trends for activity data and emissions are compared and analysed.
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 and the top-down method, the results have been compared and differences explained.
2.B.2	N_2O-emissions from Nitric Acid production	Bottom-up production data could not be compared to official data since official data for were not available in the statistical database. Only one company produces nitric acid. Calculation methods, abatement technique and production capacity is 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	Consumption of halocarbons and SF_6	Differences between country specific emission factors and default emission factors from IPCC Guidelines are documented.

When the reporting tables and the NIR are completed by SMED, a quality coordinator performs the final quality control before delivery of the inventory to the Swedish EPA.

1.3.5.2 QUALITY ASSURANCE

Key categories should be subject to external peer review according to the Tier 2 of the Good Practice Guidance. The Swedish QA/QC system includes national peer reviews by sectoral authorities prior to inventory submission. The peer review is defined in the Ordinance (2005:626) Concerning Climate Reporting 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 annual peer review. This means, among other things, ensuring that the peer reviewers have received the necessary training.

The peer review includes methodology and emissions factors used, as well as comparisons of activity and emission data with other national statistics. 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.

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. See also section 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 Swedish Environmental Protection Agency delivers the greenhouse gas inventory and the KP LULUCF inventory to the Ministry of Environment 20 working days before the European Commission reporting date (January 15th). At the same time, the inventory is published nationally[6].

The Swedish EPA, on behalf of the Ministry of Environment, submits the inventory to the European Commission on January 15th and to the UNFCCC on April 15th. Reported data in the submission of year *t* relates to emissions year *t*-2, in other words emissions which took place during 2011 are reported in early 2013.

[6] www.naturvardsverket.se

1.3.5.4 DATA STORAGE

A system for handling emission data, 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, and provides different types of quality gateways. For instance the system makes it possible for multiple users such as the SMED consortium and the national independent reviewers to view data, plot time series and make comparisons between different years and submissions. For all CRF 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 also allows for different types of data output, e.g. to the CRF Reporter or to MS Excel. Finally, TPS is used for data archiving of each submission. For access to the TPS, login with password is requested.

The CRF-tables were generated using the export function in CRF Reporter.

In addition to TPS, documentation, data and all calculations for each submission are stored at each organizations servers and, for collective use and archiving, at two projects at Projectplace[8]. One project is for documents shared between Swedish EPA, other involved agencies and SMED and the other project is primarily for SMEDs use however the Swedish EPA also has access to the project. At Projectplace, all documents are stored in versions, in other words when documents are changed a new version is automatically created. This function ensures that important information is not lost and facilitates backtracking of changes. Login with password is requested for access to projects at Projectplace.

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 also ideas from SMED and the Swedish EPA are compiled into a list for suggestions on improvements. From this list, development projects are formed each year as describes in section 1.3.3. All suggestions not implemented one year is kept on the list for next year.

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.

[7] https://tps.naturvardsverket.se/

[8] www.projectplace.com

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)[9], environmental reports[10], 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 Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines)[11] and, in general, in line with IPCC´s Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (Good Practice Guidance)[12] and IPCC's Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG-LULUCF)[13]. Some parts of the methodologies are taken directly from the IPCC Guidelines, the Good Practice Guidance and the EMEP/EEA air pollutant emission inventory guidebook (formerly called the EMEP CORINAIR emission inventory guidebook).[14] Information from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC Guidelines)[15] is used in some parts of the inventory.

In Table 1.4, all Tier methods used, which differ from Tier methods recommended in IPCC Guidelines or Good Practice Guidance, are presented. There is also a brief explanation of why the recommended methods have not been used. Note that for sectors where no specific recommendations are made in the IPCC Guidelines or Good Practice Guidance, these sectors are not included in Table 1.4. For an overview of the methods used in all sectors, see Summary 3 in the CRF tables and in each sector section, where a more detailed explanation on data sources and methodologies is given.

[9] See Annex 8.1

[10] See Annex 8.3

[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 GPG-LULUCF can be found at: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

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

[15] The 2006 IPCC Guidelines can be found at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

Table 1.4. Methods used that differ from recommended methods in the IPCC Guidelines or Good Practice Guidance for all sectors

Sector	Used method Tier	IPCC Guide-lines method Tier	Explanation
Energy: Emissions of CH_4 and N_2O from navigation	1	2	Reliable data required for Tier 2 is currently not available (various engine types etc).
Industrial processes: Emissions of PFC from aluminium production	2	3	No measurements are performed, so Tier 3 cannot be applied. The method used is Tier 2.
Industrial processes: Emissions of SF_6 from electrical insulation	2a	3	There is not enough information available to perform Tier 3.
Industrial processes: Semiconductor manufacture	1	2	There is not enough information available to perform Tier 2.
Waste: N_2O from waste water	National	1	Sweden uses national statistics on nitrogen emissions. Nitrogen emissions are only model calculated for the rural population.

SMED has carried out the calculations. In a few cases, estimates are based on expert judgements.

The combined effect of various greenhouse gases has been calculated using global warming potential factors (GWP). 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 as carbon dioxide equivalents.

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

1.4.2 KP-LULUCF inventory

The same base methodology, emission factors and data sources is used for the reporting of LULUCF under the KP as for the reporting under UNFCCC.

Data from the Swedish National Forest Inventory (NFI) have been used for developing the land use matrix and is consistent with the data used for developing the land use matrix under the UNFCCC-reporting. The main difference is that specific KP-activities are reported under the KP while broader land use categories are reported under the UNFCCC.

The carbon pool changes associated to the activities reported under the Kyoto protocol is estimated in exactly the same way as under the UNFCCC reporting, using the stock change method and area based sampling for most of the carbon pools. However, for the KP-reporting, the living biomass pool is reported separated into above-ground and below-ground biomass, respectively, and the dead organic matter is separated into litter and dead wood.

1.5 Brief description of key categories, including for KP-LULUCF key categories

1.5.1 GHG inventory (including and excluding LULUCF)

According to Good Practice Guidance, 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 in two tiers, tier 1 assessment and tier 2 assessment. The two tier assessments differ in the sense that the tier 2 assessment also includes information of uncertainties. According to Good Practice Guidance, the results from the tier 2 assessment should be utilized if the tier 2 results differ from the tier 1 results. Hence, in the Swedish inventory, the results from the tier 2 assessment is the basis for applying and describing higher tier methodologies and when prioritizing efforts in improving the quality of the inventory estimates.

The resulting tier 1 and tier 2 key categories are presented in CRF table 7 and in table A 1.1 – A 1.8 in Annex 1. There the methodology is discussed in detail and the corresponding background tables, according to tables 7.A1 - 7.A3 of the Good Practice Guidance, are presented.

Table 1.5. Tier 1 and tier 2 key categories 2012 in terms of level and trend

		Including LULUCF		Excluding LULUCF	
IPCC Source Category	GHG	Tier 1	Tier 2	Tier 1	Tier 2
1.AA.1.A (Public Electricity and Heat Production)	CH4				T
1.AA.1.A (Public Electricity and Heat Production)	CO2	L,T	L,T	L,T	L,T
1.AA.1.A (Public Electricity and Heat Production)	N2O	L,T	T	L,T	L,T
1.AA.1.B (Petroleum Refining)	CO2	L,T	L,T	L,T	L,T
1.AA.1.C (Manufacture of Solid Fuels and Other Energy Industries)	CO2	L,T		L,T	
1.AA.2.A (Iron and Steel)	CO2	L		L,T	
1.AA.2.C (Chemicals)	CO2	L,T		L,T	L,T
1.AA.2.D (Pulp. Paper and Print)	CO2	L,T		L,T	L,T
1.AA.2.E (Food Processing. Beverages and Tobacco)	CO2	L		L,T	
1.AA.2.F (Other Manufacturing Industries and Construction)	CO2	L,T	L	L,T	L
1.AA.3.A (Civil Aviation)	CO2	L		L	
1.AA.3.B (Road Transportation)	CH4			T	T
1.AA.3.B (Road Transportation)	CO2	L,T	L,T	L,T	L,T
1.AA.3.D (Navigation)	CO2			L,T	
1.AA.3.E (Other Transportation)	CO2			L,T	
1.AA.4.A (Commercial/Institutional)	CO2	L,T	T	L,T	L,T

IPCC Source Category	GHG	Including LULUCF		Excluding LULUCF	
		Tier 1	Tier 2	Tier 1	Tier 2
1.AA.4.B (Residential)	CH4		L,T	L	L,T
1.AA.4.B (Residential)	CO2	L,T	L,T	L,T	L,T
1.AA.4.B (Residential)	N2O				L
1.AA.4.C (Agriculture/Forestry/Fisheries)	CH4				T
1.AA.4.C (Agriculture/Forestry/Fisheries)	CO2	L,T	L	L,T	L
1.AA.5.B (Military Use)	CO2	T		T	T
1.B.2 (Oil and Natural Gas)	CH4				L
1.B.2 (Oil and Natural Gas)	CO2	L,T	L,T	L,T	L,T
2.A.1 (Cement production)	CO2	L,T		L,T	L,T
2.A.2 (Lime Production)	CO2	L,T		L,T	
2.B.2 (Nitric Acid Production)	N2O	T		T	T
2.C.1 (Iron and Steel Production)	CO2	L,T	L	L	L
2.C.2 (Ferroalloys Production)	CO2			T	
2.C.3 (Aluminium production)	CO2			L,T	
2.C.3 (Aluminium production)	PFC	T		T	T
2.F.1 (Refrigeration and Air Conditioning Equipment)	HFC	L,T	L,T	L,T	L,T
4.A (Enteric Fermentation)	CH4	L,T	L,T	L,T	L
4.B (Manure Management)	CH4			L,T	
4.B (Manure Management)	N2O	L	L	L,T	L,T
4.D.1 (Direct Soil Emissions)	N2O	L,T	L,T	L,T	L,T
4.D.2 (Pasture, Range and Paddock Manure)	N2O	L	L,T	L,T	L,T
4.D.3 (Indirect Emissions)	N2O	L	L,T	L	L,T
4.D.4 (Agricultural Soils. Other)	N2O	L,T	L,T	L,T	L,T
5.A.1 (Forest Land remaining Forest Land)	CO2	L,T	L,T	-	-
5.A.2 (Land converted to Forest Land)	CO2	L,T	L,T	-	-
5.B.1 (Cropland remaining Cropland)	CO2	L,T	L,T	-	-
5.B.2 (Land converted to Cropland)	N2O		T	-	-
5.C.1 (Grassland remaining Grassland)	CO2	T	T	-	-
5.E.2 (Land converted to Settlements)	CO2	L,T	L,T	-	-
6.A (Solid Waste Disposal on Land)	CH4	L,T	L,T	L,T	L,T
6.B (Wastewater Handling)	CH4		L,T	L	L,T

L=Level, T=Trend.

1.5.2 KP-LULUCF inventory

The key category assessment for KP-LULUCF is found in section 11.6.1.

Forest management, Afforestation/Reforestation and Deforestation were considered key-categories (CO_2). Part of 5III N_2O emissions from land use conversions to Cropland corresponds to D from Forest to Cropland. However, this category was not identified as key-category because most of the emissions under the UNFCCC refer to land use conversions from Grasslands to Cropland and due to a "conservative" high assumed uncertainty (100%). Every key category is estimated using higher tiers.

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

In the inventory, several data sources are confidential at micro level (e.g. plant level). This is for example the case for statistical surveys of fuel consumption used in Energy (CRF 1) and data from the Products Register at the Swedish Chemicals Agency used in Solvent and other product use (CRF 3). Results published in the inventory are aggregated, and because of this no confidentiality issues remains in the CRF or in the NIR.

1.7 General uncertainty evaluation

1.7.1 GHG inventory

An uncertainty analysis has been performed according to the Tier 1 method, described in detail in Annex 7 and Good Practice Guidance section 6.3.2. 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".

During 2005, a SMED study was performed, aiming at improving the transparency and quality in the present uncertainty estimates in the Swedish National Greenhouse Gas Inventory by making the underlying documentation and structures for uncertainty estimates more consistent and traceable. This will facilitate easier replication and updating of results as well as enable internal and external reviews of assigned uncertainties. To simplify the methodology, there have not been any adjustments for correlation between gases, even though many of them have the same activity data and therefore are correlated. The study is described in Annex 7 and in detail in a SMED report.[16]

The Good Practice Guidance Tier 1 method is based on emission estimates and 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 Good Practice Guidance, since 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.

Uncertainty estimates have been performed for the base year 1990 and 2012 for direct greenhouse gases, e.g. CO_2, CH_4, N_2O and F-gases and are presented as 95% confidence intervals.

When reporting the results in the NIR, 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 aims at showing what parts of the inventory are especially important and/or weak. This is important information when planning future inventories and, above all, 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. During each 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 tier 1 approach are presented in Annex 7. The overall uncertainty for 2012 GHG emissions (in CO_2 equivalents) in Sweden is calculated to be ±4.5%, excluding LULUCF (Figure 1.4). A considerable part of the overall uncertainty stems from uncertainty in the agricultural sector (CRF 4). The uncertainty estimates for fuel consumption are corrected to account for correlations between subcategories using the same fuel type. I.e. if the uncertainty for the total use of domestic heating oil is estimated to be ±1%, the specific uncertainty for the different subcategories using domestic

[16] Gustafsson, 2005

heating oil are corrected so that the uncertainty of the total use of domestic heating oil stays at ±1%. This is only done for subcategories sharing the same fuel type. It has not been possible to use a similar approach for subcategories sharing some other type of activity data, because there the total uncertainty could not easily be assessed in a similar way.

When including LULUCF in national total emissions the uncertainty increases (±30%), this is an effect of the large and relatively uncertain carbon sinks in combination with a percental increase due to that the total emission decreases (Figure 1.4). Table 1.6 shows the ten sources with the largest uncertainty contributions in the Swedish inventory for 2012, excluding LULUCF.

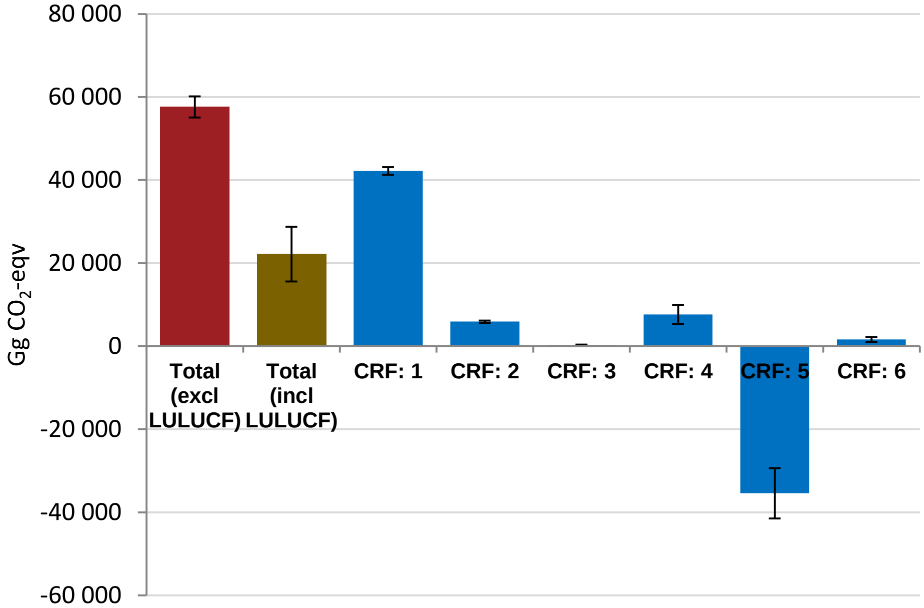

Figure 1.4. Uncertainty estimates, as 95% confidence intervals, in national total emissions (excluding and including LULUCF) and by sector

Table 1.6. The ten sources with the largest uncertainty contributions in the Swedish inventory for 2012, excluding LULUCF

IPCC Source Category	GHG	Year 2011 emissions or removals (Gg CO2-eqv)	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined uncertainty (%)	Relative contribution to variance in year 2011 (%)
4.D.1 (Direct Soil Emissions)	N2O	2 404	15	65	66	17%
4.D.4 (Agricultural Soils. Other)	N2O	684	35	150	154	11%
4.D.3 (Indirect Emissions)	N2O	823	29	122	125	11%
4.D.2 (Pasture, Range and Paddock Manure)	N2O	435	35	150	154	7%
6.A (Solid Waste Disposal on Land)	CH4	1 094	25	50	56	6%
1.AA.1.A (Public Electricity and Heat Production)	CO2	7 167	1	8	8	6%
1.AA.3.B (Road Transportation)	CO2	17 741	2	2	3	6%
4.A (Enteric Fermentation)	CH4	2 540	2	11	12	3%
1.AA.2.F (Other Manufacturing Industries and Construction)	CO2	4 232	5	3	6	3%
1.AA.4.B (Residential)	CH4	227	14	99	100	2%

The uncertainty of the trend of national total greenhouse gas emissions excluding LULUCF was ± 1.8%. The uncertainty in the trend is a percentage point range, relative to the inventory trend and should be interpreted as ± 1.8% is the estimated percentage point difference compared to the general trend. I.e. there is a 95% probability that the decrease in GHG emissions in Sweden between 1990 and 2012 is in the interval 19% to 12.6%.

1.7.2 KP-LULUCF activities

Estimates of carbon stock changes are based on the same underlying data as the reporting under the UNFCCC. These estimates 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 expert judgment.

1.8 General assessment of completeness

In the following section the completeness of the GHG inventory and the KP-LULUCF inventory is described.

1.8.1.1 GHG INVENTORY

The inventory covers all mandatory GHG emissions 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.

1.8.1.2 ENERGY

Estimated emissions are considered to be complete for most sources. Emissions of CH_4 and N_2O from liquid bio fuels used in military transportation are however not estimated. There might also still be some lack in completeness as regards in-house generated fuels in the chemical industry and in smaller companies.

1.8.1.3 INDUSTRIAL PROCESSES

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 Good Practice Guidance. However, some exceptions do exist. These are primarily in subsectors with a large number of smaller facilities with minor emissions and for which no IPCC default methodology exists.

Data is complete for all greenhouse gases, possibly with the exception of CH_4 for a few sources, e.g. within the chemical industry.

1.8.1.4 SOLVENT AND OTHER PRODUCT USE

The estimated emissions from solvent and product use are considered to be complete, since a new method was developed during 2005 in order to obtain all activity data concerning the sector from the Products register at the Swedish Chemicals Agency.

The estimated emissions of N_2O are also considered to be complete, since national data from the Products register is used in the inventory.

1.8.1.5 AGRICULTURE

All relevant agricultural emissions and sources are reported in the inventory. Reindeer, which are normally not considered as a part of the agricultural sector, are included in the inventory. There are, however, some marginal animal groups, which are not included, such as fur-bearing animals (minks, foxes and chinchillas). These groups are very small and there are no default methodologies developed for estimating their GHG emissions. 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.

1.8.1.6 LAND USE, LAND USE CHANGE AND FORESTRY

All land areas are inventoried in the field except high mountains, military impediments and urban land. We believe that their relative importance for the Swedish GHG inventory is small.

The inventory of the LULUCF-sector is complete in the sense that all carbon pools and other sources, defined based on the IPCC GPG for LULCUF, 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. Emissions/removals from below ground biomass of dead stump systems are from this submission included in the dead organic matter pool.

1.8.1.7 WASTE

The effects of possible leakage of methane and nitrous oxide from the wastewater treatment processes have not been estimated. All other data are complete.

1.8.1.8 KP-LULUCF

Sweden has elected the activity Forest management (FM) under Article 3.4 of the Kyoto Protocol (KP). All carbon pools as well as associated mandatory activities (such as fertilization of forest land, biomass burning and conversion to cropland) are reported for activities under article 3.3 and under FM.

2 Trends in greenhouse gas emissions

2.1 Description and interpretation of emission trends for aggregated greenhouse gas emissions

Total greenhouse gas emissions in Sweden, calculated as carbon dioxide equivalents, totalled 57.6 million tonnes (excl. LULUCF) in 2012, see Figure 2.1. Aggregated greenhouse gas emissions varied over the period but in all cases were less than the 1990 level during the period 1999-2012. Emissions decreased by 15 million tonnes or 21 % between 1990 and 2012. The uncertainty range in the trend is ±1.8 % relative to the inventory trend (excl. LULUCF). Decreasing emissions in almost all sectors contribute to the overall decreasing trend in total emissions since 1999.

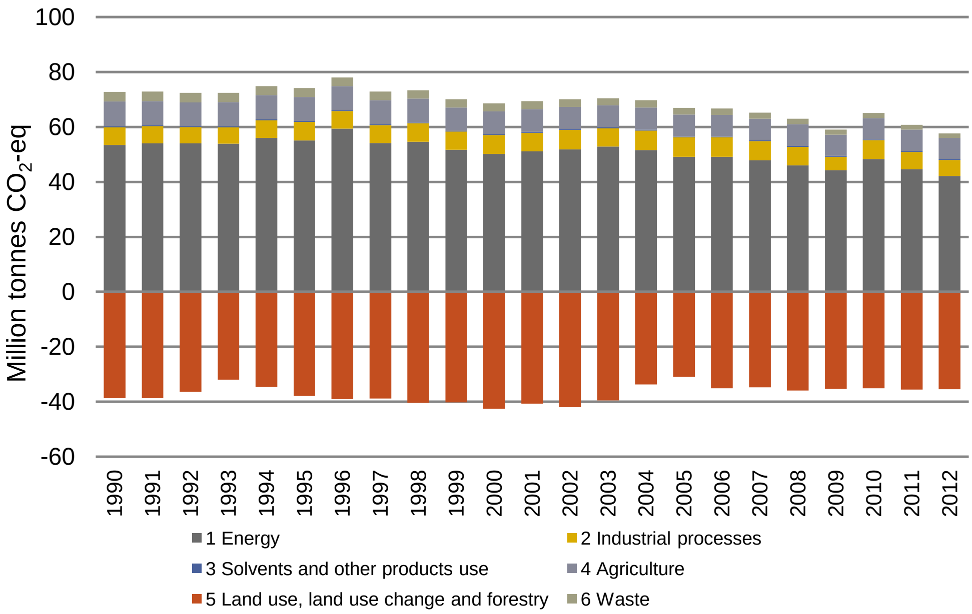

Figure 2.1. Total emissions and removals of greenhouse gases by sectors

Emissions in year 2009 and 2010 were quite extreme. During the autumn of 2008, an economic downturn began which was deepened during 2009 and has affected a number of sectors. The recession has led to that many industrial sectors have reduced production considerably, with diminished emissions in 2009 as a consequence. In 2010 most of the industries started to recover from the economic downturn. The cold winters in 2010, both in the beginning and in the end of the year, increased the need for heating. In combination with lower nuclear production than normal this led to increased use of fossil fuels in the electricity and heat production. In 2011 the emissions were almost on the same level as in 2009 and decreased further in 2012 due to a warmer winter and that the economic development in the industry somewhat stabilized.

The Land Use, Land-Use Change and Forestry sector (LULUCF) resulted in annual net removals in Sweden during the period 1990-2012. The size of the sink varied over the period.

2.1.1 Overview of emission trends per sector

Emissions of greenhouse gases have developed differently in different sectors over the period from 1990 to 2012, see Figure 2.2. The sectors which contributed mostly to the overall decrease is the sector 'Other sectors'[17] (CRF 1.A.4), combustion in manufacturing industries and construction (CRF 1.A.2), waste (CRF 6) and agriculture (CRF 4).

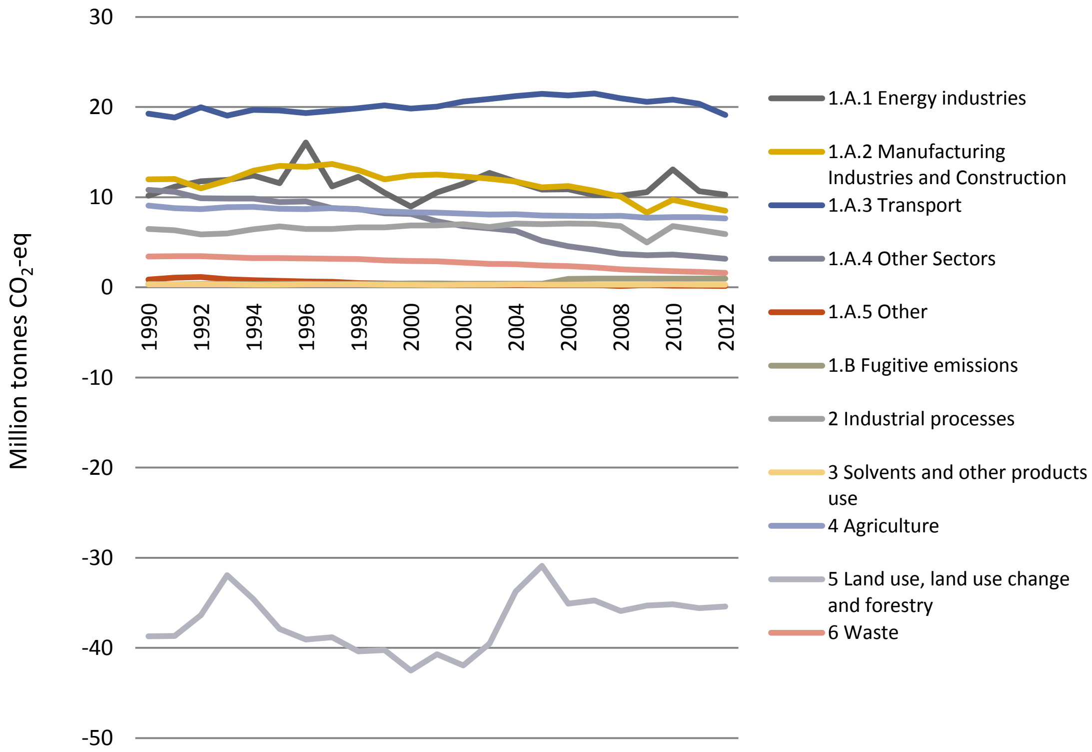

Figure 2.2. Total emissions of all greenhouse gases calculated as CO2-equivalents by sectors

[17] Other sectors include emissions from fuel combustion in the commercial and institutional, residential, and agriculture, forestry and fisheries sectors and comes primarily from stationary combustion.

2.2 Description and interpretation of emission trends by gas

In 2012, emissions (excl. LULUCF) of carbon dioxide totalled 45.7 million tonnes, which is equivalent to almost 79 % of aggregated greenhouse gas emissions counted as carbon dioxide equivalents, see Figure 2.3. Emissions of methane were 4.8 million tonnes of carbon dioxide equivalents and account for just over 8 % of emissions, while emissions of nitrous oxide totalled 6.3 million tonnes, equivalent to almost 11 %. Emissions of fluorinated greenhouse gases amounted to almost 2 % or 0.9 million tonnes of carbon dioxide equivalents of the aggregated greenhouse gas emissions. The shares of the different greenhouses gases were roughly the same over the period 1990 to 2012.

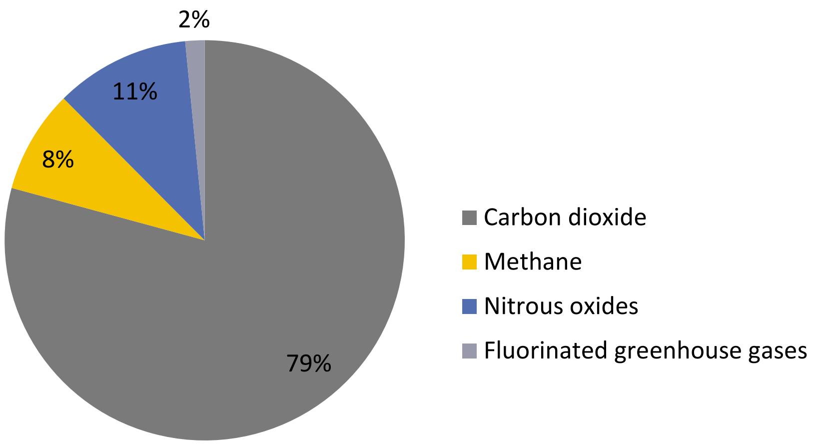

Figure 2.3. Share of greenhouse gases in emissions in year 2012, in carbon dioxide equivalents

2.2.1 Carbon dioxide

In 2012, the carbon dioxide (CO_2) emissions in Sweden totalled 45.7 million tonnes, excluding LULUCF, see Figure 2.4. 89 % of the carbon dioxide emissions originated from the energy sector (CRF 1), 11 % originated from industrial processes (CRF 2), and the remaining less than 1% originates from solvent and other product use (CRF 3) and waste (CRF 6). Emissions were 20 % lower in 2012 than in 1990, the energy sector stands for the largest reduction.

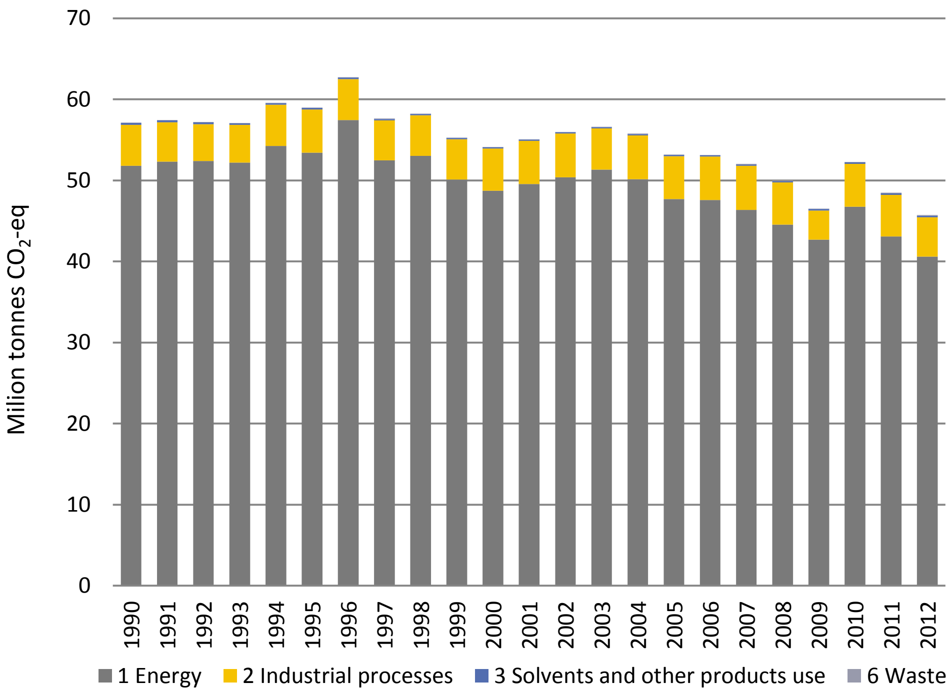

Figure 2.4. Total emissions of CO_2 from different sectors in million tonnes

2.2.2 Methane

The total emissions of methane, excluding emissions from LULUCF, totalled 228 ktonnes in 2012, which is equivalent to 4.8 million tonnes calculated as carbon dioxide equivalents or just over 8 % of total greenhouse gas emissions (Figure 2.5). Almost 60 % of the emissions of methane (CH_4) originate from agriculture (CRF 4). Almost 30 % is emitted in the waste sector (CRF 6) and 11 % is emitted in the energy sector (CRF 1). Emissions have decreased by 31 % since 1990, largely due to measures taken in the waste sector.

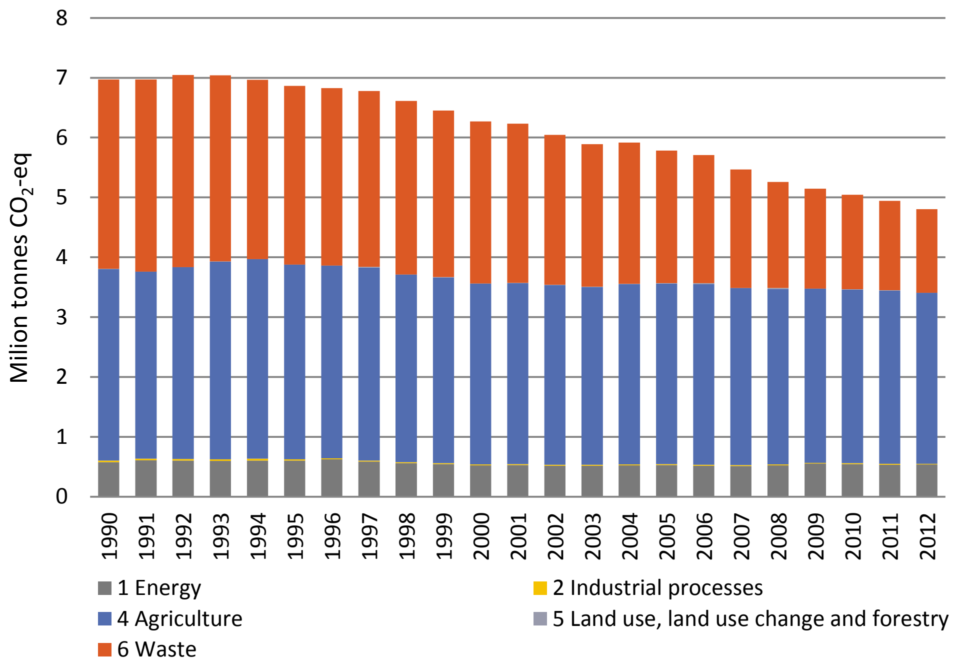

Figure 2.5. Total emissions of CH_4 from different sectors, calculated as CO_2-equivalents

2.2.3 Nitrous oxide

In 2012, emissions of nitrous oxide (N_2O) totalled 20 ktonnes or just over 6 million tonnes of carbon dioxide equivalents (excl. LULUCF), see Figure 2.6. The main source for nitrous oxide emissions is the agriculture sector, which accounted for 76 % of the emissions. Compared with 1990, emissions have decreased by 24 %, and it is primarily emissions from industrial processes that account for the decrease.

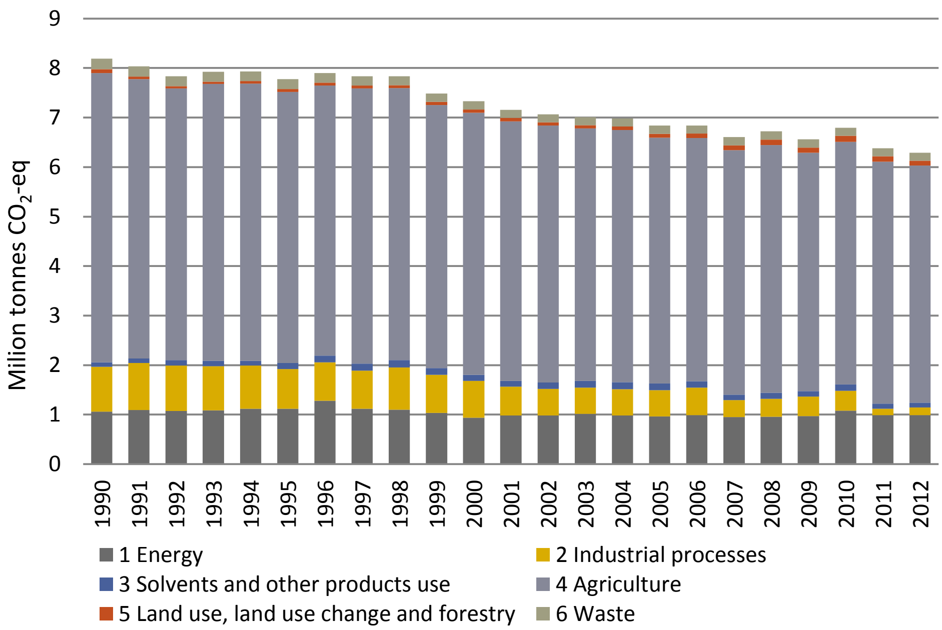

Figure 2.6. Total emissions of N_2O from different sectors calculated as CO_2-equivalents

2.2.4 Fluorinated greenhouse gases

Emissions of fluorinated greenhouse gases (f-gases), HFC, PFC, SF_6, are reported in the industrial processes sector. Total emissions of fluorinated greenhouse gases in 2012 amounted to 0.9 million tonnes calculated as carbon dioxide equivalents and account for 1,6 % of the total greenhouse gas emissions, see Figure 2.7. The emissions of f-gases have risen by 84 % since 1990.

The increasing emissions of f-gases are mainly due to increased emissions of HFCs. Emissions of HFCs increased from 4 ktonnes of carbon dioxide equivalents in 1990 to 870 ktonnes in 2009, and then decreased to 775 ktonnes in 2012. PFCs emissions, on the other hand, have decreased. In 1990 emissions of PFCs amounted to 377 ktonnes of carbon dioxide equivalents, and in 2012 they had decreased to 69 ktonnes. Emissions of SF_6 varied between 1990 and 2012. In 1990 they totalled 107 ktonnes and in 2012 they amounted to 55 ktonnes of carbon dioxide equivalents.

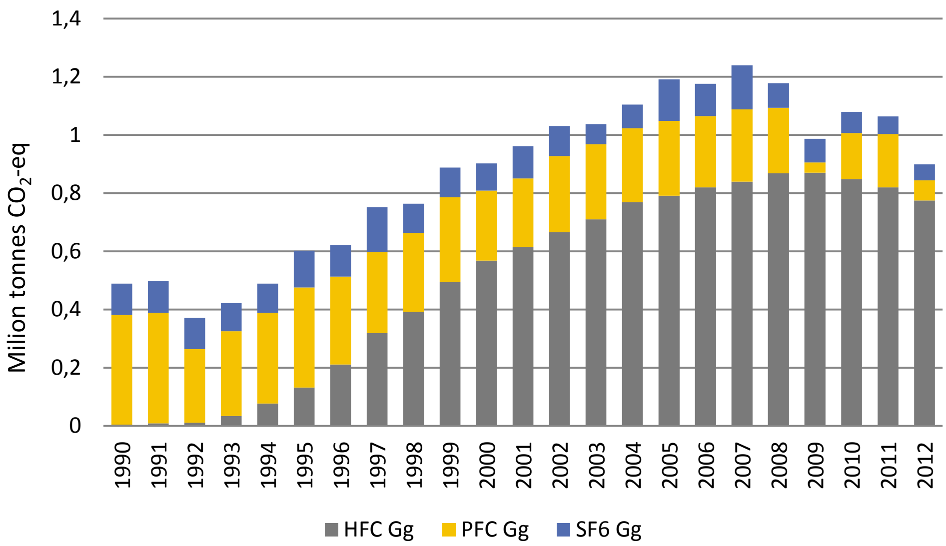

Figure 2.7. Total emissions of SF6, PFC and HFC, calculated as CO2-equivalents

2.3 Description and interpretation of emissions by category

In 2012 emissions from the Energy sector (CRF 1) made up 73 % of the total emissions, see Figure 2.8. The Energy sector includes Transport (CRF 1.A.3) (33 % of total emissions), Energy industries (CRF 1.A.1) (18% of total emissions) and combustion in Manufacturing Industries (CRF 1.A.2) (15% of total emissions). Other sectors (CRF 1.A.4) (5.5 % of total emissions), Military (CRF 1.A.5) (0.3 % of total emissions) and Fugitive emissions (CRF 1.B) (1.7 % of total emissions) are also part of the Energy sector. Agriculture (CRF 4) accounted for 13 % of total emissions and Industrial processes (CRF 2) for 10 % of total emissions. Waste (CRF 6) contributes with 2.8 % of the emissions and Solvents and other product use (CRF 3) counts for less than 0.5 %.

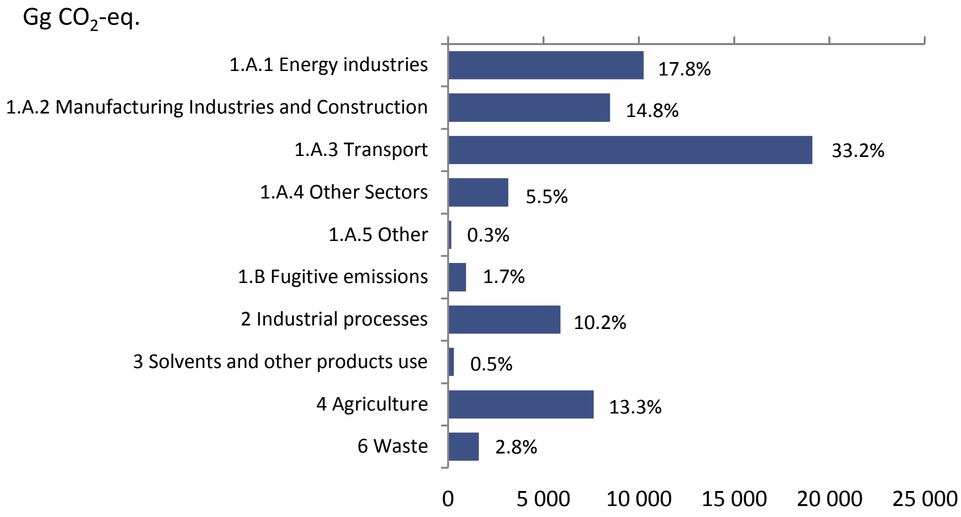

Figure 2.8. Greenhouse gas emissions by sector in year 2012

2.3.1 Energy

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), other (military transports), and fugitive emissions.

Emissions from the transport sector (1A3) dominates followed by Energy industries (1A1) and combustion from Manufacturing industries and construction (1A2), which account for almost equal shares of total emissions within the energy sector in 2012 (Figure 2.9). Important sources are production of electricity and heating within Energy industries sector (1A1) and heating in the Residential and commercial/institutional sector included in "Other sectors" (1A4).

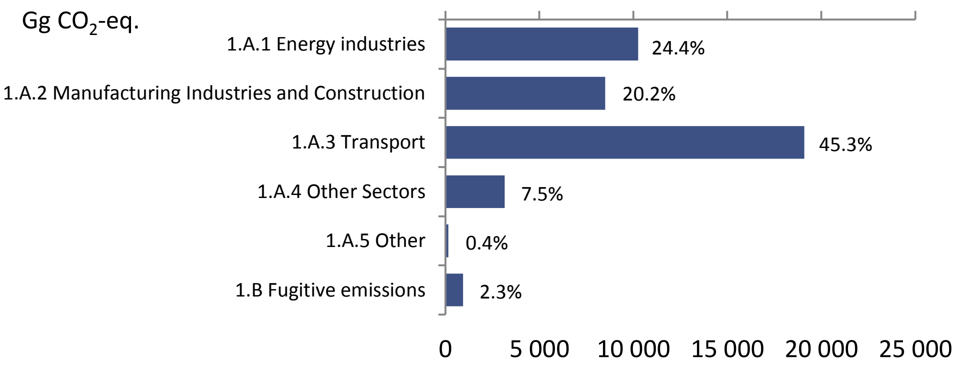

Figure 2.9. Share of emissions (2012) for the Energy sector, by subsector in year 2012

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In the Energy sector there has been a reduction in total emissions over the period 1990-2012, see Figure 2.10. Emissions have decreased from 53.4 million tonnes carbon dioxide equivalents in 1990 to 42.1 in 2012. This is a decrease with 21% compared to 1990, and the decrease is principally due to decreased use of oil for heating in residential and commercial/institutional, included in "Other Sectors" (1A4), and district heating being increasingly based on biomass fuels. Between 2011 and 2012 there was a decrease in emissions with 6%.

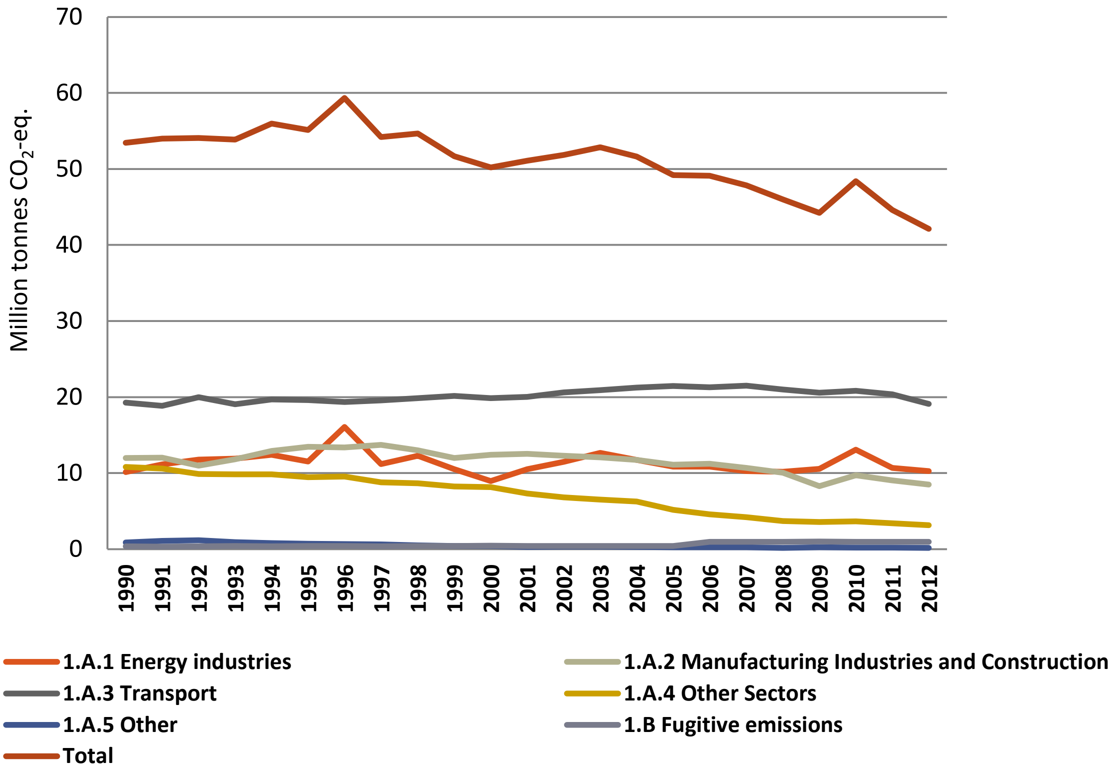


Figure 2.10. Emissions from the Energy sector, total and by subsector

2.3.1.1 ENERGY INDUSTRIES (CRF 1A1)

Total emissions for energy industries (1A1) is approximately 10.3 million tonnes carbon dioxide equivalents in 2012 (Figure 2.11), which around the same level as in 1990. However, the fluctuations between different years are large, due to the influence of the Electricity and heat production (1A1a). Electricity and heat production (1A1a) account for the larger part of the emissions (7.7 million tonnes). Emissions from Refineries (1A1b) contributes with 2.2 million tonnes and Manufacture of solid fuels (1A1c) 0.4 million tonnes in 2012.

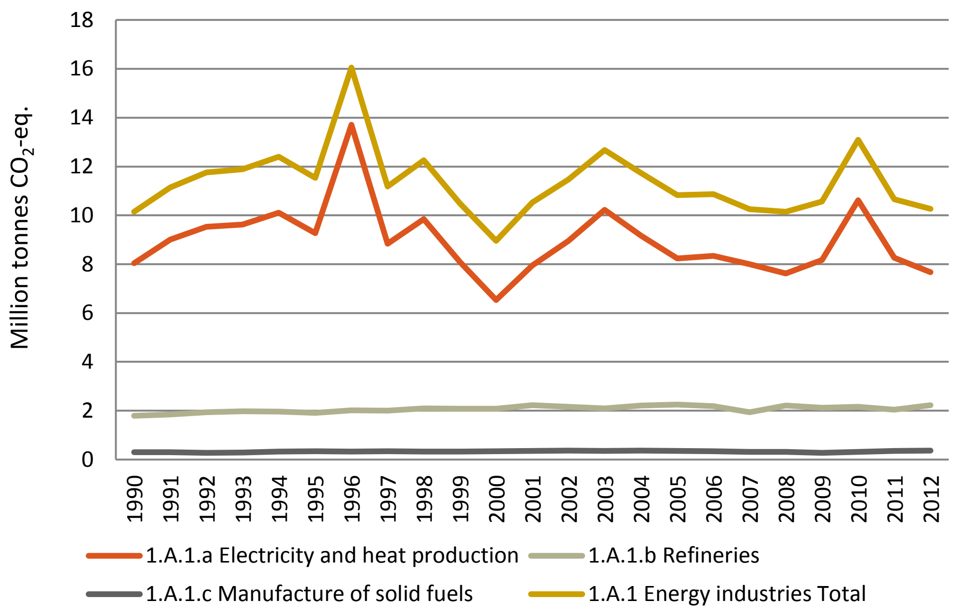


Figure 2.11. Emissions from Energy industries by subsector and total

2.3.1.1.1 Electricity and heat production (CRF1A1a)

Emissions from production of electricity and heat production totalled around 7.7 million tonnes of carbon dioxide equivalents in 2012, which is a decrease by 7 % compared to 2011. The 2012 emissions are around the same level as the emissions in 1990, only 5% lower in 2012. The emissions from electricity and heat production vary over time and no apparent trend can be seen between 1990 and 2012.

Sweden's electricity and heat production are based largely on hydropower, nuclear power and biofuels. Fossil fuels serve as a complement, often as a marginal fuel in cold weather. Temperature and precipitation conditions, which vary between years, have an impact on hydropower production and heating needs in individual years and thus lead 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.

In years of low hydropower production the emissions are affected by which kind of electricity production the shortage is offset by. Therefore the deficient production of hydropower in 2003 was offset by imports of electricity while shortage of hydropower in 1996, which was another year of low hydropower production, was partially offset by increased oil condensing production. The increased possibility to import electricity from Nordic countries can lead to decreased emissions in certain years, if offset by fossil fuels are avoided.

Emissions in this sector are also affected by the iron and steel production as residual gases from the iron and steel industry are used to produce electricity and district heating.

High prices on fossil fuels and introduction of the electricity certificate system, which improves the profitability of renewable electricity production, have increased the usage of biomass within district heating and had a reducing effect on emissions. Since beginning of 2012 Sweden and Norway have a joint market for electricity certificates[18].

Production of district heating accounts for the largest greenhouse gas emissions in this sector (5.3 million tonnes CO_2 equivalents in 2012). Since 1990 the supply of district heating have increased with around 50 %[19]. On the other hand, emissions have not increased significantly as the expansion has principally taken place through increased use of biomass fuels at the same time as the use of oil and coal has decreased. Energy and carbon dioxide taxes and the electricity certificates system have contributed to this trend[20].

Emissions from electricity production in 2012 was 2.4 million tonnes CO_2 equivalents. In this year the electricity production in Sweden consisted of 48% hydro power, 38% nuclear power and 4% wind-power. The total production of electricity in 2012 was the highest ever in a year (162 TWh) , but the usage of electricity was around the same level as in 2011. This resulted in the highest net export of electricity ever (19,6 TWh) in Sweden, which is a large increase from 2011 where the net export was 7,2 TWh[21]. In the Nordic countries there were a substantial net export (14 TWh) in 2012, compared to net import in 2011 (5 TWh)[22]. Main reasons for the low use of electricity were decreased heating demand due to warm weather in the autumn and a certain industrial slowdown[23]. The production in Swedish nuclear reactors during 2012 was higher than during the last three years, but still lower than the expected average production (61 TWh),[24] Inflow to reservoirs during 2012 was a lot higher than normal and the water level above average the whole year. The hydropower production was the third highest ever (78 TWh)[25]. Wind-power production was above 7 TWh in 2012, which is an increase with 17% compared to

[18] Swedish Energy Agency, 2013

[19] Swedish Energy Agency, 2012b

[20] Swedish Energy Agency, 2013b

[21] Swedish Energy Agency, 2013b

[22] Swedenergy, 2013, Swedish Energy Agency, 2013b

[23] Swedenergy, 2013

[24] Swedish Energy Agency, 2013b

[25] Swedish Energy Agency, 2013b, Swedenergy, 2013

2011. However, the increase was substantially lower than the increase of 74% between 2010 and 2011.[26]

The total production of district heating increased in 2012 with 6% compared to 2011 (with 6 TWh). The main reason is the increase of use of energy in households and Service sector[27]. Since more than 50% of the use of energy in these sectors comes from district heating[28], it has an influence.

The influence on emissions due to weather conditions has been analyzed with a normal-correction calculation method, which concludes that emissions in 2012 were lower than they would have been a “normal” year (Figure 2.12). Emissions from electricity and heat production (1A1a) and residential and commercial/institutional (1A4a-b) are included. Temperature and precipitation are some of the included parameters and for more information about the method used see Annex 8:2. Generally, for all years except two (1996 and 2010) the actual emissions are lower than the normal-corrected emissions. The main reasons are that years with warm winters and favorable hydro conditions with large amount of precipitation have dominated the period. Emissions in 2012 are also lower than what they would have been a “normal” year, based on preliminary fuel statistics for 2012. Even though the weather in 2012 was warmer than normal, it was not as warm as in 2011.

[26] Swedish Energy Agency, 2013b

[27] Swedish Energy Agency, 2013c

[28] Swedish Energy Agency, 2013b

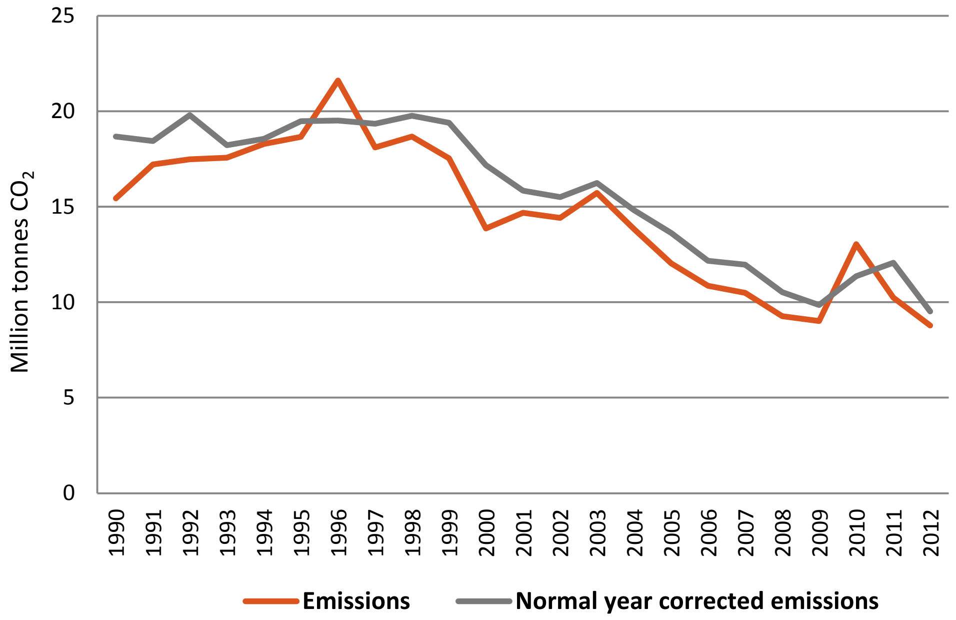


Figure 2.12. Actual and normal-year corrected fossil CO_2-emissions for heating of buildings and electricity production in Sweden for the years 1990-2012. Included sectors are production of electricity and heat (1A1a) and residential and commercial/institutional (1A4a-b). For the year 2012 preliminary statistics on fossil fuel consumption is used

All together these factors lead to lower emissions from both electricity and heating in 2012 compared to the emissions in 2011. Still warmer weather than normal, favourable conditions for hydropower production and increased production in nuclear power plants are some of the important factors behind this development.

2.3.1.1.2 Refineries (CRF 1A1b)

Production of refined products increased in Sweden during the period, which increased emissions with 24%, between 1990 and 2012. The emissions were 9% higher in 2012 than in 2011. Generally the emissions have been around 2 million tonnes carbon dioxide equivalents since 1990 (Figure 2.11).

2.3.1.2 MANUFACTURING INDUSTRIES AND CONSTRUCTION (CRF 1A2)

Emissions from combustion in the industrial sector were around 8.5 million tonnes carbon dioxide equivalents in 2012. Emissions in 2012 were 29% lower than in 1990, but they have varied upwards and downwards over the years, principally due to economic fluctuations and replacement of oil with electricity or biofuels partly depending on the difference in relative prices between electricity and oil. A small number of energy-intensive industries account for a large proportion of carbon dioxide emissions in the sector. The iron and steel industry (1A2a), the pulp and paper industry (1A2d) and chemical industry (1A2c) account for equal shares of the emissions in 2012– 14 % each. Other industries and construction (1A2f) stand for 52 % of the emissions in 2012, divided into 34% from working machinery and off road vehicles and 18% from stationary combustion (Figure 2.13)..This sector is heterogeneous and includes for instance mining industry and non-metallic mineral production. Off road vehicles and working machinery from all industries are allocated to Other industries (1A2f).

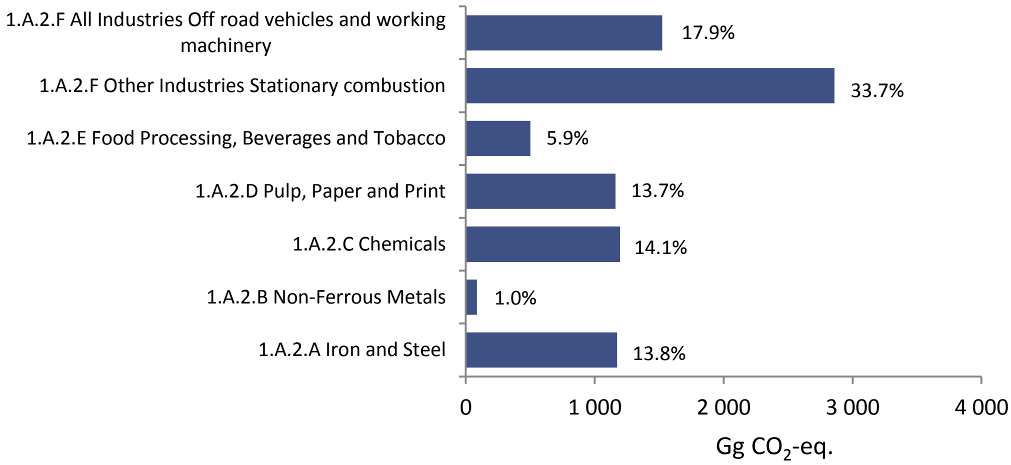
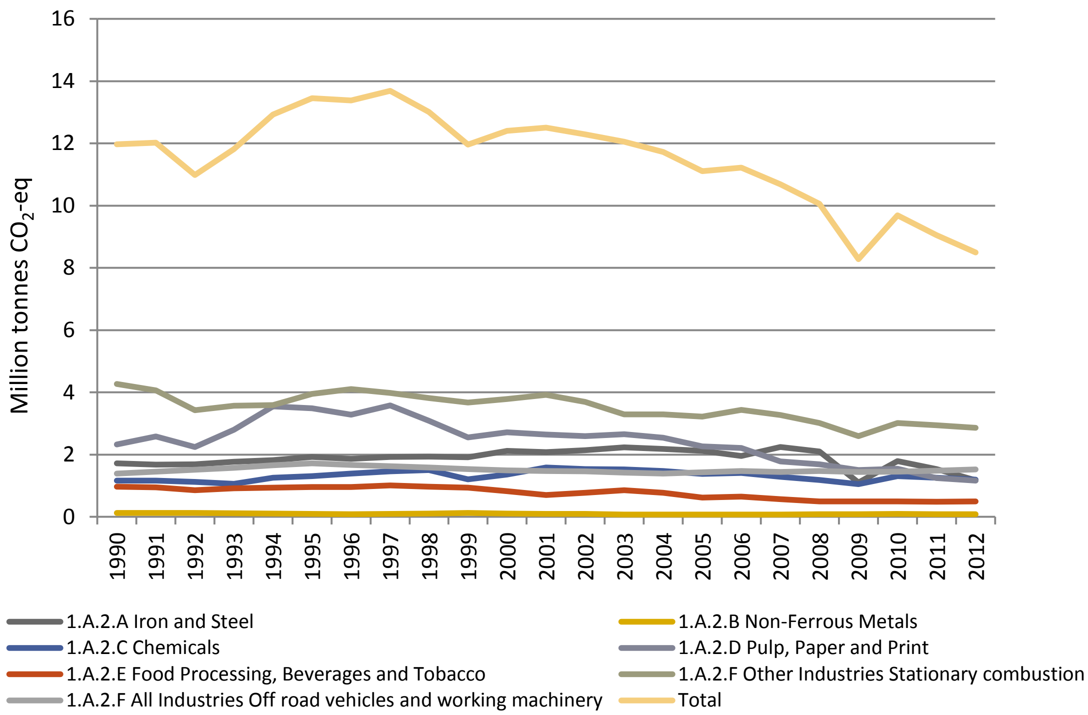


Figure 2.13. Emissions from the Energy sector; manuafacturing industries and construction in year 2012

Viewed over a longer period from 1970 on, industry has reduced its use of oil and increased its use of electricity. Today, oil stands for 9% of the total energy use within the industry compared to 48% in 1970[29]. Usage of biofuels has also increased. Biofuels and electricity are now the main energy sources within the industry and stood in 2011 for respectively 38 % and 37 % of the final energy use.[30] Another reason for the decrease in emissions is increased energy efficiency[31].

There is a downward trend in total emissions from combustion in manufacturing industries, and one reason is reduced emissions from the pulp, paper and print industry, caused mainly by fuel substitution from fossil fuels to biofuels. The pulp and paper industry has the highest energy use within the sector (52%) and therefore the substitution has had a large effect on emission with a reduction of 50% compared to 1990[32]. Also other manufacturing industries have made a transition to electricity or biofuels, leading to reduced emissions. Stationary combustion from “Other industries” also has a decreasing trend. The economic recession in 2008 and 2009 affected the emissions-. In 2010 and 2011 there was a certain industrial comeback, which decreased slightly in 2012[33].

[29] Swedish Energy Agency, 2013b
[30] Swedish Energy Agency, 2013b
[31] Swedish Energy Agency, 2013b
[32] Swedish Energy Agency, 2013b
[33] Swedenergy, 2013



Figur 2.14. Emissions from combustion in manufacturing industries by subsectors and total

2.3.1.3 FUGITIVE EMISSIONS FROM FUELS (CRF1B)

Emissions from the fugitive emissions sector come for example from refineries. Emissions were around 1.0 million tonnes of carbon dioxide in 2012 (Figure 2.15). The recent increase of fugitive emissions from oil (1B2a) is due to the establishment of new hydrogen production facilities at two oil refineries. Emissions have increased with 154% compared to 1990.

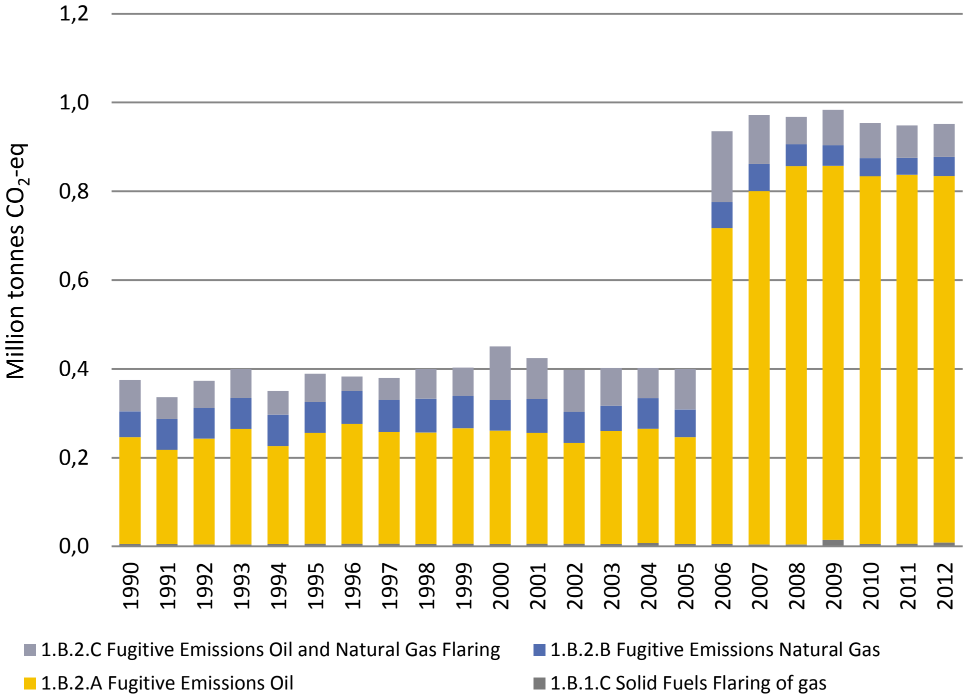


Figure 2.15. Emissions of all greenhouse gases from Fugitive emissions, total and by subsector

2.3.1.4 TRANSPORT (CRF 1.A.3)

Greenhouse gas emissions from domestic transport totalled 19.1 million tonnes of carbon dioxide equivalents in 2012 (Figure 2.16), which is about the same level as in 1990. After a peak in emissions around 2005, emissions have decreased slightly. Greenhouse gas emissions 2012 from road transportation were 17.9 million tonnes, from domestic aviation 0.5 million tonnes, from domestic navigation 0.3 million tonnes, from railways 0.1 million tonnes and from other machinery 0.3 million tonnes.

While emissions of carbon dioxide account for the by far largest share of greenhouse gas emissions from the transport sector, methane and nitrous oxide contribute with a very small share. Methane emissions totalled 0.05 million tonnes of carbon dioxide equivalents in 2012 and have fallen by 73 % since 1990 as a result of better exhaust emission control. Nitrous oxide emissions totalled 0.14 million tonnes of carbon dioxide equivalents in 2012. Emissions of nitrous oxide increased from 1990 to 2000 in connection with the switch to cars fitted with catalytic converters. Emissions decreased during the early 2000s with better exhaust treatment technology, and have remained at a fairly steady level during the latest years.

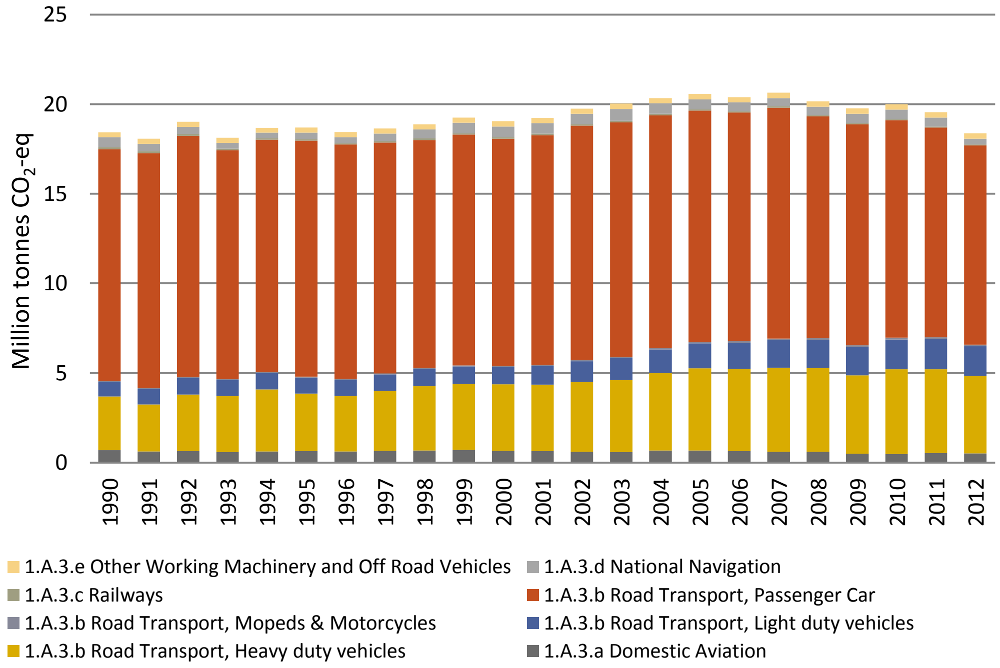


Figure 2.16. Emissions of CO2 eq. from the transport sector, total and per subsector

2.3.1.4.1 ROAD TRANSPORT

Road transportation accounts for the greatest share of the transport sector's greenhouse gas emissions and totalled 17.9 million tonnes of carbon dioxide equivalents in 2012, which is 2 % higher than 1990 emissions. Emissions increased from 1990 to 2005 before stagnating, and have since then been decreasing somewhat as a result of an increased share of renewable fuels, higher energy efficiency and reduced fuel consumption in combination with the economic downturn in 2008-2009.

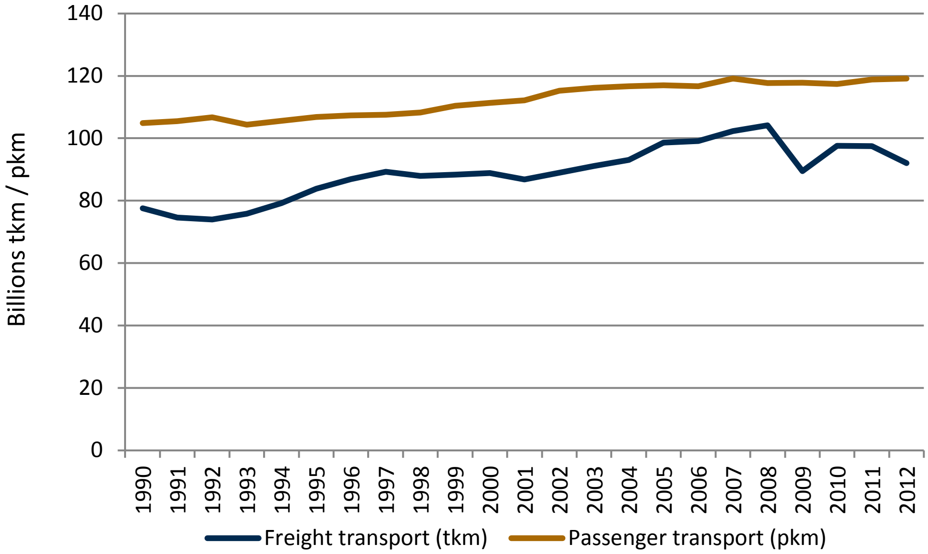


Figure 2.17. Freight transport and passenger transport 1990-2012

The increase in emissions up to the mid-2000s followed the increase in traffic and transport mileage. It was principally transport mileage with heavy duty vehicles and to some extent with light duty vehicles that increased. There was insignificant improvement in energy efficiency in vehicles during this period. The proportion of diesel-powered light duty vehicles has increased continuously since 1990, and the same change in the market began in the late 1990s for cars, steadily strengthening to the present day. The switch from petrol-powered to diesel-powered cars is leading to greater energy efficiency, which since the mid-2000s has been reinforced by a general improvement in fuel efficiency for new cars. The average CO_2 emissions per kilometer from for new cars decreased by around 25 % between 2007 and 2012, which is the largest reduction so far.

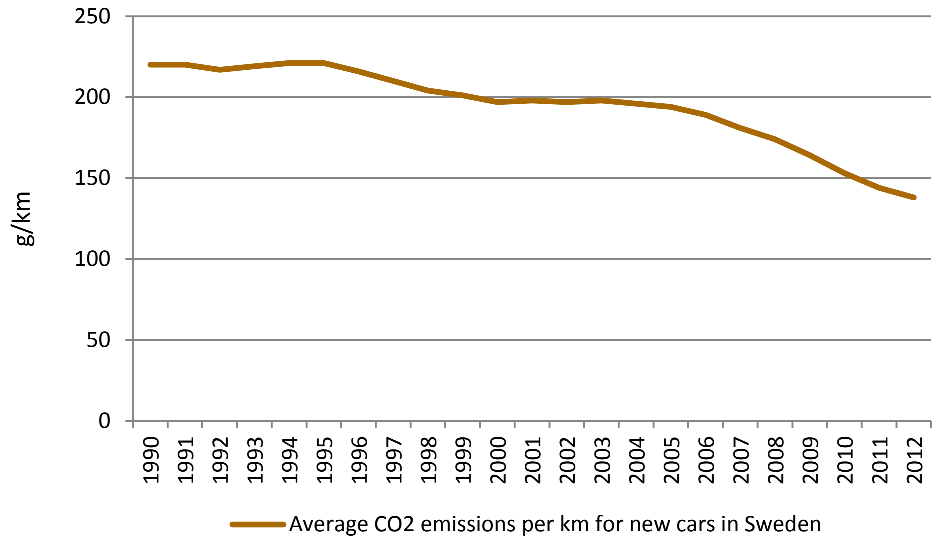


Figure 2.18. Average CO_2-emissions per kilometer for new cars in Sweden

The increasing energy efficiency has counteracted the increase in fuel consumption to which the growth in transport has led. The aggregate effect has been sharply increased consumption of diesel fuel and reduced volumes of petrol resulting in reduced CO_2-emissions. The economic downturn starting in 2008 - 2009 also led to reduced emissions from diesel-powered heavy duty vehicles in 2009 and to somewhat lower overall use of diesel fuel in the road transport sector.

Several factors have been significant in limiting emissions from road transport. Among other factors, the EU-requirements limiting the carbondioxide 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, have contributed to more fuel-efficient cars, an increased number of fuel-flexible cars and consequently a switch to renewable fuels. The use of renewable fuels has been principally boosted by the fact that since 2004 they have been exempt from carbon dioxide tax and energy tax, along with a law from 2006 requiring every major petrol station to provide a renewable fuel. 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 FAME into diesel has also increased, accounting for the proportionally largest increase among the biofuels in 2012[34]. The use of biofuels for fuel-flexible cars also increased from 2004 to 2012, particularly ethanol (E85), although in 2009 the use of E85 decreased somewhat as a result of high ethanol prices and lower petrol prices.
In 2012 the emissions from road transport continued to decrease by 6% compared to 2011. The decrease is due to more energy efficient vehicles, increased share of

[34] Swedish Petroleum and Biofuel Institute, http://spbi.se/, 2014-02-04

renewables and reduced transport milage. The increased efficiency is a result of a further shift from petrol to diesel powered cars and decline in average CO_2-emissions for new cars.

2.3.1.4.2 DOMESTIC AVIATION

In 2012, emissions from domestic aviation totalled 0.5 million tonnes of carbon dioxide equivalents (Figure 2.19), which is 24 % lower than the level for 1990. However, the emissions varied during the period. Domestic aviation has decreased since the mid-2000s because the share of train and to some extent car journeys has increased. The fact that more people are choosing train or car rather than flying for domestic travel is considered to be due in part to a decline in the availability of short-haul aviation and to new security requirements and routines having reduced the advantages of flying in terms of speed and flexibility. In 2012 the emissions continued to decrease by 2% compared to 2011.

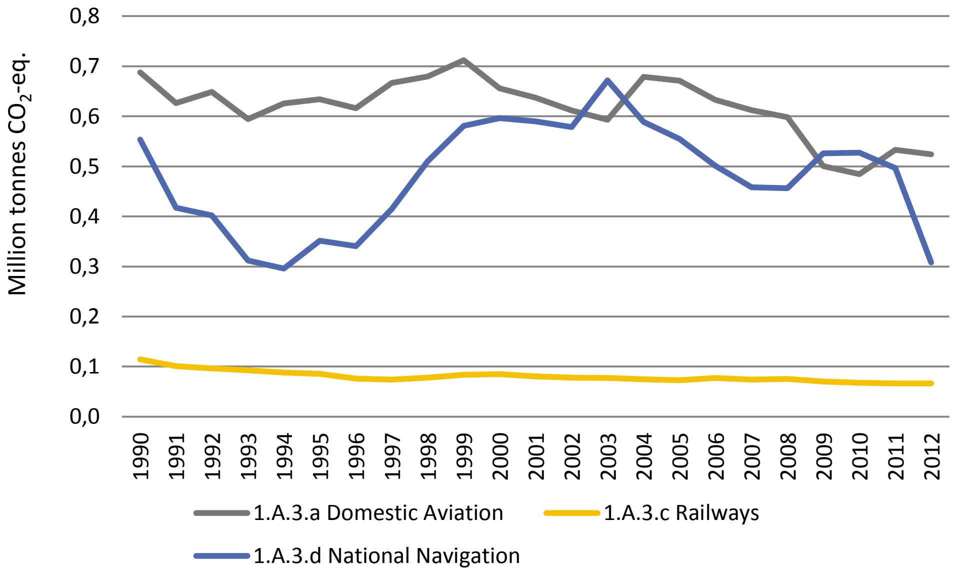


Figure 2.19. Emission of CO2 eq. from aviation, navigation and railways

2.3.1.4.3 NATIONAL NAVIGATION

Emissions for national navigation are estimated at 0.3 million tonnes of carbon dioxide equivalents in 2012 (Figure 2.19). This is 44% lower than in 1990 but emissions have varied over the period. In 2012 the emissions decreased compared to 2011, mainly due to reduced freight transport.

2.3.1.4.4 RAILWAYS

Railway greenhouse gas emissions from diesel-powered trains account for a marginal share of transport sector emissions and have decreased by around 40 % since 1990 (Figure 2.19).

2.3.1.5 OTHER SECTORS (CRF1A4)

Other Sectors include combustion in the Residential, Commercial/institutional and Agriculture, forestry and fisheries sector. Emissions from working machinery and off road vehicles are also included in the sectors Residential and Agriculture, forestry and fisheries.

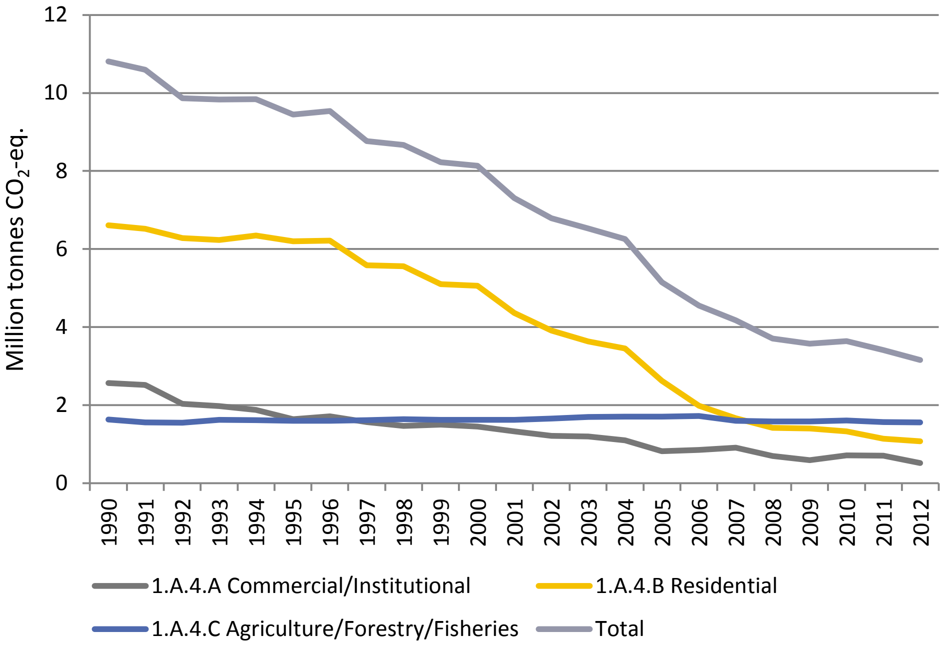


Figure 2.20. Emissions from Other sectors, total and by subsector

The emissions in Other Sectors were approximately 3.2 million tonnes of carbon dioxide equivalents in 2012, which is a decrease with 7% compared to 2011. In comparison to 1990 the decrease is 71 %. The reduction is due to a strong decrease in emissions from the Residential and Commercial/institutional (1A4a and 1A4b) sectors between 1990 and 2012 (Figure 2.20), depending on a large decrease in total use of fossil fuels. There are several reasons for this development: the shift from oil to district heating, electricity heating and biofuels and increased usage of heat pumps.[35] The most common source of heating in these sectors is district heating followed by electric heating[36] and these emissions are included in the Electricity and heat production sector (section 2.3.1.1.1) . The number of heat pumps has increased considerably and almost half of all one and two-dwelling buildings had some kind of heat pump in 2012[37]. Another contributing factor to the favourable development has been the generally warm weather since 1990. The outdoor temperature affects the need for heating, which can lead to variations in energy usage

[35] Swedish Energy Agency, Energiläget

[36] Swedish Energy Agency, 2013c.

[37] Swedish Energy Agency, 2013

between years[38]. More information about the weather and normal corrected emissions can be found in section 2.3.1.1.1, and in Annex 8:2. There is also a continued decrease in energy consumption for heating per unit of floor space area in one and two-dwelling building .[39]

In 2012 the emissions from Residential and Commercial sectors continued to decrease by 12 % compared to 2011. The decrease in emissions from dwellings and premises in 2012 is mainly due to decreased use of oil for heating and increased use of district heating and electric heating. However, even if the use of district heating increased in 2012, the emissions from Electricity and heat production sector (reported in CRF 1A1a) did not increase since the production was increased mainly by use of biofuels and waste.

In 2012 less than 1 % of one and two-dwelling buildings have oil as their sole source of heating[40]. The large decrease in emissions since 1990 from the residential sector has resulted in a substantial increase in the share of emissions from biofuels (Figure 2.21). As stated earlier the main reason for the large decrease in emissions are a shift from oil to district and electric heating.

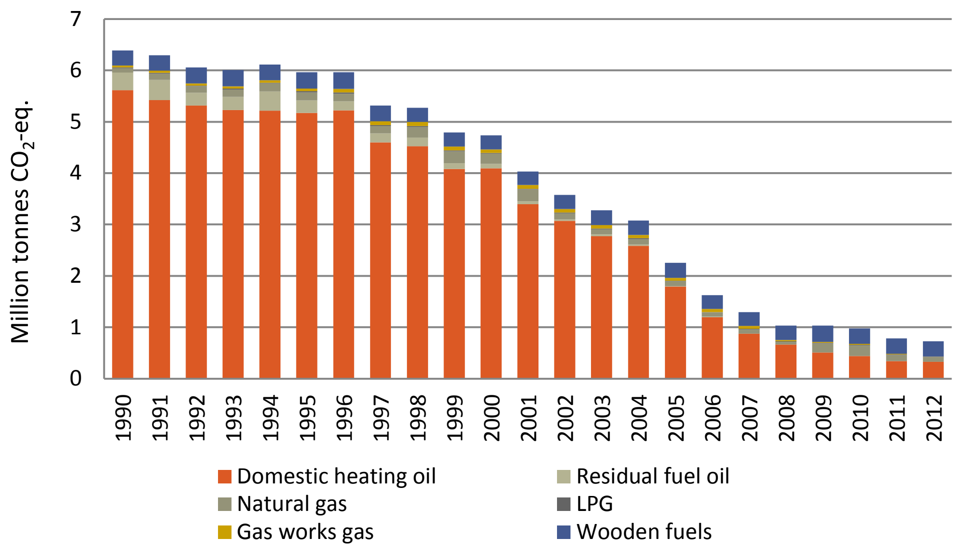


Figure 2.21. Emissions from Residential sector (1A4b) by fuel type, stationary combustion

Working machinery and off road vehicles are also included in the Residential sector (1A4b). These emissions are very low, around 0.4 million tonnes carbon diox-

38 Swedish Energy Agency, 2013b

39 Swedish Energy Agency, 2013.
40 Swedish Energy Agency, 2013

ide equivalents in the last years. Seen from 1990 there has been a slight increase in emissions.

In agriculture, forestry and fisheries (1A4c) total emissions are quite stable, with only a decrease of 4% since 1990. Emissions from stationary combustion in this sector fluctuate over the years, but show a decreasing trend. Emissions from working machinery and off road vehicles in agriculture and forestry increase slightly (Figure 2.22). In fisheries there is instead a decrease in emissions.

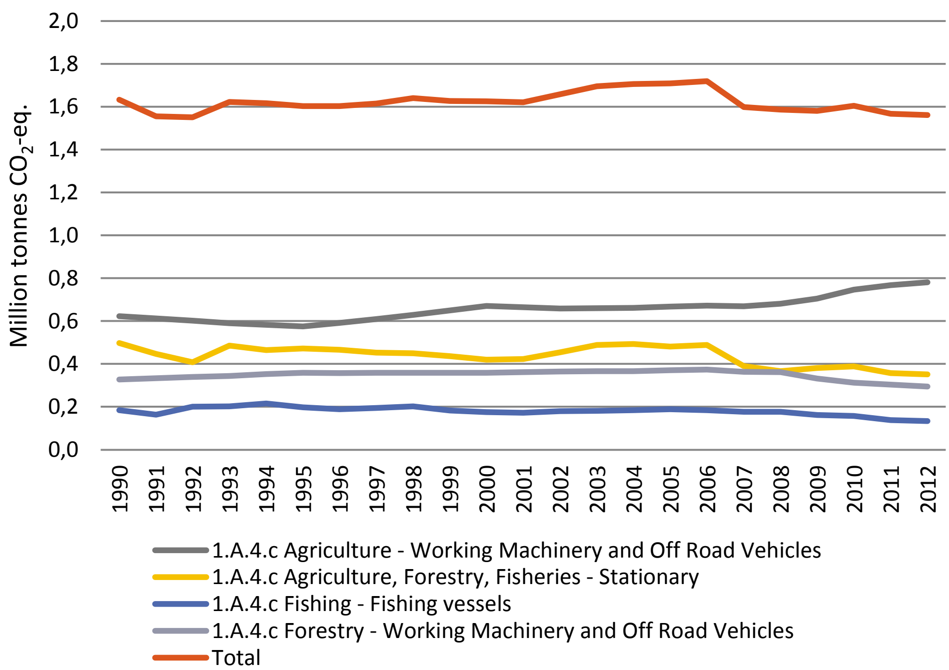


Figure 2.22. Emissions from agriculture, forestry and fisheries, mobile and stationary combustion

2.3.1.6 EMISSIONS OF METHANE AND NITROUS OXIDE FROM THE ENERGY SECTOR EXCLUDING TRANSPORTS

Only a small proportion of emissions from the energy sector are emissions of methane and nitrous oxide. Almost 4% of emissions from the energy sector are emissions of nitrous oxide, and approximately 2% are emissions of methane in 2012.

Methane emissions from the energy sector excl. transport have increased by 25% between 1990 and 2012. The increased emissions are principally due to increased use of biofuels in the residential and commercial/institutional service sector and in the production of electricity and district heating. Almost two-thirds of emissions originate from the residential and commercial/institutional service sector, and including energy use in agriculture. Also electricity and district heating had increased methane emissions principally due to increase in total emissions.

Nitrous oxide emissions have a minor decrease between 2010 and 2012, but are only slightly higher than in 1990 (2%).

2.3.2 Industrial processes

Greenhouse gas emissions within industrial processes (CRF 2) stem from the materials in the processes. The combustion of fuels in the industry, for production or heating purposes, is reported in the energy sector (CRF 1.A.2). To cover all industry related emissions one must take into consideration emissions from CRF 1.A.2 and CRF 2. Greenhouse gas emissions from industrial processes originate from the materials used in the processes, and make up 30–40% of total emissions from industry. Emissions from industrial combustion of fossil fuels account for the remainder.

Greenhouse gas emissions from industrial processes are 1.3 million tonnes CO_2 equivalents lower in 2012 compared to 1990. The decrease is 21% from 6.5 million tonnes of CO_2 equivalents in 1990 to 5.1 million tonnes CO_2 equivalents in 2012. The emissions from industrial processes make up 9% of the aggregated total emissions in 2012. The trend is mainly affected by increased emissions of HFCs and CO_2 from 1990 to 2007, after which the emissions have started to decrease. The emissions of nitrous oxide, methane and PFCs have decreasing trends over the time period.

The main sources for emissions in the industrial processes is the production of iron and steel and the cement and lime industries, see Figure 2.23. Other sources are the usage of coke in blast furnaces, of dolomite and limestone in production in the mineral industry and of coal in the reduction of copper. There are also emissions of fluorinated greenhouse gases in this sector.

Carbon dioxide emissions is the major contributor in the sector with 82 %, followed by fluorinated greenhouse gases at approximately 15 %, nitrous oxide at approximately 3 % and methane at 0.2 %, counted as CO_2 equivalents.

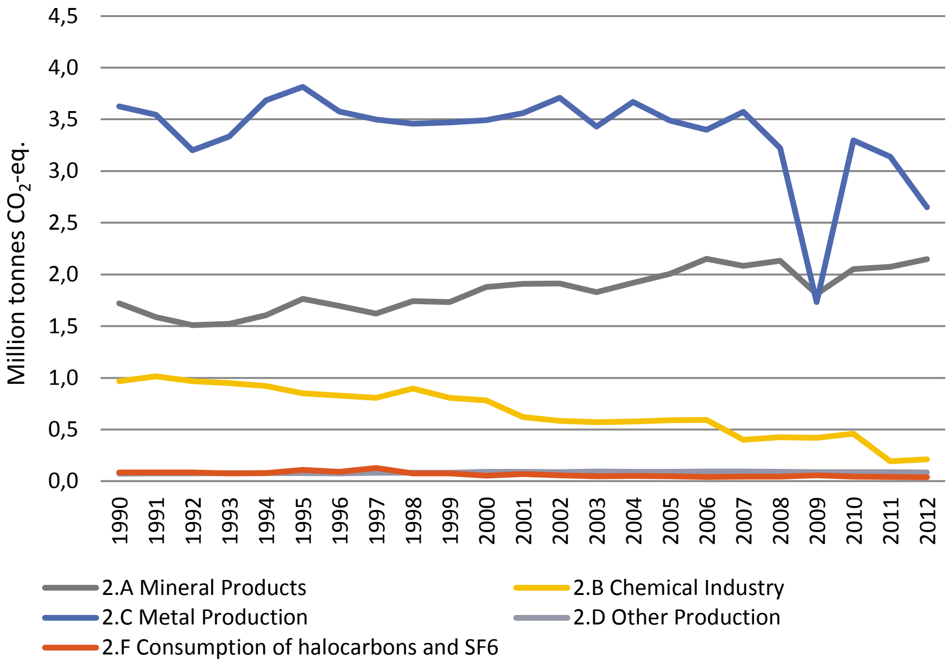


Figure 2.23. Emissions from the Industrial processes sector, per subsector

Total emissions in this sector have varied somewhat since 1990, mainly due to variation in production volumes and economic fluctuations. Except for 2009, which was an extreme year due to the economic downturn, and for 2010 when the economy recovered, there has been a slow decrease in total emissions from the sector since 2004. The development, however, differ for different industries. Emissions from the mineral industry have increased, for example, while those from the chemical industry have decreased over the same period. The emissions from the consumption of halocarbons and SF_6 has been increasing since 1992 but has started to decrease from 2009.

The main subsector is metal production (CRF 2C). Emissions in metal production have been at about the same level during the period from 1990 to 2007. After that the emissions show a decreasing trend, except for 2009, when emissions went down sharply. The emissions from the iron and steel industry were 21 % lower in 2012 compared to the 2012 level.

The subsector mineral products (CRF 2.A) is the second largest subsector and the emissions from this subsector shows an increasing trend over the period. This was principally due to improving economic conditions in the building sector, both in Sweden and in other countries to which cement is exported. Emissions decreased in 2009 as a result of a decline in production due to the economic downturn. However, the emissions started to increase again in 2010 and are, in 2012, slightly higher than in 2008.

Emissions from the chemical industry (CRF 2.B) decreased with 78% during the period 1990-2012. The decrease since 2007 is mainly due to a new treatment technology that has been installed and has resulted in reduced emissions of nitrous oxide in the nitric acid production.

2.3.2.1 FLUORINATED GREENHOUSE GASES (HFC, PFC, SF_6)

Fluorinated greenhouse gases, HFC, PFC and SF_6, are used in a number of applications. Most emissions of fluorinated greenhouse gases in Sweden today are due to leakage from refrigeration and air-conditioning systems and air conditioning in vehicles. Other sources are foam manufacturing, medical inhalers, aluminium production and magnesium foundries. Total fluorinated greenhouse gas emissions in 2012 amounted to 0.9 million tonnes calculated as carbon dioxide equivalents and account for almost 2 % of total emissions, see Figure 2.24.

Emissions of fluorinated gases are increasing from 1992 to 2007. After 2007 there is a decrease in emissions, with 2009 showing low emissions due to the economic downturn. The increase in the total emissions of fluorinated greenhouse gases is due to the increase in HFC emissions. One explanation for the increase is that HFCs in many cases have replaced the ozone-depleting substances CFCs and HCFCs as refrigerants. The ozone-depleting substances decreased sharply between 1990 and 2009 and have now been more or less completely phased out. Another explanation for the increase in HFCs is that the number of refrigeration and air-conditioning systems, air conditioning in vehicles and heat pumps has increased, particularly in the recent years.

PFC emissions mainly originate from the aluminum industry, and these emissions have decreased in recent years as a result of investments in new technology since 2007. In year 2009 the emissions went down sharply due to the economic downturn. The following years the emission levels were affected by the cold weather and disturbances in production. In 2012 the PFC emissions were lower than in 2010 and in 2011.

SF_6 emissions have remained at approximately the same level but have varied somewhat but shown a decreasing trend from 2007. One explanation to the decrease is an EU Regulation (EG 842/2006) introduced in 2006. Under this Regulation, certain fluorinated greenhouse gases were banned at various times between 2006 and 2009. Other emissions of fluorinated greenhouse gases have also started to decrease as a result of the EU Regulation.

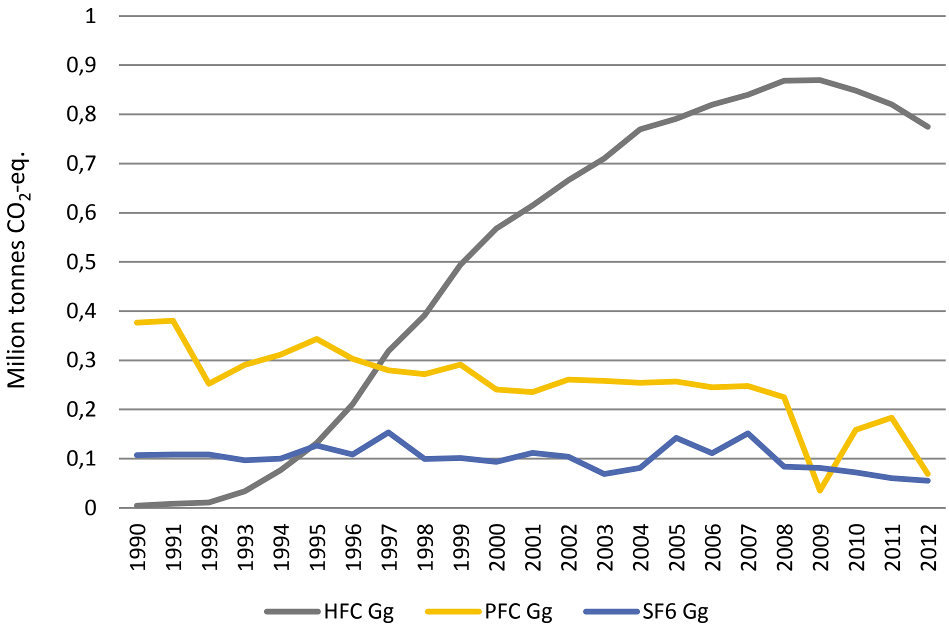


Figure 2.24. Emissions of fluorinated greenhouse gases per gas

2.3.3 Solvents and other products use

The use of solvents leads to emissions of volatile organic compounds. The carbon content of these emissions is assumed, according to the reporting guidelines, to generate carbon dioxide through oxidation of these compounds. The use of other products such as spray cans and gas springs, leads to emissions of nitrous oxide. This sector is characterized by emission of carbon dioxide and nitrous oxide as direct greenhouse gases. In 2012, the total emission from this sector is about 0.3 million tonnes CO_2-eq, which is 0.5 % of the total greenhouse gas emissions, see Figure 2.25. In comparison with 1990, total emissions from this sector have decreased with 9 %.

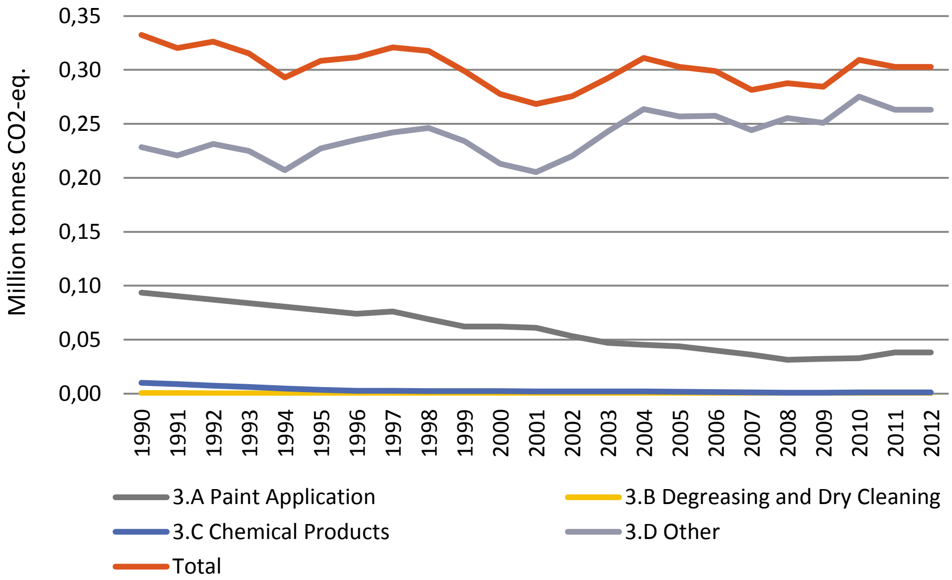


Figure 2.25. Emissions from the use of solvents and other products, per subsector

As shown in Figure 2.25 the emission trends differ between sub-sectors. Subsector Other (3.D) is increasing over the period while the emissions in paint application (3.A) is decreasing. The decrease in subsector paint application is due to a shift to water-based paints.

2.3.4 Agriculture

Agricultural activities contribute directly to emissions of greenhouse gases through a variety of processes in which methane (CH_4) and nitrous oxide (N_2O) are the primary greenhouse gases emitted. The main sources of emissions of these two gases in Sweden are domestic livestock activities with enteric fermentation in domestic livestock, livestock manure management and agricultural soil management activities, such as fertilizer application. Cattle produce the major part of methane emission from enteric fermentation, while other types of livestock are relatively of low significance in Sweden. Activities related to agricultural soil management are the major source of N_2O emissions. Emission from burning of agricultural residues does not exist as this activity is legally prohibited. In addition rice is not cultivated and savannah does not exist in Sweden.

The Agriculture sector contributes with about 13 per cent (about 7.6 million tonnes CO_2-eq) of the overall greenhouse gases in 2012, of which around 63 per cent were made up of nitrous oxide and almost 37 per cent of methane.

The aggregated emissions from various agricultural activities have decreased by 9 per cent (0.7 million tonnes CO_2-eq.) over the period 2000-2012, and they have fallen by more than 15 per cent (1.4 million tonnes CO_2-eq.) since 1990, see Figure 2.26. The main reasons for the decreasing trend are: firstly the numbers of cattle have decreased, resulting in lower methane release, and secondly lower application of synthetic nitrogen fertilizer to agricultural land has resulted in decreased release of nitrous oxide.

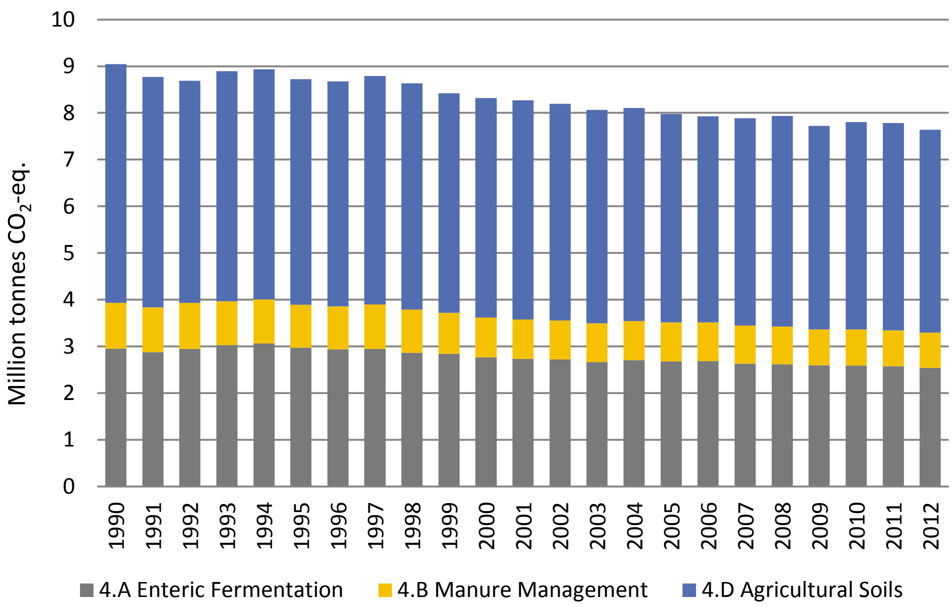


Figure 2.26 Emissions from agriculture, total and per gas and subsector.

2.3.4.1 ENTERIC FERMENTATION AND MANURE MANAGEMENT (CRF4.A AND 4.B)

Methane emissions come principally from the digestion and manure of cattle, while other types of livestock are of relatively low significance. In 2012, about one-third (33 per cent or 2.5 million tonnes CO_2-eq.) of the emissions in agriculture are related to digestion of livestock, i.e. enteric fermentation, see Figure 2.26. Methane emission from enteric fermentation has decreased by about 14 per cent over the period 1990-2012. The most important reason for the decreased emissions is reduced activities within livestock farming. For example, the population of cattle has decreased by 13 per cent from 1.718 million head to 1.5 million head over the period 1990-2012.

Emission of methane and nitrous oxide from manure of cattle, swine, horses, goats, sheep, poultry and reindeer are included in the Swedish inventory. Emissions related to manure management constitute about 10 per cent (or 0.75 million tonnes CO_2-eq.) of the total emission of the sector. Emissions have decreased by about 23 per cent since 1990. This is due to the fact that farmyard manure is declining principally as a consequence of the decreasing number of dairy cows and swine. The expansion of slurry management for pigs and dairy cows has also contributed in emission reduction.

A significant reduction in dairy cattle population (about 8 per cent) took place in 1990 and 1991, when a large number of farms abandoned milk production and shifted towards non-dairy cattle. Some of these farms changed to extensive meat production with the aid of government conversion grants, and the number of beef cattle therefore, increased by about 15per cent during the first half of the 1990s. Following Sweden's accession to the EU in 1995, the EU's Common Agricultural Policy (CAP) stabilised livestock numbers for livestock that have the right for subsidies, for example, cattle. The long-term trend is nevertheless for a successive decrease in both cattle and swine, while the number of horses, sheep and chickens for slaughter has increased. Overall, this signifies a decrease in methane emissions from both livestock and their manure. It is worth to mention that methane emissions per dairy cow in 2012 have increased by about 8per cent compared to 1990, due to increased milk yield, greater quantity of manure and a higher proportion of slurry management. Milk yield per cow in 2012 has increased by about 29 per cent since 1990. The average milk yield per cow is about 8700 litres per year.

2.3.4.2 AGRICULTURAL SOILS (CRF 4.D)

Where large applications of fertilizer are combined with soil conditions favorable to denitrification, large amounts of nitrous oxide can be produced and emitted to the atmosphere. The emission of nitrous oxide originates as a result of microbial nitrification-denitrification processes in agricultural soil. Similarly, the often poorly controlled use of animal waste as fertilizer can lead to substantial emissions of nitrous oxide from agricultural soils.

A major source of nitrous oxide emission from agricultural soils comes principally from the supply and conversion of nitrogen from synthetic fertilizer use, animal waste and sewage sludge used as fertilizer. The need for greater crop yields is the mean driver to a large increase in the use fertilizers. Cultivation of peat soils, also results in significant release of nitrous oxide, as does conversion of the nitrogen that leaches to lakes and watercourses.

In 2012, N_2O emission from agricultural soils was responsible for about 57 per cent (or 4.4 million tonnes CO_2-eq.) of the total emissions of agriculture sector Figure 2.26. The emissions show a significant long-term trend as they are highly sensitive to the amount of nitrogen applied to soils. The nitrogen input from application of synthetic fertilizers in 1990 was about 222 thousand tonnes and declined to about 147 thousand tonnes in 2012, a decreased by about one-third. However, the overall emissions from 4.D Direct Soil Emissions have decreased by about 15 per cent since 1990 due to mainly decreased application of mineral fertilizer and farmyard manure.

2.3.5 Land Use, Land Use Change and Forestry – LULUCF

The Sector Land Use, Land Use Change and Forestry (LULUCF) constituted an annual net removal in Sweden during the whole period 1990-2012, see Figure 2.27.

In 2012 the total net removal from the Land Use, Land-Use Change and Forestry LULUCF-sector was estimated to ca 35,4 million ton carbon dioxide equivalents. During the period the net removals has varied between 31 and 43 million tonnes of carbon dioxide equivalents with the highest removals in the beginning and around year 2000, but the long-term trend points to a small decrease in net removals from the sector. Since 2008 the trend seems to stabilize around a total net removal of 35 million tonnes of carbon dioxide equivalents .The decrease in net removal is mainly due to an increased harvest rate and over the last years the decrease was also enhanced due to the effect of two severe storms in the beginning of 2005 and in 2007, respectively. The storm in 2005 brought down a large quantity of timber. According to the Swedish National Board of Forestry, gross fellings ranged between 64 Mm^3sk and 89 Mm^3sk over the period 1990 to 2012, with the exception of 2005 when felling, including wood felled by storms, was estimated at 122 Mm^3sk.

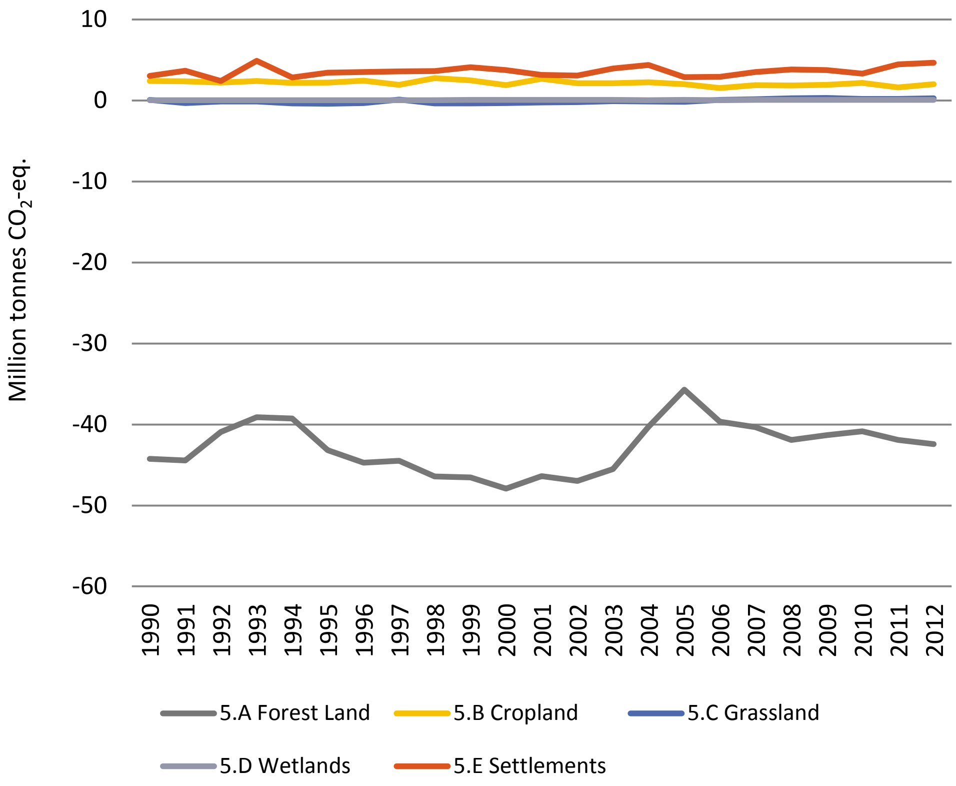


Figure 2.27. Emissions (+) and removals (-) of greenhouse gases from the LULUCF sector

The total size, variation and trend of the net removals in the LULUCF-sector are mainly affected by the carbon stock change in the Forest land. The carbon stock change in the living biomasspool counts up for the major part of these net removals and varied between approximately 24 and 38 million tonnes of carbon dioxide during the period 1990-2012 with the highest figures in the beginning of the period and with a small decrease during the last years. During the latest years (2008 and onwards) the harvest rate has stagnated but the gross removal (growth) has an increasing trend, see more in chapter 7.1.

The categories cropland, grassland, wetlands and settlements account for very small areas and small emission/removals compared to Forest land. The carbon stock change in grassland and wetlands were small during the period 1990-2012. The net emissions in the category Cropland varied during the period 1990 to 2012 between 1.5 and 2.7. million tonnes of carbon dioxide equivalents. Cropland is responsible for emissions of carbon dioxide when organogenic soils are cultivated. Emissions from drained organic soils are the dominating sources in in this land category. The trend in the emissions from drained organic soils is decreasing due to a decreasing area of drained organic soils.
Emissions from settlements were in the range of 2.4 and 4.9 million tonnes of carbon dioxide equivalents during the period 1990-2012, with the biggest emission in 1993. The emissions during the two latest years are around 4,5 million tonnes of carbon dioxide equivalents. The reasons for the trend is urbanisation with roads and power cables etc.

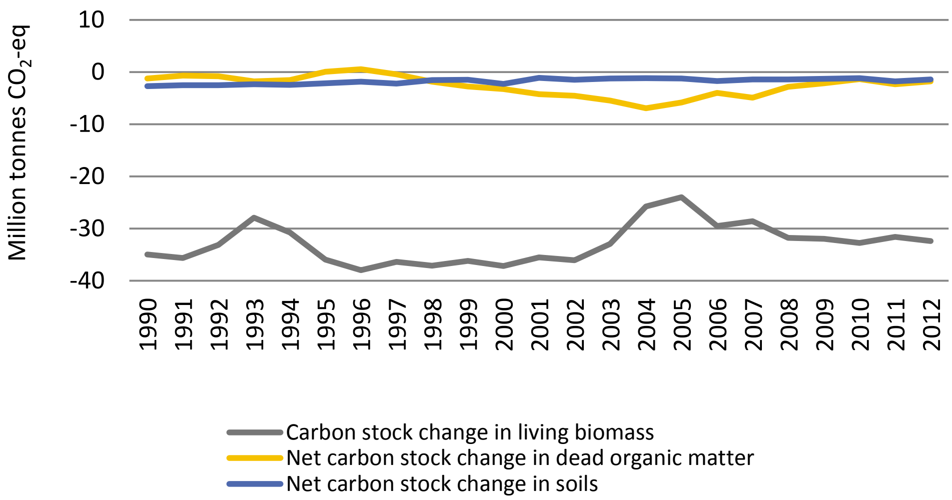


Figure 2.28. Emissions (+) and removals (-) of carbon dioxide from different carbon pools

The net removal in the LULUCF-sector is calculated as the total carbon stock change in the three carbon pools of living biomass, dead organic matter (dead wood and litter including the humus layer of soil) and soil organic carbon for different land use categories. The three carbon pools living biomass, dead organic matter and soil organic carbon contributes as an aggregate to a net removal, see Figure 2.28. In addition, emissions of N_2O from fertilization and disturbance associated with conversion to cropland, CO_2 emissions from lime application and N_2O, CH_4 and CO_2 from biomass burning are calculated and they contributes to a very small source with small emissions. The trend for the carbon pool living biomass follows the trend in the Category Forest land and the reasons are the same.

The uncertainty is the figures in this sector are generally greater in data for 2012 than 2009 since the number of sample plots monitored in the NFI gradually decrease, and extrapolations are needed for a major part of the sample plots. The uncertainties are generally bigger in the smaller categories. More is written in chapter 7.

2.3.6 Waste

Total emissions from the waste sector (CRF 6) in 2012 amounted to around 1.6 million tonnes CO_2-eq. or about 2.8 per cent of the national total of greenhouse gas emissions. In comparison with 1990, the emissions were about 53 per cent lower in 2012. Most of the emission from the waste sector comes from 6.A Solid Waste Disposal on Land (about 68 per cent) which is dominated by emission of methane gas, while emissions from 6.B Wastewater Handling account for 28 per cent. The rest (about 4 per cent) comes from 6.B Waste Incineration. Emissions by subsectors are shown in Figure 2.29.

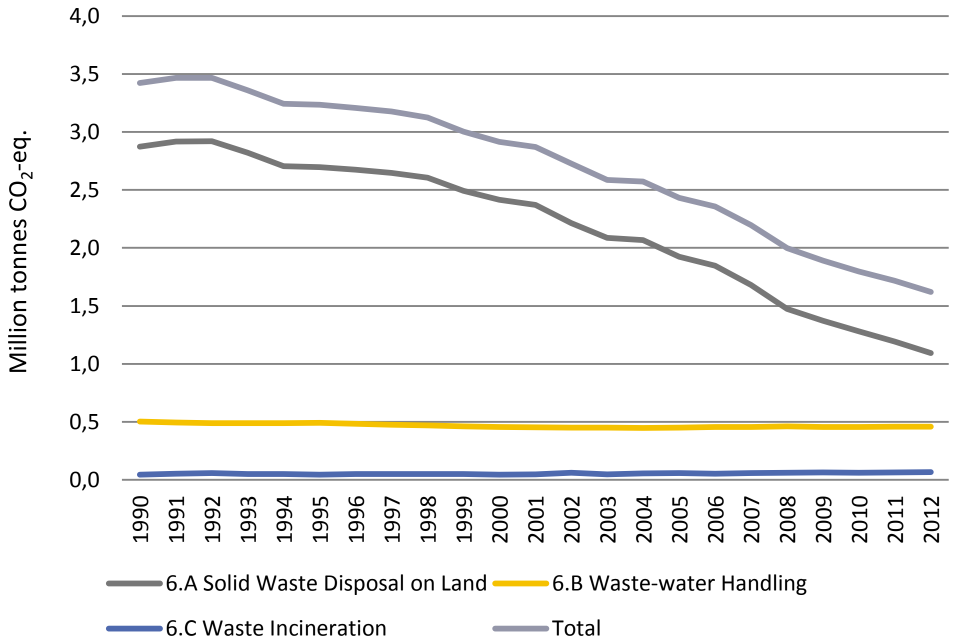


Figure 2.29. Emissions from the waste sector, total and per subsector

Landfills are the largest source for emissions of methane gas, after livestock farming, as methane is formed when organic waste is placed in landfills. Methane emissions have declined steadily since the early 1990s, partly because the amount of organic material in landfills has declined and partly due to the increased collection and management of methane gas from landfills.

Several policy instruments have been significant in this trend. During the 1990s there was, for instance, the introduction of producer responsibility for a number of different groups of articles, for example packaging, waste paper, office paper and tyres. It is also believed that the demand for municipal waste planning that was introduced in 1991 has contributed to the expansion of methane collection and to the reduction in the amount of degradable material deposited in landfills.

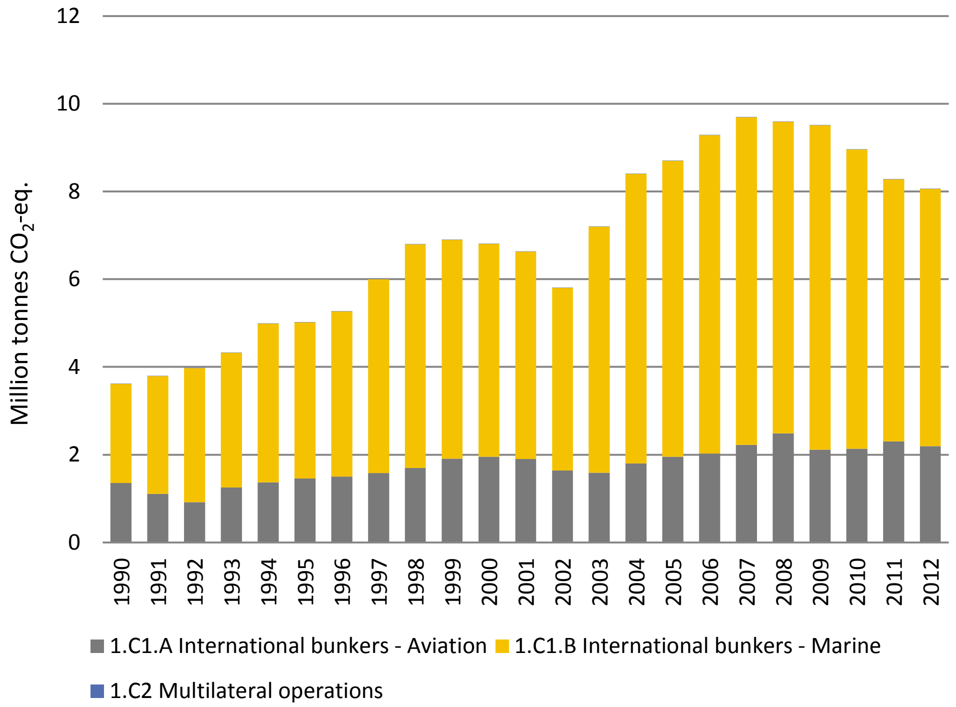
A tax on landfill waste was introduced in 2000, and bans on the landfill disposal of combustible waste (in 2002) and organic material (in 2005) have subsequently been introduced. The bans have contributed to a substantial change in waste management in Sweden. The landfilling of other types of waste has also fallen sharply. Emissions from landfills have declined by about 62 per cent since 1990.

Emissions from wastewater handling were less about 0.46 million tonnes CO_2-eq. in 2012 and accounted for 28 per cent of the waste sector is less than 1per cent of the national total. Emissions have fallen by about 8 per cent since 1990 due to improved sewage treatment.

Emissions from waste incineration were around 0.066 million tonnes CO_2-eq. in 2012. Emissions have increased somewhat in recent years in comparison with the level of emissions from 1990 to 2002. This increase is due to greater quantity of waste being managed as hazardous waste as the capacity for incineration has increased.

2.3.7 International bunkers

Greenhouse gas emissions from international shipping and aviation, known as international bunkers, are considerably larger than those from domestic shipping and aviation. In 2012 they amounted to around 8.1 million tonnes of carbon dioxide equivalents, see Figure 2.30. This includes refuelling in Sweden by international shipping and aviation. Theseemissions are not included in the reporting of the total emissions from Sweden which is calculated in the Kyoto Protocol commitments.



Figur 2.30. Emissions from international bunkers, total and per subsector

Emissions from international shipping totalled 6.0 million tonnes of carbon dioxide equivalents in 2012. This is a decrease of 2% compared with 2011 but an increase of 159% since 1990. 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 is that Swedish refineries produce low-sulphur marine fuels (fuel oil nos. 2–5), meeting strict environmental standards. This has led to more shipping companies choosing to refuel in Sweden. Fluctuations in bunker volumes between years are also dependent on fuel prices in Sweden compared with ports in other countries.

Greenhouse gas emission from international aviation bunkers was 2.2 million tonnes of carbon dioxide equivalents in 2012. This is a decrease by 5 % compared with 2011 and an increase of 62 % since 1990. Emissions from international bunkering of aviation have varied over time. The trend points to a rise in these emissions, owing to growth in foreign travel.

2.4 Description and interpretation of emission trends for indirect greenhouse gases and SO_2

2.4.1 NMVOC

In 2012, the emissions of non-methane volatile organic compounds (NMVOCs) totalled around 186 ktonnes. The energy sector (mainly road traffic, wood combustion in the residential sector) and solvent and other product use sector are the dominant sources of emissions contributing with 43 and 50 per cent, respectively Figure 2.31. In addition, some industrial activities (such as pulp and paper, and food and drink) are also significant sources for NMVOC emissions.

The emissions have sharply declined by almost one-half since 1990. The decline is clearly visible in the energy sector and solvent and other product use sector which accounts for about 66 and 8 per cent, respectively..

The greatest reduction in NMVOC emission comes from road traffic as it has decreased by about 84 per cent since 1990. The estimated emission from road traffic in 2012 has dropped to about 26 ktonnes NMVOC. The main reason for this sharp decrease is the introduction of new exhaust emission requirements. In addition, the non-compulsory environmental standards in new installation of wood-fired boilers and reduced emissions from products containing solvents have also contributed to lower emissions during the last two decades. Fugitive missions from oil refineries have also decline by more than one-half since 1990.

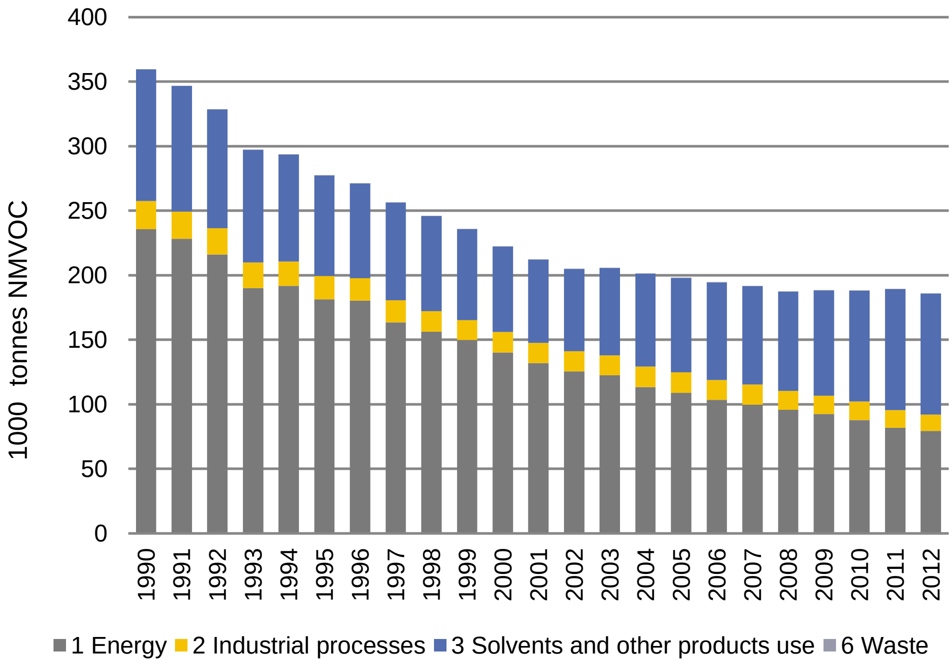


Figure 2.31. Total emissions of NMVOC and emissions from different sectors

2.4.2 NO_X

Emissions of nitrogen oxides (NO_x) amounted to about 132 ktonnes in 2012, a decrease by more than one-half since 1990, Figure 2.32. Nitrogen oxides are formed in all combustion in the energy and transport sectors, and the largest emission sources are road traffic, machinery, navigation and production of electricity and heating. Emissions of nitrogen oxides from the energy sector were about 117 ktonnes which accounts for about 90 per cent of the total emissions. Approximately one-half (48 per cent) of the energy sector's NO_x emission (about 61 ktonnes) comes from transport. Emissions from the energy sector (including transport) have declined by more than a half (53 per cent) since 1990.

Traffic is a large source of emissions of nitrogen oxides, and the emissions come largely from road traffic which accounts for 55 ktonnes or 42 per cent in 2012. The introduction of catalytic converters in cars and the subsequent successive tightening of exhaust emission requirements have contributed to a general decrease in concentrations of nitrogen oxides in urban areas. Road-traffic emissions of NO_x decreased by about 60 per cent between 1990 and 2012 and decreased by about 5 per cent between 2011 and 2012.

Approximately 11 per cent of NOx emissions in 2012 came from public electricity and district heating production. The annual NOx emissions from this source show significant long-term trend fluctuations between 1990 and 2012, although the overall emissions were 2 per cent lower in 2012 than in 1990. The trend of NO_x emissions from this source is related to weather patterns in Sweden, such as (temperature and precipitation) and consequently the need for heating, which affects the need for combustion-based production of electricity.

Industrial processes sector is the next largest source of NO_x emissions in Sweden and accounts for about 11 per cent of the total emission. These emissions originate mainly from pulp and paper industry.

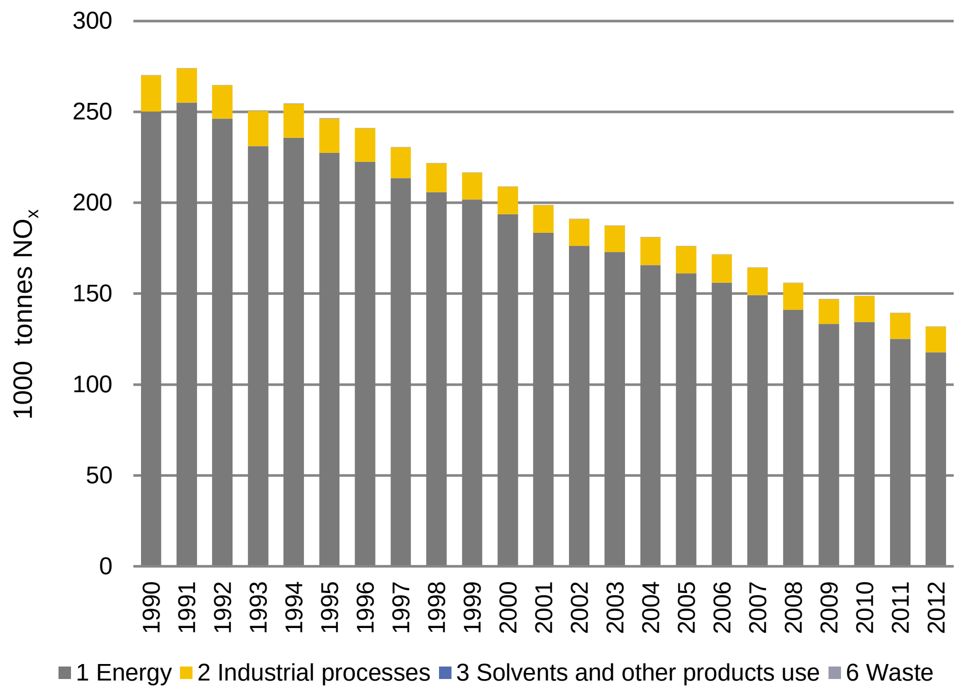


Figure 2.32. Total emissions of NO_x and emissions from the different sectors

2.4.3 CO

Emissions of carbon monoxide (CO) have developed in the same way as NO_x emissions. Emissions have decreased from about 1.28 million tonnes in 1990 to about 546 ktonnes in 2012, a reduction of 57 per cent, Figure 2.33. The emission has decreased slightly (1 per cent) compared to 2011. Most of CO emissions (95 per cent) come from the energy sector. Road traffic stands for less than one-third of the total emission. In 2012, approximately one-fourth of CO emission comes from residential small-scale plants for heat production.

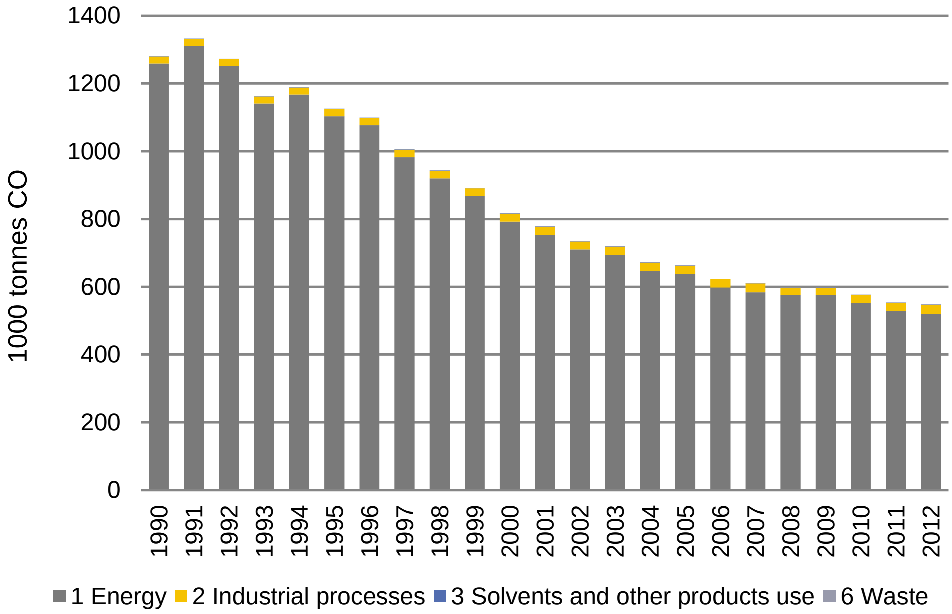


Figure 2.33. Emissions of CO from different sectors

2.4.4 SO_2

Sulphur dioxide (SO_2) emissions come from energy, transports, industrial processes and combustion of hazardous waste.

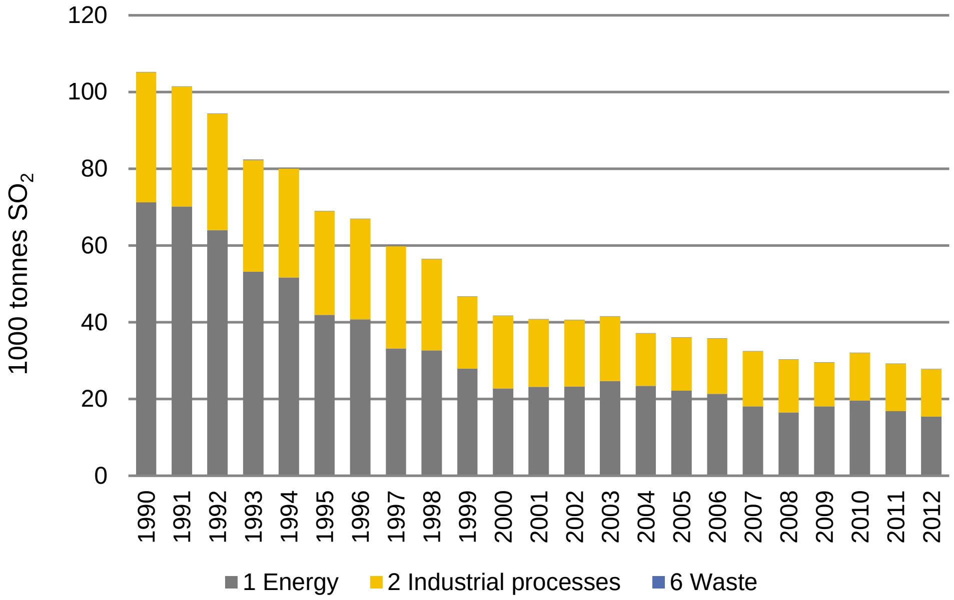


Figure 2.34. Total emissions of SO_2 and emissions from different sectors

In 2012, Sweden emitted less than 28 ktonnes of sulphur dioxide in total. Emissions have sharply declined to less than one-fourth of that in 1990, see Figure 2.34. Nearly 55 per cent of sulphur dioxide emissions derive from the energy sector (mainly from public electricity and heat production) and about 44 percent comes from industrial processes, such as metal production and pulp and paper industry. The decline is due to a shift from fuels with high-sulphur levels to low-sulphur fuels, for vehicles, industry and production of electricity and district heating. The sulphur tax introduced in 1991 has been significant in this shift. Other factors which contribute to reduced emissions include the consideration of industries under the Environmental Code.

Emissions of SO_2 from the transport sector in 2012 have decreased by about 90 per cent compared to 1990. Road traffic emissions of SO_2 were about 73 tonnes in 2012 compared to 5800 tonnes in 1990, a drop by 99 per cent due to a shift to lower sulphur levels in motor fuels. Sulphur emissions from domestic navigation have also decreased by 83 per cent since 1990 and are now less than one ktonnes due to a switch to oils with lower sulphur content.

2.4.5 Description and interpretation of emission trends for KP-LULUCF inventory in aggregate and by activity, and by gas

The net emissions from ARD in 2012 were 2, 5 million tonnes of carbon dioxide equivalents and the net removals from FM was 37, 6 million tonnes of carbon dioxide equivalents in 2012.

Since the KP-LULUCF has been reported for only five years, there is not so much of a trend to describe at least not for activities under article 3.3, afforestation/reforestation (AR) and deforestation (D). However, the reporting under forest management (FM) is strongly linked to the reporting of forest land remaining forest land under the UNFCCC-reporting, so to get a picture of the long term trend it is recommended to read section 2.3.5 which describes the trend in the LULUCF-sector.
The areas for the activities under article 3.3, ARD have been increasing continuously since 1990 by around 10 000 ha per year per activity.

The trend for AR is an increasing sink due to increasing growth and due to the increase in area.

The trend in D is an increasing source for the first 20 years due to the increase in area, and emissions from soils. Emissions and removals in living biomass show no trend since these are heavily dependent on the amount of biomass on the deforested area each year.

3 Energy (CRF sector 1)

3.1 Overview of sector

The energy sector includes emissions from fuel combustion (CRF 1.A) and fugitive emissions from fuel production and handling (CRF 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 the major part of Swedish greenhouse gas emissions, and emissions of carbon dioxide dominate overwhelmingly in this sector. However, carbon dioxide emissions per capita 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 dioxide.[41]

It can be seen in Figure 3.1 that in the energy sector, emissions of CO_2 contribute about 96 % of total greenhouse gas emissions (in CO_2 equivalents) 2012. Emissions of total greenhouse gases from the energy sector have decreased by 16.1 % from 53,439 Gg CO_2 equivalents in 1990 to 42,327 Gg CO_2 equivalents in 2012, mainly due to reduced fossil fuel consumption in the residential sector (CRF 1.A.4) (Figure 3.2).

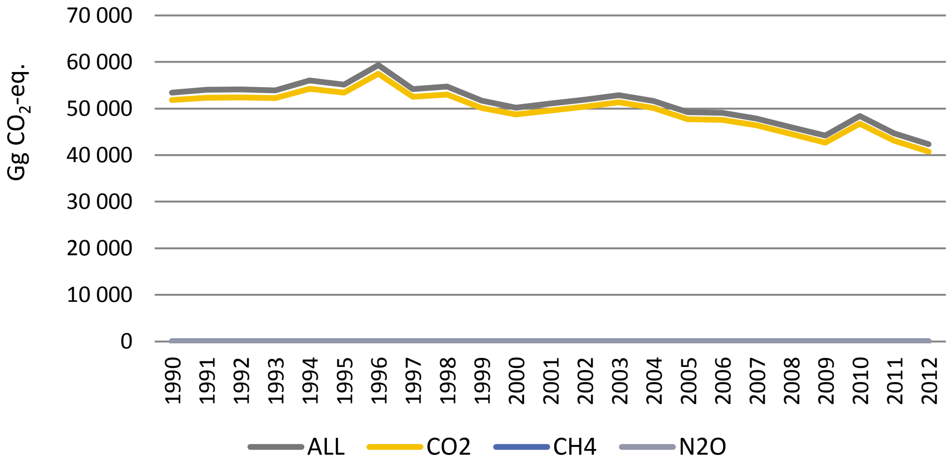


Figure 3.1. Total emissions of all greenhouse gases calculated as CO_2 equivalents from CRF 1 Energy

[41] Ministry of the Environment, 2001

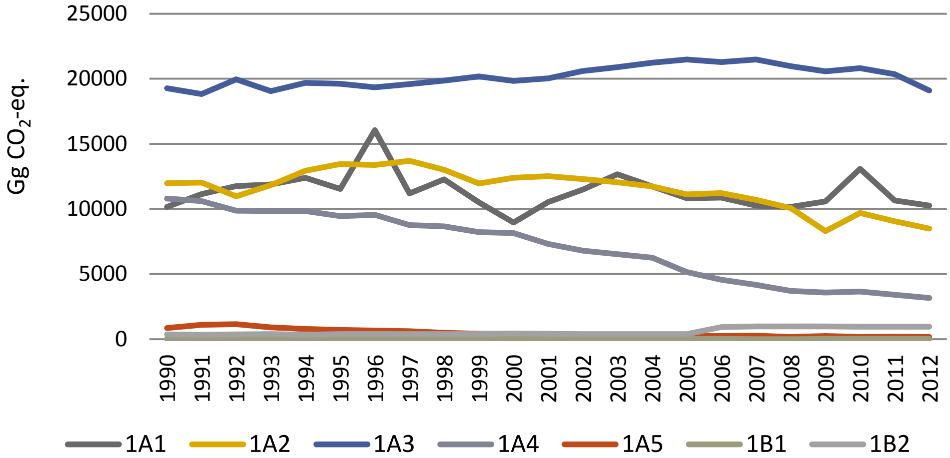


Figure 3.2. Total emissions of all greenhouse gases calculated as CO_2 equivalents from the different sub-sectors within the Energy sector. 1A1 Energy industries. 1A2 Manufacturing industries and construction. 1A3 Transport. 1A4 Other sectors. 1A5 Other. 1B1 Solid fuels (fugitive). 1B2 Oil and natural gas (fugitive).

As shown in Figure 3.2, the transport sector (CRF 1.A.3) accounts for the largest part of the GHG emissions from the energy sector. Emissions from public electricity and heat production (CRF 1.A.1) varies mainly because of temperature variations between years. As mentioned earlier, the emissions from residential heating (CRF 1.A.4) are decreasing due to the development of district heating, and to a shift from heating oils to biomass. In manufacturing industries and construction (CRF 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 CRF 1.A.1 in 1996 and 2010 are mostly due to the cold winters that year 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 recent increase in fugitive emissions from oil and natural gas (CRF 1.B.2) is caused by hydrogen production facilities put into operation at two of the oil refineries in 2005 and 2006 respectively.

Table 3.1 shows the impact of recalculations reported in submission 2014 for GHG emissions by sector and sub-sectors for 1990, 1995, 2000 and 2006-2011. The recalculations are mainly due to:

- Revised activity data regarding large diesel off-road vehicles and working machinery (mainly CRF 1A2 and 1A4).
- Updated and improved method to estimate traffic work with regard to driving distances for road traffic (1A3).
- Revised activity data for the Other sectors (1.A.4 and parts of 1.A.2) for 2010-2011
- Revised methodology for fugitive emissions from transmission and distribution of natural gas and gas works gas (1B2).

More detailed descriptions of the recalculations are found under sector specific sections below.

Table 3.1. Impact of recalculations of GHG emissions submission 2014 in the energy sector (1990, 1995, 2000, 2005-2011)

Impact of recalculations submission 2012 (Gg CO_2 eq.)									
CRF	**1A1**	**1A2**	**1A3**	**1A4**	**1A5**	**1B1**	**1B2**	**Total CRF 1**	**% CRF 1**
1990	3	-86	-29	-107	0	0	-11	-230	-0.4%
1995	-9	-182	-32	-109	1	0	9	-322	-0.6%
2000	-21	-217	-32	-125	0	0	2	-392	-0.8%
2005	-13	-229	-34	-121	0	0	-17	-414	-0.8%
2006	-38	-292	-33	-119	0	0	-24	-507	-1.0%
2007	-51	-268	94	-165	0	0	-25	-415	-0.9%
2008	NA	-298	142	-193	0	NA	-39	-389	-0.8%
2009	NA	-358	239	-237	0	NA	-42	-398	-0.9%
2010	NA	-466	298	-280	0	NA	-47	-495	-1.0%
2011	0	-466	346	-245	0	NA	-49	-414	-0.9%

0: value less than 0.5. NA: no recalculation is performed.

3.2 Fuel combustion (CRF 1.A)

Emissions from fuel combustion, CRF 1.A, are allocated to a number of subsectors. In CRF 1.A.1, emissions from 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, are reported. CRF 1.A.2 includes combustion-related emissions in manufacturing industries and construction. Emissions from working machinery within the construction sector are allocated to CRF 1.A.2, but apart from that, CRF 1.A.2 includes only stationary combustion. Emissions from transports (aviation, road traffic, railways and navigation) are reported in CRF 1.A.3. Only domestic activities are included in CRF 1.A.3, as emissions from international aviation and navigation are allocated to the category 1C1, international bunkers, and not included in the national total. In CRF 1.A.4, emissions from households, service, agriculture, forestry and fisheries are reported. CRF 1.A.5 is intended for “other” combustion, which in the Swedish inventory includes emissions from military operations. Flaring, e.g. combustion where the energy is lost and not used, is reported in CRF 1B.

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

$Emissions_{fuels}$ (unit) = $\sum$ Fuel consumption (unit) * thermal $value_{fuels}$ * EF_{fuels}

Different Tiers are used for different sub-sectors as discussed in sections below.

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

3.2.1 Comparison of the sectoral approach with the reference approach

A detailed discussion on the reference approach and its differences compared to the sectoral approach is provided in Annex 4. Figure 3.3 shows the differences in fuel consumption and CO_2 emissions between the Reference and Sectoral Approach for the whole time series 1990-2012.

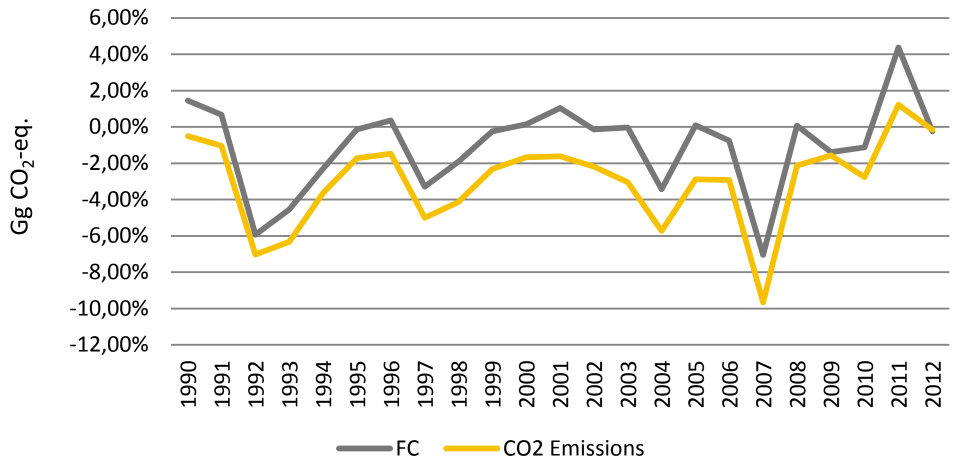


Figure 3.3. Differences between Reference Approach and Sectoral Approach (Reference minus Sectoral)

It is obvious that fuel consumption and CO_2 emissions from the Sectoral Approach exceed the Reference Approach for most years. For a number of years the difference is larger than ± 2 %. Data on fuel group level indicates that this problem is primarily related to liquid fuels. Statistical differences in energy balances contribute to a large share of differences especially in the early 1990's. Large differences for 1997, 1998, 2001 and 2007 are mainly attributed to liquid fuels and most notably crude oil and refinery feedstocks. For solid fuels, the difference in energy and emissions, respectively, is not consistent between years. On total level, this has the effect that differences expressed as energy consumption are less negative than differences expressed as CO_2 emissions, as shown in Figure 3.3. This is related to solid fuels used in the iron and steel industry. Large amounts of energy are lost in coke ovens and blast furnaces when coking coal is transformed to coke and coke oven gas, and coke is transformed to blast furnace gas. This means that the reported amounts of coke oven gas, blast furnace gas and steel converter gas reported in the sectoral approach contains all the carbon but only parts of the energy reported as coal in the reference approach, which gives a large difference between the reference and sectoral approach for consumption of solid fuels. However, the time series for both liquid and solid fuels still show very large variations after this correction. For gaseous fuels, the differences are low for most years, except for the period 2004-2008 when the amounts of natural gas used as feedstock cannot be reported in CRF 1Ad due to confidentiality reasons. Further explanations are given in Annex 4.

3.2.2 International bunker fuels

This sector includes emissions from refuelling in Sweden used for international navigation and international aviation. All gases are covered.

In accordance with IPCC guidelines, international bunkers are not included in national totals. To evaluate Swedish emissions, international bunkers are of course important, especially as international bunkering of fuel is substantially greater than the fuel used for domestic navigation and aviation. Emissions have increased significantly since 1990 due increased travelling and increased transportation of goods among other things. See also section 2.

3.2.2.1 INTERNATIONAL BUNKERS, CRF 1C1

Emissions from international bunkers for aviation and navigation are not included in the national total, but instead reported separately as a memo item in CRF 1.C.1, in accordance with the IPCC Guidelines.

The UNFCCC expert review team (ERT) has noticed that the data reported to the IEA generally is higher than what is reported to the UNFCCC. A study in 2010 showed that the differences between the IEA (International Energy Agency) and the UNFCCC reporting to can, some extent, be explained by revision policies of the different reporting obligations. Since the UNFCCC has a high demand on consistency of time series, efforts are made to ensure high quality of times series.[42] The fuel for international bunkers for aviation are purchased in Sweden and used for flights with destinations abroad. This includes the whole flight cycle, i.e. both LTO (Landing and Take-Off) and Cruise, see also Annex 2.

The emissions from aviation reported to the UNFCCC are based both on data from the monthly survey on supply and delivery of petroleum products from Statistics

[42] Hedlund & Lidén 2010

Sweden (see Annex 2) and fuel and emission data reported by the Swedish Transport Agency (STAg). Activity data from the STAg, former Swedish Civil Aviation Authority (SCAA), starts from 1994. With regards to bunkering, the data has been estimated using 1994 for CO_2 emissions. The share of LTO is estimated using an average for the years 1995 to 2001. As from 2001, ICAO standard taxi time has been used for international flights and the part of the LTO cycle occurring on international airports.[43]

The Swedish Transport Agency (STAg) is responsible for reporting the emissions from aviation. The fuel consumption and emissions published by STAg are calculated by the Swedish Defence Research Agency (FOI) by using an estimation model. The STAg provides FOI statistics 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 and 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 whole flights as well as for aircraft movements below 3000 ft at the airports, the so called LTO cycle. The FOI has written a report which describes their method for estimating the emission from aviation[44]. The emissions from aviation estimated by FOI are adjusted to be in line with data on supply and delivery of petroleum products from Statistics Sweden (see Annex 2).

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 emissions from aviation are split into national respectively bunker emissions based on data in the the monthly survey on supply and delivery of petroleum products from Statistics Sweden

International bunkers from navigation are defined as fuels bought in Sweden, by Swedish or foreign-registered ships, and used for transport to non-Swedish destinations. The split between international and domestic fuels is based on information from the monthly survey on supply and delivery of petroleum products.

[43] Näs, 2005.

[44] Calculation of exhaust emissions from air traffic. T. Mårtensson, A. Hasselrot. FOI R 3677 mSE

In 2011, the fuel consumption by national and international navigation was studied and the results were presented in the report "Emissions from navigation and fishing including international bunkers"[45]. Fuel data in the survey " Monthly fuel, gas and inventory statistics" was analysed and found to be of good quality. As a consequence of that VAT is applied on national fuel consumption, but not on international bunkers, all respondents to the survey are able to separate these fuel amounts with high accuracy. Fuels used for domestic and international navigation have been separated correctly and in line with IPCC Guidelines.

3.2.2.2 MULTILATERAL OPERATIONS, CRF 1.C.2

Emission from multilateral operations are not included in the national total but instead reported separately as a memo item in CRF 1.C.2, in accordance with the 1996 revised IPCC Guidelines. These emissions are calculated based on information from the military on the amount of fuel purchased in Sweden but used abroad by Swedish forces participating in international operations.

3.2.3 Feedstocks and non-energy use of fuels

Activity data on feedstocks and non-energy use of fuels is collected from the quarterly fuel statistics. As also noted in Annex 2 section 1.1.1, in the survey form for the quarterly fuel statistics, respondents are among many other things asked to specify whether fuels are used as raw materials or for energy purposes. This facilitates the use of data for CRF table 1.A.d, non-energy use of fuels. As mentioned in section 3.2.1, data on natural gas used as feedstock cannot be reported for the years 2004-2008 due to confidentiality reasons (this activity started in 2004, and for the years 2009 and later, the company using natural gas as feedstock has given permission to publish this data. It is not possible to get a "retroactive" permission to publish data reported in the survey before 2009).

Net calorific values and carbon emission factors are the same as in CRF 1AB. The parameter "fraction of carbon stored" has been set to 1.00 for all fuels. This is done because otherwise the emissions corresponding to CRF 2 and 1.B in the sectoral approach would not be accounted for in CRF 1.A.d but in 1.A.b, which would cause systematic differences in the comparison 1.A.c.

3.2.4 CO2 capture from flue gases and subsequent CO2 storage

So far, storage of CO_2 does not occur in Sweden[46]. There are, however, several research projects going on where CO_2 is captured from flue gases at a pilot scale.[47]

[45] Eklund et al. 2011. Emissions from navigation and fishing including international bunkers

[46] Geological Survey of Sweden, 2010

[47] E-on 2010-11-04, Fortum 2010-11-04

3.2.5 Country-specific issues

No country-specific issues are reported in this submission.

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

3.2.6.1 SOURCE CATEGORY DESCRIPTION

Swedish production of electricity is characterized by large proportions of hydropower and nuclear energy. Only a small share of electricity production is based on fuels used in conventional power plants. Public 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 2009/2010 and 2010/2011 were unusually cold, which lead to an increase in fuel consumption particularly in 2010. Liquid fuels and natural gas account for most of the increase, although the increase in natural gas use can to a large extent be explained by the fact that new gas fuelled facilities have been taken into operation. 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.

Production of district heating is currently to a large extent based on biomass and waste. There has been a change from fossil fuels towards biomass since 1990. In 1990, 15 % of fuels used were biomass and 15 % was waste. In 2012, 57 % of all fuels used for district heating were biomass, while waste accounted for 23 %. [48] 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 (1990) to

[48] All numbers are according to data used in the Greenhouse gas inventory this submission.

188 PJ (2012)[49] but, due to the more frequent use of biomass, greenhouse gas emissions from district heating were only slightly larger than in 1990.

The number and distribution of Swedish power stations in 2011 are presented in Table 3.2[50]. Changes since 1990 in number of plants and their installed effect have been minor in the electricity sector, but the number of plants that only produce district heating has increased.

Table 3.2. Number and distribution of Swedish energy stations 2011

Type of plant	Number of plants	Gross Production GWh	Gross Production TJ
Total power stations	3 155	151 150	544 240
Power generation not based on fuels	2 991	73 287	263 833
Windpower	2 036	6 101	21 964
Hydropower	955	67 186	241 870
Power generation based on fuels	164	77 863	280 307
Nuclear power	3	60 475	217 710
Conv. thermal power	161	17 388	62 597
- Manufacturing industries, ISIC 10-37	41		
- Energy plants, ISIC 40	98		
- Others	22		

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. Summary of source category description, CRF 1.A.1.a

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1A1a	CO_2	X	X		T2	CS	Yes
	CH_4		X		T2	CS	Yes
	N_2O	X	X		T2	CS	Yes

CS Country Specific. T2 Tier 2.

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.

[49] Statistics Sweden/Swedish Energy Agency EN11SM 1302 (Electricity supply, district heating and supply of natural and gasworks gas 2012. Preliminary data).

[50] Data for 2012 currently not available (i.e., these facts are not included in the preliminary data). Statistics Sweden /Swedish Energy Agency EN11SM 1301 (Electricity supply, district heating and supply of natural and gasworks gas 2011).

The activity data source for emissions in CRF 1.A.1.a is the quarterly fuel statistics, 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, CO_2 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 steel converter gas that are used to calculate CO_2 emissions from the plants using these fuels in CRF 1A1a.

The most important fuels in recent years are wooden fuels followed by domestic waste. Greenhouse gas emission factors for these fuels are national and were developed in a study made in 2004[51].

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

3.2.6.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The quarterly fuel statistics 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, accurate, complete, consistent and with very low uncertainties.

The trend in fuel consumption in this sector varies depending on the production of hydroelectric power and weather variations between years. The greatest changes in fuel consumption are for biomass fuels, where the consumption has increased significantly due to for instance increased district heating. It can also be noted that the use of natural gas in this sector was much higher in 2009-2011 than earlier years. The reason is that the number of gas-fuelled facilities has increased.

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 CO_2 EF than other solid fuels, the share of blast furnace gas has a very large influence on the aggregate CO_2 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 CRF 1.A.1.a dropped, which explains the drop in CO_2 IEF for solid fuels in 1.A.1.a in 2009. As noted by the UNFCCC ERT, submission 2012, the IEF for N_2O varies significantly. 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.

[51] Boström et al, 2004

The IEFs for the group other fuels also vary between years because the emission factors for municipal solid waste are different from the emission factors for other fuels in this group. In recent years, municipal waste accounts for 90-92% of the consumption of “other fuels”. The remaining 8-10% 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 CO_2 emission factor for this fuel is considerably higher than the emission factor for municipal waste, as the fossil fraction is assumed to be higher in unspecified fuels. The emission factors are discussed in Annex 2.

Emissions of NO_x and SO_2 and in relation to fuel consumption are also slightly variable between years due to variations in fuel mix. In the latest years, especially the SO_2 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. Wooden fuels are the most common fuels in this sector, but as CO_2 from biomass is not included in the sectoral total of GHG emissions, CO_2 from combustion of peat, blast furnace gas and “other fuels” accounts for the largest contributions to the aggregate uncertainty of GHG emissions in CRF 1A1a. The activity data uncertainties are relatively low, 2 % for peat and blast furnace gas and 10 % for “other fuels”. The CO_2 emission factor uncertainties are 20 % for peat and blastfurnace gas, and 100% for “other fuels. Thus EF uncertainties account for the greater part of the aggregate uncertainties. Activity data uncertainties are assigned by expert judgements made by staff at the energy statistics department of Statistics Sweden. Emission factor uncertainties have been assigned by national experts on emissions from stationary combustion.

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 GPG section 8.1.7.4 applicable to this sector are used. The activity data has, of course, been subject to QA/QC procedures prior to the publishing of quarterly fuel statistics. 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 CRF-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 CO_2 emissions with the reference approach, and comparing results with the sectoral approach (see Annex 4). During 2011, there was a study[52] comparing the currently used quarterly fuel statistics with two other data sources, and the conclusion was that the quarterly fuel statistics 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 major recalculation was made in this sector in submission 2014. The net calorific value and CO_2 emission factor for gas works gas has been slightly revised for 2011, resulting in an increase of 0.26 Gg CO_2 equivalents for that year. Gas works gas has been reallocated from liquid to gaseous fuels 2011. For 2011 and onwards, all gas works gas is produced using natural gas or natural gas liquids (LNG) as feedstock.

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 (CRF 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 and consequently reported under CRF 1.B.2. 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; two facilities have hydrogen production plants and four of the facilities have sulphur recovery plants. The fuel consumption in this sector consists mainly of 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. The fuel consumption was quite stable during the period 2008 to 2011. In 2012, the consumption of refinery gas was 11 % higher than in 2011.

[52] Eklund & Kanlén 2011

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 3.4.

Table 3.4. Summary of source category description, CRF 1A1b

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1A1b	CO_2	X	X		T2	CS	Yes
	CH_4				T2	CS	Yes
	N_2O				T2	CS	Yes

CS Country Specific. T2 Tier 2.

3.2.7.2 METHODOLOGICAL ISSUES

Refineries are not included in the quarterly fuel statistics. Activity data for the five refineries was collected directly from each company for 1990-1999, since the industrial energy statistics and quarterly fuel statistics 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, e.g. before the EU Emission Trading System (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. As a result of a specific SMED study during 2006[53], data from ETS are used for four refinery plants for 2005 and later years. 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 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, one of the refineries reports refinery gas and natural gas aggregated in the ETS data, and for this facility, data from the environmental reports are used to allocate the proper amount of this fuel to gaseous fuels. Environmental reports are used for verification for all five refineries. For refinery gas, plant specific CO_2 emission factors reported to the ETS are used for 2008 and later, since they are considered to be more accurate than the older national emission factor.

In addition to the five refineries, there are a few other plants with the Swedish Standard Industrial Classification 232, petroleum refining, which should be reported under refineries according to IPCC guidelines. For these plants, activity data from the quarterly fuel statistics are used together with national emission factors. It should be noted that the five refineries account for more than 99% of the fuel consumption and emissions reported in CRF 1.A.1.b.

[53] Backman & Gustafsson, 2006

3.2.7.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The use of so many different sources for this sector could of course lead to consistency problems. Data used in the inventory is however 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.

The implied emission factor for CO_2 for refinery gas is slightly lower for 2008-2012 when plant specific emission factors are used. However, as 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 alters the composition of the refinery gas.

CO_2 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 emission factor uncertainty is around 5% and the activity data uncertainty is around 1.5 % for 2012 according to the reports to ETS[54]. Activity data uncertainty for the 1990's is as high as around 10%.

3.2.7.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In general, the same QA/QC procedures are used for CRF 1.A.1.b as for 1.A.1.a described above. For each of the five refineries, 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" 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 CRF 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 mis-coded refinery gas.

3.2.7.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been carried out in submission 2014.

[54] For each reported fuel consumption, a level of is reported. In 2012, >99 % of the reported consumption of refinery gas had the highest level, which corresponds to an uncertainty level of maximum ±1.5%

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 (CRF 1.A.1.c)

3.2.8.1 SOURCE CATEGORY DESCRIPTION

Most emissions in this sector arise 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 industry. Fuel combustion in manufacturing of nuclear fuels are also included in CRF 1A1c. 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.

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 3.5.

Table 3.5. Summary of source category description, CRF 1A1c

CRF	Gas	Key Category Assessment 2012 (excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1A1c	CO_2				T2	CS	Yes
	CH_4				T2	CS	Yes
	N_2O				T2	CS	Yes

CS Country Specific. T2 Tier 2.

3.2.8.2 METHODOLOGICAL ISSUES

Activity data on coke production is taken from environmental reports. CO_2 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. The aim is to include the mass balances and flow charts for energy and carbon for both plants separately in the next submission (see Annex 3.5).

Emissions of N_2O, CH_4, NMVOC and CO are estimated with the Tier 2 methodology with national emission factors. Estimates of emissions of SO_2 and NO_X are available from environmental reports on an aggregate level, and these emissions are distributed over the different CRF codes (1.A.1.c, 1.A.2.a, 1.B.1.c and 2.C.1, SO_2 also 2.B.5 and 1.B.1.b) according to the activity data distribution. The new methodology is described in more detail in the section 4.4.1.2.2 (CRF 2.C.1.2.)

Activity data for facilities manufacturing nuclear fuels is collected from industrial energy statistics for 1990 - 1996 and 2000 - 2002 and from quarterly fuel statistics for 1997 - 1999 and from 2003 onwards. For more details on the surveys see Annex 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 inter-annual variations in IEFs for solid fuels are caused by variations in the relative amounts of blast furnace gas and coke oven gas, respectively, between years. The composition of each gas is also quite variable, and this is another explanation to the fluctuating IEF's. 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. Consumption of liquid fuels has decreased since 2006 and the consumption of biomass is small and fairly constant. (Liquid fuels and biomass are, of course, not used in the coke ovens but in the other facilities that are allocated to 1.A.1.c due to their ISIC classification).

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7. CO_2 from blast furnace gas and coke oven gas are the dominating sources of uncertainty.

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

Recalculations for the integrated iron and steel work as described in section 4.4.1.5 affected the emission estimates for coke ovens in 1990-2002 and 2005-2007. Activity data and CO_2 emissions have been revised, which is described in section 4.4.1.5. The total effect is shown in Table 3.6.

Table 3.6. Recalculations, CRF 1A1c

Year	Ghg-eqv, sub2014-sub2013
1990	2.6
1991	4.1
1992	3.6
1993	2.4
1994	1.6
1995	-8.6
1996	-17.7
1997	-19.2
1998	-18.9
1999	-18.9
2000	-21.0
2001	-21.3
2002	-20.0
2005	-12.7
2006	-38.0
2007	-50.7

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 (CRF 1.A.2.a)

3.2.9.1 SOURCE CATEGORY DESCRIPTION

The iron and steel industry is, 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 million tonnes of steel) due to the global recession. In 2012, the production was 4.3 million tonnes.[55]

Emissions from companies with less than 10 employees are allocated to CRF 1.A.2.f because the model estimate of fuel consumption within small companies is only produced on 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 3.7.

[55] The Swedish Steel Producers´ Association, 2013-10-02

Table 3.7. Summary of source category description, CRF 1.A.2.a

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.2.a	CO_2				T2,T3	CS, PS	Yes
	CH_4				T2	CS	Yes
	N_2O				T2	CS	Yes

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

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

During 2009, a new methodology was applied 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 industrial energy statistics for 1990-1996 and 2000-2002, and from quarterly fuel statistics 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 CRF 1A2a and in CRF 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 CRF 2.C.1.1 (secondary steel) and CRF 2.C.1.2 (primary pig iron and steel).

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 3.8). 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 CRF 1.A.1.a. Detailed carbon mass balances, simplified energy balances and carbon and energy flowcharst are compiled for the two plants included in the reporting according to EU ETS (see Annex 3.5).

The allocation of total CO_2 emissions and energy consumption (TJ) on plant stations and consequently CRF sub-sector is based on measured fuel consumption and associated CO_2 emissions.

Table 3.8. Allocation of fuel consumption and CO_2 emissions in 2012 from iron ore based iron and steel industry on different CRF codes

CRF	Plant station	CO_2 emissions (Gg)	Engery consumption (TJ)
1.A.1.a	Power and Heat Production (sold amount of energy gases)	1 989	7 550
1.A.1.c	Coke Oven	358	4 574
1.A.2.a	Combustion in Rolling Mills + Power and Heat Production	431	3 328
1.B.1.c	Flare in Coke Oven (COG)	9	188
2.C.1.2	Blast Furnace + Steelworks (including Flaring of BFG and LD-gas)	1 746	6 631
1.A.d	Non-energy use of fuels	NA	34 366
Total		4 532	56 637

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. National NCV:s and emission factors are used.

3.2.9.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

For the two largest facilities, the time series is very consistent as all data is based on information from these facilities, and they have checked that the calculated emission and energy data is accurate. In 2012 it was concluded that the emissions of CO_2 from coke used in blast furnaces at one of the facilities is overestimated for the years 2005 and later, see section 4.4.1.3. For CRF 1.A.2.a in total, the time series is also considered to be consistent, despite the fact that the quarterly fuel survey is used for most years and the yearly 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 CO_2 implied emission factors for solid fuels in CRF 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. This explains the fact aggregate CO_2 IEF for CRF 1.A.2.a is considerably lower in 2009 than in earlier years. See also section 4.4.1.2.1.

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7.

3.2.9.4 SOURCE SPECIFIC QA/QC AND VERIFICATION

In general, the same QA/QC procedures are used for CRF 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.

3.2.9.5 SOURCE SPECIFIC RECALCULATIONS

Recalculations for the integrated iron- and steelwork as described in section 4.4.1.5 affected the emission estimates for the years 1990-2003, 2005-2007 and 2010-2011. Activity data and CO_2 emissions have been revised. The effects of the revisions in terms of CO_2 equivalents are shown in Table 3.9.

Table 3.9. Recalculations, CRF 1A2a, submission 2014.

Year	Ghg eqv sub 2014-sub 2013
1990	67.1
1991	76.0
1992	71.9
1993	69.3
1994	68.2
1995	15.2
1996	-36.4
1997	-39.5
1998	-38.8
1999	-38.8
2000	-43.1
2001	-43.6
2002	-36.2
2003	-0.003
2004	-
2005	-62.3
2006	-120.7
2007	-2.7
2008	-
2009	-
2010	1.2
2011	1.0

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 (CRF 1.A.2.b)

3.2.10.1 SOURCE CATEGORY DESCRIPTION

This source category covers combustion-related emissions from seven aluminium producers (ISIC 27420), six copper producers (ISIC 27440) and five facilities producing various other metals. More detailed descriptions are given in section 4.4.

As for all subcategories to CRF 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 CRF 1.A.2.f.

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 and the copper- and aluminium producers account for about 40 % each. The most common fuel is LPG followed by natural gas. Smaller amounts of heating oils are also used.

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.

Table 3.10. Summary of source category description, CRF 1.A.2.b

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.2.b	CO_2				T2	CS	Yes
	CH_4				T2	CS	Yes
	N_2O				T2	CS	Yes

CS Country Specific. T2 Tier 2.

3.2.10.2 METHODOLOGICAL ISSUES

Activity data is taken from industrial energy statistics for 1990-1996 and 2000-2002, and from quarterly fuel statistics 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.

3.2.10.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As for CRF 1.A.2.a, time series consistency despite the changes in activity data source is discussed in Annex 2. In 1999 there was a large jump in the time series in previous submissions due to increased consumed amounts of natural gas. This has been identified as a possible reporting error for one facility, and in submission 2014 correct data for this facility for year 1999 was retrieved.

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 CO_2 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 CRF 1.A.2.b, and CO_2 from LPG accounts for most of the uncertainty. The uncertainty is 5%, both in activity data and in the CO_2 emission factor for this fuel. Activity data uncertainties are assigned by expert judgements by staff at the energy statistics department of Statistics Sweden. Emission factor uncertainties have been assigned by national experts on emissions from stationary combustion.

3.2.10.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The same QA/QC procedures are used for CRF 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 2010.[56] The aim of this study was to investigate suspected errors in several CRF codes. Data for selected plants were verified with environmental reports per faclility on an aggregate level, i.e. CRF 1+2 together. This study showed no reasons for revisions in CRF 1.A.2.b.

3.2.10.5 SOURCE-SPECIFIC RECALCULATIONS

Activity data for natural gas 1999 has been revised as mentioned in section 3.2.10.3. Thus, the emissions in 1A2b for year 1999 are 26 Gg CO_2 equivalents lower in submission 2014 compared to in submission 2013.

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 (CRF 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 uses 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. Throughout the time series, liquid fuels account for about 80% of the energy and gaseous fuels for 10-15%.

[56] Skårman et.al, 2010

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

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 3.11.

Table 3.11. Summary of source category description, CRF 1.A.2.c

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.2.c	CO_2	X	X		T2	CS	Yes
	CH_4				T2	CS	Yes
	N_2O				T2	CS	Yes

CS Country Specific. T2 Tier 2.

3.2.11.2 METHODOLOGICAL ISSUES

Activity data is, with exceptions mentioned below, collected from industrial energy statistics for 1990-1996 and 2000-2002, and from quarterly fuel statistics 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.3[57] in the energy statistics are included in this sector, as recommended in IPCC 1996 Revised Guidelines.

For one of the largest facilities, including two plants, ETS data is the activity data source for 2008 and later. Before 2008, this facility was not fully covered by energy statistics or ETS data, so environmental reports and several energy surveys were used in order to get complete data for this important facility.

One calcium carbide manufacturing facility uses coke both as a fuel and as a reductant 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

[57] United Nations Statistics Division, 2010

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. The major part of the raw material is, however, of liquid origin. This assumption is supported by the comparison between the reference and 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.

In 2011, a consistent time series of the CO_2 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 CO_2/GJ, was 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 CO_2 emissions. The company also provided a time series of CO_2 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-CO_2 emissions, emission factors for natural gas are used as no specific emission factors are available and both fuels consist mainly of methane.

3.2.11.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As for CRF 1A2a and 1A2b, 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 2012 was higher than in 1990. However, since 2003 there is no distinct trend. Except for 2009, when the production and hence also the fuel consumption dipped, the annual fuel consumption 2001-2012 in CRF1A2c is 25-27 PJ.

As noted by the ERT, the implied emission factors for “other fuels” are variable, 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 very different emission factors for CO_2, 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 CO_2 within CRF 1.A.2.c.

The ERT, submission 2012, also noted variable CH_4 IEF:s 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 CH_4. The exact amounts of the different biomass fuels cannot be shown due to confidentiality reasons.

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7. CO_2 from methane-based gas mixtures accounts for most of the uncertainty. The uncertainty in activity data is 1.5% (2012) and the emission factor uncertainty is assumed to be 10 % based on the variation in plant specific values. The Activity data uncertainty for this fuel 2012 is as reported to the EU ETS. For the other fuels used and for all fuels for 1990, uncertainties are assigned by expert judgements by staff at the energy statistics department of Statistics Sweden.

3.2.11.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In general, the same QA/QC procedures are used for CRF 1A2c as for 1.A.2.a–b described above. For the largest plants in terms of emissions and fuel consumption, both environmental reports and ETS data are used for verification of the estimates based on energy statistics.

In the development project in 2010[58] mentioned above, the activity data time series 1990-2008 for all fuel types and all facilities within the chemical industry were thoroughly reviewed. Reported emissions and activity data in CRF 1 and 2 were analysed on plant level and verified against environmental reports and when necessary, the plants were contacted for explanations or complementary data.

3.2.11.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations in CRF 1A2c in submission 2014.

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 (CRF 1.A.2.d)

3.2.12.1 SOURCE CATEGORY DESCRIPTION

In 2012 there were 38 paper mill plants, 135 sawmills (production capacity >10 000 m^3/year) and 41 pulp industry plants in Sweden. In total, they were producing 11.4 million tonnes of paper, 15.8 million m^3 of sawn timber and 12.0 million tonnes of pulp. [59] Since 1990, production has had an increasing trend, but not

[58] Gustafsson, Nyström & Gerner, 2010

[59] The Swedish Forest Industries Federation, 2013-10-02 http://skogsindustrierna.org/branschen/statistik_7/statistik_om_skogsindustri

in the latest few years. There is no apparent trend in total fuel consumption since 1990, but in recent years, the share of energy from biomass fuels has increased, from 68 % of fuel consumption in 2007 to 78 % in 2011. As for CRF 1.A.2 in general, emissions from companies with less than 10 employees are allocated to CRF 1A2f.

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, CRF 1.A.2.d

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.2.d	CO_2	X	X		T2	CS	Yes
	CH_4				T2	CS	Yes
	N_2O				T2	CS	Yes

CS Country Specific. T2 Tier 2.

3.2.12.2 METHODOLOGICAL ISSUES

Emissions from processes in the Pulp, paper and print industry are reported under CRF 2D1 according to IPCC Guidelines. See chapter 4.5.

Activity data is collected from industrial energy statistics for 1990-1996 and 2000-2002, and from quarterly fuel statistics for 1997-1999 and 2003 and later. For more details on these surveys see Annex 2.

Emissions from combustion of sulphur lyes are presently not reported in CRF 1A2d as this activity has been considered as an industrial process, despite the fact that the process heat is used for heat and electricity production. The emissions of CH_4, N_2O and indirect greenhouse gases from the processes in which the sulphur lyes are consumed, are reported in CRF 2.

Table 3.13. Combustion of sulphur lyes, TJ. The corresponding emissions arer reported in CRF 2D1

Year	Sulphur lyes, TJ
1990	87 361
1991	105 910
1992	104 910
1993	108 217
1994	114 958
1995	114 589
1996	117 173
1997	127 007
1998	126 491
1999	124 680
2000	122 425
2001	127 558
2002	145 831
2003	138 602
2004	148 276
2005	141 995
2006	146 040
2007	154 336
2008	149 459
2009	141 281
2010	164 329
2011	143 566
2012	147 577

3.2.12.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As for CRF 1A2 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 fuel mix. In the 1990s, petroleum coke was used in some facilities, and in the latest years, combustion of heavy heating oils has decreased a bit. Fuels classified as “other fuels” are scarcely occurring in this CRF category, and as in 1A2c, 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, especially residential fuel oil, have decreased. One effect of the increasing share of biomass is that emissions of fossil CO_2 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. N_2O from wooden fuels and CO_2 from residual fuel oil are the greatest contributors to the aggregate uncertainty in this sector. The activity data uncertainty is 2 % for all years for both of these fuels.

The N_2O emission factor uncertainty for wood is 40 % and the CO_2 emission factor for residual fuel oil is 1 %. Activity data uncertainties are assigned by expert judgements made by persons in the energy statistics department at Statistics Sweden. Emission factor uncertainties have been assigned by national experts on emissions from stationary combustion.

3.2.12.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In general, the same QA/QC procedures are used for CRF 1A2d as for 1A1a and 1A2a–c described above.

3.2.12.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations in CRF 1A2d in submission 2014.

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 (CRF 1.A.2.e)

3.2.13.1 SOURCE CATEGORY DESCRIPTION

The food and drink industry is the fourth largest branch of industry measured as production value and number of employees. There are about 3000 companies, of which only around 650 have more than 10 employees. [60] 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 1A2e. 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. In later years, gaseous fuels account for 45-49 % and liquid fuels account for about 38-40 % of the total fuel consumption. As for CRF 1A2 in general, emissions from companies with less than 10 employees are allocated to CRF 1.A.2.f.

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, CRF 1.A.2.e

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.2.e	CO_2				T2	CS	Yes

[60] The Swedish Food Federation 2013-10-02

	CH_4				T2	CS	Yes
	N_2O				T2	CS	Yes

CS Country Specific. T2 Tier 2.

3.2.13.2 METHODOLOGICAL ISSUES

Activity data is collected from industrial energy statistics for 1990-1996 and 2000-2002, and from quarterly fuel statistics 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 CRF 1.A.2 in general, time series consistency despite the changes in activity data source is discussed in Annex 2. The IEFs are slightly variable between years due to variations in fuel mix. The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7. In the early 1990's, CO_2 from residual fuel oil was the largest source of uncertainty, followed by CO_2 from natural gas. In recent years, CO_2 from natural gas accounts for most of the uncertainty. For both fuels, the activity data uncertainty is 5 %. CO_2 emission factor uncertainty is 1 % and 5% for residual fuel oil and natural gas, respectively. Activity data uncertainties are assigned by expert judgements made by persons in the energy statistics department in Statistics Sweden. Emission factor uncertainties have been assigned by national experts on emissions from stationary combustion.

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.

3.2.13.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations in CRF 1A2e in submission 2014.

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 Other Industries (CRF 1.A.2.f)

3.2.14.1 SOURCE CATEGORY DESCRIPTION

This source category is by nature quite heterogeneous. Both stationary and mobile emission sources are included. The stationary sources included are combustion within ISIC 10-37 except from the branches separately reported in 1.A.2.a-1.A.2.e, and stationary combustion within all companies with less than 10 employees regardless of branch, and stationary combustion within the construction sector. The mobile emission sources included in this sector are off-road vehicles and working machinery used in construction and manufacturing industry.

In terms of stationary fuel combustion and emissions, three branches of industry are dominating; non-metallic mineral production (ISIC 26), manufacturing of wood products (ISIC 20), and mining industry (ISIC 13). In ISIC 20, however, biomass fuels are dominating and hence the emissions of fossil CO_2 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 for stationary combustion within 1.A.2.f in total, it has decreased slightly since 1990. Liquid and biomass fuels account for most of the decrease. For mobile combustion, i.e. off road vehicles and working machinery, fuel consumption in 2010 was about 22 % higher than in 1990 but the trend has been slightly variable.

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 3.15.

Table 3.15. Summary of source category description, CRF 1.A.2.f

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.2.f	CO_2	X			T1,T2	CS	Yes
	CH_4				T1,T2,T3	CS	Yes
	N_2O				T1,T2,T3	CS	Yes

CS Country Specific. T1 Tier 1. T2 Tier 2.

3.2.14.2 METHODOLOGICAL ISSUES

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. Stationary fuel combustion in the construction sector is shown below (
Table 3.16Table 3.16).

Table 3.16 Stationary fuel combustion in the construction sector (part of 1A2f), TJ

Year	LPG	Domestic heating oil	Residual fuel oil	Natural gas
1990	46	5 051	420	39
1996	46	4 692	382	79
2000	46	4 621	382	40
2005	46	1 254	265	501
2010	92	1 648	278	525
2011	92	1 469	267	474
2012	32	1 490	138	511

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, other non-metallic mineral products, fabricated metal products and manufacturing of different types of machinery, are calculated with activity data from the industrial energy statistics for 1990-1996 and 2000-2002, and from the quarterly fuel statistics for 1997-1999 and 2003 and later. For more details on these surveys see Annex 2.

Emissions from all companies with less than 10 employees are estimated and reported under CRF 1.A.2.f. Activity data are collected from Statistics Sweden[61]. 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 Statistics Sweden.[62]. The methodology used for this subcategory is the same as for stationary combustion in the Other sector, see section 3.2.20.4.1. Activity data is basically from the annual energy balances, except for the latest emission year. However, the data in Table 3.16 differ slightly from the official energy balances due to use of slightly different calorific values especially for earlier years.

Since 2002, for one glassworks plant, it is no longer possible to separate combustion emissions of SO_2 from process emissions. The reason is that the facility has restructured its environmental report, and only reports emissions of SO_2 on an aggregate level. The median value for the share of process related SO_2 emissions to the total SO_2 emissions is 2 % for the years 1990 - 2001. Emission data reported in the plants environmental report are considered to be more accurate than emissions calculated from fuel combustion with standard emission factors. Thus for practical reasons, SO_2 and NO_X emission data available from environmental reports are reported in CRF 2A7. All other energy related emissions for this facility are reported in CRF 1A2f. For 2008 and later, activity data for the three plants within the cement production industry is taken from the EU ETS system.

Emissions from mobile combustion refer to off-road vehicles and other machinery including various mobile vehicles and machines as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump unit and any other mobile machine in industry that run on petroleum fuels. The model used to estimate emissions from off-road vehicles and other machineries is considered to correspond to Tier 3 for all emissions, except for CO_2 and SO_2 which are estimated according to Tier 2. The model is further explained in Annex 2.

[61] Statistics Sweden, EN20SM 1990-2012. See also Annex 2.

[62] Statistics Sweden, EN20SM 1990-2012. See also Annex 2.

The model was implemented for the first time in submission 2009. Allocation of emissions from off-road vehicles and working machinery is based on a report by Flodström (et al)[63]. This is the most recent inventory including an allocation of working machinery to sectors in Sweden. The model underwent a second verification in 2010 and was then revised in 2012 aiming to simplify the use of the model and at the same time update emission factors, activity data and the allocation of emissions to different sectors. In 2013 the model was updated with new activity data on larger diesel off-road vehicles and working machinery.

Emissions from off-road vehicles and other machinery are also reported under CRF 1.A.3.e, 1.A.4.b and 1.A.4.c, in line with IPCC Guidelines, see Table 3.17.

Table 3.17. Distribution of emissions from off-road vehicles and other machinery

Category	CRF	Definition IPCC Guidelines
Industry	1.A.2.f	Mobile machineries in industry that run on petroleum fuels, as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump units etc.
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.
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.f.

3.2.14.3 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.

As for CRF 1A2 in general, time series consistency despite the changes in activity data source is discussed in Annex 2. As for other categories in CRF 1.A.2, the IEFs are vary slightly between years due to variations in 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.

CO_2 from diesel and heating oils are the largest sources of uncertainty in GHG emissions within CRF 1.A.2.f. The activity data uncertainty for all heating oils

[63] Flodström et al 2004. Uppdatering av utsläpp till luft från arbetsfordon och arbetsredskap för Sveriges internatonella rapportering.

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 %.

3.2.14.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Generally, the same QA/QC procedures are applied for 1A2f 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 3.2.20.4.1 below.

3.2.14.5 SOURCE-SPECIFIC RECALCULATIONS

Activity data for the construction sector and enterprises with less than 10 employees in all industrial branches have been revised for 2010-2011 following revisions of the annual energy balances. Compared to submission 2013, stationary fuel consumption in 1.A.2.f is 2.5% lower in 2010 and 2.0% lower in 2011 in submission 2014. The differences in emissions are -78 and -61 Gg CO_2 equivalents, respectively.

In submission 2014 the model for off-road vehicles and working machinery was updated with new activity data regarding large diesel off-road vehicles and working machinery for the years 2009 and 2012 (allocated by year model). Other updates/changes to the model were the following:

- The scrapping function was adjusted.
- The model was updated to consider the amount of machines with particle filters.
- The allocation of snowmobiles by engine type was improved.
- The emission factor for N_2O was corrected as it was too high by a factor of ten. The default emission factor from EMEP/EEA guidebook is now used.
- The emission factor for SO_2 for diesel (environmental class three) was adjusted as it was too high.
- There has been a redistribution of tractors between sectors, which has affected the amount of fuel slightly, since different sectors have different scrapping functions.

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 Civil Aviation (CRF 1.A.3.a)

3.2.15.1 SOURCE CATEGORY DESCRIPTION

Presently data is provided for a total of 40 airports with regular and/or charted air traffic. The national government administers 13 of these airports, while the remaining 27 are private and/or administered by local governments.[64] The traffic routed through governmental airports account for about 90 % of the total fuel consumption within the civil aviation sector.

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 3-16.

Table 3-18. Summary of source category description, CRF 1.A.3.a

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.3.a	CO_2				T1	CS	Yes
	CH_4				T3	CS, D	Yes
	N_2O				T3	D	Yes

T1 Tier 1. T3 Tier 3. CS Country Specific. D Default.

3.2.15.2 METHODOLOGICAL ISSUES

Sweden uses Tier 1 to estimate emissions of CO_2 and SO_2, and Tier 3 to estimate CH_4, N_2O and all other gases. Emissions from aviation in agricultural and forestry sectors are reported together with domestic aviation in line with IPCC Guidelines. Emissions from domestic military use of aviation fuels are reported under Other – mobile sources (CRF 1.A.5.b).

The Swedish Transport Agency (STAg) is responsible for reporting the emissions from aviation. The fuel consumption and emissions published by STAg are calculated by the Swedish Defence Research Agency (FOI) by using an estimation model. The STAg provides FOI statistics regarding:

[64] Swedish Transport Agency.

- 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 and 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 whole flights as well as for aircraft movements below 3000 ft at the airports, the so called LTO cycle. The FOI has written a report which describes their method for estimating the emission from aviation[65]. The emissions from aviation estimated by FOI are adjusted to be in line with data from the monthly survey on supply and delivery of petroleum products from Statistics Sweden (see Annex 2).

The results from the emission calculations are aggregated into four groups based on estimated emissions from the LTO cycle & Cruise reported by STAg and the national / intenational (bunker) fuel consumption based on the monthly survey on supply and delivery of petroleum products from Statistics Sweden. The four groups are; domestic landing and take-off (LTO), domestic cruise, international LTO and international cruise. This is in line with the IPCC guidelines and data of good quality exists from 1995 and onwards.

The Swedish Transport Agency (STAg) includes the traffic from a number of non-governmental airports in their estimates from 2005 and from all Swedish airports from 2006. Since 2010 there is no separate reporting on emissions from governmental respectively private airports, instead a total is reported. STAg publishes information on aviation emissions from all Swedish airports with regular and chartered flights, in their annual environmental report.

Due to the fact that the Swedish airports generally are smaller than international airports in other countries, taxi times are much shorter for domestic flights and climb-out and take-off times are often shorter as well. The traffic from Swedish airports consumes as a result less fuel and gives rise to less emissions compared to the International Civil Aviation Organization (ICAO) standards that the IPCC guidelines follow.[66] For international flights, ICAO standard taxi time has been used for the part of the LTO cycle occurring on international airports.[67]

[65] Calculation of exhaust emissions from air traffic. T. Mårtensson, A. Hasselrot. FOI R 3677 mSE

[66] Gustafsson, 2005.

[67] Näs, 2005.

The methodology for calculating national emissions is the same for all years with a few exceptions for earlier years. Activity data from the STAg, former Swedish Civil Aviation Authority (SCAA), starts from 1994. Emissions of CO_2 are based on fuel delivery statistics and thermal values from IPCC Guidelines and country specific emission factors. All non-CO_2 emissions for 1990-1994 were calculated by SMED in cooperation with the STAg due to the lack of activity data. Emissions of CO for 1990-1994 were estimated by using the ratio between CO and CO_2 in 1995 (4.85 % of CO_2 emissions). Emissions of NO_X are calculated in a similar way and the mean value of the ratio between NO_X and CO_2 emissions in 1995-2004 is used for 1990-1994 (4.03 % of CO_2 emissions). Emissions of HC for 1990-1994 are calculated by extrapolation.

From 1995 and onwards, emissions of SO_2, NO_X, CO and HC are estimated by the Swedish Defence Research Agency (FOI) on behalf of STAg and adjusted to match the delivered amount of aviation fuels. Emissions of HC are split into NMVOC and CH_4 based on the ratio in EMEP/EEA air pollutant emission inventory guidebook 2009. N_2O emissions from LTO are estimated using information from STAg on the number of LTO cycles together with emission factors from EMEP/EEA guidebook 2009. N_2O emissions from cruise are based on delivered amounts of fuel for cruise activities estimated by FOI together with emission factors according to the EMEP/EEA guidebook 2009. Emissions of N_2O from cruise are adjusted to be in line with the national fuel delivery statistics.

In 2006, the STAg responded to the governmental call to reduce response burden on statistical compilations. As a result, private aviation as well as educational training flights are no longer covered in the STAg reports 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 will consequently be included.

The emissions of NMVOC have decreased noticeably in the last years as a result of a specific type of airplane (MD-80/82), which is a major contributor to these emissions, has been phased out.

3.2.15.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

In order to maintain consistency with the time-series the estimation procedures have been developed as described above. However, due to the fact that some of the estimations are not based on activity data but on other factors as LTO cycles, a certain degree of uncertainty exists.

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.

3.2.15.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

All Tier 1 general inventory level QC procedures and all QC procedures listed in GPG section 8.1.7.4 applicable to this sector are used. The activity data has, of course, been subject to QA/QC procedures. 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, responsible staff is contacted for an explanation. IEFs are calculated per fuel, substance and CRF-code and checked against the emission factors to make sure that no calculation errors have occurred when emissions were computed.

3.2.15.5 SOURCE-SPECIFIC RECALCULATIONS

The emission factors for methane (CH_4) and nitrous oxide (N_2O) have been changed in submission 2014, since the emission factors used in earlier submissions (EF from EMEP/Corinair 2003) have been found to be obsolete. The guidebook has been updated and new emissionfactors are used as from submission 2014(from EMEP/EEA guidebook 2009).

The consumption of jet kerosene and linked emissions has been adjusted for civil aviation for 2002-2011, as a consequence of military consumption of jet kerosene abroad for the same years.

3.2.15.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

3.2.16 Road transport (CRF 1.A.3.b)

3.2.16.1 SOURCE CATEGORY DESCRIPTION

Road transport is the single largest source category contributing to the total national greenhouse gas emissions (excluding LULUCF) in Sweden, all years. The emissions of GHG in 2012 from road transportation was just close to 18 000 Gg, which is a decrease with approximately 6 % since 2011 and represents nearly 31 % of all GHG emissions in Sweden.

Road transport includes five vehicle categories: Passenger cars, Buses, Heavy goods vehicles (HGV), Light duty vehicles (LDV) and Mopeds & Motorcycles. Gasoline has previously been the most common fuel used for road transports, but in 2012 the amount of diesel used for road traffic is on the same level as gasoline and the emissions of CO_2 from diesel surpassed the emissions of CO_2 from gasoline as from 2011. The number of HGV & LDV has increased by 80 % since 1990 and the number of passenger cars has increased by 24 %.

Large-scale blending of ethanol into petrol began in 2003 and the amount of ethanol used for road traffic has nearly tripled since then. The main part of ethanol for road transport is used as a blending component for gasoline and today all petrol sold in Sweden contains approximately 5% ethanol. The ethanol used by ethanol buses and E85 passenger cars (flexifuel cars) increases steadily.

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 3.1917.

Table 3.19. Summary of source category description, CRF 1.A.3.b

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.3.b	CO_2	X	X		T2	CS	Yes
	CH_4		X		T2, T3	CS	Yes
	N_2O				T2, T3	CS	Yes

CS Country Specific, T2 Tier 2, T3 Tier 3.

3.2.16.2 METHODOLOGICAL ISSUES

Emissions of CO_2 and SO_2 from road traffic are based on delivered amounts of fuels according to the monthly survey on supply and delivery of petroleum products from Statistics Sweden (see Annex 2) and country specific thermal values and emission factors in accordance with the IPCC Guidelines Tier 2. The emissions are distributed to vehicles according to data in the road emission model HBEFA.

Emissions of CO_2 from combustion of gasoline and diesel are based on thermal values from SPBI[68] and country-specific emission factors from Statistics Sweden and the Swedish EPA as shown in Annex 2. Emissions of SO_2 are based on the actual sulphur content for the different environmental classes of petrol and diesel fuel. The data on actual sulphur content is provided by the Swedish Transport Administration (STA) and based on estimates made by VTI[69] for the years 1990-2001 and on fuel analysis from SPBI from 2001 and onwards.

CO_2 and SO_2 from natural gas and biofuels are estimated using national official statistics on deliveries for natural gas, biogas, ethanol and FAME (Fatty Acid Methyl Ester). The thermal value and emission factor for CO_2 from ethanol are baed on a SMED report[70]. The thermal value and emission factor for FAME, as well as for natural gas, have been provided by the SEPA. Emissions of CO_2 from biogas,

[68] Swedish petroleum and biofuel institute. www.spbi.se

[69] Swedish Road- and Transport Research Institute.www.vti.se

[70] Fridell et al. 2010. ”Uppdatering av klimatrelaterade emissionsfaktorer”.

ethanol (including ethanol blended into gasoline) and FAME are reported as biomass and not included in the national totals.

The amount of gasoline and the emissions of CO_2 and SO_2 from the use of gasoline by ”Bifuel E85/petrol” vehicles are reported under “Passenger cars” and the fuel type”gasoline”. The rest of the emissions generated by ”Bifuel E85/petrol” vehicles are estimated under “Passenger cars” and the fuel type ”ethanol”.

Emissions of CH_4, N_2O, CO, NMVOC and NOx are estimated by the Swedish Transport Administration (STA) by using the road traffic emission model HBEFA 3.1. HBEFA is updated yearly with new information regarding emission factors, vehicle fleet, composition of the fuel and the current traffic work.

Data from HBEFA is separated by fuel type and five vehicle types as from submission 2014 (previously four): Passenger cars, Light duty vehicles (LDV), Heavy goods vehicles (HGV), Buses and Mopeds & Motorcycles. The estimated fuel consumption per fuel and vehicle type is used to proportionally allocate national fuel statistics over those categories.

Bottom-up estimations of the fuel consumption and CO_2 emissions provided by the Swedish Transport Administration (STA) using the HBEFA model differ slightly from those reported to the UNFCCC (based on fuel delivery). 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 only account for emissions from fuel purchased in Sweden. An overview of the two different objectives is presented in Table 3.2018.

Table 3.20. Emissions from road transport reported by the STA and in the CRF

Fuel bought in	Traffic on Swedish roads	Traffic in Sweden, not on roads	Traffic to/from other country	Traffic in other countries
Sweden	CRF 1.A.3.b STA	CRF 1.A.3.b	CRF 1.A.3.b * STA to the Swedish border	CRF 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 CRF 1A3b.

Emissions of CH_4 and N_2O from low blend ethanol-gasoline admixtures are included in the emissions from gasoline for all vehicles in the HBEFA model. HBEFA does however not calculate the emissions of N_2O and CH_4 from ethanol in E85 cars or buses running on pure bio alcohol.

As from submission 2011 are emissions of CH_4 and N_2O from ethanol used by E85 passenger cars and buses estimated by SMED. An implied emission factor derived from gasoline consumption and the related emissions of N_2O and CH_4 from passenger cars in HBEFA is applied together with the amount of ethanol consumed by E85 cars and buses.

Emissions of CH_4 and N_2O from natural gas and biogas are also missing in HBEFA. As from submission 2012 are also the emissions of CH_4 and N_2O from natural gas and biogas estimated by SMED. Activity data from national statistics on delivered amounts of natural gas and biogas is used together with country specific emission factors[71].

The trend in the implied emission factor for CH_4 for gaseous fuels (Natural gas & Biogas) shows substantial inter-annual fluctuations. The reason for these fluctuations is that the country-specific emission factors for CH_4 emissions differs noticeably between passenger cars (10 kg/TJ) and buses (309 kg/TJ) as well as the consumption of Natural gas and Biogas differs between years and vehicles categories. The implied emission factor is an average for both vehicle categories.The consumption of Natural gas and Biogas by buses and passenger cars is shown in the figures below.

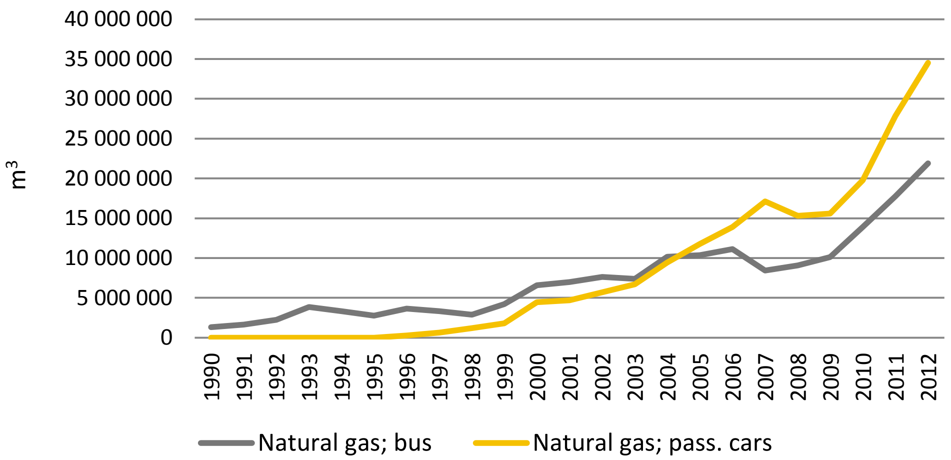


Figure 3.4 Consumption of Natural gas by road traffic in (m^3)

71 Paulrud, Fridell Stripple. Uppdatering av klimatrelaterade emissionsfaktorer. IVL report 2nd edition 2009

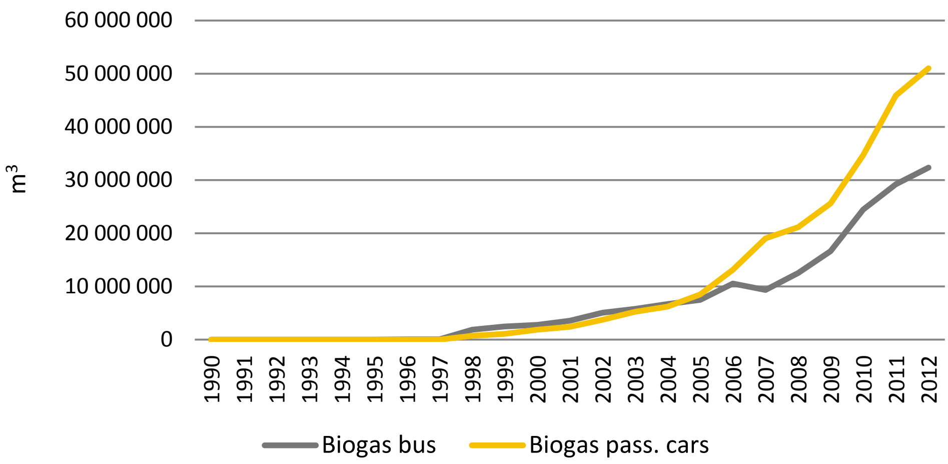


Figure 3.5. Consumption of Biogas by road traffic (m^3)

Military transport emissions are reported under CRF 1A5b to be in accordance with the IPCC Guidelines. As Military road transport is included in HBEFA 3.1, the emissions for each vehicle type are reduced by proportional amount equal to the weight of the fuel consumption reported by the Swedish Armed Forces relative to the fuel consumption from national statistics allocated to civil road transport.

3.2.16.3 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.

One important basic parameter for the HBEFA model is vehicle-km, which is calculated through another model. This second model is based on the mileage driven by the vehicle noted at time of MOT (annual testing of the vehicle).
A passenger car that goes through MOT in the beginning of 2012 has driven the most part during 2011. 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, it will not be shown as clearly in the development of vehicle mileage as in statistics on fuel consumption.

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

All Tier 1 general inventory level QC procedures and all QC procedures listed in GPG section 8.1.7.4 applicable to this sector are used. The activity data has been subject to QA/QC procedures. In addition to this, 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, responsible staff is contacted for an explanation. IEFs are calculated per fuel, substance and CRF-code and checked against the emission factors to make sure that no calculation errors have occurred when emissions were computed.

3.2.16.5 SOURCE-SPECIFIC RECALCULATIONS

The road emission model HBEFA 3.1 is updated yearly with new information regarding the Swedish road vehicle fleet, composition of the fuel and the current traffic work. But in submission 2014, the method to estimate traffic work with regard to driving distances was also updated and improved.

The distribution of segments has also been updated as well as driving distances as a function of age. Data for 1999-2012 (instead of data for 2004) is now available for the distribution of segments. This results in a decreased average driving distance for passenger cars running on diesel, as diesel vehicles were not as common in 2004 among people driving shorter distances as they are today. For driving distance as a function of age, an improved average distribution has been derived.

The amount of diesel was adjusted slightly for all years with regard to the distribution of diesel to sectors outside 1A3b.

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 Railways (CRF 1.A.3.c)

3.2.17.1 SOURCE CATEGORY DESCRIPTION

The majority of all railway traffic in Sweden runs on electricity. Only a small part runs on other fuels i.e. diesel fuel. According to IPCC’s guidelines emissions related to the use of electricity for railway should not be included in this sector. Production of electricity is accounted for in CRF 1A1A, regardless of where it’s consumed.

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 3.2119.

Table 3.21. Summary of source category description, CRF 1.A.3.c

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.3.c	CO_2				T1	CS	Yes
	CH_4				T1	D	Yes
	N_2O				T1	D	Yes

CS Country Specific. T2 Tier 2.

3.2.17.2 METHODOLOGICAL ISSUES

Both Tier 1 and Tier 2 methods are used. Information on emissions from railways is provided by the Swedish Transport Administration (STA). STA estimates the the emissions of CO_2, SO_2, NO_X, NMVOC, CH_4, CO, HC and N_2O based on the amount of diesel comsumed by the railways.

Emission factors used for calculating CO_2 emissions are supplied by the Swedish Petroleum and Biofuel Institute[72], whereas emission factors used for HC, NO_X and CO estimates are provided by the Swedish Environmental Research Institute (IVL)[73]. Remaining emissions are calculated based on default emission factors from EMEP/Corinair 2003 emission inventory guidebook.

There is a one year lag in getting the acitivity data for the consumption of diesel. As a consequence is the activity data for diesel and emissions from railways always the the same for the last two years and in each submission is the amount of diesel and emissions changed to the correct data for the next last year.

3.2.17.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Overall, the emissions for CRF 1.A.3.C is 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.

Time series are checked for consistency and recalculations are verified.

[72] www.spbi.se August 2005

[73] Å. Sjödin et al. 2005. Utsläpp till luft från järnvägstrafik; Resultat från emissionsmätningar på diesel-lok i linjedrift och i provrigg. Rapport B1655

3.2.17.4 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 GPG section 8.1.7.4 applicable to this sector are used. The activity data has been subject to QA/QC procedures. In addition to this, 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 staff responsible is contacted for an explanation. IEFs are calculated per fuel, substance and CRF-code and checked against the emission factors to make sure that no calculation errors have occurred when emissions were computed.

3.2.17.5 SOURCE-SPECIFIC RECALCULATIONS

As there is one year lag in the acitivity data for railways, the next last year (2011 in submission 2014) is always adjusted with the correct data. And the data for the last year (2012) is the same as for the previous year.

The emission factor for SO_2 for 2010 was incorrect in submission 2013 and consequently adjusted in submission 2014.

In addition, minor corrections of slightly erroneous data in submission 2013 have been made in submission 2014.

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 Navigation (CRF 1.A.3.d)

3.2.18.1 SOURCE CATEGORY DESCRIPTION

The sector covers domestic navigation and leisure boats. Emissions from diesel oil, domestic heating oil and residual fuel oil fuels that are purchased in Sweden but used abroad are reported separately as international bunker emissions (CRF 1.C). CO_2 emission from navigation does not show any particular trend, but fluctuates over time.

As from 2009 there has been a shift from the use of "Domestic heating oil" to "Residual fuel oil". And in 2012 there is a noticeable decrease in the consumption of diesel by national navigation. This reduction is due to one company's activity data for diesel, which was altered as a result of a new and improved administration system. The new system could separate diesel from domestic heating oil as well as allocate the fuel to domestic and international shipping in a more correct way. Some of the consumption of diesel was as a consequence allocated to consumption of domestic heating oil and a major part of the domestic consumption of fuels was reallocated to bunker fuels.

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 3.22. Summary of source category description, CRF 1.A.3.d

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.3.d	CO_2				T1	CS	Yes
	CH_4				T1,T2	CS, D	Yes
	N_2O				T1,T2	CS, D	Yes

T1 Tier 1. T2 Tier 2. CS Country Specific. D Default.

3.2.18.2 METHODOLOGICAL ISSUES

Emissions from national navigation are estimated using Tier 1.

Emissions from domestic navigation are based on the amount of fuels that are purchased and consumed in Sweden.[74] Emissions from fuels that are purchased in Sweden but used abroad are reported separately as international bunker emissions. The allocation of emissions from navigation is summarized in Table 3-21.

Table 3.23. Reporting of emissions from navigation, according to the Good Practice Guidance

Fuel bought in	Traffic between Swedish harbours	Traffic between Swedish and international harbours	Traffic between two international harbours
Sweden	Domestic, 1A3d	International bunkers, 1C	International bunkers, 1C
Other country	Not included	Not included	Not included

Emissions from gas/diesel oil and residual fuel oils, for 1990-2002, are calculated using emission factors from a SMED study from 2004[75]. Emissions for 2003 and 2004 have been estimated using the emissions factors for 2002 while emissions for 2005 and later have been calculated using emissions factors provided by the Swedish Maritime Administration (SMA). To ensure timeseries consistency, the emission factors provided by the SMA are based on the mentioned study by SMED.

Emissions of CO_2 and SO_2 from leisure boats are based on gasoline consumption, together with the same thermal values and emission factors as for civil road traffic. Emissions of CH_4, N_2O NO_X, NMVOC and CO are all based on gasoline consumption together with emission factors from CORINAIR for gasoline.

The gasoline consumption from leisure boats in Sweden is based on a survey carried out by SMED in 2005[76]. The results from the survey indicate no evidence of

[74] Statistics Sweden EN31SM

[75] Cooper and Gustafsson, 2004.

[76] Gustafsson, 2005.

any trend in gasoline consumption and the result of the survey (gasoline consumption by leisure boats is estimated to 32,500 m^3/year)[77] is being used as a volume estimate for the whole time period. Emissions of NO_X, NMVOC, CH_4, CO and N_2O from leisure boats also depend on the ratio between 2-stroke and 4-stroke engines. The estimated ratios between the two are based on a study by Statistics Sweden[78] from 2005. The study indicates that there is a larger share of 4-stroke engines in 2004 than in 1990. Based on the assumption that the move towards a larger number of 4-stroke engines has been gradual between since 1990, the ratio for each year between 1990 and 2004 has been estimated by interpolation. From 2005 and onwards, the ratio between 2- and 4-stroke engines is assumed to be the same as for 2004.

The Swedish Maritime Administration also report emissions from domestic navigation. These can however not be compared with emissions from the Swedish national inventory since the former include emissions from the whole Baltic Sea region.

3.2.18.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Fuel consumption based on energy statistics from Statistics Sweden's shows fluctuations for which it has been difficult to find natural explanations. SeeFigure 3.6.

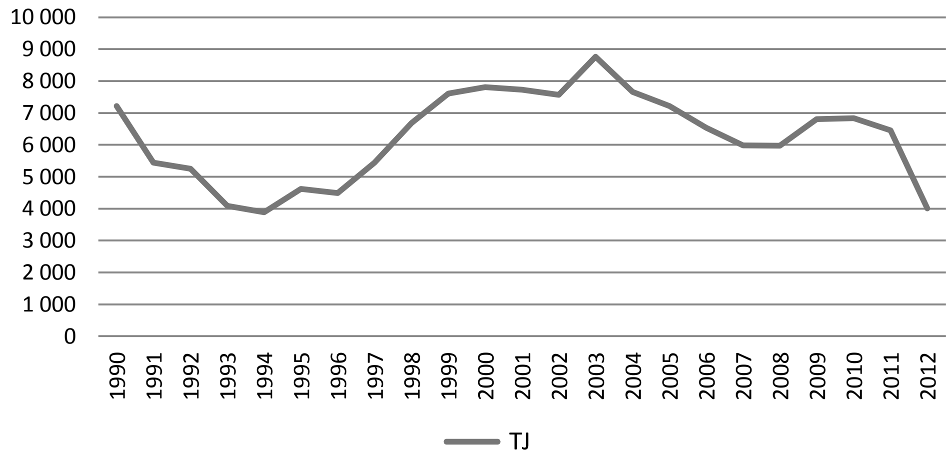


Figure 3.6. Fuel consumption by national navigation

In 2011, the fuel consumption by national and international navigation was studied and the results were presented in the report “Emissions from navigation and fishing including international bunkers”[79]. Fuel data in the survey “ Monthly fuel, gas and

[77] Statistics Sweden, 2005a.

[78] Statistics Sweden, 2005a.

[79] Eklund et al. 2011. Emissions from navigation and fishing including international bunkers

inventory statistics" was analysed and in general found to be of good quality. As a consequence of that VAT is applied on national fuel consumption, but not on international bunkers, the respondents to the survey are able to separate these fuel amounts with high accuracy. Fuels used for domestic and international navigation have been separated correctly and in line with IPCC Guidelines.

But the activity data for residual fuel oil by domestic navigation in 2010 is uncertain, due to a merge between refineries in 2008. A decision was made to interpolate the activity data for 2010, based on consumption of residual fuel oil by the company concerned in 2009 and 2011. As from 2011 the data on residual fuel oil is considered to be reliable.

As from 2009 there has been a shift from the use of "Domestic heating oil" to "Residual fuel oil". And in 2012 there is a noticeable decrease in the consumption of diesel by national navigation. This reduction is due to one company's activity data for diesel, which was altered as a result of a new and improved administration system. The new system could separate diesel from domestic heating oil as well as allocate the fuel to domestic and international shipping in a more correct way. Some of the consumption of diesel was as a consequence allocated to consumption of domestic heating oil, but the major part of the domestic consumption of fuels was reallocated to bunker fuels.

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7.

1.1.1.1 SOURCE-SPECIFIC QA/QC AND VERIFICATION

All Tier 1 general inventory level QC procedures and all QC procedures listed in GPG section 8.1.7.4 applicable to this sector are used. The activity data has been subject to QA/QC procedures. In addition to this, 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, responsible staff is contacted for an explanation. IEFs are calculated per fuel, substance and CRF-code and checked against the emission factors to make sure that no calculation errors have occurred when emissions were computed.

An attempt was made to verify the emissions for domestic shipping by comparison with an alternative, independent bottom-up calculation. The bottom-up calculation includes all ship movements in the waters around Sweden. Ship positioning data is gathered using the AIS (Automatic Identification System), which is a complement to radar that provides positions and some static information for almost all ships found in the Baltic and the North Sea. The calculations distinguish domestic shipping from international shipping by tracking each ship from its origin to its destination harbour. A route is classified as domestic if origin and destination is within the same country. Where the ship refuels is not possible to distinguish using this method, which causes a slight difference to the reporting guidelines. However, for the purpose of verification this difference is considered to be of little importance. Emission factors are assigned individually for each ship depending on its technical properties. The power output, fuel consumption and emissions are estimated with 5 minute resolution for all ships carrying an AIS transponder. For the years 2009-2011, about 40 000 unique transponder id's are registered by AIS.

The results from the bottom-up calculation show higher emissions than reported emissions from domestic navigation. This is probably related to fishing vessels (reported under CRF 1A4c) and military ships (1A5b). Further studies should also include fishing and military ships to get the whole picture. The data needs to be further analysed.

3.2.18.4 SOURCE-SPECIFIC RECALCULATIONS

The emission factor for methane (CH_4) was incorrect for 2010 and consequently corrected.

The amount of diesel was slightly modified for all years with regard to the distribution of the residual of diesel to 1A3b (road transportation), 1A3d (domestic navigation) and 1A4c (fishing).

3.2.18.5 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

3.2.19 Other transportation (CRF 1.A.3.e)

3.2.19.1 SOURCE CATEGORY DESCRIPTION

Emissions reported under CRF 1.A.3.e refer to emissions from off-road vehicles and working machinery including various mobile vehicles and machinery as for example refrigerating plants, wheel loaders, lawn movers, excavators, trimmers, snow blowers and other mobile machine that run on liquid fuels.
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 3.24. Summary of source category description, CRF 1.A.3.e

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.3.e	CO_2				T2	CS	Yes
	CH_4				T3	CS	Yes
	N_2O				T3	CS	Yes

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

3.2.19.2 METHODOLOGICAL ISSUES

The model used to estimate emissions from off-road vehicles and other machineries is considered to correspond to Tier 3 for all emissions, except for CO_2 and SO_2 which are estimated according to Tier 2. The model is further explained in Annex 2.

The model was implemented for the first time in submission 2009 and the allocation of emissions from off-road vehicles and working machinery is based on a report by Flodström (et al)[80]. This is the most recent inventory including an allocation of working machinery to sectors in Sweden. The model underwent a second verification in 2010 and was then revised in 2012 aiming to simplify the use of the model and at the same time update emission factors, activity data and the allocation of emissions to different sectors. In 2013 the model was updated with new activity data for larger diesel off-road vehicles and working machinery.

Emissions from off-road vehicles and other machinery are also reported under CRF 1.A.2.f, 1.A.4.b 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	CRF	Definition IPCC Guidelines
Industry	1.A.2.f	Mobile machineries in industry that run on petroleum fuels, as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump units etc.
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.
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.f.

3.2.19.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The calculations 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.

80 Flodström et al 2004. Uppdatering av utsläpp till luft från arbetsfordon och arbetsredskap för Sveriges internatonella rapportering.

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

The model was implemented 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.

3.2.19.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2014 the model for off-road vehicles and working machinery was updated with new activity data regarding large diesel off-road vehicles and working machinery for the years 2009 and 2012 (allocated by model year). Other updates/changes to the model were the following:

- The scrapping function was adjusted.
- The model was updated to consider the number of units equipped with particle filters.
- The allocation of snowmobiles by engine type was improved.
- The emission factor for N_2O was corrected since it was too high by a factor of ten. The default emission factor from EMEP/EEA guidebook is now used.
- The emission factor for SO_2 for diesel (environmental class three) was adjusted since it was too high.
- There has been a redistribution of tractors between sectors, which has affected the amount of fuel slightly, since there are different scrapping functions for different sectors.

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 Commercial/institutional (CRF 1.A.4.a)

3.2.20.1 SOURCE CATEGORY DESCRIPTION

This category includes stationary combustion for heating of premises used for commercial and institutional activities. Emissions from mobile combustion used in these activities are included in residential (CRF 1.A.4.b), as it is currently not possible to separate mobile combustion in these two categories from one another.

The heated area was 136 million m² in 2011[81]. Around 30 % of this area consists of schools. Since 1990, the total consumption of fuels for heating of premises has

[81] Swedish Energy Agency, ES 2012:6. Data for 2012 currently not available.

decreased significantly due to the increased use of district heating. In the early 1990s, the total annual fuel consumption in this sector was around 35000 TJ, around year 2000 it had decreased to about 20000 TJ, and in 2012 it was around 11300 TJ. Liquid fuels account for most of the decrease. Over 70 % of the area was heated solely with district heating in 2010. The corresponding share in 1990 was about 55 %.

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, CRF 1.A.4.a

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.4.a	CO_2	X	X		T1	CS	Yes
	CH_4				T1	CS	Yes
	N_2O				T1	CS	Yes

CS Country Specific. T1 Tier 1.

3.2.20.2 METHODOLOGICAL ISSUES

For stationary combustion within CRF 1.A.4.a, all activity data is on national level by fuel type and estimated emissions are therefore considered to correspond to Tier 1. 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 3.2.20.4.1 and in Annex 2.

3.2.20.3 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. CO_2 from domestic heating oil is the largest uncertainty source. The activity data and emission factor uncertainties are 20 % and 1 % respectively. The large activity data uncertainty is due to the use of Tier 1 methodology with data from the annual energy balances.

3.2.20.4 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 and CRF 1.A.2.f, construction. In 2005, a study was performed by SMED, aiming at identifying and analyzing the methods and models applied for each sub-sector and determine whether they were in line with the IPCC guideline recommendations.[82] 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.

[82] Gustafsson, et al. 2005.

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 CRF 1.A.4.a and 1.A.4.b[83]. 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 on stationary and mobile combustion. All diesel oil 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.

3.2.20.4.1 Activity data for stationary combustion in other sectors

For stationary combustion within the Other sectors, the only complete and readily available activity data source is the energy balance. Table 3.27 below shows the consumption of different fuels in 2011 in the different sub-categories within the other sector, and those parts of CRF 1.A.2.f where the energy balance is also used, e.g. construction and small industrial facilities. This data is from the annual energy balance, which is not yet completed for 2012.

Table 3.27. Excerpt from energy balance sheet. Fuel consumption in 2011, TJ

Subsector	Biomass	LPG	Domestic heating oil	Residual fuel oils	Natural gas	Gas works gas
Agriculture, fisheries, 1A4c	8 559	94	3 174	55	320	-
Forestry, 1A4c	-	0	607	352	0	-
Small industrial plants, 1A2f	217	130	818	50	57	..
Construction, 1A2f	-	97	1 486	253	484	-
Service, 1A4a	2 174	3 408	2 484	0	4 775	100
Residential, 1A4b	47 516	187	4 565	0	2 026	193

In 2008 all available methods to estimate emissions from stationary combustion in other sectors were overhauled in a SMED study[84]. The main problem is still that the timeline for the GHG inventory is too short for using final data for other sectors and construction for the latest year. All available alternatives have specific problems including higher uncertainties etc. discussed in the study. The method that was considered to give the best data was using annual energy balances for all years

[83] Paulrud et al. 2005.

[84] Lidén and Gerner, 2008

when available, and for the latest year make a model estimate of fuel combustion that adjusts the amounts from the year before with the trend in the preliminary quarterly fuel statistics, as exemplified for 2007 in the equation below:

Estimate 2007 = Annual statistics 2006* preliminary quarterly fuel statistics 2007/ quarterly fuel statistics 2006

Since emissions for the most recent years are based on this model estimate, uncertainties are a bit higher for this year. Emissions for the most recent years will be revised in next submission when annual statistics are available.

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 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. Further investigations were planned to submission 2011, but this issue was not prioritised since no suitable alternative or complementary data sources were found.

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.

3.2.20.5 SOURCE-SPECIFIC RECALCULATIONS

As indicated in the previous section, activity data has been revised for all fuels for year 2011 (in the final energy balance for 2010, the data for categories included in 1A4a was identical to the preliminary publication used in submission 2013). The greenhouse gas emissions in submission 2014 were 110 Gg CO_2 equivalents higher in 2011 compared to submission 2013.

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 Residential (CRF 1.A.4.b)

3.2.21.1 SOURCE CATEGORY DESCRIPTION

In this category both stationary and mobile combustion occur. Stationary combustion of fuels within residential decreased by around 50% between 1990 and 2012, mainly due to a continuous increase in district heating use. 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 heating oil continued to decrease while consumption of wooden fuels and natural gas increased quite considerably.

Mobile combustion in commercial and institutional services is included in the residential sector, as it is currently not possible to separate mobile combustion in these two sectors from one another. Emissions from mobile combustion refer to emissions from off-road vehicles and other machinery including various mobile vehicles and machines as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts.

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 3.28.

Table 3.28. Summary of source category description, CRF 1.A.4.b

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.4.b	CO_2	X	X		T1,T2	CS	Yes
	CH_4	X	X		T1,T3	CS	Yes
	N_2O	X			T1,T3	CS	Yes

CS Country Specific. T1 Tier 1. T3 Tier 3.

3.2.21.2 METHODOLOGICAL ISSUES

For stationary combustion, all activity data is on national level by fuel type and estimated emissions are therefore considered to correspond to Tier 1.

For stationary combustion, 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 are surveyed on the three most common combustion technologies: boiler, stoves and open fire places. Since 1998 biomass activity data is separated on wood logs, pellets/briquettes and wood chips/saw dust. Historical biomass data has been estimated by inter- and extrapolation.

Estimation models and allocation methods for fuel in the Other sectors as discussed in section 3.2.20 and use of preliminary data for stationary combustion in other sectors as discussed in section 3.2.20 also applies to CRF 1.A.4.b.

The model used to estimate emissions from off-road vehicles and other machineries is considered to correspond to Tier 3 for all emissions, except for CO_2 and SO_2 which are estimated according to Tier 2. The model is further explained in Annex 2.

The model was implemented for the first time in submission 2009. Allocation of emissions from off-road vehicles and working machinery is based on a report by Flodström (et al)[85]. This is the most recent inventory including an allocation of working machinery to sectors in Sweden. The model underwent a second verification in 2010 and was then revised in 2012 aiming to simplify the use of the model and at the same time update emission factors, activity data and the allocation of emissions to different sectors. In 2013 the model was updated with new activity data on larger diesel off-road vehicles and working machinery.

Emissions from off-road vehicles and other machinery are also reported under CRF 1.A.2.f, 1.A.3.e and 1.A.4.c in line with IPCC Guidelines, see Table 3.29.

Table 3.29. Distribution of emissions from off-road vehicles and other machinery

Category	CRF	Definition IPCC Guidelines
Industry	1.A.2.f	Mobile machineries in industry that run on petroleum fuels, as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump units etc.
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.
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.f.

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. CO_2 from domestic heating oil is the largest uncertainty source. The activity data and emission factor uncertainties are 20% and 1% respectively. The large activity data uncertainty is due to the use of Tier 1 methodology with indata from the annual energy balances.

[85] Flodström et al 2004. Uppdatering av utsläpp till luft från arbetsfordon och arbetsredskap för Sveriges internatonella rapportering.

The time series for 1.A.4.b is considered to be consistent as there haven't been any major changes in methodology or indata to the energy balances that affect this category. The estimates for the last year, however, are somewhat inconsistent due to the issues described in section 3.2.20. The CO_2 IEF for liquid fuels shows a decreasing trend because the share of residual fuel oil is decreasing. The CH_4 IEF for biomass is slightly fluctuating between years due to variations in type of biomass and technology as described in section 3.2.21.2.

3.2.21.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

See section 3.2.20.4

3.2.21.5 SOURCE-SPECIFIC RECALCULATIONS

Following revisions of the energy balances, the activity data for stationary combustion within 1.A.4.b was revised for all fuels for year 2011(in the final energy balance for 2010, the data for households, i.e. 1A4b, was identical to the preliminary publication used in submission 2013). Compared to submission 2013, greenhouse gas emissions are 71 Gg lower in 2011.

In submission 2014 the model for off-road vehicles and working machinery was updated with new activity data regarding large diesel off-road vehicles and working machinery for the years 2009 and 2012 (allocated by year model). Other updates/changes to the model were the following:

- The scrapping function was adjusted.
- The model was updated to consider the number of units equipped with particle filters.
- The allocation of snowmobiles by engine type was improved.
- The emission factor for N_2O was corrected since it was too high by a factor of ten. The default emission factor from EMEP/EEA guidebook is now used.
- The emission factor for SO_2 for diesel (environmental class three) was adjusted since it was too high.
- There has been a redistribution of tractors between sectors, which has affected the amount of fuel slightly, since there are different scrapping functions for different sectors.

3.2.21.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

3.2.22 Agriculture/forestry/fisheries (CRF 1.A.4.c)

3.2.22.1 SOURCE CATEGORY DESCRIPTION

This category includes emissions from stationary combustion for heating purposes and mobile combustion in off-road vehicles and working machinery within agriculture and forestry, and fishing vessels. The structure of the agricultural sector in Sweden is described in chapter 6.

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, CRF 1.A.4.c

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.4.c	CO_2	X			T1,T2	CS	Yes
	CH_4		X		T1,T3	CS	Yes
	N_2O				T1,T3	CS	Yes

CS Country Specific. T1 Tier 1. T2 Tier 2. T3 Tier 3.

3.2.22.2 METHODOLOGICAL ISSUES

For stationary combustion, all activity data is on national level by fuel type and estimated emissions are therefore considered to correspond to Tier 1.

For stationary combustion, 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 3.2.20, and use of preliminary data for stationary combustion in other sectors as discussed in section 3.2.20.4.1 also applies to CRF 1.A.4.c.

Emissions from Fisheries, CRF 1.A.4.c, were first reported in submission 2006. The estimated fuel consumption is based on a survey on energy consumption within the fishing industry by Statistics Sweden[86] together with data on the Swedish fishing fleets' total installed effect in kW from the Swedish Agency for Marine and Water Management (SwAM). The estimate on fuel consumption provided by Statistics Sweden refer to 2005, and for the previous and following years the fuel consumption is estimated by adjusting the 2005 value according to the development in total installed effect.

[86] Statistics Sweden, 2006 ENFT0601.

The emissions factors used to estimate emissions from Fisheries are based on a SMED study from 2005[87], producing emission factors for CO_2, SO_2, NO_X, NMVOC, CH_4 and N_2O for 1990-2004. From 2005 estimates are based on the same consumption estimate and emission factors as for 2004. However, from 2007 and onwards the emission factors for SO_2 from fisheries are assumed to be the same as for domestic navigation, which are updated every year.
Emissions from fisheries are derived under the assumption that the fishing fleet operates using medium speed diesel engines running on marine distillate fuel. The emission abatement technologies used by the fleet (e.g. Selective Catalytic Reduction (SCR) for NO_X reduction) is assumed to be negligible.

The model used to estimate emissions from off-road vehicles and other machineries is considered to correspond to Tier 3 for all emissions, except for CO_2 and SO_2 which are estimated according to Tier 2. The model is further explained in Annex 2.

The model was implemented for the first time in submission 2009. Allocation of emissions from off-road vehicles and working machinery is based on a report by Flodström (et al)[88]. This is the most recent inventory including an allocation of working machinery to sectors in Sweden. The model underwent a second verification in 2010 and was then revised in 2012 aiming to simplify the use of the model and at the same time update emission factors, activity data and the allocation of emissions to different sectors. In 2013 the model was updated with new activity data on larger diesel off-road vehicles and working machinery.

Emissions from off-road vehicles and other machinery are also reported under CRF 1.A.2.f, 1.A.3.e and 1.A.4.b in line with IPCC Guidelines, see Table 3.31.

[87] Cooper et al., 2005a.

[88] Flodström et al 2004. Uppdatering av utsläpp till luft från arbetsfordon och arbetsredskap för Sveriges internatonella rapportering.

Table 3.31. Distribution of emissions from off-road vehicles and other machinery

Category	CRF	Definition IPCC Guidelines
Industry	1.A.2.f	Mobile machineries in industry that run on petroleum fuels, as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump units etc.
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.
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.f.

3.2.22.3 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 sharp increase in 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 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.

3.2.22.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

See section 3.2.20.4

3.2.22.5 SOURCE-SPECIFIC RECALCULATIONS

Following revisions of the energy balances, the activity data for stationary combustion within 1A4c was revised for all fuels 2010-2011. The major revisions were made for heating oils, especially domestic heating oil 2011. Compared to submission 2013, greenhouse gas emissions (CO_2-eqv) in submission 2014 are 4 Gg lower in 2010 and 22 Gg higher in 2011.

In submission 2014 the model for off-road vehicles and working machinery was updated with new activity data regarding large diesel off-road vehicles and working machinery for the years 2009 and 2012 (allocated by year model). Other updates/changes to the model were the following:

- The scrapping function was adjusted.

- The model was updated to consider the amount of machines with particle filters.
- The allocation of snowmobiles by engine type was improved.
- The emission factor for N2O was corrected as it was too high by a factor of ten. The default emission factor from EMEP/EEA guidebook is now used.
- The emission factor for SO2 for diesel (environmental class three) was adjusted as it was too high.
- There has been a redistribution of tractors between sectors, which has affected the amount of fuel slightly, since different sectors have different scrapping functions.

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 Other stationary (CRF 1.A.5.a)

3.2.23.1 SOURCE CATEGORY DESCRIPTION

No emissions are reported in this sector.

3.2.23.2 METHODOLOGICAL ISSUES

-

3.2.23.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

-

3.2.23.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

-

3.2.23.5 SOURCE-SPECIFIC RECALCULATIONS

-

3.2.23.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

-

3.2.24 Other mobile (CRF 1.A.5.b)

3.2.24.1 SOURCE CATEGORY DESCRIPTION

CRF 1A5b includes emissions from military transports. Emissions from military transports have decreased over the years 1990-2008 due to a decrease in activity. However in 2009 the Swedish military increased its consumption jet kerosene compared to 2008, but in 2010 it went back down again (from 77 894 m^3) and the consumption in 2012 was 46 482 m^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 3.32.

Table 3.32. Summary of source category description, CRF 1.A.5.b

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.5.b	CO_2		X		T1	CS	Yes
	CH_4				T1	CS	No, see Annex 5
	N_2O				T1	CS	No, see Annex 5

CS Country Specific. T1 Tier 1.

3.2.24.2 METHODOLOGICAL ISSUES

Emissions from military transport are based on data on fuel consumption[89] including all military activities and are considered to correspond to Tier 1. Fuel consumption from some more administrative military activities, such as the Swedish Defence Material Administration (FMV), the Swedish Fortification Department (FORTV), the Swedish Defence Research Agency (FOI) and the National Defence Radio Institute (FRA), are not included in the calculations.

A special estimation for the use of FAME was conducted by the military for the years 1999-2001. None has been done for the other years.

CH_4 and N_2O emissions from the military are both based on a top-down approach, using fuel consumption (for aviation and navigation) and a bottom-up approach, using data from the HBEFA model (road transport). Hence, estimates are considered to be both Tier 1 and Tier 2. Emissions from military aviation are based on an average of LTO and cruise emission factors. Emissions from military navigation are estimated using emission factors from civil navigation. Emissions from the use of diesel oil by military stationed abroad is reported under Multilateral operations, CRF 1.C.2.

Military road transport is included in the road traffic emissions estimated by the HBEFA model. To subtract and separate emissions from military transport from emissions from civil road transport, emissions according to the HBEFA model for each vehicle type are reduced by an amount equal to the weight of the fuel consumption reported by the Swedish Armed Forces relative to the fuel consumption from national statistics allocated to civil road transport, according to:

Equation 0-1: $A = B - \sum((C-D)/C*E_i)$

A = Military transport emissions
B = Total HBEFA emissions
C = Total fuel consumption National Statistics

[89] Activity data on fuel consumption is supplied by the Armed Forces.

D = Military fuel consumption Swedish Armed Forces
E_i = HBEFA emissions per vehicle type

3.2.24.3 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.

3.2.24.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source specific procedures have been made.

3.2.24.5 SOURCE-SPECIFIC RECALCULATIONS

No source specific recalculations have been made.

3.2.24.6 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 Fugitive emissions from solid fuels and oil and natural gas (CRF 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 flaring of fuels in the various categories (iron and steel industry, the chemical industry, refineries and the pulp and paper industry), hydrogen production, transport of crude oil, transmission losses of gas works gas, storage and handling of oil in refineries, depots and gasoline distribution, and natural gas transmission and distribution.

3.3.1 Fugitive emissions from solid fuels (CRF 1.B.1)

3.3.1.1 SOURCE CATEGORY DESCRIPTION

There are no coalmines in Sweden and hence no fugitive emissions from coalmines occur.

Emissions of SO_2 from quenching and extinction at coke ovens are reported in CRF 1.B.1.b. Flaring of coke oven gas from the coke oven is reported in CRF 1.B.1.c since submission 2004. Since submission 2010, flaring of blast furnace gas in the blast furnace and steel converter gas in the steel converter are reported under CRF 2.C.1. CRF 1.B.1 is not really designed to include flaring, but since CRF 1B2 only refers to liquid and gaseous fuels, it is not possible to report flaring of coke oven gas in CRF Table 1.B.2. The amounts of flared gas vary considerably between years, and in 2009 it was unusually high, resulting in increasing emissions in CRF 1.B.1. According to environmental reports[90], coke oven gas 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 3.33.

Table 3.33. Summary of source category description, CRF 1.B.1

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.B.1	CO_2				T3	PS	Yes
	CH_4				T2	CS	Yes
	N_2O				T2	CS	Yes

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

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 facilities, see section 4.4. Data concerning SO_2 emissions from quenching and extinction at coke ovens are obtained directly from the operators of the two facilities.

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 extent of flaring is by nature very variable between years, and the uncertainties in activity data and emission factors are high compared to other activities.

3.3.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

See section 4.4.1.4

3.3.1.5 SOURCE-SPECIFIC RECALCULATIONS

Revisions of activity data and CO_2 emissions for the integrated iron and steel industry, as described in section 4.4.1.5, affects the emissions in CRF 1.B.1.c slightly. Differences compared to submission 2013 occur for the years 1990-2002 and 2005-2007. The differences are in the range ±0.2 Gg CO_2 equivalents. For the base

[90] SSAB, 2008 and 2009

year, 1990, the emissions in submission 2014 are 0.14 Gg higher than in submission 2013.

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 (CRF 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 this sector. These activities include hydrogen production at oil refineries (1.B.2.A.1), crude oil transport (1.B.2. A.3), activities in refineries such as catalytic, desulphurisation and storage and handling of oil (1.B.2. A.4), gasoline handling and distribution (1.B.2. A.5), fugitive emissions from transmission and distribution of gas works gas (1.B.2. A.5), fugitive emissions from transmission and distribution of natural gas (1.B.2.B.2 and 1.B.2.B.3), and flaring of liquid fuels (1.B.2.C.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 3.34.

Table 3.34. Summary of source category description, CRF 1.B.2

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.B.2	CO_2	X	X		T2, T3	CS, PS	Yes
	CH_4	X			CS, T1, T2	D, CS, PS	Yes
	N_2O				T2	CS	Yes

CS Country Specific. PS Plant Specific. T1 Tier 1. T2 Tier 2. T3 Tier 3. D Default

3.3.2.2 METHODOLOGICAL ISSUES

3.3.2.2.1 Hydrogen production plants at refineries, CRF 1.B.2.A.1

According to 2006 IPCC Guidelines, emissions from hydrogen production plants should be reported in CRF 1.B.2.A.1. Since 2005, one such facility is in operation in Sweden, and another one was taken into operation in 2006. Emissions from these facilities are reported in CRF 1.B.2.A.1 in accordance with the 2006 IPCC Guidelines.

Both CO_2 and non-CO_2 emissions are estimated using the Tier 2 method. Activity data as consumed amount of fuels (butane gas and naphtha, respectively for the two plants) and CO_2 emissions are taken from the company's report to the EU ETS system. Non-CO_2 emissions are calculated with this plant specific activity data. National emission factors are used for butane, whereas national emission factors for "other petroleum fuels" are used for naphtha due to lack of specific emission factors for this fuel. It was noted that the CO_2 emissions in 2012 reported for both plants were roughly on the same level as the previous years, but activity data for the largest plant was considerably lower. The reported activity data, emission factors and emissions are verified by an external party and are considered to be reliable. For 2012, the reported activity data uncertainty is ±2.5%. The reported emission factor for the largest plant in 2012 is 2.96 tonnes CO_2 per tonne feedstock (internally produced gases consisting mainly of buthane). This is slightly lower than in the first year, 2005, but in the years 2006-2011 the annual emission factors were around 1.1-1.2 tonnes CO_2 per tonne feedstock. The reported CO_2 emissions are consistent with the emissions reported in the environmental report.

3.3.2.2.2 Transport, CRF 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 CH_4 from transport of crude oil from submission 2010 and onwards. National statistics available from Statistics Sweden on imported and exported amounts of crude oil is used as activity data. The activity data is corresponding to the data in the Reference Approach. Since no reliable country-specific measurements are carried out, the default emission factor for Western Europe from the Revised 1996 IPCC Guidelines (745 kg CH_4/PJ) is applied. Fugitive emissions of CO_2 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.

3.3.2.2.3 Refining/Storage, CRF 1.B.2.A.4

Sweden estimates both CO_2 and non CO_2 emissions by using the 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. However, for CH_4 emissions, the IPCC Tier 2 equals a mass-balance estimate, whereas Sweden uses a country specific (CS) method (see below). Emissions are reported from catalytic cracking (CO, SO_2, NOX), desulphurisation (SO_2) and from the storage and handling of oil (NMVOC, CH_4). Catalytic cracking occurs at one plant in Sweden. CO emissions from catalytic cracking are calculated as:

$$\text{CO} = \left(\frac{\text{Batched amount of raw material in the cracker}}{\text{Total batched amount of raw material in the plant}}\right) \times \text{Total CO emission for the plant}$$

Due to some operational problems at the plant the total emissions of CO were high for 1997 and 1998 compared to other years.

Emissions of SO_2 from desulphurisation decreased dramaticallyduring the early 1990’s and have for most years after 1995 been between 0.4 and 1 Gg with the exception for 2006, when the emissions increased due to operational disturbances at one facility.

Fugitive emissions of NMVOC and CH_4 from refineries include emissions from the process area as well as emissions from the refinery harbours when loading tankers. The estimates of NMVOC are mainly based on reported data from the facilities' environmental reports and older reports from the Swedish EPA[91],[92],[93],[94] and Statistics Sweden[95]. The activity data, as crude oil throughput, is known for almost all years. Implied emission factors have been developed, based on reported emissions and known activity data. 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 3.35, reported NMVOC emissions as well as activity data can be seen. The estimate of fugitive CH_4 emissions are for two refineries based on reported data in the facilities' environmental reports. For the remaining three refineries the fugitive CH_4 emissions are estimated as 5% of the total fugitive VOC emission. This estimate has been provided by one refinery that refines about 50 % of the crude oil in Sweden. Since no information from the two remaining refineries was obtained the same percentage has been used to estimate the fugitive CH_4 emissions also from these plants. The reported emissions of CH_4 are very uncertain due to limited measurements. In Table 3.35, the reported emissions of CH_4 and also activity data can be seen.

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.

Table 3.35. Throughput of crude oil in refineries and estimated fugitive emissions of NMVOC and CH_4 (Mg) reported in CRF 1.B.2.A.4

Year	Throughput of crude oil Mg	Total emissions of NMVOC Mg	Total emissions of CH_4 Mg
1990	17 330 000	14 408	460
1995	19 430 000	7 643	400
2000	20 253 120	11 568	577
2005	19 919 968	7 691	399
2006	20 050 576	8 269	425
2007	17 706 518	8 877	417
2008	20 420 061	8 578	447
2009	19 669 472	8 779	438
2010	20 278 888	8 924	469
2011	19 034 115	8 938	431
2012	21 021 566	8 576	436

91 Swedish EPA, 1990.

92 Swedish EPA, 1994a.

93 Swedish EPA, 1994b.

94 Swedish EPA. 1995.

95 Statistics Sweden. 1996 Emissions to air in Sweden of volatile organic compounds (VOC) 1988 and 1994.

Since submission 2009, emissions from combustion of cracker coke in refineries, earlier reported in CRF 1A1b, were allocated to CRF 1.B.2.A.4 to be in line with the IPCC guidelines. This was based on a study performed by SMED[96]. 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. Hence the combustion is not carried out for energy purposes and thus the emissions should not be reported in CRF 1.A.

3.3.2.2.4 Gasoline handling and distribution, CRF 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 cover 1990 – 2012 and are based on methods given by Concawe 85/54[97] for the years 1990-2006 and on Concawe 03/07[98] for 2007 and onwards. More than 30 depots have been considered during later years. Gas recovery systems and the recovered amount of gas have been considered in the calculations. For five depot areas the reported NMVOC emissions are based on emission measurements in the depot areas and not on calculations based on the amount product handled in the depots. For years with missing data, interpolation between years with available data has been used for estimates. Handled amounts of gasoline and fugitive emissions of NMVOC from depots and gasoline stations are presented in Table 3.36.
The calculation of fugitive NMVOC emissions from gasoline distribution, 1990-2012 (Table 3.36), is based on methods given by Concawe[99], 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[100]. The basic assumptions are presented in Table 3.37. Ethanol both for use in blends with gasoline and for use unblended are included in the reported gasoline volume.

[96] 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

[97] Concawe, 1986, Hydrocarbon emissions from gasoline storage and distribution systems, Report No 85/54.

[98] Concawe Report No. 3/07, Air pollutant emission estimation methods for E-PRTR reporting by refineries

[99] Concawe, 1986, Hydrocarbon emissions from gasoline storage and distribution systems, Report No 85/54.

[100] Andersson, 2000.

Table 3.36. Handled and distributed amount of gasoline and ethanol, estimated fugitive emissions of NMVOC (Gg) from storage at depots and estimated fugitive emissions of NMVOC (Gg) from gasoline stations reported in CRF 1.B.2.a.5

Year	Volume of gasoline and ethanol m^3	Fugitive emissions of NMVOC at depots Gg	Fugitive emissions of NMVOC at gasoline stations Gg
1990	5 202 063	2.48	13.3
1995	5 260 187	1.93	3.07
2000	5 063 167	2.07	3.04
2005	5 162 889	2.31	3.10
2006	5 060 676	2.47	3.04
2007	4 928 469	2.35	2.96
2008	4 815 676	2.53	2.89
2009	4 565 468	2.41	2.74
2010	4 347 446	2.21	2.61
2011	4 073 648	2.46	2.44
2012	3 774 269	2.47	2.26

Table 3.37. Assumptions for calculating fugitive emissions from the handling and distribution of gasoline

Parameter	Assumption	
Density of gasoline	730 kg/m^3 1990 - 1996 750 kg/m^3 1997 -	
Distribution of gasoline to gas stations	0.16 %	of distributed volume
Spill	0.01 %	of distributed volume
Filling of car tanks	0.18 %	of filled volume
Measures at distribution to gas station	90 %	Efficiency of measures
Measures at filling cars	70 %	Efficiency of measures

The measures at distribution and filling were introduced over a period of time from 1991-1994, to the extent presented in Table 3.38. The amount of gasoline and ethanol sold at large and small gas stations, respectively, was assumed to be 50/50 for the years 1990-1994. Data on the distributed amounts of gasoline (Table 3.36) is taken from the HBEFA3.1 road emission model. The model is based on a bottom-up approach considered to be Tier 2. The model is described in detail in Annex 2.

Table 3.38. Fraction of gasoline stations with technical measures installed

Year	Large gas stations >2000 m^3	Small gas stations
1990	0%	0%
1991	50%	0%
1992	75%	25%
1993	100%	75%
1994 -	100%	100%

3.3.2.2.5 Natural gas transmission, CRF 1.B.2.B.4

In previous submissions, Sweden estimated fugitive emissions and emissions due to venting activities from natural gas transmission pipeline and storage based on the tier 1 default method in the Good Practice Guidance. That led to high uncertainty associated with the emission estimates (± 1000% according to Good Practice Guidance). Because the transmission pipeline in Sweden is relatively modern compared to the referenced piplines in the Good Practice Guidance[101] using the default method may overestimates the actual emissions. As a consequence of the national QA/QC programme, it was decided that resources should be allocated to improve the quality of the estimates through a national study. Therefore a national method for estimating the Swedish emissions of natural gas has been developed. This work, Jerksjö et al. [102], yielded new time series for the period 1990 to 2012. The new emission data includes transmission and storage of gas and was for the first time adopted in submission 2014. The new values are based on information provided by Swedegas, the operator of the transmission pipeline and storage of natural gas in Sweden. Swedegas performed estimates on gas leakage in conjunction to maintenance work on the transmission pipeline and metering and regulation stations (M/R stations). There is an M/R station at each connection point to the distribution gas net. The gas emissions from the M/R stations are considered to largely exceed the emissions from the transmission pipeline. According to Swedegas calculations the average emission from each of the M/R stations was 105 Nm^3 natural gas per year during the period 1990 to 2011. During the same time the number of M/R station was increased from 32 to 44. The corresponding emissions were reduced to 66 Nm^3 per M/R station during 2012 as an effect of an improved maintenance plan. Sweden has one facility for storage of natural gas. The gas storage was put into operation in 2006. Swedegas reports estimates of the annual leaks of natural gas from the gas storage. The reported emissions for year 2006 to 2012 are shown in Table 3.39 and compared with the corresponding values using the 2006 IPCC Guidelines. For the years 2006, 2007 and 2012 the emissions are at the same level as the estimations according to 2006 IPCC Guidelines , as shown in Table 3.39. But for other years Swedegas has reported emissions that are 2 to 10 times lower than using the 2006 IPCC Guidelines estimate. According to Swedegas are the higher emissions due to certain problems with the compressor in the gas store. When it is functioning properly the gas leaks are much lower[103]. The gas leaks 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 moment[92].

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101 IPCC Good Practice Guidance http://www.ipcc-nggip.iges.or.jp/public/gp/english/

102 Jerksjö M., Gerner A., Wängberg I. 2013. Development of method for estimating ....

103 Anders Hellström, Swedegas

Table 3.39. Estimated emissions of natural gas from the gas storage

Year	Swedegas Gg	IPCC (2006) Gg
2006	0.030	0.023
2007	0.034	0.024
2008	0.009	0.022
2009	0.004	0.029
2010	0.004	0.039
2011	0.004	0.031
2012	0.023	0.027

Parameters used to calculate the content of methane, carbon dioxide and NMVOC in natural gas is shown in Table 3.40. Information on gas composition was obtained from Swedegas and constitutes average values from the period 2006 to 2012.

Table 3.40. 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

3.3.2.2.6 Natural gas distribution, CRF 1.B.2.B.5

In previous submissions CH4 fugitive emissions from natural gas distribution were estimated using the default method from the IPCC Good Practice Guidance (A default emission factor of 6.15x10-4 Gg per year and per kilometre of distribution mains was used). That led to high uncertainty associated with the emission estimates (± 1000% according to Good Practice Guidance). As a consequence of the national QA/QC programme, it was decided that resources were allocated to improve the quality of the estimates through a national study including CO_2 and CH_4 emissions from natural gas, biogas and gas works gas distribution, for the period 1990 to 2012.

There are three types of gas networks for distribution of gas in Sweden.

1. The gas network for distribution of natural gas
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 Sweden. 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 and since the beginning of 2011, only pure natural gas is distributed in Gothenburg. Activity data in terms of leakage of gasworks gas has been obtained from the gasworks gasdistributor 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 CH_4 and CO_2 have been calculated with data on chemical composition of gas from cracking and natural gas/air mixture. The methodology is described in Jerksjö et al.[92]

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, 2006[104]) 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 Nm^3 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

[104] Wikkerlink. 2006.

been estimated based on statistics on production of gasworks gas and natural gas mixed with air and leakage rate obtained from Stockholm Gas[92].

Parameters used to calculate the content of methane, carbon dioxide and NMVOC in gas works gas and natural gas air mixture are shown in Table 3.41 and Table 3.42, respectively. Information on gas composition was obtained from Stockholm Gas and Swedegas.

Table 3-41. Composition and physical properties of gas works gas

Property	Unit	Value
CH_4 content	% by volume	30.0
CO_2 content	% by volume	11.5
NMVOC content	% by volume	2.0
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

Table 3.42. 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	0.71
NMVOC content	% by weight	7.40
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

3.3.2.2.7 Venting (CRF 1.B.2.C.1)

In submission 2010, emissions from venting at oil refineries were reported using the Tier 1 approach and default emissions factors from the 2000 Good Practice Guidance. For emissions of CH_4 and CO_2, the maximum values in the default EF range were chosen to avoid any risk of underestimating the emissions. In submission 2011, an analysis was carried out with the aim to investigate if vented emissions from refineries already were included in reported emissions in other CRF categories. The conclusion from this study was that the emissions from venting at refineries most probably are included in other categories of fugitive emissions; mainly in CRF 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 and later, emissions in CRF 1.B.2.C.1 are reported as IE (in 1.B.2.A.4 and 1.B.2.C.2.) The fugitive CH_4 emissions from oil refineries reported in CRF 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 enters the gas flare systems. Venting of CH_4 and CO_2 from natural gas transmission pipelines are included in CRF 1.B.2.B.3.

3.3.2.2.8 Flaring (CRF 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 of refinery gases at four refineries and one chemical industry, and flaring of LPG at three iron and steel plants and one pulp industrial plant. Emissions in this CRF category varies quite widely between years due to large variations in the amount of refinery gases that needs to be flared each year. Data has been collected directly from the plant operators. For the years 2005 and later, data from the EU ETS system has been used when possible. Data from the EU ETS system are verified against data from environmental reports and vice versa. In submission 2010 EU ETS data was analyzed carefully. It was concluded that the notation key for flaring of natural gas (NE in earlier submissions) could be changed, since no such flaring could be found in the EU ETS data and all plants that might be flaring are included in the EU ETS. There is a slight possibility that some flaring of natural gas is reported included in the flaring of liquid fuels. Because of this the notation key IE is used rather than NO, referring to emissions reported under CRF 1.B.2.C.2.1 Oil.

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. The extent of flaring is by nature very variable between years, and the uncertainties in activity data and emission factors are high compared to other activities.
1.B.2.A.1: According to data reported to the EU ETS, both hydrogen production plants use the level 2 method to measure activity data, which means that the activity data uncertainty is ± 2.5% or less. The emission factor uncertainties have not been available for the GHG inventory staff, and hence the same emission factor uncertainties as for the corresponding fuels in stationary combustion, i.e. ± 5% for CO_2 and ±20% for CH_4, are used.

1.B.2.B.3: A national method for estimating the fugitive emissions of natural gas (transmission and storage of gas) have been adopted in Submission 2014. The new estimate is based on emissions provided by the operator. The associated uncertainty is according to IPCC GPG (2.7.1.6.) ± 25-50%. Here the uncertainty was estimated to ± 50% following a conservative approach.

1.B.2.B.4: A national method for estimating emissions from distribution of natural gas, biogas and gasworks gas in Sweden has been developed and adopted in Submission 2014. Fugitive emissions from the distributing network in Stockholm contribute 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 can according to IPCC GPG (2.7.1.6.) be estimated to ± 25-50 %. The total uncertainty concerning distribution of gas in Sweden is largely influenced by the contribution from the gas network in Stockholm and is estimated to ± 50 %.

1.B.2.C.2.1: The activity data uncertainties for different fuels and plants are as reported to EU ETS and are in the range ±7.5-17.5%. The emission factor uncertainties have not been available for the GHG inventory staff, and hence the same emission factor uncertainties as for the corresponding fuels in stationary combustion, i.e. ± 5% for CO_2 and ±20% for CH_4, are used.

3.3.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The coherence between environmental reports and ETS data is checked when possible, and when differences occur, the facilities are contacted for verification. For a few plants that flare small amounts of gas, activity data as amount of flared gas is shown neither in the environmental reports, nor in the ETS data. Flaring at these plants was investigated in 2005, and the same values are used for later years. Every year, these facilities are asked to verify that the default value is still valid.

3.3.2.5 SOURCE-SPECIFIC RECALCULATIONS

- 1.B.2.A.5: Emissions of NMVOC are revised 1990 – 2011 due to updated activity data (fuel consumption) from the Swedish Road Administration road emission model HBEFA. Minor corrections of NMVOC emissions from gasoline stations for 2010 and 2011. The recalculations led to changes in reported NMVOC emissions between a decrease of 0.061 Gg to an increase of 0.004 Gg.
- Transmission of natural gas CFR 1.B.2.B.3: In previous submissions CO_2 and CH_4 fugitive emissions from natural gas transmission pipeline and storage were estimated using the default method from the IPCC Good Practice Guidance. In submission 2014 a national method for estimating the fugitive emissions of natural gas (transmission and storage of gas) has been developed for the period 1990 to 2012[92] see section 3.3.2.2.5.

  The new data series, expressed in Gg CO_2-equivalents, in comparison to the previous estimate is shown in Figure 3.7. The new national estimate gives values that on average are a factor of 500 lower than the values based on IPCC Good Practice Guidance. The large variation in emissions of natural gas during the period 2006 to 2012 is due to problems with leakage in the natural gas storage facility as mentioned above.

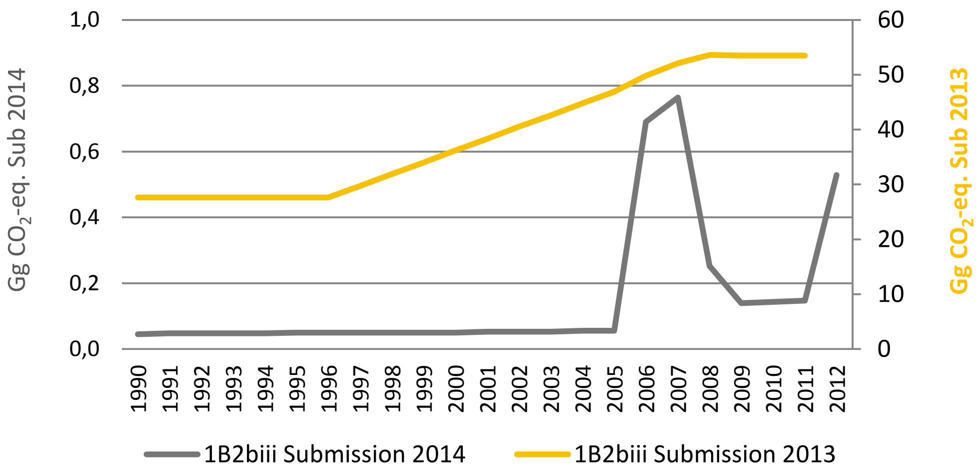

Figure 3.7. Total emissions of CH_4 and CO_2 as CO_2-equivalents reported in CRF 1.B.2.B.3 in Submission 2014 and Submission 2013

- Natural gas distribution CFR 1.B.2.B.4. In previous submissions CH_4 fugitive emissions from natural gas distribution were estimated using the default method from the IPCC Good Practice Guidance (A default emission factor of 6.15×10^{-4} Gg per year and per kilometre of distribution mains was used). To improve the emission estimate a national method for estimating the Swedish emissions of natural gas, biogas and gas works gas distribution has been developed.[92], for the period 1990 to 2012.

  The new data series, expressed in Gg CO_2-equivalents, in comparison to the former estimate is shown in Figure 3.8. The new national estimate gives values that on average are a factor of 2 times higher in comparison to previous submissions. The reason for this is that the emissions from the gasworks gas networks in Stockholm and Gothenburg have been updated.

  Distribution losses of gasworks gas have been reallocated from CRF 1.B.2.A.5 to 1.B.2.B.4 and the methodology has been revised. The new methodology is described in Jerksjö et.al.[92] and in section 3.3.2.2.6 above.

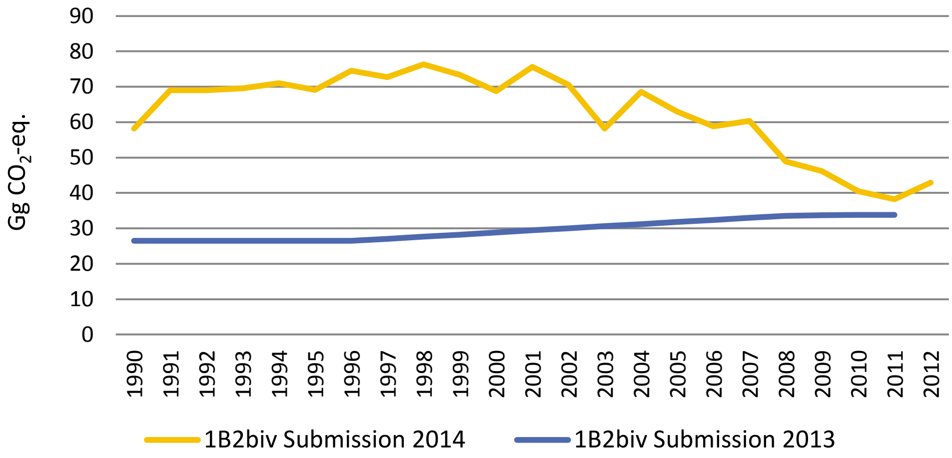

Figure 3.8. Total emissions of CH_4 and CO_2 as CO_2-equivalents reported in CRF 1.B.2.B.4 in Submission 2014 and Submission 2013

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 (CRF sector 2)

4.1 Overview of sector

For Sweden the most important industries within the industrial sector has historically been base 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 in the chemical industry.

Greenhouse gas emissions from the industrial processes sector have decreased 576 Gg CO_2 equivalents from 6,474 Gg CO_2 equivalents in 1990 to 5,899 Gg CO_2 equivalents in 2012, a decrease of 8.9% (Figure 4.1). The trend is mainly affected by decreased emissions of N_2O (-749 Gg CO_2 equivalents), but also by decreased emissions of PFCs (-308 Gg equivalents), CO_2 (-221 Gg CO_2 equivalents), CH_4 (-15 Gg CO_2 equivalents) and SF6 (-52 Gg CO_2 equivalents). Compared to 1990, only HFCs show increased emissions in 2012 (+770 Gg CO_2 equivalents). In Figure 4.1, it can be seen that in 2012, CO_2 is by far the largest contributor among the greenhouse gases in this sector, accounting for 82% of the GHG emissions. Emissions of HFCs are the second largest greenhouse gas in 2012, accounting for 13% of the sector emissions.

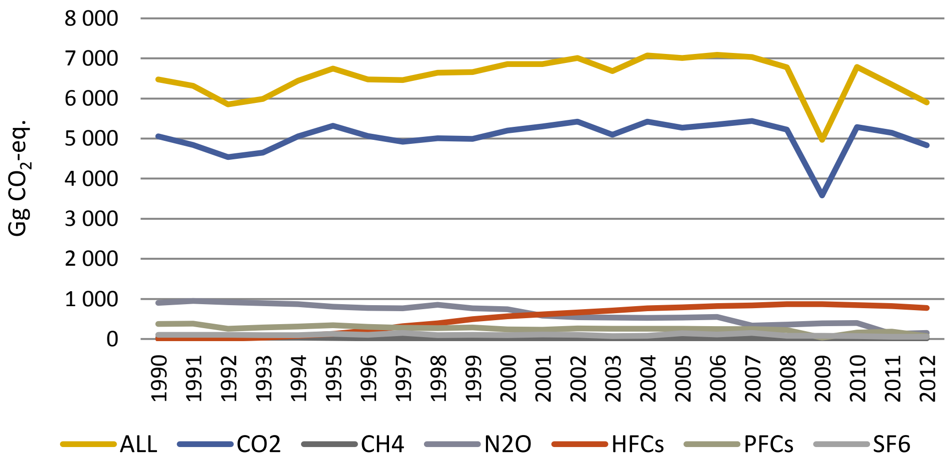

Figure 4.1. Total emissions of all greenhouse gases calculated as CO_2 equivalents from CRF 2 Industrial processes

Among the industries in this sector, metal production (CRF 2.C) is the largest contributor in 2012, accounting for 2,648 Gg CO_2 equivalents or 44.9% (Figure 4.2). In Figure 4.2 it can be seen that there was a sharp decrease in greenhouse gas emissions from metal production (CRF 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. Emissions in CRF 2.C have decreased by 976 Gg CO_2 equivalents since 1990.
The second largest contributor of greenhouse gases to this sector 2012 is mineral products (CRF 2.A) with 2,146 Gg CO_2 equivalents, or 36.4% of the sector emissions. Compared to 1990 there is an increase in greenhouse gas emissions from mineral products of about 25% (425 Gg CO_2 equivalents) (Figure 4.2), mainly due to increased production of lime and clinker.

For chemical industry (CRF 2.B), greenhouse gas emissions have decreased with 757 Gg CO_2 equivalents since 1990 and amounted to 211 Gg CO_2 equivalents in 2012. The reduction is closely linked to N_2O emissions from nitric acid production.

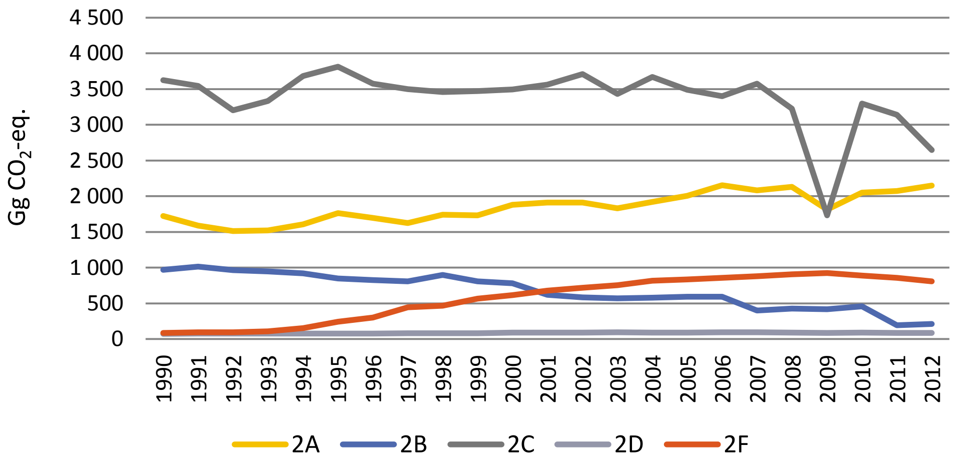

Figure 4.2. Total emissions of all greenhouse gases calculated as CO_2 equivalents from the different Industrial processes sub-sectors. 2A Mineral products. 2B Chemical industry. 2C Metal production. 2D Other production. 2F Consumption of Halocarbons and SF_6

The 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. No production of halocarbons or SF_6 (CRF 2.E) occurs in Sweden. The consumption of fluorinated greenhouse gases (CRF 2.F) has increased substantially, 720 Gg CO_2 equivalents, since 1990 (Figure 4.2). The use of HFCs as refrigerants in refrigerators, freezers and air-conditioning equipment has contributed to the larger share in later years.

Process emissions from pulp and paper in other production (CRF 2.D) do not contribute significantly to the emissions of greenhouse gases in Sweden.

Table 4.1 shows the impact of recalculations reported since submission 2013 for GHG emissions by sector and sub-sectors for 1990, 1995, 2000 and 2005-2011. The differences between the current and the previous submissions are mainly due to recalculations and reallocations performed within primary iron and steel production (CRF 2.C.1.2).

Table 4.1. Impact of recalculations of GHG emissions submission 2014¤ in the industrial processes sector.

Impact of recalculations submission 2014 (Gg CO_2 eq.)							
CRF	2A	2B	2C	2D	2F	Total CRF 2	% CRF 2
1990	NA	NA	145	NA	0	145	2.3%
1995	0.398	NA	100	NA	0	101	1.5%
2000	0.643	NA	48.5	NA	0	49.2	0.7%
2005	0.449	NA	34.4	NA	1.39	36.2	0.5%
2006	0.617	NA	121	NA	1.38	123	1.8%
2007	0.644	NA	106	NA	1.38	108	1.6%
2008	0.536	NA	-28.7	NA	1.75	-26.4	-0.4%
2009	0.611	NA	-17.4	NA	1.78	-15.0	-0.3%
2010	0.343	NA	-29.0	NA	3.13	-25.5	-0.4%
2011	0.487	NA	-319	NA	7.0	-312	-4.7%

0: value less than 0.5. NA: no recalculation is performed.

4.2 Mineral products (CRF 2.A)

Reported emissions include estimates for cement production (2.A.1), lime production (2.A.2), limestone and dolomite use (2.A.3) soda ash use (2.A.4), asphalt roofing (2.A.5), road paving with asphalt (2.A.6), and other (2.A.7). In the source category other (2.A.7), glass production (2.A7.1), non-iron ore mining and dressing plants, glass and mineral wool production, LECA production and production of roofing tiles, bricks and ceramics are included. Until 1998 also emissions from battery manufacturing are included in code 2.A.7.

4.2.1 Cement production (CRF 2.A.1)

4.2.1.1 SOURCE CATEGORY DESCRIPTION

Cement production occurs at three facilities in Sweden (owned by one company), with one being dominant. Annual production of cement in Sweden is about 2,000-3,000 ktonnes. Emissions from cement production stem both from combustion of fuels and from raw materials used in the processes. Emissions arising from fuel combustion are, with the exception of NO_X, reported in the energy sector (CRF 1.A.2.f).

For process-related emissions, facility data are obtained from environmental reports, EU ETS (European Union Emission Trading Scheme) and by direct contacts with the facilities. Process related CO_2 emissions from cement production arise as a by-product during the production of clinker as limestone is heated to produce lime. Process related CH_4 and N_2O emissions from cement production are not occurring according to the 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. An overview of the rationale for data sources used for key categories in the industrial processes sector is presented in Annex 3.6.

Table 4.2. Summary of source category description, CRF 2.A.1

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.A.1	CO_2	X	X		T2	PS	Yes
	CH_4	NA	NA		NA	NA	NA
	N_2O	NA	NA		NA	NA	NA

T2 Tier 2. PS Plant-specific.

4.2.1.2 METHODOLOGICAL ISSUES

In line with the Good Practice Guidance Tier 2 methodology, plant-specific CO_2 emission estimations in Sweden are based on clinker production and include emissions from by-pass dust and cement kiln dust (CKD) as well as emissions from organic carbon of raw meal.

For 1990-2004, information from the company on CO_2 emissions is based on clinker production and default EF from GHG protocol, CKD correction factor and organic carbon in raw meal.

CO_2 = Production of cement clinker (Gg) * 0.525 (Gg CO_2/ Gg clinker, i.e. default value in the GHG-protocol) * CKD correction factor+ CO_2 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 CO_2 Emissions Inventory Protocol, Version 1.6.), see Facts about the GHG protocol below and on their website[105]. The protocol tool calculates CO_2 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 CO_2 emissions 1991-1994 and 1996 based on mean values from adjacent years.

Facts about 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 CO_2 emissions from the production of cement (WBCSD CSI, version 2.0) can be found on: http://www.ghgprotocol.org

From 2005, the company reports plant-specific data on CO_2 emissions to the EU ETS. The CO_2 emissions are based on produced clinker and its CaO and MgO content, but also include CO_2 contained in released non-recycled dust (CKD and by-pass) as prescribed by the national guidelines (NFS 2007:5[106]) for reporting to the EU ETS [107]. Also CO_2 emissions from organic carbon of raw meal are included in the CO_2 emissions reported in the EU ETS.

Table 4.3 shows information on clinker production and total CO_2 emissions from clinker production. For the years prior to 2005 the table shows the calculated emissions from CKD and the resulting CKD correction factor as well as CO_2 emissions from organic carbon content of raw meal. The table differs from official reported data in that imported clinker is included in the reported data for emission year 2011. The number will be corrected in next year's submission.

[105] http://www.ghgprotocol.org. 2005-10-20.

[106] NFS 2007:5 Naturvårdsverkets föreskrifter och allmänna råd om utsläppsrätter för koldioxid. Available in Swedish: http://www.naturvardsverket.se/Documents/foreskrifter/nfs2007/nfs_2007_05.pdf

[107] Lyberg, A., Cementa, Personal communication, September 2011

Table 4.3. Amount of produced clinker and associated CO_2 from specific sources

Year	Clinker Production	Total CO_2 emissions	CO_2 from Clinker (from 2005 incl. CKD and organic carbon content)	CO_2 from CKD	CKD correction factor	CO_2 from organic carbon content of raw meal
	Gg	Gg	Gg	Gg		Gg
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	1 313	1 313	IE	NA	IE
2006	2 660	1 439	1 439	IE	NA	IE
2007	2 493	1 337	1 337	IE	NA	IE
2008	2 644	1 395	1 395	IE	NA	IE
2009	2 336	1 260	1 260	IE	NA	IE
2010	2 454	1 322	1 322	IE	NA	IE
2011	2 544	1 359	1 359	IE	NA	IE
2012	2 769	1 477	1 477	IE	NA	IE

IE - Included elsewhere. NA – Not applicable.

Table 4.3 differs from official reported data in that imported clinker is included in the reported data for emission year 2011. The number will be corrected in next year's submission.

Total emissions of NO_X by facility are found in the environmental reports or have been obtained directly from the company. They include emissions from fuel combustion as well as from industrial processes. Due to the use of a large variety (within and between years) of waste fuels there is a lack of correct emission factors for the energy sector (1.A.2.f), and thus all emissions are reported in this source category as process emissions. Reported emissions are decreasing over time since 1990.

Data on SO_2 emissions from cement production has been obtained directly from the company or from the environmental reports. Reported emissions are decreasing over time since 1990.

4.2.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Activity data and CO_2 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 CO_2 is judged to be ± 5 %.

All three cement producing facilities 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 CO_2 EF (0.525 Gg CO_2/Gg clinker produced) is used together with CKD correction factor and CO_2 emissions from organic carbon of raw meal. Since 2005, CO_2 emissions are retrieved from EU ETS, which 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.

4.2.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The implied emission factor for total CO_2 emissions 2005-2012 (average 0.5341 Gg CO_2/Gg clinker produced) is somewhat higher than the IPCC Guidelines default value (0.5071 Gg CO_2/Gg produced clinker) and among the highest of the reporting Parties of the Convention. The main reason for the higher implied emission factor is that the MgO content in clinker is accounted for in the Swedish reported emissions.

In addition, in Figure 4.3 it can be seen that CO_2 IEF for total emissions from clinker production show larger variations after the introduction of EU ETS data as data source. The reason for the varying CO_2 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 CO_2 has been released per unit produced clinker. Table 4.4 lists the content of CaO and MgO for the years 2008-2012 for the largest facility (accounting for an average of 73% produced clinker in the years 2008-2012). The correlation between CaO and MgO content and CO_2 IEF is illustrated in Figure 4.3, where data from 2008-2012 from the largest plant has been used. In Figure 4.4, CaO and MgO content is shown as a sum, however MgO in clinker has given rise to a slightly larger amount of CO_2 per unit than CaO, explaining the small differences of IEF and CaO and MgO content in the figure. Figure 4.3 and Figure 4.4 differ from official submitted data in that imported clinker is included in the reported data for emission year 2011. This only affect activity data and not emissions. The reported activity data for 2011 will be corrected in next submission.

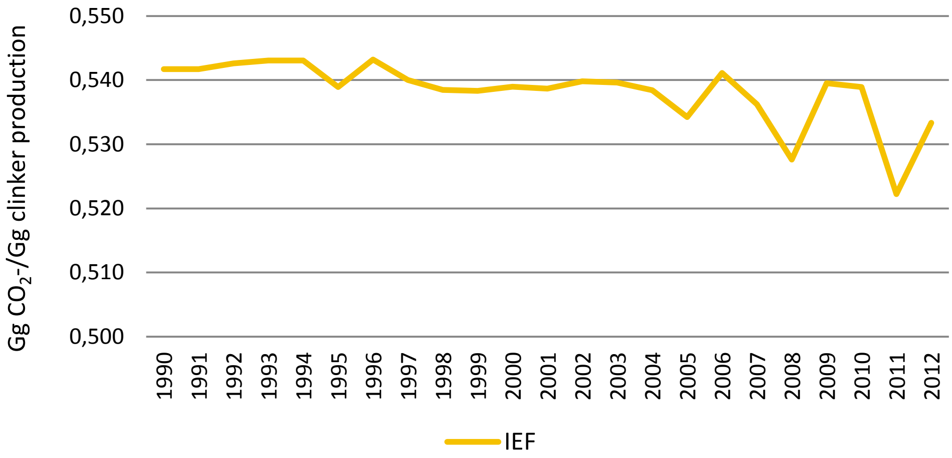

Figure 4.3. CO_2 IEF for total emissions from clinker production 1990-2012. The graph differs from official submitted data in that imported clinker (AD) is included in the reported data for emission year 2011. The reported activity data will be corrected in next submission

Table 4.4. CaO and MgO content in clinker produced in the years 2008-2012 in the largest facility (accounting for an average of 73% produced clinker in the years 2008-2012)

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

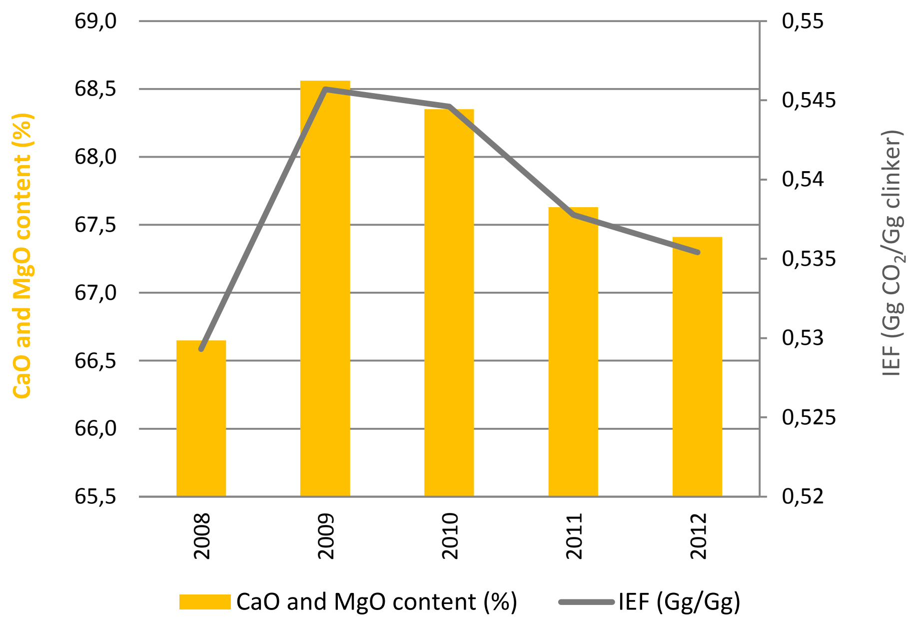

Figure 4.4. CO_2 IEF is compared to CaO and MgO content for respective year, indicating a strong correlation

Data is taken from the largest facility for the period 2008-2012. Figure 4.4 differs from official submitted data in that imported clinker (AD) is included in the reported data for emission year 2011. The reported activity data will be corrected in next submission

In response to previous UNFCCC review recommendations, discussions with the cement producers have been finalized and it has been concluded that CO_2 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 4.3 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 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.

4.2.1.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2014, activity data for 2009 has been corrected affecting the IEFs.

4.2.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.2.2 Lime production (CRF 2.A.2)

4.2.2.1 SOURCE CATEGORY DESCRIPTION

In Sweden, quicklime, hydraulic lime and dolomite 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 400 Gg to about 650 Gg in 2012. In 2009 there was a large decrease in lime production due to an economic recession in the EU.

CO_2 is emitted during lime production through calcination of the calcium carbonate ($CaCO_3$) in limestone, or through the decomposition of dolomite ($CaCO_3 \cdot MgCO_3$). Process related CH_4 and N_2O are not emitted during lime production and thus report as not applicable (NA). Lime contains sulphur which is released as SO_2 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 4.5.

Table 4.5. Summary of source category description, CRF 2.A.2

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.A.2	CO_2				D	D	Yes
	CH_4	NA	NA		NA	NA	NA
	N_2O	NA	NA		NA	NA	NA

D Default.

4.2.2.2 METHODOLOGICAL ISSUES

4.2.2.2.1 CO_2 (Gg)

The emissions of CO_2 from the production of lime are based on activity data by type of lime, i.e. on produced amounts of quicklime, hydraulic lime and dolomitic lime, and corresponding EFs and purity of the limestone from the 2006 IPCC Guidelines. As CO_2 emissions also depend on the production process, the methods for collecting activity data and estimating CO_2 emissions are described by data source (i.e. the sugar industry, the pulp and paper industry and other production of lime) below.

Sugar industry

For determining activity data and emissions of CO_2 within the sugar industry, the amounts of limestone for the production of quicklime are used. The quantities are obtained directly from the sugar producing company from 1999. For years prior to 1999 no data on used amounts of 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 $CaCO_3$.

In the production of sugar, lime is used for purification of the juice. Lime is added to the raw juice and some impurities are precipitated. In the carbonisation step CO_2 is bubbled through the juice and most of the remaining lime is precipitated as $CaCO_3$. The precipitated “limestone” is sold and used within agricultural activities. Information from the company gives that around 88% of the lime used was precipitated as $CaCO_3$ for the years before 2005. For later years this share has increased and varies between 90 and 94 %. No dolomitic lime is used for purification of the juice.

In submissions prior to submission 2010 the whole amount of lime produced and used within the sugar industry was reported as activity data without taking into account that a large amount of the produced lime is precipitated as $CaCO_3$ in the carbonation process. Since submission 2010, only the part of CaO which is not recovered as $CaCO_3$ is reported as activity data.

In Table 4.6 the used amounts of limestone, the amounts of produced lime and emitted CO_2, the precipitated $CaCO_3$, and the reported activity data and CO_2 emissions from lime production within the sugar industry is presented.

Table 4.6. Limestone used, amount of produced lime and emitted CO_2, precipitated $CaCO_3$ and reported activity data and CO_2 emissions from lime production within the sugar industry

Year	Used amounts of limestone	Amount of lime produced	CO_2 from lime production	Precipitated share of lime	Precipitated amount of lime	Reported Activity Data (lime)	Reported CO_2 emissions
	Gg	Gg	Gg	%	Gg	Gg	Gg
1990	94.7	51.4	40.4	87.5%	45.0	6.4	5.0
1995	76.4	41.5	32.6	87.5%	36.3	5.2	4.1
2000	70.0	38.0	29.9	87.5%	33.3	4.8	3.7
2005	60.9	33.1	26.0	92.0%	30.4	2.6	2.1
2006	68.1	37.0	29.1	92.0%	34.0	3.0	2.3
2007	48.6	26.4	20.7	91.3%	24.1	2.3	1.8
2008	57.3	31.1	24.4	94.4%	29.4	1.7	1.4
2009	55.8	30.3	23.8	94.1%	28.5	1.8	1.4
2010	43.3	23.5	18.5	92.7%	21.8	1.7	1.3
2011	59.8	32.5	25.5	90.4%	29.4	3.1	2.4
2012	57.5	31.2	24.5	89.9%	28.1	3.2	2.5

Pulp and paper industry

In response to previous review recommendations detailed data on the 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 Swedish Lime Association and The Swedish Lime Industry from 1995[108].

Based on 2006 IPCC Guidelines, the purity of the limestone is set to 95 % for the production of lime within the pulp and paper industry. The corresponding figure for dolomite is 100 %. For the years before 1995, the amounts of make-up lime consumed are estimated using the average ratio between the quantity of make-up lime used and kraft pulp produced for the period 1995 – 2009 and corresponding production data for 1990 – 1994. Earlier information on the need for make-up lime has indicated that it would be less than 20 kg per Mg pulp. New information from a small number of Swedish pulp and paper industries shows that the need may vary considerably, from less than 10 kg per Mg to over 30 kg per Mg[109]. The data used in submission 2011 gives an average need (1995 – 2008) of 20 kg make-up lime per Mg kraft pulp (Table 4.7) and can therefore be considered reliable to use to estimate the need for make-up lime to the pulp industry for years before the 1995. Similarly, the amount of CO_2 emitted is estimated for 1990 – 1994 by using the average ratio between emitted CO_2 and used amounts of make-up lime for the period 1995 –2008. The used amount of make-up lime was very low in 2009 which led to a reduced amount of emitted CO_2 in 2009 compared to previous and later years. Less than 1% of the total amount of make-up lime used within the pulp and paper industry is dolomitic lime.

Table 4.7. Produced amounts of kraft pulp, IEF (Make-up lime used per produced amounts of kraft pulp), IEF (CO_2 emitted per produced make-up lime) and reported activity data and CO_2 emissions from make-up lime production for the pulp and paper industry

Year	Produced amounts of kraft pulp	Reported Activity Data (Make-up lime)	IEF (Make-up lime/kraft pulp)	Reported CO2 emissions	IEF (CO2/Make-up lime)
	Gg	Gg	Gg/Gg	Gg	Gg/Gg
1990	5 944	118.7*	0.020**	88.5*	0.7457**
1995	6 377	119.4	0.019	89.0	0.7458
2000	7 557	138.0	0.018	103.0	0.7459
2005	7 784	171.5	0.022	128.4	0.7463
2006	7 828	156.0	0.020	116.8	0.7463
2007	7 835	188.4	0.024	140.7	0.7460
2008	7 635	164.7	0.022	122.8	0.7458
2009	7 299	116.9	0.016	87.2	0.7458

108 Swedish Lime Association and The Swedish Lime Industry, Svenska Kalkföreningen, personal communication

109 Håkan Sbtripple, IVL Swedish Environmental research Institute, personal communication

Year	Produced amounts of kraft pulp	Reported Activity Data (Make-up lime)	IEF (Make-up lime/kraft pulp)	Reported CO2 emissions	IEF (CO2/Make-up lime)
	Gg	Gg	Gg/Gg	Gg	Gg/Gg
2010	7 462	169.4	0.023	126.4	0.7458
2011	7 279	172.1	0.024	128.4	0.7458
2012	7 627	170.6	0.022	127.2	0.7458

*estimated
** average ratio for 1995 – 2009

Other production of lime

For all other production of quicklime, hydraulic lime and dolomitic lime, detailed data from 1990 are obtained from the Swedish Lime Association[110]. 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 set to 95 % for the production of lime in conventional lime mills. The corresponding figure for dolomite is 100 %. The produced amounts of quick lime and dolomitic lime in conventional lime mills was very low in 2009 which led to a reduced amount of emitted CO_2 in 2009 compared to previous years. Between 2% and 10% of the total production of lime in conventional lime mills is dolomitic lime.

[110] Swedish Lime Association, Svenska Kalkföreningen, personal communication

Table 4.8. Produced amounts of quick lime and dolomitic lime, emitted CO_2 and IEF (CO_2 emitted per produced quick lime and dolomitic lime) in conventional lime mills

Year	Reported Activity Data (quick lime and dolomitic lime, excluding lime in sugar and pulp industry)	Reported CO_2 emissions (excluding emissions in sugar and pulp industry)	IEF (CO_2/quick lime + dolomitic lime)
	Gg	Gg	Gg/Gg
1990	264.3	201.1	0.7609
1995	258.4	196.4	0.7599
2000	403.9	306.0	0.7576
2005	495.6	375.6	0.7578
2006	543.7	412.1	0.7581
2007	530.5	402.6	0.7590
2008	541.4	409.6	0.7566
2009	400.6	301.6	0.7528
2010	530.6	399.4	0.7527
2011	509.8	382.7	0.7507
2012	458.8	344.0	0.7498

4.2.2.2.2 SO_2 (Gg)

The emissions of SO_2 from 1990 have been estimated for production of quick lime. The estimations from quick lime production were calculated using emission factors presented in environmental reports by one of the producers[111]. The emission factor provided by the lime producer is substantially higher for 2008 than for earlier years. This resulted in an increase of reported SO_2 emissions for 2008 compared to earlier years. However in 2009 the reported SO_2 emissions were again on the same level as before 2008 due to less use of lime. For 2009-2012 the emission factor for 2008 has been used for the estimation of emissions of SO_2 due to lack of newer information in the environmental reports.

Emissions of SO_2 from quick lime production intended for the pulp and paper industry are not included in the estimates reported in CRF 2.A.2.

4.2.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty for activity data is ± 2% and the uncertainty of the emission factor for CO_2 is ± 5%. The time-series are considered accurate, consistent and complete.

4.2.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The activity data reported in CRF 2.A.2 has been compared with national statistics from Statistics Sweden in line with the Good Practice Guidance Tier 2[112].

[111] Nordkalk, http://www.nordkalk.com

[112] Statistics Sweden. Data from the Industrial production database: www.scb.se

The comparison (Figure 4.5) shows that national statistics are more irregular but for most years the coherence is good. The differences are especially high in 1998, 1999 and from 2003 and onwards. The 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[113] is used as data source.

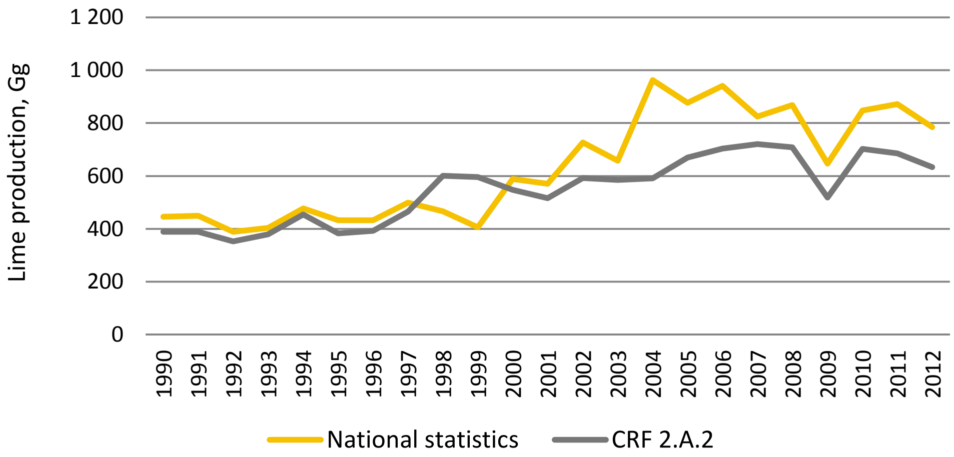

Figure 4.5. National total on produced amount of lime according to data from Statistics Sweden and reported data in CRF 2.A.2

Quick lime is also produced and used within carbide production. According to the IPCC Guidelines, CO_2 emissions arising from this lime should be reported under CRF 2.B.4, together with other CO_2 emissions from carbide production. It is not known whether this lime is included in the national statistics in Figure 4.4, but it is most likely not.

4.2.2.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been made in submission 2014.

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.

[113] Swedish Lime Association and The Swedish Lime Industry, Svenska Kalkföreningen, personal communication

4.2.3 Limestone and dolomite use (CRF 2.A.3)

4.2.3.1 SOURCE CATEGORY DESCRIPTION

Limestone and dolomite are used in various processes in Sweden such as cement production, lime production, carbide production, iron sinter production (further described in 2.C.1.3), steel and other metal production, production of clay-based products, glass wool and mineral wool production, glass production, flue gas purification in energy industries and production of chemical products. The use of limestone and dolomite in these processes gives rise to emissions of CO_2. However, not all CO_2 emissions from the use of limestone and dolomite are reported in this source category (see methodological issues below). Process-related CH_4 and N_2O are not emitted during limestone and dolomite use and thus reported as not applicable (NA). The largest contributor of CO_2 emissions in this source category is the iron sinter production. Three facilities (owned by one company) in the north of Sweden produce iron sinter. The use of dolomite in iron sinter production is on average about 80-130 Gg, while the use of limestone was introduced 1999 and has since increased over time to reach the highest use of about 100 Gg in 2010.

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.

Table 4.9. Summary of source category description, CRF 2.A.3

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.A.3	CO_2				CS	D	Yes
	CH_4	NA	NA		NA	NA	NA
	N_2O	NA	NA		NA	NA	NA

D Default. CS Country Specific

4.2.3.2 METHODOLOGICAL ISSUES

This source category comprises of activity data, CO_2 emissions from the use of limestone and dolomite within facilities producing iron sinter, glass wool and mineral wool, chemical products, but also use of limestone and dolomite for flue gas purification.

Process-related CO_2 emissions from the use of limestone and dolomite in the production of cement (2.A.1), lime (2.A.2) and carbide (2.B.4) are reported in corresponding CRF source categories in accordance with the IPCC Guidelines. According to the IPCC Guidelines, all other emissions of CO_2 from the use of limestone and dolomite should be reported as process emissions from limestone and dolomite use in CRF 2.A.3. Since the Centralized review of submission 2004 the ERT has repeatedly recommended Sweden to follow the guidelines. Since the CO_2 emissions from limestone and dolomite are small in some source categories it is not considered to be good practice to spend resources obtaining underlying data to separate these emissions.

Sweden has chosen to not include in 2.A.3 (but in corresponding categories):

- CO_2 emissions from the use of limestone and dolomite in primary and secondary production of steel (2.C.1.1, 2.C.1.2),
- CO_2 emissions from the use of limestone and dolomite in other metal production (2.C.5),
- CO_2 emissions from the use of limestone and dolomite in production of clay based products (2.A.7) and
- CO_2 emissions from the use of limestone and dolomite in glass production (2.A.7.1).

In the case of limestone and dolomite use within the production of glass, the reallocation of CO_2 emissions from 2.A.3 to 2.A.7.1 is due to recommendations from the EC (European Commission) Internal review in 2009. Emissions of CO_2 from use of limestone and dolomite for the production of clay based products are reported in 2.A.7. This is due to the fact that emissions originating from the use of limestone and dolomite seldom are separately reported in the ETS, but rather reported together with other carbon containing raw materials.

Data on the use of limestone and dolomite in this source category has been acquired from environmental reports, the ETS and through direct contacts with the companies. The calculations are made by applying the IPCC Guidelines default emission factors for limestone and dolomite[114].

Formulas for CO_2 emissions from limestone and dolomite:

$$CO_2\ (Gg) = \frac{44.0098}{100.0892} \times f \times limestone\,(Gg)$$

$$CO_2\ (Gg) = \frac{88.02}{184.4} \times f \times dolomite\,(Gg)$$

where *f* is the purity of the limestone and dolomite, set to 97% and 100% respectively.

In Table 4.10 the use of limestone and dolomite, and corresponding CO_2 emissions, for glass production (2A7.1), primary (2C1.2) iron and steel production and other metal production (2.C.5) are presented for 2005-2012. In relation to the amounts reported in 2.A.3 (Table 4.11), the yearly amounts not included in 2.A.3

[114] IPCC. Revised 1996 Guidelines for National Greenhouse Gas Inventories: Reference Manual section 2.5.2

represents around 35 % of the total use of limestone and dolomite in Sweden 2005 – 2012.

Table 4.10. Used amounts of limestone and dolomite and estimates of corresponding CO_2 emissions for glass production, primary steel production and other metal production, 2005 – 2012

Year	2A7.1		2A7-clay based products		2C1.1		2C1.2		2C5	
	AD, Gg	CO_2, Gg	AD, Gg	CO_2, Gg	AD, Gg	CO_2, Gg	AD, Gg	CO_2, Gg	AD, Gg	CO_2, Gg
2005	68	32	*	*	*	*	111	48	4.9	2.1
2006	73	34	*	*	*	*	107	46	4.2	1.8
2007	72	34	*	*	*	*	94	41	5.4	2.3
2008	73	34	*	*	*	*	125	54	4.1	1.8
2009	55	26	*	*	*	*	71	31	3.9	1.7
2010	66	31	*	*	*	*	109	47	5.9	2.5
2011	66	31	*	*	*	*	101	44	3.8	1.6
2012	57	27	*	*	*	*	75	33	4.7	2.0

* not possible to separate CO_2 from limestone/dolomite for included facilities

Table 4.11. Used amounts of limestone and dolomite and corresponding CO_2 emissions reported i 2A3

Year	Total 2A3	Total 2A3	Iron sinter production	Flue gas desulphuri-sation	Glass and mineral wool	Other che-mical indu-stry
	Activity data	CO_2	% of total CO_2	% of total CO_2	% of total CO_2	% of total CO_2
1990	194	90	42.2	11.5	26.1	20.1
1995	214	100	54.1	14.2	17.9	13.8
2000	245	113	67.4	9.5	15.1	8.0
2005	254	116	70.2	15.8	9.6	4.5
2006	242	109	64.9	18.6	10.9	5.6
2007	268	122	70.1	15.0	9.8	5.1
2008	287	131	73.6	11.7	10.0	4.7
2009	230	105	69.9	13.8	9.3	6.9
2010	298	135	75.3	10.6	9.2	5.0
2011	298	136	75.3	12.1	7.7	4.9
2012	310	141	76.7	11.3	8.0	4.1

The emissions have increased during the reporting period due to higher limestone and dolomite use in the production of ore-based iron pellets. This increase is however partly compensated by a decrease in the use within the mineral and glass wool industry and the chemical industry. Decreased emissions from the glass wool industry are partly due to an increased use of recycled materials and thereby less need for limestone and dolomite for raw glass wool production. During 2009 the used amounts of limestone and dolomite was lower compared to previous year due to the economic recession.

Data on the use of limestone and dolomite have been acquired from environmental reports, the ETS and through direct contacts with the companies.

4.2.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty for activity data is ± 7 % and the uncertainty of the emission factor for CO_2 is ± 5 %. The time series are considered accurate, consistent and complete.

4.2.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

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

4.2.3.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been made in submission 2014.

4.2.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.2.4 Soda ash use (CRF 2.A.4)

4.2.4.1 SOURCE CATEGORY DESCRIPTION

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 (2A7.1). Soda ash is not produced 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 4.12.

Table 4.12. Summary of source category description, CRF 2.A.4

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.A.4	CO_2				CS	D	Yes
	CH_4	NA	NA		NA	NA	NA
	N_2O	NA	NA		NA	NA	NA

D Default. CS Country Specific

4.2.4.2 METHODOLOGICAL ISSUES

In 2004 a study was carried out to collect data on soda ash use and calculate CO_2 emissions.[115] From this study it became clear that no production of soda ash occur

[115] Nyström. 2004. SMED-report: CO_2 from the use of soda ash.

in Sweden, and is hence reported as NO in the CRF. Activity data consists of soda ash use from ten plants within several areas:

- production of glass wool, moist snuff and chemicals
- until 2004, in flue gas desulphurisation at energy plants

As for the use of limestone and dolomite, the emissions and activity data concerning use of soda ash within the glass industries have been reallocated to 2.A.7.1 due to recommendations from the EC Internal review in 2009. This reallocation reduces the reported CO_2 emissions by approximately 50 % in the early 1990s and by over 90 % compared to the early 2000s. The reason for the large effect on reported emissions in later years is due to large changes in the use of soda ash in one chemical industry. This industry spent during the early 1990s considerable amounts of soda ash, and has since 1997 sharply reduced their consumption. In the beginning of the new millennium the soda ash used for manufacturing at this industry is bound in products, and thus no CO_2 is emitted.

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 organisations[116] and the dominant snuff manufacturer. The emissions are calculated by applying the IPCC Guidelines default emission factors for soda ash for all activity data:

$$CO_2\ (Gg) = \frac{44.0098}{105.9884} \times soda\,ash\,(Gg)$$

Data on the use of soda ash have been acquired from the ETS 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 with the data from national statistics, since the data for the inventory is collected from the ETS, from the environmental reports of the facilities or by direct contact with the plants.

4.2.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty for activity data is ± 7 % and the uncertainty of the emission factor for CO_2 is ± 5%. The time series is consistent and complete.

4.2.4.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

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

[116] The Swedish Chemicals Agency (KemI), www.kemi.se

4.2.4.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations were made in submission 2014.

4.2.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.2.5 Asphalt roofing (CRF 2.A.5)

4.2.5.1 SOURCE CATEGORY DESCRIPTION

Since the end of the 1990's there have only been two companies in Sweden producing asphalt-saturated felt. Production and emission data provided by the manufacturers have been used for developing emission factors for estimations of the NMVOC emissions. No measurements or estimations on CO emissions have been performed by the industry and are consequently reported NE, not estimated, for the whole time-series. 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 4.13.

Table 4.13. Summary of source category description, CRF 2.A.5

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.A.5	CO_2	NA	NA		NA	NA	NA

D Default. CS Country Specific. T2 Tier 2. PS Plant-specific.

4.2.5.2 METHODOLOGICAL ISSUES

Data on the total Swedish production of asphalt-saturated felt was provided by the producing companies. Emission factors for asphalt roofing manufacture are presented in EMEP/CORINAIR Emission Inventory Guidebook.[117] These are based on studies performed during the 1970s in the USA and presented by EPA.[118] As stated in the guidebook, the level of uncertainty regarding the suggested emission factors is high, and it is recommended that better factors should be developed and used.

After contact with the industry, emission factors based on measurements and calculations made by the manufacturers were developed before submission 2005 for

[117] EMEP/CORINAIR Emission Inventory Guidebook: http://reports.eea.eu.int/EMEPCORINAIR4/en

[118] Shrager, Brian and Marinshaw, Richard. 1994. Emission Factor Documentation for AP-42, Section 11.2, Asphalt Roofing, Final Report. For U.S. Environmental Protection Agency , Office for Air Quality Planning and Standards, Emission Inventory Branch. MRI Project No. 4601-01.

estimating the NMVOC emissions from the Swedish production of asphalt-saturated felt (Table 4.14)[119].

Table 4.14. Estimated emissions of NMVOC from manufacturing of asphalt-saturated felt (CRF 2A5) in Sweden 1990 – 2012

Year	NMVOC emissions from asphalt roofing, 2A5 Mg
1990	77.7
1995	98.6
2000	111.1
2005	139.7
2006	132.7
2007	142.4
2008	138.6
2009	103.1
2010	105.4
2011	109.6
2012	110.4

The NMVOC emissions from the production of asphalt-saturated felt originate from the felt saturation and coating processes and from leakage from the asphalt storage tanks, the latter being the dominating source. For the calculation of the NMVOC emissions, separate emission factors were used, 0.068 kg/Mg and 1.56 kg/Mg, respectively. The emission factors are based on measurements/estimations from 2003 and 1997. Previously reported notation keys for activity data have been changed from NE to C.

4.2.5.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The time-series are consistent

4.2.5.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

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

4.2.5.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been made.

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.

119 Danielsson, H. 2004. SMED report: Investigation on the occurrence of emissions from asphalt roofing in Sweden.

4.2.6 Road paving with asphalt (CRF 2.A.6)

4.2.6.1 SOURCE CATEGORY DESCRIPTION

Large changes have occurred in asphalt paving technology over the last decade, with a gradual change towards use of water-based emulsions instead of solvent-containing bitumen solutions. Industry representatives estimated that the naphtha content in the solutions used for road paving was on average 23 % in 2002 and 41 % in 2012. In this inventory, only NMVOC emitted in the process of paving the roads 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), is presented in Table 4.15.

Table 4.15. Summary of source category description, CRF 2.A.6

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.A.6	CO_2	NA	NA		NA	NA	NA

4.2.6.2 METHODOLOGICAL ISSUES

Estimates for the early 1990s are taken from investigations and inventories made in the early 1990s. Data for the years 2002 – 2012 has been calculated based on information from the asphalt producers on the average amount of solvent (naphtha) in the mixtures used for road paving. The producers have also provided figures on the total amount of road paving mixtures delivered in Sweden. It is assumed that all solvents in the solvent-based bitumen are emitted when used. Emissions of NMVOC reported for the years in mid- and late 1990s were interpolated (Table 4.16). In the calculations no emissions from imported solvent-based bitumen are used. The amount of imported solvent-based bitumen is most likely very small. In 2005 the emission of NMVOC was very high due to the fact that a heavy storm ruined many roads in southern Sweden. These roads needed to be restored quickly and solvent-based bitumen was used for this purpose.

Table 4.16. Emissions of NMVOC 1990–2012 from road paving with asphalt

Year	NMVOC from road paving with asphalt Mg
1990	6 200
1995	3 800
2000	1 170
2005	1 230
2006	750
2007	935
2008	855
2009	341
2010	256
2011	216
2012	322

4.2.6.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The time-series is consistent.

4.2.6.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

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

4.2.6.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed.

4.2.6.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.2.7 Other (CRF 2.A.7)

4.2.7.1 SOURCE CATEGORY DESCRIPTION

Specified sub-categories under this heading are “Glass production (2.A.7.1)”, “Non-Iron ore mining and dressing”, “Glass and mineral wool production”, “Battery manufacture” and ”Light expanded clay aggregate (LECA), roofing tile, brick, and ceramics 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 4-17.

Table 4.17. Summary of source category description, CRF 2.A.7

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.A.7	CO_2				CS	CS, D	No, see Annex 5
	CH_4	NA	NA		NA	NA	NA
	N_2O	NA	NA		NA	NA	NA

D Default. CS Country Specific. T2 Tier 2. PS Plant-specific.

4.2.7.1.1 Glass production, CRF 2.A.7.1

In Sweden there is one facility for float glass production, one for container glass and several small facilities for manual glass production. Emissions of CO_2 from the use of limestone and soda ash in glass production are from submission 2010 and onwards reported in 2.A.7.1. In earlier submissions CO_2 from the use of limestone and of soda ash in glass productions were reported under 2.A.3 and 2.A.4, respectively. The CO_2-emissions in 2009 are lower than in adjacent years due o the fact that the demand for glass was low in 2009. Also less amount of glass was manufactured from raw material that year - instead recycled glass was used. From the float glass production, the total emissions of SO_2 and NO_X from the glass furnace are allocated to 2.A.7.1 since a separation into energy-related and process-related emissions is not possible. From the container glass production, SO_2 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 (CRF 1).

4.2.7.1.2 Non-Iron ore mining and dressing, CRF 2.A.7

The only emissions reported for the non-iron ore mining and dressing are, in this submission, NO_X released from use of explosives. Also CO is emitted but no data concerning the CO emissions are available and the time series 1990 – 2012 is thus reported NE. Estimated emissions from combustion of fuels are included in the Energy sector (CRF 1).

4.2.7.1.3 Glass and mineral wool, CRF 2.A.7

Glass and mineral wool production occurs at three facilities run by two companies. Before 2004 there were four facilities but one closed down during 2003.

4.2.7.1.4 Battery manufacturing, CRF 2.A.7

One battery producer of NiCd-batteries previously used iso-propanol in their processes, which resulted in emissions of NMVOC. The process was changed in 1998 and, since then, no NMVOC emissions occur from this source.

4.2.7.1.5 Light expanded clay aggregate (LECA), roofing tile, brick and ceramics production, CRF 2.A.7

In this sub-code under 2.A.7 Sweden report CO_2 emissions from production of clay based materials such as LECA, roofing tiles, bricks and ceramics. During the production CO_2 is emitted from the burning of fuels, reported in CRF 1.A.2.f, but CO_2 originating from the clay, the limestone and from other carbon containing material is also emitted. Reported CO_2 emissions represent the emissions from totally six facilities during the years 1990-2008 and from totally five facilities from 2009 and onwards since one facility closed down during 2008. One of the facilities is dominating in CO2 emissions. All CO_2 emissions from raw material used are reported in 2.A.7.

4.2.7.2 METHODOLOGICAL ISSUES

Specified sub-categories under this heading are, “Non-Iron ore mining and dressing”, “Glass and mineral wool production”, “Glass production”, “Battery manufacture” and ”Light expanded clay aggregate (LECA), roofing tile, brick, and ceramics production“.

4.2.7.2.1 Glass production, CRF 2.A.7.1

Emissions of CO_2 from the use of limestone and from the use of soda ash in glass production are reported in CRF 2.A.7.1 together with CO_2 emissions from other carbon containing raw material. Of the reported total CO_2 emissions in 2.A.7.1, approximately 44 % is caused by the use of soda ash and 55 % on the use of limestone and dolomite. The remaining CO_2 is emitted as a result of use of other carbon containing raw materials.

Activity data and emissions are mainly collected from the ETS or from the facilities yearly environmental reports. For small glass production plants a constant amount of 0.9 Gg CO_2 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 CO_2, from weight of raw material to produced amount of glass or crystal. Both estimates result in CO_2 emissions of around 0.9 Gg, yearly.

The process-related SO_2 emissions from container and float glass production are reported for the period 1990 – 2012 in CRF 2.A.7. The reported NO_X emissions originate from the production of float glass. Data has been provided directly by the companies or collected from their environmental reports.

4.2.7.2.2 Non-Iron ore mining and dressing, 2.A.7

Data on NO_X emissions from use of explosives within the non-iron ore mining industry are reported 2002 – 2012, but for the years 1990 – 2001 no information is presently available. Data on NO_X emissions are collected from the companies' environmental reports to the authorities.

4.2.7.2.3 Glass and mineral wool production, 2.A.7

CO_2 emissions from glass and mineral wool producers in Sweden derive from the use of glass wool waste (glass wool production) and blast furnace slag (mineral 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 eg 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 incinerated 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 incineration of the organic binders gives rise to emissions of CO_2. In EU ETS CO_2 emissions from the oxymelt process are reported since 2005 for the one facility producing glass wool with this technique. In previous submissions, these CO_2 emissions were not included. In submission 2014 activity data, emission factor and data for CO_2 from “oxymelt glass” based on information from EU ETS were included for the years 2005-2012. The same information for 1991-2004 have been obtained from the company. In 1990 no oxymelt glass was used. The emission factor used is 0.13 Gg CO_2 /Gg oxymelt glass.

In the mineral wool production blast furnace slag was used in the process causing CO_2 emissions between (1990-1995 and 1998-1999).Activity data on the slag consumption has been obtained for the mentioned years from the mineral wool producers. The emission factor is 0.04 Gg CO_2 /Gg slag based on that the slag contains 1 % carbon and the CO_2 emissions are calculated by using the formula:

Emissions of CO_2 (Mg) from use of slag = Slag (Mg) * 0.01 * (C content) * 44/12

Within mineral wool production, the limestone and dolomite used also cause process emissions of CO_2 which are allocated to CRF 2.A.3 in accordance with the IPCC Guidelines.

For glass and mineral wool production, 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.

4.2.7.2.4 Battery manufacture, 2.A.7

NMVOC emissions from battery manufacture for the period 1990-1998 are compiled from data presented in the companies' environmental reports. The process has changed and no emissions of NMVOC occur after 1998.

4.2.7.2.5 Light expanded clay aggregate- (LECA), roofing tile, brick and ceramics production, 2.A.7

Activity and emissions data for LECA production 1990 - 2004 is retrieved directly from the production plant, split into emissions from clay and emissions from additives (limestone and other carbon containing material). From 2005 and onwards, the equivalent data is acquired through the ETS and the Swedish LECA producer's annual report.

For roofing tile, brick and ceramics production, activity and emission data from 2005 and onwards is acquired through the ETS. The data in the ETS does not always separate between emissions from limestone/dolomite use and CO_2 emissions from other carbon containing raw material (i.e. from the clay and other carbonates used) needed for the production. In order to as far as possible report an accurate total process-related CO_2 emission for the facilities included in this 2.A.7 sub-code, Sweden have chosen to report all CO_2 emissions in 2.A.7.

As there is a lack of data before 2005, the reported emissions for 2005 are extrapolated for 1990-2004.

As activity data reported in this 2.A.7 sub-code produced amounts of LECA is reported 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

C-content in one of the additives for LECA production was unusually high which has resulted in comparatively high CO_2-emissions for that year. The use of limestone and other additives in LECA production has declined in favour of clay which 2008-2012 contributed to between 81-83 % of all process-related CO_2 emissions from LECA production. The facility producing LECA corresponds to around 65 % of yearly reported CO_2 emissions in this 2.A.7 sub-code.

4.2.7.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainties of the direct CO_2 emissions in 2A7 are considered to be ± 7 % based on expert judgements. The expert judgements of the uncertainties of CO_2 in 2A7 were made without any knowledge of the missing oxymelt process that now is included. The estimated uncertainties are still considered to be valid.

4.2.7.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

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

4.2.7.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed except for glass and mineral wool production, 2.A.7. Data on CO_2 emissions from the "Oxymelt" process was added for the years 1991-2011. The recalculations resulted in an increase in CO_2 emissions of about 0.10 to 0.69 Gg yearly during 1991-2011.
A comparison between submission 2013 and submission 2014 is shown in Figure 4.6.

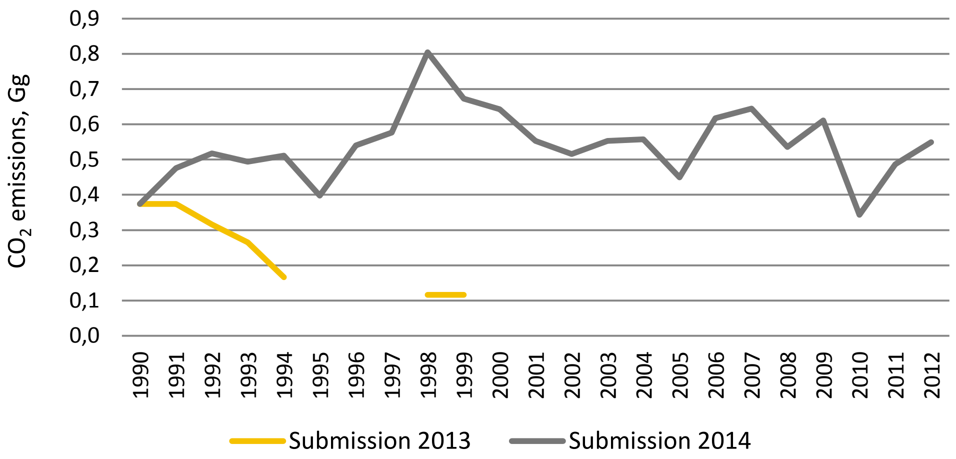

Figure 4.6. Emissions of CO_2 from glass and mineral wool production in submission 2013 and 2014

Data on NMVOC emissions for 2011 from one company that produces glass and mineral wool was updated due to new information from the company.

4.2.7.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.3 Chemical industry (CRF 2.B)

Sources covered in the reporting are nitric acid production (2.B.2), carbide production (2B4) and other (2B5), which include a large variety of processes in the chemical industry. No ammonia production (2.B.1) or adipic acid production (2B3) occurs in Sweden.

4.3.1 Ammonia production (CRF 2.B.1)

4.3.1.1 SOURCE CATEGORY DESCRIPTION

There is an annual production of about 5 Gg of ammonia in Sweden, according to United Nation statistics[120]. This ammonia is however not intentionally produced, but is a by-product in one chemical industry producing various chelates and chelating agents, such as EDTA, DTPA and NTA[121]. Emissions from this industry are included in CRF code 2B5. Ammonia production, 2.B.1, is thus reported as NO in the CRF-tables.

4.3.2 Nitric acid production (CRF 2.B.2)

4.3.2.1 SOURCE CATEGORY DESCRIPTION

Production of nitric acid has taken place at three facilities in Sweden during 1990-2000. One of these 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. 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 4.18. An overview of the rationale for data sources used for key categories in the industrial processes sector is presented in Annex 3.6.

Table 4.18. Summary of source category description, CRF 2.B.2

CRF	Gas	Key Category Assessment 2012 (tier 2, 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_2O		X		T2	PS	Yes

T2 Tier 2. PS Plant-specific.

[120] UN. Commodity Production Statistica Database. Department of Economic and Social Affairs, Statistics Division,. As referred in FCCC Synthesis and Assessment report 2002 Part I.

[121] Kindbom, 2004. SMED report: Investigation on the occurrence of ammonia production in Sweden. 2004-05-11.

4.3.2.2 METHODOLOGICAL ISSUES

Activity data, such as the produced amount of nitric acid, has been obtained from the facilities and from official statistics. Emission estimates of N_2O 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. Since two plants have been 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 4.19). The assumed emission factor of 7 kg/Mg for 1991 - 1993 is based on the 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.

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. However, this information is confidential.

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 N_2O abatement technology. This new abatement methodology 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 N_2O emissions are monitored using an automated system based on EU standards.[122], [123]

Table 4.19. Activity data, emission factors and emissions for N_2O for nitric acid production

Year	Production of nitric acid Gg	Calculated IEF, kg/Mg	Emissions of N_2O, Gg
1990	374	7.02	2.63
1995	417	5.48	2.29
2000	430	4.80	2.06
2005	264	5.37	1.42
2006	272	5.42	1.47
2007	249	3.16	0.788
2008	266	3.26	0.866
2009	243	4.05	0.983
2010	257	3.92	1.01

[122] Joint Implementation Supervisory Committee, 2011. YARA Köping S2 N2O abatement project in Sweden.pdf

[123] Joint Implementation Supervisory Committee, 2011. YARA Köping S3 N2O abatement project in Sweden.pdf

Year	Production of nitric acid Gg	Calculated IEF, kg/Mg	Emissions of N_2O, Gg
2011	263	0.50	0.132
2012	265	0.82	0.218

4.3.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty for activity data is ± 2 % and the uncertainty of the emission factor for N_2O is ± 5 %. The time-series is consistent. The fluctuations in the calculated total EF for N_2O 1994 – 2000 (Table 4.19) are mainly due to fluctuations in one of the facilities. The IEFs are within the IPCC default interval (2-19 kg N_2O/Mg). Activity data and reported emissions have been acquired from reporting in e.g. environmental reports from the facility, but since the facility has shut down, it is no longer possible to check previously reported estimates. Beside emissions of N_2O also emissions of NO_X are reported.

The lower level of N_2O 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. 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 N_2O and NO_X were reduced compared to previous years. The used abatement system is described in the BREF document for large volume inorganic chemicals[124]. During 2009 the production of nitric acid was lower compared to previous years and also lower than later years. The higher N_2O implied emission factor in 2009 is due to that the N_2O 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 N_2O emissions. For some months in 2010 N_2O-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 not 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 decrease of N_2O emissions compared to earlier years.

4.3.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The company is contacted for verification of production capacity and to collect data on purification technology and its effectiveness.

[124] European Commission, 2007

4.3.2.5 SOURCE-SPECIFIC RECALCULATIONS

The emission of NO_X for year 2011 has been adjusted from 0.2087 to 0.2075 Gg so that only NO_X from the nitric acid production is included. The adjustment is too small to be adequate to be presented in a diagram comparing submission 2013 and submission 2014.

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 Carbide production (CRF 2.B.4)

4.3.3.1 SOURCE CATEGORY DESCRIPTION

Silicium carbide production does not occur in Sweden but calcium carbide is produced at one facility. All process-related CO_2 emissions from the industry are included in the code 2.B.4.2. 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 4.20.

Table 4.20. Summary of source category description, CRF 2.B.4

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.B.4	CO_2				D	PS	Yes

D Default. PS Plant-specific.

4.3.3.2 METHODOLOGICAL ISSUES

To cover all sources of CO_2 from the production of calcium carbide, estimates of emissions from the production of quick lime, from the reduction of quick lime to calcium carbide and CO_2 from use of calcium carbide have been made. In the tables and text below the estimated CO_2 emissions to be reported in CRF 2B4.2 are presented.

4.3.3.2.1 CO_2 emissions from quick lime production

In order to estimate the CO_2 emissions from the first step of the production of calcium carbide, the amount of limestone used for quick lime production is used as activity data together with the default emission factor from Revised 1996 IPCC Guidelines, 0.44 Mg CO_2/Mg limestone used. During the time period 1990 – 2012 the facility has for some years produced all quick lime that has been used in the production while in other years large amounts of quick lime has been bought from other producers of quick lime. Thus, the CO_2 emission varies between years as can be seen in Table 4.21.

Table 4.21. Limestone used for quick lime production and associated CO_2 emissions to be reported in CRF 2.B.4.2

Year	Limestone used for quick lime production, Gg	CO_2 from quick lime production, Gg
1990	96	42
1995	79	35
2000	64	28
2005	75	33
2006	23	10
2007	69	30
2008	61	27
2009	9	4
2010	51	22
2011	51	22
2012	24	10

4.3.3.2.2 CO_2 emissions from calcium carbide production

Calcium carbide is produced in an electric arc furnace at high temperature, 2000 – 3000 ºC. Quick lime, CaO, is reduced with coke and forms CaC_2. In this process an energy rich gas is produced as a by-product. This gas is used as fuel within the facility and to some extent in other nearby plants and thus only a minor part of the gas is flared. To calculate the CO_2 emissions from the reduction of quick lime to calcium carbide, data on produced amounts of calcium carbide, share of gas flared and default emission factor in IPCC Guidelines are used. Since there only is one producer of calcium carbide in Sweden the produced amounts are reported as confidential, C.

Table 4.22. Share of flared carbide oven gas and associated CO_2 emissions to be reported in CRF 2.B.4.2

Year	Carbide oven running time / Flaring time, %	CO_2 from the reduction of CaO to CaC_2, Gg
1990	6%	4
1995	7%	4
2000	14%	6
2005	15%	7
2006	13%	6
2007	10%	4
2008	8%	4
2009	10%	3
2010	9%	3
2011	11%	4
2012	23%	9

4.3.3.2.3 CO_2 emissions from use of calcium carbide

In Revised 1996 IPCC Guidelines it is stated that in addition to reporting CO_2 emissions from calcium carbide production, also CO_2 originating from the use of calcium carbide has to be reported. To be able to estimate the CO_2 emission from use of calcium carbide only the amount of calcium carbide for acetylene production and the use within the country has to be taken into account. Information from the calcium carbide producer in Sweden indicates that one third of the calcium carbide is used for acetylene production. Assuming that imported and exported amounts of acetylene have the same utilisation it is possible to reasonably well estimate the CO_2 emissions originating from acetylene use. Yearly statistics on imported and exported amounts from 1998 and onwards are available from Statistics Sweden[125]. Amounts used for acetylene production for earlier years are estimated. The default emission factor presented in the Revised 1996 IPCC Guidelines, 1.1 Mg CO_2/Mg calcium carbide use, has been used for the estimations.

Table 4.23. Amount of calcium carbide used for acetylene production, and CO_2 emissions from acetylene use reported in CRF 2.B.4.2

Year	Amount of calcium carbide for acetylene production, Gg	CO_2 from use of acetylene, Gg
1990	7	8
1995	6	7
2000	6	7
2005	9	10
2006	8	8
2007	8	9
2008	9	9
2009	4	5
2010	5	6
2011	5	6
2012	4	4

4.3.3.2.4 Time series reported in CRF 2.B.4. 2

In Table 4.24, the total CO_2 emission for some years in the time series reported in submission 2014 is presented. Since there is only one producer of calcium carbide in Sweden production statistics are reported as confidential, C. The total reported CO_2 emissions in CRF 2.B.4.2 are based on:

- produced amounts of quick lime and emission factors from Revised 1996 IPCC Guidelines
- produced amounts of calcium carbide, share of gas flared and the default emission factor according to the Revised 1996 IPCC Guidelines

125 www.scb.se

- amount of calcium carbide used for acetylene production within the country and the default emission factor presented in the Revised 1996 IPCC Guidelines.

Table 4.24. Time series reported in CRF 2.B.4 2

Year	Produced calcium carbide, Gg	CO2 emissions from production and use of calcium carbide, Gg
1990	C	54.2
1995	C	45.5
2000	C	40.8
2005	C	49.6
2006	C	24.2
2007	C	43.4
2008	C	40.2
2009	C	11.7
2010	C	31.6
2011	C	32.5
2012	C	23.5

4.3.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As can be seen in Table 4.24, CO_2 emissions for 2006, 2009 and 2012 are lower compared to surrounding years. For these years a minor part of the quick lime needed for production of calcium carbide was produced at the facility, the remaining part was bought from external producers. In 2009 the lime kiln was only operating during the last quarter of the year.

4.3.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The amunts of quick lime bought from external producers are obtained from the calcium carbide producing facility. This data is used to verify the variation of CO_2 emissions between years.

4.3.3.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed.

4.3.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.3.4 Other (CRF 2.B.5)

4.3.4.1 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. Approximately 70 larger industrial facilities are included in the emission estimates. Emissions of CO_2,

CH_4, N_2O, NO_X, CO, NMVOC and SO_2 are reported in this sub-category. It is possible though that some emissions of NMVOC reported in CRF 2.B.5 should be reported in CRF 3C (e.g. pharmaceutical industries), but as it has been difficult to make the distinction clear between process emissions and solvent use, all NMVOC emissions from these facilities have been included in CRF 2B5.

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, CH_4-emissions decreased in 1999 due to a much lower production at one facility and N_2O-emissions increased in 1999 due to the fact that one facility within ”Pharmaceutical industry” reported higher emissions that year.

The SO_2 emissions reported in 2B5 decreased dramatically in 2004 in comparison to earlier years. This is due to that in December 2004 one facility for production of viscose staple fibre was shut down. The yearly SO_2 emissions from this facility represented between 8 and 20 % of the totally reported SO_2 emission in CRF 2 – Industrial Processes, 1990 - 2003.

CO-emission from "Other inorganic chemical production" increased from below 200 Mg in 2005 to 500 Mg in 2006. This increase is due to unusually high CO emission in 2006 from one facility producing PVC. In 2007 the CO-emissions were very low from one facility producing PVC.

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 4.25.

Table 4.25. Summary of source category description, CRF 2.B.5

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.B.5	CO_2				CS	PS	Yes
	CH_4				CS, D	PS, D	No, see Annex 5
	N_2O				CS	PS	No, see Annex 5

D Default. CS Country Specific. PS Plant-specific.

4.3.4.2 METHODOLOGICAL ISSUES

The primary information on emissions of CO_2, CH_4, N_2O, NO_X, CO, NMVOC and SO_2 is as reported by the companies in their environmental reports. A total of approximately 70 facilities are included. In the IPCC Guidelines, methods for estimating CH_4 emissions for several chemical products are presented and consequently the CRF Reporter is divided on those products (2.B.5.1-5). Since several plants in Sweden produce several chemicals products each but report emissions aggregated by plant, it is not possible to report emissions in accordance with the suggested split in the CRF Reporter. In Sweden, since submission 2006 the emissions are thus presented 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.

In Sweden there is one company producing carbon black. CH_4 emissions are included from 1990 and onwards based on production data from the company's environmental reports and IPCC Guidelines default EF (11 g CH_4/kg production). Due to data confidentiality, emissions are included under 2.B.5 (Other inorganic chemical production).

4.3.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Based on expert judgements, the uncertainties of collected emissions of CO_2, CH_4 and N_2O are as follows: ±50 %, ±100 % and ±125 %, respectively.

The time-series for GHG have been reviewed and are considered to be consistent.

4.3.4.4 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.

In addition, 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 Sweden[126]. 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 investigations[127].

Overall, the QC-project showed that total reported GHG emissions from the chemical industries in the Swedish inventory are in coherence with the plant emission data.

4.3.4.5 SOURCE-SPECIFIC RECALCULATIONS

- Chemical Industry Other CRF 2.B.5: The NMVOC emissions have been recalculated for the years 2010 and 2011 since the company ended its production 2009-12-31. This recalculation decreased the emission of NMVOC by 0.04 Gg.

[126] Gustafsson, T., Nyström, A-K., Gerner, A. Riktad kvalitetskontrollstudie av utsläpp från kemiindustrin i Sveriges internationella rapporterin. SMED report 2010.

[127] Most recommendations on further investigations refer to the energy sector

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.

4.4 Metal production (CRF 2.C)

All sub-categories are covered in the estimates, i.e. iron and steel production (2.C.1), ferroalloy production (2.C.2), aluminium production (2.C.3), SF_6 used in magnesium foundries (2.C.4) and other (2.C.5), which consists of estimates for one large non-ferrous smelter plant and one metal recycling plant.

4.4.1 Iron and steel production (CRF 2.C.1)

4.4.1.1 SOURCE CATEGORY DESCRIPTION

In Sweden, there are three primary iron and steel facilities and about ten secondary steel plants equipped with electric arc furnaces. In total, there are approximately 20 different facilities included in the different estimates. Processes occurring besides the primary processes and secondary steel production are rolling mills, pickling and other steel-related processes. From submission 2009 and onwards, emissions from two major iron ore mines and three facilities producing pellets in Sweden are reported in 2C1.3 (reallocated from previous reporting in 2.A.7). Emissions from a sinter producing facility are also included until 1995, when the production closed down.

Process emissions arising from reducing agents in the primary steel works and secondary iron and steel works are reported in CRF 2.C.1. As the plants also generate emissions from fuel combustion (CRF 1.A.1c and CRF 1.A.2.a) and fugitive emissions (CRF 1.B.1.c), the text in this section is closely connected to the text in the corresponding section in the energy chapter.

In the Swedish inventory, emissions from primary iron and steel production and secondary steel production are reported separately and fed into the CRF Reporter under 2.C.1.2 Pig iron and 2.C.1.1 Steel, respectively. This enables process emissions from the two integrated iron and steel production plants in Sweden to be reported together (2.C.1.2 Pig iron), and thus not introducing further sources of uncertainty due to additional data handling.

The GHG emission trend 1990-2008 is rather stable with some minor inter-annual variations. 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 2010 the emissions are back at the same level as before 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 4.26. An overview of the rationale for data sources used for key categories in the industrial processes sector is presented in Annex 3.6.

Table 4.26. Summary of source category description, CRF 2.C.1

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.C.1	CO_2	X			CS, T2	PS	Yes
	CH_4				T2	CS	No, see Annex 5
	N_2O	NA	NA		NA	NA	NA

CS Country Specific. T2 Tier 2. PS Plant-specific.

4.4.1.1.1 Secondary steel production, CRF 2.C.1.1

The reported CO_2 emissions include emissions from reducing agents such as coke, coal and electrodes in electric arc furnaces in secondary steel plants. These emissions are not primarily a result of combustion, but are necessary for the process and should hence be reported in CRF 2.C.1.1. Reported CO_2 emissions also include emissions from the use of limestone and dolomite in secondary steel industry.

In submissions prior to submission 2010, the reported CO_2 emissions in CRF 2.C.1.1 included data from nine plants in 1990-2003 and eight plants from 2004, since one plant was shut down in 2004. From submission 2010 another two secondary steel industries are included in the reported CO_2 time series. Also another four plants with process related NO_X and/or NMVOC emissions are included in this sector. These plants do not produce steel, and hence do not emit CO_2.

Production and consequently emissions have increased slowly since 1990 due to higher demand of these products. The high production and emissions level in 1990 compared to 1991 is explained by the fact that one plant closed its production in 1991.

From submission 2014 another two secondary steel industries were included in the reported production figures 1990-2012. The reason for this was that it was discovered that the production figures which are provided by the Swedish Steel Producers' Association did not include these two sites.

4.4.1.1.2 Primary iron and steel production, CRF 2.C.1.2

In Sweden there are three producers of primary iron and steel, i.e. the basis of their production is iron ore pellets. Two plants 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 secure oxidation and act as reducing agents, and the associated emissions are thus to be reported as industrial processes from iron and steel production in CRF 2.C.1, according to the IPCC Guidelines and Good Practice Guidance. The third plant produces iron sponge and iron powder.

4.4.1.1.3 Iron ore mining, dressing, sintering and iron ore pellets production, CRF 2.C.1.3

Emissions of CO_2 from the use of limestone and dolomite within the production of ore based iron pellets are reported in CRF 2.A.3. Estimated emissions from combustion of fuels are included in the Energy sector (CRF 1). In CRF 2.C.1.3 emissions from iron ore pellets production from 1990 and emissions from sinter production 1990-1995 are considered.

CO_2 emissions from the use of bentonite and organic binder, SO_2 from the sulphur content in the ore and NO_X emitted as a result of the use of explosives are reported from pellets production. The use of mining explosives also causes emissions of carbon monoxide, CO[128].

During 1990-1995 a sinter plant was in operation at one of the integrated primary iron and steel plants. Operation of sinter plants produces CO_2 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 CH_4, are emitted[129]. SO_2 from the sulphur content in the ore is also considered to be emitted from the facility.

4.4.1.1.4 CO2 emissions reported in Coke, CRF 2.C.1.4

Emissions of CO_2 from the production of coke are reported in CRF 1.A.1.c and emissions of CO_2 from the use of coke in blast furnaces are reported in CRF 2.C.1.2 in line with the IPCC Guidelines.

4.4.1.1.5 CO2 emissions reported in Other, CRF 2.C.1.5

No emissions of CO_2 reported in this sector.

4.4.1.2 METHODOLOGICAL ISSUES

4.4.1.2.1 Secondary steel production, CRF 2.C.1.1

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 acquired from the ETS, from the facilities environmental reports and through contacts with the companies.

[128] Wieland, M.S. 2004.

[129] IPCC 2006 Guidelines. http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf

Data in the ETS includes information concerning carbon bound in products, slag, etc, but also other sources for process related CO_2 emissions. Prior to submission 2010, these other emissions were not included for all facilities. Estimates of these missing CO_2 emissions were performed using ETS data for 2005 – 2008 and production data for years before 2005. All CO_2 emissions presented for the facile-ties in ETS 2005 – 2011 are included in 2C1.1 in submission 2013.

Reported CO_2 emissions until year 2008 are for all facilities, except the one which closed down in 2004, based on data in the ETS. Reported CO_2 emissions can therefore be classified to follow the Good Practice Guidance method Tier 2 since, according to the ETS guidelines; reported emissions shall be based on all carbon input to and carbon output from the process. For the years from 2009 background data needed for estimation of process-related CO_2 emissions for one facility, earlier included in the ETS, was collected from the facility's environmental report since this facility is not included in ETS. Before the facility shut down in 2004, plant specific methods were applied.

For non-CO_2 emissions, the companies' environmental reports are the main source of information. NO_X, NMVOC and SO_2 emissions emitted from electric arc furnaces are reported in 2.C.1.1. NO_X emissions may also arise from pickling and NMVOC emissions from rolling mills. These sources are also included in the estimates.

4.4.1.2.2 Primary iron and steel production, CRF 2.C.1.2

Production of iron powder

The emissions of CO_2 are calculated using the Good Practice Guidance method Tier 2. 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, ETS data is used and 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. CO_2 emissions from natural gas used for production of reduction gas used in the process are considered to be process-related and thus reported in 2.C.1.2. The remaining amounts of natural gas used by the facility are considered as energy-related and the corresponding emissions are reported in the Energy sector (CRF 1.A.2.a). To be consistent with calculations of emissions from production of pig iron, limestone used in the production is included in the emissions from the production of iron powder in CRF 2.C.1.2. Activity data reported is produced amount of direct-reduced iron (iron sponge).

Production of primary pig iron and steel

As a response to recommendations from UNFCCC expert review teams, since submission 2010, Sweden uses the recommended Tier 2 method according to the IPCC Guidelines, to base the calculations of CO_2 emissions on carbon mass-balances in order to reduce the risk of double counting or omitting CO_2 emissions.

The carbon contents of external input materials such as coking coal, coke, injection coal, limestone, etc., are balanced against final output materials; coke[130], pig iron[130], steel, tar, sludge, slag, etc. The remaining carbon contents are accounted for as CO_2 emissions:

$$CO_2\ emissions_{Total\,CRF\ 1\,and\,2} = \left[\sum_i (MI_i * C_i) - \sum_p (MO_p * C_p)\right] * 44/12$$

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*).

Figure 4.7 gives an overview of the input and output materials, the carbon flows between the different processes (plant stations), and the CO_2-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 other plant stations, but smaller amounts are also flared. 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. Dolomite, pig iron, carbide, etc., are added depending on the different metallurgic processes. LD-gas is produced in the steel converter and used as fuel or flared. Some steel is treated in the rolling mills where LPG and different oils are used as fuel.

[130] If put in stock or sold externally

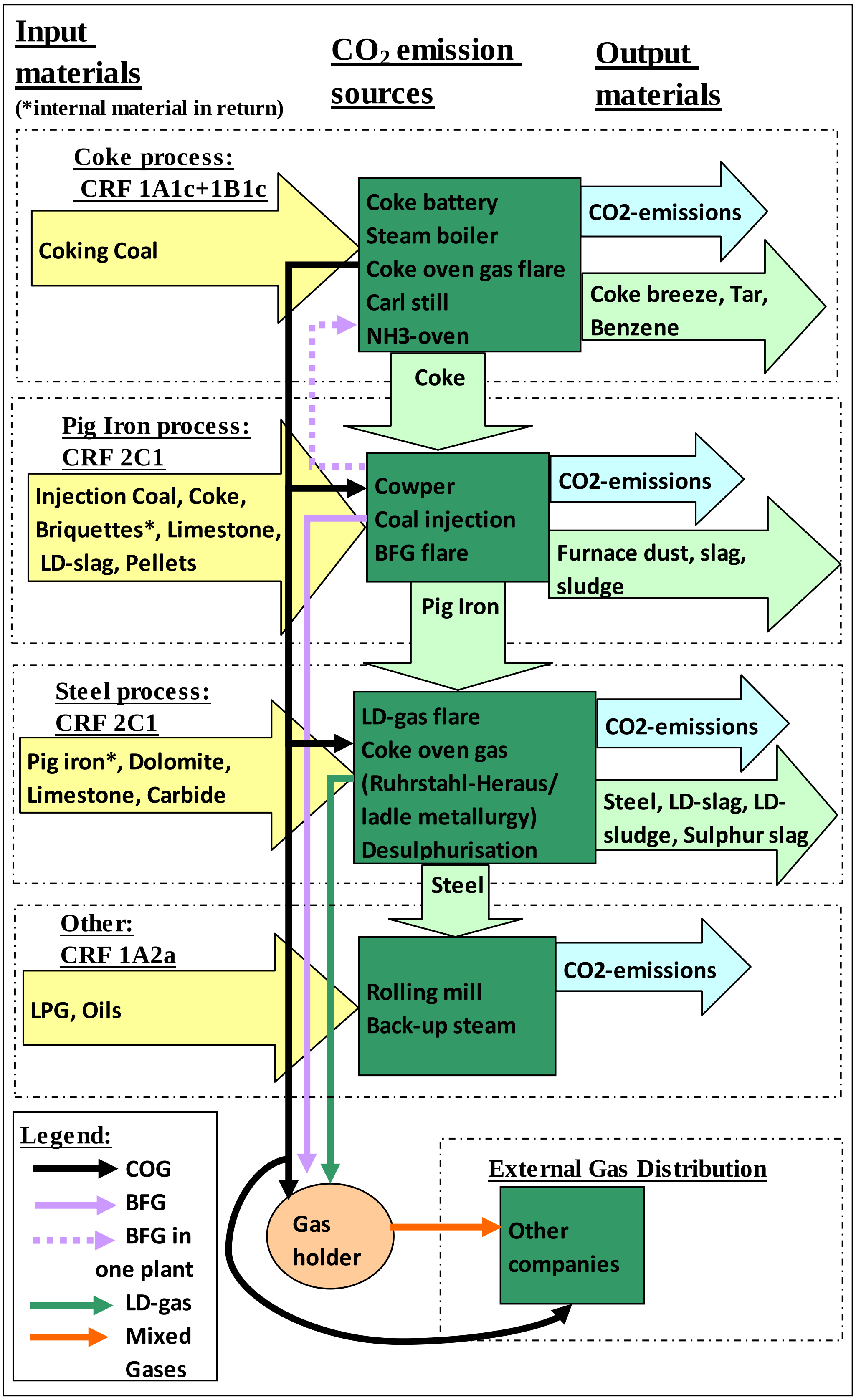

Figure 4.7. Carbon flow chart of integrated primary iron and steel plants in Sweden

Considerable amounts of energy gases (coke oven gas, blast furnace gas and LD-gas) from the different processes are collected in a gas holder and sold to external consumers (mainly in CRF 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 not in accordance with the 1996 Guidelines as they fall under the category "Auto-producers[131]", but in line with the 2006 IPCC Guidelines[132] where allocation of emissions from delivered gases is described. Sweden has chosen to follow the 2006 IPCC Guidelines in this case as they are more in line with the emission reporting for the annual environmental reports and the EU ETS reporting. Detailed carbon mass balances, simplified energy balances and carbon and energy flowcharst are compiled for the two plants included in the reporting according to EU ETS (see Annex 3.5).

During the whole process from raw material to final product, emissions of CO_2 are released. The allocation of total CO_2 emissions and energy consumption (TJ) on plant stations and consequently CRF sub-sector is based on measured fuel consumption and associated CO_2 emissions (Table 4.27). Note that energy consumption (TJ) cannot be reported in CRF-reporter for 2.C.1.2 (but as non-energy use of fuels in CRF 1.A.d). Energy allocated to non-energy use of fuels 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.

Table 4.27. CO_2 emission allocation 2012 in integrated primary iron and steel production

CRF	Plant station	CO_2 emissions (Gg)	Engery consumption (TJ)
1.A.1.a	Power and Heat Production (sold amount of energy gases)	1 989	7 550
1.A.1.c	Coke Oven	358	4 574
1.A.2.a	Combustion in Rolling Mills + Power and Heat Production	431	3 328
1.B.1.c	Flare in Coke Oven (COG)	9	188
2.C.1.2	Blast Furnace + Steelworks (including Flaring of BFG and LD-gas)	1 746	6 631
1.A.d	Non-energy use of fuels	NA	34 366
Total		4 532	56 637

According to the IPCC Guidelines, emissions of CO_2 from the use of limestone should be reported separately as process emissions from limestone and dolomite use in CRF 2.A.3. Since the Centralized review from submission 2004 the ERT has repeatedly recommended Sweden to follow the guidelines. As the CO_2 emissions

[131] See IPCC Guidelines: Reporting instructions 1.3

[132] See 2006 IPCC Guidelines: Volume 3: Industrial Processes and Product Use, Box 1.1 (page 1.8)

from limestone and dolomite are small (<1 per cent of the plants total CO_2 emissions) it is not considered to be good practice to spend resources obtaining underlying data to separate these emissions. Hence Sweden choose to include these CO_2 emissions in CRF 2.C.1.2.

Activity data (amount of pig iron produced) on integrated pig iron and steel production along with CO_2 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 CO_2 emissions are also reported to the EU ETS since 2005. For some years, CO_2 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 CO_2 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 (CRF 1.A.1.c, 1.A.2.a, 1.B.1.c and 2.C.1.2) are taken from the environmental reports. Amounts of pig iron produced 1990-2002 were obtained directly from both plants, together with total CO_2 emissions 1990-2002 for one of the plants. For the other plant, CO_2 emissions 1990-2002 are calculated using its pig iron production 1990-2002 and an average CO_2 IEF 2003-2007. Allocation of CO_2 emissions on different sub-categories (CRF 1.A.1.c, 1.A.2.a, 1.B.1.c and 2.C.1.2) 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 Good Practice Guidance surrogate method using the average values 2003-2007 and the CO_2 emissions as the surrogate parameter. Activity data reported in CRF Reporter in CRF 2C1.2 is produced amount of primary pig iron.

Emissions of CH_4, N_2O, 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 CH_4, NMVOC and CO from coke oven gas, blast furnace gas and LD-gas in the blast furnace and steel converter are allocated to CRF 2.C.1.2, whereas emissions of N_2O are assumed to be not applicable (NA) in this sub-category, in accordance with the IPCC Guidelines. Emissions of NO_X and SO_2 are based on detailed plant information from the environmental reports.

4.4.1.2.3 Iron ore mining, dressing, sintering and iron ore pellets production, CRF 2.C.1.3

Production data (ore, pellets and sinter) are collected from "Statistics of the Swedish Mining Industry"[133] produced by the Geological Survey of Sweden (SGU). SO_2 emissions have been supplied by the facilities for the entire time series. Amounts of bentonite and organic binder used for the production of iron ore pellets and the corresponding CO_2 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. No data concerning the CO emissions is available and the time series is thus reported NE.

During 1990-1995 a sinter plant was in operation at one of the integrated primary iron and steel plants. No plant-specific, national or default emission factors according to 1996 IPCC Guidelines are available. In accordance with the 2006 IPCC Guidelines, emissions should then be estimated using production data with its default emissions factors (0.2 tonnes CO_2/tonne sinter produced and 0.7 kg CH_4/ tonne sinter produced).

4.4.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

During the preparation of submission 2013 for reporting to UNFCCC a significant increase in the CO_2 implied emission factor (IEF) for year 2011 for the two primary pig iron production plants was noticed (see Figure 4.8). This was due to the fact that the reported CO_2 emissions were overestimated for one of the plants. During 2011 one of the two blast furnaces at the plant was out of operation from July until December, and consequently the production of pig iron decreased compared to the previous year. At the same time the production rate at the coke plant was kept under normal conditions. This resulted in an increased intermediate stock of coke at the plant. After consulting the operator it was concluded that the operator did not take into account any intermediate stock change of produced coke in the carbon mass balance used when calculating the CO_2 emissions, i.e. large amounts of carbon assumed to be released into the atmosphere was actually stored in the coke stocks. This led to an overestimation of CO_2 emissions not in line with the IPCC methodologies prescribed by the UNFCCC for annual greenhouse gas emission inventory reporting. The operator explained that the same method has been used for all years since emission year 2005, i.e. the first year for reporting to EU ETS. The exclusion of the change in storage of coke in the carbon mass balance is more pronounced for years when for example the operation of the blast furnaces has been restricted (e.g. 2011). During 2012 the operator applied to the county administrative board to change their monitoring methodology for CO_2 according to ETS, i.e. including any intermediate stock change of produced coke in the carbon mass

[133] Geological Survey of Sweden. 2012. Statistics of the Swedish Mining Industry 2012. http://www.sgu.se/dokument/service_sgu_publ/bergverksstatistik-2012.pdf

balance. However, the method change did not apply until emission year 2012. During 2013 the Swedish EPA initiated a project in order to achieve an accurate time series for CO_2 emissions from the plant for the submission 2014 reporting to the UNFCCC. Direct contact was taken with the operator of the plant of concern. For the purpose of UNFCCC reporting, the operator has revised its data by year excluding the annual amounts of produced coke stored at the facility from its carbon mass balance.[134]

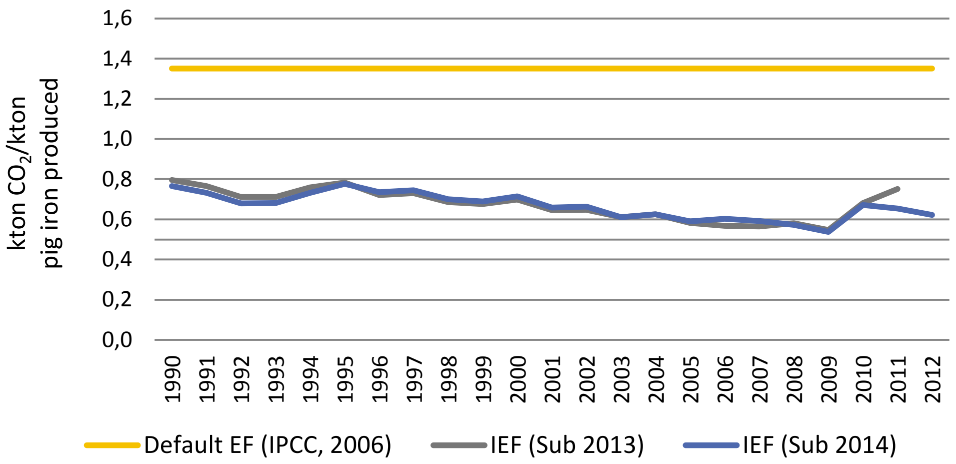

Figure 4.8 Default IPCC CO_2 EF for pig iron production and the CO_2 IEF for primary pig iron production in Sweden for submission 2013 and 2014

Figure 4.8 shows the default IPCC CO_2 EF for pig iron production and the CO_2 IEF for primary pig iron production in Sweden for submission 2013 and 2014. It is obvious that the Swedish CO_2 IEF (0.54-0.78 ktonnes CO_2/tonne pig iron) is significantly lower than the default IPCC value (1.35 ktonnes CO_2/tonne 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 CO_2 emissions) produced in the processes (blast furnace and LD-steel converters) are used in the coke plant and for power and heat production purposes. There is an obvious decrease in CO_2 IEFs since 1990 for primary pig iron and steel production, from 0.77 Gg CO_2/ktonne iron in 1990 to 0.54 Gg CO_2/ktonne pig iron in 2009 (see Figure 4.8)[135]. This is due to the undertaking of several energy efficiency measures, e.g. increased temperature in the blast furnaces and increased recycling of energy gases and by-products[136], leading to decoupling between CO_2 emissions and primary pig iron production in Sweden. In 2010 reparation work was performed at the LD gas holder at one of the plants, and during 2011 the LD gas hold-

[134] Skårman, T. and Gustafsson, T. 2013. Revision of estimated greenhouse gas emissions for integrated iron and steel production. SMED Report No 126 2013.

[135] Skårman, T. and Gustafsson, T. 2013. Revision of estimated greenhouse gas emissions for integrated iron and steel production. SMED Report No 126 2013.

[136] ENET-Steel, 2007.

er 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. The startups of the blast furnaces after disruptions require extra fuel. These activities or events lead to significantly higher CO_2 IEF for 2010-2012.

The largest implication on the national total uncertainties from this category stems from uncertainties in CO_2 emissions in primary iron and steel production (CRF 2.C.1.2); based on expert judgement by SMED expertise the estimated uncertainty is ±5%. It should be noted however, that total emissions of CO_2 from iron and steel production, including energy related emissions, are likely to deem lower uncertainty estimates. It should be noted that even though data has been revised for one facility reported in CRF 2.C.1.2, the methodology for calculating the emissions has not been changed and consequently not the uncertainty estimates.

4.4.1.4 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 report 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 Good Practice Guidance. Detailed carbon mass balances are compiled for plants included in the reporting according to EU ETS (Annex 3.5). More information on QC activities related to EU ETS is included in Annex 8.1.

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 CO_2 emissions (see section 4.4.1.3), there will be discrepancies in the annual CO_2 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 larges discrepancy in reported CO_2 emissions between the two sources (reported CO_2 emissions to UNFCCC submission 2014 is approximately 85% of the reported emissions to EU-ETS).

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.

4.4.1.5 SOURCE-SPECIFIC RECALCULATIONS

2.C.1.1

Two secondary steel industries are added in the reported production figures. The increase corresponds to 12 Gg 1990 and 215 Gg 2011.

CO_2 emissions from one plant 1992-2004 are recalculated resulting in higher emissions compared to submission 2013. CO_2 from calcium carbonate has been estimated based on the production volumes for these years and the relation between the CO_2 from calcium carbonate and the production volume in 2005. As a consequence, the total CO_2 emissions for CRF 2.C.1.1 increased 0.08 Gg 1992 and 0.38 Gg 2004.

A minor error correction was made for SO_2 for the years 2010 and 2011 for one plant (about 0.002 Gg both years).

2.C.1.2
During submission 2013 it was concluded that one of the operators did not take into account any intermediate stock change of produced coke in the carbon mass balance used when calculating the CO_2 emissions, i.e. large amounts of carbon assumed to be released into the atmosphere was actually stored in the coke stocks. For submission 2014 the operator has delivered a revised time series, 2005-2012, of CO_2 emissions allocated on different sub-categories (CRF 1.A.1.c, 1.A.2.a, 1.B.1.c and 2.C.1.2). The current calculation model (see section 4.4.1.2.2) has been updated according to the new information from the operator. Due to the fact that an average CO_2 IEF 2003-2007 is used in the calculation model to calculate the CO_2 emissions and the amounts of derived energy gases (and thus CH_4, N_2O, NMVOC and CO emissions) for 1990-2002, the new information also affects the reported emissions for previous years.

Figure 4.9 shows, for both integrated iron and steel production plants, total greenhouse gas (GHG) emissions (ktonnes CO_2 equivalent) reported 1990-2012 in submission 2013 and the revised GHG emissions suggested for submission 2014. The largest revisions in emissions are found for 1990-1995 and 2011 (Figure 4.9). Adding of emissions from sinter production 1990-1995 led to increased GHG emissions by about 3-7% of the total emissions from integrated iron and steel production. The recalculated CO_2 emissions 2005-2011 due to the exclusion of intermediate storage of coke from the carbon mass balance led to large changes in 2011 (about 9%) and minor differences 2005-2010 (about 1%). The changes in CO_2 emissions 2005-2007 affected the calculation model for all GHG emissions for 1990-2002 although these recalculations had minor impact on the emission levels (less than 1%). However it should be noted that as a consequence of the revision of the average CO_2 IEF (2003-2007) on the sub-category level (CRF 1.A.1.c, 1.A.2.a, 1.B.1.c and 2.C.1.2), the recalculation in percent per each sub-category can be significant.

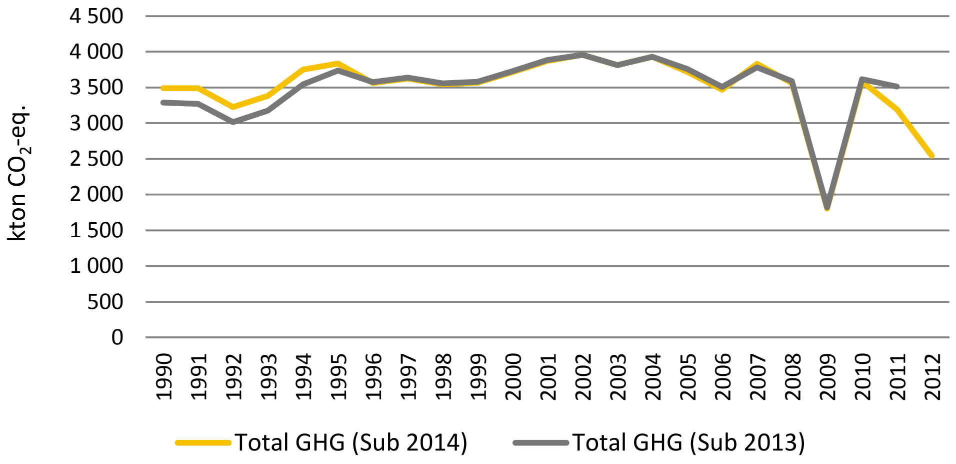

Figure 4.9. Integrated iron and steel production, total GHG emissions (ktonnes) reported 1990-2012 in submission 2013 and the revised GHG emissions suggested for submission 2014

Due to the recalculation, reported GHG emissions in 2.C.1.2 1990 - 2010 vary between -4 tonnes 5% per year and for 2011 the GHG emissions are reduced by 12%.

2.C.1.3
In submission 2014 it was concluded that emissions of CO_2 and CH_4 from sinter production at one facility were missing in the calculations for the years 1990-1995. Consequently emissions of CO_2 and CH_4 have been included in the calculations for this period in submission 2014. The corrections amount to an average increase of CO_2 emissions of 7900% over the period 1990-1995 and a change of reported CH_4 emissions from notation key NE to an average of 0.7 Gg compared to submission 2013.

SO_2 emissions were corrected for 2011 resulting in slightly lower emissions compared to submission 2013.

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 Ferroalloy production (CRF 2.C.2)

4.4.2.1 SOURCE CATEGORY DESCRIPTION

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 CRF 2.C.1- Iron and steel production. The production of iron silicide has decreased sharply since 2005, and between 2008 - 2011 there was no production at all. This led to zero emissions of CH_4 during these years. Production of ferrosilicon leads to larger emissions of SO_2 compared to production of ferrochromium. From 2005 the production of ferrosilicon has been much reduced and during 2008 - 2011 no ferrosilicon was produced. This led to a distinct decrease in SO_2 emissions during these years. In 2012 the production of ferrosilicon started again which again resulted in high emissions of SO_2. The economic recession in 2009 had a great effect on the production volumes of ferroalloys in Sweden and thus the emissions 2009 are significantly reduced.

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 4.28.

Table 4.28. Summary of source category description, CRF 2.C.2

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.C.2	CO_2				T2	PS	Yes
	CH_4				D	D	Yes
	N_2O	NA	NA		NA	NA	NA

D Default. T2 Tier 2. PS Plant-specific.

4.4.2.2 METHODOLOGICAL ISSUES

CO_2 emissions within the production of ferroalloys are plant specific (in line with Tier 2). The CO_2 emissions reported by the plant are calculated from consumed amount of reducing agents (Tier 1a[137]), i.e. electrodes and coke (and in 2003 coal) and their specific carbon contents. Input data is also the amount of carbon bound in produced ferroalloys. The common distribution of carbon in the incoming and outgoing materials is:

Coke	+	Electrodes	→	Ferroalloys	+	Emissions	+	Particles
95%	+	5%	→	10%	+	89.5%	+	0.5%

137 http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch2wb2.pdf

To verify the emissions reported by the plant, emissions are calculated from activity data on coal, coke, electrodes and the amount of carbon in produced ferroalloys and:

- Emission factors and thermal values used for stationary combustion for coke and coal and information from the company that the electrodes contain 90 % carbon.
- IPCC default factors for coal, coke and electrodes[138].

The used formula is:

$$CO_2\ (Mg) = Coke\ (Mg) \times EF \times Thermal\ value + Coal\ (Mg) \times EF \times Thermal\ value$$
$$+ Electrode (Mg) \times C\text{-}content \times \frac{44}{12} - CO_2\ in\ produced\ ferroalloys\ (Mg, plant\ data)$$

where 44/12 are the molecule weights of CO_2 and carbon. As can be seen in Table 4.29, there are differences in the plant specific data and 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 the coke may vary from one year to another.

The total amount of carbon in the produced ferroalloys is presented in Table 4.30, and is calculated based on the carbon content in coke, coal, electrodes and dust by the company. The amount of carbon in the produced ferroalloys varies between 0.1 % and 7 %. This carbon is reported under CRF 1.AD.10 - coke and coal. CH_4 emissions from production of FeSi alloys are reported from submission 2010 and calculated based on FeSi alloy production (Tier 2[139])

Data on non-CO_2 emissions has been obtained directly from the company for the whole time series. The reported emissions include NO_X and SO_2 from the process.

[138] IPCC. Revised 1996 Guidelines for National Greenhouse Gas Inventories: Reference Manual, Table 2.12.

[139] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 4.8

Table 4.29. Total emissions of CO_2 based on plant specific data (reported in the CRF), data based on Swedish EF and thermal values, and based on IPCC Guidelines default values

Year	Plant specific data, Gg CO_2	Swedish values, Gg CO_2	IPCC default values, Gg CO_2
1990	243	244	263
1995	265	274	295
2000	240	266	287
2005	225	215	231
2006	220	209	225
2007	220	188	203
2008	194	164	177
2009	48	48	52
2010	107	96	104
2011	117	122	132
2012	101	100	108

Table 4.30. Total amount of carbon bound in produced ferroalloys

Year	Carbon in ferroalloys, Gg
1990	8.4
1995	8.7
2000	9.5
2005	8.0
2006	8.3
2007	8.4
2008	7.4
2009	1.8
2010	4.0
2011	4.7
2012	2.2

4.4.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties in this category have little impact on the estimated national total emission uncertainty. Emission uncertainties of CO_2 are judged by SMED expertise to be low at ± 5% as plant-specific values and Swedish default values give similar results.

Time-series are considered to be consistent.

4.4.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

As presented in Table 4.29 verification of CO_2 emissions reported by the plant is obtained as calculated Swedish default values give similar results.

4.4.2.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed.

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 Aluminium production (CRF 2.C.3)

4.4.3.1 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. In 2012, 56 closed prebake cells in plant 1 and 242 closed prebake cells were in operation.

From 2008, when all Söderberg cells were shut down, these pot-lines have gradually been replaced by closed prebake cells. During the conversion from Söderberg to prebake technology there have been start-up problems causing increased PFC emissions.

The time series of emissions compiled for primary aluminium production include emissions of CO_2, PFCs, NO_X, CO, NMVOC and SO_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 4.31. An overview of the rationale for data sources used for key categories in the industrial processes sector is presented in Annex 3.6.

Table 4.31. Summary of source category description, CRF 2.C.3

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.C.3	CO_2				T2	PS	Yes
	CH_4	NA	NA		NA	NA	No, see Annex 5
	PFCs		X		T2	D	Yes

D Default. T2 Tier 2. PS Plant-specific.

4.4.3.2 METHODOLOGICAL ISSUES

Reported production statistics and emissions data are based on information in the environmental reports or received directly from the company.

Emission data for CO_2 from the production of primary aluminium 2002 - 2012 are derived through measurements and reported directly by the plants, whereas the emissions for 1990-2001 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. The formula used for CO_2 (Mg) for 1990-2001 is:

$$Mass\ anodes\ (100\%\ C) \times \frac{44}{12} \times (1 - 0.257^*)$$

* Mass CO_2 bound in soot and rest anodes in 2002

The value for carbon bound in soot and rest anodes (0.257) is based on the reported value for 2002. For subsequent years the amounts bound in soot and rest anodes vary between 0.181 and 0.298. The low IEF for 1992 might be explained by the use of a too high percentage of carbon bound in soot and rest anodes. Apart from 2002, the variation in IEF between years is small (-4% to 4%).

For the years from 2002 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. The results are very comparable.

The carbon bound in soot is not emitted to the atmosphere as CO_2, and it is therefore excluded in the reported CO_2 emissions in 2.C.3. Therefore, the IEF values in the Swedish inventory are lower than the IPCC Guidelines default emission factors for prebaked and Söderberg (1.8 and 1.5 Gg CO_2/Gg produced Al) (Table 4.32).

Table 4.32. Implied emission factor for CO_2 for the production of aluminium

Year	Aluminium production Gg	Emissions of CO_2 Gg	IEF Gg CO_2/Gg Al
1990	96	133	1.4
1995	94	129	1.4
2000	101	145	1.4
2005	103	144	1.4
2006	102	142	1.4
2007	100	140	1.4
2008	82	114	1.4
2009	70	98	1.4
2010	96	135	1.4
2011	113	159	1.4
2012	131	200	1.4

The two different processes for aluminium production, prebaked (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.

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 prebaked and Söderberg processes. The reported emissions and calculated Implied Emission Factors are presented in Table 4.33.

Table 4.33. Activity data, emissions of C_2F_8, CF_4 and calculated IEF for aluminium production

Year	Al production, CWPB, Gg	Al production, VSS, Gg	Total emissions, C_2F_6 Mg	Total emissions, CF_4 Mg	Calculated IEF			
					CWPB kg C_2F_6/Mg	VSS kg C_2F_6/Mg	CWPB kg CF_4/Mg	VSS kg CF_4/Mg
1990	23.4	72.9	3.05	53.66	0.0443	0.0276	0.3444	0.6255
1995	22.8	71.2	2.29	48.25	0.0106	0.0287	0.0827	0.6510
2000	23.0	78.1	1.57	33.58	0.0059	0.0184	0.0460	0.4165
2005	23.6	78.9	1.66	36.93	0.0022	0.0204	0.0171	0.4629
2006	23.6	78.1	1.59	35.21	0.0024	0.0196	0.0188	0.4453
2007	23.3	76.5	1.61	35.54	0.0026	0.0202	0.0205	0.4583
2008	29.6	52.0	1.83	31.74	0.0223	0.0226	0.1737	0.5113
2009	69.7	-	0.56	4.36	0.0080	-	0.0625	-
2010	96.1	-	2.62	20.36	0.0272	-	0.2118	-
2011	113.3	-	3.02	23.49	0.0267	-	0.2073	-
2012	130.8	-	1.09	8.49	0.0083	-	0.0649	-

Reported emissions of NO_X are calculated from production statistics using emission factors defined by Swedish EPA[140]. NMVOC emissions are calculated from reported emissions of tar, assuming that 70 % of the tar is emitted as NMVOC[140]. Closing down the Söderberg ovens also eliminated the need for anode production in late 2008. The shut down of the anode production ended the tar emissions and consequently also the NMVOC emissions. From 2009 and onwards NMVOC emissions are thus reported as NA. CO emissions were for the first time reported in submission 2008 and are for 2002 - 2012 as reported in the company's environmental reports. For the period 1990 – 2001, the CO emissions are calculated based on production statistics and emission factors provided by the company as also for the SO_2 emissions during 1990 - 2005. For later years SO_2 emissions data are based on environmental reports published by the company.

The elevated SO_2 emission in 2012 is primarily due to high sulphur content of delivered anodes. The desulfurization of flue gases in the flue gas treatment facilities has not been sufficiently efficient. Also the CO emissions are higher for 2012 compared to previous years. The reason for this is, according to the company, that a new calculation method has been used for 2012.

4.4.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As can be seen in Table 4.33 the IEFs show a downward trend from 1990 to 2007, especially so for CF_4. This reflects the company's on-going work aiming to reduce

[140] Ahmadzai, H. Swedish EPA. Personal communication. 2000.

the time and frequency of the anode minutes. Between 2008 and 2011 the Söderberg pot-lines have gradually been 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 lead 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.

The shutdown of Söderberg ovens explains the very large decline in PFC emissions in 2009 (-85% compared to 2008) (Figure 4.10). Also the reported CO_2 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.

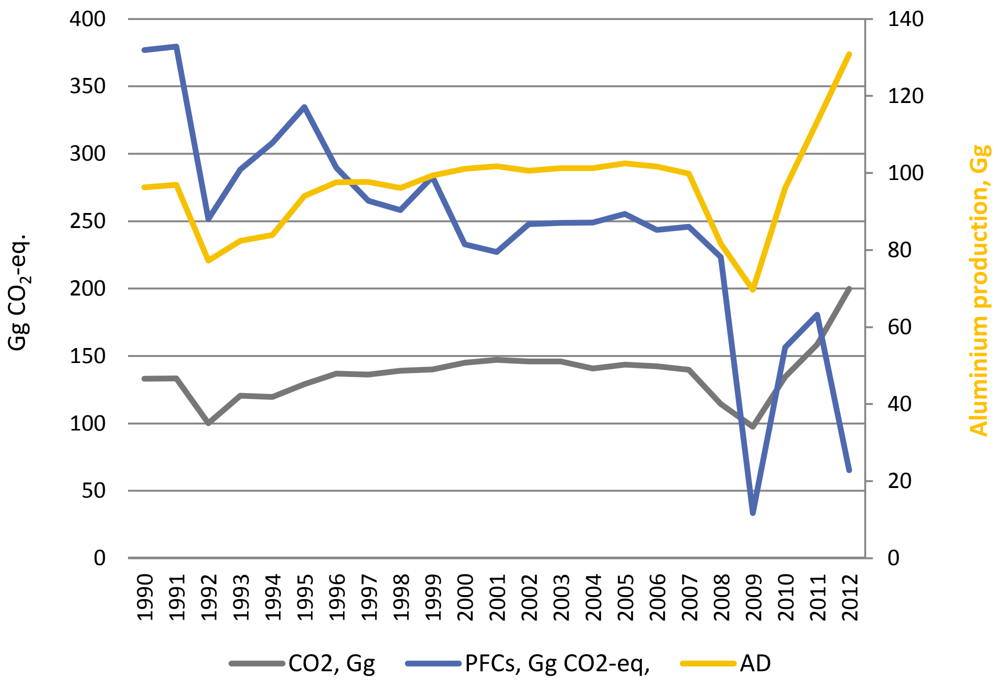

Figure 4.10. Time series for CO_2 and PCF emissions and produced amounts of primary aluminium in CRF 2.C.3

The reported time series are considered to be consistent.

4.4.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The implied emission factors för CO_2 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.

4.4.3.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed.

4.4.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.4.4 SF6 used in aluminium and magnesium foundries (CRF 2.C.4)

4.4.4.1 SOURCE CATEGORY DESCRIPTION

In Sweden, four magnesium foundries use SF_6 as a cover gas. No SF_6 is used in aluminium foundries (CRF 2.C.4.1) as far as known, and thus reported as 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 4.34.

Table 4.34. Summary of source category description, CRF 2.C.4

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.C.4	SF_6				D	D	Yes

D Default.

4.4.4.2 METHODOLOGICAL ISSUES

The total amount of SF_6 used annually in the magnesium foundries (CRF 2.C.4.2) is reported as emissions, according to the IPCC Guidelines and Good Practice Guidance. Data is obtained from companies using SF_6.

4.4.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

In submissions prior to Submission 2014 the total uncertainty in CRF 2.C.4 were ± 40%. After comments from Expert Review Team during an In Country Review in September 2013, the uncertainty estimate has been revised. For the three sites where the data is obtained directly from the companies an uncertainty of 5% is applied, according to data in the Good Practice Guidance. For the "unknown" plant a much higher uncertainty is applied. The total uncertainty has thus been estimated for CRF 2.C.4 to ± 20%. Time series are considered to be consistent.

4.4.4.4 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.

4.4.4.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed.

4.4.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.4.5 Other metal production (CRF 2.C.5)

4.4.5.1 SOURCE CATEGORY DESCRIPTION

This sub-category includes CO_2, NO_X and SO_2 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 4.35.

Table 4.35. Summary of source category description, CRF 2.C.5.

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.C.5	CO_2				D	PS	Yes
	CH_4	NA	NA		NA	NA	No, see Annex 5

D Default. CS Country Specific.

4.4.5.2 METHODOLOGICAL ISSUES

Emissions of CO_2 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.

CO_2 emissions from the smelter are calculated based on the amounts of coke, coal, limestone, plastics and other raw material used in the production. The company directly reports these activity as well as carbon content in slag products. The emissions from coal and coke are calculated based on national thermal values (TV) and emission factors (EF). IPCC default value is used for CO_2 emissions from limestone. The equation used for the smelter is:

$$CO_2\,(Mg) = Coke\,(Mg) \times EF \times Thermal\ value + Coal\,(Mg) \times EF \times Thermal\ value$$
$$+ Limestone\,(Mg) \times 0.97 \times \frac{44.0098}{100.0892} + C\ in\ raw\ material\ and\ plastics\,(Mg) \times \frac{44}{12}$$
$$- Slag\,(Mg) \times 0.0002 \times \frac{44}{12}$$

The metal recycling plant emits CO_2 from the melting of lead batteries composed of carbon containing plastics (polypropene). The total CO_2 emissions from the plant are reported by the company for all years from 1990. For the years 1990 to 2003 the reported total CO_2 emissions also include energy related emissions. From 2004 the amount of plastics, their carbon content, as well as the CO_2 emission from plastics are known. This information for 2004 is used for estimating the process related CO_2 part of the total CO_2 emissions from the plant for the years 1990 until 2003. Also CO_2 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 SO_2 originate from the sulphur content in the raw materials used.

4.4.5.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Time-series are considered to be consistent.

4.4.5.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Both plants in this category report their emissions in yearly environmental reports. For the one plant included in the EU-ETS the reported activity data and emissions are analysed and compared to EU-ETS data. Where EU ETS data is judged to be appropriate and in line with the Good Practice Guidance, it is applied. More information on QC activities related to EU ETS is included in Annex 8.1.

4.4.5.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed.

4.4.5.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.5 Other production (CRF 2.D)

Other production covers emissions from the pulp and paper industry (2.D.1) as well as estimates from the production of food and drink (2.D.2). Emissions of fossil CO_2 are not estimated for this sector. According to the IPCC Guidelines Reference Manual, emissions of fossil CO_2 from this sector are not likely.

4.5.1 Pulp and paper (CRF 2.D.1)

4.5.1.1 SOURCE CATEGORY DESCRIPTION

The pulp and paper industry in Sweden is an important source of industrial process emissions. Emissions from approximately 45 individual pulp and paper facilities were reported before 2002. After 2002 four facilities were closed down and for 2012 emissions from 40 individual pulp and paper facilities are included in the reported emissions. The Kraft process (sulphate) dominates in Sweden but there are also emissions from four sulphite facilities and 10 facilities that are mainly CTMP (Chemo Thermo Mechanical Pulp) or TMP (Thermo Mechanical Pulp) facilities reported in CRF 2.D.

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 4.36.

Table 4.36. Summary of source category description, CRF 2.D.1

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.D.1	CO_2	NA	NA		NA	NA	NA
	CH_4				CS	CS	Yes
	N_2O				CS	CS	Yes

CS Country Specific.

4.5.1.2 METHODOLOGICAL ISSUES

Reported emissions from the pulp and paper industry are primarily based on information about 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 reported emissions of NMVOC do not include therpenes.

The Swedish definition of process emissions includes the combustion of spent cooking liquor which gives rise to emissions of N_2O and CH_4. The cooking liquor contains organic compounds and chemicals and is combusted to recover Na and S, but also to utilise the energy in the cooking liquor. The recovered Na and S (as Na_2CO_3 and Na_2S) are recycled and used in the process again.

The estimated process emissions of CO_2 from quick lime production within this industry are allocated in CRF 2.A.2.

4.5.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainty in activity data is ± 5% and uncertainty in emission factors (CH_4 and N_2O) are ± 20%.

4.5.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

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

4.5.1.5 SOURCE-SPECIFIC RECALCULATIONS

Minor corrections affecting NO_X emissions in 2011, SO_2 emissions in 2011 and NMVOC in 2009 have been made.

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 Food and drink (CRF 2.D.2)

4.5.2.1 SOURCE CATEGORY DESCRIPTION

The food and drink industry is a moderate source of NMVOC 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. Greenhouse gas emissions have not been estimated due to the lack of available methodology and data. Emissions of greenhouse gases are however considered to be 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 4.37.

Table 4.37. Summary of source category description, CRF 2.D.2

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.D.2	CO_2	NA	NA		NA	NA	No, see Annex 5
	CH_4	NA	NA		NA	NA	NA
	N_2O	NA	NA		NA	NA	NA

4.5.2.2 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 amount[141] together with figures on import and export[142]. NMVOC emissions from

[141] Systembolaget. Försäljningsstatistik. http://www.systembolaget.se/

[142] Statistics Sweden. http://www.scb.se/

beer production are based on the Swedish annual total production of beer[143] [144]. 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 available at Statistics Sweden's website. For the NMVOC emission estimates, emission factors presented in Table 4.38 were used. Emissions of CO_2 are not estimated but are believed to be minor or of biogenic origin.

Table 4.38. NMVOC emission factors for the reported production activities in CRF 2.D.2 - Food and drink

Production activity	Emission factor	Unit	Reference
Wine	0.8	kg/1000 litres	141
Beer	0.35	kg/1000 litres	144
Liquors	0.6	kg/1000 litres	EF based on emission and activity data from one producer, 2001
Bread (sponge dough)	8	kg/Mg	142
Bread (white)	4.5	kg/Mg	142
Bread (whole meal and light rye)	3	kg/Mg	142
Bread (dark rye)	0	kg/Mg	142
Cakes	0.1	kg/Mg	142
Biscuits	0.1	kg/Mg	142
Breakfast cereals	0.1	kg/Mg	142
Sugar	10	kg/Mg	142
Yeast	18	kg/Mg	142
Margarine and solid cooking fats	10	kg/Mg	142
Coffee roasting	0.55	kg/Mg	142
Animal feed	0.1	kg/Mg	142

4.5.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The time series is consistent.

4.5.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

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

4.5.2.5 SOURCE-SPECIFIC RECALCULATIONS

Activity data, thus affecting reported NMVOC emissions, have been updated for:

- Beer: Produced amount 2010-2011
- Bread (sponge dough): Produced amount 2011
- Bread (white): Produced amount 2011
- Bread (dark rye): Produced amount 2011
- Cakes: Produced amounts 2011
- Biscuits: Produced amounts 2011

[143] Carlsberg Sweden. http://www.carlsberg.se

[144] Bryggeriföreningen. http://sverigesbryggerier.se

- Breakfast cereals: Produced amounts 2011
- Sugar: Produced amounts 2011
- Margarine and solid cooking fats: Produced amounts 2011
- Animal feed: Produced amounts for 2011
- Coffee roasting: Produced amounts 2011
- Yeast: Produced amounts 2011.

The recalculations resulted in changes in NMVOC emissions of about ±0.1 Gg 2010-2011.

4.5.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.6 Production of Halocarbons and SF6 (CRF 2.E)

Production of halocarbons and SF_6 does not occur in Sweden.

4.7 Consumption of Halocarbons and SF_6 (CRF 2.F)

Use and emissions of halocarbons have increased since 1990, especially in refrigeration and air-conditioning equipment, which is the major source of halocarbon emissions in Sweden in later years. The second largest source in 2012 is foam blowing (XPS-foam), followed by electrical equipment and aerosols. All remaining sources are comparatively small emitters of fluorinated greenhouse gases.

All sub-categories are covered in the estimates except solvents (2.F.5) According to the information available, solvents containing HFCs or PFCs are not used in Sweden.

An overview of actual reported emissions in CRF 2F are shown in Table 4.39.

Table 4.39. Overview of submitted actual emissions data, Gg CO_2 equivalents

CRF	Category	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012
2.F.1	Refrig.and air conditioning equipment	3	125	431	671	717	755	785	801	785	751	708
2.F.2	Foam blowing	NO	NO	111	87	74	54	51	40	32	37	35
2.F.3	Fire extinguishers	NO	NO	5	6	6	6	8	6	6	6	6
2.F.4	Aerosols/Metered dose inhalers	1	7	22	29	24	26	26	26	28	29	28
2.F.5	Solvents	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F.6	Other use of ODS substitutes	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F.7	Semiconductor manufacture	NA	11	8	NO	NO	NO	NO	NO	NO	NO	NO
2.F.8	Electrical equipment	81	95	32	28	22	29	28	44	30	30	28
2.F.9	Other	2	3	8	14	12	9	8	8	8	5	3

In estimating the actual emissions in all subcategories, as far as possible, a national model has been used, corresponding to the IPCC Tier 2 approach. The basis for the emission estimates are 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 included in products imported to or exported from Sweden (e.g. air-air heat pumps). In order to make a complete reporting of fluorinated greenhouse gas emissions and, as far as possible, to facilitate allocation of emissions onto 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 4.11 below.

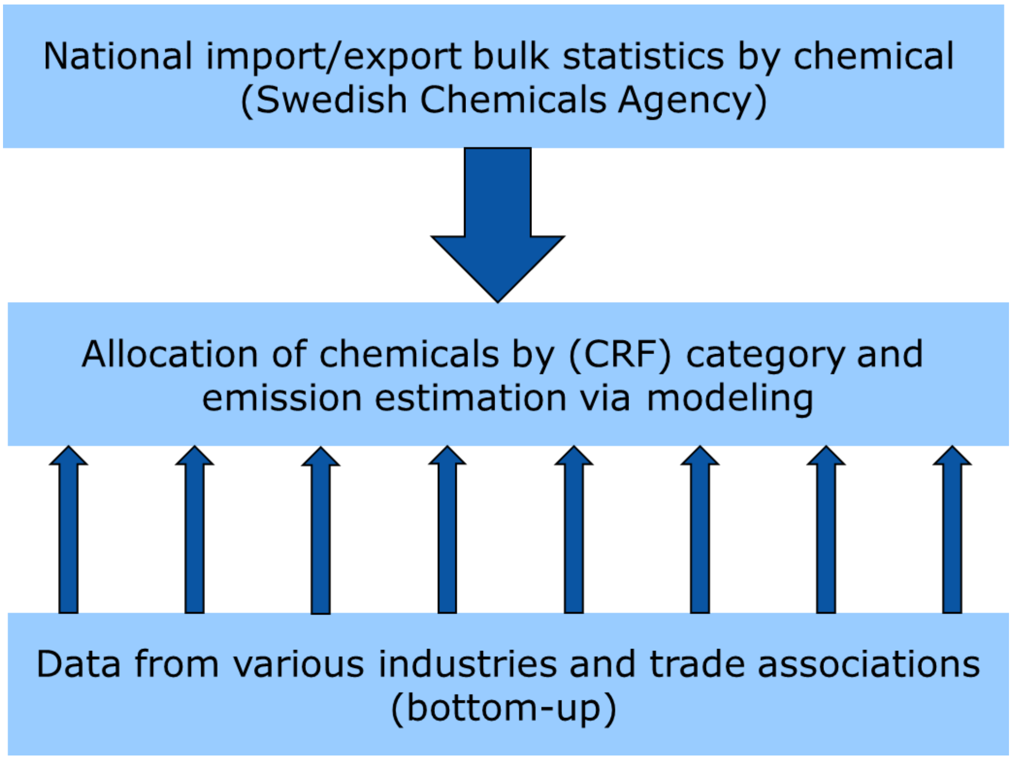

Figure 4.11. Schematic illustration of the Swedish national model used for estimation of emissions of fluorinated greenhouse gases

Based on an earlier inventory model on actual emissions of fluorinated greenhouse gases in Sweden covering the time period 1990-1999[145], in 2005, the model was updated and refined e.g. concerning the calculations from the accumulated bank [146]. The model takes into consideration changes in accumulated amounts each year

[145] Kindbom, K., Haeger Eugensson, M. and Persson, K. 2001. Kartläggning och beräkning av potentiella och faktiska utsläpp HFC, FC och SF6 i Sverige. IVL B-1428.

[146] Kindbom, K. 2005. Revision of Methodology and Estimated Emissions of Fluorinated greenhouse Gases in Sweden. Report Series SMED Nr 16 2005, www.smed.se

resulting from additional amounts of HFC, PFC and SF_6 imported and used within the country, as well as the decline in accumulated stock caused by exports or emissions from operating systems. In 2011, a SMED study[147] has been carried out to analyze the model's flexibility to adapt to the newly introduced international and national legislations on fluorinated greenhouse gases. In addition, the study aimed at updating model factors using available information, but also to analyze the accuracy of the estimates of e.g. emissions from disposal. The study resulted in several recalculations for the 2012 submission, but also suggestions on future improvements. The model is described in more details in Annex 3:1.

Due to a recurring one year lag of updating of the data from the Products Register from the Swedish Chemicals Agency, data on bulk import and export in 2011 are updated. This results in revised data on actual emission estimates from stationary refrigeration and air-conditioning equipment (2.F.1), from fire extinguishers (2.F.3) and from electrical equipment (2.F.8) for 2011 due to the calculation system (as described in Annex 3:1).

4.7.1 Refrigeration and air conditioning equipment (2.F.1)

4.7.1.1 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 SF_6 from refrigeration and air conditioning equipment are not occuring (NO) in Sweden. The most important source of greenhouse gases to the category is emissions of HFC-134a from air- conditioning in cars, representing more than 50% of the total actual emissions in 2.F.1 in later years. It can been seen in Table 4-39 that emissions of HFCs and PFCs from 2.F.1 has increased from 3 Gg CO_2 equivalents 1990 to 708 Gg CO_2 equivalents 2012. The use of HFCs as refrigerants in refrigerators, freezers, heat pumps and air-conditioning equipment in vehicles (MAC) is the main reason for the large increase in emissions. In 2010, 2011 and 2012, however, the emissions of HFCs are lower compared to 2009, mainly due to reduced use of HFC-134a in MAC and other stationary refrigeration equipment. 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 4.40.

[147] 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 4.40. Summary of source category description, CRF 2.F.1

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.F.1	HFCs	X	X		CS, T2	CS, D	Yes
	PFCs				CS	CS, D	Yes
	SF_6	NA	NA		NO	NO	NO

D Default. CS Country Specific. T2 Tier 2.

4.7.1.2 METHODOLOGICAL ISSUES

Input data for the calculation of actual emissions consists of information from various sources; the Swedish Chemicals Agency, equipment producers and importers. Table 4.40 presents 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 and IPCC default values. When data from equipment producers is used it has been compared against IPCC default data and been judged as reasonable. In the recent SMED study[148], based on contacts with the Swedish road vehicles manufacturers, several factors were modified for MAC for 2010 onwards to be more in line with the present status of the Swedish road vehicle fleet.

[148] 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 4.41. Typical values on equipment lifetimes, amounts of chemical per unit and emission factors for different applications of HFCs or PFCs used in calculations of actual emissions in Sweden

Application	Fluorinated substances	Lifetime**	Amount installed /unit, kg	Emissions at manufacturing, %	Emissions per year during use, %	Remained in product at disposal, %	Emissions at disposal, %
Household fridges and freezers	HFCs	20	0.1	2***	1	90	5
Heat pumps	HFCs	20 - 15	5 - 1	1	10 - 1	90	5
Other refrigeration and air conditioning equipment	HFCs PFC-218	15	*	3.5	7 - 2.6	90	5
Refrigerated transport	HFCs	10	10 - 6	4.5	30 - 7	90	15
Mobile air-conditioning, lorries	HFCs	6	1.2	1 - 0.5	15 - 10	90	15
Mobile air-conditioning, cars	HFCs	11	0.8 - 0.7	1 - 0.5	15 - 5	90	15
Mobile air-conditioning, buses	HFCs	12	7	1 - 0.5	10	90	15

* Top-down calculations
** Lifetime means the average expected lifetime of a product, not the designed technical lifetime from its first commissioning.
*** From Revised 1996 IPCC Guidelines

In Table 4.41, intervals given indicate changes between 1990 and the last inventory year used in the calculations.
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 chemical 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-source "other stationary refrigeration". The chemicals concerned are HFC-23, HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a and PFC-218 (C_3F_8). In addition, it was discovered in the recent SMED study that imported air-air heat pumps were prefilled with the refrigerant (R410A), and thus not included in the bulk import statistics from the Swedish Chemicals Agency.

Due to that data are derived from source-independent national statistics in the Product Register, as well as from some end users, it is currently impossible to correctly fill in the CRF background data table asking for domestic, commercial and industrial applications. Consequently, industrial refrigeration as well as stationary air-conditioning have been reported as included elsewhere (IE) and the emissions are included in commercial refrigeration in CRF table 2(II) F.

4.7.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The largest contribution to the total national emission uncertainty from this category stem from HFCs from mobile air conditioner and other refrigeration. Based on SMED expert judgement AD and EF uncertainty are ±10 % and ±40 % for mobile air conditioner, and ±25 % and ±50 % for other refrigeration.

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.

4.7.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Estimates have been checked with trade associations KYS (Kylbranschens Samarbetsstiftelse) and SVEP (Svenska Värmepumpföreningen) and with experts at the Swedish EPA[149]. 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.

As HFCs from mobile air-conditioning in cars is the most influential sub-source in the category, its underlying factors are compared to IPCC default values and differences are analysed (Table 4.42). The values for car air-conditioner lifetime, charge and annual leakage were chosen based on information in IPCC Guidelines and Good Practice Guidance. The values for EF for production, remaining at decommissioning and share recovered are attained from the Swedish car manufacture Volvo and in cooperation with experts at the Swedish EPA.

Table 4.42. Comparison of IPCC default factors and Swedish factors for MAC in cars

Parameter	1996 IPCC/ update GPG	Swedish factors	Comment
Lifetime (y)	12/ 12	11	OK
Charge (kg)	0.8	0.7	OK
Annual leakage (%/year)	10 - 30/ 10 - 20	15 - 10	OK
EFproduction (%)	4 - 5/ 0.5	1 - 0.5	OK
Remaining at decommissioning (%)	75/ 40	90	High; We assume that there is continuous maintenance and refilling of the equipment
Share recovered (%)	0/ 0	85	OK according to experts at Swedish EPA

[149] Swedish EPA . Ujfalusi, Bernekorn , and Björsell. Personal communication.

4.7.1.5 SOURCE-SPECIFIC RECALCULATIONS

General: Due to a recurring one year lag in the updating of the data from the Products Register from the Swedish Chemicals Agency, data on bulk import and export in 2011 were updated. It mainly affected emissions of HFC-134a and HFC-152 in commercial refrigeration and, in total, emissions increased about 6.5 Gg CO_2 equivalents.

Calculation errors in the model have been corrected. The correction led to minor increases of reported emissions for the years 1990 - 1993 and 2004 – 2010. Also activity data for heat pumps 1994 – 2008 were updated as new, more accurate data, has been made available by SVEP (Svenska Värmepumpföreningen).

These corrections and updates led to changes in reported emissions 1990 – 2010 from a decrease of 0.03 CO_2-eq. to an increase of 2.71 Gg CO_2-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 Foam blowing (2.F.2)

4.7.2.1 SOURCE CATEGORY DESCRIPTION

This category consists of HFCs emissions from production and use of XPS foam in Sweden. Emissions of PFCs and SF_6 from foam blowing are reported as not occuring (NO). Emissions of HFCs peaked in year 2000 and have since then decreased due to reduced leakage during manufacturing, according to data from the 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 4.43.

Table 4.43. Summary of source category description, CRF 2.F.2

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.F.2	HFCs				T2	PS	Yes
	PFCs	NA	NA		NO	NO	NO
	SF_6	NA	NA		NO	NO	NO

CS Country Specific. PS Plant-specific.

4.7.2.2 METHODOLOGICAL ISSUES

Data is obtained from the producer 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. 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 4.44). Since 2008 no HFC-134a is used during manufacturing of XPS foam in Sweden. The emissions reported represent emissions from stocks and disposal.

Table 4.44. Typical values on equipment lifetimes, amounts of chemical per unit and emission factors for different applications of HFCs used in calculations of actual emissions in Sweden

Application	Fluorinated substances	Lifetime**	Amount installed /unit, kg	Emissions at manufacturing, %	Emissions per year during use	Remained in product at disposal	Emissions at disposal, %
Foam blowing (XPS)	HFCs	> 12	*	35	Declining	$	<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.

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 CRF tables contain emissions from manufacturing.

More detailed information on the methodological issues for foam blowing is presented in Annex 3:4.

4.7.2.3 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 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

The current calculation method provided by the company, used for reporting of emissions, has been compared to the Tier 2 method given in the Good Practice Guidance, see Annex 3:4.

4.7.2.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed.

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 Fire extinguishers (2.F.3)

4.7.3.1 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 SF_6 for the category are not occuring (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 4.45.

Table 4.45. Summary of source category description, CRF 2F3

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.F.3	HFCs				CS, T2	CS	Yes
	PFCs	NA	NA		NO	NO	NO
	SF_6	NA	NA		NO	NO	NO

CS Country Specific.

4.7.3.2 METHODOLOGICAL ISSUES

All imports of HFCs to be installed in fire extinguishers are registered at the Swedish Chemicals Agency. From 2001, the use of HFC-227ea in fire extinguishers has been introduced in Sweden. Data has been obtained from the companies supplying such systems (Table 4.46).

Table 4.46. Typical values on equipment lifetimes, amounts of chemical per unit and emission factors for different applications of HFCs used in calculations of actual emissions in Sweden

Application	Fluorinated substances	Lifetime**	Amount installed /unit, kg	Emissions at manufacturing, %	Emissions per year during use, %	Remained in product at disposal, %	Emissions at disposal, %
Fire extinguishing	HFCs	30	*	0.5	2 / 0.1***	9	1

* Top-down calculations
** Lifetime means the average expected lifetime of a product, not the designed technical lifetime from its first commissioning.
*** HFC-227ea 0.1 %, other HFCs 2 %.

4.7.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties are mainly associated with the exported amounts, which are relatively large.

The time series are calculated using the same methodology for all years and are thus consistent.

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

Due to the recurring one year lag in the updating of the data from the Products Register from the Swedish Chemicals Agency, data on bulk import and export in 2011 were updated. This update affects reported emissions of HFC 125 and HFC

134a in 2.F.3 and leads to a decrease of reported emissions for 2011 of 0.06 Gg CO_2-eq.

Calculation errors in the model have been corrected. The correction led to minor decreases of reported emissions for the years 2008, 2009 and 2010 (-0.001, -0.001 and -0.012 Gg CO_2-eq., respectively).

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 Aerosols/metered dose inhalers (2.F.4)

4.7.4.1 SOURCE CATEGORY DESCRIPTION

HFC may be used as propellant gas in aerosols, but also as the actual product e.g. in cleaning sprays. In asthma medication inhalers, HFC-134a (norflurane) is sometimes used as propellant gas. Emissions of PFCs and SF_6 for the category are not occuring (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 4.47.

Table 4.47. Summary of source category description, CRF 2.F.4

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.F.4	HFCs				CS, T2	D	Yes
	PFCs	NA	NA		NO	NO	NO
	SF_6	NA	NA		NO	NO	NO

D Default. CS Country Specific. T2 Tier 2.

4.7.4.2 METHODOLOGICAL ISSUES

Emission estimates cover technical aerosols as well as metered dose inhalers. The estimates consist of emissions from production of technical aerosols at one facility, and emissions from the use of imported technical aerosols and metered dose inhalers containing HFCs. The contribution from metered dose inhalers is relatively small, but has increased in later years.

The aerosol manufacturer provided information on the used amount of HFC-134a as well as emissions from production, and exported amounts of HFC-134a in products.
Table 4.48 presents the assumptions on product lifetime, emissions at manufacturing and disposal as well as remaining HFC in product at disposal.

For metered dose inhalers, statistics on the numbers of sold inhalers was, for the years 1990 until 2008, received from the Swedish retailer for medical products, Apoteket. From 2009 and onwards the corresponding information have been received from the company Pharmacy Service AB. Information concerning the content of HFC in the inhalers was provided by the Swedish Medical Products Agency. From 2010 this information is considered to be confidential. Therefore, for new products the highest amount of HFCs in products are applied in order to minimize the risk of underestimation of the emissions.

Table 4.48. Typical values on equipment lifetimes, amounts of chemical per unit and emission factors for different applications of HFCs used in calculations of actual emissions in Sweden

Application	Fluorinated substances	Lifetime**	Amount installed /unit, kg	Emissions at manufacturing	Emissions per year during use, %	Remained in product at disposal, %	Emissions at disposal, %
Aerosols/ MDI	HFCs	2	*	NA	50	50	100

* Top-down calculations
** Lifetime means the average expected lifetime of a product, not the designed technical lifetime from its first commissioning.

4.7.4.3 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. The majority 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 activity data also includes estimates of e.g. Novelty aerosols.

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 time series are calculated using the same methodology for all years and are thus consistent.

4.7.4.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Data and information from the Products Register, hosted by the Swedish Chemicals Agency, could not be used directly for validation and reporting purposes due to confidentiality.

4.7.4.5 SOURCE-SPECIFIC RECALCULATIONS

Updated activity data for metered dose inhalers led to recalculations for 2007 – 2011. The update led to increases of reported emissions of 0.09, 0.20, 0.37, 0.62 and 0.68 Gg CO_2-eq. respectively)

4.7.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.7.5 Solvents (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.

4.7.6 Other applications using ODS substitutes (2.F.6)

No other applications are covered in the Swedish inventory.

4.7.7 Semiconductor manufacture (2.F.7)

4.7.7.1 SOURCE CATEGORY DESCRIPTION

HFC, PFC and SF_6 are used in the semiconductor manufacturing process. Semiconductor manufacture has in recent 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 4.49.

Table 4.49. Summary of source category description, CRF 2.F.7

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.F.7	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

4.7.7.2 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 by using the Good Practice Guidance Tier 1 method (top-down calculations) using an average expected lifetime of 1 year.

4.7.7.3 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 time series are calculated using the same methodology for all years and are thus consistent.

4.7.7.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Cross-references with the Products Register at the Swedish Chemicals Agency could not be made for later years, since the level of detail in the Products Register was insufficient.

4.7.7.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed.

4.7.7.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.7.8 Electrical equipment (2.F.8)

4.7.8.1 SOURCE CATEGORY DESCRIPTION

In Sweden, emissions of SF_6 from electrical equipment consist of two different parts, emissions from the production of gas-insulated switchgear (GIS), and emissions from SF_6 installed in distribution systems. Emissions of HFCs and PFCs are not occuring (NO) for this category.

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 4.50.

Table 4.50. Summary of source category description, CRF 2.F.8

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.F.8	HFCs	NA	NA		NO	NO	NO
	PFCs	NA	NA		NO	NO	NO
	SF_6				CS	CS, T2	Yes

D Default. CS Country Specific. PS Plant-specific.

4.7.8.2 METHODOLOGICAL ISSUES

The larger part of annual SF_6 emissions in earlier years originated from the manufacture of GIS (Table 4.51), where emissions in 1995 and 1997 peak due to a leaking valve in 1995 and to rebuilding and accidental leakages in 1997. The SF_6 emissions from production have decreased in later years due to measures taken at the production facility. These estimates, obtained from industry, are of medium to high quality, with better quality in later years. For the early 1990s, assumptions on the emitted amounts of SF_6 from GIS manufacture were made in cooperation with industry. Industry has also provided information concerning the used amount of SF_6 for GIS manufacture (Table 4.51), as well as the share of products that are exported from the country, which exceeds 90 % of the production.

Table 4.51. Typical values on equipment lifetimes, amounts of chemical per unit and emission factors for different applications of SF_6, used in calculations of actual emissions in Sweden

Application	Fluorinated substances	Lifetime**	Amount installed /unit, kg	Emissions at manufacturing, %	Emissions per year during use, %	Remained in product at disposal	Emissions at disposal
Electrical insulation and GIS manufacture	SF_6	30	*	12 – 0.5	0.6 - 0.5	#	NO

* Top-down calculations
** Lifetime means the average expected lifetime of a product, not the designed technical lifetime from its first commissioning.
# Estimated lifetime at least 30 years.

In Table 4.51 intervals given indicate changes between 1990 and the last inventory year used in the calculations .

Emissions from installed amounts of SF_6 for insulation purposes in operating systems have previously contributed less to the actual annual emissions. In 2001-2002, a questionnaire was sent out to power companies from the trade association Swedenergy[150] (Svensk Energi) asking for the installed amounts of SF_6 in operating equipment, and the replaced amounts of SF_6 during service. The results showed an installed accumulated amount of approximately 80 Mg SF_6 and an annual leakage rate of 0.6 % (equals the amount replaced from the questionnaire) and these were used as input data in the inventory. For later years, data on replaced amounts of SF_6 in operating systems results in a calculated annual leakage rate of 0.5 % (Swedenergy and power distribution companies).

[150] Swedenergy. Matz Tapper. Personal communication. 2005.

Table 4.52. Calculated emissions and accumulated stock of SF_6 for electrical equipment

Year	Emissions from GIS manufacture SF_6 Mg	Annual losses SF_6 Mg	Accumulated stock Mg	Total emissions SF_6 Mg
1990	3.0	0.4	65.7	3.4
1995	3.5	0.5	76.0	4.0
2000	0.7	0.6	107.9	1.3
2005	0.5	0.7	143.0	1.2
2006	0.2	0.7	148.7	0.9
2007	0.4	0.8	162.9	1.2
2008	0.3	0.9	173.4	1.2
2009	0.9	0.9	185.2	1.8
2010	0.3	1.0	196.6	1.3
2011	0.2	1.0	207.8	1.2
2012	0.1	1.1	218.4	1.2

In accordance with the methodology described for deriving amounts of refrigerant chemicals not accounted for, the same procedure was adopted for SF_6. When comparing the amounts of SF_6 accounted for in various applications with data from the Products Register, a rather large annual volume of SF_6 remains unallocated (between 5 and 18 %). Sources of SF_6 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 have not been covered and are missing from the calculations.

For all sources, except as insulation in electrical equipment, the levels of annual SF_6 consumption is comparatively easy to estimate with some confidence since there are few end-users. It was thus concluded that the amounts of SF_6 not already accounted for elsewhere, most reasonably should be allocated to the electrical equipment source. However, even though information concerning SF_6 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 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 SF_6 from the Products Register, where no export at all of SF_6 is registered.

With an assumed lifetime of 30 years for gas-insulated switchgears, emissions of SF_6 from disposal will be needed to estimate within a few years.

As the question of the remaining amount of SF_6 at present could not be unambiguously solved, the unaccounted SF_6 from the Products Register was allocated to be used as electrical insulation (accumulated stock).

4.7.8.3 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 time series are calculated using the same methodology for all years and are thus consistent.

4.7.8.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

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

4.7.8.5 SOURCE-SPECIFIC RECALCULATIONS

Due to the recurring one year lag in the updating of the data from the Products Register from the Swedish Chemicals Agency, data on bulk import and export in 2011 were updated. This update affects reported emissions of SF6 in 2.F.8. Also an update of activity data (used amounts of SF_6 for GIS manufacture) led to recalculations for 2009, 2010 and 2011 in 2.F.8.

In total, reported emissions in 2.F.8 increased with 0.39 Gg CO_2-eq. in 2009 and decreased with 0.19 Gg CO_2-eq. in 2010 and 2011.

4.7.8.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.7.9 Other (2.F.9)

4.7.9.1 SOURCE CATEGORY DESCRIPTION

The estimated emissions from the use of SF_6 in jogging shoes and in sound-proof windows are reported in CRF 2.F.9. No production of SF_6-containing shoes occurs in Sweden. Since 2008 SF_6 has not been used in production of sound-proof windows.

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 4.53.

Table 4.53. Summary of source category description, CRF 2.F.9

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.F.9	HFCs	NA	NA		NO	NO	NO
	PFCs				CS	CS	Yes
	SF_6				CS	CS, D, PS	Yes

D Default. CS Country Specific. PS Plant-specific.

4.7.9.2 METHODOLOGICAL ISSUES

For jogging 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.[151] According to the results from a study performed in early 2004[152] a phasing out of SF_6 and replacement with PFC-218 was started in 2003. The lifetime for shoes is set to 8 years in the national model (Table 4.54).

Manufacturers of windows have provided data on the amount of SF_6 used in the manufacture of barrier gas windows. The manufacturers have also provided estimates of the share of SF_6 emitted in production (Table 4.54). 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 Good Practice Guidance.

Table 4.54. Typical values on equipment lifetimes, amounts of chemical per unit and emission factors for different applications of PFCs or SF_6, used in calculations of actual emissions in Sweden.

Application	Fluorinated substances	Lifetime**	Amount installed /unit, kg	Emissions at manufacturing, %	Emissions per year during use, %	Remained in product at disposal, %	Emissions at disposal, %
Sound proof windows	SF_6	30	*	5 - 50##	1	#	NO
Jogging shoes	SF_6 PFC-218	8	*	NO	NO	100	25

* Top-down calculations
** Lifetime means the average expected lifetime of a product, not the designed technical lifetime from its first commissioning.
# Estimated lifetime at least 30 years.
Different emissions at different production units.

In Table 4.54, intervals given 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 SF_6 from disposal will be needed to estimate within a few years.

[151] Weholt, Ø. 1999. Materialstrømsanalyse av SF6. Beregning av potensielt og faktisk utslipp over tid

[152] Kindbom, K. and Skårman, T. 2004. Nya scenarier för fluorerade växthusgaser. U952, Swedish EPA.

4.7.9.3 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 time series are calculated using the same methodology for all years and are thus consistent.

4.7.9.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

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

4.7.9.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed.

4.7.9.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

4.8 Consumption of Halocarbons and SF_6 Potential Emissions (CRF 2.F.P)

4.8.1 Potential emissions

Data on bulk imports and exports are obtained from the Products Register hosted by the Swedish Chemicals Agency, which did not register these substances until 1995. Estimates of potential emissions for imports and exports were, however, made for all years in the time series, 1990-2004 in a special study in 2005[153]. The method of estimating potential emissions for the following years was made accordingly.

Due to the recurring one year lag of updating of the data from the Products Register from the Swedish Chemicals Agency, data on bulk import and export in 2011 are updated. This results in revised data on potential emissions for 2011.

4.9 Other, CRF 2G

Not applicable for Sweden.

[153] Kindbom, K. 2005. Revision of Methodology and Estimated Emissions of Fluorinated Greenhouse Gases in Sweden. Report Series SMED Nr 16 2005.

5 Solvent and other product use (CRF sector 3)

5.1 Overview of sector

This chapter describes emissions from solvents and other product use. Use of solvents and products containing solvents result in emissions of non-methane volatile organic compounds (NMVOC), which is regarded as an indirect greenhouse gas as it over a period of time will oxidise to CO_2 when emitted to the atmosphere.

Estimates reported in this sector include emissions from paint application (CRF 3.A), degreasing and dry-cleaning (CRF 3.B), chemical products, manufacture and processing (CRF 3.C) and other solvent use (CRF 3.D.5). Other use of N_2O (CRF 3.D.4) includes evaporative emissions of N_2O arising from other types of product use. This includes N_2O emissions from anaesthesia and aerosol cans.

Emissions of total greenhouse gases from the solvent and other product use sector (CRF 3) have decreased by 9% from 332 Gg CO_2-eq. in 1990 to 303 Gg CO_2-eq. in 2012 (see Figure 5.1). The decline can largely be explained by a reduction in the use of solvents in CRF 3.A (paint application) due to a shift to water-based paints, which contain a smaller fraction of solvents compared to solvent-based paints.

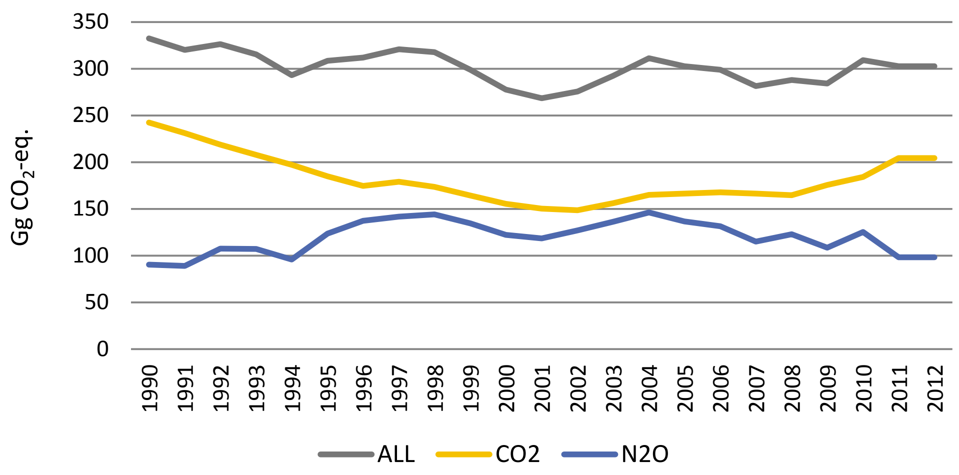

Figure 5.1. Total emissions of all greenhouse gases calculated as CO_2 equivalents from CRF 3 Solvent and Other product use

CO_2 emissions in CRF 3.A (paint application) have decreased by 59% from 94 Gg CO_2 equivalents in 1990 to 38 Gg CO_2 equivalents in 2012(Figure 5.2). The largest source of greenhouse gas emissions from solvents in CRF sector 3 is CRF 3.D (other). For emissions of CO_2 in CRF 3.D we can see an increase by 19% from 138 Gg CO_2 in 1990 to 165 Gg CO_2 in 2012. CRF 3.D (other) also consists of N_2O emissions from CRF 3.D.4 (other use of N_2O). The use of N_2O has increased with around 9% from 90 Gg CO_2 equivalents in 1990 to 98 Gg CO_2 equivalents in 2012. In total, greenhouse gas emissions in CRF 3.D have increased by 15% from 229 Gg CO_2 equivalents to 263 Gg equivalents in 2012.

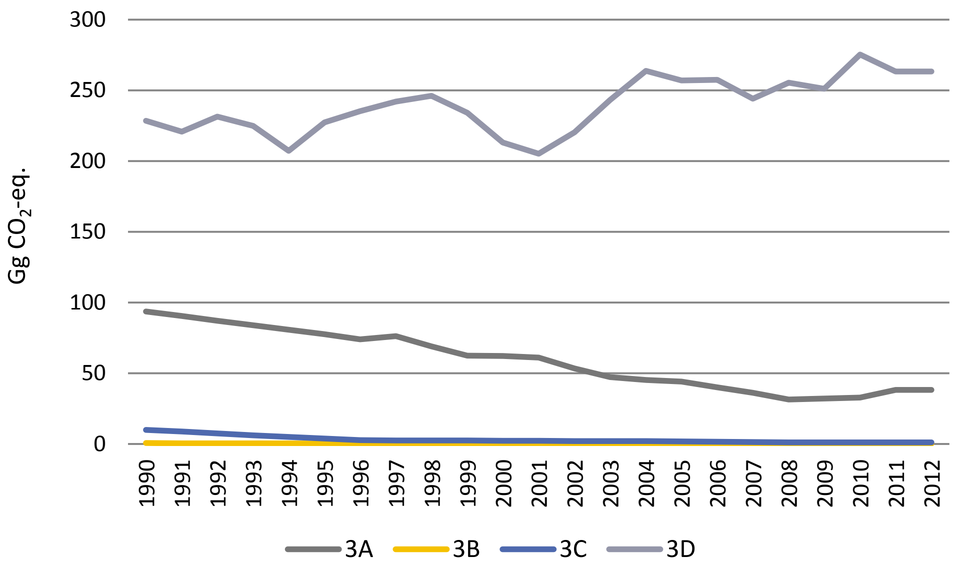

Figure 5.2. Total emissions of all greenhouse gases calculated as CO_2 equivalents from the different Solvent and Other product use sub-sectors. 3A - Paint application. 3B - Degreasing and dry-cleaning. 3C - Chemical products, manufacture and processing. 3D - Other

Table 5.1 shows the impact of recalculations reported in submission 2014 for GHG emissions by sector and sub-sectors for 1990, 1995, 2000 and 2005-2011. Detailed descriptions of the recalculations are found under sector specific sections below.

Table 5.1. Impact of recalculations of GHG emissions submission 2013 in the Solvent and Other product use sector

Impact of recalculations submission 2013 (Gg CO_2 eq.)						
CRF	3.A	3.B	3.C	3.D	Total CRF 3	% CRF 3
1990	NA	NA	NA	NA	NA	NA
1995	NA	NA	NA	NA	NA	NA
2000	NA	NA	NA	NA	NA	NA
2005	NA	NA	0	0	0	0.0%
2006	NA	NA	0	0	0	0.0%
2007	NA	NA	0	0	0	0.0%
2008	NA	NA	0	0	0	0.0%
2009	3.04	0	0.074	11.2	14.3	5.29%
2010	5.47	0	0.108	14.8	20.4	7.04%
2011	10.9	0	0.215	2.59	13.7	4.75%

0: value less than 0.05 Gg. NA: no recalculation is performed.

The model used for estimating the CO_2 and NMVOC emissions reported in sector 3 is described in detail in Annex 3.3.

5.2 Paint application (CRF 3.A)

5.2.1 Source category description

Includes paints sold for "industrial use" and for "consumer and other professional use".

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 5.2.

Table 5.2. Summary of source category description, CRF 3A

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
3.A	CO_2				CS	CS	Yes

CS Country Specific.

5.2.2 Methodological issues

All activity data from 1995 has been obtained from the Products register at the Swedish Chemicals Agency. Emissions from 1988 are taken from a time series that was compiled in a special study concerning NMVOC emissions, carried out by SMED in 2002[154]. The NMVOC emissions for 1990-1994 have been interpolated based on the information from the late 1980´s and known data for 1995. CO_2 emissions for 1990 - 1994 have been estimated using the ratio NMVOC/CO_2 for 1995 according to the Good Practice Guidance overlap method. No activity data is available for this period.

5.2.3 Uncertainties and time-series consistency

Reported time series are considered to be consistent, except for last year (2012) where data for previous year (2011) has been reported. This practice has been questioned by the ERT several times. The reason for Sweden to report activity data and emissions in CRF 3 with a delay of one year is due to the fact that activity data from the Product Register is not provided in sufficient time data to be able to perform the calculations and report in a timely manner.

[154] Kindbom, K., Boström, C-Å., Skårman, T., Gustafsson, T. and Talonpoika, M. 2003. Estimated Emissions of NMVOC in Sweden 1988-2001.

5.2.4 Source-specific QA/QC and verification

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

5.2.5 Source-specific recalculations

Due to the recurring one year lag of updating of the data from the Product Register from the Swedish Chemicals Agency and the use of moving average for compiling the NMVOC and CO_2 time series in subsector 3.A, the reported emissions for 2009 - 2011 were updated in submission 2014 (Table 5.1).

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 Degreasing and Dry cleaning (CRF 3.B)

5.3.1 Source category description

Includes solvents sold to the laundry and dry cleaning industry. Degreasing is included in CRF 3D.

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 inTable 5.3.

Table 5.3. Summary of source category description, CRF 3B

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
3.B	CO_2				CS	CS	Yes

CS Country Specific.

5.3.2 Methodological issues

All activity data from 1995 has been obtained from the Products Register at the Swedish Chemicals Agency. Emission data for 1988 is based on reported quantities of tetrachloroethylene from the Swedish Chemicals Agency. After 1995 also other substances for degreasing and dry cleaning are included. Of the total amount of NMVOC used within CRF 3B these “non tetrachloretylene” substances contribute approximately 30%. As not only tetrachloroethylene is included in the time series after 1995, the NMVOC emissions reported 1988 is recalculated using a correction factor based on the proportion of other NMVOCs of the total NMVOC for 1995 (tetrachloroethylene plus 30 %). NMVOC emissions between 1990 and 1994 have been interpolated based on the information from the late 1980´s and known data for 1995

5.3.3 Uncertainties and time-series consistency

Reported time series are considered to be consistent, except for last year (2012) where data for previous year (2011) has been reported. This practice has been questioned by the ERT several times. The reason for Sweden to report activity data and emissions in CRF 3 with a delay of one year is due to the fact that activity data from the Product Register is not provided in sufficient time data to be able to perform the calculations and report in a timely manner.

5.3.4 Source-specific QA/QC and verification

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

5.3.5 Source-specific recalculations

Due to the recurring one year lag of updating of the data from the Product Register from the Swedish Chemicals Agency and the use of moving average for compiling the NMVOC and CO_2 time series in subsector 3.B, the reported emissions for 2009 - 2011 were updated in submission 2014 (Table 5.1).

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.

5.4 Chemical products, Manufacture and Processing (CRF 3.C)

5.4.1 Source category description

Includes solvents sold for car manufacturing, paint industry and rubber industry.

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 5.4.

Table 5.4. Summary of source category description, CRF 3C

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
3.C	CO_2				CS	CS	Yes

CS Country Specific.

5.4.2 Methodological issues

The category includes emissions from car manufacturing, paint industry and from rubber industry. Emissions from car manufacturing contributed in 2005 by approximately 50%, paint industry by 35 % and rubber industry by 15 % of the reported emissions in CRF 3C. The corresponding figures for 2012 are 30 %, 43 % and 27 %, respectively. NMVOC emission data for car manufacturing has been compiled from environmental reports for 1990 and data for 1991-1994 has been interpolated. For paint industry emission data for 1990-1994 has been taken from the old time series given in a special study concerning NMVOC emissions, carried out by SMED in 2002[154]. Emission data for the rubber industry is known for 1988[154] and data for 1990-1994 have been interpolated based on the information from the late 1980´s and known data for 1995. CO_2 emissions for 1990 - 1994 have been estimated using the ratio NMVOC/CO_2 for 1995 according to the Good Practice Guidance overlap method. No activity data is available for this period.

5.4.3 Uncertainties and time-series consistency

Reported time series are considered to be consistent, except for last year (2012) where data for previous year (2011) has been reported. This practice has been questioned by the ERT several times. The reason for Sweden to report activity data and emissions in CRF 3 with a delay of one year is due to the fact that activity data from the Product Register is not provided in sufficient time data to be able to perform the calculations and report in a timely manner.

5.4.4 Source-specific QA/QC and verification

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

5.4.5 Source-specific recalculations

Due to the recurring one year lag of updating of the data from the Product Register from the Swedish Chemicals Agency and the use of moving average for compiling the NMVOC and CO_2 time series in subsector 3.C, the reported emissions for 2009 - 2011 were updated in submission 2014.
Minor corrections in CRF 3.C in the calculation model affect slightly reported emissions and activity data for 2004 – 2010 (Table 5.1).

5.4.6 Source-specific planned improvements

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

5.5 Other (CRF 3.D)

5.5.1 Source category description

All data concerning solvents, NMVOC and CO_2, are reported in CRF 3.D.5. CRF 3.D.5 includes solvents sold to the printing industry, for preservation of wood, to leather industry and to textile industry. The code also includes solvents used by other industries not reported separately, and solvents for domestic use. In CRF 3.D.4 sold amounts and use of N_2O are reported. Due to confidentiality, data for 3.D.1 - Use of N_2O for Anaesthesia and 3.D.3 – N_2O from Aerosol cans cannot be reported separately. N_2O for use in fire extinguishers is not occurring in Sweden and thus reported as 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), are presented inTable .5.5.

Table 5.5. Summary of source category description, CRF 3D

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
3.D	CO_2				CS	CS	Yes
3.D	N_2O				CS	CS	Yes

CS Country Specific.

5.5.2 Methodological issues

Solvents used in printing industry, for preservation of wood, in leather industry and in textile industry have been estimated separately. The code also includes solvents used by other industries not reported separately, and also solvents for domestic use. The printing industry contributes to totally reported CO_2 and NMVOC in CRF 3.D by around 8 %. The corresponding figure for preservation of wood and leather and textile industry is below 1%, while general solvent use represents over 90% of the total reported emissions in CRF 3D. NMVOC emission data for 1988 is known for most industries included in CRF 3D and in most cases the emissions for 1990-1994 have been interpolated based on information from the late 1980´s and known data for 1995. CO_2 emissions for 1990 - 1994 have been estimated using the ratio NMVOC/CO_2 for 1995 according to the Good Practice Guidance overlap method. For the years before 1996 no activity data is available.

There are two companies in Sweden selling N_2O 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 - 2011). The time series of use of N_2O in Sweden are reported in Other use of N_2O (3.D.4, since data for 3.D.1 - Use of N_2O for Anaesthesia and 3.D.3 – N_2O from Aerosol cans cannot be reported separately due to confidentiality). Consequently CRF codes 3.D.1 and 3.D.3 are both reported as IE. Activity data for year 2012 is not yet official and hence Sweden has chosen to report data from 2011 also for 2012. Data for 2012 will be updated in the next submission.

5.5.3 Uncertainties and time-series consistency

Reported time series are considered to be consistent, except for last year (2012) where data for previous year (2011) has been reported. This practice has been questioned by the ERT several times. The reason for Sweden to report activity data and emissions in CRF 3 with a delay of one year is due to the fact that activity data from the Product Register is not provided in sufficient time to be able to perform the calculations and report in a timely manner.

5.5.4 Source-specific QA/QC and verification

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

5.5.5 Source-specific recalculations

Due to the recurring one year lag of updating the data from the Product Register from the Swedish Chemicals Agency, the reported emissions of N_2O in CRF 3D4 for 2011 is updated in submission 2014.

Due to the recurring one year lag of updating of the data from the Product Register from the Swedish Chemicals Agency and the use of moving average for compiling the NMVOC and CO_2 time series in subsector 3D, the reported emissions for 2009 - 2011 were updated in submission 2014.

Also minor corrections have been made in the calculation model for 3.D.5. These corrections affect slightly reported emissions and activity data for 1996 – 1998 and 2002 - 2010 (Table 5.1).

5.5.6 Source-specific planned improvements

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

6 Agriculture (CRF sector 4)

6.1 Overview of sector

Only emissions of nitrous oxide (N_2O) and methane (CH_4) are reported in the agricultural sector. Carbon dioxide emissions from agriculture are reported under other sectors. Carbon dioxide from working vehicles and other energy use is reported in the energy sector and carbon dioxide from soils and from liming of agricultural land is reported in the LULUCF sector. Sweden's inventory includes emissions from enteric fermentation, manure management and agricultural soils. Rice cultivation, burning of savannas or burning of agricultural residues does not occur in Sweden. The agriculture in Sweden has undergone radical structural changes and rationalisations over the past 50 years. One fifth of the Swedish arable land cultivated in the 1950s is no longer farmed. Closures have mainly affected small holdings and those remaining are growing larger. Livestock farmers predominately engage in milk production and the main crops grown in Sweden are grain and fodder crops.[155] The decrease of agricultural land area has continued since Sweden joined the European Union in 1995 and the acreages of land for hay and silage has increased. Organic farming has increased from 6 % of the arable land area in 1996 to 17 % in 2010.[156]

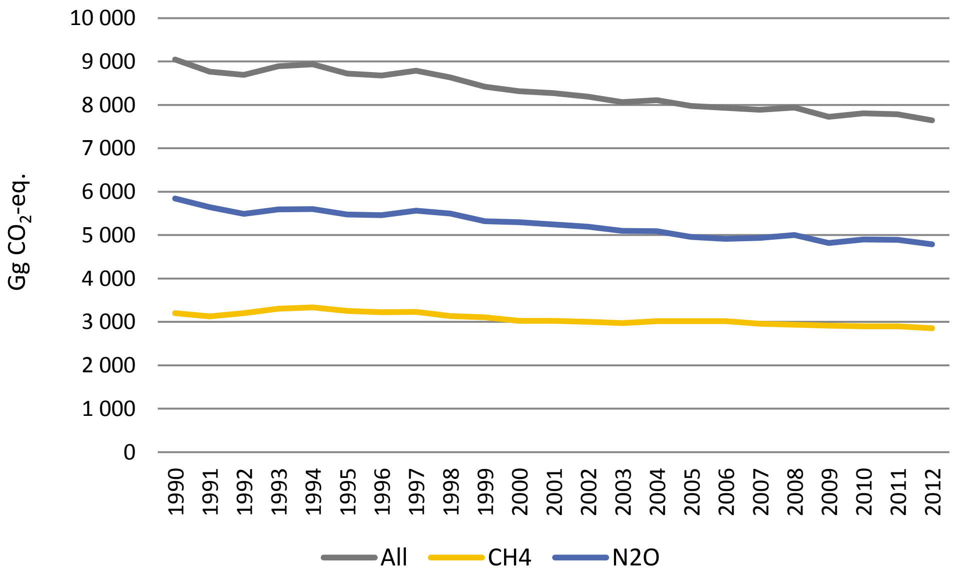

Figure 6.1. Total emissions of all greenhouse gases calculated as CO_2 equivalents from CRF 4 Agriculture

155 Ministry of the Environment, 2001.

156 Swedish Board of Agriculture, www.jordbruksverket.se., http://miljomal.nu

The total greenhouse gas (GHG) emissions from sector four have decreased by 16 % since 1990, from 9,046 Gg CO_2 equivalents to 7,641 Gg CO_2 equivalents (Figure 6.1). The most significant sub-sector is emissions from agricultural soils (4.D), see Figure 6.2.

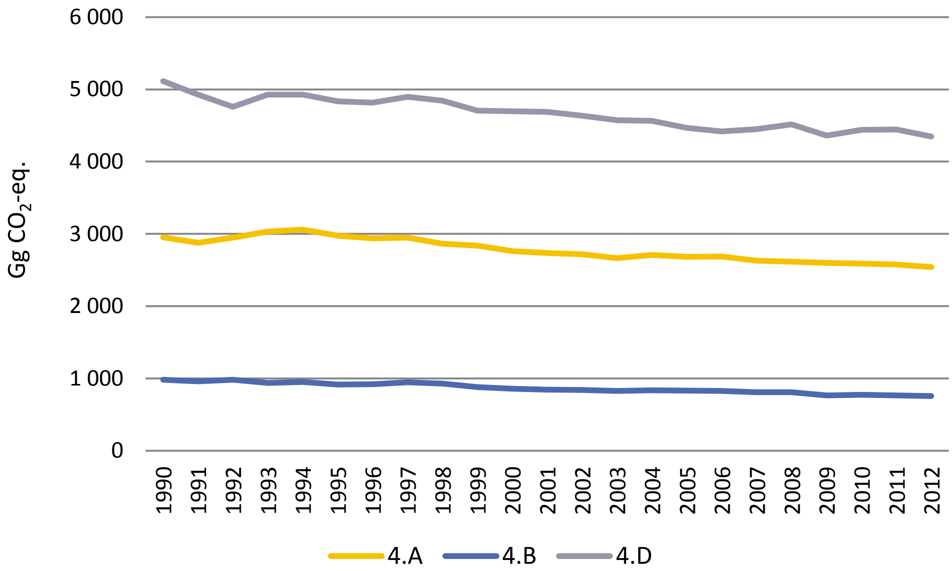

Figure 6.2. Total emissions of all greenhouse gases calculated as CO_2 equivalents from the different agricultural sub-sectors. There are no emissions from 4.C or 4.E-G

Recalculations are made in submission 2014 (Table 6.1). Detailed descriptions of the recalculations are found under the sector specific sections.

Table 6.1. Impact of recalculations of GHG emissions submission 2014 in the agricultural sector

Impact of recalculations submission 2014 (Gg CO_2 eq.)								
CRF	4.A	4.B	4.D.1	4.D.2	4.D.3	4.D.4	Total CRF 4	% CRF 4
1990	0	15	33	0	2	-1	49	0,5
1995	0	17	-16	0	1	-1	2	0,0
2000	0	15	-13	0	2	0	4	0,1
2005	0	21	-7	0	4	4	22	0,3
2008	0	19	3	0	1	1	23	0,3
2009	0	18	3	0	0	0	20	0,3
2010	0	18	2	0	1	0	20	0,3
2011	0	18	1	0	-1	-2	16	0,2

0: value less than 0.5.

Livestock (including manure distribution in 4.D) are the main contributors to greenhouse gas emissions from agriculture. In Table 6.2 all the livestock subgroups used in the calculations are presented. Mink and foxes are minor contributors to greenhouse gas emissions and are not included in the inventory due to a lack of well-founded emission factors.

Table 6.2. Livestock subgroups used in the calculations

Categories according to IPCC Guidelines	Sub-categories Enteric Fermentation	Sub-categories Methane from manure management	Sub-categories N_2O from manure management	Sub-categories N_2O from grazing animals
Dairy Cattle (**)	Dairy cows	Dairy cows	Dairy cows	Dairy cows
Non-Dairy Cattle (**)	Beef cows	Beef cows	Beef cows	Beef cows
	Other cattle	Growing animals (12-24 months)	Growing animals (12-24 months)	Growing animals (12-24 months)
		Calves > 6 months(*)	Calves > 6 months	Calves > 6 months(*)
		Calves < 6 months(*)	Calves < 6 months	Calves < 6 months(*)
Swine	Swine	Sows	Sows	NO
		Boars	Boars	
		Pigs for meat production	Pigs for meat production	
		Piglets	Piglets	
Sheep	Sheep	Sheep	Sheep	Sheep
Goats	Goats	Goats	Goats	Goats
Horses (***)	Horses	Horses	Horses	Horses
Poultry	NO	Laying hens (**)	Laying hens (**)	NO
		Chickens (**)	Chickens (**)	
		Slaughter Chickens (****)	Slaughter Chickens (****)	
Other (*****)	Reindeer	NO	NO	Reindeer

(*) The age distribution of calves is accomplished by using standard values. (**) Farm Register. (***) Statistics Sweden. (****) Swedish Poultry Meat Association. (*****) Sametinget (The Sami Parliament of Sweden).

The Farm Register provides the main basis for agricultural statistics in Sweden. The Register is administered by the Swedish Board of Agriculture and Statistics Sweden and provides annual information on the total number of animals of different categories on Swedish farms[157]. The information on livestock refers to the situation prevailing in mid-June of that year and is considered to be equivalent to a one-year average. Most of the information on livestock numbers comes from the Farm Register, but the distribution of calves (older and younger than 6 months respectively) is model-assisted: 60% are assumed to be younger than 6 months and the rest are assumed to be over 6 months old.

Concerning horses, the Farm Register gives an underestimation of the number of horses because only horses on farms are included (i.e. not horses for leisure activi-

[157] Swedish Board of Agriculture, JO 20-series.

ties). However, a separate survey[158] estimated total number of horses in Sweden in 2010 and 2004, these estimates are used in the calculations instead. The number of slaughter chickens (mean number of chickens kept during the year) is provided by the Swedish Poultry Meat Association. This estimate is generally higher than the estimate given by the Farm Register, which on the other hand may be too low. This assumption is supported by the fact that a comparison with the slaughter statistics is more in line with the data from the Poultry Meat Association.

6.2 Enteric Fermentation (CRF 4.A)

6.2.1 Source category description

The animal husbandry sub-sector is an important sector influencing GHG emissions from agriculture in Sweden. Livestock farming, including farmyard manure management, is the major source of CH4 emissions. From the total emission of CH4 about 75 % derives from enteric fermentation from cattle. The total numbers of livestock in Sweden in 1990-2012 are presented in Table 6.6 and Figure 6.3.

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 6.3.

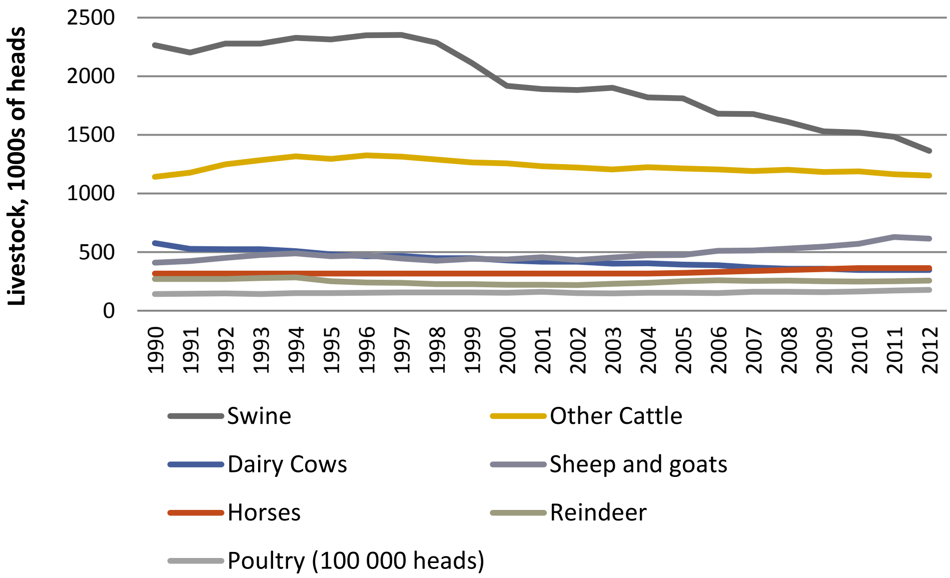

Figure 6.3. Livestock in Sweden 1990-2012, 1000s of head

158 Swedish Board of Agriculture, 2011

Table 6.3. Summary of source category description, CRF 4.A

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
4.A	CH_4	X			CS, T1, T2	CS, D	Yes

CS-Country Specific. T1-Tier 1. T2-Tier 2. D-Default.

6.2.2 Methodological issues

6.2.2.1 EMISSION FACTORS, METHANE

The livestock population (Table 6.6) in each category is multiplied by an emission factor and the total emission is calculated as:

$$emissions = \sum_i population_i \times EF_i$$

The emission factors (EF_i) for the significant cattle subgroups are national. For reindeer, where the IPCC Guidelines do not provide default values, an emission factor is calculated according to the IPCC Guidelines methodology using a Finnish value of gross energy requirements.[159] For emissions from swine, sheep, goats and horses the IPCC default values are used. Statistics on livestock categories are presented in Table 6.7. A national methodology based on feed energy requirements expressed as metabolisable energy[160] is used in the Swedish inventory to estimate emission factors for dairy cows, beef cows and other cattle. For dairy cows during the lactation we first calculate the metabolisable energy (MJ/day) from the energy requirements for maintenance and lactation. Data on milk yield is from the trade organisation Swedish Milk and built on the production evaluation tool “Kokontrollen”. It is a voluntary tool but because the farmers can use the results for optimisation and follow-up on productivity, about 80% of the farmers are connected. For the cows not connected Swedish Milk assumes a lower productivity. The reason is that these cows are generally found on smaller holdings and often not primary kept for milk production. The data used to calculate average milk production are given in Table 6.5. The metabolisable energy is then used to estimate digestible energy, and from this the emission of methane is calculated using the methane conversion rate.

The calculations for dairy cows were revised some years ago[161]. The emission factors for other cattle groups were also re-evaluated, using the same methodology[161]. The conclusion led to a decision to use the emission factor, 50 kg CH_4/head and year for the sub-category “Other Cattle”, a value close to the Good Practice

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[159] Statistics Finland, 2007

[160] Lindgren, 1980; Murphy, 1992; Bertilsson, 2002.

[161] Bertilsson, 2001.

Guidance default value for non-dairy cattle (48 kg CH_4/head and year). Due to the recommendation of the ERT during the in-country visit in Sweden in 2007, CH_4 emission factors for beef cows and reindeers were revised to 78.0 kg CH_4/head and year and 19.9 kg CH_4/head and year, respectively. Good Practise Guidelines (GPG) 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 to be two months for calves of dairy breed and three months for other calves.

Below follows a review of the different stages in the calculation for dairy cows. Metabolisable energy (MJ/day) is calculated using the formula from Spörndly 1999:

Lactation period:
Metabolisable energy (MJ/day) =1.11 × (62 + Milk Production (litres/day) × 5) - 13.6

Dry period:
Metabolisable energy (MJ/day) =62+13

Metabolisable energy is then converted to digestible energy using the formula[162]:

Metabolisable energy (% of digestible energy) = 83.2 + 2.53×L – 0.045×G – 0.184×Rp

$$\text{Digestible energy (MJ/day)} = 100 \times \frac{\text{Metabolisable energy (MJ/day)}}{\text{Metabolisable energy (\% of digestible energy)}}$$

Methane conversion rate of digestible energy is calculated using the formula[163]:

Methane conversion rate (% methane of digestible energy) = 15.7 – 0.030×SK – 1.4×L

Where L is the total feed intake expressed as multiples of maintenance energy. G is the percentage of coarse feed and Rp is the crude protein content in the food expressed as percentage of total food consumption in dry matter (dm). SK is the digestibility of the feed (% of gross energy). All used constant for the different years are given in Table 6.4. Finally, the actual emission of methane is estimated with the formula:

Emission of methane (Kg/day) = (Digestible energy × Methane conversion rate) / 55.65

The Swedish method resembles the one used by IPCC. The main difference is that Sweden uses metabolisable energy in the calculations as opposed to gross energy intake. Furthermore, the energy loss caused by methane emissions is calculated as a fraction of digestible energy. This fraction is in turn determined by total feed intake

[162] Lindgren, 1980.

[163] Lindgren, 1980.

and digestibility of the feed. IPCC instead express energy in methane as a constant fraction of gross energy in feed.

Table 6.4. Constants used for estimating methane from dairy cattle

Year	Dry cows				During lactation			
	L	G	Rp	SK	L	G	Rp	SK
1990	1.2	80.1	14	69	3.0	55	16	69
1995	1.2	80.1	14	69	3.2	55	16	69
2000	1.2	80.1	14	69	3.5	55	16	69
2005	1.2	80.1	14	69	3.5	55	16	69
2006	1.2	80.1	14	69	3.5	55	16	69
2007	1.2	80.1	14	69	3.5	55	16	69
2008	1.2	80.1	14	69	3.5	55	16	69
2009	1.2	80.1	14	69	3.5	55	16	69
2010	1.2	80.1	14	69	3.5	50	17	69
2011	1.2	80.1	14	69	3.5	50	17	69
2012	1.2	80.1	14	69	3.5	50	17	69

For the year 2012 this resulted in an emission of 387 g of methane per day for milk cows during the lactation period. The lactation period is estimated to 305 days per year. For cows during the non-lactation period the value does not change between years and is estimated to 201 g of methane per day. The final emission from milk cow per head and year is then calculated from the emission during the lactation and the non-lactation period.

From these variables it is possible to calculate gross energy intake (GE) and the methane conversion rate for gross energy (Y_m) for dairy cows that are reported in the CRF-tables despite that we do not actually use them in the calculation of the emission.

For this we use the formulas:

Gross energy intake (GE) = ((Digestible energy during lactation × 305 + Digestible energy for dry cows × 60)/365) / SK

Methane conversion rate (Y_m) = CH_4/head/year × 55.65 / (GE × 365)

The default values in the IPCC Guidelines are used for the less significant animal groups[164] and for these groups the development of a national emission factor has not been given priority. The emission factors used for all animal groups are collected in Table 6.7.

Table 6.5. Number of dairy cows and average milk production

Year	Dairy cows in country, number of head(*)	Dairy cows in the official control activity, number of head (**)	Produced milk per head in official control activity, kg/head/yr (**)	Produced milk per head, not in official control activity (**)	Average milk production per head, kg/yr (***)	CH_4 EF for Dairy Cattle
1990	576 000	421 780	7 319	5 330	6 786	120.3
1991	528 000	388 860	7 376	5 280	6 824	120.7
1992	526 000	367 452	7 376	5 400	6 780	118.3
1993	525 000	376 126	7 740	5 600	7 133	122.1
1994	509 000	383 124	8 011	6 100	7 538	124.4
1995	482 000	390 146	8 083	6 200	7 724	126.4
1996	466 000	382 511	8 033	6 150	7 696	124.0
1997	468 000	380 760	8 209	6 250	7 844	125.6
1998	449 000	380 567	8 298	6 258	7 987	124.9
1999	449 000	378 623	8 377	6 300	8 051	125.6
2000	428 000	368 350	8 537	6 430	8 243	125.4
2001	418 000	360 364	8 742	6 627	8 450	127.5
2002	417 000	354 801	8 784	6 665	8 468	127.7
2003	403 000	346 133	8 794	6 750	8 506	128.0
2004	404 000	332 367	8 994	6 750	8 596	129.0
2005	393 000	332 367	8 994	6 750	8 648	129.5
2006	388 000	318 986	9 283	6 750	8 832	131.3
2007	369 646	298 865	9 412	6 750	8 902	132.0
2008	357 194	293 939	9 322	6 750	8 867	131.7
2009	356 776	285 246	9 486	6 750	8 937	132.4

164 According to current estimations, “other animal groups” produce less then 10 % of the total methane that results from enteric fermentation.

2010	348 095	275 715	9 468	6 750	8 903	132.0
2011	346 495	287 606	9 480	6 750	9 016	133.1
2012	347 969	273 312	9 261	6 750	8 722	130.2

(*) Farm Register, (**) Swedish Dairy Association. (***) Calculated value.

Table 6.6. Population size of different animal groups (1000s heads)

Year	Dairy cows	Non-Dairy Cattle			Swine				Sheep		Horses(*)	Goats		Other	Poultry		
	Dairy Cows	Beef Cows	Growing animals (12-24 months)	Calve	Sow (****)	Pig for meat production	Piglet	Boar	Sheep	Lamb	Horse (*)	Goat (***)	Kid (***)	Reindeer	Laying hen (*****)	Chicken	Slaughter Chicken (**)
1990	576	75	543	524	221	1 276	758	8.6	162	244	316	2.9	1.4	271	6 522	2 200	5 500
1991	528	98	543	537	219	1 239	736	8.3	168	251	316	3.2	1.6	271	6 222	2 600	5 833
1992	526	136	565	548	225	1 283	763	8.3	180	267	316	3.5	1.8	271	6 222	2 200	6 333
1993	525	154	549	581	241	1 272	756	7.9	189	282	316	3.5	1.8	280	5 922	1 900	6 333
1994	509	165	561	592	241	1 264	815	8.2	196	288	316	3.5	1.8	284	6 022	2 200	6 833
1995	482	157	596	542	237	1 300	768	7.6	195	266	316	3.5	1.8	253	6 222	1 800	7 083
1996	466	164	617	543	273	1 303	765	6.9	203	266	316	3.5	1.8	241	5 822	2 200	7 250
1997	468	169	614	530	269	1 313	764	5.8	195	247	316	3.5	1.8	239	5 822	1 900	7 833
1998	449	170	611	509	255	1 293	733	4.8	187	234	316	3.5	1.8	227	5 522	2 200	7 833
1999	449	165	600	499	220	1 239	651	4.2	194	244	316	3.5	1.8	227	5 722	2 200	7 833
2000	428	167	589	500	202	1 146	566	4.2	198	234	316	3.5	1.8	221	5 822	1 700	7 917
2001	418	166	573	494	212	1 089	586	3.9	208	244	316	3.5	1.8	221	5 822	1 700	8 708
2002	417	169	553	499	208	1 096	574	3.4	197	229	316	3.5	1.8	220	4 822	1 500	8 833
2003	403	165	527	512	204	1 127	567	3.9	210	238	316	3.7	1.8	229	4 622	1 500	8 668
2004	404	172	539	514	192	1 095	528	3.1	220	246	316	3.7	1.8	239	5 122	1 600	8 752
2005	393	177	527	508	185	1 085	538	2.7	222	249	323	3.7	1.8	251	5 222	1 700	8 387
2006	388	178	530	496	184	1 002	492	2.6	244	262	331	3.7	1.8	261	4 611	1 600	8 892
2007	370	186	516	489	179	1 015	480	2.5	242	267	339	3.7	1.8	255	5 428	1 753	8 925
2008	357	196	513	492	167	974	465	2.4	251	273	347	3.7	1.8	257	5 656	1 649	8 975
2009	357	192	502	488	158	943	426	2.4	254	287	355	3.7	1.8	252	5 381	1 898	8 533
2010	348	197	513	479	154	937	427	2.3	273	292	363	3.7	1.8	250	6 191	1 647	8 565
2011	346	196	495	475	151	901	429	1.9	297	326	363	3.7	1.8	252	6 506	1 828	8 965
2012	348	193	479	481	140	851	370	1.5	297	314	363	3.7	1.8	257	6 865	1 551	9 342

Most data are from the Farm register. (*) Estimated number of horses 2004 and 2010, by Statistics Sweden and the Swedish Board of Agriculture. (**) Swedish Poultry Meat Association. (***) Data on goats were available until 1992, this data have been extrapolated. (****) Between 1995 and 1996 there was an increase in number of sows by 13 %. The reason for this sudden increase is that as from this year also uncovered gilts are included in this group. (*****) Including a small fraction of turkeys.

Table 6.7. Methane from animals, used emission factors

Livestock subgroups	Kg CH_4/head/year	Method
Dairy cows in 1990, average milk production 6786 kg/yr/head	120.3	1
Dairy cows in 2012, average milk production 8722 kg/yr/head	130,2	1
Beef cows	78	2
Growing animals (12-24 months)	50	2
Calves (excluding calves on milk)	50	2
Swine	1.5	3
Sheep	8	3
Goats	5	3
Horses	18	3
Poultry	No fermentation assumed	
Reindeer	19.9	4

(1) The emission factor is related to milk production and calculated from Spörndly, 1999 and Bertilsson, 2001. (2) Bertilsson, 2001. (3) IPCC Guidelines. (4) Statistics Finland, 2007.

6.2.3 Uncertainties and time-series consistency

Between 1995 and 1996 there was an increase in the number of sows by 13 %. The reason for this sudden increase is that as from this year also uncovered gilts are included in this group. When no estimate on number of horses exists before 2004, this value is used for all preceding years. From 2010 there was a minor adjustment of the values of the share of coarse feed and the crude protein content in dairy cow food (Table 6.4).

6.2.4 Source-specific QA/QC and verification

The time series for the different populations and milk production is checked for consistency. Recalculations are identified and verified. Emission estimates and methods are reviewed yearly by external national experts.

6.2.5 Source-specific recalculations

There were no recalculations for this source in submission 2014.

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.

6.3 Manure Management (CRF 4.B)

6.3.1 Source category description

This category includes emissions of methane and nitrous oxide from manure management. 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 6.8.

Table 6.8. Summary of source category description, CRF 4.B

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
4.B	CH_4				T1, T2	CS, D	Yes
	N_2O	X	X		T2	D	Yes

CS Country Specific. T1 Tier 1. T2 Tier 2. D Default.

6.3.2 Methodological issues

Statistics on manure management and the use of manure and fertilisers in agriculture are collected biannually by Statistics Sweden[165]. Data on stable periods (Table 6.9) and manure management systems (Table 6.10, Table 6.11 and Table 6.12) originate from this survey. Since dairy cows are often stabled at night and also 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 was produced in the stable during the grazing period. Data on manure and nitrogen production are from the underlying database to a computer program called STANK IN MIND[166]. This is the official model for input/output accounting on farm level in Sweden[167]. Among other things this database contains the data on nitrogen and manure production that are used for the Swedish greenhouse gases inventory. The data are based on various 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. Some of the data for the less significant animal groups are instead based on expert opinions. See under STANK IN MIND in the reference list for a complete list of the sources[168]. For dairy cows the nitrogen and manure production are calculated according to milk production. When the milk production has increased during the reporting period the manure and nitrogen production are also expected to have increased. Hence, the manure and nitrogen production are calculated from milk production instead of using a constant value (Table 6.13). For the other animal groups the values for manure and nitrogen production are given in Table 6.14 and Table 6.15, respectively. The data for manure and nitrogen production are estimated values per head, year and box. That is, the production if one hypothetically assumes that an animal of a specific animal category would stay in the box for a year. Total yearly production per animal category is then estimated by multiplying these values with number of animal in mid-June according to the farm register. Naturally the number of animals in the different categories/age classes will vary somewhat

165 Statistics Sweden, MI 30-series.

166 Swedish Board of Agriculture, 2008. Manual to STANK in MIND.

167 Linder, 2001.

168 STANK IN MIND.

during a year. I.e. piglets will grow and enter the next growth class. However, we use the value from the farm register as an approximation of the annual average. Due to more intense swine production, the yearly production for sows and pigs for meat production were updated in 2001. When no default emission factor exists for reindeer, we use the same value as for sheep. All emission factors used in the calculations are presented in Table 6.16.

Table 6.9. Stable periods for cattle, months

Year	Dairy cows	Beef cows	Steers and bulls	Heifers	Calves	Sheep, horses, goats	Rein-deer	Poultry, Swine
1990	7.2	6.2	7.6	6.5	7.8	6	0	12
1995	7.2	6.2	7.6	6.5	7.8	6	0	12
2000	7.2	5.8	7.6	6.1	7.6	6	0	12
2005	6.9	5.4	7.9	5.5	7.3	6	0	12
2008	7.2	5.2	8.3	5.7	8,0	6	0	12
2009	7.1	5.5	8.7	5.8	8.1	6	0	12
2010	7.1	5.5	8.7	5.8	8.1	6	0	12
2011	7.3	5.5	8.6	5.9	8,0	6	0	12
2012	7.3	5.5	8.6	5.9	8,0	6	0	12

(*) Statistics Sweden. Other values are standard values, or extrapolated.

Table 6.10. Waste management systems, fraction of liquid systems

Year	Dairy cows (*)	Other cattle (*)	Pigs for meat production (*)	Other swine (*)	Sheep, goats, horses, reindeer	Poultry
1990	0.23	0.17	0.44	0.44	0	0.25
1991	0.23	0.17	0.44	0.44	0	0.25
1992	0.23	0.17	0.44	0.44	0	0.25
1993	0.29	0.22	0.58	0.58	0	0.25
1994	0.29	0.22	0.58	0.58	0	0.25
1995	0.31	0.23	0.63	0.63	0	0.25
1996	0.31	0.23	0.63	0.63	0	0.25
1997	0.33	0.16	0.81	0.24	0	0.25
1998	0.33	0.16	0.81	0.24	0	0.25
1999	0.39	0.14	0.81	0.26	0	0.25
2000	0.39	0.14	0.81	0.26	0	0.25
2001	0.44	0.15	0.86	0.30	0	0.25
2002	0.44	0.15	0.86	0.30	0	0.25
2003	0.46	0.14	0.88	0.38	0	0.25
2004	0.46	0.14	0.88	0.38	0	0.25
2005	0.50	0.15	0.94	0.34	0	0.25
2006	0.50	0.15	0.94	0.34	0	0.25
2007	0.55	0.14	0.94	0.47	0	0.25
2008	0.55	0.14	0.94	0.47	0	0.25
2009	0.58	0.18	0.94	0.61	0	0.25
2010	0.58	0.18	0.94	0.61	0	0.25
2011	0.62	0.18	0.95	0.47	0	0.25
2012	0.62	0.18	0.95	0.47	0	0.25

(*) Data from Statistics Sweden's biannual survey "Use of fertilisers and animal manure in agriculture".

Table 6.11. Waste Management Systems, fraction of solid systems

Year	Dairy cows (*)	Other cattle (*)	Pigs for meat production (*)	Other swine (*)	Sheep, goats	Reindeer	Horses	Poultry
1990	0.52	0.32	0.54	0.45	0.5	0	0.48	0.55
1991	0.52	0.32	0.54	0.45	0.5	0	0.48	0.55
1992	0.52	0.32	0.54	0.45	0.5	0	0.48	0.55
1993	0.46	0.27	0.40	0.31	0.5	0	0.48	0.55
1994	0.46	0.27	0.40	0.31	0.5	0	0.48	0.55
1995	0.44	0.26	0.35	0.26	0.5	0	0.48	0.55
1996	0.44	0.26	0.35	0.26	0.5	0	0.48	0.55
1997	0.41	0.33	0.17	0.65	0.5	0	0.48	0.55
1998	0.41	0.33	0.17	0.65	0.5	0	0.48	0.55
1999	0.35	0.31	0.18	0.67	0.5	0	0.48	0.55
2000	0.35	0.31	0.18	0.67	0.5	0	0.48	0.55
2001	0.31	0.26	0.13	0.58	0.5	0	0.48	0.55
2002	0.31	0.26	0.13	0.58	0.5	0	0.48	0.55
2003	0.27	0.24	0.11	0.51	0.5	0	0.48	0.55
2004	0.27	0.24	0.11	0.51	0.5	0	0.48	0.55
2005	0.23	0.20	0.05	0.44	0.5	0	0.48	0.55
2006	0.23	0.20	0.05	0.44	0.5	0	0.48	0.55
2007	0.20	0.22	0.06	0.41	0.5	0	0.48	0.55
2008	0.20	0.22	0.06	0.41	0.5	0	0.48	0.55
2009	0.16	0.20	0.05	0.32	0.5	0	0.48	0.55
2010	0.16	0.20	0.05	0.32	0.5	0	0.48	0.55
2011	0.13	0.19	0.05	0.41	0.5	0	0.48	0.55
2012	0.13	0.19	0.05	0.41	0.5	0	0.48	0.55

(*) Data from Statistics Sweden's biannual survey "Use of fertilisers and animal manure in agriculture".

Table 6.12. Waste management systems, fraction of deep litter systems (categorised as “other” in the CRF-tables)

Year	Dairy cows (*)	Other cattle (*)	Pigs for meat production (*)	Other swine (*)	Sheep, goats, reindeer	Horses	Poultry
1990	0.01	0.08	0.02	0.11	0	0.02	0.20
1991	0.01	0.08	0.02	0.11	0	0.02	0.20
1992	0.01	0.08	0.02	0.11	0	0.02	0.20
1993	0.01	0.08	0.02	0.11	0	0.02	0.20
1994	0.01	0.08	0.02	0.11	0	0.02	0.20
1995	0.01	0.08	0.02	0.11	0	0.02	0.20
1996	0.01	0.08	0.02	0.11	0	0.02	0.20
1997	0.01	0.08	0.02	0.11	0	0.02	0.20
1998	0.01	0.08	0.02	0.11	0	0.02	0.20
1999	0.01	0.09	0.01	0.07	0	0.02	0.20
2000	0.01	0.09	0.01	0.07	0	0.02	0.20
2001	0.00	0.12	0.01	0.12	0	0.02	0.20
2002	0.00	0.12	0.01	0.12	0	0.02	0.20
2003	0.01	0.14	0.01	0.11	0	0.02	0.20
2004	0.01	0.14	0.01	0.11	0	0.02	0.20
2005	0.01	0.16	0.01	0.22	0	0.02	0.20
2006	0.01	0.16	0.01	0.22	0	0.02	0.20
2007	0.01	0.17	0.00	0.12	0	0.02	0.20
2008	0.01	0.17	0.00	0.12	0	0.02	0.20
2009	0.01	0.16	0.01	0.07	0	0.02	0.20
2010	0.01	0.16	0.01	0.07	0	0.02	0.20
2011	0.01	0.17	0.00	0.12	0	0.02	0.20
2012	0.01	0.17	0.00	0.12	0	0.02	0.20

(*) Data from Statistics Sweden’s biannual survey “Use of fertilisers and animal manure in agriculture”.

Table 6.13. Manure and nitrogen production from dairy cows

Animal groups	Manure kg dm/day/head	Nitrogen kg/year/head
Dairy Cows (Milk production 6,000 kg/yr)	5.75	97
Dairy Cows (Milk production 8,000 kg/yr)	6.07	117
Dairy Cows (Milk production 10,000 kg/yr)	6.19	137

Table 6.14. Manure production from other animal groups

Animal groups	Manure production, kg dm/day
Beef cows	2.64 (in stable); 3.64 (during grazing)
Growing animals (12-24 months)	2.6
Calves > 6 months	1.12
Calves < 6 months	0.69
Sows	0.74 (1990-2001); 0.793 (as from 2002)
Boars	0.52
Pigs for meat production	0.42
Piglets	0.05

Data from the Swedish Board of Agriculture

Table 6.15. Nitrogen production from other animal groups

Animal groups	Nitrogen kg/year/head, 1990-2001	Comment	Updated values on nitrogen prod. used from 2002, kg/year/head	Comment
Beef cows	63			
Growing animals 12-24 months	47			
Calves > 6 months	28			
Calves < 6 months	28			
Sows	18.5		22.5	
Boars	13			
Pigs for meat production	9.5	2.5 prod. cycles/year	10.8	3 prod. cycles / year
Piglets	0.5			
Sheep	13	Ewes incl. 1.5 lambs		
Lambs	0			
Goats	13	Does incl. 1.5 kids		
Kids	0			
Horses	50	Mean value for all animals		
Laying hens and turkeys	0.64			
Chickens	0.28	2.5 prod. cycles/year		
Slaughter Chickens	0.29	6.5 prod. cycles/year		
Reindeer*	10			

Data from the Swedish Board of Agriculture
* Data from Statistics Finland

Table 6.16. Emission factors for manure management

Manure management	Emission factor for CH_4	Note
MCF Solid manure	1% of B_0	1
MCF Liquid manure	3.5% of B_0	2
MCF Deep litter	39% of B_0	1
MCF Pasture/Range/Paddock	1% of B_0	1
Dairy Cattle - volatile solid (VS)	92% of manure production (dm)	1
Dairy Cattle – B_0	0.24 m^3 CH_4/kg VS	1
Non-Dairy Cattle – volatile solid (VS)	92% of manure production (dm)	1
Non-Dairy Cattle – B_0	0.17 m^3 CH_4/kg VS	1
Swine – volatile solids (VS)	98% of manure production (dm)	1
Swine – B_0	0.45 m^3 CH_4/kg VS	1
Sheep – emission	0.19 kg CH_4/animal/yr	1
Goats – emission	0.12 kg CH_4/animal/yr	1
Horses – emission	1.40 kg CH_4/animal/yr	1
Poultry – emission	0.078 kg CH_4/animal/yr	1
Reindeer – emission	0.19 kg CH_4/animal/yr	3
Manure management	**Emission factor for N_2O**	**Note**
Waste Management System	% N_2O-N of N-supply	
Liquid manure	0.1	1
Solid manure	2	1
Deep litter	2	1

MCF = Methane Conversion Factor. B_0 = maximum methane producing capacity for manure. (1) IPCC Guidelines. (2) National, Rodhe et al. 2008. (3) Assuming the same emissions as for sheep.

6.3.2.1 4.B(a). METHANE (INCLUDING EXCRETION FROM GRAZING ANIMALS)

The Good Practice Guidance Tier 2 methodology for estimating methane from manure management, including excretions from grazing animals, is applied for cattle and swine, and the corresponding Tier 1 methodology is used for the other animal groups[169]. The formula to calculate the emission factors for each livestock group, *i*, according to the Good Practice Guidance Tier 2 methodology is:

$$emissionfactor_i = VS_i \times B_{0i} \times 0.67 \times \sum_j MCF_j \times MS_{ij}$$

where VS_i is the volatile substance excreted per year, B_{0i} is the maximum methane producing capacity for manure produced by an animal within the livestock group,

[169] According to current estimations, cattle and swine produce about 85-90% of the total methane emissions from manure management.

MCF_j is a conversion factor for methane production, given a 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.

The B_{0i} and MCF factors used are the default values in the Good Practice Guidance, except for the revised MCF for liquid manure, where the value of 3.5% is used. This value was developed by Rodhe et al. (2008) and is considered to be more appropriate for Swedish conditions. The study measured GHG emissions for one year in a pilot-scale plant with similar conditions to full-scale storage as regards slurry temperature, climate and filling/emptying routines. The study concluded that 3.5% is an appropriate value for the MCF for liquid manure in Sweden which is a lower value compared to the IPCC default. The values reported in the CRF tables are sometimes aggregated after the calculation has been carried out for more specific animal groups. Hence, the implied emission factor for, e.g. “other 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 and the implied emission factor therefore varies between years.

Information on waste management systems is collected from the surveys published in the biannual statistical report on the use of fertilisers and animal manure in agriculture[170] and interpolated values are used for the intermediate years. Three manure management systems are considered apart from grazing animals: liquid systems (Table 6.10), solid storage (Table 6.11) and deep litter (Table 6.12) (sometimes categorised as “other” in the national inventory). National estimates of stable periods for cattle are from the same survey. Information on stable periods has been available biannually since 1997. Before 1997, the data are extrapolated to 1990.

When looking on the trends for the implied emission factor (IEF) there is a distinct increase for both non-dairy and dairy cattle. This is caused by a decreased use of solid manure storage systems. For non-dairy cattle the manure is instead stored in deep litter systems and for dairy cattle in liquid systems.

6.3.2.2 4.B(b). NITROUS OXIDE

N_2O from manure management is estimated with the IPCC Guidelines, Tier 2 methodology. Default emission factors from the IPCC Guidelines are used in combination with national activity data. The emission of N_2O from manure management is calculated as:

$$emissions = \sum_S \left(\sum_T N_T \times Nex_T \times MS_{(T,S)} \right) \times EF_s \times 44/28$$

[170] Statistics Sweden, MI 30-series.

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 (including pasture, range and paddock manure that is reported under 4.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 stable. This manure is excluded from the pasture, range and paddock manure and instead allocated to a manure system. Data on nitrogen and manure production has been derived by the Swedish Board of Agriculture (Table 6.13, Table 6.14 and Table 6.15). Stable period and manure management systems are the same as used in the methane calculations (Table 6.9, Table 6.10, Table 6.11 and Table 6.12). The emission factors are described in Table 6.16. In the CRF tables, where some animal subgroups are aggregated, the implied emission factors (IEFs) may change over the years, depending on the relative size of the respective subgroups aggregated.

6.3.3 Uncertainties and time-series consistency

Due to more intense swine production, the nitrogen production for sows and pigs for meat production were updated in 2002.

6.3.4 Source-specific QA/QC and verification

Times series and activity data are checked for consistency. Recalculations are identified and verified. Emission estimates and methods are reviewed yearly by external national experts.

6.3.5 Source-specific recalculations

The percentage of volatile solids (VS) in manure was updated. Now IPCC default values, 92% for cattle and 98% for swine, are used.

Activity data for 2011 for turkeys have been updated with the latest available statistics. This resulted in minor difference of the emissions from poultry.

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.

6.4 Agricultural Soils (CRF 4.D)

Emissions of nitrous oxide from agricultural soils are presented under CRF 4.D.1 to CRF 4.D.4. When the subsectors represent relatively different processes they are divided in separate paragraphs and also treated independently in the key categories analyses. Table 6.17 gives an overview of all emission factors used in this sector.

Table 6.17. Emission factors for N_2O emissions from soils

Direct emissions from soils	Emission factor % N_2O-N of N-supply	Note
Mineral fertiliser	0.8	1
Manure	2.5	1
Crop residue	1.25	2
N-fixing Crops	1.25	2
Manure during grazing	2	2
Background emission due to cultivation	Kg N_2O-N/ha/yr	
Cultivation of Histosols	8	2
Cultivation of Mineral Soils	0.5	1
Indirect emissions from soils		
Atmospheric Deposition	1% of emitted N	2
Nitrogen Leaching and run-off	2.5% of N lost from leaching	2

(1) National, Klemedtsson, 2001. (2) IPCC Guidelines.

6.4.1 Direct Soil Emissions (CRF 4.D.1)

6.4.1.1 SOURCE CATEGORY DESCRIPTION

The category includes the direct emission of nitrous oxide from soils. In terms of magnitude the most important emissions are from animal manure applied to soils followed by cultivation of histosols and from the use of synthetic fertilisers, respectively. Also included in this category are emissions from nitrogen fixing crops and crop residues. In this category Sweden also include emission from sewage sludge used as fertilisers. The summary of the latest key category assessment, methods and EF used, and information on completeness are presented in Table 6.18.

Table 6.18. Summary of source category description for the entire category CRF 4.D.1

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
4.D.1	N_2O	X	X		CS, T1, T1a, T1b, T2	CS, D	Yes

CS-Country Specific. T1-Tier 1. T2-Tier 2. D-Default.

6.4.1.2 METHODOLOGICAL ISSUES

6.4.1.2.1 Emission factors

For estimating direct soil emissions, the Good Practice Guidance encourages parties to use country-specific emission factors for N_2O from agricultural fields, where possible. A suggested alternative is to use factors from other countries with comparable management and climatic conditions. In order to update the emission factors used in Sweden, a literature study was carried out in 2001, requested by the Swedish EPA[171]. The study includes documented N_2O emission measurements carried

[171] Klemedtsson, 2001.

out in Sweden and in other countries in northern Europe and in Canada. The results show that data are scarce. It was for example not possible to develop different emission factors for added nitrogen to mineral or organic soils. Best data availability was found for the use of synthetic fertilisers on mineral soils. Here the emissions of N_2O-N were between 0 and 0.8% of added nitrogen. However, when the emissions are influenced by other processes than amount of added fertiliser, a correlation between added nitrogen and emitted nitrogen was not always apparent. For example, the amount of fertiliser used on cereals did not affect the magnitude of emitted N_2O. Thus, a method was suggested where the emissions are divided into two parts, one is dependent on fertiliser use and the other is a constant background emission. When the use of synthetic fertiliser on grasslands increased the emissions with some 0.8% of added nitrogen an emission factor of 0.8% was suggested for the use of synthetic fertiliser on all agricultural land. A lower value than the IPCC Good Practice Guidance default value of 1.25% for mineral fertiliser nitrogen has also been suggested in a synthesis of literature data[172]. The background emission from mineral soils was suggested to be 0.5 kg N_2O-N/ha/year (section 6.4.4). For the use of animal manure the study concluded that there are even less data available and the emissions according to different surveys varied between 0.6% and 8% of added nitrogen. Using a regression model an emission factor of 2.5% was suggested. The study also suggested country specific emission factors for background emission from organic soils and from indirect emissions of N_2O from atmospheric deposition and nitrogen leaching. These emission factors were however not adopted in the inventory as they were considered to be too unreliable. Instead IPCC default factors were used. A summary of all emission factors applied for 4.D is given in Table 6.17.

6.4.1.2.2 Emission of ammonia

The calculations of ammonia emissions from the agricultural sector are mainly built on data collected through Statistics Sweden’s field investigation among farmers[173]. 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 Engineering[174]. The calculations have been made by Statistics Sweden since 1990 at national and regional levels. However, due to a change in the questionnaire in Statistics Sweden’s field investigation among farmers and updated methods for calculating the emissions, the results from 1990-1994 are not fully compatible with these from 1995-2007. For that reason we use the value from 1995 for 1990 through 1994. As from 2005 regional results are published at the web-site of Statistics Sweden[175].

[172] Lægreid and Aastveit, 2002.

[173] Statistics Sweden, MI 30-series.

[174] Swedish Environmental Protection Agency 1997

[175] Statistics Sweden, MI 37-series.

In short the calculations are made as follows:

$$A = (V + L + S)$$
$$V = D \times N \times P \times F(v)$$
$$L = D \times N \times P \times (1 - F(v)) \times F(l)$$
$$S = D \times N \times P \times (1 - F(v)) \times (1 - F(l)) \times F(s)$$

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 handling[176]
P = stable periods[177]
F(v) = emission of nitrogen through stable ventilation, % of total nitrogen content in stable manure[178].
F(l) = emission of nitrogen during storing, % of total nitrogen content in stable manure after ventilation losses[179].
F(s) = emission of nitrogen during spreading, % of ammonium nitrogen content in stable manure after ventilation and storing losses[180].

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 farmers[181]. Ventilation-, storage- and spreading-losses originate from a data calculating program (called STANK IN MIND) from Swedish Board of Agriculture and from Swedish Institute of Agricultural and Environmental Engineering, Table 6.19, Table 6.20 and Table 6.21 give an overview of the emission factors used in the calculations.

176 Swedish Board of Agriculture 1995; Swedish Board of Agriculture 2000; Swedish Board of Agriculture 2001

177 Statistics Sweden, MI 30-series.

178 Swedish Board of Agriculture 2005

179 Swedish Institute of Agricultural and Environmental Engineering 2002

180 Swedish Institute of Agricultural and Environmental Engineering 2002

181 Statistics Sweden, 2008

Table 6.19. Nitrogen losses caused by ventilation in stables, % of Total-N.

Type of animal	Solid-manure	Deep litter	Liquid manure	Semisolid manure	Urine
Cattle	4	20	4	4	4
Swine	10	25	14	10	10
Laying hens	10	35	10		
Chickens	10	20	10		
Slaughter chickens			10		
Horses	4	15			
Sheep	4	15			

Table 6.20. Nitrogen losses caused by ammonia emissions during storage of manure, % of total-N

	Type of animal					
Type of manure, handling	**Cattle**	**Swine**	**Laying hens/ chickens**	**Slaughter chickens**	**Horses**	**Sheep**
Solid manure	20	20	12		25	25
Semisolid manure	10	10				
Liquid manure, uncovered						
Filled from underneath	6	8	8			
Filled from above	7	9	9			
Liquid manure, covered						
Filled from under-neath:						
Roof	1	1	1			
floating crust	3	4	4			
other	2	2	2			
Filled from above:						
roof	1	1	1			
floating crust	4	5	5			
other	3	3	3			
Urine, uncovered						
Filled from underneath	37	37				
Filled from above	40	40				
Urine, with cover						
Filled from under-neath:						
roof	5	5				
floating crust	17	17				
other	10	10				
Filled from above:						
roof	5	5				
floating crust	20	20				
other	12	12				
Deep litter manure	30	30	20	5		33

Table 6.21. Nitrogen losses caused by ammonia emissions during spreading of manure (% of total-N)

Season/ Spreading method	Spreading strategy and tillage timing	Solid manure	Urine	Liquid manure
Early spring/late winter				
Broadcast	Spread on frozen ground	20	40	30
Trailing hoses			30	20
Spring				
Broadcast	Immediately	15	8	10
	Mulching within 4 h	33	14	15
	Mulching within 5-24 h	50	20	20
	Spread on pasture	70	35	40
	Spread on grain		11	20
Trailing hoses	Immediately		7	5
	Mulching within 4 h		14	8
	Mulching within 5-24 h		20	10
	Spread on pasture		25	30
	Spread on grain		10	15
Shallow injection	Spread on pasture		8	15
Early summer, summer				
Broadcast	Spread on pasture	90	60	70
	Spread on grain		10	20
Trailing hoses	Spread on pasture		40	50
	Spread on grain		10	7
Shallow injection	Spread on pasture		15	30
Early autumn				
Broadcast	Immediately	20	15	5
	Mulching within 4 h	35	23	18
	Mulching within 5-24 h	50	30	30
	No mulching	70	45	70
Trailing hoses	Immediately		10	3
	Mulching within 4 h		18	9
	Mulching within 5-24 h		25	15
	No mulching		30	40
Late autumn				
Broadcast	Immediately	10	10	5
	Mulching within 4 h	15	15	8
	Mulching within 5-24 h	20	20	10
	No mulching	30	25	30
Trailing hoses	Immediately		4	3
	Mulching within 4 h		11	4
	Mulching within 5-24 h		18	5
	No mulching		25	15

6.4.1.2.3 4.D.1.1 Nitrous oxide from synthetic fertilisers

Emissions from fertilisers are calculated as:

$$emissions = N_{FERT} \times (1 - Frac_{GASF}) \times EF \times 44/28$$

where N_{FERT} is the total amount of fertiliser nitrogen consumed annually, and $Frac_{GASF}$ is the fraction that volatilises as ammonia. Statistics on sales of fertilisers, recalculated into nitrogen quantities, are published annually by Statistics Sweden. The estimated emissions are based on amount of nitrogen in mineral fertilisers sold in Sweden excluding the nitrogen lost as ammonia (Table 6.22). The proportion of nitrogen lost as ammonia ($Frac_{GASF}$) differs between different types of fertilisers. The values used are from the EMEP/EEA emission inventory guidebook 2009 and calculated using the mean spring temperature of 5.9 degrees centigrade (Table 6.23). In Table 6.22 sold quantities of ammonia-emitting products are shown, which directly explains variations in the $Frac_{GASF}$ between different years.

Table 6.22. Sold quantity of ammonia emitting fertilisers and nitrogen in sludge used as fertilizers

Year	N in sold fertilisers, tonnes	Ammonium Nitrate, AXAN, N26, N27, N28, tonnes of product	N-solution, tonnes of product	Urea, tonnes of product	NPK, tonnes of N	NP, tonnes of N	NK, tonnes of N	Proportion of emitted fertiliser-N ($Frac_{GASF}$)	Sludge, tonnes of N.
1990	224 500	225 387	10 089	5 932	64 600	11 000	0	0.0114	1 180
1991	208 600	237 612	6 498	4 683	52 100	11 000	3 700	0.0110	1 180
1992	178 400	179 234	8 837	2 980	45 400	8 500	3 000	0.0109	1 180
1993	207 200	200 004	5 257	3 501	46 100	9 800	3 300	0.0106	1 180
1994	216 400	167 150	7 820	3 061	55 900	12 300	3 000	0.0106	1 433
1995	198 300	182 486	11 193	1 955	51 050	13 451	2 912	0.0108	2 304
1996	192 300	158 613	5 949	1 474	48 000	14 000	2 500	0.0103	2 304
1997	204 600	175 558	4 399	1 104	51 500	15 900	2 300	0.0100	2 304
1998	205 600	209 463	2 631	889	53 723	14 286	2 033	0.0098	2 027
1999	179 200	166 077	3 111	745	50 092	14 619	1 746	0.0099	2 027
2000	189 400	205 869	3 772	655	51 600	11 400	2 200	0.0098	1 758
2001	196 900	235 495	2 036	553	54 000	11 300	3 000	0.0096	1 171
2002	184 800	198 981	1 641	484	54 900	10 900	2 300	0.0096	593
2003	180 100	238 828	1 083	382	53 900	10 600	2 200	0.0095	692
2004	176 800	240 553	4 928	475	54 500	11 900	1 800	0.0099	796
2005	161 500	273 036	3 364	519	59 000	8 400	1 600	0.0098	1 053
2006	160 300	267 754	3 164	225	57 800	8 500	1 800	0.0097	1 322
2007	167 100	285 064	0	271	61 100	5 300	2 000	0.0092	1 322
2008	186 500	360 415	13	235	71 029	3 931	1 805	0.0092	2 481
2009	142 400	298 882	67	1 088	43 600	2 000	1 100	0.0095	2 205
2010	168 000	348 691	0	1 002	52 800	2 600	1 400	0.0094	2 224
2011	169 800	314 225	0	1 090	56 600	1 300	900	0.0094	1 977
2012	148 100	277 262	43	632	55 825	792	710	0.0093	2 298

Statistics on fertilisers and sludge are from Swedish Board of Agriculture and Statistics Sweden.

Table 6.23. Fraction of nitrogen for different fertiliser types that is lost as ammonia

Fertiliser	Lost as ammonia (% of N)
Ammonium Nitrate, AXAN, N26, N27, N28	0.9
N-solution	6.3
Urea	12.7
NPK	0.9
NP	1.4
NK	0.9
Sludge	30

6.4.1.2.4 4.D.1.2 Nitrous oxide from animal manure applied to soils

To calculate the N_2O from animal manure, the default methodology according to the IPCC Guidelines in combination with national estimates of N content in manure (section 6.3.2) and a national estimation of ammonia-N emissions, are used. The formula is:

$$emissions = \sum_T N_T \times Nex_T \times (1 - Frac_{GASM}) \times (1 - Frac_{PRP}) \times EF \times 44/28$$

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, $Frac_{PRP}$ the fraction of the nitrogen in pasture, range and paddock manure, $Frac_{GASM}$ is a national value for the fractions nitrogen that is lost as ammonia-N (Table 6.24). $Frac_{GASM}$ is estimated by Statistics Sweden and the Swedish EPA[182]. The estimate is model-based and takes into account many factors that influence gas emissions (see 6.4.1.2.2).

Table 6.24. Ammonia-N emissions from manure, fraction

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Stable manure ($Frac_{GASM}$)	0.33	0.33	0.33	0.32	0.34	0.33	0.33	0.33	0.33
Manure from grazing animals (“$Frac_{GASG}$”)	0.12	0.12	0.08	0.08	0.09	0.09	0.09	0.09	0.09

Statistics Sweden, MI 37-series.

6.4.1.2.5 4.D.1.3 N_2O from N-fixing crops in pure stands and in temporary grass

Nitrogen fixation crops are pasture grounds with features of clover, leguminous crops (cooking and fodder peas, preserved peas, vetches, field beans etc). This nitrogen fixation by leguminous plants is a part of the nitrogen circulation in agricultural soils and the corresponding N_2O emissions are included in the inventory. Data derives from national estimates of nitrogen fixation, which account for regional differences, in combination with the Good Practice Guidance’s default emission factor for direct N_2O emissions.

The formula is:

$$emissions = \sum_{crop,county} Area_{crop,county} \times NfixingAmount_{crop,county} \times EF \times 44/28$$

Crop areas for Sweden are given in Table 6.26, Table 6.27 and Table 6.28. However, in these calculations we use county data intead for precision. Data on nitrogen fixing amounts are from Statistics Sweden’s series MI 40 on nitrogen and phospho-

[182] Statistics Sweden, MI 37-series.

rus balances for agricultural land[183]. To estimate nitrogen fixation from the atmosphere, a model according to Høgh-Jensen has been used since submission 2006[184]. The model covers fixation from root and stubble as well as transmission to other plants. It has been adapted to account for Swedish conditions[185] and has also been used by others such as the Swedish Board of Agriculture. According to the model the amount of fixed nitrogen is estimated as a part of the total amount of nitrogen in the plant's biomass. This part varies depending on the kind of leguminous plant, the age of the pasture, the number of harvests and, to some extent, the amount of fertiliser applied.

6.4.1.2.6 4.D.1.4 N_2O from crop residue

To estimate N_2O from nitrogen circulation in crop residues, we use the methodology recommended in the Good Practice Guidance in combination with national activity data on removed residues and other parameters, such as nitrogen content in different crops. The emission factor we use for the direct N_2O emissions is the default one from the Good Practice Guidance. The data on crop residues builds on a study from 1997[186] on how straw and tops from different crops are used. The formula used for the calculations is:

$$emissions = \sum_{crop} yield_{crop} \times area_{crop} \times Fracresidues_{crop} \times FracN_{crop}(1 - Fracresiduesremoved_{crop}) \times EF \times 44/28,$$

Yield are the annual yields for the different crops, *Fracresidues* are the crop residues as a fraction of the harvest, *FracN* are the fractions of nitrogen in crop residues and *Fracresiduesremoved* are the fractions of crop residues that is removed according to the field survey[187] from 1997. When calculating N-circulation in residues from cereal crops, national factors are used for the recalculation of annual yield to crop residues and the corresponding N-content[188]. For other crops, a combination of national factors and IPCC default values are used[189]. All factors used for calculating N input with crop residues are given in Table 6.25. Areas of different crops used in the calculations are stated in Table 6.26, Table 6.27 and Table 6.28. Annual yields[190] of different crops used in the calculations are presented in Table 6.29, Table 6.30 and Table 6.31). For comparability we also publish $Frac_{NCRBF}$ and $Frac_{NCR0}$ in the CRF tables. However, these two fractions are not used as input

183 Statistics Sweden, 2011

184 Høgh-Jensen et al. 2004.

185 Frankow-Lindberg, 2005.

186 Statistics Sweden, 1999.

187 Statistics Sweden, 1999.

188 Mattson, 2005.

189 Adolfsson, R. 2005.

190 Statistics Sweden, 2002e.

to the calculations, but calculate them afterwards by dividing the calculated total amount of nitrogen in the harvest with total dry biomass of the harvest.

Table 6.25. Data used for calculating nitrogen input in crop residues

Crop	Fraction of crop residues removed (Fracresiduesremoved)	Fraction of N in crop residues in dry matter (FracN)	Fraction residues in relation to harvest, (Fracresidues)	Dry matter content, fraction
Winter wheat	0.06	0.0051	0.87	0.86
Spring wheat	0.06	0.0044	0.96	0.86
Winter rye	0.09	0.0060	1.08	0.86
Winter barley	0.23	0.0051	0.87	0.86
Spring barley	0.12	0.0077	0.83	0.86
Oats	0.12	0.0073	0.89	0.86
Mixed grain	0.18	0.0067	0.98	0.86
Triticale	0.06	0.0060	1.08	0.86
Sugar beets	0.09	0.0225	0.66	0.20
Winter rape	0.02	0.0107	0.47	0.91
Spring rape	0.02	0.0107	0.47	0.91
Winter turnip rape	0.02	0.0107	0.47	0.91
Spring turnip rape	0.02	0.0107	0.47	0.91
Oil flax	0	0.0107	0.47	0.91
Table potatoes and Potatoes for starch prod.	0	0.0110	0.40	0.20
Temporary grass	0	0.0130	0.25	0.84
Temporary grass for seed	0.49	0.0130	0.94	0.84
Green fodder	0	0.0130	0.25	0.84
Maize	0.18	0.0081	1.00	0.86
Pasture ground	0	0.0130	0.40	0.67
Peas, Peas for fodder and brown beans	0.02	0.0142	1.50	0.85
Peas for conservation	0	0.0142	1.50	0.85

Adolfsson, R. 2005.

Table 6.26. Areas of different crops used in the calculations (hectares)

Year	Winter wheat	Spring wheat	Winter rye	Winter barley(*)	Spring barley	Oats	Mixed grain	Triticale(**)
1990	320 120	29 595	73 460	0	492 027	387 823	32 628	0
1991	225 330	33 387	43 239	0	490 896	364 272	40 337	0
1992	233 678	36 647	34 597	0	454 097	360 859	47 420	0
1993	271 818	32 581	46 390	0	420 437	321 961	35 330	35 330
1994	212 095	39 722	38 957	29 536	443 489	341 415	25 421	42 526
1995	222 304	39 076	39 693	26 220	427 115	278 322	27 124	44 577
1996	292 170	42 392	33 558	22 061	446 503	283 588	34 230	61 694
1997	299 594	44 588	29 416	15 272	467 628	315 465	30 247	66 473
1998	359 024	39 021	34 617	15 949	429 011	311 467	26 972	66 751
1999	209 641	65 777	24 507	11 883	470 104	305 658	33 022	32 586
2000	353 201	48 364	34 533	12 997	398 227	295 544	45 328	40 728
2001	354 495	44 670	34 403	9 577	387 922	278 174	25 370	39 642
2002	285 249	54 350	24 395	6 386	410 456	295 002	22 623	30 809
2003	364 058	47 290	24 366	6 345	362 127	279 808	25 235	44 661
2004	349 823	53 585	24 402	5 268	392 006	229 696	18 697	52 195
2005	295 325	59 430	21 386	5 356	373 208	200 122	18 857	50 292
2006	317 603	43 333	23 454	5 691	309 444	206 055	17 430	55 406
2007	323 182	38 367	24 716	8 274	318 407	207 909	15 317	53 914
2008	311 632	49 915	27 581	10 396	395 367	227 588	15 955	49 287
2009	326 838	48 297	36 633	18 278	351 878	196 038	17 050	53 571
2010	331 805	68 184	24 228	17 928	300 847	164 386	19 150	36 231
2011	349 793	66 986	24 094	14 370	313 459	181 170	18 676	24 215
2012	283 567	84 804	22 027	9 131	364 687	196 240	15 900	23 884

Statistics from Swedish Board of Agriculture, JO10-series. (*) Before 1994, statistics on winter barley and spring barley revised as one crop. (**) Before 1993, statistics on Triticale was included in mixed grain.

Table 6.27. (cont.) Areas of different crops used in the calculations (hectares)

Year	Sugar beets	Winter rape	Spring rape	Winter turnip rape	Spring turnip rape	Oil flax	Peas incl fodder	Peas for conservation (*)	Brown beans (*)
1990	1990	38 502	84 598	44 203	9 068	30 035	0	32 742	0
1991	1991	47 963	75 724	41 046	8 089	26 362	0	23 327	0
1992	1992	51 287	51 364	56 519	3 145	26 366	0	14 059	0
1993	1993	51 287	74 460	46 203	2 455	22 370	0	8 720	0
1994	1994	53 353	46 035	53 033	1 746	27 647	0	6 598	0
1995	1995	57 518	56 084	23 311	1 587	23 661	0	11 959	8 578
1996	1996	59 223	21 737	18 976	811	23 869	7 407	17 713	8 821
1997	1997	60 459	22 888	19 475	1 787	19 432	9 534	32 742	9 028
1998	1998	58 737	23 159	16 705	1 470	13 238	15 056	49 150	8 524
1999	1999	59 881	19 626	31 273	1 206	23 784	34 172	30 053	8 752
2000	2000	55 484	24 870	12 112	1 395	9 791	10 660	27 892	8 525
2001	2001	54 834	19 900	13 591	857	10 425	4 437	29 928	8 862
2002	2002	54 820	31 219	21 943	1 899	12 408	3 191	31 959	8 909
2003	2003	50 100	23 352	26 670	817	7 734	3 727	28 942	9 121
2004	2004	47 625	37 496	36 715	1 244	8 343	5 764	33 116	9 318
2005	2005	49 182	34 997	38 578	1 460	7 116	9 854	31 285	8 874
2006	2006	44 184	47 638	35 148	1 138	6 270	8 764	26 180	8 954
2007	2007	40 682	50 341	33 044	1 117	3 341	4 333	19 198	8 824
2008	2008	36 778	61 860	24 359	834	2 453	3 534	17 414	7 343
2009	2009	39 782	67 841	29 245	282	2 150	9 954	24 705	8 791
2010	2010	37 950	71 836	35 695	496	2 207	19 144	36 084	9 368
2011	2011	39 638	56 600	36 112	395	1 781	14 743	32 506	8 472
2012	2012	39 025	61 778	45 323	808	2 059	8 797	31 360	8 486

Statistics from Swedish Board of Agriculture, JO10-series. (*) Before 1995 statistics on peas & beans were aggregated.

Table 6.28. (cont.) Areas of different crops used in the calculations (hectares)

Year	Table potatoes	Potatoes starch prod.	Maize(*)	Temporary grass	Temporary grass for seed	Green forage	Pasture ground	Total area arable land (**)
1990	27 305	8 866	0	727 590	10 753	39 698	190 503	3 098 234
1991	28 269	8 807	0	696 069	10 418	33 509	239 818	3 087 734
1992	30 414	8 791	0	708 384	8 791	2 896	292 825	3 082 446
1993	27 815	8 469	0	748 094	7 863	23 137	314 458	3 068 516
1994	25 449	7 539	0	757 000	8 241	23 000	314 666	3 065 229
1995	27 630	7 371	0	766 776	7 907	23 695	276 927	3 061 780
1996	27 577	9 060	0	750 085	7 854	22 268	247 369	3 056 561
1997	26 732	9 081	0	746 832	8 470	24 443	234 677	3 051 773
1998	25 133	8 567	0	742 068	9 013	21 935	221 418	3 047 099
1999	24 422	8 391	0	760 227	8 165	21 867	198 091	3 037 966
2000	23 610	9 293	0	760 227	8 465	21 867	198 091	3 032 056
2001	23 776	8 460	0	750 200	10 300	26 400	179 400	3 028 593
2002	23 142	8 589	0	759 419	12 439	32 387	181 604	3 021 596
2003	21 923	8 617	0	769 200	12 306	31 748	164 100	3 010 855
2004	23 015	8 656	0	770 412	12 329	35 715	164 359	3 005 071
2005	22 081	8 372	0	803 920	12 847	39 628	192 670	3 001 887
2006	20 212	7 966	0	816 400	15 151	42 463	206 270	2 990 260
2007	20 330	8 032	0	831 390	14 276	46 482	190 400	2 982 527
2008	19 590	7 293	13 167	870 740	14 260	31 452	183 380	2 970 305
2009	19 706	7 252	16 210	888 800	13 969	38 232	178 210	2 965 686
2010	19 842	7 361	16 325	894 470	14 818	40 744	172 780	2 959 827
2011	20 046	7 616	15 829	917 620	14 743	39 733	152 740	2 953 508
2012	18 706	6 018	16 482	893 040	14 074	38 894	157 910	2 952 024

Statistics from Swedish Board of Agriculture, JO10-series. (*) Before 2008 Maize was included in Green forage. (**) Data from the national forest inventory.

Table 6.29. Annual yield per hectare of different crops used in the calculations (kg/hectare)

Year	Winter wheat	Spring wheat	Winter rye	Winter barley (*)	Spring barley	Oats	Mixed grain	Triticale(**)
1990	6 480	5 160	4 690	0	4 490	4 260	2 510	0
1991	5 940	4 780	3 900	0	4 090	4 080	2 510	0
1992	5 530	3 520	4 030	0	2 890	2 330	2 510	0
1993	5 920	5 040	5 060	0	4 160	4 230	2 510	5 070
1994	5 570	4 450	4 500	3 660	3 660	3 020	2 510	5 070
1995	6 190	4 920	5 250	5 310	3 910	3 440	2 510	5 070
1996	6 200	5 610	4 980	4 530	4 550	4 270	3 900	5 120
1997	6 140	5 290	4 750	4 910	4 340	4 070	3 660	4 860
1998	5 670	4 760	4 590	5 300	3 690	3 610	2 890	4 550
1999	6 250	5 000	4 730	4 870	3 780	3 410	2 790	4 670
2000	6 030	5 040	5 370	5 030	3 920	3 910	3 430	4 550
2001	5 970	4 600	5 210	5 210	4 090	3 510	3 190	4 360
2002	6 390	4 900	5 270	5 330	4 290	4 050	3 540	5 480
2003	5 560	4 900	4 860	4 550	4 190	3 960	3 470	4 580
2004	6 180	4 740	5 510	5 610	4 300	4 120	3 640	5 200
2005	6 630	4 910	5 270	5 800	4 260	3 870	3 450	5 420
2006	5 660	4 030	4 990	4 750	3 600	3 170	2 720	4 670
2007	6 460	4 470	5 580	5 320	4 460	4 370	3 180	5 160
2008	6 440	4 030	6 140	5 640	4 150	3 680	3 080	5 600
2009	6 310	4 570	5 960	5 570	4 600	4 000	3 480	4 750
2010	5 660	4 070	4 870	4 640	3 930	3 530	2 990	4 420
2011	5 630	3 980	5 290	4 600	4 350	3 940	3 060	4 460
2012	6 820	4 290	6 360	6 600	4 560	3 820	2 980	5 920

The values are corrected to a standardised moisture content (cereals 14%, pulses 15%, oleiferous plants 9% and 16.5% for temporary grass and green forage). Data are from the Swedish Board of Agriculture, Statistics Sweden, JO17- and JO19 -series. (*) Before 1994, statistics on winter barley and spring barley revised as one crop. (**) Before 1993, statistics on Triticale was included in mixed grain.

Table 6.30. (cont.) Annual yield per hectare of different crops used in the calculations (kg/hectare)

Year	Sugar beets	Winter rape	Spring rape	Winter turnip rape	Spring turnip rape	Oil flax	Peas incl fodder	Peas for conservation (*)	Brown beans (*)
1990	55 800	2 910	1 820	1 770	1 590	0	3 850	0	0
1991	43 200	2 340	1 270	1 340	1 140	0	3 850	0	0
1992	45 100	2 680	1 690	1 600	1 510	0	3 850	0	0
1993	49 600	2 680	1 690	1 600	1 510	0	3 850	0	0
1994	44 100	2 680	1 690	1 600	1 510	0	3 850	0	0
1995	43 600	2 300	1 570	1 600	1 200	0	3 850	3 850	2 737
1996	41 100	2 290	2 200	1 600	1 680	1 340	3 850	3 850	3 185
1997	44 200	2 300	1 840	1 510	1 540	1 280	3 490	3 490	3 038
1998	43 400	2 990	1 950	1 630	1 460	420	1 780	1 780	2 583
1999	46 400	2 860	2 040	1 880	1 670	950	2 720	2 720	2 646
2000	46 900	3 250	2 010	1 750	1 550	770	2 660	2 660	2 744
2001	48 500	3 100	1 980	1 460	1 550	780	2 860	2 860	2 863
2002	48 600	2 910	2 110	1 760	1 510	1 700	3 130	3 130	3 003
2003	49 600	2 860	1 920	1 490	1 360	1 850	3 270	3 270	2 933
2004	48 000	3 430	2 240	2 230	1 660	2 020	3 300	3 300	3 010
2005	48 400	3 230	1 890	1 880	1 370	1 600	2 710	2 710	2 982
2006	49 600	3 190	1 700	1 520	1 170	1 370	2 630	2 630	2 520
2007	52 600	3 040	1 910	1 740	1 330	1 560	2 850	2 850	3 122
2008	53 700	3 340	1 980	1 720	1 440	1 520	2 720	2 720	2 905
2009	60 500	3 540	1 880	1 720	1 320	1 900	3 000	3 000	3 220
2010	52 100	3 090	1 520	1 840	1 130	1 250	2 390	2 390	2 751
2011	62 900	3 070	2 050	1 840	1 340	1 570	2 690	2 690	3 045
2012	59 300	3 700	1 960	1 650	1 370	1 410	2 730	2 730	3 192

The values are corrected to a standardised moisture content (cereals 14%, pulses 15%, oleiferous plants 9% and 16.5% for temporary grass and green forage). Data are from the Swedish Board of Agriculture, Statistics Sweden, JO17- and JO19 -series. (*) Before 1995 statistics on peas & beans were aggregated.

Table 6.31. (cont.) Annua yield per hectare of different crops used in the calculations (kg/hectare)

Year	Table potatoes	Potatoes starch prod.	Maize(*)	Temporary grass	Temporary grass for seed	Green forage	Pasture ground
1990	33 060	40 090	0	7 490	7 490	5 000	7 490
1991	27 600	34 130	0	7 120	7 120	5 000	7 120
1992	32 850	34 390	0	6 010	6 010	5 000	6 010
1993	36 870	34 390	0	5 933	5 933	5 000	5 933
1994	30 430	34 390	0	5 856	5 856	5 000	5 856
1995	31 280	38 330	0	5 779	5 779	5 000	5 779
1996	33 210	38 370	0	5 702	5 702	5 000	5 702
1997	35 640	37 420	0	5 625	5 625	5 000	5 625
1998	34 720	47 440	0	5 548	5 548	5 000	5 548
1999	28 820	37 620	0	5 471	5 471	5 000	5 471
2000	26 720	38 700	0	5 394	5 394	5 000	5 394
2001	26 160	35 820	0	5 317	5 317	5 000	5 317
2002	26 470	35 050	0	5 240	5 240	5 000	5 240
2003	25 580	34 380	0	5 010	5 010	5 000	5 010
2004	27 610	39 720	0	5 010	5 010	5 000	5 010
2005	28 200	38 770	0	4 840	4 840	5 000	4 840
2006	25 990	31 690	0	4 450	4 450	5 000	4 450
2007	26 300	31 660	0	5 000	5 000	5 000	5 000
2008	28 490	40 440	6 490	4 730	4 730	5 000	4 730
2009	28 850	39 900	6 400	5 420	5 420	5 000	5 420
2010	27 360	37 140	5 610	5 620	5 620	5 000	5 620
2011	29 130	39 130	8 020	5 040	5 040	5 000	5 040
2012	29 370	42 540	6 290	5 320	5 320	5 000	5 320

The values are corrected to a standardised moisture content (cereals 14%, pulses 15%, oleiferous plants 9% and 16.5% for temporary grass and green forage). (*) Before 2008 Maize was included in Green forage. Data are from the Swedish Board of Agriculture, Statistics Sweden, JO17- and JO19 -series.

6.4.1.2.7 4.D.1.5 Background emissions of N_2O from cultivation of organic soils

In a literature survey assigned by the Swedish EPA it was suggested that the background emission from organic soils vary with different crops[191]. The emissions were also considered to be higher from ploughed soils than from pasture or temporary grass lands. The suggested emission factors were 6 and 1 kg N_2O-N ha^{-1}, respectively. The IPCC Guidelines' default value is however implemented in the inventory since a Swedish/Finnish research group concluded that not enough data exists to generate reliable emission factors for different soil managements and soil types[192]. The area of organic soils has only been estimated intermittently. The latest survey in 2009 concluded that approximately 5% of the total area of arable land consists of organic soils[193]. That fraction has then been used for all years, assuming

[191] Klemedtsson, 2001.

[192] Klemedtsson et al., 1999.

[193] Berglund, Berglund & Sohlenius, 2009

that the area of organic soils relative the total area of arable land stays constant over time.

$$emissions = Area \times EF$$

6.4.1.2.8 4.D.1.6 N_2O from sludge used as fertiliser

N_2O from sewage sludge used as fertiliser is a part of the N_2O emissions from agricultural soils and may be reported, according to the Good Practice Guidance, if sufficient information is available. This emission was included for the first time in the inventory in submission 2006. The activity data used is found in Table 6.22. Out of the total amount of nitrogen emitted, 70% is assumed to emanate from direct emissions and 30% from indirect emissions. The emission factor used for the direct emissions is 1.25% of the nitrogen in the sewage sludge. The corresponding value for the indirect emissions is 1%. Statistics on the use of sludge have been collected intermittently by Statistics Sweden and the Swedish EPA from sewage treatment plants. The emissions are calculated as:

$$emissions = \sum_i F_{Ri} \times N_{SEWAGESLUDGE} \times EF_i \times 44/28$$

F_{Ri} is the fraction of N emitted as direct/indirect emissions and EF_i is the corresponding emission factor. The direct emissions from sewage sludge is reported as an optional category in the CRF and the indirect emission is reported under CRF category 4.D.3.1.

6.4.1.3 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 farmers. Sales statistics are collected annually by the Swedish board of agriculture and Statistics Sweden[194]. Data has been collected in the same way from the larger producers and retailers since the early 1960s. Statistics on the use of fertiliser and manure have been collected biannually since the end of the 1980s[194]. When the sales statistics also includes some smaller quantities 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, but that should 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 have been used in the GHG inventory. Another advantage of the sales statistics is that they are updated annually.

194 Statistics Sweden, MI 30-series.

Historically, statistics on the use of sewage sludge have been published irregularly and in different reports, and the time series for the earlier years in the time series has been created through interpolation/extrapolation and certain assumptions. Gradually the quality of data has increased and data for the latest years are of acceptable quality.

6.4.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Times series and activity data are checked for consistency. Recalculations are identified and verified. Emission estimates and methods are reviewed yearly by external national experts.

6.4.1.5 SOURCE-SPECIFIC RECALCULATIONS

The formula to calculate ammonia emissions from mineral fertilisers was restructured. This resulted in a small decrease in the emissions from 4.D.1.1 with between 0.01% and 0.31% depending on the year (for the same reason the emissions from 4.D.3.1 increased with a comparable degree).

Activity data for 2011 for turkeys was updated with the latest available statistics. This resulted in a minor difference in 4.D.1.2.

The activity data for the calculations of emissions from crop residues was updated from standard yield to actual yearly yield. In addition, crop residues from oil flax were added and maize is now calculated separately instead of being included under green forage. All this affects the emissions from 4.D.1.4.

The total area of agricultural land has changed for all years which affects the emissions from 4.D.1.5. This is a consequence of the method used by SLU for calculating cropland (see 7.2.2.1).

Data for sludge use has been updated for 2011 which affects the emissions from 4.D.1.6. Due to a late publication it was not possible to update this year in submission 2013.

6.4.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

6.4.2 Pasture, Range and Paddock Manure (CRF 4.D.2)

6.4.2.1 SOURCE CATEGORY DESCRIPTION

The category includes N_2O emissions from nitrogen excreted during grazing. Calculations are carried out according to the methodology in the IPCC Guidelines. The summary of the latest key category assessment, methods and EF used, and information on completeness, are presented in Table 6.32.

Table 6.32. Summary of source category description for the entire category CRF 4.D.

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
4.D.2	N_2O	X	X		T2	CS, D	Yes

CS Country Specific. T2 Tier 2. D Default.

6.4.2.2 METHODOLOGICAL ISSUES

For N_2O emissions from N excreted on pastures the default emission factor of 2% N_2O-N/kg nitrogen excreted is used for all animal groups. This is probably an overestimation of the emission when the nitrogen lost as N_2O is likely to be lower in cold climates as in Sweden. However, very scarce information is available and until better empiric data is available we will use the IPCC default EF. The emissions are calculated as:

$$emissions = \sum_{T} N_T \times Nex_T \times Frac_{PRP} \times EF \times 44/28$$

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 (see Table 6.33) and EF is the emission factor. The nitrogen production for the different animal groups is presented in Table 6.13 and Table 6.15.

Table 6.33. Waste management systems, fraction of manure deposited on Pasture, Range and Paddock ($Frac_{PRP}$)

Year	Dairy cattle (*)	Other cattle (*)	Pigs for meat production (*)	Other swine (*)	Sheep, Goats	Reindeer	Horses	Poultry
1990	0.25	0.42	NO	NO	0.50	1.00	0.50	NO
1995	0.25	0.44	NO	NO	0.50	1.00	0.50	NO
2000	0.25	0.46	NO	NO	0.50	1.00	0.50	NO
2005	0.26	0.49	NO	NO	0.50	1.00	0.50	NO
2008	0.25	0.47	NO	NO	0.50	1.00	0.50	NO
2009	0.25	0.46	NO	NO	0.50	1.00	0.50	NO
2010	0.25	0.46	NO	NO	0.50	1.00	0.50	NO
2011	0.24	0.46	NO	NO	0.50	1.00	0.50	NO
2012	0.24	0.46	NO	NO	0.50	1.00	0.50	NO

(*) Data from Statistics Sweden's biannual survey "Use of fertilisers and animal manure in agriculture".

6.4.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The time-series is consistent.

6.4.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Times series and activity data are checked for consistency. Recalculations are identified and verified. Emission estimates and methods are reviewed yearly by external national experts.

6.4.2.5 SOURCE-SPECIFIC RECALCULATIONS

There were no recalculations in submission 2014.

6.4.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

6.4.3 Indirect Emissions (CRF 4.D.3)

6.4.3.1 SOURCE CATEGORY DESCRIPTION

This category includes the indirect emissions from soils. In general the Good Practice Guidance default emission factors are used. The Good Practice Guidance stresses the lack of knowledge on a global scale and the extreme variability in the suggested emission factors and parties are not encouraged to use national values unless they are rigorously documented and reviewed. However, values for losses of nitrogen as ammonia (see 6.4.1.2.2) and nitrogen leakage are national. The summary of the latest key category assessment, methods and EF used, and information on completeness, are presented in Table 6.34.

Table 6.34. Summary of source category description for the entire category CRF 4.D.3

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
4.D.3	N_2O	X	X		CS, T1a	CS, D	Yes

CS Country Specific. T1 Tier 1. D Default.

6.4.3.2 METHODOLOGICAL ISSUES

6.4.3.2.1 4.D.3.1 Atmospheric deposition

The formula for estimating atmospheric deposition is:

$$N_{Tot} = N_{Fert} \times Frac_{GASF} + N_{Sludge} \times 0.3 + N \times Nex \times Frac_{GASM} + N \times Nex \times Frac_{GASG}$$

$$N_2O = N_{Tot} \times EF \times 44/28$$

N_{Fert} is the nitrogen supply by mineral fertiliser and $Frac_{GASF}$ is the corresponding N fraction emitted as ammonia, calculated from sold quantities of different fertilisers and with emission factors from the EMEP/EEA air pollutant emission inventory guidebook 2009. N×Nex is the total amount of nitrogen excreted from animals, combined with national estimates of $Frac_{GASM}$, the fraction of nitrogen from animal manure emitted as ammonia, and $Frac_{GASG}$, the fraction of manure from grazing animals emitted as ammonia (see 6.4.1.2 for explanations on the calculations of $Frac_{GASM}$ and $Frac_{GASG}$)

6.4.3.2.2 4.D.3.2 Nitrogen Leaching and Run-off

The national estimate of nitrogen leaching is estimated by the SLU and calculated from the SOILNDB model[195], which is a part of the SOIL/SOILN model[195]. This simulation model was developed during the 1980s in order to describe nitrogen processes in agricultural soils[196]. Since then the model has been elaborated and tested on data from controlled leaching experiments, and these tests show that the model estimates the leaching from soil with good precision[197]. By using national data on crops, yields, soil, use of fertiliser/manure and spreading time, the leaching is estimated for 22 regions. These regions are based on similarities in agricultural production areas. On average data from this model has been published every five years, intermittent years have been interpolated (Table 6.35). For 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 agricultural soil.

[195] Johnsson, 1990; Swedish EPA, 2002.

[196] Johnsson et al., 1987.

[197] Swedish EPA, 2002b.

Table 6.35. Nitrogen leaching estimated by the SOIL/SOILN model

Year	Nitrogen Leaching (kg/ha)	Year	Nitrogen Leaching (kg/ha)
1990	24.6 *	2002	19.5
1991	23.9	2003	19.0
1992	23.2	2004	18.5
1993	22.4	2005	18.0 **
1994	21.7	2006	18.0
1995	21.0 **	2007	18.0
1996	21.0	2008	18.0
1997	21.0	2009	18.0 **
1998	21.0	2010	18.0
1999	21.0 **	2011	18.0
2000	20.5	2012	18.0
2001	20.0		

* Interpolated using results from 1985 and 1994.
** Estimated with the SOIL/SOILN model.
Other years are interpolated/extrapolated.

The nitrogen leaching and run-off is calculated as:

$$emissions = area \times Nitrogen\ Leaching \times EF \times 44/28$$

To estimate the implied $Frac_{LEACH}$, which is required as additional information in CRF 4.D for each reporting year, the leached nitrogen, according to the national model, is divided by the sum of nitrogen in fertilisers and animal production. This quotient varies between 0.19 and 0.25, which is relatively close to the IPCC Guidelines' default value of $Frac_{LEACH}$ (0.3).

6.4.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The average nitrogen leaching from agricultural soils, the leach factor, has been estimated by Swedish University of Agricultural Sciences. The value for 1990 is calculated from an investigation that estimated nitrogen leaching for the years 1985 and 1994, however, only for the southern part of Sweden. So the value used is corrected to apply to the whole of Sweden. The reason for the continuous decrease between 1999 and 2005 is believed to mainly be dependent on an increase in the area of catch crops. But an increased awareness of the eutrophication problem also lead to changed fertilising patterns. 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 other year,[198] the estimates can be updated at most every second year. However, due to economic reasons, the data has been published intermittently.

[198] Statistics Sweden, MI 30-series.

6.4.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Times series and activity data are checked for consistency. Recalculations are identified and verified. Emission estimates and methods are reviewed yearly by external national experts.

6.4.3.5 SOURCE-SPECIFIC RECALCULATIONS

The formula to calculate ammonia emissions from mineral fertilisers was restructured. This resulted in a small increase in the emissions from 4.D.3.1.

The recalculations in emissions from 4.D.3.2 are due to that the total area of agricultural land has changed for all years. This is a consequence of the method used by SLU for calculating cropland (see 6.4.4.3 and see 7.2.2.1).

6.4.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

6.4.4 Other (CRF 4.D.4)

6.4.4.1 SOURCE CATEGORY DESCRIPTION

Under CRF 4.D.4 Sweden report a background emission from agricultural soils. The summary of the latest key category assessment, methods and EF used, and information on completeness, are presented in Table 6.36.

Table 6.36. Summary of source category description for the entire category CRF 4.D.4

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
4.D.4	N_2O	X	X		CS	CS	Yes

CS-Country Specific.

6.4.4.2 METHODOLOGICAL ISSUES

Based on a study of national emission factors[199], a background emission from the cultivation of mineral soils have been included in the inventory with an emission factor of 0.5 kg N_2O-N/ha. The total area of mineral soils is calculated as total area of arable land minus the area of organic soils.

[199] Klemedtsson, 2001.

6.4.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The estimated emission is dependent on estimated area of agricultural land. This classification is performed by the Swedish National Forest Inventory (NFI[200]). In total the sample consists of approximately 30 000 sample plots. However, only one fifth are investigated yearly. As a consequence of this the accuracy will increase retroactively until the whole five year cycle is completed. The estimate for the last year will only be based on 6 000 sample plots, and then the accuracy gradually increases until the whole five year cycle is completed. That is, the number of sample plots for one, two, three, four and five years old data is 6 000, 12 000, 18 000, 24 000 and 30 000, respectively. However, to reduce the variation that sometimes arise for the most recent years due to sampling errors the estimates of the areas are calculated as a running average for the last five years (see 7.2.2.1).

6.4.4.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Times series and activity data are checked for consistency. Recalculations are identified and verified. Emission estimates and methods are reviewed yearly by external national experts.

6.4.4.5 SOURCE-SPECIFIC RECALCULATIONS

The total area of agricultural land has changed for all years. This is a consequence of the method used by SLU for calculating cropland (see 6.4.4.3 and 7.2.2.1).

6.4.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

[200] Ranneby et al., 1987

7 Land Use, Land-Use Change and Forestry (CRF sector 5)

7.1 Overview of LULUCF

Sweden reports carbon stock changes and greenhouse gas emissions from Forest land, Cropland, Grassland and Settlements and associated land-use transfers[201]. These land use categories are considered managed. Except for a small area used for peat extraction, Wetlands and Other land are considered unmanaged and consequently only areas of these categories are reported. The reporting also includes N_2O emissions associated with nitrogen fertilization of Forest land, N_2O emissions due to land conversions to cropland, CO_2, emissions associated with liming and N_2O as well as CH_4 emissions from biomass burning.

In 2012 the net removal from the Land Use, Land-Use Change and Forestry LULUCF-sector was estimated to ca 35,418 Gg CO_2. The net removal increased slightly from 2011 to 2012 by ca 0,187 Gg CO_2.

The long-term trend with decreasing net removals in living biomass is mainly due to an increase in harvest rates (Figure 7.1), while the increase in gross removal originating from tree growth has not been equally large. While interannual fluctuations in harvest rates are quite large, the increase in harvest rates have stagnated the latest years pointing to a slightly increasing sink. Gross removal (growth) in Sweden shows an increasing trend and currently lies around 120 Mm^3sk (approx. 160 Mtonnes CO_2 per year). In 2012 the gross harvest was approximately 85 Mm^3sk (Figure 7.1). Since the harvest level is well below the growth, this results in a steady increase in the carbon stock in living biomass which has prevailed since the beginning of the 20th century (Figure 7.1).

[201] Sweden uses random sampling methodology to estimate land-use and land-use transfers. The reporting is based on 30 000 permanent sample plots inventoried by the Swedish National Inventory of Forests (RIS) in five cycles each based on around 6000 plots per year. The permanent sample plots have been re-inventoried at intervals of 5-10 years, from 2003 every five year, and the land-use of each is described from the year of the first inventory and every year thereafter. The land-use of years between inventories has been interpolated. This means that a full record of plots comprise 30 000 plots whereas the latest year is only represented by 6 000 measured plots. As the inventory cycle continuous in subsequent years, more data covering the latest years are made available. Estimates of the four last years of the previus report are thus re-calculated using re-measured plots in each submission. From submission 2012 and onwards, results for the latest years (those years without a full record of plots per cycle) are still calculated on a full record of plots using extrapolated data per cycle as approximate values for the not-yet-inventoried plots, see Figure 7.6. Both the extrapolation and the re-calculation is made to improve the accuracy of estimates.

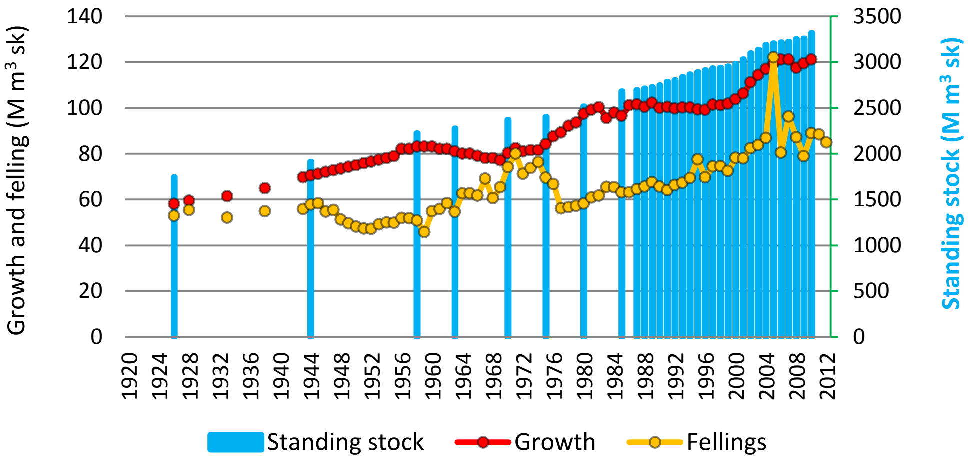

Figure 7.1. Annual growth and fellings and the standing stock (Source: Official Forest Statistics http://www.slu.se/en/webbtjanster-miljoanalys/forest-statistics/)

Since Submission 2010 Sweden reports data and supplementary information for the Kyoto Protocol including emission/removals for activities under article 3.3 (Afforestation, Reforestation and Deforestation) and for Forest management under article 3.4. In 2012 changes in carbon pools for afforestation, reforestation and deforestation together constituted an emission of 2,530 Gg CO_2 and Forest management represented a removal of 39,558 Gg CO_2. The supplementary information required for the reporting under the Kyoto Protocol is found in the NIR part II (Chapter 11).

Forest is the major land-use category in Sweden. The total forest area (FAO definition) is about 28 million hectares. The productive forests (where annual stem wood production per hectare and year is larger than 1 m^3), on which most of the reported changes in carbon pools occur, is 23 million hectares[202].

Harvest of trees is more or less restricted to productive forests and the unrestricted productive forest area has decreased since 1990, as a result of the establishment of nature reserves. There has been a continuous increase in felling during the reported period peaking at 2005 (due to wind throws originating from a severe storm), the growth rate has also increased stadily. However, harvest statistics indicate quite large fluctuations between years due to changes in demand fro forest products. It should be noted that from the base year and onwards, the reported growth is larger than the drain – defined as harvest and self-mortality.

The land use and land-use change matrices (Table 7.1a. and 7.1b) is based on about 6000 (1990-2012) and 30000 sample plots (1990-2008), respectively[203]. Due to a

[202] Swedish University of Agricultural Sciences, 2011

[203] The reason for reporting two land use matrixes is mainly because it is mandatory to report a land use matrix 1990-2012 and to show that the accuracy increases when using a full record of sample plots.

five-year inventory cycle we can only provide a full record of data 1990-2008. Note that only the area in Table 7.1b corresponds to the reported area in the CRF-tables (year 2008) while Table 7.1a might deviate somewhat because it is based on a smaller sample[1]. Forest land is the most important land-use category. The gross and net conversions indicate that conversions from Forest land to Settlements are frequent. The reason for reporting two land use matrixes is based on a request from reviewers.

Table 7.1.a.[204] Land Use Categories 1990, 2012 and gross and net land use transfers 1990-2012 (based on about 6000 permanent sample plots inventoried 1986-2012). The carbon stock of Forest land in the mountain area[205] (915 000 ha) is not monitored in the field and changes in the carbon pools for this area are not reported.

Area [1000 ha]	"From" Year 1990	"To" Year 2012 Forest Land	Crop-Land	Grass-Land	Wet-land	Settle-ments	Other Land
Forest land	27399	27035	9	55	56	202	40
Cropland	3165	122	2898	75	0	70	0
Grassland	503	84	34	366	0	19	0
Wetlands	7973	223	0	7	7646	14	83
Settlements	1710	66	29	2	20	1588	5
Other land	4518	23	0	0	77	6	4412
Sum after transfers		27554	2970	505	7799	1900	4540

Table 7.1.b. Land Use Categories 1990, 2008 and gross and net land use transfers[206] 1990-2008 (based on about 30 000 permanent sample plots inventoried 1983-2012)

Area [1000 ha]	"From" Year 1990	"To" Year 2008 Forest Land	Crop-Land	Grass-Land	Wet-land	Settle-ments	Other Land
Forest land	28128	27788	4	25	116	166	29
Cropland	3098	82	2900	45	3	69	0
Grassland	507	47	45	395	3	13	4
Wetlands	7359	267	3	3	6983	4	97
Settlements	1673	72	18	5	8	1562	8
Other land	4351	47	0	2	43	2	4257
Sum after transfers		28303	2970	474	7157	1817	4395

The largest carbon stocks are found in the living biomass and soil organic carbon pools on Forest land, and the largest annual stock change is the change in the living biomass pool (Figure 7.2 and 7.3). A net removal of CO_2 due to increases in the living biomass pool is reported for every year during the period.

[204] Table 7.1a is put together based on a request from the ERT in the centralized review (Subm 2009).

[205] Löfgren, 1998

[206] The carbon stock of Forest land in the mountain area (915 000 ha) is not monitored in the field and changes in the carbon pools for this area are not reported.

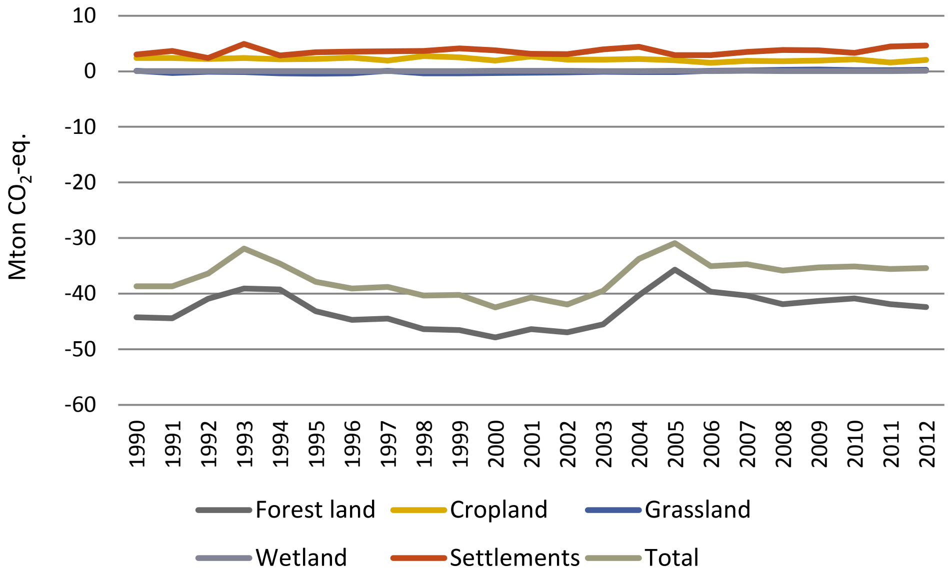

Figure 7.2. Net emissions/removals of GHG in the LULUCF sector from different land-use categories and total net removals for the LULUCF-sector

The dead organic matter pool resulted in net removals during most years of the reported period, whereas the soil organic carbon resulted in net removals during all years of the reported period. Some soils act as sources whereas others act as sinks. The major source is the emissions from drained organic soils (Histosols) on Forest land and on Cropland. An area of about 3.8 Mha of the Forest land was considered as Histosols 2012 and 1.2 Mha of the Histosols are drained. The Cropland area on Histosols is estimated to approx. 144 kha (2012) and all of that area is drained. Emissions from agricultural soils are estimated from modelled data on changes in the soil organic carbon pool with variations in yield and weather as drivers. For drained organic soils an estimation of the subsidence is added. The emissions from these areas dominate the emissions of CO_2 from agricultural soils. The area of is decreasing since the total Cropland area (the average trend) in Sweden is decreasing, leading to a trend towards decreased emissions from Cropland. The decrease in area is mainly due to conversion to Forest land and Settlements. Conversion from and to Grassland do also occur.

There has been considerable variation between submissions for specific years in the soil organic carbon pool on mineral soils. These variations are partly caused by random variation in the sample. Since the total pool is huge and the changes in the pool comparatively small the numbers are sensitive to random variation when small changes are multiplied by large areas. It should be noted that a change of 0.1% in the pool is equivalent to more than 3,000 Gg CO_2. The variation between years has been reduced after the introduction of a new method for extrapolation of data on plot basis (first time used and described as a recalculation in Submission

2011). Variation between submissions may still be substantial. We expect that this variation will decrease with time when more plots are re-inventoried.

The emissions of N_2O from nitrogen fertilization of forest land increased steadily from 2002 to 2010 but have decreased since then and there are no obvious reasons for these fluctuations. N_2O emissions from disturbance associated with land-use conversion to Cropland have increased due to an increase in area converted. The CO_2 emissions from agricultural lime application are steadily decreasing due to a more limited use of lime. The burned area which strongly drives the emissions from biomass burning shows no trend. The emissions from these categories correspond to less than 0.3 Mtonnes CO_2-equivalents per year during the entire period 1990-2012. Among these categories, the highest emissions originate from liming. Sweden does not report N_2O emissions from drainage of soils.A summary of emissions/ removals is found in Tables 7.2a and 7.2b.

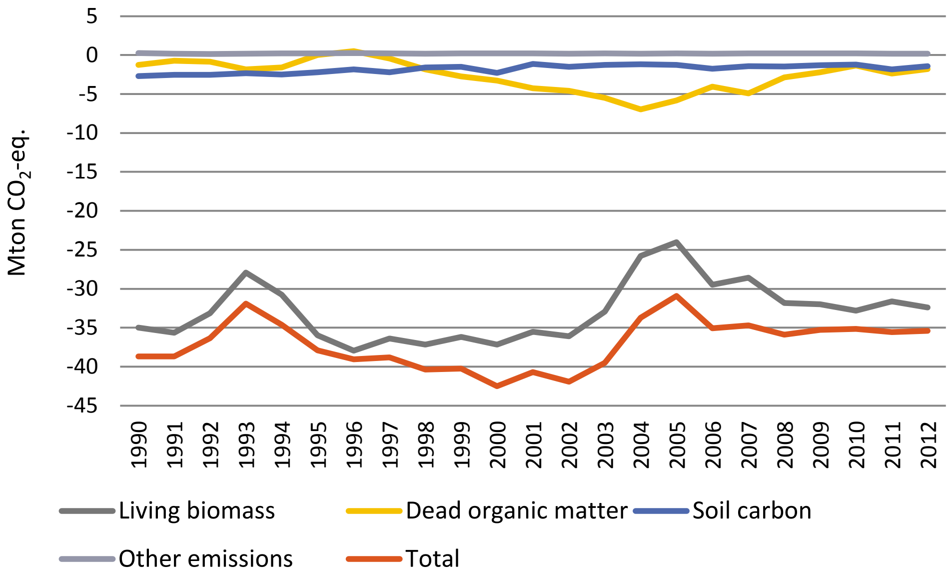

Figure 7.3. Net removals/emissions of GHG in the LULUCF sector from different carbon pools and other sources

Table 7.2.a. Summary of net removals (-)/emissions (+) in living biomass (LB), dead organic matter (DOM) and soil organic carbon (SOC) per land use category

7.2a	Net removals (minus=removal) [Mt CO_2]															
	Forest land				Cropland				Grassland				Wetland	Settlement		
	LB	DOM	SOC Min.	SOC Org.	LB	DOM	SOC Min.	SOC Org.	LB	DOM	SOC Min.	SOC Org.	SOC	LB	DOM	SOC
1990	-37.2	-1.2	-14.5	8.5	0.1	0.0	0.1	2.1	0.1	-0.3	0.0	0.4	0.0	2.0	0.3	0.7
1991	-37.8	-0.7	-14.4	8.5	0.0	0.0	0.1	2.1	-0.3	-0.3	0.0	0.4	0.0	2.5	0.4	0.9
1992	-34.1	-0.9	-14.4	8.5	0.0	0.0	0.0	2.1	-0.1	-0.3	0.0	0.4	0.0	1.1	0.4	0.9
1993	-31.3	-1.9	-14.4	8.5	0.1	0.0	0.1	2.1	-0.1	-0.3	0.0	0.4	0.0	3.4	0.5	1.1
1994	-31.6	-1.7	-14.4	8.5	0.0	0.0	-0.1	2.0	-0.3	-0.3	-0.1	0.4	0.0	1.2	0.5	1.1
1995	-37.2	-0.2	-14.4	8.5	-0.1	0.0	0.1	2.0	-0.4	-0.3	-0.1	0.4	0.0	1.7	0.5	1.2
1996	-39.2	0.2	-14.3	8.5	-0.1	0.0	0.3	2.1	-0.3	-0.3	-0.1	0.3	0.0	1.7	0.6	1.3
1997	-38.0	-0.7	-14.3	8.5	-0.1	0.0	-0.2	2.0	0.1	-0.3	0.0	0.4	0.0	1.7	0.6	1.3
1998	-38.4	-2.2	-14.4	8.6	0.0	0.0	0.5	2.1	-0.4	-0.3	0.0	0.4	0.0	1.6	0.7	1.4
1999	-37.5	-3.2	-14.4	8.6	-0.3	0.0	0.5	2.1	-0.4	-0.3	-0.1	0.4	0.1	2.0	0.7	1.5
2000	-38.2	-3.7	-14.6	8.6	0.0	0.0	-0.2	2.0	-0.4	-0.3	0.0	0.4	0.1	1.4	0.7	1.6
2001	-35.7	-4.8	-14.5	8.6	-0.3	0.0	0.7	2.1	-0.3	-0.3	0.0	0.3	0.1	0.8	0.8	1.6
2002	-36.2	-5.1	-14.3	8.6	-0.2	0.0	0.1	2.0	-0.2	-0.3	-0.1	0.3	0.1	0.6	0.8	1.7
2003	-33.7	-6.1	-14.3	8.6	-0.3	0.0	0.2	2.0	-0.2	-0.3	0.0	0.4	0.1	1.3	0.8	1.8
2004	-27.1	-7.6	-14.2	8.6	-0.3	0.0	0.3	2.0	-0.2	-0.3	0.0	0.3	0.0	1.8	0.9	1.8
2005	-23.8	-6.4	-14.1	8.6	-0.3	0.0	0.1	2.0	-0.2	-0.2	0.0	0.4	0.1	0.4	0.8	1.7
2006	-29.6	-4.6	-14.2	8.6	-0.4	0.0	-0.2	2.0	0.0	-0.2	0.0	0.4	0.0	0.5	0.7	1.6
2007	-29.4	-5.4	-14.1	8.6	-0.4	0.0	0.1	2.0	0.0	-0.2	0.0	0.4	0.1	1.2	0.7	1.6
2008	-33.0	-3.4	-14.1	8.6	-0.4	0.0	0.1	2.0	0.1	-0.2	0.0	0.4	0.1	1.5	0.7	1.6
2009	-33.1	-2.8	-14.1	8.6	-0.4	0.0	0.1	2.0	0.2	-0.2	0.0	0.4	0.1	1.3	0.7	1.7
2010	-33.3	-1.9	-14.3	8.6	-0.4	0.0	0.3	2.0	0.0	-0.2	0.0	0.4	0.1	0.9	0.7	1.7
2011	-33.3	-2.9	-14.2	8.6	-0.3	0.0	-0.2	1.9	0.0	-0.2	0.0	0.4	0.1	2.0	0.8	1.7
2012	-34.3	-2.4	-14.3	8.5	-0.4	0.0	0.2	2.0	0.1	-0.2	0.0	0.4	0.1	2.1	0.8	1.7

Table 7.2.b. Summary of net emissions (+)/removals (-) in living biomass (LB), dead organic matter (DOM) and soil organic carbon (SOC) and other sources. The total LULUCF removals are expressed as CO_2-equivalents.

7.2b	Total carbon pool changes [Mt CO_2]			Other emissions [Mt substance]						Total LULUCF
				Fert. 5 (I)	To CL 5 (III)	Lim- 5 (IV)	Biomass burning 5 (V)			
Year	LB	DOM	SOC	N_2O	N_2O	CO_2	CO_2	CH_4	N_2O	[Mt CO_2-eq]
1990	-35.0	-1.2	-2.7	1.9E-	6.0E-	1.7E-	IE	8.2E-	5.6E-	-38.7
1991	-35.6	-0.7	-2.5	1.1E-	7.0E-	1.3E-	IE	7.6E-	5.3E-	-38.7
1992	-33.2	-0.8	-2.5	7.6E-	7.7E-	1.1E-	IE	7.7E-	5.3E-	-36.4
1993	-27.9	-1.8	-2.3	6.7E-	8.5E-	1.3E-	IE	8.0E-	5.5E-	-31.9
1994	-30.8	-1.6	-2.5	5.9E-	1.0E-	1.6E-	IE	7.6E-	5.3E-	-34.6
1995	-36.0	0.0	-2.2	6.9E-	1.2E-	1.7E-	IE	7.7E-	5.3E-	-37.9
1996	-38.0	0.5	-1.8	6.2E-	1.2E-	1.9E-	IE	8.2E-	5.6E-	-39.1
1997	-36.4	-0.4	-2.2	4.9E-	1.3E-	1.7E-	IE	4.2E-	2.9E-	-38.8
1998	-37.2	-1.8	-1.6	5.0E-	1.4E-	1.3E-	IE	2.2E-	1.5E-	-40.4
1999	-36.2	-2.8	-1.5	6.5E-	1.4E-	1.6E-	IE	1.4E-	9.7E-	-40.2
2000	-37.2	-3.3	-2.3	6.4E-	1.5E-	1.6E-	IE	1.4E-	9.7E-	-42.5
2001	-35.5	-4.3	-1.1	5.4E-	1.6E-	1.4E-	IE	1.4E-	9.9E-	-40.7
2002	-36.1	-4.6	-1.5	3.6E-	1.7E-	1.3E-	IE	2.3E-	1.6E-	-41.9
2003	-33.0	-5.5	-1.3	4.4E-	1.7E-	1.3E-	IE	2.9E-	2.0E-	-39.5
2004	-25.8	-7.0	-1.2	5.5E-	1.7E-	1.2E-	IE	2.6E-	1.8E-	-33.7
2005	-24.0	-5.8	-1.3	8.2E-	1.8E-	1.2E-	IE	2.4E-	1.6E-	-30.9
2006	-29.5	-4.0	-1.7	8.8E-	1.9E-	9.1E-	IE	6.2E-	4.3E-	-35.1
2007	-28.6	-4.9	-1.4	1.2E-	1.9E-	1.2E-	IE	1.1E-	7.9E-	-34.7
2008	-31.8	-2.8	-1.5	1.6E-	2.0E-	1.0E-	IE	6.3E-	4.3E-	-35.9
2009	-32.0	-2.2	-1.3	1.5E-	2.0E-	9.8E-	IE	9.0E-	6.2E-	-35.3
2010	-32.8	-1.4	-1.2	2.1E-	1.9E-	9.1E-	IE	3.4E-	2.3E-	-35.1
2011	-31.6	-2.4	-1.8	1.4E-	2.0E-	8.8E-	IE	1.0E-	7.0E-	-35.6
2012	-32.4	-1.8	-1.4	1.2E-	2.0E-	8.5E-	IE	4.5E-	3.1E-	-35.4

7.2 Description of categories 5A, 5B, 5C, 5D, 5E and 5F

7.2.1 Characteristics of categories

On request from the External review team at the In Country Review 2013, Sweden was encouraged to change the aggregation of categories in the Key-category analysis (same aggregation in the uncertainty analysis). The old aggregation was based on underlying methods used for estimates while the new one is more focusing on reporting codes and greenhouse gases. Detailed information about the Key-category analysis is found in chapter 1.5 and a summary in Table 7.3. In the LULUCF-sector CO_2 emissions/removals for Forest land remaining Forest land, land converted to Forest land, Cropland remaining Cropland, Grassland remaining Grassland and land converted to Forest land are considered key-categories. N_2O emissions for land converted to Cropland is the least significant key-category identified and is only key for Tier 2 Trend.

CO_2: Sweden uses higher Tiers-methodologies for all carbon pools but not for liming. However, we belive that emissions from liming is not very important for the Swedish climate reporting and certainly not a Key-category of its own. N_2O: emissions from land use conversions to Cropland is estimated using a lower Tier-methodology. Sweden will consider improving the methodlogy for this emission.

Table 7.3. Summary of key category description, CRF 5

CRF	Gas	Key Category Assessment 2012 (tier 2)			Method	EF
		Level	Trend	Qualitative		
5.A.1 (Forest Land remaining Forest Land)	CH_4				T1	D
	CO_2	X	X		T2,T3	CS
	N_2O				T1	D
5.A.2 (Land converted to Forest Land)	CO_2	X	X		T1,T2,T3	CS
5.B.1 (Cropland remaining Cropland)	CO_2	X	X		T1,T2,T3	CS,D
5.B.2 (Land converted to Cropland)	CO_2				T1,T2,T3	CS
	N_2O		X		T1	D
5.C.1 (Grassland remaining Grassland)	CH_4				T1	CS
	CO_2		X		T3	CS
	N_2O				T1	CS
5.C.2 (Land converted to Grassland)	CO_2				T1,T2,T3	CS
5.D.1 (Wetlands remaining Wetlands)	CO_2				T2	CS
5.E.1 (Settlements remaining Settlements)	CO_2				T3	CS
5.E.2 (Land converted to Settlements)	CO_2	X	X		T1,T2,T3	CS

7.2.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

7.2.2.1 THE SWEDISH NATIONAL INVENTORY OF FORESTS

The Swedish National Inventory of Forests (RIS[207]) consists of the Swedish National Forest Inventory (NFI[208]) and The Swedish Forest Soil Inventory (MI[209]). The NFI and the MI are integrated in the same sample design, using the same permanent sample plots. However, the sampling interval of the soil inventory is longer since processes in the soil are much slower than in the living biomass.

The plots associated to the NFI are re-inventoried every fifth year and the plots associated to the MI are re-inventoried every tenth year. Moreover, top soil cores are only taken at every second sample plot and deeper soil horizons are only 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 MI-measurements.

The NFI is an annual, systematic, cluster-sample inventory of Sweden's forests (Figure 7.4 and 7.5). 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 of than in the northern part of the country. The clusters (tracts) are square-shaped with sample plots along each side. Each cluster consists of four to eight sample plots, depending on geographical region. Each year, about 6000 permanent survey sample plots are inventoried in the field. On each circular sample plot, with a radius usually of 10 or 20 m, information is collected about the trees, the stand and the site. The main focus of the NFI is on monitoring forests for timber production and environmental protection.

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[207] Swedish University of Agricultural Sciences, 2011

[208] Ranneby et al., 1987

[209] Swedish University of Agricultural Sciences, http://www-markinventeringen.slu.se/

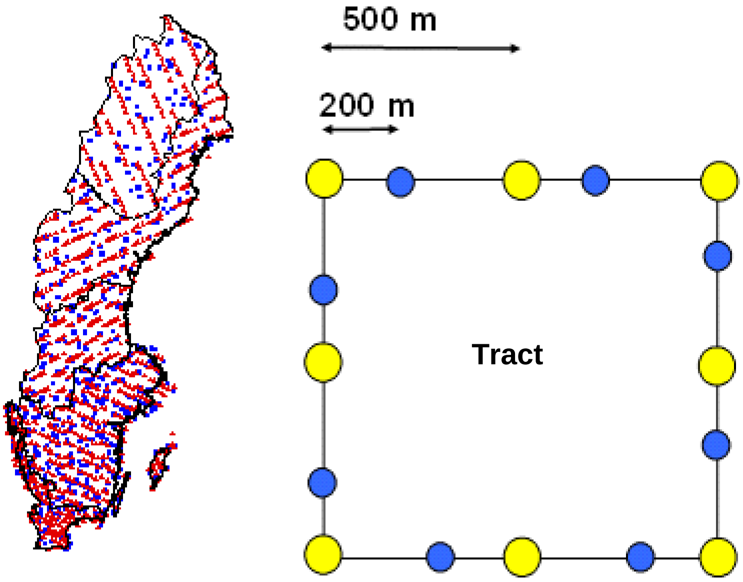

Figure 7.4. Covering the whole country of Sweden, each year a permanent sample grid (red) is re-inventoried and a temporary sample grid (blue) is inventoried. To be able to trace both gross and net land use transfers, only permanent sample plots are used in the reporting. When estimating changes of e.g. C, the accuracy is also higher using permanent then when using temporary sampling plots. Each red dot represents a cluster of sample plots (Tract) and within Tract the yellow plots are used for the inventory while the blue plots are used for validation of harvests (estimates on up to one year old stumps).

Figure 7.5. The sample plots (red) are covering all relevant land use. On the example above, plots are located on e.g. Forest land, Cropland, Wetlands and some plots are divided into more than one land use category. On the plots, measurements are made to estimate standing biomass of trees. If at the next re-inventory, the trees remains and has been growing the plot represents a net sink but if they have been harvested the plot represents a source (stock change method). Volume of dead wood per decay classes are also measured on the plot. Soil samples from different soil horizons are sampled and analyzed for C concentration and other properties. Litter is partly estimated using data from the plot and partly modeled. Observe that the size and number of tracts differs by county. An additional sample (blue) is used for estimates of harvests.

The soil inventory 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 further laboratory analysis. The O, H or A horizon[210] are sampled using an auger. The mineral soil is sampled in different 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 an ongoing European inventory, i.e. Biosoil[211] and soil samples are taken at fixed depths.

[210] O,H and A refers to the organic soil layers.

[211] http://biosoil.jrc.it/

7.2.2.2 SAMPLE BASED ESTIMATIONS

The sample frame consists of a map covering the whole land and fresh water area of Sweden. 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) and a specific number of sample units are sampled per stratum. Each cluster (tract) of sample plots 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 land use of whole plots or parts of plots may change by time but the total tract area will always represent the same 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 estimator[212]. Finally the reported value on national level is estimated as the sum of the county values (For further information, see Annex 3.2).

A five year inventory cycle is used and five different samples were randomly distributed (using a systematic grid) 1983, 1984, 1985, 1986 and 1987, respectively. Each of 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 2008 and consequently only 24000, 18000, 12000 and 6000 sample plots are available for the estimates of 2009, 2010, 2011 and 2012 respectively. When five years have proceeded since 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 previus report are re-calculated and revised in each submission.

Since the effect of the random variation on the estimates of areas and carbon stock changes are larger for the four most recent years (as also noted in the annual review reports), Sweden now extrapolates each of the five sample series (cycles) using the running average 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 7.6, the extrapolation of each sample series and its consequences on the estimates are illustrated. The effect of the extrapolation levels out "strange" area and carbon stock variations evolving from the randomness of the sampling as exemplified in Figure 7.6[213].

[212] Thompson, 1992

[213] This improvement and the information provided is a response to reviewers (ARR 2011)

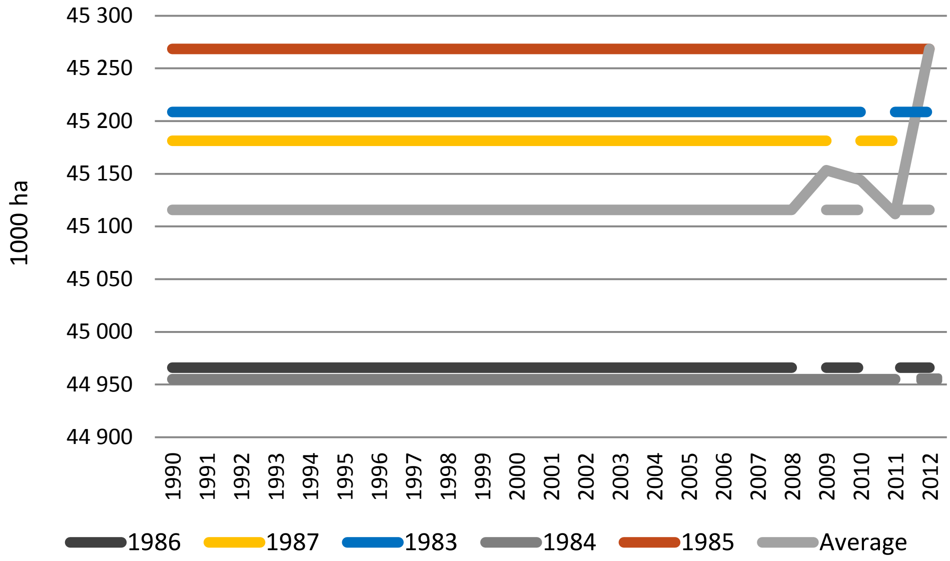

Figure 7.6. The total area of Sweden represented by five sub-samples (established in 1983, 1984, 1985, 1986 and 1987). Solid lines represent measured and dashed lines represent extrapolated values. The average solid line 1990-2012 represents average without extrapolated values and the average dashed line (2009-2012) represents the average with extrapolated values

Sweden reports "human induced" carbon changes only, where "human induced" has the interpretation of "managed", i.e. the biomass stock change on unmanaged land are set to zero. However, the "actual" stock 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.

7.2.2.3 THE LULUCF-REPORTING DATABASE

Around 30000 permanent sample plots inventoried by RIS are used for the area based sampling. The plots were distributed during the period 1983-1987, representing all land and fresh-water areas have been re-inventoried at intervals of 5-10 years (from 2003 in a five-year cycle). 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 year thereafter. The land-use of years between inventories has been interpolated by linear interpolation (see Table A.3.2.1 in Annex 3:2). Biomass pools for years between inventories are also linearly interpolated. If both harvest and a land use conversion are identified in field, then these two events are matched to the same year and the biomass in living biomass is assumed to drop to zero.

7.2.2.4 LAND USE TRANSFERS CRF-TABLES 5A, 5B, 5C, 5D, 5E AND 5F

All land use conversions are assumed to occur at a random year between consecutive re-measurements. Between 2006 and 2011, the year of conversion was as-

sessed in field but this assessment is assumed to be too uncertain and has been removed. Every plot that is converted to another land-use category is reported for 20 years in the land-use transfer class. After 20 years the plot will be reported in the class 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 land-use transfer class as in the first example. In the reporting database it is possible to trace some of the land-use transfers that occurred up to 20 years before 1983 and consequently it is possible to decide how many years a sample plot has belonged to a certain land-use category and what land-use category it was converted from already at the start of the reporting period (1990). Consequently, several land use transfer categories include areas already before 1990. The IPCCs “20 year default rule” has vast influence on reported figures. One example is the fact that accumulation of carbon in the Living biomass pool in the conversion category Cropland converted to Forest starts already before the base year. After twenty years, parts of these land areas are reported as Forest remaining Forest. Consequently a decrease in net removals may be reported under Cropland to Forest and the corresponding increase in net removals is instead reported under Forest remaining Forest. To some extent, the continuously transfer of land use between categories and the five-year inventory cycle average out such events.
The FAO definition of Forest land was introduced in the Swedish NFI in 1998. Until 1998 Forest land was assessed based on the national definition[214] of Forest land. Therefore, land-use categories have to be re-determined for the period 1990-1997. There are two main types of redetermination cases which are handled as follows:

1. If the land-use category for a sample plot was registered as Forest land at the first inventory after 1997 and the national land-use category (see Table 7.4) had been the same at all earlier inventories since 1990, the plot are assumed to have always belonged to the land-use category Forest land.
2. If the land-use category was registered as Forest land at the first inventory after 1997 and the national land-use category (see Table 7.4) had changed since 1990, the first land-use category are assumed to remain until the year of conversion. If at consecutive inventories after that, the land-use category belonged to the same land-use category, 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.

[214] The national definition of forest capture forest land where the production is (or have the potential to reach) at least 1 cubic meter per hectare and year.

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 at the first inventory, as Wetland at the next inventory and then again as Forest land at the third inventory without traces of human activities. A case like this is corrected so that the land-use category is assumed to be Forest land on all three occasions. Another example of the first type is when a recreation forest close to a city has been converted from Settlements (section 7.2.3.1, national land-use category 13, "Urban land") to Forest land and the new land-use category consists of old trees. This has been corrected so the land-use is assumed as Forest land on both occasions. One example of the second type is when the delineation of a divided plot, representing more than one land-use category, has been changed at the re-inventory due to personal judgments rather than due to actual changes. These land-use changes should not be registered as land use changes and have been corrected by keeping the newer delineation, usually if the assumed incorrect new delineation deviates approximately less than 0.75 m^2 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.

7.2.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories

Sweden has defined Forest land according to the Global Forest Resources Assessment (FAO/FRA) 2005[215]. Forest land is land with a tree crown cover (or equivalent stocking level) of more than 10 percent 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*. However, there are two small discrepancies between the FRA 2005 definition and the definition implemented in the Swedish inventory.

In the Swedish inventory permanent forest roads (width>5m) are not considered Forest land, and no minimum width to constitute Forest land is considered (note that the strict terms of Decision 11/CP.7 does neither mention the minimum width nor the forest roads[216]). All Forest land is considered managed, i.e. even protection of forests in reserves is considered as management. Cropland is defined as regularly tilled agricultural land and all Cropland is assumed managed. Grassland is defined as agricultural land that is not regularly tilled and all Grassland is assumed managed. This corresponds to natural grazing land. Generally, Wetlands is assumed unmanaged and is defined as mires and areas saturated by fresh water. However, approx. 10 000 ha of the Wetland area is used for peat extraction and therefore assumed managed. 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. Other land is defined as impediments (waste land) and includes most of the mountain area in northwest

[215] Food and Agriculture Organization of the United Nations, 2004

[216] FCCC/CP/2001/13/Add.1, p 58

Sweden. All Other land is assumed unmanaged. Land-use categories are monitored within the Swedish National Forest Inventory (NFI[217]).

7.2.3.1 THE CONNECTION BETWEEN NATIONAL AND REPORTED LAND USE CATEGORIES

The reported land use categories are based on 16 national land use categories monitored by the Swedish National Inventory of Forests (RIS). For example in year 2000 the area of Forest land, according to the definition of forest described above, was estimated to 27 414 000 ha. This corresponds to 22 749 000 ha Productive Forest land (national category 01), 1 678 000 ha Mire (04), 520 000 ha Rock Surface (05), 268 000 ha Sub alpine Coniferous Woodland (06), 376 000 ha High Mountain (07), 1 615 000 ha Protected Area, Nature Reserve (11) and 208 000 ha to other categories, using the national land use categories (Table 7.4). Note that the international land use category (FRA 2005) Forest land is superior to all other land use categories.

Table 7.4. National Land Use Categories, their connection to the UNFCCC Land Use Categories and their potential importance for carbon reporting. A=all land is considered FAO Forest land, B=large areas are considered FAO Forest land. Observe that this example is based on both temporary and permanent sample plots. Thus, the total area is not comparable with reported areas.

National Land Use Category	UNFCCC/KP-Land Use Category	Carbon Stock In Living Biomass of Trees [T gram] Year 2000	Area [1000 ha] Year 2000	Additional Explanation
Productive Forest land (01)	F	1047	22749	Land which hosts a potential yield of stem-wood exceeding one cubic metre per hectare and year (A).
Grazing Land (02)	G	5.7	494	Not regularly cultivated.
Arable Land (03)	C	1.5	3052	Regularly cultivated
Mire (04)	W	35.6	4588	Land which hosts a potential yield of stem-wood lower than one cubic metre per hectare and year (B).
Rock Surface (05)	O	16.4	896	Rocky or stony areas. (B)
Sub alpine Coniferous Woodland (06)	F	8.2	307	Land-zone usually located between (01) and (07). (A)
High Mountain (07)	O	Low	3010	Usually unstocked or sparsely stocked. (B)
Climatic Impediment (08)	O	0.7	48	Usually located in flat terrain in northern Sweden. (B)
Road and Railroad (09)	S	0.5	445	For permanent use. Not only roadway and rail but also other connected areas as embankments and ditches.
Power line Within Forest (10)	S	0.2	145	Minimum width 5 m, otherwise Productive Forest land (01)

[217] Ranneby et al., 1987

Protected Area, Nature Reserve (11)	(F)	Medium	3967	This land use category was left out 2003 and is thereafter included in the remaining land use categories.
Military Impediment (12)	S	Low	69	Could not be inventoried for security or safety reasons.
Urban Land (13)	S	Low	1185	Settlements of many different kinds.
Other land (14)	S	2.1	115	Different kinds of land that is not covered by Other land use categories. Examples: gravel pits, halting places and slalom slopes
Water (not sea) (15)	W	0	4009	Lakes, rivers, creeks, canals, pounds etc. Minimum width of 2 m.
Sea (16)	-	-	-	To check if the total land area is constant.
Total		1118	45080	

7.2.3.2 CONSISTENCY IN REPORTING LAND USE CATEGORIES

The NFI has monitored land-use categories in a reasonably consistent way since 1983. Based on permanent sample plots, it is possible to trace both gross and net land-use transfers from 1983 and onwards. On Forest land, it is also possible to determine former land-use (i.e. Cropland or Grassland) before the base year (1990). All land areas are included in the field inventory except high mountains and urban land. These latter land-use categories are only inventoried for area by remote sensing. It is assumed that their relative importance for the Swedish carbon budget is negligible.

A few historical inconsistencies in the land-use category assessment have been identified and corrected. Before year 2003, protected areas (“Protected Area, Nature Reserve”; section 7.2.3.1) were not regularly inventoried. From 2003 and onwards this areas are included in other land-use categories. Usually there are data from at least one field inventory of “protected areas” before 1990, but sometimes no data are available. If no data are available, the change in carbon pools in former “protected areas” is assumed to be zero from 1990 to 2002. From 2003 potential changes will be reported based on field inventory data. The FRA 2005 definition of Forest land was introduced in the field inventory in 1998 and therefore land-use categories in earlier inventories has been re-determined. A description on the treatment of former protected areas, re-determination of land-use categories and the methodology for correcting inconsistencies in the land-use category assessment are described in more detail in the methodology section.

7.2.4 Definition of carbon Pools, CRF 5A, 5B, 5C, 5D, 5E and 5F

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 above-ground and below-ground biomasses are reported. Above-ground 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 volume[218]. 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 (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 reported for all land-use categories assessed in the field inventory.

7.2.4.1 DEAD ORGANIC MATTER

The dead organic matter pool includes the carbon pools dead wood and litter. Dead wood is defined as fallen dead wood, snags or stumps including coarse and smaller roots down to a minimum "root diameter" of 2 mm. Dead wood of fallen dead wood or snags should have a minimum "stem diameter" of 100 mm and a length of at least 1.3 m. Dead wood of stumps with corresponding roots are reported under Forest land remaining Forest land (and Forest management under the Kyoto Protocol), while fallen dead wood and snags are reported for all relevant land-use categories. Litter includes all non-living biomass not classified as dead wood, lying dead, in various states of decomposition above the mineral or organic soil. This includes the litter, fumic, and humic layers. Live 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.

7.2.4.2 SOIL ORGANIC CARBON

The soil organic carbon pool on forest land and grassland includes all carbon in the mineral soil below the litter, fumic and humic layers in mineral soils and all organic carbon in soils classified as Histosols[219]. The carbon pool considered is soil organic carbon down to a depth of 0.5 m measured from top of the mineral soil or, alternatively, from the soil surface when the soil is classified as a Histosol. In cropland soils only the topsoil (depth of 0.25 m) is considered for carbon stock change calculations.

7.2.5 Emissions of N_2O, CO_2 and CH_4, CRF 5(I), 5(II), 5(III), 5(IV) and 5(V)

7.2.5.1 DIRECT N_2O EMISSIONS FROM N FERTILIZATION, CRF 5(I)

To increase the forest production, some middle aged or older forest stands on mineral soils are occasionally fertilized. In 1990, the fertilized forest area was estimated to 69 200 ha[220]. Since then, the annual fertilized area has decreased to about 15 000 - 33 000 ha in 1992-2006. In recent years, this area has increased to about

[218] Swedish University of Agricultural Sciences, 2011

[219] Food and Agriculture Organization of the United Nations, 1994.

[220] Swedsih Forest Agency, 2012

46 000 ha in 2012. The underlying data (areas) are based on an annual questionnaire sent to approximately 150 large-scale forest companies and constitute Official Statistics of Sweden collected by the Swedish Forest Agency. Large-scale forestry, defined as forest companies with more than 10 employees or owners of more than 5000 ha Forest land, contributes with approximately 90 % of fertilizer related emissions of N_2O. Consequently, small-scale forestry is assumed to contribute with approximately 10 % of the emissions. To estimate the total annual emission, area figures are multiplied with normal average amount of fertilizer N spread per hectare. The normal average amount N spread per hectare is obtained from companies that are carrying out the fertilization in practice (there are only a few companies in this business).

7.2.5.2 N_2O EMISSION FROM DRAINAGE OF SOILS, CRF 5(II)

According to UNFCCC (decision 13/CP.9), reporting emissions of nitrous oxide from drainage (N_2O-direct $N_{drainage}$) is optional. One reason for that is the limited understanding of the processes controlling the emissions. No N_2O emissions from drainage of soils will be reported this year, but some preliminary studies indicate that reliable methods may be available in a few years.

7.2.5.3 N_2O EMISSIONS FROM DISTURBANCE ASSOCIATED WITH LAND-USE CONVERSION TO CROPLAND, CRF 5(III)

Due to more intensive soil management on Cropland, the transfer of other land-use to Cropland is usually associated with a temporary increase in the mineralization of organic matter. Part of the released N may be converted to N_2O through denitrification. Land converted to Cropland is reported as belonging to the conversion class for twenty years (if no secondary conversion occurs). The accumulated area converted from Forest land to Cropland during 20 years has been up to around 5 000 ha and the area converted from Grassland to Cropland is now around 42 000 ha. From 2007, land converted from Wetlands to Cropland has been identified. The accumulated area in this conversion class is between 1000 and 5000 ha (2007-2011).

7.2.5.4 CARBON FROM AGRICULTURAL LIME APPLICATION, CRF 5(IV)

Lime is used for soil improvement in both agriculture and horticulture to mitigate acidification that is caused by the export of biomass, acidifying fertilizers and acid rain. The reported figures are based on quantities sold for agricultural and horticultural purposes plus lime from sugar mills and steel production. The quantities are separated into dolomite ($CaMg(CO_3)_2$) and limestone ($CaCO_3$), where dolomite and Mg-lime are reported as dolomite and all other categories are reported as limestone. All categories are supposed to contain 100 % dolomite/limestone except residual lime from sugar production which is assumed to contain 65 % limestone due to a water content of approximately 35 %. The accuracy of estimates of the sold quantities is assumed to be high and constitutes Official Statistics of Sweden[221]. Separate default IPCC emission factors are used for limestone and dolomite, respectively.

7.2.5.5 N_2O, CH_4 AND CO_2 FROM BIOMASS BURNING, CRF 5(V)

Forest fires are very rare in Sweden. Wildfires have been monitored by the Swedish Rescue Services Agency since 1996[222] and the area of wildfires has varied from 200 to 6400 ha yr^{-1}. Controlled burning after clear-cutting to improve regeneration of trees is monitored by a full record from 1990 and onwards (Swedish Forest Agency). Controlled burning for nature conservation is monitored from 2006. In recent years, an area of approximately 300-3000 ha is annually burned after clear cutting and 100-2000 ha is now annually burnt for nature conservation. The Swedish Civil Contingencies Agency (former The 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, forest in the mountain area and 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 above-ground 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 burned amount of carbon per land category is probably low. This is due to a lack of knowledge about the burned stock in typically burned forests.

7.3 Methodological issues

7.3.1 CRF-tables 5A, 5B, 5C, 5D, 5E and 5F

7.3.1.1 BASE METHODOLOGY

Sweden reports emission/removals from carbon pools mainly according to the IPCC stock change method. The stock change method is combined with a sample-based inventory design which makes it possible to estimate errors of the estimates. The Swedish National Inventory of Forests (RIS[223]) has monitored the most relevant carbon pools since 1983. 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 both gross and net land-use conversions for the six land-use categories in a consistent and transparent manner (for further details, see Annex 3:2).

[221] Statistics Sweden, 2004

[222] Swedish Rescue Services Agency, 2004

[223] Swedish University of Agricultural Sciences, 2011

7.3.1.2 METHODOLOGY LIVING BIOMASS CRF 5A, 5B, 5C, 5D, 5E AND 5F

A national methodology (Tier 3) is used. The above-ground biomass per fractions is estimated by applying Marklund's[224] biomass functions to trees on permanent sample plots of the NFI[225]. The below-ground biomass is estimated by using Peterssons and Ståhl's[226] biomass functions on biomass data from the same trees as for the above-ground biomass. The conversion factor 0.49 is used to convert biomass to carbon[227]. Estimates of the annual change in the carbon pools are based on repeated measurements. Consequently, 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.

7.3.1.3 METHODOLOGY DEAD ORGANIC MATTER CRF-TABLES 5A, 5B, 5C, 5D, 5E AND 5F

A national methodology (Tier 3) is used to estimate the dead organic matter pool. The pool includes different sub-pools (dead wood, litter and the organic soil horizon) that are estimated slightly differently.

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 and Scots pine. The volume is measured by the NFI. Below-ground 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, from measurements of increment bore cores of sample trees) converted to carbon dioxide equivalents minus the net change in the living biomass carbon pool. Growth is estimated by the National Forest Inventory and represents "productive forest land" while the net change in the living biomass pool represents all Forest land (FAO-definition)– consequently, the annual inflow to the stump carbon pool might be slightly underestimated. The harvest of stems is converted by conversion factors to stump and root biomass, and the conversion factors are calculated on estimates of stem volume[228] and stump and root biomass[229] applied to sample trees representing the standing stock of Swedish forests. The decay of stump systems is modelled[230] by simple decomposition functions. The described methodology is consistently used during the reported period. Emissions from

[224] Marklund, 1987 and 1988

[225] Ranneby et al., 1987

[226] Petersson and Ståhl, 2006

[227] Sandström et al., 2007

[228] Näslund 1947

[229] Petersson and Ståhl, 2006

[230] Melin et al., 2009

stump systems before 1990 are considered by similar methodology (1853-1989). Sweden is discussing options to improve the accuracy of estimates in future reporting[231] .

The carbon in the litter pool is estimated based on three different sources: (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 but calculated as 15 % of the above-ground dead wood. Litter fall is calculated using empirical functions based on tree 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 and thus measured by the soil inventory. The fine litter (< 2 mm) is estimated by sampling the O or H horizon sample which is taken on an area basis, weighed and analysed for carbon content (for further details, see , see Annex 3:2).

7.3.1.4 METHODOLOGY SOIL ORGANIC CARBON CRF 5A, 5B, 5C, 5D, 5E AND 5F

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 organic forest and grassland soils the changes are based on emission factors and area estimates of different sub-categories. For Cropland the ICBM model[232,233] is used to predict changes in the soil organic carbon stock on mineral soils and to calculate the change on organic soils an estimation of the subsidence is added.

7.3.1.4.1 Forest land and Grassland on mineral soils CRF 5A and 5C

The method is a Tier 3 method. The estimates are based on repeated measurements on the NFI plots of several variables. The basic function used to determine the amount of carbon in a soil layer is based on the amount of carbon in a certain soil layer and the fraction of fine earth. The amount of fine earth is dependent on the bulk density and amount of gravel, stones and boulders in the soil (for further details, see Annex 3:2).

7.3.1.4.2 Forest land and Grassland on organic soils CRF 5A and 5C

The method is a Tier 2 method. Changes in the organic carbon pool are calculated as the difference between annual below ground litter input and the heterotrophic respiration. Annual litter production is derived from the National Forest Inventory . Emission factors for heterotrophic respiration are based on studies from Sweden

[231] Petersson and Melin, 2010; Melin et al., 2010

[232] the Introductory Carbon Balance Model

[233] Andrén & Kätterer, 2001

and Finland on drained organic forest soils (for further details, see Annex 3:2). Data on on emissions from grasslands are scarce. However, they are likely to be in the same range as hos for forest land. Therefore, emission factors for foest soils are also used for Grassland.

7.3.1.4.3 Cropland on mineral soils CRF 5B

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 ICBM model is described in Andrén & Kätterer[234]. 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 texture[235](for further details see Annex 3:2).

7.3.1.4.4 Cropland on organic soils CRF 5B

The method to estimate the carbon balance of organic agricultural 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 cm soil subsidence. The emission factor is modified according to crop type. The relative area proportion of the different crop types and the total area of organic soils under agricultural production were estimated in a national survey[236] Compared to earlier estimated and reported areas the area is now essentially smaller (for further details see Annex 3:2). The area has been linked to the changes in total cropland area so that decreasing cropland area proportionally affects the area of cropland on organic soils[237] (for further details see Annex 3:2).

7.3.1.5 METHODOLOGY FOR DEAD ORGANIC MATTER AND SOIL ORGANIC CARBON FOR CONVERSION BETWEEN LAND-USE CLASSES CRF-TABLES 5A.2.1-5, 5B.2.1-5, 5C.2.1-5, 5D.2.1-5, 5E.2.1-5 AND 5F.2.1-5 CROPLAND ON ORGANIC SOILS CRF 5B

The method to estimate the emission/removals in the DOM – and the SOC pools associated with land use changes is a Tier 2 method. In general (except for dead wood and coarse litter) the carbon stock changes associated with conversion of lands is estimated using an emission/removal factor is used in combination with the areal change in land-use for further details see Annex 3:2).

[234] Andrén & Kätterer, 2001.

[235] Eriksson 1997,1999

[236] Berglund and Berglund, 2009

[237] In previous submissions a small discrepancy in the area of organic soils reported for cropland remaining cropland in the LULUCF sector and the area of cultivated organic soils reported in the agriculture sector was detected (ERT, centralised review Subm 2009). In this submission the consistency has been improved and areas have been estimated as described in the text.

7.3.1.6 CO_2 EMISSION FROM MINERALIZATION WHEN EXTRACTING PEAT CRF 5D

The method used to estimate CO_2 emission from peat extraction areas is a Tier 1 approach. A limited area of Wetlands (around 10000 ha) used for peat extraction is considered managed and reported under Wetlands remaining Wetlands. The reported CO_2 emissions refer to mineralization when extracting peat for fuel and agricultural purposes. The emitted CO_2 [Mtonnes•yr^1] is calculated as the product of the extracted area and an emission factor (for further details 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 this area is closed down and restored. Former managed peat land is usually restored by saturation by water or by conversion to Forest land. The water saturation will probably stop most carbon mineralization and Wetlands converted to Forest land is reported under Wetlands converted to Forest land (for further details see Annex 3:2). There is no new activity data (managed area) from 2010, and activity data for years 2010, 2011 and 2012 is based on the production area times the ratio managed area to production area for years 2003-2009. This ratio is estimated to 0.4175.

7.3.2 CRF 5(I), 5(II), 5(III), 5(IV) and 5(V)

7.3.2.1 DIRECT N_2O EMISSIONS FROM N FERTILIZATION, CRF 5(I)

A Tier 1 methodology is used and the reported figures refer to $N_2O_{direct\ fertilizer}$ (of N). All fertilization is assumed to occur on Forest land remaining Forest land[238]. In year 1990 nitrate of lime ($Ca(NO_3)_2$) was the dominant fertilizer but thereafter the fertilizer have been based on 50 % NO_3-N and 50 % NH_4-N. The reported annual $N_2O_{direct\ fertilizer}$ [Gg•yr^{-1}] is calculated as the product of the applied amount and the emission factor (for further details see Annex 3:2).

7.3.2.2 N_2O EMISSIONS FROM DRAINAGE OF SOILS, CRF 5(II)

Not reported (optional).

7.3.2.3 N_2O EMISSIONS FROM DISTURBANCE ASSOCIATED WITH LAND USE CONVERSION TO CROPLAND, CRF 5(III)

A Tier 1 methodology is used. The reported annual N_2O emission from disturbance associated with land use conversion to Cropland (N_2O_{conv} [Gg•yr^{-1}]) is calculated according to equation 3.3.15 in IPCC GPG for LULUCF (IPCC[239]) (for further details see Annex 3:2).

[238] ERT (centralized review submission 2009) recommended Sweden to report emissions from organic and mineral soils separately. The methodology is based on the total retailed amount and there is no appropriate statistics available on where the fertilizer is applied.

[239] Intergovernmental Panel on Climate Change, 2003

7.3.2.4 CARBON FROM AGRICULTURAL LIME APPLICATION, CRF 5(IV)

Methodology level Tier 1-2 is used for reporting carbon emissions from liming. The reporting is based on consumption studies[240] and all liming is assumed to occur on Cropland remaining Cropland. The reported annual carbon emission from agricultural lime application (C_{lime}; [Gg•yr^{-1}]) is calculated as the product of the applied lime and the emission factors (see Annex 3:2 for further details).

7.3.2.5 EMISSIONS FROM BIOMASS BURNING, CRF 5(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. Calculations are based on the amount of biomass per area, burned area and emission factors. Observe that, to avoid double-counting, CO_2 emissions from wildfires and controlled burning are included in carbon stock changes in living biomass (for further details see Annex 3:2).

7.4 Uncertainties and time series consistency

7.4.1 Uncertainties

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 NIR, Table A.7.2

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 subjectively judged with help from experts and from default error values according to IPCC[241].

7.4.2 Living biomass, CRF 5A, 5B, 5C, 5D, 5E and 5F

The estimated accuracy of the living biomass pool 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

[240] Statistics Sweden, 2004

[241] Intergovernmental Panel on Climate Change, 2003

specified models and an unrepresentative derivation data are ignored. Unpublished research indicates that the influence of model errors is less than 10%. Estimates for reporting years 1990-2008 are based on approximately 30000 sample plots and with a corresponding estimated relative standard error of 3 Mtonnes CO2/year (11%). The estimate of uncertainty is quite stable between years but the relative estimates varies du to changes in net removals. Estimates for reporting years 2009, 2010, 2011 and 2012 are based on measurements on approximately 24000, 18000, 12000 and 6000 sample plots, respectively, combined with extrapolated data. We believe that this extrapolation increases the accuracy substantially but to be on the sure side, to avoid a potentially risk of systematic errors, we gradually update extrapolated data using data from re-measured sample plots (see Annex 3:2 for further details).

7.4.3 Dead organic matter, CRF 5A, 5B, 5C, 5D, 5E and 5F

Estimates of dead organic matter are based on sampled data from the litter pool and dead wood pool from the NFI and the MI. There is probably a small error in the estimates of dead wood due to incorrect measured volumes and due 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. Compared to submission 2013 accuracy has improved since the reported figures now are based on more repeated measurements of permanent sample plots. For changes in carbon in the O-horizon the measurements are based on samples from 1993-1999 (first inventory) and from 2003-2009 (second inventory), while dead wood measurements are from the period 1995 to 2011. We are now also basing the estimate on interpolated values for years between inventories. The accuracy will increase in the future when more data from repeated measurements will be accessible.

One of the major difficulties in reporting changes in DOM and SOC is that the pool is very large and the changes small in comparison to the pool. As seen in Figure 7.7 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 can hardly be detected in the lower panel. When tested statistically the changes are not significant at $p=0.05$ and the system is sensitive to systematic errors like small changes in data collection between inventories.

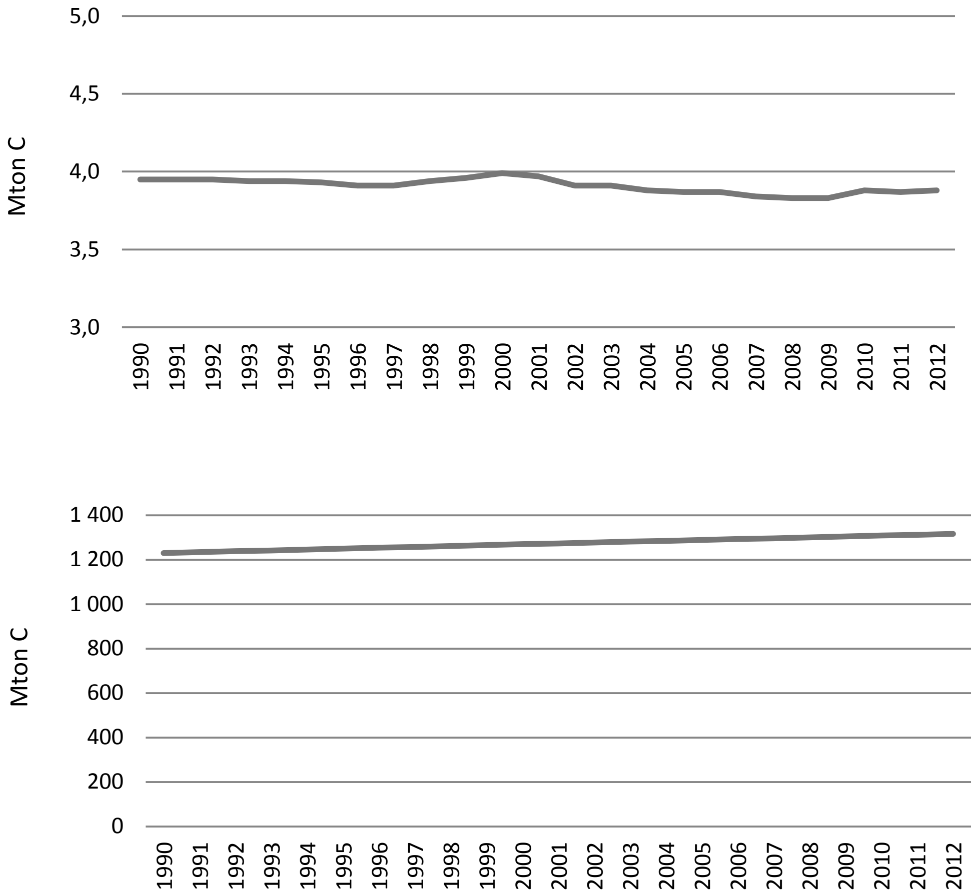

Figure 7.7. The reported change in soil carbon on mineral soils (upper panel) and the corresponding stock (lower panel) for Forest remaining Forest

7.4.4 Soil organic carbon, CRF 5A, 5B, 5C, 5D, 5E and 5F

The sample error for the soil organic carbon pool is calculated similarly to the living biomass calculation. The problems associated to the estimates of changes in the soil carbon pool is of the same nature as the ones described for the dead organic matter pool above, and significant improvements are expected when the proportion of repeated measurements will increase. Another problem associated to our 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 earlier inventories 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 CO_2 emission from drained forest land is judged to 25 % and errors in the emission factor to 25 %

as well. The uncertainty in activity data (area) for CO_2 emission from mineralization when extracting peat is judged to 25 % and the uncertainty due to errors in the emission factor chosen is judged to 300 %. The high error of the EF is based on the fact that i) the variation between different emission factors is significant[242], and ii) the underlying data of the EF does not perfectly match the target population[243,244].

7.4.5 Other CO_2 emissions, CRF 5(IV) and 5(V)

The reported CO_2 emission from agricultural lime application is based on consumption studies and the design is regarded as a total inventory with no random error. The error due to activity data is probably small and the reason for this is high quality data on quantities of limestone and dolomite sold. It is assumed that the error due to the use of incorrect emission factors used might be quite large. The reported uncertainty is based on a default error coefficient from IPCC[245].

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 actually is burned. The error of the estimated burned area is probably 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.

7.4.6 N_2O and CH_4 emissions, CRF 5(I), 5(III) and 5(V)

Generally for all N_2O and CH_4 emissions, the error in activity data is small compared to the error due to errors associated to the emission factors.

For N_2O 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 is that emission factors chosen should be within the range 0.25 % to 6 % and the interpretation is that a badly chosen emission factor could lead to an error that is much larger than 25 %. Based on this information a total error of 50 % for N_2O emissions from N-fertilization is suggested.

The accuracy of estimates of N_2O emissions from disturbance associated with land-use conversion to Cropland is assumed to be lower than for N_2O 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. The uncertainly level is based on this reasoning and on IPCC default values (IPCC).

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[242] Statistics Sweden, 2002

[243] Kasimir-Klemedtsson et al., 2000

[244] Sund et al., 2000

[245] Intergovernmental Panel on Climate Change, 2003

According to the points raised in the discussion above on uncertainties in CO_2 emissions from biomass burning, the uncertainty of N_2O and CH_4 emissions from biomass burning are assumed to be 75 % (Managing uncertainties: A.1.4).

7.4.7 Completeness

Each category has been reported only once. This is ensured by using only one source of information for the land area representation.

Sweden reports carbon stock changes in all carbon pools and all other emissions for mandatory categories considered managed (Forest land, Cropland, Grassland, Settlements and a small area of Wetland used for peat extraction). The notation key "NO" is used when there is no observed occurrence for a certain category (i.e. uncommon land use changes). 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 methods. In the latter case either gains or losses are reported "IE". The notation key "NA" is used when the reported activity does not result in emissions/removals. This notation key is also used for emissions/removals from unmanaged land. The notation key "NE" is used for categories not estimated which only include categories that currently are optional to report. Factoring out has not been considered.

7.4.8 Time series consistency and verification

The time series of change in carbon stock 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 drain) 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 extrapolates data in the beginning of the period and this because the inventory did not begin until the mid-1990th. Due to a relative high sampling error, a trend is reported and it is quite difficult to match emissions/removals from dead wood to the correct year. The dead wood pool constitutes a 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, however, no proper validation has been made.

The time series of the dead organic matter pool is consistently measured since 1994 with only minor changes in sampling methodology. 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 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 where small changes with respect to the rate of change between the models and the measurements[246].

7.5 QA/QC

7.5.1 Quality assurance

The quality assurance system of the data collection within RIS used for the UNFCCC and Kyoto reporting has been described by the Swedish University of Agricultural Sciences[247]. These routines were improved during 2006 cooperating with SLU (Swedish University of Agricultural Sciences). SLU also works closely with the Swedish EPA to enhance the QA/QC. For this submission, quality assurance has been carried out in an internal review by experts at SLU. A national independent review has been carried out by representatives for the Swedish Forest Agency and Swedish Board of Agriculture.

7.5.2 Quality control

An internal quality control has been performed following level Tier 1, (Table 5.5.1 in Good Practice Guidance 2003).

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 methodologies used) is archived by the SLU.

7.6 Source-specific Recalculations

Recalculations can be divided into four categories of which the two first ones can be considered “ordinary” recalculations due to the applied methodology using random sampling.

The first category is recalculations due to updated NFI-data which mainly affects the estimates for the previous four years as described in section 7.2.2.2. Small corrections of historical land use changes may affect estimates for earlier years, especially for categories using area as activity data.

[246] Ortiz C. et. al. 2009.

[247] Karltun, E. et. al.. 2005.

The second category is recalculations related to extended datasets for litter and soil from the MI. Since the whole dataset is included using extrapolation and interpolation techniques this may generate updated data for the entire time series.

The third category is when new activity data (not related to NFI or MI) 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.

7.6.1 Living biomass

In the current submission to improve the accuracy of estimates, the living biomass pool and areas have been recalculated for the years 2008-2012. Each estimate is now based on 6000 more sample plots and incomplete inventory cycles have been extrapolated to 2012, see also section 7.2.2.2.

To enhance the consistency between UNFCCC and KP reporting, the allocation of carbon stock changes has been revised. This means for instance that a decrease in carbon stock due to a land use conversion from Forest land to Settlements is now reported under (or allocated to) Forest land converted to Settlement (e.g. -2). Previously, this stock change was reported as an emission under Forest land remaining Forest land (e.g. -4) and a removal under Forest land converted to Settlements (e.g. +2; if some trees remained). The new reporting method is consistent with the methodology used for reporting carbon stock changes in living biomass under the KP.

The National Forest Inventory estimates living biomass per tree fraction using two different models and, to improve the accuracy of estimates and consistency, now only one model is used per fraction. This has only slightly changed the estimates and this is also valid for minor corrections of single plots.

The total effect of the recalculation on Living biomass on Forest land remaining forest land is illustrated in Figure 7.8.

7.6.2 Dead organic matter and Soil organic carbon

The pools dead organic matter and soil organic carbon on mineral soils on Forest land remaining forest land and Grassland-remaining-Grassland have been recalculated for the whole time series from 1990 to 2012 due to introduction of more re-inventoried sample plots. For land-use change categories these pools have been recalculated due to updated activity data from the NFI (areas).

7.6.3 Peat extraction

Activity data (production area of peat extraction) is no longer provided. Thus, managed area for peat extraction is converted to production area by a constant. This is valid from 2010 (see 7.3.1.6).

7.6.4 Non-carbon emissions

Recalculations have also been made for non-carbon emissions due to slightly adjustments in activity data (areas), but these re-calculations are very small. No recalculations have been made for Nitrogen emissions from Nitrogen fertilization (5I). Due to recalculated estimates of areas, emissions from disturbance associated with land use conversion to Cropland (5III) have been updated. Some minor changes in underlying activity data of limestone (5IV) and wildfires (5V) have been made.

Some rounding errors have been corrected (general for both carbon and non-carbon pools). Inconsistencies in the reporting of direct N_2O emissions for N fertilization and N_2O emissions from disturbance associated with land-use conversion to cropland between the UNFCCC-reporting and the KP-LULUCF reporting have been taken care of[248].The recalculations are summarized in Table 7.5.a. and Table 7.5.b.

[248] The inconsistency now taken care of was observed by reviewers (ARR 2011)

Table 7.5.a. and Table 7.5.b. Recalculations of carbon stock changes and other emissions between submission 2013 and submission 2014 in the LULUCF-sector. Positive numbers indicate an increase in emissions and negative numbers indicate an increase in removals (or a decrease in emissions for categories 5I to 5V).

7.5.a.	Difference between Submission 2013 and 2014 [Mt CO_2]				
Year	**Forest land**	**Cropland**	**Grassland**	**Wetland**	**Settlement**
1990	-3.7	0.0	0.4	0.0	1.9
1995	-7.6	0.1	-0.2	0.0	1.5
2000	-8.5	0.3	-0.1	0.0	1.4
2006	-1.3	0.1	0.2	0.0	0.2
2007	-4.7	0.0	0.2	0.0	1.1
2008	-4.4	-0.1	0.5	0.0	1.0
2009	-4.1	-0.1	0.5	0.0	1.3
2010	-5.2	0.0	0.3	0.0	0.6
2011	-2.6	0.3	0.2	0.0	1.8

7.5.b.	Total carbon pool changes [M tonnes CO_2]			Other emissions [M tonnes substance]						Total	
				Fert.	To CL	Liming	Biomass burning				
				5 (I)	5 (III)	5 (IV)	5 (V)				
Year	**LB**	**DOM**	**SOC**	N_2O	N_2O	CO_2	CO_2	N_2O	CH_4	[M tonnes CO2-eq]	[%]
1990	2.0	-0.2	-3.3	0.0	0.0	0.0	IE	0.0	0.0	-1.5	-4%
1995	-3.7	0.3	-3.0	0.0	0.0	0.0	IE	0.0	0.0	-6.3	-20%
2000	-3.8	-0.6	-2.5	0.0	0.0	0.0	IE	0.0	0.0	-7.0	-20%
2006	0.5	0.3	-1.4	0.0	0.0	0.0	IE	0.0	0.0	-0.7	-2%
2007	-1.9	-0.1	-1.4	0.0	0.0	0.0	IE	0.0	0.0	-3.5	-11%
2008	-3.4	2.0	-1.5	0.0	0.0	0.0	IE	0.0	0.0	-3.1	-9%
2009	-3.0	2.1	-1.5	0.0	0.0	0.0	IE	0.0	0.0	-2.4	-7%
2010	-3.6	0.8	-1.6	0.0	0.0	0.0	IE	0.0	0.0	-4.5	-15%
2011	1.9	-0.7	-1.6	0.0	0.0	0.0	IE	0.0	0.0	-0.4	-1%

0,0 equals value less than 0.5.

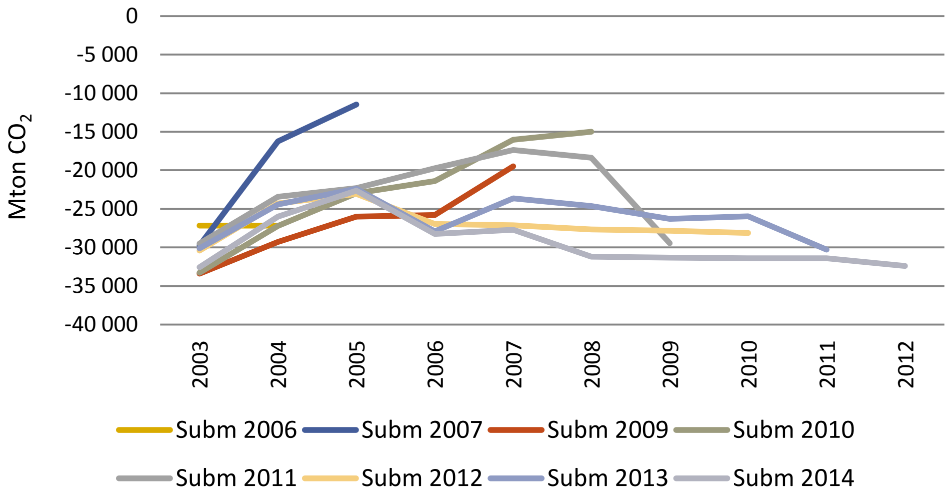

Figure 7.8. Reported living biomass on Forest land remaining forest land (5A1) according to different submissions. The values (the five latest reported years) are continuously re-calculated (due to a resubmission, submission 2008 correspond to submission 2009).

7.7 Coming improvements

For the next Submission Sweden will implement the revised UNFCCC guidelines which include several amendments to the LULUCF-sector. Of these new reporting categories HWP is one of the most important ones. The method Sweden plan to use is described below.

Other improvements include new emission categories related to organic soils. For instance Sweden will for the first time, incorporate the emissions of N_2O from drained organic forest soils in Submission 2015.

7.7.1 Reporting of HWP

From Submission 2015 and onwards Sweden will report changes in the Harvested Wood Products pool.

However, on an informal basis, Sweden reports emissions/removals from Harvested Wood Products (HWP) using the Production Approach (PA) according to decisions taken in Durban, decision 2/CMP.7 below. Thus, emissions from HWP are estimated as changes in the carbon pool of HWP in use originating from Swedish forests.

A Tier 3 model is used. Input data originates from national data sources; Swedish Forest Agency, Statistics Sweden, and Swedish Forest Industries Federation. The data used concerns production and trade of raw material and primary products and covered different length of time. Data about harvested round wood and sawn wood for instance covers 1850-2012.

The model calculates net-emissions of CO_2 by estimating differences in the size of the HWP-carbon pool between years. Equation 12.1 in IPCC 2006 Guidelines is used. Separate calculations are made for different product categories: sawn wood, wood based panels, and paper products. A HWP-carbon pool for a certain year is estimated by adding an inflow of new products to, and subtracting an outflow (decay) of consumed products from the pool of previous year. The difference between the years is translated into net CO_2 emissions or removals.

Inflow is calculated by adding primary products made from exported raw material of domestic origin such as round wood, chips and pulp, to domestically produced products of domestic origin. Domestic production from imported raw material is excluded at each step along the refinement chain. Production of primary paper products based on recovered paper is excluded since domestically collected recovered paper might originate from imported paper. Excluding recovered paper also ensures that carbon in paper is not calculated as inflow more than once.

A first-order decay is assumed, i.e. it is proportional to the size of the carbon pool, and is calculated using half-life (number of years until 50% is consumed) as input variable. Half-lifes for sawn wood, wood based panels and paper products are set to 35, 25 and 2 years respectively, according to decision 2/CMP.7 (Table 7.6).

The net-emission of CO_2 varies between -8.47 and -2.47 Mtonnes during 1990-2012 (Figure 7.9).

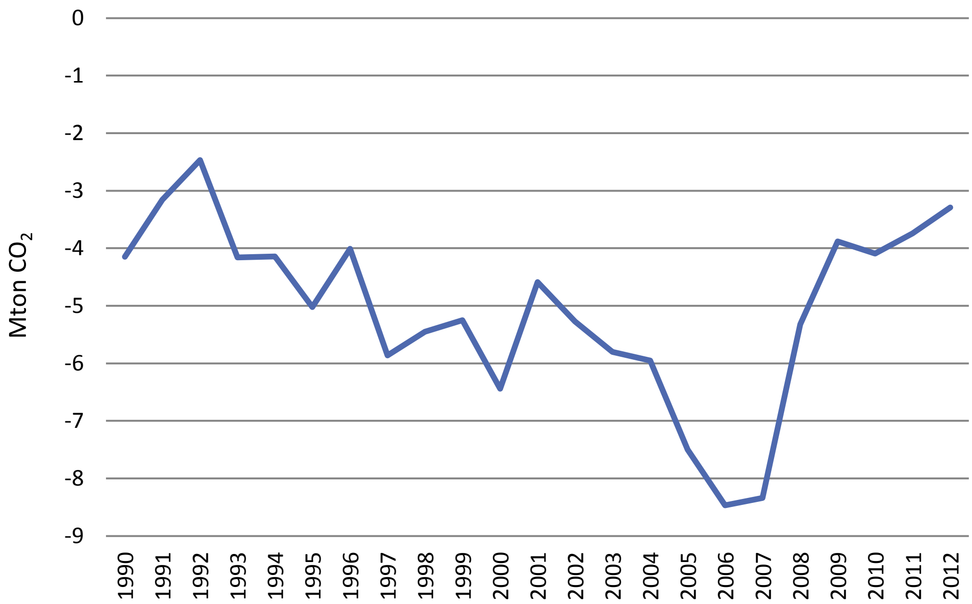

Figure 7.9 Net emissions of CO_2 from the HWP-carbon pool originating from Swedish forests during 1990-2012.

Table 7.6. Net removals (-) from the HWP-pool originating from Swedish forests 1990-2012

Year	1990	1995	2000	2005	2007	2008	2009	2010	2011	2012
M tonnes CO_2	-4.15	-5.02	-6.44	-7.5	-8.34	-5.32	-3.88	-4.09	-3.74	-3.29

8 Waste (CRF sector 6)

8.1 Overview of sector

In this sector, the most important emissions of greenhouse gases are those of CH_4 from solid waste landfills, CRF 6.A. Minor categories are the subcategories of wastewater handling, CRF 6.B, from where N_2O and CH_4 are reported. Emissions of CO_2, NO_X, SO_2 and NMVOC are reported from waste incineration, CRF 6.C. No emissions are reported in CRF 6.D.

For all greenhouse gases together, the trend over the last ten years has been a constant reduction of emissions (Figure 8.1). For CH_4, the trend can be explained by decreasing quantities of organic waste deposited at landfills. Also, the quantities of recovered landfill gas were increasing until from 1990 until 2003. For N_2O 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. Emission of greenhouse gases from waste incineration is small about 4% of the emission of CRF 6 in 2012.

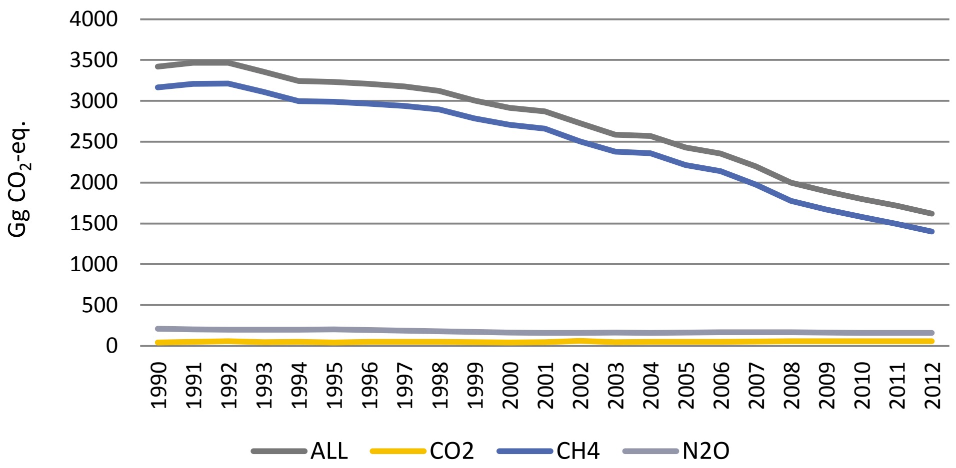

Figure 8.1. Total emissions of all greenhouse gases calculated as CO_2 equivalents from CRF 6 Waste

Figure 8.2 shows that greenhouse gas emissions from the Waste sector (CRF 6) largely come from solid waste disposal on land (CRF 6.A). CH_4 in sub-sector 6.A represents between 84.2 % and 67.6 % of totally reported greenhouse gases in the Waste sector during the period 1990 – 2012.

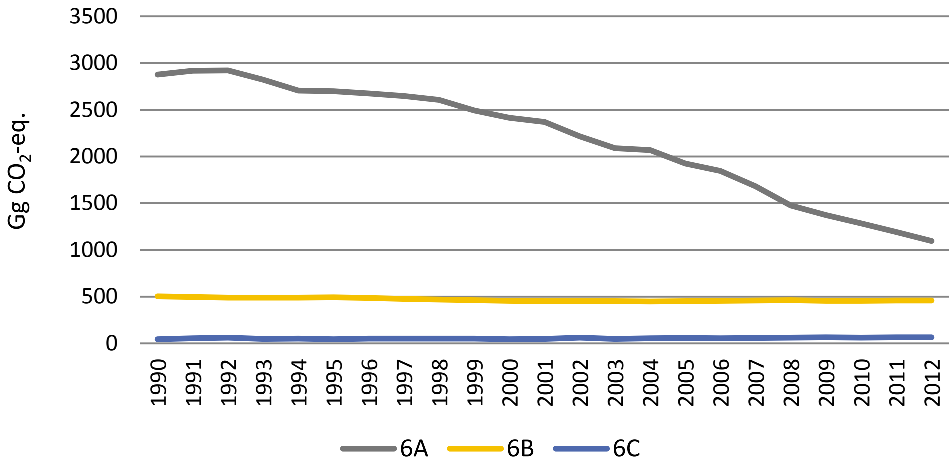

Figure 8.2. Total emissions of all greenhouse gases calculated as CO_2 equivalents from the different Waste sub-sectors

Table 8.1 shows the impact of recalculations reported in submission 2014 for GHG emissions by sector and sub-sectors for 1990, 1995, 2000 and 2005-2011. More detailed descriptions of the recalculations are found under sector specific sections below.

Table 8.1. Impact of recalculations of GHG emissions submission 2014 in the waste sector

Impact of recalculations submission 2014 (Gg CO_2 eq.)					
CRF	6.A	6.B	6.C	Total CRF 6	% CRF 6
1990	NA	NA	NA	NA	NA
1995	NA	NA	NA	NA	NA
2000	NA	NA	NA	NA	NA
2005	NA	NA	NA	NA	NA
2006	NA	NA	NA	NA	NA
2007	NA	NA	NA	NA	NA
2008	NA	NA	NA	NA	NA
2009	NA	NA	NA	NA	NA
2010	NA	NA	NA	NA	NA
2011	NA	3.1	NA	3.1	0.18%

0: value less than 0.5. NA: no recalculation is performed.

8.2 Solid waste disposal on land (CRF 6.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).

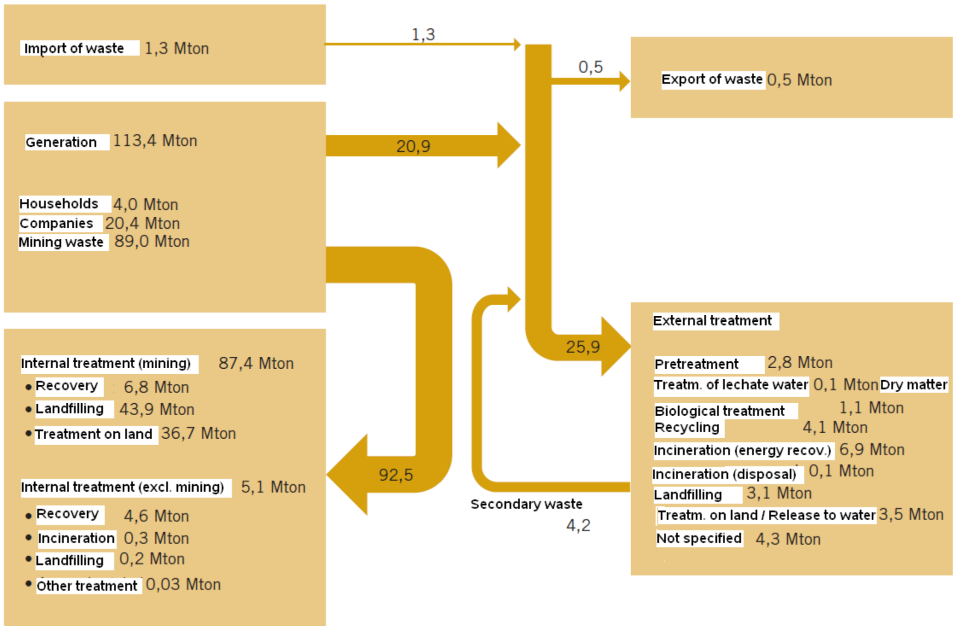

Figure 8.3. Waste streams in Sweden 2010 according to the Swedish EPA[249]

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 year 2010, 94 % of the landfilled non hazardous waste (or 43.9 Mt of 46.9 Mt) was mining waste. An overview of waste streams in Sweden 2010 is presented in Figure 8.3.

In the 1990s, the amount of deposited waste (other than mining waste) decreased significantly. This is especially notable for household waste (in Sweden also referred as "Municipal waste"), which is the largest contributor of greenhouse gases of all waste categories. Only 0.7 % of the generated household waste was deposited in 2012[250] which can be compared with 43.8 % in 1990. The remaining part of the

[249] Swedish EPA 2012

[250] Avfall Sverige / Swedish Waste Management 2013

generated household waste in 2012 was either incinerated (51.6 %), recycled (32.3 %) or treated biologically (15,3 %).

Depositing has become an expensive waste management solution for disposal of waste. Since January 1st 2000, there is taxation on depositing, currently 435 SEK[251] 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.

In the end of 2008 a new EU regulation for deposition came into force and almost 50 % of landfills for municipal waste were closed, according to the trade association Avfall Sverige – Swedish Waste Management. Landfill was conducted at 78[252] sites during 2012.

In year 2012, landfill gas was extracted at 55 landfills[253] whereof 42 were active landfills. According to a survey[254], the production of biogas in Sweden in 2012 was totally 1 589 GWh (or 114.0 Gg in methane). 16.0 % of the produced biogas was produced at landfills. The biogas production (collected gas) on landfills decreased by 49.8 % from 2003 to 2012, since the amounts of deposited organic waste has decreased significantly the past years, due to the implementation of waste treatment policies.

Biogas from landfills is mainly used for heating but also for production of electricity. Currently, none of this gas is used as vehicle fuel because of the difficulties to upgrade the gas to sufficient quality. About 19 % of the biogas produced (collected gas) at landfills was flared in 2012.

Practises regarding landfills were regulated in 1969. Since this, the unmanaged (or illegal) landfills are very uncommon in Sweden.

Sweden has some concerns about the unmanaged waste: *littering.* This occurs in particular around recycling stations. Other kinds of littering of organic waste are the disposal of smaller amounts of garden waste from households in nature or that residuals from the hunted animals are disposed in situ. When littering is discovered however, the clean-up is performed or the cost for the clean-up is paid by the re-

[251] Avfall Sverige / Swedish Waste Management 2013

[252] Avfall Sverige / Swedish Waste Management 2013

[253] Avfall Sverige / Swedish Waste Management 2013

[254] Swedish Energy Agency, 2013

sponsible operator. If the responsible operator cannot be found, the relevant municipality is responsible to perform the clean-up of the site.

8.2.1 Managed waste disposal on land (CRF 6.A.1)

8.2.1.1 SOURCE CATEGORY DESCRIPTION

Sweden is reporting emissions of methane for CRF 6.A.1 (managed waste disposal sites). For CRF 6.A.2 (unmanaged waste disposal sites), Sweden is reporting NO (not occurring), since there are no known unmanaged disposal sites for organic waste or municipal solid waste in use[255].

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 8.2.

Table 8.2. Summary of source category description, CRF 6.A.1

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
6.A	CO_2	NA	NA		NA	NA	NA
	CH_4	X	X		T2	CS, D	Yes
	N_2O	NA	NA		NA	NA	NA

CS Country Specific. T2 Tier 2. D Default.

8.2.1.2 METHODOLOGICAL ISSUES

8.2.1.2.1 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:

$$\begin{cases} 1-e^{-0,5k}, & i=0 \\ e^{-k(i-0,5)}\cdot(1-e^{-k}), & i=1,\ 2,\ldots \end{cases}$$

, where k 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.

255 Nygren, 2010

Historical data has 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 is scarce. 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 2012.

Table 8.3 Methane emission from Swedish landfills according to IPCC FOD method, deposited MSW*, sludges and total (excl. mining waste), 1990-2005

Year	Gas emissions Default method Gg CH_4	Gas emissions FOD method Gg CH_4	Deposited MSW* in 1000 tonnes	Deposited sludge from wastewater handling and pulp industry in 1000 tonnes	Total deposited waste (excl. mining waste)** in 1000 tonnes
1990	185	137	2 323	1 400	5 563
1991	170	139	2 223	1 262	5 161
1992	162	139	2 203	1 174	4 977
1993	151	134	2 199	1 086	4 824
1994	133	129	2 166	860	4 547
1995	122	128	1 974	850	4 330
1996	115	127	1 856	880	4 145
1997	116	126	1 842	975	4 203
1998	95	124	1 678	700	3 868
1999	96	119	1 756	620	3 853
2000	81	115	1 529	587	3 720
2001	76	113	1 488	514	3 488
2002	56	105	1 338	341	3 006
2003	34	99	1 034	223	2 688
2004	25	98	810	113	2 380
2005	8	92	541	58	2 067

* 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 and inorganic fractions), construction and demolition waste (organic and inorganic fractions) and sludge from wastewater handling and pulp industry.

Table 8.3 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 used currently in Sweden.

Table 8.4. Methane emission from Swedish landfills according to IPCC FOD method, deposited solid waste (containing Degradable Organic Carbon), sludges (containing DOC) and total (incl. mining waste), 2006-2012

Year	Gas emissions Default method Gg CH_4	Gas emissions FOD method Gg CH_4	Deposited solid waste (containing DOC)* in 1000 tonnes	Deposited industrial effluent sludges and common sludge* in 1000 tonnes	Total deposited waste (excl. mining waste)* in 1000 tonnes	Total deposited mining waste* in 1000 tonnes
2006	4	88	1 249	180	4 143	61 820
2007	-1	80	1 144	144	4 260	60 450
2008	-9	70	1 039	108	4 376	59 080
2009	-10	65	871	141	4 376	59 080
2010	-6	61	648	164	3 300	47 200
2011	-4	57	648	164	3 300	47 200
2012	-3	52	648	164	3 300	47 200

* Activity data and statistics for 2006, 2008 and 2010 are from Swedens reporting to the Commission according to the Waste Statistic Regulation. Activity data for 2007, 2009, 2011 and 2012 are interpolated/extrapolated values.

Table 8.4 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.

Methane potentials

IPCC values for gas potentials are used for the different fractions of household waste, as well as garden waste. As noted above, these values are somewhat higher than Swedish estimates, but lie within a reasonable interval.

The IPCC gives no gas potential for deposited sludge (already treated, for example, by rotting) from wastewater treatment. The content of Degradable Organic Carbon (DOC) in sludge from wastewater treatment is approximately 7 per cent.[256] The gas potential of the sludge is reduced by 50 % because it is treated.[257] By using formulas given in Good Practice Guidance the gas potential can be calculated to 24 kg/tonnes of sludge.

For wastewater sludge from the pulp industry, a national value of 45 kg methane /tonnes of waste is used.[258]

256 Recounted from RVF, 1996.

257 Sweco Viak, 2000.

258 Swedish EPA, 1993.

Recovered gas

Since gas recovery can be of importance for the final emissions of methane, Good Practice Guidance recommends formulas that subtract the recovered gas from the produced gas. In Sweden the first plant for biogas extraction from landfills was started in 1983. The business has increased until 2003 when gas was recovered in 72 plants. Since 2008, about 55-58 gas plants are in operation, and the amount of recovered gas is now decreasing because of the dramatic reduction of deposition of organic waste. Information on recovered gas (in energy units) is provided by Avfall Sverige and converted to quantity (in tonnes) by Statistics Sweden (Table 8.5).

Table 8.5. Recovered methane from landfill gas, tonnes

Year	Recovered gas
1982	0 [1]
1983	NE [2]
1990	12 000 [3]
1991	12 210 [3]
1992	14 430 [3]
1993	20 800 [4]
1994	27 500 [4]
1995	30 000 [4]
1996	30 000 [5]
1997	30 000 [5]
1998	30 000 [5]
1999	33 000 [5]
2000	34 000 [5]
2001	32 400 [5]
2002	35 947 [5]
2003	36 449 [5]
2004	30 135[5]
2005	29 418[5]
2006	24 567[6]
2007	24 553[6]
2008	26 979[6]
2009	24 240[6]
2010	21 439[6]
2011	19 344[6]
2012	18 311[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), 2007-2012

Table 8.6 shows quantities of produced energy from landfill gas and how much that is flared in Sweden. The energy is used for production of electricity and for heating.

Table 8.6. Energy recovery and flaring at landfills in Sweden, MWh[259]

Year	2005	2006	2007	2008	2009	2010	2011	2012
Energy recovery	340 000	282 200	290 100	310 800	294 240	262 200	237 400	205 900
Whereof production of electricity	20 000	20 800	22 600	23 700	17 400	20 400	16 000	10 500
Flaring	70 000	60 200	52 100	65 100	43 600	36 600	32 200	49 300
Total	410 000	342 400	342 200	375 900	337 840	298 800	269 600	255 200

Other parameters

The Methane Correction Factor for modern Swedish landfills is equal to one (1.0) (Table 8.7). Waste management was centralised during the 1970s. Before 1980, landfills were smaller and presumably less compact. Information that helps establish the MCF (Methane Conversion Factor) (cover material, mechanical compacting and levelling of waste) is missing. For calculations before 1980 the IPCC default value 0.6 was used.

The IPCC default value 50 % is used for the methane content in landfill gas (F) (Table 8.7). The value of DOC_F 0.5 has been chosen according to IPCC methodology.

The oxidation factor is estimated to be 10 %, and the half-life of the methanogenesis is 7.5 years.[260] 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.

Table 8.7 Other used parameters in the methane emission calculations

Parameter	Value	Motivation
MCF - 1979	0.6	IPCC Default
MCF 1980 -	1	Well managed(*)
F	50 %	IPCC Default
DOCF	0.5	IPCC Default
OX	10 %	National(**)
t½	7.5 years	National(***)

(*) Swedish EPA, 1999b, (**) Swedish EPA, 1997b, (***) Swedish EPA, 1993b.

Until about 1975, waste burning at landfills was a common waste treatment method, but it ceased about five years later. There is no information on the waste frac-

[259] Avfall Sverige (Swedish Waste Management)

[260] Börjesson, 2000

tion that was burned, except that burning was practiced at 311 of the 847 landfills in 1975.[261] An assumption is therefore made that before 1976, 37 % of all deposited household waste was burned.

8.2.1.2.2 WASTE STATISTICS IN SWEDEN, 1980 - 2005

The Swedish EPA made the first national survey in Sweden in 1980, collecting data on deposited waste (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 best 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 and composted.

There are no time series of data available on landfilled organic industrial waste (except from data on sludge from pulp industry).

8.2.1.2.3 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”) contains rules 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. The treatment of waste is to be reported by treatment method for the different types of waste according to the Waste Statistical Nomenclature (EWC-Stat). The method of treatment relates to various recovery and disposal operations (“R and D codes”) are compiled into 6 different groups. Group 4, ”Disposal opera-

[261] Swedish EPA, 1983.

tions: Land filling, deep injection, surface impoundment, permanent storage and others", is relevant for "Solid waste disposal on land, CRF 6A".

The Swedish EPA is responsible for the reporting in accordance with the regulation. So far, waste data has been reported for the reference years 2004, 2006, 2008 and 2010. No waste statistics on landfilling are compiled for the intermediate years by SEPA.

In 2010, a study[262] was carried out in order to analyze possibilities to use the reported waste data to WStatR for the calculations of CH_4 from solid waste landfills. The study recommended implementation of WStatR-data from reference year 2006 and onwards. The advantages of WStatR-data in relation to waste statistics for 1980-2005 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 has per definition 100 % coverage (completeness).

Relevant waste categories (those who is containing Degradable Organic Carbon) were chosen, and the DOC content of the chosen waste categories was investigated by analyzing the statistical source material in cooperation with waste experts. Interpolations and extrapolations have been made for the intermediate years.

8.2.1.2.4 WASTE CATEGORIES, 1980-2005

Household waste, sludge and garden waste

Table 8.8 summarizes the available statistics on household waste, sludge from waste water 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.

[262] Edborg, Stenmarck, Sundquist & Szudy, 2010

Table 8.8. Deposited household waste, sludge and garden waste (1000 tonnes)

Year	Household waste (and similar)	Sludge from waste water treatment, wet weight	Garden waste
1980 [1]	1 450	..	..
1985 [2]	1 040	..	..
1986 [3]	1 020	..	..
1988 [4]	1 080	..	..
1990 [5]	1 400	900	70
1994 [6]	1 380	610	80
1995 [7]	1 200	540	60
1996 [8]	1 110	470	70
1997 [8]	1 150	455	50
1998 [9]	1 020	490	45
1999 [10]	972.5	490	45
2000 [11]	869.5	345	53
2001 [12]	880	330	44
2002 [13]	820	215	40
2003 [14]	575	155	33
2004 [15]	380	102	0*
2005 [16]	210	58	0*

1) Swedish EPA, 1983. 2) Statistics Sweden, 1988; RVF. 3) RVF, 1988. 4) RVF, 1990. 5) Statistics Sweden, 1992. 6-16) RVF, 1996-2006.

* Included in household waste from reference year 2004. ** Estimate

The composition of household waste has been investigated in many studies over the years. Ohlsson[263] 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 composition[264] for 1990 and 1995 are presented in Table 8.9. 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.[265] 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 8.9.

[263] Ohlsson, 1998 and REFORSK, 1998

[264] Ohlsson, 1998

[265] RVF, 2005

Table 8.9. 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 the 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.

Industrial waste

As noted above, statistics on deposited industrial waste are not divided 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.[266] The estimates have been made with 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.

The first study on “specific” organic industrial waste was published in 1993;[267] the waste groups found to generate methane in landfills are presented in Table 8.10. 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.

[266] Profu, 2004.

[267] Swedish EPA, 1993

Table 8.10. Organic industrial waste, early 1990s (Swedish EPA, 1993)

Waste category	Produced quantity, 1000 tonnes/yr	Deposited fraction, %	Deposited quantity, 1000 tonnes/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 slaughter houses	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 is 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 is 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 8.11).

Table 8.11. Values of deposited wastewater sludge from the pulp industry, wet weight

Year	Quantity 1000 tonnes/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 1996[268]. In accordance with the report, the deposited waste categories are presented in Table 8.12. The gas potentials were calculated by Sweco Viak.

Table 8.12. Organic Industrial Waste 1996

Waste category	Deposited quantity, 1000 tonnes/yr	Gas potential, Mm3 CH_4/yr
Waste from slaughter houses	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.[269] In 1998, about 6,000 tonnes of paper

[268] Swedish EPA, 1996

[269] Statistics Sweden, 2000

and wrapping material were deposited. This quantity is added each year to the industrial waste already noted.

Composition of deposited waste

Table 8.13 illustrates the estimated composition of deposited waste (excl. mining waste) 1990-2005.

Table 8.13. Composition of deposited waste, in per cent

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

8.2.1.2.5 Used statistics on deposited waste, 1952-2012

Used statistics 1952-2005

Table 8.14 shows the activity data 1952-2005 used in the calculations of methane emissions from solid waste disposal on land.

Table 8.14. 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, 1000 tonnes	Deposited park and garden waste, 1000 tonnes	Deposited organic industrial waste(**), 1000 tonnes	Deposited industrial waste (not industry specific), organic fraction(**), 1000 tonnes	Deposited construction and demoli-tion waste, organic fraction(**), 1000 tonnes
1952	290	76%	37%	992	58	56	207	63
1953	290	76%	37%	998	59	56	211	64
1954	290	76%	37%	1005	59	56	215	66
1955	290	76%	37%	1012	59	56	220	68
1956	290	76%	37%	1018	60	56	226	70
1957	290	76%	37%	1024	60	56	232	71
1958	290	76%	37%	1030	60	56	234	73
1959	290	76%	37%	1035	61	56	239	75
1960	290	76%	37%	1041	61	56	250	77
1961	290	76%	37%	1049	62	56	260	78
1962	290	76%	37%	1056	62	56	272	80
1963	290	76%	37%	1064	62	56	280	82
1964	290	76%	37%	1072	63	56	301	83
1965	290	76%	37%	1079	63	56	316	85
1966	290	76%	37%	1088	64	56	325	87
1967	290	76%	37%	1096	64	56	330	89
1968	290	76%	37%	1105	65	56	345	90
1969	290	76%	37%	1114	65	56	349	92
1970	290	76%(*)	37%	1122	66	56	364	94
1971	290	76%	37%	1126	66	56	369	96
1972	290	76%	37%	1129	66	56	372	97
1973	290	66%	37%	984	66	56	391	99
1974	290	66%	37%	987	67	56	406	101
1975	290	66%(*)	37%(*)	990	67	56	409	103
1976	290	66%	30%	1109	67	56	452	116
1977	290	66%	22%	1229	67	56	483	131
1978	290	58%	15%	1186	67	56	517	145
1979	290	58%	7%	1292	68	56	593	162
1980			0%	1450(*)	68	56	628	177
1981				1400	68	56	632	179
1982				1300	68	56	627	182
1983				1200	68	56	551	158
1984				1100	68	56	579	161
1985				1040(*)	68	56	595	163
1986				1020(*)	68	56	602	165
1987				1050	69	56	615	168
1988				1080(*)	69	56	624	170
1989				1240	70	56	630	172
1990				1400(*)	70(*)	56	622	175
1991				1390	72	57.1	567	137
1992				1390	75	58.2	554	126
1993				1390	77	59.3	558	115
1994				1380(*)	80(*)	60.3	564	82
1995				1200(*)	60(*)	61.4	571	82
1996				1110(*)	70(*)	62.5	536	78
1997				1150(*)	50(*)	62.5	495	85

Year	Standard value: Household waste/ citizen (kg)	Fraction deposited household waste	Fraction of burned household waste on landfills	Deposited household waste and similar, 1000 tonnes	Deposited park and garden waste, 1000 tonnes	Deposited organic industrial waste(**), 1000 tonnes	Deposited industrial waste (not industry specific), organic fraction(**), 1000 tonnes	Deposited construction and demolition waste, organic fraction(**), 1000 tonnes
1998				1020(*)	45(*)	62.5	477	73
1999				972.5(*)	45(*)	62.5	580	96
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 8.15. Overview over used statistics on deposited waste and interpolated/extrapolated values: Sludge, wet weight

Year	Deposited sludge from waste water treatment, 1000 tonnes	Deposited sludge from pulp industry, 1000 tonnes
1952	748	500
1953	753	500
1954	759	500
1955	764	500
1956	768	500
1957	772	500
1958	777	500
1959	781	500
1960	786	500
1961	791	500
1962	797	500
1963	803	500
1964	809	500
1965	814	500
1966	821	500
1967	827	500
1968	834	500
1969	840	500
1970	847	500
1971	849	500
1972	852	500
1973	855	500
1974	857	500
1975	860	500
1976	862	500
1977	865	500
1978	867	500
1979	869	500

Year	Deposited sludge from waste water treatment, 1000 tonnes	Deposited sludge from pulp industry, 1000 tonnes
1980	871	500
1981	872	500
1982	873	500
1983	874	500
1984	875	500
1985	876	500
1986	881	500
1987	885	500
1988	890	500
1989	895	500
1990	900(*)	500(*)
1991	800	462
1992	750	424
1993	700	386
1994	610(*)	250(*)
1995	540(*)	310(*)
1996	470(*)	410(*)
1997	455(*)	520(*)
1998	490(*)	210(*)
1999	490(*)	130(*)
2000	345(*)	242(*)
2001	330(*)	184
2002	215(*)	126.3
2003	155(*)	68
2004	102(*)	10.5(*)
2005	58(*)	0(*)
2005	58(*)	0(*)

(*) Taken from statistical sources. Other values are interpolated or extrapolated.

Used statistics 2006-2009

Table 8.16 shows waste statistics for 2006-2009 used in the calculations of methane emissions from solid waste disposal on land. It also shows estimated DOC content for each waste category.

Table 8.16. Overview over used statistics* 2006-2009 on deposited waste and interpolated/extrapolated values, 1000 tonnes, and estimated DOC content, percent

EWC-Stat code	Description of waste categories	2006(*)	2007	2008(*)	2009	DOC content
03.1	Chemical deposits and residues	C	C	176.946	176.946	2
03.2	Industrial effluent sludges: Dry matter	11.914	11.247	10.580	10.580	9
05.	Health care and biological wastes: Hazardous	C	C	0.004	0.004	8
05.	Health care and biological wastes	C	C	0.010	0.005	8

EWC-Stat code	Description of waste categories	2006(*)	2007	2008(*)	2009	DOC content
07.2	Paper and cardboard wastes	38.977	20.637	2.296	1.427	36
07.5	Wood wastes	C	C	1.840	0.949	40
07.6	Textile wastes	0.228	0.600	0.972	0.486	24
09A	Animal and vegetal wastes *(excl. 09.11 & 09.3)*	11.548	8.803	6.058	6.058	15
09.11	Animal waste of food preparation and products	0.303	0.323	0.343	0.343	15
09.3	Animal faeces, urine and manure	0.372	0.224	0.075	0.038	9
10.1	Household and similar wastes	203.821	161.904	119.986	68.500	18
10.2	Mixed and undifferentiated materials	482.743	352.593	222.442	222.442	3,1
10.3	Sorting residues	311.483	409.541	507.599	393.591	2,5
11A	Common sludges *(excl. dredging spoils)*: Dry matter	26.383	19.763	13.142	19.685	28
	Total, *wet weight*	**1 428.879**	**1 287.740**	**1 146.601**	**1 011.530**	

* Waste statistics for 2006 and 2008 are from Sweden's reporting to the Commission in accordance to the Waste Statistic Regulation. Waste statistics for 2007 and 2009 are interpolated/extrapolated values. (C: Confidential)

Used statistics 2010-2012

Table 8.17 shows waste statistics for 2010-2012 used in the calculations of methane emissions from solid waste disposal on land. The EWC-stat codes as well as the DOC content differs a bit compared to those in Table 8.16. This is due to changes in the EWC-stat codes implemented in the 2010 year data, which is also mentioned in section 8.2.1.5. Due to the changes in EWC-codes there was also an investigation on the DOC-contents regarding the codes changed[270].

[270] Sundqvist & Szudy, 2012

Table 8.17. Overview over used statistics* 2010-2012 on deposited waste and extrapolated values, 1000 tonnes, and estimated DOC content, percent

EWC-Stat code	Description of waste categories	2010(*)	2011(*)	2012(*)	DOC content
02A	Chemical wastes	85.323	85.323	85.323	5
03.2	Industrial effluent sludges: Dry matter	1.282	1.282	1.282	12,5
03.2	Industrial effluent sludges: Dry matter Hazardous	7.000	7.000	7.000	2
05.	Health care and biological wastes: Hazardous	0	0	0	8
05.	Health care and biological wastes	0	0	0	8
07.2	Paper and cardboard wastes	0.577	0.577	0.577	36
07.5	Wood wastes	0.057	0.057	0.057	40
07.6	Textile wastes	0	0	0	24
09.1	Animal and mixed food waste	1.183	1.183	1.183	13
09.2	Vegetal wastes	2.304	2.304	2.304	20
09.3	Animal faeces, urine and manure	0	0	0	9
10.1	Household and similar wastes	17.013	17.013	17.013	18
10.2	Mixed and undifferentiated materials	262.226	262.226	262.226	8,5
10.3	Sorting residues	279.583	279.583	279.583	2,5
11A	Common sludges *(excl. dredging spoils)*: Dry matter	26.228	26.228	26.228	28
	Total, *wet weight*	**812.514**	**812.514**	**812.514**	

* Waste statistics for 2010 are from Sweden's reporting to the Commission in accordance to the Waste Statistic Regulation. Waste statistics for 2011 and 2012 is extrapolated values.

8.2.1.3 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 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 (se further in section Waste statistics in Sweden, 2006 and onward). It has led to lower uncertainties since the data on DOC now can be estimated with better precision.

IPCC Guidelines suggest that the error in estimated methane generation potential may be about 15 % given high quality data and 50 % given poor data on methane generation, per tonne of waste. The uncertainty in statistics on deposited waste may be 10 %, if the waste is weighted, or more than 200 % if the data quality is poor. The errors in estimated methane recovery will probably be small, according to the Good Practice Guidance. Given these standard uncertainty ranges and applying the simple error propagation formula, a total error of estimated methane emissions of about 20 % would be achievable, in the best case, given high quality data.

According to Good Practice Guidance there is some extra uncertainty in the methane generation rate constant [-40 %, 300 %], and in the oxidation factor, if oxidation is assumed. An assessment of the confidence interval for the Swedish methane estimate from landfills would be around 50-60 % for 2005. Swedish waste statistics 2005 on household waste, in particular, are of high quality, but the estimates are still dependent on lower quality data and extrapolations from earlier years. Furthermore, statistics on different waste fractions in household waste, and especially industrial waste, are still of lower quality. The quality of parameters based on IPCC default values may also be low, since they rely on older research, and data from Swedish on-site measurements is not yet extensive enough for verification.

The time series in the waste sector are calculated consistently and in line with the Good Practice Guidance. When statistics are not produced annually, interpolation and extrapolation have been necessary tools for imputation.

8.2.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

8.2.1.4.1 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.

8.2.1.4.2 Verification of data and reducing compiling errors

Statistics Sweden and the IVL has on behalf of the Swedish EPA scrutinized the activity data (quantities of deposited; household waste, park and garden waste, sludge from waste water treatment) used for calculations. The accuracy in these activity data is judged to be good.

8.2.1.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been made.

8.2.1.6 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.

8.3 Waste water handling (CRF 6.B)

In Sweden, wastewater treatment is practised both within some industries, in municipal wastewater treatment plants and in private wastewater systems. Both methane and nitrous oxide are produced from these activities.

The industrial wastewater is treated both internally and in municipal wastewater treatment plants. The industries with internal wastewater treatment are situated both by the coast and in the inland (see further in section Industries with internal wastewater treatment).

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, chemically and biologically. In some larger plants, or plants with sensitive recipients, special nitrogen treatment is performed. These wastewater treatment plants also receive wastewater from industries without internal wastewater treatment.

In addition, there are also a number of smaller plants or private plants of varying standard.[271] There are also approximately 1.3 million people in Sweden not connected to any wastewater treatment plant.

Considerable quantities of heat and bioenergy are recovered from sewage and wastewater.[272] Anaerobic wastewater treatment and anaerobic digestion of sludge is practised in Sweden and generates methane for production of electricity, heating, vehicle fuel and for local gas distribution networks. Some of the methane is flared.

[271] Swedish EPA & SMED, 2003

[272] Ministry of the Environment, 2001.

N_2O emissions are calculated and reported for wastewater treatment (Industrial Wastewater, CRF 6B1a and also for Domestic and Commercial Wastewater, CRF 6B2a) and for Human sewage.
The estimations of emissions (leakage) of nitrous oxide and methane from the wastewater treatment processes and sludge treatment processes need further improvements. However, emissions of CH_4 from wastewater treatment (Industrial Wastewater, CRF 6B1a, and Domestic and Commercial Wastewater, CRF 6B2a) are calculated and reported. Also emissions of CH_4 from sludge treatment (Domestic and Commercial Wastewater, CRF 6B2b) are calculated and reported.

According to a survey[273] by the Swedish Energy Agency on biogas production and utilization, the production of biogas in Sweden in 2012 was 1 589 GWh (or 114.0 Gg in methane) to be compared with 1 285 GWh (or 92.2 Gg in methane) in 2005[274]. In 2012, 42.0 % of the produced energy from biogas was produced at wastewater treatment plants (anaerobic digestion of sludge). The biogas production at wastewater treatment plants increased by 18.1 % from 2005 to 2012. Approximately 8.2 % of the biogas produced at wastewater treatment plants was flared in 2012.

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 8.18.

8.3.1 Industrial, domestic and commercial wastewater (CRF 6.B.1 and CRF 6.B.2)

8.3.1.1 SOURCE CATEGORY DESCRIPTION

Sweden is reporting data on emissions of nitrous oxide (N_2O) and methane (CH_4) for the sectors Industrial Wastewater, CRF 6.B.1 and Domestic and Commercial Wastewater, CRF 6.B.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 8.18.

273 Swedish Energy Agency, 2011

274 Swedish Energy Agency, 2007

Table 8.18. Summary of source category description, CRF 6.B

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources Estimated
		Level	Trend	Qualitative			
6.B	CO_2	NA	NA		NA	NA	NA
	CH_4	X	X		CS, T1	CS, D	Yes
	N_2O				CS	D	Yes

CS Country Specific. T1 Tier 1. D Default.

1.1.1.2 Methodological issues

8.3.1.1.1 Nitrous oxide (N_2O)

National activity data on nitrogen in discharged wastewater from municipal wastewater treatment plants and industries are used, in combination with a model estimating nitrogen in human sewage from people not connected to municipal wastewater treatment plants.

The general formula to calculate the emissions is:

$$(N_{Industry} + N_{WastewaterTreatmentPlants} + PROTEIN * Nr_{People} * 0.16) * EF * 44/28$$

where $N_{WastewaterTreatmentPlants}$ and $N_{Industry}$ are the nitrogen in discharged wastewater from municipal wastewater treatment plants (including industries without internal wastewater treatment) and other industries (with internal wastewater treatment) respectively. IPCC´s default emission factor, 1 % N_2O-N/N, is used as emission factor (EF) for the discharges from all three sources (Wastewater treatment plants, Industries and unconnected households).

IPCC Guidelines suggest an emission factor of 1% (N_2O-N/kg sewage N discharged sewage effluent) for sewage nitrogen that enters rivers and estuaries (Good Practice Guidance, Table 4.18), while the N_2O emissions associated with sewage treatment and land disposal are considered to be negligible. There is no Swedish research that will motivate a national emission factor concerning discharged sewage nitrogen.

Wastewater treatment statistics and activity data related to nitrous oxide emissions in Sweden

According to Swedish environmental protection law, all municipal wastewater treatment plants designed for more than 2,000 person equivalents, including industry, need to report their discharges in legal environmental reports delivered to their supervision agency. Statistics are published every other year by the Swedish EPA.[275]

[275] Statistics Sweden, MI 22 SM, Swedish EPA and SMED.

For industrial wastewater handling, Sweden has better data on discharges in tonnes than in cubic metres and therefore has chosen to publish data of discharges of nitrogen in tonnes. Discharges in tonnes are more relevant than in cubic meters because large quantities of the waste water output reported in the environmental reports are actually cooling water and not process water. It is less confusing for the reporting companies to report the quantity/quantities of their discharges of various substances in *tonnes* instead of in *cubic metres*.

The statistics on discharges of nitrogen exclude municipal wastewater treatment plants designed for less than 2,000 person equivalents. These were surveyed in 1999, and were found to represent about 6 % of the total discharged nitrogen, which is compensated for using a “1.1 factor” in the above formula.

The statistics also exclude approximately 1.3 million people in rural areas, who are not connected to municipal wastewater treatment. Until submission 2009, Sweden estimated this population to almost 1 million people. The new estimate is based on new data[276] for 1995, 2000 and 2005. The mean of these data is approx. 1 264 000 people, which is rounded up to 1.3 million people in the calculations to compensate for suspected underestimation for year 1995. Sweden cannot see any national trend or variations over the years that are significant enough to apply in the calculations, since the data for 1995 (1 205 686 people) is likely an underestimation, and 2000 (1 296 757 people) and 2005 (1 291 299 people) are very similar. However, the nitrogen from these people is accounted for in the formula as well, through the model estimate of nitrogen production.

National values for protein consumption are used and are available in time series. Previously a constant value was used.

Industries with internal wastewater treatment

The formula is: $N_{Industry} * EF * 44/28$

The 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.

276 Statistics Sweden MI 11 SM 0701, Korrigerad version

Table 8.19. 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), tonnes

Year	Pulp and paper (tot.)	Oil ref. (tot.)	Che mical (inl.)	Che mi-cal (coa st.)	Iron and steel (inl.)	Iron and steel (coa st.)	Food (inl.)	Food (coa st.)	Wood prod. (inl.)	Wood prod. (coast.)	Min-ing (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	..	109	..	..	..
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	2500	..	..	..	..	..	..	..	..	..	..
2012	2560	..	..	..	..	..	..	..	..	..	..

Source: NV 4657, NV 4434, NV 4657, NV 4924, NV 4987, NV 5114, Swedish Forest Industries Federation, MI 22 SM, Swedish EPA and SMED

Municipal wastewater treatment plants

The formula is: $N_{WastewaterTreatmentPlants} * EF * 44/28$

$N_{WastewaterTreatmentPlants}$ is magnified by 10 %, in order to compensate for wastewater from small treatment plants, not included in the statistics.

Table 8.20. Discharges of nitrogen from large municipal wastewater treatment plants (from treatment of domestic, commercial and industrial waste water), tonnes

Year	Municipal wastewater treatment plants
1990	26 200
1992	25 310
1995	25 940
1998	21 376
2000	18 977
2002	18 036
2004	17 779
2006	18 347
2008	18 433
2010	17 419

Source: MI 22 SM, Swedish EPA and SMED

Households not connected to municipal wastewater treatment plants

The formula is: $(PROTEIN * Nr_{People} * 0.16) * EF * 44/28$

PROTEIN is the annual per capita consumption per person/year, Nr_{People} is the number of people not connected to municipal wastewater treatment plants, and 0.16 is the fraction of nitrogen in proteins (Table 8.21).

Table8.21. Protein consumption in Sweden, g/person/day

Year	Protein consumption g/person/day
1980	87
1985	86
1990	89
1995	89
2000	97
2003	101
2004	102
2005	102
2008	111
2009	110
2010	112
2011	110

Source: The Swedish yearbook of agricultural statistics 2007, 2011, 2012 & 2013.

8.3.1.1.2 Methane (CH4)

Methane emissions from wastewater treatment

CRF 6B1a, Industrial wastewater, Wastewater

The majority of the facilities in Sweden are using aerobic processes, where no CH_4 is supposed to be generated because of the use of aeration in the wastewater treatment process. In 2012, there were only five (5) facilities using anaerobic wastewater treatment processes in Sweden. These facilities were in the pulp industry and food industry.

For methane emissions from industries with internal wastewater treatment, Sweden has chosen a national method to estimate the emissions based on data availability. According to wastewater treatment expertise[277], the loss of CH_4 in the energy recovery process should be within the range of 2 - 5 %. This factor can be combined with data on energy recovery from the anaerobic processes.

In 2012, 121 GWh[278] (or 8.7 Gg CH_4) was recovered. By using the upper value (5 %) of the leakage factor to ensure a conservative estimate, the emission of CH_4 is calculated to 0.46 Gg for 2012.

At the moment only statistical data sources are available and used. There is no additional statistical information available on upgrades or modifications of the recovery system in general. No plant-specific data has been used in the calculations for any year.

Statistical data on energy recovery from anaerobic processes are available for 2005-2012. For 1990-2004 no statistical data are available. Therefore the activity data for 2005 was extrapolated for 1990-2004. In other words, the value for 2005 was also used for the years 1990-2004. The trend for CH_4 emissions for the period 1990–2004 would likely rather be decreasing than increasing. This is because the number of biogasproducing plants in the pulp and paper industry using anaerobic processes has been reduced in the past ten years, according to wastewater treatment expertise[279]. Biogas production in the food industry has existed for more or less five years.

The estimate of the loss of CH_4 in the energy recovery process (5 %) is used for all years.

[277] Ek, 2010

[278] Swedish Energy Agency, 2013

[279] Ek, 2010

CRF 6B2a, Domestic and Commercial Wastewater, Wastewater

When analyzing the sector CRF 6B2a in Sweden it is necessary to divide the sector into three sections:

a) Large wastewater treatment plant (treatment capacity: more than 2 000 pe)
b) Small wastewater treatment plants (treatment capacity: 25 -2000 pe)
c) Population not connected to wastewater discharge system

a) In Sweden, all large wastewater treatment plants are using aerobic wastewater treatment processes. No CH_4 is supposed to be generated because of the use of aeration in the wastewater treatment process.

b) For small wastewater treatment plants, the situation is at the moment not well enough investigated and therefore Sweden is using the IPCC Good Practice Guidance method (Page 5.15 Box 5.1 Check method):

$WM = P \times D \times SBF \times EF \times FTA \times 365 \times 10^{-12}$ *where*

WM = Annual CH4 emission per country, from domestic wastewater (Tg)

P = Population of country or urban population for some developing countries (person)

D = Organic load in biochemical oxygen demand per person (g BOD/person/day), overall default = 60 g BOD/person/day

SBF = Fraction of BOD that readily settles, default = 0.5

EF = Emission factor (g CH4/g BOD), default = 0.6

FTA = Fraction of BOD in sludge that degrades anaerobically, default = 0.8

Activity data on population connected to small wastewater treatment plants (700 000 people) is derived of background data from a survey from 2010 on treatment methods and sewage networks in Swedish municipal waste water treatment plants. A report[280] was published in 2011.

c) For population not connected to wastewater discharge system, the following applies:
1.) The sludge in the wastewater (SBF = Fraction of BOD that readily settles) is collected and transported to anaerobic digestion plants located at larger wastewater treatment plants[281]. It is covered and reported in section CRF 6B2b (sludge treatment).

2.) CH_4 emissions from the remaining wastewater are likely to be NO (not occurring) or negligible. The waste water is rich in oxygen, and for biological processes

[280] Brånvall & Svanström, 2011

[281] Ek, 2010

to occur the water must not be too cold.[282] Sweden has a rather cold climate with an average annual temperature of 4.8 (°C) 1991-2005. At the moment Sweden does not[283] have any written references to support this statement and therefore emissions are estimated by using the default Check method (as for ‘b)’ above).

The activity data (population not connected to wastewater discharge system) is the estimate based on data[284] for 1995, 2000 and 2005 (1 300 000 people).

Methane emissions from sludge treatment

CRF 6.B.1.b, Industrial wastewater, Sludge
The European Union Waste Statistics Regulations (EC 2150/2002), also called WStatR, came into force in November 2002. It requires all Member States to provide data to the European Commission every two years on the generation and treatment of waste and on the number and capacities of waste management facilities. In this context, waste treatment covers incineration, recovery and disposal. Sweden has so far, as a Member State of the European Union, reported official national statistics on waste to the Commission for the years 2004, 2006, 2008 and 2010.

The inventory work and the data collection for WStatR have provided Sweden’s national waste experts with valuable information on existing waste management practices in Sweden. Since the WStatR by definition shall cover 100 % of the generated waste in all sectors and incineration, recovery and disposal of waste, it is considered a reliable data source.

Both environmental reports and questionnaires have been used as data sources. All companies which perform waste treatment activities need permits and also to compile an annual environmental report. These environmental reports have been read by a team of waste experts for the purpose of finding waste data for WStatR.

The conclusions[285] on the subject are that no activities such as anaerobic digestion of sludge from industrial wastewater treatment have been found during the inventory. Therefore Sweden is reporting “NO” (not occurring) for *emissions* and *recovery* for *6B1: sludge treatment.*

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282 Ibid

283 Ek & Szudy, 2011

284 Statistics Sweden MI 11 SM 0701, Korrigerad version

285 Memo ”*Occurence of treatment of sludge by anaerobic digestion in Swedish industries”, Statistics Sweden, 2011* ”

CRF 6.B.2.b, Domestic and commercial wastewater, Sludge

A study[286] conducted by SWECO (Swedish Consultants) on behalf of Stockholm Water Authority (Stockholm Vatten) on two wastewater treatment plants in Stockholm shows that this leakage is between 4 % and 7 % of the gas production. These two wastewater treatment plants are assumed to be representative for all 135 wastewater treatment plants that apply anaerobic digestion in Sweden year 2012, then a national methane emission estimates can be calculated by combining this factor with data on energy recovery from the anaerobic sludge treatment.

In 2012, 660 GWh[287] (or 47.4 Gg CH_4) was recovered. By using the upper value (7 %) of the leakage factor to ensure a conservative estimate the emission of CH_4 is calculated to 3.56 Gg for 2012. The emissions are increasing in the recent years since they follow the increasing amounts of recovered methane in this subsector.

Data on energy recovery from anaerobic sludge treatment are available for 2005-2012. For 1990-2004 no data are available and therefore the data for 2005 was extrapolated for these years. The estimate of the loss of CH_4 in the energy recovery process (7 %) is used for all years.

8.3.1.2 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 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 is considered to have a margin of inaccuracy of well under 10 % at national level. The inaccuracy in the emission factor is estimated to be at least 50 %, according to Good Practice Guidance. This results in an overall inaccuracy exceeding 50 % annually, and more for years where activity data have been extrapolated.

For methane emissions, both national methods and default methods are used. For the activity data “energy recovery” for the early years with no observations, a 50 % uncertainty is assumed, while for the recent years with actual observations a 10 % uncertainty is assumed. The uncertainty of the emission factor “leakage” is assumed to be the same for all years (40 %). All of these estimates are expert judgements.

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[286] ” Metanförluster vid avloppsreningsverken i Henriksdal och Bromma”, Stockholm Vatten, 2004

[287] Swedish Energy Agency, 2013

For the activity data “population connected to small wastewater treatment plants” and “population not connected to wastewater treatment plants” the uncertainty for the early years is judged to be higher (10 %, expert judgement) than for the recent years (5 %, IPCC default). The uncertainty of the emission factor (Equation 5.6 in Good Practice Guidance) “Check method” is based on expert judgements and assumed to be high (65 %).

The time series in the waste sector are calculated consistently and in line with the Good Practice Guidance. When statistics are not produced annually, interpolation and extrapolation have been necessary tools for imputation.

In submission 2013 the uncertainties were recalculated since errors in the data sheets were discovered. This affected mainly the calculated uncertainties for the base year 1990.

8.3.1.3 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.

8.3.1.4 SOURCE-SPECIFIC RECALCULATIONS

Recalculations have been made for CH_4 from 6.B.1 Industrial Wastewater (Wastewater) and 6.B.2 Domestical and Commercial Wastewater (Sludge) since new activity data on methane recovery are available for year 2011. The recalculations have led to an increase of emissions of CH_4 from category 6.B Waste water handling by 0.18 Gg or 0.26 % of the total CH_4 emissions in the waste sector. New data is also available on protein consumption for year 2011. The recalculation has led to a decrease of emissions of N_2O from category 6.B Waste water handling by 0.0024 Gg or 0.46 % of the total N_2O emissions in the waste sector.

8.3.1.5 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan. A development project on methane generation has started. It includes a comparison of the full IPCC default method and the national methods used in Sweden. The results are expected to be presented in NIR submission 2015.

8.4 Waste incineration (CRF 6.C)

8.4.1 Source category description

Emissions from incineration of hazardous waste, and in later years also MSW and industrial waste, from one large plant are reported in CRF 6.C. Emissions from other MSW incineration plants combusting waste for energy purposes are included in CRF 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 8.22.

Table 8.22. Summary of source category description, CRF 6.C

CRF	Gas	Key Category Assessment 2012 (tier 2, excluding LULUCF)			Method	EF	All sources Estimated
		Level	Trend	Qualitative			
6.C	CO_2				T3	PS	Yes
	CH_4				T2	PS	Yes
	N_2O				T2	PS	Yes

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

8.4.2 Methodological issues

For the whole waste category, the methodology and time series consistency are in line with the Good Practice Guidance.

Emissions from incineration of hazardous waste, and in later years also MSW and industrial waste, from one large plant are reported in CRF 6.C. Reported emissions are for the whole time series obtained from the facility's Environmental report or directly from the facility on request. CO_2, SO_2 and NO_X are measured continuously in the fumes at the plant. 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 a consequence of increased capacity, the emissions from 2003 are 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 6.C. All other emissions from incineration of MSW are reported in CRF 1.

Emissions reported are CO_2, CH_4, N_2O, NO_X, SO_2, NMVOC and CO.

In previous submissions, only the amount of CO_2 emissions of biogenic origin of the MSW fraction of the waste, have been estimated using information from a report published by the Swedish Waste Management[288]. In this report the information is given that approximately 70 % of the emitted CO_2 from incineration of MSW have biogenic origin. All other incinerated waste fractions have been assumed to be of fossil origin. The amounts of incinerated MSW have been obtained by the company for the years 2003 until 2009. For 2010 this information was considered to be market-related, not official, information. Reported MSW for 2010 was in submission 2012 estimated applying the same proportion of MSW of the total amount of incinerated waste as in 2009.

[288] Swedish Waste Management. RVF rapport 2003:12 (in Swedish). Förbränning av avfall. Utsläpp av växthusgaser jämfört med annan avfallsbehandling och annan energiproduktion.

In submission 2013 the time series of reported biogenic and fossil CO_2 was revised. For the years 2008, 2009, 2010 and 2011 the company has, beside total emissions of CO_2, also reported CO_2 with respect to biogenic or fossil origin. The company has based their reporting of biogenic and fossil CO_2 on a detailed study performed in 2008. In this study they found that 63% of the totally emitted CO_2 had biogenic origin. This finding is in good agreement with newly published results from a Swedish study showing that about one third of the carbon in solid waste is of fossil origin[289]. As the mixture of incinerated wastes has been almost the same for all years from 2003, when the new incinerator was taken into operation, the company considered this biogenic percentage of the totally emitted CO_2 to be valid also for the years 2003 to 2008. For the period before 2003 the company considers reported CO_2 emissions to be almost 100% fossil.[290]

Before 2008 occasional measurements of CH_4 in the flue gas was performed. The company reported CH_4 emission around 1.1 Mg for 2008. This information, together with information of incinerated amounts of waste 1990 until 2007, has been used for estimating a time series 1990 – 2008 for emissions of CH_4 in CRF 6C. For 2008 – 2012 reported CH_4 emissions are based on continuous measurements in the flue gas. Also N_2O from waste incineration is reported for the whole time series. The estimates are based on occasional measurements of the N_2O concentrations in the flue gas together with information on yearly flue gas volumes 2003 – 2012. 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 emission factors used for the CH_4 and N_2O estimates are presented in Table 8.23.

[289] Swedish Waste Management. RAPPORT U2012:05. Determination of the fossil carbon content in combustible municipal solid waste in Sweden.

[290] Personal communication, Hanna Eriksen, Hanna.Eriksen@sakab.se, 2012-08-23

Table 8.23. Activity data and emission factors used for estimations of CH_4 and N_2O emissions in CRF 6.C

Year	Total amounts of incinerated waste	Flue gas volume	N_2O	CH_4
	Gg	1000 m3	EF, g/1000 m^3	IEF, kg/Gg
1990	30	220 674*	15.00	7.73**
1995	33	240 637*	15.00	7.73**
2000	28	205 778*	15.00	7.73**
2005	126	1 099 338	15.00	7.73**
2006	122	902 039	15.00	7.73**
2007	140	915 032	15.00	7.73**
2008	146	1 189 691	15.00	7.73
2009	162	1 107 410	15.00	5.32
2010	115	1 007 061	15.00	7.84
2011	163	1 229 605	15.00	6.09
2012	158	1 194 418	15.00	7.81

* = estimated volume
** = IEF for 2008 used for estimations 1990 - 2007

8.4.3 Uncertainties and time-series consistency

In Revised 1996 IPCC Guidelines no information concerning uncertainties for CO_2, CH_4 and N_2O can be found. In 2006 IPCC Guidelines is stated that if a default value for emission factor is used the uncertainty has been estimated to be ± 100 per cent or more and the uncertainty for plant specific activity data is ± 5 %. In this case the activity data referred to is amount of waste incinerated. The Swedish reporting of N_2O is based on an emission factor and measured yearly amounts of flue gas and the uncertainty for 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 for measured amounts of emitted CO_2 but corresponding information for measured amounts of CH_4 is likely to be in order of ± 10 %. Due to lack of other information the emissions data uncertainty for CO_2 and CH_4 are set to ± 10 %.

As can be seen in Table 8.23 the implied emission factor (IEF) for CH_4 varies slightly for later years, especially so between 2008 and 2009. Reported emissions for 2008 – 2011 are based on continuous measurements and the reason for the variation between 2008 and 2009 may be explained by variations in the composition of the incinerated waste.

8.4.4 Source-specific QA/QC and verification

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

8.4.5 Source-specific recalculations

No recalculations have been made.

8.4.6 Source-specific planned improvements

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

9 Other

Not applicable for Sweden.

10 Recalculations and improvements

Since the last submission, recalculations of GHG emissions for several years have been carried out throughout the inventory. The recalculations are due to comments and implemented recommendations from the national and international review teams in the on-going progress to make the inventory be fully in line with the IPCC Guidelines and the Good Practice Guidance. The recalculations include new methods, emission factors, thermal values and activity data. Some recalculations are due to errors in earlier inventories detected during the work with the present inventory.

10.1 Explanations and justifications for recalculations

The explanations and justifications for the recalculations made in this submission since submission 2013, together with descriptions on their implications for the emission levels, are given in the sector specific chapters.

10.2 Implications for emission levels

This section provides a general description for each sector of the major recalculations made. The implications for emission levels of GHG emissions by sector are presented in Table 10.1. In section 10.3 the implications for emission trends are presented.

10.2.1 Energy, CRF 1

10.2.1.1 STATIONARY COMBUSTION

Activity data for stationary combustion of all fuels used in the other sector, e.g. CRF 1A4 and parts of CRF 1A2f (small industrial enterprises, the construction sector) 2010-2011 has been revised due to revisions of the annual energy balances.

Recalculations were made for the iron and steel industry for most years in the time series which affects CRF 1A1c and 1A2a. The largest changes are for the years 1990-94 (+70 to 80 Gg CO_2 equvialents annually for 1A1c and 1A2a together), 1996-2002 (-54 to -65 Gg CO_2 equvialents annually) and 2005-2007 (-75, -159 and -53 Gg CO_2 equvialents, respectively).

10.2.1.2 MOBILE COMBUSTION

The road emission model HBEFA 3.1 is updated yearly with new information regarding the Swedish road vehicle fleet, composition of the fuel and the current traffic work. In submission 2014, the method to estimate traffic work with regard to driving distances was also updated and improved as well as the distribution of segments and driving distances as a function of age. Data for 1999-2012 (instead of data for 2004) is now available for the distribution of segments. This has resulted in a decrease of the greenhouse gases with around 0.5-2.0 % for the different years as from 2007 .

In submission 2014 the model for off-road vehicles and working machinery was updated with new activity data regarding large diesel off-road vehicles and working machinery for the years 2009 and 2012 (allocated by model year). The emission factor for N_2O was also corrected since it was too high by a factor of ten. The default emission factor from EMEP/EEA guidebook is now used. Another improvement was an adjustment of the scrapping function.

The improvements to the estimation model for working machinery has resulted in decreased emissions of greenhouse gases as from 2007 with approximately 3-10% for different years.

10.2.1.3 FUGITIVE EMISSIONS

CH_4 and CO_2 emissions from venting and storage activities from natural gas transmission pipelines and venting emissions from natural gas, biogas and gas works gas distribution are recalculated using national estimates.

10.2.2 Industrial processes, CRF 2

The differences between the current and the previous submissions are mainly due to recalculations and reallocations performed within primary iron and steel production (CRF 1A and 2.C.1.2).

10.2.3 Solvents and other products use, CRF 3

No major reclaculations are performed in this sector.

10.2.4 Agriculture, CRF 4

The activity data for the calculations of emissions from crop residues was updated from standard yield to actual yearly yield. For some years this resulted in a distinct change in the subsector 4.D.1.4. However, the impact from this on the total sector was only minor.

10.2.5 LULUCF, CRF 5

For consistency reasons, carbon stock changes in the living biomass pool under the UNFCCC is now estimated in exactly the same way as under the KP (see 7.6.1). ”Ordinary” annual recalculations and recalculations of minor importance are described in chapter 7.6. The major difference between submissions under the KP is found for living biomass and AR and D respectively. This is mainly be explained by that: new sample plots have been inventoried, in submission 2013 nearly 20 plots have been incorrectly reported under ARD (land use conversion in 1989 should not be considered ARD) and due to the fact that the National Forest Inventory have revised biomass estimates for a small proportion of so called sample trees (see also 11.3.1.3).

10.2.6 Waste, CRF 6

Recalculations have been made for CH_4 from 6.B.1 Industrial Wastewater (Wastewater) and 6.B.2 Domestical and Commercial Wastewater (Sludge) since new activity data on methane recovery are available for year 2011. The recalculations have led to an increase of emissions of CH_4 from category 6.B Waste water handling by 0.18 Gg or 0.26 % of the total CH_4 emissions in the waste sector.
New data is also available on protein consumption for year 2011. The recalculation has led to a decrease of emissions of N_2O from category 6.B Waste water handling by 0.0024 Gg or 0.46 % of the total N_2O emissions in the waste sector.

Table 10.1. Recalculations of GHG emissions between submission 2014 and submission 2013 by CRF sector

Recalculation difference														
Year	Total (excl LULUCF)		CRF 1		CRF 2		CRF 3		CRF 4		CRF 5		CRF 6	
	Gg CO_2 eq.	%	Gg CO_2 eq.	%	Gg CO_2 eq.	%	Gg CO_2 eq.	%	Gg CO_2 eq.	%	Gg CO_2 eq.	%	Gg CO2 eq.	%
1990	-37	-0.1%	-230	-0.4%	145	2.3%	0	0.00	49	0.5%	-1 519	4%	0	0.0%
1991	-41	-0.1%	-213	-0.4%	156	2.5%	0	0.00	16	0.2%	-541	1%	0	0.0%
1992	-105	-0.1%	-229	-0.4%	149	2.6%	0	0.00	-26	-0.3%	-424	1%	0	0.0%
1993	-72	-0.1%	-238	-0.4%	152	2.6%	0	0.00	14	0.2%	248	-1%	0	0.0%
1994	-105	-0.1%	-246	-0.4%	155	2.5%	0	0.00	-14	-0.2%	-2 446	8%	0	0.0%
1995	-220	-0.3%	-322	-0.6%	101	1.5%	0	0.00	2	0.0%	-6 326	20%	0	0.0%
1996	-318	-0.4%	-378	-0.6%	42	0.6%	0	0.00	18	0.2%	-6 029	18%	0	0.0%
1997	-336	-0.5%	-394	-0.7%	45	0.7%	0	0.00	14	0.2%	-3 364	9%	0	0.0%
1998	-351	-0.5%	-382	-0.7%	44	0.7%	0	0.00	-14	-0.2%	-5 844	17%	0	0.0%
1999	-358	-0.5%	-404	-0.8%	44	0.7%	0	0.00	2	0.0%	-6 223	18%	0	0.0%
2000	-339	-0.5%	-392	-0.8%	49	0.7%	0	0.00	4	0.1%	-6 969	20%	0	0.0%
2001	-326	-0.5%	-383	-0.7%	50	0.7%	0	0.00	8	0.1%	-5 029	14%	0	0.0%
2002	-298	-0.4%	-377	-0.7%	57	0.8%	0	0.00	22	0.3%	-6 273	18%	0	0.0%
2003	-327	-0.5%	-334	-0.6%	1	0.0%	0	0.00	5	0.1%	-6 927	21%	0	0.0%
2004	-310	-0.4%	-323	-0.6%	1	0.0%	0	0.00	12	0.1%	-4 329	15%	0	0.0%
2005	-355	-0.5%	-414	-0.8%	36	0.5%	0	0.00	22	0.3%	-3 817	14%	0	0.0%
2006	-386	-0.6%	-507	-1.0%	123	1.8%	0	0.00	-2	0.0%	-751	2%	0	0.0%
2007	-273	-0.4%	-415	-0.9%	108	1.6%	0	0.0	34	0.4%	-3 464	11%	0	0.0%
2008	-392	-0.6%	-389	-0.8%	-26	-0.4%	0	0.00	23	0.3%	-3 066	9%	0	0.0%
2009	-378	-0.6%	-398	-0.9%	-15	-0.3%	14	0.05	20	0.3%	-2 388	7%	0	0.0%
2010	-479	-0.7%	-495	-1.0%	-25	-0.4%	20	0.1	20	0.3%	-4 437	14%	0	0.0%
2011	-693	-1.1%	-414	-0.9%	-312	-4.7%	14	0.0	16	0.2%	-356	1%	3	0.2%

10.3 Implications for emission trends

The total emissions of GHG have changed for all inventory years due to the recalculations. Below a more detailed description is presented of implications for emission trends due to recalculations of the base year emissions and the last recalculated year's emissions. Note that this section does not include implications for emission trends in the LULUCF sector. In Table 10.2 it can be seen that compared to the estimated assigned amounts, the base year emissions in submission 2014 are about 676 Gg CO_2 equivalents higher.

Table 10.2. Difference between Assigned Amount and Base Year emissions submission 2014 by GHG, excluding LULUCF

GHG	Assigned Amount (Gg CO_2 eq.)	Base Year* emissions Submission 2014 (Gg CO_2 eq.)	Difference between Base Year emissions Submission 2014 and Assigned Amount (Gg CO_2 eq.)
CO_2	56 301.08	57 140.84	839.76
CH_4	6 719.22	6 970.70	251.48
N_2O	8 534.73	8 113.82	-420.91
F-gases	596.61	602.21	5.60
Total	72 151.65	72 827.57	675.92

*1995 for F-gases and 1990 for other GHG emissions (excluding LULUCF)

Based on submission 2014, the estimated GHG emissions in Sweden decreased by 20.9% between the base year (72,828 Gg CO_2 equivalents) and 2012 (57,604 Gg CO_2 equivalents). In Table 10.3 it can be seen that in submission 2013 the trend from the base year to 2011 shows a15.7% decrease. It can also be seen that the recalculation of GHG emissions in submission 2014 increased the downward trend between the base year and 2011 by 657 Gg CO_2 equivalents or 0.9% points compared to submission 2013.

Table 10.3. Impact on emission trends (base year to 2011) due to recalculations of GHG emissions between submission 2014 and submission 2013 by GHG, excluding LULUCF

Trend Base Year* to 2011						
GHG	Submission 2013		Submission 2014		Difference between submission 2014 and submission 2013	
	Gg CO_2 eq.	%	Gg CO_2 eq.	%	Gg CO_2 eq.	% points
CO_2	-8 228	-14.4%	-8 662	-15.2%	-433	-0.7
CH_4	-1 953	-28.2%	-2 030	-29.1%	-76	-1.0
N_2O	-1 690	-20.2%	-1 843	-22.7%	-154	-2.5
F-gases	455	75.5%	462	76.6%	7	1.2
Total	-11 417	-15.7%	-12 073	-16.6%	-657	-0.9

*1995 for F-gases and 1990 for other GHG emissions (excluding LULUCF)

10.4 Recalculations and other changes made in response to the UNFCCC review process

In Table 10.4 the recalculations and other changes in data and in the NIR made in response to the UNFCCC review process are described briefly and referenced to relevant sections to the NIR. Table 10.5 describes the Expert Review team recommendations for submission 2012 and earlier not yet implemented in the Swedish inventory and the reasons for that together with possible implementation plans.

As the inventory time cycle in Sweden is planned for a national independent review of the inventory, the inventory submission 2014 was already compiled in mid-October 2013. The UNFCCC reviewfor submission 2013 took place in September 2013 in Stockholm, Sweden. Because of lack of time due to the inventory time cycle, only minor recalculations and changes have been done as a response to the preliminary results of the UNFCCC review 2013.

Table 10.4. Recalculations and other changes made in response to the UNFCCC review process

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
Submission 2006	General	12. In the NIR provided more methodological detail so that the relationship between activity data (AD), emission factors (EFs) and equivalent parameters and emission estimates was clear, and if the reasons for apparent outliers or anomalies in implied emission factors (IEFs) had been easier to understand. This would have reduced the number of questions and requests for background material during the review. The ERT recommends that the accessible style of the NIR be retained, but that more use is made of tabular and graphic material, and annexes to convey the methodological detail.	Several measures are in place to enable further review of data. E.g. IEFs are compared to IPCC defaults in CRF 2C1.2 and CRF 2F.
submission 2007/2008, (Submission 2010)	General	10, (24). The LULUCF sector requires improved descriptions of country circumstances and the approaches to estimating emissions and removals. One area where transparency could be improved is the use of EU ETS data in the national GHG inventory, in the description of the national system.	The description of the LULUCF sector has continuously been improved since submission 2008 with information concerning the national circumstances. Information on the use of EU ETS data in the Swedish GHG inventory has continuously been improved since submission 2008. See section 1 and 3 and 4 and Annex 2 (1.1.10), and Annex 8:1.

[291] FCCC/IRR/2006/SWE, FCCC/ARR/2008/SWE, FCCC/ARR/2009/SWE, FCCC/ARR/2010/SWE, FCCC/ARR/2011/SWE, FCCC/ARR/2012/SWE
and preliminary recommendations from the in-country review of the Swedish 2013 submission. The draft Annual Review Report for the 2013 submission has not been available in time for implementation in the Swedish 2014 submission.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
			Further information will be added as needed in future submissions.
Submission 2007/2008	General	83. Include information on the commitment period reserve.	Information is included in section 12.5.
Submission 2009, (Submission 2010)	General	8, (6, 13). Provide information in CRF table 7 as presented in Annex 1 to the NIR for the purpose of completeness.	Included in submission 2011.
Submission 2009, (Submission 2010)	General	19, (18). Extend the information on its national system to include the specific responsibilities of the organizations participating in SMED and consultants who assist the Swedish EPA in the inventory preparation.	Information on the national system is revised and updated in submission 2011 and in submission 2012, see section 1.2 and 1.3
Submission 2009, (Submission 2010)	General	20, (19). Total emission estimates used for the key category analysis were not the same as those reported in the NIR, CRF tables and the background tables (appendix 20B to the NIR). Perform the key category analysis correctly and report it in the next annual submission.	The key category analysis is subject to QA and QC activities before delivered to the UNFCCC but they were not fully applied in the resubmission of 2009 due to limited time.
Submission 2009	General	21. Extend its overall uncertainty analysis to include the LULUCF sector. Perform uncertainty analysis taking correlations between gases or categories into account in the next annual submission.	Uncertainty estimates for LULUCF are included in submission 2011. IPCC Tier 1 does not allow correction of correlations between activity data when used for estimating several GHG (e.g. CO2, CH4 and N2O based on fuel combustion). The activity data uncertainty is thus applied in several cells in the IPCC Table 6.1 calculations leading to underestimations of total emissions.
Submission 2009	General	23. Provide information on QA applied to data from EU ETS.	Information on the use of EU ETS data in the Swedish GHG inventory has continuously been improved since submission 2008. See section 1 and 3 and 4 and Annex 2 (1.1.10) and Annex 8:1. Further information will be added as needed in future submissions.
Submission 2009	General	24. Improve transparency by providing more precise and detailed explanations of methodologies, AD and EFs used as well as relevant category-specific QA/QC activities in cases Sweden uses AD from different sources for a single category, country-specific EFs, or methods that are not explicitly explained in the Revised 1996 IPCC Guidelines or the IPCC good practice guidance.	More information is included in submission 2011.
Submission 2009	General	28. (a) If recommendations identified during the previous review cannot be implemented, the Party should clearly explain the reasons;	Fulfilled through table 10.5
Submission 2009	General	28 (d) The implementation of QA/QC procedures needs to be improved to avoid calculation errors and inconsistency between the CRF tables and the NIR;	Sweden's internal handling plan for deliverables between contracting agency SMED and Swedish EPA have been revised in order to enable more time for

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
			internal QA/QC routines. Further efforts will be continuously made in future submissions in order to improve QA/QC procedures. Improvements will be reported in coming NIRs.
Submission 2009	General	88. In the SIAR enhance the availability of the required public information mentioned above and ensure that rejected transactions are terminated, and should report, in its next annual submission, on these two identified issues.	See complete response in Annex 6
Submission 2009	General	89. Include correct information on its commitment period reserve in its next annual submission.	Correct information on the commitment period reserve is included in section 12.5.
Submission 2009	General	90. Report any changes in its national system in accordance with section I.F of the annex to decision 15/CMP.1.	The information on the national system is revised and updated in submission 2011 and submission 2012, see section 1.2 and 1.3
Submission 2009	General	91. Report in its next annual submission any changes in its national registry in accordance with section I.G of the annex to decision 15/CMP.1.	Appropriate information is provided in submission 2011
Submission 2010	General	11, 14. Continue to include emission estimates from civil aviation, industrial wastewater and domestic and commercial wastewater raised by the ERT in the list of potential problems.	Addressed in submission 2012, see section 3.2.15 and section 8.3.1.
Submission 2010	General	21. Use the results of uncertainty analysis to prioritize improvements in the inventory for its next annual submission.	Since the 2011 submission, a Tier 2 key category analysis is performed, taking into account uncertainty estimates. The Tier 2 analysis is used when prioritizing resources and efforts for improving the inventory (see section 1.2.3) together with other input such as international reviews and national peer review.
Submission 2011	General	25. The ERT recommends that, in the NIR of its next annual submission, Sweden improve the explanation of which inventory improvements lead to recalculated inventory estimates and improved uncertainty estimates, and how these improved uncertainties are considered in the uncertainty analysis.	The Swedish inventory planning is described under 1.3.3 of the NIR. Information on improved uncertainties due to development projects is included under 1.7.1 of the NIR.
Submission 2011	General	26. There are several instances where the uncertainty of AD is indicated as “0” in table A.7.2. in annex 7 to the NIR. The ERT recommends that, in the NIR of its next annual submission, Sweden revise these uncertainty estimates.	In line with GPG (2000) uncertainties associated with measured emissions (e.g. for CH4 emissions from oil and natural gas) are allocated to either AD or EF depending on its likelihood of correlation over time. However, for clarity we now write "-" instead of "0" in table A.7.2

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
			and A.7.3 in the NIR annex.
Submission 2012	General	11. … missing information on KP-LULUCF activities in the chapter on recalculations and inventory improvement.	Has been improved, see NIR 11.3.1.4 and 11.8
Submission 2012	General	18. Report Key category UNFCCC-LULUCF according to 5.4.1	Has been carried out, see NIR 11.6
Submission 2012	General	20. The ERT recommends that Sweden improve its reporting of the key category analyses for KP-LULUCF activities in its next annual submission.	Both the aggregation under UNFCCC-LULUCF (NIR 7.2.1) and KP-LULUCF (NIR 11.6) have been improved.
Submission 2012	General	23. The ERT reiterates the recommendation made in the previous review report that Sweden provide more detailed information in the NIR regarding which specific inventory improvements lead to reduced uncertainty.	Under the paragraphs "Source-specific recalculations" in the NIR all explanations of the recalculations should come with an explaining of its effect on the uncertainty.
Submission 2012	General	24. The ERT recommends that the Party improve the transparency of its reporting by including explanations for any remaining “0” values, as well as for any changes in the uncertainty values across annual submissions and any plans for reducing the uncertainty of its estimates, in its next NIR	All zeros in the tables in the NIR annex 7, are changed to a '-' instead. Under the paragraphs "Source-specific recalculations" in the NIR all explanations of the recalculations should come with an explaining of its effect on the uncertainty.
Submission 2006	Energy	23, 37. Categories not estimated	Fugitive emissions of CH4 from transport of crude oil are estimated in submission 2010 and added to CRF 1B2a iii Transport, whereas CO2 emissions in the same category is considered to be not estimated (NE) in Sweden (see NIR 3.3.2). 1B2c Flaring: In submission 2010, all emissions are estimated. All plants where flaring occurs are part of the EU ETS system, and according to this data no flaring of natural gas occurs. If natural gas is included in the "burning gas" sometimes reported to the EU ETS, the emissions are estimated but reported as IE (in flaring of liquid fuels).

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
Submission 2007/2008	Energy, Industrial processes, Waste	19, 32, 80. Categories not estimated	1B2c Flaring: In submission 2010, all emissions are estimated. All plants where flaring occurs are part of the EU ETS, and according to this data no flaring of natural gas occurs. If natural gas is included in the "burning gas" sometimes reported to the EU ETS, the emissions are estimated but reported as IE (in flaring of liquid fuels). CH4 from Carbon Black added in CRF 2B5 all years (see NIR 4.3.4)
Submission 2006	Energy	24. Institutionalize system-level checks to minimize the risk of missing plants or data in its future submissions.	The emissions from stationary combustion are calculated with activity data from a sample survey (thoroughly described in Annex 2). SMED internal QC procedures are in place to minimize error in compilation and data handling. The procedures will be continuously improved also in future submission.
Submission 2006	Energy	32 Methodology for Iron and steel industry	Addressed in submission 2010. Emissions have been revised for all years and reported in accordance with IPCC Guidelines (see NIR section 4.4.1)
submission 2006	Energy	34. Improve explanations on fluctuating trend for fugitive emissions of refinery gas in Petroleum refining	Text in NIR section 3.3.2 clarified in submission 2010
submission 2006	Energy	36. The allocation of fuel between civil aviation and aviation bunkers is not transparently described in the NIR, especially for the period 1990–1994.	A more detailed description is provided in NIR submission 2010 section 3.2.15
submission 2007/2008	Energy	27. The CO2 IEF for diesel decreased due to the change in the mix of the different types of diesel in Sweden. The ERT recommends that Sweden provide explanations in its next NIR, together with the specific carbon content values of Swedish MK1 and MK3 diesel.	In submission 2010, these specific carbon content values are shown in Appendix 20.
submission 2007/2008	Energy	30. The ERT recommends that Sweden provide specific information in its next NIR on how technology improvements influence the CH4 EFs from biomass burning.	In submission 2010, extensive information on this issue is included in NIR Annex 2. Very detailed information is provided in Paulrud et al, 2005: Methane emissions from residential biomass combustion. This report can be provided to the ERT if requested.
submission 2007/2008	Energy and Industrial processes	28, 29, 33, 35, 36. Sweden uses a CS-method to estimate and allocate CO2 emissions from pig iron production, not in line with the good practice guidance as this method allocates all CO2 emissions to the output (i.e. the blast furnace), rather than using an input based CO2 calculation method.	Addressed in submission 2010. Emissions have been revised for all years and reported in accordance with IPCC Guidelines (see NIR section 4.4.1)
Submission 2009	Energy	32. Report emissions from some categories were reported as “NE”, such as CO2, CH4 and N2O from venting of oil and gas and flaring of gas for all years.	Emissions from venting are considered to be included in other subsectors in 1.B.2 (see section 3.3.2.2). Flaring of natural gas is probably not occurring, but if occurring, it is included in flaring of oil.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
Submission 2009	Energy	35. The ERT reiterates the recommendation made by the previous review that Sweden reconciles the differences between the reference approach and the sectoral approach.	Data and methodology for the reference approach have been reviewed and revised in the three last submissions. Although much effort has been made, there are still quite large differences between the reference approach and the sectoral approach for some years. Detailed information that explains the differences are provided in NIR and Annex 4. Further explanations are given in a SMED report from 2012.292
Submission 2009	Energy	44. Clearly describe recalculations for off road vehicles and machinery made with the logic for making the revisions in the NIR in its next annual submission.	In submission 2011 there are no recalculations on this category. All recalculations made in other categories are clearly described in the NIR and in the CRF.
Submission 2009, (Submission 2010)	Energy	38, (42). Investigate how distribution of marine distillate fuels and residual fuel oils between domestic and international navigation data corresponds to the definition of international and domestic marine transport in IPCC and explain large inter-annual variations.	Fuel data in the Monthly fuel, gas and inventory statistics, which is used as activity data for estimating emissions for national navigation and international maritime bunkers, has been analyzed in a SMED study (Eklund et al. 2011. Emissions from navigation and fishing including international bunkers). It has been found to be of good quality and fuels used for domestic and international navigation have been separated correctly and in line with IPCC Guidelines.
Submission 2009, (Submission 2010)	Energy	31, 36, 39, (39). The ERT reiterates the recommendation made by the previous review that Sweden investigates the cause of the difference between the data reported to the IEA and that reported to the UNFCCC.	An study293 was carried out in 2010. The recommendations from that study have been implemented when possible, as described in Annex 4 (Reference approach). The reference approach was revised in submission 2013.
Submission 2010	Energy	33. Provide information and improve the transparency on the amount of fuel consumed in construction.	A table showing fuel consumption in the construction sector has been included in section 3.2.14.2
Submission 2010	Energy	34. For the largest iron and steel plants include explanatory information on the accuracy of AD and the consistency of the time series of data, and ensure the accuracy of its reporting without compromising the consistency of the time series of data.	Information is included in sections 3.2.9.2.1 and 0
Submission 2010	Energy	35. Investigate the reliability of the different sources of information, use appropriate and consistent sources of data for NCVs for its next submission, and provide the justification and reasoning for revising the previously used NCVs.	Explanations are provided in Annex 2.

[292] Anderson, Eklund, Gerner & Gustafsson, 2012

[293] Hedlund & Lidén, 2010

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
Submission 2010	Energy	37. Provide explanatory information on the rationale for recalculations.	Explanations are provided in the section "Source specific recalculations" for those CRF categories where recalculations have been made in the current submission.
Submission 2010	Energy	38. … the documentation box of CRF table 1.A referred to section 3.3.6 of the NIR, which relates to the chemicals category of the energy sector and does not address the issue raised above. The ERT recommends that Sweden correct this reference in its next annual submission. ERT noted that the difference between the reference and sectoral approaches is largely associated with solid fuels (24.9 per cent) and other fuels (2.2 per cent). The ERT recommends that Sweden investigate the ways to properly separate fugitive emissions and emissions from fuel combustion in the industrial processes sector.	Documentation box: corrected in submission 2013 Differences: Data and methodology for the reference approach have been reviewed and revised in the three last submissions. Although much effort has been made, there are still quite large differences between the reference approach and the sectoral approach for some years. Detailed information that explains the differences are provided in NIR and Annex 4. Further explanations are given in a SMED report from 2012.294
Submission 2010	Energy	43. Report correct notation key for CO2 emissions from solid fuels use in agriculture/forestry/fisheries	The notation key is "NO" for 2001 and onwards which is correct since no solid fuels have been used in this category since 2000.
Submission 2010	Energy	44. Provide information in the NIR on the fluctuating trend (e.g. large inter-annual changes) in the CO2 IEFs of other fuels for public electricity and heat production.	Information is provided in the section "Uncertainties and time-series consistency" (section 3.2.6.3)
Submission 2010	Energy	46. For civil aviation explain in more detail the method used to estimate the AD for 2008.	The estimation of CO2 from civil aviation is based on the data on supply and delivery of petroleum products from Statistics Sweden. Non-CO2 emissions are based on information from the Swedish Transport Agency and adjusted to match the delivered amount of aviation fuels (see NIR section 3.2.15)
Submission 2010	Energy	48. Explain the approach and method used to estimate fugitive emissions from distribution of oil products.	Explanations are provided in section 3.3.2.2
Submission 2011	Energy	43. The ERT recommends that the Party continue to use this framework of verification and QC when considering the implementation of additional EU ETS data into the national inventory.	The verification and QC routines mentioned are used in submission 2013
Submission 2011	Energy	47. The ERT noted that in the CRF tables, small inconsistencies occur between tables 1.C and 1.A(b) for jet kerosene used in international aviation bunkers for 2009, and for gas/diesel oil and residual fuel oil used in international marine bunkers for all years. The ERT recommends that Sweden correct these discrepancies in its next annual submis-	This has been corrected in submission 2012. The same activity data and thermal values are now used for jet kerosene in CRF 1C and 1Ab.

[294] Anderson, Eklund, Gerner & Gustafsson, 2012

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		sion.	
Submission 2011	Energy	48. The EFs for coke oven gas and steel converter gas used in public electricity and heat production is based on measurements from one plant conducted in 2001. The ERT considers that EFs could vary over time and between plants.The ERT recommends that Sweden describe any recalculations and changes clearly in the NIR of its next annual submission.	Since submission 2012, facility specific emission factors are used.
Submission 2011	Energy	50. Sweden reports the CO2 emissions from the combustion of some CH4 and CH4- based gas mixtures under liquid fuels in chemicals (NIR, page 95). The ERT recommends that Sweden use fuel-specific and year-specific CO2 EFs will be used in its next annual submission, review the allocation and clearly explain any recalculations in its next annual submission, because depending on the mixture it may be more appropriate to report these emissions under gaseous fuels.	Since submission 2012, year specific emission factors based on data from the plants using the fuel used for 2001 and later years, and this is described in NIR Section 3. It has not been possible to determine how much of the gas that is of gaseous origin, but since the coherence between the reference and sectoral approaches is good for gaseous fuels, it is probably correct to assume that most of the by product gas is of liquid origin.
Submission 2011	Energy	53. In its 2011 annual submission, Sweden has reported CO2, CH4 and N2O emissions from the transfer losses of gas-works gas under the distribution of oil products category. The ERT recommends that Sweden revise the allocation of these emissions, possibly allocating them to solid fuel transformation or other (fugitive emissions from solid fuels), The ERT reiterates the recommendation from the previous review report that Sweden describe the method to estimate emissions from the transfer losses of gas-works gas.	The description in NIR has been improved. Allocation and calculation methods will be reviewed in 2013.
Submission 2011	Energy	51. In CRF table 1.B.2, Sweden has reported CO2 and CH4 emissions from venting of oil, gas and combined as included elsewhere ("IE"). The ERT recommends that Sweden allocate these emissions correctly or, if this is not possible, include additional information indicating where they are allocated in its next annual submission.	Additional information has been added to the NIR, section 3.3.2.2.8 Venting (CRF 1.B.2.C.1), to improve transparency.
Submission 2011	Energy	52. The ERT agrees with these estimates and strongly recommends that Sweden report estimates for CO2 emissions from natural gas transmission and CH4 emissions from natural gas transmission and distribution and in its next annual submission.	As ERT recommends Sweden now reports estimates for CO2 from natural gas transmission and CH4 estimates from natural gas transmission and distribution in its annual submissions.
Submission 2011	Energy	54. The ERT noted that Sweden in its 2011 annual submission did not estimate CH4 and N2O emissions from the combustion of ethanol. The ERT consid-	See NIR 3.2.16.2

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		ers the potential problem to be solved and recommends Sweden to continue the reporting of these estimates in its next annual submission.	
submission 2011	Energy	44. the ERT noted that the documentation box of CRF table 1.A(c) referred to section 3.3.6 of the NIR, which is not correct. The ERT reiterates the recommendation of the previous review report that Sweden correct this reference in its next annual submission.	The documentation box is corrected in submission 2013
submission 2011	Energy	45. The ERT noted several differences between the data reported in Sweden's annual submission and those reported to the International Energy Agency (IEA), including peat production figures, imports and exports of lubricants and liquid fuel stock changes. In its NIR Sweden notes that these differences were studied and analyzed during 2010. However, due to budget and time constraints, the recommendations from the study have not been fully implemented in the current submission. The ERT recommends that Sweden act on the recommendations of the study to improve alignment between the two data sets and report on this in its next annual submission.	Data for peat and lubricants were revised in submission 2012. Other issues were dealt with in submission 2013.
Submission 2012	Energy	40. The ERT noted that the documentation box of CRF table 1.A(c) still contains the incorrect reference to section 3.3.6 of the NIR regarding the explanation of the differences between the two approaches. The ERT therefore reiterates the recommendation made in previous review reports that Sweden correct this reference in the next annual submission	Corrected in submission 2013, table 1.AC.
Submission 2012	Energy	42. For 2010, there is a difference of 4 per cent in the apparent fuel consumption between the reference approach and the data from the International Energy Agency (IEA). The total apparent consumption according to the IEA data is higher, owing mainly to differences in the liquid fuel trade, coking coal imports and jet kerosene stock change. The growth rate of the total apparent consumption for the period 1990–2010 is 8 per cent according to the CRF tables and 0 per cent according to the IEA data. The ERT recommends that Sweden more clearly explain the differences between the two data sets once the results from the national study have been obtained	A comparative study between Eurostat data (similar to IEA data) and data reported to UNFCCC made in 2013 is documented in SMED Report No 125, 2013, which can be provided on request. The study is quoted in Annex 4
Submission 2012	Energy	45. Further, the ERT noted discrepancies between CRF tables 1.C and 1.A(b) for gas/diesel oil (international marine bunkers) and residual fuel oil (international marine bunkers) for all years of the time series, with the discrepancies being	An explanation is provided in Annex 4

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		particularly significant for residual fuel oil for the years 2001 and 2007. The ERT reiterates the recommendation made in previous review reports that Sweden correct these discrepancies or explain them in its next annual submission.	
Submission 2012	Energy	46. AD on feedstocks and non-energy use of fuels are collected from the quarterly fuel statistics, which provide information on whether fuels are used as raw materials or for energy purposes. However, the ERT noted that a fraction of 1.0 for carbon stored in feedstocks and non-energy use of fuels is used by Sweden for all fuels. The ERT strongly recommends that the Party justify the fraction used for carbon stored	An explanation is provided in Annex 4
Submission 2012	Energy	47. The ERT noted significant variations in the N2O implied emission factors (IEFs) used for solid fuels. During the review, Sweden explained that the inter-annual variations were due to changes in the fuel mix. The decreasing use of coal since 1990, with a considerably higher EF than other solid fuels (e.g. peat, steelwork gases, etc.), has resulted in a much lower IEF for solid fuels in recent years. The ERT recommends that the Party include this explanation in its next annual submission. The ERT reiterates the recommendation made in the previous review report that Sweden review the N2O EFs used for public electricity and heat production and provide further justification for the country-specific EFs used in its next annual submission	The explanation is included in NIR submission 2014, section 3.2.6
Submission 2012	Energy	50. The trend in the CH4 IEF (103.71–316.68 t/TJ) for gaseous fuels shows large inter-annual fluctuations in recent years as follows: 2006/2007 (–26.3 per cent), 2007/2008 (+12.3 per cent), 2008/2009 (+64.2 per cent) and 2009/2010 (–20.3 per cent). In response to a question raised by the ERT during the review, Sweden explained that country-specific EFs for CH4 emissions from passenger cars and heavy-duty vehicles are used. The EF differs noticeably between the two vehicle categories as the consumption of natural gas differs between years and vehicles and the IEF is the average for all vehicle categories. The ERT recommends that Sweden describe the changes in natural gas consumption by vehicle type across the entire time series in its next annual submission.	This is described in section 3.2.16.2 in the NIR. Two figures are also included to show the consumption of Natural gas and Biogas by vehicle category.

Review[291]	**Sector**	**Paragraph and recommendation in report (shortened)**	**Actions as a result of ERT recommendations**
Submission 2012	Energy	52. The CH4 IEF was constant throughout the period 1990–2005 (30 kg/TJ) but decreased to 18.18 kg/TJ in 2007. The 2010 value (19.47 kg/TJ) is 35.1 per cent lower than the 1990 value. Sweden explained that, in the early years of the time series, wood was the only biogenic fuel used in the chemical industry. Since 2006, the amounts of landfill gas and tall oil used have increased considerably, and these fuels have much lower EFs than wood, which affects the overall IEF for CH4 emissions from biomass. The ERT recommends that Sweden include this explanation, together with information on the fuel mix in a tabular format, in the NIR of its next annual submission.	The explanation is included in NIR submission 2014, section 3.2.11.
Submission 2013, ICR preliminary recommendations	Energy	It is therefore recommended that Sweden appropriately explain in future NIR on general relative consistency of these alternate databases for each key source category, whether using anyone of these databases is alright for inventory estimation, and if not, how these are reconciled. It should also be explained why a specific database is chosen for estimating national GHG inventories for that category.	Explanations are provided in Annex 2.
submission 2007/2008	Industrial processes	37. Inconsistency in IEF since 2005 is not explained in the NIR. Sweden is encouraged to provide the time series for the content of calcium oxide (CaO) in clinker to validate the single average value (65%) for the whole period.	Addressed in submission 2010. Before 2005 the company used the default EF 0.525 for the estimates. From 2005, CO2 emissions are based on analysis on the CaO content in the clinker. Data from 2008 and 2009 show a CaO content variation between 63.9 to 67.6%. See NIR 4.2.1.
submission 2007/2008	Industrial processes	38. The ERT recommends that Sweden improves the transparency of the reporting of the methodology used to estimate the CO2 removals in the pulp and paper industry.	Addressed in submission 2010. Reported data is revised in submission 2010. The revised time series affects reported activity data as well as CO2 emission data. See NIR section 4.5.1
submission 2007/2008	Industrial processes	40. The ERT encourages Sweden to correct and improve its reporting in the NIR, and to improve the transparency of the applied approach by adding an allocation table of the annual amounts of limestone used and emissions for each category.	Reported data in 2A3 is revised in submission 2010. An allocation table is added in the NIR and activity and emission data is provided for 2005 - 2008. See NIR section 4.2.3
Submission 2009	Industrial processes	46. Correct the discrepancy between figures in CRF and NIR.	Figures are correctly reported in submission 2011 as better SMED internal QC procedures are in place to minimize discrepancy between figures in CRF and NIR.
Submission 2009, (submission 2010)	Industrial processes	48, (54) Continue the discussion with the cement producing company and improve the CO2 estimates as appropriate.	Addressed in submission 2012, see NIR section 4.2.1.4

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
Submission 2009	Industrial processes	49. Complete the planned revision of methods and explain the new methods for pulp and paper industry in a transparent manner in the next annual submission.	Addressed in submission 2010, see NIR section 4.2.2
Submission 2009, (submission 2010)	Industrial processes	50, (62) Implement planned improvements in Limestone and dolomite use – CO2 with regards to transparency and allocation of emissions.	Addressed in submission 2010, see NIR section 4.2.3
Submission 2009	Industrial processes	52. Implement planned improvements in Iron and steel production and provides a transparent explanation of the revised estimation methods as well as the reallocation of emissions from the energy sector to this category. Include in the NIR a brief discussion on the results of the carbon balance checks.	Addressed in submission 2010. Emissions have been revised for all years and reported in accordance with IPCC Guidelines (see NIR section 4.4.1).
Submission 2009	Industrial processes	53. Clearly explain this in more detail in the NIR if it continues reporting CO2 from limestone use in iron and steel production.	Addressed in submission 2010, see NIR section 4.4.1
Submission 2009	Industrial processes	54. Make efforts to estimate the emissions from foam blowing that are not estimated currently, and include them in the next annual submission.	Data from the manufacturers is considered to be complete, see NIR section 4.7.2.
Submission 2009	Industrial processes	55. Calculate and include CO2 emissions from the use of calcium carbide using the default EF presented in the Revised 1996 IPCC Guidelines unless there is evidence showing that the calcium carbide produced is not used in the country.	Addressed in submission 2011, see NIR section 4.3.3
Submission 2011	Industrial processes	61. report on the progress of these discussions with the facilities about the accuracy of CO2 emissions from CKD reported by the facilities by clarifying the occurrence of CO2 emissions from CKD in its next annual submission.	After contact with the company we now know that CO2 emissions from CKD are included in ETS data (from 2005 and onwards). Recalculation performed to submission 2012.
Submission 2011	Industrial processes	62. include additional relevant information on how the CO2 EF for cement production is obtained in its next annual submission.	The EF 0.525 was used until 2004. From 2005 Plant-specific analysis data is used.
Submission 2011	Industrial processes	63. The ERT also noted that there is an inconsistency between the CO2 IEF for cement production reported for 2009 in CRF table 2(I)A-G (0.5593 t/t) and that reported in the NIR (0.5425 t/t).	Sweden has improved their QC procedures to minimize the risk of similar errors to occur.
Submission 2011	Industrial processes	69. Sweden has reported HFC and PFC emissions from the subcategory solvents as “NE” in its NIR (table 4.39) but as “NO” in CRF table 2(I). In its NIR (page 189).	The notation key for solvents in Sweden's NIR Table 4.39 has been changed to NO. The notations in the NIR and the CRF tables are now consistant. An explaination of why NO is used is given in NIR section 4.7.5 Solvents (2.F.5).
Submission 2012	Industrial processes	61. Sweden reported CO2 emission estimates for the organic carbon content of the raw meal for the period 1990–	See NIR section 4.2.1.2

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		2010. For the period 2005–2010, the CO2 emissions from the raw meal were estimated using information from the facilities for 2004 and added to the estimated CO2 emissions from clinker production. In response to questions raised by the ERT during the review, Sweden clarified that, for the period 2005–2010, the EU ETS data already included CO2 emissions from the organic carbon content of the raw meal, and that the reported emissions are therefore overestimated. The Party indicated that it plans to remove the reported CO2 emissions from the organic carbon content of the raw meal in its next annual submission. The ERT recommends that Sweden reconsider the estimates of emissions from cement production for the entire time series in its next annual submission.	
Submission 2012	Industrial processes	62. Sweden reported that the CO2 emission estimates are calculated based on lime production by type of lime and using the EF and data on the purity of lime from the 2006 IPCC Guidelines. The AD were obtained from the sugar industry, the Swedish Lime Association and the Swedish Lime Industry. The Party reported that more than 99 per cent of the lime used in the sugar and in the pulp and paper industries is quicklime, with a 95 to 97 per cent CaO content. For other lime production, the Party reported that the data on the production of quicklime, hydraulic lime and dolomitic lime were obtained from the Swedish Lime Association. In response to questions raised by the ERT during the review, Sweden indicated that about 90 to 96 per cent of the lime produced in conventional lime mills is quicklime and 4 to 10 per cent is dolomitic lime. The ERT recommends that Sweden improve the transparency of the next NIR by providing information on the ratio of limestone to dolomite used in other lime production and by clarifying the use of hydraulic lime.	See NIR section 4.2.2.
Submission 2012	Industrial processes	64. The NIR reports a downward trend in PFC emissions from 1990 to 2010, with large inter-annual fluctuations in the IEF reported from 2008 to 2010 due to the conversion of all Söderberg ovens to pre-baked cells in 2008, thereby leading to a decrease in PFC emissions in 2009. In response to questions raised by the ERT during the review, Sweden explained that the increase in PFC emissions in 2010 was due to a high power input to the anodes as a result of the cold winter and power outages. The ERT recommends that the Party include an	See NIR section 4.4.3.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		explanation of the causes of the increase in PFC emissions from 2009 to 2010 and any other relevant information on the IEF trend in the next annual submission.	
Submission 2012	Industrial processes	67. In the NIR, the Party reported that it has not been possible thus far to establish the amount of solvent used following efforts to gather national information on this category. Consequently, Sweden reported emissions from solvents as not occurring ("NO") in section 4.7.5 of the NIR and in the CRF tables. The ERT noted that emissions from solvents are still reported as "NE" in table 4.39 of the NIR. The ERT reiterates the recommendations made in the previous review report that Sweden continue its efforts to estimate these emissions, explain any recalculations and improve the consistency between the NIR and the CRF tables.	Corrected in submission 2013.
Submission 2012	Industrial processes	Recommendation: - Elaboration needed in the NIR on what data are derived from which source (e.g. the AD is from a company environmental report etc) - Elaboration needed in the NIR on methodology used when emissions are provided by company environmental reports, especially for key categories - Revision needed with the use of the notation key NA (where it is theoretically impossible to have emissions) to NO (zero emissions) when that is the case	- Information has been improved by including an explanatory table in Annex 3.6. - Information has been improved, e.g. see NIR 4.3.2 - revision of the use of notation key NA to NO in CRF 2.F sub categories in CRF.
Submission 2012	Industrial processes	Recommendation: - Inclusion of information on the composition of the raw material across the time-series for transparency that will help explain the CO_2 IEF change for 2A1, - and total allocation of limestone and dolomite use emissions to 2A3 to be in line with IPCC Guidance.	. - Resolved, see NIR section 4.2.1 - Partly resolved. Updated allocation table in NIR sections 4.2.3.2.
Submission 2012	Industrial processes	Recommendation: Inclusion of an explanation of the reductions of N_2O in the NIR needed	See NIR section 4.3.2.
Submission 2012	Industrial processes	F-gases: Recommendation: Explanation of the model in this regard needs to be strengthened in the NIR, especially on emissions from disposal and destruction. Recommendation: Revision of the use of the notation key NA to NO in Foam blowing, Electrical equipment etc needed	- Improved information on emissions from disposal and destruction in 4.7.8 and 4.7.9. - revision of the use of notation key NA to NO in CRF 2.F sub categories
Submission 2013, ICR preliminary	Industrial processes	Recommendation: Explanation of the reasons for the IE for 3D4 need to be modified in the NIR.	See NIR sections 5.5.1 and 5.5.2. Due to confidentiality (confimed by the Swedish Chemicals Agency), data for 3.D.1 - Use

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
recommendations			of N2O for Anaesthesia and 3.D.3 – N2O from Aerosol cans cannot be reported separately.
Submission 2013, ICR preliminary recommendations	Industrial processes	The ERT especially recommends to improve transparency with regard the following: 1) Since various data sources are used in each sub-category of the non-F-gases, clarity is needed on which part of the estimation uses which data source, especially for key categories 2) Confirmation of QC procedures at the various sources, especially for key categories and where there is large reduction of emissions (e.g. introduction of abatement or destruction/collection of gases)	1) Information has been improved by including an explanatory table in Annex 3.6. 2) CRF 2.B.4 - adressed in NIR section 4.3.2.2 and 4.3.2.4
submission 2006	Agriculture	52. Break in time series 1995	Addressed in submission 2010. In the footnote to Table 6.6 an explanation to this is added.
submission 2006	Agriculture	54. Background data on enteric fermentation for cattle in CRF tables not consistent with calculations.	Addressed in submission 2010. The Background data this is referring to is not used in the actual calculations. The paragraph concerning the method for the calculations of enteric fermentation has been revised.
submission 2006	Agriculture	61. Sweden does not provide sufficient information in the NIR about the volatilization ratios of ammonia (NH3) and nitrogen oxide (NOX) from the use of synthetic fertilizers and the application of animal manure.	A new paragraph named “Emission of ammonia” was added to NIR in submission 2011 to clarify this issue.
Submission 2007/2008	Agriculture	44. Provide detailed information in its NIR on the assumptions and national conditions supporting the calculation/selection of EFs (e.g. N2O emissions from manure management and from agricultural soils).	The NIR has been updated with additional information about this.
submission 2007/2008	Agriculture	46. The ERT recommends that Sweden re-examine the preparation of table 4.B(b) to ensure that it accounts for all N excretion for the estimation of N2O from manure management and for the quantification of N input for manure applied to soils and excretion on pasture range and paddock (table 4.Ds1). The ERT also recommends that Sweden ensure that its QA/QC procedures provide for accurate and correct completion of CRF tables in the agricultural sector.	This was due to a miscount that resulted in some incorrect activity data in submission 2009. It did, however, not affect the estimate of the actual emissions. This was corrected in submission 2010.
Submission 2007/2008	Agriculture	47. Revise this N-excretion rate in accordance with the conditions it is reporting for the number of pigs, that is, number of animals produced (including rotations) or number of average livestock at a given time.	The reference day for the estimation of number of pigs is the first of June. This should approximately be the average number of pigs for an arbitrary time of year.
Submission 2007/2008	Agriculture	48. Encourage Sweden to clarify the decrease in the IEF for solid storage from 0.0197 kg N2O-N/kg N in 1990 to	In CRF this value is constantly 0.02 for all reporting years.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		0.0192 kg N2O-N/kg N in 2006 and indicate which management systems underlie the IEF of 0.02 kg N2O-N/kg N in the category other.	
submission 2007/2008	Agriculture	51. The ERT recommends that Sweden ensure the consistency of information between CRF tables 4.B(b) and 4.D	In table 4.B (b) the total amount of nitrogen excreted is given. In table 4.D the amount of nitrogen directly lost as ammonia is subtracted from the total amount and the remaining amount is used as activity data for release of nitrous oxide.
submission 2007/2008	Agriculture	52. Sweden does not provide sufficient information in the NIR on the volatilization ratios of ammonia (NH3) and nitrogen oxide (NOX) from the use of synthetic fertilizers, and the application of animal manure.	A new paragraph named “Emission of ammonia” was added to NIR in submission 2011 to clarify this issue.
Submission 2009	Agriculture	58. Following the recommendations from previous reviews, the ERT recommends that Sweden improve transparency by providing additional information on how the EFs are calculated for tier 2 methods.	Additional information about the country specific EF has been included in the NIR for submission 2010.
Submission 2009	Agriculture	59. Further details on how the EF for dairy cattle is developed.	This has been clarified in submission 2011.
Submission 2009	Agriculture	60. Provide further documentation to explain the trend in emissions for manure management and the changing IEF.	The trend is explained in the beginning of section 6, Agriculture.
Submission 2009	Agriculture	63. Provide further information in the NIR on the appropriateness for Swedish conditions of the factors: country-specific EFs of 0.8 and 2.5 per cent kg N2O-N/kgN for nitrogen from synthetic fertilizer and nitrogen from manure applied to soils, respectively.	This has been clarified in submission 2011.
Submission 2009	Agriculture	64. Further explanation be provided in the NIR of the appropriateness of the use of this country-specific EF (pasture, range and paddock manure is 0.016 kg N2O-N/kg N and unfertilized pastures/grasslands is based on a value in the range of 0.002–0.01 kg N2O–N/kg N).	Sweden has now changed the EF for pasture, range and paddock manure to the IPCC default value of 2%.
Submission 2010	Agriculture	66. Use the notation key “NO” in accordance with the IPCC good practice guidance in particular in CRF table 4.D.	This has been corrected in submission 2011
Submission 2010	Agriculture	67. improve the transparency of its reporting and include all relevant information on the country-specific EFs and methodologies used in the NIR, in particular for estimating N2O emissions from agricultural soils.	The NIR has been updated with additional information in submission 2011.
Submission 2010	Agriculture	69. Include in the NIR and in the CRF tables additional information e.g. on milk yield per cow, digestibility of feed and gross energy intake, in order to improve the transparency.	This has been adjusted in submission 2011

Review[291]	**Sector**	**Paragraph and recommendation in report (shortened)**	**Actions as a result of ERT recommendations**
Submission 2010	Agriculture	70. For CH4 from manure management include explanations for the fluctuations and the increasing IEF trends.	This information is included in the NIR since submission 2011
Submission 2010	Agriculture	72. Account for the average livestock population of all growing animal species, namely piglets	This information can be found in Table 6.6
Submission 2010	Agriculture	73. For direct soil N2O emissions, include further explanations regarding country-specific EFs.	This information can now be found in the paragraph “Emission factors” under “Direct Soil Emissions (CRF 4.D.1)”
Submission 2010	Agriculture	75. For N2O from pasture, range and paddock manure, provide consistent information in the NIR and in the CRF tables, and transparent explanations of the relevant corrections and changes made.	The paragraph in the NIR has been updated and a new table included in submission 2012
Submission 2010	Agriculture	76. For N2O emissions from atmospheric deposition, include all relevant information on country-specific methodologies in the NIR, and provide well-documented explanations with regard to all country-specific EFs and parameters used.	A new paragraph regarding the emissions of ammonia from fertilisers and manure (and by that, FracGASM and FracGASG) has been included in the NIR.
Submission 2011	Agriculture	73. including further backgroundinformation on the calculation of average milk yield, on the N flow model (STANK) and on the CH4 IEF trends for manure management.	Additional information about the calculation of milk yield is included in NIR, paragraph 6.2.2.1. Information on STANK in paragraph 6.3.2 and information of IEF for emission of CH4 in paragraph 6.3.2.1.
Submission 2011	Agriculture	74. report a time series for gross energy intake and Ym in both its NIR and CRF in its next annual submission.	Time series for GE and Ym are now provided in the CRF tables.
Submission 2011	Agriculture	75. include additional information on the calculation of annual average milk yield in the NIR of its next annual submission.	Additional information on the calculation of average milk yield is now included in NIR, paragraph 6.2.2.1.
Submission 2011	Agriculture	76. improve its use of notation keys in the additional information table for CRF table 4.A in its next annual submission.	The ERT recommended notation keys are now used in the CRF tables.
Submission 2011	Agriculture	77. apply consistent definitions of animal waste management systems in the NIR for both the CH4 and the N2O calculations, in line with the IPCC good practice guidance equations 4.17 and 4.18.	This is a misunderstanding from the ERT. Our definition of PRP-manure is in agreement with GPG. MS="fraction of animal species i's manure handled using manure system j" (GPG eqv 4.17). This is also our definition of PRP-manure. However, we realise that the equation in paragraph 6.3.2.2 in NIR was confusing. The equation has now been altered to more clearly reflect how we calculate emissions from AWMS (including PRP-manure).
Submission 2011	Agriculture	78. include this information on the value of piglets presented in the NIR assumes that piglets do not grow during their first year and that the number of piglets listed in the table takes this assumption into consideration.	This information is now included in paragraph 6.3.2.
Submission 2011	Agriculture	79. report the N fraction of legumes (FracNCRBF) and that of other crops (FracNCRO) separately in the additional	This has been done since submission 2012.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		information table of CRF table 4.D, in its next annual submission.	
Submission 2011	Agriculture	80. apply the default EF and equation 4.18, in line with the IPCC good practice guidance, in its next annual submission.	This has been revised in the Swedish 2012 resubmission.
Submission 2011	Agriculture	81. provide more information on the STANK model in the NIR of in its next annual submission, especially showing whether underlying studies reflect field data, expert judgement or studies reported in the scientific literature.	Information on this is now included in paragraph 6.3.2.
Submission 2012	Agriculture	73. The reporting of the sector is generally transparent. However, the ERT noted that the recommendations made in the previous review report that Sweden improve the transparency of the NIR by including further background information on the calculation of the average milk yield, the N flow model (STANK) and the CH4 IEF trends for manure management have not been addressed in the 2012 annual submission. The ERT encourages Sweden to implement those recommendations in order to increase the transparency of its reporting in the next annual submission. Further, the ERT recommends that Sweden justify the use of country-specific values (e.g. the MCF for liquid manure), including the provision of additional information in the NIR in order to ensure the transparency of the reporting for the manure management categories, and include an analysis of the CH4 IEF used for the more significant subcategories in the NIR. The uncertainties are well documented for each subcategory in the NIR.	See paragraph 80.
Submission 2012	Agriculture	74. The sector-specific QA/QC procedures are described for each subcategory. Sweden pointed out that the AD are checked for consistency and that external national experts annually review the emission estimates and methods used. However, the ERT recommends that the Party improve its QC procedures to ensure the consistency of the information provided in the NIR and in the CRF tables (see para. 81 below).	This activity has now been included in the sector specific QC-list.
Submission 2012	Agriculture	76. Sweden applied a country-specific methodology using metabolizable energy to estimate CH4 emissions from cattle. As pointed out in the previous review report, for transparency purposes, the values of the average gross energy intake and average CH4 conversion rate should be included in the NIR for the entire time series. The ERT reiterates the recommendation made in the previous review report that Sweden include this information in its next annual	When these two variables are not actually used as indata in the calculations we have chosen to not include them in the NIR. The data are, however, included in the CRF-tables (Table 4.A) and are therefore easy assessable for everyone. All data needed to calculate the emissions are already included in the NIR.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		submission.	
Submission 2012	Agriculture	79. Sweden estimates CH4 and N2O emissions from manure management using EFs from the IPCC good practice guidance in combination with country-specific AD. In the previous review report the ERT pointed out that Sweden's definitions of animal waste management systems used for both the CH4 and the N2O emission estimates are not in line with the IPCC good practice guidance, because they do not include the fraction of N excreted on pasture. In response to a question raised by the ERT during the review, the Party explained that the definition used for pasture, range and paddock manure is in line with the IPCC good practice guidance. However, Sweden noted that the equation in paragraph 6.3.2.2 of the NIR may be confusing and confirmed that it would be explained in more detail in the next annual submission. The ERT recommends that the Party include information on the definition of animal waste management systems in the relevant chapter of the NIR, in order to ensure the transparency of its reporting.	This issue depends originally on a misunderstanding. However, we believe that the text in the NIR, and the equation in paragraph 6.3.2.2, now satisfyingly describes how we include PRP-manure in the calculations.
Submission 2012	Agriculture	80. The 2010 value of the CH4 IEF (1.40 kg/head/year) for swine is among the lowest reported by Parties (ranging from 0.58 to 39.46 kg/head/year) and below the IPCC default range (between 3 and 20 kg/head/year). The Party explained that the reason for the lower value is the lower annual mean temperature in Sweden, which results in a lower value for the MCF compared with those of other countries. In response to a question raised by the ERT during the review, Sweden provided additional information on the country-specific MCF value of 3.5 per cent for liquid manure. The ERT recommends that the Party include, in the NIR of its next annual submission, more detailed information to justify the country-specific MCF value used.	A brief summary of the methods and the conclusions of the study that has developed the CS MCF is given in ""6.3.2.1 4.B(a). METHANE (INCLUDING EXCRETION FROM GRAZING ANIMALS)"" In the NIR. The report is also available as a pdf in English (doi-number given in the reference list).
Submission 2012	Agriculture	81. In response to a question raised by the ERT during the review as to why the reported CH4 IEF for swine differs between CRF table 4.B(a) and NIR table 6.16 and why there is no information on the CH4 EF (0.19 kg/head/year) for reindeer in NIR table 6.16, Sweden responded that the relevant table in the NIR (page 245) has not been correctly updated in the 2012 annual submission with the new country-specific CH4 EF for swine and the EF used for reindeer. The ERT recommends that Sweden imple-	This activity has now been included in the sector specific QC-list.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		ment enhanced QC procedures to avoid inconsistencies between the CRF tables and the NIR in its next annual submission.	
Submission 2012	Agriculture	83. Sweden uses a default EF of 0.02 kg N2O-N/kg N excreted from the IPCC good practice guidance to estimate N2O emissions from pasture, range and paddock manure. However, in its emission calculations, the Party continues to subtract the fraction of N lost as NH3 (FracGASM) from the total amount of N excreted on pastures, which is not in line with the definition of the IPCC default EF (N2O-N/kg N excreted) and equation 4.18 of the IPCC good practice guidance, since the default EF already considers NH3 losses. To avoid a potential underestimation of N2O emissions from pasture, range and paddock, the ERT recommended that Sweden apply the default EF and equation 4.18, in line with the IPCC good practice guidance. In response to the list of potential problems and further questions raised by the ERT during the review, the Party provided revised N2O emission estimates for the whole time series. The recalculations resulted in an increase in the estimate of N2O emissions from pasture, range and paddock manure for 2010 of 9.9 per cent, from 1.31 Gg to 1.44 Gg. The ERT concluded that the potential problem had been resolved by the Party. The ERT noted that the revision has been applied to the entire time series on the basis of the AD in CRF table 4.B(b). However, the AD for N excretion on pasture, range and paddock in CRF table 4.D were not consistently changed (e.g. for 2010, 41,699,874.45 kg N/year is reported in CRF table 4.D instead of 45,702,068.07 kg N/year). The ERT recommends that Sweden ensure the consistency of the information between CRF tables 4.B(b) and 4.D in the next annual submission.	The the amount of nitrogen in CRF table 4.D have now been corrected.
Submission 2013, ICR preliminary recommendations	Agriculture	Issue: - Selection of activity data from various sources is not sufficiently justified; i.e. AD for horses and chickens differs from Farm Statistics compared to other sources (low or too high). Status: - Explanation was clear from the sector presentation during the review week. Recommendation: - Detailed information as delivered is to be included in the 2014 NIR.	See the clarifications in the end of paragraph "6.1 Overview of sector" in the NIR.
Submission 2013, ICR	Agriculture	Issue: Standard yield was used for estimating	All the crop yield activity data for the complete time series are now changed

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
preliminary recommendations		N2O emissions from N-fixing crops and crop residues. This could result in an under estimation. The status: Emission for the KP years will be re-submitted before Saturday for both sub-categories. Recommendation: The ERT strongly recommends that all time series for CRF tables 4.D.1.3 and 4.D.1.4 are to be estimated using actual yield data for all crops in the 2014 submission.	from standard yield to actual yield in submission 2014.
Submission 2010	LULUCF	20. Perform key category analysis at a more disaggregated level of categories, and as a result revise its key categories for activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol, for its next annual submission and explain in the NIR how it plans to use the key category analysis to prioritize improvements in the inventory.	Sweden performed the analysis on the level suggested by the ERT.
Submission 2010	LULUCF	82. Consider using the category other land to adjust the annual fluctuations in its total land area.	Sweden has started investigating how the estimates could be improved using complementary methods for the last reporting years. In this submission the inconsistency in total area as well as other categories has been solved using extrapolation for sample series ending earlier than 2010. See section 7.2.2.2.
Submission 2010	LULUCF	86. The ERT noted that there were some errors in the NIR. especially in the references related to the figures and tables provided in the NIR and recommended Sweden to improve the consistency of the reporting within the NIR, enhance its QC procedures and correct such errors in its next annual submission.	This has been checked and corrected in submission 2011.
Submission 2010	LULUCF	87. The ERT recommended that Sweden provide in its NIR more information on the drivers of the emission trends and their impact on the annual carbon stock changes. in order to improve the transparency of the reporting and facilitate the review of the inventory of the Party's next annual submission.	This was implemented in Submission 2011.
Submission 2010	LULUCF	88. The ERT noted that there is an inconsistency between the reported area of land converted to forest land and the area subject to the afforestation/reforestation activities reported under Article 3. paragraph 3. of the Kyoto Protocol and recommended that Sweden revise the method used to identify the relevant area and ensure the consistency of its reporting under the Convention and under the Kyoto Protocol. thus improving the transparency and accuracy of its reporting.	Sweden has started investigating how the estimates could be improved using complementary methods for the last reporting years. In this submission the inconsistency has been solved using extrapolation for sample series ending earlier than 2010. See section 7.2.2.2. However since AR and D areas are aggregated since 1990 and the area accumulation of land converted to Forest land starts earlier these are not comparable per ce.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
Submission 2009	LULUCF	59. Improve its approach for determining land-use change in order to report a consistent time series of annual land-use change matrices, as is suggested in the IPCC good practice guidance for LULUCF.	Sweden has increased the transparency in the description of methods used in the inventory in accordance with IPCCC GPG.
Submission 2009	LULUCF	55. Improve the transparency of its inventory by providing all the necessary documentation and information in its future submissions, in accordance with the IPCC good practice guidance for LULUCF.	Sweden has increased the transparency in the description of methods used in the inventory in accordance with IPCCC GPG.
Submission 2007/2008	LULUCF	70. Clarify in the NIR whether annual land-use change data are used to produce the estimates and report a consistent time series of these annual land-use change data in accordance with the IPCC good practice guidance for LULUCF.	Now clearly addressed in NIR
Submission 2007/2008	LULUCF	54. The ERT encourages the Party to improve the completeness of its reporting in its future annual submissions by providing estimates and relevant information for categories that are not estimated.	Sweden´s reporting of LULUCF is now complete except for categories that are currently not mandatory to report.
submission 2007/2008	LULUCF	55. The ERT recommends that Sweden improve the transparency of its inventory by providing all the necessary documentation and information in its future submissions, in accordance with the IPCC good practice guidance for LULUCF.	Figures have been introduced to make it easier for the reviewer to follow the quite complicated sample design use. The text is continuously improved. See NIR section 7.3.1. Estimators are moved to Annex to NIR.
submission 2007/2008	LULUCF	56. The ERT recommends that Sweden consider the use of notation keys NO or IE either for gains or losses when the stock change method is applied.	Sweden is following this advice from submission 2010.
Submission 2007/2008	LULUCF	60. The total area of organic soil reported in the LULUCF sector does not match the area of cultivated organic soils reported in the agriculture sector (CRF table 4.Ds1).	In submission 2010, the reporting of total cropland areas in the agriculture sector (CRF 4) has been revised to be consistent with the reporting in the LULUCF sector. The area of cultivated organic soils still differ due to differences in data sources. The full correction is introduced in submission 2011.
Submission 2007/2008	LULUCF	63. Sweden reports a net carbon increase for the living biomass (except 1991) and dead organic matter pools for all years. The ERT recommends that Sweden provide an explanation for this trend in its next NIR in order to improve the transparency of its reporting.	The transparency in describing this issue has improved in submission 2010. See NIR section 7.1.
Submission 2007/2008	LULUCF	66. With the exception of the years 2002, 2003 and 2005 Sweden reports a net carbon increase in living biomass associated with land-use change from forest land to grassland. The ERT recommends that Sweden provide an explanation for the outlined trend in its next NIR.	The transparency in describing this issue has improved in submission 2010. See NIR section 7.1.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
Submission 2007/2008	LULUCF	67. With the exception of the years 1992 and 2006, Sweden reports a net carbon increase in living biomass associated with land-use change from forest land to settlements. To improve the transparency, the ERT recommends that Sweden provide an explanation for the outlined trend in its next NIR.	The transparency in describing this issue has improved in submission 2010.
submission 2007/2008	LULUCF	68. Sweden has not been able to separate emissions from organic and mineral soils (CRF table 5 (III)). The ERT recommends that Sweden improve its methodology in order to be able to report the two soil categories separately.	Categories are reported separately in submission 2010.
Submission 2006	LULUCF	69. Improve consistency in the CRF tables by correcting the errors.	Corrected.
Submission 2006	LULUCF	70. Estimate CO2 emissions from land converted to wetland.	Addressed in submission 2010. No longer reported unmanaged.
Submission 2011	LULUCF	84. Sweden indicated that all reported years in its 2012 annual submission will be based on five different inventory cycles to maximize accuracy, and that all emissions and removals for the last years in the time series will be recalculated. To increase transparency, the ERT recommends that Sweden include additional information on these recalculations in the NIR of its next annual submission.	84. The information related to this issue are described in the Annex to NIR Table A 3:2.1. The new method of extrapolating data is in detail described in section 7.2.2.2, and consequences compared to not introducing extrapolation in Figure 7.6 . See also the footnotes on page 267 and on page 271.
Submission 2011	LULUCF	87. provide estimates for land converted to wetland or otherwise revise its use of notation keys for carbon stock changes in wetlands in its next annual submission.	87. As a respons to this issue Sweden introduced “Peatland” as a separate subcategory to Wetlands remaining Wetlands. See section 7.3.1.6 and 7.6 (recalculations).
Submission 2011	LULUCF	90. The ERT recommends that Sweden address the discrepancies between the areas reported for the different land-use categories (NIR tables 7.1a and 7.4) and also for the total area of the country (NIR tables 7.1a, 7.1b and 7.4 report 45,250 kha, 45,158 kha and 45,080 kha, respectively, for total area).	Sweden reports also a land use matrix 1990-2011 based on one cycle (estimates based on approximately 20% of the plots). Using such approach the total land and fresh water area deviates only 0.3%. See footnote on page 421
Submission 2011	LULUCF	92. The ERT noted that there are large differences in the areas of all land-use categories reported in the 2011 annual submission compared with the 2010 annual submission, especially in forest land area. The ERT recommends that Sweden demonstrate that this discrepancy is reduced with decreasing uncertainties for each year that adds to the full fiveyear inventory cycle in its next annual submission.	92. The introduced extrapolation (see question 84) has completely removed the problem with random variations for the most recent years.
Submission 2011	LULUCF	93. The ERT recommends that Sweden include additional information on the drivers of the emission/removal trends and their impacts on the annual carbon stock change and improve the transparency of the information in its next annual	93. See the overview section in NIR chapter 7. On page 267 and 268 we are trying to verify estimates by the IPCC default method (studying growth and harvests). In chapter 7.4 we refer to a study (2003), validating estimates based

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		submission.	on measurements by using different models.
Submission 2009	LULUCF	57. Report the subcategory mire under grassland, further distinguishing between managed and unmanaged land subcategories.	Grasscovered mires are always saturated with water and therefore reported under Wetlands.
Submission 2012	LULUCF	86. Information on the recalculations is provided in CRF table 8(b) and in the NIR (section 7.6). However, the NIR does not provide information at the category-specific level. The ERT recommends that Sweden include detailed information on the recalculations in its next annual submission, including the rationale for and the impact of the recalculations at a category- and pool-specific level. Further, the ERT encourages the Party to restructure the sectoral layout of the NIR to include category-specific sections on uncertainties and time-series consistency, QA/QC and verification procedures and planned inventory improvements, in line with the annotated outline of the NIR.	Section 7.6 now includes sub-sections explaining the rationale for recalculations per pool. We do not see any advantages to sub-divide in land use categories and pools since the same methods, data and consequently recalculations applies to a ll land use categories. The mpact is summarised in table 7.6 a-b.
Submission 2012	LULUCF	87: The ERT encourage use notation keys more properly	To make the UNFCCC-LULUCF and KP-LULUCF reporting consistent some notation keys have been revised (e.g. for biomass burning).
Submission 2012	LULUCF	90. Sweden has performed an uncertainty assessment for all reported categories, except for the category other land. The uncertainties mainly arise from random errors in sampling data in the carbon stock change estimates. The uncertainty for living biomass in all reported land-use categories was estimated to 24 per cent, while the uncertainty for DOM was estimated to 50 per cent and soil organic carbon to 35 per cent. Sweden also provided uncertainty estimates for non-CO2 categories (e.g. 100 per cent uncertainty for N2O emissions from disturbance associated with land-use conversion to cropland, 75 per cent uncertainty for N2O and CH4 emissions from biomass burning and 50 per cent uncertainty for N2O emissions from direct N fertilization). These percentages are the same as those reported in the previous annual submission. The ERT recommends that the Party update the uncertainty values when the input parameters used for the estimates are changed.	The estimated uncertainty of reported emissions/ removals are updated. However, assumed uncertainty is supposed to same – even the reported emission/ removal changes. We believe that for different years within submission, no country reports different uncertainty even if they report different estimates for different years. A revised uncertainty should be verified by some effort and Sweden only changes the assumed uncertainty if a major improvement has been made. See Tables 7.5 and 11.5 in NIR
Submission 2012	LULUCF	93. In the previous review report, the ERT recommended that Sweden provide additional information on the drivers of the emission/removal trends and their impact on the annual carbon stock change. In response to a question raised	Section 7.1 now includes more information on the drivers behind trends if any trends have been detected.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		by the ERT during the review, Sweden provided additional information to illustrate the long-term increasing trend in the carbon stock reported in the NIR, as well as the growth rate and the harvest volume during the period 1926–2008. This information enabled the ERT to confirm that the emission/removal trends reported in the 2012 annual submission and the annual harvest volume generally correspond. The ERT welcomes this additional information and reiterates the recommendation made in the previous review report that Sweden include, in the next annual submission, further information on and an analysis of the drivers behind the emission/removal trends.	
Submission 2012	LULUCF	95. Emissions from cropland remaining cropland fluctuate significantly and generally show a decreasing trend, which is mainly driven by emissions from organic soils. The carbon stock change in organic soils is estimated using a tier 2 approach with country-specific EFs derived from eight sampling data sets. The overall decrease in the emission trend is explained by the decrease in the total area of cropland. However, the Party has not provided information to explain the inter-annual fluctuations. The ERT recommends that Sweden provide information on the drivers of the inter-annual fluctuations in the next annual submission.	Section 7.1 now includes more information on the drivers behind trends if any trends have been detected.
Submission 2012	LULUCF	96. Emission estimates are provided only for forest land remaining forest land and grassland remaining grassland. For the remaining categories, the notation keys “IE”, “NA” and “NO” are used. The inconsistent use of notation keys was observed by the ERT between the LULUCF reporting and the KP-LULUCF reporting. In CRF table 5(V), CO2 emissions from biomass burning on land converted to forest land are reported as “IE”, but, in CRF table 5(KP-II)5, emissions from biomass burning on afforested and reforested land are reported as “NO”. In response to a question raised by the ERT during the review, Sweden informed the ERT that no biomass burning has so far been detected on land converted to forest land, and that it will therefore correct the notation key used in CRF table 5(V) to “NO” in its next annual submission in order to maintain the consistency and transparency of the reporting. The ERT recommends that Sweden ensure the consistent reporting of emissions from biomass burning between the LULUCF sector and the KP-LULUCF activities.	The inconsistency in the reporting of biomass burning between the LULUCF reporting under UFCCC (land converted to Forest land) and the KP-LULUCF reporting (AR) has been taken care of. The relationship between UNFCCC and KP reporting is demonstrated in table 11.2.

Review[291]	**Sector**	**Paragraph and recommendation in report (shortened)**	**Actions as a result of ERT recommendations**
Submission 2013, ICR preliminary recommendations	LULUCF	The ERT recommends that Sweden checks net removal from the Land Use, Land-Use Change and Forestry LULUCF value and reports the correct estimation in a consistent manner in the NIR and the CFR tables	This was a typing error that will be corrected in the next Submisison.
Submission 2013, ICR preliminary recommendations	LULUCF	The ERT recommends that Sweden to include information showing that the variability between units within a stratum is reduced as compared to the variability within the entire population, since the stratification is intended to increase efficiency by improving the accuracy of the estimate for the entire population (changes of carbon in tree biomass at county level).	The IPCC recommends stratification because its normally improves the accuracy of estimates. A prerequisite is that variation within stratum is small and between strata is large, however, stratification does not decrease the accuracy e.g. compared with simple random sampling. Sweden believes that the stratification has improved the accuracy of estimates e.g. because there is gradient from the North to the South with difference in trees species composition and site fertility. See 3.2.2 in Annex to NIR and NIR Figure 11-4.
Submission 2013, ICR preliminary recommendations	LULUCF	In the previous review report the ERT encouraged Sweden to include additional information in the next annual submission to explain the trend and the way in which the areas for the five subcategories are estimated using the new approach (using an extrapolation approach based on five-year rolling averages), while ensuring consistency with the areas reported under forest land remaining forest land.	In the annex to NIR, Sweden has added information that explains consequences of the extrapolation applied. See Annex to NIR 3.2.3.
Submission 2013, ICR preliminary recommendations	LULUCF	The ERT recommends provides in addition quantified information on the units of land subject to Article 3.3 and 3.4 activities (FM) within the geographic boundaries, which have resulted from the stratification of the country in accordance with the approach 3 (4.2.2.3), as well as the methods in Sections 4.2.2.5 (generic methods) and 4.2.5 to 4.2.10 (activity specific methods).	An example that matches quantified information for Art. 3.3 and 3.4 for estimates and accuracy of estimates to stratum is now found in annex to NIR 3.2.2 . The geographical location of each of 31 strata is found in NIR Figure 11.4.
Submission 2013, ICR preliminary recommendations	LULUCF	Sweden has reported in its NIR for LULUCF sector that the estimates are based on stratification by 31 counties while in the KP section points out that the sample frame is divided into about 30 strata. Sweden confirm during the review that estimates are based on stratification by 31 strata (counties) and such map with the boundaries at county level was provided. The ERT recommends that Sweden checks this information in the NIR report and correct consistently across the document.	This have been checked and changed in the NIR.
Submission 2006	Waste	75. The ERT recommends that Sweden provide further information on the utilization of gas recovery in its next NIR.	From submission 2008, the use of recovered gas is described in NIR.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
Submission 2006	Waste	79. The ERT recommends that Sweden use the notation key “not estimated” (“NE”) for CH4 emissions from wastewater treatment, instead of “included elsewhere” (“IE”), in CRF table 6.B.	From submission 2010, the notation key NE is reported for CH4 emissions from wastewater treatment (sludge). In submission 2011, by following the recommendations of ERTs Saturday paper, emission estimates has been reported for CH4 emissions from wastewater treatment (wastewater). This is further described in the NIR section 8.3.1.2.2.1
Submission 2006	Waste	76. Measure CH4 and N2O emissions from hazardous waste incineration periodically on-site.	Addressed in submission 2010, see NIR section 8.4
Submission 2006	Waste	77. Account for CO2 emission only from non-biogenic waste incineration sources according to the IPCC Good Practice Guidelines.	See NIR section 8.4.2
Submission 2007/2008	Waste	73. CO2 emissions from solid waste disposal on land could be better reported using the notation key NO.	From submission 2010, the notation key NO is reported for CO2 emissions.
Submission 2007/2008	Waste	74. CH4 emissions from wastewater treatment have been reported as NE	In submission 2011, by following the recommendations of the ERT, emission estimates has been reported for CH4 emissions from wastewater treatment (wastewater). This is further described in the NIR section 8.3.1.2.2.1
submission 2007/2008	Waste	75. The ERT recommends that Sweden change the notation key from IE to NE for the emissions from sludge resulting from treatment during the wastewater handling process.	In submission 2011, emission estimates has been reported for CH4 emissions from wastewater treatment (sludge).
Submission 2007/2008	Waste	74. Attempt to estimate CH4 emissions from wastewater treatment as part of the general assessment for “NE” categories and to provide the background data on industrial wastewater in CRF table 6.B.	CH4 emissions from wastewaster treatment (wastewater and sludge) are estimated in submission 2011. This is further described in the NIR section 8.3.1.2.2.2.
Submission 2007/2008	Waste	76. Clarifications on methodology Wastewater handling needed in NIR	In submission 2010, justifications have been made in NIR section 8.3.2 (See section 8.3.1.2.1 in NIR submission 2011)
Submission 2007/2008	Waste	80. CH4 and N2O emissions from waste incineration are reported as 'NE'. The ERT recommends that Sweden calculate these emissions (however insignificant) using IPCC default EFs, rather than wait for the outcome of actual measurements.	Estimates of N2O and CH4 emissions are included in submission 2010. See NIR section 8.4
Submission 2009	Waste	81. Clarify about unmanaged landfill sites throughout the time series from 1990 to 2007 and provide more information on managed and unmanaged landfill sites in Sweden.	In NIR submission 2011, more information is provided on the matter. This is further described in the NIR section 8.2
Submission 2009	Waste	82. Confirm which Tier is used in CH4 from Solid waste disposal on land and if necessary correct this information.	Tier 3 was changed to Tier 2 in submission 2010.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
Submission 2009	Waste	83. Give more and updated information on the amount of landfill gas recovered that was used for energy and was flared.	More information was provided in NIR 2011. This is further described in the NIR section 8.2.1.2.1.2
Submission 2009	Waste	85. Provide some additional information about the lower value in 2006 for CO2 emissions from waste incineration.	Information is provided in section 8.4. Data are direct measurements from the facilities flue gases and are considered to be correct.
Submission 2010	Waste	99. Continue to estimate and report the CH4 emissions from industrial, domestic and commercial wastewater and sludge, ensure consistency between the information reported in the NIR and that in the CRF tables and include all necessary information (e.g. category description, methodological issues, uncertainty and time-series consistency, recalculations and planned improvements) in order to improve the transparency. Provide information on the rationale for using the notation keys to report on wastewater handling	Sweden has improved the reporting of CH4 emissions from industrial, domestic and commercial wastewater and sludge in submission 2010 (resubmission) and further more in submission 2011. Emissions and methodologies are presented and described in the CRF-tables and in NIR.
Submission 2010	Waste	100. Consider using time-dependent AD on protein consumption (e.g. statistics from the Food and Agriculture Organization of the United Nations) to further improve the accuracy.	Since submission 2011, Sweden is using existing time series data on protein consumption from the Swedish yearbook of agricultural statistics.
Submission 2011	Waste	108. justify why the country-specific fossil carbon fraction for all waste incinerated at that plant can be assumed to be the same as the value obtained from a study on MSW incineration. The ERT also recommends that Sweden provide more transparent information on the carbon content used in the estimation in its next annual submission.	In submission 2011 the fossil carbon fraction of 30% is only applied to the incinerated amounts of MSW. All other wastes (industrial and hazardous) incinerated at the plant are assumed to be 100% fossil. In submission 2013 the time series of reported biogenic and fossil CO2 are revised. For the years 2008, 2009, 2010 and 2011 the company has, besides total emissions of CO2, also reported CO2 with respect to biogenic or fossil origin. The company has based their reporting of biogenic and fossil CO2 on a detailed study performed in 2008.In submission the allocation between fossil and biogenic CO2 (see NIR, 8.4 Waste incineration (CRF 6.C)).
Submission 2011	Waste	105. Sweden has reported CH4 emissions from wastewater handling for the whole time series. Data for the period 1990–2004 were obtained by extrapolating backwards the data for 2005 because data on energy recovery is only available for the period 2005–2009. The ERT recommends that Sweden provide additional information on how this extrapolation was done, including how the potential changes, upgrades or modifications of the recovery system in each plant in the period 1990–2005 was considered, in its next annual submission.	See information in NIR 8.3.1.2.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
Submission 2011	Waste	107. CH4 emissions from industrial sludge treatment in anaerobic plants are estimated based on a country-specific CH4 leakage factor during energy recovery. However, the ERT noted that this leakage factor is obtained from a study on two plants, which are assumed to be representative of all 138 plants that engage in the anaerobic treatment of sludge in Sweden (NIR, page 302). The ERT recommends that Sweden include additional information on how the Party ensures that the leakage factor obtained from two plants is representative of the other 136 plants and does not lead to an underestimation of emissions.	Note that this issue is NOT regarding industrial sludge treatment, but municipal waste water treatment (sludge). This is adressed in NIR section 8.3.1.2.2.2. To ensure a conservative estimate the upper value (7 %) of the leakage factor is used. We believe this is the most appropriate way of addressing this issue – good practice - as this is a very small source.
Submission 2011	Waste	103. Sweden has used the IPCC first order decay method with mostly default parameters and country-specific AD for estimating CH4 emissions from solid waste disposal sites. The ERT recommends that Sweden develops country-specific parameters to estimate the emissions from this category in its next annual submission.	The recommendation has been changed to an encouragement by ERT during in-country-review submission 2013, since country-specific parameters are not a reporting requirement.
Submission 2012	Waste	99. The NIR and the CRF tables provide transparent and complete information on the methods and data sources used to estimate the emissions from the waste sector. However, the use of the notation keys could be further improved: for example, the AD for sludge under wastewater handling is reported as “NE” rather than “NA”. The ERT recommends that the Party use the notation key “NA” where no default AD are used in the estimates and explain the notations keys used for the AD and emission estimates in its next annual submission.	The notation keys has been changed from NE to NA and NO in submission 2014.
Submission 2012	Waste	101. The ERT noted that Sweden has reported a relatively high level of uncertainty for the waste sector. The emission estimates are uncertain because of the simplifications made to the top-down model used and the difficulties involved in estimating many of the parameters. The ERT recommends that the Party include, in its next annual submission, information on its plans to reduce the uncertainty of the emission estimates.	The recommendation has been changed to an encouragement by ERT during in-country-review submission 2013, since country-specific parameters are not a reporting requirement.
Submission 2012	Waste	104. Sweden has used the IPCC first order decay method with mostly default parameters and country-specific AD to estimate CH4 emissions from solid waste disposal sites. The ERT reiterates the recommendation made in the previous review report that Sweden develop country-specific parameters to estimate the emissions for this category in its next annual submission. There have been significant changes in national waste	The recommendation has been changed to an encouragement by ERT during in-country-review submission 2013, since country-specific parameters are not a reporting requirement.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		management practices since 1990, which have resulted in the reduction of municipal solid waste disposal on land to only 1.0 per cent of total generated household waste for 2010 compared with 43.8 per cent for 1990. All solid waste disposal sites are categorized as managed in Sweden. The ERT welcomes the transparent reporting of this category.	
Submission 2012	Waste	105. To estimate CH4 emissions from industrial wastewater, Sweden has chosen a country-specific method, which is based on the CH4 leakage factor during energy recovery from anaerobic wastewater treatment (assessed in the range of 2–5 per cent and applied as 5 per cent in the inventory). The Party has reported that most of the facilities use aerobic processes, and only five industrial plants (in the pulp and food industries) use anaerobic wastewater processes. Data for the period 1990–2004 were obtained by extrapolating the data for 2005 backwards, because data on energy recovery are only available for the period 2005–2009. In response to a question raised by the ERT during the review on the extrapolation of data for the period 1990–2004, the Party explained that the trend in CH4 emissions for the period 1990–2004 would be expected to be decreasing rather than increasing, as the number of biogas-producing plants in the pulp and paper industry using anaerobic processes has been reduced in the past 10 years and biogas production in the food industry has existed for less than five years. The ERT recommends that Sweden include the information provided to the ERT during the review in the NIR of its next annual submission in order to document the emission trend.	Sweden added the following information in NIR submission 2014: The trend in CH4 emissions for the period 1990–2004 would be expected to be decreasing rather than increasing, as the number of biogas-producing plants in the pulp and paper industry using anaerobic processes has been reduced in the past 10 years and biogas production in the food industry has existed for less than five years. (Section 8.3.1.1.2 Methane (CH4): Methane emissions from wastewater treatment: CRF 6B1a, Industrial wastewater, Wastewater)
Submission 2012	Waste	107. The ERT noted that the CH4 IEF for domestic and commercial wastewater (0.75-1.41 kg/kg degradable organic component (DC)) is consistently the highest reported by Parties (ranging from 0.0009 to 1.4116 kg/kg DC) and has increased by 99.7 per cent over the time series (from 0.75 kg/kg DC in 1990 to 1.41 kg/kg DC in 2010). In the previous stages of the review, the Party explained that the emissions are from small wastewater treatment plants without aeration, while the AD are taken only from the large wastewater treatment plants. The ERT recommends that Sweden report consistent data in the CRF tables or report the AD using the notation key "NA" and provide further infor-	The notation keys has been changed from NE to NA in submission 2014.

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		mation in the documentation box of CRF table 6.B and in the NIR of its next annual submission.	
Submission 2012	Waste	108. Emissions from waste incineration with energy recovery were estimated at a plant-specific level and reported under the energy sector in line with the Revised 1996 IPCC Guidelines. Emissions from the incineration of hazardous waste, and in later years of the times series also from municipal solid waste (MSW) and industrial waste, from one large plant without energy recovery are reported under waste incineration. Sweden has assumed the same carbon content for all waste incinerated at the plant (MSW, hazardous waste and industrial waste) and has applied a country-specific fraction of fossil carbon content of 30.0 per cent based on a study on MSW incineration. In response to a question raised by the ERT during the review, Sweden clarified that it applied a country-specific fraction of fossil carbon content of 30.0 per cent for MSW incineration and of 100.0 per cent for hazardous and industrial waste incineration. The ERT recommends that the Party include the information provided to the ERT during the review in the NIR of its next annual submission.	In submission 2013 the time series of reported biogenic and fossil CO2 was revised. The reporting of biogenic and fossil CO2 ase based on a detailed study performed in 2008. See NIR section 8.4.2.
Submission 2013, ICR preliminary recommendations	Waste	The ERT recommends that Sweden further improves the transparency of its NIR by providing the key AD as for solid waste treatment in the form of chart flows in its next annual submission	A chart of waste flows in Sweden 2010 has been included in section 8.2 in NIR submission 2014.
Submission 2013, ICR preliminary recommendations	Waste	Recommendations of ERT: The 6.A (methane) of Sweden makes the largest contribution to uncertainty value of Waste sector. In order to improve the accuracy and reduce uncertainty of calculations the ERT reiterates recommendation from ARR2011 and ARR2012 to research country specific FOD parameters The ERT strongly recommend to include results into the 2014 national submission	The recommendation has been changed to an encouragement by ERT during in-country-review submission 2013, since country-specific parameters are not a reporting requirement.
Submission 2011	KP	111. The ERT noted that N2O emissions from the drainage of soils under forest management is reported as “NE” in table NIR-1 but as “NA” in table 5(KP-II)2. The ERT recommends that Sweden address this inconsistency in its next annual submission.	111. Sweden has now changed notation keys from “NA” to “NE” in table 5(KP-II)2.
Submission 2011	KP	112. In the NIR (page 340), Sweden has indicated that the estimates for carbon stock changes for afforestation, reforestation and deforestation are “very uncertain” and, for forest management,	112. From submission 2012, the accuracy of estimates of areas and living biomass for AR, D and FM has been improved substantially using a similar extrapolation as for the UNFCCC report-

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
		"quite uncertain". The ERT noted that, although Sweden has chosen to account for KP-LULUCF activities at the end of the commitment period, reporting on KP-LULUCF activities is mandatory since the 2010 annual submission, and therefore recommends that Sweden make every possible effort to reduce the uncertainty of these estimates in its next annual submission.	ing (question 84), see chapter 11.1.
Submission 2011	KP	113. The ERT recommends that Sweden justify how 2–3 sample plots can be representative of an activity or, if not possible, address this sampling issue, in its next annual submission.	113. See section 11.3.1.4 and 11.3.1.5 in the NIR.
Submission 2011	KP	116. In response to a question raised by the ERT during the review Sweden explained why it is not necessary that afforestation and reforestation areas and land converted to forest land areas are exactly comparable. To improve transparency, the ERT recommends that Sweden include this information in its next annual submission.	116. See NIR section 11.1.
Submission 2011	KP	117. The ERT noted that Sweden considers its estimates of carbon stock changes for deforestation as "very uncertain" and therefore reiterates the recommendation made in paragraph 112 above that Sweden make every possible effort to reduce the uncertainty of these estimates in its next annual submission.	117. This question refers to uncertainty and the reviewer refers back to question 112. We believe that we could answer this question by repeating our answers to questions 112 and 113.
Submission 2011	KP	119. The table NIR-2 shows that, for 2009, the area for forest management has increased by 720.2 kha while at the same time the area for afforestation and reforestation has not changed and the deforestation area has increased by 34.1 kha. The ERT recommends that Sweden address the inconsistencies in the Party's reporting of areas for KP-LULUCF activities in its next annual submission.	119. This question about NIR 2 (the land use matrix) is answered by our reply to question 116.
Submission 2012	LULUCF-KP	111. The rationale for the recalculations per activity and their impact are not explained in the NIR. The ERT recommends that Sweden include this information in the next annual submission.	Done, NIR 11.3.1.4
Submission 2012	LULUCF-KP	113. …as "NE" in table NIR-1 but as "NA" in CERF table 5(KP-II)2…	Corrected
Submission 2012	LULUCF-KP	116. …The ERT reiterates the recommendations that Sweden make further efforts to reduce the uncertainties and report on the progress made in its next annual submission.	To keep accuracy and to make the UNFCCC and KP reporting consistent, average extrapolation based on the five former years has been made for each cycle with no full measured record. Last year extrapolation for AR and D areas was based on trend but is now based on

Review[291]	Sector	Paragraph and recommendation in report (shortened)	Actions as a result of ERT recommendations
			average. E.g. NIR 7.2.2.2 and 11.1.
Submission 2012	LULUCF-KP	117. The ERT noted that the KP-LULUCF activities are not included in the chapter of the NIR on recalculations…	Corrected, see NIR 11.3.1.1.3 and 11.3.1.4
Submission 2012	LULUCF-KP	118. The ERT simply wants Sweden to better explain how e.g. land converted to Forest land under the UNFCCC correspond to AR under the KP.	Done, see NIR 11.3.1.1.3

Table 10.5. Recommendations from the UNFCCC review process not yet implemented in the Swedish inventory

Review[295]	Sector	Paragraph and recommendation in report (shortened)	Rationale for not yet adapting ERT recommendation and possible improvement plan
Submission 2011	General	19. The ERT noted that the areas identified by Sweden as areas for further improvement could be better linked with the pending recommendations from previous review reports, and the ERT therefore recommends that Sweden include any recommendations from the previous review report not yet addressed in the specific sections on category-specific planned improvements in the NIR of its next annual submission	The information will be kept in table 10.5 to avoid duplication error and double work. We believe this recommendation should have been expressed as an encouragement by the ERT.
Submission 2013	General	12. The ERT notes that at least two years are usually required to implement any recommendation from the annual review reports where this implies some change in methodology, EFs or AD. Therefore, the ERT recommends that Sweden improve the national system in a way that would enable it to implement the recommendations provided in the annual review reports in time for its next annual submission.	Sweden prioritizes its resources and efforts in accordance with IPCC good practice guidance before the start of each inventory cycle. It has not been and can not be possible to include all ERT recommendations each year due to limited budget. The issue with waste water handling has not been considered as import as other issues taking the whole inventory into consideration. In addition, ERT reports are usually published (even draft reports) late, after the national prioritization is made, leading to a minimum of two years implementation time. Sweden would also like to state that the introduction of preliminary ERT results (from the 2013 submission review) will help speed up the process.
Submission 2013, ICR preliminary recommendations	Registry	Following this action the 2013 SIAR report pointed out three issues and made three recommendations on: A) information to the public, which is not under the party's direct control. B) description of database structure to be improved following changes in software. C) full reporting of changes in the national registry related to change of test results. ERT recommends that Sweden implement as soon as possible the first recommendation and that act so that the implementation of the other two recommendations becomes a priority for the common EU platform.	A) Sweden has included the public information directly on a website controlled by the Party. The publicly available information is up to date (i.e. updated as close to real time as possible, but at least updated on a monthly basis). http://www.energimyndigheten.se/en/Sustainability/EU-ETS---Implementation-in-Sweden/EUETS/Reports/ B) The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. Since the successful certification of the registry on 1 June 2012, Iteration 4 of the registry, introduced in October 2012, added a

[295] FCCC/IRR/2006/SWE, FCCC/ARR/2008/SWE, FCCC/ARR/2009/SWE, FCCC/ARR/2010/SWE, FCCC/ARR/2011/SWE, FCCC/ARR/2012/SWE and preliminary recommendations from the in-country review of the Swedish 2013 submission. The draft Annual Review Report for the 2013 submission has not been available in time for implementation in the Swedish 2014 submission.

Review[295]	Sector	Paragraph and recommendation in report (shortened)	Rationale for not yet adapting ERT recommendation and possible improvement plan
			limited number of new entities, none of them relating to DES entities. A data model was attached which more clearly shows the relevant entities "RECONCILIATIONS", "NOTIFICATIONS", "RESPONSES"," INTERNAL AUDIT LOG" and "MESSAGE LOG." As specified in the DES (Section VII. Data Logging Specifications/E. Message Archive), a copy of messages sent and received is stored in standalone files in one of two managed servers in the hosting environment. For that reason, the Message Archive is not shown in the model. The "MESSAGE LOG" object holds the location of the entire message, for each Message_ID. Since the successful certification of the registry on 1 June 2012, there has been no change in the capacity of the registry or change of its infrastructure. C) The consolidated EU system of registries successfully completed a full certification procedure in June 2012. Notably, this procedure includes connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the Data Exchange Standard (DES). This included a full Annex H test. All tests were executed successfully and led to successful certification on 1 June2012 The October 2012 release (version 4.0) was only a minor iteration and changes were limited to EU ETS functionality and had no impact on Kyoto Protocol functions in the registry. The test script previously provided reflects this. However, each major release of the registry is subject to both regression testing and tests related to new functionality. These tests include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production.

Review[295]	Sector	Paragraph and recommendation in report (shortened)	Rationale for not yet adapting ERT recommendation and possible improvement plan
Submission 2007/2008	Energy	79.The ERT recommends that only one value (e.g. 25 kg CO2/GJ) be used for all years for incinerated municipal waste in order to maintain time-series consistency and consistency with reporting on incineration in category 1.A.	A study performed in 2009 296addressed this issue. It was concluded that there is not enough evidence to revise the emission factor for years prior to 2003, and SEPA decided not to revise the emission factor at all. We are aware of this issue and our ambition is to improve this emission factor in future submissions.
Submission 2009	Energy	32. Report emissions from some categories were reported as “NE”, such as the CH4 and N2O emissions from mobile military use of biomass (FAME) for the years 1999 to 2001, CO2 from oil transport for all years,	In submission 2011 all categories for which IPCC default methodologies exist are estimated. There are no emission factors available to estimate CH4 and N2O emissions from mobile military use of biomass for the years 1999 to 2001 but emissions are expected to be minor. Sweden lack information on CO2 emissions from oil transport and there is no IPCC default methodology for CO2 from oil transport using tanker ships.
submission 2011	Energy	49. The ERT noted that Sweden’s IEF for N2O (8.41–15.97 kg/TJ) is the highest across all Parties for all years for the public electricity and heat production category (0.06–15.97 kg/TJ). The high IEFs are driven largely by high N2O EFs for coal and coke. The N2O EFs for these fuels are sourced from a country-specific study conducted in 2004.6 The ERT recommends that Sweden review the N2O EFs and report on any updates or provide further justification for the existing factors in the NIR of its next annual submission.	This will be addressed in the coming submissions.
Submission 2012	Energy	41. The ERT noted that, for the reference approach reported in CRF table 1.A(b), the fuels are reported in energy units and an oxidation factor of 1.0 is used by the Party to convert net carbon emissions to CO2 emissions. In response to a question raised by the ERT during the review, Sweden explained that the oxidation is accounted for in the EFs used in the reference approach. The ERT strongly recommends that the Party follow the IPCC default reporting method for the reference approach, so that all fuels are reported in natural units and the real carbon content of fuels and default oxidation factors are used, in order to further improve the transparency of the Party’s reporting.	Partly solved in submission 2014. Fuel consumption is now reported in natural units. The carbon emission factors and oxidation factors have not been revised due to lack of resources.
Submission 2012	Energy	51. The ERT noted that the 2010 value of the CO2 IEF (27.81 t/TJ) for public electricity and heat production is the	A review has been initiated during 2013 but more work is needed before any revisions can be justified.

[296] Paulrud, Fridell Stripple, 2009

Review[295]	Sector	Paragraph and recommendation in report (shortened)	Rationale for not yet adapting ERT recommendation and possible improvement plan
		lowest reported by all Parties (within the range of 27.81 to 142.29 t/TJ). Sweden explained that the large share of emissions reported under “other fuels” in public electricity and heat production is from the combustion of municipal waste. The CO2 EFs (32.7 kg/GJ for the period 1990–1995 and 25 kg/GJ for 1996 onwards) account for the fossil-fuel share of the CO2 emitted. The ERT recommends that Sweden provide more detailed information on the fossil-fuel shares and the EF used by year, and justify the change in the value of the EF in 1996 in the next annual submission	
Submission 2013, ICR preliminary recommendations	Energy	The ERT therefore strongly recommends that Sweden minimize the differences in Energy Balance early in future submissions, in accordance with revised 1996 Guidelines	Sweden has set up an action plan to resolve this issue. The plan includes meetings and collaboration between the Swedish EPA, the Swedish Energy Agency, Statistics Sweden and SMED. The first aim is to describe the rationale behind the sometimes large statistical differences in the Energy balances and their affect on the RA-SA comparison. A more long-term goal is to work towards minimizing the statistical differences in the Energy balances.
Submission 2013, ICR preliminary recommendations	Energy	The ERT recommends Sweden to make a detailed annexure on energy and carbon mass balance in their next NIR submission	Information has been improved in terms of energy and carbon mass balances for the two integrated iron and steel producing plants in Sweden, see Annex 3:5
submission 2007/2008	Industrial processes	41. For CO2 and N2O from solvent and other product use, Sweden reported identical emission estimates for 2005 and 2006 in its 2008 submission. The ERT recommends that Sweden improve its data collection procedures in order to estimate final emissions in a timely manner.	Not implemented but addressed in NIR Annex 3.3..
Submission 2010 (Submission 2011)	Industrial processes	59. (65) Allocate CO2 emissions from limestone and dolomite used in iron and steel production to limestone and dolomite use category.	Not implemented, but addressed in NIR section 4.4.1.2.
Submission 2009, (Submission 2010) Submission 2011	Industrial processes	56. (63). 68. Report CH4 and N2O from combustion of cooking liquor in the pulp, paper and print category under the energy sector, in accordance with the Revised 1996 IPCC Guidelines.	This will be addressed in the coming submissions. Addressed in NIR section 4.5.1.
Submission 2011; Submission 2013, ICR preliminary recommen-	Industrial processes	66. The ERT recommends that Sweden report emissions from auto-producers in the iron and steel processes in accordance with the Revised 1996 IPCC Guidelines. To increase transparency in the allocation of emissions, the ERT encourages Sweden to provide a de-	Sweden will continue to report emissions allocated as prescribed in the 2006 IPCC Guidelines. Sweden will include a detailed mass balance for the two integrated primary

Review[295]	Sector	Paragraph and recommendation in report (shortened)	Rationale for not yet adapting ERT recommendation and possible improvement plan
dations		tailed carbon mass balance for all the iron and steel processes. Recommendation: Inclusion of a mass balance that illustrates carbon inputs and outputs, including all the intermediate products (COG, BFG etc), carbon in the finished products and GHG emissions in the NIR that consistently explains for both Energy and IP sectors.	iron and steel plants in annex 3.5 to the NIR.
Submission 2012	Industrial processes	58. ...high uncertainties were reported for SF6 emissions from magnesium foundries (±40 per cent) and for the EFs for mobile air conditioners (up to ±40 per cent) and other refrigeration (±50 per cent). The ERT recommends that Sweden provide information on planned improvements for the categories with high uncertainties in the next annual submission.	Generally, it is not good practice to focus attention and resources to improve category estimatetions only on the basis of high uncertaities. Sweden uses the key category tier 2 analysis for its improvement planning in line with the IPCC GPG. For SF6 emissions from magnesium foundries, uncertaity estimates have been reviesed in the 2014 submission (from previous ±40 per cent to ±20 per cent) due to better evaluation of data used (see NIR 4.4.4.3). In Sweden, the methods, EFs and data sources used for estimation of HFCs from MAC and other air conditioners are under intermittent supervision and evaluation. Hence, improvements will be made in future submissions.
Submission 2012	Industrial processes	68. The ERT recommends that Sweden continue to provide information on the allocation of the emissions and any planned changes in the allocation of the emissions from the use of limestone and dolomite in primary and secondary production of steel, other metal production, production of clay-based products and glass production.	Not fully implemented, but addressed in NIR section 4.2.3.2.
Submission 2013, ICR preliminary recommendations	Agriculture	Issue: -Where T2 methods are used, i.e. STANK in the MIND; SOIL/SOILN Description of the models are not provided in the NIR Status: During the week, an English summary was provided for STANK model. Recommendation: Description of the assumptions used in the models should be included in the next 2014 submission.	The data in STANK in MIND are based on various 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. Some of the data for the less significant animal groups are based on expert opinions. See under STANK in MIND in the reference list for a complete list of the sources.
Submission 2007/2008	LULUCF	75. The ERT reiterates the recommendation from the previous review that Sweden improve its methodology (to separate emissions from organic and mineral soils (CRF table 5 (III))) in order to be able to report the two soil categories separately in future submissions.	Currently we do not have appropriate information on exactly on which land these changes occur. Therefore the emissions are reported aggregated.

Review[295]	**Sector**	**Paragraph and recommendation in report (shortened)**	**Rationale for not yet adapting ERT recommendation and possible improvement plan**
Submission 2007/2008	LULUCF	69. The ERT noted that Sweden may be underestimating the C stock increase in living biomass and recommends that Sweden verify differences in IEF compared to Finland and Norway and make revisions if necessary.	Comparing IEF may not tell the whole story. The annual harvest may differ significantly between years in and between countries. Therefore the difference may not be seen as exceptional.
Submission 2009	LULUCF	57. Report the subcategory mire under grassland, further distinguishing between managed and unmanaged land subcategories.	Grasscovered mires are always saturated with water and therefore reported under Wetlands.
Submission 2007/2008	Waste	72. Include information on time series for industrial organic waste in order to provide a more complete picture of municipal solid waste AD.	No data are available, which has been further described in NIR section 8.2.1.2.2.
Submission 2007/2008	Waste	78. Include information on biogenic fraction of incinerated municipal waste in its next NIR, and update and validate this value regularly as the biogenic fraction of incinerated municipal solid waste varies over time. It is good practice to assume that the composition of incinerated municipal solid waste is similar to that of generated municipal solid waste (IPCC good practice guidance, page 5.28).	This will be addressed in the coming submissions.
Submission 2011	Waste	106. For estimating CH4 emissions from domestic and commercial wastewater treatment apply the method from the Revised 1996 IPCC Guidelines in order to improve the accuracy of emission estimates or justify why the check method gives more accurate estimates in its next annual submission.	This will be addressed in the coming submissions.
Submission 2012	Waste	106. The emission estimates for domestic and commercial wastewater include three components: large wastewater treatment plants with no CH4 emissions because of the use of aeration in the process; small wastewater treatment plants; and emissions from the population not connected to a wastewater discharge system. The emissions have been estimated on the basis of the IPCC 'check' method. This is not in line with the decision tree for key categories provided in the IPCC good practice guidance. The ERT reiterates the recommendation made in the previous review report that Sweden apply the method from the Revised 1996 IPCC Guidelines in order to improve the accuracy of the emission estimates, or justify why the 'check' method provides more accurate emission estimates, in its next annual submission.	Work on comparing the national method with the default IPCC method (the full method of the Revised 1996 IPPC Guidelines) has started. The results are at present not finished.
Submission 2013, ICR preliminary	Waste	There is a well-developed QC system to check GHG inventory results in Sweden. The Party has demonstrated the documented cross checks results and proto-	This will be addressed in the coming submissions.

Review[295]	Sector	Paragraph and recommendation in report (shortened)	Rationale for not yet adapting ERT recommendation and possible improvement plan
recommen-dations		cols for waste sector categories in its archiving system. Nevertheless, the weakness of sector specific QA procedures necessary for KC 6.A and 6.B for CH4 was identified -> The ERT recommends that Sweden performs and documents key category specific QA procedures and describes them in the NIR of the next submission (conducting of meetings, involving leading professionals of Sweden in this sphere for annual waste sector GHG inventory discussions)	
Submission 2013, ICR preliminary recommen-dations	Waste	For estimating CH4 emissions from domestic and commercial wastewater treatment Sweden has applied the simple check method from the IPCC good practice guidance. In the two last review reports the ERTs recommended Sweden to replace the IPCC 'check' method with the default IPCC method (the full method of the Revised 1996 IPPC Guidelines) what is appropriate for calculation of emissions of KC This recommendation it is not addressed in 2013 submission During the review week the Party demonstrated that this issue exist in the list of approved improvements for Swedish national inventory that are provided with funds	Work on comparing the national method with the default IPCC method (the full method of the Revised 1996 IPPC Guidelines) has started. The results are at present not finished.

10.5 Major changes in methodological descriptions

Table 10.6. Documentation of major changes in methodological descriptions compared to previous year NIR

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS	RECALCULATIONS	REFERENCE
	Please tick where the latest NIR includes major changes in methodological descriptions compared to the previous year NIR	Please tick where this is also reflected in recalculations compared to the previous year CRF	If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc
Total (Net Emissions)			
1. Energy			
A. Fuel Combustion (Sectoral Approach)			
1. Energy Industries			
2. Manufacturing Industries & Construction			
3. Transport			
4. Other Sectors			
5. Other			
B. Fugitive Emissions from Fuels			
1. Solid Fuels			
2. Oil and Natural Gas	X	X	See NIR 3.3.2
2. Industrial Processes			
A. Mineral Products			
B. Chemical Industry			
C. Metal Production			
D. Other Production			
E. Production of Halocarbons and SF6			
F. Consumption of Halocarbons and SF6			
G. Other			
3. Solvent and Other Product Use			
4. Agriculture			
A. Enteric Fermentation			
B. Manure Management			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS Please tick where the latest NIR includes major changes in methodological descriptions compared to the previous year NIR	RECALCULATIONS Please tick where this is also reflected in recalculations compared to the previous year CRF	REFERENCE If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc
C. Rice Cultivation			
D. Agricultural Soils	X	X	See NIR 6.4.1.5
E. Prescribed Burning of Savannas			
F. Field Burning of Agri-cultural Residues			
G. Other			
5. Land Use, Land-Use Change and Forestry			
A. Forest Land	X	X	See NIR 7.6.1
B. Cropland	X	X	See NIR 7.6.1
C. Grassland	X	X	See NIR 7.6.1
D. Wetlands			
E. Settlements	X	X	See NIR 7.6.1
F. Other Land			
G. Other			
6. Waste			
A. Solid Waste Disposal on Land			
B. Waste-water Handling			
C. Waste Incineration			
D. Other			
7. Other (as specified in Summary 1.A)			
Memo Items:			
International Bunkers			
Aviation			
Marine			
Multilateral Operations			
CO2 Emissions from Biomass			
11. The Kyoto Protocol			
Afforestation	X	X	See NIR 11.3.1.3
Deforestation	X	X	See NIR 11.3.1.3
Forest management	X	X	See NIR 11.3.1.3

PART 2: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

11 KP-LULUCF

11.1 General information

Sweden provides supplementary information under Article 7 of the Kyoto Protocol (KP) for the Land Use, Land-Use Change and Forestry sector. The requested information is further specified in Decision 15/CMP.1, 16/CMP.1 and IPCC GPG for LULUCF (IPCC[297]).

The activities Afforestation and Reforestation (AR) and Deforestation (D) are quite uncommon in Sweden, each representing around 10 kha annually in average (Table 11.1 and 11.2). The accumulated AR and D-areas steadily increase by time when estimates are based on a full set of inventory plots (30 000 plots). However, if based only on the most recently re-measured plots, this might not always be the case. This is due to the five-year inventory cycle, where the estimates for the five recent years are based on a decreasing number of plots. To avoid a risk of an incorrect decrease in AR and D area and to improve the accuracy of the estimates, inventory cycles without a full record to 2012 are extrapolated (see 7.2.2.2 and Figure 7.6). The extrapolations of areas and living biomass are based on the running average of the five previous years to the actual year. There are several options to make this extrapolation but the method chosen has the advantage that the total land and fresh water area is constant over time.”Five years” is chosen as a trade-off between being enough to reduce random variation and be reasonably up to date. In each submission, data for the four last years of the previus report are re-calculated to limit a potential small risk of bias induced by the extrapolation (a pilot study by historical data indicated that the result of re-calculated data using measured full records of sample plots does not deviate significantly from extrapolated data). IPCC recommends a five-year inventory cycle and to re-calculate data when the intention is to improve the accuracy. Chapter five in IPCC 2003 GPG describes that extrapolation is a valid approach to improve estimates for years with missing data. Comments by previous reviewers to report a constant total area and consistent areas under AR and D, initiated the introduction of extrapolation. The methodology has also the advantage to improve the accuracy of estimates. In response to a recommendation by the ERT during the ICR of Submission 2013 Sweden decided to use the same extrapolation method for KP-activities as for UNFCCC-categories. Which means that the four latest years are interpolated using the running average of the last five years before the reporting year instead of the trend as was previously used for AR and D. This means that the area of AR and D may be slightly underestimated for these years and that the direct link between AR, D and FM and other land is partially lost, i.e. the NIR-2 table cannot be filled in appropriately since the decrease in FM area is larger than D. The consistency problem is recognized and ongoing work intends to improve the reporting using extrapolation.

[297] Intergovernmental Panel on Climate Change, 2003

Sweden has elected the activity Forest management (FM) under Article 3.4 of the Kyoto Protocol (KP). The KP-reporting of FM and AR harmonize (areas) almost with the UNFCCC-reporting of Forest land and land converted to Forest land. However, according to IPCC GPG for LULUCF (e.g. decision tree 4.1.1), land that during the commitment period is converted from Forest land should either be reported under D or under FM. Thus Forest land converted to Wetland or Other land (both unmanaged) are reported under FM (KP) and under Forest converted to Wetland/Other land (UNFCCC). This explains the insignificant difference in area between FM+AR and Forest land+land converted to Forest land for years 2011 and 2012 (see also NIR 2). Due to a slow growth rate in boreal forests, land under AR will not be considered harvested during the first commitment period[298] and these juvenile forests are not fertilized. Therefore, direct N_2O emissions from N fertilization and emissions from forest fires are reported only under FM. Forest fires –both natural and wildfires– are uncommon and, this far, has not been registered on ARD-land. N_2O emissions from disturbance associated with land use conversion from Forest land to Cropland are reported under D. N_2O emissions from drainage of soils are not reported (voluntary). Liming is assumed only to occur on agricultural land and is assumed to occur only on Cropland remaining Cropland. Thus no liming is reported under the KP.

Table 11.1. The accumulated area under activities AR, D and FM

[M ha]	1990	. . .	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
AR	0.01		0.12	0.13	0.14	0.15	0.16	0.17	0.19	0.21	0.22	0.23	0.23	0.23
D	0.02		0.14	0.16	0.16	0.18	0.18	0.19	0.20	0.21	0.22	0.22	0.23	0.23
FM	28.12		28.01	27.99	27.99	27.99	27.98	28.04	28.05	28.13	28.16	28.16	28.14	28.14

Table 11.2. Emissions / removals (minus), CO_2 [Mtonnes] from reported carbon pools in AR, D and FM for the fifth year in the commitment period (2012)

[Mtonnes]	Above ground biomass	Below ground biomass	Dead wood	Litter	Soil organic carbon
AR	-0.97	-0.31	-0.01	-0.23	0.14
D	1.69	0.52	0.00	0.89	0.79
FM	-23.90	-8.0	-7.0	5.3	-6.0

The KP-reporting uses the same institutional arrangements, national system and corresponding QA/QC procedures as for the UNFCCC reporting. Emissions re-

[298] The concept “harvest” is important when a party claims to offset emissions from land under harvested AR-land (e.g. FCCC/KP/CMP/2005/8/Addd.3 p.6) but no definition of “harvest” has been found. So Sweden assumes that “harvest” refers to emissions at final felling and such AR-land is not expected to exist in Sweden during the first commitment period.

ported under Article 3, paragraph 3 and 4 are not overlapping with those emissions reported under KP Annex A. The section below focuses on differences in aggregating underlying data between the UNFCCC- and the KP-reporting.

The same underlying methodology is used for the reporting under the KP of the LULUCF-sector as described for the UNFCCC reporting of LULUCF (chapter 7). The estimates of emissions/ removals and areas are based on permanent sample plots inventoried by the Swedish National Inventory of Forests covering all land and fresh water areas. A major difference from the UNFCCC reporting is that the carbon pool living biomass is separated into above ground and below ground living biomass and that the dead organic matter pool is separated into dead wood and litter in the reporting under the KP. Only emissions/removals on land under the activities AR, D and FM are reported under the KP. ARD land is accumulated from 1990 using permanent sample plots covering all land and fresh water areas. Changes in carbon pools on ARD-land are reported for years 2008-2012.

Land under FM is accumulated from 1990 and changes in carbon pools are reported on such land 2008-2012.

Sweden has elected commitment period accounting for LULUCF for the first commitment period.

11.1.1 Definitions of forest and any other criteria

For reporting purposes under the Kyoto Protocol, Forest land is defined, according to the FAO definition, as land with a tree crown cover (or equivalent stocking level) of more than 10 %, an area of more than 0.5 ha and a minimum height of 5 m. Both crown cover and height refers to maturity *in situ*, and consequently, Forest land could temporary be unstocked due to human intervention such as final felling. Normally such land is regenerated within a few years and Forest land is not considered deforestated 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, agriculture land normally fulfils the forest criteria except for the predominant land use and is not considered Forest land. Tree-rows narrower than 10 m are not considered forests. Roads and power-line routes within forests are considered forest 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 – this implies that carbon stock changes in living biomass may be reported under any land use category.

All Forest land is assumed managed. Thus, the definition of Forest land and the assumption that all Forest land is managed are consistent with reporting under the UNFCCC. The underlying data are also consistent for the whole reporting period. In fact, the area of Forest land under the UNFCCC reporting should nearly be equal the sum of the areas subject to activities Forest management and Afforestation/ Reforestation under the Kyoto Protocol (this far all land under Afforestation/ Reforestation has secondary classification Forest management and none under Deforestation).

The definition of Forest land is consistent with former reporting under the UNFCCC and to other international bodies such as 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 and the KP 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 Swedish forest situation to other bodies. In both cases the expected values of estimates are the same but estimates might vary from randomness of the sample.

Under the Kyoto Protocol it is central to distinguish between definitions of land use categories, activities and spatial assessment units (Figure 11.1). The definition of Forest land has a minimum area but this is not the case for activities. For Sweden the spatial assessment unit is a permanent sample plot (radius 10 m) and since this plot could be delineated into more than one land use category, deforestation close to 0 m^2 could be detected. Area-based sampling is used and each sample plot represents a certain area in the estimation algorithm so that all sample plots together represent the total land and fresh water area of Sweden. The Swedish NFI has the advantage that the sample frame covers all land- categories required for the UNFCCC-reporting. This is essential when both gross and net land use transfers over time have to be traced.

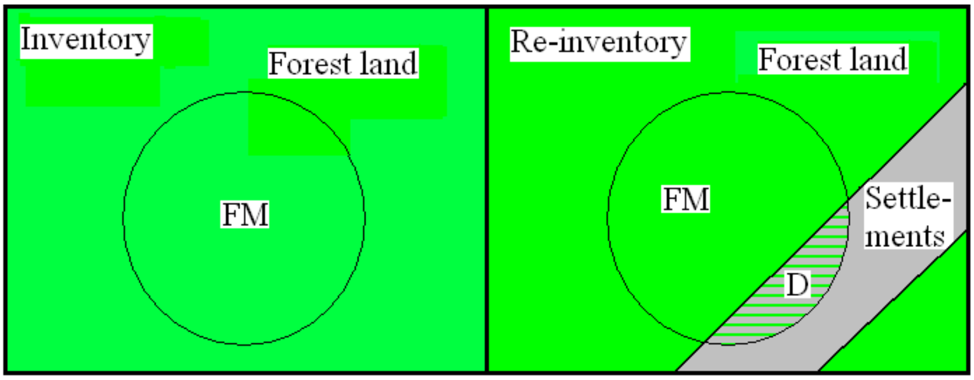


Figure 11.1. Example distinguishing the concepts of land use category, activities under the Kyoto Protocol, and spatial assessment unit in the Swedish sample based inventory

Figure 11.1: At the first inventory, only the land use category Forest land exist in an area but at the re-inventory part of the Forest land has been deforested to the land use category Settlements. Activities under the Kyoto Protocol are estimated using area based sampling by circular sampling plots (the spatial assessment unit). At the first inventory, the whole plot represents the activity Forest management (FM) but at the re-inventory the plot represent the activities FM and Deforestation (D), respectively. Observe that both land use categories and activities have definitions but Sweden has no minimum area limit set for estimating activities.

11.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

For the accounting of LULUCF-activities under article 3.4 during the first commitment period, Sweden has elected Forest management (FM). FM is defined as activities on Forest land.

11.1.3 Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time

Sweden defines Deforestation (D) as land use conversions from Forest land (all forest land area is regarded managed) to Cropland, Grasslands or Settlements (all land under these three categories are assumed managed). Afforestation/ Reforestation (AR) is defined as land use conversions in the opposite direction (Figure 11.2). Land use categories are strictly defined (see NIR chapter 7.2.3) and land use conversions are observed in field using a five-year inventory cycle. The approximately 30 000 permanent sample plots where laid out between 1983 and 1987 and have thereafter been re-inventoried in a consistent way (Figure 11.3). If the land use of a sample plot or part of a sample plot is assessed as converted between consecutive inventories the conversion is assumed to occur at a random year between the re-measurments. AR on former Cropland, Grasslands and Settlements are connected with an active human decision. Normally regeneration is following shortly after the land conversion. All AR land is by national legislation considered as Forest land and the same definition of Forest land is used in the Forestry act (1979:429 2 § 1.) as for the UNFCCC reporting. The activity Forest management (FM) is assumed occurring on all land fulfilling the forest definition (see 11.1.1). If land is subject to AR (or D), this land may have secondary classification FM. Land could only be reported under one activity or none (to avoid double counting).

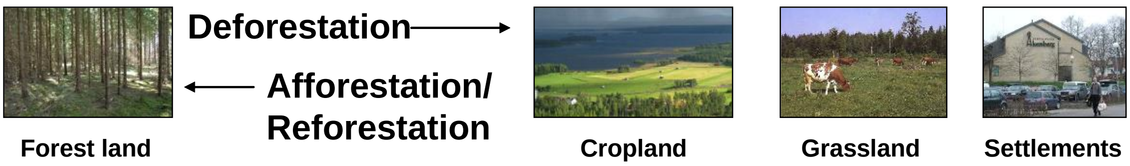


Figure 11.2. D is defined as land use conversions from Forest land (managed) to another managed land use class (all Cropland, Grasslands and Settlements are assumed managed). AR are defined as land use conversions in the opposite direction (C, G or S to F)

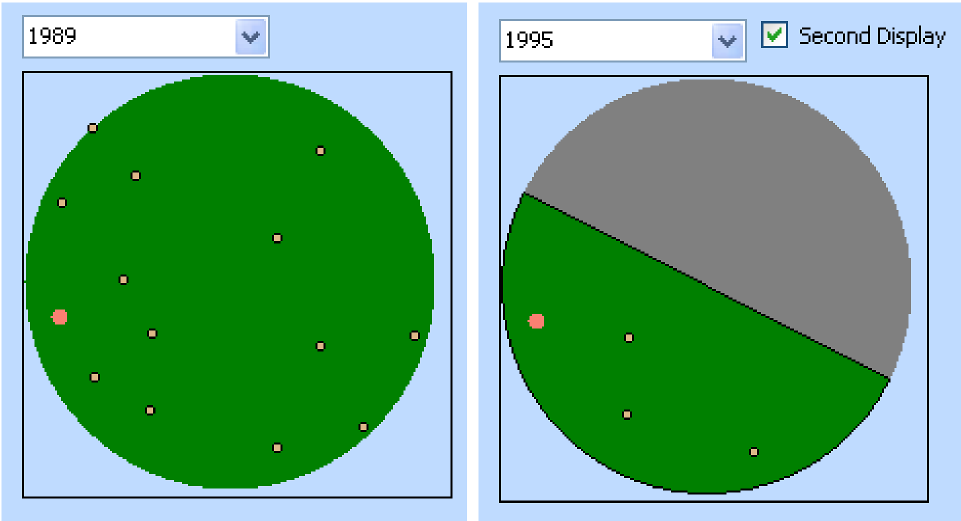


Figure 11.3. The figure shows data for a specific sample plot in the Swedish LULUCF-database. The individual tree biomass on approximately 30 000 permanent sample plots are matched to land use and traced back to before the base year in a consistent way. Applying area based sampling all 30000 permanent sample plots represents the whole land and fresh water area in Sweden and carbon stock changes are estimated using the stock change method on these plots. Part of this specific plot was Deforestated between 1991 and 1992. The positioning of trees is central when matching carbon stock changes in living biomass to activity (about 75% of Deforestated plots are divided into more than one land use category). The position and biomass of the marked tree (right panel) is identified at both inventories and demonstrates the possibility to match individual trees to activities over time

11.1.4 Descriptions of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified.

Precedence conditions are: D, AR and FM since FM is the only activity elected under article 3.4. Land under Deforestation (D) cannot leave this category. This is basically also valid for land under AR – except after D. Land under Afforestation/ Reforestation (AR) usually has secondary classification FM (always if reported under Forest land remaining Forest land or conversion to Forest land under the UNFCCC). Theoretically, land under Deforestation can have secondary classification FM (if reported under Forest land remaining Forest land or conversion to Forest land under the UNFCCC) but this far such land does not exist. Land areas under FM that are naturally degraded can leave the category until 2008 (but not during the commitment period) and is not reported under the KP (usually reported as Forest land converted to Wetland or Other land under the UNFCCC). Deforested land can leave FM at any time from 1990 and onwards and these land areas are then reported under D. Land associated with the activities reported (AR, D and FM) is accumulated from end of 1989 and onwards, and changes in carbon pools and other emissions on these land areas are reported during the commitment period.

11.2 Land-related information

11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3

The “Spatial assessment unit”, which is the same as for the UNFCCC-reporting, is used to determine the area of accounting for ARD. The “Spatial assessment unit” is defined as the minimum area used to detect a land use conversion.

Sweden monitors land use transfers based on field measurements using circular sample plots (radius 10 m). If any part of a plot is converted from one land use category to another, it can be detected. Thus, the “Spatial assessment unit” will be a sample plot part and activities down to an area of 0 m^2 could be detected. The same “Spatial assessment unit” has consistently been used in both the UNFCCC and the KP-reporting (Figure 11.1).

11.2.2 Methodology used to develop the land use matrix

Data from the Swedish National Forest Inventory (NFI) have been used for developing the land use matrix. The underlying data are consistent with the data used for developing the land use matrix under the UNFCCC-reporting. The main difference is that activities are reported under the KP while land use categories are reported under the UNFCCC.

The Swedish National Forest Inventory covers all land and fresh water areas before the base year and onwards on sample plots with a fixed position (permanent sample plots). This makes it possible to consistently trace both gross and net land use transfers over time.

11.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

Sweden uses a geographical boundary encompassing units of land (Reporting method 1) and has adopted approach 3 (Table 4.2.2 in GPG LULUCF 2003) for reporting emissions/removals under article 3 of the KP (Figure 11.4). In practice a sample frame of approximately 30000 permanent sample plots is covering all relevant managed land in Sweden (see chapter 7). The sample frame is divided into 31 strata and the distance between sample units within stratum is based on autocorrelation. A five-year inventory cycle is used and each year about 6000 sample plots are inventoried over the whole country. Each sample plot has an identification code and a registered geographical position. This information is confidential due to sampling reasons. However, on request (i.e, in connection with an in country review) it is possible to visit any plot. A certain year, each sample plot (or a part of a sample plot) could only represent one activity (D, AR or FM) or none. The status of activities on sample plots could be traced back from the current year to the base year (1990; Figure 11.4).

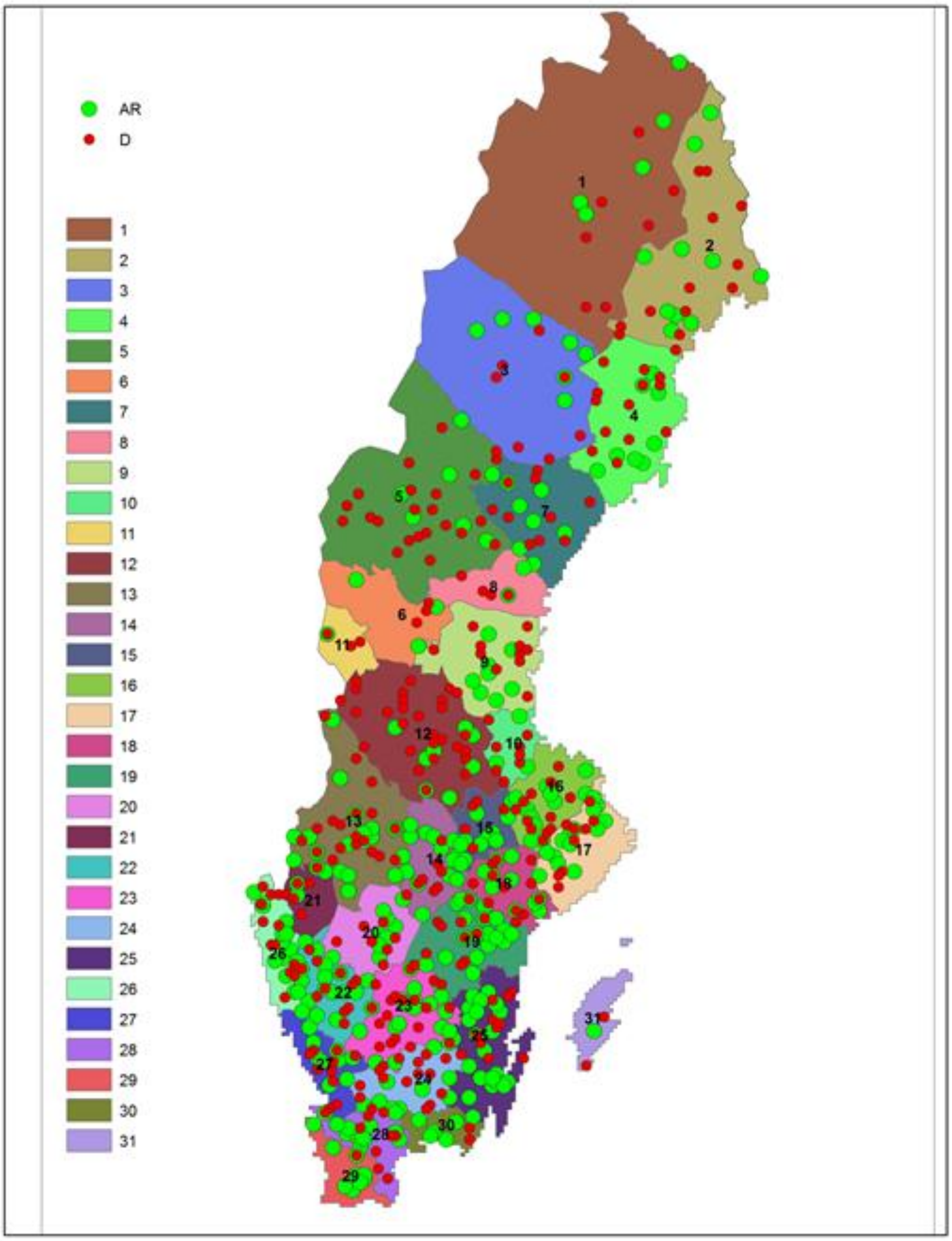


Figure 11.4. The location of sample plots partly or completely reported under ARD in Sweden (1990-2012). (On request from the 2013 in country revew, the figure is now pre-senting AR and D per stratum)

11.3 Activity-specific information

11.3.1 Methods for carbon stock change and GHG emission and removal estimates

In most cases, methodologies, models and assumptions under the KP-reporting are consistent with the UNFCCC-reporting. This chapter focuses on discrepancies.

11.3.1.1 DESCRIPTION OF THE METHODOLOGIES AND THE UNDERLYING ASSUMPTIONS USED

11.3.1.1.1 Carbon pools

The living biomass pool changes is estimated in exactly the same way as under the UNFCCC reporting using the stock change method and area based sampling (See 7.3.1.2 + NIR Annex 3:2). However, the living biomass is reported separately for above-ground and below-ground biomass, respectively.

The dead wood, litter and soil organic pools are calculated using the same methods as for the UNFCCC-reporting (See 7.3.1.3-4 + Annex 3:2) using the area distribution associated with the reported activities under the Kyoto protocol (ARD and FM).

All methods used for FM is Tier 3 whereas methods for Litter, Dead wood and Soil organic carbon for ARD is Tier 2.

11.3.1.1.2 Other emissions

Emissions associated with direct N_2O emissions from N fertilization in forests (TABLE 5(KP-II)1) are estimated in the same way as under the UNFCCC (see 7.2.5.1). The estimates are based on activity data and emission factors with no information of the actual geographical distribution of fertilizer used. The fertilization is strictly regulated by the Forestry act and Sweden assumes that no fertilizer is applied in young forests. Therefore all emissions are assumed to occur under the activity FM and none under AR and the reported figure under “Forest Land remaining Forest Land“ (UNFCCC, TABLE 5(I)) should correspond to the reported figure under FM (TABLE 5(KP-II)1)). It should be noted that fertilization is very restricted in Sweden. The annual fertilized area is expected to increase in the coming years but to cover less than 0.5 % of the total area of Forest land.

In line with the UNFCCC-reporting (TABLE 5(II)), N_2O emissions from drainage of soils (TABLE 5(KP-II)2) are not reported. The justification for omitting the emission is found in section 11.3.1.2.

The reporting of N_2O emissions from disturbance associated with land-use conversion to Cropland (TABLE 5(KP-II)3) are only relevant for the activity D and is reported. The reported figure should be similar to the figure reported under “2.1 Forest land converted to Cropland” (UNFCCC, TABLE 5(III) and discrepancies if they occur arise only from a different accumulations of land between the two reporting's (see activities).

All forest fires (TABLE 5(KP-II)5) are reported under FM and this figure should correspond to the figure reported under Forest land (UNFCCC, TABLE 5(V)). Forest fires may occur in all kinds of forests but no fires have been registered by the National Forest Inventory on land reported under activities AR. Only 0.2% of the area of Cropland is associated to D and liming does probably only occur on Cropland remaining Cropland. Thus no emissions from liming are reported under the KP (this far).

11.3.1.1.3 Activities and the relationship to UNFCCC-categories

Kyoto Protocol activity areas are accumulated from 1990 and onwards and, normally, do not leave the class.

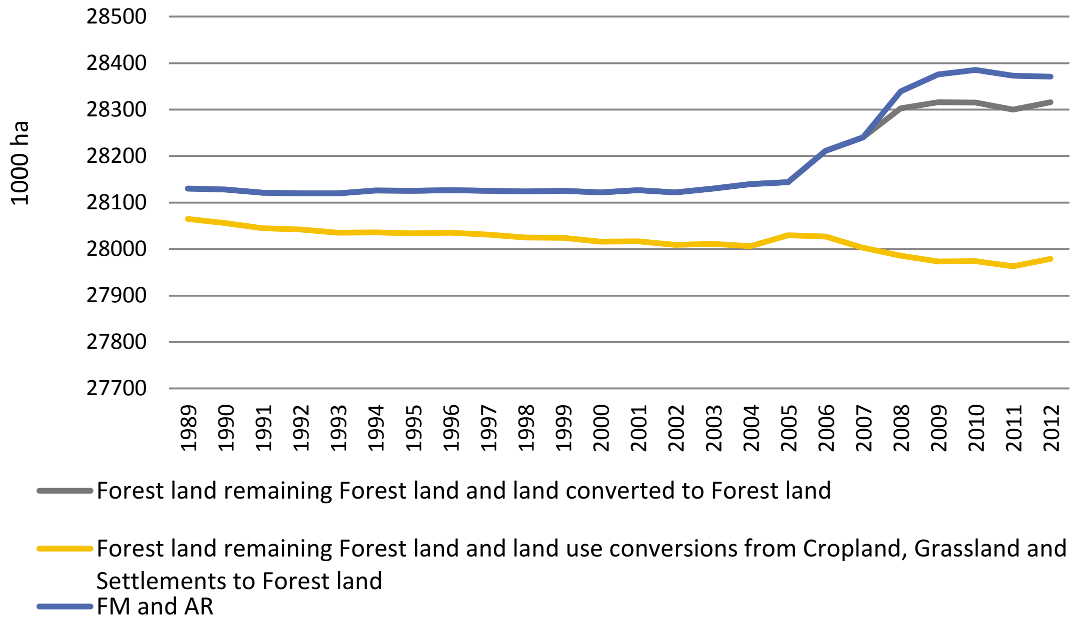
AR areas may increase due to conversions from managed land (Cropland, Grassland and Settlement) to Forest land and decrease due to land use conversions in the opposite direction. These areas are reported under deforestation (Figure 11.5).

D can only increase by land use change from Forest land to Cropland, Grassland or Settlement (Figure 11.5).

FM areas can increase due to land use change from unmanaged land (Wetland and Other land) and decrease by land use conversions to Cropland, Grassland or Settlement (reported under D). Land use conversions during the commitment period from Forest land reported under FM to unmanaged land remains in the FM reporting (Figure 11.5).

This means that Forest land remaining forest land plus Land converted to Forest land under the convention reporting is not exactly the same as Forest management plus AR during the commitment period, since FM will not decrease when Forest land is converted to unmanaged land while Forest land remaining forest land will (Figure 11.5).

In addition, for the UNFCCC-reporting converted land stays in the conversion class for twenty years and is thereafter reported under the land use category it was converted to. The twenty-year accumulation of land under the UNFCCC-reporting may begin long before the base year and is therefore not suitable to, for example, compare D under the Kyoto Protocol with Forest land converted to Cropland, Grassland or Settlements under UNFCCC. Using conversions from Forest land as a "proxy" for D has led to several misunderstandings when assessing the outcome of the UNFCCC and the KP reporting.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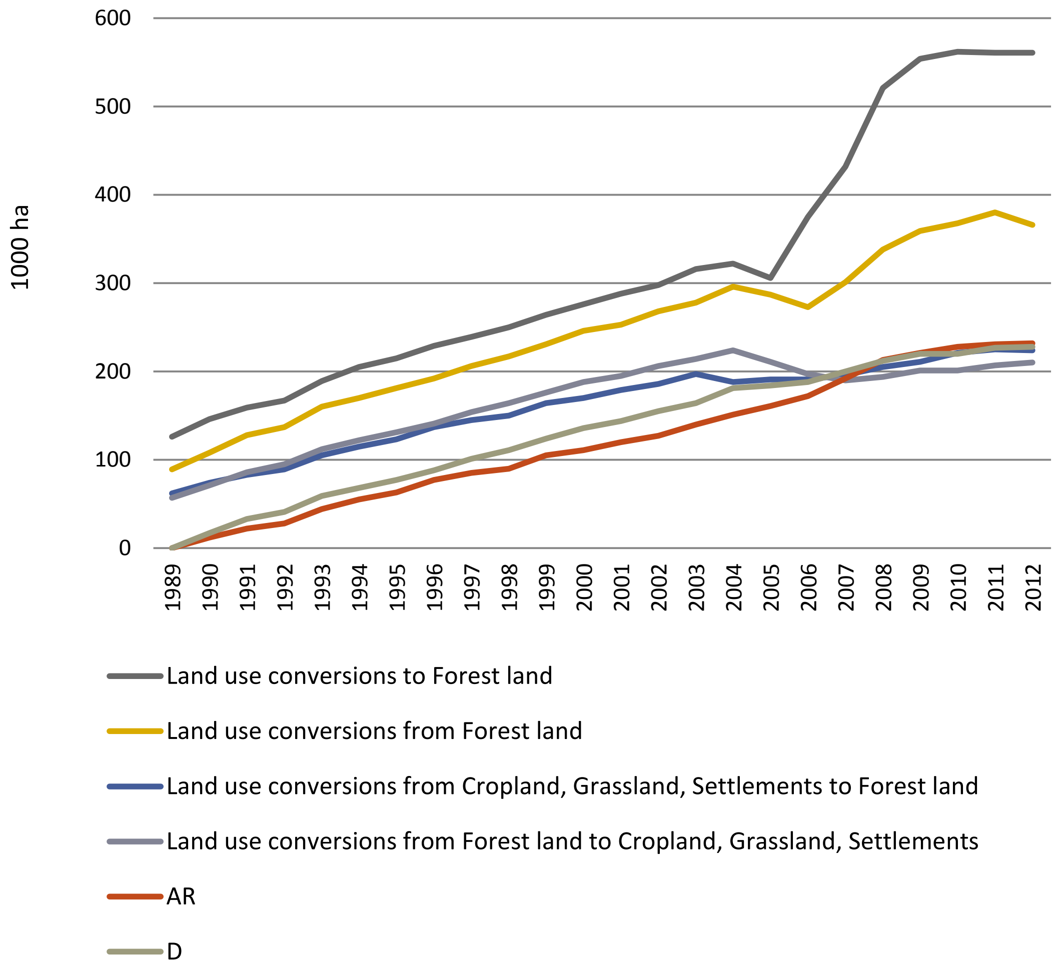

Figure 11.5. The upper panel illustrates the relationship between reported areas for UNFCCC and KP for FM+AR and Forest land remaining forest land+ Land converted to forest land. The lower panel illustrates the relationship between area reported for AR and D and the corresponding Land use change categories reported under UNFCCC.

For living biomass, both the reported removal under AR and the emission under D have increased since last submission. The explanation is probably due to a re-calculation in underlying data. Only minor differences are found for other carbon pools and this is also valid for corresponding categories under the UNFCCC.

Emissions from N_2O and CH_4 under the KP are considered very small in Sweden. How figures correspond between submissions and between the KP and the UNFCCC is listed in Table 11.3.

Table 11.3. The relationship between emissions and between the KP and the UNFCCC reporting

	CO_2 [M tonnes/year] 2011	Submission 2014 KP A	2013 KP B		2014 UNFCCC C	A-B	A-C
AR	Living biomass	-1.24	-0.80	CGS to F	-1.23	-0.44	-0.01
	Dead organic matter	-0.25	-0.27		-0.26	0.02	0.01
	Soil organic carbon	0.15	0.17		0.20	-0.02	-0.04
	Total	**-1.34**	**-0.90**		**-1.29**	-0.44	-0.05
D	Living biomass	1.95	0.64	F to CGS	2.39	1.31	-0.43
	Dead organic matter	0.96	0.95		0.87	0.01	0.09
	Soil organic carbon	0.85	0.96		0.82	-0.11	0.04
	Total	**3.77**	**2.55**		**4.07**	1.22	-0.30
FM	Living biomass	-32.06	-31.99	FOW to F	-32.12	-0.06	0.06
	Dead organic matter	-2.22	-1.68		-2.66	-0.54	0.44
	Soil organic carbon	-5.88	-5.98		-5.88	0.1	0
	Total	**-40.15**	**-39.6**		**-40.66**	-0.55	0.51

Table 11.3. (cont) The relationship between submissions and between the KP and the UNFCCC reporting

	N_2O [M tonnes/year]	Submission 2014 KP	2013 KP		2014 UNFCCC
D	N_2O emissions from disturbance associ-ated with land use conversion to cropland	0.00002	0.00001	F to C	0.00002
FM	N_2O emissions from drainage	0.00014	0.00014	F to F	0.00014
	GHG emissions from biomass burning	0.00000	0.00000	F to F	0.00000
	CH_4 [M tonnes/year]				
FM	GHG emissions from biomass burning	0.00010	0.00010	F to F	0.00010

JUSTIFICATION WHEN OMITTING ANY CARBON POOL OR GHG EMISSIONS/REMOVALS FROM ACTIVITIES UNDER ARTICLE 3.3 AND ELECTED ACTIVITIES UNDER ARTICLE 3.4

Sweden reports and accounts for all carbon pools (above-ground biomass, below-ground biomass, litter, dead wood and soil organic carbon). This is also valid for all non-carbon pool emissions except nitrous-oxide emissions from drainage of soils under FM (Table 5(KP-II)2). These emissions are optional to report since the available methods to estimate the emissions are not accurate enough (IPCC 2003 GPG, Appendix 3a.2).

11.3.1.2 INFORMATION ON WHETHER OR NOT INDIRECT AND NATURAL GHG EMISSIONS AND REMOVALS HAVE BEEN FACTORED OUT

Sweden argues that the issue of "factoring out" was solved during negotiations with the cap for FM. A footnote of par. 7 of decision 16/CMP1 "recognizes that the intent of the appendix to the annex to decision 16/CMP.1 is to factor out the effects described in paragraph 7 (a)–(c) of these guidelines for the first commitment period"). So Sweden has indirectly "factored out" 7 (a)-(c) by the cap for FM but no direct "factoring out" has been made. Moreover, sound science for a direct "factoring out" does not exist and no methodology has been adopted.

11.3.1.3 CHANGES IN DATA AND METHODS SINCE PREVIOUS SUBMISSIONS (RECALCULATIONS)

The uncertainty of estimates increases by decreasing number of sample plots and Table 11.4 illustrate the need of annual recalculations of the most recent years to increase the accuracy. In the current submission, the living biomass pool and activity areas have been recalculated for the most recent years to improve accuracy and each estimate are now based on 6000 more measured sample plots. To avoid an increasing uncertainty of estimates by decreasing number of sample plots Sweden has introduced extrapolation for inventory cycles without a full record of sample plots until 2012. Inconsistencies in the reporting of direct N_2O emissions for N fertilization and N_2O emissions from disturbance associated with land-use conversion to cropland between the UNFCCC-reporting and the KP-LULUCF reporting have been taken care of.[299]

[299] The inconsistency now taken care of was observed by reviewers (ARR 2011)

Table 11.4. The accumulated area under activities AR, D and FM and the approximate number of sample plots each estimate is based on (partly extrapolated plots inside brackets), presented by submission. Last three rows express the difference between submissions due to recalculations.

Submission		1990	· ·	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
	AR [M ha]	0.02	· ·	0.14	0.15	0.17	0.19	0.21	0.22	0.24	0.25	0.26	0.26	-
2013	D [M ha]	0.01	· ·	0.15	0.16	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.22	-
	FM [M ha]	28.20	· ·	28.07	28.07	28.07	28.08	28.11	28.15	28.18	28.18	28.16	28.13	-
No. of plots (10^3)		30	· ·	30	30	30	30	30	30	(30)	(30)	(30)	(30)	-
	AR [M ha]	0.01	· ·	0.13	0.14	0.15	0.16	0.17	0.19	0.21	0.22	0.23	0.23	0.23
2014	D [M ha]	0.02	· ·	0.16	0.16	0.18	0.18	0.19	0.20	0.21	0.22	0.22	0.23	0.23
	FM [M ha]	28.12	· ·	27.99	27.99	27.99	27.98	28.04	28.05	28.13	28.16	28.16	28.14	28.14
No. of plots (10^3)		30	· ·	30	30	30	30	30	30	30	(30)	(30)	(30)	(30)
Difference between Submission 2014 and 2013														
	AR [M ha]	-0.01	· ·	-0.01	-0.01	-0.02	-0.03	-0.04	-0.03	-0.02	-0.03	-0.03	-0.03	-
	D [M ha]	0.00	· ·	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-
	FM [M ha]	-0.08	· ·	-0.08	-0.08	-0.08	-0.09	-0.07	-0.10	-0.06	-0.02	-0.01	0.01	-

The uncertainty will most probably not influence the accounting since the net removal from FM is much larger than the net emission from ARD, thus it will be possible to offset net emissions from ARD by the net removal from FM and further claim credits from FM limited by the cap (2.13 Mtonnes CO_2 per year) (see next section: Uncertainty of estimates).

Table 11.5. Emissions / removals (minus), [Mtonnes CO_2] from reported carbon pools in AR, D and FM per submission

Activity	Carbon pool	2008 Subm. 2013	2009 Subm. 2013	2010 Submi. 2013	2011 Submi. 2013	2008 Subm. 2014	2009 Subm. 2014	2010 Subm. 2014	2011 Subm. 2014	2012 Subm. 2014
AR	Above ground biomass	-0.58	-0.60	-0.60	-0.60	-0.97	-0.99	-0.86	-0.94	-0.97
	Below ground biomass	-0.19	-0.20	-0.20	-0.20	-0.31	-0.31	-0.27	-0.30	-0.31
	Dead wood	-0.02	-0.02	-0.01	-0.01	-0.24	-0.24	-0.25	-0.24	-0.23
	Litter	-0.26	-0.28	-0.28	-0.27	-0.01	-0.01	-0.01	-0.01	-0.01
	Soil organic carbon	0.17	0.18	0.19	0.17	0.15	0.16	0.16	0.15	0.14
	Total	**-0.88**	**-0.92**	**-0.90**	**-0.90**	**1.37**	**1.40**	**1.22**	**1.34**	**1.37**
D	Above ground biomass	0.84	0.63	0.40	0.48	0.98	1.00	0.59	1.48	1.69
	Below ground biomass	0.29	0.20	0.14	0.16	0.32	0.31	0.18	0.48	0.52
	Dead wood	0.00	0.00	0.00	0.00	0.97	1.01	1.01	0.96	0.89
	Litter	0.92	0.96	0.99	0.95	0.00	0.00	0.00	0.00	0.00
	Soil organic carbon	0.94	0.98	1.00	0.96	0.85	0.88	0.88	0.85	0.79
	Total	**2.99**	**2.77**	**2.53**	**2.55**	**-3.13**	**-3.20**	**-2.66**	**-3.77**	**-3.89**
FM	Above ground biomass	-20.3	-20.4	-20.9	-23.9	-23.68	-23.72	-24.02	-24.00	-23.90
	Below ground biomass	-6.91	-6.99	-7.01	-8.10	-7.93	-7.96	-8.06	-8.06	-8.04
	Dead wood	-9.48	-9.06	-7.02	-6.87	5.29	5.33	5.40	5.26	5.28
	Litter	5.38	5.40	5.66	5.67	-8.02	-7.40	-6.60	-7.48	-6.96
	Soil organic carbon	-4.46	-4.45	-4.45	-4.44	-5.70	-5.70	-5.88	-5.88	-5.98
	Total	**-35.8**	**-35.5**	**-33.7**	**-37.6**	**-40.04**	**-39.44**	**-39.16**	**-40.15**	**-39.60**

The quite large deviation in living biomass under AR and D between submissions might be further analyzed. Except for recalculations described in 7.6.1, another major change in methodology has been made under the KP. Before the interpolation between inventories was made on a tree by tree basis but is now based on plot basis. We find the new methodology more robust. Finally the accumulation of areas and living biomass is now purely from 1990 (the accumulation has been from 1989 for some sample plots). The difference in estimates of living biomass for submissions 2013 and 2014 is found in Figure 11.6.

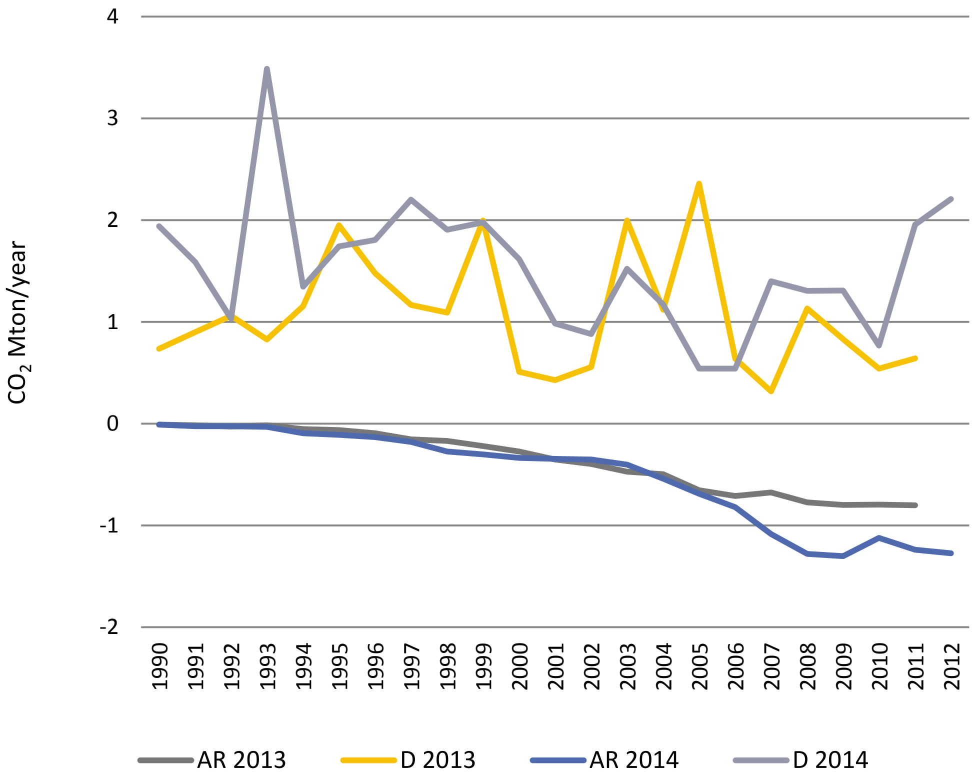

Figure 11.6. The difference in reported living biomass between submission 2013 and 2014 for activities AR and D

11.3.1.4 UNCERTAINTY ESTIMATES

Estimates of carbon stock changes are based on the same underlying data as the reporting under the UNFCCC. These estimates 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 at laboratory. We assume that the major source of uncertainty arise 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 assumed by expert judgment. From submission 2013, Sweden provides separate formal estimates of uncertainty of AR and D, respectively.

Based on 30000 sample plots the accuracy of estimates of carbon stock changes for ARD activities are certain in absolute but uncertain in relative terms. The estimated accuracy (Standard Error) for living biomass for AR and D is around 0.3 and 0.5 Mtonnes CO_2 per year, respectively. This is valid when estimates are based on all 30000 sample plots. However, if based on one year sample (6000 plots), the estimated accuracy (Standard Error) for living biomass for AR and D is much higher and to increase the accuracy Sweden uses extrapolated data for the most recent years. Since ARD is quite uncommon in Sweden and quite close to zero the relative error might be large. The corresponding estimated accuracy for FM is 3 Mtonnes CO_2 per year (when based on 6000 sample plots, 7 Mtonnes CO_2 per year). Three Mtonnes CO_2 per year should be compared with a total stock of more than 4000 Mtonnes CO_2 (relative error 0.07 %). For other carbon pools than living biomass, the uncertainty is based on assumptions[300].

Table 11.6. Estimated and assumed uncertainty for KP-activities. (Uncertainty=2•relative "standard error")

		2·Relative Standard Error [%]		
Activity	Category	CO_2	N_2O	CH_4
FM	Living biomass	22	-	-
	Dead organic matter	50	-	-
	Soil organic carbon	35	-	-
	Direct N fertilization, 5 (I)	-	50	-
	Biomass burning, 5 (V)	-	75	75
AR	Living biomass	42	-	-
	Dead organic matter	70	-	-
	Soil organic carbon	35	-	-
D	Living biomass	82	-	-
	Dead organic matter	70	-	-
	Soil organic carbon	35	-	-
	Conversion Cropland, 5 (III)	-	100	-

11.3.1.5 INFORMATION ON OTHER METHODOLOGICAL ISSUES

There are currently no methods identified that needs further clarification than those already explained.

[300] This section is an amendment due to a request from reviewrs (ARR 2011) to improve the information on uncertainties in estimates of ARD.

11.3.1.6 THE YEAR OF THE ONSET OF AN ACTIVITY, IF AFTER 2008

The onset of activities follows IPCC GPG for LULUCF (IPCC[301]) and no activity has been set on after 2008.

11.4 Article 3.3

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced

Sweden defines D as land use conversions from Forest land (all managed) to Cropland, Grasslands or Settlements (all land under these three categories are assumed managed). AR is defined as land use conversions in the opposite direction (Figure 11.2). Land use categories are strictly defined (see NIR chapter 7.2.3) and land use conversions are confirmed in field at consecutive inventories. The estimates are based on area sampling using the approximately 30 000 permanent sample plots (see chapter 7 for further details on the NFI). The inventory has been consistent since 1983.

This implies that Sweden uses the broad interpretation of “direct human induced” and an active human removal of trees followed by a land use conversion from Forest land to a managed non-forest land use category is considered direct human induced deforeststation. This is also valid for the choice to actively abandon managed land in favour for the management of forests (afforestation/reforestation). The management of Forest land on abandoned former managed non-forest land is regulated by the Forestry act (1979:429). The intention of a human induced land use conversion should be permanent. If, for example, a land owner decides to convert former Cropland to Forest land by planting trees, this action is considered AR, but if the land owner in the future decides to cultivate this land back to Cropland, then the land with be reported under D. No such reversed-conversions have been identified (this far).

The NFI is used to confirm that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced. If the land use of a sample plot or part of a sample plot is considered conversed between consecutive inventories the year of conversion is randomly distributed.

11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

Final felling is a natural step in the rotation cycle of forestry. Also storms may result in large areas of felled trees (wind-throws). If final felling or disturbances as

[301] Intergovernmental Panel on Climate Change, 2003

storms have been identified between two consecutive inventories this is not enough to classify the plot as D. However, if for instance a new road, a power line or other land use preceding the definition of forest is located on the former Forest land, then the plot is considered D. The emission from "loss of biomass" is matched to the conversion year. If final felling has occurred on a plot between two consecutive inventories with no sign of D, but D is confirmed at the next re-inventory, then the year of D is "re-calculated" to match the "loss of biomass" to the conversion year.

11.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

About 200 000 ha[302] Forest land is annually losing its forest cover as a natural step in the forest rotation cycle. The position and status of every sample plot that has lost forest cover is known but D is not reported until confirmed (see 11.4.2). The geographical position and area of all final fellings on Forest land are monitored by detection of changes using the remote sensing system ENFORMA[303]. Each land owner has to apply to the Forestry Agency before harvest and in that regard, state whether the removal of trees is a natural step in the forest rotation cycle or harvest followed by a permanent land use change (D).

11.5 Article 3.4

11.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human induced

The activity FM is assumed to occur on all Forest land and land areas with first classification FM is reported under Article 3.4 FM. Land reported under AR usually has secondary classification FM. Land under activity FM is accumulated from 1990 but could leave this category for D at any time. Before 2008 (but not during the commitment period), land under FM could leave this category by natural degradation to Wetland or Other land and is then not reported at all. This IPCC-rule has no practical significance for reported removals/ emissions. The area under FM is quite stable and all land use categories, including Forest land, are consistently monitored in field since 1983. Therefore it is possible to trace back all land use categories and land use conversions to at least 1990. "Human induced" is assumed equivalent with "managed" and all Forest land is assumed managed. Most forest biomass is actively managed for timber and pulp production and remaining forest biomass is managed for nature conservation. The definition used coincides with definition of Forest land according to the Forestry act (1979:429).

[302] Swedish University of Agricultural Sciences, 2010

[303] Olsson et al, 2005

11.5.2 Information relating to Cropland Management, Grazing Land Management, and Revegetation, if elected, for the base year

Sweden has not elected these activities.

11.5.3 Information relating to Forest Management

The net removal from living biomass is important for the total net removal reported under FM. The net removal from living biomass is the result from growth and drain and is sensitive to the demand of forest products from the forest industry.

11.6 Other information

11.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

The key-category analysis is based on a combination of correspondence to the UNFCCC-key category analysis (Table 7.3) and a qualitative approach (IPCC GPG for LULUCF (IPCC[304]), p 5.38-5.40). Thus, CO_2 emissions for FM and AR should be considered key for carbon pools. And since CO_2 for conversions to Settlements is considered key for UNFCCC and from a qualitative approach (we simply find D important) we consider also D as key. Higher Tier methologies are used for all carbon pools. (Sweden has neither elected CM nor GM and, thus, liming is not relevant under the KP).

N_2O from land use conversions to Cropland was the last key-category added under the UNFCCC. However, this category consists of land use conversions from nearly all land use categories, and not only from Forest land. Thereby, Sweden does not consider D to be key for N_2O.

No other key categories were identified.

11.7 Information relating to Article 6

Information relating to Article 6 is provided in Annex 6:1 and 6:3.

11.8 Coming improvements

The Swedish improvements will focus on the adaption to the new reporting guidelines for the second commitment period. Thus Sweden will rank efforts to improve after carefully analyzing consequences of introducing the new guidelines adopted by the COP. This work has been going on for several years and the final decisions are planned to be taken in the near future.

[304] Intergovernmental Panel on Climate Change, 2003

12 Information on accounting of Kyoto units

12.1 Background information

Each Party must include information on its aggregate holdings and transactions of Kyoto Protocol units in its annual report. The reporting will be submitted according to the special report standard, the Standard Electronic Format (SEF) with the annual inventory on 15 April. Sweden began the annual reporting in 2009.

Sweden's Standard Electronic Format report for 2014 containing the information required in paragraph 11 of the annex to decision 15/CMP.1 The SEF will be submitted to the UNFCCC Secretariat electronically.

12.2 Summary of information reported in the SEF tables

Annual Submission Item	Party provided content
15/CMP.1 annex I.E paragraph 11: Standard electronic format (SEF)	Sweden's Standard Electronic Format report for 2013 will contain the information required in paragraph 11 of the annex to decision 15/CMP.1. See document "SEF_SE_2014_1_21-11-47 3-2-2014"

12.3 Discrepancies and notifications

Annual Submission Item	Party provided content
15/CMP.1 annex I.E paragraph 12: List of discrepant transactions	Refer to Separate Electronic Attachment "SIAR Reports 2013-SE v 1.0.xls" Worksheet R2.
15/CMP.1 annex I.E paragraph 13 & 14: List of CDM notifications	No CDM notifications were received by the National Registry during the 2013 reporting period, pursuant of 15/CMP.1 annex I.E paragraphs 13 & 14. Refer to Separate Electronic Attachment "SIAR Reports 2013-SE v 1.0.xls" Worksheet R3.
15/CMP.1 annex I.E paragraph 15: List of non-replacements	No non-replacements occurred during the 2013 reporting period, pursuant of 15/CMP.1 annex I.E paragraph 15.

Annual Submission Item	Party provided content
	Refer to Separate Electronic Attachment "SIAR Reports 2013-SE v 1.0.xls" Worksheet R4.
15/CMP.1 annex I.E paragraph 16: List of invalid units	No invalid units exist as at 31 December 2013, pursuant of 15/CMP.1 annex I.E paragraph 16. Refer to Separate Electronic Attachment "SIAR Reports 2013-SE v 1.0.xls" Worksheet R5.
15/CMP.1 annex I.E paragraph 17: Actions and changes to address discrepancies	No actions and changes to address discrepancies have been performed during the reported period. This due to that the conversion transactions who resulted in final status "terminated" were terminated due to an error in the limit for conversion set in the registry.

12.4 Publicly accessible information

Annual Submission Item	Party provided content
15/CMP.1 annex I.E Publicly accessible information	The following information is now deemed publicly accessible and as such is available via the homepage of the SE registry and Swedish Energy Agency – http://www.energimyndigheten.se/en/Sustainability/EU-ETS---Implementation-in-Sweden/EUETS/Reports/ and via the link directly to the account holder information. In accordance with the requirements of Annex E to Decision 13/CMP.1, all required information for a Party with an active Kyoto registry is provided with the exceptions as outlined below.

	Account Information (Paragraph 45) and Account holders authorised to hold Kyoto units in their account (Paragraph 48) In light of the amendments introduced by Article 78 of the revised Registries Regulation that came into force in October 2010 and 2013 and for security reasons, it is considered that the representative identification information as required in paragraph 45 and paragraph 48 is held as confidential. Since there are no provisions in Swedish law on which kyoto unit types legal entities are authorised to hold in the Swedish National Registry, It is difficult to provide a list of legal entities authorized to hold party holding accounts. All legal entities (person or organisation) authorized to participate in the Swedish national registry under the Kyoto mechanisms, must have a separate holding account for each legal entity according to the Data Exchange Standards (DES). The list of legal entities that currently have party holding accounts in the Swedish registry can be found through a report tool on the following public website: http://www.energimyndigheten.se/en/Sustainability/EU-ETS---Implementation-in-Sweden/EUETS/Reports/ **JI projects in Sweden (Paragraph 46)** Two Article 6 (Joint Implementation) projects have been reported for conversion to ERU under an Article 6 project, and the conversion occurred in the specified period. The list of the conversion that occurred in the Swedish registry can be found through a reports on the following public website: http://www.energimyndigheten.se/en/Sustainability/EU-ETS---Implementation-in-Sweden/EUETS/Reports/Kyoto-units-in-SUS/ **Holding and transaction information of units (Paragraph 47)** Holding and transaction information is provided on a holding type level, due to more detailed information being declared confidential by EU Regulation. Article 10 of EU Regulation 2216/2004/EC, provides that "All information, including the holdings of all accounts and all transactions made, held in the registries and the Community independent transaction log shall be considered confidential for any purpose other than the implementation of the requirements of this Regulation, Directive 2003/87/EC or national law." Paragraph 47c The total quantity of ERUs issued and converted on the basis of Article 6 projects (Joint Implementation), are displayed in the public accessible information on the web site.

15/CMP.1 annex I.E Publicly accessible information	Paragraph 47e Sweden does not perform LULUCF activities and therefore does not issue RMUs Paragraph 47g No ERUs, CERs, AAUs and RMUs have been cancelled on the basis of activities under Article 3, paragraphs 3 and 4 to date. Paragraph 47h No ERUs, CERs, AAUs and RMUs have been cancelled following determination by the Compliance Committee that the Party is not in compliance with its commitment under Article 3, paragraph 1 to date. Paragraph 47j No ERUs, CERs, AAUs and RMUs have been retired, other than retirements of CERs and AAUs as an outcome of the EU compliance retirement within EU Emission Trading Scheme (EU ETS) and not through retirement under article 3, paragraphs 3 and 4. Retired CERs and AAUs are presented in the SEF report. Paragraph 47k There is no previous commitment period to carry ERUs, CERs, and AAUs over from.

12.5 Calculation of the commitment period reserve (CPR)

12.5.1 Assigned Amount

The assigned amount pursuant to Article 3, paragraphs 7 and 8, has been calculated in accordance with the annex to decision 13/CMP.1. Sweden's base year is 1990 and the Party has chosen 1995 as the base year for HFCs, PFCs and SF_6. Sweden's quantified emission limitation is 92 per cent as included in Annex B to the Kyoto Protocol. As Sweden is part of the European Community, whose Member States will meet their reduction commitment jointly in accordance with Article 4 of the Kyoto Protocol, Sweden's quantified emission limitation is 104 per cent. Sweden's assigned amount is calculated based on the Party's Article 4 commitment.

In response to inventory issues identified during the review of the Initial Report, Sweden submitted revised estimates of its base year inventory, which resulted in a recalculation of the assigned amount. Based on the revised estimates for Sweden's base year emissions – 72 152 Gg CO_2 eq. equal to 72 151 646 tonnes CO_2 eq. – the assigned amount is calculated to be 375 189 Gg CO_2 eq. equal to 375 188 559 tonnes CO_2 eq.

12.5.2 Commitment Period Reserve (CPR)

According to the annex to decision 11/CMP.1 (paragraph 6), “Each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90 per cent of the Party’s assigned amount calculated pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol, or 100 per cent of five times its most recently reviewed inventory, whichever is lowest.”

Sweden’s original commitment period reserve was based on 90 per cent of assigned amount. However in the centralized review of submission 2009 the ERT pointed out that the option “100 per cent of five times its most recently reviewed inventory” gave a lower CPR. The CPR for submission 2009 was recalculated and since then the CPR has been calculated as the amount of 100 per cent of five times the national total not including LULUCF.

In submission 2014 the CPR is calculated from “100 per cent of five times its most recently reviewed inventory”. The national total not including LULUCF (in 2012 reported in submission 2014) is 57 604 Gg CO_2 eq. equal to 57 604 150 tonnes CO_2 eq. The CPR is then 288 020 Gg CO_2 eq. equal to 288 020 751 tonnes CO_2 eq.

12.6 KP-LULUCF accounting

Sweden reports and accounts for activities under article 3.3 and the activity Forest management under article 3.4 of the Kyoto protocol. Detailed descriptions on definitions of activities and carbon pools as well as methods for the quantification of emissions and removals related to these activities can be found in chapter 11 of the NIR. For 2010 the activities under article 3.3 constituted a net source of 2.0 Mtonnes CO_2. Forest management under article 3.4 constituted a removal of 37 Mtonnes CO_2. After offsetting the article 3.3 source the remaining removal from Forest management constitutes 35 Mtonnes CO_2. However, final accounting quantity for 2010 is limited by the cap to 2.13 Mtonnes CO_2. It may be noted that Sweden has elected commitment period accounting. The referred figures represent only 2010.

13 Information on changes in national system

There have been no changes to the national system since last submission.

14 Information on changes in national registry

The following changes to the national registry of Sweden have therefore occurred in 2013.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	No changes of name or contact regarding the RSA.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	An updated diagram of the database structure is attached as Annex A. Iteration 5 of the national registry released in January 2013 and Iteration 6 of the national registry released in June 2013 introduces changes in the structure of the database. Changes introduced in release 5 and 6 of the national registry were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. No change to the capacity of the national registry occurred during the reported period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced in release 5 and 6 of the national registry were limited and only affected EU ETS functionality. However, each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No change of security measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	A major change in publicly available information occurred during the reporting period. Sweden has included the public information directly on a website controlled by the Party. The publicly available information is up to date (i.e. updated as close to real time as possible, updated on a monthly basis at the least). http://www.energimyndigheten.se/en/Sustainability/EU-ETS---Implementation-in-Sweden/EUETS/Reports/ and more precise http://www.energimyndigheten.se/Global/F%c3%b6retag/Handel%20med%20utsl%c3%a4ppsr%c3%a4tter/SE-REPORT-ACCOUNT-INFORMATION.XLS
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reporting period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced in release 5 and 6 of the national registry were limited and only affected EU ETS functionality. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission; the report is attached as Annex B.
The previous Annual Review recommendations FCCC/ARR/2013/SWE	See below

In response to the previous Annual Review recommendations, the following document was submitted as a second addendum to Chapter 14: 'Information on changes in national registry' of the Annual Inventory Submission for the reporting year 2012.

Reference	Recommendation description	Response
1.4.1	The assessor notes that this public information was not provided on a website controlled by the party per Paragraph 44 of the annex to decision 13/CMP.1.	Sweden has included the public information directly on a website controlled by the Party. The publicly available information is up to date (i.e. updated as close to real time as possible, but at least updated on a monthly basis). http://www.energimyndigheten.se/en/Sustainability/EU-ETS---Implementation-in-Sweden/EUETS/Reports/

2.3.3	The assessor recommends that following major changes, the party provide a data model which contains all DES required entities complete with descriptions in its annual NIR.	The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. Since the successful certification of the registry on 1 June 2012, Iteration 4 of the registry, introduced in October 2012, added a limited number of new entities, none of them relating to DES entities. A data model was attached which more clearly shows the relevant entities "RECONCILIATIONS", "NOTIFICATIONS", "RESPONSES"," INTERNAL AUDIT LOG" and "MESSAGE LOG." As specified in the DES (Section VII. Data Logging Specifications/E. Message Archive), a copy of messages sent and received is stored in standalone files in one of two managed servers in the hosting environment. For that reason, the Message Archive is not shown in the model. The "MESSAGE LOG" object holds the location of the entire message, for each Message_ID. Since the successful certification of the registry on 1 June 2012, there has been no change in the capacity of the registry or change of its infrastructure.
2.3.10	The assessor strongly recommends that the Party test each release thoroughly against the DES as part of each major release cycle and provide the results of such tests in its an-	The consolidated EU system of registries successfully completed a full certification procedure in June 2012. Notably, this procedure includes connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the Data Exchange Standard (DES). This included a full Annex H test. All tests were executed successfully and led to successful certification on 1 June2012 The October 2012 release (version 4.0) was

	nual NIR.	only a minor iteration and changes were limited to EU ETS functionality and had no impact on Kyoto Protocol functions in the registry. The test script previously provided reflects this. However, each major release of the registry is subject to both regression testing and tests related to new functionality. These tests include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production.

15 Information on minimization of adverse impacts in accordance with Article 3, paragraph 14

The Swedish reporting of information regarding minimizations of adverse impacts in accordance with Article 3, paragraph 14 of the Kyoto Protocol is presented below. The outline follows that of CMP 15: § 23 and § 24.

Changes in information provided under Article 3, paragraph 14

The following changes and complements in the information since Sweden's last annual submission have been provided:

- Paragraph 23 has been complemented with information about Sweden's policy for global development (PGD) (Paragraph 23)
- The Government's Special Climate Change Initiative (Paragraph 23)
- The Government has signed cooperation agreements on environmental or energy technology with a number of countries, among them the United States, Brazil, China, Russia and India. (Paragraph 24 (f))

Paragraph 23

Each Party included in Annex I shall provide information relating to how it is striving, under Article 3, paragraph 14, of the Kyoto Protocol, to implement its commitments mentioned in Article 3, paragraph 1, of the Kyoto Protocol in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention

According to the provisions of Article 2 of the Kyoto Protocol, each party with quantified commitments under the Protocol is to introduce policies and measures to achieve the emission reductions to which it has made a commitment. The measures implemented are to be compatible with overarching objectives of sustainable development. Measures which would mean that all greenhouse gases regulated by the Protocol can decrease and cover all sectors of society are emphasised. The parties to the Kyoto Protocol are to aim to introduce policies and measures so that adverse effects are minimised. Such effects include adverse effects of a changed climate, effects on international trade and social, environmental and economic effects on other parties, particularly on developing countries.

In connection with the implementation of policies and measures in Sweden, an impact assessment is carried out, including an environmental impact assessment as a basis for decision-making. Such an analysis as far possible also includes assessing the risk of adverse effects in other countries. Formulation of proposals for changes of policy instruments is undertaken in a consultation procedure that makes it possible for operators concerned to give their comments on the proposals. In consultations that include suggestions for new rules or guidelines that may affect trade with other country shall be notified within the EU and to be alerted under the WTO's rules. This process makes it possible for other countries to influence the design of proposals for changed policy instruments and highlight any negative side effects that may arise.

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

The Swedish research activities, as indicated in Chapter 8 of Sweden’s National Communication Report 6 (NC 6), among other things contribute to a sustainable global development. There are several examples of interdisciplinary research efforts focused on improving knowledge of effects globally (socially, economically and ecologically) of large-scale introduction of measures to reduce greenhouse gas emissions. Sweden’s focus on increased use of bioenergy, both through increased domestic production but also through increased imports in particular from developing countries, has meant that this area has been specially prioritised in systems-science research in the country.

Results from research have already influenced, and will in future influence, the development of policy. The special sustainability criteria devised for vehicle biofuels under the EU Renewables Directive is one such example.

Both positive and negative effects must be taken into account. Sweden contributes to a number of measures that may have positive effects on the prospects of developing countries adapting to climate change and implementing their own measures to reduce their greenhouse gas emissions. A description is given in Chapter 7 of NC 6 of such efforts in the areas of technology transfer, capacity building and support for adaptation measures. In addition, over the period 2009-2012 the Government’s Special Climate Change Initiative channelled resources through multilateral climate funds and initiatives as well as bilaterally to countries exposed to a high climate risk combined with high vulnerability.

Finally Sweden wishes to emphasise that its climate strategy with its broad focus on many different types of measures covering the majority of sectors of society (both in and outside the country) and all greenhouse gases governed by the Kyoto Protocol has a form which fundamentally limits (minimises) the risk of adverse effects.

Paragraph 24 (a)

Annex II Parties shall incorporate information on how they give priority to the following actions:
(a) The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities

Sweden has to a large extent reformed the energy markets and phased out any market imperfections. The market price on electricity is deregulated and governed by the balance between demand and supply on a cross-border electricity market. In Sweden fossil fuels used outside the EU emissions trading scheme (ETS) is subject to a carbon dioxide tax to reflect the external cost. In EU ETS it is mainly the price of allowances that reflects the external effect of carbon dioxide emissions and the market failure.

Paragraph 24 (b)

Removing subsidies associated with the use of environmentally unsound and unsafe technologies.

Sweden does not extract oil, natural gas or coal, and therefore, has no subsidies on these fuels. With the introduction of the EU ETS for CO2 emissions a cost has been imposed on environmentally harmful technologies such as fossil fuel based heat- and electricity production and industries.

Paragraph 24 (c)

Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end

The chemical industry including refineries contributes to a fairly small share of the overall Swedish industrial production. This technological field is not a high priority in the Swedish research policy.

Paragraph 24 (d)

Cooperating in the development, diffusion, and transfer of less-greenhouse-gas-emitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use;

and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort

Sweden has an almost fossil free heat- and power production and therefore don't give priority to research and technology development in the field of advanced fossil based techniques for electricity and heat production technology. Since there is an automotive industry in Sweden, research programmes in the areas of hybrid technologies, automatic control systems for more energy-efficient internal combustion engines and the use of diesel oil for hydrogen production have been carried out over a long period of time. The programmes are designed in particular to contribute to reduced fuel consumption for road vehicles. A development which is also of value for more fuel efficient passenger- and goods transport in non-Annex 1 countries, particularly those who are dependent on imports of oil, diesel and petrol.

Carbon Capture and Storage technology has in recent years been given priority in the Swedish research and climate policy and Sweden is keen on launching a demonstration project in this area. In the long term Sweden have the ambition to participate in the field of multilateral research collaborations.

Paragraph 24 (e)

Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities

Sweden contribute to technology development in developing countries through development assistance and CDM projects, see chapter 4 of NC 6. The focus on transfer of technologies is primarily on energy efficiency technologies and on the introduction of renewable energy, but also to contribute to capacity-building. By providing knowledge about how CDM projects evolve, are administered and implemented for approval, which Sweden has made in African countries, the ability to *inter alia* obtain technology that enhances the efficiency of fossil fuel-intensive activities as well as other climate-related environmental technology projects improves.

Paragraph 24 (f)

Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies

Sweden assists developing countries which are dependent on imports for its fossil fuel consumption with the transfer of more energy-efficient technologies, renewable energy technologies and capacity-building which enhances diversification of the economy in these countries (see chapter 7 of NC 6). Inter alia, the Government has signed cooperation agreements on environmental or energy technology with a number of countries, among them the United States, Brazil, China, Russia and India. Special emphasis within the frame of this cooperation has been given to the field of environmental and energy technologies, including sustainable urban planning.

In addition to development cooperation projects, Sweden is engaged in CDM projects in biomass based electricity generation, wind energy, biogas production, hydro-electric power production and energy efficiency projects which contribute to economic development and diversification of the economy in fossil fuel dependent developing countries. Capacity-building about how CDM projects evolve, are administered and implemented for approval, which Sweden has made in African countries, support a greater diversification of the economy in the countries concerned. (see chapter 4 of NC6).

16 Other information

16.1 References

Section 1

EMEP/CORINAIR Emission Inventory Guidebook: http://reports.eea.eu.int/EMEPCORINAIR4/en

Gustafsson, T. 2005. Improved structures for uncertainty analysis. SMED report 69 2005.

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16.2 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
A	
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
CO	Carbon monoxide
CO_2	Carbon dioxide
COP	Conference Of the Parties
CORINAIR	EMEP/CORINAIR Emission Inventory Guidebook
CRF	Common Reporting Format
D	Deforrestation
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 Ariculture Organisation of the UN
FOD model	IPCC First Order Decay model
FOI	Swedish Defence Research Agency
FORTV	Swedish Fortification Department
FRA	Forest Resource Assesment
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_2O	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
NIR	National Inventory Report
NMVOC	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 indusry 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
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

[1] Based on one cycle (estimates based on approximately 20% of the plots) the total land and fresh water area deviates 0.3%.