National Inventory Report Sweden 2019: Annexes

Greenhouse Gas Emission Inventories 1990-2017

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

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

Cover photo: Jonas Bergström

Contents

Annex 1: Key Categories

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

1.1 Description of methodology used for identifying key categories

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

In the approach 1 analysis key categories are the aggregated categories that together contribute up to either 95 % of the level or 95 % of the overall contribution to trend of all greenhouse gas emissions in Sweden. In the approach 2 analysis, information about the sources' uncertainties are also included in the analysis. Approach 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-eq.

1.1.1 Approach 1 level assessment

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

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

Lx,t= level assessment for source or sink x in latest inventory year (year t).

│Ex,t│ = absolute value of emission or removal estimate of source or sink category x in year t

∑│Ey,t│= total contribution, which is the sum of the absolute values of emissions and removals in year t calculated using the aktregation level chosen by the country for key category analysis. Because both emissions and removals are entered as absolute values, 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 % of the sum of all $L_{x,t}$.

1.1.2 Approach 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):

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

$T_{x,t}$= trend assessment of source or sink category *x* in year *t* as compared to the base year (year 0)

$|E_{x,0}|$ = 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:

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

1.1.3 Approach 2 level and trend assessments

When the information from the approach 1 key categories analysis is combined with the outcome from the uncertainty analysis, it results in an approach 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 approach 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 % of the sum of all $LU_{x,t}$ or 90 % of the contribution to trend and $TU_{x,t}$, respectively, when ranked by decreasing order of magnitude.

1.2 Results

As can be seen in Table A1.1 emissions of CO2 from gasoline and diesel combustion in passenger cars (CRF 1.A.3.b.i) together with emissions of CO2 from diesel combustion in heavy duty trucks (CRF 1.A.3.b.iii) are the top three sources in 2017 in the approach 1 level assessment excluding LULUCF. Together they contribute with 26% of the national total.

In 2017, 62 key categories in terms of trend have been identified, excluding LULUCF (Table A1.3). The Energy Sector (CRF 1) contributes with the majority of the key categories (39).

In 2017, the category with the most significant change since 1990 are CO2 from Forest Land remaining Forest Land (4.A.1), which contributes with 39% to the explanation of the overall trend.

Other interesting categories with regard to the trend are those with decreasing emissions. Among them, CO2 emissions from liquid fuels in the Residential sector (1.A.4.b) and emissions from gasoline fuelled personal cars (1.A.3.b.i) are in top in 2017.

The approach 2 level and trend assessments (Tabel A1.5 to Table A1.8) result in higher priority to categories with high uncertainties in sources or sinks compared to the approach 1 assessments, e.g. emissions from the agriculture and waste sectors.

Table A1.1. Key Category Analysis approach 1 Level Assessment, excluding LULUCF.

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO_2-eq)	Level Assessment Year 2017	Key Source Level in 2017
1 A 3 b i Road Transportation, Cars: Gasoline	CO2	6249	12%	1
1 A 3 b i Road Transportation, Cars: Diesel oil	CO2	4058	8%	2
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	CO2	3407	6%	3
1 A 1 a Public Electricity and Heat Production: Solid Fuels	CO2	2956	6%	4
1 A 1 a Public Electricity and Heat Production: Other Fuels	CO2	2479	5%	5
2 C 1 Iron and Steel Production	CO2	2230	4%	6
1 A 1 b Petroleum refining: Liquid Fuels	CO2	1863	4%	7
2 A 1 Cement Production	CO2	1484	3%	8
3 A 1 Non-dairy cattle	CH4	1470	3%	9
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	CO2	1401	3%	10
1 A 4 c Agriculture/Forestry/Fisheries: Liquid Fuels	CO2	1302	2%	11
1 A 2 g vii Off-road vehicles and other machinery: Liquid Fuels	CO2	1235	2%	12
3 A 1 Dairy cattle	CH4	1138	2%	13
2 F 1 Refrigeration and air conditioning	HFCs	1068	2%	14
3 D a 1 Inorganic N fertilizers	N2O	929	2%	15
5 A 1 Managed waste disposal sites	CH4	841	2%	16

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO_2-eq)	Level Assessment Year 2017	Key Source Level in 2017
3 D a 6 Cultivation of organic soils (i.e. histosols)	N2O	832	2%	17
2 B 10 Other	CO2	830	2%	18
1 A 2 g viii Other: Liquid Fuels	CO2	C	C	19
1 B 2 a Oil	CO2	756	1%	20
1 A 2 a Iron and Steel: Liquid Fuels	CO2	616	1%	21
1 A 2 d Pulp, Paper and Print: Liquid Fuels	CO2	596	1%	22
1 A 2 f Non-metallic minerals: Solid Fuels	CO2	C	C	23
1 A 2 a Iron and Steel: Solid Fuels	CO2	581	1%	24
1 A 3 a Domestic Aviation: Jet Kerosene	CO2	541	1%	25
1 A 4 b Residential: Liquid Fuels	CO2	524	1%	26
1 A 1 a Public Electricity and Heat Production: Peat	CO2	480	1%	27
2 A 2 Lime Production	CO2	465	1%	28
1 A 2 g viii Other: Solid Fuels	CO2	C	C	29
3 D a 4 Crop residues applied to soils	N2O	415	1%	30
1 A 1 c Manufacture of Solid fuels and Other Energy Industries: Solid Fuels	CO2	393	1%	31
3 D a 3 Urine and dung deposited by grazing animals	N2O	355	1%	32
1 A 2 f Non-metallic minerals: Liquid Fuels	CO2	C	C	33

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO_2-eq)	Level Assessment Year 2017	Key Source Level in 2017
3 D a 2 a Animal manure applied to soils	N2O	333	1%	34
1 A 2 c Chemicals: Liquid Fuels	CO2	305	1%	35
1 A 3 d Domestic Navigation: Gas/Diesel Oil	CO2	293	1%	36
1 A 1 a Public Electricity and Heat Production: Gaseous Fuels	CO2	286	1%	37
1 A 1 a Public Electricity and Heat Production: Liquid Fuels	CO2	284	1%	38
2 C 7 Other	CO2	C	C	39
2 C 7 Other	CO2	C	C	39
3 D a 5 Mineralization/immobilization associated with loss/gain of soil organic matter	N2O	258	0%	40
2 D 1 Lubricant use	CO2	254	0%	41
1 A 4 a Commercial/Institutional: Diesel Oil	CO2	216	0%	42
2 C 3 Aluminium production	CO2	206	0%	43
5 D 1 Domestic wastewater	N2O	200	0%	44
1 A 4 a Commercial/Institutional: Gasoline	CO2	199	0%	45
3 D b 2 Nitrogen leaching and run-off	N2O	186	0%	46
1 A 4 a Commercial/Institutional: Gaseous Fuels	CO2	184	0%	47
1 A 5 b Mobile: Liquid Fuels	CO2	184	0%	48
1 A 2 a Iron and Steel: Gaseous Fuels	CO2	181	0%	49

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO_2-eq)	Level Assessment Year 2017	Key Source Level in 2017
1 A 2 e Food Processing, Beverages and Tobacco: Gaseous Fuels	CO2	178	0%	50
1 A 3 e Other Transportation: Diesel Oil	CO2	165	0%	51
1 A 2 f Non-metallic minerals: Other Fuels	CO2	163	0%	52
2 C 2 Ferroalloys production	CO2	C	C	53
3 A 4 Horses	CH4	160	0%	54
1 A 1 a Public Electricity and Heat Production: Biomass	N2O	160	0%	55
2 D 3 Other	CO2	153	0%	56
1 A 4 a Commercial/Institutional: Liquid Fuels	CO2	147	0%	57
1 A 1 b Petroleum refining: Gaseous Fuels	CO2	137	0%	58
1 A 2 e Food Processing, Beverages and Tobacco: Liquid Fuels	CO2	135	0%	59
3 G Liming	CO2	127	0%	60
3 A 2 Sheep	CH4	121	0%	61
1 A 2 f Non-metallic minerals: Gaseous Fuels	CO2	120	0%	62
3 B 1 Non-dairy cattle	CH4	106	0%	63
1 A 3 b ii Road Transportation, Light duty trucks: Gasoline	CO2	96	0%	64
3 D b 1 Atmospheric deposition	N2O	94	0%	65
1 A 4 b Residential: Gaseous Fuels	CO2	92	0%	66

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO_2-eq)	Level Assessment Year 2017	Key Source Level in 2017
3 B 1 Non-dairy cattle	N2O	90	0%	67
5 B 1 Composting	CH4	88	0%	68
1 A 2 g viii Other: Gaseous Fuels	CO2	88	0%	69

Table A1.2. Key Category Analysis approach 1 Level Assessment, including LULUCF.

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO2-eq)	Level Assessment Year 2017	Key Source Level in 2017
4 A 1 Forest land remaining forest land	CO_2	-43170	38.6%	1
4 G Total HWP from domestic harvest	CO_2	-6714	6.0%	2
1 A 3 b i Road Transportation, Cars: Gasoline	CO_2	6249	5.6%	3
1 A 3 b i Road Transportation, Cars: Diesel oil	CO_2	4058	3.6%	4
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	CO_2	3407	3.0%	5
4 B 1 Cropland remaining cropland	CO_2	3331	3.0%	6
1 A 1 a Public Electricity and Heat Production: Solid Fuels	CO_2	2956	2.6%	7
1 A 1 a Public Electricity and Heat Production: Other Fuels	CO_2	2479	2.2%	8
2 C 1 Iron and Steel Production	CO_2	2230	2.0%	9
1 A 1 b Petroleum refining: Liquid Fuels	CO_2	1863	1.7%	10
2 A 1 Cement Production	CO_2	1484	1.3%	11
3 A 1 Non-dairy cattle	CH_4	1470	1.3%	12
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	CO_2	1401	1.3%	13
1 A 4 c Agriculture/Forestry/Fisheries: Liquid Fuels	CO_2	1302	1.2%	14
1 A 2 g vii Off-road vehicles and other machinery: Liquid Fuels	CO_2	1235	1.1%	15
3 A 1 Dairy cattle	CH_4	1138	1.0%	16
4 E 2 2 Cropland converted to settlements	CO_2	1079	1.0%	17
2 F 1 Refrigeration and air conditioning	HFCs	1068	1.0%	18

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO2-eq)	Level Assessment Year 2017	Key Source Level in 2017
4 A Drained organic soils	N_2O	1043	0.9%	19
3 D a 1 Inorganic N fertilizers	N_2O	929	0.8%	20
4 E 2 1 Forest land converted to settlements	CO_2	856	0.8%	21
5 A 1 Managed waste disposal sites	CH_4	841	0.8%	22
3 D a 6 Cultivation of organic soils (i.e. histosols)	N_2O	832	0.7%	23
2 B 10 Other	CO_2	830	0.7%	24
1 A 2 g viii Other: Liquid Fuels	CO_2	C	C	25
1 B 2 a Oil	CO_2	756	0.7%	26
4 A 2 4 Settlements converted to forest land	CO_2	-616	0.6%	27
1 A 2 a Iron and Steel: Liquid Fuels	CO_2	616	0.6%	28
1 A 2 d Pulp, Paper and Print: Liquid Fuels	CO_2	596	0.5%	29
1 A 2 f Non-metallic minerals: Solid Fuels	CO_2	C	C	30
1 A 2 a Iron and Steel: Solid Fuels	CO_2	581	0.5%	31
1 A 3 a Domestic Aviation: Jet Kerosene	CO_2	541	0.5%	32
1 A 4 b Residential: Liquid Fuels	CO_2	524	0.5%	33
4 A 2 1 Cropland converted to forest land	CO_2	-481	0.4%	34
1 A 1 a Public Electricity and Heat Production: Peat	CO_2	480	0.4%	35
2 A 2 Lime Production	CO_2	465	0.4%	36
1 A 2 g viii Other: Solid Fuels	CO_2	C	C	37

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO2-eq)	Level Assessment Year 2017	Key Source Level in 2017
3 D a 4 Crop residues applied to soils	N_2O	415	0.4%	38
1 A 1 c Manufacture of Solid fuels and Other Energy Industries: Solid Fuels	CO_2	393	0.4%	39
3 D a 3 Urine and dung deposited by grazing animals	N_2O	355	0.3%	40
1 A 2 f Non-metallic minerals: Liquid Fuels	CO_2	C	C	41
3 D a 2 a Animal manure applied to soils	N_2O	333	0.3%	42
1 A 2 c Chemicals: Liquid Fuels	CO_2	305	0.3%	43
1 A 3 d Domestic Navigation: Gas/Diesel Oil	CO_2	293	0.3%	44
4 C 2 1 Forest land converted to grassland	CO_2	291	0.3%	45
1 A 1 a Public Electricity and Heat Production: Gaseous Fuels	CO_2	286	0.3%	46
1 A 1 a Public Electricity and Heat Production: Liquid Fuels	CO_2	284	0.3%	47
2 C 7 Other	CO_2	C	C	48
2 C 7 Other	CO_2	C	C	48
3 D a 5 Mineralization/immobilization associated with loss/gain of soil organic matter	N_2O	258	0.2%	49
2 D 1 Lubricant use	CO_2	254	0.2%	50
4 A Drained organic soils	CH_4	217	0.2%	51
1 A 4 a Commercial/Institutional: Diesel Oil	CO_2	216	0.2%	52
2 C 3 Aluminium production	CO_2	206	0.2%	53
4 B Drained organic soils	CH_4	201	0.2%	54
5 D 1 Domestic wastewater	N_2O	200	0.2%	55

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO2-eq)	Level Assessment Year 2017	Key Source Level in 2017
1 A 4 a Commercial/Institutional: Gasoline	CO_2	199	0.2%	56
4 D 1 1 Peat extraction remaining peat extraction	CO_2	195	0.2%	57
3 D b 2 Nitrogen leaching and run-off	N_2O	186	0.2%	58
1 A 4 a Commercial/Institutional: Gaseous Fuels	CO_2	184	0.2%	59
1 A 5 b Mobile: Liquid Fuels	CO_2	184	0.2%	60
4 C 1 Grassland remaining grassland	CO_2	-183	0.2%	61
1 A 2 a Iron and Steel: Gaseous Fuels	CO_2	181	0.2%	62
1 A 2 e Food Processing, Beverages and Tobacco: Gaseous Fuels	CO_2	178	0.2%	63
1 A 3 e Other Transportation: Diesel Oil	CO_2	165	0.1%	64
1 A 2 f Non-metallic minerals: Other Fuels	CO_2	163	0.1%	65

Table A1.3. Key Category Analysis approach 1 Trend Assessment, excluding LULUCF.

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Contribution to Trend	Key Source Trend
1 A 4 b Residential: Liquid Fuels	CO_2	6234	524	12.4%	1
1 A 3 b i Road Transportation, Cars: Diesel oil	CO_2	439	4058	11.4%	2
1 A 3 b i Road Transportation, Cars: Gasoline	CO_2	11999	6249	7.9%	3
1 A 1 a Public Electricity and Heat Production: Other Fuels	CO_2	570	2479	6.3%	4
5 A 1 Managed waste disposal sites	CH_4	3422	841	5.1%	5
1 A 4 a Commercial/Institutional: Liquid Fuels	CO_2	2447	147	5.1%	6
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	CO_2	162	1401	3.9%	7
2 F 1 Refrigeration and air conditioning	HFCs	5	1068	3.2%	8
1 A 2 g viii Other: Liquid Fuels	CO_2	2062	C	C	9
1 A 2 d Pulp, Paper and Print: Liquid Fuels	CO_2	1786	596	2.2%	10
1 A 1 a Public Electricity and Heat Production: Liquid Fuels	CO_2	1277	284	2.0%	11
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	CO_2	3779	3407	1.9%	12
1 B 2 a Oil	CO_2	219	756	1.8%	13
1 A 1 b Petroleum refining: Liquid Fuels	CO_2	1778	1863	1.7%	14
2 A 1 Cement Production	CO_2	1272	1484	1.7%	15
2 B 2 Nitric Acid Production	N_2O	782	42	1.6%	16
3 A 1 Non-dairy cattle	CH_4	1268	1470	1.6%	17

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Contribution to Trend	Key Source Trend
1 A 2 g vii Off-road vehicles and other machinery: Liquid Fuels	CO_2	997	1235	1.5%	18
1 A 5 b Mobile: Liquid Fuels	CO_2	846	184	1.3%	19
1 A 3 b ii Road Transportation, Light duty trucks: Gasoline	CO_2	692	96	1.3%	20
2 B 10 Other	CO_2	598	830	1.2%	21
2 C 3 Aluminium production	PFCs	569	36	1.2%	22
1 A 1 a Public Electricity and Heat Production: Peat	CO_2	1150	480	1.1%	23
1 A 2 g viii Other: Solid Fuels	CO_2	94	C	C	24
1 A 2 e Food Processing, Beverages and Tobacco: Liquid Fuels	CO_2	596	135	0.9%	25
2 C 1 Iron and Steel Production	CO_2	2624	2230	0.9%	26
1 A 2 f Non-metallic minerals: Solid Fuels	CO_2	1135	C	C	27
2 A 2 Lime Production	CO_2	331	465	0.7%	28
3 D a 5 Mineralization/immobilization associated with loss/gain of soil organic matter	N_2O	68	258	0.6%	29
1 A 2 d Pulp, Paper and Print: Solid Fuels	CO_2	265	15	0.5%	30
1 A 1 c Manufacture of Solid fuels and Other Energy Industries: Solid Fuels	CO_2	300	393	0.5%	31
1 A 1 a Public Electricity and Heat Production: Solid Fuels	CO_2	4231	2956	0.5%	32
1 A 2 f Non-metallic minerals: Other Fuels	CO_2	0	163	0.5%	33
1 A 2 a Iron and Steel: Gaseous Fuels	CO_2	25	181	0.5%	34
3 D a 6 Cultivation of organic soils (i.e. histosols)	N_2O	914	832	0.5%	35

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Contribution to Trend	Key Source Trend
3 D a 1 Inorganic N fertilizers	N_2O	1051	929	0.5%	36
1 A 4 c Agriculture/Forestry/Fisheries: Liquid Fuels	CO_2	1572	1302	0.4%	37
2 D 1 Lubricant use	CO_2	158	254	0.4%	38
1 A 1 b Petroleum refining: Gaseous Fuels	CO_2	0	137	0.4%	39
1 A 1 a Public Electricity and Heat Production: Biomass	N_2O	34	160	0.4%	40
1 A 3 d Domestic Navigation: Residual Oil	CO_2	194	12	0.4%	41
1 A 4 a Commercial/Institutional: Gaseous Fuels	CO_2	86	184	0.4%	42
1 A 4 c Agriculture/Forestry/Fisheries: Solid Fuels	CO_2	157	0	0.4%	43
1 A 2 f Non-metallic minerals: Liquid Fuels	CO_2	625	C	C	44
2 C 3 Aluminium production	CO_2	133	206	0.3%	45
1 A 3 b i Road Transportation, Cars: Gasoline	CH_4	138	10	0.3%	46
1 A 4 a Commercial/Institutional: Diesel Oil	CO_2	170	216	0.3%	47
3 D a 3 Urine and dung deposited by grazing animals	N_2O	361	355	0.3%	48
1 A 3 b i Road Transportation, Cars: Gasoline	N_2O	132	10	0.3%	49
5 B 1 Composting	CH_4	7	88	0.3%	50
3 D a 4 Crop residues applied to soils	N_2O	452	415	0.2%	51
1 A 1 a Public Electricity and Heat Production: Gaseous Fuels	CO_2	486	286	0.2%	52
1 A 2 f Non-metallic minerals: Gaseous Fuels	CO_2	65	120	0.2%	53

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Contribution to Trend	Key Source Trend
3 D a 2 a Animal manure applied to soils	N_2O	359	333	0.2%	54
2 C 7 Other	CO_2	276	C	C	55
2 C 7 Other	CO_2	276	C	C	55
1 A 2 c Chemicals: Solid Fuels	CO_2	127	28	0.2%	56
1 A 4 a Commercial/Institutional: Gasoline	CO_2	185	199	0.2%	57
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	N_2O	13	71	0.2%	58
3 A 2 Sheep	CH_4	81	121	0.2%	59
3 B 1 Non-dairy cattle	CH_4	61	106	0.2%	60
3 A 1 Dairy cattle	CH_4	1617	1138	0.2%	61

Table A1.4. Key Category Analysis approach 1 Trend Assessment, including LULUCF.

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	Contribution to Trend	Key Source Trend
4 A 1 Forest land remaining forest land	CO_2	-37739	-43170	0.32	1
1 A 3 b i Road Transportation, Cars: Diesel oil	CO_2	439	4058	0.05	2
1 A 3 b i Road Transportation, Cars: Gasoline	CO_2	11999	6249	0.05	3
4 B 1 Cropland remaining cropland	CO_2	3291	3331	0.04	4
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	CO_2	3779	3407	0.03	5
1 A 1 a Public Electricity and Heat Production: Other Fuels	CO_2	570	2479	0.03	6
4 G Total HWP from domestic harvest	CO_2	-5016	-6714	0.03	7
1 A 1 a Public Electricity and Heat Production: Solid Fuels	CO_2	4231	2956	0.03	8
2 C 1 Iron and Steel Production	CO_2	2624	2230	0.02	9
1 A 1 b Petroleum refining: Liquid Fuels	CO_2	1778	1863	0.02	10
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	CO_2	162	1401	0.02	11
2 A 1 Cement Production	CO_2	1272	1484	0.02	12
3 A 1 Non-dairy cattle	CH_4	1268	1470	0.02	13
2 F 1 Refrigeration and air conditioning	HFCs	5	1068	0.01	14
4 E 2 2 Cropland converted to settlements	CO_2	277	1079	0.01	15
1 A 2 g vii Off-road vehicles and other machinery: Liquid Fuels	CO_2	997	1235	0.01	16
1 A 4 b Residential: Liquid Fuels	CO_2	6234	524	0.01	17

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	Contribution to Trend	Key Source Trend
1 A 4 c Agriculture/Forestry/Fisheries: Liquid Fuels	CO_2	1572	1302	0.01	18
4 A Drained organic soils	N_2O	1179	1043	0.01	19
3 A 1 Dairy cattle	CH_4	1617	1138	0.01	20
1 B 2 a Oil	CO_2	219	756	0.01	21
2 B 10 Other	CO_2	598	830	0.01	22
3 D a 1 Inorganic N fertilizers	N_2O	1051	929	0.01	23
3 D a 6 Cultivation of organic soils (i.e. histosols)	N_2O	914	832	0.01	24
4 A 2 4 Settlements converted to forest land	CO_2	-42	-616	0.01	25
4 A 2 1 Cropland converted to forest land	CO_2	141	-481	0.01	26
1 A 4 a Commercial/Institutional: Liquid Fuels	CO_2	2447	147	0.01	27
1 A 2 a Iron and Steel: Liquid Fuels	CO_2	831	616	0.01	28
1 A 2 g viii Other: Solid Fuels	CO_2	94	C	C	29
2 A 2 Lime Production	CO_2	331	465	0.01	30
1 A 3 a Domestic Aviation: Jet Kerosene	CO_2	658	541	0.01	31
1 A 2 a Iron and Steel: Solid Fuels	CO_2	849	581	0.01	32
4 E 2 1 Forest land converted to settlements	CO_2	2193	856	0.00	33
1 A 1 c Manufacture of Solid fuels and Other Energy Industries: Solid Fuels	CO_2	300	393	0.00	34
1 A 2 f Non-metallic minerals: Solid Fuels	CO_2	1135	C	C	35

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	Contribution to Trend	Key Source Trend
3 D a 4 Crop residues applied to soils	N_2O	452	415	0.00	36
1 A 2 g viii Other: Liquid Fuels	CO_2	2062	C	C	37
3 D a 3 Urine and dung deposited by grazing animals	N_2O	361	355	0.00	38
3 D a 2 a Animal manure applied to soils	N_2O	359	333	0.00	39
3 D a 5 Mineralization/immobilization associated with loss/gain of soil organic matter	N_2O	68	258	0.00	40
1 A 2 c Chemicals: Liquid Fuels	CO_2	341	305	0.00	41
2 D 1 Lubricant use	CO_2	158	254	0.00	42
2 C 7 Other	CO_2	276	C	C	43
2 C 7 Other	CO_2	276	C	C	43
1 A 1 a Public Electricity and Heat Production: Peat	CO_2	1150	480	0.00	44
1 A 3 d Domestic Navigation: Gas/Diesel Oil	CO_2	381	293	0.00	45
1 A 2 f Non-metallic minerals: Liquid Fuels	CO_2	625	C	C	46
4 D 1 1 Peat extraction remaining peat extraction	CO_2	73	195	0.00	47
4 C 2 1 Forest land converted to grassland	CO_2	476	291	0.00	48
1 A 2 a Iron and Steel: Gaseous Fuels	CO_2	25	181	0.00	49
1 A 4 a Commercial/Institutional: Diesel Oil	CO_2	170	216	0.00	50
2 C 3 Aluminium production	CO_2	133	206	0.00	51
1 A 1 a Public Electricity and Heat Production: Gaseous Fuels	CO_2	486	286	0.00	52

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	Contribution to Trend	Key Source Trend
1 A 2 d Pulp, Paper and Print: Liquid Fuels	CO_2	1786	596	0.00	53
1 A 4 a Commercial/Institutional: Gaseous Fuels	CO_2	86	184	0.00	54
1 A 2 f Non-metallic minerals: Other Fuels	CO_2	0	163	0.00	55
4 A Drained organic soils	CH_4	237	217	0.00	56
4 C 1 Grassland remaining grassland	CO_2	-193	-183	0.00	57
1 A 4 a Commercial/Institutional: Gasoline	CO_2	185	199	0.00	58
1 A 1 a Public Electricity and Heat Production: Biomass	N_2O	34	160	0.00	59
2 B 2 Nitric Acid Production	N_2O	782	42	0.00	60
4 B Drained organic soils	CH_4	220	201	0.00	61
5 D 1 Domestic wastewater	N_2O	226	200	0.00	62
1 A 1 b Petroleum refining: Gaseous Fuels	CO_2	0	137	0.00	63
3 A 4 Horses	CH_4	142	160	0.00	64
3 D b 2 Nitrogen leaching and run-off	N_2O	266	186	0.00	65
1 A 2 e Food Processing, Beverages and Tobacco: Gaseous Fuels	CO_2	254	178	0.00	66
1 A 3 e Other Transportation: Diesel Oil	CO_2	205	165	0.00	67
2 C 2 Ferroalloys production	CO_2	228	C	C	68
4 E 1 Settlements remaining settlements	CO_2	59	121	0.00	69
1 A 2 f Non-metallic minerals: Gaseous Fuels	CO_2	65	120	0.00	70

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	Contribution to Trend	Key Source Trend
2 C 3 Aluminium production	PFCs	569	36	0.00	71

Table A1.5. Key Category Analysis approach 2 Level Assessment, excluding LULUCF.

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO_2-eq)	Combined uncertainty in 2017 (%)	Contribution to Level in 2017 with Uncertainty	Key Source Level in 2017 (Approach 2)
3 D a 1 Inorganic N fertilizers	N_2O	929	203	0.15	1
3 D a 4 Crop residues applied to soils	N_2O	415	203	0.07	2
3 D a 6 Cultivation of organic soils (i.e. histosols)	N_2O	832	85	0.06	3
3 D a 2 a Animal manure applied to soils	N_2O	333	203	0.06	4
3 D a 5 Mineralization/immobilization associated with loss/gain of soil organic matter	N_2O	258	201	0.04	5
1 A 1 a Public Electricity and Heat Production: Other Fuels	CO_2	2479	20	0.04	6
5 A 1 Managed waste disposal sites	CH_4	841	56	0.04	7
3 D a 3 Urine and dung deposited by grazing animals	N_2O	355	128	0.04	8
2 F 1 Refrigeration and air conditioning	HFCs	1068	37	0.03	9
3 D b 1 Atmospheric deposition	N_2O	94	402	0.03	10
3 A 1 Non-dairy cattle	CH_4	1470	25	0.03	11
3 B Indirect N2O emissions	N_2O	81	402	0.03	12
1 A 3 b i Road Transportation, Cars: Gasoline	CO_2	6249	5	0.03	13
3 D b 2 Nitrogen leaching and run-off	N_2O	186	154	0.02	14
1 A 3 b i Road Transportation, Cars: Diesel oil	CO_2	4058	7	0.02	15
3 A 1 Dairy cattle	CH_4	1138	21	0.02	16

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO_2-eq)	Combined uncertainty in 2017 (%)	Contribution to Level in 2017 with Uncertainty	Key Source Level in 2017 (Approach 2)
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	CO_2	3407	7	0.02	17
1 A 1 a Public Electricity and Heat Production: Solid Fuels	CO_2	2956	7	0.02	18
1 A 1 b Petroleum refining: Liquid Fuels	CO_2	1863	11	0.02	19
2 C 1 Iron and Steel Production	CO_2	2230	6	0.01	20
2 D 1 Lubricant use	CO_2	254	50	0.01	21
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	CO_2	1401	7	0.01	22
5 D 1 Domestic wastewater	N_2O	200	49	0.01	23
1 A 1 a Public Electricity and Heat Production: Peat	CO_2	480	20	0.01	24
1 A 2 f Non-metallic minerals: Other Fuels	CO_2	163	58	0.01	25
2 A 1 Cement Production	CO_2	1484	5	0.01	26
1 A 2 g vii Off-road vehicles and other machinery: Liquid Fuels	CO_2	1235	6	0.01	27
1 B 2 a Oil	CH_4	26	286	0.01	28
3 A 4 Horses	CH_4	160	40	0.01	29
1 A 4 b Residential: Biomass	N_2O	63	100	0.01	30
1 A 2 c Chemicals: Other Fuels	CO_2	60	100	0.00	31
1 A 4 b Residential: Biomass	CH_4	59	100	0.00	32
3 B 1 Non-dairy cattle	CH_4	106	54	0.00	33

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO_2-eq)	Combined uncertainty in 2017 (%)	Contribution to Level in 2017 with Uncertainty	Key Source Level in 2017 (Approach 2)
1 A 2 d Pulp, Paper and Print: Other Fuels	CO_2	56	100	0.00	34
2 B 10 Other	CO_2	830	7	0.00	35
1 A 4 c Agriculture/Forestry/Fisheries: Liquid Fuels	CO_2	1302	4	0.00	36
3 D a 2 c Other organic fertilizers applied to soils	N_2O	25	203	0.00	37
1 A 3 a Domestic Aviation: Jet Kerosene	CO_2	541	9	0.00	38
3 A 2 Sheep	CH_4	121	40	0.00	39
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	N_2O	71	62	0.00	40
1 A 1 a Public Electricity and Heat Production: Biomass	N_2O	160	27	0.00	41
3 B 1 Dairy cattle	CH_4	73	54	0.00	42
1 A 4 b Residential: Liquid Fuels	CO_2	524	7	0.00	43
1 B 2 a Oil	CO_2	756	5	0.00	44
1 A 2 a Iron and Steel: Liquid Fuels	CO_2	616	6	0.00	45

Table A1.6. Key Category Analysis approach 2 Level Assessment, including LULUCF.

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO_2-eq)	Combined uncertainty in 2017 (%)	Contribution to Level in 2017 with Uncertainty	Key Source Level in 2017 (Approach 2)
4 A 1 Forest land remaining forest land	CO_2	-43170	16	0.27	1
4 G Total HWP from domestic harvest	CO_2	-6714	31	0.08	2
3 D a 1 Inorganic N fertilizers	N_2O	929	203	0.07	3
4 B 1 Cropland remaining cropland	CO_2	3331	36	0.05	4
4 A Drained organic soils	N_2O	1043	103	0.04	5
3 D a 4 Crop residues applied to soils	N_2O	415	203	0.03	6
3 D a 6 Cultivation of organic soils (i.e. histosols)	N_2O	832	85	0.03	7
3 D a 2 a Animal manure applied to soils	N_2O	333	203	0.03	8
3 D a 5 Mineralization/immobilization associated with loss/gain of soil organic matter	N_2O	258	201	0.02	9
1 A 1 a Public Electricity and Heat Production: Other Fuels	CO_2	2479	20	0.02	10
5 A 1 Managed waste disposal sites	CH_4	841	56	0.02	11
3 D a 3 Urine and dung deposited by grazing animals	N_2O	355	128	0.02	12
4 E 2 2 Cropland converted to settlements	CO_2	1079	38	0.02	13
2 F 1 Refrigeration and air conditioning	HFCs	1068	37	0.02	14
3 D b 1 Atmospheric deposition	N_2O	94	402	0.01	15
3 A 1 Non-dairy cattle	CH_4	1470	25	0.01	16

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO_2-eq)	Combined uncertainty in 2017 (%)	Contribution to Level in 2017 with Uncertainty	Key Source Level in 2017 (Approach 2)
3 B Indirect N2O emissions	N_2O	81	402	0.01	17
1 A 3 b i Road Transportation, Cars: Gasoline	CO_2	6249	5	0.01	18
4 E 2 1 Forest land converted to settlements	CO_2	856	34	0.01	19
3 D b 2 Nitrogen leaching and run-off	N_2O	186	154	0.01	20
1 A 3 b i Road Transportation, Cars: Diesel oil	CO_2	4058	7	0.01	21
3 A 1 Dairy cattle	CH_4	1138	21	0.01	22
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	CO_2	3407	7	0.01	23
4 A Drained organic soils	CH_4	217	103	0.01	24
1 A 1 a Public Electricity and Heat Production: Solid Fuels	CO_2	2956	7	0.01	25
4 B Drained organic soils	CH_4	201	103	0.01	26
1 A 1 b Petroleum refining: Liquid Fuels	CO_2	1863	11	0.01	27
4 A 2 4 Settlements converted to forest land	CO_2	-616	23	0.01	28
4 C 2 1 Forest land converted to grassland	CO_2	291	44	0.01	29
2 C 1 Iron and Steel Production	CO_2	2230	6	0.01	30
2 D 1 Lubricant use	CO_2	254	50	0.00	31
4 D 1 1 Peat extraction remaining peat extraction	CO_2	195	56	0.00	32
4 A 2 1 Cropland converted to forest land	CO_2	-481	21	0.00	33

IPCC Source Category	Substance	Year 2017 emissions or removals (kt CO_2-eq)	Combined uncertainty in 2017 (%)	Contribution to Level in 2017 with Uncertainty	Key Source Level in 2017 (Approach 2)
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	CO_2	1401	7	0.00	34
5 D 1 Domestic wastewater	N_2O	200	49	0.00	35
1 A 1 a Public Electricity and Heat Production: Peat	CO_2	480	20	0.00	36
1 A 2 f Non-metallic minerals: Other Fuels	CO_2	163	58	0.00	37
4 E 2 2 Cropland converted to settlements	N_2O	90	100	0.00	38
2 A 1 Cement Production	CO_2	1484	5	0.00	39

Table A1.7. Key Category Analysis approach 2 Trend Assessment, excluding LULUCF.

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	Combined uncertainty in 2017 (%)	Contr.to Trend with Uncertainty	Key Source Trend (Approach 2)
5 A 1 Managed waste disposal sites	CH_4	3422	841	55.90	0.16	1
3 D a 5 Mineralization/immobilization associated with loss/gain of soil organic matter	N_2O	68	258	201.00	0.07	2
1 A 1 a Public Electricity and Heat Production: Other Fuels	CO_2	570	2479	20.02	0.07	3
2 F 1 Refrigeration and air conditioning	HFCs	5	1068	37.03	0.07	4
3 D a 1 Inorganic N fertilizers	N_2O	1051	929	203.04	0.05	5
1 A 4 b Residential: Liquid Fuels	CO_2	6234	524	7.18	0.05	6
1 A 3 b i Road Transportation, Cars: Diesel oil	CO_2	439	4058	7.07	0.04	7
1 A 4 a Commercial/Institutional: Liquid Fuels	CO_2	2447	147	15.32	0.04	8
3 D a 4 Crop residues applied to soils	N_2O	452	415	203.04	0.03	9
3 D a 2 a Animal manure applied to soils	N_2O	359	333	203.04	0.02	10
3 A 1 Non-dairy cattle	CH_4	1268	1470	25.50	0.02	11
3 D a 6 Cultivation of organic soils (i.e. histosols)	N_2O	914	832	85.15	0.02	12
1 A 3 b i Road Transportation, Cars: Gasoline	CO_2	11999	6249	5.00	0.02	13
3 D a 3 Urine and dung deposited by grazing animals	N_2O	361	355	127.51	0.02	14
1 A 2 f Non-metallic minerals: Other Fuels	CO_2	0	163	58.02	0.02	15
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	CO_2	162	1401	7.07	0.02	16

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	Combined uncertainty in 2017 (%)	Contr.to Trend with Uncertainty	Key Source Trend (Approach 2)
1 A 1 a Public Electricity and Heat Production: Peat	CO_2	1150	480	20.10	0.01	17
3 D b 1 Atmospheric deposition	N_2O	103	94	401.53	0.01	18
2 D 1 Lubricant use	CO_2	158	254	50.25	0.01	19
1 A 1 b Petroleum refining: Liquid Fuels	CO_2	1778	1863	10.62	0.01	20
1 A 2 c Chemicals: Other Fuels	CO_2	6	60	100.50	0.01	21
1 A 3 b i Road Transportation, Cars: Gasoline	N_2O	132	10	60.07	0.01	22
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	CO_2	3779	3407	6.78	0.01	23
2 C 3 Aluminium production	PFCs	569	36	10.20	0.01	24
3 D a 2 c Other organic fertilizers applied to soils	N_2O	8	25	203.04	0.01	25
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	N_2O	13	71	62.06	0.01	26
1 A 3 b i Road Transportation, Cars: Gasoline	CH_4	138	10	40.11	0.01	27
1 A 1 a Public Electricity and Heat Production: Biomass	N_2O	34	160	27.09	0.01	28
3 B 1 Non-dairy cattle	CH_4	61	106	53.85	0.01	29
1 A 2 g vii Off-road vehicles and other machinery: Liquid Fuels	CO_2	997	1235	6.29	0.01	30
1 A 4 c Agriculture/Forestry/Fisheries: Biomass	CH_4	1	32	96.76	0.01	31
2 A 1 Cement Production	CO_2	1272	1484	5.39	0.00	32
2 B 2 Nitric Acid Production	N_2O	782	42	5.39	0.00	33

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	Combined uncertainty in 2017 (%)	Contr.to Trend with Uncertainty	Key Source Trend (Approach 2)
1 B 2 a Oil	CO_2	219	756	4.75	0.00	34
1 A 2 d Pulp, Paper and Print: Liquid Fuels	CO_2	1786	596	3.82	0.00	35
2 B 10 Other	CO_2	598	830	6.70	0.00	36
1 A 3 b i Road Transportation, Cars: Diesel oil	N_2O	0	40	65.19	0.00	37
3 A 2 Sheep	CH_4	81	121	40.31	0.00	38
1 B 2 a Oil	CH_4	25	26	285.75	0.00	39
1 A 5 b Mobile: Liquid Fuels	CO_2	846	184	5.12	0.00	40
3 A 4 Horses	CH_4	142	160	40.31	0.00	41
1 A 3 d Domestic Navigation: Residual Oil	CO_2	194	12	16.55	0.00	42
3 D a 2 b Sewage sludge applied to soils	N_2O	6	15	203.04	0.00	43
1 A 1 a Public Electricity and Heat Production: Liquid Fuels	CO_2	1277	284	3.21	0.00	44
1 A 3 b ii Road Transportation, Light duty trucks: Gasoline	CO_2	692	96	5.00	0.00	45
3 B Indirect N2O emissions	N_2O	103	81	401.53	0.00	46
1 A 4 b Residential: Biomass	N_2O	58	63	100.50	0.00	47
2 C 1 Iron and Steel Production	CO_2	2624	2230	5.74	0.00	48

Table A1.8. Key Category Analysis approach 2 Trend Assessment, including LULUCF.

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	Combined uncertainty in 2017 (%)	Contribution to Trend with Uncertainty	Key Source Trend (Approach 2)
4 A 1 Forest land remaining forest land	CO_2	-37739	-43170	16.26	0.22	1
3 D a 1 Inorganic N fertilizers	N_2O	1051	929	203.04	0.08	2
4 B 1 Cropland remaining cropland	CO_2	3291	3331	35.89	0.05	3
4 A Drained organic soils	N_2O	1179	1043	103.08	0.05	4
4 G Total HWP from domestic harvest	CO_2	-5016	-6714	30.69	0.04	5
3 D a 4 Crop residues applied to soils	N_2O	452	415	203.04	0.04	6
3 D a 6 Cultivation of organic soils (i.e. histosols)	N_2O	914	832	85.15	0.03	7
3 D a 2 a Animal manure applied to soils	N_2O	359	333	203.04	0.03	8
3 D a 5 Mineralization/immobilization associated with loss/gain of soil organic matter	N_2O	68	258	201.00	0.03	9
1 A 1 a Public Electricity and Heat Production: Other Fuels	CO_2	570	2479	20.02	0.03	10
2 F 1 Refrigeration and air conditioning	HFCs	5	1068	37.03	0.02	11
4 E 2 2 Cropland converted to settlements	CO_2	277	1079	38.13	0.02	12
3 D a 3 Urine and dung deposited by grazing animals	N_2O	361	355	127.51	0.02	13
3 A 1 Non-dairy cattle	CH_4	1268	1470	25.50	0.02	14
1 A 3 b i Road Transportation, Cars: Diesel oil	CO_2	439	4058	7.07	0.02	15
3 D b 1 Atmospheric deposition	N_2O	103	94	401.53	0.02	16

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	Combined uncertainty in 2017 (%)	Contribution to Trend with Uncertainty	Key Source Trend (Approach 2)
3 B Indirect N2O emissions	N_2O	103	81	401.53	0.01	17
3 D b 2 Nitrogen leaching and run-off	N_2O	266	186	154.03	0.01	18
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	CO_2	3779	3407	6.78	0.01	19
1 A 3 b i Road Transportation, Cars: Gasoline	CO_2	11999	6249	5.00	0.01	20
4 A Drained organic soils	CH_4	237	217	103.08	0.01	21
3 A 1 Dairy cattle	CH_4	1617	1138	20.62	0.01	22
1 A 1 b Petroleum refining: Liquid Fuels	CO_2	1778	1863	10.62	0.01	23
4 B Drained organic soils	CH_4	220	201	103.08	0.01	24
1 A 1 a Public Electricity and Heat Production: Solid Fuels	CO_2	4231	2956	7.39	0.01	25
4 A 2 4 Settlements converted to forest land	CO_2	-42	-616	22.68	0.01	26
4 E 2 1 Forest land converted to settlements	CO_2	2193	856	33.93	0.01	27
4 A 2 1 Cropland converted to forest land	CO_2	141	-481	21.20	0.01	28
2 D 1 Lubricant use	CO_2	158	254	50.25	0.01	29
4 D 1 1 Peat extraction remaining peat extraction	CO_2	73	195	55.90	0.01	30
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	CO_2	162	1401	7.07	0.01	31
1 A 2 f Non-metallic minerals: Other Fuels	CO_2	0	163	58.02	0.01	32
2 C 1 Iron and Steel Production	CO_2	2624	2230	5.74	0.01	33

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	Combined uncertainty in 2017 (%)	Contribution to Trend with Uncertainty	Key Source Trend (Approach 2)
4 E 2 2 Cropland converted to settlements	N_2O	32	90	100.00	0.00	34
4 C 2 1 Forest land converted to grassland	CO_2	476	291	44.03	0.00	35
5 D 1 Domestic wastewater	N_2O	226	200	48.70	0.00	36
1 A 4 b Residential: Liquid Fuels	CO_2	6234	524	7.18	0.00	37
1 A 4 a Commercial/Institutional: Liquid Fuels	CO_2	2447	147	15.32	0.00	38
2 A 1 Cement Production	CO_2	1272	1484	5.39	0.00	39
1 A 2 g vii Off-road vehicles and other machinery: Liquid Fuels	CO_2	997	1235	6.29	0.00	40
1 A 2 c Chemicals: Other Fuels	CO_2	6	60	100.50	0.00	41
1 B 2 a Oil	CH_4	25	26	285.75	0.00	42
3 A 4 Horses	CH_4	142	160	40.31	0.00	43
3 B 1 Non-dairy cattle	CH_4	61	106	53.85	0.00	44
1 A 4 b Residential: Biomass	N_2O	58	63	100.50	0.00	45
3 D a 2 c Other organic fertilizers applied to soils	N_2O	8	25	203.04	0.00	46

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

2.1 Sources for activity data in CRF 1A (stationary) 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 (expert review team) has asked for the rationale for choosing a certain data source, an explanation of how these sources are deemed accurate or inaccurate, and how time series consistency is ensured. In **Fel! Hittar inte referenskälla.** and A2.2 below, the descriptions of the different data sources and reasons for the choice of certain data sources are summarized. More details are found in the following text.

Table A2.1. Summary of the main activity data sources used in the inventory for stationary combustion.

CRF	Main acticity data sources	Comments
1A2	Energy use in the manufacturing industry (ISEN), Quarterly fuel statistics (KvBr) and environmental reports.	1990-1996 and 2000-2002: ISEN. 1997-1999 and 2003 and onwards: KvBr.
1A2g + 1A4	Energy balances.	For the parts of 1A2g and 1A4 that are not covered by regular surveys.
1A1b and 1A2c	Emissions reported to EU ETS.	Parts of 1A2c since 2005/2008.
1A1c + 1A2a	Environmental reports	AD and CO_2 for the two integrated iron and steel plants (see annex 3.5).

Table A2.2. Summarized properties of activity data sources used in the inventory for stationary combustion.

Activity data source	Description	Comments
Electricity supply, district heating and supply of natural and gasworks gas (AREL)	Annual statistics including all facilities producing and distributing heat, electricity and gas.	Not used in the inventory. Data for year t finalized in February year t+2, which is too late for the inventory calculations.
Energy use in manufacturing industry (ISEN)	Total survey of industrial facilities with 10 or more employees.	Data for year t finalized in February/March year t+2, which is too late for the inventory. Used as main AD source for 1A2 for earlier years.
Quarterly fuel statistics (KvBr)	Total survey for the energy sector, cut-off sample survey for manufacturing industry (ISEN is the sample frame)	Data for year t finalized in March year t+1. Several studies have shown that this data source is complete and consistent.
Emissions reported to EU ETS	Facilities included in the EU Emission trading scheme 2005-. Emission data is complete, activity data and/or NCVs not always reported.	The definition of “facility” is different from the one used in energy statistics. Population definitions changes between trading periods. No standardization of fuel types.
Environmental reports	All operators whose activities have an impact on the environment are obliged to report environmental reports to the authority responsible for the emission permits.	Quality and completeness is very variable. Activity data is not always included. Most of the information is only available in text reports, which means that data cannot be processed in an automatized way.The reports are also used for verification and occasionally for plant specific NCV:s
Energy balances	Includes all supply and use of fuels and other energy types on aktregate levels.	See discussions in later sections.

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 ISEN, because the industrial energy survey, at least in early years, 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.

[1] Statistics Sweden, 2009. Inventory of the energy statistics

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 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.

2.1.1 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 and 1A2 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 1A2 and parts of 1A1c.
- 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 (in later years web based) sample survey. For the manufacturing industries, i.e. CRF 1A2, the statistical unit is equivalent to working unit.[2] In the public electricity and heat production sector, i.e. 1A1a, the statistical unit is more aggregated for larger companies, who report all facilities in each municipality in one unit. In recent years, the survey includes around 850-900 units each year, of which just over 300 units belongs to CRF 1A1a. 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

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

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

The sample frame is updated annually based on the latest results of the Energy use in manufacturing industry (ISEN). The response rate to the quarterly fuel statistics is almost 100 % for ISIC 40 (that is, CRF 1A1a) and about 90 % for manufacturing industries. The non-respondents among the industries are often small companies, which means 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). By definition, the survey does not cover energy consumption in working units with less than ten employees. The energy consumption in these "small industries" is estimated with a calculation model based on an intermittent survey[3] and published in the energy balances. This estimate covers all industrial branches and the fuel consumption and emissions are reported under CRF 1A2g.

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.

In the GHG 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.

[3] In 2011, a survey of small industries was conducted as a "satellite survey" to the annual industrial energy statistics. The results are not published separately but included in the energy balances. The estimates for 2010 are used to calculate fuel consumption in later years.

2.1.2 Annual statistics on energy use in manufacturing industry (ISEN)

The statistics on energy use in manufacturing industry are used for emissions from stationary combustion in the CRF sectors 1A1b, 1A1c and 1A2 for the years 1990-1996 and 2000-2002. The data material used for these years did not include fuel consumption for back pressure power, because data on that activity is collected via a different survey, (Electricity supply, district heating and supply of natural and gasworks gas (AREL)).

Since submission 2005, for calculation of 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 above, mainly because the inventory must be submitted before the energy use in manufacturing industry statistics are completed. 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 is 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.

The response rate to the energy use in manufacturing industry statistics in the years for which this survey is used in the GHG emission inventory was 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 A2.3. For the early years, data was complemented with other data sources in order to compensate for quality problems mentioned above.

Table A2.3. 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

2.1.3 One- and two-dwelling statistics

One- and two-dwelling statistics are, together with holiday cottages statistics and multi-dwelling statistics, the main data sources for stationary biomass combustion in households in the energy balances, which in turn are used 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. Data is on national level by fuel type and considered to be of relatively good quality. To make sure that all emissions from households are included and that no double-counting occurs, activity data is taken from the annual energy balance sheets. However, the fuel consumption reported under the households category in the energy balance is based on the surveys described here.

2.1.4 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. As described above, an aktregate from the energy balances is used as activity data for stationary combustion in CRF 1A4b.

Holiday cottages are defined as residences with no permanent residents. Energy consumption in holiday cottages has been surveyed with large time intervals, i.e. in 1976, 2001 and 2012. In 2012, Statistics Sweden carried out a stratified sample survey to house owners, covering 4,500 of the 589,525 objects in the sample frame. The net sample, excluding over coverage, included 4024 objects and the response rate was 44 %. Because of difficulties regarding classification, houses with type codes other than recreational dwellings were also included in the sample frame. The questionnaire form used in 2012 was based on the one used in 2002. Results show that electricity and biomass combustion are the two predominating heating sources in holiday cottages, both in 2001 and 2011.[4]

2.1.5 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 of biomass 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 €). 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. However, the time series for 1A4b indicates that this data gap does not lead to any significant under-estimation as biomass use in multi-dwellings is sparse compared to the consumption in one- and two-dwellings.

2.1.6 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, heat and fuel combustion for heat production 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[5]. 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.

[4] Statistic Sweden. ES 2012:03. Biomass consumption in holiday cottages accounted for about 6 % of the total consumption of biomass in CRF 1A4b in 2001.

[5] Statistics Sweden EN20SM, 1990-2010, and Swedish Energy Agency (2011 and later)

2.1.7 Statistics on the supply and delivery of petroleum products

Statistics on the supply and delivery of petroleum products are used to estimate the emissions from mobile combustion. It is also the input data source for stationary combustion of heating oils in households and premises reported in the energy balances, which is used as activity data source for CRF 1A4a and 1A4b, stationary. Data from the survey is used at a national level and by fuel type. Emissions are reported in CRF 1A2g, 1A3, 1A4b, 1A4c, 1A5b and 1D. These statistics are also used for the reference approach in CRF 1Ab for all fuels except biomass, waste and peat.

In the monthly survey, data is collected from all oil companies and other sellers who keep 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 aviation and navigation are separated. The only fuels not covered are some biomass fuels, waste and peat. All figures are double-checked by both Statistics Sweden and all wholesale dealers.

2.1.8 Statistics on the delivery of gas products

Statistics on the delivery of gas products are used to calculate emissions from natural gas and biogas from road transport (CRF 1A3b). A monthly questionnaire is sent to all companies in Sweden that deliver natural gas, biogas and gasworks gas (less than ten companies). Consumption purposes are specified in the survey. Results of this survey are published by Statistics Sweden[6].

2.1.9 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 1A2g) and stationary combustion in CRF 1A4a-1A4c is taken from the annual energy balances[7]. Data is on national level and by fuel type. 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,[8] adjusted according to the number of working hours for each year. The fuel consumption for the construction sector 2004 and later is based on a survey from 2005.[9] Data on fuel consumption in the agricultural sector is based on

[6] Statistic Sweden; http://www.scb.se/sv_/Hitta-statistik/Statistik-efter-amne/Energi/Tillforsel-och-anvandning-av-energi/Leveranser-av-fordonsgas/Aktuell-pong/2013M09/

[7] Statistics Sweden EN20SM, 1990-2010, and Swedish Energy Agency (2011 and later)

[8] Statistics Sweden, 1986

[9] Statistics Sweden, 2005

two intermittent surveys, for gardening[10] and agriculture.[11] 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.

Fuel consumption in the forestry sector has been studied thoroughly in 1985 and 2007[12]. 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) reported in the annual energy balances is estimated using a model for the years 1990-2010. 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. In 2012, the annual statistics on energy use in manufacturing industries (ISEN) for the reference year 2011 included a sample survey to small companies as well. The results were not published in ISEN but in the annual energy balance for 2011, which was published in 2013 and used in submission 2014 as activity data source for small enterprises.

2.1.10 EU Emission Trading Scheme (ETS)

Data from the EU Emission Trading Scheme (ETS) is used since submission 2007 and emission years 2005 and later for oil refineries (CRF 1A1b, 1B2a and 1B2C21), as a SMED study during 2006[13] 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 ETS data contains more detailed information on fuel types 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

[10] Statistics Sweden JO36SM, 1991, 94, 97, 2000, 2003, 2006, 2010

[11] Statistics Sweden JO63SM, 1995, 2003, 2008

[12] ER 2007:15. Energianvändningen inom skogsbruket 2005

[13] Backman & Gustafsson, 2006

source of activity data. Another reason not to use ETS data as the main data source is that in some facilities, only some of the installations within the facility are included in the trading scheme, and the definition of which installations that should be included has changed between the first and second trading periods.

Mass balances reported to ETS for the two primary iron and steel works are used for allocation of emissions and energy flows in these plants (see annex 3.5).

2.1.11 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. (This mostly applies to the years before 2005, when EU ETS was introduced). 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. Data for the two largest integrated iron and steel works (1A1c, 1A2a, 1B1, 2C1) are based on information from the companies' legal environmental reports. Environmental reports are also used for verification of energy statistics data for some selected plants in the same way as ETS data is used.

2.1.12 Contacts with operators

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 by means of direct contacts with the operators, as activity data was not sufficiently covered in regular surveys or administrative sources. Operators 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 these sectors (1A1c, 1A2a, 1B1b, 1B1c, 2C1). The methodology used is described in NIR section 3.2.9.

2.1.13 Other data sources for mobile combustion

Besides using statistics on supply and delivery of petroleum products for mobile combustion, emission data from the Swedish Transport Administration for road transport (CRF 1A3b) and railways (CRF 1A3c) is used, as well as emission data for aviation (1A3a & 1D1) from the Swedish Transport Agency. An emission model is used to estimate the emissions from off-road vehicles and working machinery (1A2g, 1A3e, 1A4a, 1A4b, 1A4c). The Swedish Armed Forces provides activity data for the military fuel consumption for road traffic, navigation and aviation (1A5b). Monthly statistics on delivery of gas products are used to estimate the emissions from road vehicles powered by natural gas and biogas (CRF 1A3b).

2.2 Net calorific values

Unless otherwise stated, NCVs for each fuel type are produced by Statistics Sweden based on information from energy surveys. All NCVs refer to net calorific values (NCV) as recommended by the IPCC Guidelines. All NCVs including references are enclosed in **Fel! Hittar inte referenskälla.**. Most NCVs are calculated on basis of chemical qualities and are considered to be of good quality. When possible, the same NCVs are used in the Reference and Sectoral approaches. However, in the reference approach, it is normally not possible to use specific NCVs for each reporting company. Instead, the national NCVs recommended by the Swedish Energy agency, which are also used in the energy balances, are used for all parameters in the reference approach, which can cause minor differences between the reference and sectoral approaches. For some fuels, e.g. crude oil, NCVs are not provided by the Swedish Energy Agency. For these fuels, default values from IPCC 2006 Guidelines are used.

In the inventory, activity data for 1990-2006 on many fuel types are reported in tonne 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 NCV 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 NCVs in the GHG inventory without performing the calculation of toe. NCVs for 2007 and later years are considered to be of excellent quality. 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 calorific values that do not change between years. In submission 2010 some revisions were made. In earlier submissions, the NCV for biogas used for transports (this amount increases each year) was not known and therefore the NCV for natural gas was used for this fuel. In a SMED study[14] performed in 2009, a correct NCV for biogas was provided from the biogas supplier AGA. The same study also resulted in revision of the NCVs for ethanol (new NCV taken from Handbook of Chemistry and Physics) and Fatty Acid Methyl Ester (FAME).

[14] Paulrud et al. 2010.

An overview of NCVs used is shown in Table A2.4. For all mobile combustion, and for standard fuels for stationary combustion, national emission factors are used. For non-standard fuels, median, maximum and minimum NCVs are shown. Statistics are based on more than 100 observations unless otherwise stated in the remark column.

Table A2.4. Net Calorific Values (NCVs) used in submission 2019.

Fuel type	Unit	Median	Min	Max	Remark
Blast furnace gas	GJ/1000m^3	2.86	2.73	3.36	
Coke	GJ/tonne	28.05	27.86	32.11	
Coke oven gas	GJ/1000m^3	17.81	16.75	18.15	
Coking coal	GJ/tonne	27.21	23.46	30.71	
Diesel Oil	GJ/m^3	35.36	34.33	35.87	
Domestic Heating Oil	GJ/m^3	35.82	30.78	36.25	
Gas works gas	GJ/1000m^3	16.75	16.75	16.75	Gas works gas 1990-2010, based on naphtha
Gas works gas	GJ/1000m^3	20.8	20.8	20.8	Gas works gas 2011 and later, based on LNG
Kerosene	GJ/m^3	34.5	34.33	34.5	
LPG	GJ/tonne	46.05	46.04	46.05	
Landfill gas	GJ/1000m^3	18	8.04	39.78	
Natural Gas	GJ/1000m^3	*	*	*	Year specific NCV:s, see separate table
Other biomass	GJ/m^3	32.61	0.94	44.75	
Other biomass	GJ/tonne	34.99	3.98	43.92	
Other non-specified	GJ/1000m^3	3.02	2.99	27.61	20-99 observations 1990-2014
Other non-specified	GJ/tonne	19.08	5.55	42.48	
Other petroleum fuels	GJ/m^3	13.8	4.08	43.13	20-99 observations 1990-2014
Other petroleum fuels	GJ/tonne	32.76	12.65	40.79	20-99 observations 1990-2014
Other soild fuels	GJ/tonne	14.4	14.4	14.4	Less than 20 observations 1990-2015
Peat	GJ/tonne	10.8	3.53	18.43	
Petroleum coke	GJ/tonne	34.8	30.09	34.8	20-99 observations 1990-2014
Refinery oil	GJ/m^3	38.16	38.16	38.16	
Refinery oil	GJ/tonne	41.6	35.82	44.5	20-99 observations 1990-2014
Residual Fuel Oil	GJ/m^3	38.16	35.82	39.78	
Solid waste (fossil and biogenic)	GJ/tonne	10.96	10.51	12.89	Observations from the 7 largest incineration plants
Steel converter gas	GJ/1000m^3	7.62	7.07	8.48	20-99 observations 1990-2014

Fuel type	Unit	Median	Min	Max	Remark
Tall oil	GJ/m³	37.04	32.28	41.4	
Wooden fuels	GJ/m³	2.66	0.81	19.19	
Wooden fuels	GJ/tonne	16.92	5.9	19.44	
Gasoline	GJ/m³	32.78			Mobile combustion, all sources
Biogas	GJ/1000 m³	35.3			Mobile combustion, all sources
Diesel oil	GJ/m³	35.28			Railways
Gas/diesel oil (marine distillates)	GJ/m³	36.64			Navigation
Diesel oil	GJ/m³	*			Year specific NCV:s, see separate table
Residual fuel oil	GJ/m³	39.53			Navigation
Ethanol	GJ/m³	21.2			Road traffic
FAME	GJ/m³	33			Road traffic
Aviation Gasoline	GJ/m³	31.45			Aviation
Aviation Kerosene	GJ/m³	35.28			Aviation
Jet Gasoline	GJ/m³	32.7			Aviation

Note: refinery gas and petrochemical by product gases are reported in various units and plant specific NCV:s are used.

2.2.1 Liquid fuels

For diesel oil the NCV 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 NCV. EC 3 affects the environment most and has a higher NCV.[15] 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 NCV, which is appropriate for each year. Year specific NCVs for diesel are shown in Table A2.5.

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

Table A2.5. NCVs (NCV) for diesel except navigation and railways.

Years	NCV (GJ/m^3)
1990	35.82
1991	35.69
1992	35.55
1993	35.40
1994	35.43
1995	35.44
1996	35.36
1997	35.34
1998	35.33
1999-2000	35.31
2001-2006	35.29
2001-2015	35.29
2016-2017	35.36

NCVs for different oils (except oils used in navigation) are based on information from the Swedish Petroleum and Biofuel Institute (SPBI), which in turn is based on information from oil companies and is crosschecked with Swedish standards for calculating NCVs. NCVs for marine diesel oil, marine gas oil and residual fuel oil used for navigation are according to a SMED study in 2004.[16]

NCVs for refinery gases and other oils in refineries are specific for each operator and fuel. Data on consumption of fuels in tonne (or sometimes m^3) and corresponding NCVs are collected. 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 NCVs of excellent quality are also reported and used in the GHG inventory. In other cases, NCVs from the environmental reports are used.

In submission 2010, the NCVs for gasoline, aviation kerosene and aviation gasoline were revised following a SMED Study. The conclusion of the study was that NCVs used for these fuels before submission 2010 were not well documented. NCVs according to the 2006 IPCC Guidelines are now used, since the NCVs used earlier for these fuels were concluded to be of questionable quality. There is no indication that carbon content or NCV for aviation kerosene and aviation gasoline sold in Sweden should differ from international standards. The properties of aviation fuels are normally the same in all countries, and hence it is appropriate to use the values recommended by IPCC. The NCV for gasoline used since submission 2010 is from SPBI and relies on fuel analyses.[17]

[16] Cooper & Gustafsson, 2004.

[17] Paulrud et al. 2010

The NCV 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 NCV 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 NCVs as for mobile diesel therefore give correct time series.

In 1990-2010, naphtha was used as raw material for production of gas works gas. Since 2011, liquefied natural gas is used instead. However, the gas is mixed with air and the quality of the gas delivered to the transmission net (in terms of methane content and NCV) is stated to be similar to how it was before the change of feedstock[18]. Hence, the same NCVs and emission factors are used for gas works gas for 2011 as for earlier years. Since natural gas liquids are allocated to liquid fuels in the CRF reporter in table 1.Ab, we have chosen to allocate the gas works gas consumed in 2011 to liquid fuels also in the sectoral approach.

2.2.2 Solid fuels and peat

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

For carbon products such as coal and coke, it is difficult to establish the NCV due to lack of information on energy content in imported fuels. For 2007 and later years, NCVs 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 NCVs. For coke, this share is about 75 %.

Where no NCV is reported, the standard NCV provided from the Swedish Energy Agency is used. Hence, the NCVs used for 2007 and later are considered to be of high quality.

2.2.3 Gaseous fuels

Natural gas is a non-processed primary fuel, and hence the NCV changes between years, however without any trend. All natural gas consumed in Sweden is imported from Denmark. From submission 2019, Sweden uses the same NCVs for natural gas as reported in Denmarks National Inventory[19]. The NCVs used are shown in Table A2.6.

[18] Stockholm Gas, 2012

[19] Energistyrelsen, 2018-11-26 (https://ens.dk/ansvarsomraader/co2-kvoter/stationaere-produktionsenheder/co2-rapportering-og-returnering)

Table A2.6. Net calorific values (NCV) for natural gas, all consumption.

Years	NCV (GJ/1000 m^3)
1990	39
1991	39
1992	39
1993	39.3
1994	39.3
1995	39.3
1996	39.3
1997	39.6
1998	39.9
1999	40
2000	40.15
2001	39.97
2002	40.03
2003	39.94
2004	39.77
2005	39.67
2006	39.54
2007	39.59
2008	39.49
2009	39.46
2010	39.46
2011	39.46
2012	39.46
2013	39.46
2014	39.46
2015	39.46
2016	39.46
2017	39.62

2.2.4 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. For the other sectors, only black liquor is reported in toe. Other biomass is reported in several different units, e.g. tonne, m^3 or MWh, and NCVs are reported together with the quantity. These NCV:s are considered to be accurate.

The net calorific value for ethanol is provided by SPBI[20] and is 21.2 GJ/m^3 or 26.9 MJ/kg.

[20] Swedish Petroleum and Biofuel Institute

2.2.5 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 tonne. The NCVs for waste reported by the consumers are considered to be accurate, and thus these NCV:s were used for 2007 and later. For other not specified fuels the reporting units vary, and reported NCVs are used (sometimes, the fuel quantities are reported in an energy unit , e.g. MWh).

2.3 Emission factors

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 NCV:s 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, refinery gases, and gases produced in the petrochemical industry. These gases are used as fuels, and their NCV:s and carbon content varies between years. From submission 2017 also the emission factor for combustion of waste is variable in time for the 7 largest incineration plants in Sweden.

Other emission factors, e.g. for N_2O, CH_4, NMVOC, CO and NOx, 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.

2.3.1 Overview of emission factors for greenhouse gases

Emission factors for CO_2, CH_4 and N_2O for selected years are shown in in Table A2.7 to Table A2.10. Many of the emission factors for stationary combustion are the same for all years, and hence only a few years are shown in the tables. For CH_4 and N_2O the emission factors are only shown for stationary combustion as emissions of these gases from mobile combustion are estimated with model calculations and not as the product of fuel consumption and an emission factor. A complete list of emission factors for all fuels, years and substances can be found at the Swedish EPA website, including full references[21].

[21] http://www.naturvardsverket.se, search for “Beräkna utsläpp”,

Table A2.7. Emission factors for CO_2 (mobile combustion), kg/GJ for selected years.

Fuel type	Sector	1990	2000	2005	2010	2015	2017	Source
Aviation Gasoline	Domestic, (Cruise)	70.00	70.00	70.00	70.00	70.0	70.0	Paulrud, Fridell, Stripple & Gustafsson, 2010
Aviation Gasoline	Domestic, (LTO)	70.00	70.00	70.00	70.00	70.0	70.0	Paulrud, Fridell, Stripple & Gustafsson, 2010
Aviation Gasoline	Military, Aviation	70.00	70.00	70.00	70.00	70.0	70.0	Paulrud, Fridell, Stripple & Gustafsson, 2010
Biogas	Bus	NO	NO	56.10	56.10	56.10	56.10	AGA Biogas
Biogas	Passenger Cars	NO	NO	56.10	56.10	56.10	56.10	AGA Biogas
Diesel Oil	Bunkers, Military abroad, road traffic	74.26	72.68	72.13	72.03	72.01	72.01	Paulrud, Fridell, Stripple & Gustafsson, 2010
Diesel Oil	Bunkers, Military abroad, navigation	74.45	74.45	74.45	74.45	74.45	74.45	Cooper & Gustafsson, 2004
Diesel Oil	Bunkers, Navigation/Shipping	74.45	74.45	74.45	74.45	74.45	74.45	Cooper & Gustafsson, 2004
Diesel Oil	Bus	74.26	72.68	72.13	72.01	72.01	72.01	Paulrud, Fridell, Stripple & Gustafsson, 2010
Diesel Oil	Domestic navigation	74.45	74.45	74.45	74.45	74.45	74.45	Cooper & Gustafsson, 2004
Diesel Oil	Fisheries	74.45	74.45	74.45	74.45	74.45	74.45	Cooper & Gustafsson, 2004
Diesel Oil	Forestry	74.26	72.68	72.13	72.01	72.01	72.01	Paulrud, Fridell, Stripple & Gustafsson, 2010
Diesel Oil	Heavy goods vehicles	74.26	72.68	72.13	72.01	72.01	72.01	Paulrud, Fridell, Stripple & Gustafsson, 2010
Diesel Oil	Industry (mobile)	74.26	72.68	72.13	72.01	72.01	72.01	Paulrud, Fridell, Stripple & Gustafsson, 2010
Diesel Oil	Light duty vehicles	74.26	72.68	72.13	72.01	72.01	72.01	Paulrud, Fridell, Stripple & Gustafsson, 2010
Diesel Oil	Military, Navigation/Shipping	74.45	74.45	74.45	74.45	74.45	74.45	Cooper & Gustafsson, 2004
Diesel Oil	Military, Road Traffic	74.26	72.68	72.13	72.03	72.01	72.01	Paulrud, Fridell, Stripple & Gustafsson, 2010

Fuel type	Sector	1990	2000	2005	2010	2015	2017	Source
Diesel Oil	Other	74.26	72.68	72.13	72.03	72.01	72.01	Paulrud, Fridell, Stripple & Gustafsson, 2010
Diesel Oil	Passenger Cars	74.26	72.68	72.13	72.03	72.01	72.01	Paulrud, Fridell, Stripple & Gustafsson, 2010
Diesel Oil	Railways	74.26	74.26	72.03	72.03	72.01	72.01	Paulrud, Fridell, Stripple & Gustafsson, 2010
Diesel Oil	Small boats	74.45	74.45	74.45	74.45	74.45	74.45	Cooper & Gustafsson, 2004
Diesel Oil	Small scale combustion	74.26	72.68	72.13	72.03	72.01	72.01	Paulrud, Fridell, Stripple & Gustafsson, 2010
Domestic Heating Oil	Bunkers, Navigation/Shipping	74.45	74.45	74.45	74.45	74.45	74.45	Cooper & Gustafsson, 2004

Table A2.8. Emission factors for CO_2 (stationary combustion), kg/GJ for selected years.

Fuel type	Sector	1990	2000	2005	2010	2015	2016	2017	Source
Biogenic waste	Industry	94.30	94.30	94.30	NO	NO	NO	NO	Mawdsley, I., Wisell, T., Stripple, H., Ortiz, C. 2016
Waste fossil fraction	Power plants and district heating	60.39	60.39	60.39	60.39	56.45	56.65	60.47	Mawdsley, I., Wisell, T., Stripple, H., Ortiz, C. 2016
Waste biogenic fraction	Power plants and district heating	33.95	33.95	33.95	33.95	38.45	37.5	35.46	Mawdsley, I., Wisell, T., Stripple, H., Ortiz, C. 2016
Blast furnace gas	Iron and steel production	274.45	274.45	228.82	301.85	326.87	314.80	319.07	Gustafsson, Lidén & Gerner, 2011
Charcoal	Small scale combustion	112.00	112.00	112.00	112.00	112.00	112.00	112.00	SEPA 1995
Coke	All consumption	103.00	103.00	103.00	103.00	103.00	103.00	103.00	SEPA 1995
Coke oven gas	Iron and steel production	44.36	44.16	41.57	44.81	52.09	50.50	46.69	Gustafsson, Lidén & Gerner, 2011
Coking coal	All consumption	90.70	93.00	93.00	93.00	90.70	93	93	Boström et al., 2004a
Diesel Oil	Agriculture	74.26	72.68	72.13	72.01	72.01	72.01	72.01	Paulrud, Fridell, Stripple & Gustafsson, 2010
Diesel Oil	Small scale combustion	74.26	72.68	72.13	72.03	72.01	72.01	72.01	Paulrud, Fridell, Stripple & Gustafsson, 2010
Domestic Heating Oil	All consumption	74.26	74.26	74.26	74.26	74.26	74.26	74.26	Swedish Petroleum and Biofuel Institute

Table A2.9. Emission factors for CH_4 (stationary combustion), kg/GJ for selected years.

Fuel type	Sector	1990	2000	2010	2015	2016	2017	Source
Biogenic waste	Industry	0.02	0.02	NO	NO	NO	NO	Boström et al., 2004a
Waste fossil and biogenic fraction	Power plants and district heating	0.02	0.005	0.005	0.005	0.005	0.005	Boström et al., 2004a
Blast furnace gas	Industry, power plants and district heating	0.001	0.001	0.001	0.001	0.001	0.001	SEPA 1995
Charcoal	Small scale combustion	0.2	0.2	0.2	0.2	0.2	0.2	SEPA 1995
Coke	Industry	0.001	0. 001	0. 001	0. 001	0.001	0.001	Boström et al., 2004a
Coke	Other consumption	0.004	NO	NO	NO	NO	NO	Boström et al., 2004a
Coke oven gas	Industry, power plants and district heating	0.001	0.001	0.001	0.001	0.001	0.001	SEPA 1995
Coking coal	Industry	0. 0015	0. 0015	0. 0015	0. 0015	0. 0015	0. 0015	Boström et al., 2004a. Mawdsley, I. et al 2016
Coking coal	power plants and district heating	0.001	0.001	0.001	0.001	0.001	0.001	Boström et al., 2004a. Mawdsley, I. et al 2016
Coking coal	Other consumption	0.004	0.004	NO	NO	NO	NO	Boström et al., 2004a. Mawdsley, I. et al 2016
Diesel Oil	Industry, power plants and district heating	0.001	0.001	0.001	0.001	0.001	0.001	Boström et al., 2004a
Domestic Heating Oil	Industry, power plants and district heating	0.001	0.001	0.001	0.001	0.001	0.001	Boström et al., 2004a
Domestic Heating Oil	Other consumption, small scale combustion	0.002	0.002	0.002	0.002	0.002	0.002	Boström et al., 2004a
Gas works gas	All combustion	0.001	0.001	0.001	0.001	0.001	0.001	Boström et al., 2004a

Fuel type	Sector	1990	2000	2010	2015	2016	2017	Source
Kerosene	Industry, power plants and district heating	0.001	0.001	0.001	0.001	0.001	0.001	SEPA 1995
LPG	All combustion	0.001	0.001	0.001	0.001	0.001	0.001	Boström et al., 2004a
Landfill gas	Industry, power plants and district heating	NO	0.001	0.001	0.001	0.001	0.001	SEPA 1995
Methane etc.	Industry	0.001	0.001	0.001	0.001	0.001	0.001	Boström et al., 2004a
Natural Gas	All combustion	0.001	0.001	0.001	0.001	0.001	0.001	Boström et al., 2004a
Other biomass	All combustion	0.03	0.03	0.03	0.03	0.03	0.03	SEPA 1995. Mawdsley, I. et al 2016. Helbig et al 2018
Other non specified	Industry, power plants and district heating	0.001	0.001	0.001	0.001	0.001	0.001	SEPA 1995
Other petroleum fuels	Industry, power plants and district heating	0.001	0.001	0.001	0.001	0.001	0.001	SEPA 1995
Other solid fuels	Industry, power plants and district heating	0.001	0.001	0.001	0.001	0.001	0.001	SEPA 1995
Peat	Industry	0.011	0.011	0.011	0.011	0.011	0.011	SEPA 1995. Mawdsley, I. et al 2016
Peat	Power plants and district heating	0.011	0.011	0.011	0.011	0.011	0.011	SEPA 1995. Mawdsley, I. et al 2016
Petroleum coke	Industry	0.001	0. 001	0. 001	0. 001	0. 001	0. 001	Boström et al., 2004a
Refinery gas	Industry	0.001	0.001	0.001	0.001	0.001	0.001	SEPA 1995
Refinery oil	Industry	0.002	0.002	0.002	0.002	0.002	0.002	Boström et al., 2004a
Residual Fuel Oil	Industry, power plants and district heating	0.002	0.002	0.002	0.002	0.002	0.002	Boström et al., 2004a

Fuel type	Sector	1990	2000	2010	2015	2016	2017	Source
Residual Fuel Oil	Other consumption	0.003	0.003	0.003	0.003	0.003	0.003	Boström et al., 2004a
Steel converter gas	Industry, power plants and district heating	NO	0.001	0.001	0.001	0.001	0.001	SEPA 1995
Tall oil	Industry, power plants and district heating	0.002	0.002	0.002	0.002	0.002	0.002	SEPA 1995
Waste (non-biomass fr	Industry	0.02	0.02	NO	NO	NO	NO	Boström et al., 2004a
Waste (non-biomass fr	Power plants and district heating	0.02	0.005	0.005	0.005	0.005	0.005	Boström et al., 2004a SEPA 1995. Mawdsley, I. et al 2016. Helbig et al 2018
Wooden fuels	Households: Boilers: pellets	NO	0.003	0.003	0.003	0.003	0.003	SEPA 1995. Mawdsley, I. et al 2016. Helbig et al 2018
Wooden fuels	Households: Boilers: wood chips	0.203	0.203	0.203	0.203	0.203	0.203	SEPA 1995. Mawdsley, I. et al 2016. Helbig et al 2018
Wooden fuels	Households: Boilers: wood logs Traditional	0.088	0. 088	0. 088	0. 088	0. 088	0. 088	SEPA 1995. Mawdsley, I. et al 2016. Helbig et al 2018
Wooden fuels	Households: Boilers: wood logs Modern	0.015	0.015	0.015	0.015	0.015	0.015	SEPA 1995. Mawdsley, I. et al 2016. Helbig et al 2018
Wooden fuels	Households: Open fire places	0.318	0.318	0.318	0.318	0.318	0.318	SEPA 1995. Mawdsley, I. et al 2016. Helbig et al 2018
Wooden fuels	Households: Stoves: pellets	NO	0.007	NO	0.007	0.007	0.007	SEPA 1995. Mawdsley, I. et al 2016. Helbig et al 2018
Wooden fuels	Households: Stoves: wood chips	NO	0.344	NO	NO	NO	NO	SEPA 1995. Mawdsley, I. et al 2016. Helbig et al 2018
Wooden fuels	Households: Stoves: wood logs Traditional	0.119	0. 119	0. 119	0. 119	0. 119	0. 119	SEPA 1995. Mawdsley, I. et al 2016. Helbig et al 2018

Fuel type	Sector	1990	2000	2010	2015	2016	2017	Source
Wooden fuels	Households: Stoves: wood logs Modern	0.099	0.099	0.099	0.099	0.099	0.099	SEPA 1995. Mawdsley, I. et al 2016. Helbig et al 2018
Wooden fuels	Industry, power plants and district heating	0.011	0.011	0.011	0.011	0.011	0.011	SEPA 1995. Mawdsley, I. et al 2016. Helbig et al 2018
Wooden fuels	Other consumption	0.25	0.25	0.25	0.25	0.25	0.25	SEPA 1995. Mawdsley, I. et al 2016. Helbig et al 2018

Table A2.10. Emission factors for N_2O (stationary combustion) in kg/GJ for selected years.

Fuel type	Sector	1990	2000	2010	2015	2016	2017	Source
Biogenic waste	Industry	0.004	0.004	NO	NO	NO	NO	Boström et al., 2004a. Mawdsley, I. et al 2016
Biogenic waste	Power plants and district heating	0.005	0.004	0. 004	0. 004	0.004	0.004	Boström et al., 2004a. Mawdsley, I. et al 2016
Blast furnace gas	All consumption	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	Mawdsley & Stripple, 2014
Carbide furnace gas	All consumption	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	Mawdsley & Stripple, 2014
Charcoal	Small scale combustion	0.001	0.001	0.001	0.001	0.001	0.001	SEPA 1995
Coke	All consumption	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	Mawdsley & Stripple, 2014
Coke oven gas	All consumption	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	Mawdsley & Stripple, 2014
Coking coal	All consumption except pressurized fluidized bed	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	Mawdsley & Stripple, 2014
Coking coal	Pressurized fluidized bed	0.033	0.033	0.033	0.033	0.033	0.033	Mawdsley & Stripple, 2014
Domestic Heating Oil	Other consumption	0.002	0.002	0.002	0.002	0.002	0.002	Boström et al., 2004a. Mawdsley, I. et al 2016
Domestic Heating Oil	Industry	0.0028	0. 0028	0. 0028	0. 0028	0. 0028	0. 0028	Boström et al., 2004a. Mawdsley, I. et al 2016
Domestic Heating Oil	Power plants and district heating	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	Boström et al., 2004a. Mawdsley, I. et al 2016
Gas works gas	All consumption	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	Mawdsley & Stripple, 2014
Kerosene	All consumption	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	SEPA 1995. Mawdsley, I. et al 2016

Fuel type	Sector	1990	2000	2010	2015	2016	2017	Source
Kerosene	Industry	0. 002	0. 002	NO	NO	NO	NO	SEPA 1995. Mawdsley, I. et al 2016
LPG	All consumption	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	Mawdsley & Stripple, 2014
Landfill gas	All consumption	NO	0.0001	0.0001	0.0001	0.0001	0.0001	Mawdsley & Stripple, 2014
Methane etc.	Industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	Mawdsley & Stripple, 2014
Natural Gas	All consumption	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	Mawdsley & Stripple, 2014
Other biomass	All consumption	0.005	0.005	0.005	0.005	0.005	0.005	SEPA 1995. Mawdsley, I. et al 2016
Other biomass	Power plants and district heating	0.003	0.003	0.003	0.003	0.003	0.003	SEPA 1995. Mawdsley, I. et al 2016
Other non specified	Other consumption	0.002	0.002	0.002	0.002	0.002	0.002	SEPA 1995
Other non specified	Industry	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	SEPA 1995
Other non specified	Power plants and district heating	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	SEPA 1995
Other petroleum fuels	All consumption	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	SEPA 1995. Mawdsley, I. et al 2016
Other petroleum fuels	Power plants and district heating	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	SEPA 1995. Mawdsley, I. et al 2016
Other solid fuels	All consumption	0.002	0.002	0.002	0.002	0.002	0.002	SEPA 1995. Mawdsley, I. et al 2016
Peat	All consumption	0.01	0.005	0.005	0.005	0.005	0.005	Boström et al., 2004a
Petroleum coke	All consumption	0.0015	0. 0015	0. 0015	0. 0015	0. 0015	0. 0015	IPCC Guidelines 2006

Fuel type	Sector	1990	2000	2010	2015	2016	2017	Source
Refinery gas	Industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	Mawdsley & Stripple, 2014
Refinery oil	Industry	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	Boström et al., 2004a. Mawdsley, I. et al 2016
Residual Fuel Oil	Other consumption	0.005	0.005	0.005	0.005	0.005	0.005	Boström et al., 2004a.Mawdsley, I. et al 2016
Residual Fuel Oil	Power plants and district heating	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	Boström et al., 2004a.Mawdsley, I. et al 2016
Residual Fuel Oil	Industry	0. 0028	0. 0028	0. 0028	0. 0028	0. 0028	0. 0028	Boström et al., 2004a.Mawdsley, I. et al 2016
Steel converter gas	All consumption	NO	0.0001	0.0001	0.0001	0.0001	0.0001	Mawdsley & Stripple, 2014
Tall oil	All consumption	0.005	0.005	0.005	0.005	0.005	0.005	SEPA 1995. Mawdsley, I. et al 2016
Tall oil	Power plants and district heating	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	SEPA 1995. Mawdsley, I. et al 2016
Waste (non-biomass fr	Industry	0.004	0.004	NO	NO	NO	NO	Boström et al., 2004a. Mawdsley, I. et al 2016
Waste (non-biomass fr	Power plants and district heating	0.005	0. 004	0. 004	0.004	0.004	0.004	Boström et al., 2004a. Mawdsley, I. et al 2016
Wooden fuels	Industry and other consumption	0.005	0.005	0.005	0.005	0.005	0.005	Boström et al., 2004a. Mawdsley, I. et al 2016
Wooden fuels	Power plants and district heating	0.005	0.003	0. 003	0.003	0.003	0.003	Boström et al., 2004a. Mawdsley, I. et al 2016

2.3.2 Stationary combustion and fugitive emissions

Emission factors depend on the type of fuel, and the type of plant and abatement equipment. 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 flaring of gas. They are based on results of measurements and national studies as well as studies of international emission factors and judgments of their relevance to national conditions and are the best available factors for Swedish circumstances in the early 1990's.

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 changes over time were expected. The study is published in a SMED report.[22] 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. [23]

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

[22] Boström et al. 2004

[23] Paulrud et al. 2010.

study is published in a SMED report.[24] 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. The reason was that the emissions from all combustion of these fuels are included in the environmental reports from the integrated iron and steel industry, and use of this information also for the plants allocated to CRF 1A1a gives more accurate total emissions. The CO_2 emission factor for methane-based gas mixtures used in the chemical industry (CRF 1A2c and 1B2C) was also revised in submission 2012, because the time series in submission 2011 was not consistent. These revisions are described in the following sections.

In submission 2014, the CO_2 emission factor for gas works gas was revised for 2011 and later due to changes in feedstock and production conditions[25].

In sumbission 2018 a larger revision of emission factors for CO_2, CH_4, N_2O, PM10, PM2.5, NO_x , CO, SO_2 for several fuel types was made for sector 1A2[26].

In submission 2019, emission factor of CO_2 for natural gas, peat, landfill gas was revised[27] and the same emission factor for CO_2 from natural gas as reported in Denmarks National Inventory is used [28]. In addition, a few corrections from the last large emission factor revision for the industry sector in submission 2018 was made for petroleum coke, coal and domestic heating oil regarding emission factors for N_2O, CH_4, CO, SO_2, NOx. Moreover, a revision of the emission factor for CH_4, CO and NMVOC for small scale wooden combustion was also made. The new emission factors were updated and enhanced a new division of modern and tradidional stoves and boilers[29]. As for CRF 1.A.2.d in particular, emission factors for SO_2 and NOx were also revised for 2016.

For the GHGs following emission factors were changed in submission 2019 (Table A2.11).

[24] Kindbom et al., 2003**.**

[25] Jerksjö et al., 2013

[26] Mawdsley, I., Stripple, H. 2017. Revision of emission factors for stationary combustion within the industrial sector, SMED Report No 7.

[27] Energistyrelsen, 2018-11-26 (https://ens.dk/ansvarsomraader/co2-kvoter/stationaere-produktionsenheder/co2-rapportering-og-returnering)

[28] Helbig, T. Stripple, H., Hjort, A., Mawdsley, I. 2018. Uppdatering av emissionsfaktorer för CO2 från torv och deponigas. SMED PM 2018-05-20.

[29] Helbig, T., Gustavsson, T., Kindbom, K. Jonsson, M. 2018. Uppdatering av nationella emissionsfaktorer för övrig sektor (CRF/NFR 1A4). SMED rapport no 13 2018.

Table A2.11. Revised emission factors in submission 2019 by fuel type and years.

GHG	Fuel type	Years
CO_2	Natural gas	1990-2017
CO_2	Peat	1990-2017
CO_2	Landfill gas	1990-2017
CO_2, CH_4, N_2O	Petroleum coke	1990-2017
CO_2, CH_4, N_2O	Coal	1990-2017
CO_2, CH_4, N_2O	Domestic heating oil	1990-2017
NO_X, SO_X	All fuels	2016-2017
CH_4, NMVOC, CO	Wooden fuels, small scale combustion	1990-2017

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 A2.12.

Table A2.12. 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

In submission 2016, the 2006 IPCC Guidelines were implemented. As part of the QC activities, all national GHG emission factors used for stationary combustion were compared with the default values and confidence intervals given in the 2006 IPCC Guidelines. Most emission factors were found to be within the interval. There were, however, a few exceptions as described in Table A2.13.

Table A2.13. Emission factors outside the intervals given in the 2006 IPCC Guidelines.

Fuel type	CRF	GHG	EF (kg/GJ), low or high*	Explanation
Peat	1A2	CO_2	97.1 (low)	1)
Domestic heating oil	1A4	CH_4	0.001 (low)	2)
LPG, natural gas, gas works gas	1A4	CH_4	0.001 (low)	2)
Coal	1A2	CH_4	0.002 (low)	3)
Waste	1A1a	CH_4	0.005 (low)	4)
Other biomass	1A4	CH_4	0.03 (low)	5)
Peat	1A1a	CH_4	0.011 (high)	1, 7)
Peat	1A2	CH_4	0. 011 (high)	1, 7)
Residual fuel oil	1A1, 1A2, 1A4	N_2O	0.005 (high)	6)

* (low) indicates that national EF is lower than the lower limit of the confidence interval according to the guidelines, (high) indicates that it is higher than the upper limit.

Explanations:

1) The emission factors for peat are based on an old study[30]. A revision was planned to 2013, but unfortunately there were not enough resources to review and revise the emission factor for peat within the new study.
2) The same emission factors are considered to be accurate for both industrial and residential applications[31].
3) The same emission factor is considered to be accurate for both heat- and power plants and industrial applications[32].
4) The emission factor is based on facility specific information that indicates that the combustion in the Swedish plants is very effective which leads to lower emissions of CH_4[33].
5) Very small quantities of other biomass were reported in CRF 1A4a for the first time in submission 2015. The same emission factors were used as for industrial combustion of this kind of fuel.
6) The emission factor is based on a study from 2004.[34] Emission factors for N_2O for solid and gaseous fuels were reviewed and revised downwards in 2014[35], but liquid fuels were not prioritized this time.
7) In submission 2017 the peat emission factor in 1A1a was revised from 0.02 to 0.011 kg/GJ. The value is higher than the default. The value is based on Finnish values adapted to Swedish conditions.

[30] SEPA 1995

[31] Boström et al., 2004

[32] Boström et al., 2004

[33] Boström et al., 2004

[34] Boström et al., 2004

[35] Mawdsley & Stripple, 2014

2.3.2.1 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[36]. The major part of these gases sold to companies in ISIC 40, i.e. CRF 1A1a, is 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. Hence it is not considered relevant to calculate separate emission factors for each of the three gases, and thus an aktregate IEF is used.

A very minor part of the steel work gases used in CRF 1A1a are produced by another facility not 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 %)[37].

[36] Gustafsson, Lidén & Gerner, 2011

[37] Ivarsson, 2003.

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

In 2005, a study of the emission factors for CO_2 from refinery gas, petroleum coke and carbide furnace gas was carried out.[38] It resulted in revisions for all three fuels, as presented in Table A2.14. These emission factors were verified in a study carried out in 2008-2009.[39]

Table A2.14. Emission factors on CO_2 for carbide furnace gas, refinery gas and petroleum coke used since submission 2006.

Fuel type	CO_2 factor since submission 2006 Tonne CO_2/TJ
Carbide furnace gas	145
Refinery gas	59.3*
Petroleum coke	100

*for refinery gas, plant specific EFs are used for later years.

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, although it may indicate that emissions from flaring of refinery gas before 2008 might be overestimated.

2.3.2.3 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 NCV 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[40]. It turned out that the production process was gradually improved in 1999-2001. According to the

[38] Nyström & Cooper, 2005.

[39] Paulrud et al. 2010

[40] Gerner, 2011

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. In ETS data for 2011 and later, there is sufficient information in ETS data and environmental reports to calculate plant specific emission factors for all facilities using this gas. A few facilities use the gas from the main producer, but some of them mix it with their own by-products and sometimes natural gas, which means that the emission factor is not exactly the same for all plants. This also implies that the emission factor for flared gas is not necessarily the same as the one for the gas combusted for energy production purposes.

In submission 2016, total CO_2 emissions reported in CRF 1A-1B and CRF 2 for each of the facilities were verified against total emissions reported in the environmental reports. This check showed some inconsistencies and plant specific IEF's where calculated for the years 2007-2014 and used in submission 2016. The inconsistencies were not systematic, which means that the time series consistency is at least as good as in previous submissions.

In submission 2019, two of the these facilities were allocated to CRF 2 due to lack of information on the shares of emission between CRF 1.A and 2 or energy data for different facilities being inseparable when calculating emissions within stationary combustion, which is the case especially for the earlier years of the time series for certain facilities. This work is part of Swedens annual cross-sectoral control as part of a quality control procedure, aiming to allocate CO_2 emissions from industrial plants correctly between CRF 1 and 2 and to ensure that total emissions are reported correctly.

The emission factors shown in Table A2.15 are aggregate IEFs for all facilities using petrochemical by-product gases reported in CRF 1A2c.

Table A2.15. Emission factor for CO_2 from methane rich gas in the petrochemical industry in submission 2019.

Year	1990-2000	2005	2006	2007	2008	2009	2010	2015	2016	2017	Source
EF	55.00	52.70	46.81	69.43	58.18	64.50	52.77	44.59	63.84	62.82	Plant specific data

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

In a study conducted by SMED in 2006[41], 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[42], 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.

2.3.2.5 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 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 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[43].

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[44].

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.

---

[41] Nyström & Skårman, 2006

[42] Skårman et al, 2008

[43] Paulrud et al. 2005.

[44] Paulrud et al. 2006.

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).

According to a Swedish study[45], 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 emission factors used are based on data from measurements in Swedish residential biomass combustion experiments in the field as well as in the laboratory.

In the 2006 study, which resulted in the currently used SO_2 emission factors, an S-content of (0.01 wt % dry fuel) was applied, with the assumption that no sulphur is bound in the ash.

In submission 2019, a revision of the emission factors for CH_4, CO and NMVOC for small scale wooden combustion was made, according to Table A.2.16 below. The new emission factors were updated and enhanced a new division of modern and tradidional technology for stoves and boilers[46].

Table A2.16. 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 Traditional	Wood logs	88	5	80	3842	552	10
Boilers Modern	Wood logs	15	5	80	1189	87	10
Boilers	Wood ships	6	5	80	430	59	10
Boilers	Pellets	6	5	65	339	17	10
Stoves Traditional	Wood logs	119	5	80	2371	199	10
Stoves Modern	Wood logs	99	5	80	1740	84	10
Stoves	Wood ships	*	*	*	*	*	*
Stoves	Pellets	1	5	65	208	4	10
Open fire places	Wood logs	350	5	80	4400	220	10
Open fire places	Wood chips	*	*	*	*	*	*
Open fire places	Pellets	*	*	*	*	*	*

45 Johansson et al, 2004.

46 Helbig, T., Gustavsson, T., Kindbom, K. Jonsson, M. 2018. Uppdatering av nationella emissionsfaktorer för övrig sektor (CRF/NFR 1A4). SMED rapport no 13 2018.

2.3.2.6 EMISSION FACTORS FOR WASTE AND OTHER NON-SPECIFIED FUELS

The fuel category “other fuels” includes two types of fuels; fossil municipal/industrial waste and “other non-specified fuels”. The emission factors for CH_4 and N_2O from waste are from Boström et.al. 2004. The CO_2 emission factor for waste was revised in submission 2015[47]. “Waste” is reported to the quarterly fuel statistics as one single fuel, but in the emission inventory, it has to be split into a fossil and a biogenic fraction. It was concluded that combustion of 1 GJ waste causes emissions of 94.3 kg CO_2, of which 33.95 kg is of fossil origin and 60.35 kg is biogenic. This implies that 36 % of the CO_2 emissions are fossil, and as a rough assumption, both activity data and all emissions were allocated as 36 % fossil and 64 % biogenic. This means that for each of the fractions, the CO_2 emission factor is 94.3 kg/GJ.

In submission 2017 the CO_2 emission factor for waste was revised again for the 7 largest incineration plants that report CO_2-emissions to the EU/ETS trading accounting. These emission factors are more accurate than the national one and are therefor since 2015 used from this source. These 7 largest plants stand for around 80% of all CO_2-emissions from waste incineration in this sector. Going to plant specific emission factors from a national general emission factor for the 7 largest plants lead to a small shift in the emission factor of the fossil emission factors from 60.39 to 56.45 in submission 2017. This fraction of the fossil and biogenic part is found in table A2.17.

Table A2.17. Emission factor for CO_2 from combustion of waste.

Year	CO_2, Fossil fraction	CO_2, Biogenic fraction	Fraction biogenic/fossil waste	CO_2, Total
2014	33.95	60.39	64/36	94.32
2015	38.45	56.45	59.5/40.5	94.9
2016	37.5	56.65	60.2/39.8	94.15
2017	35.46	60.47	63/37	95.93

For “other non-specified fuels”, the fossil fraction is assumed to be 100 %[48]. The emission factor is 60 kg CO_2/GJ for “other non-specified fuels”. This means that even small variations in the relative amounts of waste and other fuels respectively cause fluctuations in the IEF’s between years.

[47] Stripple et al., 2014

[48] RVF, 2003

2.3.3 Mobile combustion

For all sectors regarding mobile combustion, national net calorific values and emission factors are used for CO_2 and SO_2. See tables above.

Emission factors used for mobile combustion calculations are country-specific and default values from IPCC Guidelines and EMEP/EEA Guidebook 2009/2013. These emission factors are described in greater detail in NIR sections 3.2.

2.3.3.1 ROAD TRAFFIC (CRF 1A3B)

The emissions of CH_4 and N_2O are estimated by the European road emission model HBEFA.

In submission 2012, the emission factor for CO_2 from ethanol was revised as a result of revised NCV for ethanol[49].

In submission 2018, the HBEFA model version 3.3 implemented updated emission factors for NOx regarding Euro IV and Euro VI passenger cars. The transition to the new model with revised emission factors for Euro 4-6 passenger cars led to higher emissions of nitrogen oxides. Emission factors for NMVOC and gas buses were also included in the new version of HBEFA 3.3 model in submission 2018.

As from submission 2018, the emissions of C_H4 and N_2O estimated by Hbefa regarding cars and buses running on natural gas/biogas are used in the inventory. The exception is the emissions of N_2O from gas-buses, since there still is no emission factor in HBEFA and the deafult emission factor from IPCC 2006 Guidelines is used still used.

2.3.3.2 RAILWAYS (CRF 1A3C)

The emission factors for CH_4 and N_2O emissions from railways were revised in submission 2015 and emission factors from EEA Guidebook 2013 are used for the whole time series and all types of railway engines.

2.3.3.3 NAVIGATION (CRF 1A3D)

The emission factors for CH_4, N_2O, NOx, CO, NMVOC and SO_2 for national and international navigation are analysed and if needed revised in every submission by Swedish Environmental Research Institute (IVL).

The IVL updated the emission factors for NOx, NMVOC & CO and leisure boats in submission 2018 for all fuel types.

[49] Paulrud et al. 2010.

2.3.3.4 PIPELINE TRANSPORT (CRF 1A3E)

The same national calorific values and emission factors as used for stationary combustion of natural gas in CRF 1A4a, were used in submission 2019 to estimate the emissions of CO, NMVOC, NOx and SO_2 from pipeline transport (CRF 1A3ei)

2.3.3.5 FISHING (1A4C)

In submission 2013 the emission factor for SO_2 from diesel for fishing (CRF 1A4c) was revised to be on the same level as for domestic navigation (1A3d).

2.3.4 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.

Energistyrelsen, 2018-11-26 (https://ens.dk/ansvarsomraader/co2-kvoter/stationaere-produktionsenheder/co2-rapportering-og-returnering)

ER 2007:15. Energianvändningen inom skogsbruket 2005

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.

Helbig, T. Stripple, H., Hjort, A., Mawdsley, I. 2018. Uppdatering av emissionsfaktorer för CO2 från torv och deponigas. SMED PM 2018-05-20.

Helbig, T., Gustavsson, T., Kindbom, K. Jonsson, M. 2018. Uppdatering av nationella emissionsfaktorer för övrig sektor (CRF/NFR 1A4). SMED rapport no 13 2018.

Ivarsson, 2003. Improved statistics for SSAB, refineries and lime producers. SMED report 59:2003.

Jerksjö M., Gerner A., Wängberg I., 2013. Utveckling av metod för att beräkna emissioner av metan, övriga kolväten och koldioxid från naturgas-, biogas- och stadsgasnät i Sverige. (Method for estimating emissions of methane, NMVOC and CO_2 from pipeline distribution of natural gas, biogas and town gas in Sweden.) SMED Report no 121, 2013.

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

Mawdsley, I & Stripple, H, 2014. Revision of N_2O emission factors for combustion of gaseous and solid fuels. SMED PM

Mawdsley, I., Wisell, T., Stripple, H., Ortiz, C. 2016. Revision of emission factors for electricity generation and district heating (CRF/NFR 1A1a). SMED Report No 194 2016. Agreement No 2250-16-003. Commissioned by the Swedish Environmental Protection Agency

Mawdsley, I., Stripple, H. 2017. Revision of emission factors for stationary combustion within the industrial sector, SMED Report No 7.

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, 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

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.

RVF, 2003. Förbränning av avfall. Utsläpp av växthusgaser jämfört med annan avfallsbehandling och annan energiproduktion. RVF rapport 2003:12

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.

Stockholm Gas, http://www.stockholmgas.se/ 2014.

Swedgas, https://www.swedegas.se/ 2014.

Swedish petroleum and biofuel institute, http://www.spi.se/produkter.asp?art=48 , 2005-10-17.

Statistic Sweden.ES 2012:03. Energy statistics for dwellings with no registered permanent resident (holiday homes) 2011 http://www.energimyndigheten.se/sv/Statistik/Slutlig-anvandning/Bostader-och-service/Fritidshus/

Statistic Sweden; http://www.scb.se/sv_/Hitta-statistik/Statistik-efter-amne/Energi/Tillforsel-och-anvandning-av-energi/Leveranser-av-fordonsgas/Aktuell-pong/2013M09/

Statistics Sweden EN20SM, 1990-2010. Årliga energibalanser (Annual energy balances) http://www.scb.se/statistik/EN/EN0202/2007I08/EN0202_2007I08_SM_EN20SM0904.pdf

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

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)

Stripple, H, Sjödin, Å, Appelberg, I, Gerner, A, Sörme, L, Szudy, M, 2014. Revidering av emissionsfaktorer för växthusgaser för förbränning av sopor och träbränslen. (Revision of emission factors for greenhouse gases from combustion of waste and wooden fuels). Draft SMED report.

Swedish Environmental Protection Agency, http://www.naturvardsverket.se, search for “Beräkna utsläpp”.

SEPA, Swedish Environmental Protection Agency. 1995. Sverige mot minskad klimatpåverkan. Uppföljning av målen för utsläpp av växthusgaser 1994. Rapport 4459. Stockholm 1995.

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

2.4 Allocation of fuels for mobile combustion

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

2.4.1 Gasoline

Data on the delivered amounts of gasoline at a national level is provided by the national statistics on supply and delivery of petroleum products (see chapter 1.1.7). National total delivered amounts of gasoline includes low blended ethanol. To separate biofuel emissions from fossil fuel emissions, all ethanol used by road traffic is reported as biomass under CRF 1A3b. Ethanol has been used by buses since 1990, but low blended ethanol started in 2000 and increased significantly in 2003. The gasoline sold at gas stations today is an admixture of about 95 % gasoline and 5 % ethanol. The total amount of ethanol reported as biomass includes, besides low blended ethanol, the volume of ethanol used by E85 cars, buses and ethanol used by the Swedish armed forces (2007-2014).

The allocation of gasoline to different subsectors is described below. In the first step, the low blended ethanol in gasoline is subtracted from the total delivered amounts of gasoline at a national level. In the next step, the gasoline consumption by domestic navigation[50], military road traffic and military navigation[51] as well as the estimated consumption by road traffic and off road vehicles is subtracted. The remaining volume of gasoline is proportionally distributed to civil road traffic and working machinery and off-road vehicles, as illustrated in figure A2.1 below.

[50] Statistic Sweden. http://www.scb.se/sv_/Hitta-statistik/Statistik-efter-amne/Energi/Tillforsel-och-anvandning-av-energi/Manatlig-bransle--gas--och-lagerstatistik/

[51] Data from the Swedish armed forces

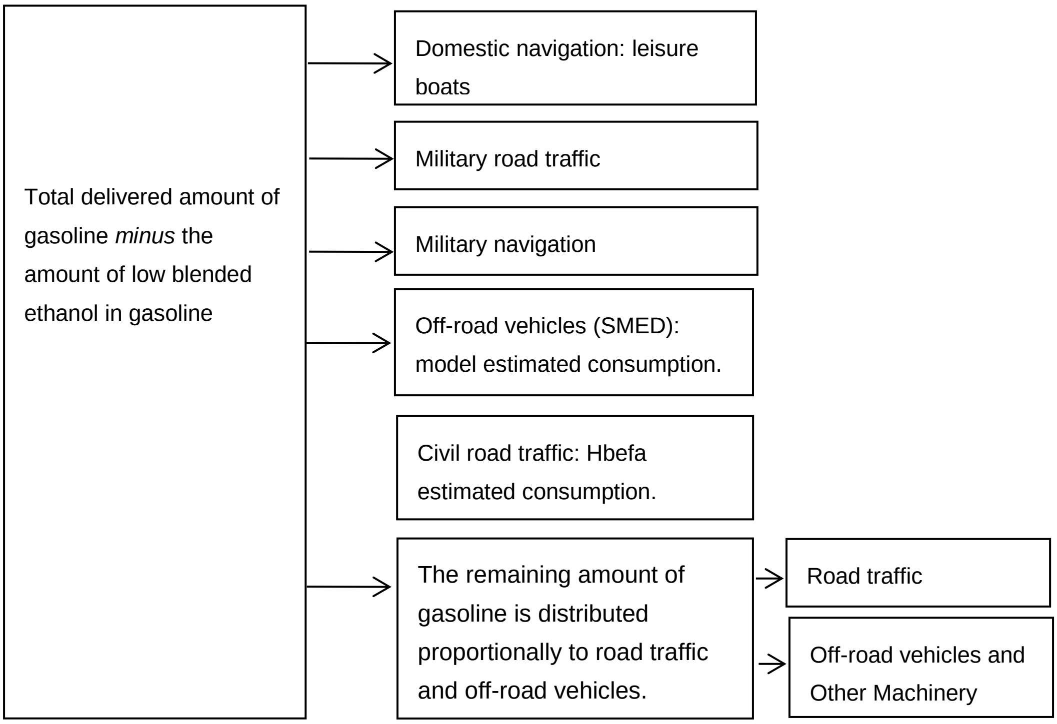

Figure A2.1. Gasoline distribution by subsector

The gasoline consumption by road traffic is estimated by the European road vehicle emission model HBEFA (se chapter 1.5). The gasoline consumption by off-road vehicles and other machinery (CRF 1A2g, 1A3e, 1A4a, 1A4b and 1A4c) is calculated using a model based on a study carried out in 2008 (se chapter 1.6)[52]. The amount of gasoline consumed by military road transport and navigation (CRF 1A5b) is provided by the Swedish Armed Forces.

The fuel consumption by leisure boats was reviewed in 2005, 2014 and 2018. The gasoline consumption by leisure boats in Sweden 1990-2004 is based on a survey from 2004[53] and a study carried out by SMED in 2005[54]. In 2010, there was a new leisure boat survey[55], which is the base for the gasoline consumption by leisure boats in 2010-2014. An assessment of the survey was carried out by SMED in 2014[56] and revised in 2018. In 2015, there was a third leisure boat study[57], which was assessed by SMED in 2018 and is the base for the gasoline consumption in

[52] Fridell, Jernström & Lindgren, 2008

[53]https://www.transportstyrelsen.se/globalassets/global/sjofart/dokument/2004_batlivsundersokningen.pdf

[54] Gustafsson, 2005.

[55]https://www.transportstyrelsen.se/globalassets/global/sjofart/dokument/fritidsbatar1/batlivsundersokningen_2010.pdf

[56] Eklund V. 2014.

[57]https://www.transportstyrelsen.se/globalassets/global/sjofart/dokument/fritidsbatar1/transportstyrelsen-batlivsundersokning-2015-rapport-v-2-160307.pdf

2015 and the following years. The consumption of gasoline in 2005-2009 and 2010-2014 was estimated by interpolation, based on the assessed consumption in each survey.

A comparison between the volume of gasoline allocated to road traffic through this top-down approach and the volume of gasoline consumed according to the bottom-up HBEFA model, used by the Swedish Transport Administration (Section 1.5), indicates a good correspondence between the two estimates. The top-down approach estimates a slightly higher consumption for most years, but the difference in the estimated gasoline consumption between the top-down and bottom-up approach is decreasing over time (Figure A2.2).

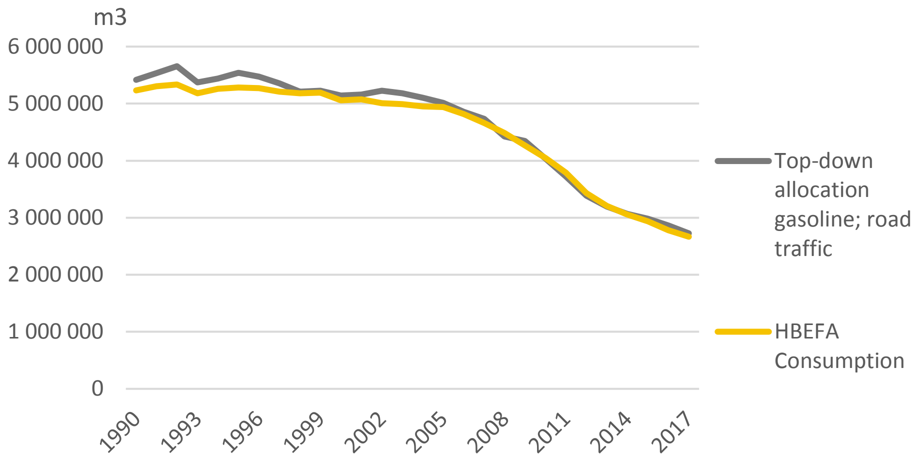

Figure A2.2. Bottom-up estimated gasoline fuel consumption versus top-down allocated gasoline consumption in submission 2019.

The approximate distribution of gasoline to subsectors in 2017 is shown in Figure A2.3. Civil road traffic accounts for almost all gasoline consumption, followed by off-road vehicles and other machinery. Gasoline consumption by domestic navigation is relatively low.

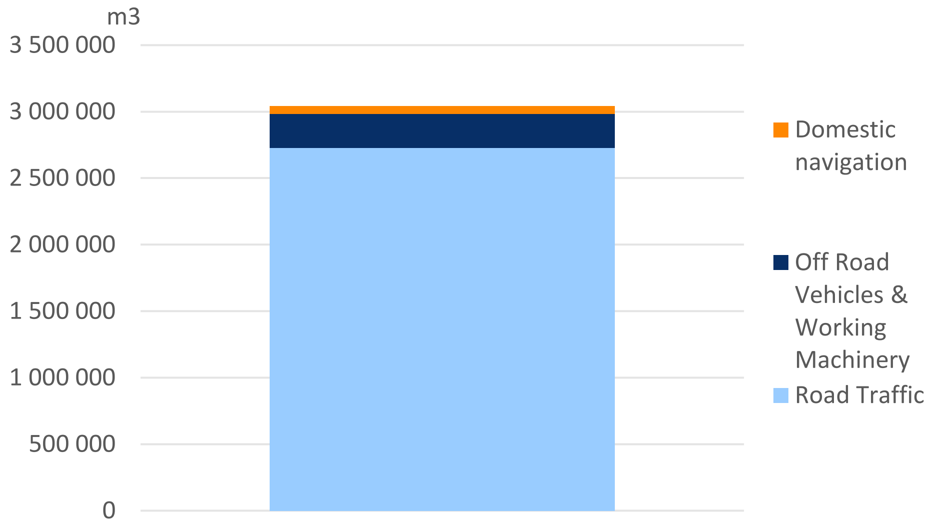

Figure A2.3. Distribution of gasoline by subsector in 2017.

2.4.2 Diesel

Data on the total amount of diesel oil delivered at a national level is 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 diesel used for stationary combustion and mobile combustion as well as FAME (biodiesel) blended into the diesel oil. *In the first step*, the volume of low blended FAME in diesel and the diesel used for stationary combustion is subtracted from total delivered amount of diesel. FAME is reported as biomass under CRF 1A3b. The volume of low blended FAME in diesel has increased considerably since 2006, when biodiesel was introduced on the Swedish market.

Data on consumption of diesel by railways is supplied by the Swedish Transport Administration and for military activities by the Swedish Armed Forces. This data is considered to be accurate and is subtracted from the total deliveries of diesel in a *second step*. The estimated consumption of diesel by leisure boats is based on three different leisure boat surveys and is also subtracted from the total deliveries.

Table A2.18. Subsectors with a diesel consumption that is subtracted in the *second step*.

Subsector	CRF	Estimation of amount of diesel consumed
Railway	1A3c	Exact amount given by the Swedish Transport Administration
Leisure boats	1A3d	SMED report, 2005. SMED PM, 2014. SMED Report No 9 2017
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	1D2	Exact amount given by the Swedish Armed Forces

In the *third and last step*, the estimated diesel consumption by fisheries, domestic navigation, off-road vehicles and other machinery as well as civil road traffic is subtracted and the remaining amount of diesel is proportionally allocated over these four subsectors, where the estimated diesel consumption is more uncertain.

Table A2.19. Subsectors with a high uncertainty in diesel consumption, by source.

Subsector	CRF	Estimation of amount of diesel consumed
Fisheries	1A4c	SMED report, 2005 & The Swedish Agency for Marine and Water Management (SwAM)
Domestic navigation	1A3d	Statistics Sweden, EN31SM
Off-road vehicles and Other Machinery	1A2g, 1A3e and 1A4a-c	Estimation model for Off-road vehicles and Other Machinery (SMED)
Civil road traffic	1A3b	HBEFA road emission model hosted by the Swedish Transport Administration.

The consumption estimates of each subsector is based on sources according to Table A2.18 and Table A2.19. Figure A2.4 gives a brief overview of the distribution of diesel among different subsectors.

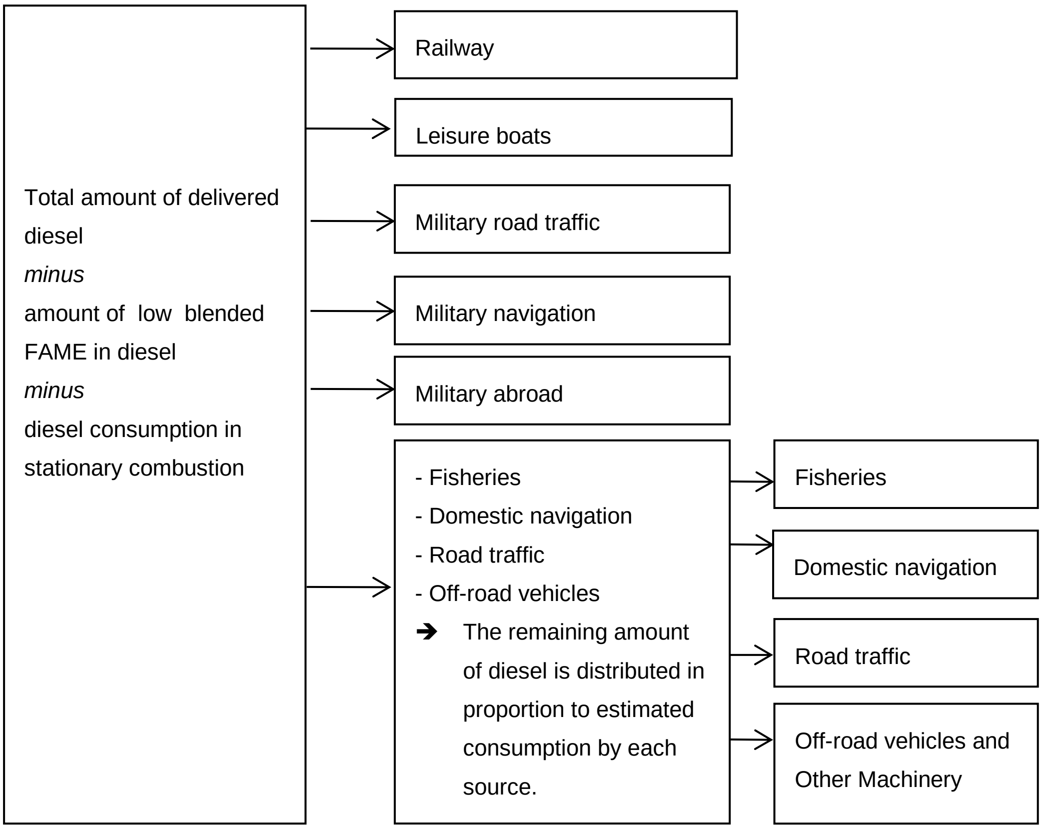

Figure A2.4. Model for allocating the total amount of delivered diesel on subsectors.

The diesel consumption by off-road vehicles and other machinery is estimated by a model, which is based on a SMED study from 2008[58], and was implemented in submission 2009. The model has been updated with new data and improved by each submission. See section 1.6 for more information.

The estimate of the Swedish fishing fleet's diesel consumption is based on a survey on energy consumption by the fishing industry carried out by Statistics Sweden[59] in 2006 and data on the Swedish fishing fleet's total installed effect in kW. The data on installed effect is provided by the Swedish Agency for Marine and Water Management (SwAM). The estimate on fuel consumption provided by SCB refer to 2005 and for both the previous and following years the fuel consumptions from 2005 is adjusting according to the development of the total installed effect. The installed effect is available from 1995 and 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 fuel consumption by leisure boats was reviewed in 2005, 2014 and 2018. The diesel consumption by leisure boats in Sweden 1990-2004 is based on a survey from 2004[60] and a study carried out by SMED in 2005[61]. In 2010, there was a new leisure boat survey[62], which is the base for the diesel consumption by leisure boats in 2010-2014. An assessment of the survey was carried out by SMED in 2014[63] and revised in 2018. In 2015, there was a third leisure boat study[64], which was assessed by SMED in 2018[65] and is the base for the diesel consumption in 2015 and the following years. The consumption of diesel in 2005-2009 and 2010-2014 was estimated by interpolation, based on the assessed consumption in each survey.

Diesel consumption from civil road traffic is estimated by the HBEFA road vehicle emission model (Section 1.5). A comparison between estimated diesel consumption according to the bottom-up emission model HBEFA and the top-down adjusted diesel delivery statistics approach gives a higher consumption for

58 Fridell, Jernström & Lindgren 2008

59 Statistics Sweden 2006

60 https://www.transportstyrelsen.se/globalassets/global/sjofart/dokument/2004_batlivsundersokningen.pdf

61 Gustafsson, 2005.

62 https://www.transportstyrelsen.se/globalassets/global/sjofart/dokument/fritidsbatar1/batlivsundersokningen_2010.pdf

63 Eklund V. 2014.

64 https://www.transportstyrelsen.se/globalassets/global/sjofart/dokument/fritidsbatar1/transportstyrelsen-batlivsundersokning-2015-rapport-v-2-160307.pdf

65 Fridell, E., Mawdsley, I., Wisell T. 2017.

the top-down approach for most years (Figure A2.5). The trend is approximately the same for the two different estimates.

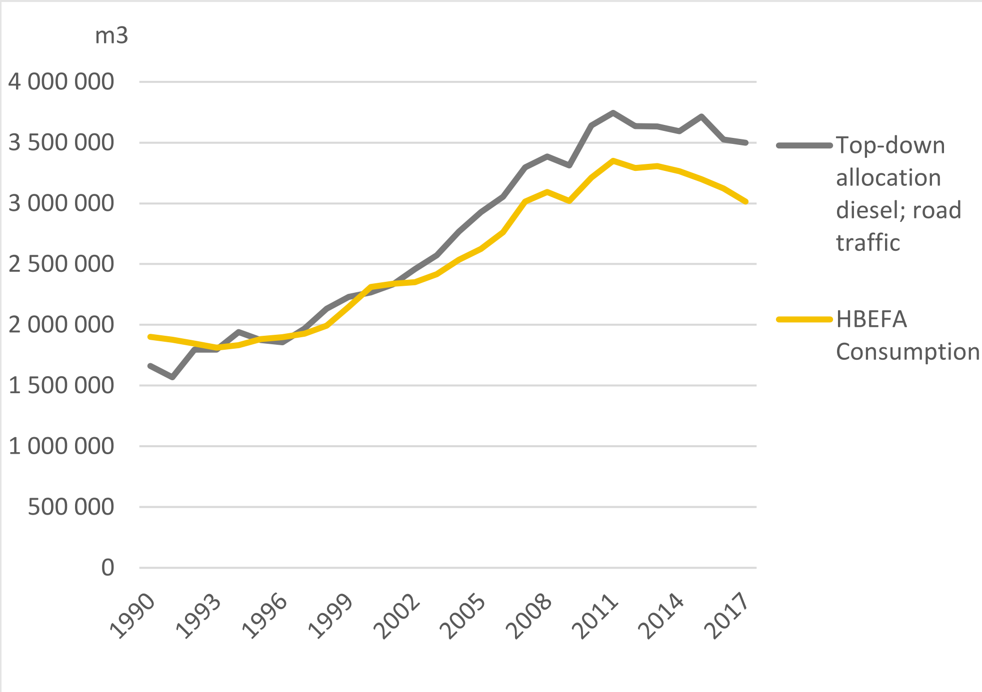

Figure A2.5. Bottom-up estimated diesel consumption versus top-down allocated diesel in submission 2019.

Figure A2.6 shows the approximate distribution of the delivered amount of diesel oil in 2017. Just 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 (22 %) of the total diesel consumption.

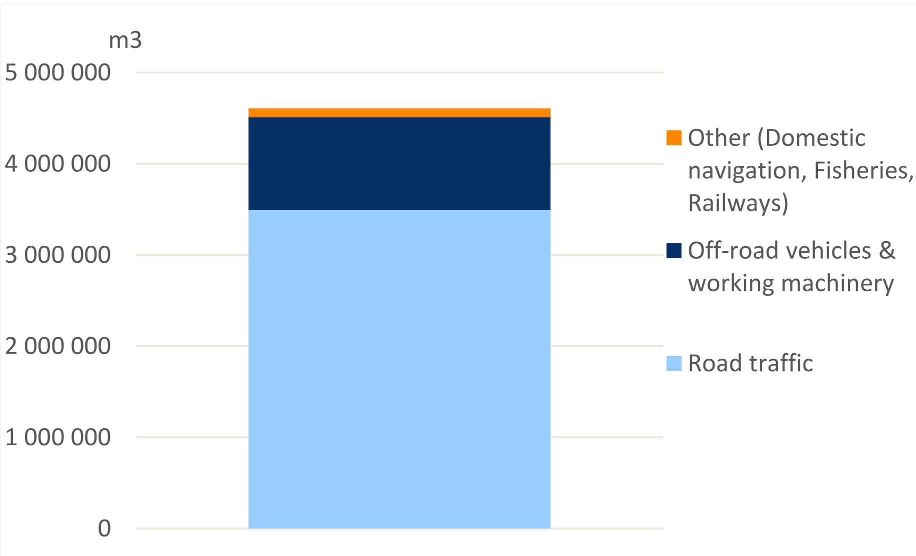

Figure A2.6. Distribution of diesel oil by subsector in 2017.

2.4.2.1 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 [66].The shift in consumption of diesels of different environmental classes has had a significant impact on the emissions.

Table A2.20 shows the characteristics for environmental class 1-3 regarding NCVs 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 former Swedish National Road Administration for the years 1990-1993 and from Statistics Sweden for 1994 and later years. The Swedish Petroleum and Biofuel Institute (SPBI) has assisted with information regarding NCVs and emission factors for CO_2[67]. SMED has calculated yearly averages of NCVs and emission factors.

Table A2.20. Impact from different environmental class diesel on NCV and emission factors for CO_2.

Diesel	NCV (GJ/m^3)	Emission factor CO_2 (tonne/TJ)	Weight 1990 (%)	Weight 2000 (%)	Weight 2013 (%)
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 2010	35.28	72.01			
Average 2013	35.28	72.01			

2.4.3 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. Delivered amount of marine gas oil for navigation is provided by the statistics on supply and delivery of petroleum products (Section 1.1.7) and the diesel consumption by leisure boats is based on three different surveys regarding

[66] The Swedish Transport Agency, https://www.transportstyrelsen.se/sv/vagtrafik/Miljo/Luftkvaliet-i-tatorter/Miljoklassade-branslen/.

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

leisure boats from 2004, 2010[68] and 2015 and three different studies by SMED[69]. Marine diesel oil for domestic navigation is discussed under the diesel section, 1.4.2. The statistics on marine distillate fuels are reported separately for domestic and international navigation and the split is based on the informations provided by the respondents to the survey on supply and delivery of petroleum products.

The amount of marine distillate fuel used for domestic navigation and leisure boats (CRF 1A3d) is shown in figure A2.7. In 2009 the consumption of marine distillate fuels drop, stay low in 2010-2011 and then decrease even more in 2012. In 2013 the trend is broken and the consumption of marine distillate fuel starts to increase. This is most likely the result of stricter rules regarding the sulphur content in marine fuels, which where decided on in 2012 and enforced in January 2015, which led to a shift from heavy oil fuel oil to lighter oil products with a lower suphur content. This can be seen in figure A2.7 and A2.8.

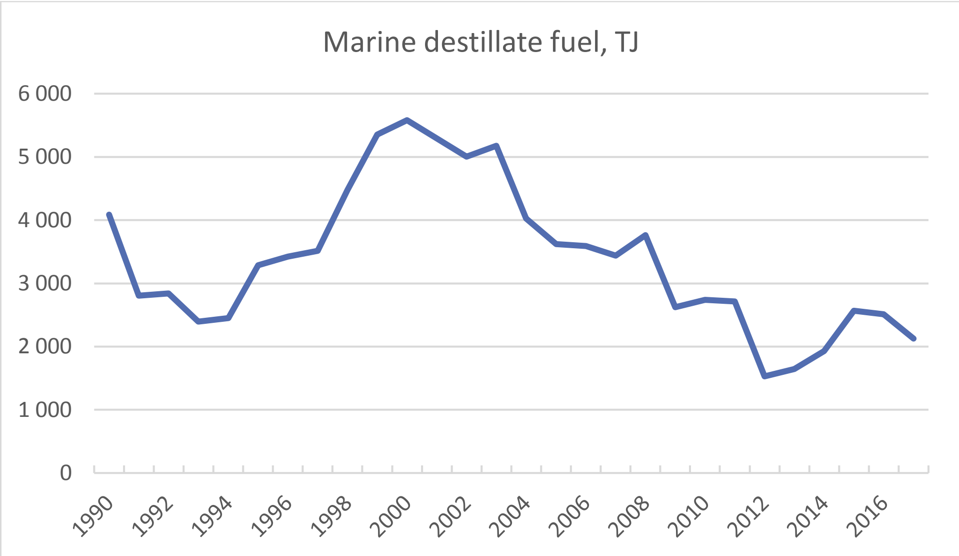

Figure A2.7. National fuel deliveries of marine diesel oil and marine gas oil (marine distillate fuel) 1990-2017.

2.4.4 Residual fuel oils

Delivered amounts of residual fuel oils for national and international navigation are provided by the statistics on supply and delivery of petroleum products and are reported separately for domestic and international navigation (Section 1.1.7). As from 2009 there is a downward trend, which as mentioned above, most likely is the result of stricter rules regarding the sulphur content in marine fuels, which where decided on in 2012 and enforced in January 2015 (Figure A2.8).

---

[68] Statistics Sweden, 2005. Transportsstyrelsen. 2010. Transportstyrelsen 2015.

[69] Gustafsson, T. 2005. Eklund, V. 2014. Fridell, E., Mawdsley, I., Wisell T. 2017

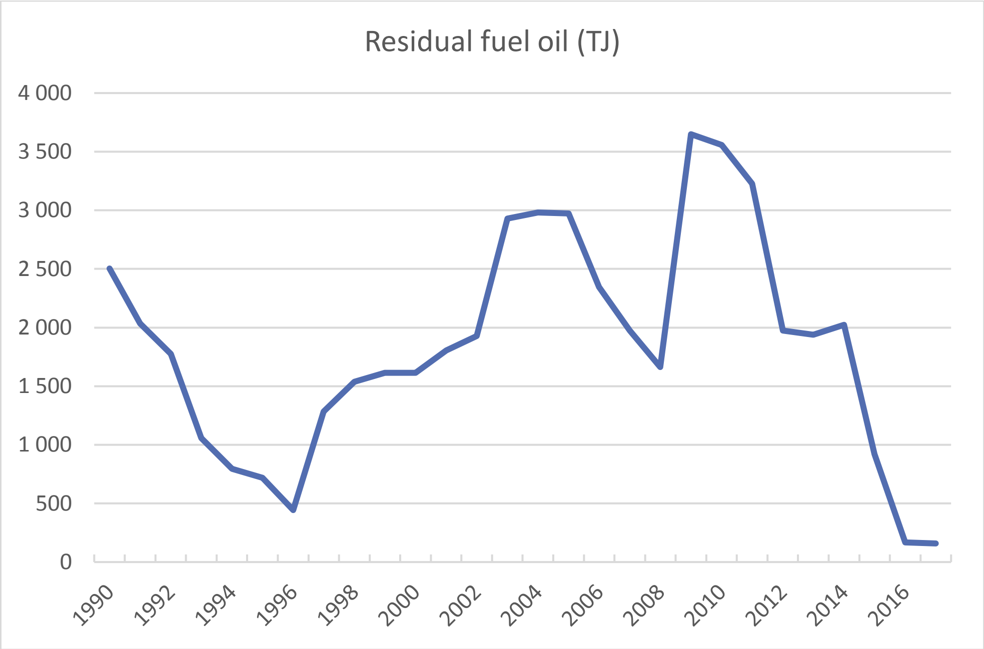

Figure A2.8. National fuel deliveries of marine Residual fuel (m3) for 1990-2017.

2.4.5 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 aviation fuels are provided at a 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 is provided by the Swedish Armed Forces and is assumed to be correct. The remaining amounts are allocated to civil aviation. Jet gasoline was only used by the military in 1990-1993.

2.4.6 Natural Gas and biofuels

Other fuels used for transports are ethanol, FAME, natural gas and biogas. Ethanol and FAME are partly blended into gasoline and diesel and partly used in a more pure forms in so-called flexifuel vehicles. Information on delivered amounts of ethanol and FAME are provided at a national level by the statistics on supply and delivery of petroleum products (Section 1.1.7). Data on delivered amounts of natural gas for transportation is provided by the statistics on delivery of gas products (Section 1.1.8). Data on the consumption of biogas for 1996 -2008 is provided by the Swedish Biogas Association and by Statistics Sweden for 2009-2011. Data for 1990-1995 is not available.

References

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

Eklund, V. 2014. Justering av småbåtars bränsleförbrukning. SMED PM 2014.

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

Fridell E., Mawdsley I., Wisell T. 2017: Development of new emission factors for shipping. SMED Report No 9 2017.

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.

Transportsstyrelsen, 2010. Båtlivsundersökningen 2010 (Swedish leisure boat survey 2010).

Transportsstyrelsen, 2015. Båtlivsundersökningen 2015 (Swedish leisure boat survey 2015).

The Swedish Transport Agency, https://www.transportstyrelsen.se/sv/vagtrafik/Miljo/Luftkvaliet-i-tatorter/Miljoklassade-branslen/.

2.5 The HBEFA road model

The HBEFA (Handbook of Emissions Factors) 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 road model was developed from a merging of the ARTEMIS road model and the former version of HBEFA – 2.1. HBEFA 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[70]. Segments are defined as groups of vehicles of similar size (e.g. passenger cars with swept engine volume between 1.4 and 2 litres, rigid trucks with weight between 14 and 20 tonne) 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[71]. 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 A2.9.

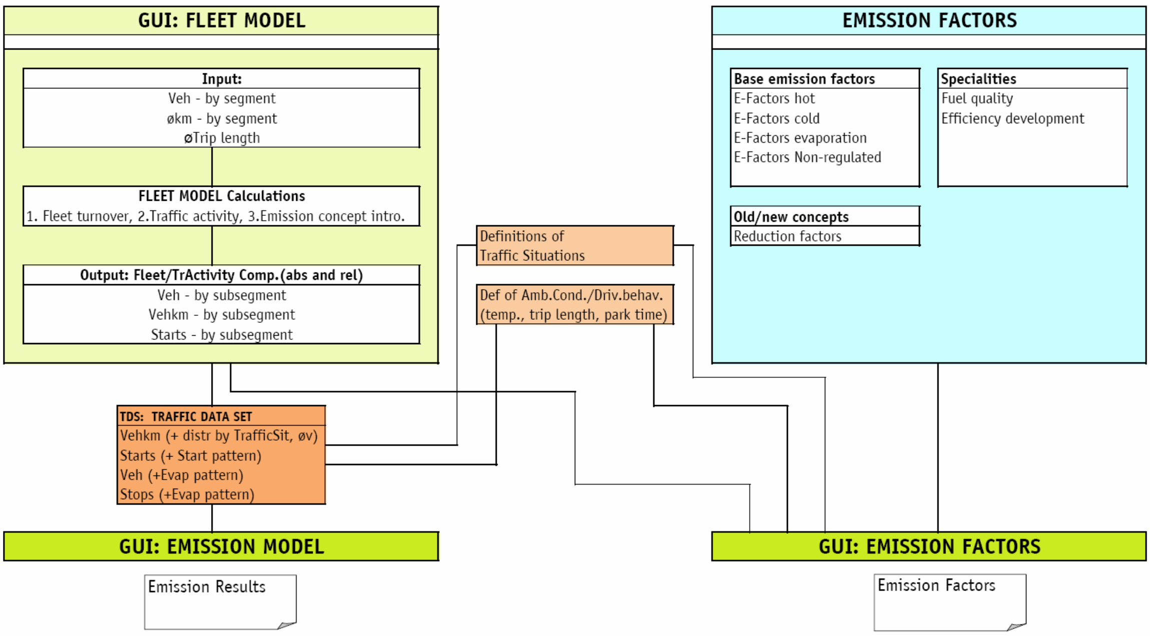

Figure A2.9. HBEFA model structure.

70 Keller et al., 2005

71 André, 2004

2.5.1 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 distributions, 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 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 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 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 tonne) 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 A2.10.

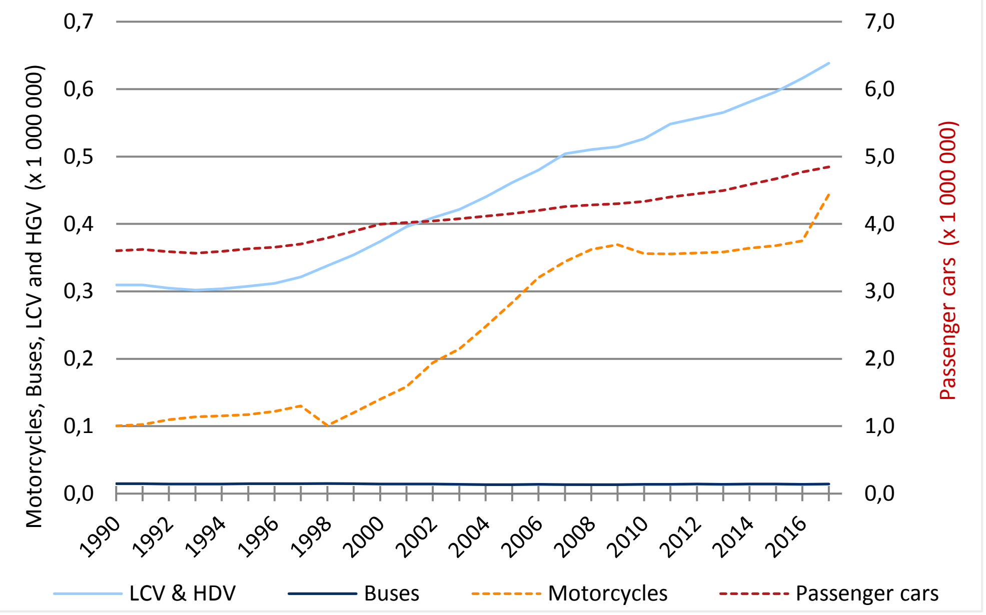

Figure A2.10. Vehicle fleet data by dec 31, numbers, 1990-2017, Statistics Sweden

2.5.2 Traffic activity data

2.5.2.1 VEHICLE MILEAGES, LOADS, TRIP LENGTHS AND FUELS

The HBEFA model requires yearly mileages per vehicle category (Figure A2.11). For Sweden these are calculated by means of a national road mileage model[72]. 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 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[73]. 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 model requires mileage distributions of load factors empty (0% load), half-load (50% load), and fully loaded (100% load),

[72] Edwards et al., 1999

[73] SIKA, 2003

by vehicle segment and vehicle age. This data is derived from a major national survey from 1997 on Swedish domestic road goods transport[74], 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[75]. 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[76]. Thus, available instrumented vehicle data was used to estimate trip lengths and parking times in Sweden.

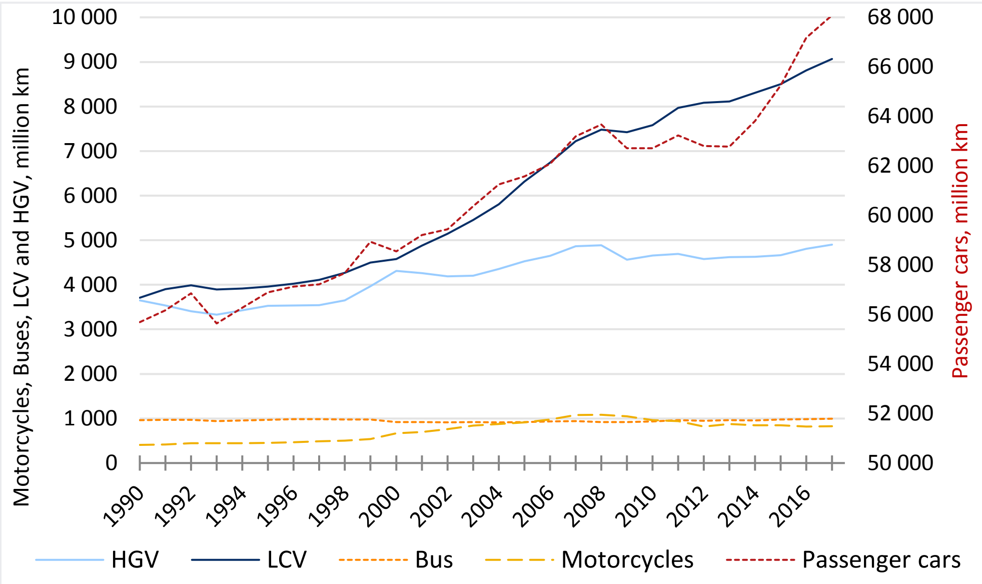

Figure A2.11. Vehicle mileages 1990-2017 according to HBEFA

2.5.2.2 TRAFFIC SITUATIONS

The HBEFA model includes 276 traffic situations, i.e. combinations of 69 road categories. For each one of these traffic situations, four classes of traffic conditions or "levels of service" is defined describing how disturbed the traffic is relative to undisturbed traffic - 1) Free Flow, 2) Heavy Traffic, 3) Saturated, and 4) Stop and Go conditions (see Figure A 2.12 and Table A2.21 below). Furthermore, it is possible to add different level of grade; however this is not done for Sweden.

[74] Hammarström and Yahya, 2000

[75] SNRA 1999

[76] André et al., 1999

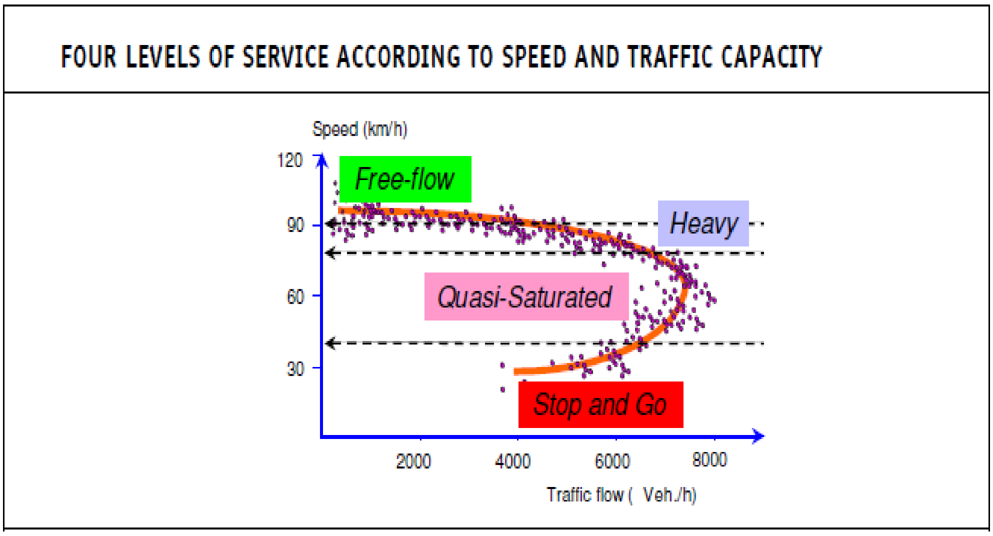

Figure A 2.12. Traffic flow.

Table A2.21. Definition of the four classes of traffic conditions.

Class	Definition
Freeflow	Free flowing conditions, low and steady traffic flow. Constant and quite high speed. Indicative speeds: 90-120 km/h on motorways, 45-60 km/h on a road with speed limit of 50 km/h. LOS A-B according to HCM.
Heavy	Free flow conditions with heavy traffic, fairly constant speed. Indicative speeds: 70-90 km/h on motorways, 30-45 km/h on a road with a speed limit of 50 km/h. LOS C-D according to HCM.
Saturated	Unsteady flow, saturated traffic. Variable intermediate speeds, with possible stops. Indicative speeds: 30-70 km/h on motorways, 15-30 km/h on a road with speed limit of 50 km/h. LOS E according to HCM.
Stop + go	Stop and go. Heavily congested flow, stop and go or gridlock. Variable and low speed and stops. Indicative speeds: 30-70 km/h on motorways, 15-30 km/h on a road with speed limit of 50 km/h. LOS E according to HCM.

The national vehicle mileages for year 1990, 1995, 1998, 2000 and 2004 were initially estimated by means of the national vehicle mileage model[77]. 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 different traffic situations in HBEFA. Two national GIS road databases (VDB) 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

[77] Edwards et al., 1999

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. The three largest cities in Sweden accounted for one fourth to almost one third of the overall vehicle mileage on urban roads. Statistics on hourly flow conditions for different road types[78] were employed to describe 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 hour, were related to volume-delay functions and 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 and saturated 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 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”.

By studying the daily traffic flow for individual congested roads (Figure A2.13), it could be seen that a local decrease in the flow sometimes occurred within a congested period (i.e. when the 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.

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

Swedish road categories were translated to HBEFA traffic situations based on the description of road hierarchy, speed limit, function and design. This made it possible to sum up the vehicle mileage in Sweden over the HBEFA traffic situations for different years.

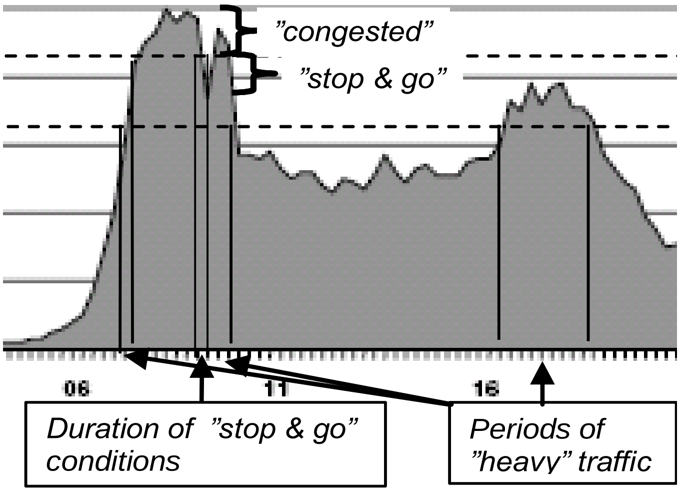

Figure A 2.13. Flow over the day for individual congested roads.

Of the 276 traffic situations in HBEFA, 115 were identified in Sweden in 2013, representing 53 road categories, for which the traffic conditions "Free Flow" or "Heavy Traffic" were predominant. In fact, as much as 93.6 % of the overall vehicle mileage driven in Sweden was characterised by free flow conditions. The ten most abundant HBEFA traffic situations all involve "Free Flow" conditions and are presented in Table A2.22.

Table A2.22. The ten most common traffic situations in Sweden in 2013, and their share of the total vehicle mileage.

Description of traffic situations	Vehicle mileage
Rural / Distributor-DistrictConnection / SpLimit:70 / Freeflow	12.9 %
Rural / Motorway / SpLimit:110 / Freeflow	10.5 %
Urban / Distributor-DistrictConnection / SpLimit:60 / Freeflow	9.1 %
Rural / Distributor-DistrictConnection / SpLimit:90 / Freeflow	7.8 %
Rural / Distributor-DistrictConnection / SpLimit:80 / Freeflow	6.8 %
Rural / TrunkRoad / SpLimit:100 / Freeflow	5.0 %
Urban / Distributor-DistrictConnection / SpLimit:50 / Freeflow	4.2 %
Rural / TrunkRoad / SpLimit:90 / Freeflow	3.8 %
Urban / City-TrunkRoad / SpLimit:70 / Freeflow	3.1 %
Urban / Access-residential / SpLimit:40 / Freeflow	2.7 %
Total	**65.9 %**

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 66 % of the national vehicle mileage. The share of the HBEFA "Stop and Go"-conditions of the overall mileage was as low 0.05 %, and only occurred in the three major cities. Further details concerning the methodology and the results are reported elsewhere[79].

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.[80]

[79] Larsson and Ericsson, 2006

[80] 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/

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

2.6 Methodology for working machinery

Fuel consumption and emissions of NO_X, NMVOC, CH_4, CO, N_2O from working machinery are estimated with a model developed by SMED in 2008, considered to correspond to Tier 3. Working machinery in this context means mobile machinery with a combustion engine that is not used on roads, waterways or railways. Included are e.g. construction machinery, handheld garden machines and snow mobiles.

Emissions and fuel consumption are calculated in the model with the equations below:[81]

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

E = Emissions in Kt
N = number of vehicles,
Hr = yearly running time in hours,
P = engine power in kW,
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).

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

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 are described as vectors with data for every model year the last 25 years.

2.6.1 Emission factors

Emissions of CO_2 and SO_2 are estimated using the same emission factors as for diesel and gasoline used for road traffic and are considered to correspond to Tier 2. The emission factors for SO_2 and CO_2 are adjusted according to fuel specifications for each year.

Emission factors for diesel machinery with an installed engine power > 37 kW are based on the emission regulations according to the EU legislation. Emission factors for diesel machinery < 37 kW are taken from Corinair[82]. For gasoline driven smaller off-road vehicles and machinery, emission factors are taken from Winther

[81] Fridell, Jernström and Lindgren, 2008

[82] EEA. 2007

and Nielsen 2006.[83] These are based on certification measurements. Fuel consumption and emission factors for snow mobiles are also taken from Winther and Nielsen 2006, except the emission factors for hydrocarbons, carbon monoxide and particles, which are taken from USEPA (2005)[93].

2.6.2 Vehicle Stocks

The number of diesel machinery 37 – 560 kW of different types is mainly based on a bottom-up inventory for the year 2006. [84] In submission 2014 the model was updated[85] with new information on the number of machines for some of the diesel vehicles in the range of 37 kW – 560 kW. In this update also improved estimates of vehicle life time were obtained from the new data and are now used in the model. In submission 2018 the model was updated with sales data for some off-road vehicles for 2005-2016. The sales data was provided by the Swedish trade association for suppliers of mobile machines.[86] Sales data is from submission 2019 and onwards used annualy for updating the model with number of new machinery.

Numbers of tractors per sector, model year and engine power interval are for most years taken from the Swedish vehicle register. The number of working machines >560 kW are taken from a IVL study conducted on behalf of the Swedish Transport Agency[87]. The number of working machines < 37 kW are based on a bottom-up inventory for the year 2002[88]. The number of machines for other years are estimated on e.g. sales data provided by the Swedish trade association for suppliers of garden machinery, estimates of lifetime or set as unchanged from 2002. Different methods are used for different types of machines.

The number of snow mobiles is obtained from the Swedish vehicle register.

2.6.3 Other parameters

Yearly running time, engine power and the load factor in equation (1) above are taken from Wetterberg[89] and Flodström[90]. Load factors for some of the machines are from a IVL study made in 2015[91]. The fuel adjustment factor, FAF, and the certification adjustment factor, CAF, for larger vehicles in equation (2) are taken

[83] Winther, M., Nielsen, O.-K., 2006.

[84] Wetterberg C, Magnusson R, Lindgren M, Åström S. 2007.

[85] Jerksjö, M. 2013.

[86] Eklund, V., Lidén, M., Jerksjö, M., 2017.

[87] Transportstyrelsen 2014

[88] Flodström, E., Sjödin, Å., Gustafsson, T. 2004.

[89] Wetterberg C, Magnusson R, Lindgren M, Åström S. 2007.

[90] Flodström, E., Sjödin, Å., Gustafsson, T. 2004.

[91] Jerksjö, M., Fridell, E., Wisell, T. 2015

from Lindgren (2007).[92] The TAF and DF factors are taken from the Non-road model[93].

2.6.4 Allocation to CRF-sectors

The allocation of emissions from working machinery is mainly based on a report by Flodström (et al)[94]. This is the most recent Swedish inventory including an allocation of working machinery to the different CRF-sectors. There has also been some changes of the allocation proposed in Flodström *et al.*, 2004. Most of these changes have been done by expert judgements in cases where the allocation did not seem to be accurate. In submission 2018 the allocation to CRF-sectors was updated, as new information was received from the Swedish trade association for suppliers of mobile machines and from the vehicle register. Table A2.23 shows the emissions of CO_2 from fuels used by working machinery 2017, split by sector and fuel type.

Table A2.23. CO_2 emissions from fossil fuels used in working machinery 2017.

			CO_2	
			(kt)	(%)
1A2g vii	Industry	Diesel	1214	38 %
1A3e ii	Other Transport	Diesel	165	5 %
1A4a ii	Commercial/institutional	Diesel	216	7 %
1A4b ii	Residential	Diesel	39	1 %
1A4c ii	Agriculture	Diesel	501	16 %
1A4c ii	Forestry	Diesel	438	14 %
1A2g vii	Industry	Gasoline	21	1 %
1A3e ii	Other Transport	Gasoline	0	0 %
1A4a ii	Commercial/institutional	Gasoline	199	6 %
1A4b ii	Residential	Gasoline	301	9 %
1A4c ii	Agriculture	Gasoline	55	2 %
1A4c ii	Forestry	Gasoline	35	1 %
Total	Total	Total	3 184	100 %

2.6.5 Most recent updates

As described above the model has since 2008 undergone a series of improvements. An update was done in 2015 and is described in Jerksjö *et. al.* (2015[95]). The update aimed in several ways to further improve the national emissions and fuel consumption estimates. The updates included adding machines with an installed

92 Lindgren M. 2007.

93 USEPA. 2005.

94 Flodström, E., Sjödin, Å., Gustafsson, T. 2004.

95 Jerksjö, M., Fridell, E., Wisell, T. 2015

power >560 kW (not included in the previous model version), updated average load factors for some machines, added emission factors for Stage V machines, implementing a function for describing the relationship between engine load and fuel consumption, and some updates concerning allocation of emissions to the different CRF- sectors.

For submission 2018 the model was updated with sales data provided by the Swedish trade association for suppliers of mobile machines. The allocation of emissions to the different CRF-sectors was also updated and the age of some of the oldest tractors was adjusted.[96]

The latest updates were made in submission 2019 and included two major changes and som minor changes. The first major change was an updated age distribution for snow mobiles and all terrain vehicles. Also the share of these vehicles that are using 2-stroke engines or 4-stroke engines respectively were updated. The other major chande was an update of the fuel consumption in g/kWh used for machinery >560kW.

[96] Eklund, V., Lidén, M., Jerksjö, M., 2017.

References

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

Eklund, V., Lidén, M., Jerksjö, M., 2017. Regelbunden indataförsörjning till beräkningsmodellen för arbetsmaskiner. SMED PM 2017.

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., Wisell, T. Non-Road Mobile Machinery Model – Updates 2015. IVL report C134

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.

Transportstyrelsen 2014, Möjligheten att minska utsläppen av sot från arbetsmaskiner – Uppdrag att analysera ett nationellt krav på partikelfilter i stora arbetsmaskiner. TSG 2013-1541

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, kunskapsuppbyktnad 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.

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

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

Annex 3:3
Methodological issues for solvent and other product use (CRF 2.D.3)

Annex 3:4
Rationale for data sources used for key categories in industrial processes sector (CRF 2)

Annex 3:5
Documents from Swedish Refrigeration & Heat Pump Association and Swedish Car Recyclers Association

Annex 3:1: Brief description of the Excel-model for calculation of emissions of fluorinated gases

3.1 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. Use of NF_3 is not occurring in Sweden. 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.

3.2 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 is 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.

3.3 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 are 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.

3.4 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 aktregation 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.

3.5 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 suktestions 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). Kartläktning 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 4)

In the following chapter we provide additional information on methodological issues used in the inventory for the LULUCF-sector. The structure follows chapter “6.4.2 Methodological issues” in the NIR and we refer to the corresponding NIR-chapter where appropriate.

3.1 Methodological issues, CRF-tables 4A, 4B, 4C, 4D, 4E and 4F

3.1.1 Sample based estimations

The sample frame of the NFI 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[97].

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

where $\hat{Y}_i$ = the ratio estimated value, A_i = the measured area (determined 1984 by the national land survey; Lantmäteriet[98]). $\hat{X}_i$ = the estimated value of the variable

[97] Thompson, 1992

[98] Lantmäteriet, http://www.lantmateriet.se/

of interest according to Horvitz-Thompson and $\hat{A}_i$ = the estimated area according to Horvitz-Thompson. Index *i* refers to county.

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

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

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

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

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

N = the total number of counties in Sweden.

Sweden only reports “human induced” carbon changes, where “human induced” has the interpretation of “managed”, i.e. the carbon stock change on unmanaged land are set to zero. However, the real carbon 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. On request from reviewers, from submission 2018, carbon stock changes for living biomass is reported for Forest land converted to Other land (even if such land is considered unmanaged).

3.1.2 The LULUCF reporting database

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, the land-use for all land and fresh-water areas are monitored. The permanent sample plots have been re-inventoried at intervals of 5-10 years, however, for economic reasons, the number of sample plots inventoried by RIS have been reduced to around 30 000. 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.

Each single sample plot has been inventoried in one of ten inventory intervals (Table A3:2.1). 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. For submission 2019, all sample plots have been re-inventoried 1990-2013 and, thus, these years are based on all 30 000 re-measured plots. The years 2014-2017 will be based on gradually smaller samples. Theoretically, both the current and the re-calculated reporting will be unbiased. However, the accuracy will be better in the latter case.

To further improve the calculations for the years not inventoried or interpolated (for the current reporting 1990-2013), each interval of data is extrapolated for years up to the latest reported year (for example, cycles 1 and 2 in Tabel A3:2.1 have been extrapolated four years up to 2017). 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. Using only data from one year of an inventory may cause unrealistic annual variations caused by random variation of the sample.

Table A3:2.1. A single sample plot is inventoried in one of ten inventory intervals. Blue coloured background refers to measurements and no colour refers to interpolated data. Brown coloured background means that data has been extrapolated.

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
2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
2016	2016	2016	2016	2016	2016	2016	2016	2016	2016
2017	2017	2017	2017	2017	2017	2017	2017	2017	2017

3.1.3 Methodology living biomass CRF 4A, 4B, 4C, 4D, 4E and 4F

A national methodology (Tier 3) is used. The aboveground biomass per tree fractions is estimated by applying Marklund's[99] biomass functions to sample trees on permanent sample plots of the NFI[100]. The below-ground biomass pool is estimated by Petersson's and Ståhl's[101] biomass functions applied to the same trees. The conversion factor 0.50 is used to convert dry weight biomass to carbon[102]. 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.

Marklund's single tree allometric regression functions (Table A3:2.2) 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 A3:2.2). 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 (DBH) 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 is calculated as the average removal over time (1990-2010). During the period, the net removal of living trees 0-99 mm in DBH was estimated to -3.986 M ton CO_2 per year. This removal assumed constant for every year.

[99] Marklund, 1987 and 1988

[100] Ranneby et al., 1987

[101] Petersson and Ståhl, 2006

[102] National Board of Forestry, 2000

Table A3:2.2. The simplest biomass functions applied to trees only measured for stem diameter at breast height (1.3 m) and species. TVSTAM=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)		
TVSTAM=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)		
TVSTAM=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

3.1.4 Methodology dead organic matter CRF-tables 4A, 4B, 4C, 4D, 4E and 4F

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.

3.1.5 Methodology dead wood CRF-tables 4A, 4B, 4C, 4D, 4E and 4F

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 A3:2.3). This is a compromise to in an acceptable way match existing data to specific reporting years. From reporting year 2008, the methodology is fixed and consistent in the way that data for each reported year is based on the stock change of two consecutive inventories for all five inventory cycles used. Due to a five-year inventory cycle, the five most recent reporting years are updated each year and are thereafter fixed. Thus reported years 1990-2013 are now fixed.

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[103]. Sandström *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[104] 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 with 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 modelled. 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 and root system biomass. The output is modelled by a decomposition function[105]. Input and output is considered from 1853-2017 (Tabel A3:2.4).

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 is gradually increasing. The conversion factors are derived by applying biomass functions [106] and stem volume functions[107] to sample trees inventoried by the National Forest Inventory and representing the standing stock of Sweden. The methodology chosen harmonize fluctuations in living biomass with net removals from stumps. Thus, if harvest will increase this is also valid for the net removal of stumps while the net removals in living biomass will decrease.

Conversion factors: 1 m^3 stem wood is assumed to correspond with 750 kg whole tree biomass and 184 kg stump and root system biomass (dry wood).

[103] Sandström et al., 2007

[104] Ranneby et al., 1987

[105] Melin et. al. 2009

[106] Marklund, 1988, Petersson and Ståhl, 2006

[107] Näslund 1947

Table A3:2.3. 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	2003/2004/2005/2006/2007	2008/2009/2010/2011/2012	30000
2009	2004/2005/2006/2007/2008	2009/2010/2011/2012/2013	30000
2010	2005/2006/2007/2008/2009	2010/2011/2012/2013/2014	30000
2011	2006/2007/2008/2009/2010	2011/2012/2013/2014/2015	30000
2012	2007/2008/2009/2010/2011	2012/2013/2014/2015/2016	30000
2013	2008/2009/2010/2011/2012	2013/2014/2015/2016/2017	30000
2014	2009/2010/2011/2012	2014/2015/2016/2017	24000
2015	2010/2011/2012	2015/2016/2017	18000
2016	2011/2012	2016/2017	12000
2017	2012	2017	6000

Table A3:2.4. Net removal (-) in stump and root systems [M tonne CO_2 equivalents] based on Growth minus net Change in living biomass (Reported) and from Harvest statistics (Validation).

Reporting year	Reported	Validation
1990	-2,41	-1,55
1991	-1.74	-0.94
1992	-4.72	-1.67
1993	-3.80	-1.90
1994	-3.55	-2.55
1995	-1.26	-5.17
1996	-1.66	-2.26
1997	-2.43	-3.74
1998	-2.63	-3.64
1999	-4.02	-2.76
2000	-4.63	-4.56
2001	-8.52	-4.25
2002	-6.65	-5.60
2003	-6.30	-5.68
2004	-7.98	-6.57
2005	-7.33	-18.14
2006	-8.18	-3.27
2007	-6.39	-8.45
2008	-5.53	-4.99
2009	-6.35	-1.97
2010	-6.22	-5.28
2011	-8.20	-5.01
2012	-8.43	-3.66
2013	-5.50	-3.53
2014	-5.46	-5.35
2015	-4.86	-5.41
2016	-4.59	-4.89
2017	-4.36	-4.43

3.1.6 Methodology litter CRF-tables 4A, 4B, 4C, 4D, 4E and 4F

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 A3:2.5) 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 from 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 horizon carbon stock is based on samples from re-inventoried plots between 1993 and 2015 (values for 1990-1992 and 2016 - 2017 are extrapolated).

Table A3:2.5. Functions used to estimate the litter part of the dead organic matter pool.

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}][108]
ALPS=6906-102.3•Lat+46.4*BAPS-4.5•Age		[kg ha^{-1}][109]
ALD= ND•0.00371•ABDH$^{1.11993}$		[kg ha^{-1}][110]
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}]

The following abbreviations are used;

CL=coarse litter,
DW=dead wood,
AL=Annual litterfall,
NS=Norway Spruce,
PS=Scots pine,
D=decidous,
Lat=Latitude,
BA=basal area,
Age=tree age,
ND=number of decidous stems ha^{-1},
ABDH=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

[108] Berg et al., 1999a

[109] Berg et al., 1999b

[110] Johansson, 1999

3.1.7 Methodology soil organic carbon Forest land and Grassland on mineral soils CRF 4A and 4C

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:

$$SOCi = C_i \cdot Wfe_i,$$

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 was completed for all plots in 2012 using a modified Viro-method [111]. 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 in the inventory and a measured boulder frequency available for all the plots were 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 change in the soil organic carbon pool but that it might affect the magnitude of the change slightly (Table A3:2.6).

Table A3:2.6. 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,

[111] Viro, 1952.

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

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 only 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 2007-2017. 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. All estimates of annual carbon stock change for each plot is area weighted with the same methods as described in section 3.1.1. Plots that have not been re-inventoried for some reason are assumed to have no change in carbon stock. The principle is illustrated in Figure A3:2.1. The upper panel shows the estimated amount of soil carbon for two plots of which plot 1 have been measured three times and plot two only two times. The change is equally distributed among the years between measurements and also extrapolated backwards and forwards in time so that each re-measured plot influence the whole time series. When there are more than two measurements of the same plot the rate of change can shift along the time series. The lower panel show the resulting rates of change in soil carbon. The green dot show the reported average for each year in the time series.

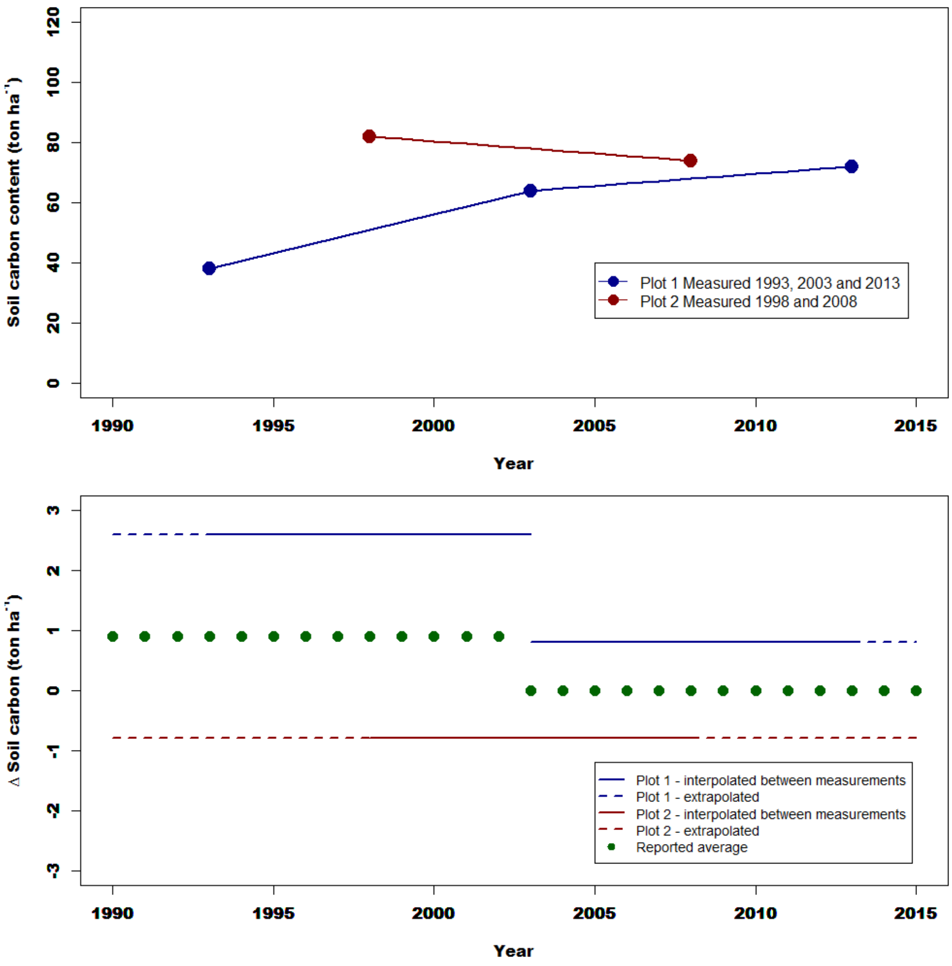

Figure A3:2.1. Principle for interpolation and extrapolation of soil carbon (and DOM) amounts (upper panel) and soil carbon change (lower panel).

3.1.8 Methodology soil organic carbon Forest land and Grassland on organic soils CRF 4A and 4C

Emissions from drained organic soils are calculated using a set of emission factors differentiated through two different classes of nutrient status (nutrient rich and nutrient poor) and two different climate zones (temperate and boreal)[112]. The method is a Tier 1 method where the emission factors are taken from the 2013 IPCC Wetland Supplement to the 2006 GL[16]. The method is identical for Forest land remaining Forest land and for Grassland remaining Grassland and can be expressed in the following way:

$$CO_{2,LU} = \sum_{i,j} A_{i,j} \cdot EF_{i,j} \cdot 44/12$$

[112] Lindgren and Lundblad (2014)

Where $CO_{2,LU}$ is the emissions for the actual land use category, $A_{i,j}$ and $EF_{i,j}$ the area and emission factor for each subcategory where *i* denotes the nutrient class and *j* the climate zone. Emission factors are applied without any consideration to carbon inputs from litter (assumed to be included in the emission factor itself). Note that litter reported in the CRF-tables therefore only comprice litter on mineral soils. Estimates are interpolated and area weighted as described above for mineral soils.

The limit between nutrient poor and nutrient rich drained organic soils should be drawn between ombrotrophic and minerotrophic conditions according to the Wetland Supplement[16]. This categorization is not directly available in the NFI. However, the categories can be determined based on the ground vegetation community. Some vegetation groups are found on both nutrient rich and nutrient poor conditions, or to be more concrete – they are found when the conditions are intermediate between rich and poor. The categorization of the different vegetation types used are given in Table A3:2.7 below.

If information on the ground vegetation community from the NFI is used to set the limit between nutrient poor and nutrient rich, the intermediate class vegetation (group 12 and 13) should most likely be located in the nutrient rich category. This assumption avoid underestimation of GHG emissions as nutrient rich conditions are associated with higher emission factors in the Wetland Supplement. .

Table A3:2.7. Categorization of vegetation types.

Nutrient rich	Nutrient poor
01 – Tall herbs without shrubs 02 – Tall herbs with shrubs/blueberry 03 – Tall herbs with shrubs/lingonberry 04 – Low herbs without shrubs 05 – Low herbs with shrubs/blueberry 06 – Low herbs with shrubs/lingonberry 07 – Without field layer (no plants, just mosses) 08 – Broad grasses 09 – Narrow grasses 12 – Horsetail 13 – Blueberry	10 – Tall *Carex* 11 – Low *Carex* 14 – Lingonberry 15 – Crowberry/*Calluna* 16 – Poor shrubs

Sweden is divided into two climate zones so that each county south of Värmland, Gävleborg, and Dalarna belongs to the temperate zone and the remaining counties belong to the boreal zone. This corresponds to climatic zone differentiation made by IPCC for the southern region of Sweden in calculations of temperate averages within the Wetlands Supplement[113]. However, it should be noted that the temperate zone often is referred to as the hemi-boreal zone.

[113] The 2013 IPCC Supplement to the 2006 GLfor N4ational GHG Inventories: Wetlands

Emission factors for Forest land are taken from the IPCC 2013 supplement for Wetlands (see Table A3:2.8). The emission factors in the supplement was evaluated in a project to determine which factors was most suitable for Sweden.

Data on emissions from grasslands are scarce and most often taken from studies looking at intensively used grasslands where nutrients are commonly applied. For this reason, the emission factors for Grasslands proposed in the IPCC Wetland supplement were put aside in favour of those applied on Forest Land as Swedish Grasslands in the reporting only includes those that are natural pastures.

Table A3:2.8 Emission factors for drained organic forest soils.

Land category	Climate	Nutrient status	Emissions t CO_2-C ha^{-1}
Forest	Boreal	Rich	0.93
		Poor	0.25
	Temperate	Rich	2.6
		Poor	2.6
Grassland	Boreal	Rich	0.93
		Poor	0.25
	Temperate	Rich	2.6
		Poor	2.6

The area data are presented in Table A3:2.9. 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 A3:2.9. The area of different organic forest soils classes.

	Area of drained organic forest soils [kha]					Area of drained organic grassland soils [kha]				
	Boreal		Temperate			Boreal		Temperate		
	poor	rich	poor	rich	total	poor	rich	poor	rich	total
1990	280	393	74	312	1060	0	5.4	0	14.7	20.1
2017	271	314	59	281	926	0	4.2	0	13.4	17.6

From Submission 2015 also the emissions from DOC has been included using the same area as described above and an emission factor of 0.12 CO_2-C ha^{-1} yr^{-1} [114].

[114] Lindgren and Lundblad 2014

3.1.9 Methodology soil organic carbon for Cropland on mineral soils CRF 4B

Swedish arable land covers approximately 3 Mha and its topsoil contains about 300 Mt C. The five-parameter soil carbon model ICBM-region is used to calculate annual C balance of the soil based on national agricultural crop yield and manure statistics, and uses allometric functions to estimate the annual C inputs to soil from crop residues[115]. The method is a Tier III method and the model is run for eight production regions (see Figure A3:2.2.). ICBM was calibrated using long-term field experiments[116] and is continuously being refined accordingly with the latest observations from both long-term field and soil inventory data.

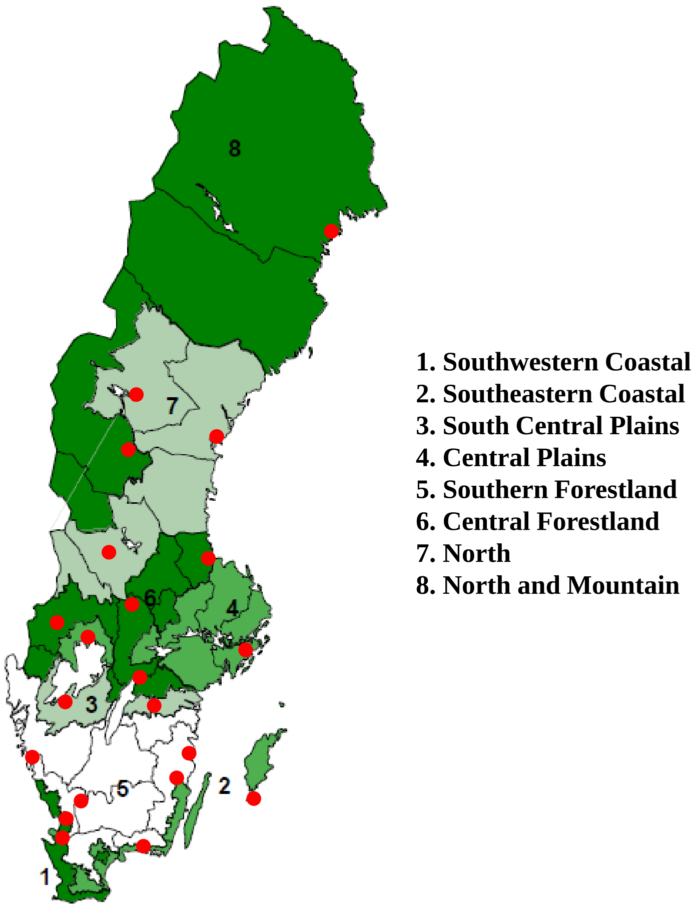

Figure. A3:2.2. The eight Swedish agricultural production regions (PO8, bold character) and location of climate stations (red circles) used (Adapted from SCB, Statistics Sweden and Andrén et al. 2008).

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 that affects the soil organic carbon decomposition rates in each region

115 Andrén, O et.al. 2004. Andrén, O. et. al. 2008.

116 Andrén, O. and Kätterer, T. 1997.

and year[117]. It is calculated 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 (see Figure A3:2.3.). The area weighted annual change per hectare is calculated on a national basis and used together with the area estimates from the NFI to scale the emissions to national level (as described in previous sections).

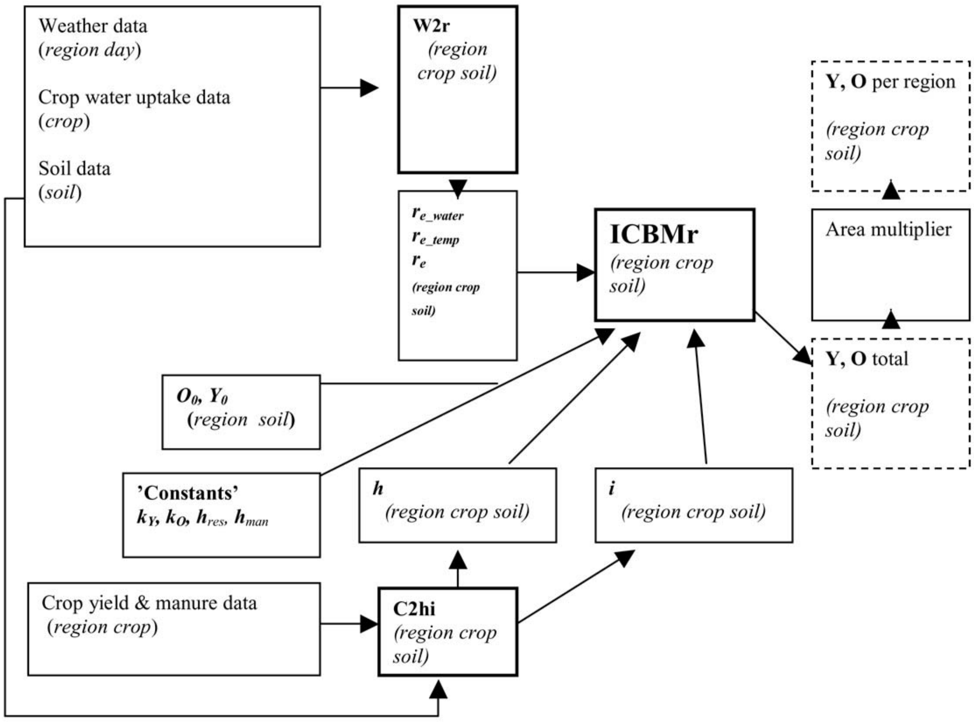

Figure A3:2.3. The ICBMregion concept. Crop, weather, and soil data for each region are used in the weather-to-re module W2re, calculating soil climate, re, for each region, crop and soil top left. The initial carbon mass values O0, Y0) are taken from soil inventory data. Parameters kY, kO, hres, hman are regarded as constants Table 1, and the indices res and man indicate crop residues and manure, respectively. Crop yield and manure input data are used to calculate C input to soil i, as well as a weighted h, by the allometric functions in the C2hi module. The two initial values O0, Y0) and the five parameters re, kY, kO, h, i) are then used for calculating Y and O kg ha 1. These are then multiplied by the actual area to obtain totals for, e.g., region.

117 Bolinder, M.A., et. al. 2012

3.1.10 Methodology soil organic carbon for Cropland on organic soils CRF 4B

The area of organic soils on cropland was assessed in a recent study[118] following upp previusly used studies[119]. In these studies, geographical information about soil types 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 2015 was estimated to be 225 722 ha of which 177 120 ha was classified as peat soils. This is a significant decrease compared to the study by total area of agricultural organic soils in Sweden 2008 which was estimated to be 267 990 ha of which 198 264 ha was classified as peat soils. This decline in the area of organic soils follows the decline in total agricultural soils.
To avoid double counting of areas, areas assessed as grazing land, tree plantations and wetlands are withdrawn from the estimated peat soil area since these areas are included in the reporting under Grassland, Forest land and Wetland respectively. 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 and the total Cropland area for 2008 and 2015 respectively based on the studies mentioned above. The relationship between organic soil and total Cropland area for intermediate years and the years from 1990 to 2007 is interpolated or extrapolated using the 2008-2015 trend in the relationship organic soils vs. total agricultural area. The total area of agricultural organic soil 2008 was 145 kha and for 2015 it was 139 kha.

Since Submission 2015 a national emission factor for cropland on organic soils is used to calculate the mean annual carbon loss per area. A literature review containing many of the references within the IPCC Wetland supplement[120] was made and the result was a lower emission factor (6.1 ton CO_2-C ha^{-1} yr^{-1}) than the one presented in the WL supplement. This emission factor was developed using Swedish, Norwegian and Finnish studies and did not take into account differences in the methods used in the studies. Such corrections was made in the WL GL but since these adjustments are not covered in detail within the WL GL it was impossible to use exactly the same method. Despite method differences it was recommended to use the national emission factor as to avoid studies from countries with temperature conditions that are not fully representable for Sweden as temperature exerts a strong control on emissions[121] .

From Submission 2015 also the emissions from DOC has been included using the same area as described above and an emission factor of 0.12 CO_2-C ha^{-1} yr^{-1}[122] (.

[118] Pahkakangas et. al. 2016

[119] Berglund et. al. 2009

[120] The 2013 IPCC Supplement to the 2006 GLfor National GHG Inventories: Wetlands

[121] Lindgren and Lundblad, 2014

[122] Lindgren and Lundblad, 2014

The annual emission from organic soils for Cropland remaining cropland is calculated as:

$$CO_{2,Organiccropland} = A \cdot (EF_{soil} + EF_{DOC}) \cdot 44/12$$

Where A is the annual area of organic soils estimated as described above, EF_{soil} is the emission factor for the loss to the atmosphere and EF_{DOC} is the loss of dissolved carbon.

3.1.11 Methodology CO_2 emissions and non-CO_2 emissions from mineralization when extracting peat CRF 4D and 4 (II)

The emitted greenhouse gases from areas used for extracting peat is calculated as the product of the extracted area and an emission factor for each of the gases CO_2, N_2O and CH_4:

Emissions (gas)=P•EF

where *P*=production area [ha] and *EF*=emission factor [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. During the period 1990-2009, production areas are obtained from Svenska Torvproducentföreningen[123]. From 2010 the production area has been provided by the Swedish geological survey. The study by Lindgren and Lundblad[124] propose that the emission factors including also the emissions due to DOC and ditches presented in the wetland Supplement should be used to calculate the emissions from peat production areas. The emission factors can be found in 10 and the extracted area is found in 1.

The off-site emissions from horticultural peat are based on the annual production volume (Table A3:2.11) and a national estimate of the carbon content of peatbased on information from the peat producers in Sweden. The estimate is based on the following assumptions for the harvested peat: A dry density of 100 kg m^{-3} , carbon content of 55 %, and an organic content of 96 %. The resulting carbon content was estimated to 0.053 ton C (m^3 of air-dry peat)$^{-1}$. The annual emission was based on measurements of carbon stocks in a long term trial (1956-2009) in Sweden where peat was used as amendment to the soil[125]. Based on the initial and final carbon

[123] Svenska Torvproducentföreningen, 2006

[124] Lindgren and Lundblad, 2014

[125] Kätterer et. al. 2011

content and the annual addition of carbon an annual decomposition rate of 1.758 % was estimated and used for the calculations of emissions from horticultural peat:

$$CO_{2,HP} = C_X \cdot D \cdot 44/12$$

Where $CO_{2,HP}$ is the annual emission C_X the actual carbon stock (t C) and D the decomposition rate (0.01758). The annual carbon stock a given year (X) is calculated as:

$$C_X = (C_{X-1} + \Delta C_i)$$

Where $C_{X-1}$is the remaining carbon from previous year and ΔC_i is the annual addition of carbon.

Emissions of CO_2 (including DOC) are reported in CRF-table 4.D (4.D.1.1, peat extraction remaining peat extraction) whereas emissions of N_2O and CH_4 are reported in CRF-table 4(II).

Table A3:2.10. The emission factors for peat extraction areas.

Land category	Emission Factors (unit mass per hectare)				
	ton CO_2-C	kg N_2O-N	kg CH_4	ditch kg CH_4	DOC ton CO_2-C
Peat Extraction	2.8	0.3	6.1	26.2	0.12

Table A3:2.11. The production area and the production of horticultural peat.

Year	Production area [ha]	Production of horticultural peat [1000 $m^3 \cdot yr^{-1}$]
1990	6600	794
1991	6100	785
1992	6600	900
1993	6400	915
1994	7000	1066
1995	7700	1055
1996	6800	1084
1997	8100	1203
1998	6700	671
1999	9700	1460
2000	10400	1000
2001	10500	1400
2002	10200	1800
2003	9400	1500
2004	8000	1108
2005	10300	1545
2006	6200	1716
2007	10300	1302
2008	9159	1434
2009	8515	1198
2010	7597	1250
2011	8366	1611
2012	8693	977
2013	8156	1 815
2014	9585	1512
2015	10127	1266
2016	10376	1676
2017	8987	1662

3.1.12 Methodology for dead organic matter and soil organic carbon for conversion between land-use categories CRF-tables 4A.2.1-5, 4B.2.1-5, 4C.2.1-5 and, 4E.2.1-5

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 about 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 [Mt 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 A3:2.12). 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:

i. When available, average carbon content per area was used to calculate the annual removal/emission over a 20 year transition period according to IPCC. Average soil carbon content (mineral soils) was 110 tonne C ha^{-1} for grassland, 100 tonne C ha^{-1} for Cropland and 45 tonne C ha^{-1} for Forest land. A sub-category representing forests on former agricultural soils hold about 87 ton C/ha. The average litter pool for Forest soils was 30 tonne C ha^{-1} for Forest land whereas the remaning litter pool after conversion was based on an assessment using areal photos for all other land use classes.

ii. The annual change in the litter pool for land use changes to Forest land is based on results from several chronosequence studies[126]. 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 was conservatively assessed to a removal factor of 0.3 kt C kha^{-1}.

iii. For conversions on organic soils the emission factor used is the same as for the initial or the final land-use.

iv. For 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.

v. 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.

vi. For conversions from Forest land to Settlements the emission factors was previously estimated for three major land-use groups: Conversion to roads, power lines and proper settlement. . Based on a new study[127] there is

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

[127] Karltun et. al. 2017

evidence that only a minor part of the litter (humus layer) and soil carbon is affected by the LUC. The assumption is now that on average 30% of the litter and soil organic carbon is lost over a 20 year period for forest land converted to settlement.

vii. For SOC on cropland or grassland converted to settlement the remaining SOC after 20 years was assumed to be 30% and 90% respectively according to the same study as reffered to above.

The same assumptions and emission/removals factors are used for the reporting of article 3.3 activities under the KP, but after 20 years, parts of the converted area is calculated as the corresponding ”remaining” category. However, the area is still reported in the same KP activity according to the KP-rules, where areas are accumulated since 1990 and do not leave the activity (except AR for D). This means that there is a subcategory under each article 3.3 activity that is calculated as a remaining category.

Table A3:2.12. The removal/emission factors used to calculate changes in carbon pools on converted land.

Removals/emissions (-) [kt 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	-0.260[1]	-6.1[3]	0.300[1]	0.300[1]
A 2.2 Grassland converted to Forest Land	-0.225[1]	-0.34[2]	0.300[1]	0.300[1]
A 2.3 Wetland converted to Forest Land	-	-0.34[2]	0.300[1]	0.300[1]
A 2.4 Settlements converted to Forest Land	0.17[4]	-0.34	0.300[1]	0.300[1]
A 2.5 Other land converted to Forest Land	0.17[4]	-0.34[2]	0.300[1]	0.300[1]
B 2.1 Forest land converted to Cropland	0.450[1]	-0.3[3]	-0.28[1]	-0.28[1]
B 2.2 Grassland converted to Cropland	-0.500[1]	-0.3[3]		-0.0005 -
B 2.3 Wetland converted to Cropland	-	-6.1[3]	-	-
B 2.4 Settlements converted to Cropland	-0.05[4]	-6.1[3]	-	-
B 2.5 Other land converted to Cropland	-0.05[4]	-6.1[3]	-	-
C 2.1 Forest land converted to Grassland	0.17	-0.34[2]		-0.075[1]
C 2.2 Cropland converted to Grassland	0.05	-6.1[3]	-	-
C 2.3 Wetland converted to Grassland	0.07[1]	-1.34[6]	-	-
C 2.4 Settlements converted to Grassland	0.07[4]	-1.34[6]		0.01[1]
C 2.5 Other land converted to Grassland	-	-0.34[2]		0.12[1]
E 2.1 Forest land converted to Settlements	-0.68[1]	-2.25	-0.495	-
E 2.2 Cropland converted to Settlements	-2.67[1]	-	0	-
E 2.3 Grassland converted to Settlements	-0.55[1]	-	0	-
E 2.4 Wetlands converted to Settlements	-	-	0	-
E 2.5 Other land converted to Settlements	-1.13[1]	-	0	-

[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.

[6] Same emission factors as for drained organic grassland soils

3.2 CRF 4(I), 4(II), 4(III), 4(IV) and 4(V)

This section relates to NIR section 6.4.2.

3.2.1 Direct N_2O emissions from N-fertilization, CRF 4(I)

The reported annual $N_2O_{direct\ fertilizer}$ [Kt 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 [kt yr^{-1}] and *EF* is the emission factor for N_2O emissions from N-inputs (IPCC-default emission factor of 1 %[128]). Finally, N_2O-N is converted by multiplying N by 44/28 (Table A3:2.33). Note that the emissions factor was updated in Submission 2015 to comply with the IPCC 2006 GL.

Table A3:2.33. The annual amount of synthetic fertilizer sold for application in forestry and the annual direct N_2O emission from nitrogen fertilization.

Year	Fertilized area, kha	Synthetic fertilizer, N, kt yr^{-1}	Emission, N_2O, kt yr^{-1}
1990	69.2	10479	0.165
1991	42.7	6104	0.096
1992	28.6	4293	0.067
1993	26.8	3809	0.060
1994	24.0	3354	0.053
1995	27.3	3885	0.061
1996	24.1	3518	0.055
1997	18.8	2771	0.044
1998	19.3	2808	0.044
1999	24.9	3662	0.058
2000	24.3	3597	0.057
2001	20.6	3044	0.048
2002	13.8	2100	0.033
2003	16.9	2491	0.039
2004	22.4	3116	0.049
2005	34.2	4624	0.073
2006	33.4	4964	0.078
2007	46.5	6971	0.110
2008	59.6	8941	0.141
2009	55.5	8325	0.131
2010	80.4	12000	0.189
2011	52.9	7930	0.125
2012	45.6	6835	0.107
2013	23.9	3580	0.056
2014	22.5	3390	0.053
2015	33.2	5000	0.079
2016	29.3	4410	0.069
2017	25.1	3786	0.059

[128] Intergovernmental Panel on Climate Change, 2006.

3.2.2 Non-CO2 emissions from drained organic soils, CRF 4(II)

A Tier 1 methodology is used and the reported figures refer to N_2O-N and CH_4 for each land use category with different emission factors depending on nutrient status and climate and multiplied with corresponding areas (forest land and grassland).

Emission of CH_4 organic includes emissions from the soil itself and from the ditches multiplied with the fraction of ditches[129].

The emission factors can be found in Table A3:2.44. Emission factors are either based on the WL SL or country specific as noted in the table.

The same source of data for AD as for CO_2-emissions is used to calculate the emissions for drained organic soils for Forest land, Cropland and Grassland. Emissions from Wetlands are covered under section 1.1.9.

Table A3:2.44. Emission factors for non-CO_2 emissions from drained organic soils.

Land category	Climate	Nutrient status	Emission Factors (unit mass per hectare)			
			kg N_2O-N	kg CH_4	ditch kg CH_4	DOC ton CO_2-C
Forest	Boreal	Rich	3.2	2	5.4	0.12
		poor	0.22	7	5.4	0.12
	Temperate	Rich	2.8	2.5	5.4	0.12
		poor	2.8	2.5	5.4	0.12
Cropland	Boreal/ Temperate		IE	0	58.3	0.12
Grassland	Boreal	Rich	3.2	1.4	10.85	0.12
		poor	0.22	1.4	10.85	0.12
	Temperate	Rich	2.8	2.5	10.85	0.12
		poor	2.8	2.5	10.85	0.12

129 Lindgren and Lundblad (2014)

3.2.3 N_2O emissions from disturbance associated with land-use or management change, CRF 4(III)

A Tier 1 methodology is used. The reported annual N_2O emission from disturbance associated with land use conversion to Cropland (N_2O_{conv} [Kt yr^{-1}]) is calculated according to the equation below, based on equation 11.8 in IPCC 2006 GL (IPCC[130]):

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

where ΔC_{min} is the annual emission of carbon due to soil mineralization (IPCC[131]), *EF* is the emitted proportion N_2O from N mineralized including volatilization (a constant of 1 %; IPCC) and 44/28 is used to convert N to N_2O. The amount of carbon lost is taken from the corresponding carbon stock changes for the relevant categories. $C:N_{ratio}$ is the average ratio between carbon and nitrogen in the soil. Previously the default ratio of 15 was used for forest land, grassland and settlements whereas a ratio of 10 was used for cropland. As recommended by reviewers the C:N-ratio has now been updated for most of the reported categories to comply with the initial conditions before LUC or according to the management system. For Cropland remaining Cropland the C:N-ratio has been estimated for each of the eight production regions (as described in section 3.1.9) based on the Soil and crop inventory[132]. The C:N-ratio varied from 10 to 14 with the highest values in the northern part of the country. For the caluclations of mineralisation regional data on carbon stock changes from the calcuations described in section 3.1.9 was used. For the LUC-categories, C:N –ratios were obtained from the SFSI and for land use change from Forest land a C:N-ratio of 23 was used, for Land use change from Grassland a C:N-ratio of 17 was used and for Land use change from Cropland (and for Settlemen converted to Cropland) a C:N-ratio of 11 was used. For LUC from other land a C:N-ratio of 15 was used.

3.2.4 Indirect emissions of N_2O

In addition to the direct emissions of N_2O from managed soils that occur through a direct pathway (i.e., directly from the soils to which N is applied), emissions of N_2O also take place through two indirect pathways, namely the volatilisation of N following the application of synthetic and organic N fertilizers and the leaching and runoff from land of N from synthetic and organic fertiliser additions.

The method to calculate the emissions is Tier 1 for volatilisation and Tier 2 for leaching and run off. Both methods are based on the amount of synthetic fertiliser applied on forest soils, adding the annual amount of N mineralised in mineral soils

130 Intergovernmental Panel on Climate Change, 2006

131 Intergovernmental Panel on Climate Change, 2003.

132 https://www.slu.se/en/departments/soil-environment/environment/akermarksinventeringen/undersokningar/soil-and-crop-inventory/

associated with loss of soil C from soil organic matter, as a result of changes to land use or management in regions where leaching/runoff occurs to the leaching part.

The parameters used for volatilisation was the IPCC default values $Frac_{GASF}$ = 0.1 and EF_4 = 0.01 [kg N–N_2O (kg NH_3–N + NO_x–N volatilised)$^{-1}$]. $Frac_{GASF}$ is the fraction of synthetic fertiliser N that volatilises as NH3 and NOx, kg N volatilised (kg of N applied)$^{-1}$. For run off the $Frac_{LEACH}$ was based on the average leakage from forest soils in Ring (2007). $Frac_{LEACH}$ was therefore set to 0.075 and the emission factor used was the IPCC-default (EF_5=0.0075). Emission was calculated according to:

$$N_2O_{indirect} = N_2O - N_{direct} \cdot (Frac_{GASF} \cdot EF_4 + Frac_{LEACH} \cdot EF_5) \cdot 44/28$$

3.2.5 Emissions from biomass burning, CRF 4(V)

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 [Kt 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 [Kt ha^{-1}].

The annual emission of nitrous dioxide ($N_2O_{burning}$ [Kt 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-$_{burning}$ [Kt 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 Table A3:2.55. To avoid double counting from submission, 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 are found inside brackets in Table A3:2.55. The method is Tier 1 and the emission factors are IPCC-default.

Table A3:2.55. Annual emissions from biomass burning.

Year	Fire category [ha yr^{-1}]					Annual emissions		
	Wildfire			Controlled burning		CO_2	N_2O	CH_4
	Forest	Sparsely covered by trees	No tree cover	Regene-ration	Bio-diversity	[Kt yr^{-1}]	[Kt yr^{-1}]	[Kt 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	77	124	221	570	0	IE (5)	0.00015	0.022
1999	794	292	240	2293	200	IE (32)	0.00097	0.141
2000	784	329	440	1138	400	IE (32)	0.00097	0.141
2001	412	286	556	2144	600	IE (33)	0.00099	0.144
2002	877	413	1334	3002	800	IE (53)	0.00160	0.232
2003	1316	1021	1665	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	4646	539	525	2693	1410	IE (143)	0.00429	0.624
2007	523	312	255	1273	377	IE (26)	0.00079	0.114
2008	4280	1377	456	1272	2012	IE (145)	0.00434	0.632
2009	370	283	259	1357	256	IE (21)	0.00062	0.090
2010	144	147	249	335	99	IE (8)	0.00023	0.034
2011	349	310	286	1139	433	IE (23)	0.00070	0.101
2012	109	85	289	758	182	IE (10)	0.00031	0.045
2013	477	316	715	581	539	IE (27)	0.00081	0.118
2014	10499	2124	2043	992	1804	IE (278)	0.00834	1.213
2015	256	244	96	444	326	IE (15)	0.00046	0.067
2016	715	247	326	433	441	IE (28)	0.00084	0.122
2017	433	168	811	340	327	IE (20)	0.00061	0.088

3.3 Uncertainties and time series consistency

This section relates to NIR section 6.4.3.

3.3.1 Living biomass, CRF 4A, 4B, 4C, 4D, 4E and 4F

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[133]. 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:

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

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

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

[133] 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:

$$Uncertainty = 2 \cdot SE$$

3.3.2 Exploring the importance of stratification for estimating carbon stock change based on random sampling.

On request from the External Review Team (preliminary In Country Review, September 2013) Sweden was encouraged to explain how data per stratum was summed up to national scale in a more transparent way. Based on a full record of sample units (year 2012 without extrapolation),

Table A3:2.66 shows that for living biomass, the summed removal over strata is the same as the reported total. Also variances over strata correspond to the total variance. The estimated Standard Error of the estimate is calculated as the square root of the variance. The geographical position of sample units partly or completely subject to activities AR and D is found in NIR, Figure 10.4. Compared with a total land and fresh water area of around 45 M ha, around 28 M ha is reported under FM. This corresponds nearly to 20 000 sample plots and, thus, a corresponding map for FM would be difficult to interpret.

Table A3:2.66. How estimates and estimated variances per stratum are summed up to national scale using formulas from section 3.2.1 (2012). Smaller trees (removal -3.986) chapter 1.1.3 are excluded from FM.

Stratum	Living biomass [Mt CO_2 yr^{-1}] (and [Mt CO_2 yr^{-1}]^2 for Variance)								
	Forest Management			Aff./ Reforestation			Deforestation		
	Estim.	Var	SE	Estim.	Var	SE	Estim.	Var	SE
1	-3,49	0,17	0,41	-0,02	0,00	0,01	0,00	0,00	0,00
2	-2,80	0,30	0,55	-0,03	0,00	0,02	0,02	0,00	0,02
3	-3,83	0,47	0,68	-0,01	0,00	0,01	0,25	0,06	0,25
4	-1,16	0,53	0,73	-0,08	0,00	0,05	0,00	0,00	0,00
5	-1,56	1,11	1,05	-0,05	0,00	0,03	0,00	0,00	0,00
6	-0,83	0,11	0,33	-0,01	0,00	0,01	0,00	0,00	0,00
7	-1,99	0,55	0,74	-0,05	0,00	0,03	0,14	0,01	0,11
8	1,34	2,00	1,41	-0,01	0,00	0,01	0,00	0,00	0,00
9	-0,91	0,75	0,87	-0,01	0,00	0,01	0,00	0,00	0,00
10	-0,64	0,14	0,37	-0,01	0,00	0,01	0,00	0,00	0,00
11	-0,26	0,01	0,11	0,00	0,00	0,00	0,00	0,00	0,00
12	-1,53	0,73	0,85	-0,01	0,00	0,01	0,00	0,00	0,00
13	-2,85	0,68	0,83	-0,20	0,01	0,09	0,03	0,00	0,04
14	-0,46	0,33	0,58	-0,07	0,00	0,06	0,00	0,00	0,00
15	-0,04	0,33	0,58	-0,02	0,00	0,01	0,00	0,00	0,00
16	-0,65	0,17	0,41	-0,09	0,00	0,04	0,18	0,03	0,17
17	-0,84	0,13	0,36	-0,03	0,00	0,03	0,51	0,22	0,47
18	-1,31	0,13	0,36	-0,01	0,00	0,01	0,06	0,00	0,05
19	-1,30	0,27	0,52	-0,09	0,00	0,06	-0,01	0,00	0,00
20	-0,60	0,21	0,46	0,00	0,00	0,03	0,00	0,00	0,00
21	-0,76	0,07	0,27	0,00	0,00	0,00	0,00	0,00	0,00
22	-1,71	0,17	0,42	-0,09	0,00	0,07	0,07	0,01	0,07
23	-1,24	0,29	0,54	-0,08	0,00	0,03	0,02	0,00	0,02
24	-0,32	0,31	0,56	-0,01	0,00	0,02	0,00	0,00	0,00
25	-1,36	0,29	0,54	-0,08	0,00	0,04	0,01	0,00	0,01
26	-0,11	0,18	0,42	-0,02	0,00	0,01	0,02	0,00	0,04
27	-0,16	0,16	0,40	0,00	0,00	0,00	0,00	0,00	0,00
28	0,65	0,28	0,53	-0,05	0,00	0,02	0,00	0,00	0,00
29	-0,22	0,05	0,22	-0,05	0,00	0,02	0,00	0,00	0,00
30	-0,24	0,08	0,28	-0,02	0,00	0,02	0,00	0,00	0,00
31	-0,27	0,01	0,10	0,00	0,00	0,00	0,06	0,00	0,05
Total	**-31**	**11**	**3.3**	**-1.2**	**0.03**	**0.18**	**1.3**	**0.34**	**0.58**

3.3.3 Evaluating consequences from extrapolation.

To reduce the effect of random variation and to make estimates more consistent for estimates of the most recent years, Sweden has introduced extrapolation for inventory cycles without a full record. Each inventory cycle is extrapolated 0, 1, 2, 3, and 4 years, respectively, but after a re-inventory, extrapolated values are substituted by values based on measurements. The advantages with extrapolation are mainly a reduced effect of random sampling variation and a more consistent (harmonised) reporting. A disadvantage is that, e.g., a large true change in removal from e.g. increased harvest intensity in 2017 would only influence on 20% of the sample plots the first year and it takes five year until the full effect of such change is reflected by all sample plots. In other words, extrapolation reports a trend based on historical data and average out estimates over time. Observe that the extrapolation is made per land use category/ land use change category, activity but not per plot.

There are different options to extrapolate data for cycles with an incomplete data record. Sweden uses trend extrapolation. Trend extrapolation is based on the five years former the missing data and is used for all estimates of changes in living biomass and areas under both the UNFCCC and the KP.

In submission 2014, consequences of different extrapolation techniques were evaluated. It was concluded that i) extrapolation improved the accuracy of estimates compared with un-weighted (no extrapolation) estimates, and ii) that extrapolation based on the 5 former years was a reasonable trade of between averaging out data and being up to date. From submission 2015, average extrapolation is substituted by trend extrapolation. The trend extrapolation has an advantage that e.g. accumulated areas under D will always increase while this is not always the case for average extrapolation. Using trend extrapolation, the estimated total land and fresh water area is the same for both measured (with a full record of around 30000 sample plots) and extrapolated areas (the for most recent years).

References

Andrén, O., & Kätterer, T. (1997). ICBM – the Introductory Carbon Balance Model for exploration of soil carbon balances. Ecological Applications, 7, 1226-1236.

Andrén, O., Kätterer, T., & Karlssson, T. (2004). ICBM regional model for estimations of dynamics of agricultural soil carbon pools. Nutrient Cycling in Agroecosystems, 70, 231-239.

Andrén, O., Kätterer, T., Karlsson, T., & Eriksson, J. (2008). Soil C balances in Swedish agricultural soils 1990-2004, with preliminary projections. Nutrient Cycling in Agroecosystems, 81, 129-144.

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.

Bolinder, M.A., Fortin, J.G.,Anctil, F., Andrén, O., Kätterer, T., de Jong, R., & Parent, L.E. (2012). Spatial and temporal variability of soil biological activity in the Province of Québec, Canada (45-58 oN, 1960-2009) – calculations based on climate records. Climatic Change, Volume: 117 Issue: 4 Pages: 739-755

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.

Intergovernmental Panel on Climate Change. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Ektleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

Intergovernmental Panel on Climate Change. 2014. 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G. (eds). Published: IPCC, Switzerland.

Hallgren, G, Berglund, G. 1962. De odlade myrjordarnas omfattning och användning. Lantbrukshögskolan 1962.

https://www.slu.se/en/departments/soil-environment/environment/akermarksinventeringen/undersokningar/soil-and-crop-inventory/

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.

Karltun, E, Nilsson, T, Lundblad, M. 2017. Litter and soil carbon stock changes in connection to land-use changes – a method assessment for the Swedish LULUCF carbon inventory

Kätterer, T, Bolinder, M, Andrén, O, Kirchmann, H, Menichetti, L. 2011. Roots contribute more to refractory soil organic matter than above-ground crop residues, as revealed by a long-term field experiment. Agriculture, Ecosystems and Environment 141 (2011) 184–192.

Lindgren, A. and Lundblad, M. 2014. Towards new reporting of draind organic soils under the UNFCCC – assessment of emission factors and areas in Sweden. SLU. Department of Soil and Environment, Rapport 14. Uppsala 2014.

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

Pahkakangas S, Berglund, Ö, Lundblad, M, Karltun, E. 2016. Land use on organic soils in Sweden – a survey on the land use of organic soils within agriculture and forest lands during 1983-2014. SLU. Department of Soil and Environment Report 21. Uppsala 2016

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 Afforesttaion: 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 use (in CRF sector 2D3 Non-energy products from fuels and solvent use)

In 2016 Swedish Environmental Emissions Data (SMED) in cooperation with the Swedish Chemicals Agency (Skårman et al., 2016[134]), has further developed the calculation model for estimating the national emissions of NMVOC and CO_2 from use of solvents in Sweden. The model has been revised in order to meet international reporting requirements according to CLRTAP and UNFCCC as well as to support national needs. The model makes it possible to test different sets of emission factors within the solvent use sector. This function can be used to assess different actions and emission reduction potentials. Furthermore, the model can generate emissions per user category and product group. This information can be used when following-up the Swedish environmental quality objectives.
The calculation model is consumption-based with a product-related approach. Amounts of NMVOC and C in solvents and solvent-based products, produced in, imported to, used in, and exported from Sweden, was derived from the Swedish Product Register hosted by the Swedish Chemicals Agency. Emission factors from the literature have been used as far as possible, but in the case when emission factors are unavailable, country specific emission factors have been developed.

3.1 Definition of NMVOC

According to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), NMVOCs are defined as:
"any non-methane organic compound having at 293.15 K a vapour pressure of 0.01 kP or more, or having a corresponding volatility under the particular conditions of use."

3.2 Substance list

A manual selection has been made in order to select each substance with vapour pressure of 0.01 kPa or more at 293.15° K according to the chosen definition of NMVOC. The final substance list for 2013 contains 427 substances defined as NMVOC. The list includes CAS-number, name, molecular formula and carbon share for each substance. The carbon share for each substance 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

[134] Skårman et al., 2016. Swedish method for estimating emissions from Solvent Use. Further development of the calculation model. SMED report 192.

estimated by the Swedish Chemicals Agency as 85% of NMVOC, based on information in the Products Register. In cases where the carbon content cannot be derived from the Products Register, the default value of 60%, given in 2006 IPCC Guidelines for National Greenhouse Gas Inventories, has been used

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.

3.3 Activity data

The substance list has been used to extract quantities of NMVOC and C in substances found in the Products Register. Data extractions have been made for each year from 1992. The extractions show for each year:

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

When analysing the extractions from the Products Register, data for 1992-1994 showed not to be reliable to use for quantitative estimates of NMVOC and C emissions. The reason is that during this period the emissions of many substances still were reported as intervals, even if work has been done by the Swedish Chemicals Agency in order to further specify the amounts. There were also changes in the code system during this period. Therefore data from the Products Register are only used for 1995 and onwards.

Due to the two year delay in official statistics from the Products Register, activity data for the last year in the reported time series, is not published in time to be used in the latest submission and hence Sweden has chosen to equal data for the last year with data for the year before that. Estimated values for last year of one submission will always be updated with official data in the next submission.

3.4 Allocation

The extractions from the Products Register for 1995 and onwards 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. If the combination should be included, it has been given a specific:

- SNAP-code (according to EMEP/EEA guidebook)
- Industry group (grouping industry categories)
- Product group (grouping of product codes)
- Use category (industry, consumer and other)

Furthermore, it has to be determined if the product is used as raw material or not. Quantities of NMVOC used as raw material have been identified and handled separately from other quantities, since most of the solvents used as raw material will not be emitted but bound in products.

In order to avoid double-counting of reported emissions within other sectors an expert judgement has been made on both industry category and product function. All industrial activities reported in other CRF-codes are excluded from the extractions from the Products Register.

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.

3.5 Emission factors

Emission factors given in the literature, for example the EMEP/EEA guidebook (EEA, 2016), EU legislations, and other countries IIR´s, have been compiled and included in the model. Two emission factors have been developed for each activity; one for solvents used as raw material and one for the remaining quantities. The emission factors for raw material have been set to 0.001 for all SNAP codes, since most of the solvents will end up in the product and will not be emitted during production. A new emission factor for products used diluted in water or removed with water has been introduced in the new model. The new emission factor is set to 0.275 and it has been calculated as average of 0.05 and 0.5 according to the information in the EMEP/EEA Guidebook 2016 for domestic solvent use including fungicides, section 3.2.4. (EEA, 2016). In the previous estimates these products were not treated separately and consequently the emission factor of 0.95 was used also for water diluted products. The country specific emission factors have been developed in order to adjust to the old time series 1990-2001, developed by SMED in 2002 (Kindbom et. al., 2004). However, for some activities errors have been identified in previously reported data for 1990, and consequently those emissions have been corrected. Furthermore, application techniques, available information in the environmental reports for specific industries, as well as other pathways of release (e.g. water), have been considered when developing the country specific emission factors.

Table III- 1. Country specific emission factors for SNAP codes in "Domestic solvent use including fungicides". Emission factor references given at the end of Annex 3:3. EFs in italic are interpolated.

Year	060408ei	060408eii	060408fi	060408fii	060408gi	060408gii	060408hi	060408hii	060408i	060411
1995	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
1996	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
1997	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
1998	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
1999	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2000	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2001	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2002	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2003	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2004	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2005	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2006	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2007	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2008	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2009	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2010	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2011	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2012	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2013	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2014	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2015	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2016	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2017	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]

Table III- 2. Country specific emission factors for SNAP codes in "Coating applications". Emission factor references given at the end of Appendix II. EFs in italic are interpolated.

Year	060101	060102	060103	060104	060105	060106	060107	060108	060109
1995	0.95[1]	0.95[1]	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.29[1]	0.95[1]	0.95[1]
1996	*0.92*	*0.92*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.29[1]	*0.93*	0.95[1]
1997	*0.89*	*0.89*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.29[1]	*0.90*	0.95[1]
1998	*0.86*	*0.86*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.29[1]	*0.88*	0.95[1]
1999	*0.83*	*0.83*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.21[3]	*0.86*	0.95[1]
2000	*0.79*	*0.79*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.83*	0.95[1]
2001	*0.76*	*0.76*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.81*	0.95[1]
2002	*0.73*	*0.73*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.78*	0.95[1]
2003	0.70[3]	0.70[3]	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.76*	0.95[1]
2004	*0.68*	*0.68*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.74*	0.95[1]
2005	*0.65*	*0.65*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.71*	0.95[1]
2006	*0.63*	*0.63*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.69*	0.95[1]
2007	*0.61*	*0.61*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.67*	0.95[1]
2008	*0.59*	*0.59*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.64*	0.95[1]
2009	*0.56*	*0.56*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.62*	0.95[1]
2010	*0.54*	*0.54*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.59*	0.95[1]
2011	*0.52*	*0.52*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.57*	0.95[1]
2012	*0.50*	*0.50*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.55*	0.95[1]
2013	*0.47*	*0.47*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.52*	0.95[1]
2014	0.45[3]	0.45[3]	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	0.50[3]	0.95[1]
2015	0.45[3]	0.45[3]	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	0.50[3]	0.95[1]
2016	0.45[3]	0.45[3]	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	0.50[3]	0.95[1]
2017	0.45[3]	0.45[3]	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	0.50[3]	0.95[1]

Table III- 3. Country specific emission factors for SNAP codes in “Degreasing”, “Dry cleaning” and “Printing”. Emission factor references given at the end of Appendix II. EFs in italic are interpolated.

Year	060201	060203	060204	060202	060403
1995	0.61[5]	0.61[5]	0.61[5]	0.30[6]	0.65[1]
1996	*0.58*	*0.58*	*0.58*	0.30[6]	*0.64*
1997	*0.55*	*0.55*	*0.55*	0.30[6]	*0.63*
1998	*0.53*	*0.53*	*0.53*	0.30[6]	*0.61*
1999	*0.50*	*0.50*	*0.50*	0.30[6]	*0.60*
2000	0.47[5]	0.47[5]	0.47[5]	0.30[6]	*0.59*
2001	*0.44*	*0.44*	*0.44*	0.30[6]	0.58[1]
2002	*0.41*	*0.41*	*0.41*	0.30[6]	*0.55*
2003	*0.39*	*0.39*	*0.39*	0.30[6]	*0.53*
2004	*0.36*	*0.36*	*0.36*	0.30[6]	*0.51*
2005	0.33[5]	0.33[5]	0.33[5]	0.30[6]	*0.49*
2006	*0.30*	*0.30*	*0.30*	0.30[6]	*0.47*
2007	*0.27*	*0.27*	*0.27*	0.30[6]	*0.45*
2008	*0.25*	*0.25*	*0.25*	0.30[6]	*0.43*
2009	*0.22*	*0.22*	*0.22*	0.30[6]	*0.41*
2010	0.19[5]	0.19[5]	0.19[5]	0.30[6]	*0.39*
2011	0.19[5]	0.19[5]	0.19[5]	0.30[6]	*0.36*
2012	0.19[5]	0.19[5]	0.19[5]	0.30[6]	*0.34*
2013	0.19[5]	0.19[5]	0.19[5]	0.30[6]	*0.32*
2014	0.19[5]	0.19[5]	0.19[5]	0.30[6]	0.30[3]
2015	0.19[5]	0.19[5]	0.19[5]	0.30[6]	0.30[3]
2016	0.19[5]	0.19[5]	0.19[5]	0.30[6]	0.30[3]
2017	0.19[5]	0.19[5]	0.19[5]	0.30[6]	0.30[3]

Table III- 4. Country specific emission factors for SNAP codes in "Chemical products". Emission factor references given at the end of Appendix II. EFs in italic are interpolated.

Year	060305	060307	060308	060309	060311	060312	060313	060314
1995	0.30[1]	0.004[1]	0.004[1]	0.004[1]	0.004[1]	0.03[3]	0.010[1]	0.50[1]
1996	0.29[1]	*0.003*	*0.003*	*0.003*	*0.003*	0.03[3]	0.010[1]	0.46[1]
1997	0.29[1]	*0.003*	*0.003*	*0.003*	*0.003*	0.03[3]	0.010[1]	0.42[1]
1998	0.28[1]	*0.003*	*0.003*	*0.003*	*0.003*	0.03[3]	0.008[1]	0.38[1]
1999	0.28[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.008[1]	0.33[1]
2000	0.27[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.008[1]	0.29[1]
2001	0.26[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.25[1]
2002	0.26[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.20[1]
2003	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.20[1]
2004	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.20[1]
2005	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.20[1]
2006	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.20[1]
2007	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.20[1]
2008	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.003[3]	0.20[1]
2009	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.003[3]	0.20[1]
2010	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.003[3]	0.20[1]
2011	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.003[3]	0.20[1]
2012	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.003[3]	0.20[1]
2013	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.002[3]	0.20[1]
2014	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.002[3]	0.20[1]
2015	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.002[3]	0.20[1]
2016	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.002[3]	0.20[1]
2017	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.002[3]	0.20[1]

Table III- 5. Country specific emission factors for SNAP codes in "Other solvent and product use". Emission factor references given at the end of Appendix II. EFs in italic are interpolated.

Year	060405	060406	060407	060409	060412i	060412ii
1995	0.56[7]	0.64[1]	0.95[1]	0.95[1]	0.95[1]	0.275[2]
1996	0.56[7]	*0.63*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
1997	0.56[7]	*0.62*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
1998	0.56[7]	*0.61*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
1999	0.56[7]	*0.60*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2000	0.56[7]	*0.59*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2001	0.56[7]	0.58[1]	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2002	0.56[7]	*0.55*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2003	0.56[7]	*0.52*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2004	0.56[7]	*0.50*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2005	0.56[7]	*0.47*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2006	0.56[7]	*0.44*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2007	0.56[7]	*0.41*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2008	0.56[7]	*0.39*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2009	0.56[7]	*0.36*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2010	0.56[7]	*0.33*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2011	0.56[7]	*0.30*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2012	0.56[7]	*0.28*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2013	0.56[7]	*0.25*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2014	0.56[7]	0.22[3]	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2015	0.56[7]	0.22[3]	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2016	0.56[7]	0.22[3]	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2017	0.56[7]	0.22[3]	0.95[1]	0.95[1]	0.95[1]	0.275[2]

[1] Skårman, T., Danielsson, H., Henningsson, E., Östman, M. 2006. Revised Method for Estimating Emissions of NMVOC from Solvent and Other Product Use in Sweden. SMED Report no 75

[2] EMEP/EEA air pollutant emission inventory guidebook - 2016. 2.D.3.a Domestic solvent use including fungicides.

[3] Environmental reports

[4] EMEP/EEA air pollutant emission inventory guidebook - 2016. 2.D.3.d Coating applications. Table 3-20.

[5] EMEP/EEA air pollutant emission inventory guidebook - 2016. 2.D.3.e Degreasing. Table 3-4. Abatement efficiency from the GAINS model.

[6] EMEP/EEA air pollutant emission inventory guidebook - 2016. 2.D.3.f Dry cleaning. Table 3-3.

[7] EMEP/EEA air pollutant emission inventory guidebook - 2016. 2.D.3.i, 2.G Other solvent and product use. Table 3-11.

References

EEA (2016). EMEP/EEA air pollutant emission inventory guidebook 2016. https://www.eea.europa.eu/publications/emep-eea-guidebook-2016

IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 1 General Guidance and Reporting.

Kindbom, K., Boström, C.-Å., Skårman, T., Gustafsson, T., Talonpoika, M. (2004). ”Estimated emissions of NMVOC in Sweden 1988-2001”. On behalf of the Swedish Environmental Protection Agency. SMED and SMED&SLU Report. Series No 6 2004.

Skårman, T., Danielson, H., Jerksjö, M., Ifverberg, M. (2016). Swedish method for estimating emissions from Solvent Use. Further development of the calculation model. SMED Report No 192 2016

Annex 3:4: Rationale for data sources used for key categories in industrial processes sector (CRF 2)

For facility and emission estimates, the data has been compared and evaluated with other available data sources in terms of timing of reporting, accuracy, transparency, time-series consistency and completeness. In many cases, where available, EU ETS data is judged to give the best estimates.

For the key category 2.F.1 (Refrigeration and Air Conditioning Equipment), the rationale for choosing methodologies and data sources used are described under NIR 4.7.

Table A3:4.1. Rationale for data sources used for key categories in the industrial processes sector.

Key category	Available data source	Used data source	Rationale for data source used
2.A.1 CO_2	From 1990: - National production statistics - Production statistics from the company - IPCC default EF - Emissions data from personal communication with the companies From 2004: - Environmental reports from the companies From 2005: - Production statistics and emissions from EU ETS	1990 – 2004: - Production statistics from the company - IPCC default EF - Emissions data from personal communication with the companies From 2005: - Production statistics and emissions from EU ETS	1990-2004: Production statistics from the company gives best estimates (highest tier) compared to national statistics. Additional emission data from the company needed to estimate CO_2 from CKD, by-pass dust and organic compounds in raw meal. From 2005: We judge that EU ETS data gives the best estimates (highest tier).
2.A.2 CO_2	From 1990: - National production statistics from the Swedish Lime Association - IPCC default EF From 2005: - Emissions from EU ETS. Production statistics calculated from reported emissions.	1990 - 2004 - National production statistics from the Swedish Lime Association - IPCC default EF From 2005: - Emissions from EU ETS. Production statistics calculated from reported emissions.	1990-2004: Production statistics from the Swedish Lime Assocication company gives best estimates. From 2005: We judge that EU ETS data gives the best estimates (highest tier).

Key category	Available data source	Used data source	Rationale for data source used
2.B.2 N_2O	1991-1993: - National production statistics - IPCC default EF - Country specific EF 1990 and 1994-2012: - National production statistics - Production statistics and emission data from personal communication with the companies - IPCC default EF - Country specific EF From 2002: - Environmental reports from the companies	1990, 1994-2001: - Production statistics and emission data from personal communication with the companies 1991 – 1993: - National production statistics and country specific EF From 2002: - Environmental reports from the companies	Data from environmental reports give correct estimates. Using data from the facilities gives more accurate emissions compared to estimates based on production statistics and EF. 1991 – 1993: reported emissions are based on national production statistics and national EF due to lack of company data.
2.C.1 (2.C.1.a) CO_2	From 1990: - National production statistics - Energy statistics surveys - Production statistics, carbon contents and emission data from personal communication with the companies - National EF - IPCC default EF From 2004: - Environmental reports from the companies From 2005: - Emissions from EU ETS	1990 – 2004: - Carbon contents and emission data from personal communication with the companies - Energy statistics surveys - National EF From 2012: - Emissions from EU ETS - Emission data from personal communication with the companies - Environmental reports from the companies - National EF	Different data sources are used depending on facility and year. Facility related information from the companies gives best estimates (highest tier) compared to national statistics and IPCC default EF. We judge that EU ETS data gives the best estimates (highest tier). From 2005, emissions are collected from EU ETS for all facilities except one where data in EU ETS is lacking.
2.C.1 (2.C.1.c – iron sponge and iron powder) CO_2	From 1990: - National production statistics - Emission data from personal communication with the company - Energy statistics surveys - National EF - IPCC default EF From 2004: - Environmental reports from the company From 2005: - Emissions from EU ETS	1990 – 2004: - Emission data from personal communication with the company From 2005: - Emissions from EU ETS for the company	1990-2004: Facility related information from the company gives better estimates (highest tier) compared to national statistics and IPCC default EF. From 2005: We judge that EU ETS data gives the best estimates (highest tier).

Key category	Available data source	Used data source	Rationale for data source used
2.C.1 (2.C.1.b – primary pig iron and steel) CO_2	From 1990: - National production statistics - Production statistics from the companies - IPCC default EF From 2003: - Environmental reports from the companies	1990 – 2002: - Production statistics from the companies and average CO_2 IEF 2003-2007. From 2003: - Environmental reports from the companies	1990-2002: Splicing technique based on IPCC good practice guidance. From 2003: Most accurate for UNFCCC reporting. Same CO_2 emissions as in EU ETS since 2008. 2005-2007, EU ETS data did not contain all CO_2 sources.
2.C.1 (2.C.1.d) CO_2	From 1990: - National production statistics - IPCC default EF - Activity data from personal communication with the companies	1990 – 1995: - National production statistics and IPCC default EF.	No national EF available.
2.C.1 (2.C.1.e) CO_2	From 1990: - National production statistics - IPCC default EF - Activity data from personal communication with the companies From 2005: - Emissions from EU ETS	1990-2008: - Activity data from the company and IEF for 2009 (bentonite) and 2005 (organic binders) From 2005: - EU ETS	Different data sources are used depending on facility and year. We judge that EU ETS data gives the best estimates (highest tier). EU ETS data has not been complete until 2009 for all facilities.
2.C.3 PFCs	From 1990: - National production statistics - Production statistics and emission data from personal communication with the companies - IPCC default EF From 1992: - Anode effects in min/oven day from the company From 2004: - Environmental reports from the companies	1990 - 1991 - Production statistics and anode effects in min/oven day for 1992 from the company, and IPCC default EF From 1992: - Production statistics and anode effects in min/oven day from the company, and IPCC default EF	Production statistics and anode effects in min/oven day from the company and IPCC default EF gives the best estimate (Tier 2) by PFCs. In environmental reports, only data on total PFCs are reported.

Annex 3:5: Documents from Swedish Refrigeration & Heat Pump Association and Swedish Car Recyclers Association

Swe Environmental Protection Agency
IVL Swedish Environmental Research Institute

Stockholm den 12 oktober 2016

Recovery of fluorinated greenhouse gases at decommissioning of stationary and mobile systems in Sweden.

The use of ozone depleting substances and fluorinated greenhouse gases for refrigerants is regulated according to the Swedish Refrigeration Code of Best Practice. This standard, which was developed in the 1980's and published in 1988, has since seen continuous development. The standard was supplemented by regulations issued by SWEDAC (Sweden's national accreditation body). There are also supplementing fact sheets associated to this Swedish Refrigeration Code of Best Practice.

The Swedish Refrigeration Code of Best Practice is applicable to all types of stationary and mobile refrigeration, air conditioning and heat pump equipment that contain CFCs, HCFCs and HFCs as refrigerants. The standard stipulates responsibilities associated with installation and service as well as responsibilities that lie with the supplier of refrigerants. It also includes general directives on the choice of refrigerants and requirements on design, service, maintenance, operation and decommissioning of equipment.

In addition to the Swedish Refrigeration Code of Best Practice, there is also a Swedish regulation on fluorinated greenhouse gases and ozone depleting substances, "Förordning om fluorerade växthusgaser och ozonnedbrytande ämnen" (2007:846) that was taken into force 2008-01-01, and the EU regulation on fluorinated greenhouse gases (now 517/2014).

Sweden has since long had stringent requirements that the installation, service, maintenance and decommissioning only should be performed by certified personnel and businesses.

In Sweden, producers and importers of products, such as stationary and mobile refrigeration, air conditioning and heat pump equipment are obliged to reclaim end-of-life equipment. In addition, importer and distributers of refrigerants are required by law to free of charge reclaim recovered amounts of all refrigerant fluids, and provide container for this purpose. Recovered

SVENSKA
KYL&VÄRMEPUMP
FÖRENINGEN

Gustavslundsvägen 135, 167 51 Bromma, Sweden. Switchboard +46 (0)8 512 549 50 www.skvp.se

amounts of refrigerants that are not recycled must, by law, be destroyed. No emissions of HFCs are allowed from the destruction/incineration processes.

Stationary refrigeration

We, the Swedish Refrigeration & Heat Pump Association, "Svenska Kyl- och Värmepumpföreningen", business association for stationary and mobile refrigeration, air conditioning and heat pump equipment, make the judgement that in Sweden at least 95 % of fluorinated greenhouse gases are recovered at decommissioning of stationary refrigeration, air conditioning and heat pump equipment.
For transport refrigeration, we make the judgement that the corresponding recovery efficiency is 85%.

Taking into consideration that the Swedish Refrigeration Code of Best Practice have been in use since the 80's we strongly claim that these recovery factors have been valid for the entire time series from 1990 onward.

We would also point out that the rate of leakage at decommissioning in Sweden should be corresponding to that of other countries with equally stringent regulations and requirements. One example is the Netherlands, which in its RIVM Report 2016-0055 reports a recovery rate of 95 %.

Thus, we strongly support the continuous use of the existing national factors for stationary refrigeration, air conditioning and heat pump equipment and transport refrigeration in the Swedish Greenhouse gas emission inventory as presented in the table below.

SVENSKA
KYL&VÄRMEPUMP
FÖRENINGEN

Gustavslundsvägen 135, 167 51 Bromma, Sweden. Switchboard +46 (0)8 512 549 50 www.skvp.se

Swedish emission factors for decommissioning of stationary refrigeration, air conditioning, heat pump equipment and transport refrigeration

	Domestic refrigeration	Heat pumps	Transport refrigeration	All other stationary refrigeration
1990	5%	5%	15%	5%
1991	5%	5%	15%	5%
1992	5%	5%	15%	5%
1993	5%	5%	15%	5%
1994	5%	5%	15%	5%
1995	5%	5%	15%	5%
1996	5%	5%	15%	5%
1997	5%	5%	15%	5%
1998	5%	5%	15%	5%
1999	5%	5%	15%	5%
2000	5%	5%	15%	5%
2001	5%	5%	15%	5%
2002	5%	5%	15%	5%
2003	5%	5%	15%	5%
2004	5%	5%	15%	5%
2005	5%	5%	15%	5%
2006	5%	5%	15%	5%
2007	5%	5%	15%	5%
2008	5%	5%	15%	5%
2009	5%	5%	15%	5%
2010	5%	5%	15%	5%
2011	5%	5%	15%	5%
2012	5%	5%	15%	5%
2013	5%	5%	15%	5%
2014	5%	5%	15%	5%
2015	5%	5%	15%	5%

Best regards,

Per Jonasson
Managing Director
Swedish Refrigeration & Heat Pump Association

SVENSKA KYL&VÄRMEPUMP FÖRENINGEN

Gustavslundsvägen 135, 167 51 Bromma, Sweden. Switchboard +46 (0)8 512 549 50 www.skvp.se

Sveriges Bilåtervinnares Riksförbund
Branschförbund sedan 1961

Recovery of fluorinated greenhouse gases at decommissioning of mobile air-conditioning (MAC) systems in Sweden

The use of ozone depleting substances and fluorinated greenhouse gases for cooling agents is regulated according to Swedish Refrigerants Code of Best Practice. This standard, which was developed in the 1980's and published in 1988, has since seen continuous development. The standard was supplemented by regulations issued by SWEDAC (Sweden's national accreditation body). There are also supplementing fact sheets associated to the Swedish Refrigerants Order.
Swedish Refrigerants Code of Best Practiceis applicable to all types of stationary and mobile refrigeration, air conditioning and heat pump equipment that contain chlorofluorocarbons, HCFCs and HFCs as refrigerants. The standard stipulates responsibilities associated with installation and service as well as responsibilities that lie with the supplier of cooling agents. It also includes general directives on the choice of refrigerants and requirements on design, service, maintenance, operation and decommissioning of equipment.

In addition to Swedish Refrigerants Order, there is also a Swedish regulation on fluorinated greenhouse gases and ozone depleting substances "Förordning om fluorerade växthusgaser och ozonnedbrytande ämnen" (2007:846) that was taken into force 2008-01-01, and the EU regulation on fluorinated greenhouse gases (now 517/2014).

In Sweden, producers and importers of products, such as stationary and mobile refrigeration, air conditioning and heat pump equipment are obliged to reclaim end-of-life equipment. In addition, importer and distributers of refrigerants are required by law to free of charge reclaim recovered amounts of all refrigerant fluids, and provide container for this purpose. Recovered amounts of refrigerants that are not recycled must, by law, be destroyed. No emissions of HFCs are allowed from the destruction/incineration processes.

Sweden has since long had stringent requirements that the installation, service, maintenance and decommissioning only should be performed by certified personnel and businesses. Since 1965 road vehicles in Sweden are annually undergoing maintenance checks. This ensure high technical standard of equipment and vehicle performance. During maintenance checks, if needed, MACs are emptied, the refrigerant fluids reclaimed and filtered, and then refilled into the MACs.

Sveriges Bilåtervinnares Riksförbund Karlavägen 14 A 114 31 Stockholm

Sveriges Bilåtervinnares Riksförbund
Branschförbund sedan 1961

In Sweden, it is illegal to dump end-of-life vehicles. Instead end-of-life vehicles are recovered and dismantled by SWEDAC accredited companies. Vehicle dismantling companies are obliged by law to drain off and recover all remaining AC fluids. The recovered amounts of HFCs are sent for recycling or destruction to the refrigerant distributing companies. Only SWEDAC accredited companies are allowed to drain off and recover remaining MAC fluids. Hence, only minor amounts of refrigerants are emitted during the recovery processes at the dismantling and disposal sites.
Each year, thousands of car accidents causing complete or partial release of AC refrigerants occurs in Sweden. Many of these vehicles are judged to be too damaged for further use and are sent for decommissioning. There is no national annual statistics available on the number of car accidents leading to decommissioning.

Vehicle dismantling is one of the oldest methods of recycling in Sweden. There are companies that have been dismantling cars since 1920 and are still in the trade. We, the Swedish Car Recyclers Association, "Sveriges Bilåtervinnares Riksförbund", started in 1961 and are a federation of companies in the car dismantling trade. The association´s purpose is to promote beneficial development in the car dismantling trade in Sweden and achieve optimal recycling of raw material and spare parts from cars.

The Swedish Car Recyclers Association makes the judgement that 90 % of fluorinated greenhouse gases are remaining at decommissioning of ACs in cars, trucks and busses in Sweden and that the recovery efficiency on average is at least 85%. This figure includes the AC erupted due to car accidents (contributing to less than ten per cent reduction of the recovery efficiency). Taking into consideration that the Swedish Refrigeration Code of Best Practice have been in use since the 80's we strongly claim that these recovery factors have been valid for the entire time series from 1990 onward.
Thus, we strongly support the continuous use of the existing national factors for ACs in cars, trucks and busses (90% refrigerants remaining at decommissioning and 85% recovery efficiency) in the Swedish Greenhouse gas emission inventory for the entire time series 1990-2014.

Best regards

Michael Abraham
Förbundsdirektör

Stockholm 2016-10-12

2 av 2

Sveriges Bilåtervinnares Riksförbund Karlavägen 14 A 114 31 Stockholm

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

This Annex describes how fuel consumption and CO_2 emissions are estimated for the reference approach, CRF 1Ab (4.1), methods and data sources for feedstocks and non-energy use of fuel, CRF 1Ab (4.2), the comparison of fuel consumption and CO_2 emission estimations based on the reference approach and the sectoral approach, CRF 1Ac (4.3), the structure of the national energy balances, and planned improvements related to these areas.

4.1 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 in line with 2006 IPCC Guidelines, Tier 1. Input data for the reference approach are provided by the Swedish Energy Agency and is consistent with the data delivered for publication in the Eurostat database[135] for years 1990 to 2004. From 2005 and onwards the Swedish Energy Balances are used. The main source is the monthly fuel statistics including supply and delivery of petroleum products, but foreign trade statistics is also used. The reason for not using energy balance data for 1990-2004 is that data for these years are not available. The only exception of the source data is for non-energy use regarding solid fuels, where instead the same data as for CRF 2 in the sectoral approach is used. The reason for this is that the non-energy use variable in the Energy Balances for solid fuels differs too much from the one used in the GHG inventory, leading to a comparison that is not reasonable. Moreover, the non-energy use variable in the Swedish energy balances primarily aims at describing the energy quantities of the portion of product manufacturing raw materials that are not generating emissions.

In previous submissions, input data for the reference approach were compiled by Statistics Sweden. The differences between reference and sectoral approach have often been large and difficult to explain. Several studies have been made in order to solve the problems[136]. Since submission 2016 a developing project has been ongoing in order to reconcile the differences between the reference and sectoral approach. The focus on these projects have been on fuel type level and in depth

[135] Eurostat, 2015 http://ec.europa.eu/eurostat/data/database

[136] Gustafsson, 2007a, Hedlund and Lidén, 2010, Andersson, Eklund, Gerner & Gustafsson, 2012, Gerner, Andersson & Gustafsson, 2013

investigations on discrepancies between the two data sources. The main findings have been found within the fuel groups Liquid and Solid Fuels[137] but as for submission 2019, the discrepancies within liquid fuels have been reduced as a result of using non-energy use data from the Swedish energy balance instead of from the IPPU (CRF 2) sector.

In CRF Table 1Ab, fuel quantities are presented in TJ, and for most liquid and solid fuels also in 1000 tonnes. In the input data the fuels are in several cases (e.g. gas/diesel oil and other oil) on a less aggregate level than in the CRF tables. In these cases, the conversion factors are implied NVCs resulting from dividing the TJ with the quantity of fuel type, i.e. a weighted average. For those fuels only available in TJ and 1000 toe (e.g. natural gas and biomass), the reporting units in the CRF tables are also in TJ and toe. Hence, the conversion factor is set to 1 and 41.68 respectively for these fuels. The conversion factors used in submission 2019 are found in table A.4.1.

[137] Viklund, L., Gerner, A., Ortiz, C., Gustafsson, T. 2016. Skillnader mellan reference approach och sectoral approach i den nationella växthusgasinventeringen. SMED report No 2016: 202

Table A4.1. Conversion factors used in submission 2019.

Fuel Type	Converstion Factor (TJ/Unit)
Bitumen	41.87
Coke Oven/Gas Coke	28.05
Coking Coal	27.21
Crude Oil	36.26
Ethane	50.40
Gas Biomass	41.87
Gas/Diesel Oil	35.36
Gasoline	32.78
Jet Kerosene	35.28
LPG	46.05
Lignite	8.50
Liquid Biomass	41.87
Lubricants	46.00
Natural Gas	43.36
Natural Gas Liquids	49.30
Other Oil	32.79
Other non-fossil fuels (biogenic waste)	41.87
Peat	41.87
Petroleum Coke	34.80
Refinery Feedstocks	36.26
Residual Fuel Oil	38.16
Solid Biomass	41.87
Waste (non-biomass fraction)	41.87

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). In those cases where the fuels are shown on a less aggregate level in the input data, the emission factors are as the NCVs implied emission factors per fuel type (weighted averages).

The emission factors used in the sectoral approach already take into account that some part of the carbon remains unoxidized. This is the reason why the parameter “fraction of carbon oxidized” is set to 1.00. For crude oil, bitumen, lubricants and refinery feedstocks, which are not reported in the sectoral approach, the emission factors used are default values from IPCC 2006 Guidelines.

The parameter "Carbon excluded" for each fuel is calculated as

$$C_{excl} = FC_{ne-use} * NCV * EF_c$$

where C_{excl}= excluded carbon in tonne, $FC_{ne\text{-}use}$ = fuel consumption for non-energy purposes in physical unit, NCV=net calorific value and EF_C= emission factor as tonne C per TJ fuel. The values reported are the same as reported in CRF 1Ad (feedstocks and non-energy use).

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

Activity data for 1990-2017 on feedstocks and non-energy use of fuels is consistent with the data reported in the Energy balances except for data for solid fuels which is consistent with data reported under the IPPU sector in the GHG inventory.

Carbon emission factors and carbon excluded are the same as reported in CRF 1Ab. CO_2 from non-energy use reported in the sectoral approach in other categories than CRF 1A includes emissions from fuels used in industrial processes (CRF 2), petroleum coke burned in catalytic crackers, hydrogen production and flaring (all CRF 1B).

4.3 Comparison of the reference approach and the sectoral approach

In order to follow the 2006 IPCC Guidelines 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 UNFCCC reporting guidelines, differences should be investigated if they are larger than ± 2 %.

Figure A4.1 shows the differences in fuel consumption and CO_2 emissions between the reference approach and the sectoral approach between 1990-2017. Fuel consumption and CO_2 emissions from the reference approach are more than 2% higher and lower than the sectoral approach for some years.

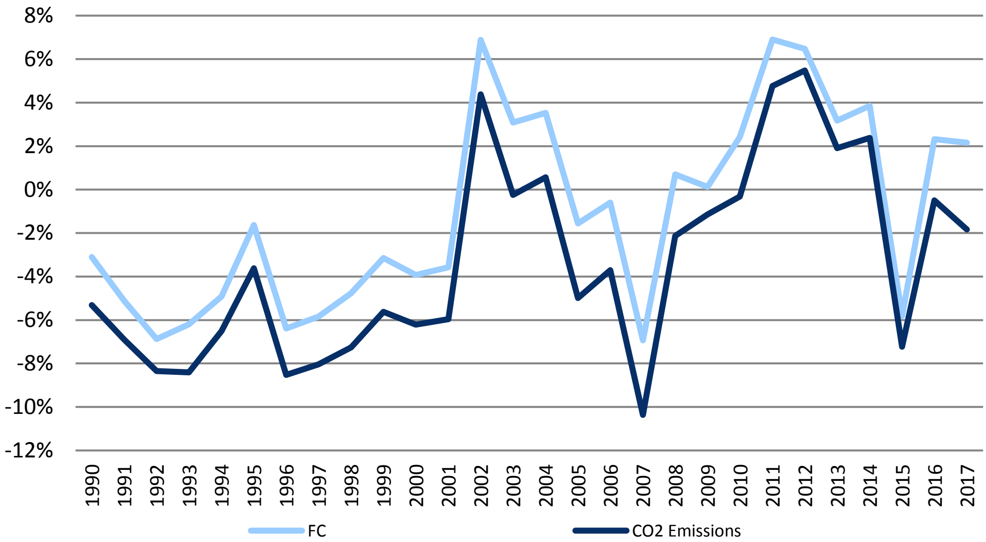

Figure A4.1. Difference (RA-SA) as the share (%) of SA. All fossil fuels.

4.4 Analysis of differences

In the following analysis, the reference approach is compared with the "real" sums for each fuel group from the sectoral approach in order to improve the transparency and show the "real" differences.

4.4.1 Liquid fuels

For liquid fuels, the 1990-2017 time series difference fluctuates considerably. For the years 1990-2001, the fuel consumption for RA is lower than SA, but for the latter part of the time series, fuel consumtion for RA tends to exceed SA for most years. The inter-annual fluctuations are however still relatively large (Figure A4.2). As from 2008, the difference expressed as CO_2 emissions is for the most part larger than the difference expressed as fuel consumption (FC), which indicates a divergence in the emission factors in those years. As can be seen in Table A4.3**Fel! Hittar inte referenskälla.**, the CO_2 IEF for SA decreases over time from 72.8 kg/GJ in 1990 to 71.2 kg/GJ in 2015. However, for the two latest years, IEF for the SA has increased again. The RA CO_2 IEF is relatively constant between 1990 and 2017 (73.6-73.0 kg/GJ).

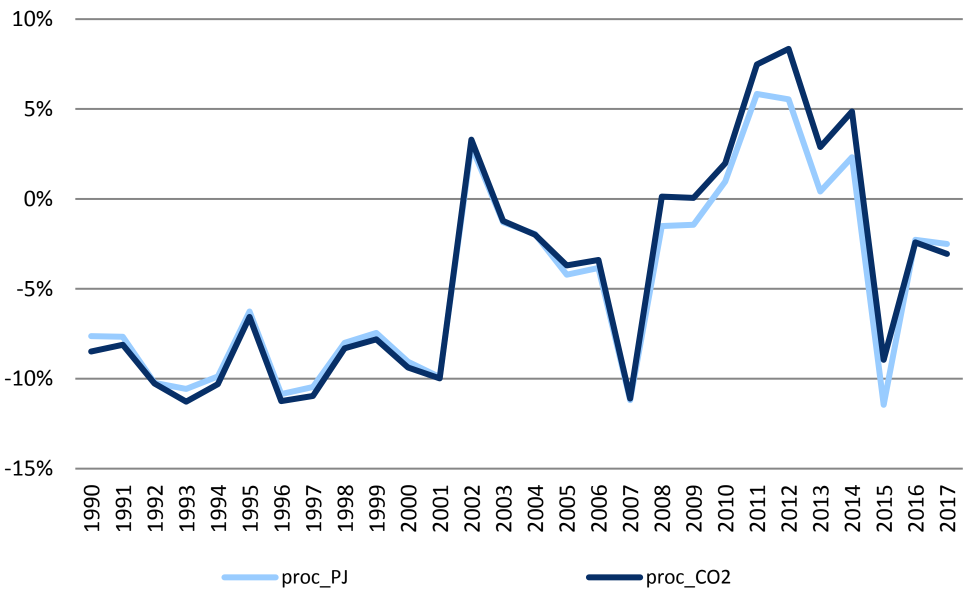

Figure A4.2 Difference (RA-SA) as percent of (SA). Liquid fuels.

As described in sections 2.3.2.2 and 2.3.2.3, emission factors for refinery gas and by-products in the petrochemical industry have gradually decreased in recent years based on information from facilities. This indicates that more carbon is stored in the produced fuels and other products, and less carbon remains in the by-products that are combusted on site and reported in CRF 1A(a) (e.g. refinery gas). In the reference approach, IPCC default emission factors are used for crude oil and refinery feedstocks.

As a first step in verifying the sectoral approach data for liquid fuels, the sectoral approach was compared with the official annual energy balances[138] in a specific study[139]. The items in the energy balance corresponding to the sectoral approach are final energy consumption, own use of fuels in the energy sector and fuels used for production of energy carriers other than fuels (i.e. heat and electricity). The comparison included all consumption of liquid fuels for energy purposes in the years 2005-2013. The conclusion was that the fuel consumption data used in the sectoral approach is consistent with official statistics on consumption of liquid fuels. The large differences are due to large differences between supply and consumption of fuels in the official energy statistics presented as statistical differences in the energy balances.

Further analysis revealed that refinery gas combusted at refineries, which is reported in CRF 1A1b in the sectoral approach, is shown as consumption for non-energy purposes in the energy balance. After correction for this, the relative difference is above ±2 % for some years, and for some years larger due to the use of different NCVs in the energy balances compared to the SA.

The time series consistency for NCVs for refinery gas will be reviewed in future submissions. It should be noted that the CO_2 emissions from combustion of refinery gas reported in CRF 1A1b are the emissions reported to ETS. These emissions are calculated by the facilities based on measurement of carbon content in the gas. Hence, the emissions reported in the inventory are accurate but the energy content may be less certain.

In Table A4.3, the CO_2 implied emission factors (IEF) for the most common liquid fuels 1990, 1995, 2000, 2005-2017 are presented. The SA IEF show a slight continuous decrease over the years compared with the RA IEF due to a lower share of consumption of fuels with high emission factors.

The increasing trends for domestic heating oil and residual fuel oil are due to that fuels with higher emission factors are used to a larger extent within navigation. In addition, the share of stationary combustion of these oils is decreasing. The decreasing trend for diesel oil is due to that the shares of different qualities have changed over time.

The emission factors for refinery gas are implicit in later years when data is taken from the ETS database. The CO_2 emissions are considered to be accurate, but the calorific values are considered to be quite uncertain.

[138] Swedish Energy agency, 2014

[139] L. Viklund, A. Gerner, C. Ortiz, T. Gustafsson. 2017.

Table A4.3. Implied CO_2 emission factors for reference and sectoral approach in submission 2019.

Year	Residual Fuel Oil (SA)	Domestic Heating Oil (SA)	Diesel Oil (SA)	Gasoline (SA)	Jet Kerosene (SA)	LPG (SA)	Refinery gas (SA)	Methane etc (SA)	CO_2 IEF SA	CO_2 IEF RA
1990	76,51	74,27	74,27	72	71,51	65,1	59,3	55	72,8	73,6
1995	76,59	74,27	72,79	72	71,51	65,1	59,3	55	72,6	73,6
2000	76,83	74,28	72,25	72	71,51	65,1	59,3	55	72,4	73,4
2005	76,97	74,28	72,12	72	71,5	65,04	59,3	52,7	72,3	73,1
2006	76,97	74,29	72,11	72	71,5	65,08	59,3	46,81	72,4	73,0
2007	77,15	74,29	72,08	72	71,5	65,1	59,3	69,43	72,5	73,0
2008	77,17	74,29	72,08	72	71,5	65,09	58,36	58,18	72,2	73,0
2009	77,21	74,29	72,08	72	71,5	65,11	55	64,5	72,1	73,1
2010	77,1	74,3	72,09	72	71,5	65,1	56,19	52,77	72,0	73,1
2011	77,24	74,31	72,07	72	71,5	65,12	55,95	51,92	71,8	73,0
2012	77,18	74,33	72,05	72	71,5	65,13	54,54	52,55	71,6	72,9
2013	77,23	74,44	72,06	72	71,5	65,11	50,68	62,58	71,3	72,9
2014	77,31	74,35	72,07	72	71,5	65,1	53,69	62,74	71,6	72,8
2015	77,3	74,39	72,07	72	71,5	65,14	52,47	58,4	71,2	72,9
2016	77,32	74,38	72,07	72	71,5	65,12	68,54	63,84	72,6	73,0
2017	77,44	74,39	72,09	72	71,5	65,12	74,49	62,82	73,1	73,0

The Swedish Energy Agency has recently made efforts to explain the large statistical differences in the energy balances. The most important source of fuel supply data in the energy balance is the monthly fuel statistics (See Annex 2). For supply of liquid fuels, it is the only data source. In May 2014, in response to a UNFCCC ERT recommendation, the Swedish energy agency started a project focusing on quality assurance of the monthly fuel statistics. The following issues were prioritized:

- Possible over/under coverage
- Consistency- and editing error checks on reported fuel quantities
- Differences in definitions of products and product categories in national, European and international reporting
- Calorific values
- Differences between monthly fuel statistics and foreign trade statistics and other available data sources /databases
- Differences between data reported to the monthly fuel statistics and similar data reported to other energy surveys

Initially, the focus is on liquid fuels because of the large statistical differences for this fuel group. The key findings and measures taken are as follows:

The sample frame does not include all companies in the fuel market, and this under coverage is a possible explanation to some of the large differences between supply and consumption in later years. In order to get better coverage of imports, exports and bunkers, four additional companies are included in the sampling frame for reference year 2014.

One conclusion is that respondents interpret the reporting instructions in the questionnaire in different ways. This issue will be addressed with additional consistency checks and improved quality assurance aiming to avoid coding- and editing errors.

It was also found that the products, i.e. fuels, listed in the questionnaire needs to be updated in order to cover all new fuels (and remove some obsolete items). Calorific values and densities used in conversions between different reporting units will be reviewed as the properties of certain products can change over time.

The analysis of statistical differences for liquid fuels shows that the differences to a large extent can be traced to quality deficits the monthly fuel survey. One important explanation is the occurrence of quite large fuel quantities reported as "other received quantities" and "other delivered quantities", which are not taken into account in the energy balances. This is an indication of under coverage in the trade statistics. The quantities reported in these variables are considered to be referring mainly to quantities delivered to and received from foreign-owned companies, which leads to the conclusion that the differences are mainly related to imports and exports.

The efforts made by the Swedish Energy Agency in cooperation with Statistics Sweden (producer of the monthly fuel statistics and several other important energy surveys) to solve the problems with statistical differences in the energy balances and specifically in the monthly fuel statistics led to a revision of the monthly fuel statistics as means to resolve the major gaps of the statistical differences.
The improvments from the review of the montly fuel statistics will be implemented in 2018 years data and used to estimate GHG emissions in in submission 2020 in the GHG inventory.

4.4.2 Solid fuels

Differences in fuel consumption (FC) and CO_2 emissions between reference and sectoral approach (as reported in CRF 1Ac) for solid fuels 1990-2017 are presented in Figure A4.3. The fuel consumption and CO_2 emissions from solid fuels are much higher according to RA than according to SA. The significant gaps are mainly due to the use of different data sources and thus different scopes and methodologies in the RA compared to the SA.

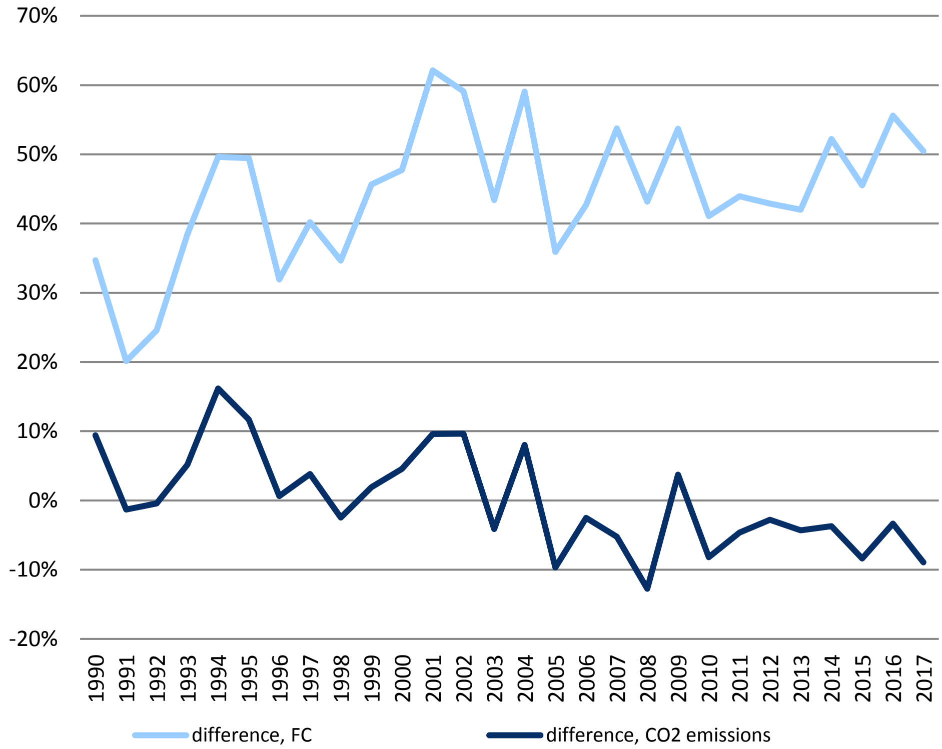

Figure A4.3 Fuel consumption (FC) and CO_2 emissions: Difference RA-SA expressed as percent of SA.

For reference approach, trade statistics from the energy balance is the main data source for import, export and stock change. For the sectoral approach, various data sources are used. These sources are energy surveys as described in Annex 2, but also other sources such as environmental reports, data from EU-ETS and other information gathered directly from the facilities. These other sources are mainly used for CRF 2 and 1B, but also for CRF 1A1c and 1A2a for the largest primary iron and steel works as described in NIR Section 3 and 4. The use of other data sources than energy balance data derives from the need to estimate as accurate GHG emissions as possible. This need causes divergences between RA and SA as carbon flows in RA data are allocated differently than in the SA data, especially regarding stock changes.

In the sectoral approach, detailed data on solid fuels from different sources are collected and compiled. As Sweden uses large quantities of solid fuels in integrated iron and steel production industries, it is important to keep track of carbon flows. As described in NIR section 4.4.1.2 and Annex 3:4 detailed data on plant station level is available from the companies and used in the SA to allocate energy and CO_2 emissions in different CRF categories. The allocation model differs from the results of the survey statistics used in the RA and CRF 1Ad. Data on allocation of energy and CO_2 from solid fuels in the integrated iron and steel works, sectoral approach, is presented in Table A4.5. Furthermore, it can be seen that a smaller proportion of energy than CO_2 emissions are allocated to CRF 1AA. This is due to the fact that fuel consumption reported in CRF 1AA are based on the use of energy gases in the coke oven, mainly recirculated blast furnace gas, for which the CO_2 emission factor is significantly higher (vary around 275-300 kg CO_2/GJ) than for coking coal (93.0 kg CO_2/GJ) or for other bituminous coal (94.6 kg CO_2/GJ). This leads to very different aggregate implied emission factors for solid fuels in RA compared to SA.

In Sweden, large quantities of primary fuels (mainly coking coal and other bituminous coal) are transformed into secondary (e.g. coke) and tertiary fuels (e.g. coke oven gas and blast furnace gas) or used as reduction agents in the transformation process. During the iron and steel making process large amounts of energy is transformed from the solid fuels into heat. Some of this heat is used for energy recovery, but the heat losses are significant. In line with the 2006 IPCC Guidelines, to avoid double counting of energy and CO_2 emissions, quantities of produced secondary and tertiary fuels are not reported in the RA. Quantities of fuels used for non-energy purposes and feedstocks are reported as 'carbon excluded' in CRF 1Ab and deducted from 'apparent consumption' in CRF 1Ac. This is in accordance with the 2006 IPCC guidelines and enables comparison with SA data derived from CRF 1AA and reported in CRF 1Ac.

Table A4.5. Allocation of energy (TJ) and CO_2 (Gg CO_2) from solid fuels from sectoral approach from the integrated iron and steel works compared to total input from solid fuels to the integrated iron and steel works.

Year	Total energy use from solid fuels, TJ	Total energy reported in CRF 1A (1A1a, 1A1c, 1A2b)	Total CO_2 emissions from solid fuels in iron and steel works (1A, 1B, 2)	CO_2 reported in CRF 1A	proportion of energy in CRF 1A	proportion of CO_2 in CRF 1A
1990	59244	13589	4861	2510	23%	52%
1995	60620	15126	5373	2826	25%	53%
2000	63290	17516	5294	2970	28%	56%
2005	70402	18936	6019	3767	27%	63%
2010	66587	15690	5589	3197	24%	57%
2011	47541	15479	5159	2975	33%	58%
2012	52047	14734	4532	2725	28%	60%
2013	55778	14021	4630	2757	25%	60%
2014	56442	14550	4792	2972	26%	62%
2015	57400	14775	4747	2990	26%	63%
2016	57282	15043	5024	2890	26%	58%
2017	59244	16229	5199	3348	27%	64%

Note that no heat losses are taken into account in CRF 1AA. As it is not possible to report heat losses (as TJ) in CRF 2, alternative comparisons of energy and CO_2 emissions between RA and SA, including correction of data reported in CRF 1B and CRF 2 as NEU, are presented in Table A4.6. The remaining differences are still larger than ±2 %, but the differences are significantly smaller than those presented in Figure A4.4. In order to resolve the remaining differences, the collaboration project between the Swedish EPA, Swedish Energy Agency, Statistics Sweden and SMED was initiated. The work is based on findings from a study made in 2011[140].

Table A4.6. Energy from solid fuels in RA and SA, comparison after correction for energy losses from NEU in the iron and steel industry.

Year	PJ, RA	PJ, SA	Difference PJ(RA)-PJ(SA)	PJ, NEU	PJ, (SA+NEU)	Difference RA-(SA+NEU)	Difference after correction, % of SA
1990	87.04	64.62	22.43	21.53	86.14	0.90	1%
1995	77.58	51.91	25.67	24.42	76.33	1.25	2%
2000	64.50	43.67	20.83	23.33	67.00	-2.50	-6%
2005	62.38	45.91	16.48	24.64	70.54	-8.16	-18%
2010	55.76	39.52	16.24	25.67	65.19	-9.43	-24%
2011	55.05	38.25	16.80	23.71	61.97	-6.91	-18%
2012	51.94	36.35	15.59	19.90	56.25	-4.31	-12%
2013	53.57	37.73	15.84	20.68	58.41	-4.84	-13%
2014	51.58	33.89	17.69	20.25	54.14	-2.56	-8%
2015	49.70	34.16	15.54	19.40	53.56	-3.85	-11%
2016	48.14	30.94	17.20	22.95	53.89	-5.75	-19%
2017	50.43	33.52	16.91	20.33	53.85	-3.42	-10%

The statistical differences for solid fuels in the data reported to Eurostat have been analysed but showed no correlation with the remaining RA-SA differences after correction for energy losses in the iron and steel industry. Sweden is continuously making efforts to improve solid fuels discrepancies through cooperation with the Swedish Energy Agency and the steelworks operators in particular.

The consumption of solid fuels reported in SA has been compared with the corresponding items of the energy balances. For CRF 1A1a + 1A2, when excluding the iron and steel works and the refineries (which do not use any carbon-based solid fuels), the difference between the sectoral approach and energy balances are in the range ± 0.8 PJ (corresponding to 2-3 %) or less from 2008 and onwards (see Table A4.7). In the GHG inventory, all use of coal and coke in the metal industry is allocated to CRF 2. This also supports the conclusion that the main problem is the reporting of data for the metal industry, and particularly the primary iron- and steelworks. As data in SA is more accurate, it is believed that the main reason for

[140] Gustafsson, Gerner & Lidén 2011

the remaining differences lies in the inaccuracy of the supply statistics for solid fuels in Sweden. However, this hypothesis needs further validation.

Table A4.7. Solid fuels in CRF 1A1a + 1A2c-g, comparison with energy balance[141]

year	TJ (CRF)	TJ (energy balance)	CRF-EB	(CRF-EB)/EB
2005	35 624	32 908	2 715	8%
2006	36 268	35 102	1 165	3%
2007	30 915	28 739	2 176	8%
2008	28 515	29 285	-770	-3%
2009	23 219	23 582	-364	-2%
2010	30 107	29 269	838	3%
2011	29 375	28 949	426	1%
2012	28 267	27 973	294	1%
2013	29 973	29 983	-10	0%

Note that it has not been possible to include 1990 in the comparison, because the energy balance for 1990 only shows fuel consumption in manufacturing industries on an aggregate level which makes it impossible to separate the metal industry.

4.4.3 **Gaseous fuels**

The differences for gaseous fuels are mostly around 2% buth larger some years, especially for the years 2005, 2006, 2014 and 2015 (Table A4.8).

[141] Swedish Energy Agency, 2014

Table A4.8. Energy from gaseous fuels in RA and SA.

Year	PJ, RA	PJ, SA	difference PJ(RA)-PJ(SA)	difference, %
1990	24.2	24.4	-0.3	-1%
1995	31.6	32.5	-0.9	-3%
2000	32.5	32.0	0.5	1%
2005	32.6	28.2	4.5	16%
2006	33.8	31.3	2.5	8%
2007	32.7	33.3	-0.6	-2%
2008	29.4	29.1	0.3	1%
2009	41.2	40.1	1.1	3%
2010	57.1	55.7	1.4	2%
2011	44.0	43.3	0.7	2%
2012	37.8	37.0	0.8	2%
2013	36.5	36.5	0.1	0%
2014	29.1	34.3	-5.1	-15%
2015	33.9	30.0	4.0	13%
2016	36.5	36.0	0.5	1%
2017	26.4	27.5	-1.1	-4%

For the RA, gaseous fuels for non-energy use and feedstocks were not reported separately from apparent consumption. Natural gas has been used for non-energy use and feedstocks since 2004 in the GHG inventory, which is reflected in the sectoral approach[142].

The reason for the larger differences are probably due to the discrepancies in allocation of NEU data in the Energy balances in comparison to what is reported to the quarternary statistics (activity data in the SA). This needs however further investigation and and are planned to be investigated during 2019.

142 Ortiz, C., Jonsson, M., Yaramenka, K., Helbig, T. 2017.

4.4.4 Other fossil fuels

This category includes the fossil fraction of municipal waste, industrial waste and any non-specified fuels that cannot be classified as purely solid, liquid, gaseous or biomass.

Table A4.9. Emission factors for other fossil fuels (municipal waste and non specified fossil fuels) in RA and SA.

Year	Municipa waste RA	Municipal waste SA (8 largest plants)	Municipal waste SA (Other plants)	Non specified fossil fuels SA and RA
1990	94.3	94.3	94.3	60
1995	94.3	94.3	94.3	60
2000	94.3	94.3	94.3	60
2005	94.3	94.3	94.3	60
2006	94.3	94.3	94.3	60
2007	94.3	94.3	94.3	60
2008	94.3	94.3	94.3	60
2009	94.3	94.3	94.3	60
2010	94.3	94.3	94.3	60
2011	94.3	94.3	94.3	60
2012	94.3	94.3	94.3	60
2013	94.3	94.3	94.3	60
2014	94.3	94.3	94.3	60
2015	94.3	94.9	94.3	60
2016	94.3	94.15	94.9	60
2017	94.3	95.93	94.15	60

The emission factors used in sectoral approach vary the very last years due to the fact that Sweden collects plant specific emission factors for the largest 8 plants (Table A4.9). The other plants in SA then apply the same emission factor as the average of the largest plants the year before. This is because Sweden started to use plant specific emission factors for the largest plants that reported annualy to EU-ETS in 2015. The emission factor for RA is still 94.3 for all years, pending investigation.

In the sectoral approach, fossil municipal waste accounts for 42-77 % of the fuels reported as “other fossil fuels”. In the RA, this share is close to 100 % in the years 1990-98 and 86-97 % in more recent years. This explains the fact that the aggregate IEF for “other fossil fuels” is systematically higher in RA than in SA although the same emission factors are applied for the individual fuels.

In the Swedish energy surveys, “municipal waste” is one single fuel including both the fossil and the biogenic fraction. In the sectoral approach, 36 % is allocated to other fossil fuels and 64 % to biomass (see Annex 2). An analysis of the RA data indicates that in 1990-2004, the proportions were 40 % biogenic and 60 % fossil. From 2004 and onwards, the relation is reversed and 60 % is biogenic and 40 % fossil. This explains the shift in the time series when RA and SA are compared.

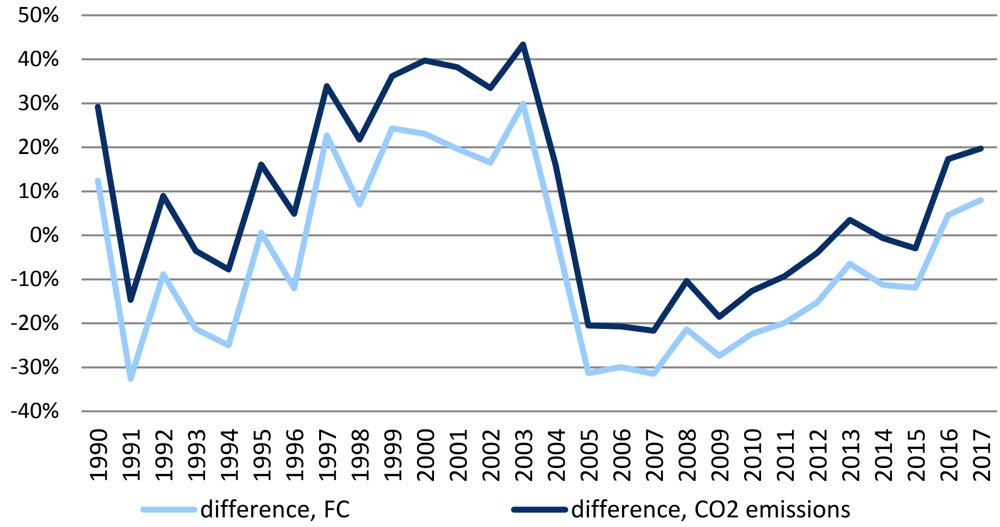

Figure A4.4 Difference RA-SA as percent of SA. Fuel consumption (FC) and CO_2 emissions.

When the sums of biogenic and fossil municipal waste according to RA and SA are compared, the differences are fluctuating and not systematic. The amounts of other fossil fuels, however, are systematically much higher in the sectoral approach. This indicates allocation differences, possibly both regarding waste/other fossil fuels and other fossil fuels/solid fuels. The amounts of waste (biogenic and fossil) and other fossil fuels are shown in Figure A4.5.

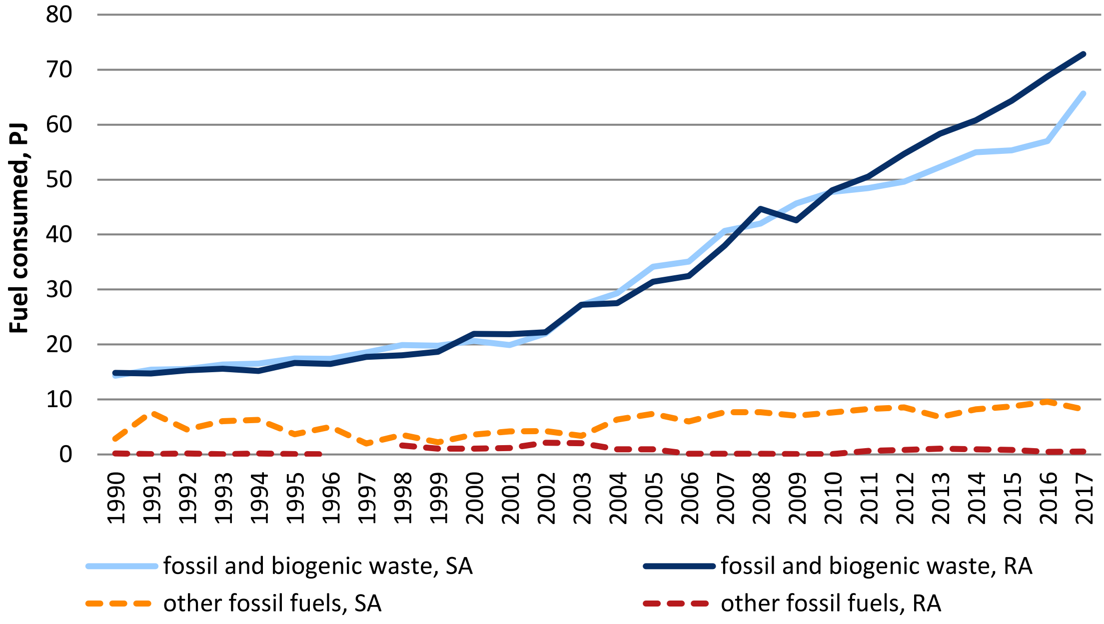

Figure A4.5 Consumption of waste and other fossil fuels, RA and SA.

When biogenic waste, fossil waste and other non-specified fossil fuels are aggregated, the fuel consumption is a bit higher in the sectoral approach (Table A4.10).

Table A4.10. Aggregate consumption of waste and other fossil fuels, RA and SA.

Year	PJ, RA	PJ, SA	difference PJ(RA)-PJ(SA)	difference, %
1990	9.0	8.0	1.0	12%
1995	10.0	9.9	0.1	1%
2000	13.6	11.0	2.5	23%
2005	13.5	19.7	-6.2	-31%
2010	19.3	24.8	-5.5	-22%
2011	20.6	25.7	-5.1	-20%
2012	22.4	26.4	-4.0	-15%
2013	24.0	25.6	-1.7	-6%
2014	24.9	28.0	-3.2	-11%
2015	26.2	29.8	-3.5	-12%
2016	33.3	31.9	1.5	5%
2017	35.4	32.7	2.6	8%

4.4.5 Peat

Peat is sparsely used in Sweden and accounts for around 2% of the fossil fuel consumption. The RA/SA-differences are fluctuating and small in absolute numbers (3.3 PJ at the most but typically around 1 PJ or less). The differences are mainly due to the use of different NCVs in RA compared to SA. The calorific values for peat are quite variable due to variations in moisture content and the fact that briquettes and raw peat are reported together. In the quarterly fuel survey, peat is mostly reported in the unit tonne and the calorific values are also reported. These NCVs used in the sectoral approach are considered to be accurate. In the years 2007-2017, the annual average NCV for peat reported in tonnes varies between around 10.5 GJ/tonne to around 11.1 GJ/tonne in 2008, a relative difference of 9 %. In the reference approach data, the activity data was delivered in toe which means that the NCV for peat is not available.

4.4.6 Non-energy use

In submission 2017, an analysis of NEU was made within the project of analyzing the differences between RA and SA, which resulted in replacing NEU from the Energy balances in RA with the NEU data reported in the IPPU sector[143] in the GHG inventory. Using NEU data from the IPPU sector is also a recommendation from reviewers to countries with a large iron and steel industry. The effects of this substitution of NEU data led to lower differences between SA and RA for solid fuels but larger differences regarding other fuel groups. However, using NEU from the IPPU sector did not explain all of the differences between RA and SA within the solid fuels group for the energy consumption in TJ. The differences decreased from around 100% to 40% for energy consumption in TJ and for CO_2 emissions the difference decreased from 40% to around 0% (Figure A4.6).

[143] Viklund, L., Gerner, A., Ortiz, C., Gustafsson, T. 2016.

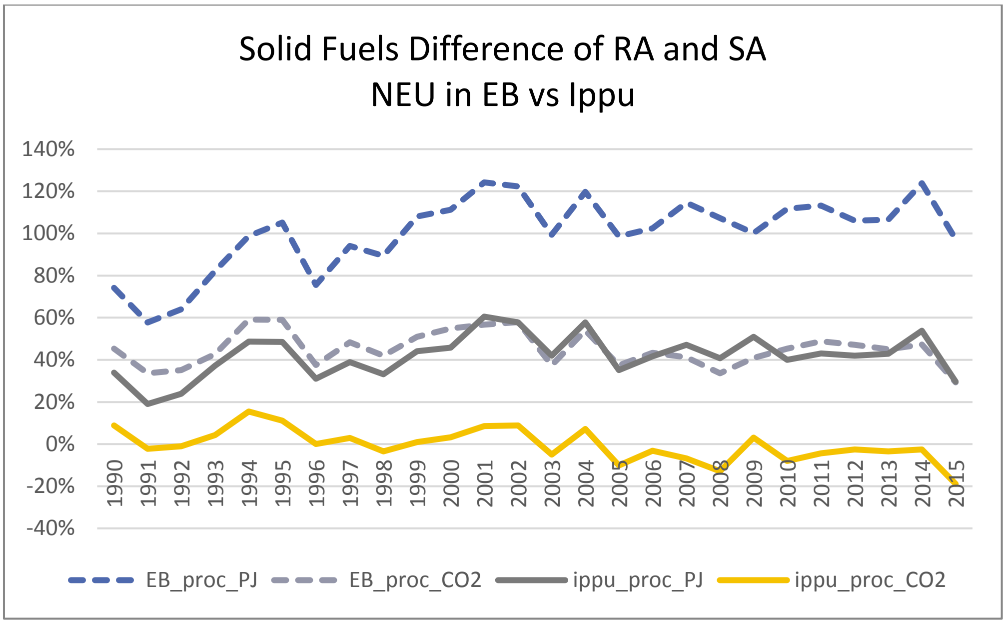

Figure A4.6 RA vs SA of NEU from the Energy balances for IPPU for Solid Fuels between 1990 and 2015 (comparison made in submission 2017).

As for submission 2019, NEU data is collected from the IPPU sector for solid fuels but collected once again from the energy balances regarding the other fuel groups. This approach showed reduced differences between RA and SA for all fuel groups.

The reason for these large differences between the NEU sources used are due to the fact that NEU in the Energy Balances is not reported in the same way as in the GHG inventory. Coking coal in the energy balances is reported as for energy purposes mostly, while in the GHG inventory (IPPU) all the NEU is assumed to come from coking coal, resulting in a quite large difference in NEU for solid fuels.

4.5 National energy balance

As stated above, the input activity data for reference approach is based on the reported energy balances to Eurostat between years 1990 and 2004 and from 2005 from the Energy Balances. Minor differences occur due to the early time plan for the GHG inventory which means that the energy balance has not yet been compiled when activity data is delivered to the GHG inventory staff. The information in this section is taken from Statistics Sweden. Tables referred to can be found at the Statistics Sweden website.[144]

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.

4.5.1 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. 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.

4.5.2 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 4:4 and 10:4. The production of derived energy is here recorded in a second flow-step comprising energy turnover in energy conversion and is also specified in

[144] EN 20 SM series http://www.scb.se/EN0202

complementary input-output tables for energy conversion industries, tables 5:5 and 11:5.

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 biofuels, peat and waste etc., the total consumption for energy purpose is recorded as inland supply of primary energy.

Bunker fuel for international navigation is fuel used by both Swedish and foreign ships with final destination outside the Swedish territory. Bunker fuels for aviation are not reported in the Swedish energy balances, i.e. all aviation fuels are aggregated with some other fuels and reported as domestic 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 (1990-2010).

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 terrajoules= 10^{12} 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.

4.6 Planned improvements

The UNFCCC In country review of submission 2013 resulted in a recommendation to solve the problems with large discrepancies between reference and sectoral approach (FCCC/ARR/2013/SWE, Para 31). As described earlier in this Annex, the data source for the reference approach has been changed in submission 2016. Since submission 2017 also the non-energy use data source is changes for RA. The largest absolute differences occur for liquid and solid fuels. In order to investigate and solve the problems, a cooperation between Swedish EPA, the Swedish Energy Agency, SMED and Statistics Sweden has been established. In 2014, the main focus has been on liquid fuels, and in 2015 to 2016 efforts will be made for solid fuels. This inventigation will continute during 2017 and will focus on solid fuels and harmonisation of various reports.

For liquid fuels, The Swedish Energy Agency has initiated improvements of the monthly fuel statistics, in order to minimize the statistical differences particularly for liquid fuels. These improvements will be implemented in submission 2020.

For solid fuels, the differences are caused by inconsistencies in how data is reported for the metal industries, especially primary iron- and steelworks. The most important reason is the differing total amounts of coal according to the different data sources used in sectoral and reference approach. Future work will focus on the amounts of fuels reported to surveys and on the data sources used in sectoral approach. As mentioned above, data on stock changes is suspected to be uncertain and will be prioritized.

Gaseous fuels show large differences for some years, probably due to the allocation of NEU in the EB in comparison to what is reported to the quarternary statistics (activity data in the SA). This needs however further investigation and are planned to be investigated during 2019.

For other fossil fuels, the differences occur due to that the emission factors and the fraction of fossil and biogenic waste differ between the RA and SA data. To reduce these differences, an investigation on the EF and fractions of biogenic and fossil waste for RA will be initiated during 2019.

References

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

Gerner, A., Andersson, M., Gustafsston, T., 2013. Differences between Eurostat and CRF data in Swedish reporting. SMED Report No 125 2013

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

Gustafsson, T., Gerner, A., Lidén, M. 2011. Emissions from integrated iron and steel industry in Sweden. SMED Report no 97, 2011.

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

EN20SM Series. Årliga energibalanser (Annual Energy Balance Sheets). Energy statistics. Available att http://www.scb.se/EN0202

Ortiz, C., Jonsson, M., Yaramenka, K., Helbig, T. 2017. Skillnader mellan reference approach och sectoral approach i den nationella växthusgasinventeringen - En analys av Energi för icke energiändamål. SMED report no 2017:12

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

Swedish Energy Agency, 2014. Annual energy balances. http://www.energimyndigheten.se/en/Facts-and-figures1/Statistics/

Swedish Energy Agency, 2015 http://www.energimyndigheten.se/Statistik/Energibalans/Energivarubalans/

Statistics Sweden 2015. Data from Sweden’s Statistical Databases (SSD) downloaded 2015-01-16 http://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__EN__EN0202/EbArDetalj/?rxid=ca2cb6a7-0321-4fb4-99a4-2c790cbe06bb

Viklund, L., Gerner, A., Ortiz, C., Gustafsson T. 2016. Skillnader mellan reference approach och sectoral approach i den nationella växthusgasinventeringen. SMED Rapport Nr 2016: 202.

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

5.1 GHG inventory

5.1.1 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, Table A5.1 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.

Table A5.1. Summary of sources not estimated

Sources and sinks not estimated (NE)			
GHG	**Sector**	**Source/sink category**	**Explanation**
CO_2	1. Energy	1.B.2.A.3 Transport	No data available
CH_4	2. Industrial processes and product use	2.B.10. Other non-specified	No data available
N_2O	2. Industrial processes and product use	2.B.10. Other non-specified	No data available
CO_2	2. Industrial processes and product use	2.B.10. Other non-specified	No data available
CH_4	2. Industrial processes and product use	2.B.10. Pharmaceutical industry	No data available
CO_2	2. Industrial processes and product use	2.B.10. Sulphuric acid production	No data available
CH_4	2. Industrial processes and product use	2.C.1.c Direct reduced iron	Considered insignificant
CH_4	2. Industrial processes and product use	2.C.1.e Pellet	No data available
CH_4	2. Industrial processes and product use	2.C.7.c Other metal production	No data available
CO_2	2. Industrial processes and product use	2.G.4 Tobacco smoking	No data available
CO_2	4. Land use, land-use change and forestry (LULUCF)	4.E.1 Mineral soils	No default method provided by IPCC

Sources and sinks not estimated (NE)			
GHG	Sector	Source/sink category	Explanation
CO_2	4. Land use, land-use change and forestry (LULUCF)	4.E.1 Organic soils	No default method provided by IPCC
CO_2	4. Land use, land-use change and forestry (LULUCF)	4.E.1 Net carbon stock change in dead organic matter	No default method provided by IPCC
CO_2	4. Land use, land-use change and forestry (LULUCF)	4.G Annual Change in stock	Since these emissions are voluntary to report, Sweden do not report HWP in SWDS
CO_2	4. Land use, land-use change and forestry (LULUCF)	4.G Gains	Since these emissions are voluntary to report, Sweden do not report HWP in SWDS
CO_2	4. Land use, land-use change and forestry (LULUCF)	4.G Losses	Since these emissions are voluntary to report, Sweden do not report HWP in SWDS
CO_2	4. Land use, land-use change and forestry (LULUCF)	4.G Net CO_2 emissions/ removals from HWP in SWDS	Since these emissions are voluntary to report, Sweden do not report HWP in SWDS
CH_4	5. Waste	5.C.2.2.a Landfill Fires	Considered insignificant
CO_2	5. Waste	5.C.2.2.a Landfill Fires	Considered insignificant
N_2O	5. Waste	5.C.2.2.a Landfill Fires	Considered insignificant
CH_4	5. Waste	5.C.2.2.b Landfill Fires	Considered insignificant
CO_2	5. Waste	5.C.2.2.b Landfill Fires	Considered insignificant

5.1.1.1 ENERGY

Emissions of CH_4 and N_2O from FAME used by military transportation (CRF 1A5b) in 1999-2001 and emissions of CH_4 and N_2O from Ethanol used by military transportation in 2007-2012 are not estimated. Emissions are expected to be minor and there is no IPCC methodology available for estimating these emissions.

5.1.1.2 INDUSTRIAL PROCESSES AND SOLVENT USE

Emissions from the sources specified below have not been estimated due to lack of information, but the emissions are expected to be insignificant.

For CH_4 emissions from ethylene production, a default methodology is provided by the 2006 IPCC Guidelines. However, as the company's own expert judgment is below the result of the default method by about a factor of ten and is below the threshold of 0.05% of national total emissions (about 30 kton CO_2-eq.). Thus, Sweden has chosen to report NE for this source, as it is judged to be insignificant in relation to the amount of effort it would require to obtain a complete and consistent time series.

For CH_4 emissions from direct reduced iron, test calculations have been made with default emission factors applied for the total amount of natural gas used at the facility. The resulting CH_4 amounts of 0.03 kton CO_2-eq are thousandfold below the national totals of 30 kton CO_2-eq, meaning that these emissions can be co considered insignificant and do not necessarily need to be reported.

CO_2 emissions from tobacco smoking 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

5.1.1.3 AGRICULTURE

All relevant agricultural emissions and sources are reported in the inventory. Reindeer, which are normally not considered as a part of the agricultural sector, are included in the inventory. There are, however, some marginal animal groups, which are not included, such as fur-bearing animals (minks, foxes and chinchillas). These groups are very small and there are no default methodologies developed for estimating their GHG emissions. All sales of fertilizers are included in the inventory, also quantities used in other sectors. N-fixing crops used in temporary grass fields, and sludge used as fertilizer is also included. This means that all anthropogenic inputs to agricultural soils are covered.

5.1.1.4 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. Only a few categories where methods are not available (4.E.1) or where reporting are voluntary (4.G) are reported as NE.

5.1.1.5 WASTE

Accidental landfill fires occur in Sweden; however emissions of CO_2, CH_4 and N_2O are reported NE since there is no default method provided by the 2006 IPCC Guidelines that can be applied in this case and emissions are estimated to be below the threshold of 0.05% of national total emissions (about 30 kton CO_2 eq.). Emissions are estimated to be insignificant in relation to the amount of effort it would require to obtain activity and emission data. All other data are complete.

5.2 KP-LULUCF inventory

Sweden´s reporting of KP-LULUCF is complete in relation to the mandatory and elected activities. No carbon pools, or other mandatory sources of greenhouse gas emissions, associated to the mandatory activities under article 3.3 (Afforestation/Reforestation and deforestation) and article 3.4 (Forest management) have been omitted from the reporting.

No additional voluntary activity under article 3.4 has been elected.

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 of the Asia Pacific Carbon Fund
Asian Development Bank as Trustee of the Future Carbon Fund
Blue World Carbon SEA Pte Ltd
Carbon Asset Management Sweden Pte Ltd
Carbon Asset Services AB
Carbon Asset Services Sweden AB
Carbon Asset Management Sweden Pte Ltd
CF Carbon Fund II Limited
Citigroup Global Markets Ltd
Cornland International AB
C-Quest Capital Malaysia Global Stoves Limited
C-Quest Capital LLC
EcoSecurities Carbon I Ltd
EcoSecurities Group Ltd
EcoSecurities Group PLC
EcoSecurities PLC
Electrade S.p.A.
Göteborg Energi AB
Macquarie Bank Limited
MGM Carbon Portfolio S.a.r.l
Nordic Environment Finance Corporation NEFCO in its capacity as Fund Manager to the NEFCO Carbon Fund (NeFC) Nordic Environment Finance Corporation (NEFCO)
Nynäs Refining AB
Perstorp Specialty Chemicals AB
Platinum Partners Value Arbitrage Fund, L.P.
Swedish Energy Agency
SIA Climate Futures
Standard Bank PLC
Svenska Cellulosa AB
Tekniska verken i Linköping
The International Bank for Reconstruction and Development (Trustee of Prototype Carbon Fund)
International Bank for Reconstruction and Development (IBRD) as Trustee of the Umbrella Carbon Facility Tranche 2 (UCFT2)

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)
International Bank for Reconstruction and Development (IBRD) as Trustee of the Carbon Partnership Facility (CPF)
Tricorona Carbon Asset Management Pte Ltd
Vattenfall Energy Trading Netherlands N.V.
WCCI World Carbon Credit Investment Limited
Vitol SA
VERT CONSERVATION PTE LTD

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:

AGO AG Energie + Anlagen
Baltic Sea Region Testing Ground Facility (TGF)
BASF SE
Carbon Solutions Sweden AB
Climate Change Management Sweden AB
Credit Suisse
MGM Carbon Portfolio, S.a.r.l.
MGM International Group LLC
N.serve Environmental Services GmbH
Nordic Environment Finance Corporation (NEFCO) in its capacity as Fund Manager to the
Saga Carbon
Swedish Energy Agency SICLIP
Yara AB

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

7.1 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[145] 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 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[146]. 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.

7.2 Expert protocols

All assigned uncertainties (%) have been documented in Swedish in Expert Protocols as given in figure A7.1.

---

http://www.scb.se/Statistik/EN/EN0202/2009I10/EN0202_2009I10_SM_E

N20SM1004.pdf

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 A7.1. 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 facilitates updating of uncertainties when something in the inventory changes in the future.

7.3 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.

7.3.1 CRF 1. Stationary combustion

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.

7.3.2 CRF 1. Mobile combustion

Activity data on fuel consumption are based on national statistics on fuel deliveries. Uncertainty estimates are mostly based on SMED reports and expert judgements, 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.

7.3.3 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.

7.3.4 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 judgements.

7.3.5 CRF 2. Industrial processes, CH_4 and N_2O

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

7.3.6 CRF 2. 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 judgements.

7.3.7 CRF 3. 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, rough expert judgements had to be made. Uncertainty estimates are assigned on an aggregated level similar to the one presented in the NIR.

7.3.8 CRF 4. LULUCF

Uncertainty estimates are generally based on area sampling, but to some extent expert judgements 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 aktregation presented in the result tables below.

7.3.9 CRF 5. Waste

Uncertainty estimates are collected from IPCC (for emission factors) and IPCC combined with expert judgements (for activity data). Uncertainty estimates are assigned on the same aggregated level as presented in the NIR, which is per CRF sector (e.g. 5A Solid waste disposal).

7.4 Combining and aggregating uncertainties for all sectors

The uncertainty analysis is performed according the approach 1 as described in IPCC 2006 guidelines. See especially equation 3.1 and 3.2, and table 3.3.

7.5 Results

Table A7.1. Approach 1 uncertainty assessment for national total emissions in 2017, including LULUCF.

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 1 a Public Electricity and Heat Production: Biomass	CH_4	8	41	1.32	26.02	26.06	0.00	391.6	0.000
1 A 1 a Public Electricity and Heat Production: Biomass	N_2O	34	160	1.35	27.06	27.09	0.00	374.0	0.000
1 A 1 a Public Electricity and Heat Production: Gaseous Fuels	CH_4	0	0	2.00	20.00	20.10	0.00	-41.5	0.000
1 A 1 a Public Electricity and Heat Production: Gaseous Fuels	CO_2	486	286	2.00	5.00	5.38	0.00	-41.1	0.000
1 A 1 a Public Electricity and Heat Production: Gaseous Fuels	N_2O	0	0	2.00	20.00	20.10	0.00	-41.5	0.000
1 A 1 a Public Electricity and Heat Production: Liquid Fuels	CH_4	1	0	1.40	27.77	27.80	0.00	-82.3	0.000
1 A 1 a Public Electricity and Heat Production: Liquid Fuels	CO_2	1277	284	1.37	2.90	3.21	0.00	-77.7	0.000
1 A 1 a Public Electricity and Heat Production: Liquid Fuels	N_2O	3	1	1.37	134.43	134.44	0.00	-75.7	0.000
1 A 1 a Public Electricity and Heat Production: Other Fuels	CH_4	3	3	1.97	40.00	40.05	0.00	22.0	0.000
1 A 1 a Public Electricity and Heat Production: Other Fuels	CO_2	570	2479	1.98	19.92	20.02	0.39	334.8	0.020
1 A 1 a Public Electricity and Heat Production: Other Fuels	N_2O	8	30	1.96	40.08	40.13	0.00	280.1	0.000
1 A 1 a Public Electricity and Heat Production: Peat	CH_4	3	1	2.00	40.00	40.05	0.00	-58.3	0.000
1 A 1 a Public Electricity and Heat Production: Peat	CO_2	1150	480	2.00	20.00	20.10	0.01	-58.3	0.000
1 A 1 a Public Electricity and Heat Production: Peat	N_2O	33	7	2.00	40.00	40.05	0.00	-79.1	0.000
1 A 1 a Public Electricity and Heat Production: Solid Fuels	CH_4	1	0	0.63	21.02	21.03	0.00	-60.0	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 1 a Public Electricity and Heat Production: Solid Fuels	CO_2	4231	2956	0.73	7.35	7.39	0.07	-30.1	0.000
1 A 1 a Public Electricity and Heat Production: Solid Fuels	N_2O	41	48	0.89	27.80	27.81	0.00	16.7	0.000
1 A 1 b Petroleum refining: Gaseous Fuels	CH_4	0	0	2.00	20.00	20.10	0.00		0.000
1 A 1 b Petroleum refining: Gaseous Fuels	CO_2	0	137	2.00	5.00	5.39	0.00		0.000
1 A 1 b Petroleum refining: Gaseous Fuels	N_2O	0	0	2.00	20.00	20.10	0.00		0.000
1 A 1 b Petroleum refining: Liquid Fuels	CH_4	1	1	9.51	90.97	91.46	0.00	-18.9	0.000
1 A 1 b Petroleum refining: Liquid Fuels	CO_2	1778	1863	9.51	4.74	10.62	0.06	4.8	0.000
1 A 1 b Petroleum refining: Liquid Fuels	N_2O	1	1	9.51	77.39	77.97	0.00	-32.4	0.000
1 A 1 c Manufacture of Solid fuels and Other Energy Industries: Solid Fuels	CH_4	0	0	4.33	17.31	17.84	0.00	1.6	0.000
1 A 1 c Manufacture of Solid fuels and Other Energy Industries: Solid Fuels	CO_2	300	393	4.33	3.56	5.60	0.00	30.9	0.000
1 A 1 c Manufacture of Solid fuels and Other Energy Industries: Solid Fuels	N_2O	0	0	4.33	17.31	17.84	0.00	1.6	0.000
1 A 2 a Iron and Steel: Biomass	CH_4	0	C	5.00	40.00	40.31	0.00	C	0.000
1 A 2 a Iron and Steel: Biomass	N_2O	0	C	5.00	40.00	40.31	0.00	C	0.000
1 A 2 a Iron and Steel: Gaseous Fuels	CH_4	0	0	5.00	20.00	20.62	0.00	611.4	0.000
1 A 2 a Iron and Steel: Gaseous Fuels	CO_2	25	181	5.00	5.00	7.07	0.00	616.4	0.000
1 A 2 a Iron and Steel: Gaseous Fuels	N_2O	0	0	5.00	20.00	20.62	0.00	611.4	0.000
1 A 2 a Iron and Steel: Liquid Fuels	CH_4	0	C	4.10	17.86	18.32	0.00	C	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 2 a Iron and Steel: Liquid Fuels	CO_2	831	616	4.10	3.88	5.64	0.00	-25.9	0.000
1 A 2 a Iron and Steel: Liquid Fuels	N_2O	1	C	4.10	21.78	22.16	0.00	C	0.000
1 A 2 a Iron and Steel: Solid Fuels	CH_4	0	0	2.51	10.03	10.34	0.00	-15.8	0.000
1 A 2 a Iron and Steel: Solid Fuels	CO_2	849	581	2.51	3.04	3.94	0.00	-31.6	0.000
1 A 2 a Iron and Steel: Solid Fuels	N_2O	0	0	2.51	10.03	10.34	0.00	-42.5	0.000
1 A 2 b Non-ferrous metals: Gaseous Fuels	CH_4	0	0	5.00	20.00	20.62	0.00	57.7	0.000
1 A 2 b Non-ferrous metals: Gaseous Fuels	CO_2	10	17	5.00	5.00	7.07	0.00	58.8	0.000
1 A 2 b Non-ferrous metals: Gaseous Fuels	N_2O	0	0	5.00	20.00	20.62	0.00	57.7	0.000
1 A 2 b Non-ferrous metals: Liquid Fuels	CH_4	0	0	3.41	16.77	17.11	0.00	-35.0	0.000
1 A 2 b Non-ferrous metals: Liquid Fuels	CO_2	110	84	3.41	2.92	4.49	0.00	-23.3	0.000
1 A 2 b Non-ferrous metals: Liquid Fuels	N_2O	0	0	3.41	24.98	25.21	0.00	-41.1	0.000
1 A 2 b Non-ferrous metals: Solid Fuels	CH_4	0	0					-100	
1 A 2 b Non-ferrous metals: Solid Fuels	CO_2	7	0					-100	
1 A 2 b Non-ferrous metals: Solid Fuels	N_2O	0	0					-100.0	
1 A 2 c Chemicals: Biomass	CH_4	0	0	2.86	43.53	43.62	0	162.73	0.000
1 A 2 c Chemicals: Biomass	N_2O	1	2	2.86	40.36	40.47	0.00	151.1	0.000
1 A 2 c Chemicals: Gaseous Fuels	CH_4	0	0	5	20	20.62	0	-30.29	0.000
1 A 2 c Chemicals: Gaseous Fuels	CO_2	155	58	5	5	7.07	0	-62.2	0.000
1 A 2 c Chemicals: Gaseous Fuels	N_2O	0	0	5.00	20.00	20.62	0.00	-30.3	0.000
1 A 2 c Chemicals: Liquid Fuels	CH_4	0	0	6.71	15.07	16.50	0.00	-28.6	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 2 c Chemicals: Liquid Fuels	CO_2	341	305	6.71	5.29	8.55	0.00	-10.6	0.000
1 A 2 c Chemicals: Liquid Fuels	N_2O	1	0	6.71	19.98	21.08	0.00	-57.5	0.000
1 A 2 c Chemicals: Other Fuels	CH_4	0	0	10.00	100.00	100.50	0.00	819.5	0.000
1 A 2 c Chemicals: Other Fuels	CO_2	6	60	10.00	100.00	100.50	0.01	975.8	0.000
1 A 2 c Chemicals: Other Fuels	N_2O	0	0	10.00	100.00	100.50	0.00	927.5	0.000
1 A 2 c Chemicals: Solid Fuels	CH_4	0	0	2.76	36.50	36.60	0.00	24.5	0.000
1 A 2 c Chemicals: Solid Fuels	CO_2	127	28	2.76	10.10	10.47	0.00	-78.0	0.000
1 A 2 c Chemicals: Solid Fuels	N_2O	0	0	2.76	31.81	31.93	0.00	-47.2	0.000
1 A 2 d Pulp, Paper and Print: Biomass	CH_4	11	12	4.24	38.39	38.62	0.00	15.8	0.000
1 A 2 d Pulp, Paper and Print: Biomass	N_2O	62	76	4.24	37.10	37.34	0.00	23.2	0.000
1 A 2 d Pulp, Paper and Print: Gaseous Fuels	CH_4	0	0	5.00	20.00	20.62	0.00	3.5	0.000
1 A 2 d Pulp, Paper and Print: Gaseous Fuels	CO_2	66	69	5.00	5.00	7.07	0.00	4.2	0.000
1 A 2 d Pulp, Paper and Print: Gaseous Fuels	N_2O	0	0	5.00	20.00	20.62	0.00	3.5	0.000
1 A 2 d Pulp, Paper and Print: Liquid Fuels	CH_4	1	0	3.54	31.70	31.90	0.00	-69.3	0.000
1 A 2 d Pulp, Paper and Print: Liquid Fuels	CO_2	1786	596	3.54	1.42	3.82	0.00	-66.6	0.000
1 A 2 d Pulp, Paper and Print: Liquid Fuels	N_2O	4	1	3.54	34.04	34.22	0.00	-72.2	0.000
1 A 2 d Pulp, Paper and Print: Other Fuels	CH_4	0	0	10.00	100.00	100.50	0.00	-62.8	0.000
1 A 2 d Pulp, Paper and Print: Other Fuels	CO_2	73	56	10.00	100.00	100.50	0.00	-23.4	0.000
1 A 2 d Pulp, Paper and Print: Other Fuels	N_2O	0	0	10.00	100.00	100.50	0.00	-40.8	0.000
1 A 2 d Pulp, Paper and Print: Solid Fuels	CH_4	0	0	4.00	30.03	30.30	0.00	-90.6	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 2 d Pulp, Paper and Print: Solid Fuels	CO_2	265	15	4.00	5.08	6.46	0.00	-94.3	0.000
1 A 2 d Pulp, Paper and Print: Solid Fuels	N_2O	2	0	4.00	28.36	28.64	0.00	-94.4	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Biomass	CH_4	0	1	3.82	49.06	49.21	0.00	317.2	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Biomass	N_2O	0	2	3.82	38.20	38.39	0.00	419.8	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Gaseous Fuels	CH_4	0	0	5.00	20.00	20.62	0.00	-30.4	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Gaseous Fuels	CO_2	254	178	5.00	5.00	7.07	0.00	-29.9	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Gaseous Fuels	N_2O	0	0	5.00	20.00	20.62	0.00	-30.4	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Liquid Fuels	CH_4	0	0	3.11	17.67	17.94	0.00	-83.4	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Liquid Fuels	CO_2	596	135	3.11	2.42	3.94	0.00	-77.4	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Liquid Fuels	N_2O	1	0	3.11	25.19	25.38	0.00	-84.7	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Other Fuels	CH_4	0	0	10.00	100.00	100.50	0.00	-40.1	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Other Fuels	CO_2	8	13	10.00	100.00	100.50	0.00	54.5	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Other Fuels	N_2O	0	0	10.00	100.00	100.50	0.00	7.6	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Solid Fuels	CH_4	0	0	5.00	20.00	20.62	0.00	-89.1	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Solid Fuels	CO_2	90	11	5.00	5.00	7.07	0.00	-88.0	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Solid Fuels	N_2O	0	0	5.00	40.00	40.31	0.00	-89.1	0.000
1 A 2 f Non-metallic minerals: Biomass	CH_4	0	C	5.05	52.93	53.17	0.00	C	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 2 f Non-metallic minerals: Biomass	N_2O	0	C	4.84	48.35	48.59	0.00	C	0.000
1 A 2 f Non-metallic minerals: Gaseous Fuels	CH_4	0	0	4.15	8.29	9.27	0.00	82.0	0.000
1 A 2 f Non-metallic minerals: Gaseous Fuels	CO_2	65	120	4.15	2.07	4.64	0.00	83.3	0.000
1 A 2 f Non-metallic minerals: Gaseous Fuels	N_2O	0	0	4.15	8.29	9.27	0.00	82.0	0.000
1 A 2 f Non-metallic minerals: Liquid Fuels	CH_4	0	C	3.94	10.29	11.02	0.00	C	0.000
1 A 2 f Non-metallic minerals: Liquid Fuels	CO_2	625	C	3.92	1.23	4.10	0.00	C	0.000
1 A 2 f Non-metallic minerals: Liquid Fuels	N_2O	1	C	4.31	15.88	16.45	0.00	C	0.000
1 A 2 f Non-metallic minerals: Other Fuels	CH_4	0	0	5.77	57.74	58.02	0.00		0.000
1 A 2 f Non-metallic minerals: Other Fuels	CO_2	0	163	5.77	57.74	58.02	0.01		0.000
1 A 2 f Non-metallic minerals: Other Fuels	N_2O	0	0	5.77	57.74	58.02	0.00		0.000
1 A 2 f Non-metallic minerals: Solid Fuels	CH_4	0	0	4.57	9.14	10.22	0.00	-49.0	0.000
1 A 2 f Non-metallic minerals: Solid Fuels	CO_2	1135	C	4.53	1.36	4.73	0.00	C	0.000
1 A 2 f Non-metallic minerals: Solid Fuels	N_2O	6	C	4.57	18.27	18.84	0.00	C	0.000
1 A 2 g vii Off-road vehicles and other machinery: Liquid Fuels	CH_4	2	2	4.42	44.43	44.65	0.00	30.3	0.000
1 A 2 g vii Off-road vehicles and other machinery: Liquid Fuels	CO_2	997	1235	4.91	3.93	6.29	0.01	23.9	0.000
1 A 2 g vii Off-road vehicles and other machinery: Liquid Fuels	N_2O	13	18	4.97	49.70	49.95	0.00	40.6	0.000
1 A 2 g viii Other: Biomass	CH_4	7	5	3.46	33.96	34.14	0.00	-18.6	0.000
1 A 2 g viii Other: Biomass	N_2O	36	29	3.53	35.35	35.53	0.00	-20.0	0.000
1 A 2 g viii Other: Gaseous Fuels	CH_4	0	0	2.18	4.35	4.87	0.00	-22.9	0.000
1 A 2 g viii Other: Gaseous Fuels	CO_2	113	88	2.18	1.09	2.43	0.00	-22.4	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 2 g viii Other: Gaseous Fuels	N_2O	0	0	2.18	4.35	4.87	0.00	-22.9	0.000
1 A 2 g viii Other: Liquid Fuels	CH_4	1	0	1.99	5.09	5.47	0.00	-64.1	0.000
1 A 2 g viii Other: Liquid Fuels	CO_2	2062	C	1.86	0.26	1.87	0.00	C	0.000
1 A 2 g viii Other: Liquid Fuels	N_2O	7	C	2.52	7.08	7.51	0.00	C	0.000
1 A 2 g viii Other: Other Fuels	CH_4	0	0	3.33	33.30	33.46	0.00		0.000
1 A 2 g viii Other: Other Fuels	CO_2	0	15	3.33	33.30	33.46	0.00		0.000
1 A 2 g viii Other: Other Fuels	N_2O	0	0	2.85	28.55	28.69	0.00		0.000
1 A 2 g viii Other: Solid Fuels	CH_4	0	0	3.41	6.98	7.77	0.00	791.3	0.000
1 A 2 g viii Other: Solid Fuels	CO_2	94	C	3.30	0.99	3.45	0.00	C	0.000
1 A 2 g viii Other: Solid Fuels	N_2O	0	C	3.31	13.22	13.62	0.00	C	0.000
1 A 3 a Domestic Aviation: Aviation Gasoline	CH_4	0	0	10.00	200.00	200.25	0.00	-83.0	0.000
1 A 3 a Domestic Aviation: Aviation Gasoline	CO_2	15	4	8.28	4.14	9.25	0.00	-73.4	0.000
1 A 3 a Domestic Aviation: Aviation Gasoline	N_2O	0	0	7.07	141.45	141.62	0.00	-80.0	0.000
1 A 3 a Domestic Aviation: Jet Kerosene	CH_4	1	0	10.00	200.00	200.25	0.00	-47.5	0.000
1 A 3 a Domestic Aviation: Jet Kerosene	CO_2	658	541	8.28	4.14	9.25	0.00	-17.8	0.000
1 A 3 a Domestic Aviation: Jet Kerosene	N_2O	13	8	7.07	141.45	141.62	0.00	-38.2	0.000
1 A 3 b i Road Transportation, Cars: Biomass	CH_4	0	0	4.36	174.31	174.37	0.00		0.000
1 A 3 b i Road Transportation, Cars: Biomass	CO_2	0	16	5.00	10.00	11.18	0.00		0.000
1 A 3 b i Road Transportation, Cars: Biomass	N_2O	0	0	3.84	153.56	153.61	0.00		0.000
1 A 3 b i Road Transportation, Cars: Diesel oil	CH_4	0	0	5.00	45.00	45.28	0.00	-14.9	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 3 b i Road Transportation, Cars: Diesel oil	CO_2	439	4058	5.00	5.00	7.07	0.13	824.6	0.010
1 A 3 b i Road Transportation, Cars: Diesel oil	N_2O	0	40	5.00	65.00	65.19	0.00	33084.9	0.000
1 A 3 b i Road Transportation, Cars: Gasoline	CH_4	138	10	3.00	40.00	40.11	0.00	-92.9	0.000
1 A 3 b i Road Transportation, Cars: Gasoline	CO_2	11999	6249	3.00	4.00	5.00	0.15	-47.9	0.010
1 A 3 b i Road Transportation, Cars: Gasoline	N_2O	132	10	3.00	60.00	60.07	0.00	-92.4	0.000
1 A 3 b i Road Transportation, Cars: LPG	CH_4	0	0	5.00	65.00	65.19	0.00	634.5	0.000
1 A 3 b i Road Transportation, Cars: LPG	CO_2	0	2	5.00	5.00	7.07	0.00	634.5	0.000
1 A 3 b i Road Transportation, Cars: LPG	N_2O	0	0	5.00	65.00	65.19	0.00	634.5	0.000
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	CH_4	0	0	5.00	45.00	45.28	0.00	-31.1	0.000
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	CO_2	162	1401	5.00	5.00	7.07	0.02	763.7	0.000
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	N_2O	0	11	5.00	65.00	65.19	0.00	41603.6	0.000
1 A 3 b ii Road Transportation, Light duty trucks: Gasoline	CH_4	8	0	3.00	40.00	40.11	0.00	-96.9	0.000
1 A 3 b ii Road Transportation, Light duty trucks: Gasoline	CO_2	692	96	3.00	4.00	5.00	0.00	-86.1	0.000
1 A 3 b ii Road Transportation, Light duty trucks: Gasoline	N_2O	7	1	3.00	60.00	60.07	0.00	-91.8	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Biomass	CH_4	0	2	3.71	148.29	148.34	0.00	2206.9	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Biomass	CO_2	3	28	5.00	10.00	11.18	0.00	851.5	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Biomass	N_2O	0	4	3.43	137.15	137.19	0.00	2124.7	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	CH_4	2	0	4.27	49.69	49.87	0.00	-92.6	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	CO_2	3779	3407	4.79	4.80	6.78	0.08	-9.9	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	N_2O	13	71	4.48	61.89	62.06	0.00	431.4	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 3 b iii Road Transportation, Heavy duty trucks: Gasoline	CH_4	0	0	3.00	40.00	40.11	0.00	-82.6	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Gasoline	CO_2	16	3	3.00	4.00	5.00	0.00	-83.7	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Gasoline	N_2O	0	0	3.00	60.00	60.07	0.00	-83.0	0.000
1 A 3 b iv Road Transportation, Motorcycles: Gasoline	CH_4	2	2	3.00	40.00	40.11	0.00	-1.2	0.000
1 A 3 b iv Road Transportation, Motorcycles: Gasoline	CO_2	38	85	3.00	4.00	5.00	0.00	119.8	0.000
1 A 3 b iv Road Transportation, Motorcycles: Gasoline	N_2O	0	0	3.00	60.00	60.07	0.00	135.0	0.000
1 A 3 c Railways: Liquid Fuels	CH_4	0	0	5.00	150.00	150.08	0.00	-58.0	0.000
1 A 3 c Railways: Liquid Fuels	CO_2	101	41	5.00	5.00	7.07	0.00	-59.3	0.000
1 A 3 c Railways: Liquid Fuels	N_2O	0	0	5.00	200.00	200.06	0.00	-58.0	0.000
1 A 3 d Domestic Navigation: Gas/Diesel Oil	CH_4	3	4	4.97	198.94	199.01	0.00	36.1	0.000
1 A 3 d Domestic Navigation: Gas/Diesel Oil	CO_2	381	293	2.89	2.93	4.12	0.00	-23.2	0.000
1 A 3 d Domestic Navigation: Gas/Diesel Oil	N_2O	6	3	2.79	61.34	61.40	0.00	-45.6	0.000
1 A 3 d Domestic Navigation: Residual Oil	CH_4	0	0	15.00	40.00	42.72	0.00	-94.3	0.000
1 A 3 d Domestic Navigation: Residual Oil	CO_2	194	12	15.00	7.00	16.55	0.00	-93.7	0.000
1 A 3 d Domestic Navigation: Residual Oil	N_2O	3	0	15.00	40.00	42.72	0.00	-94.1	0.000
1 A 3 e Other Transportation: Diesel Oil	CH_4	0	0	5.00	50.00	50.25	0.00	-6.7	0.000
1 A 3 e Other Transportation: Diesel Oil	CO_2	205	165	5.00	5.00	7.07	0.00	-19.4	0.000
1 A 3 e Other Transportation: Diesel Oil	N_2O	3	2	5.00	50.00	50.25	0.00	-10.1	0.000
1 A 3 e Other Transportation: Gaseous fuels	CH_4	0	0	5.00	150.00	150.08	0.00	14.0	0.000
1 A 3 e Other Transportation: Gaseous fuels	CO_2	2	2	5.00	5.00	7.07	0.00	14.7	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 3 e Other Transportation: Gaseous fuels	N_2O	0	0	5.00	1000.00	1000.01	0.00	14.0	0.000
1 A 4 a Commercial/Institutional: Biomass	CH_4	4	16	9.65	99.78	100.24	0.00	268.5	0.000
1 A 4 a Commercial/Institutional: Biomass	N_2O	1	4	9.65	98.22	98.69	0.00	274.4	0.000
1 A 4 a Commercial/Institutional: Diesel Oil	CH_4	0	0	5.00	50.00	50.25	0.00	47.3	0.000
1 A 4 a Commercial/Institutional: Diesel Oil	CO_2	170	216	5.00	5.00	7.07	0.00	26.8	0.000
1 A 4 a Commercial/Institutional: Diesel Oil	N_2O	2	3	5.00	50.00	50.25	0.00	40.1	0.000
1 A 4 a Commercial/Institutional: Gaseous Fuels	CH_4	0	0	9.71	19.41	21.70	0.00	112.5	0.000
1 A 4 a Commercial/Institutional: Gaseous Fuels	CO_2	86	184	9.71	4.85	10.85	0.00	114.0	0.000
1 A 4 a Commercial/Institutional: Gaseous Fuels	N_2O	0	0	9.71	19.41	21.70	0.00	112.5	0.000
1 A 4 a Commercial/Institutional: Gasoline	CH_4	2	2	5.00	50.00	50.25	0.00	-0.8	0.000
1 A 4 a Commercial/Institutional: Gasoline	CO_2	185	199	5.00	4.00	6.40	0.00	7.7	0.000
1 A 4 a Commercial/Institutional: Gasoline	N_2O	1	1	5.00	50.00	50.25	0.00	14.2	0.000
1 A 4 a Commercial/Institutional: Liquid Fuels	CH_4	2	0	15.26	34.48	37.71	0.00	-95.2	0.000
1 A 4 a Commercial/Institutional: Liquid Fuels	CO_2	2447	147	15.26	1.36	15.32	0.00	-94.0	0.000
1 A 4 a Commercial/Institutional: Liquid Fuels	N_2O	27	1	15.26	39.36	42.21	0.00	-96.6	0.000
1 A 4 b Residential: Biomass	CH_4	96	59	10.00	100.00	100.50	0.01	-38.7	0.000
1 A 4 b Residential: Biomass	N_2O	58	63	10.00	100.00	100.50	0.01	7.8	0.000
1 A 4 b Residential: Gaseous Fuels	CH_4	0	0	9.15	18.30	20.46	0.00	6.2	0.000
1 A 4 b Residential: Gaseous Fuels	CO_2	86	92	9.15	4.58	10.23	0.00	6.9	0.000
1 A 4 b Residential: Gaseous Fuels	N_2O	0	0	9.15	18.30	20.46	0.00	6.2	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 4 b Residential: Liquid Fuels	CH_4	7	4	2.93	47.81	47.90	0.00	-48.5	0.000
1 A 4 b Residential: Liquid Fuels	CO_2	6234	524	6.78	2.35	7.18	0.00	-91.6	0.000
1 A 4 b Residential: Liquid Fuels	N_2O	53	3	7.61	28.65	29.64	0.00	-93.4	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Biomass	CH_4	1	32	7.98	96.43	96.76	0.00	2353.3	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Biomass	N_2O	0	10	7.98	79.75	80.15	0.00	3007.2	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Gaseous Fuels	CH_4	0	0	10.00	20.00	22.36	0.00	-56.8	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Gaseous Fuels	CO_2	33	14	10.00	5.00	11.18	0.00	-56.5	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Gaseous Fuels	N_2O	0	0	10.00	20.00	22.36	0.00	-56.8	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Liquid Fuels	CH_4	2	3	2.32	24.74	24.84	0.00	7.0	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Liquid Fuels	CO_2	1572	1302	3.14	2.60	4.08	0.00	-17.2	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Liquid Fuels	N_2O	20	17	3.23	28.07	28.26	0.00	-13.2	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Solid Fuels	CH_4	0	0					-100.0	
1 A 4 c Agriculture/Forestry/Fisheries: Solid Fuels	CO_2	157	0					-100.0	
1 A 4 c Agriculture/Forestry/Fisheries: Solid Fuels	N_2O	1	0					-100.0	
1 A 5 b Mobile: Biomass	CH_4	0	0	5.00	100.00	100.12	0.00		0.000
1 A 5 b Mobile: Biomass	N_2O	0	0	5.00	100.00	100.12	0.00		0.000
1 A 5 b Mobile: Liquid Fuels	CH_4	1	0	3.95	153.02	153.07	0.00	-96.2	0.000
1 A 5 b Mobile: Liquid Fuels	CO_2	846	184	3.62	3.62	5.12	0.00	-78.3	0.000
1 A 5 b Mobile: Liquid Fuels	N_2O	16	3	3.57	136.66	136.70	0.00	-83.4	0.000
1 B 1 c Fugitive emissions from Solid Fuels	CH_4	0	0	50.00	20.00	53.85	0.00	-0.2	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 B 1 c Fugitive emissions from Solid Fuels	CO_2	5	5	50.00	5.00	50.25	0.00	0.1	0.000
1 B 1 c Fugitive emissions from Solid Fuels	N_2O	0	0	50.00	20.00	53.85	0.00	-0.2	0.000
1 B 2 a Oil	CH_4	25	26	0.02	285.75	285.75	0.01	6.4	0.000
1 B 2 a Oil	CO_2	219	756	2.73	3.89	4.75	0.00	245.2	0.000
1 B 2 a Oil	N_2O	1	1	6.66	22.36	23.33	0.00	15.7	0.000
1 B 2 b Natural gas	CH_4	67	34		47.16	47.16	0.00	-50.0	0.000
1 B 2 b Natural gas	CO_2	3	0		47.20	47.20	0.00	-98.8	0.000
1 B 2 c Venting and flaring	CH_4	0	0	4.13	44.90	45.09	0.00	-0.7	0.000
1 B 2 c Venting and flaring	CO_2	61	39	17.50	5.00	18.20	0.00	-35.9	0.000
1 B 2 c Venting and flaring	N_2O	0	0	17.50	80.00	81.89	0.00	-51.6	0.000
2 A 1 Cement Production	CO_2	1272	1484	2.00	5.00	5.39	0.01	16.7	0.000
2 A 2 Lime Production	CO_2	331	465	5.01	1.86	5.34	0.00	40.3	0.000
2 A 3 Glass Production	CO_2	54	17		7.00	7.00	0.00	-67.9	0.000
2 A 4 Other	CO_2	15	18	2.73	4.04	4.87	0.00	15.1	0.000
2 B 10 Other	CH_4	1	1		89.66	89.66	0.00	10.3	0.000
2 B 10 Other	CO_2	598	830		6.70	6.70	0.00	38.8	0.000
2 B 10 Other	N_2O	21	6		106.81	106.81	0.00	-69.2	0.000
2 B 2 Nitric Acid Production	N_2O	782	42	2.00	5.00	5.39	0.00	-94.7	0.000
2 B 5 Carbide production	CO_2	12	8	10.00	5.00	11.18	0.00	-35.8	0.000
2 C 1 Iron and Steel Production	CH_4	19	0	5.00	50.00	50.25	0.00	-99.0	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
2 C 1 Iron and Steel Production	CO_2	2624	2230	4.05	4.07	5.74	0.03	-15.0	0.000
2 C 2 Ferroalloys production	CH_4	1	0					-100.0	
2 C 2 Ferroalloys production	CO_2	228	C	5.00	5.00	7.07	0.00	C	0.000
2 C 3 Aluminium production	CO_2	133	206	5.00	5.00	7.07	0.00	55.1	0.000
2 C 3 Aluminium production	PFCs	569	36	2.00	10.00	10.20	0.00	-93.7	0.000
2 C 3 Aluminium production	SF6	23	13	20.00	20.00	28.28	0.00	-43.7	0.000
2 C 7 Other	CO_2	276	C	4.00	5.00	6.40	0.00	C	0.000
2 C 7 Other	CO_2	276	C	4.00	5.00	6.40	0.00	C	0.000
2 D 1 Lubricant use	CO_2	158	254	5.00	50.00	50.25	0.03	60.7	0.000
2 D 2 Paraffin wax use	CO_2	18	38	10.00	50.00	50.99	0.00	115.3	0.000
2 D 3 Other	CO_2	217	153	12.33	6.44	13.91	0.00	-29.6	0.000
2 F 1 Refrigeration and air conditioning	HFCs	5	1068	16.17	33.31	37.03	0.24	21018.3	0.010
2 F 1 Refrigeration and air conditioning	PFCs	0	1	32.98	65.97	73.76	0.00		0.000
2 F 2 Foam blowing agents	HFCs	0	30	1.43	14.30	14.37	0.00		0.000
2 F 3 Fire protection	HFCs	0	3	3.57	14.30	14.74	0.00		0.000
2 F 4 Aerosols	HFCs	1	37	37.94	15.92	41.14	0.00	2480.9	0.000
2 G 1 Electrical equipment	SF6	77	33	8.56	17.13	19.15	0.00	-56.6	0.000
2 G 2 SF6 and PFCs from other product use	SF6	2	1	5.00	50.00	50.25	0.00	-58.4	0.000
2 G 3 N2O from product uses	N_2O	87	76	10.00	10.00	14.14	0.00	-12.1	0.000
2 H Other	CH_4	6	8	6.64	19.92	20.99	0.00	33.0	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
2 H Other	CO_2	19	12	0.00	6.00	6.00	0.00	-36.0	0.000
2 H Other	N_2O	64	84	6.59	19.76	20.83	0.00	32.1	0.000
3 A 1 Dairy cattle	CH_4	1617	1138	5.00	20.00	20.62	0.09	-29.6	0.000
3 A 1 Non-dairy cattle	CH_4	1268	1470	5.00	25.00	25.50	0.22	15.9	0.010
3 A 2 Sheep	CH_4	81	121	5.00	40.00	40.31	0.00	49.3	0.000
3 A 4 Goats	CH_4	1	2	5.00	40.00	40.31	0.00	177.7	0.000
3 A 4 Horses	CH_4	142	160	5.00	40.00	40.31	0.01	12.6	0.000
3 A 4 Raindeer	CH_4	85	79	5.00	40.00	40.31	0.00	-6.2	0.000
3 A 4 Swine	CH_4	85	51	5.00	40.00	40.31	0.00	-39.8	0.000
3 B 1 Dairy cattle	CH_4	95	73	20.00	50.00	53.85	0.00	-22.4	0.000
3 B 1 Dairy cattle	N_2O	105	73	17.70	44.25	47.66	0.00	-30.4	0.000
3 B 1 Non-dairy cattle	CH_4	61	106	20.00	50.00	53.85	0.01	73.9	0.000
3 B 1 Non-dairy cattle	N_2O	71	90	12.73	31.82	34.27	0.00	26.0	0.000
3 B 3 Swine	CH_4	59	48	20.00	50.00	53.85	0.00	-19.8	0.000
3 B 3 Swine	N_2O	42	28	16.33	40.83	43.98	0.00	-34.9	0.000
3 B 4 Fur-bearing animals	CH_4	5	3	20.00	50.00	53.85	0.00	-32.6	0.000
3 B 4 Fur-bearing animals	N_2O	3	2	20.00	50.00	53.85	0.00	-32.6	0.000
3 B 4 Goats	CH_4	0	0	20.00	50.00	53.85	0.00	177.7	0.000
3 B 4 Goats	N_2O	0	0	20.00	50.00	53.85	0.00	177.7	0.000
3 B 4 Horses	CH_4	12	14	20.00	50.00	53.85	0.00	12.6	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
3 B 4 Horses	N_2O	24	27	13.37	33.42	35.99	0.00	12.6	0.000
3 B 4 Poultry	CH_4	8	13	13.84	34.59	37.25	0.00	50.1	0.000
3 B 4 Poultry	N_2O	19	28	14.05	35.12	37.82	0.00	49.1	0.000
3 B 4 Reindeer	CH_4	2	2	20.00	50.00	53.85	0.00	-6.2	0.000
3 B 4 Sheep	CH_4	2	3	20.00	50.00	53.85	0.00	49.3	0.000
3 B 4 Sheep	N_2O	3	5	20.00	50.00	53.85	0.00	86.1	0.000
3 B Indirect N2O emissions	N_2O	103	81	35.00	400.00	401.53	0.17	-21.1	0.000
3 D a 1 Inorganic N fertilizers	N_2O	1051	929	35.00	200.00	203.04	5.58	-11.6	0.150
3 D a 2 a Animal manure applied to soils	N_2O	359	333	35.00	200.00	203.04	0.71	-7.3	0.020
3 D a 2 b Sewage sludge applied to soils	N_2O	6	15	35.00	200.00	203.04	0.00	166.8	0.000
3 D a 2 c Other organic fertilizers applied to soils	N_2O	8	25	35.00	200.00	203.04	0.00	215.2	0.000
3 D a 3 Urine and dung deposited by grazing animals	N_2O	361	355	21.98	125.60	127.51	0.32	-1.5	0.010
3 D a 4 Crop residues applied to soils	N_2O	452	415	35.00	200.00	203.04	1.11	-8.3	0.030
3 D a 5 Mineralization/immobilization associated with loss/gain of soil organic matter	N_2O	68	258	20.00	200.00	201.00	0.42	280.1	0.020
3 D a 6 Cultivation of organic soils (i.e. histosols)	N_2O	914	832	5.00	85.00	85.15	0.79	-9.0	0.020
3 D b 1 Atmospheric deposition	N_2O	103	94	35.00	400.00	401.53	0.22	-8.4	0.010
3 D b 2 Nitrogen leaching and run-off	N_2O	266	186	35.00	150.00	154.03	0.13	-30.0	0.000
3 G Liming	CO_2	173	127	16.35	8.17	18.28	0.00	-26.9	0.000
3 H Urea application	CO_2	4	1	20.00	10.00	22.36	0.00	-80.8	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
4 A 1 Forest land remaining forest land	CH_4	2	2		70.94	70.94	0.00	10.8	0.000
4 A 1 Forest land remaining forest land	CO_2	-37739	-43170	5.55	15.29	16.26	77.18	14.4	2.870
4 A 1 Forest land remaining forest land	N_2O	49	18	2.97	49.55	49.64	0.00	-63.7	0.000
4 A 2 1 Cropland converted to forest land	CO_2	141	-481	1.38	21.15	21.20	0.02	-440.0	0.000
4 A 2 1 Cropland converted to forest land	N_2O	2	12		100.00	100.00	0.00	399.5	0.000
4 A 2 2 Grassland converted to forest land	CO_2	-25	-144	0.54	22.57	22.58	0.00	469.7	0.000
4 A 2 2 Grassland converted to forest land	N_2O	1	5		100.00	100.00	0.00	390.0	0.000
4 A 2 3 Wetlands converted to forest land	CO_2	0	-45	8.97	22.50	24.22	0.00	-47887.1	0.000
4 A 2 4 Settlements converted to forest land	CO_2	-42	-616	0.14	22.68	22.68	0.03	1354.6	0.000
4 A 2 5 Other land converted to forest land	CO_2	0	-34		26.05	26.05	0.00		0.000
4 A Drained organic soils	CH_4	237	217	25.00	100.00	103.08	0.08	-8.5	0.000
4 A Drained organic soils	N_2O	1179	1043	25.00	100.00	103.08	1.81	-11.5	0.050
4 B 1 Cropland remaining cropland	CO_2	3291	3331	20.85	29.21	35.89	2.24	1.2	0.110
4 B 2 1 Forest land converted to cropland	CO_2	0	69	1.63	48.55	48.58	0.00		0.000
4 B 2 2 Grassland converted to cropland	CO_2	10	73	21.40	43.26	48.27	0.00	653.8	0.000
4 B 2 2 Grassland converted to cropland	N_2O	2	5		100.00	100.00	0.00	203.0	0.000
4 B 2 4 Settlements converted to cropland	CO_2	7	1	11.22	39.80	41.35	0.00	-88.9	0.000
4 B 2 4 Settlements converted to cropland	N_2O	0	0		100.00	100.00	0.00	207.9	0.000
4 B Drained organic soils	CH_4	220	201	25.00	100.00	103.08	0.07	-8.7	0.000
4 C 1 Grassland remaining grassland	CH_4	0	0		100.00	100.00	0.00	-12.2	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
4 C 1 Grassland remaining grassland	CO_2	-193	-183	7.24	21.02	22.23	0.00	-5.0	0.000
4 C 1 Grassland remaining grassland	N_2O	7	17		99.89	99.89	0.00	141.1	0.000
4 C 2 1 Forest land converted to grassland	CO_2	476	291		44.03	44.03	0.03	-38.8	0.000
4 C 2 2 Cropland converted to grassland	CO_2	41	-26	7.77	20.69	22.11	0.00	-164.3	0.000
4 C 2 3 Wetlands converted to grassland	CO_2	0	4	15.16	30.87	34.39	0.00		0.000
4 C 2 4 Settlements converted to grassland	CO_2	-19	-4	16.38	33.44	37.24	0.00	-78.2	0.000
4 C 2 5 Other land converted to grassland	CO_2	0	-15	2.01	18.16	18.27	0.00		0.000
4 C Drained organic soils	CH_4	7	7	25.00	100.00	103.08	0.00	0.2	0.000
4 D 1 1 Peat extraction remaining peat extraction	CO_2	73	195	25.00	50.00	55.90	0.02	166.4	0.000
4 D 1 Wetlands remaining wetlands	CH_4	5	7	25.00	100.00	103.08	0.00	36.2	0.000
4 D 1 Wetlands remaining wetlands	N_2O	1	1	25.00	100.00	103.08	0.00	36.2	0.000
4 E 1 Settlements remaining settlements	CO_2	59	121		20.00	20.00	0.00	104.8	0.000
4 E 2 1 Forest land converted to settlements	CO_2	2193	856	12.33	31.61	33.93	0.13	-61.0	0.000
4 E 2 1 Forest land converted to settlements	N_2O	9	23		100.00	100.00	0.00	154.7	0.000
4 E 2 2 Cropland converted to settlements	CO_2	277	1079		38.13	38.13	0.27	289.2	0.010
4 E 2 2 Cropland converted to settlements	N_2O	32	90		100.00	100.00	0.01	180.1	0.000
4 E 2 3 Grassland converted to settlements	CO_2	6	25		43.46	43.46	0.00	299.6	0.000
4 E 2 3 Grassland converted to settlements	N_2O	0	2		100.00	100.00	0.00	246.8	0.000
4 E 2 5 Other Land converted to settlements	CO_2	65	12	25.00	50.00	55.90	0.00	-81.7	0.000
4 E 2 5 Other Land converted to settlements	N_2O	6	1		100.00	100.00	0.00	-81.7	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO_2-eq)	Year 2017 emissions or removals (kt CO_2-eq)	data uncertainty Activity in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
4 G Total HWP from domestic harvest	CO_2	-5016	-6714		30.69	30.69	6.65	33.8	0.210
4 Nitrogen Leaching and Run-off	N_2O	8	3		72.19	72.19	0.00	-61.9	0.000
4.F.2 Land Converted to Other Land	CO_2	231	-7	9.98	36.05	37.41	0.00	-103.2	0.000
5 A 1 Managed waste disposal sites	CH_4	3422	841	25.00	50.00	55.90	0.35	-75.4	0.010
5 B 1 Composting	CH_4	7	88	2.44	19.77	19.92	0.00	1094.9	0.000
5 B 1 Composting	N_2O	5	32		50.20	50.20	0.00	534.8	0.000
5 C 1 Waste Incineration	CH_4	0	0	10.00	10.00	14.14	0.00	331.0	0.000
5 C 1 Waste Incineration	CO_2	44	58	10.00	10.00	14.14	0.00	32.8	0.000
5 C 1 Waste Incineration	N_2O	1	5	10.00	100.00	100.50	0.00	425.0	0.000
5 D 1 Domestic wastewater	CH_4	38	29		44.86	44.86	0.00	-23.5	0.000
5 D 1 Domestic wastewater	N_2O	226	200		48.70	48.70	0.01	-11.5	0.000
Total		36908	8933			89.46	100	-75.8	18.99

‘0’ = uncertainty is less than 0.5. An empty AD-uncertainty cell means that all uncertainty allocated to the emission factor.

Table A7.2. Approach 1 uncertainty assessment for national total emissions in 2017, excluding LULUCF.

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 1 a Public Electricity and Heat Production: Biomass	CH_4	8	41	1.3	26.0	26.1	0.00	392	0.000
1 A 1 a Public Electricity and Heat Production: Biomass	N_2O	34	160	1.4	27.1	27.1	0.03	374	0.000
1 A 1 a Public Electricity and Heat Production: Gaseous Fuels	CH_4	0	0	2.0	20.0	20.1	0.00	-41	0.000
1 A 1 a Public Electricity and Heat Production: Gaseous Fuels	CO_2	486	286	2.0	5.0	5.4	0.00	-41	0.000
1 A 1 a Public Electricity and Heat Production: Gaseous Fuels	N_2O	0	0	2.0	20.0	20.1	0.00	-41	0.000
1 A 1 a Public Electricity and Heat Production: Liquid Fuels	CH_4	1	0	1.4	27.8	27.8	0.00	-82	0.000
1 A 1 a Public Electricity and Heat Production: Liquid Fuels	CO_2	1277	284	1.4	2.9	3.2	0.00	-78	0.000
1 A 1 a Public Electricity and Heat Production: Liquid Fuels	N_2O	3	1	1.4	134.4	134.4	0.00	-76	0.000
1 A 1 a Public Electricity and Heat Production: Other Fuels	CH_4	3	3	2.0	40.0	40.1	0.00	22	0.000
1 A 1 a Public Electricity and Heat Production: Other Fuels	CO_2	570	2479	2.0	19.9	20.0	3.36	335	0.000
1 A 1 a Public Electricity and Heat Production: Other Fuels	N_2O	8	30	2.0	40.1	40.1	0.00	280	0.000
1 A 1 a Public Electricity and Heat Production: Peat	CH_4	3	1	2.0	40.0	40.1	0.00	-58	0.000
1 A 1 a Public Electricity and Heat Production: Peat	CO_2	1150	480	2.0	20.0	20.1	0.13	-58	0.000
1 A 1 a Public Electricity and Heat Production: Peat	N_2O	33	7	2.0	40.0	40.1	0.00	-79	0.000
1 A 1 a Public Electricity and Heat Production: Solid Fuels	CH_4	1	0	0.6	21.0	21.0	0.00	-60	0.000
1 A 1 a Public Electricity and Heat Production: Solid Fuels	CO_2	4231	2956	0.7	7.4	7.4	0.65	-30	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 1 a Public Electricity and Heat Production: Solid Fuels	N_2O	41	48	0.9	27.8	27.8	0.00	17	0.000
1 A 1 b Petroleum refining: Gaseous Fuels	CH_4	0	0	2.0	20.0	20.1	0.00		0.000
1 A 1 b Petroleum refining: Gaseous Fuels	CO_2	0	137	2.0	5.0	5.4	0.00		0.000
1 A 1 b Petroleum refining: Gaseous Fuels	N_2O	0	0	2.0	20.0	20.1	0.00		0.000
1 A 1 b Petroleum refining: Liquid Fuels	CH_4	1	1	9.5	91.0	91.5	0.00	-19	0.000
1 A 1 b Petroleum refining: Liquid Fuels	CO_2	1778	1863	9.5	4.7	10.6	0.53	5	0.000
1 A 1 b Petroleum refining: Liquid Fuels	N_2O	1	1	9.5	77.4	78.0	0.00	-32	0.000
1 A 1 c Manufacture of Solid fuels and Other Energy Industries: Solid Fuels	CH_4	0	0	4.3	17.3	17.8	0.00	2	0.000
1 A 1 c Manufacture of Solid fuels and Other Energy Industries: Solid Fuels	CO_2	300	393	4.3	3.6	5.6	0.01	31	0.000
1 A 1 c Manufacture of Solid fuels and Other Energy Industries: Solid Fuels	N_2O	0	0	4.3	17.3	17.8	0.00	2	0.000
1 A 2 a Iron and Steel: Biomass	CH_4	0 C		5.0	40.0	40.3	0.00 C		0.000
1 A 2 a Iron and Steel: Biomass	N_2O	0 C		5.0	40.0	40.3	0.00 C		0.000
1 A 2 a Iron and Steel: Gaseous Fuels	CH_4	0	0	5.0	20.0	20.6	0.00	611	0.000
1 A 2 a Iron and Steel: Gaseous Fuels	CO_2	25	181	5.0	5.0	7.1	0.00	616	0.000
1 A 2 a Iron and Steel: Gaseous Fuels	N_2O	0	0	5.0	20.0	20.6	0.00	611	0.000
1 A 2 a Iron and Steel: Liquid Fuels	CH_4	0 C		4.1	17.9	18.3	0.00 C		0.000
1 A 2 a Iron and Steel: Liquid Fuels	CO_2	831	616	4.1	3.9	5.6	0.02	-26	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 2 a Iron and Steel: Liquid Fuels	N_2O	1	C	4.1	21.8	22.2	0.00	C	0.000
1 A 2 a Iron and Steel: Solid Fuels	CH_4	0	0	2.5	10.0	10.3	0.00	-16	0.000
1 A 2 a Iron and Steel: Solid Fuels	CO_2	849	581	2.5	3.0	3.9	0.01	-32	0.000
1 A 2 a Iron and Steel: Solid Fuels	N_2O	0	0	2.5	10.0	10.3	0.00	-43	0.000
1 A 2 b Non-ferrous metals: Gaseous Fuels	CH_4	0	0	5.0	20.0	20.6	0.00	58	0.000
1 A 2 b Non-ferrous metals: Gaseous Fuels	CO_2	10	17	5.0	5.0	7.1	0.00	59	0.000
1 A 2 b Non-ferrous metals: Gaseous Fuels	N_2O	0	0	5.0	20.0	20.6	0.00	58	0.000
1 A 2 b Non-ferrous metals: Liquid Fuels	CH_4	0	0	3.4	16.8	17.1	0.00	-35	0.000
1 A 2 b Non-ferrous metals: Liquid Fuels	CO_2	110	84	3.4	2.9	4.5	0.00	-23	0.000
1 A 2 b Non-ferrous metals: Liquid Fuels	N_2O	0	0	3.4	25.0	25.2	0.00	-41	0.000
1 A 2 b Non-ferrous metals: Solid Fuels	CH_4	0	0					-100	
1 A 2 b Non-ferrous metals: Solid Fuels	CO_2	7	0					-100	
1 A 2 b Non-ferrous metals: Solid Fuels	N_2O	0	0					-100	
1 A 2 c Chemicals: Biomass	CH_4	0	0	2.9	43.5	43.6	0.00	163	0.000
1 A 2 c Chemicals: Biomass	N_2O	1	2	2.9	40.4	40.5	0.00	151	0.000
1 A 2 c Chemicals: Gaseous Fuels	CH_4	0	0	5.0	20.0	20.6	0.00	-30	0.000
1 A 2 c Chemicals: Gaseous Fuels	CO_2	155	58	5.0	5.0	7.1	0.00	-62	0.000
1 A 2 c Chemicals: Gaseous Fuels	N_2O	0	0	5.0	20.0	20.6	0.00	-30	0.000
1 A 2 c Chemicals: Liquid Fuels	CH_4	0	0	6.7	15.1	16.5	0.00	-29	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 2 c Chemicals: Liquid Fuels	CO_2	341	305	6.7	5.3	8.6	0.01	-11	0.000
1 A 2 c Chemicals: Liquid Fuels	N_2O	1	0	6.7	20.0	21.1	0.00	-58	0.000
1 A 2 c Chemicals: Other Fuels	CH_4	0	0	10.0	100.0	100.5	0.00	819	0.000
1 A 2 c Chemicals: Other Fuels	CO_2	6	60	10.0	100.0	100.5	0.05	976	0.000
1 A 2 c Chemicals: Other Fuels	N_2O	0	0	10.0	100.0	100.5	0.00	928	0.000
1 A 2 c Chemicals: Solid Fuels	CH_4	0	0	2.8	36.5	36.6	0.00	24	0.000
1 A 2 c Chemicals: Solid Fuels	CO_2	127	28	2.8	10.1	10.5	0.00	-78	0.000
1 A 2 c Chemicals: Solid Fuels	N_2O	0	0	2.8	31.8	31.9	0.00	-47	0.000
1 A 2 d Pulp, Paper and Print: Biomass	CH_4	11	12	4.2	38.4	38.6	0.00	16	0.000
1 A 2 d Pulp, Paper and Print: Biomass	N_2O	62	76	4.2	37.1	37.3	0.01	23	0.000
1 A 2 d Pulp, Paper and Print: Gaseous Fuels	CH_4	0	0	5.0	20.0	20.6	0.00	3	0.000
1 A 2 d Pulp, Paper and Print: Gaseous Fuels	CO_2	66	69	5.0	5.0	7.1	0.00	4	0.000
1 A 2 d Pulp, Paper and Print: Gaseous Fuels	N_2O	0	0	5.0	20.0	20.6	0.00	3	0.000
1 A 2 d Pulp, Paper and Print: Liquid Fuels	CH_4	1	0	3.5	31.7	31.9	0.00	-69	0.000
1 A 2 d Pulp, Paper and Print: Liquid Fuels	CO_2	1786	596	3.5	1.4	3.8	0.01	-67	0.000
1 A 2 d Pulp, Paper and Print: Liquid Fuels	N_2O	4	1	3.5	34.0	34.2	0.00	-72	0.000
1 A 2 d Pulp, Paper and Print: Other Fuels	CH_4	0	0	10.0	100.0	100.5	0.00	-63	0.000
1 A 2 d Pulp, Paper and Print: Other Fuels	CO_2	73	56	10.0	100.0	100.5	0.04	-23	0.000
1 A 2 d Pulp, Paper and Print: Other Fuels	N_2O	0	0	10.0	100.0	100.5	0.00	-41	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 2 d Pulp, Paper and Print: Solid Fuels	CH_4	0	0	4.0	30.0	30.3	0.00	-91	0.000
1 A 2 d Pulp, Paper and Print: Solid Fuels	CO_2	265	15	4.0	5.1	6.5	0.00	-94	0.000
1 A 2 d Pulp, Paper and Print: Solid Fuels	N_2O	2	0	4.0	28.4	28.6	0.00	-94	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Biomass	CH_4	0	1	3.8	49.1	49.2	0.00	317	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Biomass	N_2O	0	2	3.8	38.2	38.4	0.00	420	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Gaseous Fuels	CH_4	0	0	5.0	20.0	20.6	0.00	-30	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Gaseous Fuels	CO_2	254	178	5.0	5.0	7.1	0.00	-30	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Gaseous Fuels	N_2O	0	0	5.0	20.0	20.6	0.00	-30	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Liquid Fuels	CH_4	0	0	3.1	17.7	17.9	0.00	-83	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Liquid Fuels	CO_2	596	135	3.1	2.4	3.9	0.00	-77	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Liquid Fuels	N_2O	1	0	3.1	25.2	25.4	0.00	-85	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Other Fuels	CH_4	0	0	10.0	100.0	100.5	0.00	-40	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 2 e Food Processing, Beverages and Tobacco: Other Fuels	CO_2	8	13	10.0	100.0	100.5	0.00	54	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Other Fuels	N_2O	0	0	10.0	100.0	100.5	0.00	8	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Solid Fuels	CH_4	0	0	5.0	20.0	20.6	0.00	-89	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Solid Fuels	CO_2	90	11	5.0	5.0	7.1	0.00	-88	0.000
1 A 2 e Food Processing, Beverages and Tobacco: Solid Fuels	N_2O	0	0	5.0	40.0	40.3	0.00	-89	0.000
1 A 2 f Non-metallic minerals: Biomass	CH_4	0 C		5.1	52.9	53.2	0.00 C		0.000
1 A 2 f Non-metallic minerals: Biomass	N_2O	0 C		4.8	48.4	48.6	0.00 C		0.000
1 A 2 f Non-metallic minerals: Gaseous Fuels	CH_4	0	0	4.2	8.3	9.3	0.00	82	0.000
1 A 2 f Non-metallic minerals: Gaseous Fuels	CO_2	65	120	4.2	2.1	4.6	0.00	83	0.000
1 A 2 f Non-metallic minerals: Gaseous Fuels	N_2O	0	0	4.2	8.3	9.3	0.00	82	0.000
1 A 2 f Non-metallic minerals: Liquid Fuels	CH_4	0 C		3.9	10.3	11.0	0.00 C		0.000
1 A 2 f Non-metallic minerals: Liquid Fuels	CO_2	625 C		3.9	1.2	4.1	0.00 C		0.000
1 A 2 f Non-metallic minerals: Liquid Fuels	N_2O	1 C		4.3	15.9	16.5	0.00 C		0.000
1 A 2 f Non-metallic minerals: Other Fuels	CH_4	0	0	5.8	57.7	58.0	0.00		0.000
1 A 2 f Non-metallic minerals: Other Fuels	CO_2	0	163	5.8	57.7	58.0	0.12		0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 2 f Non-metallic minerals: Other Fuels	N_2O	0	0	5.8	57.7	58.0	0.00		0.000
1 A 2 f Non-metallic minerals: Solid Fuels	CH_4	0	0	4.6	9.1	10.2	0.00	-49	0.000
1 A 2 f Non-metallic minerals: Solid Fuels	CO_2	1135 C		4.5	1.4	4.7	0.01 C		0.000
1 A 2 f Non-metallic minerals: Solid Fuels	N_2O	6 C		4.6	18.3	18.8	0.00 C		0.000
1 A 2 g vii Off-road vehicles and other machinery: Liquid Fuels	CH_4	2	2	4.4	44.4	44.7	0.00	30	0.000
1 A 2 g vii Off-road vehicles and other machinery: Liquid Fuels	CO_2	997	1235	4.9	3.9	6.3	0.08	24	0.000
1 A 2 g vii Off-road vehicles and other machinery: Liquid Fuels	N_2O	13	18	5.0	49.7	50.0	0.00	41	0.000
1 A 2 g viii Other: Biomass	CH_4	7	5	3.5	34.0	34.1	0.00	-19	0.000
1 A 2 g viii Other: Biomass	N_2O	36	29	3.5	35.4	35.5	0.00	-20	0.000
1 A 2 g viii Other: Gaseous Fuels	CH_4	0	0	2.2	4.4	4.9	0.00	-23	0.000
1 A 2 g viii Other: Gaseous Fuels	CO_2	113	88	2.2	1.1	2.4	0.00	-22	0.000
1 A 2 g viii Other: Gaseous Fuels	N_2O	0	0	2.2	4.4	4.9	0.00	-23	0.000
1 A 2 g viii Other: Liquid Fuels	CH_4	1	0	2.0	5.1	5.5	0.00	-64	0.000
1 A 2 g viii Other: Liquid Fuels	CO_2	2062 C		1.9	0.3	1.9	0.00 C		0.000
A 2 g viii Other: Liquid Fuels	N_2O	7 C		2.5	7.1	7.5	0.00 C		0.000
1 A 2 g viii Other: Other Fuels	CH_4	0	0	3.3	33.3	33.5	0.00		0.000
1 A 2 g viii Other: Other Fuels	CO_2	0	15	3.3	33.3	33.5	0.00		0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)		Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)		Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 2 g viii Other: Other Fuels	N_2O	0		0	2.9	28.6	28.7	0.00			0.000
1 A 2 g viii Other: Solid Fuels	CH_4	0		0	3.4	7.0	7.8	0.00		791	0.000
1 A 2 g viii Other: Solid Fuels	CO_2	94	C		3.3	1.0	3.5	0.00	C		0.000
1 A 2 g viii Other: Solid Fuels	N_2O	0	C		3.3	13.2	13.6	0.00	C		0.000
1 A 3 a Domestic Aviation: Aviation Gasoline	CH_4	0		0	10.0	200.0	200.3	0.00		-83	0.000
1 A 3 a Domestic Aviation: Aviation Gasoline	CO_2	15		4	8.3	4.1	9.3	0.00		-73	0.000
1 A 3 a Domestic Aviation: Aviation Gasoline	N_2O	0		0	7.1	141.5	141.6	0.00		-80	0.000
1 A 3 a Domestic Aviation: Jet Kerosene	CH_4	1		0	10.0	200.0	200.3	0.00		-48	0.000
1 A 3 a Domestic Aviation: Jet Kerosene	CO_2	658		541	8.3	4.1	9.3	0.03		-18	0.000
1 A 3 a Domestic Aviation: Jet Kerosene	N_2O	13		8	7.1	141.5	141.6	0.00		-38	0.000
1 A 3 b i Road Transportation, Cars: Biomass	CH_4	0		0	4.4	174.3	174.4	0.00			0.000
1 A 3 b i Road Transportation, Cars: Biomass	CO_2	0		16	5.0	10.0	11.2	0.00			0.000
1 A 3 b i Road Transportation, Cars: Biomass	N_2O	0		0	3.8	153.6	153.6	0.00			0.000
1 A 3 b i Road Transportation, Cars: Diesel oil	CH_4	0		0	5.0	45.0	45.3	0.00		-15	0.000
1 A 3 b i Road Transportation, Cars: Diesel oil	CO_2	439		4058	5.0	5.0	7.1	1.12		825	0.000
1 A 3 b i Road Transportation, Cars: Diesel oil	N_2O	0		40	5.0	65.0	65.2	0.01		33085	0.000
1 A 3 b i Road Transportation, Cars: Gasoline	CH_4	138		10	3.0	40.0	40.1	0.00		-93	0.000
1 A 3 b i Road Transportation, Cars: Gasoline	CO_2	11999		6249	3.0	4.0	5.0	1.33		-48	0.000
1 A 3 b i Road Transportation, Cars: Gasoline	N_2O	132		10	3.0	60.0	60.1	0.00		-92	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 3 b i Road Transportation, Cars: LPG	CH_4	0	0	5.0	65.0	65.2	0.00	635	0.000
1 A 3 b i Road Transportation, Cars: LPG	CO_2	0	2	5.0	5.0	7.1	0.00	635	0.000
1 A 3 b i Road Transportation, Cars: LPG	N_2O	0	0	5.0	65.0	65.2	0.00	635	0.000
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	CH_4	0	0	5.0	45.0	45.3	0.00	-31	0.000
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	CO_2	162	1401	5.0	5.0	7.1	0.13	764	0.000
1 A 3 b ii Road Transportation, Light duty trucks: Diesel oil	N_2O	0	11	5.0	65.0	65.2	0.00	41604	0.000
1 A 3 b ii Road Transportation, Light duty trucks: Gasoline	CH_4	8	0	3.0	40.0	40.1	0.00	-97	0.000
1 A 3 b ii Road Transportation, Light duty trucks: Gasoline	CO_2	692	96	3.0	4.0	5.0	0.00	-86	0.000
1 A 3 b ii Road Transportation, Light duty trucks: Gasoline	N_2O	7	1	3.0	60.0	60.1	0.00	-92	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Biomass	CH_4	0	2	3.7	148.3	148.3	0.00	2207	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Biomass	CO_2	3	28	5.0	10.0	11.2	0.00	852	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Biomass	N_2O	0	4	3.4	137.2	137.2	0.00	2125	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	CH_4	2	0	4.3	49.7	49.9	0.00	-93	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	CO_2	3779	3407	4.8	4.8	6.8	0.73	-10	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Diesel oil	N_2O	13	71	4.5	61.9	62.1	0.03	431	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Gasoline	CH_4	0	0	3.0	40.0	40.1	0.00	-83	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Gasoline	CO_2	16	3	3.0	4.0	5.0	0.00	-84	0.000
1 A 3 b iii Road Transportation, Heavy duty trucks: Gasoline	N_2O	0	0	3.0	60.0	60.1	0.00	-83	0.000
1 A 3 b iv Road Transportation, Motorcycles: Gasoline	CH_4	2	2	3.0	40.0	40.1	0.00	-1	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 3 b iv Road Transportation, Motorcycles: Gasoline	CO_2	38	85	3.0	4.0	5.0	0.00	120	0.000
1 A 3 b iv Road Transportation, Motorcycles: Gasoline	N_2O	0	0	3.0	60.0	60.1	0.00	135	0.000
1 A 3 c Railways: Liquid Fuels	CH_4	0	0	5.0	150.0	150.1	0.00	-58	0.000
1 A 3 c Railways: Liquid Fuels	CO_2	101	41	5.0	5.0	7.1	0.00	-59	0.000
1 A 3 c Railways: Liquid Fuels	N_2O	0	0	5.0	200.0	200.1	0.00	-58	0.000
1 A 3 d Domestic Navigation: Gas/Diesel Oil	CH_4	3	4	5.0	198.9	199.0	0.00	36	0.000
1 A 3 d Domestic Navigation: Gas/Diesel Oil	CO_2	381	293	2.9	2.9	4.1	0.00	-23	0.000
1 A 3 d Domestic Navigation: Gas/Diesel Oil	N_2O	6	3	2.8	61.3	61.4	0.00	-46	0.000
1 A 3 d Domestic Navigation: Residual Oil	CH_4	0	0	15.0	40.0	42.7	0.00	-94	0.000
1 A 3 d Domestic Navigation: Residual Oil	CO_2	194	12	15.0	7.0	16.6	0.00	-94	0.000
1 A 3 d Domestic Navigation: Residual Oil	N_2O	3	0	15.0	40.0	42.7	0.00	-94	0.000
1 A 3 e Other Transportation: Diesel Oil	CH_4	0	0	5.0	50.0	50.3	0.00	-7	0.000
1 A 3 e Other Transportation: Diesel Oil	CO_2	205	165	5.0	5.0	7.1	0.00	-19	0.000
1 A 3 e Other Transportation: Diesel Oil	N_2O	3	2	5.0	50.0	50.3	0.00	-10	0.000
1 A 3 e Other Transportation: Gaseous fuels	CH_4	0	0	5.0	150.0	150.1	0.00	14	0.000
1 A 3 e Other Transportation: Gaseous fuels	CO_2	2	2	5.0	5.0	7.1	0.00	15	0.000
1 A 3 e Other Transportation: Gaseous fuels	N_2O	0	0	5.0	1000.0	1000.0	0.00	14	0.000
1 A 4 a Commercial/Institutional: Biomass	CH_4	4	16	9.7	99.8	100.2	0.00	269	0.000
1 A 4 a Commercial/Institutional: Biomass	N_2O	1	4	9.7	98.2	98.7	0.00	274	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 4 a Commercial/Institutional: Diesel Oil	CH_4	0	0	5.0	50.0	50.3	0.00	47	0.000
1 A 4 a Commercial/Institutional: Diesel Oil	CO_2	170	216	5.0	5.0	7.1	0.00	27	0.000
1 A 4 a Commercial/Institutional: Diesel Oil	N_2O	2	3	5.0	50.0	50.3	0.00	40	0.000
1 A 4 a Commercial/Institutional: Gaseous Fuels	CH_4	0	0	9.7	19.4	21.7	0.00	113	0.000
1 A 4 a Commercial/Institutional: Gaseous Fuels	CO_2	86	184	9.7	4.9	10.9	0.01	114	0.000
1 A 4 a Commercial/Institutional: Gaseous Fuels	N_2O	0	0	9.7	19.4	21.7	0.00	113	0.000
1 A 4 a Commercial/Institutional: Gasoline	CH_4	2	2	5.0	50.0	50.3	0.00	-1	0.000
1 A 4 a Commercial/Institutional: Gasoline	CO_2	185	199	5.0	4.0	6.4	0.00	8	0.000
1 A 4 a Commercial/Institutional: Gasoline	N_2O	1	1	5.0	50.0	50.3	0.00	14	0.000
1 A 4 a Commercial/Institutional: Liquid Fuels	CH_4	2	0	15.3	34.5	37.7	0.00	-95	0.000
1 A 4 a Commercial/Institutional: Liquid Fuels	CO_2	2447	147	15.3	1.4	15.3	0.01	-94	0.000
1 A 4 a Commercial/Institutional: Liquid Fuels	N_2O	27	1	15.3	39.4	42.2	0.00	-97	0.000
1 A 4 b Residential: Biomass	CH_4	96	59	10.0	100.0	100.5	0.05	-39	0.000
1 A 4 b Residential: Biomass	N_2O	58	63	10.0	100.0	100.5	0.05	8	0.000
1 A 4 b Residential: Gaseous Fuels	CH_4	0	0	9.2	18.3	20.5	0.00	6	0.000
1 A 4 b Residential: Gaseous Fuels	CO_2	86	92	9.2	4.6	10.2	0.00	7	0.000
1 A 4 b Residential: Gaseous Fuels	N_2O	0	0	9.2	18.3	20.5	0.00	6	0.000
1 A 4 b Residential: Liquid Fuels	CH_4	7	4	2.9	47.8	47.9	0.00	-49	0.000
1 A 4 b Residential: Liquid Fuels	CO_2	6234	524	6.8	2.4	7.2	0.02	-92	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 A 4 b Residential: Liquid Fuels	N_2O	53	3	7.6	28.7	29.6	0.00	-93	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Biomass	CH_4	1	32	8.0	96.4	96.8	0.01	2353	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Biomass	N_2O	0	10	8.0	79.8	80.2	0.00	3007	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Gaseous Fuels	CH_4	0	0	10.0	20.0	22.4	0.00	-57	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Gaseous Fuels	CO_2	33	14	10.0	5.0	11.2	0.00	-57	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Gaseous Fuels	N_2O	0	0	10.0	20.0	22.4	0.00	-57	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Liquid Fuels	CH_4	2	3	2.3	24.7	24.8	0.00	7	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Liquid Fuels	CO_2	1572	1302	3.1	2.6	4.1	0.04	-17	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Liquid Fuels	N_2O	20	17	3.2	28.1	28.3	0.00	-13	0.000
1 A 4 c Agriculture/Forestry/Fisheries: Solid Fuels	CH_4	0	0					-100	
1 A 4 c Agriculture/Forestry/Fisheries: Solid Fuels	CO_2	157	0					-100	
1 A 4 c Agriculture/Forestry/Fisheries: Solid Fuels	N_2O	1	0					-100	
1 A 5 b Mobile: Biomass	CH_4	0	0	5.0	100.0	100.1	0.00		0.000
1 A 5 b Mobile: Biomass	N_2O	0	0	5.0	100.0	100.1	0.00		0.000
1 A 5 b Mobile: Liquid Fuels	CH_4	1	0	4.0	153.0	153.1	0.00	-96	0.000
1 A 5 b Mobile: Liquid Fuels	CO_2	846	184	3.6	3.6	5.1	0.00	-78	0.000
1 A 5 b Mobile: Liquid Fuels	N_2O	16	3	3.6	136.7	136.7	0.00	-83	0.000
1 B 1 c Fugitive emissions from Solid Fuels	CH_4	0	0	50.0	20.0	53.9	0.00	0	0.000
1 B 1 c Fugitive emissions from Solid Fuels	CO_2	5	5	50.0	5.0	50.3	0.00	0	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
1 B 1 c Fugitive emissions from Solid Fuels	N_2O	0	0	50.0	20.0	53.9	0.00	0	0.000
1 B 2 a Oil	CH_4	25	26	0.0	285.8	285.8	0.08	6	0.000
1 B 2 a Oil	CO_2	219	756	2.7	3.9	4.8	0.02	245	0.000
1 B 2 a Oil	N_2O	1	1	6.7	22.4	23.3	0.00	16	0.000
1 B 2 b Natural gas	CH_4	67	34		47.2	47.2	0.00	-50	0.000
1 B 2 b Natural gas	CO_2	3	0		47.2	47.2	0.00	-99	0.000
1 B 2 c Venting and flaring	CH_4	0	0	4.1	44.9	45.1	0.00	-1	0.000
1 B 2 c Venting and flaring	CO_2	61	39	17.5	5.0	18.2	0.00	-36	0.000
1 B 2 c Venting and flaring	N_2O	0	0	17.5	80.0	81.9	0.00	-52	0.000
2 A 1 Cement Production	CO_2	1272	1484	2.0	5.0	5.4	0.09	17	0.000
2 A 2 Lime Production	CO_2	331	465	5.0	1.9	5.3	0.01	40	0.000
2 A 3 Glass Production	CO_2	54	17		7.0	7.0	0.00	-68	0.000
2 A 4 Other	CO_2	15	18	2.7	4.0	4.9	0.00	15	0.000
2 B 10 Other	CH_4	1	1		89.7	89.7	0.00	10	0.000
2 B 10 Other	CO_2	598	830		6.7	6.7	0.04	39	0.000
2 B 10 Other	N_2O	21	6		106.8	106.8	0.00	-69	0.000
2 B 2 Nitric Acid Production	N_2O	782	42	2.0	5.0	5.4	0.00	-95	0.000
2 B 5 Carbide production	CO_2	12	8	10.0	5.0	11.2	0.00	-36	0.000
2 C 1 Iron and Steel Production	CH_4	19	0	5.0	50.0	50.3	0.00	-99	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
2 C 1 Iron and Steel Production	CO_2	2624	2230	4.1	4.1	5.7	0.22	-15	0.000
2 C 2 Ferroalloys production	CH_4	1	0					-100	
2 C 2 Ferroalloys production	CO_2	228	C	5.0	5.0	7.1	0.00	C	0.000
2 C 3 Aluminium production	CO_2	133	206	5.0	5.0	7.1	0.00	55	0.000
2 C 3 Aluminium production	PFCs	569	36	2.0	10.0	10.2	0.00	-94	0.000
2 C 3 Aluminium production	SF6	23	13	20.0	20.0	28.3	0.00	-44	0.000
2 C 7 Other	CO_2	276	C	4.0	5.0	6.4	0.00	C	0.000
2 C 7 Other	CO_2	276	C	4.0	5.0	6.4	0.00	C	0.000
2 D 1 Lubricant use	CO_2	158	254	5.0	50.0	50.3	0.22	61	0.000
2 D 2 Paraffin wax use	CO_2	18	38	10.0	50.0	51.0	0.01	115	0.000
2 D 3 Other	CO_2	217	153	12.3	6.4	13.9	0.01	-30	0.000
2 F 1 Refrigeration and air conditioning	HFCs	5	1068	16.2	33.3	37.0	2.13	21018	0.000
2 F 1 Refrigeration and air conditioning	PFCs	0	1	33.0	66.0	73.8	0.00		0.000
2 F 2 Foam blowing agents	HFCs	0	30	1.4	14.3	14.4	0.00		0.000
2 F 3 Fire protection	HFCs	0	3	3.6	14.3	14.7	0.00		0.000
2 F 4 Aerosols	HFCs	1	37	37.9	15.9	41.1	0.00	2481	0.000
2 G 1 Electrical equipment	SF6	77	33	8.6	17.1	19.2	0.00	-57	0.000
2 G 2 SF6 and PFCs from other product use	SF6	2	1	5.0	50.0	50.3	0.00	-58	0.000
2 G 3 N2O from product uses	N_2O	87	76	10.0	10.0	14.1	0.00	-12	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
2 H Other	CH_4	6	8	6.6	19.9	21.0	0.00	33	0.000
2 H Other	CO_2	19	12	0.0	6.0	6.0	0.00	-36	0.000
2 H Other	N_2O	64	84	6.6	19.8	20.8	0.00	32	0.000
3 A 1 Dairy cattle	CH_4	1617	1138	5.0	20.0	20.6	0.75	-30	0.000
3 A 1 Non-dairy cattle	CH_4	1268	1470	5.0	25.0	25.5	1.92	16	0.000
3 A 2 Sheep	CH_4	81	121	5.0	40.0	40.3	0.03	49	0.000
3 A 4 Goats	CH_4	1	2	5.0	40.0	40.3	0.00	178	0.000
3 A 4 Horses	CH_4	142	160	5.0	40.0	40.3	0.06	13	0.000
3 A 4 Raindeer	CH_4	85	79	5.0	40.0	40.3	0.01	-6	0.000
3 A 4 Swine	CH_4	85	51	5.0	40.0	40.3	0.01	-40	0.000
3 B 1 Dairy cattle	CH_4	95	73	20.0	50.0	53.9	0.02	-22	0.000
3 B 1 Dairy cattle	N_2O	105	73	17.7	44.3	47.7	0.02	-30	0.000
3 B 1 Non-dairy cattle	CH_4	61	106	20.0	50.0	53.9	0.04	74	0.000
3 B 1 Non-dairy cattle	N_2O	71	90	12.7	31.8	34.3	0.01	26	0.000
3 B 3 Swine	CH_4	59	48	20.0	50.0	53.9	0.01	-20	0.000
3 B 3 Swine	N_2O	42	28	16.3	40.8	44.0	0.00	-35	0.000
3 B 4 Fur-bearing animals	CH_4	5	3	20.0	50.0	53.9	0.00	-33	0.000
3 B 4 Fur-bearing animals	N_2O	3	2	20.0	50.0	53.9	0.00	-33	0.000
3 B 4 Goats	CH_4	0	0	20.0	50.0	53.9	0.00	178	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
3 B 4 Goats	N_2O	0	0	20.0	50.0	53.9	0.00	178	0.000
3 B 4 Horses	CH_4	12	14	20.0	50.0	53.9	0.00	13	0.000
3 B 4 Horses	N_2O	24	27	13.4	33.4	36.0	0.00	13	0.000
3 B 4 Poultry	CH_4	8	13	13.8	34.6	37.3	0.00	50	0.000
3 B 4 Poultry	N_2O	19	28	14.1	35.1	37.8	0.00	49	0.000
3 B 4 Reindeer	CH_4	2	2	20.0	50.0	53.9	0.00	-6	0.000
3 B 4 Sheep	CH_4	2	3	20.0	50.0	53.9	0.00	49	0.000
3 B 4 Sheep	N_2O	3	5	20.0	50.0	53.9	0.00	86	0.000
3 B Indirect N2O emissions	N_2O	103	81	35.0	400.0	401.5	1.45	-21	0.000
3 D a 1 Inorganic N fertilizers	N_2O	1051	929	35.0	200.0	203.0	48.60	-12	0.010
3 D a 2 a Animal manure applied to soils	N_2O	359	333	35.0	200.0	203.0	6.23	-7	0.000
3 D a 2 b Sewage sludge applied to soils	N_2O	6	15	35.0	200.0	203.0	0.01	167	0.000
3 D a 2 c Other organic fertilizers applied to soils	N_2O	8	25	35.0	200.0	203.0	0.04	215	0.000
3 D a 3 Urine and dung deposited by grazing animals	N_2O	361	355	22.0	125.6	127.5	2.80	-2	0.000
3 D a 4 Crop residues applied to soils	N_2O	452	415	35.0	200.0	203.0	9.68	-8	0.000
3 D a 5 Mineralization/immobilization associated with loss/gain of soil organic matter	N_2O	68	258	20.0	200.0	201.0	3.67	280	0.000
3 D a 6 Cultivation of organic soils (i.e. histosols)	N_2O	914	832	5.0	85.0	85.2	6.85	-9	0.000
3 D b 1 Atmospheric deposition	N_2O	103	94	35.0	400.0	401.5	1.95	-8	0.000
3 D b 2 Nitrogen leaching and run-off	N_2O	266	186	35.0	150.0	154.0	1.12	-30	0.000

IPCC Source Category	Substance	Base year emissions or removals (kt CO2-eq)	Year 2017 emissions or removals (kt CO2-eq)	Activity data uncertainty in 2017 (%)	Emission factor uncertainty in 2017 (%)	Combined uncertainty in 2017 (%)	Contribution to variance in 2017 (%)	Inventory trend for 2017 with respect to base year (%)	Uncertainty introduced into the trend (%)
3 G Liming	CO_2	173	127	16.4	8.2	18.3	0.01	-27	0.000
3 H Urea application	CO_2	4	1	20.0	10.0	22.4	0.00	-81	0.000
5 A 1 Managed waste disposal sites	CH_4	3422	841	25.0	50.0	55.9	3.02	-75	0.020
5 B 1 Composting	CH_4	7	88	2.4	19.8	19.9	0.00	1095	0.000
5 B 1 Composting	N_2O	5	32		50.2	50.2	0.00	535	0.000
5 C 1 Waste Incineration	CH_4	0	0	10.0	10.0	14.1	0.00	331	0.000
5 C 1 Waste Incineration	CO_2	44	58	10.0	10.0	14.1	0.00	33	0.000
5 C 1 Waste Incineration	N_2O	1	5	10.0	100.0	100.5	0.00	425	0.000
5 D 1 Domestic wastewater	CH_4	38	29		44.9	44.9	0.00	-24	0.000
5 D 1 Domestic wastewater	N_2O	226	200		48.7	48.7	0.13	-11	0.000
Total		71304	52660			5.1	100.00	-26	2.120

‘0’ = uncertainty is less than 0.5. An empty AD-uncertainty cell means that all uncertainty allocated to the emission factor.

References

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

Annex 8: Other Annexes

Annex 8:1 Description of the 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 Emissions Trading System in Sweden and comparison to the national inventory

The EU Emissions Trading System (EU ETS) was launched in January 2005. The system is based on the EU ETS Directive[147], which is implemented in Sweden through the Act (2004:1199) and the Ordinance (2004:1205) on Emissions Trading.

EU ETS covered from the beginning emissions of carbon dioxide from combustion installations and energy intensive industry (mineral oil refineries, coke ovens, iron and steel industry, pulp and paper industry and mineral industry). The scope was extended in 2013 with new greenhouse gases (nitrous oxide and perfluorocarbons) and with some new industrial activities.

Installations subject to EU ETS need a permit to emit greenhouse gases and all emissions have to be monitored and reported according to EU Regulation 601/2012. About half of the allowances are allocated for free based on fully harmonized principles. The rest of the allowances are auctioned. No free allocation is given to electricity production. EU ETS covers in Sweden approximately 750 installations (Table A8:1.1). The Swedish Environmental Protection Agency is competent authority for permitting, allocation and compliance and enforcement and the Swedish Energy Agency is competent authority for issues concerning the Union Registry.

Table A8:1.1. Swedish installations subject to EU ETS 2017.

Category	Number
Combustion installations – production of electricity and heat	585
Iron and steel industry	19
Chemical industry	18
Food and drink industry	8
Metal industry (excluding iron and steel)	5
Mineral industry (excluding metals)	18
Pulp and paper industry including printing	49
Mineral oil refineries including distribution of oil and gas	5
Other industry	26
Total	**733**

[147] DIRECTIVE 2003/87/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC

8.1 Main Activities in the EU ETS

8.1.1 Combustion installations

The majority (80 %) of the Swedish ETS-installations are combustion installations. The EU ETS directive states that combustion installations with a rated thermal input exceeding 20 MW should be covered by the system. Sweden has also included, by opt-in, all combustion installations that deliver heat to district heating networks with an aggregated installed capacity exceeding 20 MW. This is the main reason for the comparatively large amount of installations in the Swedish part of the system.

Co-incineration of municipal waste was included in the system in 2013. Incineration of other kinds of waste, such as industrial waste, has been included since the system was introduced.

8.1.2 Industrial activities

The scope of EU ETS was extended in 2013 with emissions of nitrous oxide and perfluorocarbons from some specific activities and some new industrial activities. Nitrous oxide is emitted from one installation producing nitric acid and perfluorocarbons from Sweden´s only producer of primary aluminium.

8.1.3 Aviation

International and domestic aviation was included in EU ETS in 2012. But the European Commission adopted, pending a global market-based mechanism addressing international aviation emissions, a temporary exemption for flights to and from third countries until the end of 2016. As a result of the adoption of a resolution by ICAO on a global measure (Corsia), EU has decided to maintain the reduced present scope (intra-EEA flights) from 2017 onwards.

8.2 Monitoring and reporting

Emissions in EU ETS shall be monitored and reported according to EU Regulation 601/2012[148] . The regulation is directly valid in all the Member States. Emissions have to be reported yearly, in the end of March the year after the year of emissions. Emission reports shall be verified by an accredited verifier before submitted to EPA. Reports are submitted in an electronic tool, ECO_2, provided by EPA. The number of tonne of carbon dioxide equivalents is also notified in the Union Registry.

[148] COMMISSION REGULATION (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council

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

In Table A8:1.2 below, emissions 2008-2017 of fossil CO_2 together with N_2O and PFC emissions for 2013-2017 in the ETS and non-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. 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[149].

[149] Ortiz & Danielsson, 2015

Table A8:1.2. Emissions of greenhouse gases (kt CO_2 equivalents) in the ETS and non-ETS, second and third trading period 2008 – 2012 and 2013-2017.

	Sector	Second trading period					Third trading period					Change 08-17	
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017		
ETS	1.A.1 Energy Industries	8 093	8 589	10 894	8 398	7 885	9 347	8 706	8 323	8 743	8 548	455	6%
	1.A.2 Manufacturing Industries and Construction	5 937	4 353	5 490	5 181	4 543	4 439	4 335	4 584	4 335	4 517	-1 420	-24%
	1.A.3 Transport	589	493	477	525	516	518	516	504	545	545	-45	-8%
	1.B Fugitive emissions	857	863	824	834	836	697	773	822	639	801	-57	-7%
	1 Energy	***15 478***	***14 298***	***17 685***	***14 939***	***13 780***	***15 002***	***14 330***	***14 233***	***14 262***	***14 411***	***-1 067***	***-7%***
	2.A Mineral Products	1 992	1 696	1 899	1 934	2 000	1 918	1 847	1 993	2 010	1 983	-9	0%
	2.B Chemical Industry	645	587	764	764	727	874	841	779	897	864	219	34%
	2.C Metal Production	2 538	1 387	2 772	2 726	2 163	2 857	2 834	2 727	3 102	2 906	369	15%
	2.H Other	18	17	19	17	18	11	10	8	10	12	-5	-31%
	2 Industrial Processes	***5 192***	***3 687***	***5 454***	***5 441***	***4 908***	***5 659***	***5 532***	***5 507***	***6 019***	***5 766***	***573***	***11%***
	TOTAL	**20 670**	**17 985**	**23 139**	**20 379**	**18 688**	**20 661**	**19 862**	**19 740**	**20 281**	**20 176**	**-494**	**-2%**
Total (ETS+Non-ETS)	1.A.1 Energy Industries	10 233	10 626	13 101	10 740	10 354	9 864	9 098	8 802	9 216	9 170	-1 063	-10%
	1.A.2 Manufacturing Industries and Construction	9 042	7 367	8 540	7 909	7 390	7 064	6 900	7 045	6 810	6 942	-2 100	-23%
	1.A.3 Transport	20 639	20 229	20 349	19 905	18 661	18 205	17 805	17 844	17 5042	16 573	-4 066	-20%
	1.A.4 Other Sectors	4 079	3 814	4 074	3 707	3 515	3 335	3 178	3 120	2 951	2 897	-1 181	-29%
	1.A.5 Other	154	244	176	186	166	151	166	191	179	187	32	21%
	1.B Fugitive emissions	951	953	906	905	910	770	839	886	703	862	-90	-9%
	1 Energy	***45 100***	***43 233***	***47 147***	***43 352***	***40 996***	***39 389***	***37 985***	***37 888***	***36 900***	***36 632***	***-8 468***	***-19%***
	2.A Mineral Products	1 994	1 699	1 902	1 937	2 004	1 920	1 850	1 994	2 012	1 984	-10	0%
	2.B Chemical Industry	1 021	985	1 179	873	873	902	854	789	912	886	-135	-13%
	2.C Metal Production	3 466	1 858	3 472	3 325	2 845	2 866	2 846	2 744	3 122	2 920	-546	-16%
	2.D Non-energy products from fuels and solvent use	458	414	449	414	479	496	482	429	446	445	-13	-3%
	2.F Product uses as substitutes for ODS	1 160	1 158	1 139	1 116	1 100	1 089	1 115	1 133	1 150	1 139	-21	-2%

	Sector	Second trading period					Third trading period					Change 08-17	
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017		
	2.G Other product manufacture and use	155	151	151	125	121	108	116	124	114	111	-45	-29%
	2.H Other	101	95	100	96	100	99	100	98	99	104	3	3%
	2 Industrial Processes	***8 356***	***6 360***	***8 391***	***7 886***	***7 523***	***7 480***	***7 364***	***7 312***	***7 855***	***7 588***	***-768***	***-9%***
	3 Agriculture	***6 968***	***6 694***	***6 820***	***7 136***	***6 661***	***6 889***	***6 989***	***6 860***	***6 871***	***7 187***	***219***	***3%***
	5 Waste	***2 143***	***2 053***	***1 924***	***1 833***	***1 694***	***1 609***	***1 494***	***1 400***	***1 318***	***1 253***	***-890***	***-42%***
	TOTAL (excl LULUCF)	**62 566**	**58 340**	**64 282**	**60 207**	**56 873**	**55 366**	**53 832**	**53 461**	**52 943**	**52 660**	**-9 906**	**-16%**
Share ETS of Total	1.A.1 Energy Industries	79%	81%	83%	78%	76%	95%	96%	95%	95%	93%		
	1.A.2 Manufacturing Industries and Construction	66%	59%	64%	66%	61%	63%	63%	65%	64%	65%		
	1.B Fugitive emissions	90%	90%	91%	92%	92%	91%	92%	93%	91%	93%		
	1 Energy	***33%***	***32%***	***36%***	***33%***	***32%***	***37%***	***36%***	***36%***	***37%***	***38%***		
	2.A Mineral Products	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		
	2.B Chemical Industry	63%	60%	65%	87%	83%	97%	98%	99%	98%	98%		
	2.C Metal Production	73%	75%	80%	82%	76%	100%	100%	99%	99%	100%		
	2.H Other	17%	18%	19%	18%	18%	11%	10%	9%	10%	12%		
	2 Industrial Processes	***62%***	***58%***	***65%***	***69%***	***65%***	***76%***	***75%***	***75%***	***77%***	***76%***		
	TOTAL (excl LULUCF)	**33%**	**31%**	**36%**	**34%**	**33%**	**37%**	**37%**	**37%**	**38%**	**38%**		

The trends for emissions of greenhouse gases (expressed as CO_2 equivalents) reported in ETS and reported in the UNFCCC inventory are shown in Figure A8:1.1 below. Please note that the definition of what emissions are included in the ETS has been broadened in the second and further in the third trading period.

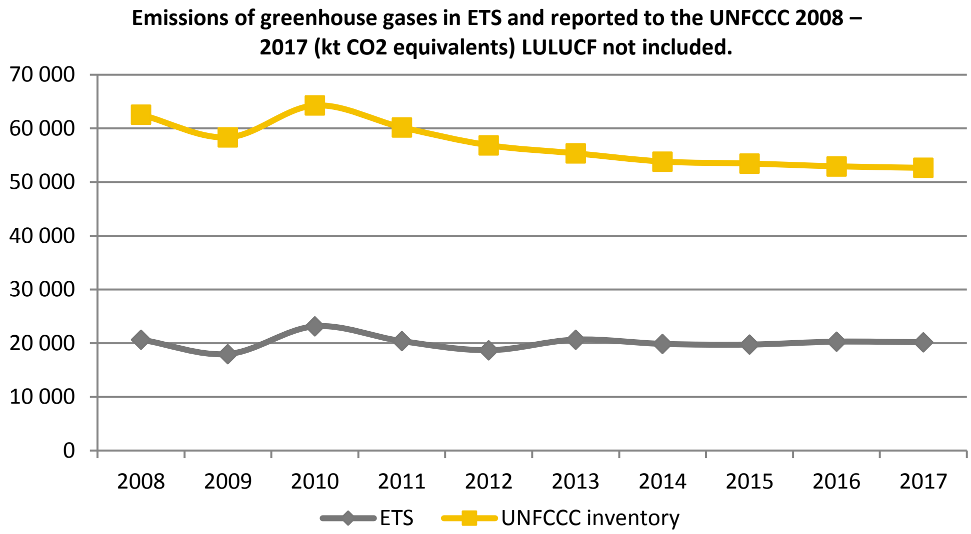

Figure A8:1.1. Emissions of greenhouse gases in ETS and reported to the UNFCCC 2008 – 2017 (kt CO2 equivalents) LULUCF not included.

8.3.1 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[150]. 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.

During 2008 a study aiming to review and when necessary update reported process related CO_2 emissions in CRF 2.A, 2.B.5.b (former 2.B.4.2), 2.C.1.a (former 2.C.1.1) and 2.C.1.e (former 2.C.1.3) was performed. Comparisons of to UNFCCC

[150] Nyström, A-K (2007).

Backman, H. and Gustafsson, T. (2006).

Cooper, D. and Nyström, A-K. (2005).

Gustafsson, T., Lidén, M. and Nyström, A-K., (2005).

Ivarsson, A-K., Kumlin, A., Lidén, M. and Olsson, B. (2004).

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 2.A.3 (former 2.A.7.1), 2.A.4.a (former 2.A.7), 2.C.1.a and 2.C.1.e (former 2.C.1.1 and 2.C.1.3, respectively). 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 is important for the compilation of the inventory.

8.3.2 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[151].

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.

8.3.3 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 1.B.

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.

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

8.3.4 Differences in the Energy sector

8.3.4.1 DIFFERENCES ON PLANT LEVEL

The quarterly fuel statistics is the main activity data source for emissions from stationary combustion in the Swedish inventory, as described in Annex 2, section 2.1.1. 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. Type and amounts of fuels reported to the quarterly fuel statistics from a facility sometimes differ from the corresponding data reported to EU ETS, which leads to differences on plant level.

Plant level comparisons between ETS data and quarterly fuel statistics were made in a SMED study in 2012. The most common reason for differences on plant level was found to be different amounts of fuels reported to the quarterly fuel statistics and ETS, respectively. In a few cases, the differences showed to be rather large. This was in turn generally caused by the different definitions of working unit (responding unit in energy statistics) and installation/facility (reporting unit in ETS). This means that a working unit reporting to the fuel statistics can include several facilities in ETS, or only parts of a facility, i.e. there is not a 1:1 relationship between units in the two data sources. A systematic (but small) difference is diesel oil used for stationary combustion in the vehicle industry, which is reported to the energy statistics but not to ETS.[152]

8.3.4.2 DIFFERENT AGGREGATIONS OF MICRO DATA IN THE ENERGY SECTOR

The reporting unit for the quarterly fuel statistics survey in the heat and electricity sector (CRF 1.A.1.a), is not installation or working unit, but by company and municipality. Identifying energy consumption and emissions for specific plants in that sector is therefore in many 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.

8.3.4.3 ONLY PARTS OF PLANTS INCLUDED IN THE ETS

Combustion of municipal solid waste was not included in the ETS in the two first periods (2005-2007 and 2008-2012), while it is included in the GHG inventory. In the third period, fossil CO_2 emissions from plants combusting of municipal solid fuels are included. Due to this, the ETS share of emissions in CRF 1A1 is much larger (93 %) in 2013 than in the second period (around 75-80 %).

[152] Gerner, 2012.

Especially in the first trading period, it was not uncommon that only parts of the installations in a certain facility were included in ETS. For instance, the plants with the largest emissions within the Chemical industries sector (CRF 1.A.2.c) were only partly included in the ETS in the first trading period.

8.3.4.4 FUEL CLASSIFICATION, EMISSION FACTORS AND NCVS

In the ETS, the plants in some cases use plant specific emission factors and NCVs, while in the GHG inventory, NCVs 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.

8.3.5 Differences in the industrial process sector

8.3.5.1 ONLY PARTS OF PLANTS INCLUDED IN THE ETS

In the ETS may not all activities within a facility be included. As an example production of calcium carbide can be mentioned. For carbide production only the lime producing part of the production of calcium carbide is included (CRF 2.A.2).

8.3.5.2 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. These industries were not included before emission year 2013.

8.3.6 Use of ETS data in CRF 1 in submission 2019

Table A8:1.3. Summary of the use of activity data in CRF 1 from ETS.

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.
2008-2017	1A1b, 1A2c, 1A2g, 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.

References

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.

Ortiz & Danielsson 2015. Särredovisning av utsläpp av fossil CO_2 inom respektive utanför ETS, submission 2016, SMED memorandum 2015

Gerner, 2012. SMED Report No 127, 2012. Jämförelse av industrins förbränningsutsläpp rapporterade till ETS respektive beräknade till klimatrapporteringen. (Comparison of industrial combustion emissions reported to ETS and calculated in the GHG inventory).

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.

Nyström, A-K (2007). Study of differences in plant data between the Energy Statistics and the EU Emission Trading Scheme. SMED report 78:2007.

Annex 8.2: Normal-year correction of greenhouse gas 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. Hydropower accounts for almost half of all Swedish electricity production.

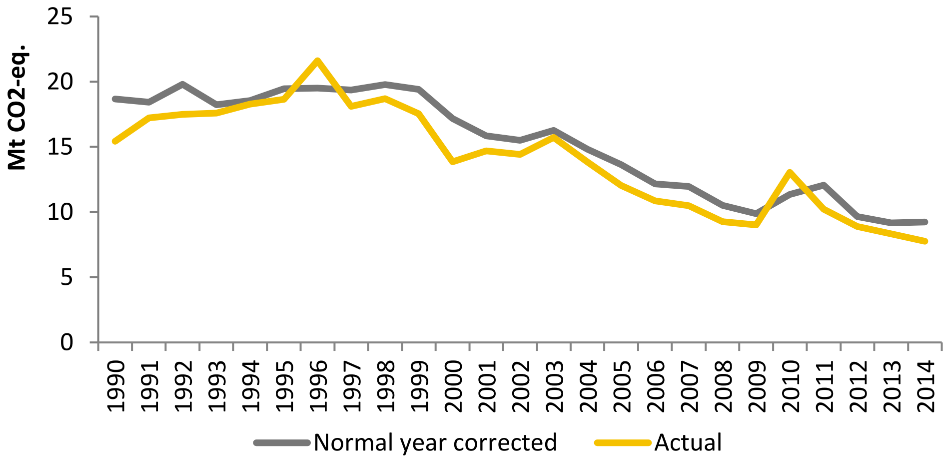

Figure A8:2.1. Actual and normal year corrected fossil CO_2-emissions for heating of buildings and electricity production in Sweden for the years 1990-2014. For the year 2014 a preliminary estimate of runoff is used. The normal corrected emissions are only available until year 2014.

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 (normal year period used is 1965 - 1995), and to 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 Persson, 2004 [1] and later further elaborated in detail in [2]. The model for normal-year corrections of CO_2-emissions from electricity production, including hydropower, is described in [3]. Actual and normal-year corrected fossil CO_2-emissions caused by heating of buildings and electricity production is shown for 1990-2014 (preliminary estimate of runoff in 2014) in Figure 1. The method for calculation of normal corrected emissions are planned to be evaluated in 2017 and therefore no updated calculations have been produced. 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 were almost constant during the period 1990-1999. Since then the emissions have decreased and were in 2009 about half of the levels during the period 1990-1999.

Table A8:2.1. Annual 1990-2014 calculated normal-year corrections of fossil CO_2-emissions (1000 ton CO_2/year). The normal corrected emissions are only available until year 2014.

Year	Electricity production & heating	Heating building excl. electrical heating	Total normal-year correction
1990	1315	1943	3258
1991	449	765	1213
1992	877	1425	2302
1993	149	502	652
1994	-238	496	258
1995	484	342	826
1996	-1338	-757	-2095
1997	560	680	1240
1998	760	325	1085
1999	807	1065	1872
2000	1708	1619	3326
2001	660	487	1147
2002	191	901	1092
2003	-133	662	529
2004	356	642	998
2005	733	859	1592
2006	333	965	1298
2007	478	991	1469
2008	339	908	1248
2009	230	626	855
2010	-398	-1277	-1674
2011	776	1059	1835
2012	356	409	765
2013	169	671	840
2014	369	1102	1471

In Table A8:2.1, 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.

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

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

Annex 8:3: Environmental reporting system

In Sweden, approximately 6,000 “environmental hazardous activities” must have a permit to operate. 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 Industrial Emissions Directive (IED)[153] and Seveso directive[154].

According to chapter 9 of the Environmental Code (SFS 1998:808)[155] permits must be obtained for the establishment, operation and in some cases modification of environmentally hazardous activities on a certain scale. The structures and operations for which permits must be obtained are covered by two ordinances:

- Ordinance on Environmental Assessment (SFS 2013:251)[156]
- Ordinance on Environmentally Hazardous Activities and the Protection of Public Health (SFS 1998:899)[157]

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 Environmental Assessment. For activities that entail a significant environmental impact (classed as A-activities in the list and totalling less than 400), 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 around 5,500) the proponent must apply for a permit to the CAB.

Rules on the operator's responsibility for self-monitoring and environmental reports are given in chapter 26 of the Environmental Code. All operations regulated by permit must return an annual environmental report. All activities and measures that require permission or notification are subject to the Ordinance on Operators’ self-

[153] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

[154] 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.

[155] SFS 1998:808. Miljöbalken

[156] SFS 2013:251, Miljöprövningsförordning

[157] SFS 1998:899, Förordning om miljöfarlig verksamhet och hälsoskydd

monitoring (SFS 1998:901)[158]. The requirements concerning environmental reports are given in the regulation on environmental reports (NFS 2016:8)[159] issued by the Swedish Environmental Protection Agency (Swedish EPA). 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.

All environmental reports have to be submitted electronically via the Swedish Portal for Environmental Reporting (SMP)[160].

The environmental reporting system is essential to the credibility of the self-monitoring. The authority checks the operator performance, asks for additional measures and monitoring. The operator is obliged to keep himself informed about the activity's impact on the environment. This is done by initiating studies and measurements, or by other means. The operator should also have routines for responding to new knowledge and new information, e.g. by taking appropriate counter-measures.

158 SFS 1998:901, Förordning om verksamhetsutövares egenkontrol

159 NFS 2016:8, Naturvårdsverkets föreskrifter om miljörapport https://www.naturvardsverket.se/Documents/foreskrifter/nfs2016/nfs-2016-8.pdf 2018-12-13

160 Svenska Miljörapporteringsportalen. https://smp.lansstyrelsen.se

References

Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control). http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:334:0017:0119:EN:PDF 2014-12-18

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. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32003L0105:EN:HTML 2010-12-03

NFS 2016:8, Naturvårdsverkets föreskrifter om miljörapport. https://www.naturvardsverket.se/Documents/foreskrifter/nfs2016/nfs-2016-8.pdf 2018-12-13

SFS 1998:808. Miljöbalken. http://www.government.se/content/1/c6/02/28/47/385ef12a.pdf 2014-12-18

SFS 2013:251, Miljöprövningsförordning. http://www.riksdagen.se/sv/Dokument-Lagar/Lagar/Svenskforfattningssamling/_sfs-2013-251/ 2014-12-18

SFS 1998:899, Förordning om miljöfarlig verksamhet och hälsoskydd. http://www.riksdagen.se/sv/Dokument-Lagar/Lagar/Svenskforfattningssamling/Miljotillsynsforordning-2011_sfs-1998-899/ 2014-12-18

SFS 1998:901, Förordning om verksamhetsutövares egenkontrol. http://www.riksdagen.se/sv/Dokument-Lagar/Lagar/Svenskforfattningssamling/Forordning-1998901-om-verks_sfs-1998-901/ 2014-12-18

Svenska Miljörapporteringsportalen. https://smp.lansstyrelsen.se 2014-12-18

Annex 8:4: Global Warming Potentials

Greenhouse gas	**GWP**
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_2O)	298
Hydrofluorocarbons (HFCs)	
HFC-23 (CHF_3)	14 800
HFC-32 (CH_2F_2)	675
HFC-41 (CH_3F)	92
HFC-43-10mee ($CF_3CHFCHFCF_2CF_3$)	1 640
HFC-125 (C_2HF_5)	3 500
HFC-134 ($C_2H_2F_4$ (CHF_2CHF_2))	1 100
HFC-134a ($C_2H_2F_4$ (CH_2FCF_3))	1 430
HFC-143 ($C_2H_3F_3$ (CHF_2CH_2F))	353
HFC-143a ($C_2H_3F_3$ (CF_3CH_3))	4 470
HFC-152 (CH_2FCH_2F)	53
HFC-152a ($C_2H_4F_2$ (CH_3CHF_2))	124
HFC-161 (CH_3CH_2F)	12
HFC-227ea (C_3HF_7)	3 220
HFC-236cb ($CH_2FCF_2CF_3$)	1 340
HFC-236ea (CHF_2CHFCF_3)	1 370
HFC-236fa ($C_3H_2F_6$)	9 810
HFC-245ca ($C_3H_3F_5$)	693
HFC-245fa ($CHF_2CH_2CF_3$)	1 030
HFC-365mfc ($CH_3CF_2CH_2CF_3$)	794
Perfluorocarbons	
Perfluoromethane – PFC-14 (CF_4)	7 390
Perfluoroethane – PFC-116 (C_2F_6)	12 200
Perfluoropropane – PFC-218 (C_3F_8)	8 830
Perfluorobutane – PFC-3-1-10 (C_4F_{10})	8 860
Perfluorocyclobutane – PFC-318 (c-C_4F_8)	10 300
Perfluouropentane – PFC-4-1-12 (C_5F_{12})	9 160
Perfluorohexane – PFC-5-1-14 (C_6F_{14})	9 300
Perfluorodecalin – PFC-9-1-18b ($C_{10}F_{18}$)	>7 500
Perfluorocyclopropanec (c-C_3F_6)	>17 340
Sulphur hexafluoride (SF_6)	
Sulphur hexafluoride (SF_6)	22 800
Nitrogen trifluoride (NF_3)	
Nitrogen trifluoride (NF_3)	17 200
Fluorinated ethers	
HFE-125 (CHF_2OCF_3)	14 900

HFE-134 (CHF_2OCHF_2)	6 320
HFE-143a (CH_3OCF_3)	756
HCFE-235da2 ($CHF_2OCHClCF_3$)	350
HFE-245cb2 ($CH_3OCF_2CF_3$)	708
HFE-245fa2 ($CHF_2OCH_2CF_3$)	659
HFE-254cb2 ($CH_3OCF_2CHF_2$)	359
HFE-347mcc3 ($CH_3OCF_2CF_2CF_3$)	575
HFE-347pcf2 ($CHF_2CF_2OCH_2CF_3$)	580
HFE-356pcc3 ($CH_3OCF_2CF_2CHF_2$)	110
HFE-449sl ((HFE-7100) $C_4F_9OCH_3$)	297
HFE-569sf2 ((HFE-7200) $C_4F_9OC_2H_5$)	59
HFE-43-10pccc124 (H-Galden 1040x)	
($CHF_2OCF_2OC_2F_4OCHF_2$)	1 870
HFE-236ca12 (HG-10) ($CHF_2OCF_2OCHF_2$)	2 800
HFE-338pcc13 (HG-01) ($CHF_2OCF_2CF_2OCHF_2$)	1 500
$(CF_3)_2CFOCH_3$)	343
$CF_3CF_2CH_2OH$)	42
$(CF_3)_2CHOH$)	195
HFE-227ea ($CF_3CHFOCF_3$)	1 540
HFE-236ea2 ($CHF_2OCHFCF_3$)	989
HFE-236fa ($CF_3CH_2OCF_3$)	487
HFE-245fa1 ($CHF_2CH_2OCF_3$)	286
HFE-263fb2 ($CF_3CH_2OCH_3$)	11
HFE-329mcc2 ($CHF_2CF_2OCF_2CF_3$)	919
HFE-338mcf2 ($CF_3CH_2OCF_2CF_3$)	552
HFE-347mcf2 ($CHF_2CH_2OCF_2CF_3$)	374
HFE-356mec3 ($CH_3OCF_2CHFCF_3$)	101
HFE-356pcf2 ($CHF_2CH_2OCF_2CHF_2$)	265
HFE-356pcf3 ($CHF_2OCH_2CF_2CHF_2$)	502
HFE-365mcfI’ll t3 ($CF_3CF_2CH_2OCH_3$)	11
HFE-374pc2 ($CHF_2CF_2OCH_2CH_3$)	557
– $(CF_2)_4CH$ (OH) –	73
$(CF_3)_2CHOCHF_2$	380
$(CF3)_2CHOCH_3$	27
Perfluoropolyethers	
PFPMIE ($CF_3OCF(CF_3)CF_2OCF_2OCF_3$)	10 300
Trifluoromethyl sulphur pentafluoride (SF_5CF_3)	
Trifluoromethyl sulphur pentafluoride (SF_5CF_3)	17 700
Hydrofluoroolefins	
HFO-1234yf ($C_3H_2F_4$)	4