NATUR VÅRDS VERKET

National Inventory Report Sweden 2012 Annexes

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

Cover photo: Vålådalen, Jämtland. Hakam Al-Hanbali

Contents

Annex 1 Key Categories

Key Categories (including and excluding LULUCF) are presented below and in section 1.5 of the NIR.

Description of methodology used for identifying key categories

The analysis has been made for all years using the tier 1 and tier 2 levels and trend assessment according to the methods described in the 2006 IPCC guidelines. The tier 1 method assesses the impacts of various source/sink categories on the level and the trend of the national emission inventory. The tier 2 method includes information on uncertainties.

In the tier 1 analysis key categories are the aggregated sources that together contribute with either 95% of the level or 95% of the overall contribution to trend of all greenhouse gas emissions in Sweden. In the tier 2 analysis information about the sources' uncertainty are also included in the analysis. Tier 2 key categories are those that add up to 90 % of the contribution to level and trend in the national inventory.

The analysis is performed for all direct greenhouse gases, i.e. CO_2, CH_4, N_2O, HFCs, PFCs and SF_6, with all emissions converted to CO_2 equivalents (GWP-values are presented in Appendix 1).

Tier 1 level assessment

The contribution of each source or sink category to the total national inventory level is calculated as:

$$L_{x,t} = \left|E_{x,t}\right| / \sum_{y} \left|E_{y,t}\right|$$

$L_{x,t}$= level assessment for source or sink *x* in latest inventory year (year *t*).

$\left|E_{x,t}\right|$ = absolute value of emission or removal estimate of source or sink category *x* in year *t*

$\sum \left|E_{y,t}\right|$ = total contribution, which is the sum of the absolute values of emissions and removals in year *t* calculated using the aggregation level chosen by the country for key category analysis. Because both emissions and removals are entered with positive sign, the total contribution/level can be larger than a country's total emissions minus removals.

Key categories are those that, when summed together in descending order of magnitude, add up to 95 percent of the sum of all $L_{x,t}$.

Tier 1 trend assessment

For the latest inventory year (year t), the trend assessment is calculated for each source or sink category and each GHG. If inventory data are available for both the base year and year t the trend assessment is calculated as (in accordance with the 2006 IPCC guidelines):

$$T_{x,t} = \frac{\left|E_{x,0}\right|}{\sum_y \left|E_{y,0}\right|} = \left| \left[\frac{(E_{x,t} - E_{x,0})}{\left|E_{x,0}\right|} \right] - \frac{\left(\sum_y E_{y,t} - \sum_y E_{y,0} \right)}{\left| \sum_y E_{y,0} \right|} \right|$$

$T_{x,t}$= trend assessment of source or sink category *x* in year *t* as compared to the base year (year 0)
$\left| E_{x,0} \right|$ = absolute value of emission or removal estimate of source or sink category *x* in year 0
$E_{x,t}$ and $E_{x,0}$ = real values of estimates of source or sink category *x* in years *t* and 0, respectively
$\sum E_{y,t}$ and $\sum E_{y,0}$ = total inventory estimates in years *t* and 0, respectively

If there is no base year emission for a given category the trend assessment is instead calculated as:

$$T_{x,t} = \left| E_{x,t} / \sum_y \left| E_{y,0} \right| \right|$$

Tier 2 level and trend assessments

When the information from the Tier 1 key categories analysis is combined with the outcome from the uncertainty analysis, it results in a Tier 2 key category analysis. IPCC encourages inventory compilers to use this approach if possible. It will provide additional insight into the reasons why particular categories are *key* and will assist in prioritizing activities to improve inventory quality and reduce overall uncertainty. The level and trend assessment including uncertainty is calculated as:

$$LU_{x,t} = (L_{x,t} \times U_{x,t}) \quad , \quad TU_{x,t} = (T_{x,t} \times U_{x,t})$$

Where $L_{x,t}$ and $T_{x,t}$ are the results from the tier 1 level and trend analysis, respectively. $U_{x,t}$ is the category percentage uncertainty in year *t* calculated as described in Annex 7. The key categories are those that add up to 90 percent of the sum of all $LU_{x,t}$ or 90 percent of the contribution to trend and $TU_{x,t}$, respectively, when ranked by decreasing order of magnitude.

Reference to the key categories tables in the CRF

Table 7 of the CRF tables, Summary Overview for Key Categories, have been filled for 1990 and 2010.

Information on the level of disaggregation

The aggregation level of sources without the LULUCF sector is in line with the aggregation found in reported CRF-tables (CRF 1, 2, 3, 4 and 6). This enables us to distinguish between, for example, stationary combustion in different sectors, which is important for the national analysis of greenhouse gas emissions. The aggregation level of sinks/sources for the LULUCF sector is made per land use category and reported greenhouse gas.

Tables 7.A1 - 7.A3 of the IPCC good practice guidance

Tables corresponding to table 7.A1 – 7.A2 in GPG, are provided in tables A1.1 – A1.8 below. Table 7.A3 is included in the CRF tables for 1990 and 2010 and in NIR section 1.5.

As can be seen in Table A1.1 emissions of CO_2 from Road transportation (CRF 1A3b) followed by emissions of CO_2 from Public electricity and heat production (CRF 1A1a) are in top in 2010 in the tier 1 level assessment excluding LULUCF. They contribute with 29 % and 15 %, respectively, of the national total and are the top two on the level assessment list for all years.

In 2010, 32 key categories in terms of trend have been identified, excluding LULUCF (Table A1.3). The Energy Sector (CRF 1) contributes with the majority of key categories (19), while Industrial Processes (CRF 2), Agriculture (CRF 4) and Waste (CRF 6) account for 7, 4 and 2 key categories, respectively.

In 2010, the sources with the most significant increase in trend since 1990 are CO_2 from Road transportation (1A3b), followed by CO_2 from Public electricity and heat production (1A1a), contributing with 14 % and 13 %, respectively, to the overall trend. Road transportation has been on the top-ten list every year since 1995.

Other interesting categories with regard to the trend are those with decreasing emissions. Among them, CO_2 emissions from the Residential sector (1A4b) and the Commercial/Institutional sector (1A4a) are in top in 2010 contributing 20 % and 7 %, respectively, to the overall trend. Emissions of CH_4 from Solid waste disposal on land (6A) account for the third most significant decrease in the overall emission trend with a 6 % contribution.

Table A1.2 and Table A1.4 show the tier 1 level and trend assessments including LULUCF categories 2010 in the national inventory. Emissions/removals of CO_2 were found to be key for one or more years for Forest land (5A), Cropland (5B), Grassland (5C) and Settlements (5E). One reason for this is that these pools

are important according to level. Another reason is changes in harvest intensity that may lead to high fluctuations in stocks between years (trend).

The tier 2 level and trend assessments (Table A.1.5 - Table A1.8) result in higher priority to categories with high uncertainties in sources or sinks compared to the tier 1 assessments, e.g. Direct soil emissions (CRF 4.D.1), Indirect emissions (CRF 4.D.3) and Solid waste disposal on land (CRF 6.A). The tier 2 assessments also add a few new key categories to the inventory, such as CH_4 in CRF 1.A.4.b (Residential), CH_4 in CRF 1.A.4.c (Agriculture/Forestry/Fisheries), N_2O in CRF 1.A.5.b (Military use) and CH_4 from fugitive emissions from oil and natural gas (CRF 1B2).

Table A 1.1. Key Category Analysis Tier 1 Level Assessment Excluding LULUCF

IPCC Source Category	Gas	Base year emissions or removals	Year 2010 emissions or removals	Level Assessment Year 2010 (Excl LULUCF)
1.AA.3.B (Road Transportation)	CO2	17310	18962	0.286
1.AA.1.A (Public Electricity and Heat Production)	CO2	7718	10014	0.151
1.AA.2.F (Other Manufacturing Industries and Construction)	CO2	5462	4564	0.069
4.A (Enteric Fermentation)	CH4	3070	2713	0.041
2.C.1 (Iron and Steel Production)	CO2	2465	2701	0.041
4.D.1 (Direct Soil Emissions)	N2O	2792	2482	0.037
1.AA.1.B (Petroleum Refining)	CO2	1778	2130	0.032
1.AA.2.A (Iron and Steel)	CO2	1638	1773	0.027
1.AA.4.C (Agriculture/Forestry/Fisheries)	CO2	1595	1684	0.025
1.AA.2.D (Pulp. Paper and Print)	CO2	2186	1399	0.021
2.A.1 (Cement production)	CO2	1272	1350	0.020
6.A (Solid Waste Disposal on Land)	CH4	2874	1279	0.019
1.AA.2.C (Chemicals)	CO2	1128	1276	0.019
1.AA.4.B (Residential)	CO2	6256	1200	0.018
1.B.2 (Oil and Natural Gas)	CO2	304	882	0.013
2.F.1 (Refrigeration and Air Conditioning Equipment)	HFC	4	844	0.013
4.D.3 (Indirect Emissions)	N2O	1132	830	0.013
1.AA.3.D (Navigation)	CO2	542	729	0.011
1.AA.4.A (Commercial/Institutional)	CO2	2533	722	0.011
4.D.4 (Agricultural Soils. Other)	N2O	718	687	0.010
2.A.2 (Lime Production)	CO2	295	526	0.008
1.AA.1.A (Public Electricity and Heat Production)	N2O	304	502	0.008
1.AA.2.E (Food Processing. Beverages and Tobacco)	CO2	948	484	0.007
1.AA.3.A (Civil Aviation)	CO2	673	465	0.007
4.B (Manure Management)	N2O	733	460	0.007
4.D.2 (Pasture, Range and Paddock Manure)	N2O	386	406	0.006
1.AA.2.F (Other Manufacturing Industries and Construction)	N2O	330	331	0.005
1.AA.1.C (Manufacture of Solid Fuels and Other Energy Industries)	CO2	299	317	0.005
2.B.2 (Nitric Acid Production)	N2O	814	312	0.005
1.AA.3.E (Other Transportation)	CO2	271	304	0.005
6.B (Wastewater Handling)	CH4	292	299	0.005
4.B (Manure Management)	CH4	233	295	0.004
Total				0.95

Table A 1.2. Key Category Analysis Tier 1 Level Assessment Including LULUCF

IPCC Source Category	Gas	Base year emissions or removals	Year 2010 emissions or removals	Level Assessment Year 2010 (Incl LULUCF)
5.A (Forest Land)	CO2	-44107	-38152	0.347
1.AA.3.B (Road Transportation)	CO2	17310	18962	0.172
1.AA.1.A (Public Electricity and Heat Production)	CO2	7718	10014	0.091
1.AA.2.F (Other Manufacturing Industries and Construction)	CO2	5462	4564	0.041
5.E (Settlements)	CO2	1228	2865	0.026
4.A (Enteric Fermentation)	CH4	3070	2713	0.025
2.C.1 (Iron and Steel Production)	CO2	2465	2701	0.025
4.D.1 (Direct Soil Emissions)	N2O	2792	2482	0.023
1.AA.1.B (Petroleum Refining)	CO2	1778	2130	0.019
5.B (Cropland)	CO2	2414	1805	0.016
1.AA.2.A (Iron and Steel)	CO2	1638	1773	0.016
1.AA.4.C (Agriculture/Forestry/Fisheries)	CO2	1595	1684	0.015
1.AA.2.D (Pulp. Paper and Print)	CO2	2186	1399	0.013
2.A.1 (Cement production)	CO2	1272	1350	0.012
6.A (Solid Waste Disposal on Land)	CH4	2874	1279	0.012
1.AA.2.C (Chemicals)	CO2	1128	1276	0.012
1.AA.4.B (Residential)	CO2	6256	1200	0.011
1.B.2 (Oil and Natural Gas)	CO2	304	882	0.008
2.F.1 (Refrigeration and Air Conditioning Equipment)	HFC	4	844	0.008
4.D.3 (Indirect Emissions)	N2O	1132	830	0.008
5.C (Grassland)	CO2	-916	-765	0.007
1.AA.3.D (Navigation)	CO2	542	729	0.007
1.AA.4.A (Commercial/Institutional)	CO2	2533	722	0.007
4.D.4 (Agricultural Soils. Other)	N2O	718	687	0.006
2.A.2 (Lime Production)	CO2	295	526	0.005
1.AA.1.A (Public Electricity and Heat Production)	N2O	304	502	0.005
1.AA.2.E (Food Processing. Beverages and Tobacco)	CO2	948	484	0.004
1.AA.3.A (Civil Aviation)	CO2	673	465	0.004
4.B (Manure Management)	N2O	733	460	0.004
4.D.2 (Pasture, Range and Paddock Manure)	N2O	386	406	0.004
Total				0.95

Table A 1.3. Key Category Analysis Tier 1 Trend Assessment Excluding LULUCF

IPCC Source Category	Gas	Base year emissions or removals	Year 2010 emissions or removals	Level Assessment Year 2010 (Excl LULUCF)
1.AA.4.B (Residential)	CO2	6256	1200	0.200
1.AA.3.B (Road Transportation)	CO2	17310	18962	0.142
1.AA.1.A (Public Electricity and Heat Production)	CO2	7718	10014	0.133
1.AA.4.A (Commercial/Institutional)	CO2	2533	722	0.070
6.A (Solid Waste Disposal on Land)	CH4	2874	1279	0.059
2.F.1 (Refrigeration and Air Conditioning Equipment)	HFC	4	844	0.037
1.B.2 (Oil and Natural Gas)	CO2	304	882	0.027
1.AA.2.D (Pulp. Paper and Print)	CO2	2186	1399	0.026
1.AA.5.B (Military Use)	CO2	801	173	0.025
1.AA.1.B (Petroleum Refining)	CO2	1778	2130	0.023
2.C.1 (Iron and Steel Production)	CO2	2465	2701	0.020
2.B.2 (Nitric Acid Production)	N2O	814	312	0.019
1.AA.2.F (Other Manufacturing Industries and Construction)	CO2	5462	4564	0.018
1.AA.2.E (Food Processing. Beverages and Tobacco)	CO2	948	484	0.017
1.AA.2.A (Iron and Steel)	CO2	1638	1773	0.013
2.A.2 (Lime Production)	CO2	295	526	0.011
1.AA.2.C (Chemicals)	CO2	1128	1276	0.011
1.AA.3.D (Navigation)	CO2	542	729	0.010
1.AA.4.C (Agriculture/Forestry/Fisheries)	CO2	1595	1684	0.010
1.AA.1.A (Public Electricity and Heat Production)	N2O	304	502	0.010
4.B (Manure Management)	N2O	733	460	0.009
4.D.3 (Indirect Emissions)	N2O	1132	830	0.009
2.A.1 (Cement production)	CO2	1272	1350	0.009
2.C.3 (Aluminium production)	PFC	377	156	0.008
1.AA.3.A (Civil Aviation)	CO2	673	465	0.007
2.C.2 (Ferroalloys Production)	CO2	243	107	0.005
1.AA.3.B (Road Transportation)	CH4	184	54	0.005
4.B (Manure Management)	CH4	233	295	0.004
4.A (Enteric Fermentation)	CH4	3070	2713	0.004
1.AA.1.A (Public Electricity and Heat Production)	CH4	21	100	0.004
1.AA.4.B (Residential)	CH4	234	293	0.004
6.C (Waste Incineration)	CO2	44	104	0.003
Total				0.95

Table A 1.4. Key Category Analysis Tier 1 Trend Assessment Including LULUCF

IPCC Source Category	Gas	Base year emissions or removals	Year 2010 emissions or removals	Level Assessment Year 2010 (Incl LULUCF)
1.AA.4.B (Residential)	CO2	6256	1200	0.178
5.A (Forest Land)	CO2	-44107	-38152	0.171
1.AA.1.A (Public Electricity and Heat Production)	CO2	7718	10014	0.073
1.AA.4.A (Commercial/Institutional)	CO2	2533	722	0.064
6.A (Solid Waste Disposal on Land)	CH4	2874	1279	0.057
5.E (Settlements)	CO2	1228	2865	0.055
1.AA.3.B (Road Transportation)	CO2	17310	18962	0.044
1.AA.2.F (Other Manufacturing Industries and Construction)	CO2	5462	4564	0.035
2.F.1 (Refrigeration and Air Conditioning Equipment)	HFC	4	844	0.029
1.AA.2.D (Pulp. Paper and Print)	CO2	2186	1399	0.029
5.B (Cropland)	CO2	2414	1805	0.023
1.AA.5.B (Military Use)	CO2	801	173	0.022
1.B.2 (Oil and Natural Gas)	CO2	304	882	0.020
2.B.2 (Nitric Acid Production)	N2O	814	312	0.018
1.AA.2.E (Food Processing. Beverages and Tobacco)	CO2	948	484	0.017
4.A (Enteric Fermentation)	CH4	3070	2713	0.014
4.D.1 (Direct Soil Emissions)	N2O	2792	2482	0.013
4.D.3 (Indirect Emissions)	N2O	1132	830	0.011
1.AA.1.B (Petroleum Refining)	CO2	1778	2130	0.011
4.B (Manure Management)	N2O	733	460	0.010
2.C.3 (Aluminium production)	PFC	377	156	0.008
2.A.2 (Lime Production)	CO2	295	526	0.008
1.AA.3.A (Civil Aviation)	CO2	673	465	0.008
1.AA.1.A (Public Electricity and Heat Production)	N2O	304	502	0.007
2.C.1 (Iron and Steel Production)	CO2	2465	2701	0.006
1.AA.3.D (Navigation)	CO2	542	729	0.006
2.C.2 (Ferroalloys Production)	CO2	243	107	0.005
1.AA.3.B (Road Transportation)	CH4	184	54	0.005
5.C (Grassland)	CO2	-916	-765	0.004
1.AA.2.C (Chemicals)	CO2	1128	1276	0.004
Total				0.95

Table A 1.5. Key Category Analysis Tier 2 Level Assessment Excluding LULUCF

IPCC Source Category	Gas	Base year emissions or removals	Year 2010 emissions or removals	Combined uncertainty (%)	Level Assessment Year 2010 (Excl LULUCF)
4.D.1 (Direct Soil Emissions)	N2O	2792	2482	67	0.160
4.D.4 (Agricultural Soils. Other)	N2O	718	687	154	0.101
4.D.3 (Indirect Emissions)	N2O	1132	830	125	0.099
6.A (Solid Waste Disposal on Land)	CH4	2874	1279	56	0.068
1.AA.3.B (Road Transportation)	CO2	17310	18962	3	0.060
4.D.2 (Pasture, Range and Paddock Manure)	N2O	386	406	154	0.060
1.AA.1.A (Public Electricity and Heat Production)	CO2	7718	10014	6	0.057
4.A (Enteric Fermentation)	CH4	3070	2713	11	0.030
1.AA.2.F (Other Manufacturing Industries and Construction)	CO2	5462	4564	6	0.028
1.AA.4.B (Residential)	CH4	234	293	100	0.028
2.F.1 (Refrigeration and Air Conditioning Equipment)	HFC	4	844	27	0.022
1.AA.4.B (Residential)	CO2	6256	1200	19	0.022
1.AA.1.B (Petroleum Refining)	CO2	1778	2130	10	0.021
4.B (Manure Management)	N2O	733	460	41	0.018
2.C.1 (Iron and Steel Production)	CO2	2465	2701	7	0.017
6.B (Wastewater Handling)	CH4	292	299	49	0.014
1.AA.4.C (Agriculture/Forestry/Fisheries)	CO2	1595	1684	8	0.014
1.B.2 (Oil and Natural Gas)	CO2	304	882	14	0.012
1.AA.4.A (Commercial/Institutional)	CO2	2533	722	16	0.011
1.AA.2.F (Other Manufacturing Industries and Construction)	N2O	330	331	34	0.011
1.AA.2.C (Chemicals)	CO2	1128	1276	9	0.011
1.AA.1.A (Public Electricity and Heat Production)	N2O	304	502	22	0.010
1.AA.4.B (Residential)	N2O	126	115	81	0.009
1.AA.3.D (Navigation)	CO2	542	729	11	0.008
1.B.2 (Oil and Natural Gas)	CH4	67	95	87	0.008
1.AA.2.A (Iron and Steel)	CO2	1638	1773	4	0.008
Total					0.90

Table A 1.6. Key Category Analysis Tier 2 Level Assessment Including LULUCF

IPCC Source Category	Gas	Base year emissions or removals	Year 2010 emissions or removals	Combined uncertainty (%)	Level Assessment Year 2010 (Incl LULUCF)
5.A (Forest Land)	CO2	-44107	-38152	20	0.383
4.D.1 (Direct Soil Emissions)	N2O	2792	2482	67	0.085
4.D.4 (Agricultural Soils. Other)	N2O	718	687	154	0.054
4.D.3 (Indirect Emissions)	N2O	1132	830	125	0.053
5.E (Settlements)	CO2	1228	2865	32	0.047
6.A (Solid Waste Disposal on Land)	CH4	2874	1279	56	0.036
1.AA.3.B (Road Transportation)	CO2	17310	18962	3	0.032
4.D.2 (Pasture, Range and Paddock Manure)	N2O	386	406	154	0.032
1.AA.1.A (Public Electricity and Heat Production)	CO2	7718	10014	6	0.030
5.B (Cropland)	CO2	2414	1805	28	0.026
4.A (Enteric Fermentation)	CH4	3070	2713	11	0.016
1.AA.2.F (Other Manufacturing Industries and Construction)	CO2	5462	4564	6	0.015
1.AA.4.B (Residential)	CH4	234	293	100	0.015
2.F.1 (Refrigeration and Air Conditioning Equipment)	HFC	4	844	27	0.011
1.AA.4.B (Residential)	CO2	6256	1200	19	0.011
1.AA.1.B (Petroleum Refining)	CO2	1778	2130	10	0.011
4.B (Manure Management)	N2O	733	460	41	0.009
2.C.1 (Iron and Steel Production)	CO2	2465	2701	7	0.009
5.C (Grassland)	CO2	-916	-765	21	0.008
6.B (Wastewater Handling)	CH4	292	299	49	0.007
1.AA.4.C (Agriculture/Forestry/Fisheries)	CO2	1595	1684	8	0.007
1.B.2 (Oil and Natural Gas)	CO2	304	882	14	0.006
Total					0.90

Table A 1.7. Key Category Analysis Tier 2 Trend Assessment Excluding LULUCF

IPCC Source Category	Gas	Base year emissions or removals	Year 2010 emissions or removals	Combined uncertainty (%)	Level Assessment Year 2010 (Excl LULUCF)
1.AA.4.B (Residential)	CO2	6256	1200	19	0.217
6.A (Solid Waste Disposal on Land)	CH4	2874	1279	56	0.193
1.AA.4.A (Commercial/Institutional)	CO2	2533	722	16	0.065
4.D.3 (Indirect Emissions)	N2O	1132	830	125	0.065
2.F.1 (Refrigeration and Air Conditioning Equipment)	HFC	4	844	27	0.058
1.AA.1.A (Public Electricity and Heat Production)	CO2	7718	10014	6	0.046
1.AA.3.B (Road Transportation)	CO2	17310	18962	3	0.027
4.D.2 (Pasture, Range and Paddock Manure)	N2O	386	406	154	0.022
4.B (Manure Management)	N2O	733	460	41	0.022
1.B.2 (Oil and Natural Gas)	CO2	304	882	14	0.021
1.AA.4.B (Residential)	CH4	234	293	100	0.020
2.C.3 (Aluminium production)	PFC	377	156	30	0.014
1.AA.1.B (Petroleum Refining)	CO2	1778	2130	10	0.013
4.D.4 (Agricultural Soils. Other)	N2O	718	687	154	0.013
1.AA.1.A (Public Electricity and Heat Production)	N2O	304	502	22	0.013
1.AA.5.B (Military Use)	CO2	801	173	8	0.011
1.AA.3.B (Road Transportation)	CH4	184	54	38	0.011
4.D.1 (Direct Soil Emissions)	N2O	2792	2482	67	0.010
1.AA.4.C (Agriculture/Forestry/Fisheries)	CH4	3	46	94	0.010
1.AA.5.B (Military Use)	N2O	26	4	170	0.009
2.C.1 (Iron and Steel Production)	CO2	2465	2701	7	0.008
1.B.2 (Oil and Natural Gas)	CH4	67	95	87	0.008
1.AA.3.D (Navigation)	CO2	542	729	11	0.007
1.AA.1.A (Public Electricity and Heat Production)	CH4	21	100	33	0.007
1.AA.2.F (Other Manufacturing Industries and Construction)	CO2	5462	4564	6	0.007
2.B.2 (Nitric Acid Production)	N2O	814	312	5	0.006
Total					0.90

Table A 1.8. Key Category Analysis Tier 2 Trend Assessment Including LULUCF

IPCC Source Category	Gas	Base year emissions or removals	Year 2010 emissions or removals	Combined uncertainty (%)	Level Assessment Year 2010 (Incl LULUCF)
5.A (Forest Land)	CO2	-44107	-38152	20	0.159
1.AA.4.B (Residential)	CO2	6256	1200	19	0.156
6.A (Solid Waste Disposal on Land)	CH4	2874	1279	56	0.148
5.E (Settlements)	CO2	1228	2865	32	0.083
4.D.3 (Indirect Emissions)	N2O	1132	830	125	0.066
1.AA.4.A (Commercial/Institutional)	CO2	2533	722	16	0.048
4.D.1 (Direct Soil Emissions)	N2O	2792	2482	67	0.040
2.F.1 (Refrigeration and Air Conditioning Equipment)	HFC	4	844	27	0.036
5.B (Cropland)	CO2	2414	1805	28	0.030
1.AA.1.A (Public Electricity and Heat Production)	CO2	7718	10014	6	0.020
4.B (Manure Management)	N2O	733	460	41	0.019
1.B.2 (Oil and Natural Gas)	CO2	304	882	14	0.012
4.D.4 (Agricultural Soils. Other)	N2O	718	687	154	0.012
2.C.3 (Aluminium production)	PFC	377	156	30	0.011
1.AA.2.F (Other Manufacturing Industries and Construction)	CO2	5462	4564	6	0.010
1.AA.4.B (Residential)	CH4	234	293	100	0.009
1.AA.5.B (Military Use)	CO2	801	173	8	0.008
1.AA.3.B (Road Transportation)	CH4	184	54	38	0.008
4.A (Enteric Fermentation)	CH4	3070	2713	11	0.008
5.B (Cropland)	N2O	23	72	100	0.008
1.AA.3.B (Road Transportation)	CO2	17310	18962	3	0.007
1.AA.1.A (Public Electricity and Heat Production)	N2O	304	502	22	0.007
Total					0.90

Annex 2 Detailed discussion of methodology and data for estimating emissions from fossil fuel combustion.

1.1 Sources for activity data in CRF 1A and parts of CRF 1B

Activity data used in the energy sector is mainly based on statistics on fuel consumption. In sections 1.1.1.-1.1.9 below, the various energy surveys, produced by Statistics Sweden on behalf of Swedish Energy Agency, are described. Other data sources are described in sections 1.1.10-1.1.13. These data sources, e.g. environmental reports and data reported to EU ETS, have a different purpose than energy statistics. The main focus in these data sources is not fuel consumption but emissions. Nevertheless, they contain useful data on fuel consumption that in some cases is more complete than the energy surveys. For stationary combustion within the Other sector, activity data from the annual energy balances is used in order to ensure that all activities are covered and no activities are double counted. The energy balances are based on a number of surveys, which are all described below.

A number of activity data sources are used and the UNFCCC ERT has asked for an explanation of how these sources are deemed accurate or inaccurate, and how time series consistency is ensured. In numerous development projects during the last ten years, several of them quoted in NIR section 3, different data sources have been compared and checked against each other, and in some of these projects industrial facilities have been contacted by phone or e-mail to verify data. Generally, the quarterly fuel statistics is considered to be more complete than the industrial energy statistics, because the industrial energy survey does not include all back pressure power. Besides, the annual industrial energy survey is not ready in time for the GHG inventory. In a study performed by Statistics Sweden in 2009[1], a detailed comparison between the quarterly fuel statistics, the annual industrial energy survey and the energy balances was made. This study showed some differences between the two surveys, but the differences did not indicate systematic errors in any of the surveys, and hence it gave no reason to believe that the quarterly fuel statistics would not be of sufficient quality.

Environmental reports are often a good source for emission data, but generally they do not contain sufficient activity data for the energy sector, and facilities with small emissions are not obliged to submit environmental reports. The EU ETS system has very good coverage of the trading facilities, but presently it is not possible to use as main data source due to several reasons. Firstly, the database is not

[1] Statistics Sweden, 2009

adapted to automatic data processing, and secondly, some facilities only report carbon balances. Furthermore, to produce correct estimates for the non-trading facilities, one must be able to separate trading facilities from non-trading ones in the energy statistics, and this is currently not possible due to different definitions of administrative units in the energy statistics and the ETS, respectively.

For the other sector, energy balances are used because none of the underlying surveys covers all emission sources in the different sub-sectors, but in the energy balances, complementary calculations are made in order to obtain full coverage and avoid double counting. Data for CRF 1A4 has been verified against the underlying surveys described in section 1.1.4-1.1.6 below, and the coherence was good for biomass fuels and oils, whereas the coverage of use of e.g. LPG was considered to be better in the energy balances.

1.1.1 Quarterly fuel statistics

Quarterly fuel statistics are used as follows:

- All years for data on stationary combustion in the CRF sector 1A1a, in CRF 1Ab (reference approach) for data on biomass, waste and peat, and finally in CRF 1Ad for data on feedstocks and non-energy use of fuels.
- 1990-1996 for information on in-house (own-produced) fuels in CRF 1A1b-c, 1A2, 1B1, 2C and 2D since the statistics of energy use in manufacturing industry did not cover own-produced fuels during these years.
- 1997-1999 and 2003 and all following years for stationary fuel-related emissions in CRF 1A1b-c and 1A2.
- 2000-2002 for data on fuel combustion for back pressure power in CRF 1A2c-e, both sold and consumed at the producing plant. This is due to that the industrial energy statistics (which is the main data source for industries 2000-2002) has been found not to cover fuel consumption for back pressure power.

Quarterly fuel statistics are carried out as a postal sample survey sent to all working units.[2] The sample to the quarterly fuel statistics is based on the sample for the annual statistics of energy use in manufacturing industry, except for electricity and heat production for which the quarterly fuel statistics is a total survey. Data are collected from all companies in electricity and heat production, all companies in the pulp and paper industry and all companies in the manufacturing industry with more than nine employees and annual fuel combustion of more than 325 tonnes oil equivalents.

The survey should cover all fuel consumption, both own-produced and purchased fuels. However, in some cases it has been noted by the inventory staff that not all in house fuels are covered. In those cases supplementary data has been collected to assure complete time series (section 1.1.9). In the survey form, respondents are also asked to specify whether fuels are used as raw materials or for ener-

[2] A company may consist of several working units, that is could be located in several places (factories).

gy purposes. This facilitates the use of the data for CRF table 1Ad, non-energy use of fuels.

To achieve a better sample frame, the quarterly fuel statistics are upgraded with information from the most recent year when the industrial energy statistics were a total survey, i.e. the sample frame for the quarterly fuel statistics for 1999 were upgraded with the information from the 1996 industrial energy survey, the sample frame for 2001 was upgraded with information from the 2000 industrial energy survey and the sample frame for 2006 was upgraded with information from the 2005 industrial energy survey. The response rate to the quarterly fuel statistics is almost 100 % for ISIC 40 (that is, CRF 1A1a) and about 90 % for industries. The non-respondents among the industries are often small companies, which mean that much more than 90% of consumed energy is covered in responses to the survey. To compensate for companies not included in the sample and companies not responding to the survey, all fuel consumption is raised with a factor which is produced from information on the line of business, number of employees and business volume from the most recent year when the statistics on energy use in manufacturing industry was a total survey (as discussed above). There is, however, no enumeration for manufacturing industries with less than 10 employees.

The quarterly fuel statistics for each year are compiled and ready for use at approximately the end of March the year after. This gives enough time to process the data for the greenhouse gas inventory. Until submission 2004 of the greenhouse gas inventory, the annual statistics on energy use in manufacturing industry were preferred when possible. However, since submission 2005, the quarterly fuel statistics is the main data source for stationary combustion in CRF 1A1a and 1A2b-1A2f. This is due to the fact that the annual statistics on energy use in manufacturing industry are compiled too late for the greenhouse gas inventory (actually after data should be submitted from Sweden), but also because the industrial energy statistics does not, for instance, cover fuel combustion for back pressure power. During the work with the inventory, it has become clear that for the purpose of the inventory, quarterly fuel statistics are better suited than statistics on energy use in manufacturing industry.

In the inventory, data on plant level and by fuel type is used. The quarterly fuel statistics is not used in the inventory for the two largest plants within the iron and steel industry, see also section 3.2.9 of the NIR. The properties of the quarterly fuel statistics are summarized in Table A 2.9.

Table A 2.9. Summarized properties of quarterly fuel statistics used in the inventory.

Year	Type of survey	Coverage	Adjustments	Quality
1990-1996	Quarterly sample survey to companies with more than 9 employees consuming more than >325 toe within manufacturing industries and to all companies in energy industries and pulp and paper industries	Working units in energy industries and manufacturing industries, all fuel combustion of in-house fuels	Weighted to reach the level of industrial energy statistics	Good
1997-	Quarterly sample survey to companies with more than 9 employees consuming more than >325 toe within manufacturing industries and to all companies in energy industries and pulp and paper industries	Working units in energy industries and manufacturing industries, all fuel combustion	Weighted to reach the level of industrial energy statistics	Good

1.1.2 Annual statistics on energy use in manufacturing industry

The statistics on energy use in manufacturing industry are used for emissions from stationary combustion in the CRF sectors 1A1bc, 1A2, 1B1, 2C and 2D 1990-1996 and 2000-2002 (the latter except fuel combustion for back pressure power, which is not covered by industrial energy statistics but by quarterly fuel statistics). The energy use in manufacturing industry statistics for 1997-1999 is not used in the inventory since the quality was not considered sufficiently good to be used for emission calculations. Instead, data from the quarterly fuel statistics has been used for these years.

Since submission 2005, regarding emissions in 2003 and later years, energy use in manufacturing industry statistics are not used as a base for estimating emissions in the inventory. This is, as discussed in the chapter above, mainly because the inventory must be submitted before the energy use in manufacturing industry statistics are completed, but also because the energy use in manufacturing industry statistics does not cover fuel combustion for industrial back pressure power. Instead, quarterly fuel statistics are used and the energy use in manufacturing industry statistics is only used to verify or correct data for single plants if errors are suspected in the quarterly fuel statistics.

The energy use in manufacturing industry statistics are based on an annual survey of manufacturing companies. In 1990-1996, 2000 and from 2004, all companies with more than 9 employees are included. In 1997-1999 and in 2001-2003 it was conducted as a sample survey to companies with less than 50 and more than 9 employees, and as a total survey to all companies with more than 50 employees. In 1990-1996, only purchased fuels were surveyed but, since 1997, information on all fuel consumption has been collected except fuel combustion for back pressure. In the greenhouse gas inventory, fuel combustion for back pressure power is instead collected from the quarterly fuel statistics.

The response rate to the energy use in manufacturing industry statistics is about 85 %. To compensate for non-response, fuel consumption is weighted with a factor

based on the line of business, number of employees and business volume. There is no adjustment for manufacturing industries with less than 10 employees. A special form is sent to electricity producing companies within manufacturing industries, where the amounts of fuels used for electricity production and manufacturing purposes are specified. All manufacturing industries with electricity production are included in the survey every year. In the inventory, all data used are on plant level and by fuel type. An overview of the industrial energy statistics used in the inventory for 1990-2002 is given in Table A 2.10.

Table A 2.10. Summarized properties of industrial energy statistics used in the inventory.

Year	Type of survey	Coverage	Adjustments	Quality
1990-1996	Annual total survey to all companies with more than nine employees	Working units, purchased fuels, quantity and economic value of purchased fuels	Weighted to represent all companies with more than 9 employees	Not so good quality for quantity, good quality for economic value
1997-1999	Annual total survey to all companies with at least 50 employees and a stratified sample of companies with 10-49 employees	Working units purchased and own-produced fuels	Weighted to represent all companies with more than 9 employees	Good on national level and on coarse branch level, poor for single fuel types and single branches
2000	Annual total survey to all companies with more than nine employees	Working units, purchased and own-produced fuels	No adjustments	Excellent
2001-2002	Annual total survey to all companies with at least 50 employees and a stratified sample of companies with 10-49 employees	Working units, purchased and own-produced fuels	Weighted to represent all companies with more than 9 employees	Good

1.1.3 One- and two-dwelling statistics

One- and two-dwelling statistics are used, together with holiday cottages statistics and multi-dwelling statistics, to calculate emissions from stationary combustion in households, CRF 1A4b.

This sample survey is conducted annually to collect data on the use of electricity and heat for a total of 7,000 one- and two-dwellings. Until 1999, the survey has a random sample from a real estate assessment, which includes all dwellings with a value higher than 50,000 SEK (about 5,600 €). From 2000, all dwellings used as permanent dwelling are included in the sample. Every third year, a postal survey collects data from agricultural properties. The sample in this sector is 3,000 objects. Activity data in the inventory is taken from annual reports prepared by Statistics Sweden.[3] Data is on national level by fuel type and considered to be of relatively good quality.

[3] Statistics Sweden EN20SM, 1990-2009.

1.1.4 Holiday cottages statistics

Holiday cottages statistics, together with one- and two-dwelling statistics and multi-dwelling statistics, is used to calculate emissions from stationary combustion in households, CRF 1A4b.

Holiday cottages are defined as residences with no permanent residents. Energy consumption in holiday cottages has been surveyed only two times in the last thirty years, 1976 and 2001. In 2002, Statistics Sweden carried out a stratified sample survey to house owners, covering 1,500 of the estimated 750,000 holiday cottages in Sweden 2001.[4] Results show that electricity and biomass combustion are the two dominating sources of heating in holiday cottages.[5]

1.1.5 Multi-dwelling statistics

Multi-dwelling statistics, together with one- and two-dwelling statistics and holiday cottages statistics, is used to calculate emissions from stationary combustion in households, CRF 1A4b.

This is a sample survey carried out each year, sent to the owners of 7,000 multi-dwelling buildings, covering the use of electricity and heat. The survey is based on a random sample from a real estate assessment. The real estate assessment includes all dwellings with an economic value higher than 50,000 SEK (about 5,600 €). Activity data in the inventory is taken from reports prepared by Statistics Sweden[2]. Data is on national level by fuel type and of relatively good quality. Statistics on biomass consumption in multi-dwelling buildings was not included in the survey until 2001.

1.1.6 Premises statistics

Premises statistics are used to calculate emissions from stationary combustion in the commercial and institutional sector, CRF 1A4a.

This survey is a sample survey carried out each year, covering the use of electricity and heat of about 8,000 premises. Premises situated in an industrial area are not covered in the dataset. Some of these premises are covered in the annual industrial energy statistics as well as in the quarterly fuel statistics and are reported in Manufacturing Industries and Construction (CRF 1A2). To get full coverage, supplementary calculations are made for the energy balance, which is the activity data source for CRF 1A4a[6]. Data is on national level by fuel type and of relatively good quality. Statistics on biomass consumption in premises was not included in the survey until 2001.

1.1.7 Statistics on the supply and delivery of petroleum products

Statistics on the supply and delivery of petroleum products are used to calculate emissions from mobile combustion. Data from the survey is used at national level and by fuel type. Emissions are reported in CRF 1A2f, 1A3, 1A4b, 1A4c, 1A5b,

[4] Statistics Sweden, 2002
[5] Biomass consumption in holiday cottages stands for about 6 % of the total consumption of biomass in CRF 1A4b
[6] Statistics Sweden EN20SM, 1990-2009

1B2a v and 1C. These statistics are also used for the reference approach in CRF 1Ab for all fuels except biomass, waste and peat.

In the monthly postal survey, data is collected from all oil companies and other sellers who have stocks of petroleum products and coal. The survey also collects stock data from companies with a large consumption of oil in the manufacturing industries and energy industries. All 70 companies are included in the survey. Fuels used for domestic and international navigation are separated. The only fuels not covered are biomass, waste and peat.

All figures are double-checked by both Statistics Sweden and all wholesale dealers. The results are published by Statistics Sweden[5].

1.1.8 Statistics on the delivery of gas products

Statistics on the delivery of gas products are used to calculate emissions from natural gas from road transport (CRF 1A3b) and transfer losses of gas works gas (CRF 1B2av). Annual questionnaires are sent to all companies in Sweden that deliver natural gas and gasworks gas (less than ten companies). Consumption purposes are specified in the survey. Results of this survey are published by Statistics Sweden[5].

1.1.9 Other statistics from Statistics Sweden

Data used in the inventory for stationary fuel consumption in the construction sector, in all companies with less than 10 employees (CRF 1A2f), in agriculture and in forestry sectors (CRF 1A4c) is taken from the annual energy balances[5]. Data is on national level and by fuel type. Fuel consumption for these subsectors has been estimated with extrapolations of older data, adjusted for each year on the basis of added value or number of working hours to estimate the fuel consumption. Total consumption for these sectors is checked against fuel deliveries, so that possible errors only occur in the allocation between these sectors.

Data on fuel consumption for the construction sector 1990-2003 is based on a survey from 1985,[7] up-graded with the number of working hours for each year. The fuel consumption for the construction sector 2004-2009 is based on a survey from 2005.[8] Data on fuel consumption in the agricultural sector is based on two intermittent surveys, for gardening[9] and agriculture.[10] The first survey is a sample survey that collects data on energy use in greenhouses and has been carried out for 1990, 1993, 1996, 1999, 2002 and 2008. Data for intermediate years is estimated using number of working hours. The second sample survey collects data for energy use in the other parts of the agricultural business and has been performed for 1994, 2002 and 2007 (fuel consumption in households in the agricultural sector is not included here but is included in the one- and two-dwellings statistics). Data for intermediate years is estimated using annual changes in value added.

[7] Statistics Sweden, 1986
[8] Statistics Sweden, 2005
[9] Statistics Sweden JO36SM, 1991, 94, 97, 2000, 2003, 2006, 2010
[10] Statistics Sweden JO63SM, 1995, 2003, 2008

Fuel consumption in the forestry sector has been studied thoroughly in 1985 and 2007[11]. Estimates for the years before 2005 are upgraded from the 1985 study with available statistics on the annual felling volume 1990-1995 and from 1996 value added are used.

Fuel consumption in small companies (9 employees or less) is estimated using a model. Fuel consumption for companies with 10-49 employees is taken from the industrial energy statistics and the average use of fuel per employee is calculated. The two information sources are combined to estimate the fuel consumption in small companies.

1.1.10 European Union Emission Trading Scheme (ETS)

Data from the European Union Emission Trading Scheme (ETS) is used since submission 2007 and emission years 2005 and later for oil refineries (CRF 1A1a and 1B2C21), as a SMED study during 2006[12] showed that this is the most accurate data source for these facilities. In addition, ETS data is used for the three cement producing facilities 2008 and onwards, one plant in CRF 1A2e for 2006 and one plant in CRF 1A2c for 2008 and onwards, since the energy statistics is not always complete for these facilities. ETS data is also used for verification of other data sources, e.g. energy statistics and environmental reports. For example, energy statistics for large facilities within the chemical industry and the steel producing industry are regularly compared with ETS data, and if major differences should be discovered, further investigations will be made. As mentioned above, for technical reasons, it is not possible to use ETS data as major source of activity data.

1.1.11 Environmental reports

Data on fuel consumption in refineries, CRF 1A1b, 1.B.2.A.4 and 1.B.2.C.2.1, is often collected from environmental reports in cases when the data sources mentioned above are not considered to be accurate. For one refinery, environmental reports are the only data source for the years 2002-2007. Environmental reports are also an important data source for fuel consumption in chemical industries, CRF 1A2c, although mostly in earlier years since the energy statistics has shown to be complete in later years. For 2007, environmental report data was partly used for one plant in the primary steel industry, CRF 1A2a. Environmental reports are also used for verification of energy statistics data for some selected plants in the same way as ETS data is used.

1.1.12 Companies

For earlier years, i.e. 2005 and before, data on fuel consumption in refineries, CRF 1A1b, and chemical industries, CRF 1A2c, was in many cases collected directly from the companies. Companies are sometimes also contacted to verify or correct data that is suspected to contain errors. Since submission 2010, the largest iron and steel company has been involved in the improvements in methodology and data for

[11] ER 2007:15. Energianvändningen inom skogsbruket 2005
[12] Backman & Gustafsson, 2006

these sectors (1A1c, 1A2a, 1B1b, 1B1c, 2C1). The methodology used is described in NIR chapter 3.2.9.

1.1.13 Other data sources for mobile combustion

For emissions from mobile combustion, CRF 1A2f, 1A3, 1A4b-c and 1A5, data from the Swedish National Rail Administration, the Swedish National Road Administration (SNRA), the Swedish Biogas Association, the Swedish Civil Aviation Authority (SCAA), the Swedish Armed Forces and several official reports is used.

1.2 Thermal values

Unless otherwise stated, thermal values for each fuel type are produced by Statistics Sweden based on information from energy surveys. All thermal values refer to net calorific values (NCV) as recommended by the IPCC Guidelines. All thermal values including references are enclosed in Appendix 1. Most thermal values are calculated on basis of chemical qualities and are considered to be of good quality.

In the inventory, activity data for 1990-2006 on many fuel types are reported in ton oil equivalents (toe), which is an energy unit. For these fuels the conversion factor of 41.87 GJ/toe is applied. In the energy surveys done by Statistics Sweden, these fuels are reported in mass unit/volume unit as well as the energy content (due to that the thermal value often varies a lot for these fuel types). To facilitate data processing, Statistics Sweden calculates the energy content in toe from this information and the result is then used in the greenhouse gas inventory. This implies that the energy content of fuels concerned is very precise.

For 2007 and later years, energy data are taken directly from energy statistics data bases, enabling the use of facility specific thermal values in the GHG inventory without performing the calculation of toe. Thermal values for 2007 and later years are considered to be of excellent quality. However, these thermal values are too many and too diverse to all be shown in Appendix 1, and because of this some simplifications are made in Appendix 1. The time series is considered to be consistent, since the conversions to toe made 2006 and earlier, made use of the same information that is used to calculate energy amounts 2007 and onwards. The only difference is that prior to 2007, the energy statistics department made these calculations, and 2007 and later, the calculations are made by the GHG inventory staff.

Fuels that are standardized products, such as for instance residual fuel oil or liquefied petroleum gas (LPG) have got thermal values that do not change between years. In submission 2010 some revisions were made. In earlier submissions, the thermal value from biogas used for transports (this amount increases each year) was not known and therefore the thermal value for natural gas was used for this fuel. In a SMED study[13] performed in 2009, a correct thermal value for biogas was provided from the biogas supplier AGA. The same study also resulted in revision

[13] Paulrud et al. 2010

of the thermal values for ethanol (new thermal value taken from Handbook of Chemistry and Physics) and Fatty Acid Methyl Ester (FAME).

1.2.1 Liquid fuels

For diesel oil the thermal value used in the inventory shows a decreasing trend. In Sweden, this fuel type is separated into three different fuel classes; diesel of environmental classes (EC) 1-3. EC 1 has the best environmental qualities, for instance lower content on aromatic hydrocarbons. EC 1 also has a lower thermal value. EC 3 affects the environment most and has a higher thermal value.[14] In 1990, EC 3 was the most common type of diesel. Over the years, the use of environmental class 3 has decreased and instead environmental class 2 and 1 are more common. In the inventory the mix of environmental class 1-3 used each year is taken into account when calculating a thermal value, which is appropriate for each year.

Thermal values for different oils (except oils used in navigation) are based on information from the Swedish Petroleum Institute (SPI), which in turn is based on information from oil companies and is crosschecked with Swedish standards for calculating thermal values.

In submission 2005, thermal values for gas/diesel oil, tall oil and residual fuel oil in all sectors as well as kerosene in stationary combustion, were revised by the Swedish EPA. Thermal values for domestic heating oil and residual fuel oil for stationary combustion were altered due to new information from SPI. The thermal value for domestic heating oil was assumed to be equivalent to diesel oil environmental class 3, and thermal values for kerosene in stationary combustion were revised to improve consistency with thermal values for mobile combustion and with thermal values used in the industrial energy statistics.

Thermal values for marine diesel oil, marine gas oil and residual fuel oil used for navigation were reviewed and revised in a SMED study in 2004.[15] Data for other petroleum fuels are surveyed by Statistics Sweden, and the conversion factors of these fuels are set to 41.87 GJ/toe.

Thermal values for refinery gases and other oils in refineries are calculated for each operator and fuel. Data is collected on consumption of fuels in tonnes and corresponding thermal values. To fit the calculation system used in the inventory for the years 1990-2006, data for these years is converted to toe and the conversion factor thereby set to 41.87 GJ/toe. For the years 2007 and later the calculation routine has been slightly changed and thus this conversion step is no longer necessary. Activity data for these fuels, used by refineries and chemical industries, is for 2007 and later mainly taken from the EU ETS system, and in most cases plant specific thermal values of excellent quality are also reported and used in the GHG inventory.

In submission 2010, the thermal values for gasoline, aviation kerosene and aviation gasoline were revised. The thermal values used in earlier submissions were from the Swedish Petroleum Institute and differed from the more recently updated

[14] http://www.spi.se/produkter.asp?art=48 , 2005-10-17.
[15] Cooper & Gustafsson, 2004.

values in 2006 IPCC Guidelines and the reason for the differences could not be justified. Default thermal values from the 2006 IPCC Guidelines are now used, since the thermal values used earlier for these fuels were concluded to be of questionable quality.

The thermal value for petroleum coke is based on information from consumers taken from the different energy surveys done by Statistics Sweden and is therefore considered to be of good quality. The thermal value for diesel used for stationary combustion is according to SPI likely approximately the same mix of environmental classes as mobile diesel for each year. Using the same thermal values as for mobile diesel therefore give correct time series.

In submission 2012, the thermal values for ethanol were revised. In earlier reporting, the same emission value used for natural gas (22.7 GJ/m3) was used for ethanol which was incorrect. According to SPBI[16] the correct thermal value for ethanol is 21.2 GJ/m3 (26.9 MJ/kg)[17].

1.2.2 Solid fuels

For coke oven gas, blast furnace gas and steel converter gas the thermal values change between years, but there is no trend in the changes, just annual fluctuations due to the quality of used primary fuels each year. Thermal values used in the inventory are based on annual information from the consumers (quite few) on actual energy content, and the quality of the thermal value is considered to be very good.

For carbon products such as coal and coke, it is difficult to establish the thermal value due to lack of information on energy content in imported fuels. For 2007 and later years, thermal values reported from the consumers are used when available. Slightly more than half of the reported observations of combusted coal in the energy statistics include specific thermal values. For coke, this share is about 75%.

Where no thermal value is reported, the median value of reported thermal values is used. Hence, the thermal values used for 2007 and later are considered to be of high quality. Data for peat and other solid fuels is reported to Statistics Sweden through a survey to consumers in toe, and the conversion factors are thereby set to 41.87 GJ/toe for these fuels.

1.2.3 Gaseous fuels

Natural gas is a non-processed primary fuel, and hence the thermal value changes between years, however without any trend. All natural gas consumed in Sweden is imported from Denmark. Statistics Sweden receives annual information on current thermal values for natural gas from the Danish Energy Authority. Thermal values for 2001 and later years are according to information from the Danish Energy Authority. Thermal values for 1990-2000 are taken from the Danish NIR submission 2004. During 2010, the Danish NIR submission 2010 was checked and it turned out that these thermal values were also received from the Danish Energy Authority. Hence, the time series is considered to be consistent.

16 Swedish Petroleum and Biofuel Institute
17 Paulrud et al. 2010

1.2.4 Biomass

Data for 2006 and earlier for wood, black liquor, tall oil, landfill gas and other biomass, other petroleum fuels, other solid fuels and other not specified fuels is reported to Statistics Sweden by surveyed consumers in toe, and the conversion factors are thereby set to 41.87 GJ/toe for these fuels. For 2007 and later years, this is true for CRF 1.A.4 and partially for the construction industry (included in CRF 1.A.2.F). For the other sectors, only black liquor is reported in toe. Other biomass is reported in several different units, e.g. tonnes, m^3 or MWh, and thermal values are often reported together with the quantity. These thermal values are considered to be accurate. Where no thermal value is reported, the median value of reported thermal values is used.

1.2.5 Other fuels

Data for waste and other not specified fuels is reported to Statistics Sweden through a survey to consumers in toe, and the conversion factors are thereby set to 41.87 GJ/toe for these fuels. In 2007 and later, waste was combusted within CRF 1A1a only and the reporting unit was tonnes. The thermal values for waste reported by the consumers are considered to be accurate, and thus these thermal values were used for 2007 and later. For other not specified fuels the reporting units vary, and reported thermal values are used when available. Otherwise, a median thermal value for similar fuels is used.

1.3 Emission factors

Emission factors are enclosed in Appendix 1, where emission factors revised in this submission are typed in red.

Emission factors for CO_2 and SO_2 depend on the content of carbon and sulphur in the fuels. For SO_2, the emissions also depend on how efficient the emission control in the plant is, for instance if scrubbers are used. For most fuels, the CO_2 emission factors do not change over the years. One exception is the emission factor for CO_2 from diesel oil. As discussed for thermal values above (1.2.1), there are three environmental classes (EC) for diesel oil in Sweden, and the emission factor used each year reflects the mix of EC:s that year. Other exceptions are non-standard fuels that are by-products of industrial processes, such as e.g. blast furnace-, coke oven- and steel converter gas from the integrated iron and steel industry, and gases produced in the petrochemical industry. These gases are used as fuels, and their thermal values and carbon content varies between years.

Other emission factors, e.g. for N_2O, CH_4, NMVOC, CO and NO_x, depend on area of consumption and/or the used combustion technique. The efficiency of emission control in the plant is also important. Therefore, these emission factors change over the years as ovens, combustion technique and emission control used becomes better.

1.3.1 Stationary combustion and fugitive emissions

National emission factors used in submission 2004 and earlier were calculated by the Swedish EPA for 1990-1995. For 1996-2002, the same emission factors as for 1995 were applied. The emission factors were used for emissions from stationary combustion (and for fugitive emissions where no other sources were available). They are based on results of measurements and national studies as well as studies of international emission factors and judgements of their relevance to national conditions. Emission factors depend on the type of fuel, and the type of plant and abatement equipment.

During 2004, an inventory and review of emission factors for stationary combustion was conducted. The basis for this inventory was reported data from different national sources, such as the company's environmental reports, research reports etc. The study focused on common fuel types where the existing emission factors were uncertain or known to be inaccurate. The study is published in a SMED report.[18] The primary aim was to revise emission factors for stationary combustion for 1996-2002, but in a few cases it was necessary to revise emission factors for the early 1990s as well, to avoid inconsistencies. It was not possible to study existing emission factors for 1990-1995 in more detail since documentation and/or data sources were insufficient for these years. Most of these resulting emission factors have been used since submission 2005. Some improvements have been made in later submissions, which are described below.

During 2008 and 2009, emission factors for CO_2, N_2O and CH_4 for stationary and mobile combustion were once again investigated in a SMED study and some revisions were made. The emission factors for CO_2 from gas works gas, natural gas, biogas, ethanol, FAME, gasoline, aviation gasoline and aviation kerosene, and the N_2O emission factor for petroleum (cracker) coke were revised for all years 1990 and later. [19]

During 2002, an inventory and review of emission factors for NMVOC, 1988-2001, was conducted. For stationary combustion and fugitive emissions within the energy sector, emission factors were derived and used together with activity data from the official national energy statistics to calculate emissions. The emission factors developed for conditions during 1990-2001 are based on knowledge on the technical development and the general effects of that, as mentioned above. The known effects of this general development has been combined with information from companies legal Environmental Reports, where actual emission factors can be derived, and information from trade associations where experts have contributed their specific knowledge on the different sectors where combustion occurs. The study is published in a SMED report.[20] Resulting emission factors has been used since submission 2003.

In submission 2012, the emission factors for CO_2 from coke oven gas, blast furnace gas and steel converter gas used in CRF 1A1a were revised, as well as the

[18] Boström et al. 2004
[19] Paulrud et al. 2010.
[20] Kindbom et al., 2003.

CO_2 emission factor for methane-based gas mixtures used in the chemical industry (CRF 1A2c and 1B2C). These revisions are described in the following sections.

For some fuels, no specific emission factors are available and thus emission factors from similar, more common fuels, are used. Fuels concerned are specified in Table A 2.11.

Table A 2.11. Fuel types for which specific emission factors are not available in the inventory.

Fuel type	Emission factor used
Kerosene	Gas/diesel oil
Landfill gas	Natural gas
Other biomass	Wood
Other petroleum fuels	Swedish default for "other fuels"
Other solid fuels	Swedish default for "other fuels"
Other not specified fuels	Swedish default for "other fuels"
Refinery gases	Swedish default for "other fuels" except for CO_2, SO_2 and NO_X where national values are used

1.3.1.1 EMISSION FACTORS FOR CO_2 FOR COKE OVEN GAS, BLAST FURNACE GAS AND STEEL CONVERTER GAS

Emission factors for CO_2 for coke oven gas, blast furnace gas and steel converter gas for iron ore-based steel production are national and are used in a few public electricity and heat production plants. Since the 2010 submission, CO_2 emissions from coke production plants as well as from iron and steel production plants in the Swedish inventory are based on plant-specific carbon mass-balances.

The carbon mass-balances are made to control the flow of carbon and are based on the carbon content in incoming and outgoing materials:

Coke oven: coal + blast furnace gas
→ *coke oven gas* + coke + slag + tar + benzene

Blast furnace: coal + coke + iron pellets + limestone + briquettes
→ *blast furnace gas* + pig iron + slag + soot

Steel converter: crude iron + carbide
→ *steel converter gas* + crude steel + slag

In submission 2012, the emission factors for coke oven gas, blast furnace gas and steel converter gas used in CRF 1A1a were revised.[21] The major part of these gases sold to companies in ISIC 40, i.e. CRF 1A1a, are produced by one iron and steel production facility. This plant keeps a record of CO_2 emissions from the energy gases sold. In order to produce as good emission estimates as possible, these emissions are used together with energy amounts reported to the quarterly fuel survey. The emissions are, however, not separately calculated for the three different gases.

[21] Gustafsson, Lidén & Gerner, 2011

Because of this, year specific aggregate emission factors for the three gases in total are calculated.

A very minor part of the steel work gases used in CRF 1A1a are produced by another facility and not the one quoted above. For this facility, no data on CO_2 emissions from energy gases sold are available. For these small amounts of steel work gases, emission factors developed in 2003 are used. The quality of the emission factor seems to be good for coke oven gas in 2001 and generally for steel converter gas. Unfortunately, carbon balances are not available prior to the years 2001. Hence the uncertainty of the values is higher for the years surrounding 1990 (about +/-10 %) than for the years surrounding 2000 (about +/- 5 %).[22]

1.3.1.2 EMISSION FACTORS FOR CO_2 FROM REFINERY GAS, PETROLEUM COKE AND CARBIDE FURNACE GAS

Due to lack of information on the Swedish conditions, the emission factors used for refinery gases in submission 2005 were the IPCC Guidelines default values. The emission factor for carbide furnace gas used in submission 2005 was the same as the Swedish default fuel category "Other fuels", and for petroleum coke, the same emission factor as for coke was used. In 2005, a study of the emission factors for CO_2 from refinery gas, petroleum coke and carbide furnace gas was carried out.[23] It resulted in revisions for all three fuels, as presented in Table A 2.12. These emission factors were verified in a study carried out in 2008-2009.[24]

Table A 2.12. Emission factors on CO_2 for carbide furnace gas, refinery gas and petroleum coke used in submission 2005 and since submission 2006.

Fuel type	CO_2 factor used in submission 2005 ton CO_2/TJ	CO_2 factor since submission 2006 ton CO_2/TJ
Carbide furnace gas	60	145
Refinery gas	66.7	59.3
Petroleum coke	103	100

In submissions 2010 and later, plant specific emission factors for CO_2 from refinery gas are used for 2008 and later years as they are readily available from the ETS data, which is considered to be the most accurate data source in this respect. The implied average emission factor for refinery gas combusted in CRF 1.A.1.b 2008 is slightly lower the one developed in submission 2006, and it is even lower in 2009 than 2008. It can also be noted that the flared refinery gas 2008-2010 reported in 1.B.2.C.2.1 has a lower implied emission factor than the gas combusted and reported in 1A1b. There has not been enough resources to investigate this in submission 2012, although it may indicate that emissions from flaring of refinery gas before 2008 might be overestimated.

[22] Ivarsson, 2003.
[23] Nyström & Cooper, 2005.
[24] Paulrud et al. 2010

1.3.1.3 EMISSION FACTOR FOR CO_2 FROM METHANE RICH GASES PRODUCED AND USED IN THE CHEMICAL INDUSTRY

In the petrochemical industry, considerable amounts of gas that is a by-product in various production processes are used for energy production. Flaring of this gas is also common. The gas is produced by one facility and used by a few other plants in the same municipality. In submission 2009 and earlier, there were no specific emission factors available for this gas, and for all emissions, including CO_2, emission factors for natural gas were used. In submission 2010 and 2011, emission factors from EU ETS were used for 2008 and onwards, and an emission factor based of the carbon content and thermal value of pure methane was used for earlier years. This resulted in an inconsistent time series since these emission factors are considerably lower than the emission factor for natural gas. In submission 2012, more information was gathered from the producing company.[25] It turned out that the production process was gradually improved in 1999-2001. According to the producing company, the emission factor used for 1990-2000 was accurate. For 2008-2010, accurate data from EU ETS is used. For the period 2001-2007, the producing company provided a time series of CO_2 emissions from different parts of the production and amounts of gas produced, and from this, it was possible to calculate year specific emission factors for CO_2 for this fuel. Hence, the time series in submission 2012 is considered to be consistent. The year specific emission factors used in submission 2012 are shown below.

Table 1Emission factor for CO_2 from methane rich gas in the petrochemical industry

Year	1990-2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
EF	55.00	60.35	50.02	51.54	47.32	52.70	46.81	44.14	43.16	44.07	45.61

1.3.1.4 EMISSION FACTORS FOR SO_2 AND NO_X FROM REFINERY OIL AND GAS

In a study conducted by SMED in 2006[26], new specific emission factors for refinery gas and refinery oil were developed for the whole time series 1990-2004, which are applied since submission 2007. In another SMED study in 2008[27], new emission factors for SO_2 from refinery oil 2005 and later and NO_X from refinery gas 2006 and later were developed. These revised values are used since submission 2011.

1.3.1.5 EMISSION FACTORS FOR COMBUSTION OF BIOMASS IN HOUSEHOLDS

In submission 2005 and earlier, only one emission factor for each gas for combustion of biomass in households was accounted for, including all technologies and all biomass fuel types. Due to the significant variation in emissions from different

[25] Gerner, 2011
[26] Nyström & Skårman, 2006
[27] Skårman et al, 2008

kinds of residential biomass systems depending on type of combustion system, type of fuel and operation conditions, studies on biomass fuel consumption and emission factors in the residential sector were performed in 2005 and 2006.

In submission 2006, time series of activity data and CH_4 emission factors were reviewed and updated. New methane emission factors for small scale combustion of wood log, pellets and wood chips/sawdust were determined (

Table A 2.13), and an improved method was used to calculate the emissions. In order to match the activity data categories, the emission factors were grouped by heating system category and fuel type. The results showed that methane emissions from wood log combustion are significantly higher compared to pellets combustion. However, significant variations in emission factors occur for specific combustion appliances and operational conditions. The revised emissions factors resulting from this study are to a large extent based on results from the Swedish Energy Agency research program "Biofuel, Health and Environment". Data from mainly five different research studies were used. The method used was to summarise and calculate mean values of measured methane emission factors from several combustion experiments of wood log and pellets, using different boilers and stoves. [28]

During 2006, as a follow-up of the revision of methane emission factors in submission 2006, emission factors for N_2O, NO_X, CO, NMVOC and SO_2 for combustion of biomass in households were reviewed and occasionally revised (

Table A 2.13)[29].

For N_2O emission factors, no new measurement studies were carried out and no new information from the literature was found, and thus no adjustments were made. For NO_X emission factors, data from mainly six Swedish studies was used. The emission of NO_X for pellets varied between 30-80 mg/MJ and for wood logs between 20-120 mg/MJ.

The emission factors for CO are mainly based on measured emission data from Swedish residential biomass combustion experiments in the field as well as in the laboratory. The variation in CO emissions is usually large and the levels may sometimes be very high, especially from wood log combustion (up to 23,700 mg/MJ have been registered).

The previously used value for NMVOC is high, 1,975 mg/MJ, in comparison to the previously used emission factor for methane, 250 mg/MJ. According to a Swedish study[30], the fraction of methane in VOC (sum of methane and NMVOC) is approximately 20-40 % by weight for pellet boilers and 30-70 % by weight for wood boilers. The revised emission factors for NMVOC now show significantly lower values compared to the previously used values. This is due to that the new emission factors are based on data from additional measurements in Swedish residential biomass combustion experiments in the field as well as in the laboratory.

In previous Swedish emission inventories, the SO_2 emission factors were based on an S-content of (0.07 wt % dry fuel) and the assumption that a majority of the

[28] Paulrud et al. 2005.
[29] Paulrud et al. 2006.
[30] Johansson et al, 2004.

sulphur is bound to the ash. In the 2006 study, a lower S-content was applied (0.01 wt %), but with the assumption that no sulphur is bound in the ash.

Table A 2.13. Emission factors for CH_4, N_2O, NO_X, CO, NMVOC and SO_2 determined from small scale combustion of wood logs, pellets and wood chip using different combustion technologies. All data are presented as mg/MJ fuel.

Combustion technology	Fuel	Emission factor (average)					
		CH_4	N_2O	NO_X	CO	NMVOC	SO_2
Boilers	Wood logs	254	5	80	4000	300	10
	Wood chips	203	5	80	1000	150	10
	Pellets	3	5	65	300	6	10
Stoves	Wood logs	430	5	80	2500	150	10
	Wood chips	344	5	80	1000	150	10
	Pellets	7	5	65	300	6	10
Open fire places	Wood logs	318	5	80	4000	200	10
	Wood chips	*	*	*	*	*	*
	Pellets	*	*	*	*	*	*
All technologies	All biomass	250**	5**	60**	2000**	1975**	30**

* Not relevant. **EF Value in submission 2006.

1.3.2 Mobile combustion

In submission 2012, emission factor for CO_2 from ethanol was revised as a result of revised thermal value for ethanol[31]. Emission factors used for mobile combustion calculations are country-specific and default values from IPCC Guidelines and CORINAIR. These emission factors are further described in NIR sections 3.2.

1.3.3 References

Backman, H., Gustafsson, T., 2006. Verification of activity data within the energy sector for reporting to the UNFCCC, EU Monitoring Mechanism, CLRTAP and the EU NEC Directive using data from the EU Emission Trading Scheme. SMED report 76:2006.

Boström, C, Flodström, E and Cooper D. 2004. Emissionsfaktorer för stationär förbränning. SMED report 3:2004

Cooper, D. and Gustafsson, T., 2004, Methodology for calculating emissions from ships: 2 Emission factors for 2004 reporting. SMED Report 5:2004.
Ivarsson, 2003. Improved statistics for SSAB, refineries and lime producers. SMED report 59:2003.

Gerner, 2011. Underlag för revidering av EF för CO_2 från bränngas. SMED Memorandum.

Gustafsson, Lidén and Gerner, 2011. Emissions from integrated iron and steel industry in Sweden. Model for estimation and allocation of energy consumption and CO_2 emissions for reporting to the UNFCCC. SMED report 97:2011.

[31] Paulrud et al. 2010.

ER 2007:15. Energianvändningen inom skogsbruket 2005

Johansson L, Leckner B, Gustavsson L, Cooper P, Tullin C, Potter A. 2004. Emission characteristics of modern and old-type residential boilers fired withwood logs and wood pellets. Atmospheric Environment 38, 4183-4195.

Kindbom, K et al., 2003, Estimated emissions of NMVOC in Sweden 1988-2001

Nyström, A-K & Cooper, D. 2005. Use of data from the EU emission trading scheme for reporting to EU Monitoring Mechanism, UNFCCC and CLRTAP. SMED report 74:2005.

Nyström, A-K & Skårman, T. 2006. Quality control of emitted NO_X and SO_2 in Swedish industries. SMED report 35:2006

Paulrud, S, Fridell, E, Stripple, H, Gustafsson, T. 2010. Uppdatering av klimatrelaterade emissionsfaktorer (Update of climate related emission factors, 2nd edition). SMED report 92:2010.

Paulrud, S, Kindbom, K, Cooper, D, Gustafsson, T. 2005. Methane emissions from residential biomass combustion. SMED report 17 2005.

Paulrud, S, Kindbom, K, Gustafsson, T. 2006. Emission factors and emissions from residential biomass combustion in Sweden. SMED report 70:2006

Skårman, T, Danielsson , H, Kindbom, K, Jernström, M, Nyström, A-K., 2008: Fortsättning av riktad kvalitetskontrollstudie av utsläpp från industrin i Sveriges internationella rapportering (Continued QC study of emissions from industrial plants the Swedish emission inventories). SMED report 36:2008.

Statistics Sweden, 1986. Report on fuel consumption in the construction and forestry sectors. Energy Statistics.

Statistics Sweden EN20SM, 1990-2009. Årliga energibalanser (Annual energy balances)
http://www.scb.se/statistik/EN/EN0202/2007I08/EN0202_2007I08_SM_EN20SM0904.pdf

Statistics Sweden, 2002. Energianvändning i fritidshus 2001. (Energy consumption in holiday cottages 2001.) Energy statistics.

Statistics Sweden, 1991, 94, 97, 2000, 2003, 2006, 2010. JO36SM: Trädgårdsräkningen (The Horticultural census). Unit for Agriculture, Forestry and Fishing Statistics.

Statistics Sweden, 1995, 2003, 2008. J63SM: Consumption of diesel oil and fuel oil in agriculture and number of ciserns and storage capacity. Unit for Agriculture Structure.

Statistics Sweden, 2005: Energy use in construction sector 2004,
http://www.scb.se/statistik/_publikationer/EN0114_2004A01_BR_ENFT0501.pdf

Statistics Sweden, 2009: Inventering av industristatistiken (Inventory of the energy statistics)

Swedish Petroleum Institute, http://www.spi.se/produkter.asp?art=48 , 2005-10-17.

1.4 Allocation of fuels for mobile combustion

This section describes the allocation and distribution of the delivered amount of fuels on subsectors.

1.4.1 Gasoline

Data on the delivered amounts of gasoline at national level is provided by the national statistics on supply and delivery of petroleum products (1.1.7). National total delivered amounts of gasoline includes ethanol blended to the gasoline. To separate emissions from fossil fuels from emissions from bio-fuels, the ethanol added to gasoline is subtracted from the total delivered amount of gasoline and reported as biomass under CRF 1A3b. Data on the amount of ethanol added in gasoline is available from 2001. Today ethanol added in gasoline accounts for 5 % of the total delivered amount of gasoline. The ethanol reported as biomass also includes the volume of ethanol used as E85 motor fuel (a mixture of 85 % ethanol and 15 % gasoline). After subtracting the volume of ethanol added to gasoline, the remaining volume of gasoline is distributed over different subsectors according to Figure A 2.1.

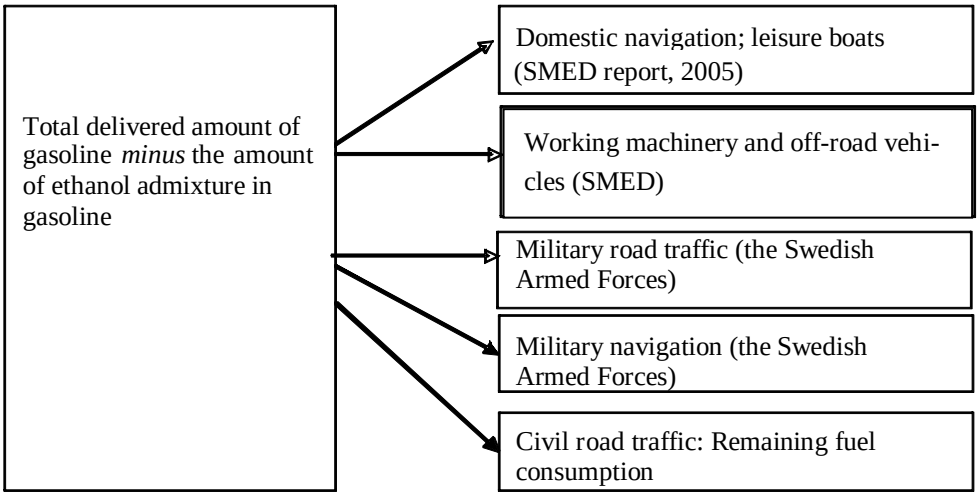


Figure A 2.1. Gasoline distribution by subsector and source.

The gasoline consumption from domestic navigation is based on a survey produced by SMED on gasoline consumption by leisure boats[32]. The results from the survey indicate no evidence of any trend in gasoline consumption and the result of the survey (gasoline consumption by leisure boats is estimated to 32,500 m3/year) is being used as a volume estimate for the whole time period

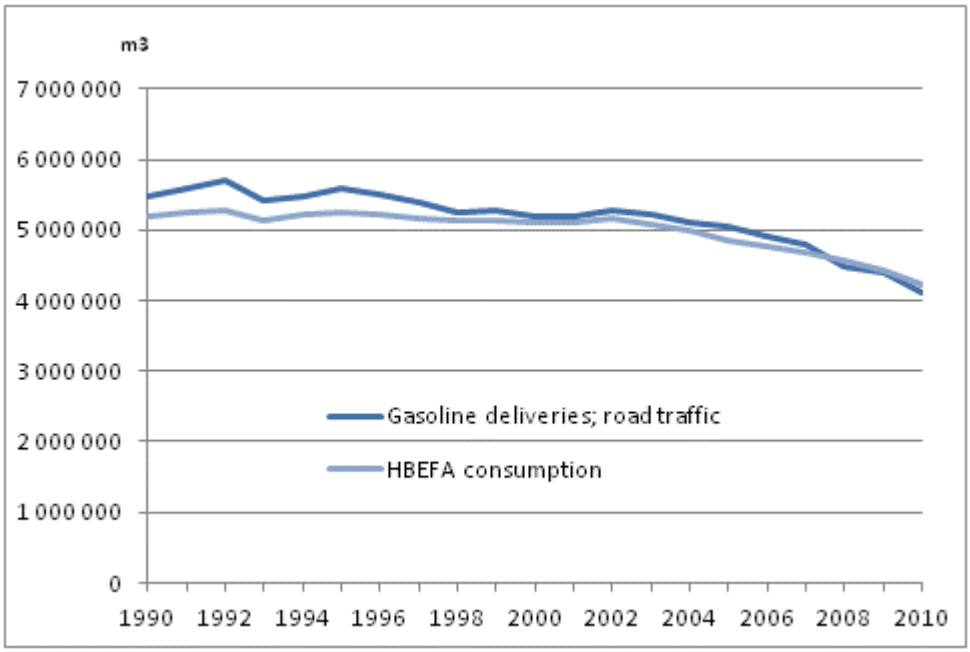
Gasoline consumption from off-road vehicles and other machinery (CRF 1A2f, 1A3e, 1A4b and 1A4c) is calculated using a recently developed SMED method based on a study made in 2008.[33]

Exact amounts of gasoline consumed by military road transport and navigation, CRF 1A5b, are provided by the Swedish Armed Forces. The volume of total gasoline deliveries remaining after the gasoline consumed by the four prior mentioned subsectors is withdrawn is assumed to be consumed within the subsector civil road traffic, CRF 1A3b.

A comparison between the volume of gasoline allocated to the civil road traffic sector through this top-down approach and the volume of gasoline consumed according to the bottom-up HBEFA 3.1 model, used by the Swedish Transport Administration (Section 1.5), indicates a good correspondence between the two estimates. The bottom-up approach estimates a slightly higher consumption in the early 90's but the difference in estimated gasoline consumption between the top-down and bottom-up approach is decreasing by time (FugureA.2.2).

[32] Gustafsson, Tomas. 2005.
[33] Fridell, Jernström & Lindgren, 2008

Figure A 2.2. Bottom-up estimated gasoline fuel consumption versus top-down allocated gasoline consumption.



The approximate distribution of gasoline on subsectors in 2010 is shown in Figure A.2.3. Civil road traffic accounts for almost all gasoline consumption, followed by off-road vehicles and other machinery. Gasoline consumption from domestic navigation and military activities is relatively low.

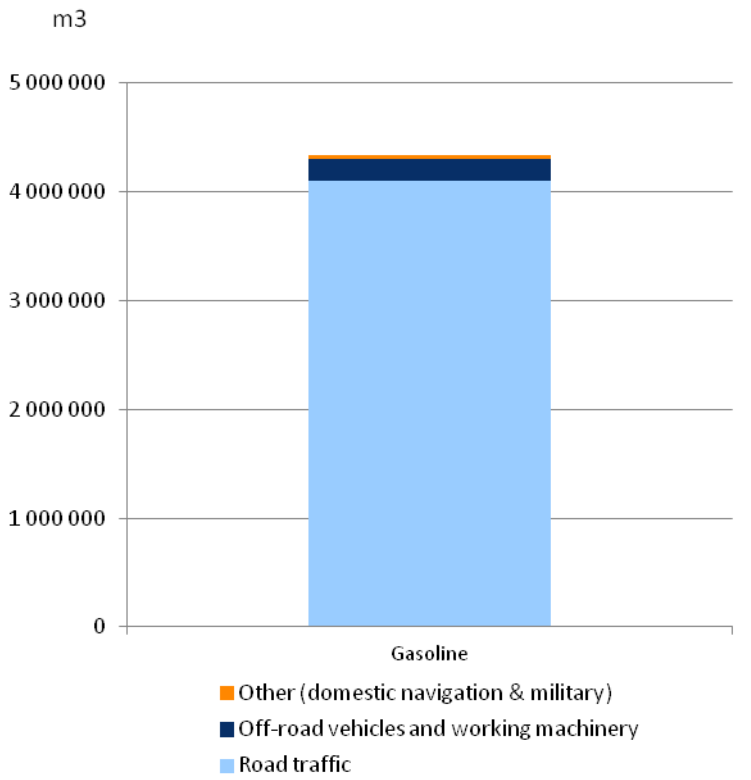


Figure A.2.3. Distribution of gasoline by subsector.

1.4.2 Diesel

Data on the total amount of diesel oil delivered at national level are provided by the statistics on supply and delivery of petroleum products (Section 1.1.7). The use of diesel by international bunkers is specified as discussed in NIR section 3.2.2. The remaining volume of diesel is distributed over different subsectors following a three-step process.

The total amount of delivered diesel includes both diesel used for stationary combustion and FAME blended to the diesel oil. In the first step, the volume used for stationary combustion and the volume of FAME added is subtracted from the total deliveries. FAME is reported as biomass under CRF 1A3b. The volume of FAME added in diesel has increased considerably since 2006 when bio-diesel, including a 5 % blend of FAME, was introduced to the Swedish market. The FAME reported as biomass also includes the volume of pure FAME (100%) sold on the Swedish market.

For Railways information on diesel consumption is collected from the Swedish National Rail Administration and for Military activities from the Swedish Armed Forces.

Table A 2.14. Subsectors with accurate and precise information on diesel consumption, by source.

Subsector	CRF	Estimation of amount of diesel consumed
Railway	1A3c	Exact amount given by the Swedish National Rail Administration
Military road transport	1A5b	Exact amount given by the Swedish Armed Forces
Military navigation	1A5b	Exact amount given by the Swedish Armed Forces
Military abroad	1C2	Exact amount given by the Swedish Armed Forces

In the third and last step, the remaining amount of the total delivered diesel is allocated over subsectors where the estimated diesel consumption is more uncertain. These are fisheries, domestic navigation, and civil road traffic. For off-road vehicles and other machinery, the consumption estimated by the recently developed method[34] used in submission 2009, 2010 and 2011 is considered to be more accurate and therefore none of the remaining amount of total delivered diesel is allocated to these sectors (CRF 1A2f, 1A3e and 1A4b-c). The allocation is made proportionally to the estimated consumption of each subsector. The consumption estimates of each subsector are based on sources according to Table A 2.15. Figure A.2.4 gives a brief overview of the distribution of diesel among different subsectors.

[34] Fridell, Jernström & Lindgren, 2008.

Table A 2.15. Subsectors with uncertain diesel consumption, by source.

Subsector	CRF	Estimation of amount of diesel consumed
Fisheries	1A4c	SMED report, 2005
Domestic navigation	1A3d	Statistics Sweden, EN31SM
Civil road traffic	1A3b	HBEFA 3.1 road model hosted by the Swedish Transport Administration.

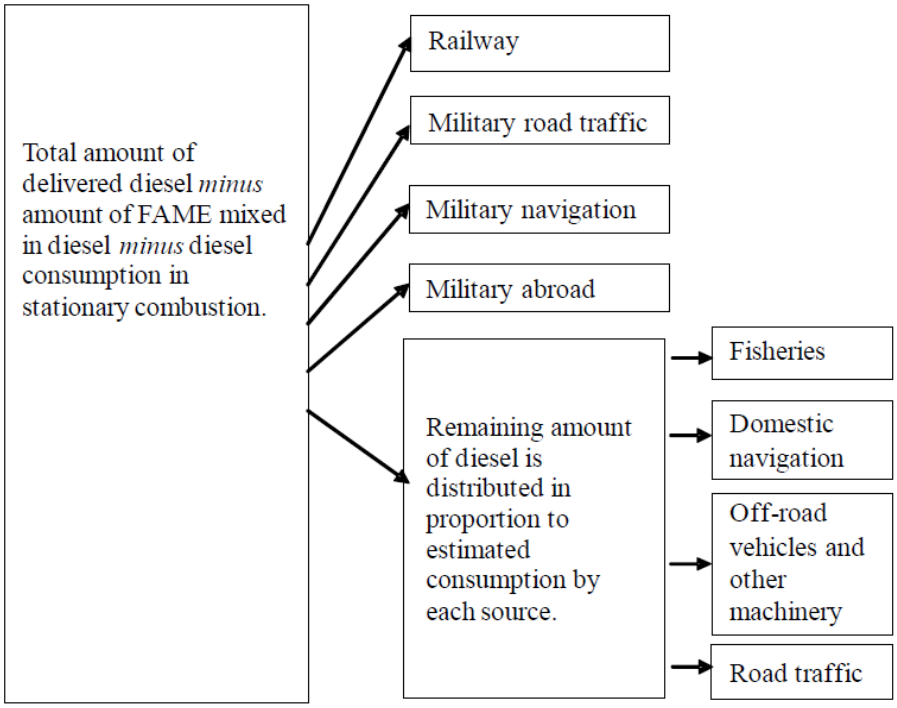


Figure A 2.4. Model for allocating the total amount of delivered diesel on subsectors

The estimate of the Swedish fishing fleet's diesel consumption is based on a survey on energy consumption within the fishing industry by Statistics Sweden[35] together with data on the Swedish fishing fleets total installed effect in kW from the Swedish board of fisheries. The estimate on fuel consumption provided by SCB refer to 2005, and for the previous and following years the fuel consumptions is estimated by adjusting the 2005 value according to the development in total installed effect. The installed effect is available from 1995, for the years prior to 1995 it is estimated through extrapolation.

The estimate for diesel consumption from domestic navigation (also called marine diesel oil) is provided by the statistics on supply and delivery of petroleum products, see 1.1.7.

The estimate for diesel consumption from off-road vehicles and other machinery (CRF 1A2f, 1A3e, 1A4b and 1A4c) is based on a SMED study from 2008.[36] In the study, diesel consumption was estimated for the year 2006. The consumption

[35] Statistics Sweden 2006
[36] Fridell, Jernström & Lindgren 2008

by different kinds of vehicles is estimated from the number and age distribution of vehicles, motor effect etc. For the years 2000, 2002, 2004, 2006, 2007 and 2008 the exact numbers and age distributions of tractors within different sectors (1A4c, 1A4b and 1A2f) are taken from Statistics Sweden's register of vehicles, and these numbers are used to calculate the number and age distribution for other kinds of vehicles. The numbers in other years are interpolated. The exact numbers of tractors within different sectors in 1990 and 1995 are also taken from Statistics Sweden's register, but since the age distribution is not available for these years, the age distribution from 2000 is used for the 1990's, while the number of vehicles are interpolated between 1990 and 1995 and 1995 and 2000, respectively.

Diesel consumption from civil road traffic is estimated by the HBEFA 3.1 road model ((Section 1.5).

A comparison between estimated diesel consumption according to the predecessor to HBEFA 3.1, the bottom-up ARTEMIS road model and the top-down adjusted diesel delivery statistics approach gives a slightly higher consumption for the bottom-up approach (

Figure A 2.5). The trend is approximately the same for the two different estimates. However, in 2009 the delivery statistics shows a sudden drop of diesel deliveries, probably related to the economic downturn. The model assumptions of the ARTEMIS are set up so that market changes cannot be considered.

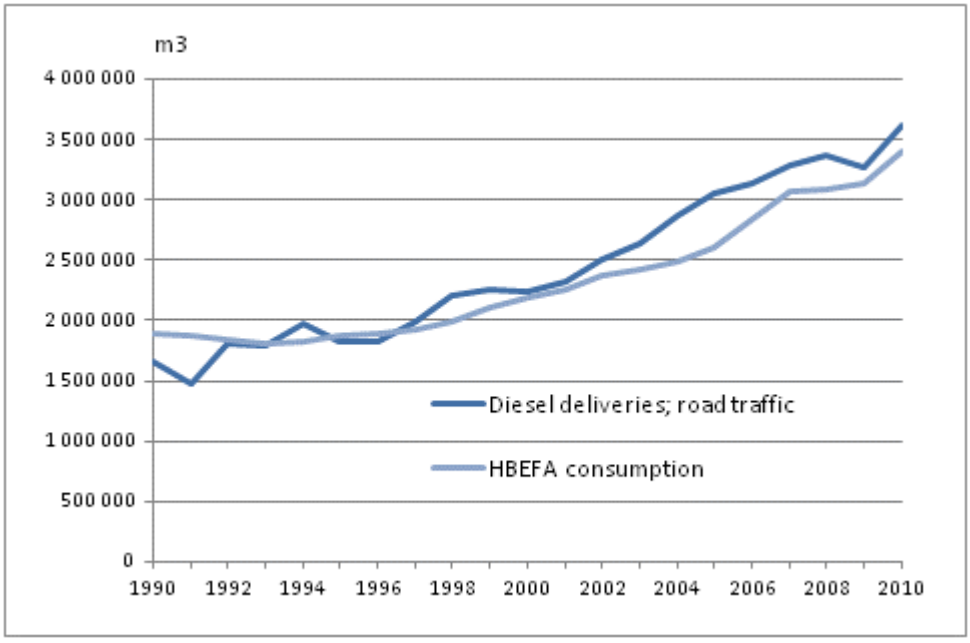


Figure A 2.5. Bottom-up estimated diesel consumption versus top-down allocated diesel.

Figure A.2.6 shows the approximate distribution of the delivered amount of diesel oil in 2010. As for gasoline, diesel from civil road traffic accounts for the majority of the consumption. However, diesel from off-road vehicles and other machinery also contributes to a considerable amount of the total diesel consumption.

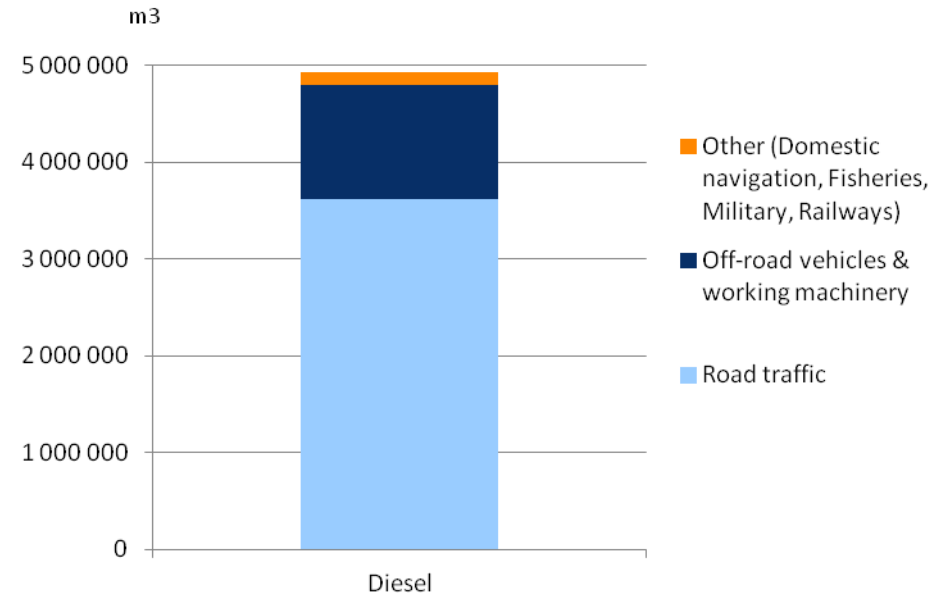


Figure A 2.6. Distribution of diesel oil by subsector 2010

1.4.2.1 ENVIRONMENTAL CLASSES OF DIESEL OIL

Diesel oil is refined into three categories; so called environmental classes 1-3. These have been gradually introduced from 1991. Today, environmental class 1 (low sulphur) diesel is the only kind of diesel sold in Sweden. The shift in consumption of diesels of different environmental classes has had a significant impact on the emissions.

Table A 2.16 shows the characteristics for environmental class 1-3 regarding thermal values and emission factors for CO_2. The transition in consumption from exclusively environmental class 3 diesels in 1990 to more or less exclusively environmental class 1 diesels today has contributed to a 3 % decrease in CO_2 emissions from diesel.

Information on the diesel distribution on environmental classes has been collected from the Swedish National Road Administration for the years 1990-1993 and from Statistics Sweden for 1994 and later years. The Swedish Petroleum Institute (SPI) has assisted with information regarding thermal values and emission factors for CO_2[37]. SMED has calculated yearly averages of thermal values and emission factors.

[37] Swedish Petroleum Institute, www.spi.se. August 2005.

Table A 2.16. Impact from different environmental class diesel on thermal value and emission factors for CO_2.

Diesel	Thermal value (GJ/m^3)	Emission factor CO_2 (tons/TJ)	Weight 1990 (%)	Weight 2000 (%)	Weight 2006 (%)
Environmental class 1	35.28	72.00	0	94	99
Environmental class 2	35.28	72.56	0	0	0
Environmental class 3	35.82	74.26	100	6	1
Average 1990	35.82	74.26			
Average 2000	35.31	72.13			
Average 2007	35.28	72.01			

1.4.3 Marine distillate fuel

Marine distillate fuel is a group name covering marine diesel oil and marine gas oil used for navigation. Emissions from these fuels are reported as gas/diesel oil in the CRF. Marine diesel oil for domestic navigation is discussed under the diesel section, 1.4.2. Delivered amount of marine gas oil for navigation is provided by the statistics on supply and delivery of petroleum products (Section 1.1.7). The statistics on marine distillate fuels are reported separately for domestic and international navigation. The division on areas of use for marine distillate fuels is provided by the respondents of the survey on supply and delivery of petroleum products. The amounts of marine distillate fuel used for domestic navigation, CRF 1A3d, is shown in Figure A 2.7. 2009 show a drop of Marine distillate fuels and the levels stay low also in 2010. The accuracy of this is verified by the respondents.

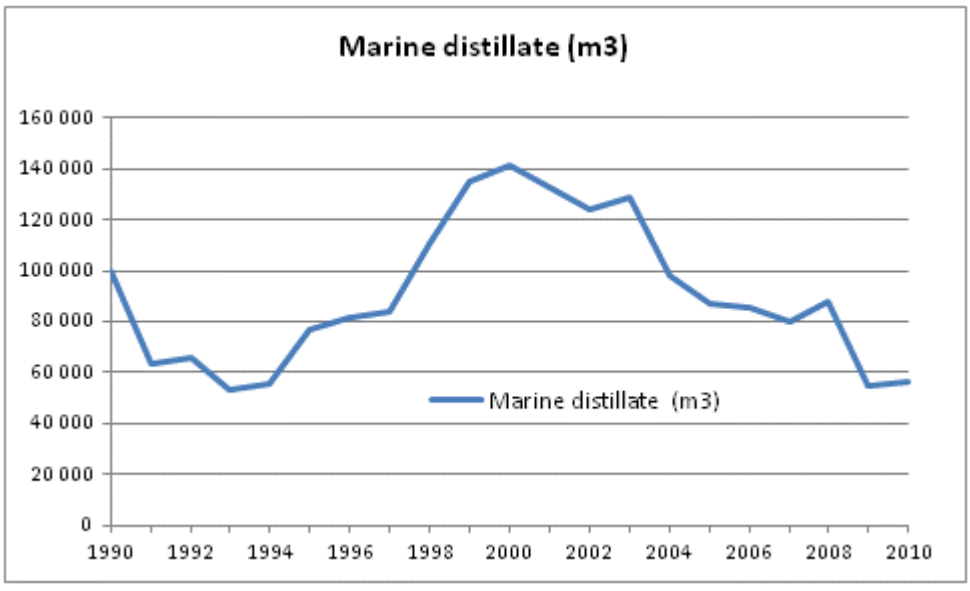


Figure A 2.7. National fuel deliveries of marine diesel oil and marine gas oil (marine distillate fuel) 1990-2009.

1.4.4 Residual fuel oils

Delivered amounts of residual fuel oils for national and international navigation are provided via the statistics on supply and delivery of petroleum products (Section 1.1.7). The statistics on residual fuel oils are reported separately for domestic and international navigation. Contrary to marine distillate, which shows a negative trend, the residual oil is increasing sharply as can be seen in Figure A 2.8.

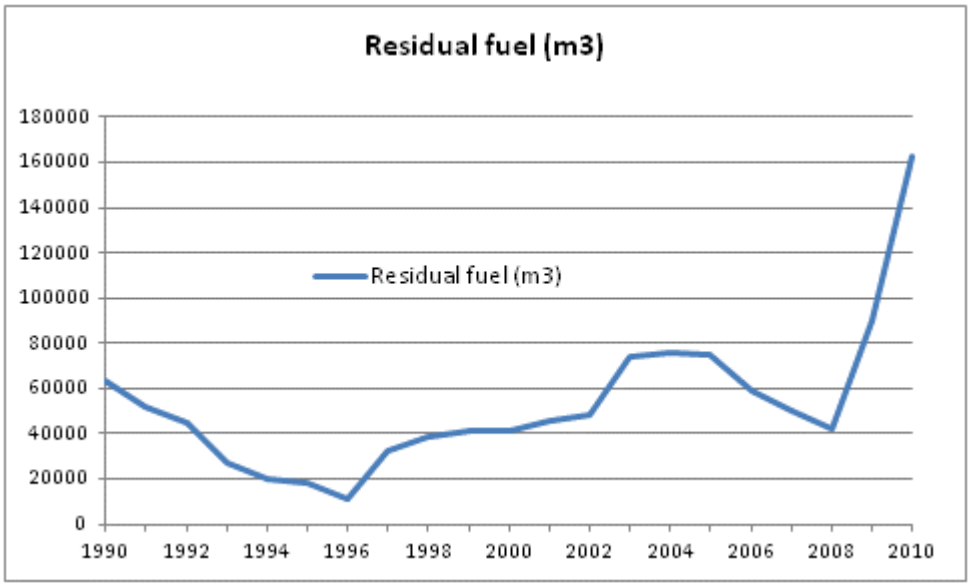


Figure A 2.8. National fuel deliveries of marine diesel oil and marine gas oil (marine distillate fuel) 1990-2009.

1.4.5 Jet kerosene, jet gasoline and aviation gasoline

All jet kerosene, jet gasoline and aviation gasoline are assumed to be used for aviation. Delivered amounts of these fuels are provided at national level by the statistics on supply and delivery of petroleum products (Section 1.1.7). Delivered amounts of jet kerosene and aviation gasoline are distributed between military and civil aviation. The information on military consumption of aviation fuels provided by the Swedish Armed Forces is assumed to be correct and that the remaining amounts are allotted to civil aviation. Jet gasoline is only used by the military and has not been used after 1993.

1.4.6 Natural Gas and biofuels

Other fuels used for transport are ethanol, FAME, natural gas and biogas. All consumption is assumed to be in the road traffic sector, CRF 1A3b.

Ethanol and FAME are partly blended in gasoline and diesel, and partly used in more pure forms in so-called flexifuel vehicles. Information on delivered amounts of ethanol and FAME are provided at national level by the statistics on supply and delivery of petroleum products (Section 1.1.7). Data on delivered amount of natural gas for transport is provided by the statistics on the delivery of gas products (Sec-

tion 1.1.8). Data on the consumption of biogas from 1996 is provided by the Swedish Biogas Association. Data for 1990-1995 is not available.

1.4.7 References

Gustafsson, T. 2005. Update of gasoline consumption and emissions from leisure boats in Sweden 1990-2003 for international reporting. SMED report 73 2005.

Fridell, E., Jernström, M., Lindgren,M., 2008. Arbetsmaskiner – Uppdatering av metod för emissionsberäkningar. SMED Report 2008.

Statistics Sweden, 2005: Båtlivsundersökningen 2004 (Leisure boats survey 2004).

Statistics Sweden, 2006: Energy consumption in the fishery sector 2005. Official Statistics of Sweden.

Swedish Petroleum Institute, www.spi.se. August 2005.

1.5 The HBEFA 3.1 road model

The HBEFA (Handbook of Emissions Factors) 3.1 road model builds on the former ARTEMIS road model used in earlier submissions (submission 2006 to submission 2011). To a large extent, the two models are principally the same, since the HBEFA 3.1 road model was developed from a merging of the ARTEMIS road model and the former version of HBEFA – 2.1. HBEFA 3.1 provides emission factors and emissions for segments and sub-segments of six main vehicle categories - passenger cars (PC), light commercial vehicles (LCV), heavy goods vehicles (HGV), urban busses, coaches, and motorcycles including mopeds (MC) - for a large number of traffic situations, as well as for average speeds[38]. Segments are defined as groups of vehicles of similar size (e.g. passenger cars with swept engine volume between 1.4 and 2 liters, rigid trucks with weight between 14 and 20 tonnes) and similar technology (e.g. petrol engines, diesel engines, biofuel, CNG/petrol engines), whereas sub-segments are defined as groups of vehicles of similar size, technology and emission concept (e.g. pre-Euro, Euro 1, 2, 3, etc.)

The emission factors are based on emission measurements according to different sets of real-world driving cycles, representative for typical European driving conditions[39]. The model calculates emissions separated into hot emissions, cold start emissions and evaporative emissions. An overview of the model structure with input and output parameters is given by Figure A 2.9.

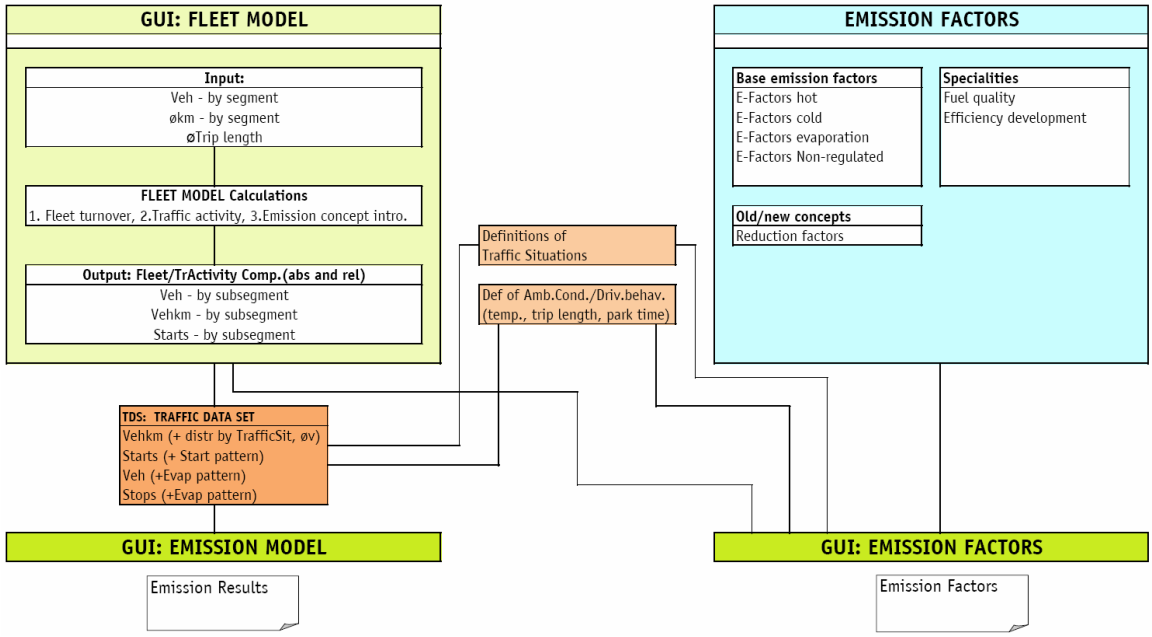


Figure A 2.9. HBEFA 3.1 model structure.

1.5.1 National fleet data

The Swedish road vehicle fleet for each year is described by means of the number of vehicles on category level, along with segment/sub-segment and age distribu-

[38] Keller et al., 2005
[39] André, 2004

tions, derived from the Swedish national vehicle register. This register is updated with new registrations and scrapped vehicles on a daily basis. Specific information on swept engine volume for passenger cars is not available from the national vehicle register. Instead, an independent fuel consumption dataset obtained from the Swedish Consumer Agency including swept engine volumes for a large number of car models available on the Swedish market, was used. This dataset has been matched with the national vehicle register, resulting in functions of swept engines volumes versus year of registration, engine power, and vehicle weight, for gasoline and diesel passenger cars separately.

The HBEFA 3.1 model distinguishes between two types of busses: urban busses, mainly used for urban driving, and coaches, mainly used for rural and motorway driving. Due to lack of specific information in the national vehicle register, the distinction between urban busses and coaches had to be based on the ratio p/w, where p is equal to the maximum allowed number of passengers, and w is equal to the gross vehicle weight, both available from the national vehicle register. Busses with a p/w-value above 3.7 were classified as urban busses, whereas busses with a p/w-value below 3.75 were classified as coaches.

In the HBEFA 3.1 model, trucks are split into two main categories: with and without trailer, respectively. Since there is no information on the use of trailers in the Swedish national vehicle register, trucks with trailers are described by means of vehicle transformation patterns in the HBEFA 3.1 model. A transformation pattern defines the mileage distributions for each weight class, with and without trailer, respectively. The truck category "with trailer" is split further into different sizes of trailers expressed as the total weight (i.e. weight range, e.g. 20-28 tonnes) of the truck and trailer combination. The transformation patterns for Sweden were derived from traffic measurements on Swedish roads. Vehicle fleet data is shown in Figure A 2.10.

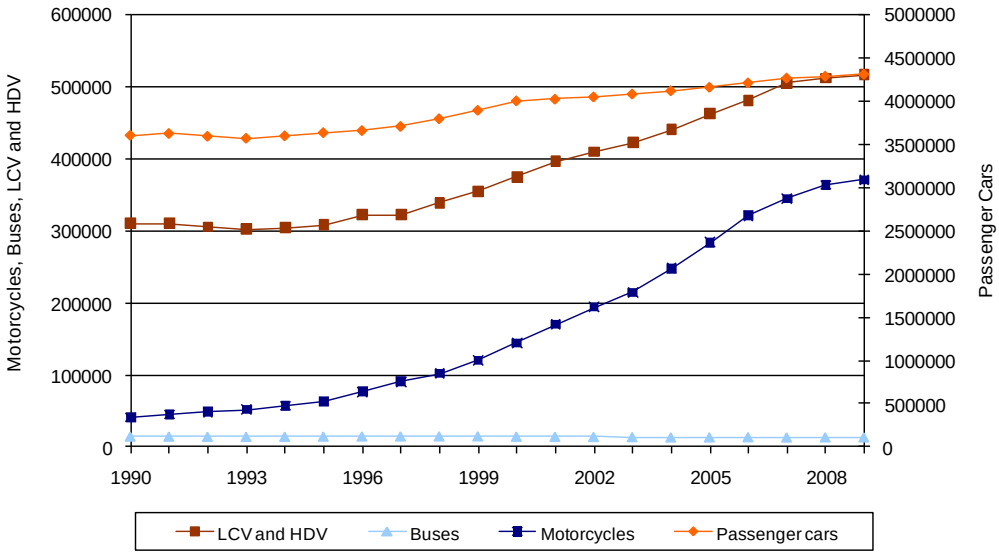


Figure A 2.10. Vehicle fleet data by dec 31, numbers, 1990-2009, Statistics Sweden

1.5.2 Traffic activity data

1.5.2.1 VEHICLE MILEAGES, LOADS, TRIP LENGTHS AND FUELS

The HBEFA 3.1 model requires yearly mileages per vehicle category (Figure A 2.11). For Sweden these are calculated by means of a national road mileage model[40]. Important inputs to this model are the overall mileage on roads, derived from traffic measurements on Swedish roads, along with the number of vehicles in different categories. The annual mileage per vehicle category is derived by dividing the total mileage per category with the number of vehicles per category. By applying the same number of vehicles together with the derived mileage, the HBEFA 3.1 model will provide the same overall national mileage as the national road mileage model.

Yearly mileages per vehicle sub-segment level are used to distribute the total mileage on sub-segments. A method has been developed, which can assign all vehicles in the register an annual mileage, based on yearly odometer readings within the Swedish inspection & maintenance (I/M) program[41]. This data is used for deriving mileage both per vehicle sub-segment, and as a function of vehicle age. For heavy duty vehicles the HBEFA 3.1 model requires mileage distributions of load factors empty (0% load), half-load (50% load), and fully loaded (100% load), by vehicle segment and vehicle age. This data is derived from a major national survey from 1997 on Swedish domestic road goods transport[42], including detailed information about both truck and trailer loads.

In order to estimate evaporative and cold start emissions, information on distributions of trip lengths and parking times, and on the seasonal and diurnal variation of ambient temperature is needed. Trip lengths and parking times can be derived from surveys, or from data from instrumented cars. For Sweden an average trip length according to surveys is 12 km, and according to instrumented cars 7 km[43]. Instrumented cars provide the trip length from engine start to engine stop. Even if instrumented car data just represents a few vehicles and use in few families, this data set has been considered more representative than the survey data, since the information requested is the distance travelled from engine start to engine stop[44]. Thus, available instrumented vehicle data was used to estimate trip lengths and parking times in Sweden.

[40] Edwards et al., 1999
[41] SIKA, 2003
[42] Hammarström and Yahya, 2000
[43] SNRA 1999
[44] André et al., 1999

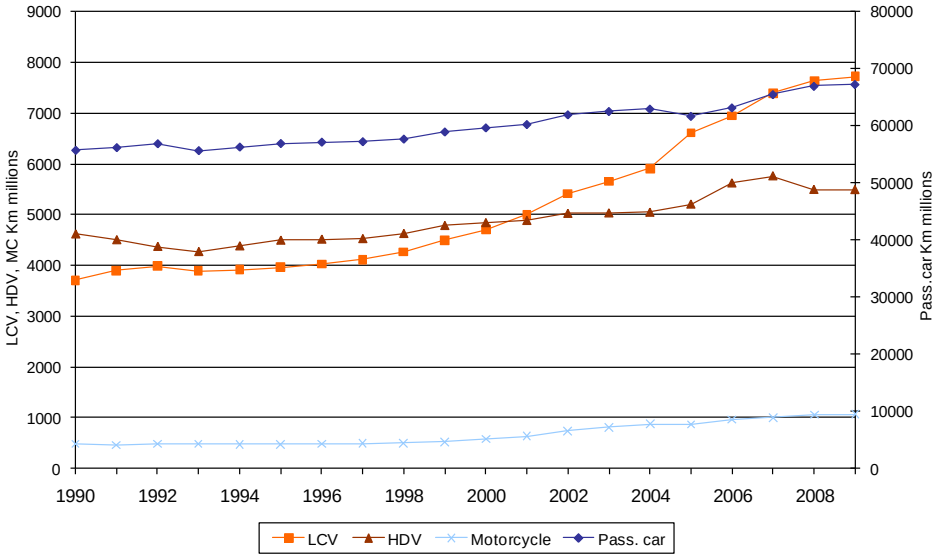


Figure A 2.11. Vehicle mileages 1990-2009 according to HBEFA 3.1.

1.5.2.2 TRAFFIC SITUATIONS

The HBEFA 3.1 model includes 276 traffic situations, i.e. combinations of 69 road categories and for each of those four classes of traffic conditions or "levels of service", defining how disturbed the traffic is relative to undisturbed traffic - 1) Free Flow, 2) Heavy Traffic, 3) Saturated, and 4) Stop and Go conditions. Furthermore it is possible to add different level of grade; however this is not done for Sweden.

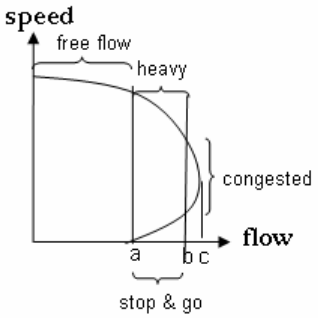
The national vehicle mileages for year 1990, 1995, 1998, 2000 and 2004 were initially estimated by means of the national vehicle mileage model[45]. Procedures were established to allocate the total vehicle mileage over 1) urban and rural roads, 2) road categories, 3) traffic conditions, and to fit the result to the traffic situations in HBEFA 3.1. Two national GIS road databases were employed. The first, VDB, contains all state road links attached with information about: length, road function, speed limit and ADT (average daily traffic) split on light- and heavy-duty vehicles. The second, NVDB, were used for municipal and private road links. NVDB contains information on road classification and road link length, but lacks information on ADT. Traffic simulations were performed for four regions in Sweden to represent the distribution of vehicle mileage over road categories for municipal and private roads. To separate between urban and rural road links, a GIS layer with polygons for built-up areas was utilized. Through this, the study was able to present new figures on the distribution of the overall vehicle mileage between urban and rural roads in Sweden: 41% and 59%, respectively (the distribution used earlier was 35% and 65%, respectively). State-owned rural and urban roads together with municipality-owned urban roads accounted for more than 90% of the overall vehicle mileage in 2004.

Furthermore, a model for distributing the urban vehicle mileage on cities of different size was demonstrated. Cities with inhabitant number exceeding 200,000 -

[45] Edwards et al., 1999

only three in Sweden - accounted for between one fourth to almost one third of the overall vehicle mileage on urban roads. Available statistics on hourly flow conditions for different road types[46] were employed for describing the yearly variation of ADT (monthly, weekly, daily and hourly) on the different road types. The hours over the year were divided into groups based on their share of ADT for different road categories, entitled ranks (categories for rural roads were: share of ADT >0.12, 0.8-1.2, 0.4-0.8 and <0.04, categories for urban roads were: share of ADT >0.1, 0.07-0.1, 0.04-0.07 and <0.04). Using the available statistics, traffic flow and vehicle mileage at different rank-hours were calculated for each link of the state road network.

Similar calculations were carried out for the municipal and private road links in the four regions. The results, traffic flow per lane and hour were related to volume-delay functions, see Figure 11, and preliminarily classified into HBEFA 3.1 traffic conditions 1-3. Hypothesis were formulated concerning the distribution of vehicle mileage for "Stop and Go"-conditions. This cannot be estimated from volume delay functions alone, since it is not possible to decide whether a flow occurring between free flow (a) and congested (b) in Figure A 2.12 is a case of demand exceeding capacity (Stop and Go) or if it is a lower flow (Heavy Traffic). To overcome this, two assumptions were made: Stop and Go would only occur on road links that had reached their capacity, c; and for these roads it was assumed that Stop and Go constituted a fixed share of the preliminary estimated vehicle mileage in the traffic condition “Heavy Traffic”.



Road speed limit	Capacity (c in figure veh./lane*h)	Condition 1 “Free flow” (a in figure)	Condition 2 “Heavy” (a-b)	Condition 3 “Congested” (b in figure)
90+	2000	<1300	1300-1700	≥ 1700
70	1550	<600	600-1300	≥ 1300
50-	1150	<600	600-900	≥ 900

Figure A 2.12. Traffic flow per lane and hour were related to volume-delay functions

By studying flow over the day for individual congested roads, see Figure A 2.13, it could be seen that a local decrease in flow sometimes occurred within a congested period (i.e. when flow is near the capacity). This period was assumed to be a “Stop and Go”-period and calculations were made accordingly. The calculations finally resulted in a distribution of the vehicle mileage (light- and heavy-duty vehicles) over road categories and traffic conditions for the Swedish road network for the years 1990, 1995, 1998, 2000 and 2004.

Swedish road categories were translated to HBEFA 3.1 traffic situations based on the description of road hierarchy, speed limit, function and design. Then it was

[46] Björketun et al., 2005, Jensen, 1997

possible to sum the vehicle mileage in Sweden over the HBEFA 3.1 traffic situations for different years.

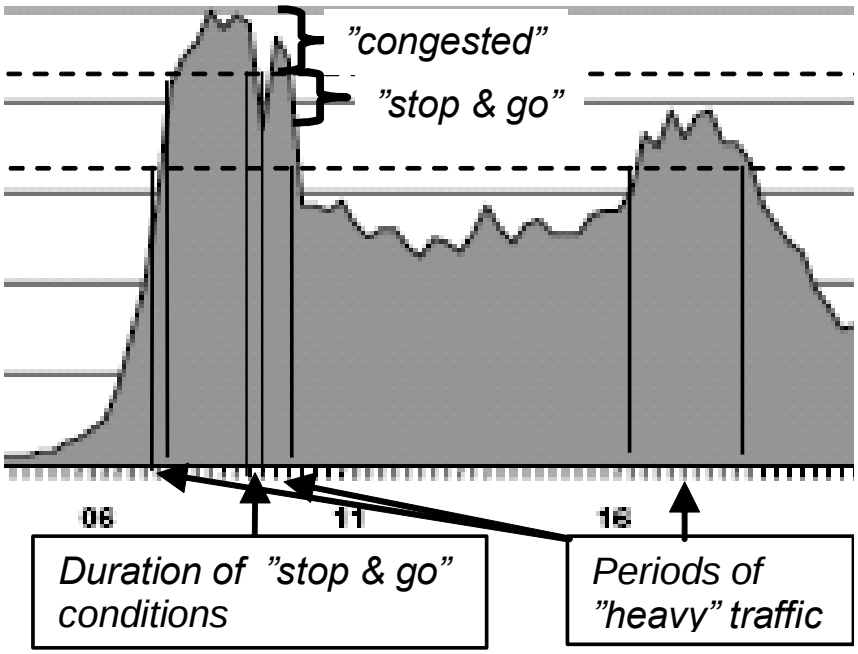


Figure A 2.13. Flow over the day for individual congested roads

85 of the overall 276 HBEFA 3.1 traffic situations were identified in Sweden in 2004, representing 33 road categories, for which the HBEFA 3.1 traffic conditions "Free Flow" or "Heavy Traffic" were predominant. In fact, as much as 94% of the overall vehicle mileage driven in Sweden was characterised by free flow conditions. The ten most abundant HBEFA 3.1 traffic situations all involved "Free Flow" conditions, and are presented in Table A 2.17.

The three most common road categories "Rural Distributor" (speed limits 90 and 70 km/h, respectively) and "Rural Motorway" (speed limit 110 km/h) accounted for more than 40% of the national vehicle mileage. Adding also urban road categories "Local Collector" and "Access Residential" (both with speed limit 50 km/h), and "Distributor" (speed limits 70 and 50 km/h, respectively), and two more rural categories ("Local Collector", 70 km/h, and "Trunk Road", 110 km/h), these ten most abundant road categories at free flow conditions accounted for about 80% of the national vehicle mileage. The share of the HBEFA 3.1 "Stop and Go"-conditions of the overall mileage was as low 0.05%, and only occurred in the three major cities (having more than 200,000 inhabitants). Further details concerning the methodology and the results are reported elsewhere[47].

[47] Larsson and Ericsson, 2006

Table A 2.17. The ten most common traffic situations in Sweden in 2004, and their share of the total vehicle mileage.

Description of traffic situation		Vehicle mileage
Rural / Distributor-District connection	/ Speed limit: 90 km/h / Free flow	21.3%
Rural / Distributor-District connection	/ Speed limit: 70 km/h / Free flow	11.1%
Rural / Motorway	/ Speed limit: 110 km/h / Free flow	10.7%
Urban / Local collector	/ Speed limit: 50 km/h / Free flow	9.7%
Urban / Access-Residential	/ Speed limit: 50 km/h / Free flow	6.6%
Urban / Distributor-District connection	/ Speed limit: 70 km/h / Free flow	5.9%
Rural / Local collector	/ Speed limit: 70 km/h / Free flow	5.7%
Urban / Distributor-District connection	/ Speed limit: 50 km/h / Free flow	4.8%
Urban / Access-Residential	/ Speed limit: 30 km/h / Free flow	2.2%
Rural / Trunk road	/ Speed limit: 110 km/h / Free flow	2.0%
Total		79.9%

Starting in 2008 there has been a change in the speed limit scheme in Sweden. Also speed limits 40, 60, 80, 100 and 120 km/h have been implemented in parallel with the old speed limits. In the model the mileage share on the different speed limits and traffic situations have been updated from year 2010. This includes a use of a more updated methodology for allocating traffic into different traffic situations.[48]

1.5.2.3 COMPARING HBEFA 3.1 TO ARTEMIS

The consumption of gasoline and diesel from road traffic calculated by HBEFA 3.1 is lower than the consumption calculated by ARTEMIS. One reasonable explanation is that a new approach is applied to calibrate the fuel consumption of the vehicle fleet in the model. In the ARTEMIS model the calculated fuel consumption for new passenger cars was calibrated to national statistics on fuel consumption for new passenger cars in the NEDC (New European Driving Cycle). The basis for this statistics is the Swedish reporting to the European Commission on CO_2 emissions from new cars. This was done to get a better description of the annual change in the energy efficiency of the Swedish vehicle fleet. In HBEFA 3.1 the fuel consumption for new vehicles is calculated for the NEDC driving cycle and calibrated to the national statistics on CO_2 emissions for new vehicles in the NEDC driving cycle. A correction is done to recalculate the emissions from NEDC including cold start to NEDC with hot start assuming cold starts stands for 4 percent of the CO_2 emissions. The new approach allows the total fuel consumption to be dependent on the traffic situation distribution for Sweden at same time as the vehicle fleet in the model is calibrated to Swedish vehicle fleet. In ARTEMIS only the latter was possible. Further investigations to the cause to these differences are under way.

But as the fuel consumption is adjusted to correlate with the statistics of the national fuel deliveries for reporting to the UNFCCC , the change to HBEFA from

[48] TU06 – New V/D-functions for urban environments – Revision of the TU71-functions
http://www.vti.se/en/publications/tu06--new-vd-functions-for-urban-environments--revision-of-the-tu71-functions/

ARTEMIS does not affect this estimate. Nor does it affect the estimations of emissions of CO_2 and SO_2, since these are based on national fuel deliveries.

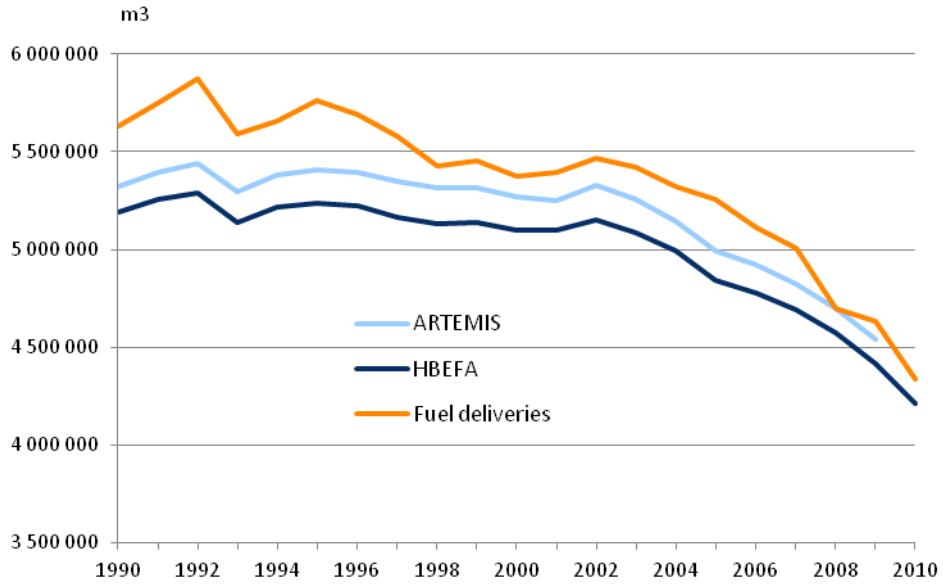


Figure A 2.14 Comparison between estimated gasoline by HBEFA 3.1 and ARTEMIS. The total amount of gasoline supplied in Sweden, also for other purposes than road traffic, is shown[49].

1.5.2.3.1.1 Hydrocarbons

The emissions of hydrocarbons (HC) from HBEFA 3.1 are about 35 percent larger than from ARTEMIS. One significant reason for this is the difference between the models in estimating the emissions from cold starts. In this case, the estimate from HBEFA 3.1 is higher than the estimate from ARTEMIS. The difference between the two emission models with regard to hydrocarbons emissions, arise from cold starts estimations as a result of the new cold start model.

[49] Swedish Transport Agency (SNRA). Leverans av data till klimatrapportering 2012, vägtrafik. 2011

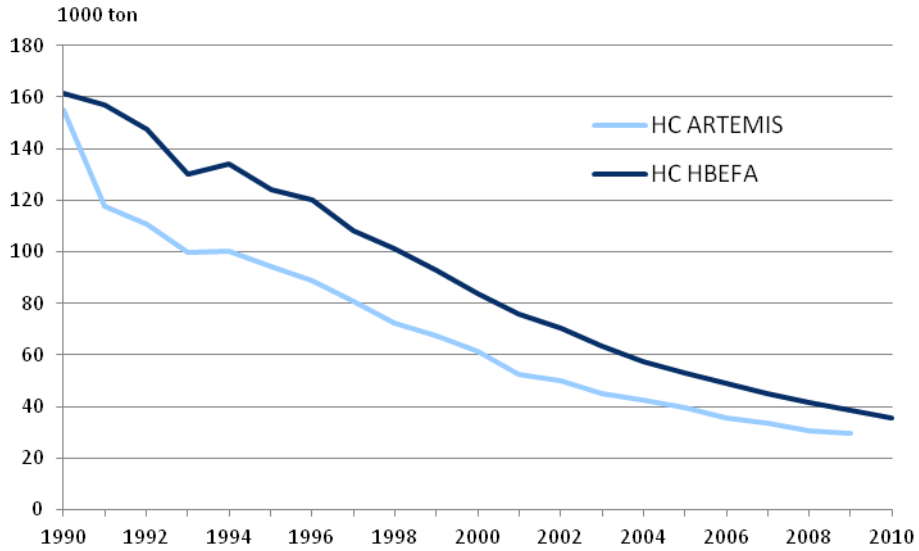


Figure A 2.15. Comparison between emissions of HC estimated by HBEFA 3.1 and ARTEMIS.

1.5.2.3.1.2 Nitrogen oxide

The emissions of nitrogen oxides (NOx) in 1990 are lower according to HBEFA 3.1 than ARTEMIS, but the difference slowly decreases until 2003. As from 2003 the total emissions from HBEFA 3.1 are slightly higher. This difference results mainly from passenger cars. The reason for the difference is a new model approach for calculating emissions for passenger cars.

As for city buses, the percental change in emissions between the two models is large (but not in absolute emissions). One possible explanation is an underestimation of emissions from Euro 4 & 5 engines in ARTEMIS. The exhaust emission control for buses with Euro 4 & 5 engines turns out to work poorly in city traffic, since the exhaust temperature at lower speeds will not be high enough for an optimal function of the exhaust emission control. HBEFA 3.1. includes adjustments for this problem and the estimated emissions of nitrogen oxide are thus higher.

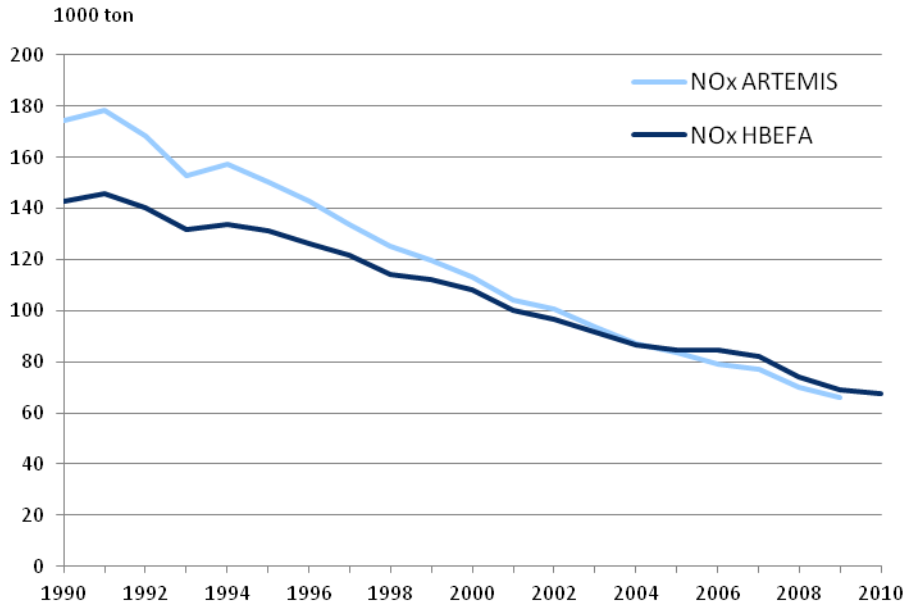
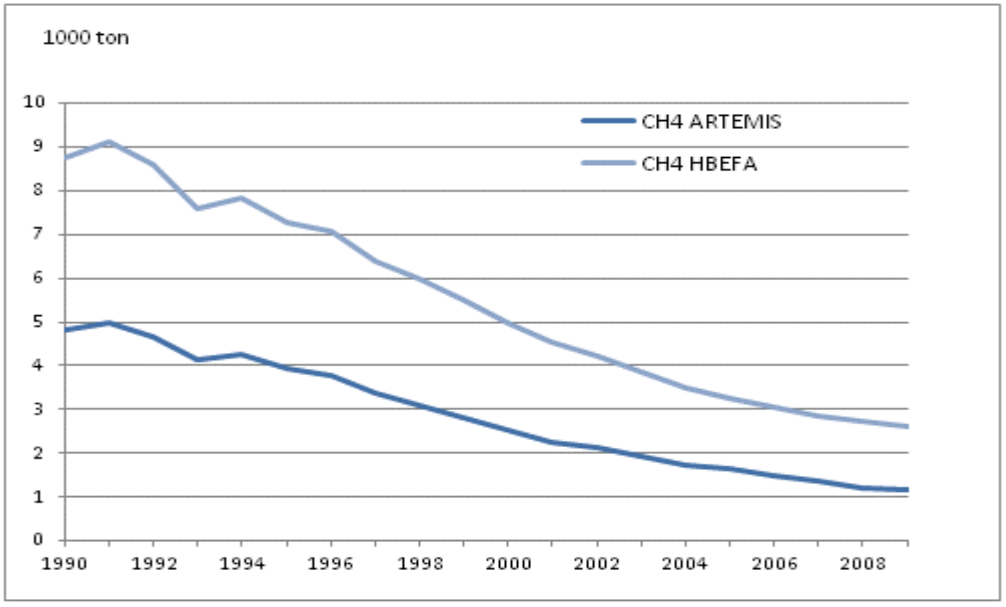


Figure A 2.16. Comparison between emissions of NOx estimated by HBEFA 3.1 and ARTEMIS.

1.5.2.3.1.3 Methane

Regardless of year, the emissions of methane (CH_4)are twice as high from HBEFA 3.1 as from ARTEMIS. Around 90 percent of the emissions of methane derive from passenger cars. The difference between the two models with regard to methane emissions arise from cold start emissions as a result of the new cold start model.

Figure A 2.17. Comparison between emissions of CH4 estimated by HBEFA 3.1 and ARTEMIS.



1.5.2.3.1.4 Nitrous oxide

When catalysers were introduced on cars, the emissions of nitrous oxide (N_2O) increased as a result of incomplete reduction of the nitrogen oxides (NOx); foremost at cold starts. As the number of cars with three-way catalysts increased, the emissions of nitrous oxide from cars increased. But as the three-way catalyst technology developed over the years, the emissions of nitrous oxides at cold start have declined.

Passenger cars was in the past mainly responsible for the emission of nitrous oxide and accounted for 80 percent of all the nitrous oxide emissions from road traffic in 2000, but by 2010 it had declined to 60 percent.

The emissions of nitrous oxide from HDV (heavy duty vehicles) have in recent years increased according to HBEFA and by 2010 they accounted for 30 % of these emissions, due to an introduction of catalysers for HDV. This development was not accounted for in ARTEMIS, which could be one of the reasons for a higher estimate of nitrous oxide emissions in ARTEMIS for later years. The reason for the difference in levels of emissions of N_2O between ARTEMIS and HBEFA 3.1 lies in the new cold start model in HBEFA 3.1. The increase for HBEFA 3.1 for the last years that cannot be seen in ARTEMIS depends on that that HBEFA 3.1 is later updated and also include measurements on the latest technology of exhaust aftertreatment equipment on HDV.

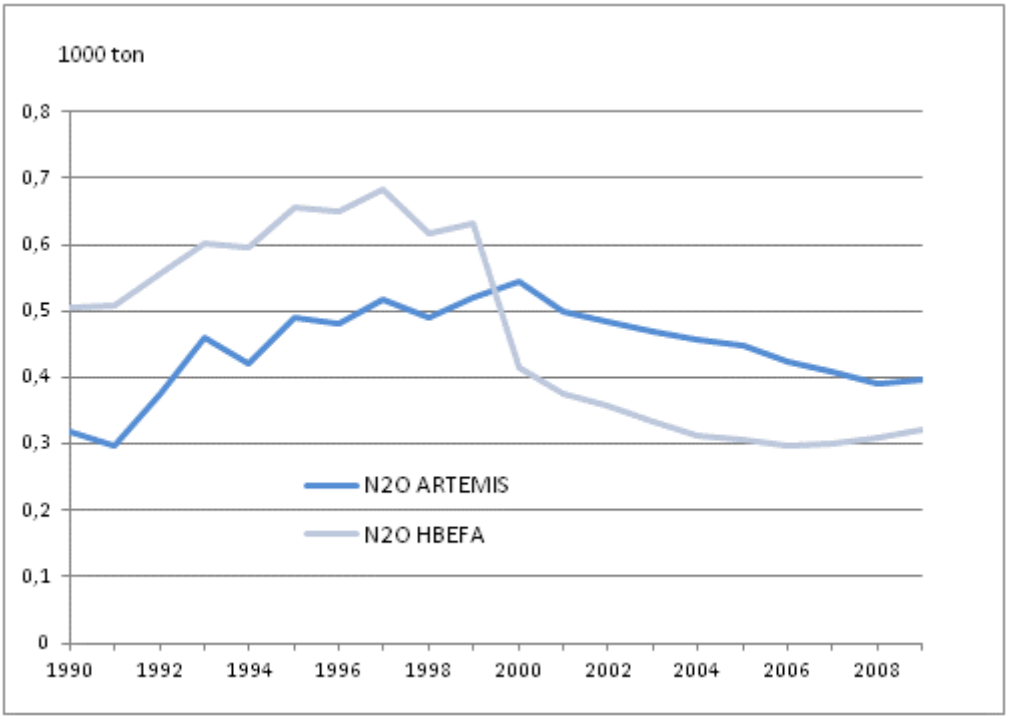


Figure A 2.18. Comparison between emissions of N_2O estimated by HBEFA 3.1 and ARTEMIS.

References

André, M., Hammarström, U. and Reynaud, I., 1999. Driving statistics for the assessment of pollutant emissions from road transport. INRETS Report LTE 9906. February 1999.

André, M., 2004. The ARTEMIS European driving cycles for measuring car pollutant emissions. Science of the Total Environment, 334/335, 73-84.

Björketun U., Carlsson A., (2005), Trafikvariation över dygnet, Trafikindex och rangkurvor beräknade från mätdata, VTI-kod N31-2005, www.vti.se/publikationer (in Swedish).

Edwards, H., Nilsson, G., Thulin, H., Vorwerk, P., 1999. Trafikarbetet uttryckt i fordonskilometer på väg i Sverige 1950-1997 ("Model for estimating vehicle mileage on Swedish roads 1950-1997"). VTI Rapport 439-1999 (in Swedish). www.vti.se/publikationer.

Hammarström, U. and Yahya, M.-R., 2000. Estimation of representative fuel factors for heavy lorries – Questionnaire survey. VTI Report 445 (in Swedish). www.vti.se/publikationer.

Jensen, S., 1997. Standardised Traffic inputs for the Operational Street Pollution Model (OSPM), NERI Technical Report No. 197, Ministry of Env. and Energy, Copenhagen, ISBN: 87-7772-332-5.

Keller, M., Kljun, N., Zbinden, I., 2005. ARTEMIS Road Emission Model 0.2R Model description (draft). INFRAS, Berne, Switzerland, 03.12.2005.

Larsson H., Ericsson E., 2006. Relating Swedish traffic activity data to ARTEMIS traffic situations, In: Proceedings of the International Symposium "Environment & Transport - Transport and Air Pollution", Reims, France, June 12-14 2006, vol. 2, 338-344.

SIKA, 2003. Körsträckor under 2001. Resultat och metoder för att skatta fordons körsträckor baserade på besiktningsuppgifter ("Mileage for 2001. Results and methods in order to estimate mileage of road vehicles based on odometer readings at vehicle inspections"). SIKA Rapport 2003:3 (in Swedish). www.sika-institute.se.

SNRA (1999) Initial study of driving patterns and exhaust emissions in urban areas and development of a method in order to measure changes in acceleration and speed around road junctions. Driving behaviour 1998. SNRA Publication 1999:137.

Swedish Transport Agency (SNRA). Leverans av data till klimatrapportering 2012, vägtrafik. 2011

1.6 Methodology for off-road vehicles and working machinery

Estimated emissions for off-road vehicles and other machinery are calculated with a bottom up method and are therefore considered to correspond to Tier 2.

Emissions of CO_2 and SO_2 are based on the same thermal values and emission factors for diesel and gasoline as used for road traffic.

Fuel consumption and emissions of CO_2, SO_2, NO_X, NMVOC, CH_4, CO, N_2O are estimated based on a model developed by SMED in 2008. The methodology for estimating emissions from off-road vehicles and working machinery was revised in submission 2012[50]. The revision did not imply in an updated methodology but aimed to simplify the use of the model and at the same time update some emission factors, activity data and the allocation of emissions to different sectors. Allocation of emissions from off-road vehicles and working machinery is based on a report by Flodström (et al)[51]. This is the most recent inventory including an allocation of working machinery to sectors carried out in Sweden.

The calculations in the method are based on the equations below:[52]

$$E = N \times Hr \times P \times Lf \times EF_{adj} \quad (1)$$

Where:

- N = number of vehicles,
- Hr = yearly running time in hours,
- P = motor effect i kW,

[50] Jerksjö, M., Fridell, E., Gerner, A., Eklund, V., Segersson, D., 2010
[51] Flodström, E., Sjödin, Å., Gustafsson, T. 2004.

[52] Fridell, Jernström and Lindgren, 2008

- Lf = load factor, and
- EF_{adj} =adjusted emission factors in g kWh^{-1} according to equation below (applied for larger off road vehicles and snow scooters).

$$EF_{adj} = EF_l \times CAF \times TAF \times DF \times FAF \quad (2)$$

Where:

- EF_l = emission regulations according to EU legislation in g kWh^{-1},
- CAF = adjustment factor for difference between regulation and value measured at certification,
- TAF = adjustment factor for transient (i.e.difference between static test cycle and real use of the machine),
- DF = adjustment factor for decline of the motor by increasing age, and
- FAF = adjustment factor for difference between certification fuel and Swedish diesel of type "MK1".

All variables in the equations above are described as vectors with data for every year model the last 25 years.

For gasoline driven smaller off-road vehicles and machinery, emission factors are taken from Winther and Nielsen.[53] These are based on certification measurements, and the different emission classes are separated in the calculations. Emission factors for diesel driven smaller off-road vehicles and machinery are taken from Corinair[54].

Number of larger off-road vehicles of different types is based on a bottom up inventory for 2006. [55] Numbers of tractors per sector, year-model and motor effect interval are taken from Statistics Sweden's registers for 2000, 2002, 2004, 2006, 2007 and 2008, as are the number of tractors per sector and motor effect interval for 1990 and 1995. For other years, numbers are interpolated by year model etc., but the proportions of different vehicle types are assumed to be constant. Number of smaller vehicles and machinery are based on a bottom up inventory for 2002[56], and other years the number is updated with the same trend as for the larger vehicles. The number of snow scooters is taken from Statistics Sweden's register for each year.

The yearly running time, motor effect, the load factor and the different adjustment factors in equations above are taken from Wetterberg[57] and Flodström[58]. The fuel adjustment factor, FAF, and the certification adjustment factor, CAF, for larger vehicles in equation (2) are taken from Lindgren (2007).[59] The TAF and DF factors are taken from the Nonroad model[60]. Fuel consumption for snow scooters are taken from Winther and Nielsen 2006[61] and DF and emission factors from the

[53] Winther, M., Nielsen, O.-K., 2006.
[54] EEA. 2007
[55] Wetterberg C, Magnusson R, Lindgren M, Åström S. 2007.
[56] Flodström, E., Sjödin, Å., Gustafsson, T. 2004.
[57] Wetterberg C, Magnusson R, Lindgren M, Åström S. 2007.
[58] Flodström, E., Sjödin, Å., Gustafsson, T. 2004.
[59] Lindgren M. 2007.
[60] USEPA. 2005.
[61] Winther, M., Nielsen, O.-K., 2006.

Nonroad model[62] are used. Emission factors for smaller gasoline driven vehicles and machinery are taken from Winther and Nielsen. These are based on certification measurements, and the emissions are calculated separately for each emission class.

For all types of vehicles and machinery, the emission factors for SO_2 and CO_2 are adjusted according to fuel specifications for each year.

1.6.1 References

EEA. 2007. EMEP/CORINAIR Emission Inventory Guidebook - 2007. Technical report No 16 European Environment Agency, Copenhagen Denmark.

Flodström, E., Sjödin, Å., Gustafsson, T. 2004. Uppdatering av utsläpp till luft från arbetsfordon och arbetsredskap för Sveriges internationella rapportering. Rapportserie SMED och SMED&SLU Nr 2 2004.

Fridell, E., Jernström, M., Lindgren,M., 2008. Arbetsmaskiner – Uppdatering av metod för emissionsberäkningar. SMED report 39 2008.

Jerksjö, M., Fridell, E., Gerner, A., Eklund, V., Segersson, D., 2010 - Arbetsmaskiner – Långsiktig plan för uppdatering av bränsleförbrukning och emissioner. SMED report 88 2010

Lindgren M. 2007. A methodology for estimating annual fuel consumption and emissions from non-road mobile machinery – Annual emissions from the non-road mobile machinery sector in Sweden for year 2006. Report – Environment, Engineering and Agriculture 2007:01. Department of Biometry and Engineering, SLU, Uppsala, Sweden.

Statistics Sweden, 2006: Energy consumption in the fishery sector 2005. Official Statistics of Sweden.

USEPA. 2005. Exhaust emission factors for nonroad engine modeling: spark-ignition. EPA420-R-05-019, NR-010e

Wetterberg C, Magnusson R, Lindgren M, Åström S., 2007. Utsläpp från större dieseldrivna arbetsmaskiner – Invertering, kunskapsuppbyggnad och studier om åtgärder och styrmedel. Rapport – miljö, teknik och lantbruk 2007:03. Institutionen för biometri och teknik SLU

Winther, M., Nielsen, O.-K., 2006. Fuel use and emissions from non-road machinery in Denmark from 1985-2004 - and projections from 2005-2030. Danish Ministry of the Environment project 1092, 2006.

[62] USEPA. 2005.

Annex 3 Other detailed methodological descriptions for individual source or sink categories, including for KP-LULUCF

Annex 3.1 Brief description of the Excel-model for calculation of emissions of fluorinated gases

Background

In 2000 the first inventory of actual emissions of fluorinated greenhouse gases in Sweden was performed, covering the time period 1990-99 (Kindbom et. al 2001). At this time a first version of an excel model was developed. In early 2004, the model was refined concerning the calculations from the accumulated bank. After the improvement the leakage factor for equipment produced one specific year is used throughout its lifetime. For several sub-sources the produced newer equipment has been assigned lower annual leakage, while the older equipment still is assigned the original higher leakage rate in the calculations.

In 2005 a thorough update of the calculations and the model was made since additional information had become available, indicating that an update of the way of utilizing background data, and of the calculation methodology was necessary (Kindbom, K. 2005).

Activity data used for calculating emissions from the categories stationary refrigeration (HFCs and PFCs) and electrical insulation (SF_6) were revised in cooperation with Product Register staff at the Swedish Chemicals Agency. Furthermore, national calculation methodologies for emissions from semi-conductor manufacture and from foam blowing were studied in relation to the descriptions in IPCC Good Practice Guidance (2000). The result from these comparisons was that the methodology for calculating emissions from semi-conductor manufacture was revised according to the Tier 1 methodology given in IPCC Good Practice Guidance, while the national method for calculating emissions from foam blowing was retained.

Due to improved information during the course of the work, revisions of emission calculations were also made for mobile air conditioning and for metered dose inhalers. Additionally, from the improved information on fluorinated substances followed that the reporting of potential emissions, where previously only data from 1995 and on were covered, could be made complete for the whole time series.

Structure of the excel model

The model consists of an excel file with:

- 19 sheets, one sheet for each sub-source considered (plus 3 sheets for aggregated sub-sources) where all input data from 1990 until present are registered and where calculations of accumulated amounts and actual emissions occur.
- one summary sheet where emissions for each year from 1990 are transferred from the sub-source sheets and are summarized by year, substance and source.
- one sheet where background information such as GWP-values are automatically taken into the calculations in the summary sheet.

The individual sub-source sheets may look slightly different as far as the input data cells are concerned. These have been adapted to suit the actual input data available and needed for the calculations. For all sub-sources calculations are however made concerning annual accumulated bank and actual emissions by substance. Where appropriate also imported and exported amounts in products are calculated.

Input data and calculated data

Every sub-source sheet has input cells for each year where the production, import and export of F-gases for that particular source are entered. For each year an expected lifetime, leakage factors and a minimum content factor is given. Each sub-source then has its specific composition of use of species of HFC, PFC and SF_6, which are calculated separately. For each component the leakage in each year is calculated taking into account the leakage from production, the leakage from the accumulated bank and from decommissioning. In these calculations each year uses the leakage factor for that year's production until minimum content is reached or the expected lifetime is reached.

Changes in accumulated amounts each year 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, have been taken into consideration.

Most calculations is made with standard worksheet functions in excel. But to simplify the worksheets some VBA functions have been written. These are:

Function **get_emission** (SheetName, ColName, RowName)
Used in the summary sheet to collect results on actual emissions from the detailed sub-source sheets.

Function **accumulated_minus_leakage** (year_range, cond_range, _
year, sum_range, leakage_range, min_content)
Calculates the sum of each year's additions of HFC, PFC and SF_6 minus the leakage taking into account the different leakage factors for each year and the minimum content in each equipment.

Function **leakage_per_year** (year_range, cond_range, _
year, sum_range, leakage_range, min_content)
Calculates the sum of the leakage of the accumulated bank.

Development of new functionalities in the model in 2005

Most of the information necessary for a complete reporting of fluorinated greenhouse gases according to the guidelines was already present as background data in the model. The model until 2005 however efficiently supported only the compilation of annual actual emissions. The development in 2005 in particular applied to

the information required in the background tables in the CRF reporting system, and to the reporting of potential emissions.

New definitions relating to the reporting requirements were developed and included in all source specific data sheets. These cover all required data in the CRF background tables, such as the amounts of chemical filled in new manufactured products, accumulated stock and remaining amounts at decommissioning, as well as the emission factors for production, during use and at decommissioning.
Some adjustment and development relating to specific sources and calculation sheets were also made:

- an aggregation of sources in the group of stationary refrigeration and air conditioning, with previously seven separate sources/sheets were aggregated into three calculation sheets.
- the calculations for metered dose inhalers and technical (other) aerosols were split on two separate sheets.
- the calculations of emissions of SF_6 from electrical equipment was split on two separate sheets, one for emissions from manufacture of gas insulated switchgear and one for electrical insulation.
- a harmonisation of the presentation of columns and calculations in the different sheets/sources in the model was also made, since source specific improvements and changes over time had made the calculation sheets develop along different lines.
- sheets for registering and adjustment of import and export data from the Product Register were added to the model. This enables the automatic calculation of volumes of chemicals not already accounted for in the model. As a result, surplus HFCs not already accounted for are automatically allocated to stationary refrigeration and accordingly for SF_6, which is automatically allocated to electrical insulation.

The model before did not support the reporting of potential emissions regarding import and export of chemicals in bulk. The sheets for registering and adjustment of import and export data from the Product Register also enables a compilation of the import and export in bulk as a basis for the reporting of potential emissions in the CRF-system.

Review of the model input and output in 2011

In 2011 SMED performed a review study (Gustafsson, T., 2011) on the national model for estimating emissions of fluorinated greenhouse gases in Sweden. The aim of the study was to improve the quality of the collection and emission estimation system in Sweden for F-gases reported to the UNFCCC and the EU Monitoring Mechanism, and especially in order to enable better annual follow-up of changes in chemicals flows and emissions of F-gases, e.g. due to increased amounts of HFC recovered and the enforced national and international legislations.

The national statistics available and the most important additional information sources and emission factors were reviewed. The results of the study showed that the national statistics from the Swedish Chemicals Agency and the additional information sources continues to be a good foundation for the Swedish emission inventory reporting.

In the study no major adjustments were recommended for the collection and emission estimation system, but there were some suggestions on modifications of emission factors and model macros. In addition, the study included several recommendations for future improvements on emission inventory quality control checks as well as on national data management procedures.

References

Kindbom, K., Haeger Eugensson, M., Persson, K. (2001). Kartläggning och beräkning av potentiella och faktiska utsläpp av HFC, FC och SF_6 i Sverige. IVL report B 1428. (In Swedish)

Kindbom, K. (2005) Revision of Methodology and Estimated Emissions of Fluorinated Greenhouse Gases in Sweden. SMED Report 16 2005.

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 98 2011.

Annex 3:2 Land Use, Land-Use Change and Forestry (CRF sector 5)

In the following chapter we provide additional information on methodological issues used in the inventory for the LULUCF-sector. The structure follows chapter "7.3 Methodological issues" in the NIR and we refer to the corresponding NIR-chapter where appropriate.

1.1 Methodological issues, CRF-tables 5A, 5B, 5C, 5D, 5E and 5F

1.1.1 Sample based estimations

See NIR 7.2.2.2. 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 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 tract number *j* will represent a large area in the estimations of area weight and the sum of all represented areas will be equal to the total county area (A_i).

$$Area\ weight_{ij} = \frac{A_i}{n_i \cdot a_{ij}}$$

where $Area\ weight_{ij}$ = the area that tract *j* within county *i* will represent, n_i = number of sampled tracts within county *i*, and a_{ij} = the inventoried area of tract *j* within county *i*. In a consistent manner the $Area\ weight_{ij}$ will be the same for each year from 1990 onward. Whole plots or plot parts may change land use category by time but the total tract area will always represent the same area. At the county level, the reported value (e.g. the Δ- carbon for land use category Forest land remaining Forest land) will be estimated by a ratio estimator[63].

$$\hat{Y}_i = A_i \frac{\hat{X}_i}{\hat{A}_i}$$

where $\hat{Y}_i$ = the ratio estimated value, A_i = the measured area (determined 1984 by the national land survey; Lantmäteriet[64]). $\hat{X}_i$ = the estimated value of the variable of interest according to Horvitz-Thompson and $\hat{A}_i$ = the estimated area according to Horvitz-Thompson. Index *i* refers to county.

[63] Thompson, 1992
[64] Lantmäteriet, http://www.lantmateriet.se/

The two values estimated by the Horvitz-Thompson estimator are calculated similarly, e.g. as:

$$\hat{X}_i = Area\ weight_{ij} \sum_{j=1}^{n_i} x_{ij}$$

where x_{ij} = is the inventoried value of tract j (within county i).

Finally the reported value on national level, $\hat{Y}$, is estimated as:

$$\hat{Y} = \sum_{i=1}^{N} \hat{Y}_i$$

where N = the total number of counties in Sweden.

Sweden will only report "human induced" carbon changes, 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. All areas, managed or unmanaged, are reported.

1.1.2 The LULUCF reporting database

See NIR 7.2.2.3. The reporting database is based on permanent sample plots inventoried by RIS. In total, around 40 000 permanent sample plots were laid out during the period 1983-1987 representing the whole area of the country. Thus all land and fresh-water areas are monitored. The permanent sample plots have been re-inventoried at intervals of 5-10 years, however, for economical reasons, the number of sample plots have been reduced to around 30000. The 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. In Table A 3:2.1 below the structure of the reporting database and the inventories are illustrated

Each single sample plot has been inventoried in one of ten inventory intervals. When all plots of a specific reporting year have been re-inventoried at least once, after the specific reporting year, the figures will be re-calculated based on all sample plots. Theoretically, both the current and the re-calculated reporting will be unbiased. However, the accuracy will be better in the latter case.

To improve the calculations for the years not inventoried or interpolated, each set of data is extrapolated for years up to the latest reported year. This means that the average for each reported year for which there is not a full record of plots inventoried or interpolated is weighted, thus reducing the significance of the inventory of last reported year, which may cause unrealistic annual variations.

Table A 3:2.1. A single sample plot is inventoried in one of ten inventory intervals. Blue background refers to measurements and no colour refers to interpolated data. Orange background means that data has been extrapolated (exemplified at end of commitment period) .

1	2	3	4	5	6	7	8	9	10
1983	1983	-	-	-	-	-	-	-	-
1984	1984	1984	1984	-	-	-	-	-	-
1985	1985	1985	1985	1985	1985	-	-	-	-
1986	1986	1986	1986	1986	1986	1986	1986	-	-
1987	1987	1987	1987	1987	1987	1987	1987	1987	1987
1988	1988	1988	1988	1988	1988	1988	1988	1988	1988
1989	1989	1989	1989	1989	1989	1989	1989	1989	1989
1990	1990	1990	1990	1990	1990	1990	1990	1990	1990
1991	1991	1991	1991	1991	1991	1991	1991	1991	1991
1992	1992	1992	1992	1992	1992	1992	1992	1992	1992
1993	1993	1993	1993	1993	1993	1993	1993	1993	1993
1994	1994	1994	1994	1994	1994	1994	1994	1994	1994
1995	1995	1995	1995	1995	1995	1995	1995	1995	1995
1996	1996	1996	1996	1996	1996	1996	1996	1996	1996
1997	1997	1997	1997	1997	1997	1997	1997	1997	1997
1998	1998	1998	1998	1998	1998	1998	1998	1998	1998
1999	1999	1999	1999	1999	1999	1999	1999	1999	1999
2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
2001	2001	2001	2001	2001	2001	2001	2001	2001	2001
2002	2002	2002	2002	2002	2002	2002	2002	2002	2002
2003	2003	2003	2003	2003	2003	2003	2003	2003	2003
2004	2004	2004	2004	2004	2004	2004	2004	2004	2004
2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
2006	2006	2006	2006	2006	2006	2006	2006	2006	2006
2007	2007	2007	2007	2007	2007	2007	2007	2007	2007
2008	2008	2008	2008	2008	2008	2008	2008	2008	2008
2009	2009	2009	2009	2009	2009	2009	2009	2009	2009
2010	2010	2010	2010	2010	2010	2010	2010	2010	2010
2011	2011	2011	2011	2011	2011	2011	2011	2011	2011
2012	2012	2012	2012	2012	2012	2012	2012	2012	2012
2013	2013	2013	2013	2013	2013	2013	2013	2013	2013
2014	2014	2014	2014	2014	2014	2014	2014	2014	2014

1.1.3 Methodology living biomass CRF 5A, 5B, 5C, 5D, 5E and 5F

See NIR 7.3.1.2. A national methodology (Tier 3) is used. The aboveground biomass per tree fractions is estimated by applying Marklund's[65] biomass functions to calliper and sample trees on permanent sample plots of the NFI[66]. The belowground biomass pool is estimated by Petersson's and Ståhl's[67] biomass functions applied to the same trees. The conversion factor 0.49 is used to convert dry weight biomass to carbon[68]. Estimates are based on repeated measurements and the stock change of for a specific year (X) is calculated as the difference in stock between year X and year X-1.

[65] Marklund, 1987 and 1988
[66] Ranneby et al., 1987
[67] Petersson and Ståhl, 2006
[68] National Board of Forestry, 2000

Marklund's single tree allometric regression functions (Table 11) were developed for predicting biomass of the following tree fractions; needles (not leaves), branches, bark and stem for Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*) and birch (*Betula pendula* and *Betula pubescens*). The total fresh weight of each tree (in total, about 1300 trees) and the fresh weight of samples from different fractions were measured in field. The dry weight of each sample, defined as the constant weight at 105°C, was determined in the laboratory. The calculations of dry weight per fraction were based on these measurements. The trees were selected from 123 stands from different parts of Sweden, covering a wide variety of stand and site conditions.

Petersson and Ståhl developed allometric single tree below ground biomass functions for Scots pine, Norway spruce and birch in Sweden (Table A 3:2.2). The idea was to calibrate an existing comprehensive data set of about 600 trees inventoried by Marklund that only covered the stump and coarse roots, by a new data set that covered roots down to 2 mm diameter. The new data set consisted of about 80 trees sampled using the same sampling design as Marklund, but supplemented with a detailed inventory of the fine root fractions remaining in the ground. The old data set was calibrated before the two data sets were merged. The merged data set was used for deriving the functions.

At application, trees with a diameter at breast height larger than 99 mm are positioned on the sample plots and perfectly matched to land use over time, while smaller trees, 0-99 mm, are reported under Forest land remaining Forest land/ FM. The removal of smaller trees are calculated as the average removal over time (1990-2010).

Table A 3:2.2. The simplest biomass functions applied to trees only measured for stem diameter at breast height (1.3 m) and species. TVSTEM=dry weight, stem including bark [kg], TVLGREN=dry weight, branches and needles (not leaves) [kg], TVBARR=dry weight, needles (not leaves) [kg], TVROTSTU=dry weight, stump and roots down to 2 mm [0.1 kg], D=stem diameter at breast height (1.3 m) [cm] and dbh=stem diameter at breast height (1.3 m) [mm]

Biomass function	Unit	Reference
Scots pine (Pinus sylvestris)		
TVSTEM=exp(11.3264*D/(D+13.)-2.338)	[kg]	Marklund, T-1
TVLGREN=exp(9.1015*D/(D+10.)-2.8604)	[kg]	Marklund, T-13
TVBARR=exp(7.7681*D/(D+7.)-3.7983)	[kg]	Marklund, T-17
TVROTSTU=exp(3.44275+((dbh/(dbh+113))*11.06537)+((0.35449**2)/2.))/100.	[0.1 kg]	Petersson & Ståhl
Norway spruce (Picea abies)		
TVSTEM=exp(11.3341*D/(D+14.)-2.0571)	[kg]	Marklund, G-1
TVLGREN=exp(8.5242*D/(D+13.)-1.2804)	[kg]	Marklund, G-11
TVBARR=exp(7.8171*D/(D+12.)-1.9602)	[kg]	Marklund, G-15
TVROTSTU=exp(4.58761+((dbh/(dbh+138))* 10.44035)+((0.32308**2)/2.))/100.	[0.1 kg]	Petersson & Ståhl
Birch (Betula pendula and B. pubescens)		
TVSTAM=exp(11.0735*D/(D+8.)-3.0932)	[kg]	Marklund, B-1
TVLGREN=exp(10.2806*D/(D+10.)-3.3633)	[kg]	Marklund, B-11
TVROTSTU=exp(6.17080+((dbh/(dbh+225))* 10.01111)+((0.36266**2)/2.))/100.	[0.1 kg]	Petersson & Ståhl

1.1.4 Methodology dead organic matter CRF-tables 5A, 5B, 5C, 5D, 5E and 5F

See NIR 7.3.1.3. A national methodology is used to estimate the dead organic matter pool. The pool includes different sub-pools (dead wood, coarse litter and the organic soil horizon) that are estimated using different methods.

The inventory of fallen and standing dead wood began in 1994 for northern Sweden and from 1995 for the whole country. However, for consistency reasons we began using data from 1997. Thus the same value is reported 1990-1997 (extrapolation). The inventory cycles used are quite complicated (Table A.3.2.4). From 1997 and onwards, each year's estimate is based on around 6000 to 24000 sample plots. The idea is to combine samples in a way that data in average represent year X and the next year, year X+1.

The carbon content in dead wood is assessed by first measuring the volume of dead wood and then converting volume to carbon content by multiplying by constants. The constants are differentiated according to decay class and species[69]. Sandström

[69] Sandström et al., 2007

et al. developed conversion factors from dead wood volume per decay class to biomass for the species Norway spruce, Scots pine and birch in Sweden. About 2500 discs were collected from logs in managed forests located on 290 NFI[70] sample plots and in 11 strips located in preserved forests. The data represented different site-, stand-, species- and dead wood properties in Sweden. The volume per sample disc was measured (divided into species and decay classes). The dry weight of each sample, defined as the constant weight at 85°C, was measured at the laboratory. The carbon content per dry weight biomass for Norway spruce and Scots pine was estimated to 50.0 and 51.2 % of the dry weight biomass pool respectively, based on a sub-sample. The conversion factors decreased significantly by decay class and the average dry densities were 0.226, 0.239 and 0.275 [g•cm^{-3}], for Norway spruce, Scots pine and birch, respectively.

Below-ground dead wood originating from stump and root systems is partly estimated and partly modeled. The input to this pool is estimated as the difference between growth (in CO_2 equivalents) minus net change in living biomass (= harvest). A constant is used to convert whole tree harvest to retained stump system biomass. The output is modeled by a decomposition function[71]. Input and output is considered from 1853-2010 (Table A 3:2 3). The long time series is necessary to consider emissions from decomposition of "historical stumps". In the long run, the stump pool will only end up in a removal if harvest are gradually increasing. The conversion factors are derived by applying biomass functions [72] and stem volume functions[73] to sample trees inventoried by the National Forest Inventory and representing the standing stock of Sweden.

Table A 3:2.3. Whole tree growth on productive forest land, net whole tree removal on Forest land (FAO), gross removal in stump systems and net removal in stump systems [M ton CO2 equivalents]. Conversion factors: 1 m3 stem wood is assumed to correspond with 750 kg whole tree biomass and 184 kg stump system biomass (dry wood). (minus=removal)

Reporting year	Whole tree growth	Whole tree removal	Gross removal stumps	Net removal stumps
1990	-138	94.6	-24.8	-4.20
2010	-163	134	-32.7	-6.33

For all inventory occasions, the reported figures are estimated by the same monitoring design using the same conversion factors, and data for years between inventories are interpolated. The reported figures are based on the trend between inventory years as described in table A.3:2.4.

[70] Ranneby et al., 1987
[71] Melin et. al. 2009
[72] Marklund, 1988, Petersson and Ståhl, 2006
[73] Näslund 1947

Table A 3:2.4. Description on data-sets used to estimate changes in the dead wood pool

Reporting year	Trend between years		No. of plots
1990…1997	1997	2004	6000
1998	1997/1998	2004/2005	12000
1999	1997/1998/1999	2004/2005/2006	18000
2000…2004	1997/1998/1999/2000	2004/2005/2006/2007	24000
2005	1998/1999/2000	2005/2006/2007	18000
2006	1999/2000	2006/2007	12000
2007	2000	2007	6000
2008	2000/2003	2007/2008	12000
2009	2003/2004	2008/2009	12000
2010	2004/2005	2009/2010	12000

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 aboveground fallen or standing dead wood. Litter fall for coniferous species is calculated using empirical functions (Table A 3:2.5) and litter fall for deciduous species by biomass functions based on leaf biomass. The annual litter pool is included since it will not be part of any of the other fractions. It may contain both coarse and fine litter but is not related to dead wood like the coarse litter fraction defined above, and it is not part of the fine litter fraction sampled since all parts of the litter layer that are considered to have fallen during the inventory year are removed before sampling. 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.

The annual stock change in the O or H-horizon carbon stock is based on samples from re-inventoried plots between 1993 and 2008 (values for 1990-1992 and 2009 to 2010 are extrapolated).

Table A 3:2.5. Functions used to estimate the litter part of the dead organic matter pool. The following abbreviations are used; CL=coarse litter, DW=dead wood, AL=Annual litter-fall, NS=Norway Spruce, PS=Scots pine, D=decidous, Lat=Latitude, BA=basal area, Age=tree age, ND=number of decidous stems ha^{-1}, ABHD=average diameter at breast height (1.3 m), C=carbon, Cconc=Carbon concentration in %, SDW=sample dry weight in Mg, SA=sampled area in ha, TL=total litter)

Coarse litter (CL)		**Unit**
CL=0.15•DW		[kg •ha^{-1}]
CCL=0.5•CL/1000	(CCL=Carbon in coarse litter)	[Mg•ha^{-1}]
Annual litterfall (AL)		
ALNS=16509-245.8•Lat+5.22•BANS		[kg •ha^{-1}][74]
ALPS=6906-102.3•Lat+46.4*BAPS-4.5•Age		[kg •ha^{-1}][75]
ALD= ND•0.00371•ABDH$^{1.11993}$		[kg •ha^{-1}][76]
CAL=0.5• (ALNS+ALPS+ALD)/1000	(CAL=Carbon in annual litterfall)	[Mg•ha^{-1}]
Fine litter (CFL) <2 mm		
CFL=SDW•Cconc•0.01/SA		[Mg•ha^{-1}]
Total litter carbon (CTL)		
CTL=CCL+CAL+CFL		[Mg•ha^{-1}]

1.1.5 Methodology soil organic carbon Forest land and Grassland on mineral soils CRF 5A and 5C

See NIR 7.3.1.4.1. The method is a Tier 3 method. The estimates are based on repeated measurements 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:

$$SOCi = C_i \bullet Wfe_i,$$

where SOC_i is the amount of carbon found in soil layer $_i$ [Mg•ha^{-1}] and C_i is the carbon concentration [%] in the fine earth fraction (<2 mm) and *Wfe*, is the amount of fine earth in the soil layer [Mg•ha^{-1}]. The amount of fine earth is dependent on the bulk density and amount of gravel, stones and boulders in the soil, hereafter referred to as stoniness. There are no direct measurements of stoniness in the soil inventory during the period 1993 to 2002. However, measurements of the stoniness started in 2003 and will be completed for all plots in 2012 using a modified[77]. Since data on stoniness is not expected to change, the reported data can be recalculated for the whole reporting period at the end of the commitment period.
For this reporting period the relationships between stoniness data collected 2003 and 2004 and a measured boulder frequency available for all the plots is used. Separate relationships were determined for the categories till, poorly sorted waterlaid sediments and well-sorted waterlaid sediments. It is important to note that any error in the estimate of stoniness have no influence on the direction of changes in the soil organic carbon pool but that it might affect the magnitude of the change slightly (Table A 3:2.6).

[74] Berg et al., 1999a
[75] Berg et al., 1999b
[76] Johansson, 1999
[77] Viro, 1952.

Table A 3:2.6. Stoniness correction coefficients.

Boulders (number/plot)	Parent material class	Stoniness (vol-%)
0	Well sorted sediment.	3.64
1-10	Well sorted sediment	4.72
11-50	Well sorted sediment	8.10
51-100	Well sorted sediment	ND
>100	Well sorted sediment	ND
0	Poorly sorted sediments and glacial till	23.6
1-10	Poorly sorted sediments and glacial till	31.2
11-50	Poorly sorted sediments and glacial till	37.5
51-100	Poorly sorted sediments and glacial till	46.9
>100	Poorly sorted sediments and glacial till	54.2

Bulk density (BD) is not measured for the mineral soil samples. Bulk density is instead predicted using a pedotransfer function,

$$BD = 1.5463 \cdot e^{-0.3130\sqrt{C_i}} + 0.00207 AD$$

where C_i is the carbon concentration [%] in the fine earth fraction (<2 mm) and AD the average depth of the soil layer in cm.

After the estimates for stoniness and bulk density have been made the carbon amount in each sampled soil horizon at each plot is determined. Thereafter the soil carbon in soil horizons not sampled is determined by interpolation between layers and finally the soil carbon content down to 50 cm can be calculated on a plot basis.

The annual carbon stock change for each plot is estimated using interpolation between the inventory years and extrapolation for years before and after the inventory of a single plot. For example, the carbon stock change for a plot measured in 1996 and 2006 will be calculated by using the measured values in 1996 and 2006. The annual change is interpolated between 1996 and 2006 and extrapolated for 1990-1995 and for 2007-2010. The stock change in soil organic carbon pool on mineral soils is then based on the average of these annual changes for all inventoried plots. Plots that are not re-inventoried yet are assumed to have no change in carbon stock. The principle is illustrated in Figure A:3.2.1.

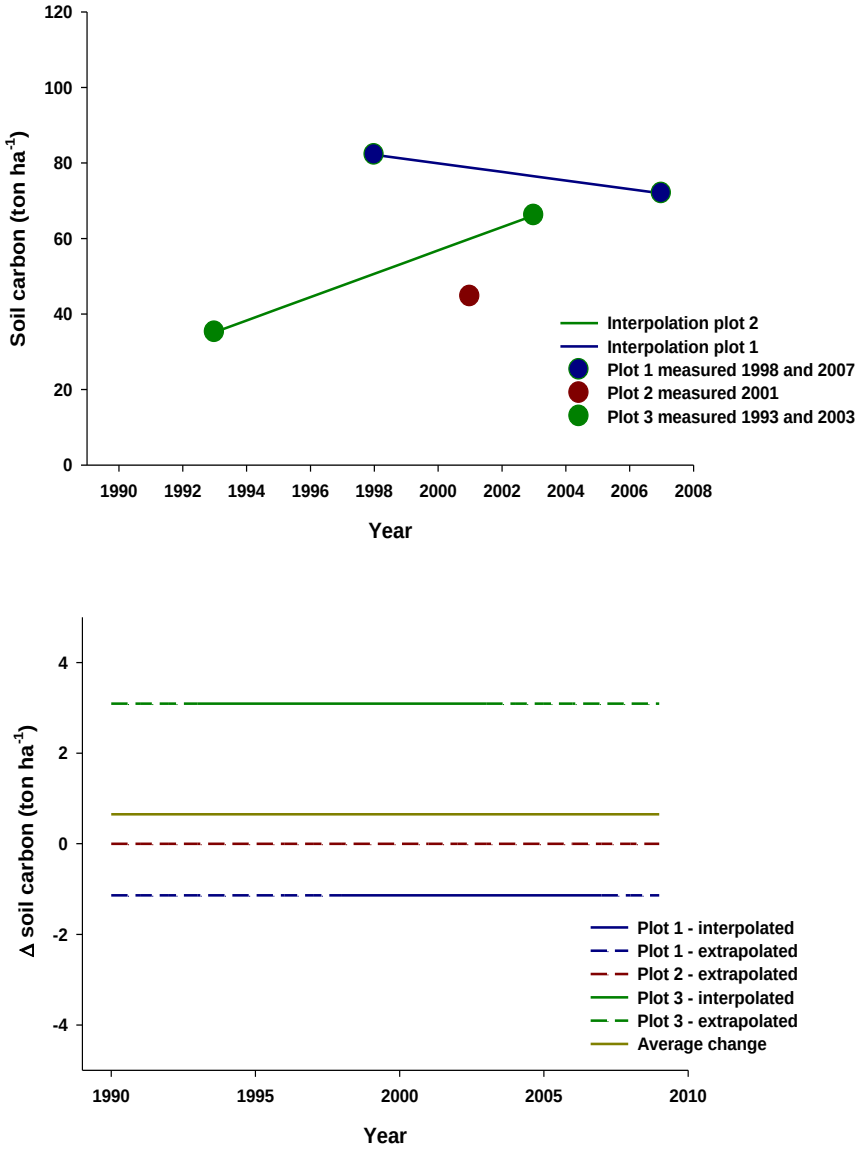


Figure A:3.2.1. Principle for interpolation of soil carbon (and DOM). The upper panel shows the estimated amount of soil carbon for three plots of which plot 1 and 3 have been measured two times and plot 2 only one. The change is equally distributed among the years between measurements and also extrapolated backwards and forwards in time. The lower panel show the resulting rates of change in soil carbon. Note that plot 2 is assumed to have zero change until it will be re-measured.

1.1.6 Methodology soil organic carbon Forest land and Grassland on organic soils CRF 5A and 5C

See NIR 7.3.1.4.2. The method is a Tier 2 method. The annual below ground litter input was estimated using annual above ground litter production from the NFI and the assumption that the fraction of below ground litter production is equal to the above ground litter production. The proportion of decomposed carbon assumed to correspond to the input to the soil organic carbon pool was set to 40% of the annual litter production.

The emission factors for heterotrophic respiration derived from the calculations made by von Arnold et .al. (2005)[78] were used to calculate the emissions from drained organic forest soils. The emission factors were 3.0 t CO_2-C ha^{-1} $year^{-1}$ (range 2.49-3.51) for well drained soils and 1.9 t CO_2-C ha^{-1} $year^{-1}$ (range 1.45-2.35) for poorly drained soils. Undisturbed organic soils were assumed to be in balance and accordingly no emissions or removals were estimated on these soils.. The total area of organic soils and the sub-area of drained soils were estimated from the NFI-database. Of the drained soils, the well-drained soil part was estimated to 91%. Data on the emissions are presented in Table A 3:2.7. Since the figures are more or less constant for the whole period only the first and last year in the time series are shown.

Table A 3:2.7. The area, below ground litter input and total emission on organic forest soils.

	Area of organic forest soils (Histosol)	Area of drained organic forest soils		Litter input[1]	Total emissions[1]
		Well-drained	Poorly drained		
Year	[Mha]	[Mha]	[Mha]	[Mton C]	[Mton C]
1990	4.3	1.1	0.13	0.073	-2.5
..	..	..	..	..	..
2010	4.3	1.1	0.13	0.092	-2.6

[1]Figure refers to drained, not total, Histosol area

1.1.7 Methodology soil organic carbon Cropland on mineral soils CRF 5B

See NIR 7.3.1.4.3. Swedish arable land covers 3 Mha and its topsoil contains about 300 Mton C. The mineral soils seem to be close to steady-state. The five-parameter soil carbon model ICBM-region is used to calculate annual C balance of the soil based on national agricultural crop yield/manuring statistics and allometric functions. The model is run for eight production regions and is calibrated using long-term field data.

Daily weather station data for each region together with crop type (bulked from individual crop data) and soil type is used to calculate an annual soil climate parameter for each crop/soil type permutation in each region. The model set up for the reporting to UNFCCC use 14 soil types and 9 crop types, which gives 126 parameter sets for each year and region, each representing a fraction of the region's area. For each year, region, crop and soil type, ICBM-region calculates the change in young and old soil carbon per hectare, and sums up the changes to, e.g., national changes. The annual change per hectare is calculated on a national basis and used together with the area estimates from the RIS (as described in previous sections).

[78] von Arnold et. al. 2005

1.1.8 Methodology soil organic carbon Cropland on organic soils CRF 5B

See NIR 7.3.1.4.4. The area of organic soils on cropland was assessed by Berglund et.al. [79]. Digitised maps of Quaternary deposits, 40K radiation and agricultural databases (IACS) were used to estimate the distribution and land use of agricultural organic soils in Sweden. The total area of agricultural organic soils in Sweden was estimated to be 267 990 ha of which 198 264 ha was classified as peat soils. To avoid double reporting we withdraw areas assessed as grazing land, tree plantations and wetlands representing 26 % of the area. These areas are included in the reporting under Grassland, Forest land and Wetland respectively. The area used in the reporting is much less than the area used in earlier calculations.
Since the reporting of LULUCF is based on the NFI-sample of all land-use categories we calculate the annual area of organic soils on cropland based on the relationship between the estimate of organic soils by Berglund and Berglund (2009) for 2008 and the total Cropland area in 2008. Since the reported area for 2008 may be affected by the randomness of the sample the total cropland area in 2008 was calculated using extrapolation of the trend of the cropland area for 1990-2005. The total cropland area for 2008 used in this calculation was 296420 ha and the area of organic soil (as described above) was 145 019 ha.

The emission factor for cropland on organic soils has been estimated using data from eight Swedish sites where the mean annual subsidence rates for peat soils cultivated with different crops have been studied[80]. First, the mean annual carbon loss per cm soil subsidence, hereafter referred to as the carbon loss factor (CLF), was calculated;

$$CLF = C_{ox} \cdot BD \cdot C_c$$

where C_{ox} is the carbon oxidation rate given as a fraction of total subsidence rate in cm yr^{-1}, BD is the bulk density in g cm^{-3}, C_c the carbon concentration in % of the soil material. Carbon oxidation has been calculated to make up 30 – 40 % of the total subsidence and a fixed value of 35 % has been used. Assuming a bulk density of 0.2 g cm^{-3} and a carbon concentration of the oxidized soil layer of 45 % the CLF was estimated to 3.15 Mg C ha^{-1} cm^{-1}.

Total carbon emissions from organic soils in Sweden were estimated using the formula:

$$CO_2 - C\ emmission = \sum SR_i \cdot area_i \cdot CLF$$

where areai and SRi denotes the area and the subsidence rate of crop type i. The background data for subsidence rates are for pasture 0.5 cm yr^{-1}, for lay 1.0 cm yr^{-1}, for cereals 1.5 cm yr^{-1} and for row crops 2.5 cm yr^{-1}. The relative area proportion of

[79] Berglund, et. al. 2009
[80] Berglund, 1989

the different crop types are 58, 30, 9.7 and 2.0 %, respectively, and the total area of organic soils under agricultural production is set to 4.9 % of the total cropland area.

1.1.9 Methodology CO2 emission from mineralization when extracting peat CRF 5D

See NIR 7.3.1.6. The emitted CO_2 [M ton•yr^{1}] from areas used for extracting peat is calculated as the product of the extracted area and an emission factor:

$$CO_2 = P \bullet EF$$

where *P*=production area [ha] and *EF*=emission factor [M ton•ha^{-1}•yr^{-1}]. The production area is the area suitable for peat extraction which is a limited part of the concession area for peat extraction. It should be noted that peat extraction is only carried out on parts of the production area. The peat extraction is usually proceeding on the same production area during several years. After extraction the area is 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. Production areas are obtained from Svenska Torvproducentföreningen[81]. The emission factor (6 [ton CO_2•ha^{-1}•yr^{-1}]) is based on studies made by Kasimir-Klemedtsson et al.[82] and by Sundh et al.[83], (Table A 3:2.8). The method is considered Tier 2 and the emission factors as country specific (CS).

[81] Svenska Torvproducentföreningen, 2006
[82] Kasimir-Klemedtsson et al., 2000
[83] Sund et al., 2000

Table A 3:2.8. The production area and emission associated with mineralization when extracting peat on Wetlands. An emission factor of 6 [ton CO_2•ha^{-1}•yr^{-1}] have been used.

Year	Production area [ha]	Emission, CO_2 [M ton•yr^{-1}]
1990	6600	0.040
1991	6100	0.037
1992	6600	0.040
1993	6400	0.038
1994	7000	0.042
1995	7700	0.046
1996	6800	0.041
1997	8100	0.049
1998	6700	0.040
1999	9700	0.058
2000	10400	0.062
2001	10500	0.063
2002	10200	0.061
2003	9400	0.056
2004	8000	0.048
2005	10300	0.062
2006	6200	0.037
2007	10300	0.062
2008	9159	0.055
2009	8965	0.054
2010	8965	0.054

1.1.10 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

See NIR 7.3.1.5. 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 in combination with the areal change in land-use.

The dead wood part (and the coarse litter part) of the dead organic matter pool is calculated using the total dead wood carbon pool change for each main land-use category (estimated by the NFI). The dead wood stock was distributed on the main classes (i.e. Land remaining Land) and the conversion categories according to their relative share of the total land use in each main category. For example: Cropland to Forest land constituted ca 1% of the total Forest land area and the associated carbon pool change for Dead wood was calculated as 1 % of the total Dead wood pool change for Forest land. Coarse litter was calculated as 15 % of the fallen or standing dead wood pool.

The emitted or sequestered CO_2 [M ton•yr^{1}] for the litter and soil organic carbon pools is calculated as the product of the total area in the conversion class and an emission factor (Table A 3:2.9). Since no information is available on whether the conversions took place on mineral or organic soils, the conversion area was assumed to have the same share of organic soils as soils not converted.

The emission factors for litter and Soil organic carbon are based on different assumptions:

a. When available, average carbon content per area was used to calculate the annual removal/emission over a 20 year transition period according to IPCC GPG 2003. Average soil carbon content (mineral soils) was 110 ton C/ha for grassland, 100 ton C /ha for Cropland and 45 ton C/ha for Forest land. The average litter pool for Forest soils was 30 ton C/ha for Forest land whereas the litter pool was assumed to be zero for all other land use classes.
b. The annual change in the litter pool for land use changes to Forest land is based on results from several chronosequence studies[84]. Due to a broad range of forest types and species in the studies there is a large variation in the annual increase in the litter layer among the different studies. However, the area estimate from the NFI does not comprise these differentiations. Therefore the calculations are based on one single value that where conservatively assessed to a removal factor of 0,3 Gg C/kha.
c. For conversions on organic soils the emission factor used is the same as for the final land-use.
d. For some categories where only the final land-use carbon content was known the average emission/removal from mineral soils for the final land-use was used to calculate the emission/removal from soil or litter.
e. Since conversion from Forest to other land uses may constitute a large loss of carbon a study was undertaken to estimate the final land-use and the associated emissions more accurately:
    - For conversions to Cropland the emission factors was estimated given the assumption that all litter are decomposed over the 20 year period whereas the soil organic carbon pool is assumed to increase by 20 % over the 20 year transition period.
    - For conversions to Grassland the emission factors was estimated given the assumption that 50 % of the litter are decomposed over the 20 year period whereas the soil organic carbon pool is assumed to increase by 10 % over the 20 year transition period.
    - For conversions to Settlements the emission factors was estimated for three major land-use groups: (i) For conversion to roads all litter and 80% of the soil organic carbon are assumed to disappear over 20 years, (ii) for conversion to power lines 20 % of the litter and 10% of the soil organic carbon are assumed to disappear over 20 years and (iii) for conversion to proper settlement 80 % of the litter and 50% of the Soil organic carbon are assumed to disappear over 20 years.
    - The time series 1990-2008 of conversions to Settlements was used to estimate the average annual differentiation between the three groups. Roads constituted 45 %, Power line 14 % and Proper Settlement 41 % respectively.

[84] Vesterdal et. al. 2007. Karltun et. al (manuscript). Thuille, A. and Schulze E. D. 2006.

Table A 3:2.9. The removal/emission factors used to calculate changes in carbon pools on converted land.

Removals/emissions (-) [Mg C ha^{-1} yr^{-1}]	Soil organic carbon		Litter	
	Mineral soils	Organic soils	Mineral soils	Organic soils
A 2.1 Cropland converted to Forest Land	-0,45[1]	-0,57[2]	0,3[1]	0,3[1]
A 2.2 Grassland converted to Forest Land	-0,225[1]	-0,57[2]	0,3[1]	0,3[1]
A 2.3 Wetland converted to Forest Land	0,17[4]	-0,57[2]	0,3[1]	0,3[1]
A 2.4 Settlements converted to Forest Land	0,17[4]	-0,57[2]	0,3[1]	0,3[1]
A 2.5 Other land converted to Forest Land	0,17[4]	-0,57[2]	0,3[1]	0,3[1]
B 2.1 Forest land converted to Cropland	0,45[1]	-3,73[3]	-1,5[1]	-1,5[1]
B 2.2 Grassland converted to Cropland	-0, 5[1]	-3,73[3]	0	0
B 2.3 Wetland converted to Cropland	-0,008[4]	-3,73[3]	0	0
B 2.4 Settlements converted to Cropland	-0,008[4]	-3,73[3]	0	0
B 2.5 Other land converted to Cropland	-0,008[4]	-3,73[3]	0	0
C 2.1 Forest land converted to Grassland	0,225	-1,6[5]	-0,75[1]	-0,75[1]
C 2.2 Cropland converted to Grassland	0,5	-1,6[5]	0	0
C 2.3 Wetland converted to Grassland	0,21[4]	-1,6[5]	0	0
C 2.4 Settlements converted to Grassland	0,21[4]	-1,6[5]	0	0
C 2.5 Other land converted to Grassland	0,21[4]	-1,6[5]	0	0
E 2.1 Forest land converted to Settlements	-1,30[1]	-	-1,2[1]	-
E 2.2 Cropland converted to Settlements	-2,5[1]	-	-	-
E 2.3 Grassland converted to Settlements	-2,75[1]	-	-	-
E 2.4 Wetlands converted to Settlements	-3,73[4]	-	-	-
E 2.5 Other land converted to Settlements	-1,30[1]	-	-	-

[1] Based on initial carbon content and assumptions described in text.

[2] Same emission factors as for drained organic forest soils.

[3] Same emission factors as for cropland on organic soils .

[4] Estimated average emission from mineral soils.

[5] Estimated average emission from mineral soils.

1.2 CRF 5(I), 5(II), 5(III), 5(IV) and 5(V)

This section relates to NIR section 7.3.2.

1.2.1 Methodology direct N2O emissions from N-fertalization, CRF 5(I)

NIR 7.3.2.1. The reported annual $N_2O_{direct\ fertilizer}$ [Gg•yr^{-1}] is calculated as:

$$N_2O_{direct\ fertilizer} = F_{synt} \bullet EF \bullet 44/28$$

where F_{synt}= is the amount of synthetic fertilizer nitrogen applied [Gg•yr^{-1}] and EF is the emission factor for N_2O emissions from N-inputs (IPCC-default emission

factor of 1.25 %[85]). F_{synt} is adjusted for volatilisation by a fixed loss rate of 10 %. Finally, N_2O-N is converted by multiplying N by 44/28 (

Table A 3:2.10).

Table A 3:2.10. The annual amount of synthetic fertilizer sold for application in forestry and the annual direct N_2O emission from nitrogen fertilization

	Synthetic fertilizer, N [Gg•yr^{-1}]			Emission, N_2O [Gg•yr^{-1}]
Year	Large scale forestry	Small scale forestry	Total	Total
1990	10.418	0.061	10.48	0.185
1991	6.043	0.061	6.10	0.108
1992	4.232	0.061	4.29	0.076
1993	3.748	0.061	3.81	0.067
1994	3.293	0.061	3.35	0.059
1995	3.824	0.061	3.88	0.069
1996	3.457	0.061	3.52	0.062
1997	2.710	0.061	2.77	0.049
1998	2.747	0.061	2.81	0.050
1999	3.601	0.061	3.66	0.065
2000	3.536	0.061	3.60	0.064
2001	2.983	0.061	3.04	0.054
2002	2.039	0.061	2.10	0.037
2003	2.430	0.061	2.49	0.044
2004	3.055	0.061	3.12	0.055
2005	4.563	0.061	4.62	0.082
2006	4.903	0.061	4.96	0.088
2007	6.910	0.061	6.971	0.123
2008	8.880	0.061	8.941	0.158
2009	8.264	0.061	8.325	0.147
2010	11.94	0.061	12.00	0.212

1.2.2 Methodology N2O emissions from disturbance associated with land-use conversion to cropland, CRF 5(III)

NIR 7.3.2.3. 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[86])

$$N_2O_{conv} = \Delta C_{min} \cdot \frac{1}{C:N_{ratio}} \cdot EF \cdot 44/28$$

where ΔC_{min}= is the annual emission of carbon due to soil mineralization (IPCC[87]), $C:N_{ratio}$= the average ratio between carbon and nitrogen in the soil (a constant of

[85] Intergovernmental Panel on Climate Change, 2003
[86] Intergovernmental Panel on Climate Change, 2003
[87] Intergovernmental Panel on Climate Change, 2003

15; IPCC), EF= the emitted proportion N_2O from N (a constant of 1.25 %; IPCC) and 44/28 is used to convert N to N_2O. 2.5 % of the carbon is assumed to be mineralised. The amount of carbon is calculated as the area converted times a constant of 120 ton C per ha. Summary results are found in Table A 3:2.11. The method is considered Tier 1 and the emission factors are IPCC default (D).

Table A 3:2.11. Annual N_2O emission from disturbance associated with land use conversion to Cropland (Conversions from Settlements should not be reported and the emission factors used in calculation might be incorrect for this type of conversion).

	N_2O emission associated with conversion to Cropland [Gg•yr^{-1}]	
Year	Forest land	Grassland
1990	0.009	0.066
1991	0.009	0.083
1992	0.006	0.088
1993	0.009	0.106
1994	0.009	0.117
1995	0.009	0.128
1996	0.009	0.135
1997	0.009	0.148
1998	0.013	0.148
1999	0.013	0.148
2000	0.018	0.157
2001	0.018	0.170
2002	0.014	0.182
2003	0.015	0.194
2004	0.015	0.199
2005	0.015	0.210
2006	0.015	0.211
2007	0.019	0.207
2008	0.019	0.221
2009	0.016	0.216
2010	0.017	0.214

1.2.3 Methodology carbon from agricultural lime application, CRF 5(IV)

NIR 7.3.2.4. The reported annual carbon emission from agricultural lime application (C_{lime}; [Gg•yr^{-1}]) is calculated as::

$$C_{lime} = M_{limestone} \bullet EF_{limestone} + M_{dolomite} \bullet EF_{dolomite}$$

where $M_{limestone}$=annual amount of sold calcic limestone [Gg•yr^{-1}], $M_{dolomite}$=annual amount of sold calcic dolomite [Gg•yr^{-1}], $EF_{limestone}$=emission factor for limestone=0.120, and $EF_{dolomite}$=emission factor for dolomite=0.122. Carbon (C) is converted to carbon dioxide (CO_2) by the conversion factor 44/12 (Table A 3:2.12). The method is Tier 1 and the emission factors IPCC-default.

Table A 3:2.12. Annual CO_2 equivalents from emission of lime products.

Year	Annual CO_2 emissions from liming [Gg•yr^{-1}]								
	Dolomite products		Limestone products						
	Dolo-mite	Mg-lime	Lime-stone	Find-ground raw lime	Lime for gar-dens	Lime from steel-pro-duc-tion	Lime from sugar pro-duc-tion	Other lime-prod-ucts	To tal
1990	25	32	35	12	21	14	30	1	170
1991	17	28	31	14	17	5	21	0	134
1992	11	20	21	16	14	5	22	0	109
1993	12	22	30	16	14	4	32	0	130
1994	13	26	39	27	11	4	36	0	156
1995	12	25	48	31	12	4	35	0	169
1996	17	37	54	35	10	4	35	0	193
1997	15	37	52	23	9	6	32	0	174
1998	14	21	27	21	9	2	36	0	131
1999	17	34	30	28	6	7	35	0	156
2000	17	28	30	36	7	5	34	0	156
2001	10	29	25	32	6	3	31	0	137
2002	17	20	30	23	4	5	29	2	131
2003	18	27	20	19	3	4	29	7	128
2004	16	27	18	15	3	4	28	12	122
2005	15	26	16	10	3	4	26	17	117
2006	8	19	10	8	3	3	24	16	91
2007	7	31	13	10	3	2	23	29	119
2008	12	25	16	11	3	3	23	13	104
2009	10	24	15	11	3	2	20	13	98
2010	9	22	14	10	3	1	18	14	91

1.2.4 Emissions from biomass burning, CRF 5(V)

NIR 7.3.2.5. Calculations of emissions from biomass burning are based on the area burned, the average standing stock on these areas, and on assumptions on the amount of biomass burned. Based on the average above ground standing stock of living and dead biomass on Forest land remaining forest land and by assuming that 25 % of the biomass is burned, the amount of carbon burned is assumed to be 5.78, 1.02 and 0.72 C [Mg•ha^{-1}] for the categories "Forest", "Sparsely covered by trees" and "No tree cover", respectively. The biomass of dead wood constitute about 0.3-0.6 % of this biomass. When controlled burning is performed for regeneration or nature conservation purposes, respectively, 1.15 and 5.78 C [Mg•ha^{-1}] are assumed to be released. The annual emission of carbon dioxide (CO_2-burning [Gg•yr^{-1}]) due to burning of wildfires or controlled burning is calculated as:

$$CO_2\text{-}_{burning} = A \bullet B \bullet 44/12$$

where A=the annual burned area [ha•yr^{-1}], B=amount of carbon burned [Gg•ha^{-1}].

The annual emission of nitrous dioxide ($N_2O_{burning}$ [Gg•yr^{-1}]) due to burning of wildfires or controlled burning is calculated as:

$$N_2O_{burning} = A \bullet B \bullet 0.01 \bullet 0.007 \bullet 44/28$$

The annual emission of methane (CH_4-$_{burning}$ [Gg•yr^{-1}]) due to burning of wildfires or controlled burning is calculated as:

$$CH_4\text{-}_{burning} = A \bullet B \bullet 0.012 \bullet 16/12$$

Emissions are presented in Table A 3:2.313. To avoid double counting from sub-mission, CO_2 emissions from biomass burning is assumed to be included (IE) in estimates of living biomass. For information purposes, the CO_2 emissions from biomass burning is found inside brackets in Table A.3.2.13. The method is Tier 1 and the emission factors are IPCC-default.

Table A 3:2.3. Annual emissions from biomass burning.

Year	Fire category [ha•yr^{-1}]					Annual emission		
	Wildfire			Controlled burning		CO_2	N_2O	CH_4
	Forest	Sparsely covered by trees	No tree cover	Regene-ration	Bio-diversity	[Gg•yr^{-1}]	[Gg•yr^{-1}]	[Gg•yr^{-1}]
1990	567	647	924	459	0	IE (19)	0.00056	0.082
1991	567	647	924	155	0	IE (18)	0.00053	0.076
1992	567	647	924	201	0	IE (18)	0.00053	0.077
1993	567	647	924	334	0	IE (18)	0.00055	0.080
1994	567	647	924	152	0	IE (18)	0.00053	0.076
1995	567	647	924	177	0	IE (18)	0.00053	0.077
1996	567	647	924	455	0	IE (19)	0.00056	0.082
1997	3810	1092	1484	1720	0	IE (96)	0.00288	0.419
1998	74	123	216	570	0	IE (5)	0.00015	0.022
1999	792	282	227	2293	200	IE (32)	0.00097	0.141
2000	783	323	430	1138	400	IE (32)	0.00096	0.140
2001	411	277	542	2144	600	IE (33)	0.00099	0.143
2002	874	403	1322	3002	800	IE (53)	0.00159	0.232
2003	1321	1016	1663	2073	1000	IE (66)	0.00198	0.288
2004	896	550	437	2694	1200	IE (59)	0.00177	0.257
2005	665	474	423	1888	1400	IE (54)	0.00163	0.238
2006	4206	495	480	2693	1410	IE (133)	0.00400	0.582
2007	523	312	255	1273	377	IE (26)	0.00079	0.115
2008	4280	1377	456	1272	2012	IE (145)	0.00434	0.632
2009	730	283	394	1357	256	IE (29)	0.00086	0.125
2010	144	147	249	335	99	IE (8)	0.00023	0.034

1.3 Uncertainties and time series consistency

This section relates to NIR section 7.4.

1.3.1 Living biomass, CRF 5A, 5B, 5C, 5D, 5E and 5F

NIR 7.4.2. 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 specified models and an unrepresentative derivation data could probably be ignored.

The reported estimated standard errors of the estimates are calculated by formulas for a ratio estimator[88]. The tracts (clusters) are assumed to be sample units and these units are assumed to be randomly distributed within strata. Small trees, shrubs and other vegetation, such as herbs, are not included in the figures. It is assumed that the net change in the stock of this vegetation is small.

A ratio estimator is calculated on county level:

$$\hat{Y}_i = A_i \frac{\hat{X}_i}{\hat{A}_i} = A_i \frac{\sum x_{ij}}{\sum a_{ij}} = A_i \cdot R_i$$

where $\hat{Y}_i$ = the ratio estimated value for county *i* (for example the change in biomass stock), A_i = the measured area of county *i*, $\hat{X}_i$ = the estimated value of the variable of interest according to Horvitz-Thompson for county *i* and $\hat{A}_i$ = the estimated area according to Horvitz-Thompson for county *i*. $\sum x_{ij}$ is the sum of the variable of interest over sampling units (tract) *j* within county *i*. $\sum a_{ij}$ is the total inventoried area over sampling units (tract) *j* within county *i*. The estimated variance on county level is calculated as:

$$\hat{Var}(\hat{Y}_i) \approx \frac{A_i^2}{(\sum a_{ij})^2} \cdot n_i \cdot S^2_{x_{ij} - R_i \cdot a_{ij}}$$

where n_i=the number of sampling units (tracts) within county *i* and $S^2_{x_{ij} - R_i \cdot a_{ij}}$ is the standard deviation based on x_{ij}-$R_i \cdot a_{ij}$. Each county constitute a stratum and the estimated variance over all strata (whole Sweden) is calculated as:

$$\hat{Var}\left(\hat{Y}_{Swe}\right) = \sum_{i=1}^{N} \hat{Var}\left(\hat{Y}_i\right)$$

[88] Thompson, 1992

where *N*=number of strata (counties in Sweden), $\hat{Var}\left(\hat{Y}_{Swe}\right)$ = the estimated variance for the reported estimate on national level and the corresponding standard error of this estimate is:

$$SE = \sqrt{\hat{Var}(\hat{Y}_{Swe})}$$

Finally, the reported Uncertainty is calculated as:

$$Uncertainty = 2 \cdot SE$$

1.4 References

Berg, B., Johansson, M-B., Tjarve, I., Gaitneks, T., Rokjanis, B., Beier, C., Rothe, A., Bolger, T., Göttlein, A. and Gertsberger, P. 1999a. Needle litterfall in a northern European spruce forest transect. Reports in Ecology and Forest Soils, Report 80, Department of forest Soils, Swedish university of agricultural Sciences, Uppsala, Sweden. 36 pp.

Berg, B., Albrektsson, A., Berg, M.P., Cortina, J., Johansson, M-B., Gallardo, A., madeira,M., Pausaa,J., Kratz,W., Vallejo, R., and McClaugherty, C. 1999b. Amounts of litterfall in some pine forests in a European transect, in particular Scots pine. Ann. For. Sci. 56:625-639.

Berglund, K. 1989. Ytsänkning av mosstorvjord. Swedish University of Agricultural Sciences, Dept. of Soil Sciences, Division of hydrotechnics. Report 89:3. (In Swedish).

Berglund, Ö., Berglund, K. Sohlenius, G. 2009. Organogen jordbruksmark i Sverige 1990-2008 Swedish University of agricultural Sciences, Department of Soil Sciences, Division of Hydrotechnics report 12, Uppsala 2009.

Intergovernmental Panel on Climate Change. 2003. Good Practice Guidance for Land Use, Land-Use Change and Forestry. Penman, J., Gytarsky, M., Hiraishi, T., Krug T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K., and Wagner, F. (Eds.). IPCC/OECD/IEA/IGES, Hayama, Japan. ISBN 4-88788-003-0.

Johansson,T. 1999. Biomass equations for determining fractions of pendula and pubescent birches growing on abandoned farmland and some practical implications. Biomass and Bioenergy, 16:223-238.

Karltun et. al (manuscript) Soil carbon dynamics under a chronosequence of forests planted on agricultural land, as shown by 14C-bomb analysis. Swedish University of Agricultural Sciences.

Kasimir-Klemedtsson, Å., Nilsson, M., Sundh, I., Svensson, B., 2000. Växthusgasflöden från myrar och organogena jordar. Naturvårdsverket, Rapport 5132. ISBN 91-620-5132.

Marklund, L.G. 1987. Biomass functions for Norway spruce in Sweden. Swedish University of Agricultural Sciences, Department of Forest Survey, report 43. 127p. ISSN 0348-0496.

Marklund, L.G. 1988. Biomassafunktioner för tall, gran och björk i Sverige. Sveriges Lantbruksuniversitet, Institutionen för skogstaxering, rapport 45. 73 sidor ISSN 0348-0496.

Melin Y., Petersson H., Nordfjell T . 2009. Decomposition of stump and root systems of Norway spruce in Sweden - a modelling approach. Forest Ecology and Management . 257: 5, 1445-1451

National Board of Forestry. 2000. Skogliga konsekvensanalyser 1999. Skogsstyrelsen, Jönköping 2000. 331 sidor. ISSN 1100-0295.

Näslund M. 1947. Funktioner och tabeller för kubering av stående träd . Tall, gran och björk i södra Sverige samt i hela landet. Meddelande från Statens skogsforskningsinstitut. Band 36:3. Stockholm.

Petersson, H., and Ståhl, G. 2006. Functions for Below Ground Biomass of Pinus sylvestris, Picea abies, Betula pendula and B. pubescens in Sweden. Scandinavian Journal of Forest Research, 21(Suppl 7): 84-93.

Ranneby, B., Cruse, T., Hägglund, B., Jonasson, H., and Swärd, J. 1987. Designing a new national forest survey for Sweden. Studia Forestalia Suecica 177, 29 p.

Sandström, F., Petersson, H., Kruys, N. & Ståhl, G. 2007. Biomass conversion factors (density and carbon concentration) by decay classes for dead wood of Pinus sylvestris, Picea abies and Betula spp. in boreal forests of Sweden. Forest Ecology & Management, 243: 19-27.

Sundh, I., Nilsson, M., Mikkelä, C., Granberg, G., Svensson, B.H., 2000. Fluxes of methane and carbon dioxide on peat-mining areas in Sweden. Ambio 29, no 8: 499-503.

Svenska Torvproducentföreningen. 2006. Torvåret 2005 – Statistik över Sveriges Torvproduktion 2005. Sammanställd av Svenska Torvproducentföreningen, In Swedish

Thompson, S.K. 1992. Sampling. Wiley Series in Probabilty and Mathematical Statistics, USA, 343 p. ISBN 0-471-54045-5.

Thuille, A. and Schulzem E-D. 2006. Carbon dynamics in successional and afforested spruce stands in Thuringia and the Alps. Global Change Biology (2006) 12, 325-342.

Vesterdal et. al. 2007. Carbon Sequestration in Soil and Biomass Following Affo-resttaion: Expe-riences from Oak and Norway Spruce Chronosequences in Denmark, Sweden and the Netherlands. In: Environmental effects of afforestation in north-western Europe. 19-52. Springer Plant and vegetation 2007.

Viro, 1952. On the determination of stoniness. Comm. Inst. For. Fenn. 40:1-19.

Von Arnold, K., Hånell, B., Stendahl, J., Klemedtsson, L. 2005 Greenhouse gas fluxes from drained organic forestland in Sweden. Scandinavian Journal of Forest Research, 20:400-411

Annex 3:3 Methodological issues for solvent and other product use (CRF sector 3)

In 2005 a new method for estimating emissions from Solvent and Other Product Use was developed by SMED in cooperation with the Swedish Chemicals Agency[89]. The method is more complete, accurate and transparent, and data can easily be updated on a yearly basis. The Swedish method is consumption-based with a product-related approach. With the new method emissions are calculated with activity data from the Products Register hosted by the Swedish Chemicals Agency, and country specific emissions factors.

The Products Register is a register over chemical products imported to or manufactured in Sweden. Official statistics from the Products Register is only available with a two years delay.

Substance list

A list of substances defined as NMVOCs, and found in the Products Register in quantities over 100 tonnes, has been compiled. The threshold of 100 tonnes is based on the fact that substances found in the Products Register in quantities less than 100 tonnes are equivalent to 0.03 % of the total solvent sales of 400 000 tonnes. The following definition of NMVOC has been used:

> "Volatile organic compounds (VOC) mean any organic compound having a vapour pressure of 0.01 kPa or more at 293.15 K, or having a corresponding volatility under the particular conditions of use. The fraction of creosote which exceeds this value of vapour pressure at 293.15 K shall be considered a VOC."[90]

The list includes 397 substances (Cas-nr, name, carbon contents for each substance), and was used for extracting quantities of NMVOC and C in substances found in the Products Register for year 2009. The carbon share (C) for each substance defined as NMVOC has been calculated based on the molecular formula. In some cases a mixture of substances are included in the substance list, and for the mixtures the carbon content has been estimated by the Swedish Chemicals Agency as 85 % of NMVOC, based on information in the Products Register. In those cases when the carbon content cannot be derived from the Products Register, the default value, given in the 2006 IPCC guidelines, of 60 % has been used.

Activity data

The sold amount of solvents and solvent based products, (production + import – export), is derived from the Products Register at the Swedish Chemicals Agency. When a company is reporting to the Products Register it should be stated, among

[89] Skårman, Tina. et al., 2006.
[90] COUNCIL DIRECTIVE 1999/13/EC of 11 March 1999 and UNECE Emission Reporting Guidelines

other things, to which industrial sectors the product is sold, and the intended use of the product.

The substance list has been used to extract quantities of NMVOC and C in substances found in the Products Register. Due to confidentiality, data cannot be delivered on substance level. Consequently, data are delivered on product and industrial category level. An advantage of making a more targeted selection like this on product and industry category is that the risk that chemicals are double-reported in the Products Register is minimized. Hence it is highly unlikely that the same chemical will appear in a particular product that is sold twice to the same industrial sector.

Data extractions have been made for each year from 1995 to 2009, since reliable activity data, for this purpose, can only be obtained from 1995. The extractions show for each year:

- The intended use of the product and the type of product (product code)
- Industry to which the product is sold (industry category)
- Quantity NMVOC
- Quantity C

The extractions from the Products Register for 1995-2009 have been used in order to compile a connection diagram with all combinations of "product codes" and "industry categories". For all combinations, decisions whether to include or exclude from reporting are based on expert judgements in order to avoid double-counting of reported emissions within other sectors. The industries that are excluded in the extractions from the Products Register are considered to be reported in CRF 1, 2 or 6. If the combination should be included, its specific CRF code has been decided. Furthermore, it has to be determined if the product is used as raw material or not. The quantities of NMVOC used as raw material in processes have been identified and treated separately from remaining quantities for each CRF code, due to that most of the solvents used as raw material will not be emitted. An Excel macro has been written in order to compile time series with quantities of NMVOC and C for each sub-code within CRF sector 3.

The sold amount of solvent is not always identical to the amount of solvent used, i.e. stock of solvents. Therefore activity data has been recalculated using a running average over three years. This leads to the need for updating of reported emissions for the latest three years in the time series in every new submission.

Emission factors

Country specific emission factors for solvents used as raw material and for remaining solvents were developed for each reported activity within each CRF code (see Table A 3:3.1). The emission factors have been based on the old emission time series 1988-2001, which were developed by SMED in 2002[91]. The old time series were mostly based on information in earlier national reports, investigations and estimations of national NMVOC emissions. These investigations were dedicated specific emission inventories focusing on NMVOC, which is why they are still to

[91] Kindbom, K., Boström, C-Å., Skårman, T., Gustafsson, T. and Talonpoika, M. 2003.

be considered as reliable. The emission factors have been developed also considering the application techniques, the reported emissions presented in environmental reports for specific industries, as well as other pathways of release (e.g. waste or water). The emission factors for raw material are set very low, since most of the solvents will not be emitted during production, but will end up in the product.

Emissions

Since accurate data for compiling time series for NMVOC and CO_2 from "Solvents and other product use" only can be found in the Products Register from 1995, reported emissions for CRF codes 3A-D for 1990 until 1994 were taken from the old time series[91] and in some cases emission data for 1990 - 1994 has been interpolated.

Emission of CO_2 has been calculated with the following equation:

$$\text{Emission } (CO_2) = C_{quantity} \times \text{Emission Factor} \times \frac{44}{12}$$

$C_{quantity}$ is the carbon quantity of the solvents. 44 and 12 are the molecular weights of CO_2 and C, respectively.

As the method for calculating CO_2 emissions have been changed compared to the method used in previous submissions, the reported emissions of NMVOC for 1990-94 have been related to the NMVOC emissions for 1995. The ratio has been used to calculate the emissions of CO_2 for each CFR code (3A-D) according to the Good Practice Guidance overlap method.

Activity data for the latest year, 2010, is not yet official and hence Sweden has chosen to report data for 2009 also for 2010. Data for 2010 will be updated in the next submission.

References

COUNCIL DIRECTIVE 1999/13/EC of 11 March 1999 and UNECE Emission Reporting Guidelines.

Kindbom, K., Boström, C-Å., Skårman, T., Gustafsson, T. and Talonpoika, M. 2003. Estimated Emissions of NMVOC in Sweden 1988-2001.

Skårman, Tina. et al., 2006, Revised Method for Estimating Emissions of NMVOC from Solvent and Other Product Use in Sweden. SMED Nr 18 2006.

Table A 3:3.1. Country specific NMVOC emission factors (as fraction emitted) for CRF 3A-C for Sweden.

Year	3A Paint Application - industry		3A Paint Application – consumers		3B Dry Cleaning		3C-Car manufacturing		3C - Rubber industry		3C - Paint industry	
	Remain-ing	Raw material	Remain-ing	Raw material	Remain-ing	Raw material	Remain-ing	Raw material	Remain-ing	Raw material	Remain-ing	Raw material
1995	0.95	0.001	0.95	0.001	0.57	0.001	0.5	0.001	0.3	0.001	0.0035	0.001
1996	0.95	0.001	0.95	0.001	0.57	0.001	0.46	0.001	0.29	0.001	0.0034	0.001
1997	0.95	0.001	0.95	0.001	0.57	0.001	0.42	0.001	0.29	0.001	0.0033	0.001
1998	0.8	0.001	0.95	0.001	0.57	0.001	0.38	0.001	0.28	0.001	0.0031	0.001
1999	0.6	0.001	0.95	0.001	0.57	0.001	0.33	0.001	0.28	0.001	0.0030	0.001
2000	0.6	0.001	0.95	0.001	0.57	0.001	0.29	0.001	0.27	0.001	0.0029	0.001
2001	0.55	0.001	0.95	0.001	0.57	0.001	0.25	0.001	0.26	0.001	0.0028	0.001
2002	0.4	0.001	0.95	0.001	0.57	0.001	0.2	0.001	0.26	0.001	0.0026	0.001
2003	0.3	0.001	0.95	0.001	0.57	0.001	0.2	0.001	0.25	0.001	0.0025	0.001
2004	0.3	0.001	0.95	0.001	0.57	0.001	0.2	0.001	0.25	0.001	0.0025	0.001
2005	0.3	0.001	0.95	0.001	0.57	0.001	0.2	0.001	0.25	0.001	0.0025	0.001
2006	0.3	0.001	0.95	0.001	0.57	0.001	0.2	0.001	0.25	0.001	0.0025	0.001
2007	0.3	0.001	0.95	0.001	0.57	0.001	0.2	0.001	0.25	0.001	0.0025	0.001
2008	0.3	0.001	0.95	0.001	0.57	0.001	0.2	0.001	0.25	0.001	0.0025	0.001
2009	0.3	0.001	0.95	0.001	0.57	0.001	0.2	0.001	0.25	0.001	0.0025	0.001
2010	0.3	0.001	0.95	0.001	0.57	0.001	0.2	0.001	0.25	0.001	0.0025	0.001

Table A 3:3.1. Country specific NMVOC emission factors (as fraction emitted) for CRF 3D for Sweden.

Year	3D Other - Other - Printing industry		3D Other - Other - Preservation of woods		3D Other - Other - Leather industry		3D Other - Other - Textile finishing		3D Other - Other - Other solvent use		3D Other - Other - De-iser	
	Remaining	Raw material	Remaining	Raw material	Remaining	Raw material	Remaining	Raw material	Remaining	Raw material	Remaining	Raw material
1995	0.65	0.001	0.15	0.001	0.35	0.1	0.1	0.1			0.1	0.001
1996	0.64	0.001	0.15	0.001	0.31	0.1	0.1	0.1	0.95	0.95	0.1	0.001
1997	0.63	0.001	0.15	0.001	0.27	0.1	0.1	0.1	0.95	0.95	0.1	0.001
1998	0.61	0.001	0.15	0.001	0.23	0.1	0.1	0.1	0.95	0.95	0.1	0.001
1999	0.6	0.001	0.15	0.001	0.18	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2000	0.59	0.001	0.15	0.001	0.14	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2001	0.58	0.001	0.15	0.001	0.1	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2002	0.56	0.001	0.15	0.001	0.1	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2003	0.55	0.001	0.15	0.001	0.1	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2004	0.55	0.001	0.15	0.001	0.1	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2005	0.55	0.001	0.15	0.001	0.1	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2006	0.55	0.001	0.15	0.001	0.1	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2007	0.55	0.001	0.15	0.001	0.1	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2008	0.55	0.001	0.15	0.001	0.1	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2009	0.55	0.001	0.15	0.001	0.1	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2010	0.55	0.001	0.15	0.001	0.1	0.1	0.1	0.1	0.95	0.95	0.1	0.001

Annex 3:4 Methodological issues for foam blowing (CRF 2.F.2)

In the national model, changes in accumulated amounts each year resulting from additional amounts of HFC in new products, as well as the annual decline in accumulated stock caused by emissions from operating systems, are taken into consideration. In order to calculate leakage according to the national method, the specific amount of HFC-134a and HFC-152a introduced in a particular year follows the decline in leakage according to Table A.3:4.1, where the leakage factors for the first 15 years are presented. The factors used in the national method were provided by the manufacturing company. All comparisons presented below only refer to annual losses from products and does not include manufacturing losses.

According to the information provided by the manufacturing company the HFC-134a remains in products for a very long time, while all HFC-152a is emitted during the first 10 years. The default factors from Good Practice Guidance are presented as comparison. The Good Practice Guidance methodology does not distinguish between HFC-species in suggested leakage rates. Furthermore, the Guidelines for estimating these emissions have changed in the 2006 IPCC Guidelines, which present separate leakage rates for HFC-134a and HFC-152.

Table A.3:4.1. Leakage factor used for the first 15 years in the national method compared to Good Practice Guidance default factors from GPG Table 3.18

	National method		Good Practice Guidance table 3.18
Year	Leakage factor	Leakage factor	Leakage factor
	HFC-134a	HFC-152a	GPG: HFC
1	0.095	0.659	0.40
2	0.039	0.198	0.03
3	0.030	0.083	0.03
4	0.025	0.035	0.03
5	0.022	0.015	0.03
6	0.020	0.006	0.03
7	0.019	0.003	0.03
8	0.017	0.001	0.03
9	0.016	0.001	0.03
10	0.015	0.000	0.03
11	0.015	0	0.03
12	0.014	0	0.03
13	0.013	0	0.03
14	0.013	0	0.03
15	0.012	0	0.03

The calculated emissions according to the national method and the Good Practice Guidance Tier 2 method are presented in Table A.3:4.2. The calculations were

made in a special SMED project[92] where different calculation methods were compared (national method compared to Good Practice Guidance). The Good Practice Guidance Tier 2 default method results in a lower rate of emissions when calculated as emitted tonnes of HFC (Figure A.3:4.1 and Table A.3:4.3). When calculating emissions as CO_2 equivalents, using the annual amount of HFC-134a and HFC-152a, respectively, which remains in products in Sweden, the result is the opposite. The national method in this case results in lower emissions than the Good Practice Guidance method, due to the differing GWP-values of HFC-134a (1300) and HFC-152a (140).

Table A.3:4.2. Estimated emissions of HFCs (Gg CO_2 eq) from products in Sweden using national method and Tier 2 according to GPG, 1996 - 2003.

Emissions	National method		Good Practice Guidance		Sum of emissions, Gg CO_2 eq	
Gg CO_2 eq	HFC-134a	HFC-152a	HFC-134a	HFC-152a	National method	GPG
1996	1	3	2	2	4	4
1997	6	9	23	5	15	28
1998	11	11	36	5	22	41
1999	16	11	48	5	27	53
2000	18	12	42	5	29	48
2001	19	13	42	7	32	48
2002	20	11	41	5	32	46
2003	21	17	41	9	38	50
Sum	111	87	276	43	198	319

The ratio of HFC-134a to HFC-152a in products in Sweden has not been constant over the years. This means that since expected leakage rates are very different for the two chemicals, the resulting annual emissions from products varies according to chemical composition and product age in the national method. HFC in this application was not used before 1996 in Sweden.

Since the product life time of XPS-foam is very long, several decades, the total amounts of emitted chemical will however in the long run be comparable. The differences due to the different calculation methods lie primarily in estimates of how quickly the chemical is expected to leak from the product. (Figure A.3:4.1 and Table A.3:4.3).

[92] Kindbom, K. 2005.

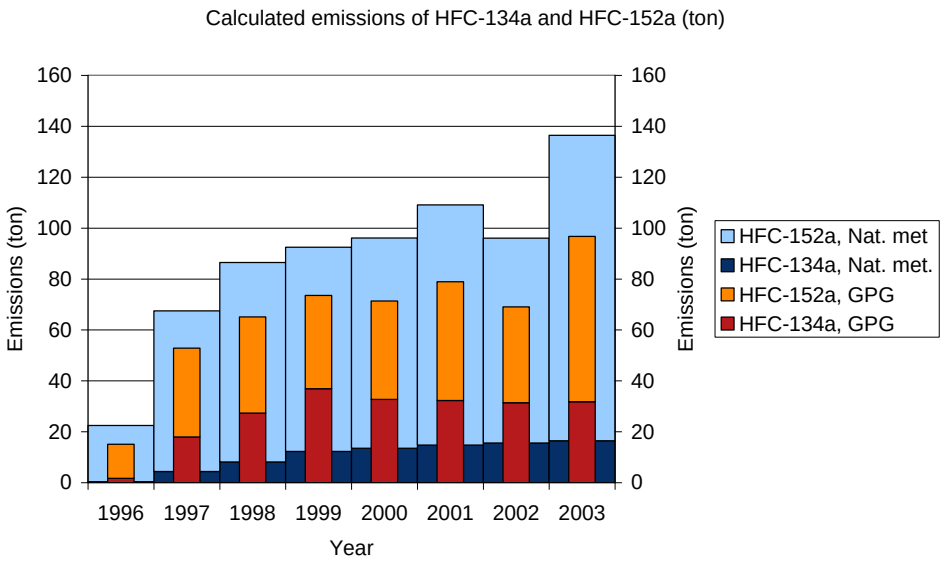


Figure A.3:4.1. Estimated emissions of individual HFC-species (ton) by the national method and the Good Practice Guidance (GPG) Tier 2 method, 1996 - 2003.

Table A.3:4.3. Calculated total emissions of HFC-134a and HFC-152a (Mg) from products in Sweden according to the national method and according to Good Practice Guidance Tier 2 method, 1996 - 2003.

Year	Emissions of HFC-134a and HFC-152a according to national method (Mg)	Emissions of total HFC according to Good Practice Guidance Tier 2 method (Mg)
1996	22.5	15.1
1997	67.4	52.8
1998	86.5	65.1
1999	92.5	73.5
2000	96.1	71.4
2001	109.1	78.9
2002	96.1	69.0
2003	136.4	96.7
Sum 1995-2003	706.5	522.6

From the above presented comparisons, it has been decided to continue using the national method in Swedish reporting. The reason behind the decisions is twofold; the national method is species specific, which has a considerable influence on the results, and secondly, due to the change in recommended method and default leakage factors from the Good Practice Guidance to the 2006 IPCC Guidelines, it was concluded to retain the national detailed method.

References

Kindbom, K. 2005. Revision of Methodology and Estimated Emissions of Fluorinated Greenhouse Gases in Sweden. Report Series SMED Nr 16 2005.

Annex 4 CO_2 reference approach and comparison with sectoral approach, and relevant information on the national energy balance

Reference approach, CRF 1Ab

The reference approach includes all domestic fuel consumption in Sweden regardless of sector. The reference approach is based on the supply of fuels. The main source is the supply and delivery of petroleum products statistics, but foreign trade statistics is also used. Since biomass, waste and peat are not covered in the supply and delivery statistics, data from Statistics Sweden[93] is used for those fuels. The data from Statistics Sweden is derived from almost all the surveys discussed in Annex 2, sections 1.1.1-1.1.9.

During 2007, the underlying statistics for reference approach were overhauled and updated[94]. In addition, CO_2 emissions derived from non-energy use of fuels and reported under CRF 1B and CRF 2 (e.g. flaring of gases and iron and steel process emissions) are since submission 2008 also included under CRF 1Ad and linked to the CRF 1Ab as carbon stored.

Stocks, imports and exports of biomass, waste and peat are presently not known.

Data on international bunkers for navigation is given in the supply and delivery statistics. International bunkers for aviation are calculated from information from Statistics Sweden.

During 2010 differences between energy amounts reported in the reference approach and energy amounts reported to the IEA have been studied and analyzed[95]. Due to restricted budget and timeline, recommendations from the study have not been fully implemented in the inventory (only simple corrections etc have been done).

In submission 2011, spreadsheets used in calculations were revised and transferred into more transparent, safe and easily replicable SAS programming. The linking of data between tables 1Ab, 1Ac and 1Ad have also been checked and included in the SAS programming. As a result of this, several minor errors due to data handling were detected and corrected for all years in tables 1Ab, 1Ac and 1Ad. However, the results of the submission 2012 calculations indicate that some unresolved issues may remain. An overview that will possibly lead to further revisions will be made in 2012, which may lead to a revision in the calculation routine for submission 2013.

[93] Statistics Sweden EN20SM 1990-2006.
[94] Gustafsson, 2007a
[95] Hedlund and Lidén, 2010

Emission factors used in the reference approach are the same as those used in the Sectoral Approach, multiplied by 12/44 to convert the emission factor for CO_2 to an emission factor for carbon (C). Exceptions from this rule are emission factors for crude oil, bitumen and refinery feedstocks (not reported in the sectoral approach). These emission factors are default values from IPCC 2006 Guidelines taken from the IPCC EFDB since submission 2011.

Feedstocks and non-energy use of fuels, CRF 1Ad

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 1Ad, non-energy use of fuels.

Data on carbon from coke, bound in produced ferroalloys is collected directly from the only ferroalloy producer and is added to the remaining data on carbon from coke. Estimates of carbon stored are derived by multiplying given energy amount with emission factors for CO_2 (as given in section 1.2 and Appendix 1) multiplied by 12/44 (the weight of one atom of carbon is by definition 12/44 the weight of one molecule of CO_2).

CO_2 emissions derived from non-energy use of fuels and reported under CRF 1B and CRF 2 (e.g. flaring of gases and iron and steel process emissions) are added under CRF 1Ad and reported in CRF 1Ab as carbon stored.

Detailed comparison of the reference approach and the sectoral approach

In order to follow the recommendations in IPCC Good Practice Guidance and ensure that no omissions or double counting occurs, it is necessary to compare the results in the sectoral approach (calculated bottom-up) with the results in the reference approach (calculated top-down). Large differences indicate possible errors, and according to the IPCC Good Practice Guidance, differences should be investigated if they are larger than ± 2 %.

The reference approach shows all domestic fuel consumption, regardless of sector. On this level it is not possible to separate fugitive emissions (CRF 1B) or emissions from fuel combustion in industrial processes (CRF 2C-D). These emissions are included as non-energy use of fuels in CRF 1A(d) and reported in CRF 1A(b) as carbon stored and thus accounted for in CRF 1A(c).

Results

Figure A 4.1 shows the differences in fuel consumption and CO_2 emissions between the Reference and Sectoral Approach for the whole time series 1990-2010. 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%.

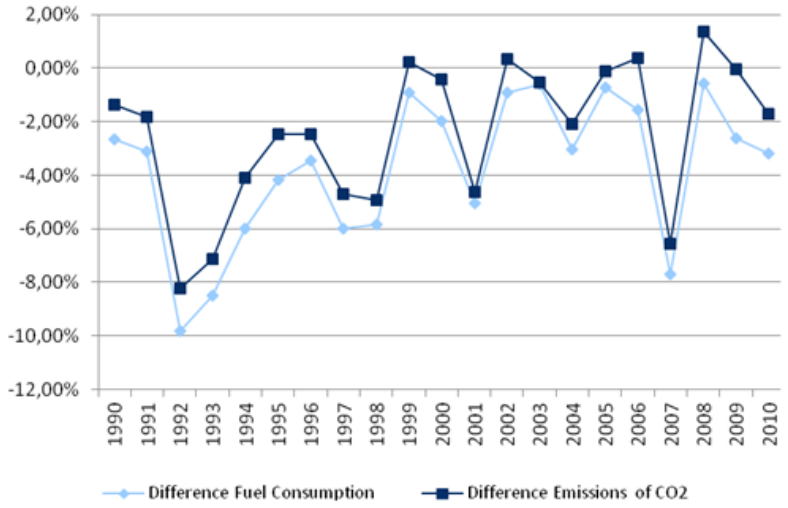


Figure A 4.1. Differences between Reference Approach and Sectoral Approach (Reference minus Sectoral).

Analysis of differences

Emission factors

For most years, the difference (negative) in CO_2 emissions is smaller than the difference in energy consumption. This indicates that some of the emission factors used in the reference approach might be too high. Data on fuel group level indicates that this problem is related to liquid fuels. For solid fuels, the difference in energy and emissions, respectively, is not consistent between years. This is related to solid fuels used in iron and steel industry, see below.

Statistical differences in energy balances

Statistical differences in energy balances contribute to a large share of differences especially in the early 1990's. This was discovered in a SMED study in 2007[96]. That is to say, similar differences between fuel supply and fuel consumption are found in the energy balances.

Figure A 4.2 shows the comparison of fuel consumption from the energy balances and the sectoral approach of submission 2007 that was performed in the 2007 SMED study. It is obvious that differences in this comparison are significantly lower compared to the reference and sectoral approach presented in CRF 1Ac.

[96] Gustafsson, 2007a

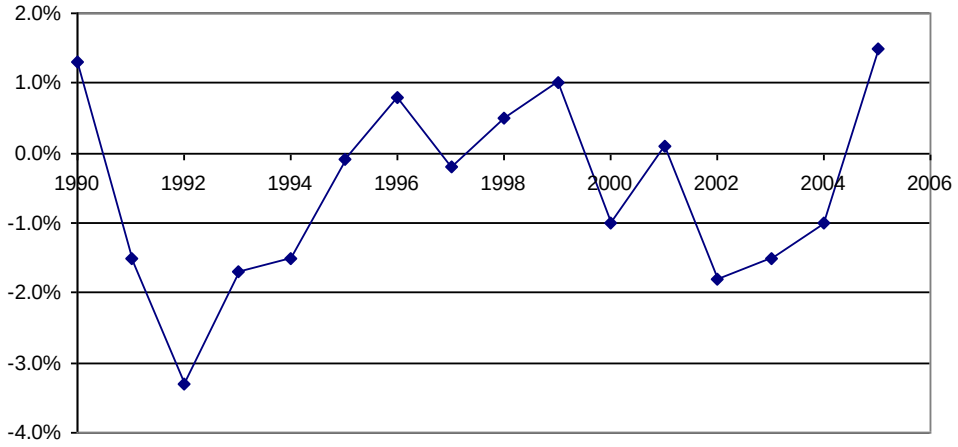


Figure A 4.2. Differences in fuel consumption between energy balances and sectoral approach 1990-2005 (submission 2007).

Crude oil

When studying Figure A 4.1 and the differences in percent it is obvious that differences for both fuel consumption and emissions are too large for 1992-1998, 2001 and 2007. These differences have of course been studied carefully. Background data and all calculations are double-checked and no errors have been found. Differences mainly refer to the Reference Approach since CO_2 emissions in the Reference Approach are decreasing with as much as 4.3 % between 2006 and 2007 which seems a bit odd. CO_2 emissions in the Sectoral Approach are decreasing with 1.7% in the same time period which is much more plausible. The decrease is mainly found in liquid fuels, and most notably for Crude Oil. Further investigations on this in future submissions are being considered.

Solid fuels

Emissions from the iron- and steel industries are large and difficult to estimate correctly. This is discussed in detail in NIR section 3 and 4. A dedicated study on the iron and steel industry was made in 2010, but more work is needed on this issue. The iron and steel industry accounts for a large share of solid fuels used in Sweden, and difficulties in this sector is reflected in the differences between the reference approach and sectoral approach for solid fuels.

In submission 2004 and earlier, there was a big difference in reported energy consumption for solid fuels. This was due to the fact that transformation losses (energy losses) in the iron and steel industry were not included in the sectoral approach. CO_2 emissions and other emissions were correctly reported and thus not affected. In submissions 2005-2011, transformation losses of energy were estimated and reported under CRF 1A5a in the Sectoral Approach. This resulted in smaller differences between the reference and sectoral approaches. In submission 2012, a different approach was used. Data on all flows of energy within the integrated iron and steel industry was collected directly from the facilities and accounted for in CRF

1A1, 1A2 and 2C1 in the sectoral approach. However, there are still large differences for many years in the time series, which will be addressed in the investigation planned prior to submission 2013.

National energy balance

The information in this section is taken from Statistics Sweden.[97] Tables referred to can be found at the Statistics Sweden website.[98]

The purpose of energy balances is to give a brief description of supply, transformation and final consumption of energy for follow-up and analysis of Sweden's maintenance of energy.

Before the oil crisis in 1973, the main purpose of the energy statistics was to account for the supply of specific types of energy. Due to the oil crisis the need to relate the oil problems to energy issues in general increased, as well as the interest in more extensive information about energy consumption. For that reason, energy balance models were developed both nationally and internationally with the purpose to describe the entire flow of energy for different energy carriers, from extraction and import through transformation to export or domestic consumption. Principles for the presentation of Swedish energy balances were compiled by Statistics Sweden in cooperation with the Swedish Energy authority and the Council of Transport (that was later closed down). In the official statistics, quarterly energy balances with relatively brief accounts for the energy consumption side have been published since 1975. Yearly energy balances with a more detailed and thoroughly account for the energy consumption side have been compiled since 1987, with time series back to 1983.

Methodological comments

BALANCE SHEETS OF ENERGY SOURCES

The balance sheets of energy sources are showing the total supply and consumption of energy sources expressed in original units, i.e. units recorded in the primary statistics – mainly commercial units, tables 1:1 and 7:1[99]. The production of derived energy commodities is recorded on the supply – side of the balance sheets of energy sources, which is not the case in the energy balance sheets. The balance sheets of energy sources also include specifications of input–output and energy consumption in energy conversion industries, tables 2:2 and 8:2[100].

ENERGY BALANCE SHEETS

The energy balance sheets are based on data primary recorded in the balance sheets of energy sources, here expressed in a common energy unit, TJ (terajoule), tables

[97] EN 20 SM 0705
[98] Ibid. at www.scb.se
[99] http://www.scb.se/Statistik/EN/EN0202/2009I10/EN0202_2009I10_SM_EN20SM1004.pdf
[100] http://www.scb.se/Statistik/EN/EN0202/2009I10/EN0202_2009I10_SM_EN20SM1004.pdf

4:4 and 10:4[101]. The production of derived energy is here recorded in a second flow-step comprising energy turnover in energy conversion and is also specified in complementary input-output tables for energy conversion industries, tables 5:5 and 11:5[102].
The following items are shown in the energy balance sheets:

1.1 Inland supply of primary energy
1.3 Import
1.4 Export
1.5 Changes in stocks
1.6 Statistical differences (supply-level)
1 Gross consumption of primary energy and equivalents
2 Bunkering for foreign shipping
3 Input for conversion into derivative energy forms (sources)
1.2 Gross production by energy conversion industries
4 Consumption by energy producing industries
5 Losses in transport and distribution
6 Consumption for non-energy purposes
7 Final inland consumption
7.1 Agriculture, fishing
7.2 Forestry
7.3 Mining and manufacturing
7.3.1 Industry statistics' level
7.3.2 Small establishment's consumption (calculated)
7.3.3 Other (non specified)
7.4 Construction
7.5 Government services
7.6 Transport
7.7 Other services
7.8 Households (housing and other)
8 Statistical differences (non-specified consumption)

Gross consumption of primary energy and equivalents (1) is calculated from the following items: Inland supply (1.1), Import (1.3), Export (1.4) Changes in stocks (1.5) and Statistical differences (1.6). The gross consumption is calculated as (1) = (1.1) + (1.3) – (1.4) – (1.5) – 1.6).

Concerning wood, wood waste, sulphite and sulphate lyes, peat and wastes the total consumption for energy purpose is recorded as inland supply of primary energy. The efficiency of the hydroelectric power stations has been estimated to about 85 per cent.

Nuclear energy corresponds to measured heat released in reactors, which is recorded as inland supply of primary energy.

[101] http://www.scb.se/Statistik/EN/EN0202/2009I10/EN0202_2009I10_SM_EN20SM1004.pdf
[102] http://www.scb.se/Statistik/EN/EN0202/2009I10/EN0202_2009I10_SM_EN20SM1004.pdf

Bunkering for foreign shipping (2) covers supply to bunkers for seagoing ships of all flags. Supplies for international air traffic are evaluated as final inland consumption.

Input for conversion into derivative energy (3) covers the input of crude oil and other feed stocks in refineries, coal for conversion to coke and coke-oven gas in coke-oven plants, the estimated net quantity of coke that is converted into blast furnace gas (100 per cent efficiency in the conversion is assumed), electricity for pumping in pumping stations, the fuel consumption in conventional thermal power plants, heating (or heat-electric) plants and gasworks, consumption of fuels for production of electric energy in industrial back pressure power stations and consumed nuclear fuel and utilised primary hydro power in nuclear power plants respectively hydro-electric power plants.

Production of derivative energy (1.2). The production is calculated gross, i.e. including own consumption and losses in transmission and distribution.

Consumption by energy producing industries (4) covers the consumption of electric energy, fuel oils, gases etc. for the operation of power stations, thermal power plants, refineries, coke-oven plants and gasworks.

Losses in transport and distribution (5) covers losses in deliveries of electric energy, gas work gas, coke-oven gas, blast-furnace gas and district heating.

Consumption for non-energy purposes (6) covers products that are used as input in chemical industries as raw material as well as other non-energy purposes.

Final inland consumption (7) covers all consumption not covered by titles 1–8.

The efficiency of the final consumption in not considered in the balance sheets. The quantities (recalculated to terajoules= 1012 joules) as recorded under final consumption refer to the total energy actually consumed by the consumers including conversion losses.

Statistical differences (8) between total consumption measured from supply-side and actual consumption statistics.

References

Gustafsson, T. 2007a. Översyn av rapportering till Reference Approach, bränsleanvändning för icke-energiändamål samt jämförelsen mellan Reference och Sectoral Approach. (eng. Overhaul of reporting of the reference approach, the non-energy use of fuels and the comparison of reference and sectoral approach). SMED report 80:2007

Hedlund, H and Lidén, M. 2010. Jämförelse av energirapportering till IEA och UNFCCC. (eng. Comparison of energy reported to the IEA and the UNFCCC) SMED report 91:2010

Schöllin, M. 2002. CO_2 emissions inventories harmonisation- the Swedish case. Report made by Statistics Sweden, Energy Statistics. Eurostat file no. 200045500002.

Statistics Sweden EN20SM 1990-2010. Årliga energibalanser (Yearly Energy Balance Sheets). Energy statistics.

Annex 5 Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded for the annual inventory submission and for the KP-LULUCF inventory

GHG inventory

General assessment of completeness

The Swedish inventory covers both emissions and removals in Sweden, all greenhouse gases required and all relevant sources and sinks with a few exceptions. A general assessment of the completeness in the Swedish Greenhouse Gas Inventory is given in chapter 1.8 in the main National Inventory Report.

Below the CRF Table 9(a) lists all instances of the use of the notation key NE, not estimated, in the Swedish inventory, including short explanations to why these are not estimated. Further explanations and justifications are given in the following paragraphs.

ENERGY

In the energy sector emissions of CH_4 and N_2O from biomass (FAME) used in CRF 1A5b (military transportation) 1999-2001 are not estimated. Data are currently not available but emissions are expected to be minor. There is no IPCC methodology available for estimating these emissions.

Source category	GHG
1.AA.5.B Military use	CH_4, N_2O

INDUSTRIAL PROCESSES

Emissions from the sources specified below have not been estimated due to lack of information, but the emissions are expected to be insignificant. There is no IPCC methodology available for estimating these emissions.

Source category	GHG
2.A.7 Non-iron ore mining and dressing	CO_2
2.B.5 Base chemicals for plastic industry	CH_4
2.B.5 Other non-specified	CH_4, N_2O
2.B.5 Pharmaceutical industry	CH_4
2.C.1.3 Sinter	CH_4
2.C.1.4 Coke	CH_4
2.C.3 Aluminium Production	CH_4
2.C.5 Silicon production	CO_2, CH_4 (1990 only)
2.C.5 Non-ferrous metals	CH_4
2.D.2 Food and Drink	CO_2
2.F.P3.1 In bulk	SF_6
2.F.P4 Destroyed amount	HFCs, PFCs, SF_6

SOLVENT AND OTHER PRODUCT USE

All source categories are covered in the inventory.

AGRICULTURE

All source categories are covered in the inventory.

LAND USE, LAND USE CHANGE AND FORESTRY

The inventory covers all categories. However according to the guidelines only emissions/removals for managed land are reported. Emissions of CH_4 are only reported from biomass burning. Emissions of N_2O are only reported for direct use of fertilizer, from conversion to cropland and from biomass burning. N_2O emissions from drained organic soils may be a significant source but reliable methods for estimating this source is still lacking. Therefore this source is optional to report and Sweden has decided to not report these emissions.

WASTE

All source categories are covered in the inventory.

Sources and sinks not estimated (NE)			
GHG	**Sector**	**Source/sink category**	**Explanation**
CH_4	1 Energy	1.AA.5.B Military use	No data available
N_2O	1 Energy	1.AA.5.B Military use	No data available
CO_2	1 Energy	1.B.2.A.3 Transport	No data available
CH_4	2 Industrial Processes	2.B.5 Base chemicals for plastic industry	No data available
CH_4	2 Industrial Processes	2.B.5 Other non-specified	No data available
CH_4	2 Industrial Processes	2.B.5 Pharmaceutical industry	No data available
CH_4	2 Industrial Processes	2.C.1.3 Sinter	No data available
CH_4	2 Industrial Processes	2.C.1.4 Coke	No data available
CH_4	2 Industrial Processes	2.C.3 Aluminium Production	No data available
CH_4	2 Industrial Processes	2.C.5 Silicon production	No data available
CH_4	2 Industrial Processes	2.C.5 Non-ferrous metals	No data available
CO_2	2 Industrial Processes	2.A.7 Non-iron ore mining and dressing	No data available
CO_2	2 Industrial Processes	2.D.2 Food and Drink	No data available
CO_2	2 Industrial Processes	2.C.5 Silicon production	No data available
N_2O	2 Industrial Processes	2.B.5 Other non-specified	No data available
SF_6	2 Industrial Processes	2.F.P3.1 In bulk	Exported amounts of SF6 are not known
SF_6	2 Industrial Processes	2.F.P4 Destroyed amount	No data available
Carbon	5 LULUCF	5.E.1 Settlements remaining Settlements	Reporting optional. No methodology exists
CH_4	5 LULUCF	5.A.1 Forest Land remaining Forest Land	Optional to report emissions from drainage, Sweden has decided to not report this category
CH_4	5 LULUCF	5.E.1 Settlements remaining Settlements	Optional, Sweden has decided to not report this category
CH_4	5 LULUCF	5.E.2 Land converted to Settlements	Optional, Sweden has decided to not report this category
CH_4	5 LULUCF	5.G Harvested Wood Products	Optional, Sweden has decided to not report this category
CH_4	5 LULUCF	5 Forest Land converted to Other Land-Use Categories	Optional, Sweden has decided to not report this category
CH_4	5 LULUCF	5 Grassland converted to Other Land-Use Categories	Optional, Sweden has decided to not report this category
CO_2	5 LULUCF	5.G Harvested Wood Products	Optional, Sweden has decided to not report this category
N_2O	5 LULUCF	5.A.1 Forest Land remaining Forest Land	Optional to report drainage, Sweden has decided to not report N_2O emissions for this category
N_2O	5 LULUCF	5.E.1 Settlements remaining Settlements	Optional, Sweden has decided to not report N_2O emissions for this category
N_2O	5 LULUCF	5.E.2 Land converted to Settlements	Optional, Sweden has decided to not report N_2O emissions for this category
N_2O	5 LULUCF	5.G Harvested Wood Products	Optional, Sweden has decided to not report N_2O emissions for this category

KP-LULUCF inventory

Sweden´s reporting of KP-LULUCF is complete. No carbon pools, or other sources of green house gas emissions, associated to the mandatory activities under article 3.3 (Afforeststion/Reforestation and deforeststion) has been omitted from the reporting.

Under article 3.4 Sweden has elected Forest management. No carbon pools, or other sources of green house gas emissions, associated to Forest management has been omitted from the reporting.

Annex 6 Additional information regarding reporting under the Kyoto Protocol and other information

Annex 6:1 Legal entities authorised to participate in CDM

Annex 6:2 Legal entities authorised to participate in JI

Annex 6:3 Legal entities authorised to participate in article 17 of the Kyoto Protocol

Annex 6:1 Legal entities authorised to participate in CDM

Information on legal entities authorised to participate in mechanisms under Article 12 (Clean Development Mechanism) of the Kyoto Protocol. The legal entities are listed below:

ABN AMRO Bank London Branch NV
Asian Development Bank as Trustee for Asia Pacific Carbon Fund
Carbon Asset Management Sweden AB
Carbon Asset Services AB
Carbon Asset Services Sweden AB
Cornland International AB
EcoSecurities Carbon I Ltd
EcoSecurities Group Ltd
EcoSecurities Group PLC
EcoSecurities PLC
Göteborg Energi AB
MGM Carbon Protfolio S.a.r.l
Nordic Environment Finance Corporation (NEFCO) in its capacity as Fund Manager to the NEFCO Carbon Fund
Nordic Environment Finance Corporation (NEFCO)
Nynäs Refining AB
Perstorp Specialty Chemicals AB
SICLIP/ Swedish Energy Agency
Standard Bank PLC
Svenska Cellulosa AB
Tekniska verken i Linköping
The International Bank for Reconstruction and Development (Trustee of Prototype Carbon Fund
The International Bank for Reconstruction and Development (Trustee of the First Tranche of the Umbrella Carbon Facility
The International Bank for Reconstruction and Development as Trustee and managing company of the Community Development Carbon Fund (CDCF)
Tricorona Carbon Asset Management Pte Ltd
WCCI World Carbon Credit Investment Limited
Vitol SA

Annex 6:2 Legal entities authorised to participate in JI

Information on legal entities authorised to participate in mechanisms under Article 6 (Joint Implementation) of the Kyoto Protocol. The legal entities are listed below:

Swedish Energy Agency SICLIP
Nordic Environment Finance Corporation
Credit Suisse
AGO AG Energie + Anlagen
Saga Carbon
BASF SE
MGM International Group LLC
MGM Carbon Portfolio S.a.r.l.

Annex 6:3 Legal entities authorised to participate in article 17 of the Kyoto Protocol

There are no provisions in Swedish law on which Kyoto unit types legal entities are authorised to hold in the Swedish National Registry. This concerns legal entities authorised by the Member State to hold assigned amount units (AAUs), removal units (RMUs), emission reduction units (ERUs) and certified emission reductions (CERs), including temporary CERs (tCERS) and long-term CERs (lCERs).

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).

Annex 7 Uncertainties

Methodology for Uncertainty analysis

Uncertainty estimates are performed for 1990 and the latest reported year for direct greenhouse gases, e.g. CO_2, CH_4, N_2O and F-gases. For sources based on fuel consumption that share the same activity data, and consequently are correlated, we have adjusted the activity data uncertainties to account for that. For the emission factor uncertainties we have not done any adjustment due to potential correlations, the reason being that it is difficult to identify possible correlations and the relative effect of these. As of submission 2011, emission data is imported to the SAS® software[103] from the Technical Production System, ensuring consistence in data reported in the CRF Reporter. In SAS, emissions and uncertainty estimates are merged and aggregated to the proper the IPCC category consistent with the category split used for the key category analysis. During 2005, a SMED study was carried out, aiming at improving the transparency and quality in the uncertainty estimates in the Swedish National Greenhouse Gas Inventory by making the underlying documentation and structures for uncertainty estimates more consistent and traceable[104]. That facilitated easier replication and updating of results as well as enabling internal and external reviews of assigned uncertainties. The study did not include improvement of single uncertainties, for instance by contacting external experts for better information on uncertainties on different sources. LULUCF was not included in the study.

Expert protocols

All assigned uncertainties (%) have been documented in Swedish in Expert Protocols as given in Figure A 7.1.

[103] SAS is a Business Analytics and Business Intelligence software
[104] Gustafsson, 2005

Reference number: 1
Date: 2005-04-28
Expert: NN
Kvalifications: eg working several years with this sector of the GHG inventory
Documented by: NN (expert or other person)

External review by: NN, 200x-xx-xx
Result of external review: approved/not approved
(references to other material if necessary)
Approved by SEPA: NN, 200x-xx-xx
Responsible authority according to National system: Name of authority

Estimated uncertainties:

Year	CRF	Activity	Activity data	Emission factor	Emissions	most likely value	minimum[1]	maximum[1]	probability distribution[2]	Foot-note
2004	1A1a	domestic heating oil	m3			according to indata	-2%	2%	normal	1
2004	1A1a	domestic heating oil		CO2		73,5	70	76	triangular	2
2004	1	Petroleum coke	tonne							x

[1] limits for 95% konfidence interval, that is 2,5% risk that the true value is below minimum and 2,5% risk that the true value is above maximum.
[2] If probability distribution is unknown the following applies:
if only minimum and maximum is given, assume a uniform distribution. If also a most likely value is given, assume a triangular distribution.

Basis for expert judgement including logic and scientifical reasons and references to other relevant material:

1)

2)

x)

Figure A 7.1. Design of Expert protocols

In the protocols, specially designed to be in compliance with the recommendations in the IPCC Good Practice Guidance chapter 6.2.5 (IPCC 2000), information is provided on what uncertainties are estimated (what CRF codes concerned, what years, what type of activity data, emission factor, emission data, etc.), the value or range of the estimated uncertainty, explanations on the reasons behind the given values, name and qualification of the expert etc.

All expert protocols are given a reference number and gathered in one Excel file. All in all, there are about thirty expert protocols documenting uncertainties in the Swedish GHG Inventory. This transparent documentation enables replicating of results and facilitate updating of uncertainties when something in the inventory changes in the future.

Estimating uncertainties for each source

When estimating uncertainties for each source, a wide range of information has been used. IPCC recommendations have been studies as well as fluctuations in time series, comparison with other sources, studies of statistical differences and studies of reports that are the basis for instance for many emission factors. Below some comments are given on how the work was conducted for each sector.

CRF 1. Stationary combustion

Activity data on fuel consumption has been assumed to be uncorrelated between CRF sectors. Uncertainties for activity data are estimated for each year, fuel type and CRF sector. Uncertainties for emission factors are estimated for each greenhouse gas, year, fuel type and CRF sector.

Several expert elicitations have been performed, with SMED reports and information from the IPCC as the main basis for the expert judgements. In some cases no referenced information was available, and in those cases very rough expert judgements had to be made.

CRF 1. Mobile combustion

Activity data on fuel consumption are based on national statistics on fuel deliveries. Hence, correlation therefore exists between the different CRF sectors when the fuel is allocated. As uncertainties generally are low for fuel sold, reporting uncertainty estimates by CRF category does not introduce significant errors.

Uncertainties for emission factors of CO_2 are estimated by fuel type, whereas uncertainties for emission factors for CH_4 and N_2O are estimated by fuel type and CRF sector, e.g. CH_4 for gasoline in CRF 1A3e.

Uncertainty estimates are mostly based on SMED reports and expert judgement, but in a few cases IPCC and CORINAIR default recommendations have been applied. Uncertainty estimates for activity data, emission factors and actual emissions for mobile combustion sources are set to be the same 1990 as the latest reported year.

CRF 2. Industrial processes, CO_2

The emission factors used in the calculations are based on IPCC defaults or on information on emission factors and/or emissions directly from the companies. Generally 5 % have been assigned as uncertainty to the emission factors when no other indications or relevant information affecting the uncertainty have been available.

CRF 2. Industrial processes, F-gases

Activity data for most sources in 2F1, refrigeration and air conditioning equipment, is based on national statistics. Uncertainty was assigned in cooperation with the Swedish Chemicals Agency. Other activity data is obtained directly from producers or consumers, and uncertainty was discussed with relevant experts, if possible. Emission factors are IPCC default, country specific, obtained from producers/consumers or derived in discussion with national experts. Uncertainty estimates are to a large extent based on expert judgement.

CRF 2. Industrial processes, CH_4 and N_2O

For nitric acid production, uncertainty estimates was obtained from producers. For other sources, expert judgement or suggested uncertainties from IPCC Guidelines and Good Practice Guidance were used, if available. In estimating uncertainties by expert judgement for some sources, Environmental reports from comparable facilities were used as a basis for estimating reasonable uncertainty levels.

CRF 3. Solvent use

Activity data are obtained from national statistics at the Swedish Chemicals Agency. Uncertainty estimates were discussed and assigned in cooperation with experts at the Products register at the Swedish Chemicals Agency. Uncertainty estimates for the country specific emission factors used were estimated by expert judgement.

CRF 4. Agriculture

Uncertainty estimates are generally collected from the same source as emission estimates, for instance IPCC or nationally referenced data. When no uncertainty estimates were available, estimates from similar statistics were used instead. When neither uncertainty estimates nor any similar statistics were available, very rough expert judgements had to be made. Uncertainty estimates are assigned on an aggregated level very similar to the one presented in the NIR.

CRF 5. LULUCF

Uncertainty estimates are generally based on area sampling, but some extent expert judgement and IPCC default values are also applied. Equation 6.3 and 6.4 in Good Practice Guidance have been used to fit the uncertainty estimates to the level of aggregation presented in the result tables below.

CRF 6. Waste

Uncertainty estimates are collected from IPCC (for emission factors) and IPCC combined with expert judgment (for activity data). Uncertainty estimates are assigned on the same aggregated level as presented in the NIR, which is per CRF sector (e.g. 6A Solid waste).

Updating uncertainties for each sector

Table A 7.1 gives an example on how input data is given for estimating uncertainties for a single sector.

Table A 7.1. Example of design of sectoral uncertainty estimates; CRF 2. Industrial Processes – CO_2

Year	IPCC source categ-ory	Source	Emis-sion	Acivity data	Activi-ty data unit	Activity data value	Emissions of CO2, Gg	Emission of CO2, Gg CO2 eq	Activity data uncertain-ty %	Emission factor uncertain-ty %	Emission data Uncer-tainty %	Activity Data uncertain-ty quality indicator	Emission factor uncertainty quality indicator	Emission data uncertain-ty quality indicator	Expert judgement reference number	Footnote reference number
1990	2A1	Cement production	CO2	Clinker prod.	Kton	2348	1271.95	1271.95	5	5		R	R		11	
1990	2A2	Lime production	CO2	Lime prod.	Kton	923	497.96	497.96	5	5		R	R, D		11	5
1990	2A3	Limestone- and dolomite use	CO2	Limestone- and dolomite use	Kton	234	109.43	109.43	7	5		R	D		11	
1990	2A4	Soda Ash use	CO2	Soda Ash use	Kton	95	39.56	39.56	7	5		R	D		11	
1990	2A7	Other mineral use	CO2	Leca production, (use of slagg)	Kton	58	3.36	3.36			10			R	11	
1990	2B4	Carbide production (Ca)	CO2	Carbide produc-tion (Ca)	kton	55	68.80	68.80	5	7		R	R		11	
1990	2C11	Iron and steel produc-tion	CO2	Steel production	kton	1819	129.23	129.23			5			R	11	
1990	2C12	Iron and steel produc-tion	CO2	Iron production	kton	2845	1666.91	1666.91	5	5					11	
1990	2C2	Ferroalloys produc-tion	CO2	Reducing agents	kton	77	243.00	243.00			5			R	11	
1990	2C3	Aluminium produc-tion	CO2	Al. Production	kton	93	133.12	133.12			5			R	11	
1990	2C5	Other metal produc-tion	CO2	Pb and Zn production	kton	70	203.84	203.84	7	5		R	R		11	
2004	2A1	Cement production	CO2	Clinker prod.	kton	2386	1284.43	1284.43	2	5		R	R		11	
2004	2A2	Lime production	CO2	Lime prod.	kton	1039	537.25	537.25	2	5		R	R, D		11	5
2004	2A3	Limestone- and dolomite use	CO2	Limestone- and dolomite use	kton	307	141.46	141.46	5	5		R	D		11	
2004	2A4	Soda Ash use	CO2	Soda Ash use	kton	72,96	30.30	30.30	7	5		R	D		11	
2004	2A7	Other meineral use	CO2	Leca production, (use of slag)	kton	140	7.65	7.65			5			R	11	
2004	2B4	Carbide prdocution (Ca)	CO2	Carbide produc-tion (Ca)	kton	43	53.38	53.38	5	5		R	R		11	
2004	2C11	Iron and steel produc-tion	CO2	Steel production	kton	1872	143.77	143.77			5			R	11	
2004	2C12	Iron and steel produc-tion	CO2	Iron production	kton	3992	1654.46	1654.46	5	5					11	
2004	2C2	Ferroalloys produc-tion	CO2	Reducing agents	kton	99,50	256.40	256.40			5			R	11	
2004	2C3	Aluminium produc-tion	CO2	Al. Production	kton	101	145.29	145.29			5			R	11	
2004	2C5	Other metal produc-tion	CO2	Pb and Zn production	kton	62	166.05	166.05	5	5		R	R		11	

In the sectoral spreadsheets, there is one row for each source, according to where independency between sources is assumed to exist. For each source, emissions may be derived either from activity data and emission factors or information on actual emission data from companies or models.

The first section (green colour headings) includes information on reference year, IPCC source category, GHG, description of activity data (if relevant), quantified activity data and emissions. The "green" data should be updated each submission.

The second section (yellow colour headings) includes information on uncertainty estimates for activity data and emission factors, and emission data in those cases only estimated emissions are available. As required by the IPCC Good Practice Guidance, quality indicators are given for activity data and each GHG Emission factor (D - IPCC default, M - Measurement based, R - National referenced data). The expert judgment reference number(s) refer to what expert protocol(s) are used for this source. The footnote reference number(s) refer to additional information in a footnote spreadsheet, for instance if a choice has been made between two different expert protocols concerning the same source and the rationale behind the choice. The "yellow" data should be reviewed each submission, to make sure that they are correctly linked to the corresponding "green" data. "Yellow" data are updated when better information is available, for instance if new studies on emission factors have been conducted and it has been possible to update the expert protocols.

Combining and aggregating uncertainties for all sectors

The uncertainty analysis is performed according the IPCC Guidelines Tier 1 method as described in Good Practice Guidance section 6.3.2, see especially equation 6.3 and 6.4, and table 6.1. The 2006 IPCC Guidelines are used to calculate the contribution to variance by category.

Results

Table A 7.2. Tier 1 uncertainty assessment for national total emissions in 2010, including LULUCF.

IPCC Source Category	Substance	Base year emissions or removals (Gg CO2-eqv)	Year 2010 emissions or removals (Gg CO2-eqv)	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined uncertainty (%)	Contribution to variance in year 2010 (%)	Inventory trend for year 2010 with respect to base year (%)	Uncertainty introduced into the trend (%)
1.AA.1.A (Public Electricity and Heat Production)	CH4	21	100	2.2	33.0	33.1	0.00	368.1	0.00
1.AA.1.A (Public Electricity and Heat Production)	CO2	7718	10014	0.9	5.8	5.9	0.53	29.7	0.00
1.AA.1.A (Public Electricity and Heat Production)	N2O	304	502	1.4	21.5	21.5	0.02	65.0	0.00
1.AA.1.B (Petroleum Refining)	CH4	1	1	8.9	89.1	89.6	0.00	19.8	0.00
1.AA.1.B (Petroleum Refining)	CO2	1778	2130	9.1	4.5	10.1	0.07	19.8	0.01
1.AA.1.B (Petroleum Refining)	N2O	21	24	8.8	87.6	88.1	0.00	16.3	0.00
1.AA.1.C (Manufacture of Solid Fuels and Other Energy Industries)	CH4	0	0	4.8	16.2	16.9	0.00	16.5	0.00
1.AA.1.C (Manufacture of Solid Fuels and Other Energy Industries)	CO2	299	317	4.3	3.5	5.6	0.00	6.0	0.00
1.AA.1.C (Manufacture of Solid Fuels and Other Energy Industries)	N2O	3	3	5.6	17.2	18.1	0.00	-5.5	0.00
1.AA.2.A (Iron and Steel)	CH4	0	0	3.7	16.4	16.8	0.00	-5.0	0.00
1.AA.2.A (Iron and Steel)	CO2	1638	1773	3.5	2.8	4.4	0.01	8.2	0.00
1.AA.2.A (Iron and Steel)	N2O	15	14	3.7	17.5	17.9	0.00	-6.3	0.00
1.AA.2.B (Non-Ferrous Metals)	CH4	0	0	3.9	15.8	16.3	0.00	-31.9	0.00
1.AA.2.B (Non-Ferrous Metals)	CO2	128	90	3.9	2.4	4.6	0.00	-29.4	0.00
1.AA.2.B (Non-Ferrous Metals)	N2O	2	1	4.0	17.0	17.5	0.00	-35.4	0.00
1.AA.2.C (Chemicals)	CH4	1	1	4.2	20.3	20.8	0.00	55.5	0.00
1.AA.2.C (Chemicals)	CO2	1128	1276	6.9	5.3	8.7	0.02	13.1	0.00

1.AA.2.C (Chemicals)	N2O	19	19	6.3	14.2	15.5	0.00	0.6	0.00
1.AA.2.D (Pulp. Paper and Print)	CH4	25	32	2.5	38.3	38.3	0.00	26.6	0.00
1.AA.2.D (Pulp. Paper and Print)	CO2	2186	1399	2.3	2.0	3.0	0.00	-36.0	0.00
1.AA.2.D (Pulp. Paper and Print)	N2O	117	113	1.8	29.2	29.2	0.00	-3.3	0.00
1.AA.2.E (Food Processing. Beverages and Tobacco)	CH4	1	1	5.1	32.1	32.5	0.00	71.8	0.00
1.AA.2.E (Food Processing. Beverages and Tobacco)	CO2	948	484	4.5	2.5	5.1	0.00	-48.9	0.00
1.AA.2.E (Food Processing. Beverages and Tobacco)	N2O	19	8	3.4	14.9	15.3	0.00	-56.8	0.00
1.AA.2.F (Other Manufacturing Industries and Construction)	CH4	19	15	9.8	70.8	71.5	0.00	-19.8	0.00
1.AA.2.F (Other Manufacturing Industries and Construction)	CO2	5462	4564	5.9	2.5	6.4	0.13	-16.4	0.01
1.AA.2.F (Other Manufacturing Industries and Construction)	N2O	330	331	4.0	34.0	34.2	0.02	0.4	0.00
1.AA.3.A (Civil Aviation)	CH4	0	0	10.0	199.3	199.6	0.00	-57.9	0.00
1.AA.3.A (Civil Aviation)	CO2	673	465	7.9	4.0	8.9	0.00	-30.9	0.00
1.AA.3.A (Civil Aviation)	N2O	14	9	7.0	141.0	141.1	0.00	-34.1	0.00
1.AA.3.B (Road Transportation)	CH4	184	54	2.4	37.4	37.5	0.00	-70.4	0.00
1.AA.3.B (Road Transportation)	CO2	17310	18962	2.2	2.5	3.3	0.60	9.5	0.03
1.AA.3.B (Road Transportation)	N2O	157	106	2.1	31.6	31.7	0.00	-32.3	0.00
1.AA.3.C (Railways)	CH4	0	0	5.0	150.0	150.1	0.00	-36.1	0.00
1.AA.3.C (Railways)	CO2	103	62	5.0	5.0	7.1	0.00	-39.6	0.00
1.AA.3.C (Railways)	N2O	12	8	5.0	200.0	200.1	0.00	-36.7	0.00
1.AA.3.D (Navigation)	CH4	2	2	2.9	190.6	190.6	0.00	-19.6	0.00
1.AA.3.D (Navigation)	CO2	542	729	10.3	4.9	11.4	0.01	34.4	0.00
1.AA.3.D (Navigation)	N2O	9	11	10.5	30.3	32.1	0.00	29.2	0.00
1.AA.3.E (Other Transportation)	CH4	1	1	2.7	35.9	36.0	0.00	8.0	0.00
1.AA.3.E (Other Transportation)	CO2	271	304	3.9	3.9	5.5	0.00	12.0	0.00
1.AA.3.E (Other Transportation)	N2O	26	31	4.9	49.3	49.6	0.00	19.8	0.00
1.AA.4.A (Commercial/Institutional)	CH4	5	12	13.5	97.3	98.3	0.00	118.5	0.00
1.AA.4.A (Commercial/Institutional)	CO2	2533	722	15.8	2.2	15.9	0.02	-71.5	0.00

1.AA.4.A (Commercial/Institutional)	N2O	31	10	10.8	34.3	36.0	0.00	-67.0	0.00
1.AA.4.B (Residential)	CH4	234	293	13.7	98.7	99.6	0.13	24.9	0.00
1.AA.4.B (Residential)	CO2	6256	1200	18.7	1.4	18.7	0.08	-80.8	0.01
1.AA.4.B (Residential)	N2O	126	115	11.3	80.5	81.3	0.01	-8.7	0.00
1.AA.4.C (Agriculture/Forestry/Fisheries)	CH4	3	46	12.9	93.2	94.1	0.00	1221.2	0.00
1.AA.4.C (Agriculture/Forestry/Fisheries)	CO2	1595	1684	8.1	2.4	8.4	0.03	5.6	0.00
1.AA.4.C (Agriculture/Forestry/Fisheries)	N2O	131	159	3.5	33.1	33.3	0.00	21.1	0.00
1.AA.5.B (Military Use)	CH4	1	0	6.8	137.6	137.8	0.00	-92.5	0.00
1.AA.5.B (Military Use)	CO2	801	173	7.1	3.7	8.0	0.00	-78.4	0.00
1.AA.5.B (Military Use)	N2O	26	4	8.5	169.4	169.7	0.00	-85.1	0.00
1.B.1 (Solid Fuels)	CH4	0	0	5.0	20.0	20.6	0.00	-6.1	0.00
1.B.1 (Solid Fuels)	CO2	5	5	5.0	5.0	7.1	0.00	-3.3	0.00
1.B.1 (Solid Fuels)	N2O	0	0	5.0	20.0	20.6	0.00	-6.1	0.00
1.B.2 (Oil and Natural Gas)	CH4	67	95	0.0	87.5	87.5	0.01	41.3	0.00
1.B.2 (Oil and Natural Gas)	CO2	304	882	12.9	4.4	13.6	0.02	190.3	0.00
1.B.2 (Oil and Natural Gas)	N2O	1	4	13.4	19.4	23.6	0.00	197.2	0.00
2.A.1 (Cement production)	CO2	1272	1350	2.0	5.0	5.4	0.01	6.1	0.00
2.A.2 (Lime Production)	CO2	295	526	2.0	5.0	5.4	0.00	78.5	0.00
2.A.3 (Limestone and Dolomite Use)	CO2	90	135	7.0	5.0	8.6	0.00	49.5	0.00
2.A.4 (Soda Ash use)	CO2	20	1	7.0	5.0	8.6	0.00	-93.3	0.00
2.A.7 (Other Mineral Use)	CO2	44	64	6.1	6.1	8.7	0.00	44.9	0.00
2.B.2 (Nitric Acid Production)	N2O	814	312	2.0	5.0	5.4	0.00	-61.6	0.00
2.B.4 (Carbide Production)	CO2	54	32	10.0	6.0	11.7	0.00	-41.6	0.00
2.B.5 (Other Chemical Industry)	CH4	8	8	0.0	92.7	92.7	0.00	9.8	0.00
2.B.5 (Other Chemical Industry)	CO2	72	99	0.0	35.4	35.4	0.00	37.9	0.00
2.B.5 (Other Chemical Industry)	N2O	22	7	0.0	109.7	109.7	0.00	-68.5	0.00
2.C.1 (Iron and Steel Production)	CH4	0	0	5.0	20.0	20.6	0.00	-7.6	0.00

2.C.1 (Iron and Steel Production)	CO2	2465	2701	4.7	4.7	6.6	0.05	9.6	0.00
2.C.2 (Ferroalloys Production)	CH4	1	0					-100.0	
2.C.2 (Ferroalloys Production)	CO2	243	107	5.0	5.0	7.1	0.00	-56.0	0.00
2.C.3 (Aluminium production)	CO2	133	135	2.0	5.0	5.4	0.00	1.1	0.00
2.C.3 (Aluminium production)	PFC	377	156	2.0	30.0	30.1	0.00	-58.5	0.00
2.C.4 (Magnesium Foundries)	SF6	24	34	0.0	40.0	40.0	0.00	43.5	0.00
2.C.5 (Metal Production. Other)	CO2	238	193	5.0	5.0	7.1	0.00	-18.9	0.00
2.D.1 (Other Production. Pulp and Paper)	CH4	5	6	5.0	20.0	20.6	0.00	25.4	0.00
2.D.1 (Other Production. Pulp and Paper)	N2O	66	83	5.0	20.0	20.6	0.00	24.8	0.00
2.F.1 (Refrigeration and Air Conditioning Equipment)	HFC	4	844	9.8	24.9	26.8	0.08	20215.1	0.01
2.F.1 (Refrigeration and Air Conditioning Equipment)	PFC	0	2	24.1	48.3	54.0	0.00		0.00
2.F.3 (Fire Extinguishers)	HFC	0	6	4.9	19.8	20.4	0.00		0.00
2.F.8 (Electrical equipment)	SF6	81	31	8.0	16.1	18.0	0.00	-61.3	0.00
2.F.9 (Other)	SF6	2	8	42.8	43.4	61.0	0.00	211.0	0.00
3.A (Paint Applications)	CO2	94	31	11.8	15.7	19.7	0.00	-67.0	0.00
3.B (Degreasing and Dry Cleaning)	CO2	1	0	15.0	20.0	25.0	0.00	-71.9	0.00
3.C (Chemical Products, Manufacture and Processing)	CO2	10	1	15.0	20.0	25.0	0.00	-89.1	0.00
3.D (Other)	CO2	138	170	11.5	15.3	19.2	0.00	23.3	0.00
3.D (Other)	N2O	90	109	10.0	10.0	14.1	0.00	20.3	0.00
4.A (Enteric Fermentation)	CH4	3070	2713	2.2	11.2	11.4	0.15	-11.6	0.00
4.B (Manure Management)	CH4	233	295	7.1	17.7	19.0	0.00	26.3	0.00
4.B (Manure Management)	N2O	733	460	15.1	37.7	40.6	0.05	-37.2	0.00
4.D.1 (Direct Soil Emissions)	N2O	2792	2482	15.0	65.8	67.4	4.28	-11.1	0.03
4.D.2 (Pasture, Range and Paddock Manure)	N2O	386	406	35.0	150.0	154.0	0.60	5.4	0.00
4.D.3 (Indirect Emissions)	N2O	1132	830	28.4	121.9	125.2	1.65	-26.7	0.03
4.D.4 (Agricultural Soils. Other)	N2O	718	687	35.0	150.0	154.0	1.71	-4.4	0.01
5.A (Forest Land)	CH4	1	1	0.0	75.0	75.0	0.00	-56.6	0.00

5.A (Forest Land)	CO2	-44107	-38152	0.0	19.8	19.8	87.10	-13.5	0.19
5.A (Forest Land)	N2O	58	66	0.0	49.7	49.7	0.00	14.3	0.00
5.B (Cropland)	CO2	2414	1805	0.0	28.4	28.4	0.40	-25.2	0.00
5.B (Cropland)	N2O	23	72	0.0	100.0	100.0	0.01	207.3	0.00
5.C (Grassland)	CH4	0	0	0.0	75.0	75.0	0.00	-73.0	0.00
5.C (Grassland)	CO2	-916	-765	0.0	20.8	20.8	0.04	-16.5	0.00
5.C (Grassland)	N2O	0	0	0.0	75.0	75.0	0.00	-72.6	0.00
5.D (Wetlands)	CO2	40	54	0.0	35.0	35.0	0.00	35.8	0.00
5.E (Settlements)	CO2	1228	2865	0.0	32.3	32.3	1.31	133.4	0.03
6.A (Solid Waste Disposal on Land)	CH4	2874	1279	25.0	50.0	55.9	0.78	-55.5	0.09
6.B (Wastewater Handling)	CH4	292	299	4.4	48.8	49.0	0.03	2.7	0.00
6.B (Wastewater Handling)	N2O	211	161	4.2	33.8	34.1	0.00	-23.4	0.00
6.C (Waste Incineration)	CH4	0	0	5.0	10.0	11.2	0.00	330.5	0.00
6.C (Waste Incineration)	CO2	44	104	5.0	3.0	5.8	0.00	137.9	0.00
6.C (Waste Incineration)	N2O	1	5	5.0	100.0	100.1	0.00	356.4	0.00
Total		**31495**	**32177**			**25.2**	**100**	**2.2**	**7.00**

Table A 7.3. Tier 1 uncertainty assessment for national total emissions in 2010, excluding LULUCF.

IPCC Source Category	Substance	Base year emissions or removals (Gg CO2-eqv)	Year 2010 emissions or removals (Gg CO2-eqv)	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined uncertainty (%)	Contribution to variance in year 2010 (%)	Inventory trend for year 2010 with respect to base year (%)	Uncertainty introduced into the trend (%)
1.AA.1.A (Public Electricity and Heat Production)	CH4	21	100	2.2	33.0	33.1	0.01	368.1	0.000
1.AA.1.A (Public Electricity and Heat Production)	CO2	7718	10014	0.9	5.8	5.9	4.80	29.7	0.001
1.AA.1.A (Public Electricity and Heat Production)	N2O	304	502	1.4	21.5	21.5	0.16	65.0	0.000
1.AA.1.B (Petroleum Refining)	CH4	1	1	8.9	89.1	89.6	0.00	19.8	0.000
1.AA.1.B (Petroleum Refining)	CO2	1778	2130	9.1	4.5	10.1	0.64	19.8	0.001
1.AA.1.B (Petroleum Refining)	N2O	21	24	8.8	87.6	88.1	0.01	16.3	0.000
1.AA.1.C (Manufacture of Solid Fuels and Other Energy Industries)	CH4	0	0	4.8	16.2	16.9	0.00	16.5	0.000
1.AA.1.C (Manufacture of Solid Fuels and Other Energy Industries)	CO2	299	317	4.3	3.5	5.6	0.00	6.0	0.000
1.AA.1.C (Manufacture of Solid Fuels and Other Energy Industries)	N2O	3	3	5.6	17.2	18.1	0.00	-5.5	0.000
1.AA.2.A (Iron and Steel)	CH4	0	0	3.7	16.4	16.8	0.00	-5.0	0.000
1.AA.2.A (Iron and Steel)	CO2	1638	1773	3.5	2.8	4.4	0.09	8.2	0.000
1.AA.2.A (Iron and Steel)	N2O	15	14	3.7	17.5	17.9	0.00	-6.3	0.000
1.AA.2.B (Non-Ferrous Metals)	CH4	0	0	3.9	15.8	16.3	0.00	-31.9	0.000
1.AA.2.B (Non-Ferrous Metals)	CO2	128	90	3.9	2.4	4.6	0.00	-29.4	0.000
1.AA.2.B (Non-Ferrous Metals)	N2O	2	1	4.0	17.0	17.5	0.00	-35.4	0.000
1.AA.2.C (Chemicals)	CH4	1	1	4.2	20.3	20.8	0.00	55.5	0.000
1.AA.2.C (Chemicals)	CO2	1128	1276	6.9	5.3	8.7	0.17	13.1	0.000
1.AA.2.C (Chemicals)	N2O	19	19	6.3	14.2	15.5	0.00	0.6	0.000
1.AA.2.D (Pulp. Paper and Print)	CH4	25	32	2.5	38.3	38.3	0.00	26.6	0.000

1.AA.2.D (Pulp. Paper and Print)	CO2	2186	1399	2.3	2.0	3.0	0.02	-36.0	0.000
1.AA.2.D (Pulp. Paper and Print)	N2O	117	113	1.8	29.2	29.2	0.01	-3.3	0.000
1.AA.2.E (Food Processing. Beverages and Tobacco)	CH4	1	1	5.1	32.1	32.5	0.00	71.8	0.000
1.AA.2.E (Food Processing. Beverages and Tobacco)	CO2	948	484	4.5	2.5	5.1	0.01	-48.9	0.000
1.AA.2.E (Food Processing. Beverages and Tobacco)	N2O	19	8	3.4	14.9	15.3	0.00	-56.8	0.000
1.AA.2.F (Other Manufacturing Industries and Construction)	CH4	19	15	9.8	70.8	71.5	0.00	-19.8	0.000
1.AA.2.F (Other Manufacturing Industries and Construction)	CO2	5462	4564	5.9	2.5	6.4	1.17	-16.4	0.003
1.AA.2.F (Other Manufacturing Industries and Construction)	N2O	330	331	4.0	34.0	34.2	0.18	0.4	0.000
1.AA.3.A (Civil Aviation)	CH4	0	0	10.0	199.3	199.6	0.00	-57.9	0.000
1.AA.3.A (Civil Aviation)	CO2	673	465	7.9	4.0	8.9	0.02	-30.9	0.000
1.AA.3.A (Civil Aviation)	N2O	14	9	7.0	141.0	141.1	0.00	-34.1	0.000
1.AA.3.B (Road Transportation)	CH4	184	54	2.4	37.4	37.5	0.01	-70.4	0.000
1.AA.3.B (Road Transportation)	CO2	17310	18962	2.2	2.5	3.3	5.42	9.5	0.006
1.AA.3.B (Road Transportation)	N2O	157	106	2.1	31.6	31.7	0.02	-32.3	0.000
1.AA.3.C (Railways)	CH4	0	0	5.0	150.0	150.1	0.00	-36.1	0.000
1.AA.3.C (Railways)	CO2	103	62	5.0	5.0	7.1	0.00	-39.6	0.000
1.AA.3.C (Railways)	N2O	12	8	5.0	200.0	200.1	0.00	-36.7	0.000
1.AA.3.D (Navigation)	CH4	2	2	2.9	190.6	190.6	0.00	-19.6	0.000
1.AA.3.D (Navigation)	CO2	542	729	10.3	4.9	11.4	0.10	34.4	0.000
1.AA.3.D (Navigation)	N2O	9	11	10.5	30.3	32.1	0.00	29.2	0.000
1.AA.3.E (Other Transportation)	CH4	1	1	2.7	35.9	36.0	0.00	8.0	0.000
1.AA.3.E (Other Transportation)	CO2	271	304	3.9	3.9	5.5	0.00	12.0	0.000
1.AA.3.E (Other Transportation)	N2O	26	31	4.9	49.3	49.6	0.00	19.8	0.000
1.AA.4.A (Commercial/Institutional)	CH4	5	12	13.5	97.3	98.3	0.00	118.5	0.000
1.AA.4.A (Commercial/Institutional)	CO2	2533	722	15.8	2.2	15.9	0.18	-71.5	0.001
1.AA.4.A (Commercial/Institutional)	N2O	31	10	10.8	34.3	36.0	0.00	-67.0	0.000
1.AA.4.B (Residential)	CH4	234	293	13.7	98.7	99.6	1.17	24.9	0.000

1.AA.4.B (Residential)	CO2	6256	1200	18.7	1.4	18.7	0.69	-80.8	0.002
1.AA.4.B (Residential)	N2O	126	115	11.3	80.5	81.3	0.12	-8.7	0.000
1.AA.4.C (Agriculture/Forestry/Fisheries)	CH4	3	46	12.9	93.2	94.1	0.03	1221.2	0.000
1.AA.4.C (Agriculture/Forestry/Fisheries)	CO2	1595	1684	8.1	2.4	8.4	0.28	5.6	0.001
1.AA.4.C (Agriculture/Forestry/Fisheries)	N2O	131	159	3.5	33.1	33.3	0.04	21.1	0.000
1.AA.5.B (Military Use)	CH4	1	0	6.8	137.6	137.8	0.00	-92.5	0.000
1.AA.5.B (Military Use)	CO2	801	173	7.1	3.7	8.0	0.00	-78.4	0.000
1.AA.5.B (Military Use)	N2O	26	4	8.5	169.4	169.7	0.00	-85.1	0.000
1.B.1 (Solid Fuels)	CH4	0	0	5.0	20.0	20.6	0.00	-6.1	0.000
1.B.1 (Solid Fuels)	CO2	5	5	5.0	5.0	7.1	0.00	-3.3	0.000
1.B.1 (Solid Fuels)	N2O	0	0	5.0	20.0	20.6	0.00	-6.1	0.000
1.B.2 (Oil and Natural Gas)	CH4	67	95	0.0	87.5	87.5	0.09	41.3	0.000
1.B.2 (Oil and Natural Gas)	CO2	304	882	12.9	4.4	13.6	0.20	190.3	0.001
1.B.2 (Oil and Natural Gas)	N2O	1	4	13.4	19.4	23.6	0.00	197.2	0.000
2.A.1 (Cement production)	CO2	1272	1350	2.0	5.0	5.4	0.07	6.1	0.000
2.A.2 (Lime Production)	CO2	295	526	2.0	5.0	5.4	0.01	78.5	0.000
2.A.3 (Limestone and Dolomite Use)	CO2	90	135	7.0	5.0	8.6	0.00	49.5	0.000
2.A.4 (Soda Ash use)	CO2	20	1	7.0	5.0	8.6	0.00	-93.3	0.000
2.A.7 (Other Mineral Use)	CO2	44	64	6.1	6.1	8.7	0.00	44.9	0.000
2.B.2 (Nitric Acid Production)	N2O	814	312	2.0	5.0	5.4	0.00	-61.6	0.000
2.B.4 (Carbide Production)	CO2	54	32	10.0	6.0	11.7	0.00	-41.6	0.000
2.B.5 (Other Chemical Industry)	CH4	8	8	0.0	92.7	92.7	0.00	9.8	0.000
2.B.5 (Other Chemical Industry)	CO2	72	99	0.0	35.4	35.4	0.02	37.9	0.000
2.B.5 (Other Chemical Industry)	N2O	22	7	0.0	109.7	109.7	0.00	-68.5	0.000
2.C.1 (Iron and Steel Production)	CH4	0	0	5.0	20.0	20.6	0.00	-7.6	0.000
2.C.1 (Iron and Steel Production)	CO2	2465	2701	4.7	4.7	6.6	0.44	9.6	0.001
2.C.2 (Ferroalloys Production)	CH4	1	0					-100.0	

2.C.2 (Ferroalloys Production)	CO2	243	107	5.0	5.0	7.1	0.00	-56.0	0.000
2.C.3 (Aluminium production)	CO2	133	135	2.0	5.0	5.4	0.00	1.1	0.000
2.C.3 (Aluminium production)	PFC	377	156	2.0	30.0	30.1	0.03	-58.5	0.000
2.C.4 (Magnesium Foundries)	SF6	24	34	0.0	40.0	40.0	0.00	43.5	0.000
2.C.5 (Metal Production. Other)	CO2	238	193	5.0	5.0	7.1	0.00	-18.9	0.000
2.D.1 (Other Production. Pulp and Paper)	CH4	5	6	5.0	20.0	20.6	0.00	25.4	0.000
2.D.1 (Other Production. Pulp and Paper)	N2O	66	83	5.0	20.0	20.6	0.00	24.8	0.000
2.F.1 (Refrigeration and Air Conditioning Equipment)	HFC	4	844	9.8	24.9	26.8	0.70	20215.1	0.001
2.F.1 (Refrigeration and Air Conditioning Equipment)	PFC	0	2	24.1	48.3	54.0	0.00		0.000
2.F.3 (Fire Extinguishers)	HFC	0	6	4.9	19.8	20.4	0.00		0.000
2.F.8 (Electrical equipment)	SF6	81	31	8.0	16.1	18.0	0.00	-61.3	0.000
2.F.9 (Other)	SF6	2	8	42.8	43.4	61.0	0.00	211.0	0.000
3.A (Paint Applications)	CO2	94	31	11.8	15.7	19.7	0.00	-67.0	0.000
3.B (Degreasing and Dry Cleaning)	CO2	1	0	15.0	20.0	25.0	0.00	-71.9	0.000
3.C (Chemical Products, Manufacture and Processing)	CO2	10	1	15.0	20.0	25.0	0.00	-89.1	0.000
3.D (Other)	CO2	138	170	11.5	15.3	19.2	0.01	23.3	0.000
3.D (Other)	N2O	90	109	10.0	10.0	14.1	0.00	20.3	0.000
4.A (Enteric Fermentation)	CH4	3070	2713	2.2	11.2	11.4	1.32	-11.6	0.000
4.B (Manure Management)	CH4	233	295	7.1	17.7	19.0	0.04	26.3	0.000
4.B (Manure Management)	N2O	733	460	15.1	37.7	40.6	0.48	-37.2	0.000
4.D.1 (Direct Soil Emissions)	N2O	2792	2482	15.0	65.8	67.4	38.40	-11.1	0.005
4.D.2 (Pasture, Range and Paddock Manure)	N2O	386	406	35.0	150.0	154.0	5.37	5.4	0.001
4.D.3 (Indirect Emissions)	N2O	1132	830	28.4	121.9	125.2	14.78	-26.7	0.003
4.D.4 (Agricultural Soils. Other)	N2O	718	687	35.0	150.0	154.0	15.33	-4.4	0.002
6.A (Solid Waste Disposal on Land)	CH4	2874	1279	25.0	50.0	55.9	7.00	-55.5	0.012
6.B (Wastewater Handling)	CH4	292	299	4.4	48.8	49.0	0.30	2.7	0.000
6.B (Wastewater Handling)	N2O	211	161	4.2	33.8	34.1	0.04	-23.4	0.000

6.C (Waste Incineration)	CH4	0	0	5.0	10.0	11.2	0.00	330.5	0.000
6.C (Waste Incineration)	CO2	44	104	5.0	3.0	5.8	0.00	137.9	0.000
6.C (Waste Incineration)	N2O	1	5	5.0	100.0	100.1	0.00	356.4	0.000
Total		**72755**	**66232**			**4.1**	**100.00**	**-9.0**	**2.06**

References

Gustafsson, T. 2005. Improved structures for uncertainty analysis. SMED report 69 2005.

Annex 8 Other Annexes

Annex 8:1 Description of Sweden's Emission Trading Scheme and comparison to the national inventory system

Annex 8:2 Normal-year corrected emissions

Annex 8:3 Environmental reports

Annex 8:1 EU Emission Trading Scheme in Sweden and comparison to the national inventory

The EU Emissions Trading Scheme (EU ETS) was launched on the 1st of January 2005 and covers approximately 740 installations in Sweden. Installations include combustion plants, oil refineries, coke ovens, iron and steel plants and factories making cement, glass, lime, ceramics, pulp and paper. The second trading period, 2008-2012, includes more installations, and a larger share of those installations that were included in the first period 2005-2007, due to the broader definition of combustion installation applied by the EU commission.

The system is divided into different sectors, depending on the main activity at the installation. An installation is defined as a stationary technical unit where a listed Main Activity is carried out. All installations have a permit to emit carbon dioxide. An installation can be all or part of a plant or industry. If several different operators are situated in one plant, it may be divided into several installations.

Main Activities in the EU ETS

Energy activities

The definition includes combustion installations with a rated thermal input exceeding 20 MW, mineral oil refineries and coke ovens. Sweden has an opt-in of small combustion installations that includes all combustion installations connected to a district heating grid with an aggregated installed capacity exceeding 20 MW.

Installations which incinerate municipal waste and/or hazardous waste are not included in the scheme. During the first trading period (2005-2007) Sweden has interpreted this in the following way: If an installation, or a certain boiler in an installation, mainly incinerates municipal waste or hazardous waste, they are excluded. But from 2008 and onwards (2nd trading period) all installations, or boilers at an installation, with a permit to the Environmental Code to incinerate municipal waste and/or hazardous waste will be excluded. Incineration of other kinds of waste, such as industrial waste, is included in the scheme.

Sweden has used a semi broad definition of combustion installation which means that an installation producing electricity, hot water, hot oil and steam were included but not kilns and ovens. For the second trading period (2008-2012) Sweden has followed the recommendation from the EU Commission to broaden the definition. From 2008 all combustion installations irrespective of fuel and irrespective of the purpose of the combustion will be included.

Production and processing of ferrous metals

The definition includes metal ore roasting or sintering installations, installations for the production of pig iron or steel (primary or secondary fusion) including continuous casting.

In the production and processing of ferrous metals, the works are included in the process until the continuous casting. In the first trading period, the rolling mill was not included in the EU ETS as part of an iron and steel plant, but from 2008 and onwards several rolling mills are included as combustion installations, i.e. if the requirements for an Energy activity are met.

Mineral industry

Installations for the production of cement clinker in rotary kilns or lime in rotary kilns or other furnaces are included. Also included are installations for the manufacture of glass including glass fibre and installations for the manufacture of ceramic products by firing.

Other activities

Industrial plants for the production of pulp from timber or other fibrous materials, or for the production of paper and board are included.

Monitoring and reporting

The emissions are reported yearly to the competent authority, the Swedish Environmental Protection Agency. The deadline for reporting is March the year following the year when the emissions took place. Carbon dioxide is the only greenhouse gas included in the scheme in the first trading period. From 2008 some Member States, have included N_2O in their national scheme.

In the ETS, the yearly emission report is verified by an independent accredited verification body. The verifier controls the emissions report, and secures that the correct tiers, according to the ETS guidelines and the operators permit, are used and that the total emissions figure is accurate.

Emissions in the ETS in relation to emissions in the greenhouse gas inventory

In Table A.8.1 and Table A.8.2 below emissions 2005-2010 of fossil CO_2 in the ETS distributed on different CRF categories are shown. The results are uncertain and should be interpreted with caution since the ETS data are sometimes difficult to allocate to CRF categories. For example, emissions from large plants in iron- and steel industry are reported aggregated by plant and not by type of emission. Also, ETS data are only partially used within the inventory, so the share of ETS emissions for each CRF category does not mean that ETS emissions are included in the inventory to this extent. The results should be seen as an approximation.[105]

[105] Gerner et al, *Särredovisning av utsläpp av fossil CO_2 inom respektive utanför ETS, submission 2012*, SMED memorandum 2011

Table A.8.1 Emissions of fossil CO_2 in the ETS 2005 – 2010 (Gg).

CRF category	2005	2006	2007	2008	2009	2010
1.A.1 Energy Industries	8 776	9 149	8 349	8 090	8 586	10 891
1.A.2 Manufacturing Industry and Construction	5 657	5 559	5 292	6 467	4 865	6 144
1.B Fugitive emissions	275	810	845	885	902	865
2.A Mineral Products	1 989	2 082	2 028	2 073	1 768	1 994
2.C Metal Production	2 564	2 426	2 571	2 486	1 335	2 703
2.B Chemical Industry	33,5	10,5	29,6	22,6	4,4	22,6
2.D Other Production						
2.G Other						
Total CRF 1	14 708	15 518	14 486	15 442	14 353	17 900
Total CRF 2	4 587	4 519	4 629	4 582	3 107	4 719
TOTAL	**19 295**	**20 037**	**19 115**	**20 024**	**17 460**	**22 619**

Table A.8.2 Share of ETS emissions of fossil CO_2 2005 – 2010.

CRF category	2005	2006	2007	2008	2009	2010
1.A.1 Energy Industries	85%	88%	85%	84%	86%	87%
1.A.2 Manufacturing Industry and Construction	52%	51%	51%	66%	60%	64%
1.B Fugitive emissions	87%	95%	95%	99%	99%	98%
2.A Mineral Products	98%	95%	96%	96%	96%	96%
2.C Metal Production	83%	82%	83%	83%	79%	86%
2.B Chemical Industry	25%	9%	21%	16%	4%	17%
2.D Other Production						
2.G Other						
Total CRF 1	31%	33%	31%	35%	34%	38%
Total CRF 2	87%	86%	86%	87%	86%	88%
TOTAL	**36%**	**38%**	**37%**	**40%**	**37%**	**43%**

The trends for emissions of fossil CO_2 in ETS and non-ETS sectors are shown in Figure 1 below. Please note that the definition of what emissions are included in the ETS has been broadened in the second trading period.

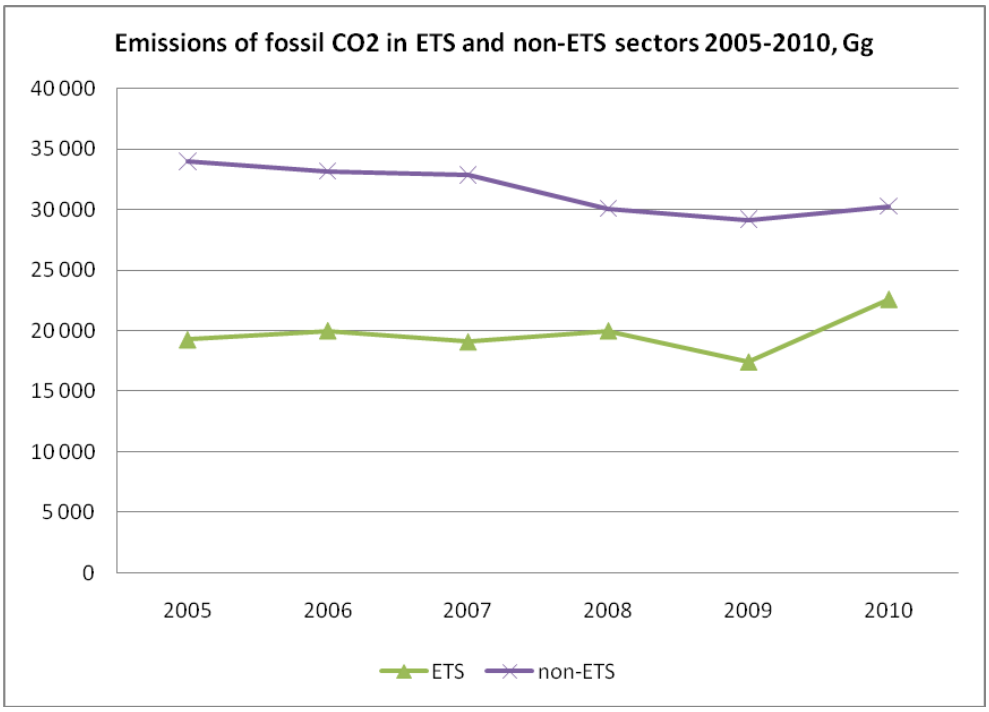


Figure 1. Emissions of fossil CO_2 in ETS and non-ETS sectors 2005 – 2010 (Gg).

Comparisons of data in the GHG inventory and EU ETS in Sweden

Ever since the Swedish national allocation plan was prepared in 2004, Sweden has performed a number of studies to compare data in the both systems and improve the greenhouse gas (GHG) inventory[106]. One result of the studies is that for a number of plants in the Energy and Industrial process sectors, data from the ETS is used in the GHG inventory since it is convenient and the quality is considered higher than that from data sources used in earlier submissions.
In Sweden, emissions from the systems need to be compared on plant level and not on a total or sector based level, since the ETS does not cover all plants in the GHG inventory.

In 2006, a study on plants in the ETS Energy sector was performed based on data from 2005. The 63 plants with the largest emissions in the ETS in 2005, which

[106] Nyström, A-K (2007). Study of differences in plant data between the Energy Statistics and the EU Emission Trading Scheme. SMED report 78:2007.
Backman, H. and Gustafsson, T. (2006). Verification of activity data within the energy sector for the reporting to the UNFCCC, EU Monitoring Mechanism, CLRTAP and the EU NEC Directive using data from the EU Emission Trading Scheme. SMED report 76:2006..
Cooper, D. and Nyström, A-K. (2005). Use of data from the EU emission trading scheme for reporting to EU Monitoring Mechanism, UNFCCC and CLRTAP. SMED report 74:2005..
Gustafsson, T., Lidén, M. and Nyström, A-K., (2005). Användning av data från utsläppshandelssystemet för svensk internationell utsläppsrapportering. Delprojekt 1 Underlag till beslut om datakällor för rapporteringarna. SMED report 66:2005.
Ivarsson, A-K., Kumlin, A., Lidén, M. and Olsson, B. (2004). Dataunderlag för Sveriges nationella fördelningsplan I EU:s system för handel med utsläppsrätter. SMED report.

accounted for 75% of the CO_2 emissions from all plants within the ETS, were included in the study. Activity data, thermal values and CO_2 emission factors from the plants were compared with the energy statistics and analyzed. The results show that for one third of the plants, accounting for about 50% of the CO_2 emissions of the 63 plants investigated, no significant difference between the two data sources were identified. That is, the difference between the energy consumption in the ETS and the quarterly fuel statistics were lower than the reported uncertainty limits in the GHG inventory.

For about 20 of the remaining plants other explanations were possible that still made the quarterly fuels statistics appropriate to use, such as that the fossil fuel activity data in the quarterly fuel statistics was consistent with the time series, while the data from the ETS showed large discrepancies. For the remaining plants closer studies were made and for three plants (refineries) ETS data was recommended as data source for the GHG inventory. For the other remaining plants a number of reasons for the differences were identified, for instance the absence of waste fuel in ETS data.

In 2007, a new study was performed based on data from 2006. The study focused on the plants with the largest differences in the previous study and where sufficient explanations for the differences were not found. Comparisons between the ETS and the quarterly fuel statistics showed that energy amounts and emissions differed between the data sets in several cases. A difference of 17% between the datasets was found when the fossil energy consumption was compared for 19 plants included in the study. When waste was excluded the difference was smaller. In the following text, some main conclusions are summarized, which will explain differences between the data sets.

During 2008 a study aiming to review and when necessary update reported process related CO_2 emissions in CRF 2A, 2B4, 2C1.1 and 2C1.3 was performed. Comparisons of to UNFCCC reported CO_2 emissions and ETS data were made to secure that all facilities included in the ETS were included in the inventory and that all in ETS included process related CO_2 emissions were covered by the inventory. The comparison resulted in adjustments of CO_2 emissions reported in 2A7, 2C1.1 and 2C1.3. Information in the ETS is however not sufficient enough to be the base for reporting of CO_2 emissions in all CRF 2 sub-sectors. To be able to report correct activity data and corresponding CO_2 emissions to UNFCCC, other sources of information are needed. In the Swedish inventory, information from the facilities' environmental reports, from industry trade associations or by direct contact with the facilities are important for the compilation of the inventory.

General differences

Not all of the plants in the GHG inventory are included in the ETS, due to the definitions used in ETS. For combustion plants for instance, only installations with a rated thermal input exceeding a certain limit are included in ETS, but in GHG inventories all plants are included.[107]

[107] For further information of the completeness, see each sector chapter in the National Inventory Report.

In the GHG inventory emissions are separated in Energy and Industrial process emissions and into different subsectors (CRF codes). In the ETS, there is a similar system but a number of plants that are reported in specific industrial CRF sectors in the GHG inventory are included as a combustion installation in the ETS and are hence included in the Energy sector. That is for instance the case for chemical producers and pulp and paper producers. Some technical units in food industry and engineering industry are also included in the ETS as combustion plants in the Energy sector.

Definitions of Energy and Industrial process emissions

When comparing data with emissions from the use of raw materials, the definitions and the interpretation of the IPCC Guidelines results in different categorization of energy and process related emissions in the two systems.

For instance emissions from catalytic cracking in oil refineries are reported as process related in the ETS, while in the GHG inventory they are reported in the Energy sector in the sub-sector fugitive emissions, CRF 1B.

Primary iron and steel works calculate and report their emissions according to a mass balance approach in the ETS, whereas in the GHG inventory emissions are reported in several different sectors (CRF codes) in line with the interpretation of the IPCC guidelines.

Differences in the Energy sector

DIFFERENT CERTAINTY ON PLANT LEVEL DATA

Data from Statistics Sweden's quarterly fuels statistics is used in the GHG inventory in the Energy sector. Data is reported quarterly from the plants and might have to be estimated if data is not available. ETS data on the other hand are reported after the year ends for all sectors and is in addition verified by an independent accredited verification body.

DIFFERENT AGGREGATIONS OF MICRO DATA IN THE ENERGY SECTOR

The reporting unit for the quarterly fuel statistics survey, used for energy production plants (CRF 1A1a), is not installation, but by company and municipality. Identifying energy consumption and emissions for specific plants in that sector is therefore in some cases not possible. Furthermore, some reporting units may include both large combustion installations included in the ETS system and smaller installations not included in the ETS system, and hence it is currently not possible to specify which fuel consumptions reported to the quarterly fuel statistics that are included in the ETS.

ONLY PARTS OF PLANTS INCLUDED IN THE ETS

Combustion of municipal solid waste is not included in the ETS, while it is included in the GHG inventory. For instance, the plant with the largest emissions within the Chemical industries sector (CRF 1A2c) was only partly included in the ETS in the first trading period.

EMISSION FACTORS AND THERMAL VALUES

In the ETS, the plants in some cases use plant specific emission factors and thermal values, while in the GHG inventory, thermal values and CO_2 emission factors are in many cases general and yield good estimates on national level. Hence, they are to some extent not representative on plant level.

Another smaller problem in the GHG inventory is that unconventional fuels are grouped together into for instance "other non specific fuels" which leads to high uncertainties on plant level since the emission factors are not specific for a certain fuel. Besides, some of those unconventional fuels are incorrectly classified. In the ETS some of these fuels are often partly biogenic and should hence be classified as "Other biomass" in GHG inventory.

Differences in the industrial process sector

ONLY PARTS OF PLANTS INCLUDED IN THE ETS

In the ETS may not all activities within a facility be included. As an example calcium carbide can be mentioned. For carbide production only the lime producing part of the production of calcium carbide is included.

FACILITIES NOT INCLUDED

Some, in the GHG inventory important, industries are not covered in the ETS. As examples can non-iron metal production and aluminium production be pointed out.

Use of ETS data in submission 2012

The use of activity data in CRF 1 from ETS is summarized in the following table:

Year	CRF	Facilities
2005	1A1b, 1B2C21	Four refineries,including one hydrogen production plant
2006	1A1b, 1A2e, 1B2A1,1B2C21	Four refineries, including two hydrogen production plants, and one sugar production plant
2007	1A1b, 1B2A1, 1B2C21	Five refineries, including two hydrogen production plants.
2008-2010	1A1b, 1A2c, 1A2f, 1B2A1, 1B2C21	Five refineries including two hydrogen production plants, three cement factories and one chemical industry,

For the hydrogen production plants, CO_2 emissions reported in the ETS system are used in the GHG inventory. This is also the case for all emissions from combustion and flaring of refinery gas and methane based gas mixtures in 2008 and later.

Annex 8:2 Normal-year corrected emissions

In the UNFCCC Reporting Guidelines on Annual Inventories, Parties are encouraged to give information on application of adjustments as it is regarded as important information in relation to the monitoring of emission and removal trends, and the performance of national policies and measures. Information on fossil CO_2-emissions adjusted for weather and climatic conditions in Sweden was included in the Third National Communication on Climate Change in 2001, and up-dated in the Fourth and Fifth National Communication in 2005 and 2009, respectively.

The Swedish weather conditions vary a great deal from year to year. Temperature, solar radiation and wind influence the amount of energy needed to heat buildings in order to maintain normal indoor temperatures. Precipitation affects the quantity of water flowing in watercourses and hence the potential for generating electric energy using hydropower.

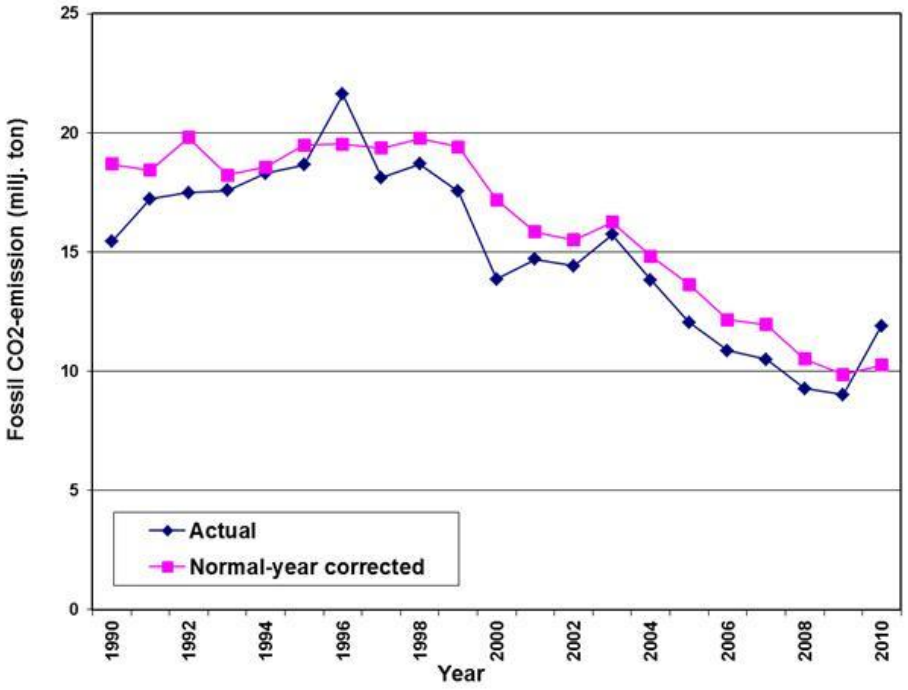


Figure 1. Actual and normal-year corrected fossil CO_2-emissions for heating of buildings and electricity production in Sweden for the years 1990-2010. For the year 2010 preliminary statistics on fossil fuel consumption is used.

Sweden has developed a normal-year correction method, which makes it possible to adjust actual fossil CO_2-emissions in Sweden for a specific year to the fossil CO_2-emissions which should have taken place in a climatic "normal" year and facilitate a comparison. Normal-year correction includes emissions from heating of buildings (but not cooling) and from electricity generation. The model used to calculate the need, depending on weather, for heating of buildings is described in more detail in reference [1] and later further elaborated in details [3]. The model for normal-year corrections of CO_2-emissions from electricity production, including hydro-power, is described in [2]. Actual and normal-year corrected fossil CO_2-emissions caused by heating of buildings and electricity production is shown for 1990-2010 (preliminary data for fossil fuel consumption in 2010) in Figure 1. In Table 1 the normal-year corrections of fossil CO_2-emissions (1000 tons CO_2/year) in total and separated for electricity production (including electric heating) and heating of buildings (except electric heating) are shown. The correction shall be added to the actual emission to obtain the normal-year emission. The normal-year corrected total emissions of fossil CO_2 for heating of buildings and electricity production was almost constant during the period 1990-1999. Since then the emission has gradually decreased and was in 2009 about half of the levels during the period 1990-1999. In 2010, which was an exceptional year with regard to low Swedish nuclear power production combined with an unusually long and cold winter, there was a slight increase in the normal-year corrected fossil CO_2-emissions compared to in 2009.

Table 1. Annual 1990-2010 (2010 preliminary data) calculated normal-year corrections of fossil CO_2-emissions (1000 ton CO_2/year). Values are given for the total correction as well as separated into heating of buildings (excluding electric heating) and electricity production (including electric heating). The correction shall be added to the actual emission to obtain the normal-year emission.

	Normal-year corrections of fossil CO2 [1000 ton CO2/year]		
Year	Electricity production&heating	Heating building excl el-heating	Total normal-year correction
1990	1 315	1 943	3 258
1991	449	765	1 213
1992	877	1 425	2 302
1993	149	502	652
1994	-238	496	258
1995	484	342	826
1996	-1 338	-757	-2 095
1997	560	680	1 240
1998	760	325	1 085
1999	807	1 065	1 872
2000	1 708	1 619	3 326
2001	660	487	1 147
2002	191	901	1 092
2003	-133	662	529
2004	356	642	998
2005	733	859	1 592
2006	333	965	1 298
2007	478	991	1 469
2008	339	908	1 248
2009	230	626	855
2010	-410	-1 228	-1 639

References

[1] Persson C. Normalårskorrigering av Sveriges utsläpp av fossil CO_2 från uppvärmning. Summary in English. Rapportserie SMED och SMED&SLU, Nr 1. 2004

[2] Holmberg J. & Axelsson J. Kortfattad metodbeskrivning – Normalårskorrigering av el. SwedPower. 2006

[3] Normalårskorrigering av fjärrvärmebränslen. Rapport till Naturvårdsverket. Profu AB 2006.

Annex 8:3 Environmental reports

In Sweden, the types of activities or operations for which permits are compulsory are specified directly in the Environmental Code[108] or in the Ordinance on hazardous activity and health protection[109]. As an example, approximately 7,500 "environmental hazardous activities" must have a permit. Such activities are conducted on a real estate and result or may result in discharges or other disturbances to the environment, e.g. water and air pollution or noise. The number includes activities regulated in EC-directives, e.g. under the IPPC[110] and Seveso directives[111].

For permitting procedures the Code divides competence between the regional administrations and the Environmental Courts. Permits are granted by the Environmental Courts and the Environmental Permitting Committees (EPC). The EPC is a special function at the County Administrative Board (CAB). There are 21 EPCs, one in each county, and five Environmental Courts.

The allocation of licensing tasks between the EPCs and the Courts is regulated in the Ordinance on environmentally hazardous activities. For activities that entail a significant environmental impact (classed as A-activities in the list and totalling less than 500), the proponent must apply for a permit to the Court. For activities with less impact on the environment (classed as B-activities in the list and totally 7,000) the proponent must apply for a permit to the CAB.

All operations regulated by permit must return annual environmental reports as required by Chapter 26, section 20, of the Environmental Code. The reporting obligations for the environmental report are regulated in the direction for environmental report[112].The environmental report consists of three parts:

- Administrative information about the facility.
- Text section (for example, a description of the facility and the processes, the use of energy, chemicals and raw materials, emissions and conditions in the permit).
- Emission declaration (for example, production data, fuel consumption data, emission data and, information on how emission data have been determined i.e. measured, calculated or estimated).

The data in the environmental reports often originates from measurements or mass balances. The use of default emission factors is limited. Only the operators that exceed the thresholds for the substances listed in Swedish environmental law governing environmental reports are obliged to compile the emission declaration.

108 SFS 1998:808. Miljöbalken.
109 SFS 2007:674. Förordning om ändring i förordningen (1998:899) om miljöfarlig verksamhet och hälsoskydd.
110 Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control (Codified version)
111 Directive 2003/105/EC of the European Parliament and of the Council of 16 December 2003 amending Council Directive 96/82/EC on the control of major-accident hazards involving dangerous substances.
112 NFS 2006:9, Naturvårdsverkets föreskrifter om miljörapport för tillståndspliktiga miljöfarliga verksamheter.

Since the beginning of year 2007 environmental reports can be submitted electronically via the Swedish Portal for Environmental Reporting (SMP)[113].

References

Directive 2003/105/EC of the European Parliament and of the Council of 16 December 2003 amending Council Directive 96/82/EC on the control of major-accident hazards involving dangerous sub-stances. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32003L0105:EN:HTML 2010-12-03

Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control (Codified version) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:024:0008:0029:EN:PDF 2010-12-03

NFS 2006:9, Naturvårdsverkets föreskrifter om miljörapport för tillståndspliktiga miljöfarliga verksamheter. http://www.naturvardsverket.se/Documents/foreskrifter/nfs2006/nfs_2006_9.pdf 2010-12-03

SFS 1998:808. Miljöbalken. http://www.sweden.gov.se/content/1/c6/02/28/47/385ef12a.pdf 2010-12-03

SFS 2007:674. Förordning om ändring i förordningen (1998:899) om miljöfarlig verksamhet och hälsoskydd. http://www.notisum.se/rnp/SLS/sfs/20070674.pdf 2010-12-03

Svenska Miljörapporteringsportalen. https://smp2.naturvardsverket.se/ 2010-12-03

[113] Svenska Miljörapporteringsportalen. https://smp2.naturvardsverket.se/