Annexes

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A1 ANNEX 1: Key Categories

A1.1 KEY CATEGORY ANALYSIS

Up to and including the 2007 NIR this Annex referred to key sources. The NIR now refers to key categories, or key source categories, rather than key sources. “Key categories” is the terminology used in the IPCC’s Good Practice Guidance (2000) and the word category is used, rather than source, to avoid any potential confusion with sources and corresponding sinks of carbon.

In the UK inventory, certain source categories are particularly significant in terms of their contribution to the overall uncertainty of the inventory. These key source categories have been identified so that the resources available for inventory preparation may be prioritised, and the best possible estimates prepared for the most significant source categories. We have used the method set out in Section 7.2 of the IPCC Good Practice Guidance (2000) (*Determining national key source categories*) to determine the key source categories.

The results of the key source category analysis with and without LULUCF, for the base year and the latest reported year, are summarised by sector and gas in **Table A1.1.11** to **Table A1.1.14**. A trend cannot be calculated for the base year alone, and so **Table A1.1.11** and **Table A1.1.12** only contain key source categories identified by level.

The key category analysis is based on the level analysis and trend analysis which are part of the Approach 1 uncertainty analysis. The Approach 1 uncertainty analysis is an error propagation approach, as described in Section 3.2.3.1 of the IPCC 2006 Guidelines. This analysis has been performed using the data shown in **Tables A7.6.1** to **A7.6.4** using the same categorisation and the same estimates of uncertainty. The table indicates whether a key category arises from the level assessment or the trend assessment. The factors that make a source a key category are:

- A high contribution to the total;
- A high contribution to the trend; and
- High uncertainty.

For example, transport fuel (1A3b) is a key category for carbon dioxide because it is large; landfill methane (6A) is key because it is large, has a high uncertainty and shows a significant trend.

Both the level and the trend assessments have been completed, following the procedure set out in the IPCC Good Practice Guidance (2000). A qualitative assessment was not conducted, but we do not anticipate that additional source categories would have been identified using such an assessment. The emission estimates were taken from the current inventory.

The results of the level assessment with and without LULUCF the base year, 1990, and the latest reported year are shown in **Table A1.1.1** to **Table A1.1.6**.

The key source categories are highlighted by the shaded cells in the table. The source categories (i.e. rows of the table) were sorted in descending order of magnitude based on the results of the "Level Parameter", and then the cumulative total was included in the final column of the table. The key source categories are those whose contributions add up to 95% of the total uncertainty in the final column after this sorting process.

The results of the trend assessment with and without LULUCF the base year, 1990 and the latest reported year are shown in **Table A1.1.7** and **Table A1.1.10**. The key source categories are highlighted by the shaded cells in the table. The trend parameter was calculated using absolute value of the result; an absolute function is used since Land Use, Land Use Change and Forestry contains negative sources (sinks) and the absolute function is necessary to produce positive uncertainty contributions for these sinks. The source categories (i.e. rows of the table) were sorted in descending order of magnitude based on the results of the trend parameter, and then the cumulative total was included in the final column of the table. The key source categories are those whose contributions add up to 95% of the total uncertainty in the final column after this sorting process.

The emissions of nitric and adipic acid are both key categories in the UK inventory and the emissions from nitric acid production are associated with a very high uncertainty. The uncertainties assigned to the AD and EFs are: 2B2 Nitric acid production, AD 10%, EF 230%; 2B3 Adipic acid production, AD 0.5%, EF 15%. The uncertainty associated with N_2O emissions released from nitric acid production dominate the overall uncertainty of N_2O emissions in sector 2B. The uncertainty assigned to the EF of nitric acid production was taken from a study commissioned by UK Defra (Salway *et al.*, 1998). The uncertainty in the emission factor from nitric acid production was estimated from a range of values in the available literature - the reference in the report indicates the main source was the 1996 IPCC guidelines. The UK has not reviewed the uncertainties associated with nitric and adipic acid for some time. A review of the uncertainties was planned with the manufacturers during the compilation of the 2009 NIR but this has been deferred until the 2010 NIR.

Any improvements methodological improvements to the uncertainty analysis are discussed in **Annex 7**.

Table A 1.1.1: Key Category Analysis for the base year based on level of emissions (including LULCUF)

IPCC category	Source category	Gas	Base year emissions	Year Y emissions	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)		Level / Sum(Level)*100	Cumulative %
			Gg CO2 equiv.	Gg CO2 equiv.					
			1990 & 1995	2007				%	
4D	Agricultural Soils	N2O	30414.922	23280.408	424.001	0.1652540		51.45595	
6A	Solid Waste Disposal	CH4	49816.593	20271.579	48.384	0.0308868		9.61738	61.07333
1A(stationary)	Oil	CO2	92552.464	54871.488	15.133	0.0179475		5.58840	66.66173
4B	Manure Management	N2O	2221.015	1745.582	414.001	0.0117829		3.66889	70.33062
1A1&1A2&1A4&1A5	Other Combustion	N2O	4657.530	3522.108	195.000	0.0116383		3.62387	73.95449
2B	Nitric Acid Production	N2O	3903.850	1763.497	230.217	0.0115167		3.58602	77.54051
5B	5B LUCF	CO2	15822.096	15288.354	50.010	0.0101396		3.15720	80.69772
1A3b	Auto Fuel	CO2	109618.322	121854.045	4.482	0.0062961		1.96045	82.65817
5C	5C LUCF	CO2	-6186.303	-8132.070	70.007	0.0055497		1.72805	84.38621
6B	Wastewater Handling	N2O	1033.345	1255.546	401.125	0.0053116		1.65389	86.04010
4A	Enteric Fermentation	CH4	18388.861	15560.693	20.000	0.0047129		1.46748	87.50758
5E	5E LUCF	CO2	6904.219	6212.445	50.010	0.0044246		1.37770	88.88528
2B	Adipic Acid Production	N2O	20737.345	989.613	15.008	0.0039883		1.24184	90.12712
5A	5A LUCF	CO2	-12155.074	-14173.378	25.020	0.0038971		1.21346	91.34058
2	Industrial Processes	HFC	15587.667	9611.187	19.026	0.0038004		1.18336	92.52394
1A	Coal	CO2	248733.724	144792.411	1.077	0.0034329		1.06892	93.59287
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2650.163	73.455	0.0030502		0.94975	94.54262
1A3b	Auto Fuel	N2O	1180.977	1256.130	170.023	0.0025730		0.80118	95.34380
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5444.677	27.001	0.0023035		0.71724	96.06104
1A	Natural Gas	CO2	108929.762	193143.255	1.513	0.0021123		0.65773	96.71877
4B	Manure Management	CH4	3588.777	2872.483	30.000	0.0013796		0.42959	97.14836
1A	All Fuel	CH4	2068.219	1054.264	50.002	0.0013252		0.41263	97.56099
1B	Oil & Natural Gas	CO2	5760.176	5091.682	17.088	0.0012613		0.39274	97.95373
2B5	NEU	CO2	1562.918	1860.990	53.852	0.0010785		0.33583	98.28956
5G	5G LUCF	CO2	-1657.215	-1233.925	30.017	0.0006374		0.19848	98.48804
6B	Wastewater Handling	CH4	709.572	813.273	50.010	0.0004547		0.14159	98.62963
1A3b	Auto Fuel	CH4	693.729	145.800	50.078	0.0004452		0.13862	98.76825
1A3	Other Diesel	N2O	231.203	318.328	140.010	0.0004148		0.12916	98.89741
6C	Waste Incineration	CO2	1206.508	464.674	21.190	0.0003276		0.10201	98.99942
1A3a	Aviation Fuel	CO2	1244.229	2139.999	20.270	0.0003232		0.10063	99.10006
2	Industrial Processes	SF6	1239.300	793.505	20.025	0.0003180		0.09902	99.19908
4F	Field Burning	N2O	77.762	0.000	231.355	0.0002305		0.07178	99.27086
2A1	Cement Production	CO2	7295.263	6117.015	2.417	0.0002259		0.07034	99.34120
1A4	Peat	CO2	476.999	443.334	31.623	0.0001933		0.06019	99.40139
4F	Field Burning	CH4	266.045	0.000	55.902	0.0001906		0.05934	99.46073
2C1	Iron&Steel Production	CO2	2309.274	2657.967	6.119	0.0001811		0.05638	99.51711
2B	Ammonia Production	CO2	1321.667	1208.935	10.112	0.0001713		0.05333	99.57044
2A7	Fletton Bricks	CO2	179.866	181.440	72.801	0.0001678		0.05225	99.62269
1A	Lubricant	CO2	386.896	261.922	30.067	0.0001491		0.04642	99.66910
6C	Waste Incineration	N2O	47.900	49.018	230.106	0.0001412		0.04398	99.71308
1A3d	Marine Fuel	CO2	4004.664	4840.036	2.202	0.0001130		0.03519	99.74827
6C	Waste Incineration	CH4	134.423	6.488	50.488	0.0000870		0.02708	99.77535
2A3	Limestone & Dolomite use	CO2	1285.328	1442.990	5.099	0.0000840		0.02615	99.80150
2A2	Lime Production	CO2	1191.520	688.410	5.099	0.0000779		0.02424	99.82574
1A3d	Marine Fuel	N2O	31.174	37.482	170.008	0.0000679		0.02115	99.84689
1B	Solid Fuel Transformation	CO2	856.418	137.957	6.013	0.0000660		0.02055	99.86744
2B	Chemical Industry	CH4	169.425	76.209	28.284	0.0000614		0.01912	99.88656
2	Industrial Processes	PFC	470.886	215.603	10.050	0.0000606		0.01888	99.90544
1B2	Oil & Natural Gas	N2O	42.396	39.534	111.158	0.0000604		0.01880	99.92425
1A	Other (waste)	CO2	206.961	1252.311	21.190	0.0000562		0.01750	99.94174
1A3	Other Diesel	CO2	1949.748	2677.505	2.202	0.0000550		0.01713	99.95888
2A4	Soda Ash Use	CO2	167.317	237.912	15.133	0.0000324		0.01010	99.96898
2A7	Fletton Bricks	CH4	23.602	18.501	101.980	0.0000308		0.00960	99.97858
1A3a	Aviation Fuel	N2O	12.252	21.070	171.172	0.0000269		0.00837	99.98695
2C	Iron & Steel	N2O	11.107	9.359	118.001	0.0000168		0.00523	99.99218
2C	Iron & Steel Production	CH4	16.357	18.178	50.002	0.0000105		0.00326	99.99544
1B1	Coke Oven Gas	N2O	2.085	0.993	118.001	0.0000032		0.00098	99.99643
5E2	5E2 LUCF	CH4	9.354	6.453	20.025	0.0000024		0.00075	99.99717
1A3a	Aviation Fuel	CH4	3.178	1.604	53.852	0.0000022		0.00068	99.99786
1A3	Other Diesel	CH4	3.221	4.057	50.029	0.0000021		0.00064	99.99850
5A	5A LUCF	N2O	6.852	2.782	20.025	0.0000018		0.00055	99.99905
5A	5A LUCF	CH4	4.298	15.279	20.025	0.0000011		0.00034	99.99939
1A3d	Marine Fuel	CH4	1.320	1.587	50.029	0.0000008		0.00026	99.99965
5C2	5C2 LUCF	CH4	3.077	9.073	20.025	0.0000008		0.00025	99.99990
5E2	5E2 LUCF	N2O	0.949	0.655	20.025	0.0000002		0.00008	99.99998
5C2	5C2 LUCF	N2O	0.312	0.921	20.025	0.0000001		0.00002	100.00000
1A	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A4	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CH4	0.000	0.000	33.541	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	N2O	0.000	0.000	33.541	0.0000000		0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	50.990	0.0000000		0.00000	100.00000
		Sum -- >	780,372.35	638,211.39		0.3212		100.00	
		check	0.000000	0.000000		0.000000			

Table A 1.1.2: Key Category Analysis for the base year based on level of emissions (excluding LULCUF)

IPCC category	Source category	Gas	Base year emissions	Year Y emissions	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)		Level / Sum(Level)*100	Cumulative %
			Gg CO2 equiv.	Gg CO2 equiv.					
			1990 & 1995	2007				%	
4D	Agricultural Soils	N2O	30414.922	23280.408	424.001	0.1658389		55.73463	
6A	Solid Waste Disposal	CH4	49816.593	20271.579	48.384	0.0309961		10.41708	66.15171
1A(stationary)	Oil	CO2	92552.464	54871.488	15.133	0.0180110		6.05309	72.20480
4B	Manure Management	N2O	2221.015	1745.582	414.001	0.0118246		3.97397	76.17877
1A1&1A2&1A4&1A5	Other Combustion	N2O	4657.530	3522.108	195.000	0.0116795		3.92521	80.10398
2B	Nitric Acid Production	N2O	3903.850	1763.497	230.217	0.0115575		3.88421	83.98818
1A3b	Auto Fuel	CO2	109618.322	121854.045	4.482	0.0063184		2.12346	86.11165
6B	Wastewater Handling	N2O	1033.345	1255.546	401.125	0.0053304		1.79141	87.90306
4A	Enteric Fermentation	CH4	18388.861	15560.693	20.000	0.0047296		1.58950	89.49256
2B	Adipic Acid Production	N2O	20737.345	989.613	15.008	0.0040024		1.34511	90.83767
2	Industrial Processes	HFC	15587.667	9611.187	19.026	0.0038139		1.28176	92.11943
1A	Coal	CO2	248733.724	144792.411	1.077	0.0034451		1.15780	93.27724
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2650.163	73.946	0.0030610		1.02873	94.30596
1A3b	Auto Fuel	N2O	1180.977	1256.130	170.023	0.0025822		0.86780	95.17376
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5444.677	27.181	0.0023116		0.77688	95.95064
1A	Natural Gas	CO2	108929.762	193143.255	1.513	0.0021198		0.71242	96.66306
4B	Manure Management	CH4	3588.777	2872.483	30.000	0.0013845		0.46531	97.12837
1A	All Fuel	CH4	2068.219	1054.264	50.002	0.0013299		0.44694	97.57531
1B	Oil & Natural Gas	CO2	5760.176	5091.682	17.088	0.0012658		0.42540	98.00072
2B5	NEU	CO2	1562.918	1860.990	53.852	0.0010824		0.36375	98.36447
6B	Wastewater Handling	CH4	709.572	813.273	50.010	0.0004563		0.15336	98.51783
1A3b	Auto Fuel	CH4	693.729	145.800	50.078	0.0004468		0.15015	98.66798
1A3	Other Diesel	N2O	231.203	318.328	140.010	0.0004163		0.13990	98.80788
6C	Waste Incineration	CO2	1206.508	464.674	21.190	0.0003288		0.11049	98.91837
1A3a	Aviation Fuel	CO2	1244.229	2139.999	20.270	0.0003243		0.10900	99.02737
2	Industrial Processes	SF6	1239.300	793.505	20.025	0.0003191		0.10726	99.13463
4F	Field Burning	N2O	77.762	0.000	231.355	0.0002314		0.07775	99.21238
2A1	Cement Production	CO2	7295.263	6117.015	2.417	0.0002267		0.07619	99.28857
1A4	Peat	CO2	476.999	443.334	31.623	0.0001940		0.06519	99.35377
4F	Field Burning	CH4	266.045	0.000	55.902	0.0001913		0.06428	99.41804
2C1	Iron&Steel Production	CO2	2309.274	2657.967	6.119	0.0001817		0.06107	99.47911
2B	Ammonia Production	CO2	1321.667	1208.935	10.112	0.0001719		0.05776	99.53687
2A7	Fletton Bricks	CO2	179.866	181.440	72.801	0.0001684		0.05659	99.59346
1A	Lubricant	CO2	386.896	261.922	30.067	0.0001496		0.05027	99.64374
6C	Waste Incineration	N2O	47.900	49.018	230.106	0.0001417		0.04764	99.69137
1A3d	Marine Fuel	CO2	4004.664	4840.036	2.202	0.0001134		0.03812	99.72949
6C	Waste Incineration	CH4	134.423	6.488	50.488	0.0000873		0.02933	99.75882
2A3	Limestone & Dolomite use	CO2	1285.328	1442.990	5.099	0.0000843		0.02833	99.78715
2A2	Lime Production	CO2	1191.520	688.410	5.099	0.0000781		0.02626	99.81340
1A3d	Marine Fuel	N2O	31.174	37.482	170.008	0.0000682		0.02290	99.83631
1B	Solid Fuel Transformation	CO2	856.418	137.957	6.013	0.0000662		0.02226	99.85857
2B	Chemical Industry	CH4	169.425	76.209	28.284	0.0000616		0.02071	99.87928
2	Industrial Processes	PFC	470.886	215.603	10.050	0.0000609		0.02045	99.89973
1B2	Oil & Natural Gas	N2O	42.396	39.534	111.158	0.0000606		0.02037	99.92010
1A	Other (waste)	CO2	206.961	1252.311	21.190	0.0000564		0.01895	99.93905
1A3	Other Diesel	CO2	1949.748	2677.505	2.202	0.0000552		0.01856	99.95761
2A4	Soda Ash Use	CO2	167.317	237.912	15.133	0.0000326		0.01094	99.96855
2A7	Fletton Bricks	CH4	23.602	18.501	101.980	0.0000310		0.01040	99.97895
1A3a	Aviation Fuel	N2O	12.252	21.070	171.172	0.0000270		0.00906	99.98802
2C	Iron & Steel	N2O	11.107	9.359	118.001	0.0000169		0.00566	99.99368
2C	Iron & Steel Production	CH4	16.357	18.178	50.002	0.0000105		0.00353	99.99722
1B1	Coke Oven Gas	N2O	2.085	0.993	118.001	0.0000032		0.00106	99.99828
1A3a	Aviation Fuel	CH4	3.178	1.604	53.852	0.0000022		0.00074	99.99902
1A3	Other Diesel	CH4	3.221	4.057	50.029	0.0000021		0.00070	99.99971
1A3d	Marine Fuel	CH4	1.320	1.587	50.029	0.0000008		0.00029	100.00000
1A	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A4	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
5A	5A LUCF	CO2	0.000	0.000	25.020	0.0000000		0.00000	100.00000
5B	5B LUCF	CO2	0.000	0.000	50.010	0.0000000		0.00000	100.00000
5C	5C LUCF	CO2	0.000	0.000	70.007	0.0000000		0.00000	100.00000
5E	5E LUCF	CO2	0.000	0.000	50.010	0.0000000		0.00000	100.00000
5G	5G LUCF	CO2	0.000	0.000	30.017	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CH4	0.000	0.000	33.541	0.0000000		0.00000	100.00000
5A	5A LUCF	CH4	0.000	0.000	20.025	0.0000000		0.00000	100.00000
5C2	5C2 LUCF	CH4	0.000	0.000	20.025	0.0000000		0.00000	100.00000
5E2	5E2 LUCF	CH4	0.000	0.000	20.025	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	N2O	0.000	0.000	33.541	0.0000000		0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	50.990	0.0000000		0.00000	100.00000
5A	5A LUCF	N2O	0.000	0.000	20.025	0.0000000		0.00000	100.00000
5C2	5C2 LUCF	N2O	0.000	0.000	20.025	0.0000000		0.00000	100.00000
5E2	5E2 LUCF	N2O	0.000	0.000	20.025	0.0000000		0.00000	100.00000
		Sum -- >	777,619.78	640,214.80		0.2976		100.00	
		check	0.000000	0.000000		0.000000			

Table A 1.1.3: Key Category Analysis for 1990 based on level of emissions (including LULCUF)

IPCC category	Source category	Gas	Emissions	Year Y emissions	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)		Level / Sum(Level)*100	Cumulative %
			Gg CO2 equiv.	Gg CO2 equiv.					
			1990	2007				%	
4D	Agricultural Soils	N2O	30414.922	23280.408	424.001	0.1659944		51.60996	
6A	Solid Waste Disposal	CH4	49816.593	20271.579	48.384	0.0310252		9.64616	61.25613
1A(stationary)	Oil	CO2	92552.464	54871.488	15.133	0.0180279		5.60513	66.86125
4B	Manure Management	N2O	2221.015	1745.582	414.001	0.0118357		3.67987	70.54113
1A1&1A2&1A4&1A5	Other Combustion	N2O	4657.530	3522.108	195.000	0.0116904		3.63472	74.17585
2B	Nitric Acid Production	N2O	3903.850	1763.497	230.217	0.0115683		3.59675	77.77260
5B	5B LUCF	CO2	15822.096	15288.354	50.010	0.0101850		3.16665	80.93925
1A3b	Auto Fuel	CO2	109618.322	121854.045	4.482	0.0063243		1.96631	82.90557
5C	5C LUCF	CO2	-6186.303	-8132.070	70.007	0.0055746		1.73322	84.63879
6B	Wastewater Handling	N2O	1033.345	1255.546	401.125	0.0053354		1.65884	86.29763
4A	Enteric Fermentation	CH4	18388.861	15560.693	20.000	0.0047340		1.47187	87.76950
5E	5E LUCF	CO2	6904.219	6212.445	50.010	0.0044444		1.38182	89.15132
2B	Adipic Acid Production	N2O	20737.345	989.613	15.008	0.0040061		1.24556	90.39688
5A	5A LUCF	CO2	-12155.074	-14173.378	25.020	0.0039146		1.21710	91.61398
1A	Coal	CO2	248733.724	144792.411	1.077	0.0034483		1.07212	92.68610
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2650.163	73.784	0.0030639		0.95260	93.63869
2	Industrial Processes	HFC	11385.546	9611.187	19.026	0.0027884		0.86694	94.50563
1A3b	Auto Fuel	N2O	1180.977	1256.130	170.023	0.0025846		0.80358	95.30921
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5444.677	27.122	0.0023138		0.71939	96.02859
1A	Natural Gas	CO2	108929.762	193143.255	1.513	0.0021218		0.65970	96.68829
4B	Manure Management	CH4	3588.777	2872.483	30.000	0.0013858		0.43087	97.11916
1A	All Fuel	CH4	2068.219	1054.264	50.002	0.0013311		0.41387	97.53303
1B	Oil & Natural Gas	CO2	5760.176	5091.682	17.088	0.0012670		0.39392	97.92695
2B5	NEU	CO2	1562.918	1860.990	53.852	0.0010834		0.33683	98.26378
5G	5G LUCF	CO2	-1657.215	-1233.925	30.017	0.0006403		0.19908	98.46286
6B	Wastewater Handling	CH4	709.572	813.273	50.010	0.0004568		0.14201	98.60487
1A3b	Auto Fuel	CH4	693.729	145.800	50.078	0.0004472		0.13903	98.74391
1A3	Other Diesel	N2O	231.203	318.328	140.010	0.0004167		0.12955	98.87346
6C	Waste Incineration	CO2	1206.508	464.674	21.190	0.0003291		0.10231	98.97577
1A3a	Aviation Fuel	CO2	1244.229	2139.999	20.270	0.0003246		0.10094	99.07671
2	Industrial Processes	SF6	1029.948	793.505	20.025	0.0002655		0.08254	99.15925
4F	Field Burning	N2O	77.762	0.000	231.355	0.0002316		0.07200	99.23124
2A1	Cement Production	CO2	7295.263	6117.015	2.417	0.0002269		0.07055	99.30180
1A4	Peat	CO2	476.999	443.334	31.623	0.0001942		0.06037	99.36217
4F	Field Burning	CH4	266.045	0.000	55.902	0.0001914		0.05952	99.42169
2C1	Iron&Steel Production	CO2	2309.274	2657.967	6.119	0.0001819		0.05655	99.47823
2	Industrial Processes	PFC	1401.595	215.603	10.050	0.0001813		0.05637	99.53461
2B	Ammonia Production	CO2	1321.667	1208.935	10.112	0.0001720		0.05349	99.58809
2A7	Fletton Bricks	CO2	179.866	181.440	72.801	0.0001685		0.05240	99.64050
1A	Lubricant	CO2	386.896	261.922	30.067	0.0001497		0.04655	99.68705
6C	Waste Incineration	N2O	47.900	49.018	230.106	0.0001419		0.04411	99.73116
1A3d	Marine Fuel	CO2	4004.664	4840.036	2.202	0.0001135		0.03530	99.76646
6C	Waste Incineration	CH4	134.423	6.488	50.488	0.0000874		0.02716	99.79362
2A3	Limestone & Dolomite use	CO2	1285.328	1442.990	5.099	0.0000844		0.02623	99.81985
2A2	Lime Production	CO2	1191.520	688.410	5.099	0.0000782		0.02431	99.84416
1A3d	Marine Fuel	N2O	31.174	37.482	170.008	0.0000682		0.02121	99.86537
1B	Solid Fuel Transformation	CO2	856.418	137.957	6.013	0.0000663		0.02061	99.88598
2B	Chemical Industry	CH4	169.425	76.209	28.284	0.0000617		0.01918	99.90516
1B2	Oil & Natural Gas	N2O	42.396	39.534	111.158	0.0000607		0.01886	99.92402
1A	Other (waste)	CO2	206.961	1252.311	21.190	0.0000564		0.01755	99.94157
1A3	Other Diesel	CO2	1949.748	2677.505	2.202	0.0000553		0.01718	99.95875
2A4	Soda Ash Use	CO2	167.317	237.912	15.133	0.0000326		0.01013	99.96889
2A7	Fletton Bricks	CH4	23.602	18.501	101.980	0.0000310		0.00963	99.97852
1A3a	Aviation Fuel	N2O	12.252	21.070	171.172	0.0000270		0.00839	99.98691
2C	Iron & Steel	N2O	11.107	9.359	118.001	0.0000169		0.00525	99.99216
2C	Iron & Steel Production	CH4	16.357	18.178	50.002	0.0000105		0.00327	99.99543
1B1	Coke Oven Gas	N2O	2.085	0.993	118.001	0.0000032		0.00098	99.99642
5E2	5E2 LUCF	CH4	9.354	6.453	20.025	0.0000024		0.00075	99.99716
1A3a	Aviation Fuel	CH4	3.178	1.604	53.852	0.0000022		0.00068	99.99785
1A3	Other Diesel	CH4	3.221	4.057	50.029	0.0000021		0.00064	99.99849
5A	5A LUCF	N2O	6.852	2.782	20.025	0.0000018		0.00055	99.99904
5A	5A LUCF	CH4	4.298	15.279	20.025	0.0000011		0.00034	99.99939
1A3d	Marine Fuel	CH4	1.320	1.587	50.029	0.0000008		0.00026	99.99965
5C2	5C2 LUCF	CH4	3.077	9.073	20.025	0.0000008		0.00025	99.99990
5E2	5E2 LUCF	N2O	0.949	0.655	20.025	0.0000002		0.00008	99.99997
5C2	5C2 LUCF	N2O	0.312	0.921	20.025	0.0000001		0.00003	100.00000
1A	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A4	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CH4	0.000	0.000	33.541	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	N2O	0.000	0.000	33.541	0.0000000		0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	50.990	0.0000000		0.00000	100.00000
		Sum -- >	776,891.58	638,211.39		0.3216		100.00	
		check	0.000000	0.000000		0.000000			

Table A 1.1.4: Key Category Analysis for 1990 based on level of emissions (excluding LULCUF)

IPCC category	Source category	Gas	Emissions	Year Y emissions	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)	Level / Sum(Level)*100	Cumulative %
			Gg CO2 equiv.	Gg CO2 equiv.				
			1990	2007			%	
4D	Agricultural Soils	N2O	30414.922	23280.408	424.001	0.1665846	55.91537	
6A	Solid Waste Disposal	CH4	49816.593	20271.579	48.384	0.0311355	10.45086	66.36623
1A(stationary)	Oil	CO2	92552.464	54871.488	15.133	0.0180920	6.07272	72.43895
4B	Manure Management	N2O	2221.015	1745.582	414.001	0.0118777	3.98686	76.42580
1A1&1A2&1A4&1A5	Other Combustion	N2O	4657.530	3522.108	195.000	0.0117320	3.93794	80.36374
2B	Nitric Acid Production	N2O	3903.850	1763.497	230.217	0.0116095	3.89680	84.26054
1A3b	Auto Fuel	CO2	109618.322	121854.045	4.482	0.0063468	2.13035	86.39089
6B	Wastewater Handling	N2O	1033.345	1255.546	401.125	0.0053543	1.79722	88.18811
4A	Enteric Fermentation	CH4	18388.861	15560.693	20.000	0.0047508	1.59466	89.78277
2B	Adipic Acid Production	N2O	20737.345	989.613	15.008	0.0040204	1.34947	91.13224
1A	Coal	CO2	248733.724	144792.411	1.077	0.0034605	1.16156	92.29380
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2650.163	74.278	0.0030747	1.03206	93.32586
2	Industrial Processes	HFC	11385.546	9611.187	19.026	0.0027983	0.93926	94.26512
1A3b	Auto Fuel	N2O	1180.977	1256.130	170.023	0.0025938	0.87062	95.13573
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5444.677	27.303	0.0023220	0.77940	95.91513
1A	Natural Gas	CO2	108929.762	193143.255	1.513	0.0021293	0.71473	96.62986
4B	Manure Management	CH4	3588.777	2872.483	30.000	0.0013908	0.46682	97.09668
1A	All Fuel	CH4	2068.219	1054.264	50.002	0.0013359	0.44839	97.54507
1B	Oil & Natural Gas	CO2	5760.176	5091.682	17.088	0.0012715	0.42678	97.97185
2B5	NEU	CO2	1562.918	1860.990	53.852	0.0010872	0.36493	98.33679
6B	Wastewater Handling	CH4	709.572	813.273	50.010	0.0004584	0.15386	98.49065
1A3b	Auto Fuel	CH4	693.729	145.800	50.078	0.0004488	0.15063	98.64128
1A3	Other Diesel	N2O	231.203	318.328	140.010	0.0004182	0.14036	98.78164
6C	Waste Incineration	CO2	1206.508	464.674	21.190	0.0003302	0.11085	98.89248
1A3a	Aviation Fuel	CO2	1244.229	2139.999	20.270	0.0003258	0.10936	99.00184
2	Industrial Processes	SF6	1029.948	793.505	20.025	0.0002664	0.08943	99.09127
4F	Field Burning	N2O	77.762	0.000	231.355	0.0002324	0.07800	99.16927
2A1	Cement Production	CO2	7295.263	6117.015	2.417	0.0002277	0.07644	99.24571
1A4	Peat	CO2	476.999	443.334	31.623	0.0001948	0.06540	99.31111
4F	Field Burning	CH4	266.045	0.000	55.902	0.0001921	0.06448	99.37560
2C1	Iron&Steel Production	CO2	2309.274	2657.967	6.119	0.0001825	0.06127	99.43687
2	Industrial Processes	PFC	1401.595	215.603	10.050	0.0001820	0.06107	99.49794
2B	Ammonia Production	CO2	1321.667	1208.935	10.112	0.0001726	0.05795	99.55589
2A7	Fletton Bricks	CO2	179.866	181.440	72.801	0.0001691	0.05678	99.61266
1A	Lubricant	CO2	386.896	261.922	30.067	0.0001503	0.05044	99.66310
6C	Waste Incineration	N2O	47.900	49.018	230.106	0.0001424	0.04779	99.71089
1A3d	Marine Fuel	CO2	4004.664	4840.036	2.202	0.0001139	0.03824	99.74913
6C	Waste Incineration	CH4	134.423	6.488	50.488	0.0000877	0.02943	99.77856
2A3	Limestone & Dolomite use	CO2	1285.328	1442.990	5.099	0.0000847	0.02842	99.80697
2A2	Lime Production	CO2	1191.520	688.410	5.099	0.0000785	0.02634	99.83332
1A3d	Marine Fuel	N2O	31.174	37.482	170.008	0.0000685	0.02298	99.85630
1B	Solid Fuel Transformation	CO2	856.418	137.957	6.013	0.0000665	0.02233	99.87863
2B	Chemical Industry	CH4	169.425	76.209	28.284	0.0000619	0.02078	99.89940
1B2	Oil & Natural Gas	N2O	42.396	39.534	111.158	0.0000609	0.02043	99.91984
1A	Other (waste)	CO2	206.961	1252.311	21.190	0.0000566	0.01901	99.93885
1A3	Other Diesel	CO2	1949.748	2677.505	2.202	0.0000555	0.01862	99.95747
2A4	Soda Ash Use	CO2	167.317	237.912	15.133	0.0000327	0.01098	99.96845
2A7	Fletton Bricks	CH4	23.602	18.501	101.980	0.0000311	0.01044	99.97888
1A3a	Aviation Fuel	N2O	12.252	21.070	171.172	0.0000271	0.00909	99.98798
2C	Iron & Steel	N2O	11.107	9.359	118.001	0.0000169	0.00568	99.99366
2C	Iron & Steel Production	CH4	16.357	18.178	50.002	0.0000106	0.00355	99.99721
1B1	Coke Oven Gas	N2O	2.085	0.993	118.001	0.0000032	0.00107	99.99827
1A3a	Aviation Fuel	CH4	3.178	1.604	53.852	0.0000022	0.00074	99.99902
1A3	Other Diesel	CH4	3.221	4.057	50.029	0.0000021	0.00070	99.99971
1A3d	Marine Fuel	CH4	1.320	1.587	50.029	0.0000009	0.00029	100.00000
1A	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000	0.00000	100.00000
5A	5A LUCF	CO2	0.000	0.000	25.020	0.0000000	0.00000	100.00000
5B	5B LUCF	CO2	0.000	0.000	50.010	0.0000000	0.00000	100.00000
5C	5C LUCF	CO2	0.000	0.000	70.007	0.0000000	0.00000	100.00000
5E	5E LUCF	CO2	0.000	0.000	50.010	0.0000000	0.00000	100.00000
5G	5G LUCF	CO2	0.000	0.000	30.017	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CH4	0.000	0.000	33.541	0.0000000	0.00000	100.00000
5A	5A LUCF	CH4	0.000	0.000	20.025	0.0000000	0.00000	100.00000
5C2	5C2 LUCF	CH4	0.000	0.000	20.025	0.0000000	0.00000	100.00000
5E2	5E2 LUCF	CH4	0.000	0.000	20.025	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	N2O	0.000	0.000	33.541	0.0000000	0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	50.990	0.0000000	0.00000	100.00000
5A	5A LUCF	N2O	0.000	0.000	20.025	0.0000000	0.00000	100.00000
5C2	5C2 LUCF	N2O	0.000	0.000	20.025	0.0000000	0.00000	100.00000
5E2	5E2 LUCF	N2O	0.000	0.000	20.025	0.0000000	0.00000	100.00000
		Sum -- >	774,139.02	640,214.80		0.2979	100.00	
		check	0.000000	0.000000		0.000000		

Table A 1.1.5: Key Category Analysis for the latest reported year based on level of emissions (including LULCUF)

IPCC category	Source category	Gas	Emissions	Year Y emissions	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)		Level / Sum(Level)*100	Cumulative %
			Gg CO2 equiv. 1990	Gg CO2 equiv. 2007				%	
4D	Agricultural Soils	N2O	30414.922	23280.408	424.001	0.1546654		53.23547	
6A	Solid Waste Disposal	CH4	49816.593	20271.579	48.384	0.0153682		5.28971	58.52518
1A(stationary)	Oil	CO2	92552.464	54871.488	15.133	0.0130107		4.47825	63.00343
5B	5B LUCF	CO2	15822.096	15288.354	50.010	0.0119799		4.12345	67.12688
4B	Manure Management	N2O	2221.015	1745.582	414.001	0.0113234		3.89749	71.02437
1A1&1A2&1A4&1A5	Other Combustion	N2O	4657.530	3522.108	195.000	0.0107615		3.70409	74.72847
5C	5C LUCF	CO2	-6186.303	-8132.070	70.007	0.0089203		3.07034	77.79881
1A3b	Auto Fuel	CO2	109618.322	121854.045	4.482	0.0085579		2.94560	80.74441
6B	Wastewater Handling	N2O	1033.345	1255.546	401.125	0.0078913		2.71616	83.46057
2B	Nitric Acid Production	N2O	3903.850	1763.497	230.217	0.0063613		2.18956	85.65013
5A	5A LUCF	CO2	-12155.074	-14173.378	25.020	0.0055564		1.91251	87.56264
4A	Enteric Fermentation	CH4	18388.861	15560.693	20.000	0.0048764		1.67845	89.24108
5E	5E LUCF	CO2	6904.219	6212.445	50.010	0.0048680		1.67557	90.91666
1A	Natural Gas	CO2	108929.762	193143.255	1.513	0.0045797		1.57631	92.49296
1A3b	Auto Fuel	N2O	1180.977	1256.130	170.023	0.0033464		1.15182	93.64479
2	Industrial Processes	HFC	11385.546	9611.187	19.026	0.0028653		0.98622	94.63101
1A	Coal	CO2	248733.724	144792.411	1.077	0.0024435		0.84104	95.47205
2B5	NEU	CO2	1562.918	1860.990	53.852	0.0015703		0.54049	96.01254
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5444.677	17.120	0.0014605		0.50272	96.51526
1B	Oil & Natural Gas	CO2	5760.176	5091.682	17.088	0.0013633		0.46924	96.98450
4B	Manure Management	CH4	3588.777	2872.483	30.000	0.0013503		0.46476	97.44925
1A	All Fuel	CH4	2068.219	1054.264	50.002	0.0008260		0.28430	97.73355
1A3	Other Diesel	N2O	231.203	318.328	140.010	0.0006983		0.24037	97.97392
1A3a	Aviation Fuel	CO2	1244.229	2139.999	20.270	0.0006797		0.23395	98.20787
6B	Wastewater Handling	CH4	709.572	813.273	50.010	0.0006373		0.21935	98.42722
5G	5G LUCF	CO2	-1657.215	-1233.925	30.017	0.0005803		0.19975	98.62697
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2650.163	13.033	0.0005412		0.18628	98.81325
1A	Other (waste)	CO2	206.961	1252.311	21.190	0.0004158		0.14311	98.95637
2C1	Iron&Steel Production	CO2	2309.274	2657.967	6.119	0.0002548		0.08771	99.04408
2	Industrial Processes	SF6	1029.948	793.505	20.025	0.0002490		0.08570	99.12977
2B	Adipic Acid Production	N2O	20737.345	989.613	15.008	0.0002327		0.08010	99.20988
2A1	Cement Production	CO2	7295.263	6117.015	2.417	0.0002316		0.07972	99.28960
1A4	Peat	CO2	476.999	443.334	31.623	0.0002197		0.07561	99.36521
2A7	Fletton Bricks	CO2	179.866	181.440	72.801	0.0002070		0.07124	99.43645
2B	Ammonia Production	CO2	1321.667	1208.935	10.112	0.0001915		0.06593	99.50238
6C	Waste Incineration	N2O	47.900	49.018	230.106	0.0001767		0.06083	99.56321
1A3d	Marine Fuel	CO2	4004.664	4840.036	2.202	0.0001670		0.05749	99.62070
6C	Waste Incineration	CO2	1206.508	464.674	21.190	0.0001543		0.05310	99.67380
1A	Lubricant	CO2	386.896	261.922	30.067	0.0001234		0.04247	99.71627
2A3	Limestone & Dolomite use	CO2	1285.328	1442.990	5.099	0.0001153		0.03968	99.75595
1A3b	Auto Fuel	CH4	693.729	145.800	50.078	0.0001144		0.03938	99.79533
1A3d	Marine Fuel	N2O	31.174	37.482	170.008	0.0000998		0.03437	99.82970
1A3	Other Diesel	CO2	1949.748	2677.505	2.202	0.0000924		0.03180	99.86150
1B2	Oil & Natural Gas	N2O	42.396	39.534	111.158	0.0000689		0.02370	99.88520
1A3a	Aviation Fuel	N2O	12.252	21.070	171.172	0.0000565		0.01945	99.90465
2A4	Soda Ash Use	CO2	167.317	237.912	15.133	0.0000564		0.01942	99.92407
2A2	Lime Production	CO2	1191.520	688.410	5.099	0.0000550		0.01893	99.94300
2	Industrial Processes	PFC	1401.595	215.603	10.050	0.0000340		0.01169	99.95468
2B	Chemical Industry	CH4	169.425	76.209	28.284	0.0000338		0.01163	99.96631
2A7	Fletton Bricks	CH4	23.602	18.501	101.980	0.0000296		0.01018	99.97648
2C	Iron & Steel	N2O	11.107	9.359	118.001	0.0000173		0.00596	99.98244
2C	Iron & Steel Production	CH4	16.357	18.178	50.002	0.0000142		0.00490	99.98734
1B	Solid Fuel Transformation	CO2	856.418	137.957	6.013	0.0000130		0.00447	99.99181
6C	Waste Incineration	CH4	134.423	6.488	50.488	0.0000051		0.00177	99.99358
5A	5A LUCF	CH4	4.298	15.279	20.025	0.0000048		0.00165	99.99523
1A3	Other Diesel	CH4	3.221	4.057	50.029	0.0000032		0.00109	99.99633
5C2	5C2 LUCF	CH4	3.077	9.073	20.025	0.0000028		0.00098	99.99731
5E2	5E2 LUCF	CH4	9.354	6.453	20.025	0.0000020		0.00070	99.99800
1B1	Coke Oven Gas	N2O	2.085	0.993	118.001	0.0000018		0.00063	99.99864
1A3a	Aviation Fuel	CH4	3.178	1.604	53.852	0.0000014		0.00047	99.99910
1A3d	Marine Fuel	CH4	1.320	1.587	50.029	0.0000012		0.00043	99.99953
5A	5A LUCF	N2O	6.852	2.782	20.025	0.0000009		0.00030	99.99983
5C2	5C2 LUCF	N2O	0.312	0.921	20.025	0.0000003		0.00010	99.99993
5E2	5E2 LUCF	N2O	0.949	0.655	20.025	0.0000002		0.00007	100.00000
1A	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A4	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CH4	0.000	0.000	33.541	0.0000000		0.00000	100.00000
4F	Field Burning	CH4	266.045	0.000	55.902	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	N2O	0.000	0.000	33.541	0.0000000		0.00000	100.00000
4F	Field Burning	N2O	77.762	0.000	231.355	0.0000000		0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	50.990	0.0000000		0.00000	100.00000
		Sum -- >	776,891.58	638,211.39		0.2905		100.00	
		check	0.000000	0.000000		0.000000			

Table A 1.1.6: Key Category Analysis for the latest reported year based on level of emissions (excluding LULCUF)

IPCC category	Source category	Gas	Emissions	Year Y emissions	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)		Level / Sum(Level)*100	Cumulative %
			Gg CO2 equiv. 1990	Gg CO2 equiv. 2007				%	
4D	Agricultural Soils	N2O	30414.922	23280.408	424.001	0.1541814		59.80535	
6A	Solid Waste Disposal	CH4	49816.593	20271.579	48.384	0.0153201		5.94252	65.74787
1A(stationary)	Oil	CO2	92552.464	54871.488	15.133	0.0129700		5.03091	70.77878
4B	Manure Management	N2O	2221.015	1745.582	414.001	0.0112880		4.37849	75.15727
1A1&1A2&1A4&1A5	Other Combustion	N2O	4657.530	3522.108	195.000	0.0107278		4.16122	79.31849
1A3b	Auto Fuel	CO2	109618.322	121854.045	4.482	0.0085311		3.30912	82.62761
6B	Wastewater Handling	N2O	1033.345	1255.546	401.125	0.0078666		3.05137	85.67898
2B	Nitric Acid Production	N2O	3903.850	1763.497	230.217	0.0063414		2.45977	88.13875
4A	Enteric Fermentation	CH4	18388.861	15560.693	20.000	0.0048611		1.88559	90.02434
1A	Natural Gas	CO2	108929.762	193143.255	1.513	0.0045653		1.77084	91.79518
1A3b	Auto Fuel	N2O	1180.977	1256.130	170.023	0.0033359		1.29397	93.08915
2	Industrial Processes	HFC	11385.546	9611.187	19.026	0.0028563		1.10793	94.19708
1A	Coal	CO2	248733.724	144792.411	1.077	0.0024358		0.94484	95.14192
2B5	NEU	CO2	1562.918	1860.990	53.852	0.0015654		0.60719	95.74911
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5444.677	17.120	0.0014560		0.56476	96.31387
1B	Oil & Natural Gas	CO2	5760.176	5091.682	17.088	0.0013590		0.52715	96.84102
4B	Manure Management	CH4	3588.777	2872.483	30.000	0.0013460		0.52211	97.36313
1A	All Fuel	CH4	2068.219	1054.264	50.002	0.0008234		0.31939	97.68252
1A3	Other Diesel	N2O	231.203	318.328	140.010	0.0006962		0.27003	97.95255
1A3a	Aviation Fuel	CO2	1244.229	2139.999	20.270	0.0006776		0.26282	98.21537
6B	Wastewater Handling	CH4	709.572	813.273	50.010	0.0006353		0.24642	98.46179
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2650.163	13.033	0.0005395		0.20927	98.67106
1A	Other (waste)	CO2	206.961	1252.311	21.190	0.0004145		0.16077	98.83184
2C1	Iron&Steel Production	CO2	2309.274	2657.967	6.119	0.0002540		0.09854	98.93037
2	Industrial Processes	SF6	1029.948	793.505	20.025	0.0002482		0.09627	99.02665
2B	Adipic Acid Production	N2O	20737.345	989.613	15.008	0.0002320		0.08999	99.11663
2A1	Cement Production	CO2	7295.263	6117.015	2.417	0.0002309		0.08956	99.20620
1A4	Peat	CO2	476.999	443.334	31.623	0.0002190		0.08494	99.29114
2A7	Fletton Bricks	CO2	179.866	181.440	72.801	0.0002063		0.08003	99.37117
2B	Ammonia Production	CO2	1321.667	1208.935	10.112	0.0001909		0.07407	99.44523
6C	Waste Incineration	N2O	47.900	49.018	230.106	0.0001762		0.06834	99.51357
1A3d	Marine Fuel	CO2	4004.664	4840.036	2.202	0.0001665		0.06458	99.57815
6C	Waste Incineration	CO2	1206.508	464.674	21.190	0.0001538		0.05966	99.63781
1A	Lubricant	CO2	386.896	261.922	30.067	0.0001230		0.04771	99.68552
2A3	Limestone & Dolomite use	CO2	1285.328	1442.990	5.099	0.0001149		0.04458	99.73010
1A3b	Auto Fuel	CH4	693.729	145.800	50.078	0.0001140		0.04424	99.77434
1A3d	Marine Fuel	N2O	31.174	37.482	170.008	0.0000995		0.03861	99.81294
1A3	Other Diesel	CO2	1949.748	2677.505	2.202	0.0000921		0.03573	99.84867
1B2	Oil & Natural Gas	N2O	42.396	39.534	111.158	0.0000686		0.02663	99.87530
1A3a	Aviation Fuel	N2O	12.252	21.070	171.172	0.0000563		0.02185	99.89715
2A4	Soda Ash Use	CO2	167.317	237.912	15.133	0.0000562		0.02181	99.91896
2A2	Lime Production	CO2	1191.520	688.410	5.099	0.0000548		0.02127	99.94023
2	Industrial Processes	PFC	1401.595	215.603	10.050	0.0000338		0.01313	99.95336
2B	Chemical Industry	CH4	169.425	76.209	28.284	0.0000337		0.01306	99.96642
2A7	Fletton Bricks	CH4	23.602	18.501	101.980	0.0000295		0.01143	99.97785
2C	Iron & Steel	N2O	11.107	9.359	118.001	0.0000173		0.00669	99.98454
2C	Iron & Steel Production	CH4	16.357	18.178	50.002	0.0000142		0.00551	99.99004
1B	Solid Fuel Transformation	CO2	856.418	137.957	6.013	0.0000130		0.00503	99.99507
6C	Waste Incineration	CH4	134.423	6.488	50.488	0.0000051		0.00198	99.99706
1A3	Other Diesel	CH4	3.221	4.057	50.029	0.0000032		0.00123	99.99829
1B1	Coke Oven Gas	N2O	2.085	0.993	118.001	0.0000018		0.00071	99.99900
1A3a	Aviation Fuel	CH4	3.178	1.604	53.852	0.0000013		0.00052	99.99952
1A3d	Marine Fuel	CH4	1.320	1.587	50.029	0.0000012		0.00048	100.00000
1A	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A4	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
5A	5A LUCF	CO2	0.000	0.000	25.020	0.0000000		0.00000	100.00000
5B	5B LUCF	CO2	0.000	0.000	50.010	0.0000000		0.00000	100.00000
5C	5C LUCF	CO2	0.000	0.000	70.007	0.0000000		0.00000	100.00000
5E	5E LUCF	CO2	0.000	0.000	50.010	0.0000000		0.00000	100.00000
5G	5G LUCF	CO2	0.000	0.000	30.017	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CH4	0.000	0.000	33.541	0.0000000		0.00000	100.00000
4F	Field Burning	CH4	266.045	0.000	55.902	0.0000000		0.00000	100.00000
5A	5A LUCF	CH4	0.000	0.000	20.025	0.0000000		0.00000	100.00000
5C2	5C2 LUCF	CH4	0.000	0.000	20.025	0.0000000		0.00000	100.00000
5E2	5E2 LUCF	CH4	0.000	0.000	20.025	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	N2O	0.000	0.000	33.541	0.0000000		0.00000	100.00000
4F	Field Burning	N2O	77.762	0.000	231.355	0.0000000		0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	50.990	0.0000000		0.00000	100.00000
5A	5A LUCF	N2O	0.000	0.000	20.025	0.0000000		0.00000	100.00000
5C2	5C2 LUCF	N2O	0.000	0.000	20.025	0.0000000		0.00000	100.00000
5E2	5E2 LUCF	N2O	0.000	0.000	20.025	0.0000000		0.00000	100.00000
		Sum -- >	774,139.02	640,214.80		0.2578		100.00	
		check	0.000000	0.000000		0.000000			

Table A 1.1.7: Key Category Analysis based on trend in emissions (from base year to latest reported year, including LULCUF)

IPCC category	Source category	Gas	Base year emissions	Year Y emissions	Combined uncertainty range as a % of source category	Trend Parameter (used to order sources)	Trend / Sum(Trend)*100	Cumulative %
			Gg CO2 equiv. 1990 & 1995	Gg CO2 equiv. 2007			%	
4D	Agricultural Soils	N2O	30414.922	23280.408	424.001	0.0548963	53.09202	
2B	Nitric Acid Production	N2O	3903.850	1763.497	230.217	0.0145123	14.03537	67.12739
6B	Wastewater Handling	N2O	1033.345	1255.546	401.125	0.0126529	12.23700	79.36439
6A	Solid Waste Disposal	CH4	49816.593	20271.579	48.384	0.0091810	8.87925	88.24364
4B	Manure Management	N2O	2221.015	1745.582	414.001	0.0023259	2.24945	90.49309
1A1&1A2&1A4&1A5	Other Combustion	N2O	4657.530	3522.108	195.000	0.0020905	2.02183	92.51493
1A3b	Auto Fuel	N2O	1180.977	1256.130	170.023	0.0016078	1.55493	94.06986
5B	5B LUCF	CO2	15822.096	15288.354	50.010	0.0011254	1.08837	95.15823
1A(stationary)	Oil	CO2	92552.464	54871.488	15.133	0.0009135	0.88346	96.04170
2B	Adipic Acid Production	N2O	20737.345	989.613	15.008	0.0006892	0.66654	96.70824
1A3	Other Diesel	N2O	231.203	318.328	140.010	0.0004854	0.46945	97.17769
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2650.163	13.033	0.0003995	0.38637	97.56406
2B5	NEU	CO2	1562.918	1860.990	53.852	0.0003238	0.31316	97.87722
1A	All Fuel	CH4	2068.219	1054.264	50.002	0.0003052	0.29518	98.17241
5E	5E LUCF	CO2	6904.219	6212.445	50.010	0.0002712	0.26228	98.43469
2	Industrial Processes	HFC	15587.667	9611.187	19.026	0.0002176	0.21041	98.64510
1A3b	Auto Fuel	CH4	693.729	145.800	50.078	0.0002025	0.19589	98.84099
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5444.677	17.120	0.0001989	0.19239	99.03337
1A3b	Auto Fuel	CO2	109618.322	121854.045	4.482	0.0001240	0.11988	99.15326
6B	Wastewater Handling	CH4	709.572	813.273	50.010	0.0001116	0.10796	99.26122
6C	Waste Incineration	N2O	47.900	49.018	230.106	0.0000999	0.09658	99.35780
1A	Other (waste)	CO2	206.961	1252.311	21.190	0.0000932	0.09011	99.44790
1A3a	Aviation Fuel	CO2	1244.229	2139.999	20.270	0.0000884	0.08546	99.53336
1A3d	Marine Fuel	N2O	31.174	37.482	170.008	0.0000664	0.06420	99.59756
1A3a	Aviation Fuel	N2O	12.252	21.070	171.172	0.0000620	0.05999	99.65755
6C	Waste Incineration	CH4	134.423	6.488	50.488	0.0000505	0.04886	99.70641
1A	Natural Gas	CO2	108929.762	193143.255	1.513	0.0000457	0.04415	99.75056
6C	Waste Incineration	CO2	1206.508	464.674	21.190	0.0000449	0.04343	99.79399
4A	Enteric Fermentation	CH4	18388.861	15560.693	20.000	0.0000400	0.03867	99.83266
2A7	Fletton Bricks	CO2	179.866	181.440	72.801	0.0000349	0.03372	99.86639
1B	Oil & Natural Gas	CO2	5760.176	5091.682	17.088	0.0000213	0.02061	99.88699
2	Industrial Processes	SF6	1239.300	793.505	20.025	0.0000169	0.01635	99.90334
1A	Coal	CO2	248733.724	144792.411	1.077	0.0000130	0.01260	99.91594
1B2	Oil & Natural Gas	N2O	42.396	39.534	111.158	0.0000115	0.01113	99.92707
4B	Manure Management	CH4	3588.777	2872.483	30.000	0.0000108	0.01043	99.93750
1A4	Peat	CO2	476.999	443.334	31.623	0.0000102	0.00986	99.94736
2B	Chemical Industry	CH4	169.425	76.209	28.284	0.0000096	0.00924	99.95661
1A	Lubricant	CO2	386.896	261.922	30.067	0.0000094	0.00913	99.96573
2C1	Iron&Steel Production	CO2	2309.274	2657.967	6.119	0.0000055	0.00534	99.97107
2A4	Soda Ash Use	CO2	167.317	237.912	15.133	0.0000044	0.00429	99.97536
1B	Solid Fuel Transformation	CO2	856.418	137.957	6.013	0.0000039	0.00377	99.97913
2	Industrial Processes	PFC	470.886	215.603	10.050	0.0000033	0.00317	99.98230
2B	Ammonia Production	CO2	1321.667	1208.935	10.112	0.0000025	0.00243	99.98473
2C	Iron & Steel Production	CH4	16.357	18.178	50.002	0.0000023	0.00222	99.98695
2A3	Limestone & Dolomite use	CO2	1285.328	1442.990	5.099	0.0000020	0.00189	99.98884
1B1	Coke Oven Gas	N2O	2.085	0.993	118.001	0.0000019	0.00184	99.99067
2A7	Fletton Bricks	CH4	23.602	18.501	101.980	0.0000016	0.00155	99.99222
1A3d	Marine Fuel	CO2	4004.664	4840.036	2.202	0.0000015	0.00141	99.99363
2A2	Lime Production	CO2	1191.520	688.410	5.099	0.0000014	0.00138	99.99500
1A3	Other Diesel	CO2	1949.748	2677.505	2.202	0.0000010	0.00097	99.99598
5A	5A LUCF	CH4	4.298	15.279	20.025	0.0000009	0.00087	99.99685
2C	Iron & Steel	N2O	11.107	9.359	118.001	0.0000007	0.00071	99.99756
1A3	Other Diesel	CH4	3.221	4.057	50.029	0.0000007	0.00066	99.99822
1A3a	Aviation Fuel	CH4	3.178	1.604	53.852	0.0000006	0.00053	99.99876
5C2	5C2 LUCF	CH4	3.077	9.073	20.025	0.0000005	0.00049	99.99924
1A3d	Marine Fuel	CH4	1.320	1.587	50.029	0.0000002	0.00024	99.99948
5A	5A LUCF	N2O	6.852	2.782	20.025	0.0000002	0.00021	99.99969
2A1	Cement Production	CO2	7295.263	6117.015	2.417	0.0000002	0.00016	99.99985
5E2	5E2 LUCF	CH4	9.354	6.453	20.025	0.0000001	0.00009	99.99994
5C2	5C2 LUCF	N2O	0.312	0.921	20.025	0.0000001	0.00005	99.99999
5E2	5E2 LUCF	N2O	0.949	0.655	20.025	0.0000000	0.00001	100.00000
1A	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000	0.00000	100.00000
5A	5A LUCF	CO2	-12155.074	-14173.378	25.020	0.0000000	0.00000	100.00000
5C	5C LUCF	CO2	-6186.303	-8132.070	70.007	0.0000000	0.00000	100.00000
5G	5G LUCF	CO2	-1657.215	-1233.925	30.017	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CH4	0.000	0.000	33.541	0.0000000	0.00000	100.00000
4F	Field Burning	CH4	266.045	0.000	55.902	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	N2O	0.000	0.000	33.541	0.0000000	0.00000	100.00000
4F	Field Burning	N2O	77.762	0.000	231.355	0.0000000	0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	50.990	0.0000000	0.00000	100.00000
		Sum -- >	780,372.35	638,211.39		0.1034	100.00	
		check	0.000000	0.000000		0.000000		

Table A 1.1.8: Key Category Analysis based on the trend in emissions (from base year to latest reported year, excluding LULCUF)

IPCC category	Source category	Gas	Base year emissions	Year Y emissions	Combined uncertainty range as a % of source category	Trend Parameter (used to order sources)	Trend / Sum(Trend)*100	Cumulative %
			Gg CO2 equiv. 1990 & 1995	Gg CO2 equiv. 2007			%	
4D	Agricultural Soils	N2O	30414.922	23280.408	424.001	0.0600365	55.89484	
2B	Nitric Acid Production	N2O	3903.850	1763.497	230.217	0.0145856	13.57935	69.47419
6B	Wastewater Handling	N2O	1033.345	1255.546	401.125	0.0123569	11.50440	80.97859
6A	Solid Waste Disposal	CH4	49816.593	20271.579	48.384	0.0092125	8.57696	89.55555
4B	Manure Management	N2O	2221.015	1745.582	414.001	0.0026984	2.51221	92.06776
1A1&1A2&1A4&1A5	Other Combustion	N2O	4657.530	3522.108	195.000	0.0022540	2.09849	94.16625
1A3b	Auto Fuel	N2O	1180.977	1256.130	170.023	0.0015567	1.44927	95.61552
1A(stationary)	Oil	CO2	92552.464	54871.488	15.133	0.0009266	0.86266	96.47817
2B	Adipic Acid Production	N2O	20737.345	989.613	15.008	0.0006873	0.63991	97.11808
1A3	Other Diesel	N2O	231.203	318.328	140.010	0.0004760	0.44313	97.56121
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2650.163	13.033	0.0003988	0.37131	97.93252
2B5	NEU	CO2	1562.918	1860.990	53.852	0.0003159	0.29415	98.22666
1A	All Fuel	CH4	2068.219	1054.264	50.002	0.0003076	0.28639	98.51305
2	Industrial Processes	HFC	15587.667	9611.187	19.026	0.0002213	0.20603	98.71908
1A3b	Auto Fuel	CH4	693.729	145.800	50.078	0.0002024	0.18842	98.90749
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5444.677	17.120	0.0002005	0.18662	99.09412
1A3b	Auto Fuel	CO2	109618.322	121854.045	4.482	0.0001205	0.11215	99.20627
6B	Wastewater Handling	CH4	709.572	813.273	50.010	0.0001087	0.10120	99.30747
6C	Waste Incineration	N2O	47.900	49.018	230.106	0.0000963	0.08961	99.39708
1A	Other (waste)	CO2	206.961	1252.311	21.190	0.0000922	0.08581	99.48289
1A3a	Aviation Fuel	CO2	1244.229	2139.999	20.270	0.0000870	0.08097	99.56385
1A3d	Marine Fuel	N2O	31.174	37.482	170.008	0.0000648	0.06033	99.62418
1A3a	Aviation Fuel	N2O	12.252	21.070	171.172	0.0000611	0.05684	99.68102
6C	Waste Incineration	CH4	134.423	6.488	50.488	0.0000504	0.04691	99.72793
6C	Waste Incineration	CO2	1206.508	464.674	21.190	0.0000450	0.04193	99.76985
1A	Natural Gas	CO2	108929.762	193143.255	1.513	0.0000449	0.04185	99.81170
2A7	Fletton Bricks	CO2	179.866	181.440	72.801	0.0000335	0.03123	99.84293
4A	Enteric Fermentation	CH4	18388.861	15560.693	20.000	0.0000320	0.02976	99.87268
1B	Oil & Natural Gas	CO2	5760.176	5091.682	17.088	0.0000194	0.01802	99.89070
2	Industrial Processes	SF6	1239.300	793.505	20.025	0.0000173	0.01606	99.90677
4B	Manure Management	CH4	3588.777	2872.483	30.000	0.0000140	0.01306	99.91983
1A	Coal	CO2	248733.724	144792.411	1.077	0.0000132	0.01229	99.93212
1B2	Oil & Natural Gas	N2O	42.396	39.534	111.158	0.0000109	0.01010	99.94222
1A	Lubricant	CO2	386.896	261.922	30.067	0.0000097	0.00904	99.95126
2B	Chemical Industry	CH4	169.425	76.209	28.284	0.0000096	0.00894	99.96020
1A4	Peat	CO2	476.999	443.334	31.623	0.0000096	0.00894	99.96915
2C1	Iron&Steel Production	CO2	2309.274	2657.967	6.119	0.0000054	0.00500	99.97415
2A4	Soda Ash Use	CO2	167.317	237.912	15.133	0.0000044	0.00405	99.97820
1B	Solid Fuel Transformation	CO2	856.418	137.957	6.013	0.0000039	0.00362	99.98182
2	Industrial Processes	PFC	470.886	215.603	10.050	0.0000033	0.00307	99.98489
2B	Ammonia Production	CO2	1321.667	1208.935	10.112	0.0000023	0.00218	99.98708
2C	Iron & Steel Production	CH4	16.357	18.178	50.002	0.0000022	0.00208	99.98916
1B1	Coke Oven Gas	N2O	2.085	0.993	118.001	0.0000019	0.00178	99.99094
2A3	Limestone & Dolomite use	CO2	1285.328	1442.990	5.099	0.0000019	0.00177	99.99270
2A7	Fletton Bricks	CH4	23.602	18.501	101.980	0.0000018	0.00171	99.99441
2A2	Lime Production	CO2	1191.520	688.410	5.099	0.0000014	0.00134	99.99576
1A3d	Marine Fuel	CO2	4004.664	4840.036	2.202	0.0000014	0.00132	99.99708
1A3	Other Diesel	CO2	1949.748	2677.505	2.202	0.0000010	0.00092	99.99800
1A3	Other Diesel	CH4	3.221	4.057	50.029	0.0000007	0.00062	99.99862
2C	Iron & Steel	N2O	11.107	9.359	118.001	0.0000006	0.00053	99.99915
1A3a	Aviation Fuel	CH4	3.178	1.604	53.852	0.0000006	0.00052	99.99966
1A3d	Marine Fuel	CH4	1.320	1.587	50.029	0.0000002	0.00022	99.99989
2A1	Cement Production	CO2	7295.263	6117.015	2.417	0.0000001	0.00011	100.00000
1A	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000	0.00000	100.00000
5A	5A LUCF	CO2	0.000	0.000	25.020	0.0000000	0.00000	100.00000
5B	5B LUCF	CO2	0.000	0.000	50.010	0.0000000	0.00000	100.00000
5C	5C LUCF	CO2	0.000	0.000	70.007	0.0000000	0.00000	100.00000
5E	5E LUCF	CO2	0.000	0.000	50.010	0.0000000	0.00000	100.00000
5G	5G LUCF	CO2	0.000	0.000	30.017	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CH4	0.000	0.000	33.541	0.0000000	0.00000	100.00000
4F	Field Burning	CH4	266.045	0.000	55.902	0.0000000	0.00000	100.00000
5A	5A LUCF	CH4	0.000	0.000	20.025	0.0000000	0.00000	100.00000
5C2	5C2 LUCF	CH4	0.000	0.000	20.025	0.0000000	0.00000	100.00000
5E2	5E2 LUCF	CH4	0.000	0.000	20.025	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	N2O	0.000	0.000	33.541	0.0000000	0.00000	100.00000
4F	Field Burning	N2O	77.762	0.000	231.355	0.0000000	0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	50.990	0.0000000	0.00000	100.00000
5A	5A LUCF	N2O	0.000	0.000	20.025	0.0000000	0.00000	100.00000
5C2	5C2 LUCF	N2O	0.000	0.000	20.025	0.0000000	0.00000	100.00000
5E2	5E2 LUCF	N2O	0.000	0.000	20.025	0.0000000	0.00000	100.00000
		Sum -- >	777,619.78	640,214.80		0.1074	100.00	
		check	0.000000	0.000000		0.000000		

Table A 1.1.9: Key Category Analysis based on trend in emissions (from 1990 to latest reported year, including LULCUF)

IPCC category	Source category	Gas	Emissions	Year Y emissions	Combined uncertainty range as a % of source category	Trend Parameter (used to order sources)		Trend / Sum(Trend)*100	Cumulative %
			Gg CO2 equiv. 1990	Gg CO2 equiv. 2007				%	
4D	Agricultural Soils	N2O	30414.922	23280.408	424.001	0.0584729		54.64317	
2B	Nitric Acid Production	N2O	3903.850	1763.497	230.217	0.0145922		13.63649	68.27966
6B	Wastewater Handling	N2O	1033.345	1255.546	401.125	0.0124802		11.66282	79.94248
6A	Solid Waste Disposal	CH4	49816.593	20271.579	48.384	0.0092215		8.61758	88.56006
4B	Manure Management	N2O	2221.015	1745.582	414.001	0.0025816		2.41249	90.97256
1A1&1A2&1A4&1A5	Other Combustion	N2O	4657.530	3522.108	195.000	0.0022050		2.06058	93.03313
1A3b	Auto Fuel	N2O	1180.977	1256.130	170.023	0.0015767		1.47347	94.50661
5B	5B LUCF	CO2	15822.096	15288.354	50.010	0.0010927		1.02112	95.52773
1A(stationary)	Oil	CO2	92552.464	54871.488	15.133	0.0009242		0.86369	96.39142
2B	Adipic Acid Production	N2O	20737.345	989.613	15.008	0.0006894		0.64423	97.03565
1A3	Other Diesel	N2O	231.203	318.328	140.010	0.0004801		0.44863	97.48428
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2650.163	13.033	0.0003999		0.37370	97.85798
2B5	NEU	CO2	1562.918	1860.990	53.852	0.0003192		0.29829	98.15626
1A	All Fuel	CH4	2068.219	1054.264	50.002	0.0003075		0.28733	98.44359
5E	5E LUCF	CO2	6904.219	6212.445	50.010	0.0002579		0.24102	98.68462
1A3b	Auto Fuel	CH4	693.729	145.800	50.078	0.0002029		0.18957	98.87419
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5444.677	17.120	0.0002004		0.18725	99.06144
1A3b	Auto Fuel	CO2	109618.322	121854.045	4.482	0.0001219		0.11388	99.17532
6B	Wastewater Handling	CH4	709.572	813.273	50.010	0.0001099		0.10269	99.27802
6C	Waste Incineration	N2O	47.900	49.018	230.106	0.0000976		0.09125	99.36926
1A	Other (waste)	CO2	206.961	1252.311	21.190	0.0000927		0.08662	99.45588
1A3a	Aviation Fuel	CO2	1244.229	2139.999	20.270	0.0000876		0.08187	99.53775
1A3d	Marine Fuel	N2O	31.174	37.482	170.008	0.0000655		0.06117	99.59892
1A3a	Aviation Fuel	N2O	12.252	21.070	171.172	0.0000615		0.05747	99.65639
6C	Waste Incineration	CH4	134.423	6.488	50.488	0.0000505		0.04722	99.70362
1A	Natural Gas	CO2	108929.762	193143.255	1.513	0.0000453		0.04231	99.74593
6C	Waste Incineration	CO2	1206.508	464.674	21.190	0.0000451		0.04213	99.78806
4A	Enteric Fermentation	CH4	18388.861	15560.693	20.000	0.0000347		0.03240	99.82046
2A7	Fletton Bricks	CO2	179.866	181.440	72.801	0.0000340		0.03182	99.85228
1B	Oil & Natural Gas	CO2	5760.176	5091.682	17.088	0.0000200		0.01872	99.87100
2	Industrial Processes	PFC	1401.595	215.603	10.050	0.0000180		0.01685	99.88785
2	Industrial Processes	HFC	11385.546	9611.187	19.026	0.0000178		0.01665	99.90450
1A	Coal	CO2	248733.724	144792.411	1.077	0.0000132		0.01231	99.91681
4B	Manure Management	CH4	3588.777	2872.483	30.000	0.0000130		0.01214	99.92895
1B2	Oil & Natural Gas	N2O	42.396	39.534	111.158	0.0000111		0.01037	99.93931
1A4	Peat	CO2	476.999	443.334	31.623	0.0000098		0.00918	99.94849
1A	Lubricant	CO2	386.896	261.922	30.067	0.0000096		0.00901	99.95750
2B	Chemical Industry	CH4	169.425	76.209	28.284	0.0000096		0.00898	99.96648
2C1	Iron&Steel Production	CO2	2309.274	2657.967	6.119	0.0000054		0.00508	99.97155
2A4	Soda Ash Use	CO2	167.317	237.912	15.133	0.0000044		0.00410	99.97565
2	Industrial Processes	SF6	1029.948	793.505	20.025	0.0000040		0.00376	99.97941
1B	Solid Fuel Transformation	CO2	856.418	137.957	6.013	0.0000039		0.00365	99.98306
2B	Ammonia Production	CO2	1321.667	1208.935	10.112	0.0000024		0.00225	99.98530
2C	Iron & Steel Production	CH4	16.357	18.178	50.002	0.0000023		0.00211	99.98742
2A3	Limestone & Dolomite use	CO2	1285.328	1442.990	5.099	0.0000019		0.00179	99.98921
1B1	Coke Oven Gas	N2O	2.085	0.993	118.001	0.0000019		0.00179	99.99100
2A7	Fletton Bricks	CH4	23.602	18.501	101.980	0.0000018		0.00165	99.99264
2A2	Lime Production	CO2	1191.520	688.410	5.099	0.0000014		0.00135	99.99399
1A3d	Marine Fuel	CO2	4004.664	4840.036	2.202	0.0000014		0.00134	99.99533
1A3	Other Diesel	CO2	1949.748	2677.505	2.202	0.0000010		0.00093	99.99626
5A	5A LUCF	CH4	4.298	15.279	20.025	0.0000009		0.00084	99.99710
1A3	Other Diesel	CH4	3.221	4.057	50.029	0.0000007		0.00063	99.99773
2C	Iron & Steel	N2O	11.107	9.359	118.001	0.0000006		0.00058	99.99831
1A3a	Aviation Fuel	CH4	3.178	1.604	53.852	0.0000006		0.00052	99.99883
5C2	5C2 LUCF	CH4	3.077	9.073	20.025	0.0000005		0.00047	99.99930
1A3d	Marine Fuel	CH4	1.320	1.587	50.029	0.0000002		0.00022	99.99952
5A	5A LUCF	N2O	6.852	2.782	20.025	0.0000002		0.00020	99.99973
2A1	Cement Production	CO2	7295.263	6117.015	2.417	0.0000001		0.00013	99.99986
5E2	5E2 LUCF	CH4	9.354	6.453	20.025	0.0000001		0.00009	99.99994
5C2	5C2 LUCF	N2O	0.312	0.921	20.025	0.0000001		0.00005	99.99999
5E2	5E2 LUCF	N2O	0.949	0.655	20.025	0.0000000		0.00001	100.00000
1A	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A4	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
5A	5A LUCF	CO2	-12155.074	-14173.378	25.020	0.0000000		0.00000	100.00000
5C	5C LUCF	CO2	-6186.303	-8132.070	70.007	0.0000000		0.00000	100.00000
5G	5G LUCF	CO2	-1657.215	-1233.925	30.017	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CH4	0.000	0.000	33.541	0.0000000		0.00000	100.00000
4F	Field Burning	CH4	266.045	0.000	55.902	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	N2O	0.000	0.000	33.541	0.0000000		0.00000	100.00000
4F	Field Burning	N2O	77.762	0.000	231.355	0.0000000		0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	50.990	0.0000000		0.00000	100.00000
		Sum -- >	776,891.58	638,211.39		0.1070		100.00	
		check	0.000000	0.000000		0.000000			

Table A 1.1.10: Key Category Analysis based on trend in emissions (from 1990 to latest reported year, excluding LULCUF)

IPCC category	Source category	Gas	Emissions	Year Y emissions	Combined uncertainty range as a % of source category	Trend Parameter (used to order sources)		Trend / Sum(Trend)*100	Cumulative %
			Gg CO2 equiv.	Gg CO2 equiv.					
			1990	2007				%	
4D	Agricultural Soils	N2O	30414.922	23280.408	424.001	0.0635908		57.27162	
2B	Nitric Acid Production	N2O	3903.850	1763.497	230.217	0.0146649		13.20764	70.47925
6B	Wastewater Handling	N2O	1033.345	1255.546	401.125	0.0121853		10.97441	81.45366
6A	Solid Waste Disposal	CH4	49816.593	20271.579	48.384	0.0092528		8.33332	89.78699
4B	Manure Management	N2O	2221.015	1745.582	414.001	0.0029524		2.65904	92.44603
1A1&1A2&1A4&1A5	Other Combustion	N2O	4657.530	3522.108	195.000	0.0023677		2.13244	94.57847
1A3b	Auto Fuel	N2O	1180.977	1256.130	170.023	0.0015258		1.37419	95.95266
1A(stationary)	Oil	CO2	92552.464	54871.488	15.133	0.0009372		0.84411	96.79677
2B	Adipic Acid Production	N2O	20737.345	989.613	15.008	0.0006875		0.61919	97.41596
1A3	Other Diesel	N2O	231.203	318.328	140.010	0.0004707		0.42389	97.83986
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2650.163	13.033	0.0003992		0.35954	98.19939
2B5	NEU	CO2	1562.918	1860.990	53.852	0.0003114		0.28042	98.47981
1A	All Fuel	CH4	2068.219	1054.264	50.002	0.0003098		0.27905	98.75887
1A3b	Auto Fuel	CH4	693.729	145.800	50.078	0.0002027		0.18255	98.94141
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5444.677	17.120	0.0002019		0.18183	99.12324
1A3b	Auto Fuel	CO2	109618.322	121854.045	4.482	0.0001184		0.10662	99.22986
6B	Wastewater Handling	CH4	709.572	813.273	50.010	0.0001070		0.09634	99.32620
6C	Waste Incineration	N2O	47.900	49.018	230.106	0.0000941		0.08470	99.41090
1A	Other (waste)	CO2	206.961	1252.311	21.190	0.0000917		0.08257	99.49348
1A3a	Aviation Fuel	CO2	1244.229	2139.999	20.270	0.0000862		0.07765	99.57113
1A3d	Marine Fuel	N2O	31.174	37.482	170.008	0.0000639		0.05753	99.62866
1A3a	Aviation Fuel	N2O	12.252	21.070	171.172	0.0000605		0.05451	99.68317
6C	Waste Incineration	CH4	134.423	6.488	50.488	0.0000504		0.04539	99.72856
6C	Waste Incineration	CO2	1206.508	464.674	21.190	0.0000452		0.04072	99.76928
1A	Natural Gas	CO2	108929.762	193143.255	1.513	0.0000446		0.04014	99.80942
2A7	Fletton Bricks	CO2	179.866	181.440	72.801	0.0000327		0.02947	99.83889
4A	Enteric Fermentation	CH4	18388.861	15560.693	20.000	0.0000267		0.02402	99.86292
1B	Oil & Natural Gas	CO2	5760.176	5091.682	17.088	0.0000181		0.01629	99.87921
2	Industrial Processes	PFC	1401.595	215.603	10.050	0.0000180		0.01621	99.89542
4B	Manure Management	CH4	3588.777	2872.483	30.000	0.0000162		0.01461	99.91003
2	Industrial Processes	HFC	11385.546	9611.187	19.026	0.0000134		0.01203	99.92206
1A	Coal	CO2	248733.724	144792.411	1.077	0.0000133		0.01202	99.93408
1B2	Oil & Natural Gas	N2O	42.396	39.534	111.158	0.0000104		0.00940	99.94348
1A	Lubricant	CO2	386.896	261.922	30.067	0.0000099		0.00893	99.95240
2B	Chemical Industry	CH4	169.425	76.209	28.284	0.0000097		0.00870	99.96110
1A4	Peat	CO2	476.999	443.334	31.623	0.0000092		0.00831	99.96941
2C1	Iron&Steel Production	CO2	2309.274	2657.967	6.119	0.0000053		0.00476	99.97418
2	Industrial Processes	SF6	1029.948	793.505	20.025	0.0000044		0.00397	99.97815
2A4	Soda Ash Use	CO2	167.317	237.912	15.133	0.0000043		0.00388	99.98203
1B	Solid Fuel Transformation	CO2	856.418	137.957	6.013	0.0000039		0.00351	99.98554
2B	Ammonia Production	CO2	1321.667	1208.935	10.112	0.0000022		0.00202	99.98755
2C	Iron & Steel Production	CH4	16.357	18.178	50.002	0.0000022		0.00198	99.98953
2A7	Fletton Bricks	CH4	23.602	18.501	101.980	0.0000020		0.00180	99.99133
1B1	Coke Oven Gas	N2O	2.085	0.993	118.001	0.0000019		0.00173	99.99306
2A3	Limestone & Dolomite use	CO2	1285.328	1442.990	5.099	0.0000019		0.00168	99.99474
2A2	Lime Production	CO2	1191.520	688.410	5.099	0.0000015		0.00131	99.99606
1A3d	Marine Fuel	CO2	4004.664	4840.036	2.202	0.0000014		0.00126	99.99732
1A3	Other Diesel	CO2	1949.748	2677.505	2.202	0.0000010		0.00088	99.99820
1A3	Other Diesel	CH4	3.221	4.057	50.029	0.0000007		0.00059	99.99879
1A3a	Aviation Fuel	CH4	3.178	1.604	53.852	0.0000006		0.00051	99.99929
2C	Iron & Steel	N2O	11.107	9.359	118.001	0.0000005		0.00041	99.99971
1A3d	Marine Fuel	CH4	1.320	1.587	50.029	0.0000002		0.00021	99.99992
2A1	Cement Production	CO2	7295.263	6117.015	2.417	0.0000001		0.00008	100.00000
1A	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
1A4	Combined Fuel	CO2	0.000	0.000	21.213	0.0000000		0.00000	100.00000
5A	5A LUCF	CO2	0.000	0.000	25.020	0.0000000		0.00000	100.00000
5B	5B LUCF	CO2	0.000	0.000	50.010	0.0000000		0.00000	100.00000
5C	5C LUCF	CO2	0.000	0.000	70.007	0.0000000		0.00000	100.00000
5E	5E LUCF	CO2	0.000	0.000	50.010	0.0000000		0.00000	100.00000
5G	5G LUCF	CO2	0.000	0.000	30.017	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CH4	0.000	0.000	33.541	0.0000000		0.00000	100.00000
4F	Field Burning	CH4	266.045	0.000	55.902	0.0000000		0.00000	100.00000
5A	5A LUCF	CH4	0.000	0.000	20.025	0.0000000		0.00000	100.00000
5C2	5C2 LUCF	CH4	0.000	0.000	20.025	0.0000000		0.00000	100.00000
5E2	5E2 LUCF	CH4	0.000	0.000	20.025	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	N2O	0.000	0.000	33.541	0.0000000		0.00000	100.00000
4F	Field Burning	N2O	77.762	0.000	231.355	0.0000000		0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	50.990	0.0000000		0.00000	100.00000
5A	5A LUCF	N2O	0.000	0.000	20.025	0.0000000		0.00000	100.00000
5C2	5C2 LUCF	N2O	0.000	0.000	20.025	0.0000000		0.00000	100.00000
5E2	5E2 LUCF	N2O	0.000	0.000	20.025	0.0000000		0.00000	100.00000
		Sum -- >	774,139.02	640,214.80		0.1110		100.00	
		check	0.000000	0.000000		0.000000			

Table A 1.1.11: Key Source Category Analysis summary for the base year (including LULUCF)

Quantitative Method Used: Approach 1 (Error propagation approach)					
A		B	C	D	E
			Category	If Column C is	
	IPCC Source Categories	Gas	Key Source	Yes, Criteria for	Comments
			Category	Identification	
1A	Coal	CO2		Level	
1A(stationary)	Oil	CO2		Level	
1A	Natural Gas	CO2			
1A	Other (waste)	CO2			
1A	Lubricant	CO2			
1A3a	Aviation Fuel	CO2			
1A3b	Auto Fuel	CO2		Level	
1A3d	Marine Fuel	CO2			
1A3	Other Diesel	CO2			
1A4	Peat	CO2			
1B	Solid Fuel Transformation	CO2			
1B	Oil & Natural Gas	CO2			
2A1	Cement Production	CO2			
2A2	Lime Production	CO2			
2A3	Limestone & Dolomite use	CO2			
2A4	Soda Ash Use	CO2			
2A7	Fletton Bricks	CO2			
2B	Ammonia Production	CO2			
2C1	Iron&Steel Production	CO2			
5A	5A LUCF	CO2		Level	
5B	5B LUCF	CO2		Level	
5C	5C LUCF	CO2		Level	
5E	5E LUCF	CO2		Level	
5G	5G LUCF	CO2			
6C	Waste Incineration	CO2			
7C	Other	CO2			
1A	All Fuel	CH4			
1A3a	Aviation Fuel	CH4			
1A3b	Auto Fuel	CH4			
1A3d	Marine Fuel	CH4			
1A3	Other Diesel	CH4			
1B1	Coal Mining	CH4		Level	
1B2	Oil & Natural Gas	CH4			
2A7	Fletton Bricks	CH4			
2B	Chemical Industry	CH4			
2C	Iron & Steel Production	CH4			
4A	Enteric Fermentation	CH4		Level	
4B	Manure Management	CH4			
4F	Field Burning	CH4			
5C2	5C2 LUCF	CH4			
5E2	5E2 LUCF	CH4			
6A	Solid Waste Disposal	CH4		Level	high uncertainty
6B	Wastewater Handling	CH4			
6C	Waste Incineration	CH4			
1A1&1A2&1A4&1A5	Other Combustion	N2O		Level	
1A3a	Aviation Fuel	N2O			
1A3b	Auto Fuel	N2O		Level	
1A3d	Marine Fuel	N2O			
1A3	Other Diesel	N2O			
1B1	Coke Oven Gas	N2O			
1B2	Oil & Natural Gas	N2O			
2B	Adipic Acid Production	N2O		Level	
2B	Nitric Acid Production	N2O		Level	
2C	Iron & Steel	N2O			
4B	Manure Management	N2O		Level	high uncertainty
4D	Agricultural Soils	N2O		Level	high uncertainty
4F	Field Burning	N2O			
5C2	5C2 LUCF	N2O			
5E2	5E2 LUCF	N2O			
6B	Wastewater Handling	N2O		Level	
6C	Waste Incineration	N2O			
2	Industrial Processes	HFC		Level	
2	Industrial Processes	PFC			
2	Industrial Processes	SF6			
			Count --->	18	
			should be "ok" --->	ok	

Table A 1.1.12: Key Source Category Analysis summary for the base year (excluding LULUCF)

Quantitative Method Used: Approach 1 (Error propagation approach)					
A		**B**	**C**	**D**	**E**
			Category	**If Column C is**	
	IPCC Source Categories	**Gas**	**Key Source**	**Yes, Criteria for**	**Comments**
			Category	**Identification**	
1A	Coal	CO2		Level	
1A(stationary)	Oil	CO2		Level	
1A	Natural Gas	CO2			
1A	Other (waste)	CO2			
1A	Lubricant	CO2			
1A3a	Aviation Fuel	CO2			
1A3b	Auto Fuel	CO2		Level	
1A3d	Marine Fuel	CO2			
1A3	Other Diesel	CO2			
1A4	Peat	CO2			
1B	Solid Fuel Transformation	CO2			
1B	Oil & Natural Gas	CO2			
2A1	Cement Production	CO2			
2A2	Lime Production	CO2			
2A3	Limestone & Dolomite use	CO2			
2A4	Soda Ash Use	CO2			
2A7	Fletton Bricks	CO2			
2B	Ammonia Production	CO2			
2C1	Iron&Steel Production	CO2			
5A	5A LUCF	CO2			
5B	5B LUCF	CO2			
5C	5C LUCF	CO2			
5E	5E LUCF	CO2			
5G	5G LUCF	CO2			
6C	Waste Incineration	CO2			
7C	Other	CO2			
1A	All Fuel	CH4			
1A3a	Aviation Fuel	CH4			
1A3b	Auto Fuel	CH4			
1A3d	Marine Fuel	CH4			
1A3	Other Diesel	CH4			
1B1	Coal Mining	CH4		Level	
1B2	Oil & Natural Gas	CH4			
2A7	Fletton Bricks	CH4			
2B	Chemical Industry	CH4			
2C	Iron & Steel Production	CH4			
4A	Enteric Fermentation	CH4		Level	
4B	Manure Management	CH4			
4F	Field Burning	CH4			
5C2	5C2 LUCF	CH4			
5E2	5E2 LUCF	CH4			
6A	Solid Waste Disposal	CH4		Level	high uncertainty
6B	Wastewater Handling	CH4			
6C	Waste Incineration	CH4			
1A1&1A2&1A4&1A5	Other Combustion	N2O		Level	
1A3a	Aviation Fuel	N2O			
1A3b	Auto Fuel	N2O		Level	
1A3d	Marine Fuel	N2O			
1A3	Other Diesel	N2O			
1B1	Coke Oven Gas	N2O			
1B2	Oil & Natural Gas	N2O			
2B	Adipic Acid Production	N2O		Level	
2B	Nitric Acid Production	N2O		Level	
2C	Iron & Steel	N2O			
4B	Manure Management	N2O		Level	high uncertainty
4D	Agricultural Soils	N2O		Level	high uncertainty
4F	Field Burning	N2O			
5C2	5C2 LUCF	N2O			
5E2	5E2 LUCF	N2O			
6B	Wastewater Handling	N2O		Level	
6C	Waste Incineration	N2O			
2	Industrial Processes	HFC		Level	
2	Industrial Processes	PFC			
2	Industrial Processes	SF6			
			Count --->	14	
			should be "ok" --->	ok	

Table A 1.1.13: Key Source Category Analysis summary for the latest reported year (including LULUCF)

Quantitative Method Used: Approach 1 (Error propagation approach)					
A		B	C	D	E
			Category	If Column C is	
IPCC Source Categories		Gas	Key Source	Yes, Criteria for	Comments
			Category	Identification	
1A	Coal	CO2		Level	
1A(stationary)	Oil	CO2		Level	
1A	Natural Gas	CO2		Level	
1A	Other (waste)	CO2			
1A	Lubricant	CO2			
1A3a	Aviation Fuel	CO2			
1A3b	Auto Fuel	CO2		Level	
1A3d	Marine Fuel	CO2			
1A3	Other Diesel	CO2			
1A4	Peat	CO2			
1B	Solid Fuel Transformation	CO2			
1B	Oil & Natural Gas	CO2			
2A1	Cement Production	CO2			
2A2	Lime Production	CO2			
2A3	Limestone & Dolomite use	CO2			
2A4	Soda Ash Use	CO2			
2A7	Fletton Bricks	CO2			
2B	Ammonia Production	CO2			
2C1	Iron&Steel Production	CO2			
5A	5A LUCF	CO2		Level	
5B	5B LUCF	CO2		Level, Trend	
5C	5C LUCF	CO2		Level	
5E	5E LUCF	CO2		Level	
5G	5G LUCF	CO2			
6C	Waste Incineration	CO2			
7C	Other	CO2			
1A	All Fuel	CH4			
1A3a	Aviation Fuel	CH4			
1A3b	Auto Fuel	CH4			
1A3d	Marine Fuel	CH4			
1A3	Other Diesel	CH4			
1B1	Coal Mining	CH4			
1B2	Oil & Natural Gas	CH4			
2A7	Fletton Bricks	CH4			
2B	Chemical Industry	CH4			
2C	Iron & Steel Production	CH4			
4A	Enteric Fermentation	CH4		Level	
4B	Manure Management	CH4			
4F	Field Burning	CH4			
5C2	5C2 LUCF	CH4			
5E2	5E2 LUCF	CH4			
6A	Solid Waste Disposal	CH4		Level, Trend	high uncertainty
6B	Wastewater Handling	CH4			
6C	Waste Incineration	CH4			
1A1&1A2&1A4&1A5	Other Combustion	N2O		Level, Trend	
1A3a	Aviation Fuel	N2O			
1A3b	Auto Fuel	N2O		Level, Trend	
1A3d	Marine Fuel	N2O			
1A3	Other Diesel	N2O			
1B1	Coke Oven Gas	N2O			
1B2	Oil & Natural Gas	N2O			
2B	Adipic Acid Production	N2O			
2B	Nitric Acid Production	N2O		Level, Trend	
2C	Iron & Steel	N2O			
4B	Manure Management	N2O		Level, Trend	high uncertainty
4D	Agricultural Soils	N2O		Level, Trend	high uncertainty
4F	Field Burning	N2O			
5C2	5C2 LUCF	N2O			
5E2	5E2 LUCF	N2O			
6B	Wastewater Handling	N2O		Level, Trend	
6C	Waste Incineration	N2O			
2	Industrial Processes	HFC		Level	
2	Industrial Processes	PFC			
2	Industrial Processes	SF6			

Table A 1.1.14: Key Source Category Analysis summary for the latest reported year (excluding LULUCF)

Quantitative Method Used: Approach 1 (Error propagation approach)					
A		B	C	D	E
			Category	If Column C is	
IPCC Source Categories		Gas	Key Source	Yes, Criteria for	Comments
			Category	Identification	
1A	Coal	CO2		Level	
1A(stationary)	Oil	CO2		Level	
1A	Natural Gas	CO2		Level	
1A	Other (waste)	CO2			
1A	Lubricant	CO2			
1A3a	Aviation Fuel	CO2			
1A3b	Auto Fuel	CO2		Level	
1A3d	Marine Fuel	CO2			
1A3	Other Diesel	CO2			
1A4	Peat	CO2			
1B	Solid Fuel Transformation	CO2			
1B	Oil & Natural Gas	CO2			
2A1	Cement Production	CO2			
2A2	Lime Production	CO2			
2A3	Limestone & Dolomite use	CO2			
2A4	Soda Ash Use	CO2			
2A7	Fletton Bricks	CO2			
2B	Ammonia Production	CO2			
2C1	Iron&Steel Production	CO2			
5A	5A LUCF	CO2			
5B	5B LUCF	CO2			
5C	5C LUCF	CO2			
5E	5E LUCF	CO2			
5G	5G LUCF	CO2			
6C	Waste Incineration	CO2			
7C	Other	CO2			
1A	All Fuel	CH4			
1A3a	Aviation Fuel	CH4			
1A3b	Auto Fuel	CH4			
1A3d	Marine Fuel	CH4			
1A3	Other Diesel	CH4			
1B1	Coal Mining	CH4			
1B2	Oil & Natural Gas	CH4			
2A7	Fletton Bricks	CH4			
2B	Chemical Industry	CH4			
2C	Iron & Steel Production	CH4			
4A	Enteric Fermentation	CH4		Level	
4B	Manure Management	CH4			
4F	Field Burning	CH4			
5C2	5C2 LUCF	CH4			
5E2	5E2 LUCF	CH4			
6A	Solid Waste Disposal	CH4		Level, Trend	high uncertainty
6B	Wastewater Handling	CH4			
6C	Waste Incineration	CH4			
1A1&1A2&1A4&1A5	Other Combustion	N2O		Level, Trend	
1A3a	Aviation Fuel	N2O			
1A3b	Auto Fuel	N2O		Level, Trend	
1A3d	Marine Fuel	N2O			
1A3	Other Diesel	N2O			
1B1	Coke Oven Gas	N2O			
1B2	Oil & Natural Gas	N2O			
2B	Adipic Acid Production	N2O			
2B	Nitric Acid Production	N2O		Level, Trend	
2C	Iron & Steel	N2O			
4B	Manure Management	N2O		Level, Trend	high uncertainty
4D	Agricultural Soils	N2O		Level, Trend	high uncertainty
4F	Field Burning	N2O			
5C2	5C2 LUCF	N2O			
5E2	5E2 LUCF	N2O			
6B	Wastewater Handling	N2O		Level, Trend	
6C	Waste Incineration	N2O			
2	Industrial Processes	HFC		Level	
2	Industrial Processes	PFC			
2	Industrial Processes	SF6			

A2 ANNEX 2: Detailed Discussion of Methodology and Data for Estimating CO_2 Emissions from Fossil Fuel Combustion

Methodology for estimating CO_2 emissions from fossil fuel combustion is discussed together with the methodologies for other emissions in Annex 3. This is because the underlying methodology for such estimates applies to a range of pollutants and not just CO_2.

A3 ANNEX 3: Other Detailed Methodological Descriptions

This Annex contains background information about methods used to estimate emissions in the UK GHG inventory. This information has not been incorporated in the main body of the report because of the level of detail, and because the methods used to estimate emissions cut across sectors.

This Annex provides:

- Background information on the fuels used in the UK GHG inventory.
- Mapping between IPCC and NAEI source categories.

Detailed description of methods used to estimate GHG emissions, and emission factors used in those methods – presented in **Section A3.3** onwards.

A3.1 FUELS DATA

The fuels data are taken from DUKES - the Digest of UK Energy Statistics (BERR, 2008), so the fuel definitions and the source categories used in the NAEI reflect those in DUKES. Categories used in the inventory for non-combustion sources generally reflect the availability of data on emissions from these sources.

IPCC Guidelines (IPCC, 1997a) lists fuels that should be considered when reporting emissions. **Table A3.1.1** lists the fuels that are used in the GHGI and indicates how they relate to the fuels reported in the NAEI. In most cases the mapping is obvious but there are a few cases where some explanation is required.

(i) ***Aviation Fuels***
UK energy statistics report consumption of aviation turbine fuel and this is mapped onto jet kerosene in the GHGI. Aviation turbine fuel includes fuel that is described as jet gasoline using IPCC terminology.

(ii) ***Coal***
The IPCC Guidelines (IPCC, 1997a) classify coal as anthracite, coking coal, other bituminous coal and sub-bituminous coal. In mapping the UK fuel statistics to these categories it is assumed that only the coal used in coke ovens is coking coal; and the rest is reported as either coal or anthracite. Most coal used in the UK is bituminous coal; anthracite is reported separately in UK energy statistics.

(iii) ***Coke Oven Coke***
Gas works coke is no longer manufactured in the UK so all coke and coke breeze consumption is reported as coke oven coke.

(iv) ***Colliery Methane***
The IPCC Guidelines do not refer to colliery methane but significant use is made of it as a fuel in the UK so emissions are included in the GHGI.

(v) ***Orimulsion***
Orimulsion® is an emulsion of bitumen and water and was burnt in some power stations in the UK, however its use has now been discontinued

(vi) ***Slurry***
This is a slurry of coal and water used in some power stations.

(vii) ***Sour Gas***
Unrefined natural gas is used as a fuel on offshore platforms and in some power stations. It has a higher carbon and sulphur content than mains gas.

(viii) ***Wastes used as fuel***
The following wastes are used for power generation: municipal solid waste, scrap tyres, poultry litter, meat and bone meal, landfill gas, sewage gas, and waste oils. Some waste oils and scrap tyres are burnt in cement kilns. Further waste oils are burnt by other industrial sectors, and it is assumed that some lubricants consumed in the UK are destroyed (burnt) in engines[1].

[1] 13% in 2007 for lubricants burnt in all types of engines - this is made up of 8% burnt in road vehicle engines, 4% burnt in marine engines and the remaining 1% split between agricultural, industrial and aircraft engines.

Table A 3.1.1: Mapping of fuels used in the GHGI and the NAEI

	GHGI	NAEI
Category	**Subcategory**	**Subcategory**
Liquid	Motor Gasoline	Petrol
	Aviation Gasoline	Aviation Spirit
	Jet Kerosene	Aviation Turbine Fuel[1] (ATF)
	Other Kerosene	Burning Oil
	Gas/Diesel Oil	Gas Oil/ DERV
	Residual Fuel Oil	Fuel Oil
	Orimulsion	Orimulsion
	Liquefied Petroleum Gas	Liquefied Petroleum Gas (LPG)
	Naphtha	Naphtha
	Petroleum Coke	Petroleum Coke
	Refinery Gas	Other Petroleum Gas (OPG)
	Other Oil: Other	Refinery Miscellaneous
	Other Oil: Other	Waste Oils
	Lubricants	Lubricants
Solid	Anthracite	Anthracite
	Coking Coal	Coal[2]
	Coal	Coal
	Coal	Slurry[3]
	Coke Oven Coke	Coke
	Patent Fuel	Solid Smokeless Fuel (SSF)
	Coke Oven Gas	Coke Oven Gas
	Blast Furnace Gas	Blast Furnace Gas
Gas	Natural Gas	Natural Gas
	Natural Gas	Sour Gas[4]
	Colliery Methane[5]	Colliery Methane
Other Fuels	Municipal Solid Waste	Municipal Solid Waste
	Industrial Waste: Scrap Tyres	Scrap Tyres
Biomass	Wood/Wood Waste	Wood
	Other Solid Biomass: Straw	Straw
	Other Solid Biomass: Poultry Litter, Meat & Bone Meal	Poultry Litter, Meat & bone meal
	Landfill Gas	Landfill Gas
	Sludge Gas	Sewage Gas

1 Includes fuel that is correctly termed jet gasoline.
2 Used in coke ovens.
3 Coal-water slurry used in some power stations
4 Unrefined natural gas used on offshore platforms and some power stations
5 Not referred to in IPCC Guidelines (IPCC, 1997a) but included in GHGI.

A3.2 NAEI SOURCE CATEGORIES AND IPCC EQUIVALENTS

Tables A3.2.1 to **A3.2.7** relate the IPCC source categories to the equivalent NAEI base categories. In most cases it is possible to obtain a precise mapping of an NAEI source category to a specific IPCC source category. In some cases the relevant NAEI source category does not correspond exactly to the IPCC source category and in a few cases an equivalent NAEI source category is not estimated or is defined quite differently. As a result, total annual emissions given in the NAEI and GHGI differ slightly. The source categories responsible for the differences between the GHGI and the NAEI are Land Use, Land Use Change and Forestry sources.

Tables A3.2.1 to **A3.2.7** refer to NAEI base categories. Normally the NAEI is not reported in such a detailed form but in the summary UNECE/CORINAIR SNAP97, eleven-sector format or the new NFR (Nomenclature For Reporting) system used for submission to CORINAIR.

Table A 3.2.1: Mapping of IPCC Source Categories to NAEI Source Categories – fuel combustion

IPCC Source Category	NAEI Source Category
1A1a Public Electricity and Heat Production	Power Stations
1A1b Petroleum Refining	Refineries (Combustion)
1A1ci Manufacture of Solid Fuels	SSF Production Coke Production
1A1cii Other Energy Industries	Collieries Gas Production Gas Separation Plant (Combustion) Offshore Own Gas Use Production of Nuclear Fuel Town Gas Production
1A2a Iron and Steel	Iron and Steel (Combustion) Iron and Steel (Sinter Plant) Iron and Steel (Blast Furnaces)
1A2b Non-Ferrous Metals 1A2c Chemicals 1A2d Pulp, Paper and Print 1A2e Food Processing, Beverages, Tobacco	Included under Other Industry (Combustion)
1A2fi Other	Other Industry (Combustion) Cement (Fuel Combustion) Cement (Non-decarbonising) Lime Production (Combustion) Autogenerators Ammonia (Combustion)
1A2fii Other (Off-road Vehicles and Other Machinery)	Other Industry Off-road
1A3a Civil Aviation	No comparable category
1A3b Road Transportation	Road Transport
1A3c Railways	Railways (Freight) Railways (Intercity) Railways (Regional)
1A3di International Marine	International Marine
1A3dii Internal Navigation	Coastal Shipping
1A3e Other Transport	Aircraft Support
1A4a Commercial/Institutional	Miscellaneous Public Services Railways (Stationary Sources)
1A4bi Residential	Domestic
1A4bii Residential Off-road	Domestic, House & Garden
1A4ci Agriculture/Forestry/Fishing (Stationary)	Agriculture
1A4cii Agriculture/Forestry/Fishing (Off-road Vehicles and Other Machinery)	Agriculture Power Units
1A4ciii Agriculture/Forestry/Fishing (Fishing)	Fishing
1A5a Other: Stationary	No comparable category-included in 1A4a
1A5b Other: mobile	Aircraft Military Shipping Naval

Table A 3.2.2: Mapping of IPCC Source Categories to NAEI Source Categories (Fugitive emissions from fuels)

IPCC Source Category	NAEI Source Category
1B1a Coal Mining i Mining activities	Deep-Mined Coal
1B1a Coal Mining ii Post mining activities	Coal Storage & Transport
1B1a Coal Mining ii Surface Mines	Open-Cast Coal
1B1b Solid Fuel Transformation	Coke Production (Fugitive) SSF Production (Fugitive) Flaring (Coke Oven Gas)
1B1c Other	Not Estimated
1B2a Oil i Exploration	Offshore Oil and Gas (Well Testing)
1B2a Oil ii Production	Offshore Oil and Gas
1B2a Oil iii Transport	Offshore Loading Onshore Loading
1B2a Oil iv Refining/Storage	Refineries (drainage) Refineries (tankage) Refineries (Process) Oil Terminal Storage Petroleum Processes
1B2a Oil vi Other	Not Estimated
1B2a Oil v Distribution of oil products	Petrol Stations (Petrol Delivery) Petrol Stations (Vehicle Refuelling) Petrol Stations (Storage Tanks) Petrol Stations (Spillages) Petrol Terminals (Storage) Petrol Terminals (Tanker Loading) Refineries (Road/Rail Loading)
1B2b i Natural Gas Production	Gasification Processes
1B2b ii Natural Gas. Transmission/Distribution	Gas Leakage
1B2ciii Venting: Combined	Offshore Oil and Gas (Venting)
1B2ciii Flaring: Combined	Offshore Flaring Refineries (Flares)

Table A 3.2.3: Mapping of IPCC Source Categories to NAEI Source Categories (Industrial Processes)

IPCC Source Category	NAEI Source Category
2A1 Cement Production	Cement (Decarbonising)
2A2 Lime Production	Lime Production (Decarbonising)
2A3 Limestone and Dolomite Use	Glass Production: Limestone and Dolomite Iron and Steel (Blast Furnace): Limestone and Dolomite Power Stations (FGD)
2A4 Soda Ash Production and Use	Glass Production: Soda Ash
2A5 Asphalt Roofing	Not Estimated
2A6 Road Paving with Asphalt	Road Construction
2A7 Other	Brick Manufacture (Fletton) Glass (continuous filament glass fibre) Glass (glass wool)
2B1 Ammonia Production	Ammonia Feedstock

IPCC Source Category	NAEI Source Category
2B2 Nitric Acid Production	Nitric Acid Production
2B3 Adipic Acid Production	Adipic Acid Production
2B4 Carbide Production	
2B5 Other	Sulphuric Acid Production Chemical Industry Chemical Industry (Carbon Black) Chemical Industry (Ethylene) Chemical Industry (Methanol) Chemical Industry (Nitric Acid Use) Chemical Industry (Pigment Manufacture) Chemical Industry (Reforming) Chemical Industry (Sulphuric Acid Use) Coal, tar and bitumen processes Solvent and Oil recovery Ship purging
2C1 Iron and Steel	Iron and Steel (other) Iron and Steel (Basic Oxygen Furnace) Iron and Steel (Electric Arc Furnace) Iron and Steel Flaring (Blast Furnace Gas) Rolling Mills (Hot & Cold Rolling)
2C2 Ferroalloys Productions	No Comparable Source Category
2C3 Aluminium Production	Non-Ferrous Metals (Aluminium Production)
2C4 SF6 Used in Aluminium and Magnesium Foundries	SF_6 Cover Gas
2C5 Other	Non-Ferrous Metals (other non-ferrous metals) Non-Ferrous Metals (primary lead/zinc) Non-Ferrous Metals (secondary Copper) Non-Ferrous Metals (secondary lead)
2D1 Pulp and Paper	Wood Products Manufacture
2D2 Food and Drink	Brewing (barley malting, fermentation, wort boiling) Bread Baking Cider Manufacture Other Food (animal feed; cakes, biscuits, cereals; coffee, malting, margarine and other solid fats; meat, fish and poultry; sugar) Spirit Manufacture (barley malting, casking distillation, fermentation, maturation, spent grain drying) Wine Manufacture
2E1 Halocarbon & SF6 By-Product Emissions 2E2 Halocarbon & SF6 Fugitive Emissions	Halocarbons Production (By-Product and Fugitive)
2E3 Halocarbon & SF6 Other	Not Estimated
2F1 Refrigeration & Air Conditioning Equipment	Refrigeration Supermarket Refrigeration Mobile Air Conditioning
2F2 Foam Blowing	Foams
2F3 Fire Extinguishers	Fire Fighting

IPCC Source Category	NAEI Source Category
2F2 Aerosols	Metered Dose Inhalers Aerosols (Halocarbons)
2F5 Solvents	Not Occurring
2F8a One Component Foams	
2F8 Semiconductors, Electrical and Production of Trainers	Electronics Training Shoes Electrical Insulation

Table A 3.2.4: Mapping of IPCC Source Categories to NAEI Source Categories

IPCC Source Category	NAEI Source Category
3A Paint Application	Decorative paint (retail decorative) Decorative paint (trade decorative) Industrial Coatings (automotive) Industrial Coatings (agriculture & construction) Industrial Coatings (aircraft) Industrial Coatings (Drum) Industrial Coatings (coil coating) Industrial Coatings (commercial vehicles) Industrial Coatings (high performance) Industrial Coatings (marine) Industrial Coatings (metal and plastic) Industrial Coatings (metal packaging) Industrial Coatings (vehicle refinishing) Industrial Coatings (wood)
3B Degreasing & Dry Cleaning	Dry Cleaning Surface Cleaning Leather Degreasing
3C Chemical Products, Manufacture & Processing	Coating Manufacture (paint) Coating Manufacture (ink) Coating Manufacture (glue) Film Coating Leather coating Other Rubber Products Tyre Manufacture Textile Coating
3D Other	Aerosols (Car care, Cosmetics & toiletries, household products) Agrochemicals Use Industrial Adhesives Paper Coating Printing Other Solvent Use Non Aerosol Products (household, automotive, cosmetics & toiletries, domestic adhesives, paint thinner) Seed Oil Extraction Wood Impregnation

Table A 3.2.5: Mapping of IPCC Source Categories to NAEI Source Categories (Agriculture)

IPCC Source Category	NAEI Source Category
4A1 Enteric Fermentation: Cattle	Dairy Cattle Enteric Other Cattle Enteric
4A2 Enteric Fermentation: Buffalo	Not Occurring
4A3 Enteric Fermentation: Sheep	Sheep Enteric
4A4 Enteric Fermentation: Goats	Goats Enteric
4A5 Enteric Fermentation: Camels & Llamas	Not Occurring
4A6 Enteric Fermentation: Horses	Horses Enteric
4A7 Enteric Fermentation: Mules & Asses	Not Occurring
4A8 Enteric Fermentation: Swine	Pigs Enteric
4A9 Enteric Fermentation: Poultry	Not Occurring
4A10 Enteric Fermentation: Other: Deer	Deer Enteric
4B1 Manure Management: Cattle	Dairy Cattle Wastes Other Cattle Wastes
4B2 Manure Management: Buffalo	Not Occurring
4B3 Manure Management: Sheep	Sheep Wastes
4B4 Manure Management: Goats	Goats Wastes
4B5 Manure Management: Camels & Llamas	Not Occurring
4B6 Manure Management: Horses	Horses Wastes
4B7 Manure Management: Mules & Asses	Not Occurring
4B8 Manure Management: Swine	Pigs Wastes
4B9 Manure Management: Poultry	Broilers Wastes Laying Hens Wastes Other Poultry
4B9a Manure Management: Other: Deer	Deer Wastes
4B10 Anaerobic Lagoons	Not Occurring
4B11 Liquid Systems	Manure Liquid Systems
4B12 Solid Storage and Dry Lot	Manure Solid Storage and Dry Lot
4B13 Other	Manure Other
4C Rice Cultivation	Not Occurring
4D 1 Agricultural Soils: Direct Soil Emissions 4D 2 Agricultural Soils: Animal Emissions 4D 4 Agricultural Soils: Indirect Emissions	Agricultural Soils Fertiliser Agricultural Soils Crops
4E Prescribed Burning of Savannahs	Not Occurring
4F1 Field Burning of Agricultural Residues: Cereals	Barley Residue Wheat Residue Oats Residue
4F5 Field Burning of Agricultural Residues: Other: Linseed	Linseed Residue
4G Other	Not Estimated

Emissions in this NIR are reported used the reporting nomenclature specified in the LULUCF Good Practice Guidance and agreed at the 9th Conference of Parties for reporting to the UNFCCC. These reporting categories are very different to those previously used, and to the NAEI source categories, which are based on NFR codes. **Table A 3.2.6** summarises the categories used, and which NAEI categories they correspond to.

Table A 3.2.6: Mapping of IPCC Source Categories to NAEI Source Categories (Land Use, Land Use Change and Forestry)

IPCC Source Category	NAEI Source Category
5A Forest Land (Biomass Burning - wildfires)	Not Reported
5A Forest Land (Drainage of soils)	Not Reported
5A1 Forest Land Remaining Forest Land	Not Reported
5A2 Forest Land (N fertilisation)	Not Reported
5A2 Land Converted to Forest Land	Not Reported
5B Cropland (Biomass Burning - controlled)	Not Reported
5B Liming	4D1 Liming of Agricultural Soils
5B1 Cropland Remaining Cropland	Not Reported
5B2 Land Converted to Cropland	Not Reported
5C Grassland (Biomass burning - controlled)	Not Reported
5C Liming	4D1 Liming of Agricultural Soils
5C1 Grassland Remaining Grassland	Not Reported
5C2 Land converted to grassland	Not Reported
5D Wetlands (Biomass burning - controlled)	Not Reported
5D1 Wetlands remaining wetlands	Not Reported
5D2 Land converted to wetlands	Not Reported
5E Settlements (Biomass burning - controlled)	Not Reported
5E1 Settlements remaining settlements	Not Reported
5E2 Land converted to settlements	Not Reported
5F Other land (Biomass burning - controlled)	Not Reported
5F1 Other land remaining other land	Not Reported
5F2 Land converted to other land	Not Reported
5G Other (Harvested wood)	Not Reported
No relevant category	5B Deforestation

Table A 3.2.7: Mapping of IPCC Source Categories to NAEI Source Categories (Waste)

IPCC Source Category	NAEI Source Category
6A1 Managed Waste Disposal on Land	Landfill
6A2 Unmanaged Waste Disposal on Land	Not Occurring
6A3 Other	Not Occurring
6B1 Industrial Wastewater 6B2 Domestic and Commercial Wastewater 6B3 Other	Sewage Sludge Disposal
6C Waste Incineration	Incineration: MSW Incineration: Sewage Sludge Incineration: Clinical Incineration: Cremation
6D Other Waste	Not estimated

A3.3 ENERGY (CRF SECTOR 1)

The previous two sections defined the fuels and source categories used in the NAEI and the GHGI. This section describes the methodology used to estimate the emissions arising from fuel combustion for energy. These sources correspond to IPCC Table 1A.

There is little continuous monitoring of emissions performed in the UK; hence information is rarely available on actual emissions over a specific period of time from an individual emission source. In any case, emissions of CO_2 from fuel are probably estimated more accurately from fuel consumption data.
The majority of emissions are estimated from other information such as fuel consumption, distance travelled or some other statistical data related to the emissions. Estimates for a particular source sector are calculated by applying an emission factor to an appropriate statistic. This is as follows:

$$\text{Total Emission} = \text{Emission Factor} \times \text{Activity Statistic}$$

Emission factors are typically derived from measurements on a number of representative sources and the resulting factor applied to the UK environment.

For the indirect gases, emissions data are sometimes available for individual sites from databases such as the Environment Agency's Pollution Inventory (PI). Hence the emission for a particular sector can be calculated as the sum of the emissions from these point sources. That is:

$$\text{Emission} = \Sigma \quad \text{Point Source Emissions}$$

However it is still necessary to make an estimate of the fuel consumption associated with these point sources, so that the emissions from non-point sources can be estimated from fuel consumption data without double counting. In general the point source approach is only applied to emissions of indirect greenhouse gases for well-defined point sources (e.g. power stations, cement kilns, coke ovens, refineries). Direct greenhouse gas emissions and most non-industrial sources are estimated using emission factors.

A3.3.1 Basic Combustion Module

For the pollutants and sources discussed in this section the emission results from the combustion of fuel. The activity statistics used to calculate the emission are fuel consumption statistics taken from BERR (2008). A file of the fuel combustion data used in the inventory is provided on a CD ROM attached to this report. Emissions are calculated according to the following equation:

$$E(p,s,f) = A(s,f) \times e(p,s,f)$$

where

E(p,s,f) = Emission of pollutant *p* from source s from fuel *f* (kg);
A(s,f) = Consumption of fuel *f* by source *s* (kg or kJ); and
e(p,s,f) = Emission factor of pollutant *p* from source s from fuel *f* (kg/kg or kg/kJ).

The pollutants estimated in this way are as follows:

- Carbon dioxide as carbon;
- Methane;
- Nitrous oxide;
- NO_x as nitrogen dioxide (some source/fuel combinations only);
- NMVOC;
- Carbon monoxide (some source/fuel combinations only); and
- Sulphur dioxide (some source/fuel combinations only).

The sources covered by this module are:

- Domestic;
- Miscellaneous;
- Public Service;
- Refineries (Combustion);
- Iron & Steel (Combustion);
- Iron & Steel (Blast Furnaces);
- Iron & Steel (Sinter Plant);
- Other Industry (Combustion);
- Autogenerators;
- Gas Production;
- Collieries;
- Production of Nuclear Fuel;
- Coastal Shipping;
- Fishing;
- Agriculture;
- Ammonia (Combustion);
- Railways (Stationary Sources);
- Aircraft Military; and
- Shipping Naval.

The fuels covered are listed in **Annex 3, Section 3.1**, though not all fuels occur in all sources.

For the estimation of CO and NO_x emissions from industrial, commercial/institutional and domestic sources the methodology allows for source/fuel combinations to be further broken down by a) thermal input of combustion devices; b) type of combustion process e.g. boilers, furnaces, turbines etc. Different emission factors are applied to these subdivisions of the source/fuel combination. Most of these emission factors are taken from literature sources, predominantly from US EPA, (2005), EMEP/CORINAIR (2003), and Walker *et al*, (1985). Some emissions data reported in the Pollution Inventory (Environment Agency, 2008) are also used to generate emission factors.

Tables A3.3.1 to **A3.3.4** list the emission factors used in this module. Emission factors are expressed in terms of kg pollutant/tonne for solid and liquid fuels, and g/TJ gross for gases. This differs from the IPCC approach, which expresses emission factors as tonnes pollutant/TJ based on the *net calorific value* of the fuel. For gases the NAEI factors are based on the *gross* *calorific value* of the fuel. This approach is used because the gas consumption data in BERR (2008) are reported in terms of energy content on a gross basis.

For most of the combustion source categories, the emission is estimated from fuel consumption data reported in DUKES and an emission factor appropriate to the type of combustion e.g. commercial gas fired boiler.

However the DUKES category ‘Other Industries’ covers a range of sources and types, so the Inventory disaggregates this category into a number of sub-categories, namely:

- Other Industry;
- Other Industry Off-road;
- Ammonia Feedstock (natural gas only);
- Ammonia (Combustion) (natural gas only);
- Cement (Combustion); and
- Lime Production (non-decarbonising).

Thus the GHGI category Other Industry refers to stationary combustion in boilers and heaters by industries not covered elsewhere (including the chemicals, food & drink, non-ferrous metal, glass, ceramics & bricks, textiles & engineering sectors). The other categories are estimated by more complex methods discussed in the sections indicated. For certain industrial processes (e.g. Lime production, cement production and ammonia production), the methodology is discussed in **Section A3.4** as the estimation of the fuel consumption is closely related to the details of the process. However, for these processes, where emissions arise from fuel combustion for energy production, these are *reported* under IPCC Table 1A. The fuel consumption of Other Industry is estimated so that the total fuel consumption of these sources is consistent with DUKES (BERR, 2008).

According to IPCC 1996 Revised Guidelines, electricity generation by companies primarily for their own use is autogeneration, and the emissions produced should be reported under the industry concerned. However, most National Energy Statistics (including the UK) report emissions from electricity generation as a separate category. The UK inventory attempts to report as far as possible according to the IPCC methodology. Hence autogenerators would be reported in the relevant sector where they can be identified e.g. iron and steel (combustion), refineries (combustion). In some cases the autogenerator cannot be identified from the energy statistics so it would be classified as other industry (combustion). This means that the split between iron and steel (combustion) and other industry (combustion) may be uncertain. Also, for certain sectors, data on fuel deliveries are used in preference to data on fuel consumption because deliveries will include autogeneration whereas consumption does not.

In 2004, an extensive review of carbon factors in the UK GHG inventory was carried out (Baggott *et al.*, 2004). This review covered over 90% of carbon emissions in the UK and focused on obtaining up-to-date carbon factors and oxidation factors for use in the inventory. The methods used to derive the carbon factors are described below.

In the UK, power stations and the cement industry are important users of coal. Power station emissions account for approximately 85% of UK carbon emissions. The carbon contents of coal used by these two industries are obtained directly from industry representatives and this ensures that the inventory contains emissions of CO_2 that are estimated as accurately as possible. Normally, the carbon contents of power station coal are updated annually.

The cement industry imports most of the coal it uses from abroad, and the coal burnt is considered to be 100% oxidised due to the high operating temperatures of cement kilns.

The carbon contents of fuels used by other industry sectors are not requested annually, but a time series is updated each year by scaling the carbon contents to the GCVs presented in the latest version of the Digest of UK Energy Statistics (BERR, 2008). The carbon content of a fuel is closely correlated with the calorific value and so using calorific values as a proxy provides a good estimate of the changing carbon contents.

The major liquid fuel carbon factors in the inventory have been from the UK Petroleum Institute Association (UKPIA). During the review in 2004, UKPIA undertook fuel analysis and provided carbon emission factors for the following fuels:

- Petrol;
- Burning oil;
- ATF;
- Aviation spirit;
- Diesel;
- Fuel oil;
- Gas oil;
- Petroleum coke;
- Naphtha;
- OPG;
- Propane; and
- Butane.

UKPIA advise whether these factors are still valid each year.

For the cement sector, industry specific petroleum coke carbon factors are used as like coal, the sector uses different types of petroleum coke to other industries.

Natural gas factors are provided by the UK gas network distributors. These data are derived from extensive measurements which are carried out by the various network distributors and data are provided to us each year.

In the 2009 GHGI, carbon factors from the EUETS were introduced for certain sector and fuel combinations. These sectors are listed below, along with the years for which EUETS data was introduced.

- Power Stations – coal – for 2005, 2006, 2007
- Power Stations – fuel oil – for 2005, 2006, 2007
- Power Stations – natural gas – for 2005, (interpolated 2006, 2007)
- Autogenerators – coal – 2005, 2006, 2007
- Refineries – fuel oil - 2005, (interpolated 2006, 2007)

- Refineries – Petroleum coke – 2005, 2006, 2007

For years and sectors not listed, carbon factors remained the same as in previous inventories and as described in the carbon factors review from 2004.

Implied emission factors (IEFs) for carbon are partly driven by the carbon emission factors and so there is some variability across the time series due to changes in UK factors. Updating carbon emission factors each year can cause large inter-annual changes in carbon implied emission factors (IEFs). One approach to avoid this, which has been suggested by an UNFCCC Expert Review Team, is to use regression analysis and derive the CEFs from the best fit line. We have considered this approach and discussed with UK DECC. For the moment, the UK continues to update CEFs on an annual basis because it considers that this approach provides the most accurate estimates of carbon emissions in a given year.

For gas in sector 1A1, the carbon IEFs for gas are high in relation to other Member States of the European Union. This is because sour gas has been used in the UK ESI sector from 1992 onwards, and sour gas has a much greater IEF than natural gas. The increase in the CO_2 IEF between 1991 and 1992 is explained by the commissioning of Peterhead power station in Scotland.

Table A 3.3.1: Emission Factors for the Combustion of Liquid Fuels for 2007[1] (kg/t)

Fuel	Source	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
ATF	Aircraft Military	859[a]	0.103[ad]	0.1[g]	8.5[ad]	8.2[ad]	1.1[ad]	10.9[z]
Burning Oil	Domestic	859[a]	0.462[g]	0.0277[g]	3.23[l]	1.85[l]	0.047[f]	0.59[z]
Burning Oil	Other Industry	859[a]	0.0924[g]	0.0277[g]	3.32[l]	0.19[l]	0.028[e]	0.59[z]
Burning Oil	Public Service, Railways (Stationary)	859[a]	0.462[g]	0.0277[g]	2.05[l]	0.16[l]	0.047[f]	0.59[z]
Burning Oil	Miscellaneous	859[a]	0.462[g]	0.0277[g]	2.70[l]	0.16[l]	0.047[f]	0.59[z]
Gas Oil	Agriculture	870[a]	0.455[g]	0.0273[g]	0[ap]	0[ap]	0.048[f]	2.9[z]
Gas Oil	Domestic	870[a]	0.455[g]	0.0273[g]	3.19[l]	1.82[l]	0.047[f]	2.7[z]
Gas Oil	Fishing, Coastal Shipping, Naval, International Marine	870[a]	0.05[ap]	0.08 [ap]	72.3 [aq]	7.4[ap]	3.5 [aq]	19.6 [ar]
Gas Oil	Iron&Steel	870[a]	0.0910[g]	0.0273[g]	20.17[l]	7.95[l]	0.028[f]	2.7[z]
Gas Oil	Refineries	870[a]	0.136[g]	0.0273[g]	4.55[k]	0.24[i]	0.028[f]	2.7[z]
Gas Oil	Other Industry	870[a]	0.0910[g]	0.0273[g]	5.08[l]	0.90[l]	0.028[f]	2.7[z]
Gas Oil	Public Service	870[a]	0.455[g]	0.0273[g]	2.44[l]	0.38[l]	0.047[f]	2.7[z]
Gas Oil	Miscellaneous	870[a]	0.455[g]	0.0273[g]	1.34[l]	0.17[l]	0.047[f]	2.7[z]
Fuel Oil	Agriculture	879[a]	0.433[g]	0.026[g]	7.69[l]	0.31[l]	0.14[f]	16.8[z]
Fuel Oil	Public Service	879[a]	0.433[g]	0.026[g]	7.62[l]	0.81[l]	0.14[f]	17.0[z]
Fuel Oil	Miscellaneous	879[a]	0.433[g]	0.026[g]	0.85[l]	0.034[l]	0.14[f]	17.0[z]
Fuel Oil	Fishing; Coastal Shipping, International Marine	879[a]	0.05[ap]	0.08 [ap]	72.3 [aq]	7.4[ap]	3.5 [aq]	52.9 [ar]
Fuel Oil	Domestic	879[a]	0.433[g]	0.026[g]	0[ap]	0[ap]	0.14[f]	17.0[z]
Fuel Oil	Iron&Steel	879[a]	0.087[g]	0.026[g]	7.[34]	0.86[l]	0.035[f]	17.06[z]
Fuel Oil	Railways (Stationary)	879[a]	0.433[g]	0.026[g]	7.62[l]	0.81[l]	0.14[f]	17.0[z]
Fuel Oil	Other Industry	879[a]	0.087[g]	0.026[g]	8.84[l]	1.15[l]	0.035[f]	17.0[z]
Fuel Oil	Refineries (Combustion)	877.4[at]	0.130[g]	0.026[g]	3.90[ag]	0.74[ag]	0.035[f]	24.7[ag]
Lubricants	Other Industry	865[x]	0.091[e]	0.027[e]	4.55[k]	0.25[f]	0.13[f]	11.4[x]
Petrol	Refineries	855[a]	0.141[an]	0.028[g]	4.62[k]	0.24[e]	0.028[e]	0.061[z]

Table A 3.3.2: Emission Factors for the Combustion of Coal for 2007[1] (kg/t)

Source	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Agriculture	639.1[ao]	0.011[o]	0.147[w]	4.75[l]	8.25[l]	0.05[o]	17.7[aa]
Collieries	687.3[ao]	0.011[o]	0.148[w]	4.75[l]	8.25[l]	0.05[o]	22.8[aa]
Domestic	683.5[ao]	15.7[o]	0.122[w]	2.34[l]	160.0[l]	14[o]	24.8[aa]
Iron and Steel (Combustion)	693.8[a]	0.011[o]	0.237[w]	IE	IE	0.05[o]	17.68[aa]
Lime Production (Combustion)	645.4[ao]	0.011[o]	0.214[w]	60.44[v]	15.73[v]	0.05[o]	17.68[aa]
Miscellaneous	702.8[ao]	0.011[o]	0.148[w]	4.72[l]	7.75[l]	0.05[o]	17.7[aa]
Public Service	702.8[ao]	0.011[o]	0.148[w]	4.78[l]	5.99[l]	0.05[o]	17.7[aa]
Other Industry	645.4[ao]	0.011[o]	0.214[w]	4.38[l]	1.69[l]	0.05[o]	17.7[aa]
Railways	702.8[ao]	0.011[o]	0.148[w]	4.78[l]	5.99[l]	0.05[o]	17.68[aa]
Autogenerators	594.5[at]	0.02[o]	0.0660[w]	5.55[l]	1.60[l]	0.03[o]	17.68[aa]

Table A 3.3.3: Emission Factors for the Combustion of Solid Fuels 2007[1] (kg/t)

Fuel	Source	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Anthracite	Domestic	820.7[ap]	2[o]	0.14[w]	3.38[k]	202.8[k]	1.7[o]	16.3[aa]
Coke	Agriculture	799.5[r]	0.011[p]	0.150[w]	5.15[l]	1.17[l]	0.05[p]	19[ab]
Coke	SSF Production	799.5[r]	0.011[p]	0.230[w]	IE	IE	0.05[p]	19[ab]
Coke	Domestic	799.5[r]	5.8[o]	0.117[w]	3.04[l]	118.6[l]	4.9[o]	16.3[aa]
Coke	I&S[ak] (Sinter Plant)	799.5[r]	1.27[ae]	0.230[w]	11.6[ae]	278[ae]	0.41[ae]	12.2[ae]
Coke	I&S[ak] (Combustion)	799.5[r]	0.011[p]	0.230[w]	0.87[l]	226[l]	0.05[p]	19[ab]
Coke	Other Industry	799.5[r]	0.011[p]	0.230[w]	5.15[l]	1.17[l]	0.05[p]	19[ab]
Coke	Railways	799.5[r]	0.011[p]	0.150[w]	5.15[l]	1.17[l]	0.05[p]	19[ab]
Coke	Miscellaneous; Public Service	799.5[r]	0.011[p]	0.150[w]	5.15[l]	1.17[l]	0.05[p]	19[ab]
MSW	Miscellaneous	75[ah]	2.85[g]	0.038[g]	0.88[v]	0.10[v]	0.0050[v]	0.028[v]
Petroleum Coke	Domestic	930[a]	NE	NE	3.95[k]	158[k]	4.9[am]	142.4[as]
Petroleum Coke	Refineries	1000[at]	0.107[ai]	0.281[w]	8.51[ag]	1.97[ag]	0.054[ai]	45.2[ag]
Petroleum Coke	Cement Production –Combustion	813	0.107	0.143	4.67[k]	46.7[k]	0.05[p]	19[ab]
SSF	Miscellaneous; Public Service	766.3[n]	0.011[p]	0.151[w]	3.11[k]	124.4[k]	4.9[o]	16[ab]
SSF	Domestic	774.2[n]	5.8[o]	0.118[w]	4.67[k]	46.7[k]	0.05[p]	19[ab]
SSF	Other Industry	766.3[n]	0.011[p]	0.232[w]	1.5[g]	75[g]	9[g]	0
Straw	Agriculture	418[g]	4.5[g]	0.06[g]	0.7[k]	70[g]	24[k]	0.108[f]
Wood	Domestic	387[g]	4.17[g]	0.06[g]	3.38[k]	202.8[k]	1.7[o]	16.3[aa]

Table A 3.3.4: Emission Factors for the Combustion of Gaseous Fuels 2007[1] (g/GJ gross)

Fuel	Source	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Blast Furnace Gas	Coke Production	75402[r]	112[k]	2.0[k]	79[k]	39.5[k]	5.6[k]	0
Blast Furnace Gas	I&S[ak] (Combustion), I&S[ak] (Flaring)	75402[r]	112[k]	2.0[k]	79[k]	39.5[k]	5.6[k]	0
Blast Furnace Gas	Blast Furnaces	75402[r]	112[k]	2.0[k]	35.1[v]	39.5[k]	5.6[k]	0
Coke Oven Gas	Other Sources	11089[r]	57.25[k]	2.0[k]	80.5[k]	40.0[k]	4.35[k]	280[v]
Coke Oven Gas	I&S[ak] Blast Furnaces	11089[r]	57.25[k]	2.0[k]	35.1[v]	40.0[k]	4.35[k]	280[v]
Coke Oven Gas	Coke Production	11089[r]	57.25[k]	2.0[k]	374[v]	40.0[k]	4.35[k]	280[v]
LPG	Domestic	16227[a]	0.889[f]	0.10[g]	64.3[f]	8.9[f]	1.55[f]	0
LPG	I&S[ak], Other Industry, Refineries, Gas Production	16227[a]	0.889[f]	0.10[g]	88.7[f]	15.1[f]	1.55[f]	0
Natural Gas	Agriculture	14003[r]	5.0[g]	0.10[g]	39.2[l]	2.13[l]	2.22[f]	0
Natural Gas	Miscellaneous	14003[r]	5.0[g]	0.10[g]	53.15[l]	10.6[l]	2.22[f]	0
Natural Gas	Public Service	14003[r]	5.0[g]	0.10[g]	56.0[l]	12.85[l]	2.22[f]	0
Natural Gas	Coke Production, SSF Prodn[al],	14003[r]	1.0[g]	0.10[g]	175.0[k]	2.37[l]	2.22[f]	0
Natural Gas	Refineries	14003[r]	1.0[g]	0.10[g]	70.0[k]	2.37[l]	2.22[f]	0
Natural Gas	Blast Furnaces	14003[r]	5.0[g]	0.10[g]	35.1[v]	2.37[l]	2.22[f]	0
Natural Gas	Domestic	14003[r]	5.0[g]	0.10[g]	69.2[l]	30.8[l]	2.22[f]	0
Natural Gas	Gas Prodn[al],	14003[r]	1.0[g]	0.10[g]	92.87[l]	17.4[l]	2.22[f]	0
Natural Gas	I&S[ak]	14003[r]	5.0[g]	0.10[g]	178.56[l]	177.2[l]	2.22[f]	0
Natural Gas	Railways	14003[r]	5.0[g]	0.10[g]	92.87[l]	33.8[l]	2.22[f]	0
Natural Gas	Other Industry	14003[r]	5.0[g]	0.10[g]	142.95[l]	62.6[l]	2.22[f]	0
Natural Gas	Nuclear Fuel Prodn[al], Collieries		1.0[g]	0.10[g]	142.95[l]	62.6[l]	2.22[f]	0

Fuel	Source	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Natural Gas	Autogenerators	14003[r]	5.0[g]	0.10[g]	80.1[l]	19.95[l]	2.22[f]	0
Natural Gas	Ammonia (Combustion)	14003[r]	5.0[g]	0.10[g]	203.97[d]	NE	2.22[f]	0
OPG	Gas production	15582[a]	1.0[g]	NE	70.0[k]	2.37[i]	1.54[f]	0
OPG	Refineries (Combustion)	15582[a]	1.0[g]	NE	96.3[ag]	13.5[z]	1.54[f]	0
OPG	Other Industry	15582[a]	5.0[g]	NE	70.0[k]	2.37[i]	1.54[f]	0
Colliery Methane	Other Industry	13930[a]	5.0[s]	0.10[g]	70.0[k]	2.37[i]	2.21[f]	0
Colliery Methane	Coke Production, Gas Production	13930[a]	1.0[s]	0.10[g]	70.0[k]	2.37[i]	2.21[f]	0
Sewage Gas	Public Services	27405[g]	5.0[g]	0.10[g]	66.78[f]	7.1[f]	2.42[f]	0
Landfill Gas	Miscellaneous	27405[g]	5.0[g]	0.10[g]	39.0[f]	122.4[f]	3.62[f]	0

Footnotes to Tables A3.3.1 to A3.3.4:

a	Carbon Factor Review (2004), Review of Carbon Emission Factors in the UK Greenhouse Gas Inventory. Report to UK Defra. Baggott, SL, Lelland, A, Passant and Watterson, JW, and selected recent updates to the factors presented in this report.
b	CORINAIR (1992)
b+	Derived from CORINAIR(1992) assuming 30% of total VOC is methane
c	Methane facto r estimated as 12% of total hydrocarbon emission factor taken from EMEP/CORINAIR(1996) based on speciation in IPCC (1997c)
d	Based on operator data: Terra Nitrogen (2008), Invista (2008), BP Chemicals (2008)
e	As for gas oil
f	USEPA (2005)
g	IPCC (1997c)
h	EMEP (1990)
i	Walker *et al* (1985)
j	As for fuel oil.
k	EMEP/CORINAIR (2003)
l	AEA Energy & Environment estimate based on application of literature emission factors at a greater level of detail than the sector listed (see Section A.3.3.1).
m	USEPA (1997)
n	British Coal (1989)
o	Brain *et al,* (1994)
p	As for coal
q	EMEP/CORINAIR (2003)
r	AEA Energy & Environment estimate based on carbon balance
s	As for natural gas
t	EMEP/CORINAIR (1996)
u	IPCC (2000)
v	Emission factor derived from emissions reported in the Pollution Inventory (Environment Agency, 2008)
w	Fynes *et al* (1994)
x	Passant (2005)
y	UKPIA (1989)
z	Emission factor derived from data supplied by UKPIA (2006, 2007, 2008)
aa	Emission factor for 2005 based on data provided by UK Coal (2005), Scottish Coal (2006), Celtic Energy (2006), Tower (2006), Betwys (2000)
ab	Munday (1990)
ac	Estimated from THC data in CRI (Environment Agency, 1997) assuming 3.% methane split given in EMEP/CORINAIR (1996)
ad	EMEP/CORINAIR (1999)
ae	AEA Energy & Environment estimate based on data from Environment Agency (2005) and Corus (2005)
af	UKPIA (2004)
ag	AEA Energy & Environment estimate based on data from Environment Agency (2005), UKPIA, DUKES, and other sources
ah	Royal Commission on Environmental Pollution (1993)
ai	DTI (1994)
aj	Emission factor as mass carbon per unit fuel consumption
ak	I&S = Iron and Steel
al	Prodn = Production
am	As for SSF
an	As for burning oil
ao	AEA Energy & Environment estimate based on carbon factors review
ap	EMEP/CORINAIR
aq	AEA Energy & Environment estimate
ar	Directly from annual fuel sulphur concentration data
as	Based on sulphur content of pet coke used in Drax trials (Drax Power Ltd, 2008)
at	Based on factors presented in EU-ETS returns

NE Not estimated
NA Not available
IE Included elsewhere
[1] These are the factors used the latest inventory year. The corresponding time series of emission factors and calorific values may are available electronically [on the CD accompanying this report]. Note that all carbon emission factors used for Natural Gas include the CO_2 already present in the gas prior to combustion.

A3.3.2 Conversion of Energy Activity Data and Emission Factors

The NAEI databases store activity data in Mtonnes for solid and liquid fuels and Mtherms (gross) for gaseous fuels. Emission factors are in consistent units namely: ktonnes/Mtonne for solid and liquid fuels and ktonnes/Mtherm (gross) for gaseous fuels. For some sources emission factors are taken from IPCC and CORINAIR sources and it is necessary to convert them from a net energy basis to a gross energy basis. For solid and liquid fuels:

$$H_n = m\, h_g\, f$$

and for gaseous fuels:

$$H_n = H_g\, f$$

where:

H_n	Equivalent energy consumption on net basis	(kJ)
m	Fuel consumption	(kg)
h_g	Gross calorific value of fuel	(kJ/kg)
f	Conversion factor from gross to net energy consumption	(-)
H_g	Energy Consumption on gross basis	(kJ)

In terms of emission factors:

$$e_m = e_n\, h_g\, f$$

or

$$e_g = e_n\, f$$

where:

e_m	Emission factor on mass basis	(kg/kg)
e_n	Emission factor on net energy basis	(kg/kJ net)
e_g	Emission factor on gross energy basis	(kg/kJ gross)

The gross calorific values of fuels used in the UK are tabulated in BERR, (2008). The values of the conversion factors used in the calculations are given in **Table A3.3.5**.

Table A 3.3.5: Conversion Factors for Gross to Net Energy Consumption

Fuel	Conversion Factor
Other Gaseous Fuels	0.9
Solid and Liquid Fuels	0.95
LPG and OPG	0.92
Blast Furnace Gas	1.0

The values given for solid, liquid and other gaseous fuels are taken from IPCC Guidelines (IPCC, 1997c). The value used for LPG is based on the calorific value for butane, the major constituent of LPG (Perry *et al*, 1973). Blast furnace gas consists mainly of carbon monoxide and carbon dioxide. Since little hydrogen is present, the gross calorific value and the net calorific values will be the same.

A3.3.3 Energy Industries (1A1)

A3.3.3.1 Electricity Generation

The NAEI category Power Stations is mapped onto 1A1 Electricity and Heat Production, and this category reports emissions from electricity generation by companies whose main business is producing electricity (Major Power Producers) and hence excludes autogenerators. Activity data for this category are taken from fuel consumption data in the annual publication *The Digest of UK Energy Statistics* (BERR, 2008) in conjunction with site-specific fuel use data obtained directly from plant operators. Coal and natural gas data from DUKES are very close to the category definition (i.e. exclude autogenerators) but fuel oil data does contain a small contribution from transport undertakings and groups of factories. From 1999 onwards, the fuel oil consumption reported within DUKES has been significantly lower than that estimated from returns from the power generators. In the inventory, the fuel oil use data from the power station operators are used; if the DUKES data was to be used, the emission factors implied by the data reported to UK environmental regulators (EA, SEPA, NIDoE) would be impossibly high. A correction is applied to the Other Industry (Combustion) category in the NAEI to ensure that total UK fuel oil consumption corresponds to that reported in DUKES[2].

[2] Making use, from 2000 onwards, of supplementary data from BERR because of a revision to the DUKES reporting format.

Table A 3.3.6: Emission Factors for Power Stations in 2007 [A time series of carbon emission factors can be found in the background energy tables on the accompanying CD]

Source	Unit	CO_2[1]	CH_4	N_2O	NO_X	CO	NMVOC	SO_2
Coal	Kt/Mt	615.4[s]	0.02[e]	0.063[l]	5.86[n]	0.865[n]	0.0227[n]	5.34[n]
Petroleum Coke	Kt/Mt	615.9 [a]	0.107[q]	0.087[r]	4.30[n]	21.3[n]	0.032[n]	7.80[n]
Fuel Oil	Kt/Mt	871.2[s]	0.130[h]	0.0260[h]	13.23[n]	1.17[n]	0.0161[n]	7.95[n]
Gas Oil	Kt/Mt	870[a]	0.136[h]	0.0273[h]	14.11[n]	0.64[n]	0.075[n]	7.95[n]
Burning Oil	Kt/Mt				3.74[n]	2.70[n]	0.032[n]	0.00039[n]
Natural gas	Kt/Mth	1.463[s]	0.000106[h]	1.06E-05[h]	0.00393[n]	0.00134[n]	0.000170[n]	3.19E-05[n]
MSW	Kt/Mt	75[d]	0.285[h]	0.038[h]	0.877[o]	0.101[o]	0.00495[o]	0.0276[o]
Sour gas	Kt/Mth	1.916[c]	0.000106[h]	1.06E-05[h]	0.00360[n]	0.00137[o]	9.85 E-05[n]	0.0013[n]
Poultry Litter	Kt/Mt	NE	0.278[h]	0.0370[j]	1.093[n]	0.646[o]	1.292[o]	0.299[n]
Sewage Gas	Kt/Mth	NE	0.000106[h]	1.06E-05[h]	0.00704[k]	0.000749[k]	0.000255[k]	NE
Waste Oils	Kt/Mt	864.8[b]	NE	NE	13.23[n]	1.17[n]	0.0161[n]	13.24[n]
Landfill gas	Kt/Mth	NE	0.000106[h]	1.06E-05[h]	0.00411[k]	0.0129[k]	0.000382[k]	NE

Footnotes to **A3.3.6:** (Emission Factors for Power Stations)

1 Emission factor as mass carbon/ unit fuel consumption
a Baggott *et al* (2004) - Review of Carbon Emission Factors in the UK Greenhouse Gas Inventory. Report to UK Defra. Baggott, SL, Lelland, A, Passant and Watterson, JW Plus selected updates. (UKPIA (2004)-Liquid Fuels, Transco (2008) – Natural Gas, Quick (2004) and AEP(2004) – Power Station Coal). Note that all carbon emission factors used for Natural Gas include the CO_2 already present in the gas prior to combustion.
b Passant, N.R., Emission factors programme Task 1 – Summary of simple desk studies (2003/4), AEA Technology Plc, Report No AEAT/ENV/R/1715/Issue 1, March 2004
c Stewart et al (1996) Emissions to Atmosphere from Fossil Fuel Power Generation in the UK, AEAT-0746, ISBN 0-7058-1753-3
d RCEP (Royal Commission on Environmental Protection) 17th Report - Incineration of Waste, 1993. Recently photosynthesised carbon **is excluded** from the carbon EF for MSW used in the GHG inventory, and is assumed to be 75% of total carbon. This indicates a total carbon EF of 300 kg/t.
e Brain (1994)
f Stewart *et al* (1996) estimated from total VOC factor assuming 27.2% is methane after USEPA(1997)
g CORINAIR (1992)
h IPCC (1997c)
i EMEP/CORINAIR (1996)
j IPCC (1997)
k USEPA (2004)
l Fynes *et al* (1994)
m Stewart (1997)
n Based on reported emissions data from the EA Pollution Inventory (Environment Agency, 2008), SEPA's Scottish Pollutant Release inventory (SEPA, 2008), NI DoE's Inventory of Sources and Releases list (NI DoE, 2008) and direct communications with plant operators (Pers. Comms., 2008)
o Environment Agency (2008)
p USEPA (1997)
q IPCC (2006)
r Based on Fynes, G. & Sage, P.W (1994)
s Based on EU-ETS data
NE Not Estimated

The emission factors used for Power Stations are shown in **Table A3.3.6**. National emission estimates for SO_2, NO_x, CO and NMVOC are based on estimates for each power station provided by the process operators to UK regulators (EA, SEPA, NIDoE, all 2008). These emission estimates are reported on a power station basis and comprise emissions from more than one fuel in many cases (for example, those from coal fired plant will include emissions from oil used to light up the boilers). It is necessary to estimate emissions by fuel in order to fulfil IPCC and UNECE reporting requirements. Therefore, the reported emissions are allocated across the different fuels burnt at each station. Plant-specific fuel use data are obtained directly from operators, or obtained from EU ETS data held by UK regulators, or estimated from carbon emissions in a few cases where no other data are available. The allocation of reported emissions of a given pollutant across fuels is achieved as follows:

- Emissions from the use of each fuel at each power station are calculated using the reported fuel use data and a set of literature-based emission factors to give 'default emission estimates';
- For each power station, the 'default emission estimates' for the various fuels are summed, and the percentage contribution that each fuel makes to this total is calculated; and

- The reported emission for each power station is then allocated across fuels by assuming each fuel contributes the same percentage of emissions as in the case of the 'default emission estimates'.

From 1991 to 1997 some UK power stations burnt orimulsion, an emulsion of bitumen and water. DTI (1998) gives the UK consumption of orimulsion. This fuel was only used by the electricity supply industry so these data were used in the category power stations. The carbon content of the fuel was taken from the manufacturers specification (BITOR, 1995). The emissions of NO_x, SO_2, NMVOC and CO were taken from Environment Agency (1998) but emission factors for methane and N_2O were derived from those of heavy fuel oil but adjusted on the basis of the gross calorific value. The CO emission factor is based on measured data. This fuel is no longer used.

Electricity has been generated from the incineration of municipal solid waste (MSW) to some extent from before 1990, though generation capacity increased markedly in the mid 1990s owing to construction and upgrading of incinerators to meet regulations which came into force at the end of 1996. Data are available (BERR, 2008) on the amount of waste used in heat and electricity generation and the emissions from the incinerators (Environment Agency, 2008). Since 1997, all MSW incinerators have generated electricity so emissions are no longer reported under the waste incineration category.

In addition to MSW combustion, the inventory reports emissions from the combustion of scrap tyres. The carbon emissions are based on estimates compiled by DTI (2000) and a carbon emission factor based on the carbon content of tyres (Ogilvie, 1995). IPCC default factors based on oil are used. In 2000, the tyre-burning plant closed down.

Also included are emissions from four plants that were designed to burn poultry litter, a plant burning wood, and a plant burning straw. In 2000 one of the poultry litter plants was converted to burn meat and bone meal. A number of large coal-fired power stations co-fire small quantities of biofuels. Most co-firing is with solid fuels such as short-rotation coppice (SRC), and these fuels were included in the GHGI for the first time for the 2008 version of the inventory. Quantities of liquid biofuels are very much lower and have not been included to date since the impact on emission estimates would be trivial. This will be reviewed annually, in case the quantities being consumed increase.

Carbon emissions for poultry litter, straw and wood/SRC are not included in the UK total since these derive from biomass, but emissions are reported for information in the CRF. Emissions of CH_4, N_2O, CO, NO_x, SO_2, and NMVOC are also estimated. Emission factors are based on Environment Agency (2008) data and IPCC (1997) defaults for biomass. Fuel use data are provided directly by the operators of three poultry litter plant and have been estimated for the fourth poultry litter plant and the wood and straw-burning plant either by using EU ETS data or, where that is not available, based on information published on the internet by the operators of the power stations. There is considerable variation in emission factors for different sites due to the variability of fuel composition.

Emission estimates are made from the generation of electricity from landfill gas and sewage gas (BERR, 2008). It is assumed that the electricity from this source is fed into the public supply or sold into non-waste sectors and hence classified as public power generation. The gases are normally used to power reciprocating gas (or dual-fuel engines), which may be part of combined heat and power schemes. Emission factors for landfill gas and sewage gas burnt in reciprocating engines have not been found so those for these gases burnt in gas turbines have been used instead (USEPA, 2008). BERR (2008) reports the energy for electricity production and for heat production separately. The emissions for electricity generation are allocated to 'Public Power' whilst those for heat production are reported under 'Miscellaneous' for landfill gas and 'Public Services' for sewage gas.

The carbon emissions are not included in the UK total as they are derived from biomass, but emissions are reported for information in the CRF.

A3.3.3.2 Petroleum Refining

The NAEI category refinery (combustion) is mapped onto the IPCC category 1A1b Petroleum Refining. The emission factors used are shown in **Table A3.3.1**. Included in this category is an emission from the combustion of petroleum coke. This emission arises from the operation of fluidized bed catalytic crackers. During the cracking processes coke is deposited on the catalyst degrading its performance. The catalyst must be continuously regenerated by burning off the coke. The hot flue gases from the regeneration stage are used as a source of heat for the process. Since the combustion provides useful energy and the estimated amount of coke consumed is reported (BERR, 2008), the emissions are reported under 1A1b Petroleum Refining rather than as a fugitive emission under 1B2. Emission factors are either based on operators' data (UKPIA, 2008) or IPCC (1997) defaults for oil. The NAEI definition of Refinery (Combustion) includes all combustion sources: refinery fuels, electricity generation in refineries and fuel oils burnt in the petroleum industry.

A3.3.3.3 Manufacture of Solid Fuels

The mappings used for these categories are given in **Sections A3.1-3.2** and emission factors for energy consumption in these industries are given in **Tables A3.3.1-3.3.4**. The fuel consumption for these categories are taken from BERR (2008). The emissions from these sources (where it is clear that the fuel is being burnt for energy production) are calculated as in the base combustion module and reported in IPCC Table 1A Energy. Where the fuel is used as a feedstock resulting in it being transformed into another fuel, which may be burnt elsewhere, a more complex treatment is needed. The approach used by the NAEI is to perform a carbon balance over solid smokeless fuel (SSF) production and a separate carbon balance over coke production, sinter production, blast furnaces and basic oxygen furnaces. This procedure ensures that there is no double counting of carbon and is consistent with IPCC guidelines. No town gas was manufactured in the UK over the period covered by these estimates so this is not considered.

The transformation processes involved are:

Solid Smokeless Fuel Production

coal → SSF + carbon emission

Coke Production/Sinter production/Blast furnaces/Basic oxygen furnaces (simplified)

coal → coke + coke oven gas + benzoles & tars + fugitive carbon emission
coke + limestone + iron ore → sinter + carbon emission
sinter + coke + other reducing agents → pig iron + blast furnace gas
pig iron + oxygen → steel + basic oxygen furnace gas

Carbon emissions from each process can be estimated by comparing the carbon inputs and outputs of each stage of the transformation. The carbon content of the primary fuels are fixed based on the findings of the 2004 UK carbon factor review, as is the carbon content of coke oven gas, blast furnace gas, pig iron, and steel.

The carbon contents of coke, coke breeze, and basic oxygen furnace gas are allowed to vary in order to enable the carbon inputs and outputs to be balanced. The calculations are so arranged that the total carbon emission corresponds to the carbon content of the input fuels in accordance with IPCC Guidelines.

In the case of SSF production, the carbon content of both input (coal) and output (SSF) are held constant with the difference being treated as an emission of carbon from the process (since the carbon content of the input is always greater than the output). This procedure has been adopted because it has been assumed that some carbon would be emitted in the form of gases, evolved during the production process, and possibly used as a fuel for the transformation process.

In reporting emissions from coke ovens and SSF manufacturing processes, emissions arising from fuel combustion for energy are reported under 1A1ci Manufacture of Solid Fuels, whilst emissions arising from the transformation process are reported under 1B1b Solid Fuel Transformation. In the case of blast furnaces, energy emissions are reported under 1A2a Iron and Steel and process emissions under 2C1 Iron and Steel Production.

A3.3.3.4 Other Energy Industries

Section A3.2 shows the NAEI source categories mapped onto 1A1cii Other Energy Industries. All these emissions are treated according to the base combustion module using emission factors given in **Tables A3.3.1** to **A3.3.4**. However, the treatment of gas oil use on offshore installations is anomalous: this is accounted for within the NAEI category Coastal Shipping and is mapped to 1A3dii National Navigation, based on the reporting of gas oil use in DUKES and the absence of any detailed data to split gas oil used in coastal vessels and that used to service offshore installations. There are no double counts in these emissions.

The estimation of emissions from natural gas, LPG and OPG used as a fuel in offshore installations and onshore terminals is discussed in **Section A3.3.8.** These emissions are reported in category 1A1cii, but the methodology used in their estimation is closely linked to the estimation of offshore fugitive emissions.

A3.3.4 Manufacturing Industries and Construction (1A2)

A3.3.4.1 Other Industry

In the NAEI, the autogenerators category reports emissions from electricity generation by companies primarily for their own consumption. The Inventory makes no distinction between electricity generation and combined heat and power or heat plants. Hence CHP systems where the electricity is fed into the public supply are classified as power stations and CHP systems where the electricity is used by the generator are classified as autogeneration. The autogenerators category is mapped onto the IPCC category 1A2f Other Industry. The IPCC 1A1 category also refers to CHP plant and heat plant.

A3.3.5 Transport (1A3)

A3.3.5.1 Aviation

A3.3.5.1.1 Overview of method to estimate emissions from civil aviation

In accordance with the agreed guidelines, the UK inventory contains estimates for both domestic and international civil aviation. Emissions from international aviation are recorded as a memo item, and are not included in national totals. Emissions from both the Landing and Take Off (LTO) phase and the Cruise phase are estimated. The method used to estimate emissions from military aviation can be found towards the end of this section on aviation.

In 2004, the simple method previously used to estimate emissions from aviation overestimated fuel use and emissions from domestic aircraft because only two aircraft types were considered and the default emission factors used applied to older aircraft. It is clear that more smaller modern aircraft are used on domestic and international routes. Emissions from international aviation were correspondingly underestimated. A summary of the more detailed approach now used is given below, and a full description is given in Watterson *et al.* (2004).

The current method estimates emissions from the number of aircraft movements broken down by aircraft type at each UK airport, and so complies with the IPCC Tier 3 specification. Emissions of a range of pollutants are estimated in addition to the reported greenhouse gases. In comparison with earlier methods used to estimate emissions from aviation, the current approach is much more detailed and reflects differences between airports and the aircraft that use them. Emissions from additional sources (such as aircraft auxiliary power units) are also now included.

This method utilises data from a range of airport emission inventories compiled in the last few years by AEA. This work includes the RASCO study (23 regional airports, with a 1999 case calculated from CAA movement data) carried out for the Department for Transport (DfT), and the published inventories for Heathrow, Gatwick and Stansted airports, commissioned by BAA and representative of the fleets at those airports. Emissions of NOx and fuel use from the Heathrow inventory have been used to verify the results of this study.

In 2006, the Department for Transport (DfT) published its report “Project for the Sustainable Development of Heathrow” (PSHD). This laid out recommendations for the improvement of emission inventories at Heathrow and lead to a revised inventory for Heathrow for 2002.

For departures, the PSDH made recommendations for revised thrust setting at take-off and climb-out as well as revised cut-back heights. For landing, the PSDH made recommendations for revised reverse thrust setting and durations along with revised landing-roll times. In 2007, these recommendations for Heathrow were incorporated into the UK inventory.

Since publication of the PSDH report, inventories at Gatwick and Stansted have been updated. These inventories incorporated many of the recommendations of the PSDH and have been used as a basis for the current UK inventory.

Separate estimates have been made for emissions from the LTO cycle and the cruise phase for both domestic and international aviation. For the LTO phase, fuel consumed and emissions per LTO cycle are based on detailed airport studies and engine-specific emission factors (from the ICAO database). For the cruise phase, fuel use and emissions are estimated using distances (based on great circles) travelled from each airport for a set of representative aircraft.

In the current UK inventory there is a noticeable reduction in emissions from 2005 to 2006 despite a modest increase in aircraft movements and kilometres flown. This is attributable to the propagation of more modern aircraft into the fleet. From 2006 to 2007 there is a further reduction in emissions, which is attributable to both a modest decrease in aircraft movements and kilometres flown and the propagation of more modern aircraft into the fleet.

A3.3.5.1.2 Emission Reporting Categories for Civil Aviation

Table A3.3.7 below shows the emissions included in the emission totals for the domestic and international civil aviation categories currently under the UNFCCC, the EU NECD and the LRTAP Convention. Note the reporting requirements to the LRTAP Convention have altered recently – the table contains the most recent reporting requirements

Table A 3.3.7: Components of Emissions Included in Reported Emissions from Civil Aviation

	EU NECD	LRTAP Convention	EU-MM/UNFCCC
Domestic aviation (landing and take-off cycle [LTO])	Included in national total	Included in national total	Included in national total
Domestic aviation (cruise)	Not included in national total	Not included in national total	Included in national total
International aviation (LTO)	Included in national total	Included in national total	Not included in national total
International aviation (cruise)	Not included in national total	Not included in national total	Not included in national total

Notes

Emissions from the LTO cycle include emissions within a 1000 m ceiling of landing.

A3.3.5.1.3 Aircraft Movement Data (Activity Data)

The methods used to estimate emissions from aviation require the following activity data:

- **Aircraft movements and distances travelled**

  Detailed activity data has been provided by the UK Civil Aviation Authority (CAA). These data include aircraft movements broken down by: airport; aircraft type; whether the flight is international or domestic; and, the next/last POC (port of call) from which sector lengths (great circle) have been calculated.

  A summary of aircraft movement data is given in **Table A3.3.8**.

- **Inland Deliveries of Aviation Spirit and Aviation Turbine Fuel**

  Total inland deliveries of aviation spirit and aviation turbine fuel to air transport are given in BERR (2008). This is the best approximation of aviation bunker fuel consumption available and is assumed to cover international, domestic and military use.

- **Consumption of Aviation Turbine Fuel by the Military**

  Total consumption by military aviation is given in ONS (1995) and MOD (2005a) and is assumed to be aviation turbine fuel.

Table A 3.3.8: Aircraft Movement Data

	International LTOs (000s)	Domestic LTOs (000s)	International Aircraft, Gm flown	Domestic Aircraft, Gm flown
1990	410.1	318.1	635.4	98.8
1991	397.4	312.6	623.9	97.0
1992	432.8	331.0	705.9	102.8
1993	443.6	338.0	717.3	106.5
1994	461.9	316.3	792.6	102.2
1995	480.9	329.6	831.9	107.4
1996	507.2	341.2	871.5	113.1
1997	537.7	346.0	948.9	118.3
1998	576.4	360.0	1034.6	124.3
1999	610.1	368.1	1101.4	129.1
2000	646.8	378.8	1171.3	134.1
2001	653.8	393.1	1186.4	142.5
2002	650.2	391.6	1178.7	141.9
2003	669.3	401.7	1230.7	145.2
2004	700.6	434.2	1335.1	155.4
2005	739.4	458.0	1427.3	165.3
2006	762.4	458.4	1492.6	165.9
2007	788.4	450.9	1547.6	163.0

Notes

Gm Giga metres, or 10^9 metres

Estimated emissions from aviation are based on data provided by the CAA / International aircraft, Gm flown, calculated from total flight distances for departures from UK airports

A3.3.5.1.4 Emission factors used

The following emission factors were used to estimate emissions from aviation. The emissions of CO_2, SO_2 and metals depend on the carbon, sulphur and metal contents of the aviation fuels'. Emissions factors for CO_2, SO_2 and metals have been derived from the contents of carbon, sulphur and metals in aviation fuels. These contents are reviewed, and revised as necessary, each year. Full details of the emission factors used are given in Watterson *et al.* (2004).

Table A 3.3.9: Carbon Dioxide and Sulphur Dioxide Emission Factors for Civil and Military Aviation for 2007 (kg/t)

Fuel	CO_2	SO_2
Aviation Turbine Fuel	859	0.87
Aviation Spirit	853	0.87

Notes

Carbon and sulphur contents of fuels provided by UKPIA (2008)
Carbon emission factor as kg carbon/tonne
Military aviation only uses ATF

For the LTO-cycle calculations, emissions per LTO cycle are required for each of a number of representative aircraft types. Emission factors for the LTO cycle of aircraft operation have been taken from the International Civil Aviation Organization (ICAO) database. The cruise emissions have been taken from CORINAIR data (which are themselves developed from the same original ICAO dataset).

Table A 3.3.10: Non-CO_2 Emission Factors for Civil and Military Aviation

	Fuel	Units	CH_4	N_2O	NO_x	CO	NMVOC
Civil aviation							
Domestic LTO	AS	kt/Mt	1.49	0.10	5.17	956.25	13.56
Domestic Cruise	AS	kt/Mt	-	0.10	6.75	3.62	0.24
Domestic LTO	ATF	kt/Mt	0.15	0.10	10.67	9.30	1.52
Domestic Cruise	ATF	kt/Mt	-	0.10	13.70	2.51	0.55
International LTO	AS	kt/Mt	1.92	0.10	2.97	1157.78	17.54
International Cruise	AS	kt/Mt	-	0.10	6.90	-	-
International LTO	ATF	kt/Mt	0.11	0.10	12.92	8.46	1.15
International Cruise	ATF	kt/Mt	-	0.10	14.16	1.15	0.52
Military aviation	ATF	kt/Mt	0.10	0.10	8.5	8.2	1.10

Notes

AS – Aviation Spirit

ATF – Aviation Turbine Fuel

Use of all aviation spirit assigned to the LTO cycle

A3.3.5.1.5 Method used to estimate emissions from the LTO cycle – civil aviation – domestic and international

The basic approach to estimating emissions from the LTO cycle is as follows. The contribution to aircraft exhaust emissions (in kg) arising from a given mode of aircraft operation (see list below) is given by the product of the duration (seconds) of the operation, the engine fuel flow rate at the appropriate thrust setting (kg fuel per second) and the emission factor for the pollutant of interest (kg pollutant per kg fuel).

The annual emissions total for the mode (kg per year) is obtained by summing contributions over all engines for all aircraft movements in the year.

The time in each mode of operation for each type of airport and aircraft has been taken from individual airport studies. The time in mode is multiplied by an emission rate (the product of fuel flow rate and emission factor) at the appropriate engine thrust setting in order to estimate emissions for phase of the aircraft flight. The sum of the emissions from all the modes provides the total emissions for a particular aircraft journey. The modes considered are:

- Taxi-out;
- Hold;
- Take-off Roll (start of roll to wheels-off);
- Initial-climb (wheels-off to 450 m altitude);
- Climb-out (450 m to 1000 m altitude);
- Approach (from 1000 m altitude);
- Landing-roll;
- Taxi-in;
- APU use after arrival; and
- Auxiliary Power Unit (APU) use prior to departure.

Departure movements comprise the following LTO modes: taxi-out, hold, take-off roll, initial-climb, climb-out and APU use prior to departure.

Arrivals comprise: approach, landing-roll, taxi-in and APU use after arrival.

A3.3.5.1.6 Method used to estimate emissions in the cruise – civil aviation - domestic and international

The approaches to estimating emissions in the cruise are summarised below. Cruise emissions are only calculated for aircraft departures from UK airports (emissions therefore associated with the departure airport), which gives a total fuel consumption compatible with recorded deliveries of aviation fuel to the UK. This procedure prevents double counting of emissions allocated to international aviation.

A3.3.5.1.7 Estimating emissions of the indirect and non-greenhouse gases

The EMEP/CORINAIR Emission Inventory Guidebook (EMEP/CORINAIR, 1996) provides fuel consumption and emissions of non-GHGs (NO_x, HC and CO) for a number of aircraft modes in the cruise. The data are given for a selection of generic aircraft type and for a number of standard flight distances.

The breakdown of the CAA movement by aircraft type contains a more detailed list of aircraft types than in the EMEP/CORINAIR Emission Inventory Guidebook. Therefore, each specific aircraft type in the CAA data has been assigned to a generic type in the Guidebook. Details of this mapping are given in Watterson *et al.* (2004).

A linear regression has been applied to these data to give emissions (and fuel consumption) as a function of distance:

$$E_{Cruise_{d,g,p}} = m_{g,p} \times d + c_{g,p}$$

Where:

$E_{Cruise_{d,g,p}}$	is the emissions in cruise of pollutant p for generic aircraft type g and flight distance d (kg)
d	is the flight distance
g	is the generic aircraft type
p	is the pollutant (or fuel consumption)
$m_{g,p}$	is the slope of regression for generic aircraft type g and pollutant p (kg / km)
$c_{g,p}$	is the intercept of regression for generic aircraft type g and pollutant p (kg)

Emissions of SO_2 and metals are derived from estimates of fuels consumed in the cruise (see equation above) multiplied by the sulphur and metals contents of the aviation fuels for a given year.

A3.3.5.1.8 Estimating emissions of the direct greenhouse gases

Estimates of CO_2 were derived from estimates of fuel consumed in the cruise (see equation above) and the carbon contents of the aviation fuels.

Methane emissions are believed to be negligible at cruise altitudes, and the emission factors listed in EMEP/CORINAIR guidance are zero (EMEP/CORINAIR, 1996); we have also assumed them to be zero. This was the assumption in the previous aviation calculation method also.

Estimates of N_2O have been derived from an emission factor recommended by the IPCC (IPCC, 1997c) and the estimates of fuel consumed in the cruise (see equation above).

A3.3.5.1.9 Classification of domestic and international flights

The UK CAA has provided the aircraft movement data used to estimate emissions from civil aviation. The definitions the CAA use to categorise whether a movement is international or domestic are (CAA, *per. comm.*)

- **Domestic** A flight is domestic if the initial point on the service is a domestic and the final point is a domestic airport; and
- **International** A flight is international if either the initial point or the final point on the service is an international airport.

Take, for example, a flight (service) that travels the following route: **Glasgow** (within the UK) – **Birmingham** (within the UK) – **Paris** (outside the UK). The airport reporting the aircraft movement in this example is Glasgow, and the final airport on the service is Paris. The CAA categorises this flight as international, as the final point on the service is outside the UK.

Flights to the Channel Islands and the Isle of Man are considered to be within the UK in the CAA aircraft movement data.

By following the IPCC Good Practice Guidance (IPCC, 2000), it is necessary to know whether passengers or freight are put down before deciding whether the whole journey is considered as an international flight or consisting of a (or several) domestic flight(s) and an international flight. We feel the consequence of the difference between CAA and IPCC definitions will have a small impact on total emissions.

The CAA definitions above are also used by the CAA to generate national statistics of international and domestic aircraft movements. Therefore, the aircraft movement data used in this updated aviation methodology are consistent with national statistical datasets on aircraft movements.

A3.3.5.1.10 Overview of method to estimate emission from military aviation

LTO data are not available for military aircraft movements, so a simple approach is used to estimate emissions from military aviation. A first estimate of military emissions is made using military fuel consumption data and IPCC (1997) and EMEP/CORINAIR (1999) cruise defaults shown in Table 1 of EMEP/CORINAIR (1999) (see **Table A3.3.10**). The EMEP/CORINAIR (1999) factors used are appropriate for military aircraft. The military fuel data include fuel consumption by all military services in the UK. It also includes fuel shipped to overseas garrisons, casual uplift at civilian airports, but not fuel uplifted at foreign military airfields or *ad hoc* uplift from civilian airfields.

Emissions from military aircraft are reported under IPCC category 1A5 Other.

A3.3.5.1.11 Fuel reconciliation

The estimates of aviation fuels consumed in the commodity balance table in the BERR publication DUKES are the national statistics on fuel consumption, and IPCC guidance states that national total emissions must be on the basis of fuel sales. Therefore, the estimates of emissions have been re-normalised based on the results of the comparison between the fuel consumption data in DUKES and the estimate of fuel consumed produced from the civil aviation emissions model. The ATF fuel consumptions presented in BERR DUKES include the use of both civil and military ATF, and the military ATF use must be subtracted from the DUKES total to provide an estimate of the civil aviation consumption. This estimate of civil ATF consumption has been used in the fuel reconciliation. Emissions will be re-normalised each time the aircraft movement data is modified or data for another year added.

A3.3.5.1.12 Geographical coverage of aviation emission estimates

According to the IPCC Guidelines, "inventories should include greenhouse gas emissions and removals taking place within national (including administered) territories and offshore areas over which the country has jurisdiction." IPCC, (1997c); (IPPC Reference Manual, Overview, Page 5).

The national estimates of aviation fuels consumed in the UK are taken from BERR DUKES. The current (and future) methods used to estimate emissions from aviation rely on these data, and so the geographical coverage of the estimates of emissions will be determined by the geographical coverage of DUKES.

UK BERR has confirmed that the coverage of the energy statistics in DUKES is England, Wales, Scotland and Northern Ireland plus any oil supplied from the UK to the Channel

Islands and the Isle of Man. This clarification was necessary since this information cannot be gained from UK trade statistics.

BERR have confirmed estimates in DUKES exclude Gibraltar and the other UK overseas territories. The BERR definition accords with that of the "economic territory of the United Kingdom" used by the UK Office for National Statistics (ONS), which in turn accords with the definition required to be used under the European System of Accounts (ESA95).

A3.3.5.2 Railways

The UK GHGI reports emissions from both stationary and mobile sources. The inventory source "*railways (stationary)*" comprises emissions from the combustion of burning oil, fuel oil and natural gas by the railway sector. The natural gas emission derives from generation plant used for the London Underground. These stationary emissions are reported under 1A4a Commercial/Institutional in the IPCC reporting system. Most of the electricity used by the railways for electric traction is supplied from the public distribution system, so the emissions arising from its generation are reported under 1A1a Public Electricity. These emissions are based on fuel consumption data from BERR (2008). Emission factors are reported in **Tables A3.3.1** to **A3.3.3**.

The UK GHGI reports emissions from diesel trains in three categories: freight, intercity and regional. Emission estimates are based on train kilometres travelled and gas oil consumption by the railway sector.

Gas oil consumption by passenger trains was calculated utilising data provided by the Association of Train Operating Companies (ATOC). As a result of issues regarding the availability of gas oil consumption data by passenger trains, fuel consumption was estimated on the basis of reported train kilometres travelled. Following compilation of the inventory, new fuel consumption data for 2007 was received from ATOC. However, due to concerns regarding the completeness of the latest data, the data will need to be quality checked before use in the Inventory. This data will be reviewed with the rail industry in the next round of the Inventory. For freight trains, the data is estimated by combining fuel consumption factors with train kilometre data from the UK's national rail trends yearbook. Emissions from diesel trains are reported under the IPCC category 1A3c Railways.

As a consequence of increased train km travelled, the estimated fuel consumption in passenger and freight rail showed an increase in 2007 in comparison to 2006.

Carbon dioxide, sulphur dioxide and nitrous oxide emissions are calculated using fuel-based emission factors and fuel consumption data. The fuel consumption is distributed according to:

Train km data taken from the National rail trends yearbook (2008) http://www.rail-reg.gov.uk/upload/pdf/375.pdf for the three categories[3];
Assumed mix of locomotives for each category; and
Fuel consumption factors for different types of locomotive (LRC (1998), BR (1994) and Hawkins & Coad (2004)).

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[3] For TOC where train km data was not available for 2007, the data was assumed to be unchanged from the previous year (2006).

Emissions of CO, NMVOC, NO_x and methane are based on the train km estimates and emission factors for different train types. The emission factors shown in **Table A3.3.11** are aggregate implied factors so that all factors are reported on the common basis of fuel consumption.

Compared with the last version of the inventory, very minor changes to implied emission factors are noted for regional and intercity passenger rail with respect to NO_x, CO and NMVOC, with the emission factors for regional trains increasing slightly and intercity showing a minor decrease from values used in 2006. These changes to the implied factors are a net result in minor changes in estimated km travel and fuel consumed.

The emission factor for SO_2 has declined from 3.0 kt/ Mt in 2006 to 2.67 kt/ Mt in 2007 in line with UKPIA's Table of the S-content in fuels in 2007 (UKPIA, 2008).

Table A 3.3.11: Railway Emission Factors (kt/Mt)

	C[1]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Freight	870	0.17	1.2	80.1	8.9	4.5	2.67
Intercity	870	0.22	1.2	42.1	13.2	5.7	2.67
Regional	870	0.38	1.2	33.0	36.6	6.4	2.67

1 Emission factors expressed as ktonnes carbon per Mtonne fuel

A3.3.5.3 Road Transport

Emissions from road transport are calculated either from a combination of total fuel consumption data and fuel properties or from a combination of drive related emission factors and road traffic data.

A3.3.5.3.1 Improvements in the 2007 inventory

There have been a number of significant improvements made to the road transport inventory including the use of new sets of emission factor-speed relationships for some pollutants (N_2O and NO_x), changes to vehicle speed data (affecting emission factors) and use for the first time of more detailed activity data showing annual variations in car fleet by engine size and travel survey information indicating variations in mileage done by cars of different engine size and fuel type on different types of road.

A major change has been the adoption of new N_2O emission factors and functions given by the COPERT 4 methodology for the Emissions Inventory Guidebook (EEA, 2007). These indicate a trend of decreasing emissions with higher Euro standards of petrol cars after the initial increase that occurred with the introduction of three-way catalyst technology at Euro 1 standards. A new set of emission factor-speed relationships for NO_x has been adopted from the new database of factors developed by TRL on behalf of DfT (Boulter et al, 2008).

Another major change has resulted from the update of vehicle speed data for different road and area types. This was done following a review of more up-to-date speed data from various DfT sources. The methodology of allocating vehicle-kilometres between petrol and diesel cars has also been changed. The new method has taken account of the fact that diesel cars do more annual mileage than petrol cars and lead to a different fuel mix on different road types. This is based on information collected from the National Travel Survey and the effect is applied from 1990 to 2007. In addition, the proportion of cars by engine size are taken to be variable from each year from 2000 reflecting a growing trend of bigger engine-sized cars purchased in recent years. These ratios have further been adjusted to take account of fact that bigger engine-sized cars do more annual mileage than smaller cars. This is again based on information collected from the National Travel Survey and is applied across the time series. Car fleet specific data for Northern Ireland are also incorporated into the 2007 inventory as Northern Ireland has seen a greater penetration of diesel cars than in Great Britain. DfT has revised their average miles per gallon fuel efficiency for HGVs between 1993 and 2007.

These changes have only affected the distribution of fuel consumption and hence CO_2 emissions between vehicle types, but the total CO_2 emissions for road transport in all years remains unchanged, because these are based on the total fuel consumption figures reported in DUKES. Estimates of fuel consumption calculated for individual types of vehicles are normalised so the total adds up to the DUKES figures for petrol and diesel consumption (corrected for off-road consumption). However, for other pollutants where emissions are not directly related to fuel consumption, the changes in activity data and emission factors alter the total emissions for road transport reported in each year.

A3.3.5.3.2 Fuel-based emissions

Emissions of carbon dioxide and sulphur dioxide from road transport are calculated from the consumption of petrol and diesel fuels and the sulphur content of the fuels consumed. Data on petrol and diesel fuels consumed by road transport in the UK are taken from the Digest of UK Energy Statistics published by the BERR and corrected for consumption by off-road vehicles.

In 2007, 17.59 Mtonnes of petrol and 21.04 Mtonnes of diesel fuel (DERV) were consumed in the UK (a very small proportion of this was used in the Crown Dependencies). It was estimated that of this, around 1.5% of petrol was consumed by off-road vehicles and machinery, leaving 17.32 Mtonnes of petrol consumed by road vehicles in 2007. According to figures in DUKES (BERR, 2008), 0.119 Mtonnes of LPG were used for transport in 2007, down from 0.126 Mtonnes the previous year.

Since 2005, there has been a rapid growth in consumption of biofuels in the UK. These are not included in the totals presented above for petrol and diesel which according to BERR refer only to mineral-based fuels (fossil fuels). According to statistics in DUKES and from HMRC (2008), an additional 0.11 Mtonnes bioethanol and 0.30 Mtonnes biodiesel were consumed in the UK in 2007, representing around 0.6% and 1.4% of fossil-fuel based petrol and diesel consumed, respectively. The CO_2 emissions arising from consumption of these fuels are not included in the national totals.

Emissions of CO_2, expressed as kg carbon per tonne of fuel, are based on the carbon content (by mass) of the fuel; emissions of SO_2 are based on the sulphur content of the fuel. Values of the fuel-based emission factors for CO_2 and SO_2 from consumption of petrol and diesel fuels are shown in **Table A3.3.12**. Values for SO_2 vary annually as the sulphur-content of fuels change, and are shown in **Table A3.3.12** for 2007 fuels based on data from UKPIA (2008

Table A 3.3.12: Fuel-Based Emission Factors for Road Transport (kg/tonne fuel)

Fuel	C[a]	SO_2[b]
Petrol	855	0.061
Diesel	863	0.030

a Emission factor in kg carbon/tonne, based on UKPIA (2005)
b 2007 emission factor calculated from UKPIA (2008) – figures on the weighted average sulphur-content of fuels delivered in the UK in 2007

Emissions of CO_2 and SO_2 can be broken down by vehicle type based on estimated fuel consumption factors and traffic data in a manner similar to the traffic-based emissions described below for other pollutants.

In the 2007 inventory, the same procedure was used as in the 2006 inventory in the way that factors based on drive cycle test data, relating fuel consumption and speed, were combined with fleet-averaged fuel efficiency and vehicle CO_2 factors from other sources. Depending on available sources of data, slightly different approaches were used for different vehicle classes, but the aim was to reconcile as much available information as possible.

The important equations relating fuel consumption to average speed are based on the set of tailpipe CO_2, CO and total hydrocarbon (THC) emission-speed equations developed by TRL (Barlow *et al*, 2001). The TRL equations were derived from their large database of emission measurements compiled from different sources covering different vehicle types and drive cycles. A substantial part of the emission measurements for Euro 1/I and 2/II standard vehicles come from test programmes funded by DfT and Defra and carried out in UK test laboratories between 1999 and 2001. The measurements were made on dynamometer test facilities under simulated real-world drive cycles.

For cars, average fuel consumption factors were calculated from UK fleet-averaged CO_2 emission factors for different car vintages (years of production) provided by DfT (2004a) following consultation with the Society of Motor Manufacturers and Traders (SMMT). Their dependence on speed used the TRL-based speed relations for vehicles categorised into each Euro emission class described in a later section. Each year of car production and entry into service was associated with different Euro emission standards. In this case then, the average fuel consumption factors for each petrol and diesel car Euro standard are linked directly to the average CO_2 factors of cars entering new into the fleet from the information provided by DfT/SMMT and the TRL speed-related functions are used to define the variation, relative to the averaged value, in fuel consumption with speed and hence road type.

For HGVs, the DfT provide statistics from a survey of haulage companies on the average miles per gallon fuel efficiency of different sizes of lorries (DfT, 2008a). A time-series of mpg figures from 1989 to the current year is provided by the road freight statistics and these can be converted to g fuel per kilometre fuel consumption factors. The figures will reflect the operations of haulage companies in the UK in terms of vehicle load factor and typical driving cycles, e.g. distances travelled at different speeds on urban, rural and motorway roads. The TRL speed-related functions based on test cycle measurements of more limited samples of vehicles are then used to define the variation, relative to the averaged value, in fuel consumption with speed and hence road type in a similar way to the method used for cars.

For LGVs, buses and motorcycles, there are no additional statistics or datasets to use in conjunction with the research-based TRL speed-related functions. For these vehicles the inventory uses fuel consumption factors expressed as g fuel per kilometre for each vehicle type and road type calculated directly from the TRL equations grouped into Euro standards.

Average fuel consumption factors are shown in **Table A3.3.13** for cars, LGVs, buses and motorcycles, and respective Euro emission standard and road type in the UK. The different emission standards are described in a later section.

Table A3.3.14 presents the fleet-averaged fuel consumption factors for rigid and articulated HGVs from 1990-2007 for urban, rural and motorway conditions based on the road freight statistics for HGVs up to 2007 published in DfT (2008a); for 1993 onwards HGV fuel consumption figures have been revised in DfT (2008a) as a result of data quality improvements and methodological changes, leading to a change in the factors presented in this table compared with the corresponding figures in last year's version of the inventory.

Using a model to calculate total petrol and diesel consumption by combining these factors with relevant traffic data (discussed in Section A3.3.5.3.1.1), the figures are compared with BERR figures for total fuel consumption in the UK published in DUKES (adjusted for off-road consumption). A normalisation procedure is used to correct the figures for each vehicle class so that the total calculated fuel consumption adds up to the DUKES figures.

This normalisation process introduces uncertainties into the fuel consumption and hence CO_2 emission estimates for individual vehicle classes even though the totals for road transport are known with high accuracy.

Table A 3.3.13: Fuel Consumption Factors for Road Transport (in g fuel/km)

g fuel/km		Urban	Rural	Motorway
Petrol cars	ECE 15.04	59.4	49.5	58.4
	Euro I	58.3	51.9	60.5
	Euro II	58.1	54.8	66.2
	Euro III	54.6	51.4	62.2
	Euro IV	48.7	45.9	55.5
Diesel cars	Pre-Euro I	57.6	45.5	54.1
	Euro I	56.5	49.4	64.2
	Euro II	55.2	50.3	66.6
	Euro III	49.2	44.9	59.4
	Euro IV	44.7	40.8	54.0
Petrol LGVs	Pre-Euro I	65.1	54.2	87.9
	Euro I	82.1	73.2	96.4
	Euro II	86.8	77.8	102.6
	Euro III	82.8	74.2	97.8
	Euro IV	76.2	68.3	90.0
Diesel LGV	Pre-Euro I	84.0	84.0	122.3
	Euro I	83.8	72.4	117.1
	Euro II	84.8	73.2	118.5
	Euro III	77.9	67.3	108.9
	Euro IV	72.7	62.8	101.7
Buses	Pre-1988	399	178	229
	88/77/EEC	386	174	224
	Euro I	319	195	213
	Euro II	288	191	208
	Euro III	288	191	208
	Euro IV	279	185	202
	Euro V	271	179	196
Mopeds, <50cc, 2st	Pre-2000	25	25	25
	Euro I	11	11	11
	Euro II	11	11	11
Motorcycles, >50cc, 2st	Pre-2000	30.6	32.9	38.0
	Euro I	24.2	27.1	29.3
	Euro II	24.2	27.1	29.3
Motorcycles, >50cc, 4st	Pre-2000	30.9	30.0	36.9
	Euro I	26.9	27.2	33.3
	Euro II	26.9	27.2	33.3

Table A 3.3.14: Fuel Consumption Factors for HGVs (in g fuel/km) based on DfT's road freight statistics

g fuel/km	Rigid			Artic		
	Urban	Rural	Motorway	Urban	Rural	Motorway
1990	239	224	261	399	322	367
1991	244	227	266	398	321	366
1992	244	228	266	395	319	363
1993	234	219	255	373	303	345
1994	227	212	248	357	300	339
1995	231	216	252	340	296	330
1996	228	213	249	328	291	324
1997	226	211	247	323	292	323
1998	217	203	237	304	278	307
1999	222	207	242	304	281	309
2000	221	207	242	302	282	309
2001	231	216	253	305	286	313
2002	225	210	246	301	284	310
2003	234	219	256	305	287	314
2004	226	211	247	293	277	302
2005	222	207	242	289	273	298
2006	228	213	249	291	275	300
2007	234	219	256	295	280	305

For petrol, cars consume the vast majority of this fuel, so the DUKES figures provide a relatively accurate description of the trends in fuel consumption and CO_2 emissions by petrol cars. A small residual is consumed by petrol LGVs and motorcycles, so their estimates are susceptible to fairly high levels of uncertainty introduced by the normalisation process.

In order to provide a consistent comparison in the fuel consumption figures for petrol and diesel cars, the same normalisation factor (the relative adjustment necessary to bring the calculated petrol consumption in line with DUKES totals) derived for petrol cars was applied to diesel cars. The calculated fuel consumption for HGVs is also taken directly as implied by DfT's fuel efficiency statistics and are excluded from the normalisation process, so it is the calculated residual diesel consumption by LGVs and buses that are adjusted to bring the total diesel consumed to the same amount as reported in DUKES. This inevitably introduces uncertainties to the reported fuel consumption figures for these vehicle types.

Total CO_2 emissions from vehicles running on LPG are estimated on the basis of national figures (from BERR) on the consumption of this fuel by road transport. The CO_2 emissions from LPG consumption cannot be broken down by vehicle type because there are no figures available on the total number of vehicles or types of vehicles running on this fuel. This is unlike vehicles running on petrol and diesel where the DfT has statistics on the numbers and types of vehicles registered as running on these fuels. It is believed that many vehicles running on LPG are cars and vans converted by their owners and that these conversions are not necessarily reported to vehicle licensing agencies. It is for this same reason that LPG vehicle emission estimates are not possible for other pollutant types, because these would need to be based on traffic data and emission factors for different vehicle types rather than on fuel consumption. The LPG consumption figures from BERR suggest that in comparison with petrol and diesel, relatively small numbers of vehicles run on LPG.

Emissions from vehicles running on natural gas are not estimated at present, although the number of such vehicles in the UK is very small. Estimates are not made as there are no separate figures from BERR on the amount of natural gas used by road transport, nor are there useable data on the total numbers and types of vehicles equipped to run on natural gas.

A3.3.5.3.3 Traffic-based emissions

Emissions of the pollutants NMVOCs, NO_x, CO, CH_4 and N_2O are calculated from measured emission factors expressed in grammes per kilometre and road traffic statistics from the Department for Transport. The emission factors are based on experimental measurements of emissions from in-service vehicles of different types driven under test cycles with different average speeds. The road traffic data used are vehicle kilometre estimates for the different vehicle types and different road classifications in the UK road network. These data have to be further broken down by composition of each vehicle fleet in terms of the fraction of diesel- and petrol-fuelled vehicles on the road and in terms of the fraction of vehicles on the road made to the different emission regulations which applied when the vehicle was first registered. These are related to the age profile of the vehicle fleet in each year.

Emissions from motor vehicles fall into three different types, which are each calculated in a different manner. These are hot exhaust emissions, cold-start emissions and, for NMVOCs, evaporative emissions.

Hot exhaust emissions

Hot exhaust emissions are emissions from the vehicle exhaust when the engine has warmed up to its normal operating temperature. Emissions depend on the type of vehicle, the type of fuel its engine runs on, the driving profile of the vehicle on a journey and the emission regulations which applied when the vehicle was first registered as this defines the type of technology the vehicle is equipped with that affects emissions

For a particular vehicle, the drive cycle over a journey is the key factor that determines the amount of pollutant emitted. Key parameters affecting emissions are the acceleration, deceleration, steady speed and idling characteristics of the journey, as well as other factors affecting load on the engine such as road gradient and vehicle weight. However, work has shown that for modelling vehicle emissions for an inventory covering a road network on a national scale, it is sufficient to calculate emissions from emission factors in g/km related to the average speed of the vehicle in the drive cycle (Zachariadis and Samaras, 1997). Emission factors for average speeds on the road network are then combined with the national road traffic data.

Vehicle and fuel type

Emissions are calculated for vehicles of the following types:

- Petrol cars;
- Diesel cars;
- Petrol Light Goods Vehicles (Gross Vehicle Weight (GVW) ≤ 3.5 tonnes);
- Diesel Light Goods Vehicles (Gross Vehicle Weight (GVW) ≤ 3.5 tonnes);
- Rigid-axle Heavy Goods Vehicles (GVW > 3.5 tonnes);
- Articulated Heavy Goods Vehicles (GVW > 3.5 tonnes);
- Buses and coaches; and

- Motorcycles.

Total emission rates are calculated by multiplying emission factors in g/km with annual vehicle kilometre figures for each of these vehicle types on different types of roads.

Vehicle kilometres by road type

Hot exhaust emission factors are dependent on average vehicle speed and therefore the type of road the vehicle is travelling on. Average emission factors are combined with the number of vehicle kilometres travelled by each type of vehicle on rural roads and higher speed motorways/dual carriageways and many different types of urban roads with different average speeds and the emission results combined to yield emissions on each of these main road types:

- Urban;
- Rural single carriageway; and
- Motorway/dual carriageway.

DfT estimates annual vehicle kilometres for the road network in Great Britain by vehicle type on roads classified as trunk, principal and minor roads in built-up areas (urban) and non-built-up areas (rural) and motorways (DfT, 2008b). The DfT Report "Transport Statistics Great Britain" (DfT, 2008b) provides vehicle kilometres data up to 2007. Slight changes were made by DfT to the vehicle kilometres data for 2006 in the 2007 publication, but data for other years were not changed.

Vehicle kilometre data for Northern Ireland by vehicle type and road class were provided by the Department for Regional Development (DRD), Northern Ireland, Road Services (DRDNI, 2002, 2003, 2006, 2007, 2008a). These provided a consistent time-series of vehicle km data for all years up to 2007.

The Northern Ireland data have been combined with the DfT data for Great Britain to produce a time-series of total UK vehicle kilometres by vehicle and road type from 1970 to 2007.

The vehicle kilometre data were grouped into the three road types mentioned above for combination with the associated hot exhaust emission factors. **Table A 3.3.15** shows the time series in the UK vehicle kilometre data by vehicle and road type from 1990-2007.

Table A 3.3.15: UK vehicle km by road vehicles

billion vkm		1990	1995	2000	2001	2002	2003	2004	2005	2006	2007
Petrol cars	urban	143.0	139.7	139.2	138.7	140.1	136.2	133.8	129.8	127.6	124.9
	rural	138.5	128.3	127.4	127.4	127.2	124.6	122.7	118.6	117.1	113.4
	m-way	47.8	46.0	48.4	48.8	48.2	46.4	45.9	44.0	43.1	41.5
Diesel cars	urban	4.8	13.9	21.3	23.0	25.9	28.3	31.2	33.9	37.0	39.9
	rural	8.1	23.0	35.3	38.2	42.6	46.9	51.7	55.9	61.0	65.1
	m-way	4.2	11.9	19.1	20.8	23.0	24.9	27.7	29.8	32.3	34.3
Petrol LGVs	urban	11.1	7.7	4.3	3.7	3.0	2.6	2.3	1.9	1.9	1.7
	rural	11.4	8.3	4.7	4.1	3.6	3.1	2.7	2.3	2.3	2.2
	m-way	4.0	3.0	2.0	1.8	1.4	1.2	1.1	0.9	1.0	0.9
Diesel LGVs	urban	5.9	10.6	16.4	17.5	17.8	19.6	21.1	22.0	22.6	23.8
	rural	6.4	11.8	18.4	19.8	22.2	23.9	25.5	27.0	28.0	30.5
	m-way	2.0	4.1	7.6	8.3	8.5	9.1	10.0	10.5	11.1	11.7
Rigid HGVs	urban	4.7	4.4	4.2	4.2	4.1	4.3	4.4	4.3	4.2	4.0
	rural	7.5	7.0	7.6	7.6	8.1	8.3	8.2	8.2	8.3	8.5
	m-way	3.7	3.5	4.3	4.3	4.3	4.3	4.4	4.3	4.3	4.3
Artic HGVs	urban	1.1	1.1	1.1	1.1	1.0	1.0	1.1	1.0	1.0	1.0
	rural	4.3	5.1	5.6	5.6	5.3	5.3	5.3	5.3	5.5	5.6
	m-way	4.7	5.6	7.0	7.0	7.5	7.4	8.0	7.9	8.0	8.3
Buses	urban	2.4	3.0	3.0	3.0	3.0	3.2	3.2	3.2	3.3	3.4
	rural	1.7	1.5	1.6	1.6	1.8	1.8	1.6	1.5	1.6	1.8
	m-way	0.6	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.6	0.6
M/cycle	urban	3.3	1.9	2.2	2.4	2.6	3.1	2.8	3.0	2.7	3.2
	rural	2.0	1.6	2.0	2.1	2.1	2.2	2.1	2.2	2.1	2.2
	m-way	0.3	0.3	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4

Vehicle speeds by road type

The vehicle speed data used to calculate emission factors from the emission factor-speed relationships available for different pollutants were updated and applied to all previous years. Average speed data for traffic in a number of different areas were taken from the following main sources: Transport Statistics Great Britain (DfT, 2008b) provided averages of speeds in Central, Inner and Outer London surveyed at different times of day during 1990 to 2007. Speeds data from other DfT's publications such as 'Road Statistics 2006: Traffic, Speeds and Congestion' (DfT, 2007a) and 2008 national road traffic and speed forecasts (DfT, 2008c) were used to define speeds in other urban areas, rural roads and motorways. Where new information is not available, previous NAEI assumptions were maintained or road speed limits used for the vehicles expected to observe these on the type of road concerned. **Table A3.3.16** shows the speeds used in the 2007 inventory for light duty vehicles, HGVs and buses.

Table A 3.3.16: Average Traffic Speeds in Great Britain

		Lights kph	Heavies kph	Buses kph
URBAN ROADS				
Central London	Major principal roads	16	16	16
	Major trunk roads	24	24	16
	Minor roads	16	16	16
Inner London	Major principal roads	21	21	24
	Major trunk roads	32	32	24
	Minor roads	20	20	20
Outer London	Major principal roads	31	31	32
	Major trunk roads	46	46	32
	Minor roads	29	29	29
	Motorways	108	87	87
Connurbation	Major principal roads	31	31	24
	Major trunk roads	38	37	24
	Minor roads	30	30	20
	Motorways	97	82	82
Urban	Major principal roads	36	36	32
	Major trunk roads	53	52	32
	Minor roads	35	34	29
	Motorways	97	82	82
RURAL ROADS				
Rural single carriageway	Major roads	77	72	71
	Minor roads	61	62	62
Rural dual carriageway		111	90	93
Rural motorway		113	90	95

<u>Vehicle fleet composition: by age, technology and fuel type</u>

Vehicle kilometre data based on traffic surveys do not distinguish between the type of fuels the vehicles are being run on (petrol and diesel) nor on their age. DfT Vehicle Licensing Statistics (DfT, 2008d) provide number of vehicles licensed on the road by fuel type; this data has traditionally been used to split the vehicle kilometres data by fuel type. However, in the 2007 inventory, this information is combined with data on the relative mileage done by petrol and diesel cars (DfT, 2008e, pers comm). This indicates that diesel cars do on average 60% more annual mileage than petrol cars. The information originated from the National Travel Survey (DfT, 2007b). It has been assumed that the additional mileage done by diesel cars is mainly done on motorways and rural roads. On this basis, the petrol car/diesel car mix on urban roads is assumed to be that indicated by the population mix according to vehicle licensing data (i.e. that there is no preferential use of diesel or petrol cars on urban roads) and the mix on rural and motorways adjusted to give an overall mileage pattern over all roads in the UK that leads to an average 60% higher annual mileage by diesel cars compared with petrol cars. This leads to the vehicle km data for petrol and diesel cars on different road types shown in **Table A 3.3.15**.

In previous inventories, the same proportion of cars by engine size was used in the time series; however, the vehicle licensing statistics have shown that there has been a growing trend in the sales of bigger engine-sized cars in recent years, in particular for diesel cars. In the 2007 inventory, the proportion of cars by engine size varies from 2000 onwards based on the vehicle licensing data (DfT, 2008d). In addition, the relative mileage done by different size of vehicles was factored into the ratios, this is to take account of the fact that larger cars do more annual mileage than smaller cars (DfT, 2008e).

The age of a vehicle determines the type of emission regulation that applied when it was first registered. These have successively entailed the introduction of tighter emission control technologies, for example three-way catalysts and better fuel injection and engine management systems. **Table A3.3.17** shows the regulations that have come into force up to 2007 for each vehicle type.

The average age profile and the fraction of petrol and diesel cars and LGVs in the fleet each year are based on the composition of the UK vehicle fleet using DfT Vehicle Licensing Statistics. The Transport Statistics Bulletin "Vehicle Licensing Statistics: 2007" (DfT, 2008d) either gives historic trends in the composition of the UK fleet by age directly or provides sufficient information for this to be calculated from new vehicle registrations and average vehicle survival rates. Thus, year-of-first registration data for vehicles licensed in each year from 1990 to 2007 have been taken to reflect the age distribution of the fleet in these years. Statistics are also available on the number of new registrations in each year up to 2007, reflecting the number of new vehicles entering into service in previous years. The two sets of data combined allow an average survival rate to be determined for each type of vehicle. Particularly detailed information is available on the composition of the HGV stock by age and size. The age composition data are combined with data on the change in annual vehicle mileage with age to take account of the fact that newer vehicles on average travel a greater number of kilometres in a year than older vehicles. For cars and LGVs, such mileage by age data are from the National Travel Survey (DETR, 1998a); data for HGVs of different weights are taken from the Continuous Survey of Road Goods Transport (DETR, 1996a).

Separate vehicle licensing statistics for private and light goods vehicles (PLG) in Northern Ireland are available from the Central Statistics and Research Branch of the Department of Regional Development in Northern Ireland (DRDNI, 2008b). These show a higher proportion of diesel cars here than in Great Britain. Unlike other regional licensing statistics, it is more likely that these statistics reflect the actual fuel mix of cars on the road in Northern Ireland and so this information was used in the inventory.

Table A 3.3.17: Vehicles types and regulation classes

Vehicle Type	Fuel	Regulation	Approx. date into service in UK
Cars	Petrol	Pre ECE-15.00	
		ECE-15.00	1/1/1971
		ECE-15.01	1/7/1975
		ECE-15.02	1/7/1976
		ECE-15.03	1/7/1979
		ECE-15.04	1/7/1983
		91/441/EEC (Euro 1)	1/7/1992
		94/12/EC (Euro 2)	1/1/1997
		98/69/EC (Euro 3)	1/1/2001
		98/69/EC (Euro 4)	1/1/2006
	Diesel	Pre-Euro 1	
		91/441/EEC (Euro 1)	1/1/1993
		94/12/EC (Euro 2)	1/1/1997
		98/69/EC (Euro 3)	1/1/2001
		98/69/EC (Euro 4)	1/1/2006
LGVs	Petrol	Pre-Euro 1	
		93/59/EEC (Euro 1)	1/7/1994
		96/69/EEC (Euro 2)	1/7/1997
		98/69/EC (Euro 3)	1/1/2001 (<1.3t) 1/1/2002 (>1.3t)
		98/69/EC (Euro 4)	1/1/2006
	Diesel	Pre-Euro 1	
		93/59/EEC (Euro 1)	1/7/1994
		96/69/EEC (Euro 2)	1/7/1997
		98/69/EC (Euro 3)	1/1/2001 (<1.3t) 1/1/2002 (>1.3t)
		98/69/EC (Euro 4)	1/1/2006
HGVs and buses	Diesel (All types)	Pre-1988	
		88/77/EEC (Pre-Euro I)	1/10/1988
		91/542/EEC (Euro I)	1/10/1993
		91/542/EEC (Euro II)	1/10/1996
		99/96/EC (Euro III)	1/10/2001
		99/96/EC (Euro IV)	1/10/2006
Motorcycles	Petrol	Pre-2000: < 50cc, >50cc (2 st, 4st)	
		97/24/EC: all sizes (Euro 1)	1/1/2000
		2002/51/EC (Euro 2)	1/7/2004
		2002/51/EC (Euro 3)	1/1/2007

Assumptions are made about the proportion of failing catalysts in the petrol car fleet. For first-generation catalyst cars (Euro 1), it is assumed that the catalysts fail in 5% of cars fitted with them each year (for example due to mechanical damage of the catalyst unit) and that 95% of failed catalysts are repaired each year, but only for cars more than three years in age, when they first reach the age for MOT testing. Following discussions with DfT, a review of information from the Vehicle Inspectorate, TRL, the Cleaner Vehicles Task Force, industry experts and other considerations concerning durability and emission conformity requirements in in-service tests, lower failure rates are assigned to Euro 2, 3 and 4 petrol cars manufactured since 1996. The following failure rates are assumed in the inventory:

- Euro 1 5%
- Euro 2 1.5%
- Euro 3, 4 0.5%

The inventory takes account of the early introduction of certain emission and fuel quality standards and additional voluntary measures to reduce emissions from road vehicles in the UK fleet. The Euro 3 emission standards for passenger cars (98/69/EC) came into effect from January 2001 (new registrations). However, some makes of cars sold in the UK already met the Euro 3 standards prior to this (DfT, 2001). Figures from the Society of Motor Manufacturers and Traders suggested that 3.7% of new cars sold in 1998 met Euro 3 standards (SMMT, 1999). Figures were not available for 1999 and 2000, but it was assumed that 5% of new car sales met Euro 3 standards in 1999 increasing to 10% in 2000. In 2001, an assumption was made that 15% of all new petrol cars sold in the UK met Euro 4 standards, increasing to 81% in 2004 even though the mandatory date of introduction of this standard is not until 2006 (DfT, 2004b). The remaining new petrol car registrations in 2001 - 2005 would meet Euro 3 standards. From 2006, all new cars must fully comply with Euro 4 standards.

In January 2000, European Council Directive 98/70/EC came into effect relating to the quality of petrol and diesel fuels. This introduced tighter standards on a number of fuel properties affecting emissions. The principal changes in UK market fuels were the sulphur content and density of diesel and the sulphur and benzene content of petrol. The volatility of summer blends of petrol was also reduced, affecting evaporative losses. During 2000-2004, virtually all the diesel sold in the UK was of ultra-low sulphur grade (<50 ppmS), even though this low level sulphur content was not required by the Directive until 2005. Similarly, ultra-low sulphur petrol (ULSP) became on-line in filling stations in 2000, with around one-third of sales being of ULSP quality during 2000, the remainder being of the quality specified by the Directive. In 2001-2004, virtually all unleaded petrol sold was of ULSP grade (UKPIA, 2004). These factors and their effect on emissions were taken into account in the inventory. It is assumed that prior to 2000, only buses had made a significant switch to ULSD, as this fuel was not widely available in UK filling stations.

Freight haulage operators have used incentives to upgrade the engines in their HGVs or retrofit them with particle traps. DETR estimated that around 4,000 HGVs and buses were retrofitted with particulate traps in 2000, and this would rise to 14,000 vehicles by the end of 2005 (DETR, 2000). This was accounted for in the inventory for its effects on NO_x, CO and VOC emissions.

Detailed information from DVLA was used on the composition of the motorcycle fleet in terms of engine capacity (DfT, 2008d). The information was used to calculate the proportion of motorcycles on the road less than 50cc (i.e. mopeds), >50cc, 2-stroke and >50cc, 4-stroke.

Hot Emission Factors

The emission factors for all pollutants are currently in the process of being reviewed and updated.

For the direct Greenhouse Gases, the emission factors for N_2O for all vehicle types have been updated with the latest recommendation of the Emissions Inventory Guidebook (EEA, 2007) derived from the COPERT 4 methodology "*Computer Programme to Calculate Emissions from Road Transport*". For petrol cars and LGVs, emission factors are provided for different Euro standards and driving conditions (urban, rural, highway) with adjustment factors that take into account the vehicle's accumulated mileage and the fuel sulphur content; both of these tend to increase emission factors. For diesel cars and LGVs, bulk emission factors are provided for different Euro standards and road types, with no fuel and mileage effects. The factors for HGVs, buses and motorcycles are unchanged and make no distinction between different Euro standards and road types. **Table A 3.3.22** summarises the N_2O emission factor for all vehicle types and road conditions in mg/km; the factors for petrol cars and LGVs are shown for zero accumulated mileage, but the inventory takes account of the increase in emissions with mileage. For the latest Euro 3 and 4 cars, emission factors in urban areas increase by around 15% over 50,000km, while for rural and motorway conditions, emission factors increase by as much as 38% over this distance, though starting from a smaller base. N_2O emissions were considered to be a problem mainly with petrol cars fitted with three-way catalysts, being formed as a by-product on the catalyst surface during the NO_x reduction process. Previously, the inventory assumed that petrol car emission factors for all Euro standards from Euro 1-4 were the same and larger than those for pre-Euro 1 cars, leading to an increase in the N_2O inventory since the introduction of three-way catalysts in the 1990s. The latest compilation of emission factors now shows that emission factors have been declining with successive Euro standards since the first generation of catalysts for Euro 1, presumably due to better catalyst formulations as well as reductions in fuel sulphur content.

Road transport is a relatively unimportant emitter of methane, being only produced as a consequence of incomplete combustion, but largely controlled by catalysts on petrol vehicles. Emission factors were unchanged in the inventory this year and are shown in **Table A 3.3.20** in mg/km. Factors for pre-Euro I and/or Euro I standards for each vehicle type were taken from COPERT III (EEA, 2000) which provided either full emission factor-speed relationships or single average factors for urban, rural and highway roads. Methane emission factors for other Euro standards were scaled according to the ratio in the total hydrocarbon emission factors between the corresponding Euro standards (described below for NMVOC emissions). This assumes that methane emissions are changed between each successive Euro standard to the same extent as total hydrocarbons so that the methane fraction remains constant.

The uncertainties in the CH_4 and N_2O factors can be expected to be quite large. However, the emission factors used for different technologies, Euro standards and fuels are likely to reflect realistic trends.

Emission factors for NO_x were updated in this year's inventory following a major review and release of a new compilation of emission factors by TRL in a research programme for DfT

(Boulter et al, 2008). This review considered a wide range of pollutants, but the factors released by DfT were for consultation and have yet to be finalised in light of responses from this consultation. The emission factors for NO_x were, however, adopted for the 2007 inventory because of the urgent need to undertake some emissions mapping, forecasting and air quality modelling for this important air pollutant, even though there is a possibility the finalised figures may be altered slightly.

Emission factors for NO_x were provided for a more extensive range of vehicle types, sizes and Euro standards than had previously been available and were based on more up-to-date emission test data for in-service vehicles. The factors were presented as a series of emission factor-speed relationships for vehicles normalised to an accumulated mileage of 50,000 kilometres. Scaling factors were provided to take account of degradation in emissions with accumulated mileage – for some vehicle classes, emission factors actually improved with mileage, but most deteriorated. Scaling factors were also provided to take into account the effects of fuel quality since some of the measurements would have been made during times when available fuels were of inferior quality than they are now, particularly in terms of sulphur content. **Table A 3.3.24** summarises the NO_x emission factors for all vehicle types and road conditions in g/km normalised to zero accumulated mileage (i.e. corresponding to new vehicles) and current fuels. The inventory takes into account the change in emissions with mileage using the TRL functions and change in mileage with age data and uses the fuel scaling factors to take into account the prevailing fuel quality in different years. Note that the new TRL compilation lumps together emission factors for all the pre-Euro 1 classes of petrol cars that were previously separated. This would only affect the time-series trends in the 1970's and 1980's.

The emission factors used for CO and NMVOCs are the same as those used in last year's inventory. Factors used for pre-Euro I vehicles are based on data from TRL (Hickman, 1998) and COPERT II, "*Computer Programme to Calculate Emissions from Road Transport*" produced by the European Topic Centre on Air Emissions for the European Environment Agency (EEA, 1997). Both these sources provide emission functions and coefficients relating emission factor (in g/km) to average speed for each vehicle type and Euro emission standard derived by fitting experimental measurements to some polynomial functional form. Emission factors for Euro 1/I and Euro 2/II vehicles are based on speed-emission factor relationships derived by TRL from emission test programmes carried out in the UK (Barlow *et al*, 2001). The tests were carried out on in-service vehicles on dynamometer facilities under simulated real-world drive cycles. The factors for NMVOCs are actually based on emission equations for total hydrocarbons (THC), the group of species that are measured in the emission tests. To derive factors for non-methane VOCS, the calculated g/km factors for methane were subtracted from the corresponding THC emission factors.

The older in-service vehicles in the test surveys that were manufactured to a particular emission standard would have covered a range of different ages. Therefore, an emission factor calculated for a particular emission standard (e.g. ECE 15.04) from the emission functions and coefficients from TRL and COPERT II is effectively an average value for vehicles of different ages which inherently takes account of possible degradation in emissions with vehicle age. However, for the Euro 1 and 2 emission standards, the vehicles would have been fairly new when the emissions were measured. Therefore, based on data from the European Auto-Oil study, the deterioration in emissions with age or mileage was taken into account for catalyst cars. It was assumed that emissions of CO increase by 60% over 80,000 km, while emissions of NMVOCs increase by 30% over the same mileage (DETR, 1996b). Based on the average annual mileage of cars, 80,000 km corresponds to a time period of 6.15 years.

Due to lack of measured data, emission factors for Euro 3/III and 4/IV vehicles had been estimated by applying scaling factors to the Euro 2/II factors. The scale factors for light duty vehicles take into consideration the requirement for new vehicles to meet certain durability standards set in the Directives. Scaling factors were first estimated by considering how much emissions from Euro 2/II vehicles would need to be reduced to meet the Euro 3/III and 4/IV limit values taking account of the characteristics and average speed of the regulatory test cycles used for type-approval of the vehicle. It was then assumed that emissions from new vehicles would be a certain percentage lower than the limit value-derived figure when new so that the vehicle would not have emissions that degrade to levels higher than the limit value over the durability period of the vehicle set in the Directives. The emission degradation rates permitted for Euro 3 and 4 light duty vehicles by Directive 98/69/EC are as follows:

Table A 3.3.18: Emission Degradation rates permitted for Euro 3 and 4 Light-Duty Vehicles by Directive 98/69/EC

			Degradation rate
Petrol vehicles	HC and CO	Euro 3	x1.2 over 80,000km
		Euro 4	x1.2 over 100,000km
Diesel vehicles	CO	Euro 3	x1.1 over 80,000km
		Euro 4	x1.1 over 100,000km

For heavy-duty vehicles, the emission scaling factors were taken from COPERT III (EEA, 2000).

The speed-emission factor equations were used to calculate emission factor values for each vehicle type and Euro emission standard at each of the average speeds of the road and area types shown in **Table A1.3.16**. The calculated values were averaged to produce single emission factors for the three main road classes described earlier (urban, rural single carriageway and motorway/dual carriageway), weighted by the estimated vehicle kilometres on each of the detailed road types taken from DfT. **Table A 3.3.25 to 26** summarises the CO and NMVOC emission factor for all vehicle types and road conditions in g/km.

For many pollutant and vehicle types, both TRL and COPERT provide separate equations for different ranges of vehicle engine capacity or vehicle weight. Emission factors calculated from these equations were therefore averaged, weighted according to the proportion of the different vehicle sizes in the UK fleet according to vehicle licensing statistics, to produce a single average emission factor for each main vehicle type and road type. This is the basis of the emission factors seen in these tables.

Various other assumptions were applied to the emission factors, as follows.

The emission factors used for NMVOCs, NO_x and CO are already adjusted to take account of improvements in fuel quality for conventional petrol and diesel, mainly due to reductions in the fuel sulphur content of refinery fuels. An additional correction was also made to take account of the presence of biofuels blended into conventional fossil fuel. Uptake rates of biofuels were based on the figures from HMRC (2008) and it was assumed that all fuels were consumed as weak (typically 5%) blends with fossil fuel. The effect of biofuel (bioethanol and biodiesel) on exhaust emissions was represented by a set of scaling factors given by Murrells and Li (2008). A combined scaling factor was applied to the emission factors according to both the emission effects of the biofuel and its uptake rates each year. The effects are generally rather small for these weak blends.

For CO and NMVOC emissions from motorcycles, speed-dependent functions provided by TRL (Hickman, 1998) for different engine sizes were used. Prior to 2000, all motorcycles are assumed to be uncontrolled. It was also assumed that mopeds (<50cc) operate only in urban areas, while the only motorcycles on motorways are the type more than 50cc, 4-stroke. Otherwise, the number of vehicle kilometres driven on each road type was disaggregated by motorcycle type according to the proportions in the fleet. Motorcycles sold since the beginning of 2000 were assumed to meet the Directive 97/24/EC and their emission factors were reduced according to the factors given in COPERT III (EEA, 2000). Further stages in emission reductions occur for >50cc motorcycles first registered from July 2004 and January 2007 and are referred to as Euro 2 and Euro 3.

Account was taken of some heavy duty vehicles in the fleet being fitted with pollution abatement devices, perhaps to control particulate matter emissions (PM), or that otherwise lead to reductions in NO_x, CO and NMVOC emissions beyond that required by Directives. Emissions from buses were scaled down according to the proportion fitted with oxidation catalysts or diesel particulate filters (DPFs) and the effectiveness of these measures in reducing emissions from the vehicles. The effectiveness of these measures in reducing emissions from a Euro II bus varies for each pollutant and is shown in **Table A3.3.19**.

Table A 3.3.19: Scale Factors for Emissions from a Euro II Bus Running on Fitted with an Oxidation Catalyst or DPF

		NO_x	CO	NMVOCs
Oxidation catalyst	Urban	0.97	0.20	0.39
	Rural	0.95	0.22	0.55
DPF	Urban	0.90	0.17	0.19
	Rural	0.88	0.19	0.27

These scale factors based on data from LT Buses (1998).

Euro II HGVs equipped with DPFs have their emissions reduced by the amounts shown in **Table A3.3.20**.

Table A 3.3.20: Scale Factors for Emissions from a Euro II HGV Fitted with a DPF

		NO_x	CO	NMVOCs
DPF	Urban	0.81	0.10	0.12
	Rural	0.85	0.10	0.12

Cold-Start Emissions

When a vehicle's engine is cold it emits at a higher rate than when it has warmed up to its designed operating temperature. This is particularly true for petrol engines and the effect is even more severe for cars fitted with three-way catalysts, as the catalyst does not function properly until the catalyst is also warmed up. Emission factors have been derived for cars and LGVs from tests performed with the engine starting cold and warmed up. The difference between the two measurements can be regarded as an additional cold-start penalty paid on each trip a vehicle is started with the engine (and catalyst) cold.

The procedure for estimating cold-start emissions is taken from COPERT II (EEA, 1997), taking account of the effects of ambient temperature on emission factors for different vehicle technologies and its effect on the distance travelled with the engine cold. A factor, the ratio of cold to hot emissions, is used and applied to the fraction of kilometres driven with cold engines to estimate the cold start emissions from a particular vehicle type using the following formula:

$E_{cold} = \beta \cdot E_{hot} \cdot (e^{cold}/e^{hot} - 1)$
where

E_{hot}	= hot exhaust emissions from the vehicle type
β	= fraction of kilometres driven with cold engines
e^{cold}/e^{hot}	= ratio of cold to hot emissions for the particular pollutant and vehicle type

The parameters β and e^{cold}/e^{hot} are both dependent on ambient temperature and β is also dependent on driving behaviour in, particular the average trip length, as this determines the time available for the engine and catalyst to warm up. The equations relating e^{cold}/e^{hot} to ambient temperature for each pollutant and vehicle type were taken from COPERT II and were used with an annual mean temperature for the UK of 11^{o}C. This is based on historic trends in Met Office data for ambient temperatures over different parts of the UK.

The factor β is related to ambient temperature and average trip length by the following equation taken from COPERT II:

$\beta = 0.698 - 0.051 \cdot l_{trip} - (0.01051 - 0.000770 \cdot l_{trip}) \cdot t_a$
where

l_{trip}	= average trip length
t_a	= average temperature

An average trip length for the UK of 8.4 km was used, taken from Andre *et al* (1993). This gives a value for β of 0.23.

This methodology was used to estimate annual UK cold start emissions of NO_x, CO and NMVOCs from petrol and diesel cars and LGVs. Emissions were calculated separately for catalyst and non-catalyst petrol vehicles. Cold start emissions data are not available for heavy-duty vehicles, but these are thought to be negligible (Boulter, 1996).

All the cold start emissions are assumed to apply to urban driving.

Cold start emissions of N_2O have been estimated for the first time using a method provided by the COPERT 4 methodology for the Emissions Inventory Guidebook (EEA, 2007). The method is simpler in the sense that it uses a mg/km emission factor to be used in combination with the distances travelled with the vehicle not fully warmed up., i.e. under "cold urban" conditions. For petrol cars and LGVs, a correction is made to the cold start factor that takes into account the vehicle's accumulated mileage and the fuel sulphur content, in the same way as for the hot exhaust emission. The cold start factors in mg/km for N_2O emissions from light duty vehicles are shown in **Table A 3.3.21**. There are no cold start factors for HGVs and buses.

Table A 3.3.21: Cold Start Emission Factors for N_2O (in mg/km)

mg/km	Petrol cars	Petrol LGVs
Pre-Euro 1	10.0	10.0
Euro 1	34.0	43.4
Euro 2	23.7	55.0
Euro 3	11.6	20.9
Euro 4	6.1	15.6

Data for estimating cold start effects on methane emissions are not available and are probably within the noise of uncertainty in the hot exhaust emission factors. Cold start effects are mostly an issue during the warm up of three-way catalyst on petrol cars when the catalyst is not at its optimum efficiency in reducing hydrocarbon, NO_x and CO emissions, but without measured data, it would be difficult to estimate the effects on methane emissions. During this warm-up phase, one might expect higher methane emissions to occur, but as the catalyst is less effective in reducing methane emissions when fully warmed up compared with other, more reactive hydrocarbons on the catalyst surface, the cold start effect and the excess emissions occurring during the catalyst warm up phase is probably smaller for methane emissions than it is for the NMVOCs. As petrol cars contribute only 0.2% of all UK methane emissions, the effect of excluding potential and unquantifiable cold start emissions will be very small.

Evaporative Emission

Evaporative emissions of petrol fuel vapour from the tank and fuel delivery system in vehicles constitute a significant fraction of total NMVOC emissions from road transport. The procedure for estimating evaporative emissions of NMVOCs takes account of changes in ambient temperature and fuel volatility.

There are three different mechanisms by which gasoline fuel evaporates from vehicles:

i) Diurnal Loss

This arises from the increase in the volatility of the fuel and expansion of the vapour in the fuel tank due to the diurnal rise in ambient temperature. Evaporation through "tank breathing" will occur each day for all vehicles with gasoline fuel in the tank, even when stationary.

ii) Hot Soak Loss
This represents evaporation from the fuel delivery system when a hot engine is turned off and the vehicle is stationary. It arises from transfer of heat from the engine and hot exhaust to the fuel system where fuel is no longer flowing. Carburettor float bowls contribute significantly to hot soak losses.

iii) Running Loss
These are evaporative losses that occur while the vehicle is in motion.

Evaporative emissions are dependent on ambient temperature and the volatility of the fuel and, in the case of diurnal losses, on the daily *rise* in ambient temperature. Fuel volatility is usually expressed by the empirical fuel parameter known as Reid vapour pressure (RVP). For each of these mechanisms, equations relating evaporative emissions to ambient temperature and RVP were developed by analysis of empirically based formulae derived in a series of CONCAWE research studies in combination with UK measurements data reported by TRL. Separate equations were developed for vehicles with and without evaporative control systems fitted such as carbon canister devices. The overall methodology is similar to that reported by COPERT II (EEA, 1997), but the data are considered to be more UK-biased.

Evaporative emissions are calculated using monthly average temperature and RVP data. Using this information, evaporative emissions are calculated from the car fleet for each month of the year and the values summed to derive the annual emission rates. Calculating emissions on a monthly basis enables subtle differences in the seasonal fuel volatility trends and differences in monthly temperatures to be better accounted for. Monthly mean temperatures from 1970-2007 were used for the calculations based on Met Office for Central England (CET data). The monthly average, monthly average daily maximum and monthly average diurnal rise in temperatures were required. The monthly average RVP of petrol sold in the UK used historic trends data on RVP and information from UKPIA on the RVP of summer and winter blends of fuels supplied in recent years and their turnover patterns at filling stations (Watson, 2001, 2003). The average RVP of summer blends of petrol in the UK in 2007 was 68 kPa, 2kPa below the limit set by European Council Directive 98/70/EC for Member States with “arctic” summer conditions (UKPIA, 2008).

All the equations for diurnal, hot soak and running loss evaporative emissions from vehicles with and without control systems fitted developed for the inventory are shown in **Table A3.3.27**. The inventory uses equations for Euro 1 cars with “first generation” canister technology, based on early measurements, but equations taken from COPERT III leading to lower emissions were used for Euro 2-4 cars as these better reflected the fact that modern cars must meet the 2g per test limit on evaporative emissions by the diurnal loss and hot soak cycles under Directive 98/69/EC.

For **diurnal losses**, the equations for pre-Euro 1 (non-canister) and Euro 1 cars were developed from data and formulae reported by CONCAWE (1987), TRL (1993) and ACEA (1995). Equations for Euro 2-4 cars were taken from COPERT III. The equations specified in **Table A3.3.27** give diurnal loss emissions in g/vehicle.day for uncontrolled ($DL_{uncontrolled}$) and Euro 1 and Euro 2-4 canister controlled vehicles (DL_{EU1}, $DL_{EUII-IV}$). Total annual diurnal losses were calculated from the equation:

$E_{diurnal} = 365 \,.\, N \,.\, (DL_{uncontrolled} \,.\, F_{uncontrolled} + DL_{EU1} \,.\, F_{EUI} + DL_{EUII\text{-}IV} \,.\, F_{EUII\text{-}IV})$

where:

N	=	number of petrol vehicles (cars and LGVs) in the UK parc
$F_{uncontrolled}$	=	fraction of vehicles not fitted with carbon canisters, assumed to be the same as the fraction of pre-Euro 1 vehicles
F_{EUI}	=	fraction of Euro 1 vehicles in the fleet
$F_{EUII\text{-}IV}$	=	fraction of Euro 2-4 vehicles in the fleet

For **hot soak losses**, the equations were developed from data and formulae reported by CONCAWE (1990), TRL (1993) and COPERT II. The equations specified in **Table A3.3.27** give hot soak loss emissions in g/vehicle.trip for uncontrolled ($HS_{uncontrolled}$) and Euro 1 and Euro 2-4 canister controlled (HS_{EUI}, $HS_{EUII\text{-}IV}$) vehicles. Total annual hot soak losses were calculated from the equation:

$E_{hot\ soak} = (VKM/\ l_{trip}) \,.\, (HS_{uncontrolled} \,.\, F_{uncontrolled} + HS_{EU1} \,.\, F_{EUI} + HS_{EUII\text{-}IV} \,.\, F_{EUII\text{-}IV})$

where

VKM	=	total number of vehicle kilometres driven in the UK by the petrol vehicles (cars and LGVs)
ltrip	=	average trip length (8.4 km in the UK)

For **running losses**, the equations were developed from data and formulae reported by CONCAWE (1990) and COPERT II.

The equations specified in **Table A3.3.27** give running loss emissions in g/vehicle.km for uncontrolled ($RL_{uncontrolled}$) and canister controlled ($RL_{controlled}$) vehicles with no distinction made between Euro 1 and Euro 2-4 canister cars. Total annual running losses were calculated from the equation:

$E_{running\ loss} = VKM. \,(RL_{uncontrolled} \,.\, F_{uncontrolled} + RL_{controlled} \,.\, F_{controlled})$

where

$\mathbf{F_{controlled} = F_{EUI} + F_{EUII\text{-}IV}}$

Table A 3.3.22: N_2O Emission Factors for Road Transport (in mg/km)

mg/km	Standard	Urban	Rural	Motorway
Petrol cars	Pre-Euro 1	10.0	6.5	6.5
	Euro 1	21.3	13.8	6.9
	Euro 2	10.7	3.4	1.8
	Euro 3	1.4	0.6	0.5
	Euro 4	1.8	0.6	0.5
Diesel cars	Pre-Euro 1	0	0	0
	Euro 1	2	4	4
	Euro 2	4	6	6
	Euro 3	9	4	4
	Euro 4	9	4	4
Petrol LGVs	Pre-Euro 1	10.0	6.5	6.5
	Euro 1	22.0	13.8	6.9
	Euro 2	16.3	9.3	5.8
	Euro 3	10.5	4.6	4.6
	Euro 4	0.8	1.3	1.3
Diesel LGV	Pre-Euro 1	0	0	0
	Euro 1	2	4	4
	Euro 2	4	6	6
	Euro 3	9	4	4
	Euro 4	9	4	4
Rigid HGVs	Pre-1988	30	30	30
	88/77/EEC	30	30	30
	Euro I	30	30	30
	Euro II	30	30	30
	Euro III	30	30	30
	Euro IV	30	30	30
Artic HGVs	Pre-1988	30	30	30
	88/77/EEC	30	30	30
	Euro I	30	30	30
	Euro II	30	30	30
	Euro III	30	30	30
	Euro IV	30	30	30
Buses	Pre-1988	30	30	30
	88/77/EEC	30	30	30
	Euro I	30	30	30
	Euro II	30	30	30
	Euro III	30	30	30
	Euro IV	30	30	30
Mopeds, <50cc, 2st	Pre-Euro 1	1		
	Euro 1	1		
	Euro 2	1		
	Euro 3	1		
Motorcycles, >50cc, 2st	Pre-Euro 1	2	2	
	Euro 1	2	2	
	Euro 2	2	2	
	Euro 3	2	2	
Motorcycles, >50cc, 4st	Pre-Euro 1	2	2	2
	Euro 1	2	2	2
	Euro 2	2	2	2
	Euro 3	2	2	2

Table A 3.3.23: Methane Emission Factors for Road Transport (in mg/km)

mg/km	Standard	Urban	Rural	Motorway
Petrol cars	ECE 15.01	105	33	48
	ECE 15.02	106	33	49
	ECE 15.03	106	33	49
	ECE 15.04	85	26	39
	Euro 1	37	17	23
	Euro 2	26	11	7
	Euro 3	15	7	4
	Euro 4	12	5	3
Diesel cars	Pre-Euro 1	8	10	18
	Euro 1	4	5	11
	Euro 2	3	4	7
	Euro 3	2	2	5
	Euro 4	2	2	5
Petrol LGVs	Pre-Euro 1	150	40	25
	Euro 1	36	17	27
	Euro 2	22	11	18
	Euro 3	13	6	11
	Euro 4	10	5	8
Diesel LGV	Pre-Euro 1	5	5	5
	Euro 1	2	3	3
	Euro 2	2	3	3
	Euro 3	2	3	2
	Euro 4	1	1	1
Rigid HGVs	Pre-1988	241	91	79
	88/77/EEC	120	45	39
	Euro I	44	15	12
	Euro II	35	13	11
	Euro III	24	9	8
	Euro IV	17	6	6
Artic HGVs	Pre-1988	441	201	176
	88/77/EEC	175	80	70
	Euro I	187	97	96
	Euro II	154	86	92
	Euro III	108	60	64
	Euro IV	75	42	45
Buses	Pre-1988	722	330	289
	88/77/EEC	175	80	70
	Euro I	130	69	58
	Euro II	94	59	53
	Euro III	66	41	37
	Euro IV	46	29	26
Mopeds, <50cc, 2st	Pre-Euro 1	219		
	Euro 1	48		
	Euro 2	48		
	Euro 3	48		
Motorcycles, >50cc, 2st	Pre-Euro 1	150	150	
	Euro 1	104	107	
	Euro 2	40	41	
	Euro 3	14	14	
Motorcycles, >50cc, 4st	Pre-Euro 1	200	200	200
	Euro 1	84	79	59
	Euro 2	32	30	23
	Euro 3	11	11	8

Table A 3.3.24: NOx Emission Factors for Road Transport (in g/km)

g NOx (as NO2 eq)/km		Urban	Rural	Motorway
Petrol cars	Pre-Euro 1	1.376	1.808	2.389
	Euro 1	0.142	0.150	0.175
	Euro 2	0.168	0.175	0.215
	Euro 3	0.088	0.091	0.108
	Euro 4	0.030	0.028	0.029
Diesel cars	Pre-Euro 1	0.579	0.585	0.755
	Euro 1	0.459	0.468	0.649
	Euro 2	0.611	0.617	0.883
	Euro 3	0.618	0.617	0.790
	Euro 4	0.345	0.378	0.536
Petrol LGVs	Pre-Euro 1	1.338	1.860	2.538
	Euro 1	0.159	0.173	0.207
	Euro 2	0.118	0.108	0.146
	Euro 3	0.070	0.080	0.108
	Euro 4	0.024	0.019	0.017
Diesel LGV	Pre-Euro 1	1.659	1.719	2.269
	Euro 1	1.015	1.156	1.699
	Euro 2	1.251	1.456	2.194
	Euro 3	0.961	1.175	1.876
	Euro 4	0.404	0.494	0.789
Rigid HGVs	Pre-Euro I	8.314	8.002	8.686
	Euro I	5.535	5.374	5.810
	Euro II	5.831	5.571	5.978
	Euro III	4.596	4.267	4.587
	Euro IV	2.835	2.684	2.907
Artic HGVs	Pre-Euro I	15.156	13.283	14.143
	Euro I	10.614	9.331	9.935
	Euro II	10.961	9.610	10.236
	Euro III	8.728	7.582	8.072
	Euro IV	5.434	4.730	5.017
Buses & coaches	Pre-Euro I	21.426	10.110	10.167
	Euro I	13.368	7.583	7.609
	Euro II	14.138	8.206	8.243
	Euro III	13.423	6.529	6.589
	Euro IV	7.662	4.025	4.057
Mopeds, <50cc, 2st	Pre-Euro 1	0.030		
	Euro 1	0.030		
	Euro 2	0.010		
	Euro 3	0.010		
Motorcycles, >50cc, 2st	Pre-Euro 1	0.030	0.049	
	Euro 1	0.038	0.057	
	Euro 2	0.043	0.067	
	Euro 3	0.020	0.035	
Motorcycles, >50cc, 4st	Pre-Euro 1	0.237	0.377	0.615
	Euro 1	0.244	0.377	0.597
	Euro 2	0.138	0.244	0.514
	Euro 3	0.070	0.124	0.262

Table A 3.3.25: CO Emission Factors for Road Transport (in g/km)

g CO/km		Urban	Rural	Motorway
Petrol cars	ECE 15.01	18.85	11.84	14.26
	ECE 15.02	15.63	9.82	11.82
	ECE 15.03	16.40	10.30	12.41
	ECE 15.04	10.10	6.34	7.64
	Euro 1	1.02	0.98	2.84
	Euro 2	0.684	0.493	0.411
	Euro 3	0.637	0.459	0.383
	Euro 4	0.506	0.364	0.304
Diesel cars	Pre-Euro 1	0.647	0.430	0.399
	Euro 1	0.282	0.147	0.196
	Euro 2	0.233	0.072	0.072
	Euro 3	0.148	0.046	0.046
	Euro 4	0.148	0.046	0.046
Petrol LGVs	Pre-Euro 1	13.70	10.62	31.87
	Euro 1	2.064	1.245	1.401
	Euro 2	0.477	0.418	0.394
	Euro 3	0.444	0.389	0.367
	Euro 4	0.353	0.309	0.292
Diesel LGV	Pre-Euro 1	0.980	0.763	1.171
	Euro 1	0.453	0.510	0.909
	Euro 2	0.453	0.510	0.909
	Euro 3	0.288	0.324	0.578
	Euro 4	0.288	0.324	0.578
Rigid HGVs	Pre-1988	3.286	2.780	2.589
	88/77/EEC	2.526	2.137	1.990
	Euro I	1.427	1.216	1.178
	Euro II	1.156	0.977	0.910
	Euro III	0.802	0.678	0.631
	Euro IV	0.616	0.494	0.460
Artic HGVs	Pre-1988	3.830	3.278	3.269
	88/77/EEC	2.923	2.502	2.495
	Euro I	4.001	3.409	3.303
	Euro II	3.106	2.628	2.447
	Euro III	2.155	1.823	1.698
	Euro IV	1.657	1.328	1.237
Buses	Pre-1988	18.37	7.47	9.24
	88/77/EEC	8.159	3.319	4.102
	Euro I	2.541	1.135	1.100
	Euro II	2.106	0.916	0.853
	Euro III	1.461	0.636	0.592
	Euro IV	1.184	0.463	0.431
Mopeds, <50cc, 2st	Pre-Euro 1	23.81		
	Euro 1	2.38		
	Euro 2	2.38		
	Euro 3	2.38		
Motorcycles, >50cc, 2st	Pre-Euro 1	23.37	25.80	
	Euro 1	12.04	21.54	
	Euro 2	5.05	9.05	
	Euro 3	1.32	2.37	
Motorcycles, >50cc, 4st	Pre-Euro 1	20.81	22.20	30.83
	Euro 1	6.97	10.01	18.38
	Euro 2	2.93	4.21	7.72
	Euro 3	0.77	1.10	2.02

Table A 3.3.26: NMVOC Emission Factors for Road Transport (in g/km)

g VOCs/km		Urban	Rural	Motorway
Petrol cars	ECE 15.01	1.748	1.116	0.936
	ECE 15.02	1.764	1.126	0.945
	ECE 15.03	1.764	1.126	0.945
	ECE 15.04	1.416	0.904	0.758
	Euro 1	0.033	0.030	0.082
	Euro 2	0.024	0.021	0.024
	Euro 3	0.018	0.016	0.019
	Euro 4	0.018	0.015	0.018
Diesel cars	Pre-Euro 1	0.139	0.074	0.041
	Euro 1	0.070	0.039	0.026
	Euro 2	0.057	0.026	0.017
	Euro 3	0.042	0.019	0.013
	Euro 4	0.038	0.018	0.011
Petrol LGVs	Pre-Euro 1	1.356	0.735	0.812
	Euro 1	0.036	0.038	0.029
	Euro 2	0.022	0.025	0.019
	Euro 3	0.017	0.019	0.015
	Euro 4	0.016	0.018	0.014
Diesel LGV	Pre-Euro 1	0.270	0.137	0.146
	Euro 1	0.121	0.095	0.086
	Euro 2	0.121	0.095	0.086
	Euro 3	0.099	0.078	0.070
	Euro 4	0.052	0.041	0.037
Rigid HGVs	Pre-1988	3.350	2.872	2.779
	88/77/EEC	1.667	1.429	1.383
	Euro I	0.609	0.487	0.435
	Euro II	0.481	0.414	0.401
	Euro III	0.329	0.283	0.274
	Euro IV	0.243	0.198	0.192
Artic HGVs	Pre-1988	3.563	2.494	1.960
	88/77/EEC	1.415	0.990	0.778
	Euro I	1.509	1.205	1.063
	Euro II	1.244	1.067	1.021
	Euro III	0.850	0.729	0.698
	Euro IV	0.628	0.511	0.489
Buses	Pre-1988	5.252	1.915	1.806
	88/77/EEC	1.272	0.464	0.438
	Euro I	0.945	0.402	0.362
	Euro II	0.681	0.341	0.332
	Euro III	0.465	0.233	0.227
	Euro IV	0.461	0.163	0.159
Mopeds, <50cc, 2st	Pre-Euro 1	12.085		
	Euro 1	2.659		
	Euro 2	2.659		
	Euro 3	2.659		
Motorcycles, >50cc, 2st	Pre-Euro 1	9.370	8.129	
	Euro 1	6.484	5.796	
	Euro 2	2.464	2.203	
	Euro 3	0.843	0.753	
Motorcycles, >50cc, 4st	Pre-Euro 1	1.627	1.068	1.055
	Euro 1	0.686	0.424	0.313
	Euro 2	0.261	0.161	0.119
	Euro 3	0.089	0.055	0.041

Table A 3.3.27: Equations for diurnal, hot soak and running loss evaporative emissions from vehicles with and without control systems fitted

Emission factor	Units	Uncontrolled vehicle (pre-Euro I)
Diurnal loss ($DL_{uncontrolled}$)	g/vehicle.day	$1.54 * (0.51*T_{rise} + 0.62*T_{max} + 0.22*RVP - 24.89)$
Hot soak ($HS_{uncontrolled}$)	g/vehicle.trip	$exp(-1.644 + 0.02*RVP + 0.0752*T_{mean})$
Running loss ($RL_{uncontrolled}$)	g/vehicle.km	$0.022 * exp(-5.967 + 0.04259*RVP + 0.1773*T_{mean})$

Emission factor	Units	Carbon canister controlled vehicle (Euro I)
Diurnal loss (DL_{EUI})	g/vehicle.day	$0.3 * (DL_{uncontrolled})$
Hot soak (HS_{EUI})	g/vehicle.trip	$0.3 * exp(-2.41 + 0.02302*RVP + 0.09408*T_{mean})$
Running loss ($RL_{controlled}$)	g/vehicle.km	$0.1 * (RL_{uncontrolled})$

Emission factor	Units	Carbon canister controlled vehicle (Euro II-IV)
Diurnal loss ($DL_{EUII-IV}$)	g/vehicle.day	$0.2 * 9.1 * exp(0.0158*(RVP-61.2) + 0.0574*(T_{max}-T_{rise}-22.5) + 0.0614*(T_{rise}-11.7))$
Hot soak ($HS_{EUII-IV}$)	g/vehicle.trip	0
Running loss ($RL_{controlled}$)	g/vehicle.km	$0.1 * (RL_{uncontrolled})$

Where:

T_{rise} = diurnal rise in temperature in ^oC
T_{max} = maximum daily temperature in ^oC
T_{mean} = annual mean temperature in ^oC
RVP = Reid Vapour Pressure of petrol in kPa

A3.3.5.4 Navigation

The UK GHGI provides emission estimates for coastal shipping, naval shipping and international marine. Coastal shipping is reported within IPCC category 1A3dii National Navigation and includes emissions from diesel use at offshore oil & gas installations. A proportion of this diesel use will be for marine transport associated with the offshore industry but some will be for use in turbines, motors and heaters on offshore installations. Detailed fuel use data is no longer available to determine emissions from diesel use in fishing vessels, as the DTI gas oil dataset was revised in the 2004 inventory cycle. All emissions from fishing are now included within the coastal shipping sector, 1A3dii National Navigation.

The emissions reported under coastal shipping and naval shipping are estimated according to the base combustion module using the emission factors given in **Table A3.3.1**.

The NAEI category International Marine is the same as the IPCC category 1A3i International Marine. The estimate used is based on the following information and assumptions:

(i) Total deliveries of fuel oil, gas oil and marine diesel oil to marine bunkers are given in BERR (2008);

(ii) Naval fuel consumption is assumed to be marine diesel oil (MOD, 2008). Emissions from this source are not included here but are reported under 1A5 Other; and

(iii) The fuel consumption associated with international marine is the marine bunkers total minus the naval consumption. The emissions were estimated using the emission factors shown in **Table A3.3.1**.

Emissions from 1A3i International Marine are reported for information only and are not included in national totals. Bunker fuels data for shipping are provided to the BERR by UKPIA, and are based on sale of fuels to UK operators going abroad and overseas operators (assumed to be heading abroad) (DTI 2004, per. comm.[4]).

Emissions from navigation are based on emission factors for different types of shipping and a detailed examination of their activities in UK waters. In particular, detailed information on shipping emission factors has been used from the study done by Entec UK Ltd for the European Commissions (Entec, 2005) and from the more recent EMEP/CORINAIR Handbook (EMEP/CORINAIR, 2003).

Lloyds Marine Intelligence Unit (LMIU) publishes ship arrivals at UK ports by type and dead weight for four different vessel types: tankers, Ro-Ro ferry vessels, fully cellular container vessels and other dry cargo vessels. Fuel use between different vessel types has been apportioned on the basis of the vessels' main engine power as well as number of port arrivals. The main engine power for the Gross Registered Tonnage (GRT) groups used in the LMIU table was estimated. Then the product of vessel (type, GRT) port visits multiplied by the estimated main engine power was calculated and summed for each of the four vessel types. The distribution of total engine power summed over a year was then used to distribute the DUKES fuel consumption among the four vessel types.

Different engine types when fuelled with fuel oil, marine gas oil or marine diesel oil have different emission factors (kg pollutant emitted /tonne of fuel used). For NO_x and NMVOCs,

[4] DTI (2004) Personal communication from Martin Young, DTI.

it was possible to use data from the Entec study to produce a weighted mean emission factor for each of the four LMIU vessel types based on their average engine size and fuel type. Aggregated emission factors for the whole UK shipping activity were then calculated by weighting each vessel type's factor with the proportion of fuel consumed by each vessel type. Emissions of CH_4, CO and N_2O are not covered in the Entec report, so emission factors quoted in the Corinair handbook were used. Emissions of SO_2 are based on the fuel sulphur content and amount of each type of fuel used.

A3.3.6 Other Sectors (1A4)

The mapping of NAEI categories to 1A4 Other Sectors is shown in **Section A3.2**. For most sources, the estimation procedure follows that of the base combustion module using BERR reported fuel use data and emission factors from **Table A3.3.1**. The NAEI category public service is mapped onto 1A4a Commercial and Institutional. This contains emissions from stationary combustion at military installations, which should be reported under 1A5a Stationary. Also included are stationary combustion emissions from the railway sector, including generating plant dedicated to railways. Also included in 1A4 are emissions from the 'miscellaneous' sector, which includes emissions from the commercial sector and some service industries.

Emissions from 1A4b Residential and 1A4c Agriculture/Forestry/Fishing are disaggregated into those arising from stationary combustion and those from off-road vehicles and other machinery. The estimation of emissions from off-road sources is discussed in **Section A3.3.7.1** below. Emissions from fishing vessels are now included within the coastal shipping sector, due to the withdrawal of more detailed fuel use datasets that have historically been provided by BERR but are now determined to be of questionable accuracy.

A3.3.7 Other (1A5)

Emissions from military aircraft and naval vessels are reported under 1A5b Mobile. The method of estimation is discussed in **Sections A3.3.5.1** and **A3.3.5.4** with emission factors given **Table A3.3.1**. Note that military stationary combustion is included under 1A4a Commercial and Institutional due to a lack of more detailed data. Emissions from off-road sources are estimated and are reported under the relevant sectors, i.e. Other Industry, Residential, Agriculture and Other Transport. The methodology of these estimates is discussed in **Section A3.3.7.1**.

A3.3.7.1 Estimation of Other Off-Road Sources

Emissions are estimated for 77 different types of portable or mobile equipment powered by diesel or petrol driven engines. These range from machinery used in agriculture such as tractors and combine harvesters; industry such as portable generators, forklift trucks and air compressors; construction such as cranes, bulldozers and excavators; domestic lawn mowers; aircraft support equipment. In the NAEI they are grouped into four main categories:

- domestic house & garden
- agricultural power units (includes forestry)
- industrial off-road (includes construction and quarrying)
- aircraft support machinery.

The mapping of these categories to the appropriate IPCC classes is shown in **Section 3.2**. Aircraft support is mapped to Other Transport and the other categories map to the off-road vehicle subcategories of Residential, Agriculture and Manufacturing Industries and Construction.

Emissions are calculated from a bottom-up approach using machinery- or engine-specific emission factors in g/kWh based on the power of the engine and estimates of the UK population and annual hours of use of each type of machinery.

The emission estimates are calculated using a modification of the methodology given in EMEP/ CORINAIR (1996). Emissions are calculated using the following equation for each machinery class:

$$E_j = N_j . H_j . P_j . L_j . W_j.(1 + Y_j . a_j /2). e_j$$

where

E_j	=	Emission of pollutant from class j	(kg/y)
N_j	=	Population of class j.	
H_j	=	Annual usage of class j	(hours/year)
P_j	=	Average power rating of class j	(kW)
L_j	=	Load factor of class j	(-)
Y_j	=	Lifetime of class j	(years)
W_j	=	Engine design factor of class j	(-)
a_j	=	Age factor of class j	(y^{-1})
e_j	=	Emission factor of class j	(kg/kWh)

For petrol-engined sources, evaporative NMVOC emissions are also estimated as:

$$E_{vj} = N_j . H_j . e_{vj}$$

where

E_{vj}	=	Evaporative emission from class j	kg
evj	=	Evaporative emission factor for class j	kg/h

The population, usage and lifetime of different types of off-road machinery were updated following a study carried out by AEA Energy & Environment on behalf of the Department for Transport (Netcen, 2004a). This study researched the current UK population, annual usage rates, lifetime and average engine power for a range of different types of diesel-powered non-road mobile machinery. Additional information including data for earlier years were based on research by Off Highway Research (2000) and market research polls amongst equipment suppliers and trade associations by Precision Research International on behalf of the former DoE (Department of the Environment) (PRI, 1995, 1998). Usage rates from data published by Samaras *et al* (1993, 1994) were also used.

The population and usage surveys and assessments were only able to provide estimates on activity of off-road machinery for years up to 2004. These are one-off studies requiring intensive resources and are not updated on an annual basis. There are no reliable national statistics on population and usage of off-road machinery nor figures from the BERR on how these fuels, once they are delivered to fuel distribution centres around the country, are ultimately used. Therefore, other activity drivers were used to estimate activity rates for the four main off-road categories from 2005-2007. For industrial machinery, manufacturing output statistics were used to scale 2005-2007 activity rates relative to 2004; for domestic house and garden machinery, trends in number of households were used; for airport machinery, statistics on number of take-off and landings at UK airports were used.

The emission factors used came mostly from EMEP/CORINAIR (1996) though a few of the more obscure classes were taken from Samaras & Zierock (1993). The load factors were taken from Samaras (1996). Emission factors for garden machinery, such as lawnmowers and chainsaws were updated following a review by Netcen (2004b), considering the impact of Directive 2002/88/EC on emissions from these types of machinery.

Aggregated emission factors for the four main off-road machinery categories in 2007 are shown in **Table A3.3.28** by fuel type.

Table A 3.3.28 Aggregate Emission Factors for Off-Road Source Categories in 2007 (t/kt fuel)

Source	Fuel	C[2]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2[3]
Domestic House&Garden	DERV	863	0.165	1.358	49.87	4.5	2.7	0.030
Domestic House&Garden	Petrol	855	1.477	0.032	4.11	698.3	97.4	0.061
Agricultural Power Units	Gas Oil	870	0.156	1.271	33.94	16.0	5.9	2.67
Agricultural Power Units	Petrol	855	2.175	0.015	1.45	716.3	248.6	0.061
Industrial Off-road	Gas Oil	870	0.161	1.360	35.26	17.0	6.1	2.67
Industrial Off-road	Petrol	855	3.624	0.049	6.00	994.8	38.0	0.061
Aircraft Support	Gas Oil	870	0.165	1.293	33.35	12.5	4.8	2.67

1 Emission factors reported are for 2007
2 Emission factor as kg carbon/t, UKPIA (2004)
3 Based on sulphur content of fuels in 2007 from UKPIA (2008).

The emission factors used for carbon were the standard emission factors for DERV, gas oil and petrol given in **Table A3.3.1**.

A3.3.8 Fugitive Emissions From fuels (1B)

A3.3.8.1 Solid Fuels (1B1)

A3.3.8.1.1 Coal Mining

Emissions for IPCC categories 1B1ai Underground Mines-mining, 1B1ai Underground Mines-post-mining and 1B1aii Surface Mines are calculated from saleable coal production statistics reported by BERR (2008). Licensed mines referred to privately owned mines and were generally smaller and shallower than previously nationalised mines. The distinction was sufficiently marked to allow the use of a separate emission factor. Data on the shallower licensed mines are supplied by Barty (1995) up to 1994. Following privatisation, the distinction between licensed mines and deep mines no longer exists and all domestically produced coal that is not open-cast is assumed to be deep mined. For 1995, data from 1994 were used but in subsequent years the distinction has been abandoned. The emission factors used are shown in **Table A3.3.29**.

Table A 3.3.29: Methane Emission Factors for Coal Mining (kg/t coal)

Year	Deep Mined	Coal Storage & Transport[a]	Licensed Mine[c]	Open Cast[c]
1990	10.0[a]	1.16	1.36	0.34
1991	10.2[a]	1.16	1.36	0.34
1992	11.0[a]	1.16	1.36	0.34
1993	13.1[b,d]	1.16	1.36	0.34
1994	13.0[b,d]	1.16	1.36	0.34
1995	13.0[b,d]	1.16	1.36	0.34
1996	13.4[b,d]	1.16	1.36	0.34
1997	13.4[b,d]	1.16	1.36	0.34
1998	13.4[b]	1.16	-	0.34
1999	13.5[b]	1.16	-	0.34
2000	14.0[b]	1.16	-	0.34
2001	12.6[b]	1.16	-	0.34
2002	13.5[b]	1.16	-	0.34
2003	11.7[b]	1.16	-	0.34
2004	13.7[b]	1.16	-	0.34
2005	12.6[b]	1.16	-	0.34
2006	10.6[b]	1.16	-	0.34
2007	7.45[b]	1.16	-	0.34

[a] Bennet *et al* (1995)
[b] Factor based on UK Coal Mining Ltd data
[c] Williams (1993)
[d] Based on 1998 factor from UK Coal Mining Ltd. (in m^3/tonne) extrapolated back from 1998 to 1993 as no other data are available

The licensed and open cast factors are taken from Williams (1993). The deep mined factors for 1990 -1992 and the coal storage factor are taken from Bennet *et al* (1995). This was a study on deep mines which produced estimates of emissions for the period 1990-93. This was a period over which significant numbers of mines were being closed, hence the variation in emission factors. The emission factors for 1998-2004 are based on operator's measurements of the methane extracted by the mine ventilation systems. The mines surveyed cover around 90% of deep mined production. No time series data are available for 1993-97, so the 1998 factor was used. Methane extracted is either emitted to atmosphere or utilised for energy production. Methane is not flared for safety reasons. The factors reported in **Table A3.3.26** refer to emissions and exclude the methane utilised. The coal storage and transport factor is only applied to deep mined coal production.

The activity data for the coal mining emissions are reported in the CRF tables attached as a CD to this report. The number of active deep mines reported is defined as the number of mines producing at any one time during the period (Coal Authority, 2005). Hence, this would include large mines as well as small ones or those that only produced for part of the year. The colliery methane utilisation data are taken from BERR (2008).

Methane emissions from closed coal mines are accounted for within Sector 1B1a of the UK inventory, with estimates based on consultation with the author of a recent study funded by Defra (Kershaw, UK Coal, 2007).

The original study into closed coal mine emissions was conducted during 2005. The estimation method for both historic and projected methane emissions from UK coal mines comprised two separate sets of calculations to estimate emissions from (1) coal mines that had been closed for some years, and (2) methane emissions from mines that had recently closed or were forecast to close over 2005 to 2009. The 2005 study derived emission estimates for the years 1990 to 2050 using a relationship between emissions and the quantity of the underlying methane gas within the abandoned mine workings, including site-specific considerations of the most appropriate decay model for the recently closed mines. Consultation with the author has confirmed the actual mine closure programme in the UK and has thus provided updated estimates for 2005 and 2006. The emission calculations include estimates for the methane utilised or burned at collieries and other mitigating factors such as flooding of closed coal mines which reduces the source of methane gas over time.

Methane emissions from closed mines reach the surface through many possible flow paths: vents, old mine entries, diffuse emission through fractured and permeable strata. Direct measurement of the total quantity of gas released from abandoned mines is not practical. Emission estimates for 1990 to 2050 have been calculated using a relationship between emission and the quantity of the underlying methane gas within the abandoned mine workings.

Methane reserves have been calculated for all UK coalfields that are not totally flooded from 1990 with projections to 2050. The gas reserves are calculated by totalling all the gas quantities in individual seams likely to have been disturbed by mining activity. To enable calculation of the reserves over time, it has been necessary to calculate the rises in water levels in the abandoned mines due to water inflow. As workings become flooded they cease to release significant amounts of methane to the surface.

Monitoring has been carried out to measure methane emission from vents and more diffuse sources. Monitoring of vents involved measurement of the flows and concentrations of the gas flowing out of the mine. Monitoring of more diffuse sources required collection of long-term gas samples to measure any increases in background atmospheric methane level in the locality.

Methane flows measured by both methods showed a general increase with the size of the underlying gas reserve. The data indicated an emission of 0.74% of the reserve per year as a suitable factor to apply to the methane reserve data in order to derive methane emission estimates for abandoned UK coalfields for 1990 to 2050.

A3.3.8.1.2 Solid Fuel Transformation

Fugitive emissions from solid fuel transformation processes are reported in IPCC category 1B1b. The IPCC Revised 1996 Guidelines do not provide any methodology for such estimates, hence emissions are largely based on default emission factors. Combustion emissions from these processes have already been discussed in **Section A3.3.3**.

In a coke oven, coal is transformed into coke and coke oven gas. The coke oven gas is used as a fuel to heat the coke oven or elsewhere on the site. The coke may be used elsewhere as a fuel or as a reducing agent in metallurgical processes. A carbon balance is performed over the coke oven on the fuels input and the fuels produced as described in **Section A.3.3.1**.

Process emissions of other pollutants from coke ovens are estimated either on the basis of total production of coke or the coal consumed. Emission factors are given in **Table A3.3.30**.

Emissions of carbon from solid smokeless fuel production are calculated using a mass balance approach, described previously in Section A.3.3.1. A similar mass balance is carried out for SO_2. For emissions of other pollutants, a mass balance approach is not used. It is likely that emissions will arise from the combustion of the gases produced by some SSF retorts but this combustion is not identified in the energy statistics. Process emissions from SSF plant are estimated on the basis of total production of SSF. The emission factors used are given in **Table A3.3.30** and are based on US EPA (2008) factors for coke ovens. There are a number of processes used in the UK ranging from processes similar to coking to briquetting of anthracite dust and other smokeless fuels. Given the number of processes in use these estimates will be very uncertain.

Data are available on the production of SSF and the fuels used (BERR, 2008). It is clear that in recent years both coke and imported petroleum coke have been used in the production of smokeless fuels. Data on the total UK imports and exports of petroleum coke are available but little information is available on its consumption. In the GHGI, it is assumed that 245 kt *per annum* of petroleum coke were used in SSF production from 1990 to 1998 based on data provided within DUKES (DTI, 1999). For 1999-2006 approximate estimates based on data provided in later versions of DUKES are used, with petroleum coke known to be burnt by other sectors subtracted from the DUKES figures. The data for 1999 onwards are believed to be more accurate than the earlier data, and are considerably lower as well. Further development of the petroleum coke activity data would be desirable.

The carbon content of the petroleum coke consumed is not included in the SSF carbon balance – instead it is allocated to the domestic sector as a separate fuel. Coke used by SSF manufacturers is assumed to be burnt as a fuel and is also not included in the carbon balance. The model used is not entirely satisfactory but further information would be required before a more accurate carbon balance could be developed.

Emissions from the combustion of fuels to heat the smokeless fuel retorts are reported under 1A1ci Manufacture of Solid Fuels, however process emissions and the residual carbon emission discussed above are considered to be fugitives and are reported under 1B1b Solid Fuel Transformation.

Table A 3.3.30: Emission Factors Used for Coke and Solid Smokeless Fuel Production

	Units	CH_4	CO	NO_x	SO_2	NMVOC
Coke	kt/Mt coke made	0.0802[a]	2.22[c]	-	1.77[c]	0.0261[e]
Coke	kt/Mt coal consumed	-	-	0.02[b]		-
SSF	kt/Mt SSF made	0.0802[a]	0.0156[c]	0.0236[c]	-	0.0178[a]
SSF	kt/Mt coal consumed	-	-	-	5.957[d]	-

a EIPPCB, (2000)
b USEPA (2004)
c Factor for 2006 based on Environment Agency (2007)
d Based on mass balance but zero for 2002 (because calculated sulphur content of SSF produced was higher than the sulphur content of coal used to make the SSF).
e Derived from benzene emission factor assuming a VOC/benzene ratio of 3.9:2.195, which is based on emission factors suggested by Corus, 2000

A3.3.8.2 Oil and Natural Gas (1B2)

The emissions reported in this sector pertain to the offshore platforms and onshore terminals on the UK Continental Shelf Area and represented by the Oil and Gas UK trade association (formerly UKOOA).

Data Source: The EEMS Reporting System, (1995 onwards)

Emission estimates for the offshore oil & gas industry are based on data provided by the UK regulatory agency (the Department of Energy & Climate Change), called the Environmental Emissions Monitoring System (EEMS). The EEMS system has been developed by DECC and the trade organisation, Oil and Gas UK (formerly UKOOA). This system provides a detailed inventory of point source emissions estimates, based on operator returns for the years 1995-2007. Additional data on CO_2 emissions from some offshore combustion processes has become available via the National Allocation Plan and annual operator emission estimates for sites participating in the EU Emission Trading Scheme. In recent years these EU ETS data have been used by operators to update their EEMS emission estimates for combustion processes, ensuring consistency between EEMS and EU ETS, and by the Inventory Agency as a useful Quality Check on time-series consistency of carbon emission factors.

Development of the EEMS Quality Assurance System

The EEMS dataset continues to develop in quality; the quality system in place, developed by the regulatory body (DECC) in conjunction with the trade association (UK Oil & Gas), is now based on an online reporting system with controls over data entry, together with guidance notes provided to operators to provide estimation methodology options and emission factors for specific processes. The online reporting system was introduced for the 2006 data submission, and several glitches in the system were evident during the compilation of the 1990-2006 GHGI. Many of these issues have now been resolved by the DECC oil & gas team of regulators, although in the latest dataset from plant operators there remain some gaps in reported emissions for 2006 and 2007. This indicates that the EEMS reporting quality system requires further development to ensure that operators report a consistent and comprehensive series of emissions data, with time-series consistency a key factor. Where a site intermittently reports emissions from a specific process source, these gaps ought to be identified and rectified “at source”. The inventory agency has worked through many of the data inconsistencies in the EEMS dataset with the DECC team, to identify where gaps in data provision require provisional estimates to be used for the UK GHGI reporting system.

Reference Sources for Emission Estimates, 1990-1995

For years prior to 1995 (i.e. pre-EEMS), emission totals are based on an internal Oil and Gas UK summary report produced in 1998. The 1990-1994 detailed estimates are based on (1) total emission estimates and limited activity data (for 1990-1994) from the 1998 UKOOA summary report, and (2) the detailed split of emissions from the 1997 EEMS dataset.

The 1998 UKOOA report presents data from detailed industry studies in 1991 and 1995 to derive emission estimates for 1990 from available operator estimates. Emission estimates for 1991-1994 are then calculated using production-weighted interpolations. Only limited data are available from operators in 1990-1994, and emission totals are only presented in broadly aggregated sectors of: drilling (offshore), production (offshore), loading (offshore) and total emissions onshore. Estimates of the more detailed oil & gas processing source sectors for 1990-1994 are therefore based on applying the fraction of total emissions derived from the 1997 data from EEMS (as gaps and inconsistencies within the 1995 and 1996 datasets indicate that these early years of the EEMS dataset are somewhat unreliable).

Other Data Sources: Onshore Terminal Emissions

Emission estimates for onshore oil and gas terminals are also based on annual emissions data reported by process operators under the EEMS system, regulated by DECC. These onshore sites also report emissions data to the UK environmental regulatory agencies (the Environment Agency of England & Wales and the Scottish Environmental Protection Agency) under IPC/IPPC regulations. Emissions data for Scottish plant are available for 2002 and 2004 onwards, whilst in England & Wales the Pollution Inventory of the EA holds emissions data from industrial plant from around 1995 onwards. For some terminals, occasional data gaps are evident in the EEMS data, most notably for methane and NMVOC emissions from oil loading activities. In these instances, the emission estimates reported under IPC/IPPC are used to provide an indication of the level of emissions in that year, but the longer time-series of the EEMS data for Scottish sites has led the Inventory Agency to use the EEMS data as the primary data source for these terminals.

UK GHGI Compilation: Method Development and Quality Control

For the EEMS reporting cycle for 2006 data, a new online system of operator reporting was implemented by DECC. However, due to complications with this new system the operator emissions data provided to the Inventory Agency was incomplete for several sources including drilling and well testing (all activity data and emissions data), onshore loading (missing NMVOC emissions for several sites), onshore fugitive emission sources (missing methane data for some sites), and onshore own gas use data (CO_2 emissions for some sites).

In the 2007 dataset, many of these problems had been resolved, as the DECC Oil & Gas team of regulators had engaged with several operators to identify and resolve reporting gaps and inconsistencies. However, one or two non-reporting sites for some sources were still evident.

To resolve these data gaps, the Inventory Agency agreed the following actions with DECC (Furneaux, 2008):

- Onshore loading: Two sites had omitted to report in 2007, and data were extrapolated from earlier years;

- Onshore Fugitive sources: Several sites had omitted to report the quite minor fugitive emissions data estimates in 2007, and all of these were estimated based on extrapolation of previous data and comparison against PI/SPRI data;
- Onshore Own Gas use: One site had omitted to report in 2007, and data were extrapolated from previous years.

Some significant revisions to emissions data reporting have been made in the 1990-2007 data compilation, following discussion with the DECC Oil & Gas team, and the DECC Energy Statistics team.

There are two reporting systems from upstream oil & gas processing in the UK; the EEMS system provides emissions data to the DECC Oil & Gas team, whilst the Petroleum Processing Reporting System (PPRS) is used to report data to the DECC Energy Statistics team as part of the wider system of regulation of oil & gas extraction and production permitting system. These data reported via the PPRS include data on gas flaring & venting volumes at offshore and onshore installations, and have previously been used as the “activity data” within the UK GHGI. The EEMS system meets an environmental emissions reporting requirement, whilst the PPRS meets other regulatory licensing reporting requirements. Whilst the two systems might be expected to reflect similar trends in activities, where reported activities coincide (such as gas flaring and venting), consultation with the DECC teams has indicated that the two systems are largely independent.

Further to this, the development of the EEMS dataset has enabled greater access to reported activity data that have been used to calculate the emissions. These EEMS-derived activity data enable greater analysis of the oil & gas emissions and related emission factors.

In the compilation of the 1990-2007 inventory data, where previously the EEMS emissions were reported alongside the PPRS activity data (e.g. in the case of gas flaring and venting), the EEMS-derived activity data are now used. In most cases, this has led to an improvement in data transparency and easier query of Implied Emission Factor trends. However, the EEMS activity data are only available back to 1997. Where necessary, therefore, the activity data back to 1990 have been extrapolated using the PPRS time-series to provide the indicative trend.

Data Reconciliation with UK Energy Statistics Across Reporting Categories

The data reported from the EEMS system must be reconciled with the UK Energy Statistics and integrated into the NAEI without double-counting emissions. The diesel oil consumption by offshore installations is not reported separately in the UK Energy Statistics but is included under coastal shipping. In order to avoid double counts, the Oil and Gas UK estimates have been corrected to remove diesel oil emissions.

In the NAEI, offshore emissions are estimated in the following categories each with its own methodology:

- Offshore flaring
- Offshore Oil & Gas (well testing)
- Offshore Oil & Gas (venting)
- Offshore Oil & Gas Process Emissions (including fugitive emissions)

- Offshore Loading
- Onshore Loading
- Oil Terminal Storage
- Offshore own gas use (reported under 1A1c Other Energy Industries)
- Gas Separation Plant (Combustion) (reported under 1A1c Other Energy Industries)

The mapping of these sources to IPCC categories is described in **Section A3.2**. Activity data are reported in the CRF Background Table 1B2, however in most cases these data are not used to calculate the emissions, but are provided for comparison with other inventories.

A3.3.8.2.1 Offshore Flaring

This includes flaring from offshore platforms and onshore terminals. Flaring emission data for CO_2, SO_2, NO_x, CO, NMVOC, and CH_4 are taken from the EEMS dataset (DECC, 2008). Data from 1995-2007 are based on detailed operator returns, whilst 1990-1994 data are calculated from extrapolation of total emissions data and the use of 1997 data splits between sources. N_2O emissions are based on operator information from 1999-2007, and on emission factors and production throughput data for 1990-1998.

The activity data and implied emission factors are given in **Table A3.3.31**. The implied emission factors for 1997-2007 are reported as kg pollutant per kg gas flared and are calculated from emissions and activity data reported annually by operators via the EEMS reporting system. The data for 1990-1996 are estimated based on reported emission totals and extrapolated activity data.

Table A 3.3.31: Activity Data & Implied Emission Factors: Offshore Flaring

	Activity Data	CO_2	CH_4	NO_x	CO	NMVOC	SO_2	N_2O
	ktonnes	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg	kg/kg
2007	1657	2.56	0.0095	0.0012	0.0067	0.0080	0.00011	0.00008
2006	1539	2.54	0.0099	0.0013	0.0068	0.0072	0.00013	0.00008
2005	1773	2.59	0.0093	0.0013	0.0067	0.0078	0.00015	0.00008
2004	1556	2.60	0.0097	0.0013	0.0067	0.0068	0.00021	0.00008
2003	1506	2.64	0.0102	0.0013	0.0068	0.0067	0.00016	0.00008
2002	1736	2.64	0.0097	0.0016	0.0068	0.0070	0.00015	0.00008
2001	1890	2.63	0.0099	0.0013	0.0066	0.0070	0.00022	0.00008
2000	1928	2.50	0.0108	0.0012	0.0064	0.0063	0.00019	0.00008
1999	1890	2.66	0.0107	0.0016	0.0069	0.0078	0.00028	0.00009
1998	2092	2.69	0.0107	0.0014	0.0070	0.0090	0.00014	0.00008
1997	2080	2.69	0.0107	0.0015	0.0073	0.0090	0.00013	0.00008
1996	2308	2.45	0.0105	0.0014	0.0075	0.0097	0.00013	0.00008
1995	2272	2.46	0.0103	0.0014	0.0075	0.0098	0.00014	0.00008
1994	2164	2.18	0.0100	0.0012	0.0083	0.0117	0.00006	0.00007
1993	2034	2.19	0.0107	0.0013	0.0085	0.0123	0.00006	0.00007
1992	1905	2.19	0.0125	0.0013	0.0087	0.0129	0.00006	0.00007
1991	1775	2.18	0.0133	0.0014	0.0089	0.0135	0.00006	0.00007
1990	1796	2.18	0.0139	0.0014	0.0089	0.0129	0.00006	0.00007

Flaring is reported under 1B2ciii Flaring – Combined, since many of the platforms produce both oil and gas. An estimate of NMVOC emissions from refinery flares is reported in 1B2ci Venting and Flaring: Oil. This is based on estimates supplied by UKPIA (2008).

A3.3.8.2.2 Offshore Own Gas Use

This refers to the use of unrefined natural gas on offshore platforms and onshore terminals as a fuel in heaters, boilers, turbines and reciprocating engines. Gas combustion emission data for CO_2, SO_2, NO_x, CO, NMVOC, and CH_4 are taken from the EEMS dataset (DECC, 2008). Data from 1995-2007 are based on detailed operator returns, whilst 1990-1994 data are calculated from extrapolation of total emissions data and the use of 1995 data splits between sources. N_2O emissions are based on operator information from 1999-2007, and on emission factors and production throughput data for 1990-1998.

The activity data and implied emission factors are given in **Table A3.3.32**. The implied emission factors for 1990-2007 are reported as tonne pollutant per Mtherm gas used and are calculated from the emissions data reported within the EEMS dataset, and the activity data reported as "Producer's Own Use" within the Digest of UK Energy Statistics.

Table A 3.3.32: Activity Data & Implied Emission Factors: Offshore Own Gas Use

	Activity Data	CO_2	CH_4	NO_x	CO	NMVOC	SO_2	N_2O
	Mth	kt/Mth	t/Mth	t/Mth	t/Mth	t/Mth	t/Mth	t/Mth
2007	2228	6.37	2.55	18.54	6.87	0.19	0.15	0.45
2006	2393	5.65	2.33	17.73	6.27	0.18	0.20	0.45
2005	2531	6.15	2.91	20.51	6.90	0.30	0.15	0.49
2004	2653	6.21	3.08	19.90	6.83	0.31	0.16	0.49
2003	2622	6.40	2.88	19.31	6.97	0.24	0.21	0.51
2002	2708	6.50	3.08	20.62	6.85	0.26	0.20	0.58
2001	2677	6.39	2.89	15.59	6.93	0.24	1.15	0.51
2000	2237	7.26	3.10	18.42	7.80	0.24	1.45	0.59
1999	2205	7.27	3.49	19.03	7.82	0.30	1.88	0.55
1998	2235	7.15	3.49	19.03	7.82	0.30	0.33	0.55
1997	1989	8.03	3.49	19.03	7.82	0.30	0.33	0.55
1996	1906	8.03	3.49	19.03	7.82	0.30	0.33	0.55
1995	1680	8.03	3.49	19.03	7.82	0.30	0.33	0.55
1994	1647	8.03	3.49	19.03	7.82	0.30	0.33	0.55
1993	1388	8.03	3.49	19.03	7.82	0.30	0.33	0.55
1992	1314	8.03	3.49	19.03	7.82	0.30	0.33	0.55
1991	1235	8.03	3.49	19.03	7.82	0.30	0.33	0.55
1990	1188	8.03	3.49	19.03	7.82	0.30	0.33	0.55

These emissions apply to the mixture of methane, ethane, propane and butane used. In the NAEI database they are reported in the categories:

- Offshore own gas use: natural gas;
- Gas separation plant: LPG; and
- Gas separation plant: OPG.

Emissions are reported under 1A1cii Other Energy Industries.

A3.3.8.2.3 Well Testing

This activity involves the combustion of crude oil and crude gas during well testing, and is an activity that is not recorded within the Digest UK Energy Statistics. Combustion emission data for CO_2, SO_2, NO_x, CO, NMVOC, and CH_4 are taken from the EEMS dataset (DECC, 2008). Activity data (tonnes fuel burnt) are also now available from the EEMS dataset for 1998 onwards, whilst the activity data for 1990-1997 has been estimated, based on the assumption that the Carbon emission factor remains constant back to 1990. This revised approach is more transparent for the assessment of implied emission factors for 1998 onwards, as the previous approach compared emissions against “numbers of wells explored” which is a poor parameter to use to represent gas and oil consumption during well testing. This new approach does create new “estimated” activity data for 1990-1997, but the emissions data are unchanged (as there is no new data on emissions during 1990-1997) and overall the method change is considered an improvement. This new approach has also helped to identify possible inconsistencies in emissions data within the earlier years of the time-series, most notably for emissions of SO_2 during 1990-1997 and for N_2O during 1990-1994. Further enquiries with DECC and Oil & Gas UK may enable further improvements to these emission trends in the next inventory cycle.

Emissions data from 1995-2007 are based on operator returns, whilst 1990-1994 data are calculated from extrapolation of total emissions data and the use of 1997 data splits between sources. N_2O emissions are based on operator information from 1999-2007, and on emission factors and production throughput data for 1990-1998. The 2006 dataset has been completely revised since the previous inventory submission.

The activity data and implied emission factors are given in **Table A3.3.33**.

Well testing is reported under 1B2a Oil Production since many of the wells produce oil and gas.

Table A 3.3.33: Activity Data and Implied Emission Factors: Well Testing

	Activity Data	**CO_2**	**SO_2**	**NO_x**	**CO**	**NMVOC**	**CH_4**	**N_2O**
	ktonnes	**kt/kt**	**t/kt**	**t/kt**	**t/kt**	**t/kt**	**t/kt**	**t/kt**
2007	25.7	2.82	44.0	3.59	7.27	6.02	0.013	0.075
2006	29.2	2.82	25.9	2.92	7.27	19.2	0.012	0.072
2005	40.3	3.00	34.8	2.47	12.5	15.2	0.013	0.081
2004	43.3	2.94	38.0	2.07	10.6	12.0	0.013	0.081
2003	45.1	2.96	37.2	2.17	11.1	12.8	0.013	0.081
2002	48.3	3.05	32.7	2.73	13.6	17.3	0.013	0.081
2001	35.3	3.07	31.4	2.90	14.4	18.6	0.013	0.081
2000	44.7	3.09	30.5	3.01	14.9	19.5	0.013	0.081
1999	70.4	3.01	34.4	2.52	12.7	15.6	0.013	0.081
1998	218.7	2.94	34.4	2.59	13.3	14.1	0.013	0.081
1997	211.6	2.94	34.8	2.59	13.3	15.0	29.9	0.081
1996	210.3	2.94	36.9	2.74	14.1	15.8	31.6	0.085
1995	201.1	2.94	34.8	2.59	13.3	14.9	29.8	0.081
1994	554.2	2.94	11.2	17.9	10.4	6.09	14.2	0.029
1993	521.0	2.94	11.9	19.1	10.6	6.37	14.7	0.029

	Activity Data	CO_2	SO_2	NO_x	CO	NMVOC	CH_4	N_2O
	ktonnes	kt/kt	t/kt	t/kt	t/kt	t/kt	t/kt	t/kt
1992	487.9	2.94	14.0	20.4	10.9	6.68	15.2	0.029
1991	454.7	2.94	14.9	22.0	67.7	7.04	15.9	0.029
1990	459.9	2.94	15.7	22.0	11.2	6.73	15.9	0.029

A3.3.8.2.4 Other Emissions from Offshore Platforms and Onshore Terminals

These include emissions from offshore platforms and onshore terminals, including the following sources:

- Gas Venting (CO_2 CH_4, NMVOC estimates only);
- Fugitive emissions (CO_2 CH_4, NMVOC estimates only);
- Direct process emissions, such as acid gas stripping plant at terminals (CO_2, NO_x, SO_2, CO, CH_4, NMVOC);
- Storage vessel emissions from the storage of crude oil at terminals (CH_4, NMVOC estimates only).

Emissions data are taken from the EEMS dataset (DECC, 2008) and previous industry studies by Oil & Gas UK (1998). Data from 1995-2007 are based on detailed operator returns, whilst 1990-1994 data are calculated from extrapolation of total emissions data and the use of 1997 data splits between sources.

Note that there are no "activity data" for these activities available from DECC or UK Oil & Gas, and hence the method used in the compilation of the UK GHGI is merely to compile the sum of the operator emissions reported via the EEMS system, and report the emissions against an activity data of "1".

Gaps in reported fugitive & storage tank emissions by certain operators and sites are evident in recent years, and where possible, data have been extrapolated from previous years to provide estimates to fill these gaps. There have also been some significant changes in activities at some sites that have led to notable emission reductions in recent years, including: Reductions in direct process emissions of SO_2 have been achieved at the Elgin PUQ platform, due to a change to venting acid gases rather than flaring them.

In 2007, large reductions in NO_x emissions from the acid gas removal system have been achieved at the SAGE – St Fergus terminal.

These other emissions from platforms and terminals are reported in the following NAEI categories, all mapped to 1B2a Oil ii Production: offshore oil & gas (fugitive and process emissions), offshore venting and oil terminal storage. It is not possible to split oil and gas production emissions since oil and gas are frequently produced on the same platform.

Table A 3.3.34: Aggregate Emission Factors used for Emissions from Platforms and Terminals

	Period	Units	CH_4	NMVOC
Gas Platforms	1970-92	kt/installation	0.589	0.0754
Oil Platforms	1970-92	kt/installation	0.327	0.393
Oil/Gas Platforms	1970-92	kt/installation	0.763	0.686
Gas Terminals	1970-92	kt/installation	3.0	0.425
Oil Terminals	1970-92	kt/installation	0.076	0.315

A3.3.8.2.5 Oil Loading Emissions

This sector includes emissions of CH_4 and NMVOCs from tanker loading and unloading based on data from the EEMS dataset (DECC, 2008). Data from 1995-2007 are based on detailed operator returns, whilst 1990-1994 data are calculated from extrapolation of total emissions data and the use of 1997 data splits between sources. In 2006 and 2007, the methane and NMVOC data from operators appear to be incomplete in the EEMS dataset, most notably from ship emissions at two BP terminals at Sullom Voe and Hound Point. Hence estimates have been made for emissions from these sources, extrapolating emission estimates from earlier years. These emission totals for methane and NMVOCs are therefore subject to quite considerable uncertainty, and the clarification of actual emissions from these sources is a priority for the next inventory cycle.

This source is another example of where new activity data have now been made available to the Inventory Agency, following improvements to the EEMS reporting system. Activity data (tonnes oil loaded / unloaded) are also now available from the EEMS dataset for 1998 onwards, whilst the activity data for 1990-1997 has been estimated, based on the assumption that the methane emission factor remains constant back to 1990. This revised approach is more transparent for the assessment of implied emission factors for 1998 onwards, as the previous approach compared emissions against oil production data from a separate data source. This new approach does create new “estimated” activity data for 1990-1997, but the emissions data are unchanged (as there is no new data on emissions during 1990-1997) and overall the method change is considered an improvement.

Emissions data from 1995-2007 are based on operator returns, whilst 1990-1994 data are calculated from extrapolation of total emissions data and the use of 1997 data splits between sources. The activity data and implied emission factors are given in **Table A3.3.35.**

Table A 3.3.35: Activity Data and Implied Emission Factors: Crude Oil Loading, Onshore and Offshore

	ONSHORE LOADING			OFFSHORE LOADING		
	Activity	**CH_4**	**NMVOC**	**Activity**	**CH_4**	**NMVOC**
	kt	**t/kt**	**t/kt**	**kt**	**t/kt**	**t/kt**
2007	60,291	0.012	0.67	19,948	0.114	1.43
2006	59,676	0.011	0.67	24,699	0.072	1.25
2005	66,447	0.012	0.70	21,721	0.097	1.30
2004	64,387	0.012	0.68	32,784	0.084	1.12
2003	74,824	0.013	0.79	36,547	0.080	1.38

	ONSHORE LOADING			OFFSHORE LOADING		
	Activity	CH_4	NMVOC	Activity	CH_4	NMVOC
	kt	t/kt	t/kt	kt	t/kt	t/kt
2002	82,464	0.012	0.86	41,171	0.115	1.64
2001	86,663	0.012	0.85	42,277	0.113	1.54
2000	93,192	0.012	0.87	30,644	0.118	1.67
1999	102,395	0.011	0.83	35,484	0.074	1.34
1998	104,354	0.013	0.94	30,639	0.043	1.44
1997	104,776	0.013	0.94	24,013	0.043	2.39
1996	114,031	0.013	0.94	19,640	0.043	2.40
1995	125,628	0.013	0.94	17,163	0.043	2.40
1994	177,194	0.013	0.94	15,676	0.043	2.76
1993	176,810	0.013	0.94	15,642	0.043	2.72
1992	193,646	0.013	0.94	17,132	0.043	2.44
1991	193,224	0.013	0.94	17,094	0.043	2.40
1990	204,684	0.013	0.94	18,108	0.043	2.19

A3.3.8.2.6 Leakage from the Gas Transmission System

The NAEI category Gas Leakage covers emissions of CH_4 and NMVOC from the UK gas transmission and distribution system. This is accounted for within the IPCC category 1B2b Natural Gas ii Transmission/Distribution. Data on gas leakage and the methane & NMVOC content of natural gas are provided by UK Transco and four companies (newly formed in 2005) that operate the low-pressure gas distribution networks. The leakage estimates are determined in three parts:

- Losses from High Pressure Mains (UK Transco);
- Losses from Low Pressure Distribution Network (UKD, Scotia Gas, Northern Gas Networks, Wales & West); and
- Other losses, from Above Ground Installations and other sources (UK Transco).

Estimates are derived from specific leakage rates measured on the various types of gas mains and installations, together with data on the infrastructure of the UK supply system (such as length and type of pipelines and other units). Historic data for the leakage from the low-pressure distribution network and other losses (Above Ground Installations (AGIs) etc.) is based on studies from British Gas in the early 1990s (British Gas, 1993; Williams, 1993). Emission estimates for 1997 to 2007 are derived from an industry leakage model (data provided by the four network operator companies independently due to commercial confidentiality concerns), whilst emission estimates from 1990-96 are based on an older British Gas model that provided historical data for 1991-94 but projected estimates for 1995-96.

The methane and NMVOC content of natural gas is shown in **Table A3.3.36**. These data were provided by contacts within British Gas Research for 1990-1996 and by UK Transco from 1997 to 2005 (Personal Communication: Dave Lander, 2008), and from the gas network operators from 2006 onwards (UKD, Scotia Gas, Northern Gas Networks, Wales & West). Data on NMVOC content for 2001-2003 has been estimated by interpolation due to a lack of data.

Table A 3.3.36: Methane and NMVOC Composition of Natural Gas

Period	CH_4 weight %	NMVOC weight %
1990-96[1]	84.3	8.9
1997-99[2]	77.1	14.7
2000[2]	77.6	14.7
2001[2]	77.1	14.8[3]
2002[2]	77.3	15.0[3]
2003[2]	77.4	15.2[3]
2004[2]	77.4	15.3
2005[4]	77.9	15.3
2006	78.4	15.0
2007	78.2	14.8

1 British Gas (1994)
2 UK Transco (2005)
3 AEA Energy & Environment estimate (2005), based on data provided for other years
4 National Grid UK (2006)

A3.3.8.2.7 Petrol Distribution

The NAEI reports emissions from the storage, distribution and sale of petrol in the following categories each of which is further divided into emissions of leaded and unleaded petrol:

- Refineries (Road/Rail Loading). Emissions during loading of petrol on to road and rail tankers at refineries;
- Petrol Terminals (Storage). Emissions from storage tanks at petrol distribution terminals;
- Petrol Terminals (Tanker Loading). Emissions during loading of petrol on to road and rail tankers at petrol terminals;
- Petrol Stations (Petrol Delivery). Emissions during loading of petrol from road tankers into storage tanks at petrol stations;
- Petrol Stations (Storage Tanks). Emissions from storage tanks at petrol stations;
- Petrol Stations (Vehicle Refuelling). Emissions due to displacement of vapour during the refuelling of motor vehicle at petrol stations; and
- Petrol Stations (Spillages). Emissions due to spillages during refuelling of motor vehicles at petrol stations.

Emissions also occur from storage tanks at refineries. This source is included together with emissions from the storage of crude oil and other volatile materials in the NAEI source category, refineries (tankage).

The emission estimates from road and rail tanker loading at refineries are supplied by UKPIA (2008). The remaining estimates are based on methodologies published by the Institute of Petroleum (2000) or, in the case of petrol terminal storage, based on methods given by CONCAWE (1986). The calculations require information on petrol density, given in DECC (2008), and petrol Reid Vapour Pressure (RVP), data for which have been obtained from a series of surveys carried out by Associated Octel between 1970 and 1994.

More recent, detailed RVP data are not available, but UKPIA have suggested values for 1999 onwards. Central England Temperature (CET) data (Met Office, 2008) are used for ambient

UK temperatures. The methodology also includes assumptions regarding the level of vapour recovery in place at terminals and petrol stations. These assumptions draw upon annual account surveys carried out by the Petroleum Review (2000 onwards) that include questions on petrol station controls, and the timescales recommended in Secretary of State's Guidance for petrol terminals (PG 1/13 (97)). The activity data are the sales of leaded and unleaded petrol from BERR (2008).

A3.3.8.2.8 Refineries and Petroleum Processes

The IPCC category 1B2aiv Refining and Storage reports estimates of NMVOC emissions from oil refineries. In the NAEI these are split into:

- Refineries (drainage);
- Refineries (tankage); and
- Refineries (process).

All are based on UKPIA (2008) estimates for 1994-2007. The UKPIA data refer to the following installations:

- Texaco, Milford Haven;
- Elf, Milford Haven;
- BP, Coryton;
- Shell, Shell Haven (closed during 1999);
- Conoco, South Killingholme;
- Lindsey, Killingholme;
- Shell, Stanlow;
- PIP, North Tees;
- Esso, Fawley;
- BP, Grangemouth; and
- Gulf, Milford Haven (closed during 1997).

UKPIA also supply estimates for loading of petrol into road and rail tankers at refineries – see **Section A3.3.8.2.7**

Prior to 1994, process emissions are estimated by extrapolation from the 1994 figure on the basis of refinery throughput, whereas emissions from tankage, flares and drainage systems are assumed to be constant.

Also included under 1B2aiv Refining and Storage are NMVOC emissions from the NAEI category petroleum processes. This reports NMVOC emissions from specialist refineries (Llandarcy, Eastham, Dundee, & Harwich), onshore oil production facilities, and miscellaneous petroleum processes not covered elsewhere in the inventory (most significant of which are the Tetney Lock and Tranmere oil terminals). Emissions are taken from the Pollution Inventory (Environment Agency, 2008). No emissions data have been found for the Dundee refinery.

A3.3.8.2.9 Gasification Processes

The NAEI also reports NMVOC emissions from on shore gas production facilities, refining and odourisation of natural gas, natural gas storage facilities, and processes involving reforming of natural gas and other feedstocks to produce carbon monoxide and hydrogen gases. Emissions are taken from the Pollution Inventory (Environment Agency, 2008). For the years prior to 1994, they are extrapolated based on gas throughput. Care is taken to avoid double counting with the offshore emissions.

A3.3.9 Stored Carbon

As part of our review of the base year GHG inventory estimates, the UK reviewed the treatment of stored carbon in the UK GHG inventory and the fate of carbon from the non-energy use (NEU) of fuels and other fossil carbon products.

This appraisal included a review of the National Inventory Reports (NIRs) of other countries. The US NIR contained a detailed methodology of the approach used in the US inventory to estimate emissions of stored carbon, and the US NIR presents ‘storage factors’ for a range of products. Some of these factors have been used in the new UK method.

The UK Inventory Agency has conducted a series of calculations to estimate the fate of carbon contained in those petroleum products shown in the NEU line of the UK commodity balance tables. The analysis indicates that most of the carbon is stored, although a significant quantity does appear to be emitted. Some of the emitted carbon has been included in previous versions of the GHG inventory, e.g. carbon from chemical waste incinerators; most has not. A summary of the estimates of emitted/stored carbon has been produced and these have been presented in a separate technical report[5]. The study also provides subjective, qualitative commentary regarding the quality of the estimates.

Following the review of stored carbon, the procedure adopted is to assume that emissions from the non-energy use of fuels are zero (i.e. the carbon is assumed to be sequestered as products), except for cases where emissions could be identified and included in the inventory:

- Catalytic crackers – regeneration of catalysts;
- Ammonia production;
- Aluminium production – consumption of anodes;
- Combustion of waste lubricants and waste solvents;
- Burning of lubricants during use in engines;
- Use of waste products from chemical production as fuels;
- Emissions of carbon due to use and/or disposal of chemical products;
- Incineration of fossil carbon in products disposed of as waste.

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5 Passant, Watterson and Jackson. (2007) *Review of the Treatment of Stored Carbon and the Non-Energy Uses of Fuel in the UK Greenhouse Gas Inventory*. AEA Energy and Environment, The Gemini Building, Fermi Avenue, Harwell, Didcot, Oxfordshire, OX11 0QR, UK. Report to Defra CESA for contract RMP/2106.

Methodology for some of these sources has been described in detail elsewhere and so is not repeated here.

Carbon deposits build up with time on catalysts used in refinery processes such as catalytic cracking. These deposits need to be burnt off to ensure continued effectiveness of the catalyst and emissions from this process are treated as use of a fuel (since heat from the process is used) and reported under IA1a. Details are given in Chapter 3 of the report.

Natural gas is used as a feedstock in the manufacture of ammonia and emissions from this process are reported under 2B1. Coal tar pitch and petroleum coke are used in the manufacture of carbon anodes used by the aluminium industry and CO_2 is emitted during use of the anodes. Details of methodology for both sources are given in Chapter 4.

AEA estimates of the quantities of lubricants burnt are based on data from Recycling Advisory Unit, 1999; BLF/UKPIA/CORA, 1994; Oakdene Hollins Ltd, 2001 &ERM, 2008.. Separate estimates are produced for the following sources:

- Power stations;
- Cement kilns; and
- Other industry.

The figures for power station and other industrial use of waste lubricants were revised for this version of the GHGI. This was partly due to new information being generally available, and partly due to the recognisation that the Waste Incineration Directive (WID) was likely to have had a profound impact on the market for waste oil, used as a fuel. After WID was introduced in 2006, it is assumed that no waste oil is burnt either in power stations or by roadstone coating plant. One repercussion of these changes is that it is assumed that, since 2006, a large quantity (> 200 ktonnes/annum) of waste oil is recovered but not used. In reality new markets for waste oil as a fuel may have developed or the waste oil may have been sent for incineration (in both cases this would have resulted in CO_2 emissions which are not reflected in the GHGI), or the excess oil might have been stockpiled or exported. Further investigation is needed to ascertain the fate of this oil. Emissions from use of waste oils as fuels are reported under 1A1a and 1A2f.

In addition, an estimate is made of lubricants burnt in vehicle engines. Carbon emissions from these sources are calculated using a carbon factor derived from analysis of eight samples of waste oil (Passant, 2004). In 2005, the combustion of lubricating oils within engines was reviewed. Analysis by UK experts in transport emissions and oil combustion have lead to a revision to the assumptions regarding re-use or combustion of lubricating oils from vehicle and industrial machinery.

The fate of the unrecovered oil has now been allocated across several IPCC source sectors including road, rail, marine, off-road and air transport. Emissions from these sources are reported under 1A3b, 1A3d & 1A4c. Some of the unrecovered oil is now allocated to non-oxidising fates such as coating on products, leaks and disposal to landfill.

Emissions can occur from products from the chemical industry. Sources of emissions include burning of waste products and final products (e.g. flaring and use of wastes as fuels, or burning of candles, firelighters and other products etc.) or degradation of products after disposal resulting in CO_2 emissions (including breakdown of consumer products such as detergents etc.).

After considering the magnitude of the sources in relation to the national totals, the uncertainty associated with emissions, and the likely forthcoming IPCC reporting requirements in the 2006 Guidelines, emissions of carbon from the following sources were included in the 2004 GHG inventory (2006 NIR) and subsequent NIRs:

- Petroleum waxes;
- Carbon emitted during energy recovery - chemical industry;
- Carbon in products - soaps, shampoos, detergents etc; and
- Carbon in products – pesticides.

A full time series of emissions is included in the inventory, and details of the methodology for these sectors are given in Passant, Watterson & Jackson, 2007. Emissions are reported under 2B5.

Fossil carbon destroyed in MSW incinerators and clinical waste incinerators is included in the GHG inventory, as is carbon emitted by chemical waste incinerators. These emissions are reported under 1A1a & 6C, and methodology is detailed in Chapters 3 and 8 of the report.

The analysis also included an assessment of the fate of carbon from the use of coal tars and benzoles. Benzoles and coal tars are shown as an energy use in the BERR DUKES and up until the 2002 version of the GHG inventory, the carbon was included in the coke ovens carbon balance as an emission of carbon from the coke ovens.

When the carbon balance methodology was improved for the 2003 GHG inventory, the UK inventory treated the carbon in these benzoles and coal tars as a non-emissive output from the coke ovens. However, we were not sure what the ultimate fate of the carbon was but were unable to research this in time for the 2003 GHG inventory. It was therefore treated as an emission from the waste disposal sector - thus ensuring that total UK carbon emissions were not altered until we had sufficient new information to judge what the fate of the carbon was.

New information from Corus UK Ltd (the sole UK operator of coke ovens) indicates that the benzoles & coal tars are recovered and sold on for other industrial uses, the emissions from which are already covered elsewhere within the inventory. Hence the carbon content from these coke oven by-products is now considered as stored and the carbon emissions included in previous inventories has been removed from the new version of the GHG inventory.

The analysis estimates emissions from:

- The energy uses of coal tars and benzoles; and
- NEU of petroleum products.

Since emissions of carbon are estimated, carbon which is not emitted (i.e. stored) can be calculated from the BERR DUKES consumption data by difference.

A3.4 INDUSTRIAL PROCESSES (CRF SECTOR 2)

A3.4.1 Mineral Processes (2A)

A3.4.1.1 Cement Production (2A1)

Emission factors for the production of cement, as described **in Chapter 4,** are as follows:

Table A 3.4.1: Emission Factors for Cement Kilns based on Fuel Consumption, 2007

Fuel	C [a]	CH_4	N_2O	Units
Coal	647.1[j]	0.3[e]	0.109[h]	Kt / Mt fuel
Fuel Oil	879[b]	0.0866[f]	0.0262[f]	Kt / Mt fuel
Gas Oil	870[b]	0.0910[f]	0.0273[f]	Kt / Mt fuel
Natural Gas	1.48[b]	0.000528[f]	NE	Kt / Mtherm
Petroleum Coke	813.0[j]	0.1071[g]	0.143[h]	Kt / Mt fuel
Scrap Tyres	455.11[j]	0.96[f]	NE	Kt / Mt fuel
Waste Oils	825.2[j]	0.0910[i]	NE	Kt / Mt fuel
Waste Solvent	439.8[j]	NE	NE	Kt / Mt fuel
Other Waste	204.1[j]	NE	NE	Kt / Mt fuel

a Emission factor as mass carbon per unit fuel consumed
b Derived using the methods given in Baggott *et al* (2004)
c Emission factor derived from emissions reported in the PI
d Passant, N.R., 2004
e Brain, SA et al. British Coal Corp, CRE (1994)
f IPCC 1997c
g IPCC (2006)
h Fynes *et al* (1994)
i As for gas oil
j Data supplied by British Cement Association/Lafarge Cement, 2007

Table A 3.4.2: Emission Factors for Cement Kilns based on Clinker Production, 1990-2007

Year	CO	NO_x	NMVOC	SO_2	Units
1990-94	2.96	5.70	0.146	3.19	kt/Mt Clinker
1995	2.86	5.20	0.146	3.38	kt/Mt Clinker
1996	4.39	3.63	0.146	2.24	kt/Mt Clinker
1997	1.90	3.91	0.146	2.56	kt/Mt Clinker
1998	2.27	4.11	0.146	2.34	kt/Mt Clinker
1999	2.58	3.61	0.125	2.27	kt/Mt Clinker
2000	2.49	3.42	0.123	1.88	kt/Mt Clinker
2001	2.32	3.07	0.157	1.94	kt/Mt Clinker
2002	2.40	2.89	0.117	2.06	kt/Mt Clinker
2003	NR	NR	NR	NR	kt/Mt Clinker
2004	2.57	3.20	0.064	1.74	kt/Mt Clinker
2005	2.86	3.07	0.064	1.58	kt/Mt Clinker
2006	2.84	2.67	0.065	1.24	kt/Mt Clinker
2007	2.87	2.54	0.086	1.00	kt/Mt Clinker

NR – 2003 emission factor data are not reported due to issues of commercial confidentiality raised by the BCA.

A3.4.1.2 Lime Production (2A2)

Emission factors for the production of lime, as discussed in **Chapter 4**, **Section 4.3**:

Table A 3.4.3: Emission Factors for Lime Kilns based on Fuel Consumption, 2007

Fuel	C [a]	CH_4	N_2O	Units
Coal	645.4[b]	0.011[c]	0.214[e]	Kt / Mt fuel
Natural Gas	1.48[b]	0.00053[f]	1.055E-05[f]	Kt / Mtherm
Coke	799.5[d]	0.011[c]	0.230[e]	Kt / Mt fuel

a Emission factor as mass carbon per unit fuel consumed
b Derived using the method given in Baggott *et al* (2004)
c Brain, SA et al. British Coal Corp, CRE (1994)
d AEA estimate based on carbon balance
e Fynes *et al* (1994)
f IPCC(1997) IPCC Revised 1996 Guidelines

Table A 3.4.4: Emission Factors for Lime Kilns, 2007: Indirect GHGs

Fuel	CO	NO_x	NMVOC	Units
Coal	15.7	60.44	0.05	Kt / Mt fuel
Natural Gas	0.0566	0.0311	0.00023	Kt / Mtherm
Coke	9.92	0.324	0.05	Kt / Mt fuel

A3.4.2 Chemical Industry (2B)

A3.4.2.1 Nitric Acid Production (2B2)

Table A 3.4.5: Summary of Nitric Acid Production in the UK, 1990-2007

Year	No of sites	Production (Mt 100% Nitric Acid)	Aggregate EF (kt N_2O / Mt Acid)	Aggregate EF (kt NO_X / Mt Acid)
1990	8	2.41	5.23	3.36
1994	6	2.49	3.89	1.93
1995	6	2.40	3.82	0.81
1996	6	2.44	3.83	0.74
1997	6	2.35	3.78	0.90
1998	6	2.61	3.99	0.73
1999	6	2.44	6.29	0.91
2000	6	2.03	6.94	0.99
2001	5	1.65	6.62	0.66
2002	4	1.64	4.20	0.39
2003	4	1.71	4.38	0.43
2004	4	1.71	5.00	0.44
2005	4	1.71	3.80	0.37
2006	4	1.47	3.87	0.42
2007	4	1.61	3.54	0.38

A3.4.2.2 Adipic Acid Production (2B3)

There is only one company manufacturing adipic acid in the UK. Production data are not provided in the NIR because of commercial confidentiality concerns.

Emissions have been estimated based on information from the process operator (Invista, 2008). These emission estimates are based on the use of plant-specific emission factors for unabated flue gases, which were determined through a series of measurements on the plant, combined with plant production data and data on the proportion of flue gases that are unabated.

In 1998 an N_2O abatement system was fitted to the plant. The abatement system is a thermal oxidation unit and is reported by the operators to be 99.99% efficient at N_2O destruction. The abatement unit is not available 100% of the time, and typically achieves 90-95% availability during AA production. The abatement plant availability has a very significant impact upon the annual emissions of N_2O, and leads to somewhat variable trends in IEFs over the time-series.

A small nitric acid (NA) plant is associated with the adipic acid plant. This NA plant also emits nitrous oxide but has no abatement fitted. Operator emission estimates from the NA plant are based on emission factors; there is no online measurement of N_2O in the stack from the NA plant. From 1994 onwards this emission is reported as nitric acid production but prior to 1994 it is included under adipic acid production. This will cause a variation in reported effective emission factor for these years. This allocation reflects the availability of data.

The level of uncertainty associated with reported emissions of N_2O is not known, but the data are considered to be reliable as they are subject to QA/QC checks by the operator, by the Environment Agency (before being reported in the Pollution Inventory) and by the regulators of the UK Emission Trading Scheme (DEFRA NCCP).

A3.4.3 Metal Production (2C)

A3.4.3.1 Iron and Steel (2C1)

The following emissions are reported under 2C1 Iron and Steel Production:

- Blast furnaces: process emissions of CO, NO_X, and SO_2;
- Flaring of blast furnace gas/basic oxygen furnace gas;
- Electric arc furnace emissions;
- Basic oxygen furnaces: process emissions of CO and NO_X.;
- Rolling mill process emissions of VOC; and
- Slag processing: process emissions of SO_2.

Emissions arising from the combustion of blast furnace gas and other fuels used for heating the blast furnace are reported under 1A2a Iron and Steel. Emissions of CO, NO_X, and SO_2 from integrated steelworks, and the flaring of blast furnace gas and basic oxygen furnace gas are reported under 2C1 Iron & Steel Production. CO_2 emissions from limestone and dolomite use in iron and steel production are reported under 2A3 Limestone and Dolomite use.

A3.4.3.1.1 Carbon Dioxide Emissions

Carbon emissions from flaring of blast furnace gas (BFG) and basic oxygen furnace gas (BOFG) are calculated using emission factors which are calculated as part of the carbon balance used to estimate emissions from CRF category 1A2a. The figure for 2007 was 75.4 ktonnes C/PJ. Emissions from electric arc furnaces are 2.2 kt C/Mt steel in 1990, falling to 2 kt C/Mt steel in 2000 and constant thereafter (Briggs, 2005).

A3.4.3.1.2 Other Pollutants

Emissions from blast furnaces of other pollutants are partly based on the methodology described in IPCC (1997) for blast furnace charging and pig iron tapping and partly on emissions data reported by the process operators. The emission factors are expressed in terms of the emission per Mt of pig iron produced and are given in **Table A3.4.6**. Data on iron production are reported in ISSB (2006).

Table A 3.4.6: Emission Factors for Blast Furnaces (BF), Electric Arc Furnaces (EAF) and Basic Oxygen Furnaces (BOF), 2007

	C [a]	CH_4	N_2O	NO_x	SO_2	NMVOC	CO	Units
Blast furnaces	IE	NE	NE	NE	0.1179[b]	0.12[c]	2.25[c]	kt/Mt pig iron
Electric arc furnaces	2[d]	0.01[e]	0.005[e]	0.1[e]	0.154[b]	0.09[e]	0.71[b]	kt/Mt Steel
Basic oxygen furnaces	IE	NE	NE	0.012[f]	IE	NE	7.33[b]	kt/Mt Steel
Losses of BFG/BOFG	7.96 [g]	NE	NE	NE	NE	NE	NE	kt/Mtherm gas
Slag processing	NE	NE	NE	NE	7.3E-6[b]	NE	NE	kt/Mt Pig iron

a Emission factor as kt carbon/unit activity
b Emission factor for 2006 based on data from Corus (2007) and data for non-Corus plant from EA (2007)
c IPCC (1997)
d Briggs (2005)
e EMEP/CORINAIR(1999)
f EIPPCB(2000), Corus (2001, 2000)
g AEA estimate based on carbon balance
NE Not estimated
IE Emission included elsewhere.

Emissions from electric arc furnaces are calculated mainly using default emission factors taken from EMEP/CORINAIR (1999). The CO_2 emission arises from the consumption of a graphite anode and the emission factor has been suggested by Briggs (2005). Emissions of CO from basic oxygen furnaces are based on data supplied by Corus (2007) while the NO_x emission is based on an EIPPCB default.

Emissions of NMVOC are estimated from the hot rolling and cold rolling of steel using emission factors of 1 g/tonne product and 25g/tonne product respectively (EMEP/CORINAIR, 1996). Activity data were taken from ISSB (2007).

There is insufficient activity or emission factor data to make an estimate for emissions from ferroalloys. Emissions of CO_2 will be included in 1A2a, since the fuels used as reducing agents are included in the energy statistics.

A3.4.3.2 Aluminium Production (2C3)

Details of the method used to estimate emissions of F-gases from this source are given in AEA (2008). Emission factors for aluminium production, as discussed in **Chapter 4**, **Section 4.16**, are shown in **Table A3.4.7.**

Table A 3.4.7: Emission Factors for Aluminium Production, 2007

	C [a]	SO_2 [b]	NO_x [b]	CO [b]	Units
Prebake	420	13.4	0.754	96.6	Kt / Mt Al
Anode Baking	IE	1.44	0.42	3.89	Kt / Mt anode

a Emission factor as kt carbon per unit activity, Walker, 1997.
b Environment Agency Pollution Inventory (2008) and SEPA (2008)
IE Emission included elsewhere.

A3.4.3.3 SF_6 used in Aluminium and Magnesium Foundries (2C4)

The method used to estimate emissions of SF_6 from this source is described in AEA (2008).

A3.4.3.4 Food and Drink (2D2)

NMVOC emission factors for food and drink, as discussed in **Chapter 4**, **Section 4.20**.

Table A 3.4.8: NMVOC Emission Factors for Food and Drink Processing, 2007

Food/Drink	Process	Emission Factor	Units
Beer	Barley Malting Wort Boiling Fermentation	0.6[c] 0.0048[c] 0.02[c]	g/L beer
Cider	Fermentation	0.02[c]	g/L cider
Wine	Fermentation	0.2[c]	kg/m^3
Spirits	Fermentation Distillation Casking Spent grain drying Barley Malting Maturation	1.58[d] 0.79[g] 0.40[h] 1.31[i] 4.8[c] 15.78[d]	g/ L alcohol g/ L alcohol g/ L whiskey kg/ t grain kg/ t grain g/ L alcohol
Bread Baking		1[a]	kg/tonne
Meat, Fish & Poultry		0.3[f]	kg/tonne
Sugar		0.020[b]	kg/tonne
Margarine and solid cooking fat		10[f]	kg/tonne
Cakes, biscuits, breakfast cereal, animal feed		1[f]	kg/tonne
Malt production (exports)		4.8[c]	kg/ t grain
Coffee Roasting		0.55[f]	kg/tonne

a Federation of Bakers (2000)
b Environment Agency (2007)
c Gibson *et al* (1995)
d Passant *et al* (1993)
e Assumes 0.1% loss of alcohol based on advice from distiller
f EMEP/CORINAIR, 2006
g Unpublished figure provided by industry
h Based on loss rate allowed by HMCE during casking operations
i US EPA, 2007

A3.4.4 Production of Halocarbons and SF_6 (2E)

Details of the method used to estimate emissions of F-gases from this source are given in AEA (2008).

A3.4.5 Consumption of Halocarbons and SF_6 (2F)

A3.4.5.1 Refrigeration and Air Conditioning Equipment (2F1)

Details of the method used to estimate emissions of F-gases from this source are given in AEA (2008).

A3.4.5.2 Foam Blowing (2F2)

Details of the method used to estimate emissions of F-gases from this source are given in AEA (2008).

A3.4.5.3 Fire Extinguishers (2F3)

Details of the method used to estimate emissions of F-gases from this source are given in AEA (2008).

A3.4.5.4 Aerosols/ Metered Dose Inhalers (2F4)

Details of the method used to estimate emissions of F-gases from this source are given in AEA (2008).

A3.4.5.5 Solvents (2F5)

Details of the method used to estimate emissions of F-gases from this source are given in AEA (2008).

A3.4.5.6 Semiconductor Manufacture (2F6)

Details of the method used to estimate emissions of F-gases from this source are given in AEA (2008).

A3.4.5.7 Electrical Equipment (2F7)

Details of the method used to estimate emissions of F-gases from this source are given in AEA (2008).

A3.4.5.8 One Component Foams (2F8A)

Details of the method used to estimate emissions of F-gases from this source are given in AEA (2008).

A3.4.5.9 Semiconductors, Electrical and Production of Trainers (2F8B)

Details of the method used to estimate emissions of F-gases from this source are given in AEA (2008).

A3.5 SOLVENT AND OTHER PRODUCT USE (CRF SECTOR 3)

There is currently no additional information for this sector in this Annex.

A3.6 AGRICULTURE (CRF SECTOR 4)

A3.6.1 Enteric Fermentation (4A)

Methane is produced in herbivores as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by microorganisms. Emissions are calculated from animal population data (**Table A3.6.1**) collected in the June Agricultural Census and published in Defra (2008a) and the appropriate emission factors. Data for earlier years are often revised so information was taken from the Defra agricultural statistics database.

Table A3.6.2 shows the emission factors used.

Apart from cattle, lambs and deer, the methane emission factors are IPCC Tier 1 defaults (IPCC, 1997) and do not change from year to year. The dairy cattle emission factors are estimated following the IPCC Tier 2 procedure (IPCC, 1997) and vary from year to year. For dairy cattle, the calculations are based on the population of the ‘dairy breeding herd’ rather than ‘dairy cattle in milk’. The former definition includes ‘cows in calf but not in milk’. The emission factors for beef and other cattle were also calculated using the IPCC Tier 2 procedure (**Table A3.6.4**), but do not vary from year to year. The enteric emission factors for beef cattle were almost identical to the IPCC Tier 1 default so the default was used in the estimates.

The base data and emission factors for cattle for 1990-2007 are given in **Table A3.6.3** and **Table A3.6.4**. The emission factor for lambs is assumed to be 40% of that for adult sheep (Sneath *et al.* 1997). In using the animal population data, it is assumed that the reported numbers of animals are alive for that whole year. The exception is the treatment of sheep where it is normal practice to slaughter lambs and other non-breeding sheep after 6 to 9 months. Hence it is assumed that breeding sheep are alive the whole year but that lambs and other non-breeding sheep are only alive 6 months of a given year (based on Smith and Frost, 2000). The sheep emission factors in **Table A3.6.2** are reported on the basis that the animals are alive the whole year.
The main parameters involved in the calculation of the emissions factors for beef are shown in **Table A3.6.5**.

Table A 3.6.1: Livestock Population Data for 2007 by Animal Type

Animal Type	Number
Cattle:	
Dairy Breeding Herd	1,953,980
Beef Herd[a]	1,698,196
Beef and others >1 year old[b]	5,492,919
Others < 1 year old	2,735,801
Pigs:	
All breeding pigs	537,138
Other pigs > 50 kg	1,836,736
Other pigs 20-50 kg	1,207,779
Pigs <20 kg	1,252,721
Sheep:	
Breeding sheep	16,063,634
Other sheep	1,026,744
Lambs < 1 year	16,855,428
Goats	95,478
Horses	383,748
Deer	30,933
Poultry (000 head):	
Broilers	108,753,182
Breeders	12,502,480
Layers	27,320,752
Growing Pullets	8,936,348
Ducks, geese and guinea fowl	2,510,166
Turkeys	3,848,330

a Beef herd refers to mature beef cows
b Beef and others >1 year old include dairy heifers, beef heifers, others>2 and others 1-2 years old.

Table A 3.6.2: Methane Emission Factors for Livestock Emissions

Animal Type	Enteric methane[a] kg CH_4/head/year	Methane from manures[a] kg CH_4/head/year
Dairy Breeding Herd	105.0[b]	25.8[b]
Beef Herd	48	2.74
Other Cattle >1 year, Dairy Heifers	48	6
Other Cattle <1 year	32.8	2.96
Pigs	1.5	7.06[f]
Breeding Sheep	8	0.19
Other Sheep	8[e]	0.19[e]
Lambs < 1 year	3.2[ce]	0.076[ce]
Goats	5	0.12
Horses	18	1.4
Deer: Stags & Hinds	10.4[c]	0.26[c]
Deer: Calves	5.2[c]	0.13[c]
Poultry[d]	NE	0.078

a IPCC (1997)
b Emission factor for year 2007
c Sneath *et al.* (1997)

d Chickens, turkeys, geese, ducks and guinea fowl
e Factor quoted assumes animal lives for a year; emission calculation assumes animal lives for 6 months
f Factor changed according to 2000 GPG

Table A 3.6.3: Dairy Cattle Methane Emission Factors[a]

	Average Weight of cow (kg) [b]	Average Rate of Milk Production (litre/d)	Average Fat Content (%)	Enteric Emission Factor (kg CH_4/head/y)	Manure Emission Factor (kg CH_4/head/y)
1990	550	14.3	4.01	88.1	21.6
1991	549	14.2	4.04	88.4	21.7
1992	564	14.5	4.06	90.1	22.1
1993	564	14.7	4.07	90.8	22.3
1994	559	14.7	4.05	90.9	22.3
1995	559	15.0	4.05	92.3	22.7
1996	563	15.1	4.08	93.2	22.8
1997	566	15.9	4.07	96.0	23.6
1998	558	16.1	4.07	96.8	23.8
1999	555	16.4	4.03	97.8	24.0
2000	563	16.6	4.03	98.7	24.2
2001	575	16.7	4.01	99.4	24.4
2002	579	17.9	3.97	102.7	25.2
2003	576	18.3	3.96	103.8	25.5
2004	579	18.1	4.00	101.8	24.9
2005	577	18.8	4.02	103.5	25.4
2006	577	18.5	4.04	102.8	25.2
2007	577	19.1	4.06	105.0	25.8

a In 2003, 46% of animals graze on good quality pasture, rest confined
Gestation period 281 days
Digestible energy 74% (Bruce Cottrill, ADAS, *pers. comm.*)
Methane conversion rate 6%
Ash content of manure 8%
Methane producing capacity of manure 0.24 m^3/kg VS
b Weights according to Steve Walton, Defra, pers. comm., from 1990 to 2004, Helen Mason, 2005, 2006, 2007 was the average of the weight of the previous 5 years

Table A 3.6.4: Parameters used in the calculation of the Methane Emission Factors[a] for Beef and Other Cattle

	Beef herd[b]	Others>1[c]	Others<1
Average Weight of Animal (kg)	500	400-500	180
Time Spent Grazing	50%	43-50%[d]	46%
GE (MJ/d)	123.3	123.3	83.4[e]
Daily weight gain (kg day^{-1})	0	0.30[f]	0.60
Enteric Emission Factor (kg CH_4/head/y)	48.5[g]	48	32.8
Manure Emission Factor (kg CH_4/head/y)	2.74	6	2.96

a Digestible Energy 65%, Ash content of manure 8%, Methane producing capacity of manure 0.17 m^3/kg VS
b Beef herd refers to mature cows
c Includes dairy heifers, beef heifers, others>2, others 1-2
d Time spent grazing is 43% and 50% for dairy and beef cattle respectively
e Calculated following IPCC guidelines
f Only for animals less than 2 years old
g IPCC (1997) default (48 kg/head/y) used since calculated factor is very close to default and the difference under the Tier 2 method will not affect the accuracy of the emission factor at the required level of precision

Table A 3.6.5: Parameters in calculation of Beef herd Emission Factors[a]

Factor	Equation[a]	
Average Weight of Animal (kg)		500
NEm (Maintenance energy), MJ/d	1	35.42
NE_{feed} (Energy for obtaining food), MJ/d[b]	2	3.01
NEg (Energy required for growth), MJ/d	3	0
NE (Lactation energy), MJ/d	4	0
$NE_{pregnancy}$ (Daily energy for pregnancy), MJ/d	6	2.89
GE (Gross energy intake), MJ/d	13	123.3
EF enteric, kg CH_4/head/y		48.5[c]
EF manure, kg CH_4/head/y		2.74

a From IPCC Revised guidelines 1996
b Based on 17% of NEm, grazing factor of 0.085 introduced to account for proportion of time spent grazing/housed
c Methane conversion rate is 6%

A3.6.2 Manure Management (4B)

A3.6.2.1 Methane emissions from animal manures

Methane is produced from the decomposition of manure under anaerobic conditions. When manure is stored or treated as a liquid in a lagoon, pond or tank it tends to decompose anaerobically and produce a significant quantity of methane. When manure is handled as a solid or when it is deposited on pastures, it tends to decompose aerobically and little or no methane is produced. Hence the system of manure management used affects emission rates.

Emissions of methane from animal manures are calculated from animal population data (Defra, 2008a) in the same way as the enteric emissions. The emission factors are listed in **Table A3.6.2**. Apart from cattle, lambs and deer, these are all IPCC Tier 1 defaults (IPCC, 1997) and do not change from year to year. The emission factors for lambs are assumed to be 40% of that for adult sheep. Emission factors for dairy cattle were calculated from the IPCC Tier 2 procedure using data shown in **Table A3.6.3** and **Table A3.6.6** (Defra, 2002). There was a revision (in 2002) of the allocation of manure to the different management systems based on new data. This is detailed in **Section 6.3.2.2**. For dairy cattle, the calculations are based on the population of the 'dairy breeding herd' rather than 'dairy cattle in milk' used in earlier inventories. The former definition includes 'cows in calf but not in milk'. The waste factors used for beef and other cattle are now calculated from the IPCC Tier 2 procedure but do not vary from year to year. Emission factors and base data for beef and other cattle are given in **Table A3.6.4**.

Table A 3.6.6: Cattle Manure Management Systems in the UK

Manure Handling System	Methane Conversion Factor % [a]	Fraction of manure handled using manure system %	Fraction of manure handled using manure system %
		Dairy	*Beef and Other*
Pasture Range	1	45.5	50.5
Liquid System	39	30.6	6
Solid Storage	1	9.8	20.7
Daily Spread	0.1	14.1	23

a IPCC (2000)

A3.6.2.2 Nitrous Oxide emissions from Animal Waste Management Systems

Animals are assumed not to give rise to nitrous oxide emissions directly, but emissions from their manures during storage are calculated for a number of animal waste management systems (AWMS) defined by IPCC. Emissions from the following AWMS are reported under the Manure Management IPCC category:

- Flushing anaerobic lagoons. These are assumed not to be in use in the UK.
- Liquid systems
- Solid storage and dry lot (including farm-yard manure)
- Other systems (including poultry litter, stables)

According to IPCC (1997) guidelines, the following AWMS are reported in the Agricultural Soils category:

- All applied animal manures and slurries
- Pasture range and paddock

Emissions from the combustion of poultry litter for electricity generation are reported under power stations.

The IPCC (1997) method for calculating emissions of N_2O from animal waste management systems can be expressed as:

$$N_2O_{(AWMS)} = 44/28 \cdot \sum N_{(T)} \cdot Nex_{(T)} \cdot AWMS_{(W)} \cdot EF_{(AWMS)}$$

where

$N_2O_{(AWMS)}$	=	N_2O emissions from animal waste management systems (kg N_2O/yr)
$N_{(T)}$	=	Number of animals of type T
$Nex_{(T)}$	=	N excretion of animals of type T (kg N/animal/yr)
$AWMS_{(W)}$	=	Fraction of Nex that is managed in one of the different waste management systems of type W
$EF_{(AWMS)}$	=	N_2O emission factor for an AWMS (kg N_2O-N/kg of Nex in AWMS)

The summation takes place over all animal types and the AWMS of interest. Animal population data are taken from Agricultural Statistics (Defra, 2008a). **Table A3.6.7** shows emission factors for nitrogen excretion per head for domestic livestock in the UK (Nex) from Ken Smith and Bruce Cottrill (ADAS).

Table A 3.6.7: Nitrogen Excretion Factors, kg N hd^{-1} $year^{-1}$ for livestock in the UK[a] (1990-2000)[b]

Animal Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Dairy Cows	97	97	98	98	99	100	101	104	104	106	106	110	112	113	114	115.1	116.2	117.3
Dairy heifers in calf	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67
Beef cows and heifers	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79
Other Cattle > 2 year	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Other Cattle 1-2 year	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Other Cattle <1 year	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38
Pigs < 20kg	4.6	4.6	4.5	4.5	4.4	4.4	4.3	4.3	4.3	4.2	4.2	4.1	4.1	4.0	4	3.9	3.8	3.7
Other Pigs 20-50 kg	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11.0	10.9	10.7	10.6	10.5	10.4	10.3	10.2	10.0	9.8	9.6
Fattening & Other Pigs > 50 kg	18.26	18.09	17.94	17.77	17.64	17.52	17.44	17.22	17.03	16.88	16.73	16.59	16.46	16.36	16.16	15.86	15.50	15.16
Breeding Pigs > 50 kg	23.06	22.85	22.63	22.36	22.20	21.99	21.7	21.48	21.34	21.12	20.94	20.87	20.55	20.35	19.57	19.72	19.33	18.55
Breeding Sheep	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
Other Sheep <1 year	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
Lambs	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Goats	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6
Broilers	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.55	0.54	0.53	0.52	0.51	0.49	0.47	0.46
Broiler Breeders	1.16	1.16	1.15	1.15	1.14	1.13	1.13	1.12	1.12	1.11	1.10	1.10	1.09	1.09	1.08	1.07	1.06	1.05
Layers	0.86	0.85	0.85	0.84	0.83	0.82	0.82	0.81	0.80	0.80	0.79	0.79	0.78	0.78	0.77	0.76	0.76	0.74
Ducks,	1.30	1.33	1.35	1.37	1.39	1.41	1.43	1.45	1.47	1.49	1.52	1.54	1.56	1.58	1.60	1.62	1.64	1.66
Turkeys	1.5	1.52	1.54	1.55	1.57	1.59	1.61	1.62	1.64	1.66	1.68	1.70	1.71	1.73	1.75	1.76	1.77	1.79
Growing Pullets	0.42	0.41	0.41	0.40	0.39	0.39	0.38	0.38	0.37	0.37	0.36	0.36	0.35	0.35	0.34	0.34	0.34	0.34
Horses	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Deer: Stags, hinds and calves	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13

a Ken Smith, Bruce Cottrill, ADAS

b Nex factors do not exclude 20% N volatilising as NO_x and NH_3

The UK methodology assumes that 20% of the total N emitted by livestock volatilises as NO_x and NH_3 and therefore does not contribute to N_2O emissions from AWMS. This is because in the absence of a more detailed split of NH_3 losses at the different stages of the manure handling process it has been assumed that NH_3 loss occurs prior to major N_2O losses. Thus, the Nex factors used in the AWMS estimates exclude the fraction of N volatilising and are 20% less than if they were reported on the same basis as the 'total' Nex factors reported in the IPCC Guidelines. Values of total N excreted shown in the Common Reporting Format are not corrected in this way and are estimates of total N excreted from livestock.

The conversion of excreted N into N_2O emissions is determined by the type of manure management system used. The distribution of waste management systems for each animal type ($AWMS_{(T)}$) is given in **Table A3.6.8**. The distributions used were revised for cattle and poultry in the 2000 Inventory. The change related to the way that data on 'no significant storage capacity' of farmyard manure (FYM) were allocated. This could have a large effect on emissions because it amounted to around 50% of manure and the 'Daily spread (DS)' category has an emission factor of zero, compared to 0.02 for the 'Solid storage and dry lot (SSD)' category. However, we are advised (Smith, 2002) that:

In terms of slurry, it seems likely that where a proportion of the estimated slurry production is attributed with "nil" or little storage (<1 month capacity), as above, it can be assumed that such units will rely on a significant amount of daily – weekly spreading activity, according to land availability and trafficability, throughout. With FYM and poultry manure, however, significant storage capacity exists within the house and so, "no storage" generally implies that manure is cleared from the house/straw littered yard and spread direct on land. Storage capacity within the house or yard might comprise between 7 weeks – 12 months (poultry) or several months (cattle) and is unlikely to require "daily" spreading activity.

Therefore, assigning this 'stored in house' manure to 'daily spread' is acceptable only if emissions from the housing phase are thought to be very small. Calculations were performed with the N_2O Inventory of Farmed Livestock to compare housing and storage phases (Sneath *et al.* 1997). For pigs and poultry, the emission factor for housing is the same as or greater than that of storage. It would therefore lead to significant underestimation to use the daily spread emission factor. A proportion of the pig waste (as FYM) is therefore allocated to SSD. Poultry waste is allocated to 'other' except for that dropped outside by free-range poultry (PRP) and that exported for incineration in power stations (fuel).

For dairy and non-dairy cattle, the emission factor for the housing phase is around 10% of the storage phase, so the non-stored FYM has been split between SSD and DS to account for this.

Table A 3.6.8: Distribution of Animal Waste Management Systems used for Different Animal types[c]

Animal Type	Liquid System	Daily Spread	Solid Storage and Dry Lot[a]	Pasture Range and Paddock	Other[b]	Fuel
Dairy Cows	30.6	14.1	9.8	45.5	NA	NA
Other Cattle >1 year	6.0	23.0	20.4	50.5	NA	NA
Other Cattle <1 year		22.9	22.3	54.8	NA	NA

Animal Type	Liquid System	Daily Spread	Solid Storage and Dry Lot[a]	Pasture Range and Paddock	Other[b]	Fuel
Fattening & Other Pigs > 20 kg,	29.2	5.8	64.0	1.0	NA	NA
Breeding sows	35.5	7.1	28	29.3	NA	NA
Pigs <20 kg	38.3	7.7	46.0	8.0	NA	NA
Sheep	NA	NA	2.0	98.0	NA	NA
Goats	NA	NA	NA	96.0	4.0	NA
Broilers & Table Fowl (2003)	NA	NA	NA	1.0	63.0	36.0
Breeders	NA	NA	NA	1.0	99.0	NA
Layers[e]	NA	NA	NA	10.0	90.0	NA
Pullets[e]	NA	NA	NA	10.0	90.0	NA
Ducks, Geese & Guinea Fowl[e]	NA	NA	NA	50.0	50.0	NA
Turkeys[e]	NA	NA	NA	8.0	92.0	NA
Horses	NA	NA	NA	96.0	4.0	NA
Deer: Stags[d]	NA	NA	NA	100	NA	NA
Deer: Hinds & Calves[d]	NA	NA	NA	75.0	25.0	NA

a Farmyard manure
b Poultry litter, Stables from NH_3 inventory (T. Misselbrook)
c ADAS (1995a), Smith (2002)
d Sneath *et al.* (1997)
e Tucker and Canning (1997)

Table A3.6.9 gives the N_2O emission factor for each animal waste management system ($EF_{(AWMS)}$). These are expressed as the emission of N_2O-N per mass of excreted N processed by the waste management system.

Emissions from grazing animals (pasture range and paddock) and daily spread are calculated in the same way as the other AWMS. However, emissions from land spreading of manure that has previously been stored in a) liquid systems, b) solid storage and dry lot and c) other systems, are treated differently. These are discussed in **Section A3.6.3**.

Table A 3.6.9: Nitrous Oxide Emission Factors for Animal Waste Handling Systems[a]

Waste Handling System	Emission Factor kg N_2O-N per kg N excreted
Liquid System	0.001
Daily Spread[b]	0
Solid Storage and Dry Lot	0.02
Pasture, Range and Paddock[b]	0.02
Other (all poultry except layers)	0.02[c]
Other (layers)	0.005

a IPCC (1997)
b Reported under Agricultural Soils
c 2000 GPG

A3.6.3 Agricultural Soils (4D)

A3.6.3.1 Source category description

Direct emissions of nitrous oxide from agricultural soils are estimated using the IPCC recommended methodology (IPCC, 1997) but incorporating some UK specific parameters. The IPCC method involves estimating contributions from:

(i) The use of inorganic fertilizer
(ii) Biological fixation of nitrogen by crops
(iii) Ploughing in crop residues
(iv) Cultivation of Histosols (organic soils)
(v) Spreading animal manures on land
(vi) Manures dropped by animals grazing in the field

In addition to these, the following indirect emission sources are estimated:

(vii) Emission of N_2O from atmospheric deposition of agricultural NO_x and NH_3
(viii) Emission of N_2O from leaching of agricultural nitrate and runoff

Descriptions of the methods used are described in **Section 6.5.2**.

A3.6.3.2 Inorganic Fertiliser

Emissions from the application of inorganic fertilizer are calculated using the IPCC (1997) methodology and IPCC default emission factors. They are given by:

$$N_2O_{(SN)} = 44/28 \,.\, N_{(FERT)} \,.\, (1-Frac_{(GASF)}) \,.\, EF_1$$

where

$N_2O_{(SN)}$ = Emission of N_2O from synthetic fertiliser application (kg N_2O/yr)
$N_{(FERT)}$ = Total use of synthetic fertiliser (kg N/yr)
$Frac_{(GASF)}$ = Fraction of synthetic fertiliser emitted as NO_x + NH_3
= 0.1 kg NH_3-N+NO_x -N / kg synthetic N applied
EF_1 = Emission Factor for direct soil emissions
= 0.0125 kg N_2O-N/kg N input

Annual consumption of synthetic fertilizer is estimated based on crop areas (Defra, 2008a) and fertilizer application rates (BSFP, 2008) as shown in **Table A.3.6.10**. Figure 1 shows data compiled by the ONS (2008) and BSFP (used in the inventory) at UK level. The ONS data is derived from a combination of sources, including import/export statistics, BSFP and industry production data. The graph shows the BSFP is 8.8% larger in average.

Table A 3.6.10: Areas of UK Crops and rates of fertiliser applied

Crop Type	Crop area, ha	Fertiliser rate, ktN
Winter wheat	1,815,878	344.7
Spring barley	514,979	50.47
Winter barley	382,934	51.98
Oats	129,347	12.3
Rye, triticale & mixed corn	24,561	1.4

Crop Type	Crop area, ha	Fertiliser rate, ktN
Maize	146,308	7.6
Maincrop potatoes	140,153	17.9
Sugar beet	124,994	11.5
Oilseed rape	601,605	114.0
Peas (green, human cons)	37,700	0.0
Peas (dry, human cons)	7,051	0.0
Peas, dry, animal cons)	29,996	0.0
Broad beans	373	0.0
Beans (human cons)	9	0.0
Beans (animal cons)	123,973	0.12
Rootcrops for stockfeed	35,387	3.43
Leafy forage crops	5,982	0.3
Other forage crops	31.541	0.0
Vegetables (brassicae)	30,521	4.19
Vegetables (other)	37,770	2.9
Soft fruit	9,508	0.3
Top fruit	23,151	2.5
Hops	1,100	0.0
Linseed	10,958	0.0
Other tillage	144,244	8.3
Grass under 5 years	1,176,011	117.4
Permanent grass	5,964,915	346.8

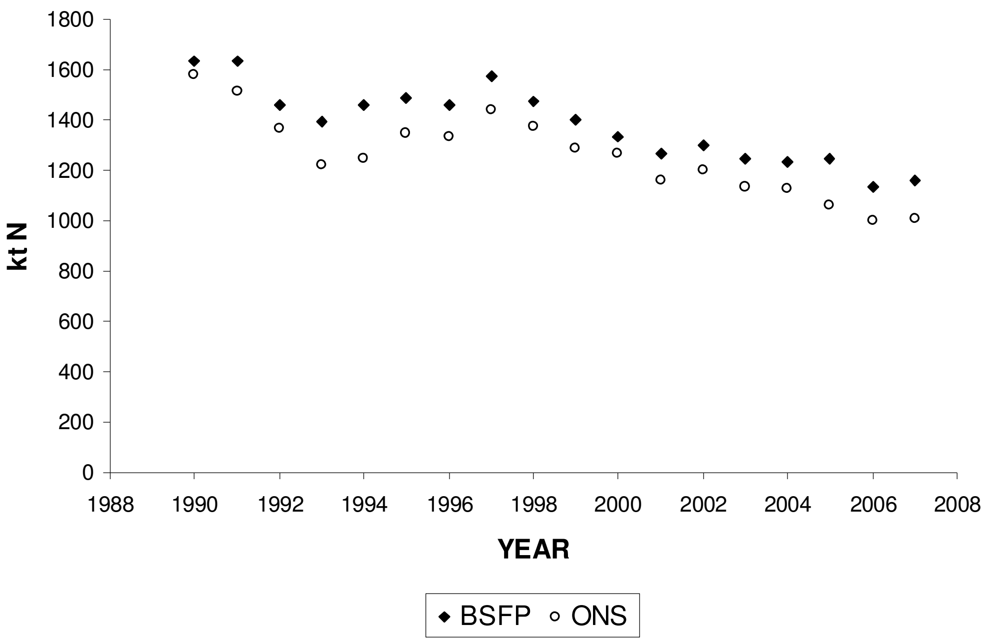

Figure A3.6.1 Comparison of fertiliser data, sources BSFP and ONS

A3.6.3.3 Biological Fixation of Nitrogen by crops

Emissions of nitrous oxide from the biological fixation of nitrogen by crops are calculated using the IPCC (2000) Tier 1a methodology and IPCC default emission factors. They are given by:

$N_2O_{(BF)}$ = 44/28 . 2 . $Crop_{(BF)}$. $Frac_{DM}$. $Frac_{(NCRBF)}$. EF_1

where

$N_2O_{(BF)}$	=	Emission of N_2O from biological fixation (kg N_2O/yr)
$Crop_{(BF)}$	=	Production of legumes (kg /yr)
$Frac_{DM}$	=	Dry matter fraction of crop
$Frac_{(NCRBF)}$	=	Fraction of nitrogen in N fixing crop
	=	0.03 kg N/ kg dry mass
EF_1	=	Emission Factor for direct soil emissions
	=	0.0125 kg N_2O-N/kg N input

The factor of 2 converts the edible portion of the crop reported in agricultural statistics to the total biomass. The fraction of dry mass for the crops considered is given in **Table A3.6.11**.

Table A 3.6.11: Dry Mass Content and Residue Fraction of UK Crops

Crop Type	Fraction dry mass[b]	Residue/Crop
Broad Beans, Green Peas	0.08	1.1
Field Bean[d], Peas(harvest dry)	0.86	1.1
Rye, Mixed corn, Triticale	0.855[a]	1.6
Wheat, Oats	0.855[a]	1.3
Barley	0.855[a]	1.2
Oilseed Rape, Linseed	0.91[a]	1.2
Maize	0.50	1
Hops[c]	0.20	1.2
Potatoes	0.20	0.4
Roots, Onions	0.07	1.2
Brassicas	0.06	1.2
Sugar Beet	0.1	0.2
Other	0.05	1.2
Phaseolus beans	0.08	1.2

a Defra (2002)
b Burton (1982), Nix (1997) or Defra estimates
c Hops dry mass from Brewers Licensed Retail Association (1998)
d Field beans dry mass from PGRE (1998)

The data for the ratio residue/crop are default values found under Agricultural Soils or derived from Table 4.17 in Field Burning of Agricultural Residues (IPCC, 1997). Crop production data are taken from Defra (2008a, 2008b). The total nitrous oxide emission reported also includes a contribution from improved grass calculated using a fixation rate of 4 kg N/ha/year (Lord, 1997).

A3.6.3.4 Crop Residues

Emissions of nitrous oxide from the ploughing in of crop residues are calculated using a combination of the IPCC (2000) Tier 1b and 1a methodology, for non-N fixing and N-fixing crops, respectively, and IPCC default emission factors. They are given by:

$N_2O_{(CR)}$ = $\sum_i (Crop_O \cdot Res_{oi}/Crop_{oi} \cdot FracDM_i \cdot Frac_{(NCRO)} \cdot (1-Frac_B) + \sum_j (2 \cdot Crop_{(BFj)} \cdot FracDM_j \cdot Frac_{(NCRBFj)}) \cdot (1-Frac_{Rj}) \cdot (1-Frac_{Bj}))) \cdot EF_1 \cdot 44/28$

where

$N_2O_{(CR)}$	=	Emission of N_2O from crop residues (kg N_2O/yr)
$Crop_{Oi}$	=	Production of non-N fixing crop i (kg /yr)
$Frac_{(NCRO)}$	=	Fraction of nitrogen in non-N fixing crops
	=	0.015 kg N/ kg dry mass
$FracDM_{i,j}$	=	dry matter fraction of crop i, j.
$Frac_R$	=	Fraction of crop that is remove from field as crop
$Frac_B$	=	Fraction of crop residue that is burnt rather than left on field
EF_1	=	Emission Factor for direct soil emissions
	=	0.0125 kg N_2O-N/kg N input
$Crop_{(BFj)}$	=	Production of legume crop j (kg /year)
$Frac_{(NCRBF)}$	=	Fraction of nitrogen in N fixing crop
	=	0.03 kg N/ kg dry mass

Production data of crops are taken from Defra (2008a, 2008b) and are shown in **Table A3.6.12**. The dry mass fraction of crops and residue fraction are given in **Table A3.6.11**. Field burning has largely ceased in the UK since 1993. For years prior to 1993, field-burning data were taken from the annual MAFF Straw Disposal Survey (MAFF, 1995).

Table A 3.6.12: Production of UK Crops

Crop Type	Crop production, kt
Broad beans	9.6
Field Beans	375
Peas green for market	6
Peas green for processing	97.8
All peas harvested dry	17
Rye, mixed corn, triticale	118
Wheat	13138
Oats	712
Barley	5079
OSR	1901
Linseed	17
Maize	0
Sugar beet	7525
Hops	0
Potatoes	5635
Total roots & onions	1292
Total brassicas	439
Total others	323
Phaseolus beans	17

A3.6.3.5 Histosols

Emissions from Histosols were estimated using the IPCC (2000) default factor of 8 kg N_2O-N/ha/yr. The area of cultivated Histosols is assumed to be equal to that of eutric organic soils in the UK and is based on a FAO soil map figure supplied by SSLRC (now NSRI).

A3.6.3.6 Grazing Animals

Emissions from manure deposited by grazing animals are reported under agricultural soils by IPCC. The method of calculation is the same as that for AWMS (see **Section A3.6.2.2**), using factors for pasture range and paddock.

A3.6.3.7 Organic Fertilizers

Emissions from animal manures and slurries used as organic fertilizers are reported under agricultural soils by IPCC. The calculation involves estimating the amount of nitrogen applied to the land and applying IPCC emission factors. For daily spreading of manure, the emission is given by:

$$N_2O_{(DS)} = 44/28 \, . \, \sum_T (N_T \, . \, Nex_{(T)} \, . \, AWMS_{(DS)}) \, . \, EF_1$$

where

$N_2O_{(DS)}$ = N_2O emissions from daily spreading of wastes (kg N_2O/yr)
N_T = Number of animals of type T
$Nex_{(T)}$ = N excretion of animals of type T (kg N/animal/yr), net of N volatilising as NOx and NH_3 (values in **Table A3.6.7** are without the volatilised fraction removed)
$AWMS_{(DS)}$ = Fraction of Nex that is daily spread
EF_1 = Emission Factor for direct soil emissions
= 0.0125 kg N_2O-N/kg N input

For the application of previously stored manures to land, a correction is applied to account for previous N_2O losses during storage.

$$N_2O_{(FAW)} = 44/28 \, . \, \sum_T (N_T \, . \, Nex_{(T)} \, . \, AWMS_{(W)} - N_{(AWMS)}) \, . \, EF_1$$

where

$N_2O_{(FAW)}$ = N_2O emission from organic fertiliser application
N_T = Number of animals of type T
$Nex_{(T)}$ = N excretion of animals of type T (kg N/animal/yr) net of N volatilising as NOx and NH_3 (values in **Table A3.6.7** are without the volatilised fraction removed)
$AWMS_{(W)}$ = Fraction of Nex that is managed in one of the different waste management systems of type W
$N_{(AWMS)}$ = N_2O emissions from animal waste management systems as nitrogen (kg N_2O-N/yr)

The summation is for all animal types and manure previously stored in categories defined as a) liquid, b) solid storage and dry lot and c) other.

A3.6.3.8 Atmospheric deposition of NOx and NH_3

Indirect emissions of N_2O from the atmospheric deposition of ammonia and NOx are estimated according to the IPCC (1997) methodology but with corrections to avoid double counting N. The sources of ammonia and NOx considered are synthetic fertiliser application and animal manures applied as fertiliser.

The contribution from synthetic fertilisers is given by:

$N_2O_{(DSN)}$ = 44/28 . $N_{(FERT)}$. $Frac_{(GASF)}$. EF_4

where

$N_2O_{(DSN)}$ = Atmospheric deposition emission of N_2O arising from synthetic fertiliser application (kg N_2O/yr)
$N_{(FERT)}$ = Total mass of nitrogen applied as synthetic fertiliser (kg N/yr)
$Frac_{(GASF)}$ = Fraction of total synthetic fertiliser nitrogen that is emitted as $NO_x + NH_3$
= 0.1 kg N/ kg N
EF_4 = N deposition emission factor
= 0.01 kg N_2O-N/kg NH_3-N and NO_x-N emitted

The indirect contribution from waste management systems is given by:

$N_2O_{(DWS)}$ = 44/28. ($N_{(EX)}$/(1-$Frac_{(GASM)}$) -$N_{(F)}$) . $Frac_{(GASM)}$. EF_4

where

$N_2O_{(DWS)}$ = Atmospheric deposition emission of N_2O arising from animal wastes (kg N_2O/yr)
$N_{(EX)}$ = Total N excreted by animals (kg N/yr), net of N volatilising as NOx and NH_3 (values in **Table A3.6.7** are without the volatilised fraction removed)
$Frac_{(GASM)}$ = Fraction of livestock nitrogen excretion that volatilises as NH_3 and NO_x
= 0.2 kg N/kg N
$N_{(F)}$ = Total N content of wastes used as fuel (kg N/yr)

The equation corrects for the N content of manures used as fuel.

A3.6.3.9 Leaching and runoff

Indirect emissions of N_2O from leaching and runoff are estimated according the IPCC methodology but with corrections to avoid double counting N. The sources of nitrogen considered, are synthetic fertiliser application and animal manures applied as fertiliser.

The contribution from synthetic fertilisers is given by:

$N_2O_{(LSN)}$ = 44/28 . ($N_{(FERT)}$. (1-$Frac_{(GASF)}$)- $N_{(SN)}$) . $Frac_{(LEACH)}$. EF_5

where

$N_2O_{(LSN)}$ = Leaching and runoff emission of N_2O arising from synthetic fertiliser application (kg N_2O/yr)
$N_{(FERT)}$ = Total mass of nitrogen applied as synthetic fertiliser (kg N/yr)

$N_{(SN)}$	=	Direct emission of $N_2O_{(SN)}$ as nitrogen (kg N_2O-N/yr)
$Frac_{(GASF)}$	=	Fraction of total synthetic fertiliser nitrogen emitted as $NO_x + NH_3$
	=	0.1 kg N/ kg N
$Frac_{(LEACH)}$	=	Fraction of nitrogen input to soils lost through leaching and runoff
	=	0.3 kg N/ kg fertiliser or manure N
EF_5	=	Nitrogen leaching/runoff factor
	=	0.025 kg N_2O-N /kg N leaching/runoff

The estimate includes a correction to avoid double counting N_2O emitted from synthetic fertiliser use.

The indirect contribution from waste management systems is given by:

$$N_2O_{(LWS)} = 44/28 . ((N_{(EX)} - N_{(F)} - N_{(AWMS)}) . Frac_{(LEACH)} . EF_5$$

where

$N_2O_{(LWS)}$	=	Leaching and runoff emission of N_2O from animal wastes (kg N_2O/yr)
$N_{(EX)}$	=	Total N excreted by animals (kg N/yr), net of N volatilising as NOx and NH_3 (values in **Table A3.6.7** are without the volatilised fraction removed)
$N_{(F)}$	=	Total N content of wastes used as fuel (kg N/yr)
$N_{(AWMS)}$	=	Total N content of N_2O emissions from waste management systems including daily spread and pasture range and paddock (kg N_2O-N/yr)
$Frac_{(LEACH)}$	=	Fraction of nitrogen input to soils that is lost through leaching and runoff
	=	0.3 kg N/ kg fertiliser or manure N
EF_5	=	Nitrogen leaching/runoff factor
	=	0.025 kg N_2O-N /kg N leaching/runoff

The equation corrects both for the N lost in the direct emission of N_2O from animal wastes and the N content of wastes used as fuel.

A3.6.4 Field Burning of Agricultural Residues (4F)

The National Atmospheric Emissions Inventory reports emissions from field burning under the category agricultural incineration. The estimates are derived from emission factors calculated according to IPCC (1997) and from USEPA (1997) shown in **Table A3.6.13**.

Table A 3.6.13: Emission Factors for Field Burning (kg/t)

	CH_4	CO	NO_x	N_2O	NMVOC
Barley	3.05[a]	63.9[a]	2.18[a]	0.060[a]	7.5[b]
Other	3.24[a]	67.9[a]	2.32[a]	0.064[a]	9.0[b]

a IPCC (1997)
b USEPA (1997)

The estimates of the masses of residue burnt of barley, oats, wheat and linseed are based on crop production data (Defra, 2008b) and data on the fraction of crop residues burnt (MAFF, 1995; ADAS, 1995b). Field burning ceased in 1993 in England and Wales. Burning in

Scotland and Northern Ireland is considered negligible, as is grouse moor burning, so no estimates are reported from 1993 onwards. The carbon dioxide emissions are not estimated because under the IPCC Guidelines they are considered to be part of the annual carbon cycle.

A3.7 LAND USE, LAND USE CHANGE AND FORESTRY (CRF SECTOR 5)

The following section describes in detail the methodology used in the Land-Use Change and Forestry Sector. Further information regarding this Sector can be found in **Chapter 7**.

A3.7.1 Land Converted to Forest Land (5A2)

The carbon uptake by the forests planted since 1920 is calculated by a carbon accounting model (Dewar and Cannell 1992; Cannell and Dewar 1995; Milne et al. 1998) as the net change in pools of carbon in standing trees, litter, soil in conifer and broadleaf forests and in products. Restocking is assumed in all forests. The method is Tier 3, as defined in the Good Practice Guidance for LULUCF (IPCC 2003). Two types of input data and two parameter sets were required for the model (Cannell and Dewar 1995). The input data are: (a) areas of new forest planted in each year in the past, and (b) the stemwood growth rate and harvesting pattern. Parameter values were required to estimate (i) stemwood, foliage, branch and root masses from the stemwood volume and (ii) the decomposition rates of litter, soil carbon and wood products.

For the estimates described here we used the combined area of new private and state planting from 1921 to 2007 for England, Scotland, Wales and Northern Ireland sub-divided into conifers and broadleaves. Restocking was dealt with in the model through the second and subsequent rotations, which occur after clearfelling at the time of Maximum Area Increment (MAI). Therefore areas restocked in each year did not need to be considered separately. The key assumption is that the forests are harvested according to standard management tables. However, a comparison of forest census data over time has indicated that there are variations in the felling/replanting date during the 20th century, i.e. non-standard management. These variations in management have been incorporated into the forest model, and the methodology will be kept under review in future reporting.

The carbon flow model uses Forestry Commission Yield Tables (Edwards and Christie 1981) to describe forest growth after thinning commences and an expo-linear curve for growth before first thinning. It was assumed that all new conifer plantations have the same growth characteristics as Sitka spruce (*Picea sitchensis* (Bong.) Carr.) under an intermediate thinning management regime. Sitka spruce is the commonest species in UK forests being about 50% by area of conifer forests. Milne et al. (1998) have shown that mean Yield Class for Sitka spruce varied across Great Britain from 10-16 m^3 ha^{-1} a^{-1}, but with no obvious geographical pattern, and that this variation had an effect of less than 10% on estimated carbon uptake for the country as a whole. The Inventory data has therefore been estimated by assuming all conifers in Great Britain followed the growth pattern of Yield Class 12 m^3 ha^{-1} a^{-1}, but in Northern Ireland Yield Class 14 m^3 ha^{-1} a^{-1} was used. Milne et al. (1998) also showed that different assumptions for broadleaf species had little effect on carbon uptake. It is assumed that broadleaf forests have the characteristics of beech (*Fagus sylvatica* L.) of Yield Class 6 m^3 ha^{-1} a^{-1}. The most recent inventory of British woodlands (Forestry Commission 2002) shows that beech occupies about 8% of broadleaf forest area (all ages) and no single species occupies greater than 25%. Beech was selected to represent all broadleaves as it has characteristics intermediate between fast growing species e.g. birch, and very slow growing species e.g. oak.

However, using oak or birch Yield Class data instead of beech data has been shown to have an effect of less than 10% on the overall removal of carbon to UK forests (Milne et al. 1998). The use of beech as the representative species will be kept under review.

Irrespective of species assumptions, the variation in removals from 1990 to the present is determined by the afforestation rate in earlier decades and the effect this has on the age structure in the present forest estate, and hence the average growth rate. At the current (declining) rate of forest expansion removals of atmospheric carbon increased until 2004 and have now started to decrease, reflecting the reduction in afforestation rate after the 1970s. This afforestation is all on ground that has not been wooded for many decades. **Table A 3.7.1** shows the afforestation rate since 1921 and a revised estimate of the present age structure of these forests.

A comparison of historical forest census data and the historical annual planting rates has been undertaken. Forest censuses were taken in 1924, 1947, 1965, 1980 and the late 1990s. The comparison of data sources showed that discrepancies in annual planting rates and inferred planting/establishment date (from woodland age in the forest census) are due to restocking of older (pre-1920) woodland areas and variations in the harvesting rotations. However, there is also evidence of shortened conifer rotations in some decades and transfer of woodland between broadleaved categories (e.g. between coppice and high forest). As a result, the afforestation series for conifers in England and Wales were sub-divided into the standard 59 year rotation (1921-2004), a 49 year rotation (1921-1950) and a 39 year rotation (1931-1940, England only). It is difficult to incorporate non-standard management in older conifer forests and broadleaved forests into the Inventory because it is not known whether these forests are on their first rotation or subsequent rotations (which would affect carbon stock changes, particularly in soils). Further work is planned for this area.

In addition to these planted forests, there are about 822,000 ha of woodland planted prior to 1921 or not of commercial importance. These forests are assumed to fall in Category 5.A.1 (Forest Land remaining Forest Land). It is evident from the comparison of historical forest censuses that some of this forest area is still actively managed, but overall this category is assumed to be carbon-neutral. The possible contribution of this category to carbon emissions and removals will be considered in more detail in future reporting.

Table A 3.7.1: Afforestation rate and age distribution of conifers and broadleaves in the United Kingdom since 1921

Period	Planting rate (100 ha a^{-1})			Age distribution	
	Conifers on all soil types	Conifers on organic soil	Broadleaves	Conifers	Broadleaves
1921-1930	5.43	0.54	2.44	1.4%	7.8%
1931-1940	7.46	0.73	2.13	2.5%	8.4%
1941-1950	7.43	0.82	2.22	6.1%	11.8%
1951-1960	21.66	3.06	3.09	16.0%	11.4%
1961-1970	30.08	5.28	2.55	22.8%	8.3%

Period	Planting rate (100 ha a^{-1})			Age distribution	
	Conifers on all soil types	Conifers on organic soil	Broadleaves	Conifers	Broadleaves
1971-1980	31.38	7.61	1.14	22.4%	5.9%
1981-1990	22.31	6.05	2.19	19.1%	4.9%
1991	13.46	3.41	6.71	0.9%	0.6%
1992	11.56	2.97	6.48	0.8%	0.6%
1993	10.06	2.43	8.87	0.7%	0.8%
1994	7.39	1.74	11.16	0.5%	1.0%
1995	9.44	2.37	10.47	0.6%	1.0%
1996	7.42	1.79	8.93	0.5%	0.8%
1997	7.72	1.87	9.46	0.5%	0.9%
1998	6.98	1.62	9.67	0.5%	0.9%
1999	6.63	1.44	10.12	0.5%	0.9%
2000	6.53	1.37	10.91	0.4%	1.0%
2001	4.90	1.01	13.45	0.3%	1.2%
2002	3.89	0.75	9.99	0.3%	0.9%
2003	3.74	0.72	9.22	0.3%	0.8%
2004	2.94	0.59	8.89	0.2%	0.8%
2005	2.10	0.40	9.19	0.1%	0.8%
2006	1.14	0.21	7.03	0.1%	0.6%

Afforestation rates and ages of GB forests planted later than 1989 are from planting records. The age distribution for GB forests planted before 1990 is from the National Inventory of Woodland and Trees carried out between 1995 and 1999. The age distribution for pre-1990 Northern Ireland forests is estimated from planting records. Conifer planting on organic soil is a subset of total conifer planting. All broadleaf planting is assumed to be on non-organic soil.

Increases in stemwood volume were based on standard Yield Tables, as in Dewar and Cannell (1992) and Cannell and Dewar (1995). These Tables do not provide information for years prior to first thinning so a curve was developed to bridge the gap (Hargreaves et al. 2003). The pattern fitted to the stemwood volume between planting and first thinning from the Yield Tables follows a smooth curve from planting to first thinning. The formulation begins with an exponential pattern but progresses to a linear trend that merges with the pattern in forest management tables after first thinning.

The mass of carbon in a forest was calculated from volume by multiplying by species-specific wood density, stem:branch and stem:root mass ratios and the fraction of carbon in wood (0.5 assumed). The values used for these parameters for conifers and broadleaves are given in **Table A 3.7.2**.

The parameters controlling the transfer of carbon into the litter pools and its subsequent decay are given in **Table A 3.7.2**. Litter transfer rate from foliage and fine roots increased to a maximum at canopy closure. A fraction of the litter was assumed to decay each year, half of which was added to the soil organic matter pool, which then decayed at a slower rate. Tree species and Yield Class were assumed to control the decay of litter and soil matter. Additional litter was generated at times of thinning and felling. These carbon transfer parameters have been used to split the living biomass output from C-Flow between gains and losses.

Table A 3.7.2: Main parameters for forest carbon flow model used to estimate carbon uptake by planting of forests of Sitka spruce (P. sitchensis and beech (F. sylvatica) in the United Kingdom (Dewar & Cannell 1992)

	P. sitchensis	*P. sitchensis*	*F. sylvatica*
	YC12	**YC14**	**YC6**
Rotation (years)	59	57	92
Initial spacing (m)	2	2	1.2
Year of first thinning	25	23	30
Stemwood density (t m^{-3})	0.36	0.35	0.55
Maximum carbon in foliage (t ha^{-1})	5.4	6.3	1.8
Maximum carbon in fine roots (t ha^{-1})	2.7	2.7	2.7
Fraction of wood in branches	0.09	0.09	0.18
Fraction of wood in woody roots	0.19	0.19	0.16
Maximum foliage litterfall (t ha^{-1} a^{-1})	1.1	1.3	2
Maximum fine root litter loss (t ha^{-1} a^{-1})	2.7	2.7	2.7
Dead foliage decay rate (a^{-1})	1	1	3
Dead wood decay rate (a^{-1})	0.06	0.06	0.04
Dead fine root decay rate (a^{-1})	1.5	1.5	1.5
Soil organic carbon decay rate (a^{-1})	0.03	0.03	0.03
Fraction of litter lost to soil organic matter	0.5	0.5	0.5
Lifetime of wood products	57	59	92

Estimates of carbon losses from the afforested soils are based on measurements taken at deep peat moorland locations, covering afforestation of peat from 1 to 9 years previously and at a 26 year old conifer forest (Hargreaves et al. 2003). These measurements suggest that long term losses from afforested peatlands are not as great as had been previously thought, settling to about 0.3 tC ha^{-1} a^{-1} thirty years after afforestation. In addition, a short burst of regrowth of moorland plant species occurs before forest canopy closure.

Carbon incorporated into the soil under all new forests is included, and losses from pre-existing soil layers are described by the general pattern measured for afforestation of deep peat with conifers. The relative amounts of afforestation on deep peat and other soils in the decades since 1920 are considered. For planting on organo-mineral and mineral soils, it is assumed that the pattern of emissions after planting will follow that measured for peat, but the emissions from the pre-existing soil layers will broadly be in proportion to the soil carbon density of the top 30 cm relative to that same depth of deep peat. A simplified approach was taken to deciding on the proportionality factors, and it is assumed that emissions from pre-existing soil layers will be equal to those from the field measurements for all planting in Scotland and Northern Ireland and for conifer planting on peat in England and Wales. Losses from broadleaf planting in England and Wales are assumed to proceed at half the rate of those in the field measurements. These assumptions are based on consideration of mean soil carbon densities for non-forest in the fully revised UK soil carbon database. The temporary re-growth of ground vegetation before forest canopy closure is, however, assumed to occur for all planting at the same rate as for afforested peat moorland. This assumption agrees with qualitative field observations at plantings on agricultural land in England.

It is assumed in the carbon accounting model that harvested material from thinning and felling is made into wood products. The net change in the carbon in this pool of wood products is reported in Category 5G.

Nitrogen fertilisation of forest land is assumed to occur only when absolutely necessary, i.e. new planting on 'poor' soils (slag heaps, impoverished brown field sites, or upland organic soils). In terms of the inventory, this means that N fertilisation is assumed for Settlement converted to Forest land and Grassland converted to Forest Land on organic soils. The areas of new planting with these conditions were taken from the same dataset used in the CFlow model for 5.A.2. Land converted to Forest land.

An application rate of 150 kg N ha^{-1} is assumed based on Forestry Commission fertilisation guidelines (Taylor 1991). The guidelines recommend applying fertiliser on a three-year cycle until canopy closure (at c. 10 years), but this is thought to be rather high (Skiba 2007) and unlikely to occur in reality, so two applications are adopted as a compromise. These applications occur in year 1 and year 4 after planting. As a result, emissions from N fertilisation since 1990 include emissions from forests that were planted before 1990 but received their second dose of fertiliser after 1990. The emission factor for N_2O of applied nitrogen fertiliser is the default value of 1.25%. Emissions of N_2O from N fertilisation of forests have fallen since 1990 due to reduced rates of new forest planting.

A3.7.2 Land Use Change and Soils (5B2, 5C2, 5E2)

The method for assessing changes in soil carbon due to land use change uses a matrix of change from land surveys linked to a dynamic model of carbon stock change. For Great Britain (England, Scotland and Wales), matrices from the Monitoring Landscape Change (MLC) data from 1947 & 1980 (MLC 1986) and the Countryside Surveys (CS) of 1984, 1990 and 1998 (Haines-Young et al. 2000) are used. In Northern Ireland, fewer data are available to build matrices of land use change, but for 1990 to 1998 a matrix for the whole of Northern Ireland was available from the Northern Ireland Countryside Survey (Cooper and McCann 2002). The only data available for Northern Ireland pre-1990 is land use areas from The Agricultural Census and The Forest Service (Cruickshank and Tomlinson 2000). Matrices of land use change were then estimated for 1970-79 and 1980-89 using area data. The basis of the method devised was to assume that the relationship between the matrix of land use transitions for 1990 to 1998 and the area data for 1990 is the same as the relationship between the matrix and area data for each of two earlier periods – 1970-79 and 1980-89. The matrices developed in this approach were used to extrapolate areas of land use transition back to 1950 to match the start year in the rest of the UK.

The Good Practice Guidance for Land Use, Land Use Change and Forestry (IPCC 2003) recommends use of six classes of land for descriptive purposes: Forest, Grassland, Cropland, Settlements, Wetlands and Other Land. The data presently available for the UK does not distinguish wetlands from other types, so land in the UK has been placed into the five other types. The more detailed categories for the two surveys in Great Britain were combined as shown in **Table A 3.7.3** for MLC and **Table A 3.7.4** for CS.

The area data used between 1947 and 1998 are shown in **Table A 3.7.5** and **Table A 3.7.6**. The land use change data over the different periods were used to estimate annual changes by assuming that these were uniform across the measurement period. Examples of these annual changes (for the period 1990 to 1999) are given in **Table A 3.7.7** to **Table A 3.7.10.**

The data for afforestation and deforestation shown in the Tables are adjusted before use for estimating carbon changes to harmonise the values with those used in the calculations for Land converted to and from Forest Land.

Table A 3.7.3: Grouping of MLC land cover types for soil carbon change modelling

CROPLAND	GRASSLAND	FORESTLAND	SETTLEMENTS (URBAN)	OTHER
Crops	Upland heath	Broadleaved wood	Built up	Bare rock
Market garden	Upland smooth grass	Conifer wood	Urban open	Sand/shingle
	Upland coarse grass	Mixed wood	Transport	Inland water
	Blanket bog	Orchards	Mineral workings	Coastal water
	Bracken		Derelict	
	Lowland rough grass			
	Lowland heather			
	Gorse			
	Neglected grassland			
	Marsh			
	Improved grassland			
	Rough pasture			
	Peat bog			
	Fresh Marsh			
	Salt Marsh			

Table A 3.7.4: Grouping of Countryside Survey Broad Habitat types for soil carbon change modelling

CROPLAND	GRASSLAND	FORESTLAND	SETTLEMENTS (URBAN)	OTHER
Arable	Improved grassland	Broadleaved/ mixed	Built up areas	Inland rock
Horticulture	Neutral grassland	Coniferous	Gardens	Supra littoral rock
	Calcareous grassland			Littoral rock
	Acid grassland			Standing waters
	Bracken			Rivers
	Dwarf shrub heath			Sea
	Fen, marsh, swamp			
	Bogs			
	Montane			
	Supra littoral sediment			
	Littoral sediment			

Table A 3.7.5: Sources of land use change data in Great Britain for different periods in estimation of changes in soil carbon

Year or Period	Method	Change matrix data
1950-1979	Measured LUC matrix	MLC 1947->MLC1980
1980 - 1984	Interpolated	CS1984->CS1990
1984 - 1989	Measured LUC matrix	CS1984->CS1990
1990 - 1998	Measured LUC matrix	CS1990->CS1998
1999-2003	*Extrapolated*	CS1990->CS1998

Table A 3.7.6: Sources of land use change data in Northern Ireland for different periods in estimation of changes in soil carbon. NICS = Northern Ireland Countryside Survey

Year or Period	Method	Change matrix data
1950 – 1969	Extrapolation and ratio method	NICS1990->NICS1998
1970 – 1989	Land use areas and ratio method	NICS1990->NICS1998
1990 – 1998	Measured LUC matrix	NICS1990->NICS1998
1999-2003	*Extrapolated*	NICS1990->NICS1998

Table A 3.7.7: Annual changes (000 ha) in land use in England in matrix form for 1990 to 1999. Based on land use change between 1990 and 1998 from Countryside Surveys (Haines-Young *et al.* 2000). Data have been rounded to 100 ha

From / To	Forestland	Grassland	Cropland	Settlements
Forestland		8.9	3.4	2.1
Grassland	8.7		55.3	3.4
Cropland	0.5	62.9		0.6
Settlements	1.2	8.5	2.1	

Table A 3.7.8: Annual changes (000 ha) in land use in Scotland in matrix form for 1990 to 1999. Based on land use change between 1990 and 1998 from Countryside Surveys (Haines-Young *et al.* 2000). Data have been rounded to 100 ha

From / To	Forestland	Grassland	Cropland	Settlements
Forestland		11.1	0.6	0.2
Grassland	5.0		16.8	0.7
Cropland	0.1	21.4		0.3
Settlements	0.3	2.2	0.1	

Table A 3.7.9: Annual changes (000 ha) in land use in Wales in matrix form for 1990 to 1999. Based on land use change between 1990 and 1998 from Countryside Surveys (Haines-Young *et al.* 2000). Data have been rounded to 100 ha

From / To	Forestland	Grassland	Cropland	Settlements
Forestland		2.4	0.2	0.2
Grassland	1.5		5.5	0.6
Cropland	0.0	8.0		0.0
Settlements	0.1	1.8	0.2	

Table A 3.7.10: Annual changes (000 ha) in land use in Northern Ireland in matrix form for 1990 to 1999. Based on land use change between 1990 and 1998 from Northern Ireland Countryside Surveys (Cooper & McCann 2002). Data have been rounded to 100 ha

From / To	Forestland	Grassland	Cropland	Settlements
Forestland		1.6	0.0	0.0
Grassland	0.3		5.9	0.0
Cropland	0.0	3.7		0.0
Settlements	0.1	1.0	0.0	

A database of soil carbon density for the UK (Milne & Brown 1997, Cruickshank *et al.* 1998, Bradley *et al.* 2005) is used in conjunction with the land use change matrices. There are three soil survey groups covering the UK and the field data, soil classifications and laboratory methods have been harmonized to reduce uncertainty in the final joint database. The depth of soil considered was also restricted to 1 m at maximum as part of this process. **Table A 3.7.11** shows total stock of soil carbon (1990) for different land types in the four devolved areas of the UK.

Table A 3.7.11: Soil carbon stock (TgC = MtC) for depths to 1 m in different land types in the UK

Region / Type	England	Scotland	Wales	N. Ireland	**UK**
Forestland	108	295	45	20	467
Grassland	995	2,349	283	242	3,870
Cropland	583	114	8	33	738
Settlements	54	10	3	1	69
Other	0	0	0	0	-
TOTAL	**1,740**	**2,768**	**340**	**296**	**5,144**

The dynamic model of carbon stock change requires the change in equilibrium carbon density from the initial to the final land use. The core equation describing changes in soil carbon with time for any land use transition is:

$$C_t = C_f - (C_f - C_0)e^{-kt}$$

where

C_t is carbon density at time t
C_0 is carbon density initial land use
C_f is carbon density after change to new land use
k is time constant of change

By differentiating we obtain the equation for flux f_t (emission or removal) per unit area:

$$f_t = k(C_f - C_o)e^{-kt}$$

From this equation we obtain, for any inventory year, the land use change effects from any specific year in the past. If A_T is area in a particular land use transition in year T considered from 1950 onwards then total carbon lost or gained in an inventory year, e.g. 1990, is given by:

$$F_{1990} = \sum_{T=1950}^{t=1990} kA_T (C_f - C_o)(e^{-k(1990-T)})$$

This equation is used with k, A_T and (C_f-C_0) chosen by Monte Carlo methods within ranges set by prior knowledge, e.g. literature, soil carbon database, agricultural census, LUC matrices.

In the model, the change is required in equilibrium carbon density from the initial to the final land use during a transition. Here, these are calculated for each land use category as averages for Scotland, England, Wales and Northern Ireland. These averages are weighted by the area of Land Use Change occurring in four broad soil groups (organic, organo-mineral, mineral, unclassified) in order to account for the actual carbon density where change has occurred.

Hence mean soil carbon density change is calculated as:

$$\overline{C}_{ijc} = \frac{\sum_{s=1}^{6}(C_{sijc}L_{sijc})}{\sum_{s=1}^{6}L_{sijc}}$$

This is the weighted mean, for each country, of change in equilibrium soil carbon when land use changes, where:

i = initial land use (Forestland, Grassland, Cropland, Settlements)
j = new land use (Forestland, Grassland, Cropland, Settlements)
c = country (Scotland, England, N. Ireland & Wales)
s = soil group (organic, organo-mineral, mineral, unclassified)
C_{sijc} is change in equilibrium soil carbon for a specific land use transition

The most recent land use data (1990 to 1998) is used in the weighting. The averages calculated are presented in **Table A 3.7.12-Table A 3.7.15.**

Table A 3.7.12: Weighted average change in equilibrium soil carbon density (kg m^{-2}) to 1 m deep for changes between different land types in England

To \ From	Forestland	Grassland	Cropland	Settlements
Forestland	0	25	32	83
Grassland	-21	0	23	79
Cropland	-31	-23	0	52
Settlements	-87	-76	-54	0

Table A 3.7.13: Weighted average change in equilibrium soil carbon density (kg m^{-2}) to 1 m deep for changes between different land types in Scotland

To \ From	Forestland	Grassland	Cropland	Settlements
Forestland	0	47	158	246
Grassland	-52	0	88	189
Cropland	-165	-90	0	96
Settlements	-253	-187	-67	0

Table A 3.7.14: Weighted average change in equilibrium soil carbon density (kg m^{-2}) to 1 m deep for changes between different land types in Wales

To \ From	Forestland	Grassland	Cropland	Settlements
Forestland	0	23	57	114
Grassland	-18	0	36	101
Cropland	-53	-38	0	48
Settlements	-110	-95	-73	0

Table A 3.7.15: Weighted average change in equilibrium soil carbon density (kg m^{-2}) to 1 m deep for changes between different land types in Northern Ireland

To \ From	Forestland	Grassland	Cropland	Settlements
Forestland	0	94	168	244
Grassland	-94	0	74	150
Cropland	-168	-74	0	76
Settlements	-244	-150	-76	0

The rate of loss or gain of carbon is dependent on the type of land use transition (**Table A 3.7.16**). For transitions where carbon is lost e.g. transition from Grassland to Cropland, a ‘fast’ rate is applied whilst a transition that gains carbon occurs much more slowly. A literature search for information on measured rates of changes of soil carbon due to land use was carried out and ranges of possible times for completion of different transitions were selected, in combination with expert judgement. These are shown in **Table A 3.7.17**.

Table A 3.7.16: Rates of change of soil carbon for land use change transitions. ("Fast" & "Slow" refer to 99% of change occurring in times shown in Table A3.7.17)

		Initial			
		Forestland	**Grassland**	**Cropland**	**Settlement**
Final	**Forestland**		*slow*	*slow*	*slow*
	Grassland	*fast*		*slow*	*slow*
	Cropland	*fast*	*fast*		*slow*
	Settlement	*fast*	*fast*	*fast*	

Table A 3.7.17: Range of times for soil carbon to reach 99% of a new value after a change in land use in England (E), Scotland (S) and Wales (W)

	Low (years)	High (years)
Carbon loss ("fast") E, S, W	50	150
Carbon gain ("slow") E, W	100	300
Carbon gain ("slow") S	300	750

Changes in soil carbon from equilibrium to equilibrium (C_f-C_o) were assumed to fall within ranges based on 2005 database values for each transition and the uncertainty indicated by this source (up to ± 11% of mean). The areas of land use change for each transition were assumed to fall a range of uncertainty of ± 30% of mean.

A Monte Carlo approach is used to vary the rate of change, the area activity data and the values for soil carbon equilibrium (under initial and final land use) for all countries in the UK. The model of change was run 1000 times using parameters selected from within the ranges described above. The mean carbon flux for each region resulting from this imposed random variation is reported as the estimate for the Inventory. An adjustment was made to these calculations for each country to remove increases in soil carbon due to afforestation, as the C-Flow model provides a better estimate of these fluxes in the Land Converted to Forest Land category. Variations from year to year in the reported net emissions reflect the trend in land use change as described by the matrices of change.

A3.7.3 Changes in stocks of carbon in non-forest biomass due to land use change (5B2, 5C2, 5E2)

Changes in stocks of carbon in biomass due to land use change are based on the same area matrices used for estimating changes in carbon stocks in soils (see previous section). The biomass carbon density for each land type is assigned by expert judgement based on the work of Milne and Brown (1997) and these are shown in **Table A 3.7.18**. Five basic land uses were assigned initial biomass carbon densities, then the relative occurrences of these land uses in the four countries of the UK were used to calculate mean densities for each of the IPCC types, Cropland, Grassland and Settlements. Biomass carbon stock changes due to conversions to and from Forest Land are dealt with elsewhere.

The mean biomass carbon densities for each land type were further weighted by the relative proportions of change occurring between land types (**Table A 3.7.19-**

Table A 3.7.22), in the same way as the calculations for changes in soil carbon densities. Changes between these equilibrium biomass carbon densities were assumed to happen in a single year.

Table A 3.7.18: Equilibrium biomass carbon density (kg m^{-2}) for different land types

Density (kg m^{-2})	Scotland	England	Wales	N. Ireland
Arable	0.15	0.15	0.15	0.15
Gardens	0.35	0.35	0.35	0.35
Natural	0.20	0.20	0.20	0.20
Pasture	0.10	0.10	0.10	0.10
Urban	0	0	0	0
	IPPC types weighted by occurrence			
Cropland	**0.15**	**0.15**	**0.15**	**0.15**
Grassland	**0.18**	**0.12**	**0.13**	**0.12**
Settlements	**0.29**	**0.28**	**0.28**	**0.26**

Table A 3.7.19: Weighted average change in equilibrium biomass carbon density (kg m^{-2}) to 1 m deep for changes between different land types in England (Transitions to and from Forestland are considered elsewhere)

To \ From	Forestland	Grassland	Cropland	Settlements
Forestland				
Grassland		0	0.08	-0.08
Cropland		-0.08	0	-0.13
Settlements		0.08	0.13	0

Table A 3.7.20: Weighted average change in equilibrium biomass carbon density (kg m^{-2}) to 1 m deep for changes between different land types in Scotland. (Transitions to and from Forestland are considered elsewhere)

To \ From	Forestland	Grassland	Cropland	Settlements
Forestland				
Grassland		0	0.02	-0.09
Cropland		-0.02	0	-0.14
Settlements		0.09	0.14	0

Table A 3.7.21: Weighted average change in equilibrium biomass carbon density (kg m-2) to 1 m deep for changes between different land types in Wales. (Transitions to and from Forestland are considered elsewhere)

To \ From	Forestland	Grassland	Cropland	Settlements
Forestland				
Grassland		0	0.07	-0.08
Cropland		-0.07	0	-0.13
Settlements		0.08	0.13	0

Table A 3.7.22: Weighted average change in equilibrium biomass carbon density (kg m^{-2}) to 1m deep for changes between different land types in Northern Ireland. (Transitions to and from Forestland are considered elsewhere)

To \ From	Forestland	Grassland	Cropland	Settlements
Forestland				
Grassland		0	0.08	-0.06
Cropland		-0.08	0	-0.11
Settlements		0.06	0.11	0

A3.7.4 Biomass Burning due to De-forestation (5C2, 5E2)

Levy and Milne (2004) discuss methods for estimating deforestation using a number of data sources. Here we use their approach of combining Forestry Commission felling licence data for rural areas with Ordnance Survey data for non-rural areas.

In Great Britain, some activities that involve tree felling require permission from the Forestry Commission, in the form of a felling licence, or a felling application within the Woodland Grant Scheme. Under the Forestry Act 1967, there is a presumption that the felled areas will be restocked, usually by replanting. Thus, in the 1990s, around 14,000 ha a^{-1} were felled and restocked. However, some licences are granted without the requirement to restock, where there is good reason – so-called unconditional felling licences. Most of these areas are small (1-20 ha), but their summation gives some indication of areas deforested. These areas are not published, but recent figures from the Forestry Commission have been collated. These provide estimates of rural deforestation rates in England for 1990 to 2002 and for GB in 1999 to 2001. The most recent deforestation rate available for rural areas is for 2002 so rates for 2003-2007 were estimated by extrapolating forwards from the rates for 1999-2002.

Only local planning authorities hold documentation for allowed felling for urban development, and the need for collation makes estimating the national total difficult. However, in England, the Ordnance Survey (national mapping agency) makes an annual assessment of land use change from the data it collects for map updating and provides this assessment the Department of Communities and Local Government. Eleven broad land-use categories are defined, with a number of sub-categories.

The data for England (1990 to 2007) were available to produce a land-use change matrix, quantifying the transitions between land-use classes. Deforestation rate was calculated as the sum of transitions from all forest classes to all non-forest classes providing estimates on non-rural deforestation.

The rural and non-rural values for England were each scaled up to GB scale, assuming that England accounted for 72 per cent of deforestation, based on the distribution of licensed felling between England and the rest of GB in 1999 to 2002. However, the Ordnance Survey data come from a continuous rolling survey programme, both on the ground and from aerial photography. The changes reported each year may have actually occurred in any of the preceding 1-5 years (the survey frequency varies among areas, and can be up to 10 years for moorland/mountain areas). Consequently, a five-year moving average was applied to the data to smooth out the between-year variation appropriately, to give a suitable estimate with annual resolution. Deforestation is not currently estimated for Northern Ireland. Rural deforestation is assumed to convert the land to Grassland use (reported in Category 5C2) and non-rural deforestation causes conversion to the Settlement land type (reported in 5E2). Information from land use change matrices indicates that conversion of forest to cropland is negligible.

On deforestation it is assumed that 60% of the standing biomass is removed as timber products and the remainder is burnt. The annual area loss rates were used in the method described in the IPCC 1996 guidelines (IPCC 1997 a, b, c) to estimate immediate emissions of CO_2, CH_4 and N_2O from this biomass burning. Only immediate losses are considered because sites are normally completely cleared for development, leaving no debris to decay. Changes in stocks of soil carbon after deforestation are included with those due to other land use transitions.

A3.7.5 Biomass Burning – Forest Wildfires (5A2)

The method for estimating emissions of CO_2 and non-CO_2 gases from wildfires within managed forests is that described in the GPG LULUCF (Section 3.2.1.4).

Estimates of the area burnt in wildfires 1990-2004 are published in different locations (FAO/ECE 2002; Forestry Commission 2004; FAO 2005) but all originate from either the Forestry Commission (Great Britain) or the Forest Service (Northern Ireland). No data on areas burnt in wildfires has been collected or published since 2004, although this is apparently under review. Activity data for 2005 and 2007 is extrapolated using a Burg regression equation based on the trend and variability of the 1990-2004 dataset. These areas refer only to fire damage in state forests; no information is collected on fire damage in privately owned forests.

Table A 3.7.23: Area burnt in wildfires in state (Forestry Commission) forests 1990-2007 (* indicates an estimated area)

Year	Area burnt, ha Great Britain	Northern Ireland	UK	% UK forest area burnt
1990	185	127	312	0.021%
1991	376*	88*	464	0.042%
1992	92*	22*	114	0.010%
1993	157*	37*	194	0.018%

Year	Area burnt, ha			
	Great Britain	Northern Ireland	UK	% UK forest area burnt
1994	123*	24	147	0.014%
1995	1023*	16	1039	0.119%
1996	466	94	560	0.055%
1997	585	135	720	0.069%
1998	310	22	332	0.037%
1999	45	9	54	0.005%
2000	165	6	171	0.020%
2001	181	85	266	0.023%
2002	141	85	226	0.018%
2003	147	1	148	0.019%
2004	146	91	237	0.019%
2005	5*	75*	80*	0.008%
2006	429*	3*	432*	0.045%
2007	412*	97*	508*	0.054%

The area of private-owned forest that was burnt each year was assumed to be in proportion to the percentage of the state forest that was burnt each year. An estimated 921 ha of forest was burnt on average every year (the sum of state-owned and privately-owned forests) between 1990 and 2007.

There is no information on the type (conifer or broadleaf) or age of forest that is burnt in wildfires in the UK. Therefore, the amount of biomass burnt is estimated from the mean forest biomass density in each country of the UK, as estimated by the C-Flow model. These densities vary with time due to the different afforestation histories in each country (**Table A 3.7.24**).

Table A 3.7.24: Biomass densities, tonnes DM ha^{-1}, used to estimate mass of available fuel for wildfires

Year	Forest biomass density, tonnes DM ha^{-1}				
	England	Scotland	Wales	Northern Ireland	UK
1990	92.372	59.531	84.793	88.159	71.394
1995	97.184	69.535	95.832	97.727	80.189
2000	100.937	79.323	101.856	106.353	88.056
2005	107.628	93.177	119.397	116.110	100.353
2007	110.301	98.319	125.671	118.154	104.846

A combustion efficiency of 0.5 is used with a carbon fraction of dry matter of 0.5 to estimate the total amount of carbon released, and hence emissions of CO_2 and non-CO_2 gases (using the IPCC emission ratios).

A3.7.6 Liming of Agricultural Soils (5B1, 5C1)

The method for estimating CO_2 emissions due to the application of lime and related compounds is that described in the IPCC 1996 Guidelines. For limestone and chalk, an emission factor of 120 tC/kt applied is used, and for dolomite application, 130 tC/kt. These factors are based on the stoichiometry of the reaction and assume pure limestone/chalk and dolomite.

Only dolomite is subjected to calcination. However, some of this calcinated dolomite is not suitable for steel making and is returned for addition to agricultural dolomite – this fraction is reported annually by the Office of National Statistics (ONS) as ‘material for calcination’ under agricultural end use. Calcinated dolomite, having already had its CO_2 removed, will therefore not cause the emissions of CO_2 and hence is not included here. Lime (calcinated limestone) is also used for carbonation in the refining of sugar but this is not specifically dealt with in the UK LUCF GHG Inventory.

Lime is applied to both grassland and cropland. The annual percentages of arable and grassland areas receiving lime in Great Britain for 1994-2006 were obtained from the Fertiliser Statistics Report (Agricultural Industries Confederation 2006), and the British Survey of Fertiliser Practice (BSFP 2007). These data are produced annually and used to update the inventory, however due to new time restrains the data were unavailable for the 2007 accounting period. The projected value for 2007 estimated in the 2006 accounting period has been used as the 2007 figure. Percentages for 1990-1993 were assumed to be equal to those for 1994.

A3.7.7 Lowland Drainage (5B1)

Lowland wetlands in England were drained many years ago for agricultural purposes and continue to emit carbon from the soil. Bradley (1997) described the methods used to estimate these emissions. The baseline (1990) for the area of drained lowland wetland for the UK was taken as 150,000 ha. This represents all of the East Anglian Fen and Skirtland and limited areas in the rest of England. This total consists of 24,000 ha of land with thick peat (more than 1 m deep) and the rest with thinner peat. Different loss rates were assumed for these two thicknesses as shown in **Table A 3.7.25**. The large difference between the implied emission factors is due to the observation that peats described as ‘thick’ lose volume (thickness) more rapidly than peats described as ‘thin’. The ‘thick’ peats are deeper than 1m, have 21% carbon by mass and in general have different texture and less humose topsoil than the ‘thin’ peats, which have depths up to 1m (many areas ~0.45 m deep) and carbon content of 12% by mass.

Table A 3.7.25: Area and carbon loss rates of UK fen wetland in 1990

	Area	Organic carbon content	Bulk density $kg\ m^{-3}$	Volume loss rate $m^3\ m^{-2}\ a^{-1}$	Carbon mass loss $GgC\ a^{-1}$	Implied emission factor $gC\ m^{-2}\ a^{-1}$
‘Thick’ peat	$24 \times 10^7\ m^2$ (24,000 ha)	21%	480	0.0127	307	1280
‘Thin’ peat	$126 \times 10^7\ m^2$ (126,000 ha)	12%	480	0.0019	138	109
Total	**$150 \times 10^7\ m^2$ (150 kha)**				**445**	**297**

The emissions trend since1990 was estimated assuming that no more fenland has been drained since then but that existing drained areas have continued to lose carbon.

The annual loss for a specific location decreases in proportion to the amount of carbon remaining. Furthermore, as the peat loses carbon it becomes more mineral in structure. The Century model of plant and soil carbon was used to average the carbon losses from these fenland soils over time (Bradley 1997): further data on how these soil structure changes proceed with time is provided in Burton (1995).

A3.7.8 Changes in Stocks of Carbon in Non-Forest Biomass due to Yield Improvements (5B1)

There is an annual increase in the biomass of cropland vegetation in the UK that is due to yield improvements (from improved species strains or management, rather than fertilization or nitrogen deposition). Under category 5.B.1 an annual value is reported for changes in carbon stock, on the assumption that the annual average standing biomass of cereals has increased linearly with increase in yield between 1980 and 2000 (Sylvester-Bradley et al. 2002).

A3.7.9 Peat Extraction (5C1)

Cruickshank and Tomlinson (1997) provide initial estimates of Emissions due to peat extraction. Since their work, trends in peat extraction in Scotland and England over the period 1990 to 2007 have been estimated from activity data taken from the Business Monitor of Mineral Extraction in Great Britain (Office of National Statistics 2007). In Northern Ireland, no new data on use of peat for horticultural use has been available but a recent survey of extraction for fuel use suggested that there is no significant trend for this purpose. The contribution of emissions due to peat extraction in Northern Ireland is therefore incorporated as constant from 1990 to 2007. Peat extraction is negligible in Wales. Emissions factors are from Cruickshank and Tomlinson (1997) and are shown in **Table A 3.7.26**.

Table A 3.7.26: Emission Factors for Peat Extraction

	Emission Factor kg C m^{-3}
Great Britain Horticultural Peat	55.7
Northern Ireland Horticultural Peat	44.1

A3.7.10 Harvested Wood Products (5G)

The activity data used for calculating this activity is the annual forest planting rates. C-Flow assumes an intermediate thinning management regime with clear-felling and replanting at the time of Maximum Area Increment (57 or 59 years for conifers and 92 years for broadleaves). Hence, for a given forest stand, carbon enters the HWP pool when thinning is undertaken (depending on the species first thinning occurs c. 20 years after planting) and when harvesting takes place.

Harvesting operations that result in deforestation and land use changes are assumed to be conversions to either Grasslands or Settlements and are report in 5C2 and 5E2 respectively. The UK has no records showing the reduction rate of Forest Land from thinning operations, therefore a nominal (822 kha y^{-1}) is subtracted from the pre 1921 Forest records (these Forests are assumed to be C neutral), reductions are now reported in 5.A.1.

A living biomass carbon stock loss of 5% is assumed to occur immediately at harvest (this carbon is transferred to the litter or soil pools). The remaining 95% is transferred to the HWP pool. The residence times of wood products in the HWP pool depend on the type and origin of the products and are based on exponential decay constants. Residence times are estimated as the time taken for 95% of the carbon stock to be lost (from a quantity of HWP entering the HWP pool at the start).

Harvested wood products from thinnings are assumed to have a lifetime (residence time) of 5 years, which equates to a half-life of 0.9 years. Wood products from harvesting operations are assumed to have a residence time equal to the rotation length of the tree species. For conifers this equates to a half life of 14 years (59 years to 95% carbon loss) and for broadleaves a half life of 21 years (92 years to 95% carbon loss). This approach captures differences in wood product use: fast growing softwoods tend to be used for shorter lived products than slower growing hardwoods.

These residence time values fall mid range between those tabled in the LULUCF GPG (IPCC 2003) for paper and sawn products: limited data were available for the decay of HWP in the UK when the C-Flow model was originally developed. A criticism of the current approach is that the mix of wood products in the UK may be changing and this could affect the 'true' mean value of product lifetime. At present there is very limited accurate data on either decay rates or volume statistics for different products in the UK, although this is kept under review.

The C-Flow method does not precisely fit with any of the approaches to HWP accounting described in the IPCC Guidelines (2006) but is closest to the Production Approach (see Thomson and Milne in Milne and Mobbs 2005). The UK method is a top-down approach that assumes that the decay of all conifer products and all broadleaf products can be approximated by separate single decay constants. While this produces results with high uncertainty it is arguably as fit-for-purpose as bottom-up approaches where each product is given an (uncertain) decay and combined with (uncertain) decay of other products using harvest statistics which are in themselves uncertain.

According to this method the total HWP pool from UK forests is presently increasing, driven by historical expansion of the forest area and the resulting history of production harvesting (and thinning). The stock of carbon in HWP (from UK forests planted since 1921) has been increasing since 1990 but this positive stock change rate recently reversed, reflecting a severe dip in new planting during the 1940s. The net carbon stock change in the HWP pool has returned to a positive value (i.e. an increasing sink) in 2006, and is forecast to increase sharply as a result of the harvesting of the extensive conifer forests planted between 1950 and the late 1980s.

A3.7.11 Emissions of Non-CO_2 Gases from Disturbance Associated with Land use Conversion

Emissions of greenhouse gases other than CO_2 in the Land Use Change and Forestry Sector come from four activities: (i) biomass burning as part of deforestation producing CO_2, CH_4 and N_2O emissions; (ii) biomass burning during wildfires on forest land producing CO_2, CH_4 and N_2O emissions; (iii) application of fertilisers to forests producing N_2O; and (iv) disturbance of soils due to some types of land use change producing N_2O associated with CO_2 emissions, or CH_4. Emissions by biomass burning are discussed elsewhere**.** Emissions from other activities were considered by Skiba (in Milne and Mobbs 2005) but have not yet been reported in the CRF. Here we discuss these emissions in more detail with a view to their reporting in future CRF submissions.

The CRF provides two tables where emissions of non-CO_2 gases associated with soil disturbance after land use change can be reported. CRF Table 5(II) is provided for reporting emissions due to drainage of forest soils or wetlands (which are not reported in the UK). Drainage of some form has often occurred when new forests are planted in the UK but there is no information readily available on the extent of this. Table 5(III) specifically provides for reporting of emissions after land use conversion to Cropland but this table is also appropriate for reporting N_2O emissions from other land use change (excepting emissions from conversion to Forest Land which are already covered elsewhere).

A3.7.12 Emissions of N_2O due Disturbance Associated with Land Use Conversion

In the UK six land use transitions cause immediate and delayed emissions of CO_2. These are as follows:

- Forest Land to Grassland;
- Forest Land to Cropland;
- Forest Land to Settlement;
- Grassland to Cropland;
- Grassland to Settlement; and
- Cropland to Settlement.

The method recommended in the LULUCF GPG for calculating N_2O emissions due to land use change is to take the CO_2 emission due to a specific change and then use the C:N ratio for the soils being disturbed to estimate the N lost due to the mineralisation of organic matter. The default emission factor for the N_2O pathway (1.25%) is then used to calculate the emitted flux of N_2O-N. **Table A 3.7.27** shows the emissions for the period from 1990 to 2007 adopting this approach with a C:N ratio of 15:1 for all land

Table A 3.7.27: Emissions of N_2O in the UK due to disturbance of soils after land use change estimated by the method of the LULUCF GPG

	Forest Land to Grassland	Forest Land to Cropland	Forest Land to Settlement	Grassland to Cropland	Grassland to Settlement	Cropland to Settlement	ALL LUC
	Gg N_2O	Gg N_2O	Gg N_2O	Gg N_2O	Gg N_2O	Gg N_2O	Gg N_2O
1990	0.035	0.004	0.026	4.995	2.019	0.401	7.482
1991	0.035	0.004	0.029	5.001	2.008	0.390	7.466
1992	0.035	0.004	0.031	5.006	1.997	0.378	7.452
1993	0.034	0.004	0.035	5.012	1.986	0.368	7.439
1994	0.034	0.003	0.037	5.018	1.977	0.358	7.428
1995	0.036	0.003	0.038	5.024	1.968	0.349	7.419
1996	0.037	0.003	0.039	5.031	1.960	0.340	7.410
1997	0.034	0.003	0.044	5.037	1.953	0.332	7.403
1998	0.034	0.003	0.046	5.044	1.946	0.324	7.396
1999	0.045	0.003	0.037	5.050	1.939	0.317	7.391
2000	0.050	0.002	0.033	5.057	1.933	0.310	7.386
2001	0.054	0.002	0.031	5.064	1.928	0.303	7.382
2002	0.056	0.002	0.031	5.071	1.923	0.297	7.379
2003	0.056	0.002	0.032	5.077	1.918	0.292	7.377

	Forest Land to Grassland	Forest Land to Cropland	Forest Land to Settlement	Grassland to Cropland	Grassland to Settlement	Cropland to Settlement	ALL LUC
	Gg N_2O	Gg N_2O	Gg N_2O	Gg N_2O	Gg N_2O	Gg N_2O	Gg N_2O
2004	0.054	0.002	0.035	5.084	1.913	0.286	7.375
2005	0.056	0.002	0.035	5.090	1.909	0.281	7.373
2006	0.056	0.002	0.036	5.096	1.905	0.276	7.372
2007	0.053	0.002	0.041	5.103	1.902	0.272	7.371

The 1990 emission rate for all land use change is equivalent to an emission of 2319 Gg CO_2 (using a GWP of 310) which is similar to the net uptake of CO_2 equivalents by all other activities in the UK LULUCF Sector. It is therefore of considerable importance that the methodology used is scientifically sound. On further investigation this does not appear to be the case. The LULUCF GPG methodology relies on estimating gross nitrogen loss from a gross carbon loss and a C:N ratio, but several factors suggest that this approach does not lead to reliable values. There are few measurements of C:N ratios for different land use and for different environmental conditions, making it difficult to generalise values for a whole country. More importantly, understanding of the mechanisms that cause C:N ratios to vary with different land management is weak, particularly in relation to how changes in the C:N ratio of different pools in the soil affect the gross C:N ratio. For example Pineiro *et al.* (2006) show that it is possible to obtain gross N – mineralisation changes of opposite sign depending on whether changes in whole-soil or individual pool C:N ratios are considered in a model of the effect of grazing on soil. It would therefore seem prudent to await an alternative approach to estimating N_2O emissions due to land use change before including any data in the inventory. The UK National Inventory System is currently supporting research to measure change in stocks of soil carbon and nitrogen due to ploughing of an upland grassland.

A3.7.12.1 Emissions from Disturbance of Soils by Afforestation (drainage etc)

The methodology used to estimate CO_2 removals and emissions due to the establishment of forests is described in **Section A3.7.1**. Included in these estimates are emissions relating to the loss of carbon (as CO_2) as a result of disturbance of the pre-existing soil. The calculation of N_2O emissions from this disturbance was discussed in the 1990-2005 NIR. In this discussion it was assumed that nitrogen in the soil was lost with the carbon in proportion to the C:N ratio as suggested by the LULUCF GPG for other types of land use change that cause carbon mineralization. The resulting N_2O emissions were of the same order of magnitude as those suggested as Tier 1 Defaults in the LULUCF GPG. However, the criticisms of using gross C:N ratios to obtain N loss also apply. A further consideration of methods will therefore be needed before data can be included in the inventory. Emissions of methane due to drainage of forests are estimated to be very small (Skiba in Milne and Mobbs (2005)).

A3.7.13 Methods for the Overseas Territories and Crown Dependencies

The UK includes direct GHG emissions in its GHGI from those UK Crown Dependencies (CDs) and Overseas Territories (OTs) which have joined, or are likely to join, the UK's instruments of ratification to the UNFCCC and the Kyoto Protocol. Currently, these are: Guernsey, Jersey, the Isle of Man, the Falkland Islands, the Cayman Islands, Bermuda, Montserrat and Gibraltar. The 2007 figures have been estimated from the 2006 projections, as no updated information has been made available. An MSc project to calculate LULUCF net emissions/removals for the OTs and CDs was undertaken during 2007 (Ruddock 2007).

The availability of data for the different OTs and CDs is very variable, so that emission estimates can only be made for the Isle of Man, Guernsey, Jersey and the Falkland Islands. These four comprise over 95% of the area in all the OTs and CDs. Gibraltar wished to produce their own inventory: their LULUCF net emissions/removals are likely to be extremely small, given the size of the country (6km^2), and will have little impact on overall numbers. A lack of suitable data for the Caribbean territories (discussed in the 1990-2006 NIR) makes it impossible to create inventories for them at the present time.

Information on the area of each IPCC land category, dominant management practices, land use change, soil types and climate types were compiled for each OT/CD from statistics and personal communications from their government departments and global land/soil cover databases. This allowed Tier 1 level inventories to be constructed for the four OT/CDs already mentioned, and a Tier 3 approach for Forest Land on the Isle of Man (using the C-Flow model also used for the UK). The estimates have high uncertainty and probably do not capture all relevant activities, in particular land use change to Settlement from land uses other than Forest Land (there are no default IPCC methods for these transitions).

A3.8 WASTE (CRF SECTOR 6)

A3.8.1 Solid Waste Disposal on Land (6A)

Degradable Organic Carbon (DOC) and Fraction Dissimilated (DOCF)

UK values for DOC and DOC_f are based on an emissions model developed by LQM (2003) that uses updated degradable carbon input parameters with values based on well-documented US research for the USEPA's life-cycle programme (Barlaz et al., 1997). The data taken from this report relate to those waste fractions most representative of UK municipal waste, on the basis that the biochemistry of individual fractions of waste in the US will be comparable to the same fractions in the UK. This has been adapted to UK conditions and incorporated into (1) the Environment Agency's WISARD life cycle assessment model (WS Atkins, 2000); (2) the HELGA framework model (Gregory et al., 1999) and (3) GasSim (Environment Agency, 2002).

Cellulose and hemi-cellulose are known to make up approximately 91% of the degradable fraction, whilst other potential degradable fractions which *may* have a small contribution (such as proteins and lipids) are ignored. The amount of degradable carbon that produces landfill gas is determined using the mass (expressed on a percentage dry weight basis) and degradability (expressed as a percentage decomposition) of cellulose and hemi-cellulose using data provided by Barlaz et al. (1997). The input values for these parameters are provided in **Tables A3.8.1** and **A3.8.2** below for each of the waste fractions for both municipal (MSW) and commercial and industrial (C&I) waste categories, respectively. Also included are the proportions of individual waste streams that are considered to be rapidly, moderately or slowly degradable.

The moisture content of the components of the waste is derived from The National Household Waste Analysis Project (1994). This detailed report provides the range of moisture contents analysed for each of the fractions of waste collected and sampled. These fractions came from a number of different waste collection rounds, across the UK, representing different types of communities. The waste is analysed in its "as collected" form, which is then sorted and chemically analysed as separate fractions. The report also gives the averages used in the model. More recent waste arisings data collated by the Devolved Administrations, not available at the time of LQM (2003), do not include chemical analysis data.

These data are used within the model to determine the amount of degradable carbon that decays at the relevant decay rate. This process requires complete disaggregation of the waste streams into their component parts, allocation of degradability and rate of decomposition to each component and hence the application of the IPCC model approach at this disaggregated level.

Table A 3.8.1: Waste degradable carbon model parameters for MSW waste

Waste category	Fraction				Moisture content	Cellulose	Hemi-cellulose	DOC	DOC	Decomposition (DOC_f)
	Readily Degradable	Moderately Degradable	Slowly Degradable	Inert	(%)	(% Dry waste)	(% Dry waste)	(% Dry waste)	(% Wet waste)	(% Dry waste)
Paper and card	0	25	75	0	30	61.2	9.1	31.24	21.87	61.8
Dense plastics	0	0	0	100	5	0	0	0	0.00	0
Film plastics (until 1995)	0	0	0	100	30	0	0	0	0.00	0
Textiles	0	0	100	0	25	20	20	17.78	13.33	50
Misc. combustible (plus non-inert fines from 1995)	0	100	0	0	20	25	25	22.22	17.78	50
Misc. non-combustible (plus inert fines from 1995)	0	0	0	100	5	0	0	0	0.00	0
Putrescible	100	0	0	0	65	25.7	13	17.20	6.02	62
Composted putrescibles	0	50	50	0	30	0.7	0.7	0.62	0.44	57
Glass	0	0	0	100	5	0	0	0	0.00	0
Ferrous metal	0	0	0	100	5	0	0	0	0.00	0
Non-ferrous metal and Al cans	0	0	0	100	10	0	0	0	0.00	0
Non-inert fines	100	0	0	0	40	25	25	22.22	13.33	50
Inert fines	0	0	0	100	5	0	0	0	0.00	0

Notes:
1. DOC is Degradable Organic Carbon.
2. DOC_f is the portion of DOC that is converted to landfill gas.

Table A 3.8.2: Waste degradable carbon model parameters for C & I waste

Waste category	Fraction				Moisture content	Cellulose	Hemi-cellulose	DOC	DOC	Decomposition (DOC_f)
	Readily Degradable	Moderately Degradable	Slowly Degradable	Inert	(%)	(% Dry waste)	(% Dry waste)	(% Dry waste)	(% Wet waste)	(% Dry waste)
Commercial	15	57	15	13	37	76	8	37.33	23.52	85
Paper and card	0	25	75	0	30	87.4	8.4	42.58	29.80	98
General industrial waste	15	43	20	22	37	76	8	37.33	23.52	85
Food solids	79	10	0	11	65	55.4	7.2	27.82	9.74	76
Food effluent	50	5	0	45	65	55.4	7.2	27.82	9.74	76
Abattoir waste	78	10	0	12	65	55.4	7.2	27.82	9.74	76
Misc processes	0	5	5	90	20	10	10	8.89	7.11	50
Other waste	15	35	35	15	20	25	25	22.22	17.78	50
Power station ash	0	0	0	100	20	0	0	0	0	0
Blast furnace and steel slag	0	0	0	100	20	0	0	0	0	0
Construction/demolition	0	5	5	90	30	8.5	8.5	7.56	5.29	57
Sewage sludge	100	0	0	0	70	14	14	12.44	3.73	75

Notes:
1. DOC is Degradable Organic Carbon. .
2. DOC_f is the portion of DOC that is converted to landfill gas.

A3.8.2 Flaring and Energy Recovery

Flaring and energy recovery constitutes the method likely to reduce methane emissions from landfills by the largest amount, and was surveyed in 2002, as described below. It is estimated that in 2005 onwards 70% (Golders (2005)) of the total landfill gas generated in the UK was flared or utilised (**Table 3.8.2**).

A3.8.2.1 Gas Utilisation

The gas utilisation data are based on comparison of information from the trade association, the Renewables Energy Association, formerly Biogas Association (Gaynor Hartnell, Pers. Comm. 2002) and current DTI figures. In addition, LQM (2003) included data on utilisation prior to the first round of the Non Fossil Fuel Obligation (NFFO) contracts (Richards and Aitchison, 1990). The first four NFFO rounds (NFFO 1-4) and the Scottish Renewables Order (SRO) round are all taken to be completed and operational schemes, since there are relatively few outstanding schemes still to be implemented. It is known that not all of the proposed early schemes were found to be economic, and no NI-NFFO (Northern Ireland-NFFO) schemes have progressed, so those known schemes have not been included in the total (Gaynor Hartnell, Pers. Comm. 2002).

This approach, comparing the trade association and Government data sources, provides a reasonable correlation, and so LQM is confident in the accuracy of its estimates of current installed capacity. The latest round of NFFO (NFFO 5) has been implemented in the forecasting model over the period 2000 – 2005, to give a reasonable lead in time for these new projects. Various industry sources have indicated in confidence that some of the proposed NFFO 5 projects are now also considered uneconomic under NFFO. Some of these have definitely been abandoned, some have been surrendered and re-started under the new renewables order, and others are likely to follow this route. These figures are likely to have only a small uncertainty, as they are directly derived from power generation figures supplied by the industry and the Department of Trade and Industry.

A3.8.2.2 Flaring

Information on flaring capacity was obtained through consultation with flare manufacturers. LQM (2003) collected information from all but one of the UK flare companies contacted. The data collected was divided into flares supplied for routine flaring and flares supplied as back-up to generation sets. The data produced demonstrates total flare capacity as opposed to the actual volumes of gas being flared in each year. There are difficulties in ascertaining the actual volumes of LFG burnt, as detailed records, if they exist at all, are held by individual site operators. It is rare to find a flare stack with a flow measurement.

The operational capacity is derived by subtracting the back-up capacity from the total. LQM's total for generation back-up capacity remains at a fairly constant percentage of the installed generation capacity (around 60%), indicating that these figures are realistic. In the model, there is a further correction factor used in arriving at the final volume of gas flared each year, to take account of maintenance downtime (15%). In addition, it is assumed that since 1984 (i.e. three years after the first flare was commissioned) 7% of capacity in any given year is treated as replacement. This effectively gives the flare an expected 15-year operational lifetime. In 1990, the methane captured equates to 11% of the total generated, rising to 70% in 2005, averaged over the UK (**Table 3.8.3**). The downtime and replacement figures are LQM assessments following inquiries made as part of the 2002 survey.

The last input of gas utilisation data in the model is year 2005 and the last input of flare data is year 2002. Gas utilisation and flaring is assumed constant thereafter. Collection efficiency at any site is limited to 75%. Further work is still to be completed on flare and engine utilization at UK landfills, this research will be incorporated when published into the latest report and any amendments to the model will also be completed to provide a better picture for the future.

Table A 3.8.3: Amount of methane generated, captured, utilised, flared, oxidised and emitted.

Year	Mass of waste landfilled (Mt)			Methane generated (kt)	Methane captured (kt)	Methane captured (%)	Methane Utilised (kt)	Methane Utilised (%)	Methane Flared (kt)	Methane Flared (%)	Residual methane oxidised	Residual methane oxidised (%)	Methane emitted (kt)
	MSW	C&I	Combined waste streams								(kt)		MSW
1990	18.19	81.83	100.02	2947	322	11	49	1.67	272	9.24	263	8.91	2363
1991	18.84	81.77	100.61	3024	436	14	66	2.18	370	12.25	259	8.56	2329
1992	19.47	81.72	101.19	3098	576	19	110	3.56	465	15.02	252	8.14	2270
1993	20.09	81.66	101.76	3170	712	22	136	4.29	576	18.18	246	7.75	2212
1994	20.71	81.61	102.32	3240	832	26	163	5.03	669	20.64	241	7.43	2167
1995	23.83	81.56	105.39	3294	962	29	209	6.35	752	22.85	233	7.08	2099
1996	24.76	78.17	102.93	3330	1077	32	255	7.67	822	24.68	225	6.76	2027
1997	26.14	72.86	99.00	3352	1279	38	378	11.29	901	26.86	207	6.19	1866
1998	25.94	74.01	99.95	3389	1447	43	459	13.55	988	29.15	194	5.73	1748
1999	27.03	71.99	99.02	3425	1649	48	587	17.15	1061	30.99	178	5.19	1598
2000	27.54	69.98	97.51	3461	1793	52	639	18.45	1155	33.37	167	4.82	1501
2001	26.87	67.96	94.82	3492	2039	58	737	21.12	1301	37.26	145	4.16	1308
2002	27.18	65.94	93.13	3523	2195	62	772	21.90	1423	40.41	133	3.77	1195
2003	26.41	65.94	92.35	3551	2386	67	956	26.92	1431	40.29	116	3.28	1048
2004	25.48	65.94	91.43	3577	2492	70	1054	29.48	1437	40.19	109	3.03	977
2005	24.19	65.94	90.13	3600	2528	70	1151	31.99	1378	38.27	107	2.98	964
2006	21.69	65.94	87.63	3617	2545	70	1156	31.96	1390	38.43	107	2.96	965
2007	20.06	65.94	86.00	3631	2561	71	1160	31.95	1402	38.60	107	2.95	963

A3.8.3 Wastewater Handling (6B)

A3.8.3.1 Use of the 1996 Hobson Model within the UK GHG Inventory

The NAEI estimate is based on the work of Hobson *et al* (1996) who estimated emissions of methane for the years 1990-95. Subsequent years are extrapolated on the basis of population. Sewage disposed to landfill is included in landfill emissions.

The basic activity data are the throughput of sewage sludge through the public system. The estimates are based on the UK population connected to the public sewers and estimates of the amount of sewage per head generated. From 1995 onwards the per capita production is a projection (Hobson *et al*, 1996). The main source of sewage activity data is the UK Sewage Survey (DOE, 1993). Emissions are calculated by disaggregating the throughput of sewage into 14 different routes. The routes consist of different treatment processes each with specific emission factors. The treatment routes and emission factors are shown in **Table A3.8.4.**

A3.8.3.2 Industrial Wastewater Treatment Plants

There is no separate estimate made of emissions from private wastewater treatment plants operated by companies prior to discharge to the public sewage system or rivers, as there is no available activity data for this source and it has historically been assumed to be a minor source.

Where an IPPC-regulated industrial process includes an on-site water treatment works, any significant emission sources (point-source or fugitive) are required to be reported within their annual submission to UK environmental regulatory agencies, including emissions from their water treatment plant. Therefore, methane emissions from industrial wastewater treatment should be included within operator returns to the pollution inventories of the EA, SEPA and NIDoE, and therefore accounted for within the Industrial Process sector of the GHG Inventory. In practice it is not straightforward to ascertain the extent to which this is the case across different industry sectors. Within sector-specific guidance to plant operators on pollution inventory data preparation, emissions of methane from wastewater treatment are not highlighted as a common source to be considered (whereas in some guidance, wastewater treatment is singled out as a potentially significant source of NH_3 and N_2O emissions).

A3.8.3.3 Sludge Applications to Agricultural Land

The Hobson model includes emissions of methane from sewage sludge applications to agricultural land, and these emissions are therefore included within sector 6B2, rather than within the agricultural sector as recommended in IPCC guidance. There is no double-counting of these emissions as methane emissions from sludge application to land are excluded from the agricultural inventory compiled by IGER.

A3.8.3.4 Sewage Treatment Systems Outside of the National Network

The model does not take account for sewage treatment systems that are not connected to the national network of treatment works. The emissions are all determined on a population basis, using factors that pertain to mainstream treatment systems. Differences in emissions from alternative systems such as septic tanks are not considered, as it is assumed that the vast majority of the UK population is connected to the public wastewater treatment system.

A3.8.3.5 Design of Wastewater Treatment Systems in the UK

Most UK wastewater treatment works comprise the following components as a minimum:

- Initial screening / grit removal;
- Primary settlement tanks, using simple sedimentation; and
- Secondary treatment (usually a biological process such as activated sludge systems & sedimentation or percolating filters).

Many also have a tertiary treatment unit to complete waste-water filtration, remove target nutrients (such as nitrogen or phosphorus) or specific industrial pollutants, to "polish" the water as required prior to outputting treated water to watercourses.

In each of the treatment phases, sewage sludge is produced and may be treated in a variety of ways, each with different methane emission characteristics, and these options are accounted for within the model.

A3.8.3.6 Emissions from Anaerobic Digestion

The Hobson model includes calculations to account for different designs of anaerobic digesters, primary and secondary digestion phases, the utilisation of digester gas flaring, CHP and venting systems, and uses emission factors derived for each design type, which include consideration of fugitive losses of methane in each case. The dataset refers to plant survey data and emission factor research from the early 1990s, and so may not be fully representative of current emissions research, plant design and practice.

Table A 3.8.4: Specific Methane Emission Factors for Sludge Handling (kg CH_4/Mg dry solids, Hobson et al (1996))

Sludge Handling System	Gravity Thickening[1]	Long term storage	Anaerobic Digestion[2]	Agricultural Land	Landfill
Anaerobic digestion to agriculture	0.72		143	5	
Digestion, drying, agriculture	0.72		143	5	
Raw sludge, dried to agriculture	0.72			20	
Raw sludge, long term storage (3m), agriculture	0.72	36		20	
Raw sludge, dewatered to cake, to agriculture	0.72			20	
Digestion, to incinerator	0.72		143		
Raw sludge, to incinerator	0.72				
Digestion , to landfill	0.72		143		0
Compost, to agriculture	0.72			5	
Lime raw sludge, to agriculture	0.72			20	
Raw Sludge , to landfill	0.72				0
Digestion , to sea disposal	0.72		143		
Raw sludge to sea disposal	0.72				
Digestion to beneficial use (e.g. land reclamation)	0.72		143	5	

1 An emission factor of 1 kg/tonne is used for gravity thickening. Around 72% of sludge is gravity thickened hence an aggregate factor of 0.72 kg CH_4/Mg is used.
2 The factor refers to methane production, however it is assumed that 121.5 kg CH_4/Mg is recovered or flared

Table A 3.8.5: Time-Series of Methane Emission Factors for Emissions from Wastewater Handling, based on Population (kt CH_4 / million people)

Year	CH_4 Emission (kt)	CH_4 EF (kt CH_4/ million people)
1990	33.38	0.583
1991	31.27	0.544
1992	34.76	0.604
1993	34.46	0.597
1994	35.96	0.622
1995	34.33	0.593
1996	35.27	0.608
1997	36.21	0.623
1998	37.15	0.637
1999	36.02	0.616
2000	36.89	0.629
2001	37.13	0.628
2002	37.35	0.630
2003	37.58	0.631
2004	37.80	0.632
2005	38.03	0.632
2006	38.16	0.630
2007	38.29	0.628

Nitrous oxide emissions from the treatment of human sewage are based on the IPCC (1997c) default methodology. The most recent average protein consumption per person is based on the Expenditure and Food Survey (Defra, 2008); see **TableA 3.8.6**. Between 1996 and 1997 there is a step change in the reported data. This is because Defra revised their publication (formally National Food Survey) and in doing so revised the method used to calculate protein consumption. The new method only provides data back to 1997 and so a step change occurs.

Table A 3.8.6: Time-series of per capita protein consumptions (kg/person/yr)

Year	Protein consumption (kg/person/yr)
1990	23.0
1991	22.7
1992	22.9
1993	22.7
1994	24.6
1995	23.0
1996	23.7
1997	26.3
1998	26.0
1999	25.0
2000	25.7
2001	26.3
2002	26.0
2003	26.0
2004	25.9

Year	Protein consumption (kg/person/yr)
2005	27.8
2006	26.3
2007	26.3

A3.8.4 Waste Incineration (6C)

This source category covers the incineration of wastes, excluding waste-to-energy facilities. For the UK, this means that all MSW incineration is excluded, and is reported under CRF source category 1A instead. Emission factors for the municipal solid waste incinerated, and the treatment of biogenic emissions from MSW incineration, can be found the section Energy Industries, in this Annex.

A3.9 EMISSIONS FROM THE UK'S CROWN DEPENDENCIES AND OVERSEAS TERRITORIES

Emissions from the UK Overseas Territories (OTs) were first included in the UK Greenhouse Gas Inventory in the 1990-2004 inventory, published in 2006. Emissions from fuel use the UK Crown Dependencies (CDs), however, have always been included in the UK inventory because their fuel use is included in the UK energy statistics, produced by BERR. Emissions from non-fuel sources were introduced into the inventory at the same time as the estimates for the OTs.

This year, the database structure and method used for estimating emissions from the Overseas Territories and Crown Dependencies has been updated and improved. This has allowed the methods and emission factors used to be more consistent with those used for the UK inventory, and also allows more flexibility in reporting, for example it allows the correct coverage for the EUMM (UK and Gibraltar only) to be easily extracted from the database.

A summary of the new method and improvements is as follows:

- All emission sources from the Overseas Territories and Crown Dependencies were identified, and where possible assigned the same "Source codes" and "activity codes" used for the UK inventory sources.
- Each OT and CD (and the UK) was assigned a Territory Code, which identifies where the emissions originate.
- For the Crown Dependencies' fuel use, the UK spreadsheets were modified to include separate data for each of the Crown Dependencies. These fuel totals were then subtracted from the totals from DUKES to maintain the overall fuel balance (DUKES total = UK + CDs).
- Where the emissions are calculated using a simple activity multiplied by emission factor calculation, and there is no information available about the likely emission factors in the OTs or CDs, only emission factors for the UK were entered into the database. The database then "derives" emission factors for the OTs and CDs, where corresponding activity data exist (i.e. the emission factors from the UK are applied to the OT or CD activity data).

- If the emissions in the OTs or CDs are based on proxy data, or the UK emission factors are known to be not appropriate, then emission factors for the OTs and CDs are entered into the database, with the appropriate territory code.

This has led to a number of recalculations of the data, since the UK's emissions factors for each year are applied to the majority of sources, whereas in previous inventory versions, a fixed emission factor for each source (taken from the 2003 UK GHGi) was applied across all years. In addition, the treatment of fuel use for the Crown Dependencies has led to a reallocation of fuels between the power stations and industrial combustion sectors. This is because the estimates of fuels used in power stations in the inventory are known to cover only power stations in the UK, whereas the DUKES final consumption also includes Crown Dependencies. Therefore, in order to maintain the fuel balance with DUKES, and to retain the accuracy of the UK power station emissions estimates, fuel used for power generation in the CDs has been reallocated from the Other Industry sector to power stations.

These changes have also meant that indirect greenhouse gas emissions from the Overseas Territories are also included in the inventory. In addition, the improvements also mean that the database now includes activity data for fuels used in the OTs and CDs, which allows reporting in the CRF to be more transparent.

Table A 3.9.1: Summary of category allocations in the CRF tables and the NIR

Source	Category in CRF	Category in NIR	Notes
Power stations (OTs and CDs)	1A1a: Public Electricity and Heat Production (Other Fuels)	1A1a	The activity data and emissions data in the CRF for the relevant fuels now includes the component of emissions from the OTs and CDs. In previous years, the OT emissions were included as a separate estimate and the CDs were assumed to be part of the UK total (fuels used for power generation in the CDs has been reallocated from the UK's Other Industry sector, as explained above).
Domestic Aviation (CDs only)	1A3a: Aviation	1A3a	Flights between the UK and the CDs are classified as domestic
Industrial Combustion (OTs and CDs)	1A2f: Other - OT Industrial Combustion	1A2f	The activity data and emissions data in the CRF for the relevant fuels now includes the component of emissions from the OTs and CDs. In previous years, the OT emissions were included as a separate estimate and the CDs were assumed to be part of the UK total.
Road Transport (OTs and CDs)	1A3b: Road Transport (Other Fuels)	1A3b	The activity data and emissions data in the CRF for the relevant fuels now includes the component of emissions from the OTs and CDs. In previous years, the OT emissions were included as a separate estimate and the CDs were assumed to be part of the UK total. The assumption that the CDs were included as part of the UK total was only true for CO_2 – for other GHGs, the emissions are calculated based on vkm and therefore these emissions are additional for this inventory.
Memo items: Aviation (OTs only)	Footnoted	1C1a	It was not possible to include emissions from aviation under 1C1a in the CRF because there was no option to create another fuel category, and adding the OT emissions to the UK figures would affect the IEFs. Emissions are therefore displayed as a footnote. This does not affect the national total.
Residential and Commercial Combustion (OTs and CDs)	1A4a and 1A4b	1A4a and 1A4b	The activity data and emissions data in the CRF for the relevant fuels now includes the component of emissions from the OTs and CDs. In previous years, the OT emissions were included as a separate estimate and the CDs were assumed to be part of the UK total.
OT and CD F gases	2F9: Other - OT and CD F Gas Emissions	2F	This has been included in the CRF as a separate category for all F Gas emissions from the OTs and CDs.
OT and CD Enteric Fermentation	4A10: Other - OTs and CDs All Livestock	Relevant animal categories within 4A	A separate category for all livestock in the OTs and CDs is used.

Source	Category in CRF	Category in NIR	Notes
OT and CD Manure Management	4G: Other - OT and CD Emissions from Manure Management	Relevant categories within 4B	It was not possible to introduce a new category in which to put emissions of N_2O from manure from the OTs and CDs into Sector 4B. A separate category was therefore included in Sector 4G - Other.
OT and CD LULUCF Emissions	5G: Other	7	Total net LULUCF emissions from the OTs and CDs are included in sector 7 as it was not possible to report these emissions as a separate total within sector 5 in the CRF.
OT and CD Landfill	6A3: Other - OT and CD Landfill Emissions	6A	This has been included in the CRF as a separate category under 6A.
OT and CD Sewage Treatment	6B3: Other - OT and CD Sewage Treatment (all)	6B	This has been included in the CRF as a separate category under 6B.
OT and CD Waste Incineration	6C3: Other - OT and CD MSW Incineration	6C	This has been included in the CRF as a separate category under 6C.

GHG emissions are included from those UK Crown Dependencies (CDs) and Overseas Territories (OTs) which have joined the UK's instruments of ratification to the UNFCCC and the Kyoto Protocol[6]. The relevant CDs and OTs are:

- Guernsey;
- Jersey;
- The Isle of Man;
- The Falkland Islands;
- The Cayman Islands;
- Bermuda;
- Montserrat; and
- Gibraltar.

Separate CRF tables have also been submitted to the EU to include only the parts of the UK that are also members of the EU. These are the UK itself, and Gibraltar.

Country specific data have been sought to estimate emissions as accurately as possible. In general the data were requested by questionnaire asking for information on fuel use, the vehicle fleet, shipping movements, aircraft, livestock numbers and waste treatment. In some cases (such as for the Channel Islands) much of the data were readily available from government statistical departments, and the inventory already included all emissions from energy use in the CDs because of the coverage of the Digest of UK Energy Statistics. In these cases it was possible make estimates of the emissions using the same methodology as used for the UK inventory.

There were some difficulties obtaining information for some sectors in some of the OTs to estimate emissions using the same methods applied to the existing UK GHG inventory. Modifications were therefore made to the existing methods and surrogate data were used as necessary; this is discussed in the sections below. For sectors such as waste treatment in some of the Overseas Territories, no data were available and it was not possible to make any estimates of emissions.

Emissions of GHGs from fuel combustion in IPCC Sector 1 (but not waste incineration) were already included in the GHG inventory from the CDs, but emissions from other sources from these CDs were not previously estimated or included before 2004. In this inventory, the database structure has been changed to allow emissions from the CDs to be reported separately and easily removed from the UK total.

[6] Emissions from the UK military bases in Cyprus are assumed to be included elsewhere – emissions from on-base activities are included within the military section of the UK greenhouse gas inventory, whereas any off-base activities will be included within the inventory submitted for Cyprus.

A summary of the emissions of the direct GHGs from the UK's Crown Dependencies and Overseas Territories are given in **Table A3.9.3** and **Table A3.9.5**.

A3.9.1 Crown Dependencies: the Channel Islands and the Isle of Man

The methods used to estimate emissions from the Channel Islands and the Isle of Man are summarised in **Table A3.9.2**. These data are supplied by energy statisticians and other government officials and are thought to be of good quality. Emissions are summarised in **Table A3.9.3.**

Although the fuel used in the Crown Dependencies is included in the total energy statistics for the UK, as published in DUKES, the estimates made of the fuel use in the individual CDs has been used to modify the UK fuel balance, to allow separate reporting of emissions from the CDs. The total fuel used in the UK plus the Crown Dependencies matches the totals published in DUKES.

A3.9.1.1 Jersey

The largest sources of CO_2 emissions for Jersey in 2007 are the commercial and domestic sectors and road transport. Emissions from power generation make up 17% of total CO_2 emissions, which is an increase compared with earlier years since the proportion of electricity imported from France has decreased.

Agricultural activity is the main source of methane emissions, accounting for around 75% - 80% of total methane emissions across the time series. Waste is incinerated, and so there are no methane emissions from landfill sites. These emissions were estimated using emission factors from the GHGi.

N_2O emissions only make up a small proportion of the total emissions in Jersey.

F-gas emissions are based on UK emissions, scaled using proxy statistics such as population or GDP. There are no emissions from industrial sources and so the F-gas emissions show a similar trend to the UK emissions from non-industrial sources.

Estimates of emissions from fuel combustion are based on real data supplied for fuel use and vehicle movements, and we consider the uncertainty on these emissions to be low and probably similar in magnitude to the uncertainties on UK emissions from these sources.

Emissions from livestock were based on an incomplete time series, and rely on extrapolated figures, introducing greater uncertainty for this sector. Emissions from sewage treatment are based on UK per capita emission factors, which may not be an accurate representation of the technology in use for Jersey.

Net emissions of CO_2 from LULUCF were calculated for the 1990 to 2006 inventory. These estimates were not updated for the current inventory, and emissions in 2007 have been rolled from 2006.

A3.9.1.2 The Isle of Man

The main sources of carbon emissions in the Isle of Man are road transport and power generation, which together contribute 55% to total CO_2 emissions. Residential and commercial combustion are also significant sources, accounting for a further 29% of total emissions. Some minor industrial sources of combustion emissions also exist - the sewage treatment plant and quarries.

The most significant methane source is agriculture, which accounted for 97% of methane emissions in 2007. The only other significant source was waste treatment and disposal to landfill, until the incinerator replaced the landfill sites.

N_2O emissions arise mainly from agricultural practices – livestock manure management. No estimate has been made of N_2O from agricultural soils.

The emissions for fuel combustion and transportation sources for the majority of the time series are based on real data and emission factors sourced from the existing GHG inventory, and so estimates have a fairly low uncertainty. However, for later years, data has not always been obtained and therefore emissions are based on extrapolated data, which makes it much more uncertain. Further data has been received from the Isle of Man after the 1990-2007 Inventory was compiled and this will be included in the 1990 – 2008 Inventory. Emissions from landfill, sewage treatment, and F-gas use rely on UK data scaled to population and therefore assume similar characteristics and usage patterns to the UK.

A3.9.1.3 Guernsey

The largest single source of CO_2 in 2007 was road transport. Power stations accounted for around 19% of CO_2 emissions showing a decrease from the previous year. 2006 emissions were much higher than 2005, going against the trend of decreasing emissions that had been observed reflecting changes in the amount of electricity imported from France.

The largest methane source is from waste disposed to landfill. Major improvements were made to these estimates for the 2008 Greenhouse Gas Inventory.

The estimates of emissions from fuel consumption for Guernsey are based on a number of assumptions. Fuel consumption figures for power generation were calculated based on electricity consumption figures, total fuel imports, and fuel consumption data for a few years taken from the power station statistical report. Domestic and commercial combustion figures also needed to be separated out from the total imports, and split into different fuel types based on data given in a previous inventory for Guernsey. Shipping and agriculture figures are based on incomplete time series and the missing data have been interpolated or extrapolated as necessary, and are therefore subject to greater uncertainty. The improvements to emissions from landfill, and also aviation (see **Section 3.9.1.2**) have helped to decrease the uncertainties associated with these sources.

In addition to the improvements outlined above, emissions and removals from LULUCF have been estimated this year. The LULUCF sector in Guernsey is a net source when calculated using Tier 1 methods and stable over time. This is because there is very limited land use change on Guernsey and most emissions come from agricultural liming. Land cover is only available for 1999 and 2006 (a constant rate of change is assumed between these points).

Table A 3.9.2: Isle of Man, Guernsey and Jersey – Summary of Methodologies

Sector	Source name	Activity data	Emission factors	Notes
1	Energy - power stations and small combustion sources	Fuel use data supplied	1990-2007 GHGi emission factors used for all sources	In some cases time series were incomplete - other years were based on extrapolated/interpolated values. Fuel imports for Guernsey were not always broken down into different fuel classes - this information was derived from data in a previous report (2002).
	Energy - road transport	Time series of vehicle numbers and fuel consumption supplied, age profile and vehicle km data calculated using UK figures	Factors for vehicle types based on UK figures	Breakdown of vehicle types not always detailed, some fuel use is based on extrapolated figures. Assumes the same vehicle age profile as the UK.
	Energy - other mobile sources	Aircraft and shipping movements supplied, and some data about off road machinery	Aircraft emissions taken from the UK aviation model, shipping from 2003/2002 NAEI	Incomplete datasets were supplied in many cases - the time series were completed based on passenger number data or interpolated values.
2	Industrial processes	Population, GDP	Some sources assumed zero. Per capita emission factors based on UK emissions, where appropriate.	Based on the assumption that activities such as MDI use and refrigeration will be similar to the UK, whilst industrial sources will not be present. Industrial process emissions are assumed to be zero.
3	Solvent use	Population, GDP, vehicle and housing numbers	Per capita (or similar) emission factors based on UK emissions	Assumes that solvent use for activities such as car repair, newspaper printing, and domestic painting will follow similar patterns to the UK, whilst the more industrial uses will be zero.
4	Agriculture	Livestock statistics supplied	Ammonia and N_2O from manure management are based on a time series of UK emissions. Methane emissions based on IPCC guidelines	Ammonia and N_2O emissions assume similar farm management practices as for the UK. Some of the farming statistics time series were incomplete - other years were based on interpolated values
5	Land use change and forestry	Land use and forest planting data	Emissions and removals have been calculated using a Tier 1 method in most cases, with a Tier 3 method for forestry in the Isle of Man also being used.	Differing amounts of data were supplied for each CD, which has meant that the same methodologies could not be used for all.
6	Waste – MSW	Landfill estimates based on population or waste amounts, incineration estimates based on limited data on the amount of waste incinerated	Time series of UK per capita emission factors used for land fill sites, improved emission model for Guernsey	Estimates of amounts of incinerated waste are based on limited data and interpolated values. The emission model that has been implemented for Guernsey has improved estimates for this source.
	Waste - Sewage treatment	Population	Time series of UK per capita emission factors	Assumes the same sewage treatment techniques as for the UK. In practice, treatment not thought to be as comprehensive as UK, but no details available.

Table A 3.9.3: Isle of Man, Guernsey and Jersey – Emissions of Direct GHGs (Mt CO_2 equivalent)

Sector	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
1. Energy	1.38	1.45	1.51	1.48	1.53	1.59	1.71	1.74	1.82	1.75	1.65	1.36	1.34	1.29	1.30	1.31	1.33	1.35
2. Industrial Processes	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
3. Solvent and Other Products Use																		
4. Agriculture	0.14	0.14	0.14	0.13	0.14	0.14	0.13	0.14	0.14	0.14	0.14	0.13	0.14	0.10	0.10	0.10	0.12	0.10
5. Land Use, Land Use Change and Forestry	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.03	0.03	0.03
6. Waste	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.09	0.09	0.07	0.07	0.04	0.06	0.06	0.06
7. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	
Total	**1.66**	**1.74**	**1.81**	**1.76**	**1.81**	**1.88**	**2.00**	**2.04**	**2.13**	**2.06**	**1.91**	**1.61**	**1.58**	**1.51**	**1.49**	**1.52**	**1.57**	**1.57**

A3.9.2 Overseas Territories: Bermuda, Falklands Islands, Montserrat, the Cayman Islands and Gibraltar

Table A3.9.4 summarises the methods used to estimate emissions from the Falklands Islands, Montserrat and the Cayman Islands. Emissions from some sources are not estimated due to lack of data. Emissions are summarised in **Table A3.9.5**. The government of Bermuda has prepared its own GHG inventory estimates and methodological report, so **Table A3.9.4** only refers to the methodologies used for Falkland Islands, Montserrat and the Cayman Islands. **Table A3.9.7** does, however, include emissions estimates for Bermuda, and further information has been provided (after the compilation of the 1990-2007 Inventory) from Bermuda to update and improve these emission estimates. These improvements will be made in the 1990-2008 Inventory.

A3.9.2.1 Falklands Islands

The most significant source of CO_2 is domestic heating. There are no industrial combustion sources. Estimates have been made for aviation, but no data were available to calculate emissions from shipping or off road machinery.

Methane emissions are mostly from agriculture – there are around 500,000 sheep on the island. Agriculture is also a major source of N_2O. Methane emissions from waste disposal are small, as waste is burnt. Sewage is disposed of to sea.

The LULUCF sector in the Falkland Islands is a net source (stable 1990-2000 and increasing to 2005) when calculated using Tier 1 methods. This is due to the requirement to estimate emissions from organic soil under Cropland. The Cropland area in the Falklands is very small but is the only active variable in the Inventory when Tier 1 methods are used. Consistent information on land use in the Falklands is available since 1984. There is very little land use change on the islands (93% of their area is natural Grassland).

The estimates of emissions from power generation are based on a complete time series of annual fuel consumptions, and can therefore be considered fairly reliable. Domestic fuel consumption statistics, however, were only provided for six years, so the time series was extrapolated back to 1990, and forwards to 2007 based on population statistics. Vehicle numbers were only provided for one year, so this time series was also generated based on population statistics. We consider the uncertainties associated with emissions from domestic fuel consumption and transport to be high, with the greatest uncertainties earlier in the time series.

A3.9.2.2 Montserrat

Only limited activity data were supplied for Montserrat, so it was not possible to make estimates of GHG emissions from all source sectors. In addition half of the island is currently uninhabitable due to recent volcanic activity. Nevertheless a reliable time series of the island's population was supplied, and it was possible to use this to extend some of the time series of available emission estimates.

Estimates have been made for power generation, residential combustion, aviation, road transport and F-gases. No information was supplied about shipping. There was also no information supplied about the disposal of waste, treatment of sewage, or livestock numbers.

Since emissions from different waste disposal and sewage treatment techniques vary greatly, there is no way of calculating a reliable estimate based on any surrogate statistics. It is also difficult to predict livestock figures without any indication of the importance of agriculture to the island. It has also not been possible to calculate emissions and removals from LULUCF activities for Montserrat.

Of the sectors calculated, road transport is the most important. Only fuel consumption figures were supplied for this sector and emissions of non-CO_2 greenhouse gases are therefore quite uncertain. It is assumed that emissions from some off road transport and machinery will be included in the figure calculated for the road transport sector. Power generation is the other major source.

A3.9.2.3 Cayman Islands

This year, a more detailed data set has been received from the Cayman Islands in order to calculate a more comprehensive inventory for this Overseas Territory. Fuel import data has been received, and fuel use for the power station, together with livestock statistics and more qualitative information about the likely emission sources on the Islands.

The largest CO_2 emission source is power generation, accounting for 41% of emissions. There are also significant industrial combustion emissions from the water desalination plant and the cement industry. Agriculture is not a large source of emissions, and therefore methane and N_2O emissions are small. No data were available to estimate LULUCF emissions from the Cayman Islands.

The new data provided has led to large improvements in the inventory for the Cayman Islands. However, in some cases assumptions had to be made to fill gaps in the data, or where the data were inconsistent. For example, the total fuel imports data was inclusive of the power station fuel use, however in some years the reported consumption at the power station was greater than the total fuel imports.

A3.9.2.4 Bermuda

The Bermuda Department for Environmental Protection has produced its own greenhouse gas inventory, compiled according to the IPCC guidelines. Calculated emissions and the methodology used for Bermuda are detailed in Bermuda’s Greenhouse Gas Inventory – Technical Report 1990-2000 (the Department of Environmental Protection, Government of Bermuda). An estimate of emissions from waste incineration (excluded from Bermuda’s report) has also been made based on UK emission factors, and statistics contained in Bermuda’s report on the amount of waste generated per person per day.

This report is now becoming very out of date, and therefore information has been requested from Bermuda to update and improve this inventory. The data requested have now been received and will be incorporated into the 1990-2008 inventory.

The major sources for carbon are road transport and power generation. Emissions from landfill were the main source of methane in 1990, but waste is now disposed of by incineration. N_2O emissions arise mainly from sewage treatment.

Table A 3.9.4: Cayman Islands, Falklands Islands and Montserrat – Methodology (for estimates of carbon, CH_4 and N_2O)

Sector	Source name	Activity data	Emission factors	Notes
1	Energy - power stations and small combustion sources	Fuel use data supplied	1990-2007 Emission factors from the UK GHGi	Fuel data in most cases was only supplied for the latter part of the time series. Extrapolated figures based on population trends have been used to calculate fuel consumption for earlier years.
	Energy - road transport	Vehicle numbers and fuel use supplied for the Falkland Islands, vehicle numbers and vehicle kilometres and fuel use for the Cayman Islands, fuel use for Montserrat.	Factors for vehicle types based on UK figures	Vehicle numbers have only been supplied for one year (time series are based on population), and the age profiles are based on UK figures - which may not be appropriate. Emissions for Montserrat are subject to a greater degree of uncertainty as there is no information about vehicle types or numbers.
	Energy - other mobile sources	Aircraft movements supplied for FI and Montserrat.	EMEP/CORINAIR factors	It has not been possible to make any estimates of emissions from shipping activities for any of these - no information was supplied, and the use of any surrogate statistics would not be suitable for this source.
2	Industrial processes	Population, GDP	Some sources assumed zero. Per capita emission factors based on UK/Gibraltar emissions.	Assumes activities such as aerosol use and refrigeration will be similar to the UK. In practice, this is unlikely, but there is no other data available. The Cayman Island estimates were based on figures calculated for Gibraltar rather than for the UK - it was assumed that trends in the use of air conditioning etc would be similar.
5	Land use change and forestry	Land use data	Tier 1 data	Data were only available to estimate emissions from the Falklands.
6	Waste - MSW	Tonnes of waste incinerated (Falkland Islands), NE for Montserrat and Cayman Islands, waste generation (Bermuda)	US EPA factors for the open burning of municipal refuse, NAEI factors for clinical waste incineration and MSW incineration in Bermuda	Information on the amount of waste incinerated was limited. No information about the type of waste treatment was available for Montserrat or the Cayman Islands.
	Waste - Sewage treatment	NO (Falkland Islands), NE (Cayman Islands ands Montserrat)		Sewage from the Falkland Islands is disposed of to sea. Emissions Not Estimated (NE) for the Cayman Islands and Montserrat, as no information was available.

Table A 3.9.5: Cayman Islands, Falklands Islands, Bermuda and Montserrat – Emissions of Direct GHGs (Mt CO_2 equivalent)

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy	1.12	1.15	1.17	1.21	1.25	1.28	1.28	1.33	1.42	1.43	1.46	1.54	1.54	1.58	1.65	1.66	1.74	1.81
2. Industrial Processes	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
3. Solvent and Other Products Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Agriculture	0.17	0.17	0.17	0.17	0.17	0.17	0.16	0.17	0.16	0.16	0.17	0.17	0.16	0.15	0.15	0.14	0.14	0.14
5. Land Use, Land Use Change and Forestry	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.03	0.03	0.03
6. Waste	0.07	0.07	0.07	0.07	0.07	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
7. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**1.38**	**1.40**	**1.42**	**1.46**	**1.50**	**1.49**	**1.49**	**1.55**	**1.64**	**1.65**	**1.68**	**1.76**	**1.76**	**1.81**	**1.87**	**1.88**	**1.96**	**2.03**

A3.9.2.5 Gibraltar Emissions

A greenhouse gas inventory for Gibraltar has been created which contains annual emission estimates from 1990 to 2007 inclusive and emissions for the Base Year. The year 1995 has been chosen as the Base Year for the fluorinated gases, in agreement with the year the UK has chosen, and in accordance with Article 3(8) of the Kyoto Protocol. Gibraltar made the decision to join the UK's instrument of ratification of the Kyoto Protocol in 2006.

Gibraltar already reports emissions under other international agreements. During the compilation of the Gibraltar GHG inventory, steps have been taken to ensure the existing Gibraltar inventories and the GHG inventory share common activity data where appropriate.

Data specific to Gibraltar have been collected to estimate emissions as accurately as possible. In general the data were requested by questionnaire asking for information on fuel use, the vehicle fleet, shipping movements, aircraft, livestock numbers and waste treatment. Communications between the Gibraltar Environmental Agency and other companies is extremely good, allowing the acquisition of reliable data relating to the larger emission sources. The Gibraltar Environmental Agency was able to provide information from the government of Gibraltar statistics office, which holds much information relating to several source sectors. However, there are laws in Gibraltar restricting the data available from the Government statistics department. In general these were introduced to protect commercially sensitive information, which is more likely to occur in smaller administrations. For example it is not possible to obtain information on petrol sales from the eight petrol stations on Gibraltar without special dispensation. However, it is possible to obtain information on services that have no direct competitors (and hence the information is not regarded as being commercially sensitive).

There were some difficulties obtaining information for some sectors to estimate emissions using the same methods applied to the existing UK GHG inventory. Modifications were therefore made to the existing methods and surrogate data were used as necessary; this is discussed in the sections below. Where possible, emissions were estimated using same methods used in the UK inventory.

Emission factors for most sources are taken from the NAEI, to be consistent with the UK GHG inventory. Emissions from aircraft were calculated using default factors from the EMEP/CORINAIR guidebook, since the information available about aircraft movements from Gibraltar was limited.

Whilst the data availability was regarded as good for an administrative area the size of Gibraltar, there were a number of sources for which detailed activity data was not available. In these cases expert judgement was required to enable an emission estimate to be obtained. **Table A3.9.6** summarises the methodologies used to produce emission estimates for Gibraltar. In addition, no further data were provided to update the inventory to 2007. Some recalculations have occurred to the historic estimates due to the database changes, which means that the emissions are now calculated using up to date emission factors from the UK GHGI.

Emissions from LULUCF have not been estimated from Gibraltar but are believed to be very small.

Emissions from military activities in Gibraltar have been excluded from the totals. This is because the fuel used for these activities is likely to be sourced from the UK, and therefore to include emissions in the Gibraltar inventory would result in a double-count. All shipping and aviation emissions are currently classified as international, on the basis that Gibraltar has only one port and one airport.

A summary of the emissions of the direct GHGs from Gibraltar is given in **Table A3.9.7**.

Table A 3.9.6: Summary of methodologies used to estimate emissions from Gibraltar

Sector	Source name	Activity data	Emission factors	Notes
1	Energy - power stations, domestic, and small combustion sources	Fuel use data supplied for the three power stations. No activity data available for domestic, commercial and institutional combustion and so estimates made. Fuel use available for industrial combustion.	Emission factors from the 1990 – 2007 GHGI	In some cases time series were incomplete - other years were based on extrapolated (on population)/interpolated values.
	Energy - road transport	Time series of vehicle numbers and typical annual vehicle km per car, age profile calculated using UK figures.	Factors for vehicle types based on UK figures.	Breakdown of vehicle types not always detailed, some fuel use is based on extrapolated figures. Assumes the same vehicle age profile as the UK.
	Energy - other mobile sources	Aircraft and shipping movements supplied	Aircraft factors taken from EMEP/CORINAIR, shipping from 2003/2002 NAEI.	Incomplete datasets were supplied in many cases - the time series were completed based on passenger number data or interpolated values.
2	Industrial processes	No industrial processes identified with GHG emissions. Emissions of F-gases from air conditioning units are included in this sector.	Per capita (or similar) emission factors based on UK emissions.	Estimates of HFCs from air conditioning were based on percentages of homes, cars etc using the equipment, provided by the Environmental Agency.
4	Agriculture	No commercial agricultural activity. No emissions from this sector.		
5	Land use change and forestry			Emissions Not Estimated, as insufficient data are available. These emissions are likely to be negligible.
6	Waste - MSW	Incineration estimates based on limited data on the amount of waste incinerated up to 2001. After 2001, waste transported to Spain to be land filled.	Emission factors taken from 1990-2007 GHGI	Estimates of waste incinerated between 1990 and 1993 are based on extrapolated values. Data for the remainder of the time series was provide. Emissions from this source are assumed zero after the closure of the incinerator in 2000.
	Waste - Sewage treatment	No emissions from this sector; all sewage is piped directly out to sea, with no processing.		

Table A 3.9.7: Emissions of Direct GHGs (Mt CO_2 equivalent) from Gibraltar

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy	0.17	0.18	0.19	0.16	0.17	0.17	0.17	0.17	0.18	0.19	0.19	0.20	0.20	0.20	0.21	0.22	0.22	0.22
2. Industrial Processes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3. Solvent and Other Products Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5. Land Use, Land Use Change and Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6. Waste	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.18**	**0.19**	**0.19**	**0.17**	**0.18**	**0.18**	**0.18**	**0.19**	**0.19**	**0.20**	**0.21**	**0.20**	**0.20**	**0.21**	**0.22**	**0.23**	**0.23**	**0.22**

A4 ANNEX 4: Comparison of CO_2 Reference and Sectoral Approaches

This annex presents information about the Reference Approach calculations, and its comparison with the Sectoral Approach.

A4.1 ESTIMATION OF CO_2 FROM THE REFERENCE APPROACH

The UK greenhouse gas inventory uses the bottom-up (sectoral) approach based on the combustion of fuels in different economic sectors and estimates of non-combustion emissions from other known sectors to produce detailed sectoral inventories of the 10 pollutants. In addition, estimates are also provided of carbon dioxide emissions using the IPCC Reference Approach. This is a top down inventory calculated from national statistics on production, imports, exports and stock changes of crude oil, natural gas and solid fuels. It is based on a different set of statistics and methodology and produces estimates around between 1% lower to 3 % higher than the bottom-up approach when categories not included in the reference approach are removed from the sectoral approach estimate.

A4.2 DISCREPANCIES BETWEEN THE IPCC REFERENCE AND SECTORAL APPROACH

The UK GHGI contains a number of sources not accounted for in the IPCC Reference Approach and so gives a higher estimate of CO_2 emissions. The sources not included in the reference approach are:

- Land use change and forestry;
- Offshore flaring and well testing;
- Waste incineration; and
- Non-Fuel industrial processes.

In principle the IPCC Reference Total can be compared with the IPCC Table 1A Total plus the emissions arising from fuel consumption in 1B1 Solid Fuel Transformation and Table 2 Industrial Processes (Iron and Steel and Ammonia Production). The IPCC Reference totals range between 1% lower to 3 % higher than the comparable bottom up totals.

The IPCC Reference Approach is based on statistics of production, imports, exports and stock changes of fuels whilst the sectoral approach uses fuel consumption data. The two sets of statistics can be related using mass balances (see the publication 'Digest of UK Energy Statistics' BERR, 2008), but these show that some fuel is unaccounted for. This fuel is reported in DUKES as statistical differences – these differences consist of measurement errors and losses. The system of energy statistics operated by BERR aims to keep UK statistical differences (without normalisation) at less than 0.5% of energy supply, and generally manages to meet this target, not only for total supply but by fuel.

Nevertheless a proportion of the difference between the Reference Approach and the sectoral totals will be accounted for by statistical differences, particularly for liquid fuels.

1. The sectoral approach only includes emissions from the non-energy use of fuel where they can be specifically identified and estimated such as with fertilizer production and iron and steel production. The IPCC Reference approach implicitly treats the non-energy use of fuel as if it were combustion. A correction is then applied by deducting an estimate of carbon stored from non-energy fuel use. The carbon stored is estimated from an approximate procedure that does not identify specific processes. The result is that the IPCC Reference approach is based on a higher estimate of non-energy use emissions.

2. The IPCC Reference Approach uses data on primary fuels such as crude oil and natural gas liquids, which are then corrected for imports, exports and stock changes of secondary fuels. Thus the estimates obtained will be highly dependent on the default carbon contents used for the primary fuels. The sectoral approach is based wholly on the consumption of secondary fuels where the carbon contents are known with greater certainty. In particular the carbon contents of the primary liquid fuels are likely to vary more than those of secondary fuels.

A4.3 TIME SERIES OF DIFFERENCES IN THE IPCC REFERENCE AND SECTORAL INVENTORIES

Table A4.3.1 shows the percentage differences between the IPCC Reference Approach and the National Approach. These percentages include a correction for the fact that a significant proportion of fuel consumption emissions occur in the 2C Metal Production and 2B1 Ammonia Production sectors.

Table A 4.3.1: Modified comparison of the IPCC Reference Approach and the National Approach

Year	1990	1991	1992	1993	1994	1995
Percentage difference	-1.4	-0.1	0.8	0.3	0.5	2.0

Year	1996	1997	1998	1999	2000	2001
Percentage difference	0.2	-0.1	0.7	1.3	1.5	1.1

Year	2002	2003	2004	2005	2006	2007
Percentage difference	0.6	0.1	1.0	0.8	2.3	2.0

A5 ANNEX 5: Assessment of Completeness

A5.1 ASSESSMENT OF COMPLETENESS

Table A5.1.1 shows sources of GHGs that are not estimated in the UK GHG inventory, and the reasons for those sources being omitted. This table is taken from the CRF; “Table9(a)”.

Table A 5.1.1: GHGs and sources not considered in the UK GHG inventory

GHG	CRF sector	Source/sink category	Reason
CO_2	2. Industrial Processes	2A5/6 Asphalt Roofing/Paving	No methodology available but considered negligible
CO_2	3. Solvent and Other Product Use		Carbon equivalent of solvent use not included in total - provided for information
CO_2	5. Land-Use Change and Forestry	5C1 Grassland remaining Grassland - Carbon stock change in living biomass	Emissions believed small
CO_2	2. Industrial Processes	2A4 – soda ash production	Emissions from fuels used in soda ash production are reported elsewhere. Carbon evolved from the initial calcination stage of the process is assumed to be entirely converted into soda ash and therefore not emitted
CO_2	5. Land-Use Change and Forestry	5B2/5C1/5C2/5E Biomass burning by Wildfires	Methodology being developed - believed small
N_2O	3. Solvent and Other Product Use	3D Other –Anaesthesia	Activity not readily available – believed small
N_2O	5. Land-Use Change and Forestry	5A1 Direct N2O emissions from N fertilisation	Now included for new forests (5A2)
N_2O	5. Land-Use Change and Forestry	5A N2O emissions from drainage of soils	Methodology under consideration
N_2O	5. Land-Use Change and Forestry	5B2 N2O emissions from disturbance associated with LUC to Cropland	Methodology under consideration
N_2O	5. Land-Use Change and Forestry	5B2/5C1/5C2/5E Biomass burning by Wildfires	Methodology being developed - believed small
CH_4	2. Industrial Processes	2B1 Ammonia Production	Manufacturers do not report emission - believed negligible
CH_4	2. Industrial Processes	2C1 Iron and Steel	EAF emission and flaring only estimated - methodology not available for other sources
CH_4	2. Industrial Processes	2C2 Ferroalloys	Methodology not available but considered negligible
CH_4	2. Industrial Processes	2C3 Aluminium	Methodology not available but considered negligible
CH_4	5. Land-Use Change and	5B2/5C1/5C2/5E Biomass	Methodology being developed -

GHG	CRF sector	Source/sink category	Reason
	Forestry	burning by Wildfires	believed small
CH_4	6. Waste	6B1 Industrial Waste Water	Activity data unavailable - most waste water treated in public system-believed small
CH_4	6. Waste	6B1 Industrial Waste Water	Activity data unavailable - most waste water treated in public system-believed small
PFC	2. Industrial processes	2F1 Refrigeration and air-conditioning equipment	Data not available, but assumed negligible
SF6	2.Industrial Processes	2C4. Aluminium Foundries	Data not available, but assumed negligible

A6 ANNEX 6: Additional Information Quantitative Discussion of 2007 Inventory

This Annex discusses the emission estimates made in the 1990-2007 Greenhouse Gas Inventory. Each IPCC sector is described in detail with significant points noted for each pollutant where appropriate. The tables show rounded percentages only. All calculations are based on IPCC categorisation.

A6.1 ENERGY SECTOR (1)

Figure A6.1 and **A6.2** show both emissions of direct and indirect Greenhouse Gases for the Energy sector (category 1) in the UK for the years 1990-2007. Emissions from direct greenhouse gases in this sector have declined 11% since 1990, with a decrease of 1.95% between 2006 and 2007 continuing this trend.

Tables A6.1.1 to **A6.1.4** summarise the changes observed through the time series for each pollutant, as well as the contribution the emissions make to both sector 1 and the overall emissions in the UK during 2007.

A6.1.1 Carbon Dioxide

Analysing emissions by pollutant shows that 98% of total net CO_2 emissions in 2007 came from the Energy sector (**Table A6.1.4**), making this sector by far the most important source of CO_2 emissions in the UK. Overall, CO_2 emissions from sector 1 have decreased by 8% since 1990 (**Table A6.1.1**) and have also shown a decrease of 1.8% between 2006 and 2007 (**Table A6.1.2**).

Energy industries (category 1A1) were responsible for 39% of the sector's CO_2 emissions in 2007 (**Table A6.1.3**). There has been an overall decline in emissions from this sector of 11% since 1990 (**Table A6.1.1**). Although recently relatively high gas prices have led to more coal being burnt, in general since the privatisation of the power industry in 1990, there has been a move away from coal and oil generation towards combined cycle gas turbines (CCGT) and nuclear power, the latter through greater availability. During this time there has been an increase in the amount of electricity generated but a decrease in CO_2 emissions from Power stations (1A1a). This can be attributed to several reasons. Firstly, the greater efficiency of the CCGT stations compared with conventional stations – around 49% as opposed to 36%.[7] Secondly, the calorific value of natural gas per unit mass carbon is higher than that of coal and oil. Emissions from this sector showed a 2% decrease from 2006 to 2007, due to a significant decrease in the amount of coal used for electricity generation in 2007.

Emissions of from category 1A2 – Manufacturing Industries and Construction contributed 15% (**Table A6.1.4**) to overall net CO_2 emissions in the UK in 2007. Since 1990, these emissions have declined by 20%, (**Table A6.1.1**) mostly as a result of a decline in the emissions from the Iron and steel industry. This sector has seen a significant decrease in

[7] Plant loads, demand and efficiency, Table 5.10, BERR (2008)

coke, coal and fuel oil usage, with an increase occurring in the emissions from combustion of natural gas.

Emissions of CO_2 from 1A3 (Transport) have increased by 12% since 1990 (**Table A6.1.1**). In 2007, this sector contributed 25% (**Table A6.1.4**) to overall CO_2 emissions within the UK. Emissions from transport are dominated by road transport (1A3b), which in 2007 contributed 93% to the total emissions from transport. Since 1990, emissions from road transport have increased by 11%. Emissions from domestic aviation have almost doubled since 1990, but has shown a decrease of 10% since 2005 despite an increase in the total number of km flown. This is because of a move to use more fuel efficient aeroplanes in 2006.

Emissions of CO_2 from 1A4 (Other) have decreased by 8% since 1990 (**Table A6.1.1**). During this period, residential emissions have decreased by 3% and emissions from the commercial/institutional subsector have decreased by 19%. Fuel consumption data shows a trend away from coal, coke, fuel oil and gas oil towards burning oil and natural gas usage.

Emissions of CO_2 from 1A5 (Fuel Combustion; Other), 1B1 (Fugitive Emissions from Fuels; Solid fuels) and 1B2 (Fugitive Emissions from Fuels; Oil and Natural Gas) all show decreases between 1990-2007, although they only contribute a small percentage towards emissions from the energy sector.

A6.1.2 Methane

In 2007, 19% (see **Table A6.1.4**) of total methane emissions came from the energy sector, the majority (59%, **Table A6.1.3**) from fugitive emissions from oil and natural gas (1B2). Emissions from this category have decreased by 47% since 1990 (**Table A6.1.1**). Sources include leakage from the gas transmission and distribution system and offshore emissions. Estimates of leakage from the gas distribution system are based on leakage measurements made by National Grid UK together with data on their gas main replacement programme, and have declined since 1990 as old mains are replaced. The major sources of emissions from the offshore oil and gas industry are venting, fugitive emissions and loading and flaring from offshore platforms.

A6.1.3 Nitrous Oxide

The energy sector accounted for 15% of total N_2O emissions in the UK during 2007. Of this, a majority (31%, **Table A6.1.3**) arose from the transport sector (1A3). Between 1990 and 2007, emissions increased by 12% (**Table A6.1.1**). This is because of the increasing numbers of petrol driven cars fitted with three-way catalysts. These are used to reduce emissions of nitrogen oxides, carbon monoxide and non-methane volatile organic compounds. However, nitrous oxide is produced as a by-product and hence emissions from this sector have increased.

The other major contribution towards N_2O emissions within the energy sector comes from energy industries (1A1). Within this category, emissions from public electricity production have shown a 34% decrease, whilst emissions from petroleum refining have increased by 5%. Emissions from 1A1c (Manufacture of Solid Fuels and Other Energy Industries) have increased by 33% between 1990 and 2007. N_2O emissions have decreased overall by 47% since 1990. Over this period the use of coal has decreased and the use of natural gas increased.

A6.1.4 Nitrogen Oxides

In 2007, over 99% of NO_x emissions in the UK came from the energy sector. Since 1990 emissions from this sector have decreased by 45% (**Table A6.1.1**), mostly as a result of abatement measures on power stations, three-way catalysts fitted to cars and stricter emission regulations on trucks. The main source of NO_x emissions is transport: in 2007, emissions from transport contributed 41% (**Table 6.1.4**) to the total emissions of NO_x in the UK, with 17% arising from road transport (1A3b). From 1970, emissions from transport increased (especially during the 1980s) and reached a peak in 1989 before falling by 50% (**Table A6.1.1**) since 1990. This reduction in emissions is due to the requirement since the early 1990s for new petrol cars to be fitted with three way catalysts and the further tightening up of emission standards on these and all types of new diesel vehicles over the last decade.

Emissions from the energy industries (1A1) contributed 30% (**Table A6.1.4**) to total NO_x emissions in the UK during 2007. Between 1990 and 2007, emissions from this sector decreased by 48% (**Table A6.1.1**). The main reason for this was a decrease in emissions from public electricity and heat (1A1a) of 53%. Since 1998 the electricity generators adopted a programme of progressively fitting low NO_x burners to their 500 MWe coal fired units. Since 1990, further changes in the electricity supply industry such as the increased use of nuclear generation and the introduction of CCGT plant have resulted in additional reduction in NO_x emissions.

Emissions from Manufacturing, Industry and Construction (1A2) have fallen by 37% (**Table A6.1.1**) since 1990. In 2007, emissions from this sector contributed 17% (**Table A6.1.4**) to overall emissions of NO_x. Over this period, the iron and steel sector has seen a move away from the use of coal, coke and fuel oil towards natural gas and gas oil usage.

A6.1.5 Carbon Monoxide

Emissions of carbon monoxide from the energy sector contributed 90% (**Table A6.1.4**) to overall UK CO emissions in 2007. Of this, 45% of emissions (**Table A6.1.3**) occur from the transport sector. Since 1990, emissions from 1A3 have declined by 86% (**Table A6.1.1**), which is mainly because of the increased use of three way catalysts, although a proportion is a consequence of fuel switching in moving from petrol to diesel cars.

Emissions from sector 1A2 contributed 25% (**Table A6.1.4**) to overall emissions of CO in 2007. Emissions from within this category mostly come from the Iron and Steel industry and from petrol use in off-road vehicles within the Manufacturing, industry and combustion sector.

A6.1.6 Non Methane Volatile Organic Compounds

In 2007, 43% (**Table A6.1.4**) of non-methane volatile organic compound emissions came from the energy sector. Of these, the largest contribution arises from the fugitive emissions of oil and natural gas (1B2), which contributed 22% (**Table A6.1.4**) towards the overall UK emissions of NMVOCs in 2007. This includes emissions from gas leakage, which comprise around 10% of the total for the energy sector. Remaining emissions arise from oil transportation, refining, storage and offshore.

Emissions from transport (1A3) contribute 10% (**Table A6.1.4**) to overall emissions of NMVOC in the UK in 2007. Since 1990, emissions from this sector have decreased by 89% (**Table A6.1.1**) due to the increased use of three way catalysts on petrol cars.

A6.1.7 Sulphur Dioxide

95% (**Table A6.1.4)** of emissions of sulphur dioxide came from the energy sector in 2007. 66% (**Table A6.1.3**) of these emissions arose from the energy industries sector (1A1). A majority of these emissions are from the public electricity and heat production category (1A1a). Since 1990, emissions from power stations have declined by 89%. This decline has been due to the increase in the proportion of electricity generated CCGT stations and other gas fired plant. CCGTs run on natural gas and are more efficient (see **Section A6.1.1.1**) than conventional coal and oil stations and have negligible SO_2 emissions.

Emissions from Manufacturing, Industry and Construction were responsible for 16% (**Table A6.1.4**) of UK emissions of SO_2 in 2007. Since 1990, emissions from this sector have declined by 78% (**Table A6.1.1**). This decline is due to the reduction in the use of coal and oil in favour of natural gas, and also some improvement in energy efficiency.

Figure A6.1: UK emissions of Direct Greenhouse Gases from IPCC sector 1, 1990-2007

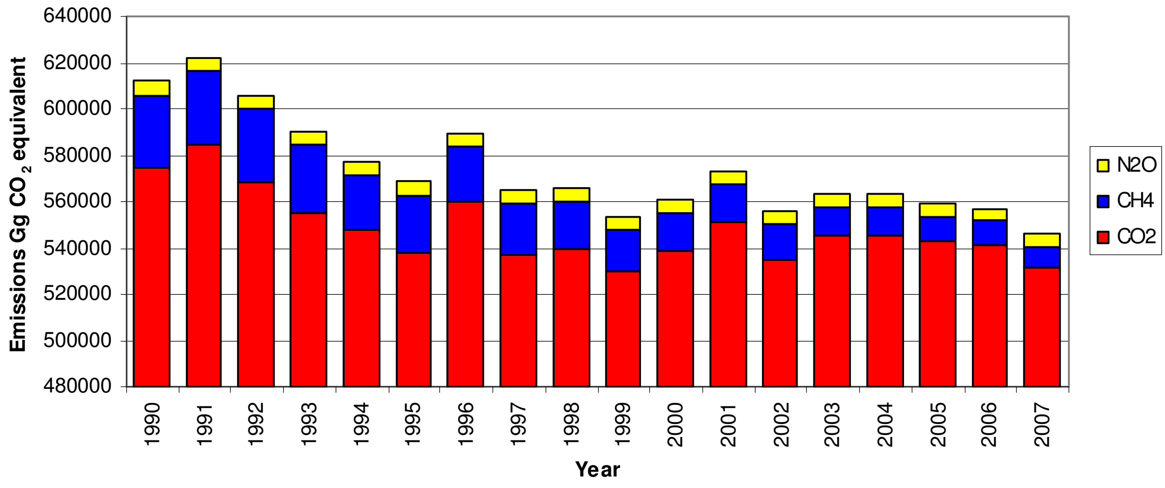

Figure A6.2: UK emissions of Indirect Greenhouse Gases from IPCC sector 1, 1990-2007

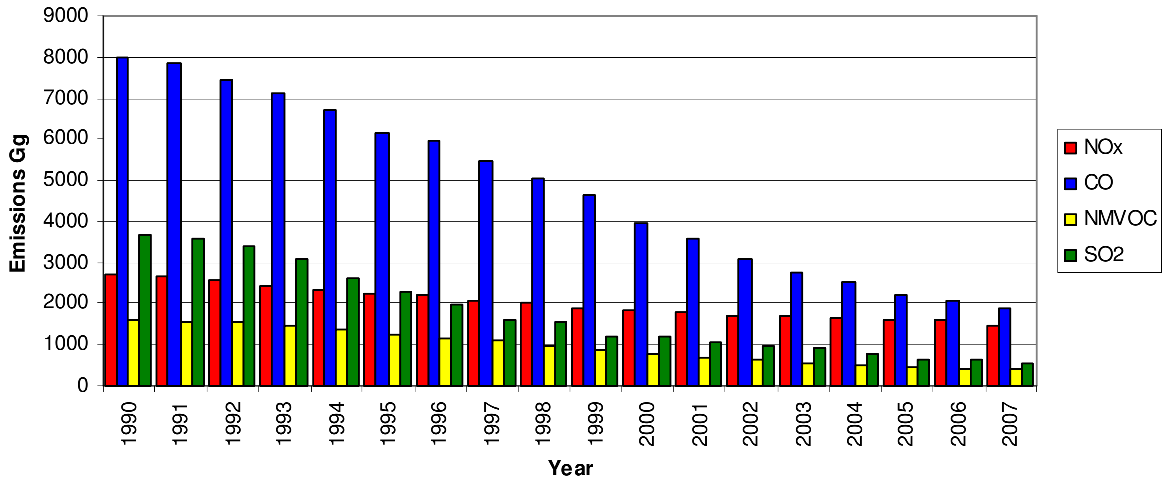

Table A 6.1.1: % Changes from 1990 to 2007 in Sector 1

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
1A1	-11%	19%	-23%	-48%	-22%	-32%	-87%
1A2	-20%	-16%	-18%	-37%	-28%	-11%	-78%
1A3	12%	-78%	12%	-50%	-86%	-89%	-43%
1A4	-8%	-65%	-37%	-24%	-67%	-41%	-87%
1A5	-34%	-31%	-33%	-44%	-34%	-40%	-45%
1B1	-84%	-86%	-52%	-56%	-74%	-62%	-52%
1B2	-12%	-47%	-7%	-84%	-48%	-63%	-95%
Overall	**-8%**	**-70%**	**-16%**	**-45%**	**-76%**	**-72%**	**-85%**

Table A 6.1.2: % Changes from 2006 to 2007 in Sector 1

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
1A1	-2%	2%	-8%	-7%	1%	-5%	-16%
1A2	-3%	-2%	-1%	-6%	-4%	-2%	-5%
1A3	0%	-9%	-3%	-8%	-15%	-12%	-4%
1A4	-4%	6%	-3%	-8%	3%	3%	-1%
1A5	27%	32%	29%	7%	28%	16%	0%
1B1	-1%	-30%	-8%	-4%	0%	-3%	27%
1B2	4%	0%	4%	-14%	6%	-3%	-61%
Overall	**-1.8%**	**-11%**	**-4%**	**-7%**	**-8%**	**-4%**	**-12%**

Table A 6.1.3: % Contribution to Sector 1

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
1A1	40%	3%	30%	30%	5%	1%	66%
1A2	15%	3%	26%	17%	28%	6%	16%
1A3	25%	2%	31%	41%	45%	25%	10%
1A4	19%	6%	12%	11%	21%	15%	5%
1A5	1%	0%	1%	2%	0%	0%	1%
1B1	0%	28%	0%	0%	1%	0%	2%
1B2	1%	59%	1%	0%	1%	52%	0%

Table A 6.1.4: % Contribution to Overall Pollutant Emissions

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
1A1	39%	0%	5%	30%	5%	1%	63%
1A2	15%	1%	4%	17%	25%	3%	16%
1A3	24%	0%	5%	41%	40%	10%	9%
1A4	19%	1%	2%	11%	18%	7%	5%
1A5	1%	0%	0%	2%	0%	0%	1%
1B1	0%	5%	0%	0%	0%	0%	2%
1B2	1%	11%	0%	0%	1%	22%	0%
Overall	**98%**	**19%**	**15%**	**99.7%**	**90%**	**43%**	**95%**

A6.2 INDUSTRIAL PROCESSES SECTOR (2)

Figure A6.3 and **A6.4** show both emissions of direct and indirect Greenhouse Gases for the UK industrial processes sector in 1990-2007. Emissions from direct Greenhouse gases within this sector have decreased by 48% since 1990. **Tables A6.2.1** to **A6.2.4** summarise the changes observed through the time series for each pollutant as well as the contribution the emissions make to Sector 2 and total UK emissions during 2007.

A6.2.1 Carbon Dioxide

The industrial processes sector is not a major source of emissions in the UK for carbon dioxide. In 2007, just 2.6% (**Table A6.2.4**) of UK emissions originated from this sector.

A6.2.2 Methane

Emissions of methane from the industrial processes sector are very small and have a negligible effect on overall methane emissions in the UK.

A6.2.3 Nitrous Oxide

In 2007, 6% (**Table A6.2.4**) of N_2O emissions in the UK came from the industrial processes sector. Between 1990 and 2007, emissions from this sector declined by an estimated 89% (**Table A6.2.1**) due to reductions in emissions from adipic acid manufacture (a feedstock for nylon) and nitric acid production. N_2O emissions from nitric acid manufacture show a fall in 1995 due to the installation of an abatement system at one of the plants. Emissions from adipic acid manufacture were reduced significantly from 1998 onwards due to the retrofitting of an emissions abatement system to the only adipic acid plant in the UK.

A6.2.4 Hydrofluorocarbons

Table A6.2.4 shows that the industrial processes sector was responsible for 100% of emissions of HFCs in the UK in 2007. Since 1990, emissions of HFCs have decreased by 16% (**Table A6.2.1**). The largest contribution to this sector in 2007 arises from category 2F1 – refrigeration and air conditioning equipment. In 2007, these contributed 59% (**Table A6.2.4**) to the overall emissions of HFCs. Emissions from this category arise due to leakage from refrigeration and air conditioning equipment during its manufacture and lifetime. Emissions from aerosols contribute the next largest percentage (31%, **Table A6.2.4**) to overall HFC emissions. In this category, it is assumed that all the fluid is emitted in the year of manufacture. This category contains mainly industrial aerosols and also metered dose inhalers (MDI).

The remaining emissions arise mainly from foam blowing (4%, **Table A6.2.4**), by-product emissions (3%, **Table A6.2.4**) and fire extinguishers (2%, **Table A6.2.4**). A small emission also arises from the use of HFCs as a cover gas in aluminium and magnesium foundries.

A6.2.5 Perfluorocarbons

In 2007, 100% (**Table A6.2.4**) of PFC emissions came from the industrial processes sector. Since 1990, emissions from this sector have declined by 85% (**Table A6.2.1**). Within this sector, the main contribution to emissions comes from aluminium production (38%, Table **A6.2.4**). During the process of aluminium smelting, PFC is formed as a by-product.
The emissions are caused by the anode effect, which occurs when alumina concentrations become too low in the smelter. This can cause very high electrical current and decomposition

of the salt – fluorine bath. The fluorine released then reacts with the carbon anode to create CF_4 and C_2F_6. Since 1990, emissions arising from aluminium production have shown a 94% decrease (**Table A6.2.1**) due to significant improvements in process control and an increase in the rate of aluminium recycling.

The next largest source is 2F8, which includes a range of sources including the semiconductor and electronics industries. In 2007, this sector contributed 37% (**Table A6.2.4**) to overall PFC emissions in the UK .The remaining contribution arises from fugitive emissions from PFC manufacture. In 2007, this contributed 25% (**Table A6.2.4**) to overall PFC totals in the UK.

A6.2.6 Sulphur Hexaflouride

In 2007, the industrial processes sector contributed 100% (**Table A6.2.4**) of emissions of SF_6 in the UK. Emissions arise from two main sectors. The use of SF_6 in magnesium foundries contributed 19% (**Table A6.2.4**) towards total emissions in 2007. Emissions from 2F8 – Other contributed 81% (**Table A6.2.4**) towards emissions, which includes emissions from electrical insulation. Emissions arise during the manufacture and filling of circuit breakers and from leakage and maintenance during the equipment lifetime. It also includes emissions from applications in the electronics industry and sports shoes. Since 1990, emissions from SF_6 have decreased by 23% (**Table A6.2.1**).

A6.2.7 Nitrogen Oxides

Although emissions of NO_x from this sector do occur, overall they have little impact on emissions of NO_x in the UK (see **Table A6.2.4**).

A6.2.8 Carbon Monoxide

During 2007, emissions from the industrial sector contributed 8% (**Table A6.2.4**) to overall CO emissions in the UK. Contributions within this sector arise mainly from the chemical industry, iron and steel production, and aluminium production. For details see **Table A6.2.3**. Since 1990, emissions from this sector have decreased by 36% (**Table A6.2.1**).

A6.2.9 Non Methane Volatile Organic Compounds

In 2007, emissions from the industrial processes sector contributed 13% (**Table A6.2.4**) to overall UK emissions of NMVOCs. The majority of emissions within this category come from the food and drink sector. Emissions also arise from the chemical industry.

A6.2.10 Sulphur Dioxide

In 2007, SO_2 emissions from the industrial processes sector contributed just 5% (**Table A6.2.4**) to overall emissions in the UK. Emissions arise from a variety of sources including the chemical industry, metal production and mineral products (Fletton brick production). Since 1990, SO_2 emissions from this sector have declined 46% (**Table A6.2.1**).

Figure A6.3: UK emissions of Direct Greenhouse Gases from IPCC sector 2, 1990-2007

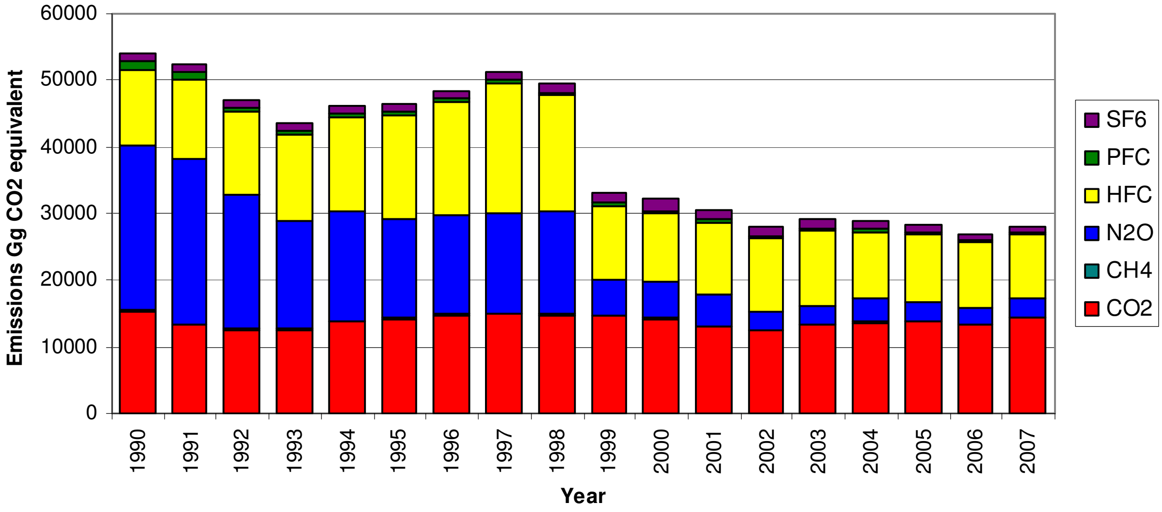

Figure A6.4: UK emissions of Indirect Greenhouse Gases from IPCC sector 2, 1990-2007

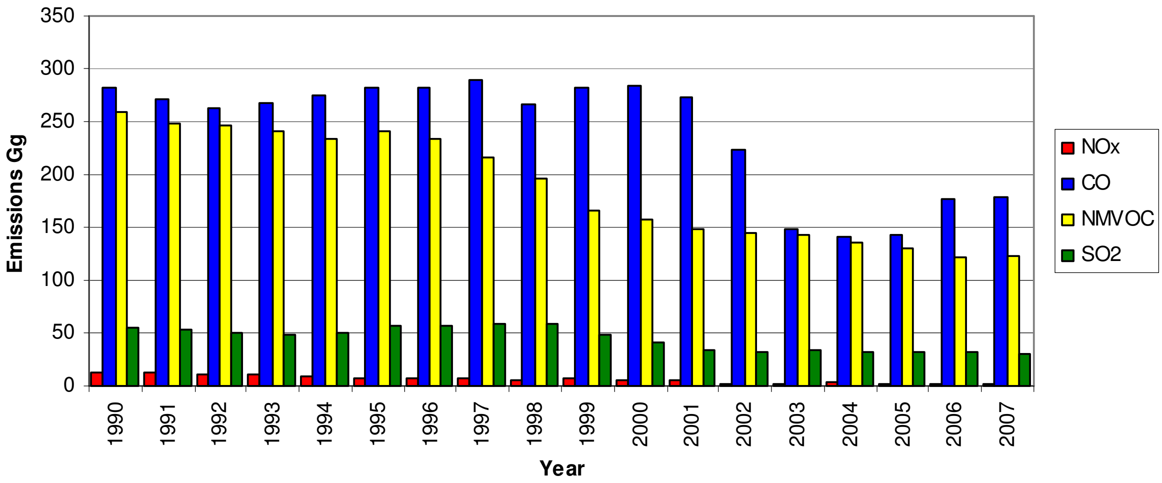

Table A 6.2.1: % Changes from 1990 to 2007 in Sector 2

	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NOx	CO	NMVOC	SO_2
2A1	-16%									
2A2	-42%									
2A3	12%									
2A4	42%									
2A5										
2A6									-37%	
2A7	1%	-22%						-35%	17%	272%
2B1	-9%									
2B2			-55%				-92%			
2B3			-95%							
2B4										
2B5	19%	-55%					30%	-64%	-80%	-86%
2C1	13%	11%	-16%				-74%	-13%	-17%	-43%
2C2										
2C3	25%				-94%		-59%	65%		27%
2C4						-65%				
2C5								-99%		-33%
2D1									-96%	
2D2									8%	
2E1				-98%						
2E2					400%					
2E3										
2F1				868287372%	-100%					
2F2										
2F3										
2F4				25405%						
2F5										
2F8					37%	7%				
2G										
Overall	**-6%**	**-46%**	**-89%**	**-16%**	**-85%**	**-23%**	**-81%**	**-36%**	**-52%**	**-46%**

Table A 6.2.2: % Changes from 2006 to 2007 in Sector 2

	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NOx	CO	NMVOC	SO_2
2A1	4%									
2A2	0%									
2A3	-3%									
2A4	15%									
2A5										
2A6									-2%	
2A7	-4%	6%						-26%	18%	-14%
2B1	42%									
2B2			0%				-2%			
2B3			64%							
2B4										
2B5	0%	13%					35%	12%	0%	2%
2C1	33%	30%	21%				11%	0%	4%	42%
2C2										
2C3	1%				-36%		0%	0%		-5%
2C4				7%		-17%				
2C5								-28%		-4%
2D1									-36%	
2D2									2%	
2E1				-55%						
2E2					-40%					
2E3										
2F1				-3%		0%				
2F2				-3%						
2F3				1%						
2F4				0%						
2F5				21%						
2F8				3%	-4%	-7%				
2G										
Overall	**8%**	**14%**	**16%**	**-4%**	**-28%**	**-9%**	**10%**	**1%**	**1%**	**-7%**

Table A 6.2.3: % Contribution to Sector 2

	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NOx	CO	NMVOC	SO_2
2A1	42%									
2A2	5%									
2A3	10%									
2A4	2%									
2A5										
2A6									5%	
2A7	1%	16%						2%	3%	53%
2B1	8%									
2B2			64%				24%			
2B3			36%							
2B4										
2B5	13%	68%					20%	16%	27%	19%
2C1	15%	16%	0%				42%	61%	1%	6%
2C2										
2C3	4%				38%		14%	20%		17%
2C4				0%		19%				
2C5								0%		4%
2D1									0%	
2D2									64%	
2E1				2%						
2E2					25%					
2E3										
2F1				59%		0%				
2F2				4%						
2F3				2%						
2F4				31%						
2F5				1%						
2F8				1%	37%	81%				
2G										

Table A 6.2.4: % Contribution to Overall Pollutant Emissions

	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NOx	CO	NMVOC	SO_2
2A1	1%									
2A2	0%									
2A3	0%									
2A4	0%									
2A5										
2A6									1%	
2A7	0%	0%						0%	0%	3%
2B1	0%									
2B2			5%				0%			
2B3			3%							
2B4										
2B5	0%	0%					0%	1%	3%	1%
2C1	0%	0%	0%				0%	5%	0%	0%
2C2										
2C3	0%				38%		0%	2%		1%
2C4				0%		19%				
2C5								0%		0%
2D1									0%	
2D2									8%	
2E1				2%						
2E2					25%					
2E3										
2F1				59%		0%				
2F2				4%						
2F3				2%						
2F4				31%						
2F5				1%						
2F8				1%	37%	81%				
2G										
Overall	**3%**	**0.23%**	**8%**	**100%**	**100%**	**100%**	**0.17%**	**8%**	**13%**	**5%**

A6.3 SOLVENTS AND OTHER PRODUCT USE SECTOR (3)

Only emissions of NMVOCs occur from the solvents category. **Figure A6.5** displays total NMVOC emissions for 1990-2007. **Tables A6.3.1-6.3.4** summarise the changes observed through the time series as well as the contribution the emissions make to both sector 3 and the overall emissions in the UK during 2007. Emissions from this sector contribute 43% to overall emissions of NMVOC in the UK (**Table A6.3.4**), and since 1990 emissions have declined by 40% (**Table A6.3.1**).

The largest source of emissions within the solvents sector is category 3D (solvent and other product use: other), contributing 59% of NMVOC emissions in this sector (**Table A6.3.3**).

Figure A6.5: UK emissions of NMVOC from IPCC sector 3, 1990-2007

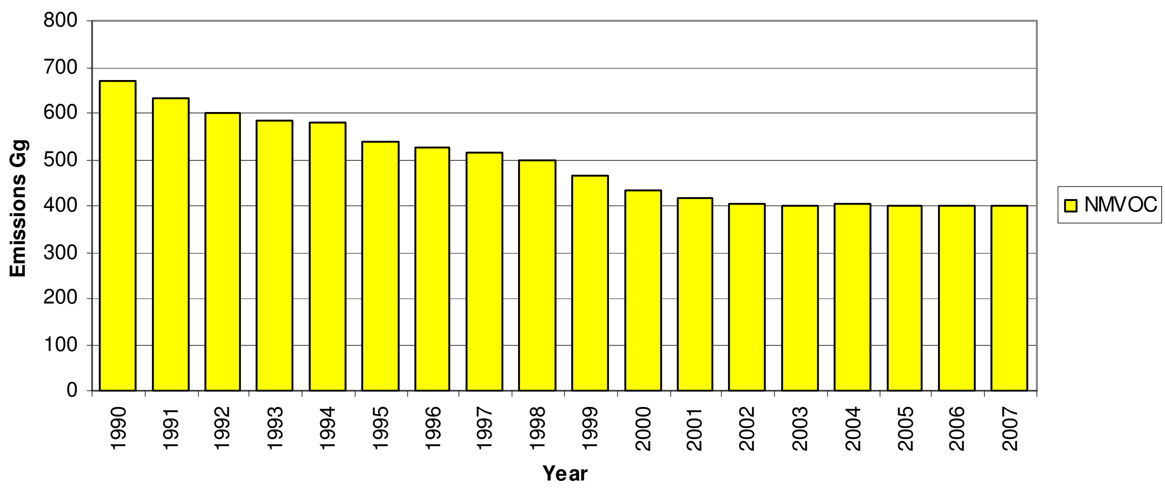

Table A 6.3.1: % Changes 1990-2007 within Sector 3

	NMVOC
3A	-42%
3B	-65%
3C	-69%
3D	-28%
Overall	**-40%**

Table A 6.3.2: % Changes 2006-2007 within Sector 3

	NMVOC
3A	-2%
3B	0%
3C	0%
3D	0%
Overall	**-0.4%**

Table A 6.3.3: % Contribution to Sector 3

	NMVOC
3A	30%
3B	8%
3C	4%
3D	59%

Table A 6.3.4: % Contribution to Overall Pollutant Emissions

	NMVOC
3A	13%
3B	3%
3C	2%
3D	25%
Overall	**43%**

A6.4 AGRICULTURE SECTOR (4)

Figures A6.6 and **A6.7** show both emissions of direct and indirect greenhouse gases for the agricultural sector (category 4) in the UK for the years 1990-2007. Emissions of direct greenhouse gases from this sector have decreased by 21% since 1990.

Tables A6.4.1-A6.4.4 summarise the changes observed through the time series for each pollutant emitted from the agricultural sector, as well as the contribution emissions make to both the sector and the overall UK estimates during 2007.

A6.4.1 Methane

Agriculture is the second largest source of methane in the UK, and in 2007 emissions from this sector totalled 38% (**Table A6.4.4**) of the UK total. Since 1990, methane emissions from agriculture have declined by 17% (**Table A6.4.1**). The largest single source within the agricultural sector is 4A1 – enteric fermentation from cattle. This accounts for 64% of methane emissions from this sector (**Table A6.4.3**), and 24% of total methane emissions in 2007 (**Table A6.4.4**). Since 1990, emissions from this sector have declined by 13% (**Table A6.4.1**) and this is due to a decline in cattle numbers over this period.

A6.4.2 Nitrous Oxide

In 2007, nitrous oxide emissions from agriculture contributed 73% (**Table A6.4.4**) to the UK total emission. Of this, 93% (**Table A6.4.4**) came from the agricultural soils sector, 4D. Since 1990, emissions of N_2O from the agricultural sector have declined by 23% (**Table A6.4.1**), driven by a fall in synthetic fertiliser application and a decline in animal population over this period.

A6.4.3 Nitrogen Oxides

Emissions from the agricultural sector occur for NO_X until 1993 only. During 1993, agricultural stubble burning was stopped and therefore emissions of NO_X became zero after this time.

A6.4.4 Carbon Monoxide

Emissions from the agricultural sector occur for CO until 1993 only. During 1993, agricultural stubble burning was stopped and therefore emissions of CO became zero after this time.

A6.4.5 Non-Methane Volatile Organic Compounds

Emissions from the agricultural sector occur for NMVOC until 1993 only. During 1993, agricultural stubble burning was stopped and therefore emissions of NMVOC became zero after this time.

Figure A6.6: UK emissions of Direct Greenhouse Gases from IPCC sector 4, 1990-2007

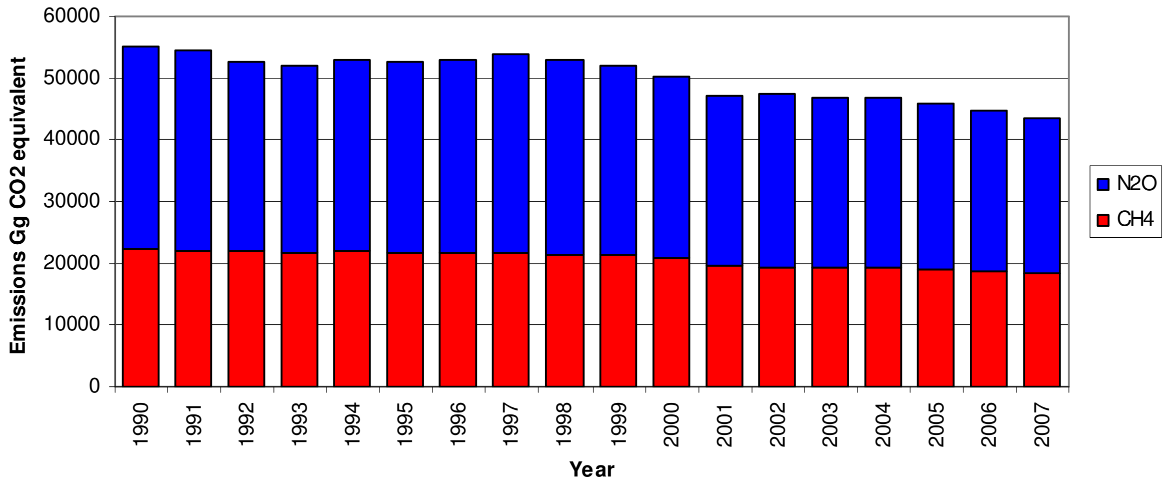

Figure A6.7: UK emissions of Indirect Greenhouse Gases from IPCC sector 4, 1990-2007

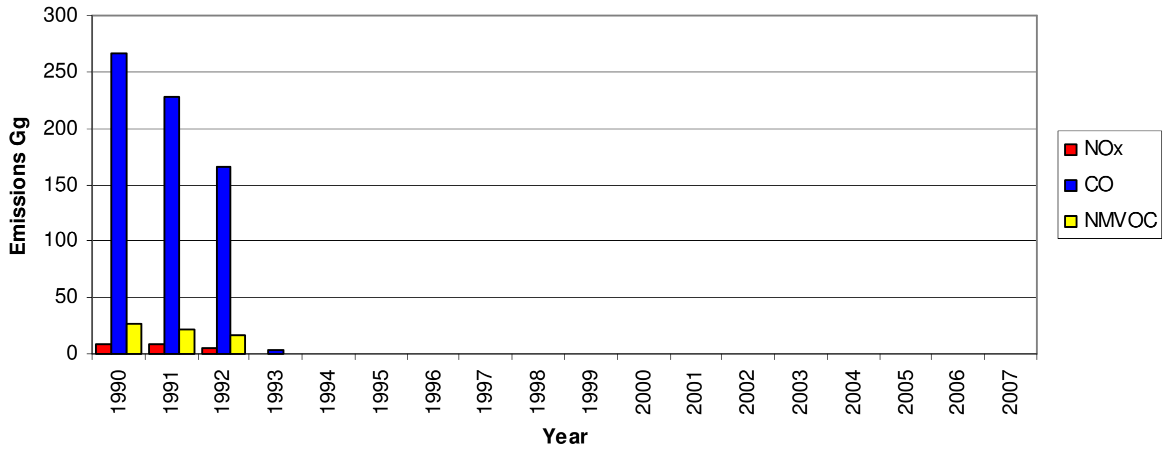

Table A 6.4.1: % Changes 1990-2007 within Sector 4

	CH_4	N_2O	NO_x	CO	NMVOC
4A1	-13%				
4A2					
4A3	-23%				
4A4	-15%				
4A5					
4A6	88%				
4A7					
4A8	-36%				
4A9					
4A10	-35%				
4B1	-16%				
4B2					
4B3	-23%				
4B4	-13%				
4B5					
4B6	87%				
4B7					
4B8	-36%				
4B9	20%				
4B10					
4B11					
4B12		-21%			
4B13		-20%			
4B14		-23%			
4C					
4D		-23%			
4E					
4F1	-100%	-100%	-100%	-100%	-100%
4F2					
4F3					
4F4					
4F5	-100%	-100%	-100%	-100%	-100%
4G					
Overall	**-17%**	**-23%**	**-100%**	**-100%**	**-100%**

Table A 6.4.2: % Changes 2006-2007 within Sector 4

	CH_4	N_2O	NOx	CO	NMVOC
4A1	-1%				
4A2					
4A3	-3%				
4A4	-3%				
4A5					
4A6	-1%				
4A7					
4A8	-2%				
4A9					
4A10	-13%				
4B1	-3%				
4B2					
4B3	-3%				
4B4	-3%				
4B5					
4B6	-2%				
4B7					
4B8	-2%				
4B9	-2%				
4B10					
4B11					
4B12		-4%			
4B13		-1%			
4B14		-5%			
4C					
4D		-3%			
4E					
4F1					
4F2					
4F3					
4F4					
4F5					
4G					
Overall	**-2%**	**-3%**			

Table A 6.4.3: % Contribution to Sector 4

	CH_4	N_2O	NOx	CO	NMVOC
4A1	64%				
4A2					
4A3	19%				
4A4	0%				
4A5					
4A6	1%				
4A7					
4A8	1%				
4A9					
4A10	0%				
4B1	10%				
4B2					
4B3	0%				
4B4	0%				
4B5					
4B6	0%				
4B7					
4B8	4%				
4B9	1%				
4B10					
4B11					
4B12		0%			
4B13		5%			
4B14		2%			
4C					
4D		93%			
4E					
4F1					
4F2					
4F3					
4F4					
4F5					
4G					

Table A 6.4.4: % Contribution to Overall Pollutant Emissions

	CH_4	N_2O	NOx	CO	NMVOC
4A1	24%				
4A2					
4A3	7%				
4A4	0%				
4A5					
4A6	0%				
4A7					
4A8	0%				
4A9					
4A10	0%				
4B1	4%				
4B2					
4B3	0%				
4B4	0%				
4B5					
4B6	0%				
4B7					
4B8	1%				
4B9	1%				
4B10					
4B11					
4B12		0%			
4B13		3%			
4B14		2%			
4D		68%			
4E					
4F1					
4F2					
4F3					
4F4					
4F5					
4G					
Overall	**38%**	**73%**	**0%**	**0%**	**0%**

A6.5 LAND USE, LAND USE CHANGE AND FORESTRY (5)

Figures A6.8 and **A6.9** show both net emissions of direct Greenhouse gases, and emissions of indirect Greenhouse gases for the land-use, land use change and forestry sector (sector 5) in the UK for the years 1990-2007.

Tables A6.5.1 and **A6.5.2** summarise the changes observed through the time series for each pollutant.

A6.5.1 Carbon Dioxide

Figure 6.8 shows net emissions/removals of carbon dioxide. In 1990, the UK was a net source of CO_2 from LULUCF activities. In 2007, the UK was a net sink, therefore showing a decrease in emissions of 159%.

A6.5.2 Methane

Emissions of methane from Land Use Change and Forestry are emitted from forestry, grassland and settlements categories (5A, 5C and 5E). Emissions from this sector have increased by 2% since 2006 (**Table A6.5.2**), and have increased overall by 84% since 1990 (**Table A6.5.1**).

A6.5.3 Nitrous Oxide

Emissions of nitrous oxide from Land Use Change and Forestry are emitted from forestry, grassland and settlements categories (5A, 5C and 5E). Emissions of nitrous oxide from this sector have decreased by 46% since 1990 (**Table A6.5.1**), and shown a decline of just 1% since 2005 (**Table A6.5.2**).

A6.5.4 Nitrogen Oxides

Emissions of nitrogen oxides from Land Use Change and Forestry are emitted from forestry, grassland and settlements categories (5A, 5C and 5E). Emissions from this sector have increased by 2% since 2006 (**Table A6.5.2**), and have increased overall by 84% since 1990 (**Table A6.5.1**).

A6.5.5 Carbon Monoxide

Emissions of carbon monoxide from Land Use Change and Forestry are emitted from forestry, grassland and settlements categories (5A, 5C and 5E), due to the burning of biomass.

Figure A6.8: UK net emissions/removals of Direct Greenhouse Gases from IPCC sector 5, 1990-2007

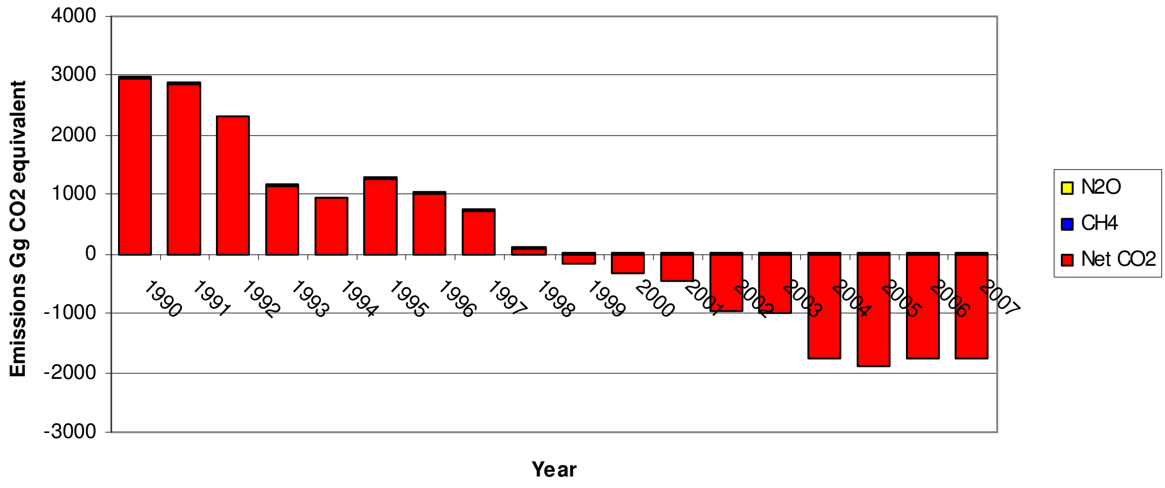

Figure A6.9: UK emissions of Indirect Greenhouse Gases from IPCC sector 5, 1990-2007

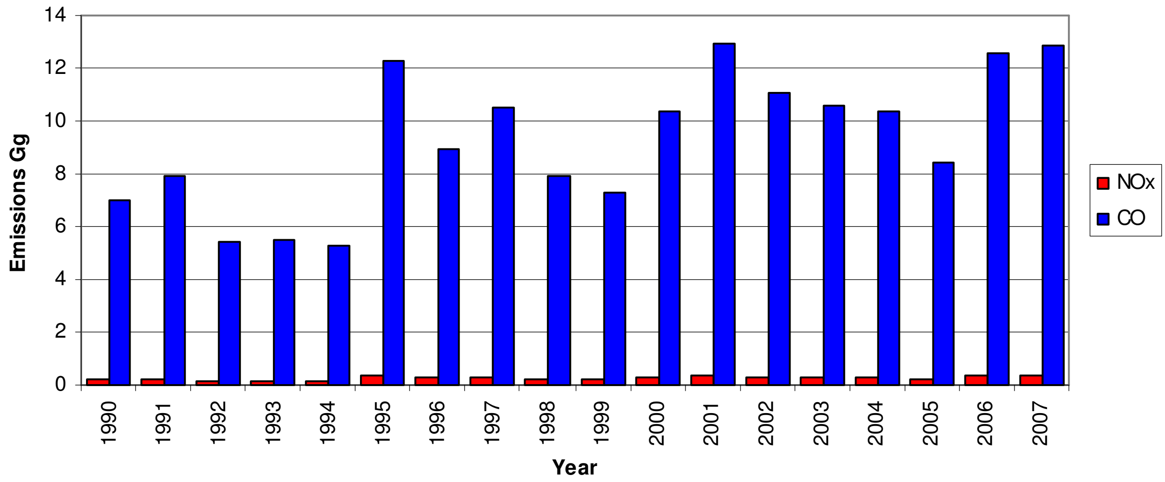

Table A 6.5.1: % Changes 1990-2007 within Sector 5

	CO_2	CH_4	N_2O	NOx	CO
5A	17%	255%	-59%	255%	255%
5B	-3%				
5C	30%	195%	195%	195%	195%
5D					
5E	-11%	-31%	-31%	-31%	-31%
5F					
5G	-26%				
Overall	**-159%**	**84%**	**-46%**	**84%**	**84%**

Table A 6.5.2: % Changes 2006-2007 within Sector 5

	CO_2	CH_4	N_2O	NOx	CO
5A	-6%	14%	4%	14%	14%
5B	0%				
5C	2%	-16%	-16%	-16%	-16%
5D					
5E	0%	7%	7%	7%	7%
5F					
5G	154%				
Overall	**0%**	**2%**	**-1%**	**2%**	**2%**

A6.6 WASTE (6)

Figures A6.10 and **A6.11** show emissions of both direct and indirect greenhouse gases from the waste category (sector 6) in the UK for the years 1990-2007. Emissions from direct greenhouse gases in this sector have declined by 57% since 1990. This is mostly as a result of a decline in methane emissions, although emissions of nitrous oxide have shown an increase.

Tables A6.6.1 to **A6.6.4** summarise the changes observed through the time series for each pollutant, as well as the contribution the emissions make to both sector 6 and the overall emissions in the UK during 2007.

A6.6.1 Carbon Dioxide

Emissions of carbon dioxide from the waste sector occur from waste incineration only. These emissions are small in comparison to CO_2 emissions from other sectors and have a negligible effect on overall net CO_2 emissions in the UK (see **Table A6.6.4**). Since 1990, CO_2 emissions arising from the waste sector have decreased by 61% (**Table A6.6.1**), and have shown a small decrease since 2006 (4%, **Table A6.6.2**).

A6.6.2 Methane

Emissions of methane from the waste sector accounted for around 43% (**Table A6.6.4**) of total CH_4 emissions in the UK during 2007. Emissions from methane occur from landfills, waste water treatment and waste incineration. The largest single source is landfill (6A1), with emissions from wastewater treatment and incineration being small in comparison (see **Table A6.6.3**). Emissions estimates from landfill are derived from the amount of putrescible waste disposed of to landfill and are based on a model of the kinetics of anaerobic digestion involving four classifications of landfill site. The model accounts for the effects of methane recovery, utilisation and flaring. Since 1990, methane emissions from landfill have declined by 59% (**Table 6.6.1**) due to the implementation of methane recovery systems. This trend is likely to continue as all new landfill sites are required to have these systems and many existing sites may have systems retrofitted.

A6.6.3 Nitrous Oxide

Nearly all nitrous oxide waste emissions in the UK occur from the wastewater handling sector (see **Table A6.6.3**). Since 1990, N_2O emissions from this sector have increased by 22% (**Table A6.6.1**). Overall, this sector contributes just 4% (**Table A6.6.4**) to overall nitrous oxide emissions.

A6.6.4 Nitrogen Oxides

Emissions of NO_x from the waste category have a negligible effect on overall UK emissions.

A6.6.5 Carbon Monoxide

Emissions of CO from the waste category have a negligible effect on overall UK emissions, contributing around 1% during 2007 (**Table A6.6.4**).

A6.6.6 Non-Methane Volatile Organic Compounds

Emissions of NMVOC from the waste category have a very small influence (2%, **Table A6.6.4**) on overall UK emissions.

A6.6.7 Sulphur Dioxide

Emissions of SO_2 from the waste category have a negligible effect on overall UK emissions.

Figure A6.10: UK emissions of Direct Greenhouse Gases from IPCC sector 6, 1990-2007

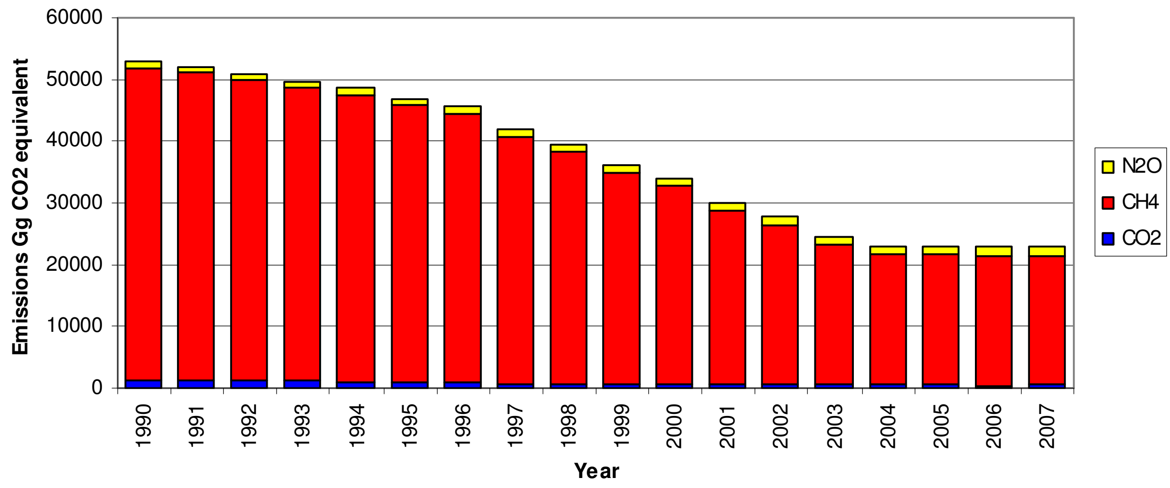

Figure A6.11: UK emissions of Indirect Greenhouse Gases from IPCC sector 6, 1990-2007

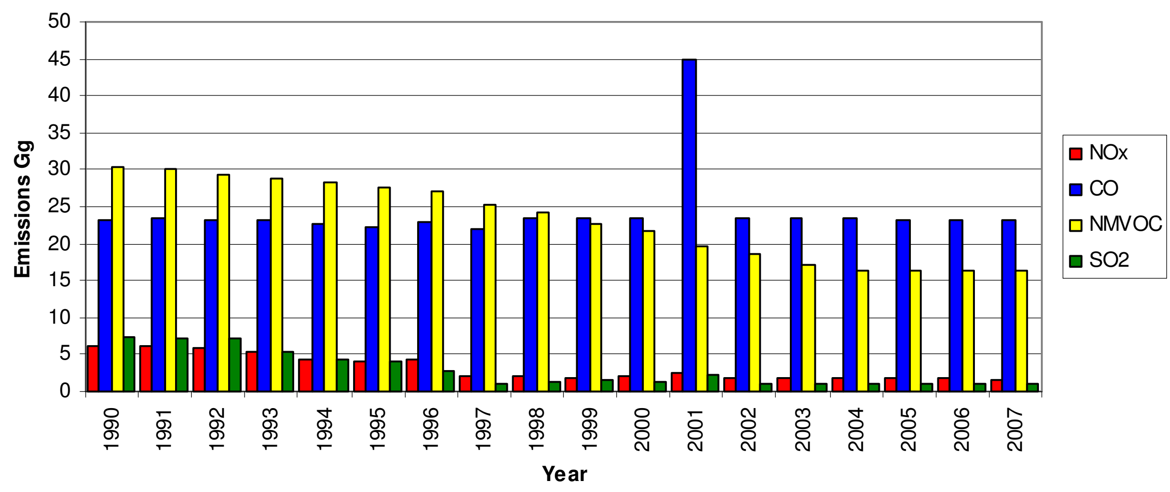

Table A 6.6.1: % Changes 1990-2007 within Sector 6

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
6A1		-59%				-59%	
6B2		15%	22%				
6C	-61%	-95%	2%	-73%	-1%	0%	-88%
Overall	**-61%**	**-58%**	**21%**	**-73%**	**-1%**	**-46%**	**-88%**

Table A 6.6.2: % Changes 2006-2007 within Sector 6

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
6A1		-0.2%				-0.2%	
6B2		0.3%	0.6%				
6C	4.1%	0.2%	0.0%	-2.5%	0.0%	-1.6%	0.8%
Overall	**4.1%**	**-0.2%**	**0.6%**	**-2.5%**	**0.0%**	**-0.8%**	**0.8%**

Table A 6.6.3: % Contribution to Sector 6

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
6A1		96%				59%	
6B2		4%	96%				
6C	100%	0%	4%	100%	100%	41%	100%

Table A 6.6.4: % Contribution to Overall Pollutant Emissions

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
6A1		41%				1%	
6B2		2%	4%				
6C	0%	0%	0%	0%	1%	1%	0%
Overall	**0.1%**	**43%**	**4%**	**0.1%**	**1%**	**2%**	**0.2%**

A7 ANNEX 7: Uncertainties

Uncertainty estimates are calculated using two methods: Approach 1 (error propagation) and Approach 2 (Monte Carlo simulation). Our use of the terminology Approach 1 and Approach 2 follows that defined in the IPCC's General Guidance and Reporting (IPCC, 2006).

The uncertainty assessment in this NIR continues a number of improvements that were introduced in the 2007 submission, including presenting estimates of uncertainties according to IPCC sector in addition to presenting estimates by direct greenhouse gas.

The Monte Carlo method was reviewed and revised in the 2007 NIR, taking into account guidance from the 2006 Guidelines (IPCC, 2006), a summary of recommendations from the EUMM Workshop on Uncertainties held in Finland in 2005, and from an internal review of the uncertainty work. In the 2008 NIR, there was also a major review of the correlations used in the Monte Carlo simulation, which included discussions with the LULUCF sector experts. The overall method is described below. The work to improve the accuracy of the uncertainty analysis continues.

A7.1 ESTIMATION OF UNCERTAINTY BY SIMULATION (APPROACH 2)

A7.1.1 Overview of the Method

Quantitative estimates of the uncertainties in the emissions were calculated using a Monte Carlo simulation. This corresponds to the IPCC Approach 2 method, discussed in the 2006 Guidelines (IPCC, 2006). The background to the implementation of the Monte Carlo simulation is described in detail by Eggleston *et al* (1998), with the estimates reported here revised to reflect changes in the latest inventory and improvements made in the model. This section gives a brief summary of the methodology, assumptions and results of the simulation.

The computational procedure is detailed below.

- A probability distribution function (PDF) was allocated to each unique emission factor and piece of activity data. The PDFs were mostly normal or log-normal. The parameters of the PDFs were set by analysing the available data on emission factors and activity data or by expert judgement;
- A calculation was set up to estimate the total emissions of each gas for the years 1990 and the latest reported year;
- Using the software tool @RISK™, each PDF was sampled 20,000 times and the emission calculations performed to produce a converged output distribution;
- It was assumed that the distribution of errors in the parameter values was normal. The quoted range of possible error of uncertainty is taken as 2s, where s is the standard deviation. If the expected value of a parameter is E and the standard deviation is s, then the uncertainty is quoted as 2s/E expressed as a percentage.

  For a normal distribution the probability of the parameter being less than E-2s is 0.025 and the probability of the emission being less than E+2s is 0.975.

- The uncertainties used for the fuel activity data were estimated from the statistical difference between the total supply and demand for each fuel. Data on the statistical difference between supply and demand for individual sectors are not available. This means that the quoted uncertainties in **Table A7.1.1** refer to the total fuel consumption rather than the consumption by a particular sector, e.g. coal consumed in the residential sector. Hence, to avoid underestimating uncertainties, it was necessary to correlate the uncertainties used for the same fuel in different sectors; and
- The uncertainty in the trend between 1990 and the latest reported year, according to gas, was also estimated.

A7.1.1.1 Uncertainty Distributions

Distributions

With the exception of one distribution, all of the distributions of emissions from sources in the inventory are now modelled used normal or log normal distributions.

Custom distributions

Emissions from landfill have been modelled using a custom distribution. Aitchson *et al.* (cited in Eggelston *et al.*, 1998) estimated the uncertainty for landfill emissions using Monte Carlo analysis and found it to be skewed. The distribution histogram was used to generate an empirical distribution of emissions. For this study we examined the distribution and fitted a log normal distribution to Aitchison's data. The emissions are scaled according to the mean estimate of landfill emissions for each year.

A7.1.1.2 Correlations

The Monte Carlo model contains a number of correlations. Omitting these correlations would lead to the uncertainties being underestimated. These correlations were not included in the very early versions of the Monte Carlo model used in the UK NIR, and were introduced over the years to improve the accuracy of the predicted uncertainties. The trend uncertainty in the Monte Carlo model is particularly sensitive to some correlations, for example, the correlation across years in emissions of N_2O from agricultural soils. Other correlations have only a minor influence.

The type and implementation of the correlations has been examined as part of a review (Abbott *et al.*, 2007). The sensitivity analysis that we have completed on the Monte Carlo model suggest that the uncertainties are not sensitive to the correlations between emission factors for fuel used, and for LULUCF sources.

A7.1.1.2.1 Across years

In running this simulation it was necessary to make assumptions about the degree of correlation between sources in 1990 and the latest reported year. If source emission factors are correlated this will have the effect of reducing the trend uncertainty.

The model has been designed to aggregate activities and emission factors where possible, and the correlations included are listed at the start of the sections presenting uncertainties according to gas.

The trend estimated by the Monte Carlo model is particularly sensitive to N_2O emissions from agricultural soils (lognormal, with the 97.5 percentile being 100 times the 2.5 percentile). Correlations are also included for N_2O emissions from sewage sludge, calculated from a lognormal distribution. The LULUCF correlations are discussed below. Other correlations are listed at the start of the sections presenting uncertainties according to gas.

A7.1.1.2.2 Between Sources in the same year

Where we have estimated the uncertainty on the activity data based on statistical difference produced by BERR in DUKES, it has been necessary to correlate the fuel use for all sources using the same fuel.

A7.1.2 Review of Recent Improvements to the Monte Carlo Model

Abbott *et al* (2007) completed an internal review was of the Monte Carlo uncertainty analysis used for the UK NIR. This review was commissioned following suggestions from an FCCC Expert Review Team about improvements that the UK could make to the transparency of the uncertainty analysis. The review evaluated the Monte Carlo model, and the documentation of the model, as presented in the 2005 NIR. The review was informed by the FCCC comments from the Third Centralised Review, from recommendations made at the EU workshop on uncertainties in Greenhouse Gas Inventories[8], and by the IPCC 2006 Guidelines. A range of changes were made to the model to simplify its structure and review and improve the correlations used.

A7.1.2.1 Method Changes

A number of changes have been introduced to the Monte Carlo model, and these are listed below.

A7.1.2.1.1 Change of Simulation Method

Following recommendations in the 2006 IPCC Guidelines, the model now uses a true Monte Carlo sampling method as opposed to the Latin Hypercube method used previously. The revision makes very little difference to the uncertainties estimated by the model.

A7.1.2.1.2 Treatment of Zero Emissions

The original Monte Carlo model contained a number of sources where the emissions were zero, but uncertainties were still allocated to the activity data and emission factors. These zero emissions existed for several reasons:

- Emissions occurred in 1990 but were absent in later years;
  - The activity had been banned (for example, burning of agricultural straw residues);
  - Emissions had been transferred to another sector (for example MSW emissions from waste to IPCC category 6C to 1A1a.); and
- Because data had been included in the analysis for completeness where either the emission factor or the activity data were zero thus leading to a zero emission.

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8 EU workshop on uncertainties in Greenhouse Gas Inventories Work 5-6 September, Helsinki, Finland. Ministry of the Environment, Finland. Arranged by the VTT Technical Research Centre of Finland (Jaakko Ojala, Sanna Luhtala and Suvi Monni).

The estimated uncertainties were unaffected when the ‘zero emissions’ were removed from the model.

A7.1.2.1.3 Aggregation

For the new Monte Carlo model, the detailed data from the GHG inventory was aggregated where appropriate in order to minimise the number of sources used in the calculation. Emissions were aggregated where possible for fuels (any emission arising from combustion), by activity data type e.g. coal, petrol, natural gas, and by emission factor. In doing so, the data are also being correlated as any uncertainty in the emission factor is then applied once, to all appropriate emissions, and the same is true of the activity data. Minimising the number of calculations performed in the Monte Carlo simulation ensures that the overall uncertainty is more accurately estimated by the model.

A7.1.2.2 F-gas uncertainties

Estimated emissions and projections of F-gases have recently been reviewed and updated (AEA, 2009). This work also included an update to the uncertainty analysis, which has been taken into account in the over all uncertainty analysis for the greenhouse gas inventory.

A7.1.2.3 Uncertainty Parameter Reviews

As part of the ongoing inventory improvement process many of the uncertainty distributions for our emission factors and activity data have been reviewed, with expert elicitation sought where appropriate. Further information is given in **Section A7.6.1**.

A7.1.3 Review of changes made to the Monte Carlo model since the last NIR

Only the uncertainty parameters for emissions of F-gases have been revised since the last NIR was published.

A7.1.4 Quality Control Checks on the Monte Carlo Model Output

A number of quality control checks are completed as part of the uncertainty analysis.

a) *Checks against totals of the national emissions*
To ensure the emissions in the Monte Carlo model closely agree with the reported totals in the NIR, the emissions in the model were checked against the national totals both before the simulation was run. The central estimates from the model are expected to be similar to the emissions totals, but are not expected to match completely.

b) *Inter-comparison between the output of the error propagation and Monte Carlo models*
We have introduced a new formal check to compare the output of the error propagation and Monte Carlo model. The results of this comparison are discussed in **Section A7.4**.

c) *Calculation of uncertainty on the total*
The uncertainty on the 1990 and the 2007 emissions was calculated using two different methods;

i) Using $.\frac{2s.d}{\mu}$

ii) Using $\frac{\frac{(97.5Percentile - 2.5Percentile)}{2}}{\mu}$

The first method uses the standard deviation calculated by @Risk and the mean to give an overall uncertainty, while the second method averages out the implied standard deviation(s) given by the percentiles quoted. When a distribution is completely normally distributed, the two methods will give the same results as the calculated standard deviation will be equal to the implied standard deviation. When a distribution is skewed however, the first method will give a much higher overall uncertainty than the second due to the inequality in the distribution. The overall uncertainty quoted in **Table A.7.3.1** is calculated using the first method in order that uncertainties should not be underestimated in sectors showing a skewed distribution such as agricultural soils and N_2O as a whole.

Calculating the uncertainty using both of these methods allows us to check that the Monte Carlo analysis is behaving in the way we would expect. Comparing the results using both calculations showed that the uncertainties were almost the same for gases where the distributions used were predominantly normal, but higher for N_2O and the GWP weighted total, as expected.

A7.2 UNCERTAINTIES ACCORDING TO GAS

The following for sections present the uncertainties in emissions, and the trend in emissions according to gas. The F-gases are grouped into one section.

A7.2.1 Carbon Dioxide Emission Uncertainties

A7.2.1.1 General Considerations

The uncertainties in the activity data for major fuels were estimated from the statistical differences data in the UK energy statistics. This is explained further in **Section A7.6.1**. These are effectively the residuals when a mass balance is performed on the production, imports, exports and consumption of fuels. For solid and liquid fuels both positive and negative results are obtained indicating that these are uncertainties rather than losses. For gaseous fuels these figures include losses and tended to be negative. The uncertainties in activity data for minor fuels (colliery methane, orimulsion, SSF, petroleum coke) and non-fuels (limestone, dolomite and clinker) were estimated based on judgement comparing their relative uncertainty with that of the known fuels. The high uncertainty in the aviation fuel consumption reflects the uncertainty in the split between domestic and international aviation fuel consumption. DECC indicate the total consumption of aviation fuel is accurately known. This uncertainty was reviewed in 2005. Additional uncertainty for this source is also introduced by the use of a model to estimate emissions.

The uncertainties in carbon emission factors (CEFs) for natural gas, coal used in power stations, and selected liquid fuels were derived from the Carbon Factor Review (see **Section A 7.6.1** for further details). The uncertainties in other factors are based on expert judgement.

In the case of non-fuel sources, the uncertainty depended on the purity of limestone or the lime content of clinker so the uncertainties estimated were speculative.

The uncertainties in certain sources were estimated directly. Offshore flaring uncertainties were estimated by comparing the UKOOA flaring time series data with the flaring volumes reported by DTI (2001). The uncertainty in the activity data was found to be around 16%. This uncertainty will be an over estimate since it was assumed that the flaring volume data reported by DTI should be in a fixed proportion to the mass data reported by UKOOA. The uncertainty in the carbon emission factor was estimated by the variation in the time series to be around 6%. Again this will be an over estimate since it was assumed that the carbon emission factor is constant. Uncertainties for fuel gas combustion were estimated in a similar way. Uncertainties in the land use change sources were ascribed to each sector by Milne (pers. comm., 2006). The uncertainty for Fletton bricks and peat combustion is based on expert assessment of the data used to make the estimate. The uncertainty used for cement production is based on the estimates reported in IPCC (2000). Clinical waste incineration was assumed to have the same uncertainty as MSW incineration.

A7.2.1.2 Uncertainty Parameters

Two tables are provided in this section – a table of uncertainties in the activity data and emission factors for the major fuels used to estimate emissions of carbon dioxide, and a table of the same parameters for “non-fuels”. These non-fuels relate to emissions from a range of sources, including the following:

- The release of carbon from the breakdown of pesticides and detergents; and
- Use of natural gas for the production of ammonia.

In some cases the individual uncertainties for the activity data and the emission factor are unknown, but the uncertainty on the total emission is known. In these cases, the uncertainties are listed in the column marked “uncertainty in emission”.

Table A 7.2.1: Uncertainties in the activity data and emission factors for fuels used in the carbon dioxide inventory

	1990			2007		
Fuel	Activity uncertainty (%)	Emission factor uncertainty (%)	Uncertainty in emission (%)	Activity uncertainty (%)	Emission factor uncertainty (%)	Uncertainty in emission (%)
Anthracite	1.5	6	‡	0.2	6	‡
Aviation spirit	20	3.3	‡	20	3.3	‡
Aviation turbine fuel	20	3.3	‡	20	3.3	‡
Blast furnace gas	1.5	6	‡	0.2	6	‡
Burning oil	6	2	‡	1.9	2	‡
Chemical waste	7	15	‡	7	15	‡
Clinical waste	7	20	‡	7	20	‡
Clinker production	1	2.2		1	2.2	‡
Coal	1.5	1	‡	0.2	1	‡
Coke	3	3	‡	0.5	3	‡
Coke oven gas	1.5	6	‡	0.2	6	‡
Colliery methane	5	5	‡	5	5	‡
DERV	1.8	2.1	‡	0.6	2.1	‡
Dolomite	1	5	‡	1	5	‡
Exploration drilling	1	28		1	28	
Energy recovery - chemical industry	-	-	20	-	-	20
Fuel oil	5.5	1.7	‡	12.3	1.7	‡
Fletton bricks	20	70		20	70	
Gas oil	1.8	1.4	‡	0.6	1.4	‡
Limestone	1	5	‡	1	5	‡
LPG	25.7	3	‡	4.9	3	‡
Lubricants	20	5	‡	20	5	‡
MSW	7	20	‡	7	20	‡
Naphtha	7.3	3	‡	not used	not used	‡
Natural gas	2.8	1.5	‡	0.4	1.5	‡
OPG	1.4	3	‡	1.3	3	‡
Orimulsion	1	2	‡	not used	not used	‡
Peat	25	25	‡	25	25	‡
Petrol	1	4.8	‡	1.4	4.8	‡
Petroleum coke	7.8	3	‡	0.8	3	‡
Petroleum waxes	-	-	20	-	-	20
Refinery miscellaneous	11.9	3	‡	not used	not used	‡
Soda ash	15	2		15	2	
Scrap tyres	15	10	‡	15	10	‡
Sour gas	not used	not used	‡	0.2	1	‡
SSF	3.3	3	‡	5.6	3	‡
Waste	not used	not used		1	50	
Waste oils	20	5	‡	20	5	‡
Waste solvent	not used	not used	‡	1	10	‡

Notes
1. Uncertainties expressed as 2s/E
2. ‡ input parameters were uncertainties of activity data and emission factors

Not used = Fuel not used

Table A 7.2.2: Uncertainties in the activity data and emission factors for "non-fuels" used in the carbon dioxide inventory

		1990			2007		
Sector	Sources	Activity uncertainty (%)	Emission factor uncertainty (%)	Uncertainty in emission (%)	Activity uncertainty (%)	Emission factor uncertainty (%)	Uncertainty in emission (%)
1B2a	Offshore oil and gas - processes	-	-	28	-	-	28
1B2c_Flaring	Offshore oil and gas - flaring	16	6	‡	16	6	‡
1B2c_Venting	Offshore oil and gas - venting	16	6	‡	16	6	‡
5A	5A2 Forest Land - biomass burning; 5A2 Land converted to forest land	-	-	25	-	-	25
2B1	Ammonia production - feedstock use of gas	0.4	1.5		0.4	1.5	
5B	5B1 Cropland – Liming; 5B1 Cropland remaining cropland; 5B2 Land converted to cropland	-	-	45	-	-	50
5C	5C Grassland - biomass burning; 5C1 Grassland – liming; 5C1 Grassland remaining grassland; 5C2 Land converted to grassland	-	-	70	-	-	55
5E	5E Settlements - biomass burning; 5E2 Land converted to settlements	-	-	35	-	-	50
5G	5G Harvested Wood Products; 5G LULUCF emissions from OTs and CDs	-	-	30	-	-	30
	Carbon in detergents	-	-	20	-	-	20
	Carbon in pesticides	-	-	20	-	-	20
	Gypsum produced	none produced	none produced	-	1	5	‡
	Primary aluminium production	1	5	‡	1	5	‡
	Steel production (electric arc and oxygen converters)	1	20	‡	1	20	‡

Notes

1. Uncertainties expressed as 2s/E

‡ input parameters were uncertainties of activity data and emission factors

A7.2.1.3 Uncertainty in the Emissions

The overall uncertainty was estimated as around **2% in 2007**.

The central estimate of total CO_2 emissions in 2007 was estimated as 544,657 Gg. The Monte Carlo analysis suggested that 95% of the values were between 535,814 Gg and 553,499 Gg.

A7.2.1.4 Uncertainty in the Trend

The uncertainty in the trend between 1990 and 2007 was estimated. In running this simulation it was necessary to make assumptions about the degree of correlation between sources in 1990 and 2007. If source emission factors are correlated this will have the effect of reducing the trend uncertainty. The assumptions were as follows:

- Activity data are uncorrelated;
- Emission factors of some similar fuels are correlated;
- Land Use Change and forestry emissions are correlated (i.e. 5A with 5A etc);
- Offshore emissions are not correlated since they are based on separate studies using emission factors appropriate for the time;
- Emission factors covered by the Carbon Factors Review (Baggott *et al*, 2004) are not correlated; and
- Process emissions from blast furnaces, coke ovens and ammonia plant were not correlated.

This analysis indicates that there is a 95% probability that CO_2 emissions in 2007 were between **6% and 10%** below the level in 1990.

A7.2.2 Methane Emission Uncertainties

A7.2.2.1 General Considerations

In the methane inventory, combustion sources are a minor source of emissions. The uncertainties on the quantities of fuel burnt are known, although the effect of the large uncertainty associated with the emission factors will dominate the overall uncertainty on the emissions. The uncertainties are listed in **Table A7.2.3**. The uncertainty on the activities for the fuels burnt are not pollutant specific, and are reported in **Table A7.2.1**.

A7.2.2.2 Uncertainty Parameters

Table A 7.2.3: Estimated uncertainties in the activity data and emission factors used in the methane inventory

		1990			2007		
Source	Reference	Activity %	Emission Factor %	Source Uncertainty %	Activity %	Emission Factor %	Source Uncertainty %
Coal			50	‡		50	‡
Coke			50	‡		50	‡
Petroleum coke			50	‡		50	‡
SSF			50	‡		50	‡
Burning oil			50	‡		50	‡
Fuel oil			50	‡		50	‡
Gas oil			50	‡		50	‡
DERV			50	‡		50	‡
Petrol			50	‡		50	‡
Orimulsion			50	‡		50	‡
Aviation turbine fuel			50	‡		50	‡
Natural gas			50	‡		50	‡
Colliery methane			50	‡		50	‡
LPG			50	‡		50	‡
OPG			50	‡		50	‡
MSW			50	‡		50	‡
Sour gas			50	‡		50	‡
Naphtha			50	‡		50	‡
Refinery miscellaneous			50	‡		50	‡
Blast furnace gas			50	‡		50	‡
Coke oven gas			50	‡		50	‡
Town gas			50	‡		50	‡
Lubricants			50	‡		50	‡
Waste oils			50	‡		50	‡
Scrap tyres			50	‡		50	‡
Aviation spirit			50	‡		50	‡

		1990			2007		
Source	Reference	Activity %	Emission Factor %	Source Uncertainty %	Activity %	Emission Factor %	Source Uncertainty %
Anthracite			50	‡		50	‡
Burning oil (premium)			50	‡		50	‡
Vaporising oil			50	‡		50	‡
Clinical waste			50	‡		50	‡
Poultry litter			50	‡		50	‡
Landfill gas			50	‡		50	‡
Sewage gas			50	‡		50	‡
Wood			50	‡		50	‡
Straw			50	‡		50	‡
Sewage sludge combustion			50	‡		50	‡
Field burning	*	25	50	‡	25	50	‡
Landfill	Brown *et al* 1999	-	-	~48[1]	-	-	~48[1]
Livestock: enteric	Williams, 1993	-	-	20	-	-	20
Livestock: wastes	Williams, 1993	-	-	30.5	-	-	30.5
Coal Mining	Bennett *et al*, 1995	-	-	13.3	-	-	13.3
Offshore	*	16	20	‡	16	20	‡
Gas Leakage	Williams, 1993	-	-	17-75[2]	-	-	17-75[2]
Chemical industry	*	20	20	‡	20	20	‡
Fletton bricks	*	20	100	‡	20	100	‡
Sewage sludge	Hobson *et al*, 1996	-	-	50	-	-	50

Notes

1 Skewed distribution
2 Various uncertainties for different types of main and service
* See text
‡ Input parameters were uncertainties of activity data and emission factors
Fuel combustion uncertainties expressed as 2s/E
Uncertainties in the activity data for fuels burnt are reported in **Table A7.2.1**.

The non fuel combustion sources are mainly derived from the source documents for the estimates or from the Watt Committee Report (Williams, 1993). The uncertainty in offshore emissions was revised for the 2000 inventory using improved estimates of the activity data. The methane factors were assumed to have an uncertainty of 20% since the flaring factors are based on test measurements.

The sources quoted in **Table A7.2.3** are assumed to have normal distributions of uncertainties with the exception of landfills. Brown *et al.* (1999) estimated the uncertainty distribution for landfill emissions using Monte Carlo analysis and found it to be skewed. For normal distributions there is always a probability of negative values of the emission factors arising. For narrow distributions this probability is negligible; however with wide distributions the probability may be significant. In the original work (Eggleston *et al,* 1998) this problem was avoided by using truncated distributions. However, it was found that this refinement made very little difference to the final estimates. In these estimates a lognormal distribution was used rather than truncated normal distributions.

A7.2.2.3 Uncertainty in the Emissions

The overall uncertainty was estimated as around **23% in 2007**.

The central estimate of total CH_4 emissions in 2007 was estimated as 49,015 Gg CO_2 equivalent. The Monte Carlo analysis suggested that 95% of the values were between 40,987 and 59,417 Gg CO_2 equivalent.

A7.2.2.4 Uncertainty in the Trend

The uncertainty in the trend between 1990 and 2007 was estimated. In running this simulation it was necessary to make assumptions about the degree of correlation between sources in 1990 and 2007. If source emission factors are correlated this will have the effect of reducing uncertainty in the emissions trend. The assumptions were:

- Activity data are uncorrelated between years, but activity data for major fuels were correlated in the same year in a similar manner to that described above for carbon;
- Landfill emissions were partly correlated across years in the simulation. It is likely that the emission factors used in the model will be correlated, and also the historical estimates of waste arisings will be correlated since they are estimated by extrapolation from the year of the study. However, the reduction in emissions is due to flaring and utilisation systems installed since 1990 and this is unlikely to be correlated. As a simple estimate it was assumed that the degree of correlation should reflect the reduction. Emissions have reduced by 59% hence the degree of correlation was 31%;
- Offshore emissions are not correlated across years since they are based on separate studies using emission factors that reflected the processes in use at the time;
- Gas leakage emissions were partially correlated across years. As a simple estimate it was assumed that the degree of correlation should reflect the reduction in emissions. Emissions have reduced by 45% hence the degree of correlation was 55%; and
- Emissions from deep mines were not correlated across years as they were based on different studies, and a different selection of mines. Open cast and coal storage and transport were correlated since they are based on default emission factors.

This analysis indicates that there is 95% probability that methane emissions in 2007 were between **50% and 56%** below the level in 1990.

A7.2.3 Nitrous Oxide Emission Uncertainties

A7.2.3.1 General Considerations

The analysis of the uncertainties in the nitrous oxide emissions is particularly difficult because emissions sources are diverse, and few data are available to form an assessment of the uncertainties in each source. Emission factor data for the combustion sources are scarce and for some fuels are not available. The parameter uncertainties are shown in **Table A7.2.4**. The uncertainty for the fuels burnt are not pollutant specific and are reported in **Table A7.2.1**. The uncertainty assumed for agricultural soils uses a lognormal distribution since the range of possible values is so high. Here it is assumed that the 97.5 percentile is greater by a factor of 100 than the 2.5 percentile based on advice from the Land Management Improvement Division of DEFRA (pers. comm.).

A7.2.3.2 Uncertainty Parameters

Listed in table overleaf.

Table A 7.2.4: Estimated uncertainties in the activity data and emission factors used in the N_2O inventory

	1990			2007		
Source	Activity %	Emission Factor %	Source Uncertainty %	Activity %	Emission Factor %	Source Uncertainty %
Coke		195	‡		195	‡
Petroleum coke		118	‡		118	‡
SSF		118	‡		118	‡
Burning oil		118	‡		118	‡
Fuel oil		140	‡		140	‡
Gas oil		140	‡		140	‡
DERV		140	‡		140	‡
Petrol		170	‡		170	‡
Orimulsion		170	‡		170	‡
Aviation turbine fuel		140	‡		140	‡
Natural gas		170	‡		170	‡
Colliery methane		110	‡		110	‡
LPG		110	‡		110	‡
OPG		110	‡		110	‡
MSW		110	‡		110	‡
Sour gas		230	‡		230	‡
Naphtha		110	‡		110	‡
Refinery miscellaneous		140	‡		140	‡
Blast furnace gas		140	‡		140	‡
Coke oven gas		118	‡		118	‡
Town gas		118	‡		118	‡
Lubricants		118	‡		118	‡
Waste oils		140	‡		140	‡
Scrap tyres		140	‡		140	‡
Aviation spirit		140	‡		140	‡
Anthracite		170	‡		170	‡
Burning oil (premium)		387	‡		387	‡
Vaporising oil		140	‡		140	‡
Limestone		140	‡		140	‡
Clinical waste		230	‡		230	‡
Poultry litter		230	‡		230	‡
Landfill gas		230	‡		230	‡
Sewage gas		110	‡		110	‡
Wood		110	‡		110	‡
Straw		230	‡		230	‡
Sewage sludge combustion		230	‡		230	‡
Agricultural soils			Log-normal[2]			Log-normal[2]
Wastewater treatment			Log-normal[2]			Log-normal[2]
Adipic Acid	0.5	15		0.5	15	
Nitric Acid	10	230		10	230	

Notes

1 Expressed as 2s/E

2 With 97.5 percentile 100 times the 2.5 percentile and the mean the distribution factor equal to 1. The logarithm for the variable is normally distributed with standard deviation,σ, equal to ln (100)/(2 x 1.96) and mean equal to $(-\sigma^2)/2$.

3 Uncertainties in the activity data for fuels burnt are reported in **Table A7.2.1**.

‡ Input parameters were uncertainties of activity data and emission factors

A7.2.3.3 Uncertainty in the Emissions

The overall uncertainty was estimated as around 271% in 2007.

The central estimate of total N_2O emissions in 2007 was estimated as 34,898 Gg CO_2 equivalent. The Monte Carlo analysis suggested that 95% of the values were between 10,372 and 97,083 Gg CO_2 equivalent.

A7.2.3.4 Uncertainty in the Trend

The uncertainty in the trend between 1990 and 2007 was also estimated. In running this simulation it was necessary to make assumptions about the degree of correlation between sources in 1990 and 2007. If sources are correlated this will have the effect of reducing the emissions. The assumptions were as follows:

- Activity data are uncorrelated between years, but similar fuels are correlated in the same year;
- Emissions from agricultural soils were correlated;
- The emission factor used for sewage treatment was assumed to be correlated, though the protein consumption data used as activity data were assumed not to be correlated;
- Nitric acid production emission factors were assumed not to be correlated, since the mix of operating plant is very different in 2007 compared with 1990 – only 4 of the original 8 sites are still operating, 2 of which now have differing levels of abatement fitted; and
- Adipic acid emissions were assumed not to be correlated because of the large reduction in emissions due to the installation of abatement plant in 1998.

This analysis indicates that there is a 95% probability that N_2O emissions in 2007 were between **32% and 71%** below the level in 1990.

A7.2.4 Halocarbons and SF_6

A7.2.4.1 Uncertainty Parameters

The uncertainties in the emissions of HFCs, PFCs and SF_6 have been updated in this year's NIR, based on the recent study to update emissions and projections of F-gases (AEA, 2008). The previous estimates had been taken from AEAT (2004), but had not been consistently updated to reflect the estimated uncertainty in the emissions estimates for the latest reported year. The spreadsheet model has been modified to ensure that the uncertainty estimates for these gases are consistent with the correct year from the latest F-gas study.

A7.2.4.2 Uncertainty in the Emissions

The uncertainties were estimated as

1990 (1995)

- 15%(14%) for HFCs,
- 6%(7%) for PFCs
- 17%(17%) for SF_6

2007
- 22% for HFCs
- 24% for PFCs
- 15% for SF_6

A7.2.4.3 Uncertainty in the Trend

This analysis indicates that there is a 95% probability that emissions in 2007 differed from those in 1990 by the following percentages

- -33% to +4% for HFCs
- -88% to -82% for PFCs
- -36% to -7% for SF_6

A7.3 UNCERTAINTIES IN GWP WEIGHTED EMISSIONS

A7.3.1 Uncertainty in the Emissions

The uncertainty in the combined GWP weighted emission of all the greenhouse gases was estimated as **15%** in both 1990 and 2007.

A7.3.2 Uncertainty in the Trend

This analysis indicates that there is a 95% probability that the total GWP GHG emissions in 2006 were between 16% and 20% below the level in 1990.

The uncertainty estimates for all gases are summarised in **Table A7.3.1**. The source which makes the major contribution to the overall uncertainty is 4D Agricultural Soils. This source shows little change over the years, but other sources have fallen since 1990.

In previous years, trend uncertainties from the base year to the current inventory year have also been reported here. The base year in these calculations was not the true base year as it did not included the emissions/removals in the elected LULUCF articles under the Kyoto Protocol. This table has not been included this year. Base year emissions can be found in **Table ES5**.

Table A 7.3.1: Summary of Monte Carlo Uncertainty Estimates 1990 - 2007

Gas	1990 Emissions	2007 Emissions	Uncertainty in 1990 emissions as % of emissions in category		Uncertainty introduced on national total in 1990	Uncertainty in 2007 emissions as % of emissions in category		Uncertainty introduced on national total in 2007	% change in emissions between 2007 and 1990	Range of likely % change between 2007 and 1990	
			2.5 percentile	97.5 percentile		2.5 percentile	97.5 percentile			2.5 percentile	97.5 percentile
	Gg CO_2e	Gg CO_2e	Gg CO_2e	Gg CO_2e	%	Gg CO_2e	Gg CO_2e	%	%	%	%
CO_2 (net)	594,192	544,657	584,627	603,603	2.0%	535,814	553,499	2.0%	-8%	-10.4%	-6.2%
CH_4	104,569	49,015	85,440	129,685	26%	40,987	59,417	23%	-53%	-56%	-50%
N_2O	64,949	34,898	32,856	146,077	179%	10,372	97,083	271%	-53%	-71%	-32%
HFC	11,390	9,614	9,992	12,790	15%	7,897	11,317	22%	-15%	-33%	4%
PFC	1,402	216	1,346	1,457	5%	174	257	24%	-85%	-88%	-82%
SF_6	1,030	794	887	1,173	17%	692	894	15%	-22%	-36%	-7%
All	777,532	639,194	733,190	861,317	15%	608,565	702,239	15.0%	-18%	-20.0%	-15.6%

Notes
Uncertainty calculated as 2s/E where s is the standard deviation and E is the mean, calculated in the simulation.
N_2O quoted but distribution is highly skewed and uncertainty quoted exceeds 100%.
Emissions of CO_2 are net emissions (i.e. sum of emissions and removals).

Important - Emissions in this table are taken from the Monte Carlo model output. The central estimates, according to gas, for 1990 and the latest inventory year are very similar but not identical to the emission estimates in the inventory. The Executive Summary of this NIR and the accompanying CRF tables present the agreed national GHG emissions reported to the UNFCCC.

A7.4 COMPARISON OF UNCERTAINTIES FROM THE ERROR PROPAGATION AND MONTE CARLO ANALYSES

Comparing the results of the error propagation approach, and the Monte Carlo estimation of uncertainty by simulation, is a useful quality control check on the behaviour of the Monte Carlo model.

The reason that the error propagation approach is used as a reference is because the mathematical approach to the error propagation approach has been defined and checked by the IPCC, and is clearly set out in the IPCC 2000 Good Practice Guidance and the 2006 Guidelines. The UK has implemented the IPCC error propagation approach as set out in this guidance. The implementation of an uncertainty estimation by simulation cannot be prescriptive, and will depend on the Monte Carlo software a country chooses to use, how the country constructs its model, and the correlations included within that model. Therefore, there is a greater likelihood of errors being introduced in the model used to estimate uncertainty by simulation.

If all the distributions in the Monte Carlo model were normal, and there were no correlations between sources, the estimated errors on the trend from the Monte Carlo model should be identical to those estimated by the error propagation approach. In reality there will be correlations between sources, and some distributions are not normal and are heavily skewed.

Table A7.4.1 shows that the estimates of uncertainty on the trend provided by the two methods are almost identical, and this provides confidence in our implementation of the Monte Carlo model. The error propagation approach does not account for correlations, and so we might expect the trend uncertainty estimated by this method to be greater than that reported by the Monte Carlo model. The assumption of equivalence between the two methods relies on the fact that the distributions of individual uncertainties in the activity data and emissions factors in the two approaches are both normal. However, there are a number of log-normal distributions in the Monte Carlo model and the effects of these cannot be fully reproduced in the error propagation model. These log-normal distributions will have the effect of increasing the uncertainty on the trend as the distributions are more skewed.

The central estimates of emissions generated by the Monte Carlo model in 1990, and those in the latest inventory year, are also very close. Mathematically we would not expect the central estimates from the two methods to be identical.

Table A 7.4.1: Comparison of the central estimates and trends in emissions from the error propagation (Approach 1) and Monte Carlo (Approach 2) uncertainty analyses

Method of uncertainty estimation	Central estimate ($Gg\ CO_2$ equivalent) [b]		Uncertainty on trend, 95% CI (1990 to 2007)
	1990	2007	
Error propagation	776,892	638,211	4.9
Monte Carlo	777,532	639,194	4.4 [a]

Notes
CI Confidence Interval
[a] 2.5th percentile, -20%, 97.5th percentile, -15.6%. Difference between these values is the 95th percentile which assuming a normal distribution is equal to ±2 standard deviations on the central estimate.
[b] Net emissions, including emissions and removals from LULUCF

A7.5 SECTORAL UNCERTAINTIES

A7.5.1 Overview of the Method

Sectoral uncertainties were calculated from the same base data used for the "by gas" analysis. The emissions and uncertainties per sector are presented in **Table A7.5.1**. We recommend that the estimates in the table are taken only as indicative.

A7.5.2 Review of Changes made to the Monte Carlo Model since the last NIR

The estimates of uncertainty for F-gas emissions have been updated based on AEA (2008).

Table A 7.5.1: Sectoral Uncertainty Estimates

IPCC Source Category	Gas	1990 Emissions	2007 Emissions	Uncertainty in 2007 emissions as % of emissions in category		Uncertainty Introduced on national total in 2007	% change in emissions between 1990 and 2007	Range of likely % change between 1990 and 2007	
				2.5 percentile	97.5 percentile			2.5 percentile	97.5 percentile
1A1a	GWP weighted total	206,929	179,440	177,949	181,071	1%	-13%	-15%	-12%
1A1b	GWP weighted total	18,388	15,120	14,689	15,547	3%	-18%	-21%	-15%
1A1c	GWP weighted total	14,102	17,821	17,564	18,113	2%	26%	23%	30%
1A2a	GWP weighted total	24,453	18,999	18,302	19,693	4%	-22%	-26%	-18%
1A2f	GWP weighted total	76,536	61,941	61,111	62,971	2%	-19%	-21%	-17%
1A3a	GWP weighted total	1,261	2,164	1,820	2,512	19%	73%	37%	114%
1A3b	GWP weighted total	111,752	123,418	120,820	126,011	3%	10%	7%	14%
1A3c	GWP weighted total	1,881	2,482	2,333	2,707	10%	32%	18%	47%
1A3d	GWP weighted total	4,145	4,970	4,775	5,163	5%	20%	15%	25%
1A3e	GWP weighted total	303	518	484	569	11%	71%	52%	92%
1A4a	GWP weighted total	25,703	20,744	20,492	20,997	1%	-19%	-21%	-18%
1A4b	GWP weighted total	80,473	76,887	76,027	77,753	1%	-4%	-7%	-2%
1A4c	GWP weighted total	5,740	4,614	4,355	5,015	9%	-19%	-27%	-11%
1A5b	GWP weighted total	5,341	3,525	3,056	3,996	16%	-34%	-45%	-21%
1B1a	GWP weighted total	18,270	2,641	2,451	2,829	9%	-85%	-87%	-84%
1B1b	GWP weighted total	878	149	144	153	4%	-83%	-84%	-82%
1B2a	GWP weighted total	2,784	1,050	872	1,231	21%	-62%	-70%	-53%
1B2b	GWP weighted total	7,955	4,371	4,350	4,391	1%	-45%	-45%	-45%
1B2c_Flaring	GWP weighted total	4,485	4,608	4,016	5,214	16%	3%	-14%	23%
1B2c_Venting	GWP weighted total	884	549	436	667	26%	-37%	-54%	-16%
2A1	GWP weighted total	7,295	6,117	5,997	6,240	2%	-16%	-18%	-14%
2A2	GWP weighted total	1,191	688	659	717	5%	-42%	-46%	-39%
2A3	GWP weighted total	1,285	1,443	1,407	1,479	3%	12%	8%	17%
2A4	GWP weighted total	167	238	208	267	15%	43%	19%	70%

IPCC Source Category	Gas	1990 Emissions	2007 Emissions	Uncertainty in 2007 emissions as % of emissions in category		Uncertainty Introduced on national total in 2007	% change in emissions between 1990 and 2007	Range of likely % change between 1990 and 2007	
				2.5 percentile	97.5 percentile			2.5 percentile	97.5 percentile
2A7	GWP weighted total	203	200	125	299	53%	5%	-47%	79%
2B1	GWP weighted total	1,322	1,209	1,193	1,224	2%	-9%	-11%	-6%
2B2	GWP weighted total	3,899	1,746	548	3,904	130%	-35%	-89%	80%
2B3	GWP weighted total	20,733	989	867	1,111	15%	-95%	-96%	-94%
2B5	GWP weighted total	1,733	1,936	1,690	2,187	16%	12%	-6%	32%
2C1	GWP weighted total	1,886	2,125	2,022	2,228	6%	13%	5%	21%
2C3	GWP weighted total	1,783	643	616	670	5%	-64%	-66%	-62%
2E1	GWP weighted total	11,378	176	160	191	11%	-98%	-99%	-98%
2E2	GWP weighted total	11	55	48	61	15%	404%	321%	498%
2F1	GWP weighted total	0	5,628	3,962	7,252	36%	4498709%	2535740%	7495327%
2F2	GWP weighted total	0	410	308	513	30%	NA	NA	NA
2F3	GWP weighted total	0	198	165	230	20%	NA	NA	NA
2F4	GWP weighted total	12	3,013	2,590	3,442	17%	25606%	20655%	31306%
2F5	GWP weighted total	0	70	56	85	25%	NA	NA	NA
2F8	GWP weighted total	662	842	732	948	16%	28%	NA	NA
4A1	GWP weighted total	13,545	11,794	9,848	13,732	20%	-12%	-31%	10%
4A10	GWP weighted total	9	6	5	7	20%	-34%	-48%	-17%
4A3	GWP weighted total	4,503	3,464	2,906	4,030	20%	-22%	-39%	-3%
4A4	GWP weighted total	12	10	8	12	20%	-15%	-33%	7%
4A6	GWP weighted total	77	145	121	169	20%	90%	49%	137%
4A8	GWP weighted total	238	152	127	177	20%	-35%	-49%	-19%
4B1	GWP weighted total	2,127	1,792	1,343	2,244	31%	-14%	-41%	21%
4B3	GWP weighted total	109	83	63	105	31%	-21%	-47%	11%
4B4	GWP weighted total	0	0	0	0	30%	-10%	-39%	25%
4B6	GWP weighted total	6	11	8	14	30%	92%	30%	170%
4B8	GWP weighted total	1,118	717	538	897	30%	-34%	-56%	-8%

IPCC Source Category	Gas	1990 Emissions	2007 Emissions	Uncertainty in 2007 emissions as % of emissions in category		Uncertainty Introduced on national total in 2007	% change in emissions between 1990 and 2007	Range of likely % change between 1990 and 2007	
				2.5 percentile	97.5 percentile			2.5 percentile	97.5 percentile
4B9	GWP weighted total	224	269	201	337	31%	23%	-17%	73%
4B9a	GWP weighted total	0	0	0	0	30%	-33%	-54%	-6%
Agriculture - N2O	GWP weighted total	32,966	25,620	1,817	88,096	369%	-24%	-25%	-22%
5A	GWP weighted total	-12,126	-14,166	-17,100	-11,261	-25%	19%	-13%	57%
5B	GWP weighted total	15,811	15,311	8,928	21,620	50%	3%	-48%	72%
5C	GWP weighted total	-6,134	-7,939	-11,131	-5,395	-45%	39%	-26%	132%
5E	GWP weighted total	7,083	6,343	3,722	8,972	50%	-7%	-50%	46%
5G	GWP weighted total	-1,658	-1,234	-1,537	-932	-30%	-24%	-48%	7%
6A1	GWP weighted total	49,904	20,307	12,607	30,442	54%	-59%	-59%	-59%
6B2	GWP weighted total	1,725	2,061	781	5,171	203%	69%	-69%	365%
6C	GWP weighted total	1,389	520	458	593	16%	-62%	-68%	-56%
Grand Total	GWP weighted total	777,520	639,151	608,555	702,731	15%	-18%	-20%	-16%

Important - Emissions in this table are taken from the Monte Carlo model output. The central estimates, according to gas, for 1990 and the latest inventory year are very similar but not identical to the emission estimates in the inventory. The Executive Summary of this NIR and the accompanying CRF tables present the agreed national GHG emissions reported to the UNFCCC.

A7.6 ESTIMATION OF UNCERTAINTIES USING AN ERROR PROPAGATION APPROACH (APPROACH 1)

The IPCC Good Practice Guidance (IPCC, 2000) and 2006 Guidelines defines error propagation and Monte Carlo modelling approaches to estimating uncertainties in national greenhouse gas inventories. The results of the error propagation approach are shown in **Tables A7.5.2-5**. In the error propagation approach the emission sources are aggregated up to a level broadly similar to the IPCC Summary Table 7A. Uncertainties are then estimated for these categories. The uncertainties used in the error propagation approach are not exactly the same as those used in the Monte Carlo Simulation since the error propagation source categorisation is far less detailed. However, the values used were chosen to agree approximately with those used in the Monte Carlo Simulation. The error propagation approach is only able to model normal distributions. This presented a problem in how to estimate a normal distribution approximation of the lognormal distribution used for agricultural soils and wastewater treatment. The approach adopted was to use a normal distribution with the same mean as the lognormal distribution.

There were a number of major improvements to the key source analysis in the 2006 NIR. In part, these improvements have been made following comments made in the Fourth Centralised Review and have been made to improve the transparency of the uncertainty analysis. The improvements are summarised below.

A7.6.1 Review of Recent Improvements to the Error Propagation Model

- An ERT commented that the key source analysis was not consistent with the IPCC GPG. The comment was in reference to the guidance where it says "*The (key source) analysis should be performed at the level of IPCC source categories*". Our analysis included disaggregation of 1B1 and 1B2 in the case of CH_4, rather than treating each of these as a single source category. This has been revised by summing these categories; and
- The uncertainties associated with some of the fuel consumptions in the 2005 NIR were derived from an analysis of the statistical differences between supply and demand for one year, presented in the 1996 UK energy statistics. This analysis was updated for the 2008 NIR, and we have now revised the uncertainty associated the consumptions of the fuels listed below this bullet point. The uncertainties were calculated from the differences between supply and demand[9] for fuel categories presented in the 1996 DTI DUKES. We have now chosen to use a 5-year rolling average since this is a time period short enough to allow a satisfactory estimate of the change in the variability in the supply and demand, but avoids the sometimes large year-to-year variability that can be a feature of the UK energy statistics.

  This large year-to-year variability is in part controlled by the historical revisions to the energy statistics that the BERR (now DECC) perform each year, and in some years, by revisions to historic estimates of supply and demand which will then alter the uncertainty calculated from previous data.

9 We have assumed that the distribution of errors in the parameter values was normal. The quoted range of possible error of uncertainty is taken as 2s, where s is the standard deviation. If the expected value of a parameter is E and the standard deviation is s, then the uncertainty is quoted as 2s/E expressed as a percentage. For a normal distribution the probability of the parameter being less than E-2s is 0.025 and the probability of the emission being less than E+2s is 0.975.

The uncertainty between supply and demand has been estimated for the following fuels:

- Coal
- Coke
- Petroleum coke
- Solid smokeless fuel
- Burning oil
- Fuel oil
- Gas oil
- Petrol
- Natural gas
- LPG
- OPG
- Naphtha
- Miscellaneous
- Blast furnace gas
- Coke oven gas

- In a few cases in this uncertainty analysis, types of fuels are grouped into one class: for example, oil in IPCC sector 1A used in stationary combustion; this oil is a combination of burning oil (minimal quantities used), fuel oil, and gas oil. In this case, and in other instances like it, we have used expert judgement to assign an uncertainty to a fuel class from the estimated uncertainties associated with individual fuels of that class. The uncertainties in the consumption of Aviation Turbine Fuel and Aviation Spirit has been reviewed and this is discussed below;

- We have reviewed the uncertainties associated with the emissions of HFC, PFC and SF_6 from industrial processes. The uncertainties associated with the total F-gas emissions has been assigned to the EF in the error propagation analysis since uncertainties are not known individually for the ADs and EFs as the emissions are produced from a model. The uncertainties used are weighted values, and reflect the individual uncertainties and the magnitude of emissions in each of the respective sectors;

- The LULUCF sectoral experts, CEH, have revised the uncertainties associated with emissions associated with Land Use Change and Forestry. The uncertainties associated with the emissions in each LULUCF category have been assigned to the EF in the error propagation analysis, since uncertainties are not known individually for the ADs and EFs as emissions are produced from a complicated model;

- We have reviewed the uncertainties associated with the consumptions of Aviation Turbine Fuel and Aviation Spirit

  For this review we contacted BERR (now DECC) for their view about the 95% CI that could be applied to the demand of Aviation Spirit and Aviation Turbine Fuel in the UK energy statistics. We then considered the additional uncertainty that would be introduced by the Tier 3 aviation model, which is used to estimate emissions. The overall uncertainty in the AD has been assigned by expert judgement considering the uncertainty in the BERR fuel consumption data and the additional uncertainty introduced by the model;

- We have reviewed the uncertainties associated with carbon emission factors (CEFs) for natural gas, coal used in power stations, and selected liquid fuels. The CEF uncertainty for natural gas was taken from analytical data of determinations of the carbon contents presented in a TRANSCO report - this report was produced for the Carbon Factor Review. The CEF uncertainty for the coal used in power stations has been derived from expert judgement following a consultation with representatives from the UK electricity supply industry, and takes into account analytical data of determinations of the carbon contents of power station coal. Analytical data of determinations of the carbon contents of liquid fuels from UKPIA have been used to determine the CEF uncertainties associated with the following fuels: motor spirit, kerosene, diesel, gas oil, and fuel oil. Analytical data were available for naphtha and aviation spirit, but these were not used to modify the existing uncertainties, as the sample sizes were too small. The existing CEF uncertainties were retained for these fuels; and

- Uncertainties for the ADs and EFs for peat combustion have been assigned using expert judgement.

A7.6.1.1 Review of Changes Made to the Error Propagation Model since the last NIR

There have been no substantial changes to error propagation model since the last NIR.

A7.6.2 Uncertainty in the Emissions

The error propagation analysis, **including** LULUCF emissions, suggests an uncertainty of 16% in the combined GWP total emission in 2007, the latest reported inventory year in this NIR; GWP emission uncertainty of 16% in the 2006 inventory, reported in the 2008 NIR.

The error propagation analysis, **excluding** LULUCF emissions, suggests an uncertainty of 16% in the combined GWP total emission in 2007, the latest reported inventory year in this NIR; GWP emission uncertainty of 16% in the 2006 inventory, reported in the 2008 NIR.

A7.6.3 Uncertainty in the Trend

The analysis, **including** LULUCF emissions, estimates an uncertainty of 2.4% in the trend between the base year and 2007, the latest reported inventory year in this NIR; trend uncertainty of 3% (with respect to 1990) in the 2006 inventory, reported in the 2008 NIR.

The analysis, **excluding** LULUCF emissions, estimates an uncertainty of 2.5% in the trend between the base year and 2007, the latest reported inventory year in this NIR; trend uncertainty of 3% (with respect to 1990) in the 2006 inventory, reported in the 2008 NIR.

A7.6.4 Key Categories

In the UK inventory, certain source categories are particularly significant in terms of their contribution to the overall uncertainty of the inventory. These key source categories have been identified so that the resources available for inventory preparation may be prioritised, and the best possible estimates prepared for the most significant source categories. We have used the method set out in Section 7.2 of the IPCC Good Practice Guidance (2000) (*Determining national key source categories*) to determine the key source categories. The results of this key source analysis can be found in **Annex 1**.

A7.6.5 Tables of uncertainty estimates from the error propagation approach

See overleaf.

Table A 7.6.1: Summary of error propagation uncertainty estimates including LULUCF, base year to the latest reported year

	Source Category (Analysis **with** LULUCF)	Gas	Emissions 1990 Gg CO2 equiv	Year Y emissions 2007 Gg CO2 equiv	Activity data uncertainty %	Emission factor uncertainty %	Combined uncertainty %	Combined uncertainty range as % of national total in year t %	Type A sensitivity %	Type B sensitivity %	Uncertainty in trend in national emissions introduced by emission factor uncertainty %	Uncertainty in trend in national emissions introduced by activity data uncertainty %	Uncertainty introduced trend in total emissions by source category %
	A	B	C	D	E	F	G	H	I	J	K	L	M
1A	Coal	CO2	248734	144792	0.4	1	1.077	0.244349	-0.076395	0.186374	-0.076395	0.105429	0.130198
1A(stationary)	Oil	CO2	92552	54871	15	2	15.133	1.301068	-0.027204	0.070630	-0.054408	1.498279	1.499266
1A	Natural Gas	CO2	108930	193143	0.2	1.5	1.513	0.457965	0.133240	0.248610	0.199860	0.070318	0.211869
1A	Other (waste)	CO2	207	1252	7	20	21.190	0.041579	0.001393	0.001612	0.027862	0.015957	0.032108
1A	Lubricant	CO2	387	262	30	2	30.067	0.012339	-0.000072	0.000337	-0.000144	0.014304	0.014304
1A	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1A3a	Aviation Fuel	CO2	1244	2140	20	3.3	20.270	0.067969	0.001439	0.002755	0.004748	0.077911	0.078055
1A3b	Auto Fuel	CO2	109618	121854	2.8	3.5	4.482	0.855786	0.040879	0.156848	0.143076	0.621087	0.637354
1A3b	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1A3d	Marine Fuel	CO2	4005	4840	1.7	1.4	2.202	0.016701	0.001995	0.006230	0.002793	0.014978	0.015236
1A3	Other Diesel	CO2	1950	2678	1.7	1.4	2.202	0.009239	0.001385	0.003446	0.001939	0.008286	0.008510
1A4	Peat	CO2	477	443	30	10	31.623	0.021967	0.000066	0.000571	0.000663	0.024211	0.024220
1A4	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1B	Solid Fuel Transformation	CO2	856	138	0.4	6	6.013	0.001300	-0.000728	0.000178	-0.004368	0.000100	0.004369
1B	Oil & Natural Gas	CO2	5760	5092	16	6	17.088	0.136329	0.000463	0.006554	0.002778	0.148298	0.148324
2A1	Cement Production	CO2	7295	6117	1	2.2	2.417	0.023162	0.000160	0.007874	0.000351	0.011135	0.011141
2A2	Lime Production	CO2	1192	688	1	5	5.099	0.005500	-0.000374	0.000886	-0.001869	0.001253	0.002250
2A3	Limestone & Dolomite use	CO2	1285	1443	1	5	5.099	0.011529	0.000498	0.001857	0.002491	0.002627	0.003620
2A4	Soda Ash Use	CO2	167	238	15	2	15.133	0.005641	0.000129	0.000306	0.000259	0.006496	0.006501
2A7	Fletton Bricks	CO2	180	181	20	70	72.801	0.020697	0.000043	0.000234	0.003035	0.006606	0.007269
2B	Ammonia Production	CO2	1322	1209	10	1.5	10.112	0.019154	0.000159	0.001556	0.000238	0.022007	0.022008
2B5	NEU	CO2	1563	1861	50	20	53.852	0.157029	0.000743	0.002395	0.014855	0.169383	0.170033
2C1	Iron&Steel Production	CO2	2309	2658	1.2	6	6.119	0.025483	0.000979	0.003421	0.005876	0.005806	0.008261
5A	5A LUCF	CO2	-12155	-14173	1	25	25.020	-0.555643	-0.005392	-0.018244	-0.134791	-0.025800	0.137238
5B	5B LUCF	CO2	15822	15288	1	50	50.010	1.197990	0.002948	0.019679	0.147391	0.027830	0.149996
5C	5C LUCF	CO2	-6186	-8132	1	70	70.007	-0.892029	-0.003926	-0.010467	-0.274841	-0.014803	0.275239
5E	5E LUCF	CO2	6904	6212	1	50	50.010	0.486805	0.000696	0.007997	0.034794	0.011309	0.036586
5G	5G LUCF	CO2	-1657	-1234	1	30	30.017	-0.058035	0.000164	-0.001588	0.004922	-0.002246	0.005411
6C	Waste Incineration	CO2	1207	465	7	20	21.190	0.015428	-0.000678	0.000598	-0.013553	0.005921	0.014790
		CO2 Total	593,967.75	544,327.70									
1A	All Fuel	CH4	2068.219044	1054.263914	0.4	50	50.002	0.082598	-0.000830	0.001357	-0.041495	0.000768	0.041502
1A3a	Aviation Fuel	CH4	3.178077887	1.604295358	20	50	53.852	0.000135	-0.000001	0.000002	-0.000065	0.000058	0.000087
1A3b	Auto Fuel	CH4	693.7294913	145.8004359	2.8	50	50.078	0.011440	-0.000546	0.000188	-0.027294	0.000743	0.027304
1A3b	Combined Fuel	CH4	0	0	15	30	33.541	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1A3d	Marine Fuel	CH4	1.31985	1.586934551	1.7	50	50.029	0.000124	0.000001	0.000002	0.000032	0.000005	0.000033
1A3	Other Diesel	CH4	3.220782165	4.057293357	1.7	50	50.029	0.000318	0.000002	0.000005	0.000091	0.000013	0.000092
1B1	Coal Mining	CH4	18285.666	2648.237	0.4	13	13.006	0.053969	-0.015923	0.003409	-0.206998	0.001928	0.207007
	Solid Fuel Transformation	CH4	4.043	1.926	0.4	50	50.002	0.000151	-0.000002	0.000002	-0.000090	0.000001	0.000090
1B2	Natural Gas Transmission	CH4	7954.835	4370.651	1	15	15.033	0.102952	-0.002785	0.005626	-0.041781	0.007956	0.042532
	Offshore Oil& Gas	CH4	2349.176	1074.026	16	20	25.612	0.043102	-0.001102	0.001382	-0.022031	0.031282	0.038261
2A7	Fletton Bricks	CH4	23.602	18.501	20	100	101.980	0.002956	-0.000001	0.000024	-0.000114	0.000674	0.000683
2B	Chemical Industry	CH4	169.425	76.209	20	20	28.284	0.003377	-0.000081	0.000098	-0.001621	0.002775	0.003213
2C	Iron & Steel Production	CH4	16.357	18.178	0.4	50	50.002	0.001424	0.000006	0.000023	0.000305	0.000013	0.000305
4A	Enteric Fermentation	CH4	18388.861	15560.693	0.1	20	20.000	0.487641	0.000585	0.020029	0.011694	0.002833	0.012032
4B	Manure Management	CH4	3588.777	2872.483	0.1	30	30.000	0.135026	-0.000097	0.003697	-0.002922	0.000523	0.002968
4F	Field Burning	CH4	266.045	0.000	25	50	55.902	0.000000	-0.000281	0.000000	-0.014066	0.000000	0.014066
5A	5A LUCF	CH4	4.298	15.279	1	20	20.025	0.000479	0.000015	0.000020	0.000302	0.000028	0.000304
5C2	5C2 LUCF	CH4	3.077	9.073	1	20	20.025	0.000285	0.000008	0.000012	0.000168	0.000017	0.000169
5E2	5E2 LUCF	CH4	9.354	6.453	1	20	20.025	0.000202	-0.000002	0.000008	-0.000032	0.000012	0.000034
6A	Solid Waste Disposal	CH4	49816.593	20271.579	15	46	48.384	1.536823	-0.026566	0.026093	-1.222053	0.553520	1.341566
6B	Wastewater Handling	CH4	709.572	813.273	1	50	50.010	0.063728	0.000297	0.001047	0.014826	0.001480	0.014900
6C	Waste Incineration	CH4	134.423	6.488	7	50	50.488	0.000513	-0.000134	0.000008	-0.006689	0.000083	0.006690
		CH4 total	104,493.77	48,970.36									

Table A 7.6.2: Summary of error propagation uncertainty estimates including LULUCF, base year to the latest reported year (continued)

	Source Category	Gas	Emissions 1990 Gg CO2 equiv	Year Y emissions 2007 Gg CO2 equiv	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty range as % of national total in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced trend in total emissions by source category
					%	%	%	%	%	%	%	%	%
	A	B	C	D	E	F	G	H	I	J	K	L	M
1A1&1A2&1A4&1A5	Other Combustion	N2O	4657.530	3522.108	0.4	195	195.000	1.076152	-0.000391	0.004534	-0.076305	0.002565	0.076348
1A3a	Aviation Fuel	N2O	12.252	21.070	20	170	171.172	0.005651	0.000014	0.000027	0.002408	0.000767	0.002527
1A3b	Auto Fuel	N2O	1180.977	1256.130	2.8	170	170.023	0.334640	0.000368	0.001617	0.062574	0.006402	0.062901
1A3b	Combined Fuel	N2O	0.000	0.000	15	30	33.541	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1A3d	Marine Fuel	N2O	31.174	37.482	1.7	170	170.008	0.009985	0.000015	0.000048	0.002598	0.000116	0.002601
1A3	Other Diesel	N2O	231.203	318.328	1.7	140	140.010	0.069834	0.000165	0.000410	0.023138	0.000985	0.023159
1B1	Coke Oven Gas	N2O	2.085	0.993	0.4	118	118.001	0.000184	-0.000001	0.000001	-0.000109	0.000001	0.000109
1B2	Oil & Natural Gas	N2O	42.396	39.534	16	110	111.158	0.006886	0.000006	0.000051	0.000666	0.001151	0.001330
2B	Adipic Acid Production	N2O	20737.345	989.613	0.5	15	15.008	0.023272	-0.020649	0.001274	-0.309729	0.000901	0.309730
2B	Nitric Acid Production	N2O	3903.850	1763.497	10	230	230.217	0.636133	-0.001858	0.002270	-0.427326	0.032102	0.428530
2C	Iron & Steel	N2O	11.107	9.359	0.4	118	118.001	0.001730	0.000000	0.000012	0.000036	0.000007	0.000036
4B	Manure Management	N2O	2221.015	1745.582	1	414	414.001	1.132341	-0.000102	0.002247	-0.042080	0.003178	0.042200
4D	Agricultural Soils	N2O	30414.922	23280.408	1	424	424.001	15.466537	-0.002194	0.029966	-0.930303	0.042378	0.931268
4F	Field Burning	N2O	77.762	0.000	25	230	231.355	0.000000	-0.000082	0.000000	-0.018912	0.000000	0.018912
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	10	50	50.990	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5A	5A LUCF	N2O	6.852	2.782	1	20	20.025	0.000087	-0.000004	0.000004	-0.000073	0.000005	0.000073
5C2	5C2 LUCF	N2O	0.312	0.921	1	20	20.025	0.000029	0.000001	0.000001	0.000017	0.000002	0.000017
5E2	5E2 LUCF	N2O	0.949	0.655	1	20	20.025	0.000021	0.000000	0.000001	-0.000003	0.000001	0.000003
6B	Wastewater Handling	N2O	1033.345	1255.546	10	401	401.125	0.789128	0.000523	0.001616	0.209899	0.022855	0.211140
6C	Waste Incineration	N2O	47.900	49.018	7	230	230.106	0.017673	0.000012	0.000063	0.002862	0.000625	0.002930
		N2O Total	64,612.97	34,293.03									
2	Industrial Processes	HFC	11386	9611	1	19	19.026	0.286528	0.000332	0.012371	0.006310	0.017496	0.018599
2	Industrial Processes	PFC	1402	216	1	10	10.050	0.003395	-0.001205	0.000278	-0.012045	0.000392	0.012052
2	Industrial Processes	SF6	1030	794	1	20	20.025	0.024898	-0.000068	0.001021	-0.001354	0.001444	0.001980
		Halocarbon & SF6 Total	13,817.09	10,620.30									
	TOTALS	GWP	776,891.58	638,211.39									
	Total Uncertainties%							15.8					2.44

Table A 7.6.3: Summary of error propagation uncertainty estimates excluding LULUCF, base year to the latest reported year

	Source Category (Analysis **without** LULUCF)	Gas	Emissions 1990 Gg CO2 equiv	Year Y emissions 2007 Gg CO2 equiv	Activity data uncertainty %	Emission factor uncertainty %	Combined uncertainty %	Combined uncertainty range as % of national total in year t %	Type A sensitivity %	Type B sensitivity %	Uncertainty in trend in national emissions introduced by emission factor uncertainty %	Uncertainty in trend in national emissions introduced by activity data uncertainty %	Uncertainty introduced trend in total emissions by source category %
	A	B	C	D	E	F	G	H	I	J	K	L	M
1A	Coal	CO2	248734	144792	0.4	1	1.077	0.243584	-0.078430	0.187037	-0.078430	0.105804	0.131703
1A(stationary)	Oil	CO2	92552	54871	15	2	15.133	1.296996	-0.027958	0.070881	-0.055917	1.503606	1.504645
1A	Natural Gas	CO2	108930	193143	0.2	1.5	1.513	0.456532	0.132939	0.249494	0.199409	0.070568	0.211527
1A	Other (waste)	CO2	207	1252	7	20	21.190	0.041449	0.001397	0.001618	0.027932	0.016014	0.032197
1A	Lubricant	CO2	387	262	30	2	30.067	0.012301	-0.000075	0.000338	-0.000150	0.014355	0.014355
1A	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1A3a	Aviation Fuel	CO2	1244	2140	20	3.3	20.270	0.067756	0.001435	0.002764	0.004736	0.078188	0.078331
1A3b	Auto Fuel	CO2	109618	121854	2.8	3.5	4.482	0.853108	0.040245	0.157406	0.140858	0.623296	0.639014
1A3b	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1A3d	Marine Fuel	CO2	4005	4840	1.7	1.4	2.202	0.016649	0.001974	0.006252	0.002763	0.015031	0.015283
1A3	Other Diesel	CO2	1950	2678	1.7	1.4	2.202	0.009210	0.001376	0.003459	0.001926	0.008315	0.008535
1A4	Peat	CO2	477	443	30	10	31.623	0.021898	0.000063	0.000573	0.000631	0.024297	0.024305
1A4	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1B	Solid Fuel Transformation	CO2	856	138	0.4	6	6.013	0.001296	-0.000737	0.000178	-0.004420	0.000101	0.004421
1B	Oil & Natural Gas	CO2	5760	5092	16	6	17.088	0.135902	0.000424	0.006577	0.002542	0.148825	0.148847
2A1	Cement Production	CO2	7295	6117	1	2.2	2.417	0.023090	0.000108	0.007902	0.000238	0.011175	0.011177
2A2	Lime Production	CO2	1192	688	1	5	5.099	0.005483	-0.000384	0.000889	-0.001918	0.001258	0.002294
2A3	Limestone & Dolomite use	CO2	1285	1443	1	5	5.099	0.011493	0.000491	0.001864	0.002454	0.002636	0.003602
2A4	Soda Ash Use	CO2	167	238	15	2	15.133	0.005624	0.000129	0.000307	0.000257	0.006519	0.006524
2A7	Fletton Bricks	CO2	180	181	20	70	72.801	0.020632	0.000042	0.000234	0.002956	0.006629	0.007258
2B	Ammonia Production	CO2	1322	1209	10	1.5	10.112	0.019095	0.000150	0.001562	0.000225	0.022085	0.022086
2B5	NEU	CO2	1563	1861	50	20	53.852	0.156537	0.000734	0.002404	0.014686	0.169985	0.170618
2C1	Iron&Steel Production	CO2	2309	2658	1.2	6	6.119	0.025403	0.000966	0.003433	0.005799	0.005827	0.008220
5A	5A LUCF	CO2	0	0	1	25	25.020	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5B	5B LUCF	CO2	0	0	1	50	50.010	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5C	5C LUCF	CO2	0	0	1	70	70.007	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5E	5E LUCF	CO2	0	0	1	50	50.010	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5G	5G LUCF	CO2	0	0	1	30	30.017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6C	Waste Incineration	CO2	1207	465	7	20	21.190	0.015380	-0.000689	0.000600	-0.013773	0.005942	0.015000
		CO2 Total	591,240.03	546,366.28									
1A	All Fuel	CH4	2068.219044	1054.263914	0.4	50	50.002	0.082339	-0.000848	0.001362	-0.042379	0.000770	0.042386
1A3a	Aviation Fuel	CH4	3.178077887	1.604295358	20	50	53.852	0.000135	-0.000001	0.000002	-0.000066	0.000059	0.000088
1A3b	Auto Fuel	CH4	693.7294913	145.8004359	2.8	50	50.078	0.011405	-0.000553	0.000188	-0.027638	0.000746	0.027648
1A3b	Combined Fuel	CH4	0	0	15	30	33.541	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1A3d	Marine Fuel	CH4	1.31985	1.586934551	1.7	50	50.029	0.000124	0.000001	0.000002	0.000032	0.000005	0.000032
1A3	Other Diesel	CH4	3.220782165	4.057293357	1.7	50	50.029	0.000317	0.000002	0.000005	0.000090	0.000013	0.000091
1B1	Coal Mining	CH4	18285.666	2648.237	0.4	13	13.006	0.053800	-0.016110	0.003421	-0.209425	0.001935	0.209434
	Solid Fuel Transformation	CH4	4.043	1.926	0.4	50	50.002	0.000150	-0.000002	0.000002	-0.000092	0.000001	0.000092
1B2	Natural Gas Transmission	CH4	7954.835	4370.651	1	15	15.033	0.102630	-0.002852	0.005646	-0.042779	0.007984	0.043518
	Offshore Oil& Gas	CH4	2349.176	1074.026	16	20	25.612	0.042968	-0.001122	0.001387	-0.022444	0.031393	0.038590
2A7	Fletton Bricks	CH4	23.602	18.501	20	100	101.980	0.002947	-0.000001	0.000024	-0.000132	0.000676	0.000689
2B	Chemical Industry	CH4	169.425	76.209	20	20	28.284	0.003367	-0.000083	0.000098	-0.001651	0.002784	0.003237
2C	Iron & Steel Production	CH4	16.357	18.178	0.4	50	50.002	0.001420	0.000006	0.000023	0.000300	0.000013	0.000301
4A	Enteric Fermentation	CH4	18388.861	15560.693	0.1	20	20.000	0.486115	0.000456	0.020101	0.009119	0.002843	0.009552
4B	Manure Management	CH4	3588.777	2872.483	0.1	30	30.000	0.134603	-0.000123	0.003711	-0.003699	0.000525	0.003736
4F	Field Burning	CH4	266.045	0.000	25	50	55.902	0.000000	-0.000284	0.000000	-0.014211	0.000000	0.014211
5A	5A LUCF	CH4	0.000	0.000	1	20	20.025	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5C2	5C2 LUCF	CH4	0.000	0.000	1	20	20.025	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5E2	5E2 LUCF	CH4	0.000	0.000	1	20	20.025	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6A	Solid Waste Disposal	CH4	49816.593	20271.579	15	46	48.384	1.532013	-0.027015	0.026186	-1.242692	0.555488	1.361195
6B	Wastewater Handling	CH4	709.572	813.273	1	50	50.010	0.063528	0.000293	0.001051	0.014626	0.001486	0.014701
6C	Waste Incineration	CH4	134.423	6.488	7	50	50.488	0.000512	-0.000135	0.000008	-0.006761	0.000083	0.006762
		CH4 total	104,477.04	48,939.56									

Table A 7.6.4: Summary of error propagation uncertainty estimates excluding LULUCF, base year to the latest reported year (continued)

	Source Category	Gas	Emissions 1990 Gg CO2 equiv	Year Y emissions 2007 Gg CO2 equiv	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty range as % of national total in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced trend in total emissions by source category
					%	%	%	%	%	%	%	%	%
	A	B	C	D	E	F	G	H	I	J	K	L	M
1A1&1A2&1A4&1A5	Other Combustion	N2O	4657.530	3522.108	0.4	195	195.000	1.072785	-0.000426	0.004550	-0.083039	0.002574	0.083079
1A3a	Aviation Fuel	N2O	12.252	21.070	20	170	171.172	0.005633	0.000014	0.000027	0.002402	0.000770	0.002522
1A3b	Auto Fuel	N2O	1180.977	1256.130	2.8	170	170.023	0.333593	0.000361	0.001623	0.061368	0.006425	0.061704
1A3b	Combined Fuel	N2O	0.000	0.000	15	30	33.541	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1A3d	Marine Fuel	N2O	31.174	37.482	1.7	170	170.008	0.009953	0.000015	0.000048	0.002570	0.000116	0.002572
1A3	Other Diesel	N2O	231.203	318.328	1.7	140	140.010	0.069616	0.000164	0.000411	0.022990	0.000989	0.023011
1B1	Coke Oven Gas	N2O	2.085	0.993	0.4	118	118.001	0.000183	-0.000001	0.000001	-0.000111	0.000001	0.000111
1B2	Oil & Natural Gas	N2O	42.396	39.534	16	110	111.158	0.006864	0.000006	0.000051	0.000636	0.001156	0.001319
2B	Adipic Acid Production	N2O	20737.345	989.613	0.5	15	15.008	0.023199	-0.020869	0.001278	-0.313042	0.000904	0.313044
2B	Nitric Acid Production	N2O	3903.850	1763.497	10	230	230.217	0.634143	-0.001892	0.002278	-0.435235	0.032216	0.436425
2C	Iron & Steel	N2O	11.107	9.359	0.4	118	118.001	0.001725	0.000000	0.000012	0.000026	0.000007	0.000027
4B	Manure Management	N2O	2221.015	1745.582	1	414	414.001	1.128798	-0.000118	0.002255	-0.048773	0.003189	0.048877
4D	Agricultural Soils	N2O	30414.922	23280.408	1	424	424.001	15.418138	-0.002418	0.030073	-1.025342	0.042529	1.026224
4F	Field Burning	N2O	77.762	0.000	25	230	231.355	0.000000	-0.000083	0.000000	-0.019106	0.000000	0.019106
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	10	50	50.990	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5A	5A LUCF	N2O	0.000	0.000	1	20	20.025	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5C2	5C2 LUCF	N2O	0.000	0.000	1	20	20.025	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5E2	5E2 LUCF	N2O	0.000	0.000	1	20	20.025	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6B	Wastewater Handling	N2O	1033.345	1255.546	10	401	401.125	0.786659	0.000518	0.001622	0.207697	0.022937	0.208959
6C	Waste Incineration	N2O	47.900	49.018	7	230	230.106	0.017618	0.000012	0.000063	0.002794	0.000627	0.002864
		N2O Total	64,604.86	34,288.67									
2	Industrial Processes	HFC	11386	9611	1	19	19.026	0.285631	0.000252	0.012415	0.004793	0.017558	0.018200
2	Industrial Processes	PFC	1402	216	1	10	10.050	0.003384	-0.001219	0.000279	-0.012188	0.000394	0.012194
2	Industrial Processes	SF6	1030	794	1	20	20.025	0.024820	-0.000075	0.001025	-0.001505	0.001450	0.002090
		Halocarbon & SF6 Total	13,817.09	10,620.30									
	TOTALS	GWP	774,139.02	640,214.80									
	Total Uncertainties%							15.7					2.47

A8 ANNEX 8: Verification

This Annex discusses the verification of the UK estimates of the Kyoto Gases.

A8.1 MODELLING APPROACH USED FOR THE VERIFICATION OF THE UK GHGI

In order to provide some verification of the UK Greenhouse Gas Inventory (GHGI) DECC (formerly Defra) have established and maintained a high-quality observation station at Mace Head on the west coast of Ireland. The station reports high-frequency concentrations of the key greenhouse gases and is under the supervision of Dr. Simon O'Doherty of the University of Bristol (Simmonds *et al.* 1996).

The Met Office, under contract to DECC, employs the Lagrangian dispersion model NAME (Numerical Atmospheric dispersion Modelling Environment) (Ryall *et al*. 1998) (Jones et al. 2004) driven by 3D synoptic meteorology from the Met Offices's numerical weather prediction model, the Unified Model, to generate so called air-history maps. The air-history maps represent the recent 10-day history of the air before it arrives at the observing station, Mace Head, and estimate the dilution in concentration that surface sources would undergo during this transport. These maps have been generated for each 3-hour period from 1995 to current day and enable the observations made at Mace Head to be sorted into those that represent Northern Hemisphere baseline air masses and those that represent regionally-polluted air masses arriving from Europe. From the sorted data an estimate of the time-varying Northern Hemisphere mid-latitude baseline concentration is made.

The Mace Head observations, with the baseline removed, and the 3-hourly air-history maps are applied in an inversion algorithm to estimate the magnitude and spatial distribution of the European emissions that best support the observations (Manning *et al.* 2003). The technique has been applied to methane, nitrous oxide and a range of HFCs where data are available.

The inversion (best-fit) technique, simulated annealing, is used to fit the model emissions to the observations. It assumes that the emissions from each grid box are uniform in both time and space over the duration of the fitting period. This implies that the release is independent of meteorological factors such as temperature and diurnal cycles, and that in its production and use there are no definite cycles or intermittency. The geographical area defined as UK within the NAME estimates includes the coastal waters around the UK. A 'best fit' solution has been determined for each two-year period (Jan'95-Dec'96, Feb'95-Jan'97,… Jan'07-Dec'08). The uncertainty ranges have been estimated by solving multiple times with a random noise perturbation applied to the observations. The annual estimates have been calculated by taking the mean of all of the solutions with the full year represented in the solution period.

A8.2 METHANE

In **Table A8.2.1** the emission estimates made for the UK with the NAME-inversion methodology are compared to the GHGI emission estimates for the period 1995-2007 inclusive.

Methane has a natural (biogenic) component and it is estimated that 22% of the annual global emission is released from wetlands (Nilsson *et al*. 2001). Usually natural emissions are strongly dependent on a range of meteorological factors such as temperature and diurnal, annual, growth and decay cycles. Such non-uniform emissions will add to the uncertainties in the modelling, although in North West Europe the natural emissions are thought to be small compared to the anthropogenic emissions. Due to the relatively strong local (within 20km) influence of biogenic emissions at Mace Head, a peat bog area, observations taken when local emissions will be significant (low wind speeds and low boundary layer heights) have been removed from the data set prior to applying the inversion technique.

The GHGI trend is monotonically downwards whereas the NAME estimates show no clear trend (**Figure A8.1**). The agreement from 2001 onwards is good. It must be remembered however that the GHGI totals only include anthropogenic emissions whereas the NAME estimates are total emissions combining both anthropogenic and biogenic releases however biogenic emissions in the UK are thought to be low.

For 2006 the NAME-inversion method has been applied using data from 11 stations, including Mace Head, across Europe as part of the FP6 European project NitroEurope. The agreement between the Mace Head only results and the GHGI estimates are excellent for this year.

Table A 8.2.1: Verification of the UK emission inventory estimates for methane in Gg yr-1 for 1995-2007. NAME uncertainty ±500 Gg yr-1. NAME1 use Mace Head observations only, NAME2 use observations from 11 sites across Europe including Mace Head.

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CH_4 – NAME[1]	2070	2110	2000	1920	2090	2460	2400	2160	2250	2230	2580	2320	1960
CH_4 – NAME[2]												2510	
CH_4 – GHGI	4334	4219	3990	3782	3532	3319	3034	2891	2606	2520	2430	2398	2326

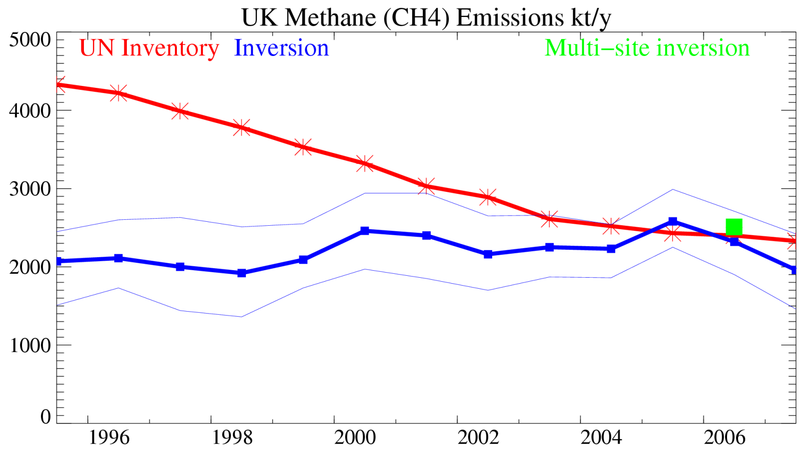

Figure A8.1: Verification of the UK emission inventory estimates for methane in Gg yr^{-1} for 1995-2007. GHGI estimates are shown in red with crosses. NAME[1] (blue squares) use Mace Head observations only, NAME[2] (green square) use observations from 11 sites across Europe including Mace Head. NAME uncertainty is shown with the thin blue lines. Note 1 kt yr^{-1} is equivalent to 1 Gg yr^{-1}.

A8.3 NITROUS OXIDE

The main activities in Europe resulting in the release of nitrous oxide are agricultural soils (~60%), chemical industry (~20%) and combustion (~15%) (UNFCCC 1998 figures). The amount emitted from soils has significant uncertainty and has a diurnal and seasonal release cycle. It is driven by the availability of nitrogen, temperature and the soil moisture content.

Late in 1998, DuPont introduced technology at its adipic acid plant in Wilton, north east England. It has been estimated that this has cut its emissions of N_2O by 90%, from 46 thousand tonne yr^{-1} to around 6 thousand tonne yr^{-1} (DEFRA, 2000).

Table A8.3.1 shows the NAME-inversion and GHGI emission estimates for the UK for nitrous oxide for the period 1995-2007. The NAME estimates are in excellent agreement with the GHGI estimates throughout the whole time period. Both show declining UK totals (**Figure A8.2**). The GHGI estimates show a sharp decline (40 Gg) between 1998 and 1999 in line with the introduction of the clean technology at the DuPont plant.

The nature of the nitrous oxide emissions challenges the NAME technique assumption of uniformity of release both in time and space. The uncertainty of the NAME estimates is calculated to be ±30 Gg yr^{-1}. Also the point of release to the atmosphere may not be coincident with the activity generating the nitrous oxide e.g. the nitrous oxide may be transported from its source, for example by rivers to an ocean, prior to its release to the atmosphere.

Table A 8.3.1 Verification of the UK emission inventory estimates for nitrous oxide in Gg yr^{-1} for 1995-2007. NAME uncertainty varies but is approximately ±30 Gg yr^{-1}.

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
N_2O -NAME	167	162	140	145	156	140	135	122	107	122	123	94	86
N_2O- GHGI	173	171	175	173	138	135	127	122	120	121	118	113	111

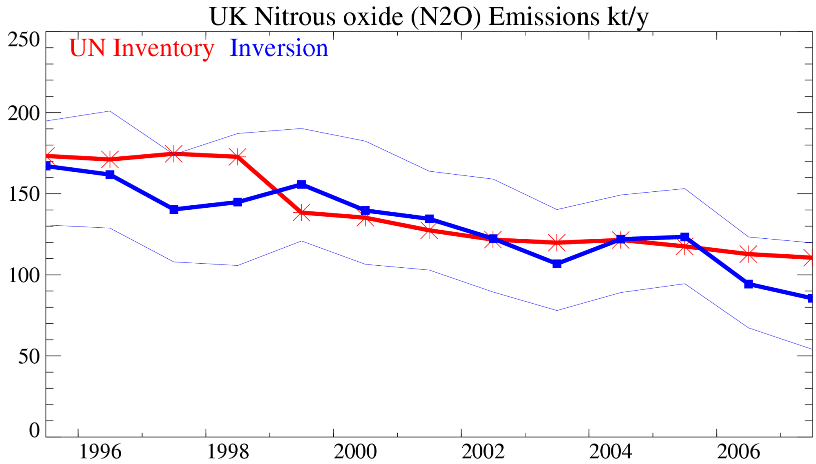

Figure A8.2: Verification of the UK emission inventory estimates for nitrous oxide in Gg yr^{-1} for 1995-2007. The blue line with solid square points are the NAME-inversion results and the red line with crosses are the GHGI estimates. The thin lines with no points are the min-max uncertainty of the NAME-inversion results.

A8.4 HYDROFLUOROCARBONS

A8.4.1 HFC-134a

Table A8.4.1 shows the NAME-inversion and GHGI emission estimates for the UK for HFC-134a for the period 1995-2007. The GHGI shows an earlier increase in emission compared to the NAME estimates, the NAME estimates begin their rise in 1999-2000 whereas the GHGI estimates began to rise from 1995 (**Figure A8.3**).

Table A 8.4.1: Verification of the UK emission inventory estimates for HFC-134a in Gg yr-1 for 1995-2007. The NAME estimates have a calculated error of ±0.4 Gg yr-1.

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HFC-134a –NAME	1.0	0.9	1.0	1.0	1.1	1.6	1.8	2.3	2.4	2.3	2.2	2.7	3.0
HFC-134a – GHGI 2007	0.7	1.1	1.6	2.3	2.2	2.6	2.9	3.2	3.5	3.6	3.7		

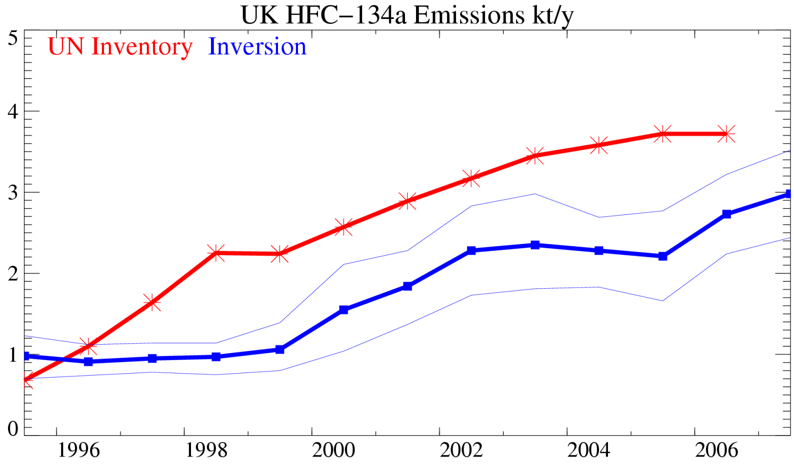

Figure A8.3: Verification of the UK emission inventory estimates for HFC-134a in Gg yr^{-1} for 1995-2007. The NAME estimates are in blue with squares and the GHGI are shown in red with crosses. The thin lines with no points are the min-max uncertainty of the NAME-inversion results.

A8.4.2 HFC-152a

Table A8.4.2 and **Figure 8.4** show the NAME and the GHGI emission estimates for the UK for HFC-152a for the period 1995-2007. The agreement between the two datasets is poor. The GHGI shows a steep rise in 1997 whereas the NAME-inversion results show a rise in 2000 but then a fall in 2002 and then a later rise in 2006-2007.

Table A 8.4.2: Verification of the UK emission inventory estimates for HFC-152a in Gg yr-1 for 1995-2007. The NAME estimates have a calculated error of up to ±0.06 Gg yr-1

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HFC-152a –NAME	0.03	0.03	0.02	0.02	0.03	0.09	0.10	0.07	0.05	0.04	0.05	0.08	0.11
HFC-152a – GHGI 2007	0.03	0.06	0.12	0.16	0.14	0.16	0.17	0.16	0.17	0.16	0.16		

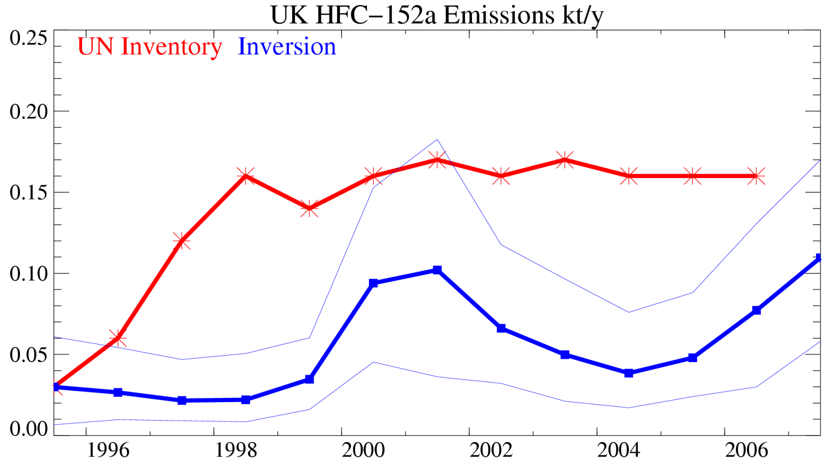

Figure A8.4: Verification of the UK emission inventory estimates for HFC-152a in Gg yr^{-1} for 1995-2007. The NAME estimates are in blue with squares and the GHGI are shown in red with crosses. The thin lines with no points are the min-max uncertainty of the NAME-inversion results.

A8.4.3 HFC-125

NAME emission estimates for the UK for HFC-125 for the period 1998-2007 are shown below in **Table A8.4.3**. The estimates suggest that the emissions of HFC-125 from the UK have been increasing.

Table A 8.4.3: Verification of the UK emission inventory estimates for HFC-125 in Gg yr-1 for 1998-2007. The NAME estimates have a calculated error of ±0.10 Gg yr-1.

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HFC-125 –NAME					0.28	0.31	0.36	0.38	0.38	0.42	0.49	0.64	0.71

A8.4.4 HFC-365mfc

NAME emission estimates for the UK for HFC-365mfc for the period 2004-2007 are shown below in **Table A8.4.4**. The estimates show a rise and then a fall in the emissions.

Table A 8.4.4: Verification of the UK emission inventory estimates for HFC-365mfc in Gg yr^{-1} for 2003-2007. The NAME estimates have a calculated error of ±0.07 Gg yr-1.

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HFC-365mfc – NAME										0.28	0.51	0.47	0.20

A8.4.5 HFC-143a

NAME emission estimates for the UK for HFC-143a for the period 2004-2007 are shown below in **Table A8.4.5**. The estimates suggest that the emissions of HFC-125 from the UK have been increasing.

Table A 8.4.5: Verification of the UK emission inventory estimates for HFC-143a in Gg yr-1 for 2004-2007. The NAME estimates have a calculated error of ±0.1 Gg yr-1.

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HFC-143a –NAME										0.50	0.52	0.64	0.66

A8.4.6 HFC-23

NAME emission estimates for the UK for HFC-23 for 2007 are shown below in **Table A8.4.6**.

Table A 8.4.6: Verification of the UK emission inventory estimates for HFC-23 in Gg yr-1 for 2007. The NAME estimates have a calculated error of ±0.02 Gg yr-1.

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HFC-23 –NAME													0.02

A9 ANNEX 9: IPCC Sectoral Tables of GHG Emissions

The tables in this Annex present summary data for UK greenhouse gas emissions for the years 1990-2007, inclusive. The data are given in IPCC reporting format. These data are updated annually to reflect revisions in the methodology and the availability of new information. These adjustments are applied retrospectively to earlier years, which accounts for any differences in data published in previous reports, to ensure a consistent time series.

These tables are taken directly from the CRF.

A9.1 SUMMARY TABLES

Tables A9.1.1 to **A9.1.17** present UK GHG emissions as summary reports for national greenhouse gas inventories (IPCC Table 7A).

Table A 9.1.1: SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 1990

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**594,193.84**	**4,975.89**	**208.43**	**11.88**	**11,385.55**	**73.47**	**1,401.60**	**0.10**	**0.04**	**6,558.38**	**29,148.10**	**5,224.42**	**7,580.11**
1. Energy	**574,720.36**	**1,493.49**	**19.86**							**6,533.41**	**28,582.12**	**4,242.37**	**7,524.42**
A. Fuel Combustion — Reference Approach	564,058.67												
Sectoral Approach	568,103.77	131.89	19.72							6,519.49	28,522.29	3,686.31	7,495.97
1. Energy Industries	237,170.24	9.71	6.54							1,312.65	183.63	11.91	5,005.52
2. Manufacturing Industries and Construction	99,045.52	15.40	5.24							714.10	768.29	28.79	1,552.17
3. Transport	117,187.24	33.40	4.70							3,980.20	24,709.94	3,532.46	275.94
4. Other Sectors	109,415.95	73.23	3.08							470.35	2,847.06	110.26	653.01
5. Other	5,284.82	0.15	0.16							42.18	13.37	2.89	9.33
B. Fugitive Emissions from Fuels	6,616.59	1,361.61	0.14							13.92	59.84	556.06	28.46
1. Solid Fuels	856.42	870.94	0.01							0.58	38.35	0.34	20.68
2. Oil and Natural Gas	5,760.18	490.67	0.14							13.34	21.49	555.72	7.78
2. Industrial Processes	**15,313.15**	**9.97**	**79.52**	**11.88**	**11,385.55**	**73.47**	**1,401.60**	**0.10**	**0.04**	**9.58**	**269.62**	**258.15**	**48.37**
A. Mineral Products	10,119.29	1.12	IE,NO							IE,NE,NO	5.31	13.08	4.27
B. Chemical Industry	2,884.58	8.07	79.49	NO	NO	NO	NO	NO	NO	8.49	81.29	165.80	36.39
C. Metal Production	2,309.27	0.78	0.04				1,332.75		0.02	1.09	183.02	1.61	7.71
D. Other Production	NE									NE	NE	77.67	NE
E. Production of Halocarbons and SF_6					11,373.73		10.90		NA,NO				
F. Consumption of Halocarbons and SF_6				11.88	11.82	73.47	57.95	0.10	0.03				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE**							**NO**	**NO**	**667.60**	**NO**
4. Agriculture		**1,059.22**	**105.53**							**9.07**	**266.04**	**26.06**	**NO**
A. Enteric Fermentation		875.66											
B. Manure Management		170.89	6.94									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils		NE	98.11									NO	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		12.67	0.25							9.07	266.04	26.06	
G. Other		NA	0.23							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**2,929.06**	**0.80**	**0.03**							**0.20**	**6.97**	**NA,NO**	**NA**
A. Forest Land	-12,155.07	0.20	0.02							0.05	1.79	NO	
B. Cropland	15,822.10	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-6,130.33	0.15	0.00							0.04	1.28	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	7,074.34	0.45	0.00							0.11	3.90	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	-1,681.97	NE	NE							NE	NE	NA	NA
6. Waste	**1,206.51**	**2,412.41**	**3.49**							**6.12**	**23.34**	**30.24**	**7.32**
A. Solid Waste Disposal on Land	NA,NE,NO	2,372.22								NA,NE	NA,NE	23.63	
B. Waste-water Handling		33.79	3.33							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	1,206.51	6.40	0.15							6.12	23.34	6.61	7.32
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*	**24.76**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**38,170.09**	**0.73**	**1.17**							**229.05**	**28.86**	**12.84**	**92.16**
Aviation	31,401.61	0.62	1.00							75.34	13.13	5.40	2.99
Marine	6,768.48	0.11	0.17							153.71	15.73	7.44	89.17
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**2,980.26**												

Table A 9.1.2: SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 1991

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**601,507.24**	**4,939.27**	**208.28**	**11.88**	**11,853.70**	**82.77**	**1,170.92**	**0.10**	**0.05**	**6,537.49**	**28,430.52**	**5,075.30**	**7,077.39**
1. Energy	**584,226.19**	**1,510.14**	**19.81**							**6,514.67**	**27,909.64**	**4,144.58**	**7,023.29**
A. Fuel Combustion — Reference Approach	580,669.69												
Sectoral Approach	578,010.75	134.33	19.67							6,501.07	27,827.04	3,598.42	6,998.10
1. Energy Industries	237,304.97	9.73	6.55							1,190.55	177.56	11.46	4,428.84
2. Manufacturing Industries and Construction	99,016.94	15.18	5.11							737.08	726.35	27.38	1,658.07
3. Transport	116,607.31	32.71	4.71							4,025.04	23,900.62	3,443.34	254.43
4. Other Sectors	120,789.12	76.60	3.17							507.71	3,011.75	113.65	647.09
5. Other	4,292.42	0.12	0.13							40.69	10.77	2.59	9.68
B. Fugitive Emissions from Fuels	6,215.43	1,375.81	0.14							13.60	82.59	546.16	25.18
1. Solid Fuels	519.42	895.22	0.00							0.41	35.63	0.31	17.49
2. Oil and Natural Gas	5,696.02	480.59	0.14							13.19	46.97	545.85	7.69
2. Industrial Processes	**13,215.55**	**9.48**	**80.02**	**11.88**	**11,853.70**	**82.77**	**1,170.92**	**0.10**	**0.05**	**8.77**	**261.84**	**247.36**	**46.91**
A. Mineral Products	8,611.32	0.91	IE,NO							IE,NE,NO	4.31	12.62	3.46
B. Chemical Industry	2,920.52	8.03	79.99	NO	NO	NO	NO	NO	NO	7.68	79.52	155.67	35.85
C. Metal Production	1,683.72	0.53	0.03				1,095.57		0.02	1.09	178.01	1.55	7.60
D. Other Production	NE									NE	NE	77.52	NE
E. Production of Halocarbons and SF_6					11,841.76		10.91		NA,NO				
F. Consumption of Halocarbons and SF_6				11.88	11.94	82.77	64.44	0.10	0.03				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE**							**NO**	**NO**	**630.92**	**NO**
4. Agriculture		**1,042.96**	**104.97**							**7.76**	**227.78**	**22.52**	**NO**
A. Enteric Fermentation		862.45											
B. Manure Management		169.66	6.93									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils		NE	97.60									NO	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		10.85	0.21							7.76	227.78	22.52	
G. Other		NA	0.23							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**2,840.89**	**0.90**	**0.03**							**0.22**	**7.91**	**NA,NO**	**NA**
A. Forest Land	-12,635.55	0.35	0.02							0.09	3.02	NO	
B. Cropland	15,978.23	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-6,074.88	0.16	0.00							0.04	1.37	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	6,989.43	0.40	0.00							0.10	3.52	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	-1,416.34	NE	NE							NE	NE	NA	NA
6. Waste	**1,200.45**	**2,375.80**	**3.45**							**6.07**	**23.35**	**29.92**	**7.20**
A. Solid Waste Disposal on Land	NA,NE,NO	2,337.78								NA,NE	NA,NE	23.29	
B. Waste-water Handling		31.67	3.30							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	1,200.45	6.35	0.15							6.07	23.35	6.63	7.20
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*	**24.16**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**37,510.75**	**0.60**	**1.15**							**221.86**	**27.39**	**11.83**	**88.31**
Aviation	30,950.51	0.50	0.98							72.99	12.15	4.62	3.93
Marine	6,560.24	0.10	0.16							148.87	15.24	7.21	84.38
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**3,138.43**												

Table A 9.1.3: SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 1992

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**584,328.24**	**4,866.78**	**187.29**	**13.02**	**12,323.17**	**93.79**	**573.62**	**0.10**	**0.05**	**6,238.96**	**26,751.26**	**4,861.07**	**6,519.97**
1. Energy	**568,408.75**	**1,489.58**	**19.58**							**6,219.48**	**26,305.50**	**3,970.90**	**6,469.49**
A. Fuel Combustion — Reference Approach	569,364.79												
Sectoral Approach	561,838.72	126.27	19.43							6,205.97	26,250.85	3,420.66	6,445.54
1. Energy Industries	226,173.10	9.76	6.27							1,014.17	165.20	10.36	3,674.68
2. Manufacturing Industries and Construction	95,985.91	14.48	5.14							728.20	736.77	27.09	1,851.09
3. Transport	117,858.15	31.28	4.86							3,926.25	22,581.39	3,270.57	272.12
4. Other Sectors	117,734.77	70.64	3.04							499.43	2,757.23	110.20	638.51
5. Other	4,086.79	0.11	0.12							37.93	10.26	2.44	9.15
B. Fugitive Emissions from Fuels	6,570.04	1,363.32	0.15							13.51	54.65	550.24	23.95
1. Solid Fuels	450.00	887.17	0.00							0.35	32.44	0.28	16.04
2. Oil and Natural Gas	6,120.04	476.14	0.15							13.16	22.20	549.96	7.91
2. Industrial Processes	**12,451.74**	**9.92**	**65.07**	**13.02**	**12,323.17**	**93.79**	**573.62**	**0.10**	**0.05**	**7.81**	**251.79**	**245.74**	**43.41**
A. Mineral Products	8,023.20	0.82	IE,NO							IE,NE,NO	3.86	12.54	3.10
B. Chemical Industry	2,978.08	8.64	65.04	NO	NO	NO	NO	NO	NO	6.87	78.76	154.05	33.26
C. Metal Production	1,450.46	0.46	0.03				490.38		0.02	0.94	169.18	1.50	7.06
D. Other Production	NE									NE	NE	77.64	NE
E. Production of Halocarbons and SF_6					12,310.08		10.96		NA,NO				
F. Consumption of Halocarbons and SF_6				13.02	13.09	93.79	72.27	0.10	0.03				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE**							**NO**	**NO**	**598.37**	**NO**
4. Agriculture		**1,046.19**	**99.13**							**5.63**	**165.25**	**16.72**	**NO**
A. Enteric Fermentation		868.64											
B. Manure Management		169.68	6.45									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils		NE	92.30									NO	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		7.87	0.16							5.63	165.25	16.72	
G. Other		NA	0.23							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**2,284.79**	**0.62**	**0.03**							**0.15**	**5.41**	**NA,NO**	**NA**
A. Forest Land	-13,320.03	0.09	0.02							0.02	0.77	NO	
B. Cropland	15,983.46	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-6,177.50	0.17	0.00							0.04	1.50	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	6,907.44	0.36	0.00							0.09	3.15	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	-1,108.57	NE	NE							NE	NE	NA	NA
6. Waste	**1,159.24**	**2,320.47**	**3.48**							**5.88**	**23.31**	**29.33**	**7.07**
A. Solid Waste Disposal on Land	NA,NE,NO	2,279.20								NA,NE	NA,NE	22.70	
B. Waste-water Handling		35.17	3.34							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	1,159.24	6.09	0.15							5.88	23.31	6.63	7.07
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*	**23.71**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**41,102.37**	**0.58**	**1.26**							**236.31**	**28.94**	**12.20**	**92.58**
Aviation	34,229.83	0.47	1.09							80.04	12.94	4.63	5.43
Marine	6,872.54	0.11	0.17							156.28	16.00	7.57	87.14
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**3,553.92**												

Table A 9.1.4 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 1993

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**569,404.99**	**4,720.39**	**172.65**	**631.79**	**13,012.72**	**106.82**	**490.75**	**0.10**	**0.05**	**5,955.30**	**24,866.81**	**4,534.61**	**6,042.97**
1. Energy	**554,741.80**	**1,411.79**	**19.38**							**5,942.58**	**24,577.40**	**3,683.49**	**5,996.51**
A. Fuel Combustion — Reference Approach	552,117.10												
Sectoral Approach	547,853.74	123.95	19.22							5,929.05	24,523.88	3,153.80	5,972.95
1. Energy Industries	208,301.29	9.96	5.52							872.24	149.41	9.84	3,210.22
2. Manufacturing Industries and Construction	95,180.71	14.51	4.93							701.12	730.27	27.38	1,831.35
3. Transport	119,048.27	29.51	5.55							3,812.70	20,835.59	3,004.57	255.76
4. Other Sectors	121,182.53	69.86	3.10							507.90	2,798.17	109.67	667.52
5. Other	4,140.93	0.12	0.12							35.09	10.44	2.34	8.10
B. Fugitive Emissions from Fuels	6,888.07	1,287.83	0.16							13.53	53.52	529.68	23.56
1. Solid Fuels	344.83	825.64	0.00							0.39	30.36	0.27	15.43
2. Oil and Natural Gas	6,543.24	462.19	0.16							13.14	23.15	529.42	8.13
2. Industrial Processes	**12,439.90**	**8.71**	**52.44**	**631.79**	**13,012.72**	**106.82**	**490.75**	**0.10**	**0.05**	**6.99**	**257.10**	**240.00**	**41.16**
A. Mineral Products	8,053.44	0.69	IE,NO							IE,NE,NO	3.24	12.09	2.61
B. Chemical Industry	3,021.49	7.59	52.42	NO	NO	NO	NO	NO	NO	6.06	80.92	148.32	31.49
C. Metal Production	1,364.97	0.44	0.03				381.33		0.02	0.93	172.94	1.49	7.06
D. Other Production	NE									NE	NE	78.09	NE
E. Production of Halocarbons and SF_6					12,779.93		27.23		NA,NO				
F. Consumption of Halocarbons and SF_6				631.79	232.79	106.82	82.20	0.10	0.03				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE**							**NO**	**NO**	**581.87**	**NO**
4. Agriculture		**1,038.56**	**97.34**							**0.12**	**3.53**	**0.47**	**NO**
A. Enteric Fermentation		867.46											
B. Manure Management		170.94	6.51									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils		NE	90.61									NO	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		0.17	0.00							0.12	3.53	0.47	
G. Other		NA	0.22							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**1,123.70**	**0.63**	**0.02**							**0.16**	**5.48**	**NA,NO**	**NA**
A. Forest Land	-13,678.57	0.15	0.02							0.04	1.35	NO	
B. Cropland	15,566.14	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-6,609.50	0.13	0.00							0.03	1.15	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	6,848.20	0.34	0.00							0.08	2.99	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	-1,002.57	NE	NE							NE	NE	NA	NA
6. Waste	**1,075.87**	**2,260.70**	**3.46**							**5.46**	**23.30**	**28.79**	**5.30**
A. Solid Waste Disposal on Land	NA,NE,NO	2,220.43								NA,NE	NA,NE	22.12	
B. Waste-water Handling		34.87	3.32							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	1,075.87	5.41	0.15							5.46	23.30	6.68	5.30
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*	**23.72**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**43,239.95**	**0.55**	**1.33**							**239.58**	**29.42**	**12.16**	**91.67**
Aviation	36,448.52	0.45	1.16							85.14	13.61	4.69	4.63
Marine	6,791.44	0.11	0.17							154.45	15.81	7.48	87.04
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**3,705.44**												

Table A 9.1.5 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 1994

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
					P	A	P	A	P	A				
		(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals		**563,359.50**	**4,387.63**	**177.01**	**2,532.59**	**14,056.80**	**122.25**	**490.69**	**0.09**	**0.05**	**5,681.14**	**22,543.82**	**4,240.65**	**5,061.38**
1. Energy		**547,770.36**	**1,116.03**	**20.45**							**5,670.37**	**22,252.58**	**3,401.85**	**5,012.86**
A. Fuel Combustion	Reference Approach	545,903.62												
	Sectoral Approach	540,663.97	110.14	20.28							5,656.83	22,197.73	2,867.98	4,990.20
1. Energy Industries		205,584.42	11.37	5.48							824.20	154.17	10.30	2,695.43
2. Manufacturing Industries and Construction		95,657.97	15.24	4.96							680.97	774.90	29.20	1,467.08
3. Transport		119,198.18	27.63	6.79							3,629.54	18,995.01	2,728.84	277.72
4. Other Sectors		116,263.59	55.79	2.94							489.29	2,263.66	97.43	542.25
5. Other		3,959.80	0.11	0.12							32.84	10.00	2.21	7.72
B. Fugitive Emissions from Fuels		7,106.39	1,005.89	0.17							13.54	54.85	533.87	22.66
1. Solid Fuels		163.25	547.72	0.00							0.44	30.84	0.27	14.31
2. Oil and Natural Gas		6,943.14	458.16	0.16							13.10	24.01	533.60	8.35
2. Industrial Processes		**13,728.38**	**10.28**	**53.05**	**2,532.59**	**14,056.80**	**122.25**	**490.69**	**0.09**	**0.05**	**6.18**	**263.30**	**233.28**	**44.24**
A. Mineral Products		9,029.83	0.77	IE,NO							IE,NE,NO	3.65	12.61	5.45
B. Chemical Industry		3,059.19	8.95	53.02	NO	NO	NO	NO	NO	NO	5.26	85.66	140.00	31.85
C. Metal Production		1,639.35	0.56	0.03				345.16		0.02	0.91	173.99	1.54	6.94
D. Other Production		NE									NE	NE	79.12	NE
E. Production of Halocarbons and SF_6						13,264.93		49.01		NA,NO				
F. Consumption of Halocarbons and SF_6					2,532.59	791.87	122.25	96.52	0.09	0.03				
G. Other		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use		**IE,NE**		**IE,NE**							**NO**	**NO**	**577.22**	**NO**
4. Agriculture			**1,044.10**	**99.77**							**NA,NO**	**NA,NO**	**NA,NO**	**NO**
A. Enteric Fermentation			872.00											
B. Manure Management			172.09	6.62									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils			NE	92.93									NO	
E. Prescribed Burning of Savannas			NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues			NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other			NA	0.23							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry		**916.58**	**0.61**	**0.02**							**0.15**	**5.32**	**NA,NO**	**NA**
A. Forest Land		-14,164.06	0.12	0.01							0.03	1.07	NO	
B. Cropland		15,618.32	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland		-6,547.73	0.14	0.00							0.03	1.22	NO	
D. Wetlands		IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements		6,803.12	0.35	0.00							0.09	3.03	NO	
F. Other Land		NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other		-793.07	NE	NE							NE	NE	NA	NA
6. Waste		**921.54**	**2,216.62**	**3.72**							**4.44**	**22.62**	**28.31**	**4.27**
A. Solid Waste Disposal on Land		NA,NE,NO	2,176.26								NA,NE	NA,NE	21.67	
B. Waste-water Handling			36.38	3.60							NA,NE	NA,NE	NA,NE	
C. Waste Incineration		921.54	3.98	0.12							4.44	22.62	6.64	4.27
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*		**22.65**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:														
International Bunkers		**44,293.51**	**0.50**	**1.36**							**233.19**	**28.05**	**11.49**	**83.45**
Aviation		37,934.79	0.40	1.20							88.63	13.26	4.49	6.02
Marine		6,358.72	0.10	0.16							144.56	14.80	7.00	77.43
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**4,914.03**												

Table A 9.1.6 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 1995

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**554,593.27**	**4,341.05**	**173.38**	**5,520.32**	**15,587.67**	**140.50**	**470.89**	**0.10**	**0.05**	**5,309.70**	**20,155.54**	**3,816.91**	**4,067.81**
1. Energy	**538,283.68**	**1,157.34**	**21.71**							**5,301.95**	**19,850.19**	**3,011.81**	**4,011.93**
A. Fuel Combustion — Reference Approach	543,457.24												
Sectoral Approach	529,644.75	95.50	21.51							5,287.60	19,795.13	2,556.96	3,994.54
1. Energy Industries	203,232.49	11.40	5.37							730.63	150.48	10.37	2,342.31
2. Manufacturing Industries and Construction	92,301.96	15.51	4.82							585.17	770.45	29.49	1,004.68
3. Transport	118,178.93	25.56	8.48							3,470.49	17,169.24	2,429.13	229.19
4. Other Sectors	112,045.21	42.92	2.72							468.28	1,695.17	85.77	410.72
5. Other	3,886.18	0.11	0.12							33.03	9.80	2.20	7.64
B. Fugitive Emissions from Fuels	8,638.92	1,061.84	0.20							14.35	55.06	454.86	17.40
1. Solid Fuels	225.84	599.65	0.00							0.47	30.89	0.26	10.79
2. Oil and Natural Gas	8,413.09	462.19	0.20							13.88	24.17	454.59	6.61
2. Industrial Processes	**14,159.18**	**8.31**	**47.99**	**5,520.32**	**15,587.67**	**140.50**	**470.89**	**0.10**	**0.05**	**3.34**	**270.73**	**240.37**	**51.70**
A. Mineral Products	9,155.67	0.77	IE,NO							IE,NE,NO	3.64	11.93	9.67
B. Chemical Industry	3,065.28	6.84	47.95	NO	NO	NO	NO	NO	NO	2.40	87.75	147.76	35.12
C. Metal Production	1,938.24	0.70	0.03				286.29		0.02	0.94	179.34	1.59	6.90
D. Other Production	NE									NE	NE	79.09	NE
E. Production of Halocarbons and SF_6					13,980.68		70.79		NA,NO				
F. Consumption of Halocarbons and SF_6				5,520.32	1,606.99	140.50	113.81	0.10	0.03				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE**							**NO**	**NO**	**537.13**	**NO**
4. Agriculture		**1,030.73**	**100.17**							**NA,NO**	**NA,NO**	**NA,NO**	**NO**
A. Enteric Fermentation		862.48											
B. Manure Management		168.25	6.47									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils		NE	93.47									NO	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other		NA	0.23							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**1,242.37**	**1.41**	**0.02**							**0.35**	**12.31**	**NA,NO**	**NA**
A. Forest Land	-13,727.88	0.96	0.02							0.24	8.38	NO	
B. Cropland	15,749.94	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-6,460.78	0.16	0.00							0.04	1.36	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	6,722.26	0.29	0.00							0.07	2.57	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	-1,041.17	NE	NE							NE	NE	NA	NA
6. Waste	**887.46**	**2,143.27**	**3.49**							**4.06**	**22.30**	**27.61**	**4.18**
A. Solid Waste Disposal on Land	NA,NE,NO	2,104.71								NA,NE	NA,NE	20.99	
B. Waste-water Handling		34.75	3.37							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	887.46	3.81	0.12							4.06	22.30	6.62	4.18
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*	**20.58**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**47,147.42**	**0.49**	**1.45**							**248.80**	**29.59**	**12.10**	**93.18**
Aviation	40,340.47	0.39	1.28							93.99	13.75	4.60	5.12
Marine	6,806.95	0.11	0.17							154.81	15.84	7.49	88.06
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**5,239.55**												

Table A 9.1.7 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 1996

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**576,803.37**	**4,226.07**	**171.22**	**9,330.51**	**16,956.71**	**162.12**	**493.47**	**0.06**	**0.05**	**5,141.10**	**18,767.77**	**3,503.52**	**3,641.72**
1. Energy	**560,136.72**	**1,103.70**	**19.28**							**5,133.36**	**18,464.87**	**2,716.46**	**3,586.95**
A. Fuel Combustion — Reference Approach	555,725.73												
Sectoral Approach	550,873.35	98.43	19.08							5,121.95	18,410.83	2,288.11	3,568.34
1. Energy Industries	205,348.80	12.21	5.18							688.30	152.97	11.06	2,143.60
2. Manufacturing Industries and Construction	93,437.69	16.01	4.70							533.03	786.17	29.62	824.51
3. Transport	122,971.34	24.10	6.30							3,349.73	15,687.54	2,156.65	176.80
4. Other Sectors	125,310.54	46.00	2.79							517.84	1,774.57	88.60	415.74
5. Other	3,804.99	0.11	0.11							33.05	9.59	2.18	7.69
B. Fugitive Emissions from Fuels	9,263.36	1,005.27	0.20							11.40	54.03	428.35	18.61
1. Solid Fuels	366.77	556.22	0.00							0.45	30.87	0.26	11.49
2. Oil and Natural Gas	8,896.60	449.05	0.20							10.95	23.16	428.09	7.12
2. Industrial Processes	**14,742.07**	**9.51**	**47.69**	**9,330.51**	**16,956.71**	**162.12**	**493.47**	**0.06**	**0.05**	**3.21**	**271.13**	**234.24**	**52.03**
A. Mineral Products	9,443.12	0.72	IE,NO							IE,NE,NO	3.40	10.69	10.16
B. Chemical Industry	3,073.51	8.00	47.65	NO	NO	NO	NO	NO	NO	2.25	84.86	140.60	34.67
C. Metal Production	2,225.45	0.79	0.03				282.17		0.02	0.96	182.87	1.66	7.19
D. Other Production	NE									NE	NE	81.28	NE
E. Production of Halocarbons and SF_6					14,320.56		77.13		NA,NO				
F. Consumption of Halocarbons and SF_6				9,330.51	2,636.15	162.12	134.17	0.06	0.04				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE**							**NO**	**NO**	**525.91**	**NO**
4. Agriculture		**1,038.79**	**100.62**							**NA,NO**	**NA,NO**	**NA,NO**	**NO**
A. Enteric Fermentation		869.88											
B. Manure Management		168.91	6.46									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils		NE	93.94									NO	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other		NA	0.23							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**1,000.44**	**1.02**	**0.02**							**0.25**	**8.91**	**NA,NO**	**NA**
A. Forest Land	-13,604.66	0.50	0.01							0.12	4.36	NO	
B. Cropland	15,787.97	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-6,704.72	0.18	0.00							0.05	1.60	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	6,707.07	0.34	0.00							0.08	2.96	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	-1,185.22	NE	NE							NE	NE	NA	NA
6. Waste	**902.50**	**2,073.06**	**3.61**							**4.28**	**22.86**	**26.90**	**2.75**
A. Solid Waste Disposal on Land	NA,NE,NO	2,033.22								NA,NE	NA,NE	20.27	
B. Waste-water Handling		35.69	3.48							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	902.50	4.15	0.13							4.28	22.86	6.63	2.75
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*	**21.65**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**50,210.38**	**0.51**	**1.55**							**269.57**	**31.80**	**13.06**	**101.18**
Aviation	42,762.65	0.39	1.36							100.19	14.46	4.86	5.43
Marine	7,447.73	0.12	0.19							169.39	17.34	8.20	95.75
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**5,478.57**												

Table A 9.1.8: SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 1997

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
					P	A	P	A	P	A				
		(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals		**553,123.91**	**3,997.19**	**174.72**	**14,222.10**	**19,561.47**	**187.70**	**417.07**	**0.05**	**0.05**	**4,752.81**	**16,818.94**	**3,215.68**	**2,698.23**
1. Energy		**537,026.65**	**1,050.00**	**18.70**							**4,746.98**	**16,508.97**	**2,463.05**	**2,641.90**
A. Fuel Combustion	Reference Approach	532,077.94												
	Sectoral Approach	529,592.38	93.36	18.52							4,742.20	16,459.74	2,013.73	2,623.07
1. Energy Industries		192,119.39	12.30	4.71							537.01	81.06	8.27	1,444.76
2. Manufacturing Industries and Construction		93,437.93	16.62	4.57							487.39	769.33	29.69	654.75
3. Transport		124,400.81	22.05	6.39							3,200.55	13,915.29	1,888.46	146.23
4. Other Sectors		116,003.53	42.29	2.74							483.18	1,684.97	85.13	369.09
5. Other		3,630.71	0.10	0.11							34.06	9.11	2.18	8.23
B. Fugitive Emissions from Fuels		7,434.27	956.64	0.18							4.78	49.22	449.32	18.84
1. Solid Fuels		459.63	532.68	0.00							0.38	30.86	0.26	11.40
2. Oil and Natural Gas		6,974.65	423.96	0.18							4.40	18.36	449.06	7.44
2. Industrial Processes		**14,863.76**	**8.02**	**48.29**	**14,222.10**	**19,561.47**	**187.70**	**417.07**	**0.05**	**0.05**	**3.58**	**277.69**	**215.80**	**55.21**
A. Mineral Products		10,289.48	0.71	IE,NO							IE,NE,NO	3.35	10.13	13.41
B. Chemical Industry		2,612.38	6.62	48.26	NO	NO	NO	NO	NO	NO	2.60	85.77	124.25	32.30
C. Metal Production		1,961.90	0.69	0.03				220.26		0.02	0.98	188.57	1.69	9.49
D. Other Production		NE									NE	NE	79.73	NE
E. Production of Halocarbons and SF_6						15,622.21		38.32		NA,NO				
F. Consumption of Halocarbons and SF_6					14,222.10	3,939.26	187.70	158.49	0.05	0.03				
G. Other		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use		**IE,NE**		**IE,NE**							**NO**	**NO**	**511.59**	**NO**
4. Agriculture			**1,028.87**	**103.76**							**NA,NO**	**NA,NO**	**NA,NO**	**NO**
A. Enteric Fermentation			858.35											
B. Manure Management			170.52	6.52									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils			NE	97.02									NO	
E. Prescribed Burning of Savannas			NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues			NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other			NA	0.23							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry		**693.15**	**1.20**	**0.02**							**0.30**	**10.48**	**NA,NO**	**NA**
A. Forest Land		-13,360.12	0.65	0.01							0.16	5.72	NO	
B. Cropland		15,529.82	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland		-6,821.67	0.15	0.00							0.04	1.33	NO	
D. Wetlands		IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements		6,709.90	0.39	0.00							0.10	3.44	NO	
F. Other Land		NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other		-1,364.77	NE	NE							NE	NE	NA	NA
6. Waste		**516.67**	**1,909.11**	**3.94**							**1.95**	**21.80**	**25.25**	**1.11**
A. Solid Waste Disposal on Land		NA,NE,NO	1,872.15								NA,NE	NA,NE	18.66	
B. Waste-water Handling			36.63	3.87							NA,NE	NA,NE	NA,NE	
C. Waste Incineration		516.67	0.33	0.07							1.95	21.80	6.59	1.11
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)***		**23.67**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:														
International Bunkers		**53,809.31**	**0.50**	**1.65**							**295.78**	**34.33**	**14.19**	**119.92**
Aviation		45,463.69	0.37	1.44							106.43	14.95	5.02	7.22
Marine		8,345.62	0.13	0.21							189.36	19.38	9.17	112.70
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**5,761.72**												

Table A 9.1.9 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 1998

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs P	HFCs A	PFCs P	PFCs A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**555,237.32**	**3,788.69**	**172.84**	**20,029.78**	**17,604.02**	**193.40**	**412.04**	**0.05**	**0.05**	**4,576.11**	**15,166.86**	**2,868.55**	**2,448.67**
1. Energy	**539,767.47**	**962.80**	**18.83**							**4,570.93**	**14,879.97**	**2,153.34**	**2,395.57**
A. Fuel Combustion — Reference Approach	539,140.32												
Sectoral Approach	532,704.55	93.66	18.65							4,566.71	14,831.55	1,747.15	2,384.73
1. Energy Industries	196,826.91	13.52	4.96							528.69	100.35	5.41	1,466.31
2. Manufacturing Industries and Construction	91,721.13	16.08	4.45							461.98	731.42	29.53	506.92
3. Transport	123,678.11	20.14	6.50							3,066.86	12,302.18	1,624.71	119.22
4. Other Sectors	117,284.39	43.83	2.64							483.39	1,689.53	85.74	286.26
5. Other	3,194.00	0.09	0.10							25.79	8.07	1.76	6.03
B. Fugitive Emissions from Fuels	7,062.92	869.13	0.18							4.22	48.42	406.19	10.83
1. Solid Fuels	158.41	454.48	0.00							0.38	30.75	0.26	9.46
2. Oil and Natural Gas	6,904.51	414.65	0.18							3.84	17.68	405.93	1.37
2. Industrial Processes	**14,847.57**	**6.14**	**49.19**	**20,029.78**	**17,604.02**	**193.40**	**412.04**	**0.05**	**0.05**	**3.04**	**255.50**	**196.01**	**51.87**
A. Mineral Products	10,248.30	0.71	IE,NO							IE,NE,NO	3.35	9.93	13.09
B. Chemical Industry	2,812.40	4.80	49.16	NO	NO	NO	NO	NO	NO	2.49	68.20	104.80	30.37
C. Metal Production	1,786.87	0.63	0.03				208.07		0.02	0.55	183.95	1.65	8.42
D. Other Production	NE									NE	NE	79.63	NE
E. Production of Halocarbons and SF_6					12,117.13		42.50		NA,NO				
F. Consumption of Halocarbons and SF_6				20,029.78	5,486.89	193.40	161.48	0.05	0.03				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE**							**NO**	**NO**	**495.05**	**NO**
4. Agriculture		**1,027.24**	**100.82**							**NA,NO**	**NA,NO**	**NA,NO**	**NO**
A. Enteric Fermentation		856.35											
B. Manure Management		170.89	6.70									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils		NE	93.89									NO	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other		NA	0.23							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**77.02**	**0.91**	**0.02**							**0.23**	**7.94**	**NA,NO**	**NA**
A. Forest Land	-13,321.59	0.36	0.01							0.09	3.17	NO	
B. Cropland	15,417.91	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-7,219.86	0.16	0.00							0.04	1.39	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	6,669.02	0.39	0.00							0.10	3.38	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	-1,468.47	NE	NE							NE	NE	NA	NA
6. Waste	**521.34**	**1,791.60**	**3.98**							**1.91**	**23.45**	**24.15**	**1.23**
A. Solid Waste Disposal on Land	NA,NE,NO	1,753.66								NA,NE	NA,NE	17.48	
B. Waste-water Handling		37.58	3.82							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	521.34	0.37	0.16							1.91	23.45	6.67	1.23
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*	**23.93**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**59,711.42**	**0.51**	**1.83**							**324.58**	**37.34**	**15.37**	**121.61**
Aviation	50,590.46	0.37	1.61							118.09	16.21	5.37	8.03
Marine	9,120.96	0.14	0.23							206.49	21.13	10.00	113.58
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**5,823.07**												

Table A 9.1.10 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 1999

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**544,638.02**	**3,539.34**	**138.46**	**25,577.50**	**11,086.05**	**224.58**	**396.03**	**0.05**	**0.06**	**4,248.26**	**13,727.88**	**2,505.55**	**1,855.20**
1. Energy	**529,688.52**	**870.50**	**18.32**							**4,242.99**	**13,421.55**	**1,856.14**	**1,812.35**
A. Fuel Combustion — Reference Approach	533,063.80												
Sectoral Approach	523,667.73	94.02	18.15							4,238.40	13,383.58	1,498.24	1,802.62
1. Energy Industries	187,038.19	13.27	4.49							486.22	94.24	5.36	1,146.56
2. Manufacturing Industries and Construction	92,329.96	15.72	4.44							420.31	710.14	28.83	327.67
3. Transport	124,440.92	18.28	6.51							2,824.88	10,805.80	1,375.50	87.94
4. Other Sectors	116,709.03	46.66	2.61							479.55	1,765.47	86.74	234.12
5. Other	3,149.63	0.09	0.09							27.45	7.93	1.81	6.32
B. Fugitive Emissions from Fuels	6,020.80	776.49	0.17							4.59	37.97	357.90	9.74
1. Solid Fuels	112.08	380.84	0.00							0.32	23.94	0.26	8.01
2. Oil and Natural Gas	5,908.71	395.65	0.17							4.27	14.03	357.64	1.73
2. Industrial Processes	**14,647.27**	**5.35**	**17.31**	**25,577.50**	**11,086.05**	**224.58**	**396.03**	**0.05**	**0.06**	**3.26**	**275.47**	**165.40**	**41.41**
A. Mineral Products	9,709.73	0.59	IE,NO							IE,NE,NO	1.56	8.57	8.94
B. Chemical Industry	2,846.55	4.03	17.28	NO	NO	NO	NO	NO	NO	2.69	64.98	74.27	24.99
C. Metal Production	2,090.98	0.73	0.03				187.75		0.03	0.57	208.94	1.57	7.48
D. Other Production	NE									NE	NE	81.00	NE
E. Production of Halocarbons and SF_6					4,881.55		19.50		NA,NO				
F. Consumption of Halocarbons and SF_6				25,577.50	6,204.50	224.58	188.78	0.05	0.03				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE**							**NO**	**NO**	**461.37**	**NO**
4. Agriculture		**1,021.38**	**98.97**							**NA,NO**	**NA,NO**	**NA,NO**	**NO**
A. Enteric Fermentation		855.87											
B. Manure Management		165.51	6.94									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils		NE	91.80									NO	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other		NA	0.23							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**-201.67**	**0.83**	**0.01**							**0.21**	**7.28**	**NA,NO**	**NA**
A. Forest Land	-13,489.27	0.06	0.01							0.01	0.50	NO	
B. Cropland	15,320.53	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-7,124.11	0.39	0.00							0.10	3.43	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	6,604.51	0.38	0.00							0.10	3.35	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	-1,513.34	NE	NE							NE	NE	NA	NA
6. Waste	**480.35**	**1,641.28**	**3.85**							**1.81**	**23.58**	**22.64**	**1.44**
A. Solid Waste Disposal on Land	NA,NE,NO	1,604.45								NA,NE	NA,NE	15.98	
B. Waste-water Handling		36.44	3.70							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	480.35	0.38	0.16							1.81	23.58	6.65	1.44
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)***	**23.55**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**61,642.20**	**0.43**	**1.91**							**277.25**	**32.57**	**12.85**	**87.86**
Aviation	54,977.15	0.33	1.75							126.67	17.16	5.56	6.11
Marine	6,665.05	0.10	0.17							150.58	15.41	7.29	81.75
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**6,410.95**												

Table A 9.1.11 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 2000

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**552,766.28**	**3,325.79**	**135.29**	**32,769.99**	**9,987.88**	**260.51**	**498.07**	**0.08**	**0.08**	**4,010.18**	**11,024.10**	**2,157.59**	**1,758.50**
1. Energy	**538,380.65**	**792.39**	**18.44**							**4,005.08**	**10,711.85**	**1,549.12**	**1,722.13**
A. Fuel Combustion — Reference Approach	543,271.21												
Sectoral Approach	532,662.30	80.43	18.29							4,001.88	10,674.42	1,193.34	1,713.27
1. Energy Industries	197,567.53	12.55	4.95							514.91	106.06	6.66	1,173.71
2. Manufacturing Industries and Construction	92,144.39	15.15	4.35							394.82	593.67	28.26	301.46
3. Transport	123,681.45	16.24	6.46							2,598.26	8,609.95	1,079.57	50.84
4. Other Sectors	116,352.62	36.42	2.46							467.46	1,357.42	77.15	181.09
5. Other	2,916.31	0.08	0.09							26.42	7.33	1.71	6.16
B. Fugitive Emissions from Fuels	5,718.35	711.96	0.15							3.20	37.42	355.78	8.86
1. Solid Fuels	102.36	333.43	0.00							0.31	24.42	0.20	7.31
2. Oil and Natural Gas	5,615.99	378.53	0.15							2.89	13.00	355.58	1.55
2. Industrial Processes	**14,219.98**	**5.04**	**17.90**	**32,769.99**	**9,987.88**	**260.51**	**498.07**	**0.08**	**0.08**	**2.95**	**278.38**	**156.09**	**35.18**
A. Mineral Products	9,208.41	0.59	IE,NO							IE,NE,NO	2.75	9.79	10.51
B. Chemical Industry	3,028.83	3.78	17.87	NO	NO	NO	NO	NO	NO	2.43	82.48	65.64	17.73
C. Metal Production	1,982.75	0.68	0.03				257.46		0.05	0.52	193.15	1.42	6.94
D. Other Production	NE									NE	NE	79.24	NE
E. Production of Halocarbons and SF_6					2,619.64		23.08		NA,NO				
F. Consumption of Halocarbons and SF_6				32,769.99	7,368.24	260.51	217.53	0.08	0.03				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE**							**NO**	**NO**	**430.72**	**NO**
4. Agriculture		**985.03**	**94.96**							**NA,NO**	**NA,NO**	**NA,NO**	**NO**
A. Enteric Fermentation		827.81											
B. Manure Management		157.22	6.37									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils		NE	88.36									NO	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other		NA	0.23							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**-339.44**	**1.19**	**0.02**							**0.29**	**10.37**	**NA,NO**	**NA**
A. Forest Land	-13,755.67	0.20	0.01							0.05	1.75	NO	
B. Cropland	15,339.05	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-7,221.49	0.59	0.00							0.15	5.15	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	6,566.55	0.40	0.00							0.10	3.47	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	-1,267.88	NE	NE							NE	NE	NA	NA
6. Waste	**486.79**	**1,542.14**	**3.97**							**1.85**	**23.51**	**21.67**	**1.18**
A. Solid Waste Disposal on Land	NA,NE,NO	1,504.43								NA,NE	NA,NE	15.01	
B. Waste-water Handling		37.31	3.81							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	486.79	0.39	0.16							1.85	23.51	6.66	1.18
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*	**18.30**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**66,507.59**	**0.37**	**2.07**							**271.20**	**31.90**	**12.29**	**75.91**
Aviation	60,621.00	0.28	1.92							138.26	18.30	5.86	6.93
Marine	5,886.58	0.09	0.15							132.94	13.61	6.44	68.98
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**6,572.84**												

Table A 9.1.12 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 2001

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**564,271.98**	**3,040.52**	**127.53**	**39,524.16**	**10,725.62**	**157.40**	**419.97**	**0.07**	**0.06**	**3,815.93**	**9,421.26**	**1,902.66**	**1,557.92**
1. Energy	**551,213.10**	**757.77**	**18.48**							**3,810.95**	**9,094.57**	**1,320.38**	**1,525.90**
A. Fuel Combustion — Reference Approach	553,084.27												
Sectoral Approach	545,298.57	74.99	18.33							3,807.58	9,067.87	971.11	1,516.12
1. Energy Industries	207,896.58	13.38	5.21							535.63	105.57	5.56	992.90
2. Manufacturing Industries and Construction	91,880.95	14.00	4.39							395.33	628.96	28.25	322.80
3. Transport	123,349.56	14.27	6.21							2,374.06	7,075.91	862.05	35.26
4. Other Sectors	119,249.58	33.26	2.42							477.65	1,250.07	73.60	159.39
5. Other	2,921.90	0.08	0.09							24.91	7.37	1.66	5.76
B. Fugitive Emissions from Fuels	5,914.54	682.79	0.15							3.38	26.70	349.26	9.78
1. Solid Fuels	101.68	301.86	0.00							0.25	13.68	0.17	8.16
2. Oil and Natural Gas	5,812.86	380.93	0.15							3.13	13.01	349.09	1.62
2. Industrial Processes	**12,994.10**	**4.46**	**15.54**	**39,524.16**	**10,725.62**	**157.40**	**419.97**	**0.07**	**0.06**	**2.17**	**268.97**	**148.54**	**29.70**
A. Mineral Products	8,361.93	0.58	IE,NO							IE,NE,NO	2.54	9.22	9.07
B. Chemical Industry	3,117.14	3.46	15.52	NO	NO	NO	NO	NO	NO	1.62	81.50	57.54	13.45
C. Metal Production	1,515.02	0.42	0.02				217.59		0.03	0.55	184.94	1.27	7.18
D. Other Production	NE									NE	NE	80.50	NE
E. Production of Halocarbons and SF_6					2,387.42		54.05		NA,NO				
F. Consumption of Halocarbons and SF_6				39,524.16	8,338.20	157.40	148.33	0.07	0.03				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE**							**NO**	**NO**	**414.05**	**NO**
4. Agriculture		**926.84**	**89.40**							**NA,NO**	**NA,NO**	**NA,NO**	**NO**
A. Enteric Fermentation		777.24											
B. Manure Management		149.60	6.21									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils		NE	82.95									NO	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other		NA	0.24							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**-460.48**	**1.47**	**0.02**							**0.37**	**12.90**	**NA,NO**	**NA**
A. Forest Land	-14,280.31	0.28	0.01							0.07	2.42	NO	
B. Cropland	15,286.51	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-7,175.78	0.77	0.01							0.19	6.78	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	6,543.21	0.42	0.00							0.11	3.71	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	-834.11	NE	NE							NE	NE	NA	NA
6. Waste	**508.70**	**1,349.97**	**4.08**							**2.44**	**44.81**	**19.69**	**2.33**
A. Solid Waste Disposal on Land	NA,NE,NO	1,312.08								NA,NE	NA,NE	13.08	
B. Waste-water Handling		37.56	3.93							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	508.70	0.33	0.16							2.44	44.81	6.61	2.33
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*	**16.56**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**65,702.49**	**0.33**	**2.04**							**282.68**	**32.53**	**12.75**	**77.53**
Aviation	59,119.35	0.23	1.88							133.91	17.30	5.55	7.51
Marine	6,583.13	0.10	0.16							148.77	15.23	7.20	70.03
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**7,261.41**												

Table A 9.1.13 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 2002

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**546,688.21**	**2,897.35**	**121.81**	**47,865.09**	**11,053.51**	**154.38**	**314.73**	**0.07**	**0.06**	**3,515.95**	**7,904.61**	**1,707.53**	**1,286.22**
1. Energy	**534,750.14**	**738.68**	**18.10**							**3,512.21**	**7,650.25**	**1,143.25**	**1,257.99**
A. Fuel Combustion — Reference Approach	533,588.78												
Sectoral Approach	529,109.67	67.16	17.95							3,508.49	7,630.66	804.48	1,250.98
1. Energy Industries	205,270.50	13.74	5.25							514.91	100.40	6.56	879.49
2. Manufacturing Industries and Construction	83,589.13	12.81	4.28							348.27	567.21	27.09	233.74
3. Transport	125,368.53	12.57	6.03							2,171.44	5,952.28	700.96	31.10
4. Other Sectors	111,824.87	27.96	2.31							450.12	1,003.04	68.22	101.41
5. Other	3,056.63	0.09	0.09							23.75	7.74	1.65	5.25
B. Fugitive Emissions from Fuels	5,640.47	671.51	0.15							3.73	19.59	338.77	7.01
1. Solid Fuels	107.95	301.96	0.00							0.26	7.11	0.13	5.81
2. Oil and Natural Gas	5,532.52	369.55	0.14							3.46	12.48	338.64	1.21
2. Industrial Processes	**12,387.30**	**4.35**	**8.61**	**47,865.09**	**11,053.51**	**154.38**	**314.73**	**0.07**	**0.06**	**1.64**	**219.72**	**144.01**	**27.30**
A. Mineral Products	8,185.79	0.59	IE,NO							IE,NE,NO	2.53	9.60	12.00
B. Chemical Industry	3,029.91	3.47	8.60	NO	NO	NO	NO	NO	NO	1.09	39.07	53.19	9.60
C. Metal Production	1,171.60	0.29	0.02				150.49		0.04	0.54	178.11	1.11	5.69
D. Other Production	NE									NE	NE	80.12	NE
E. Production of Halocarbons and SF_6					2,034.23		57.35		NA,NO				
F. Consumption of Halocarbons and SF_6				47,865.09	9,019.28	154.38	106.88	0.07	0.03				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE**							**NO**	**NO**	**401.75**	**NO**
4. Agriculture		**917.09**	**91.02**							**NA,NO**	**NA,NO**	**NA,NO**	**NO**
A. Enteric Fermentation		769.73											
B. Manure Management		147.36	5.96									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils		NE	84.81									NO	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other		NA	0.25							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**-977.63**	**1.27**	**0.02**							**0.32**	**11.11**	**NA,NO**	**NA**
A. Forest Land	-14,986.41	0.23	0.01							0.06	2.05	NO	
B. Cropland	15,312.53	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-7,511.89	0.67	0.00							0.17	5.89	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	6,474.94	0.36	0.00							0.09	3.17	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	-266.79	NE	NE							NE	NE	NA	NA
6. Waste	**507.84**	**1,235.96**	**4.06**							**1.78**	**23.54**	**18.53**	**0.93**
A. Solid Waste Disposal on Land	NA,NE,NO	1,197.85								NA,NE	NA,NE	11.95	
B. Waste-water Handling		37.78	3.90							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	507.84	0.33	0.16							1.78	23.54	6.58	0.93
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*	**20.56**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**63,552.43**	**0.29**	**1.98**							**255.21**	**29.64**	**11.51**	**67.46**
Aviation	58,018.36	0.21	1.84							130.32	16.86	5.47	6.08
Marine	5,534.07	0.09	0.14							124.89	12.78	6.05	61.38
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**7,506.25**												

Table A 9.1.14 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**558,035.72**	**2,612.34**	**119.89**	**53,012.73**	**11,396.61**	**157.57**	**271.43**	**0.06**	**0.06**	**3,432.06**	**6,787.97**	**1,508.62**	**1,236.96**
1. Energy	**545,343.88**	**598.81**	**17.86**							**3,428.24**	**6,607.39**	**948.74**	**1,206.52**
A. Fuel Combustion — Reference Approach	542,726.12												
Sectoral Approach	539,981.40	64.24	17.73							3,425.30	6,585.94	676.97	1,198.01
1. Energy Industries	212,782.68	13.05	5.30							539.07	107.63	5.45	862.48
2. Manufacturing Industries and Construction	84,638.29	13.65	4.26							352.05	547.80	26.85	199.19
3. Transport	126,774.27	11.09	5.84							2,063.88	5,002.19	576.60	41.33
4. Other Sectors	112,971.03	26.36	2.25							452.28	921.15	66.69	91.25
5. Other	2,815.12	0.08	0.09							18.02	7.18	1.37	3.76
B. Fugitive Emissions from Fuels	5,362.48	534.56	0.13							2.93	21.44	271.77	8.51
1. Solid Fuels	111.87	259.87	0.00							0.28	10.74	0.12	7.28
2. Oil and Natural Gas	5,250.61	274.70	0.12							2.65	10.70	271.65	1.23
2. Industrial Processes	**13,186.82**	**5.56**	**9.10**	**53,012.73**	**11,396.61**	**157.57**	**271.43**	**0.06**	**0.06**	**1.73**	**146.49**	**142.84**	**29.50**
A. Mineral Products	8,369.08	0.62	IE,NO							IE,NE,NO	2.67	9.24	16.37
B. Chemical Industry	2,970.13	4.35	9.08	NO	NO	NO	NO	NO	NO	1.19	36.78	51.87	6.20
C. Metal Production	1,847.60	0.59	0.02				110.91		0.03	0.54	107.04	1.31	6.94
D. Other Production	NE									NE	NE	80.42	NE
E. Production of Halocarbons and SF_6					1,981.33		55.71		NA,NO				
F. Consumption of Halocarbons and SF_6				53,012.73	9,415.28	157.57	104.81	0.06	0.03				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE**							**NO**	**NO**	**400.00**	**NO**
4. Agriculture		**917.70**	**88.84**							**NA,NO**	**NA,NO**	**NA,NO**	**NO**
A. Enteric Fermentation		773.18											
B. Manure Management		144.52	5.87									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils		NE	82.77									NO	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other		NA	0.20							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**-1,029.64**	**1.21**	**0.02**							**0.30**	**10.58**	**NA,NO**	**NA**
A. Forest Land	-15,595.04	0.20	0.01							0.05	1.73	NO	
B. Cropland	15,384.30	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-7,320.87	0.63	0.00							0.16	5.55	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	6,459.58	0.38	0.00							0.09	3.30	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	42.39	NE	NE							NE	NE	NA	NA
6. Waste	**488.25**	**1,089.07**	**4.08**							**1.80**	**23.51**	**17.05**	**0.93**
A. Solid Waste Disposal on Land	NA,NE,NO	1,050.74								NA,NE	NA,NE	10.48	
B. Waste-water Handling		38.01	3.92							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	488.25	0.33	0.16							1.80	23.51	6.57	0.93
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*	**46.42**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**64,772.08**	**0.29**	**2.02**							**253.61**	**29.33**	**11.37**	**70.78**
Aviation	59,431.26	0.21	1.89							133.31	17.02	5.55	7.17
Marine	5,340.82	0.08	0.13							120.30	12.31	5.82	63.61
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**8,365.69**												

Table A 9.1.15 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**557,828.74**	**2,526.05**	**121.56**	**55,907.00**	**9,989.37**	**157.74**	**336.80**	**0.05**	**0.05**	**3,313.40**	**5,949.19**	**1,360.94**	**1,077.12**
1. Energy	**545,458.71**	**583.35**	**17.53**							**3,309.51**	**5,781.32**	**807.06**	**1,047.75**
A. Fuel Combustion — Reference Approach	548,797.00												
Sectoral Approach	540,190.98	62.39	17.40							3,306.59	5,763.81	560.97	1,037.80
1. Energy Industries	211,015.75	13.58	5.12							539.50	109.42	6.22	681.79
2. Manufacturing Industries and Construction	83,090.08	13.30	4.30							356.02	574.90	26.92	218.52
3. Transport	128,230.99	9.82	5.71							1,930.40	4,169.39	458.97	47.30
4. Other Sectors	114,950.94	25.61	2.19							456.60	902.76	67.24	84.64
5. Other	2,903.23	0.08	0.09							24.06	7.33	1.62	5.54
B. Fugitive Emissions from Fuels	5,267.73	520.96	0.13							2.92	17.51	246.09	9.95
1. Solid Fuels	168.08	234.90	0.01							0.36	6.61	0.10	8.60
2. Oil and Natural Gas	5,099.64	286.06	0.13							2.56	10.90	245.99	1.35
2. Industrial Processes	**13,625.48**	**5.36**	**11.53**	**55,907.00**	**9,989.37**	**157.74**	**336.80**	**0.05**	**0.05**	**1.81**	**134.15**	**135.94**	**28.46**
A. Mineral Products	8,497.53	0.61	NE,NO							NE,NO	2.61	9.36	16.55
B. Chemical Industry	3,076.03	4.09	11.51	NO	NO	NO	NO	NO	NO	1.30	27.89	45.03	4.94
C. Metal Production	2,051.92	0.66	0.03				153.04		0.02	0.51	103.65	1.31	6.96
D. Other Production	NO									NE	NE	80.25	NE
E. Production of Halocarbons and SF_6					444.68		90.23		NA,NO				
F. Consumption of Halocarbons and SF_6				55,907.00	9,543.51	157.74	93.53	0.05	0.03				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE,NO**							**NO**	**NO**	**401.51**	**NO**
4. Agriculture		**919.47**	**88.40**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation		775.02											
B. Manure Management		144.45	5.75									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils		NA,NE	82.45									NA,NE	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other		NA	0.20							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**-1,771.16**	**1.18**	**0.01**							**0.29**	**10.35**	**NA,NO**	**NA**
A. Forest Land	-16,238.04	0.26	0.01							0.06	2.29	NO	
B. Cropland	15,315.52	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-7,640.07	0.57	0.00							0.14	4.95	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	6,422.96	0.36	0.00							0.09	3.12	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	368.48	NE	NE							NE	NE	NA	NA
6. Waste	**489.40**	**1,016.69**	**4.08**							**1.78**	**23.36**	**16.42**	**0.91**
A. Solid Waste Disposal on Land	NA,NE,NO	978.14								NA,NE	NA,NE	9.77	
B. Waste-water Handling		38.23	3.92							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	489.40	0.32	0.16							1.78	23.36	6.65	0.91
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*	**26.30**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**71,159.00**	**0.29**	**2.22**							**283.01**	**32.17**	**12.56**	**81.67**
Aviation	65,063.69	0.19	2.07							145.71	18.12	5.92	8.47
Marine	6,095.31	0.09	0.15							137.29	14.05	6.65	73.20
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**9,548.24**												

Table A 9.1.16 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 2005

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
					P	A	P	A	P	A				
		(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals		**555,075.37**	**2,435.54**	**117.63**	**59,610.54**	**10,175.53**	**146.95**	**256.35**	**0.05**	**0.05**	**3,181.82**	**5,096.13**	**1,246.44**	**948.55**
1. Energy		**542,669.53**	**527.63**	**17.38**							**3,178.27**	**4,926.66**	**701.74**	**918.57**
A. Fuel Combustion	Reference Approach	544,554.79												
	Sectoral Approach	536,809.91	58.57	17.23							3,175.13	4,908.13	476.51	909.64
1. Energy Industries		211,060.77	13.06	5.25							546.27	106.07	5.64	559.40
2. Manufacturing Industries and Construction		82,974.46	13.03	4.28							353.69	554.21	26.56	221.93
3. Transport		129,523.45	8.77	5.53							1,816.51	3,421.79	377.18	52.13
4. Other Sectors		110,462.86	23.63	2.08							436.43	819.01	65.60	71.14
5. Other		2,788.38	0.08	0.08							22.21	7.05	1.52	5.05
B. Fugitive Emissions from Fuels		5,859.62	469.06	0.15							3.14	18.53	225.23	8.93
1. Solid Fuels		111.98	194.71	0.00							0.24	6.13	0.11	7.67
2. Oil and Natural Gas		5,747.65	274.35	0.15							2.90	12.40	225.12	1.26
2. Industrial Processes		**13,794.57**	**4.88**	**9.05**	**59,610.54**	**10,175.53**	**146.95**	**256.35**	**0.05**	**0.05**	**1.54**	**137.75**	**129.68**	**29.06**
A. Mineral Products		8,362.34	0.51	NE,NO							NE,NO	4.28	9.62	17.25
B. Chemical Industry		2,975.66	3.52	9.02	NO	NO	NO	NO	NO	NO	1.04	24.60	40.19	3.73
C. Metal Production		2,456.57	0.84	0.03				60.02		0.01	0.50	108.87	1.30	8.08
D. Other Production		NO									NE	NE	78.57	NE
E. Production of Halocarbons and SF_6						442.32		110.28		NA,NO				
F. Consumption of Halocarbons and SF_6					59,610.54	9,731.30	146.95	86.06	0.05	0.04				
G. Other		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use		**IE,NE**		**IE,NE,NO**							**NO**	**NO**	**398.68**	**NO**
4. Agriculture			**896.54**	**87.11**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			757.09											
B. Manure Management			139.45	5.60									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils			NA,NE	81.32									NA,NE	
E. Prescribed Burning of Savannas			NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues			NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other			NA	0.19							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry		**-1,933.61**	**0.96**	**0.01**							**0.24**	**8.43**	**NA,NO**	**NA**
A. Forest Land		-15,721.42	0.06	0.01							0.01	0.49	NO	
B. Cropland		15,233.03	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland		-7,689.08	0.57	0.00							0.14	4.99	NO	
D. Wetlands		IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements		6,384.15	0.34	0.00							0.08	2.95	NO	
F. Other Land		NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other		-140.27	NE	NE							NE	NE	NA	NA
6. Waste		**486.55**	**1,005.52**	**4.08**							**1.76**	**23.29**	**16.34**	**0.91**
A. Solid Waste Disposal on Land		NA,NE,NO	966.75								NA,NE	NA,NE	9.64	
B. Waste-water Handling			38.46	3.92							NA,NE	NA,NE	NA,NE	
C. Waste Incineration		486.55	0.31	0.16							1.76	23.29	6.69	0.91
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*		**58.32**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:														
International Bunkers		**76,282.14**	**0.30**	**2.38**							**294.08**	**33.32**	**12.98**	**87.64**
Aviation		70,183.31	0.20	2.23							156.82	19.27	6.34	9.14
Marine		6,098.83	0.09	0.15							137.26	14.05	6.64	78.50
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**10,800.67**												

Table A 9.1.17 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 2006

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
					P	A	P	A	P	A				
		(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals		**553,055.49**	**2,403.21**	**112.84**	**62,505.72**	**9,980.24**	**146.10**	**301.38**	**0.04**	**0.04**	**3,054.22**	**4,690.04**	**1,166.94**	**948.82**
1. Energy		**541,053.62**	**495.60**	**17.42**							**3,050.76**	**4,481.04**	**629.35**	**919.00**
A. Fuel Combustion	Reference Approach	551,448.54												
	Sectoral Approach	536,031.62	56.72	17.30							3,047.98	4,460.41	415.76	910.30
1. Energy Industries		214,761.56	11.27	5.45							563.20	110.84	6.34	550.42
2. Manufacturing Industries and Construction		81,670.13	13.22	4.33							337.01	556.06	25.81	211.47
3. Transport		131,185.44	7.99	5.44							1,710.76	2,932.57	315.75	64.70
4. Other Sectors		105,667.68	24.17	2.00							415.07	853.99	66.36	78.61
5. Other		2,746.81	0.08	0.08							21.94	6.94	1.50	5.09
B. Fugitive Emissions from Fuels		5,022.00	438.88	0.13							2.78	20.63	213.59	8.70
1. Solid Fuels		138.77	180.42	0.00							0.26	10.01	0.13	7.75
2. Oil and Natural Gas		4,883.23	258.45	0.12							2.51	10.62	213.46	0.95
2. Industrial Processes		**13,312.98**	**4.70**	**7.65**	**62,505.72**	**9,980.24**	**146.10**	**301.38**	**0.04**	**0.04**	**1.49**	**173.22**	**121.67**	**28.91**
A. Mineral Products		8,467.25	0.83	NE,NO							NE,NO	4.67	9.59	18.39
B. Chemical Industry		2,719.78	3.21	7.62	NO	NO	NO	NO	NO	NO	1.00	25.83	32.79	2.97
C. Metal Production		2,125.95	0.66	0.02				128.38		0.01	0.50	142.72	1.36	7.56
D. Other Production		NO									NE	NE	77.93	NE
E. Production of Halocarbons and SF_6						387.47		90.23		NA,NO				
F. Consumption of Halocarbons and SF_6					62,505.72	9,590.59	146.10	82.77	0.04	0.03				
G. Other		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use		**IE,NE**		**IE,NE,NO**							**NO**	**NO**	**399.55**	**NO**
4. Agriculture			**895.47**	**83.57**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			755.06											
B. Manure Management			140.41	5.56									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils			NA,NE	77.81									NA,NE	
E. Prescribed Burning of Savannas			NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues			NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other			NA	0.21							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry		**-1,816.47**	**1.44**	**0.01**							**0.36**	**12.59**	**NA,NO**	**NA**
A. Forest Land		-15,090.61	0.64	0.01							0.16	5.58	NO	
B. Cropland		15,279.27	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland		-7,789.54	0.51	0.00							0.13	4.48	NO	
D. Wetlands		IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements		6,328.71	0.29	0.00							0.07	2.52	NO	
F. Other Land		NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other		-544.29	NE	NE							NE	NE	NA	NA
6. Waste		**446.54**	**1,006.00**	**4.18**							**1.61**	**23.19**	**16.37**	**0.90**
A. Solid Waste Disposal on Land		NA,NE,NO	967.10								NA,NE	NA,NE	9.65	
B. Waste-water Handling			38.59	4.02							NA,NE	NA,NE	NA,NE	
C. Waste Incineration		446.54	0.31	0.16							1.61	23.19	6.72	0.90
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*		**58.81**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:														
International Bunkers		**78,340.97**	**0.31**	**2.44**							**318.15**	**35.61**	**14.14**	**100.16**
Aviation		71,294.69	0.20	2.26							159.52	19.38	6.47	10.98
Marine		7,046.28	0.11	0.18							158.63	16.24	7.68	89.18
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**10,882.11**												

Table A 9.1.18 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A) - 2007

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/removals	CH_4	N_2O	HFCs		PFCs		SF_6		NO_x	CO	NMVOC	SO_2
				P	A	P	A	P	A				
	(Gg)			CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**544,610.09**	**2,329.50**	**110.62**	**64,936.39**	**9,611.19**	**148.36**	**215.60**	**0.04**	**0.03**	**2,835.07**	**4,339.47**	**1,124.20**	**845.47**
1. Energy	**531,505.95**	**442.96**	**16.76**							**2,831.53**	**4,127.36**	**586.63**	**817.89**
A. Fuel Combustion — Reference Approach	540,463.42												
Sectoral Approach	526,276.31	57.49	16.63							2,829.10	4,106.11	378.44	807.69
1. Energy Industries	210,585.66	11.54	5.02							519.06	102.67	5.68	447.92
2. Manufacturing Industries and Construction	79,334.91	12.89	4.30							323.50	532.24	25.21	208.46
3. Transport	131,763.44	7.29	5.27							1,573.48	2,525.46	277.85	61.14
4. Other Sectors	101,103.69	25.67	1.94							389.60	936.86	67.97	85.08
5. Other	3,488.61	0.10	0.11							23.45	8.88	1.74	5.09
B. Fugitive Emissions from Fuels	5,229.64	385.47	0.13							2.42	21.25	208.18	10.19
1. Solid Fuels	137.96	126.20	0.00							0.25	10.00	0.13	9.82
2. Oil and Natural Gas	5,091.68	259.27	0.13							2.17	11.25	208.05	0.37
2. Industrial Processes	**14,395.66**	**5.38**	**8.91**	**64,936.39**	**9,611.19**	**148.36**	**215.60**	**0.04**	**0.03**	**1.61**	**176.09**	**123.34**	**26.67**
A. Mineral Products	8,667.77	0.88	NE,NO							NE,NO	3.45	10.01	15.86
B. Chemical Industry	3,069.92	3.63	8.88	NO	NO	NO	NO	NO	NO	1.11	28.84	32.78	3.14
C. Metal Production	2,657.97	0.87	0.03				81.67		0.01	0.50	143.80	1.39	7.67
D. Other Production	NO									NE	NE	79.16	NE
E. Production of Halocarbons and SF_6					175.60		54.56		NA,NO				
F. Consumption of Halocarbons and SF_6				64,936.39	9,433.25	148.36	79.36	0.04	0.03				
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**IE,NE**		**IE,NE,NO**							**NO**	**NO**	**397.99**	**NO**
4. Agriculture		**877.68**	**80.73**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation		740.89											
B. Manure Management		136.78	5.43									NO	
C. Rice Cultivation		NA,NO										NA,NO	
D. Agricultural Soils(4)		NA,NE	75.10									NA,NE	
E. Prescribed Burning of Savannas		NA	NA							NO	NO	NO	
F. Field Burning of Agricultural Residues		NA,NO	NA,NO							NA,NO	NA,NO	NA,NO	
G. Other		NA	0.20							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	**-1,815.00**	**1.47**	**0.01**							**0.36**	**12.84**	**NA,NO**	**NA**
A. Forest Land	-14,173.38	0.73	0.01							0.18	6.37	NO	
B. Cropland	15,288.35	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	-7,967.05	0.43	0.00							0.11	3.78	NO	
D. Wetlands	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	6,329.81	0.31	0.00							0.08	2.69	NO	
F. Other Land	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	-1,292.74	NE	NE							NE	NE	NA	NA
6. Waste	**464.67**	**1,002.02**	**4.21**							**1.57**	**23.19**	**16.24**	**0.91**
A. Solid Waste Disposal on Land	NA,NE,NO	962.98								NA,NE	NA,NE	9.63	
B. Waste-water Handling		38.73	4.05							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	464.67	0.31	0.16							1.57	23.19	6.61	0.91
D. Other	NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)*	**58.81**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items:													
International Bunkers	**77,088.80**	**0.30**	**2.40**							**317.12**	**35.35**	**14.11**	**104.73**
Aviation	69,937.09	0.18	2.22							156.22	18.88	6.32	9.65
Marine	7,151.71	0.11	0.18							160.90	16.47	7.79	95.07
Multilateral Operations	**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**11,654.34**												

A10 Annex 10: Supplementary information for estimates of greenhouse gas emissions by sources and removals by sinks resulting from activities under Article 3.3 and 3.4 of the Kyoto Protocol

The supplementary information in this Annex was first provided in the 1990-2005 NIR in accordance with Decisions 15/CP.10 (FCCC/CP/2004/10/Add.2). The UK will use entire commitment period accounting for activities under Article 3.3 and 3.4, reporting in 2014. Progress in the development of methodologies for estimating emissions and removals from such activities are described here.

A10.1 GENERAL INFORMATION

A10.1.1 Definition of Forest

Article 3.3 of the Kyoto Protocol requires Parties to account for Afforestation, Reforestation and Deforestation (ARD) since 1990 in meeting their emissions reduction commitments. The UK has chosen the following definition of forest and single minimum values:

A definition of 'forest' as agreed with the Forestry Commission comprising:

- a minimum area of 0.1 hectares;
- a minimum width of 20 metres;
- tree crown cover of at least 20 per cent, or the potential to achieve it;
- a minimum height of 2 metres, or the potential to achieve it.

These single minimum values are used for reporting UK forestry statistics (Forestry Commission, 2006) and the UK's greenhouse gas inventory submitted under the UNFCCC. The definitions are consistent with information provided by the UK to the FAO. However, if an international enquiry uses a different minimum definition, for example 0.5 ha in the Global Forest Resource Assessment 2005, the UK areas are adjusted (explicitly or implicitly) to this different definition (FAO, 2005).

A10.1.2 Elected activities under Article 3.4

The UK has chosen to elect Forest Management (FM) as an activity under Article 3.4. In accordance with the Annex to Decision 16/CMP.1, credits from Forest Management are capped in the first commitment period. For the UK the cap is a relatively modest 0.37 MtC (1.36 $MtCO_2$) per year, or 6.78 $MtCO_2$ for the whole commitment period.

A10.1.3 Description of how the definitions of each activity under Article 3.3 and 3.4 have been implemented and applied consistently over time

The areas of forest land reported for AR and FM under the Kyoto protocol equal the area reported under 5A2 (Land converted to Forest Land) in the UNFCCC greenhouse gas inventory. The Afforestation/Reforestation area is land that has been converted to forested land since 1990 (inclusive), while the Forest Management area is the area converted to forest land between 1921 and 1989. In the UK Land converted to Forest Land is considered to stay in that category beyond the 20 year default period in order to take account of the long term soil carbon dynamics. Deforestation since 1990 is taken to be the land area permanently converted from forest land to either grassland or settlement (conversion to cropland is estimated to be negligible based on land use surveys). All ARD and FM definitions are consistent with those used in the UNFCCC inventory and updates to methodologies over time have been back-calculated to 1990 to ensure consistency over time.

The afforestation and reforestation datasets are provided by the Forestry Commission and the Forest Service of Northern Ireland (the national forestry agencies) and are consistent with the definition of forest given above. There is an assumption of restocking after harvesting on the national estate, although open habitat can make up 13-20% of stand area on restocking. Therefore, Afforestation and Reforestation under Article 3.3 can be considered together. A felling license is required for felling outside the national forest estate; there is a legal requirement to restock under such a license unless an unconditional felling license is granted (in which case this would be formally reported as deforestation). Information on deforestation activities is assembled from data provided by the Forestry Commission and by the Ordnance Survey (the national cartographic agency) through the UK government. To the best of knowledge, these definitions have been applied consistently over time, although larger uncertainties are associated with deforestation estimates compared with afforestation estimates.

A10.1.4 Precedence conditions and hierarchy among Art. 3.4 activities

Not applicable, as only Forest Management has been elected as an Article 3.4 activity.

A10.2 LAND-RELATED INFORMATION

A10.2.1 Spatial assessment unit used

The spatial assessment units used for the provisional Kyoto Protocol LULUCF tables in 2008 are the four countries of the UK: England, Scotland, Wales and Northern Ireland. A methodology for reporting using units of 20x20km grid cells is in development, where the location of ARD and FM land will be statistically determined for the 853 grid cells covering the UK (GPG LULUCF Reporting Method 1). Each 20x20km cell has a unique identification code produced from the coordinates of the lower left corner of the cell (using the Ordnance Survey British National Grid projection).

A10.2.2 Methodology used to develop the land transition matrix

Several datasets are either available, or will become available, for the assessment of ARD and FM activities in the UK (**Table A10.2.1**). The UK GHGI currently uses the national planting statistics from 1921 to the present, which are provided by the Forestry Commission and the Northern Ireland Forest Service for each of the countries in the UK. This data is used for the estimation of AR and FM in the submitted LULUCF tables. Estimates of Deforestation are made using the Unconditional Felling Licences and the Land Use Change Statistics (LUCS), a survey of land converted to developed use.

The relationship between the national datasets and the land transition matrix is shown in **Table A10.2.2**. With current methods it is not possible to assess the split in the Deforestation area between areas under Afforestation/ Reforestation and Forest Management although it is reasonable to assume that there will be little Deforestation on areas afforested since 1990. We are in the process of progressing from the situation shown in **Table A10.22** to that shown in **Table A10.2.3** (using 20km grid scale datasets).

Table A 10.2.1: Data sources on ARD and FM activities (additional data sources may become available in the future)

Activity	Dataset	Available scale	Time period	Details
AR & FM	Annual planting statistics	Country (England, Scotland, Wales, Northern Ireland)	1921-present	New planting on previously non-forested land. Updated annually. Categorized into conifer and broadleaved woodland.
AR	Grant-aided woodland database	Local administrative unit/NI counties	1995-present	Private woodland planted with grant aid since 1995. Categorized into conifer and broadleaved planting.
AR & FM	Forestry Commission management database	20km grid cells	1995-present	Database of state woodland planting since 1995, indicating the rotation (1st rotation will be Afforestation, 2nd or greater rotations are restocking). Categorised by species.
AR & FM	National Inventory of Woodland and Trees (NIWT)	20km grid cells (sample statistics)	1995	Grid cell database includes the area and planting decade of each species within the grid cell. A digital map of woodland over 2ha is also available.
ARD, FM	*NIWT2*	*20km grid cells (sample statistics)*	*Planned for 2009-2017*	*Update of the 1995 NIWT. A partial repeat of the grid cell analysis should be available by 2013. An update of the digital map will be available, initially from 2009, which can be used to asses deforestation since NIWT1.*
D	Forestry Commission Unconditional Felling Licence data	England only (data from other countries should become available)	1990-2002	Unconditional Felling Licences are issued for felling without restocking. Used to estimate deforestation in rural areas (primarily for heathland restoration). English data is extrapolated to GB scale and to current reporting year. Omits felling for development purposes, e.g. construction of wind turbines.
D	Land Use Change Statistics (survey of land converted to developed uses)	England only (data from other countries should become available)	1990-2003 (updated in 2007)	Estimates of the conversion of forest to urban/developed land use. Based on Ordnance Survey map updates, identifying changes through aerial surveys and other reporting, expected to capture most changes within five years. English data is extrapolated to GB scale and to current reporting year.

Table A 10.2.2: Land transition matrix using national datasets

From \ To	Article 3.3		Article 3.4
	Afforestation/ Reforestation	Deforestation	Forest Management
Afforestation/ Reforest-ation	New planting since 1990 (national planting statistics).	Not estimated at present.	
Deforestation		Unconditional felling licences/LUCS	
Forest Management		Unconditional felling licences/LUCS	Forest planted 1921-1989 (national planting statistics) and NIWT.

Table A 10.2.3: Proposed land transition matrix with the 20km grid for end of commitment period accounting

From \ To	Article 3.3		Article 3.4
	Afforestation/ Reforestation	Deforestation	Forest Management
Afforestation/ Reforest-ation	1990-1995: national planting statistics, spatially distributed in proportion to NIWT data on planting in 1990s. 1995-2012: FC management database and grant-aided woodland database.	Comparison between NIWT and NIWT2 forest cover map. Unconditional felling licences.	
Deforestation		NIWT vs. NIWT2 forest cover map.	
Forest Management		NIWT vs. NIWT2 forest cover map. Unconditional felling licences	Use NIWT and NIWT2.

A10.2.3 Identification of geographical locations

National spatial units have been used for the 2008 voluntary submission (Figure A10.1): the proposed units for future submissions (when a suitable electronic submission format is made available) are also shown.

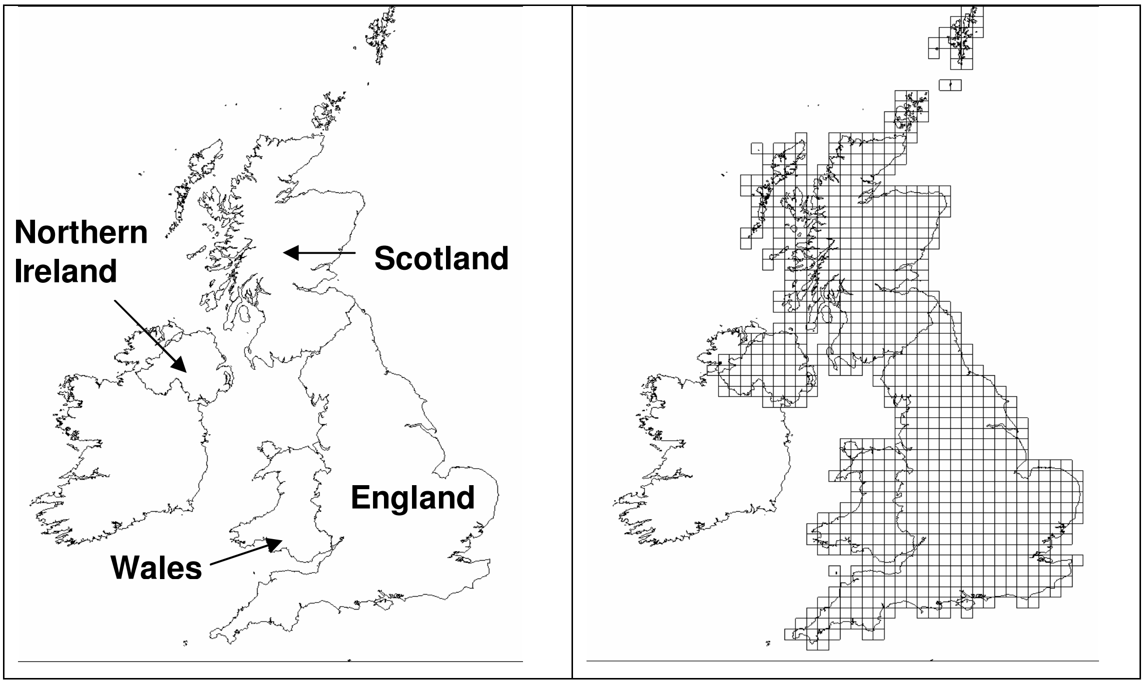

Figure A10- 1: Spatial units used for reporting Kyoto protocol LULUCF activities: (left) the four countries of the UK, (right) 20 x 20km grid cells covering the UK.

A10.3 ACTIVITY-SPECIFIC INFORMATION

A10.3.1 Methods for carbon stock change and GHG emission and removal estimates

A10.3.1.1 Description of methodologies and assumptions

Carbon uptake by UK forests is estimated by a carbon accounting model, C-Flow (Cannell and Dewar, 1995; Dewar and Cannell, 1992; Milne et al., 1998). The model estimates the net change in pools of carbon in standing trees, litter and soil in conifer and broadleaf forests. The methodologies and assumptions are described in the UK's National Inventory Report, Annex 3.7. The C-Flow model was originally set up in Microsoft Excel to run at the national scale. The model has now been moved to the Matlab programming environment and modified to run with spatially disaggregated input data (20km grid cells in this instance). C-Flow is used to estimate carbon stock changes from Article 3.3 Afforestation/Reforestation and Article 3.4 Forest Management.

The next stage is the construction of the activity dataset on an annual basis from the various spatially disaggregated data sources. This has initially been done for Article 3.3 Afforestation/Reforestation. The ArcMap geographical information system was used for this work. There are still some issues to resolve between national and regional annual planting totals, so at present the spatially disaggregated data is used to weight the distribution of the national planting totals across the 20km cells, rather than using the spatially disaggregated data directly.

Great Britain state and private planting 1990-1995. Records of state/private planting in the decade since April 1990 were extracted from the National Inventory of Woodland and Trees (NIWT) for each 20km cell. These records include large areas of restocking as well as new planting, so the area of new planting per cell was estimated using ratios of new planting to restocking for broadleaf/conifer and state/private woodland. These ratios were obtained from published forest statistics reports and the Forestry Commission planting database (1995 onwards). The areas of planting were used to assign a weight to each cell for each country (England, Scotland and Wales): these weights were then used to distribute the national annual planting area (1990-1995) across all cells.

Northern Ireland state and private planting 1990-1996. The NIWT does not cover Northern Ireland so the only planting areas are available are the national ones. Forest cover is not evenly distributed in Northern Ireland, with the dominant conifer plantations concentrated in the western uplands. The national planting areas were distributed across the country using a 20 km cell weighted distribution based on the size and location of state-owned forests (Forest Service Facts & Figures 2001/02 and the Forest Service website http://www.forestserviceni.gov.uk/). This approach is not ideal, because the forest distribution only reflects that of state forests in 2001, and more appropriate data will be sought.

Great Britain state planting 1995- present. The Forestry Commission Sub-Compartment Database (SCDB) was used to estimate state afforestation from 1995 onwards. The SCDB is the stand management database for state-owned and managed forest, containing information on species, age, yield class and management, and spatially referenced by 20km cells. Records of annual new planting areas were extracted for conifer and broadleaf planting. The areas of planting were used to assign a weight to each cell for each country (England, Scotland and Wales): these weights were then used to distribute the national annual planting area across all cells.

Great Britain private planting 1995- present. Woodland Grant Schemes (WGS) is the schemes by which the government (i.e. the Forestry Commission) encourages planting and management of private woodland. They covers almost all private woodland planting since 1995: there is a small amount of non-grant aided woodland (mostly in England) which is assumed to be broadleaved natural regeneration but we have no further information on the management or permanence of this area. Information on planting under the WGS is available for each country in Great Britain, split by new planting and restocking. The information provided is the area for which new planting grants have been paid and the planting has actually been completed. The FC will not pay grants prior to the planting taking place so we know that the areas are therefore all stocked. Conifer and broadleaf planting is split by NUTS4 administrative regions (local authority areas). The planting areas were re-assigned in proportion to the appropriate co-incident 20km cells. The areas of planting were used to assign a weight to each cell for each country (England, Scotland and Wales): these weights were then used to distribute the national annual planting area across all cells.

Northern Ireland state and private planting 1996-2006. New data was not available for reporting the 2007 values, and has therefore not been updated. Northern Ireland will be making the data available annually for the whole commitment period of the Kyoto Protocol reporting period. Information is available on the areas planted annually under the Northern Ireland Woodland Grant Scheme since 1996. These are reported by the old county districts for 1996-2006 (Antrim, Armagh, Down, Fermanagh, Derry and Tyrone) and by NUTS4 district for 2006. The planting areas were re-assigned in proportion to the appropriate co-incident 20km cells. Information on the relative distribution of conifer and broadleaf planting was only available in 2006, otherwise the same distribution is assumed for both forest types. No specific information was available on the distribution of state planting. The 20km cell weighting for private woodland planting was used to distribute the national annual planting area across all cells. The methods and data sources for Northern Ireland will be kept under review.

These separate activity datasets were combined into spatial annual planting series for conifer and broadleaf woodland from 1990 to 2006. The maps of cumulative planting to 2006 are shown in Figure A10- 2. The differences in afforestation distribution between conifer and broadleaf woodland and between countries can be seen clearly.

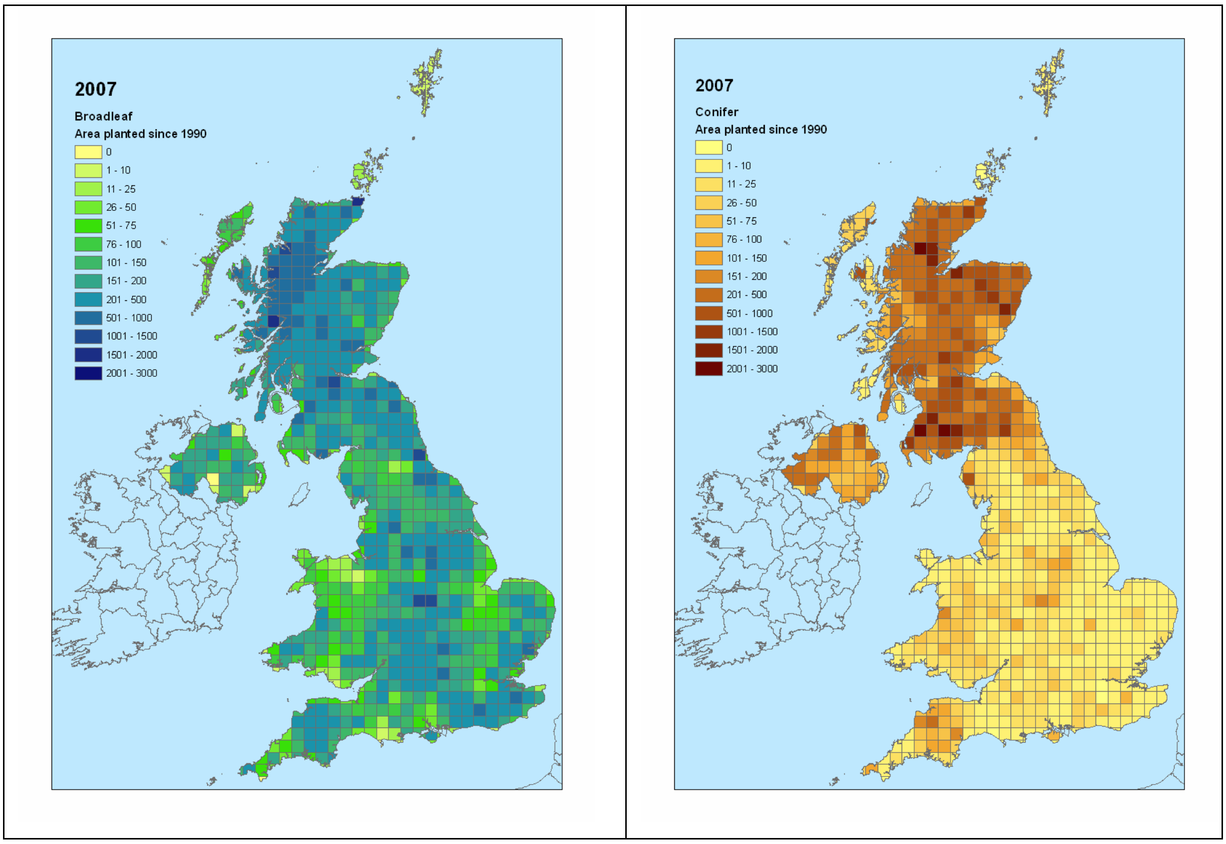

Figure A10- 2: Cumulative planting 1990-2007 of broadleaf and conifer woodland, ha

The combined spatial planting series were run in the new Matlab version of the CFlow accounting model. This produces preliminary estimates of carbon stock changes due to Article 3.3 Afforestation (Figure A10- 3). It should be noted that this methodology still needs further development. The initial results are interesting, with most of the carbon sink located in Scotland although the National Forest (in the English Midlands), where there has been extensive planting in the past decade, also shows up on the map. The small carbon source in the Shetland Islands (in the far north of the UK) is probably due to planting disturbance of organic soils, although this requires further investigation.

The methods currently used for the reporting of Article 3.3 Deforestation and Article 3.4 Forest Management are those reported in the NIR. Progress in method development for these activities will be described in future annexes.

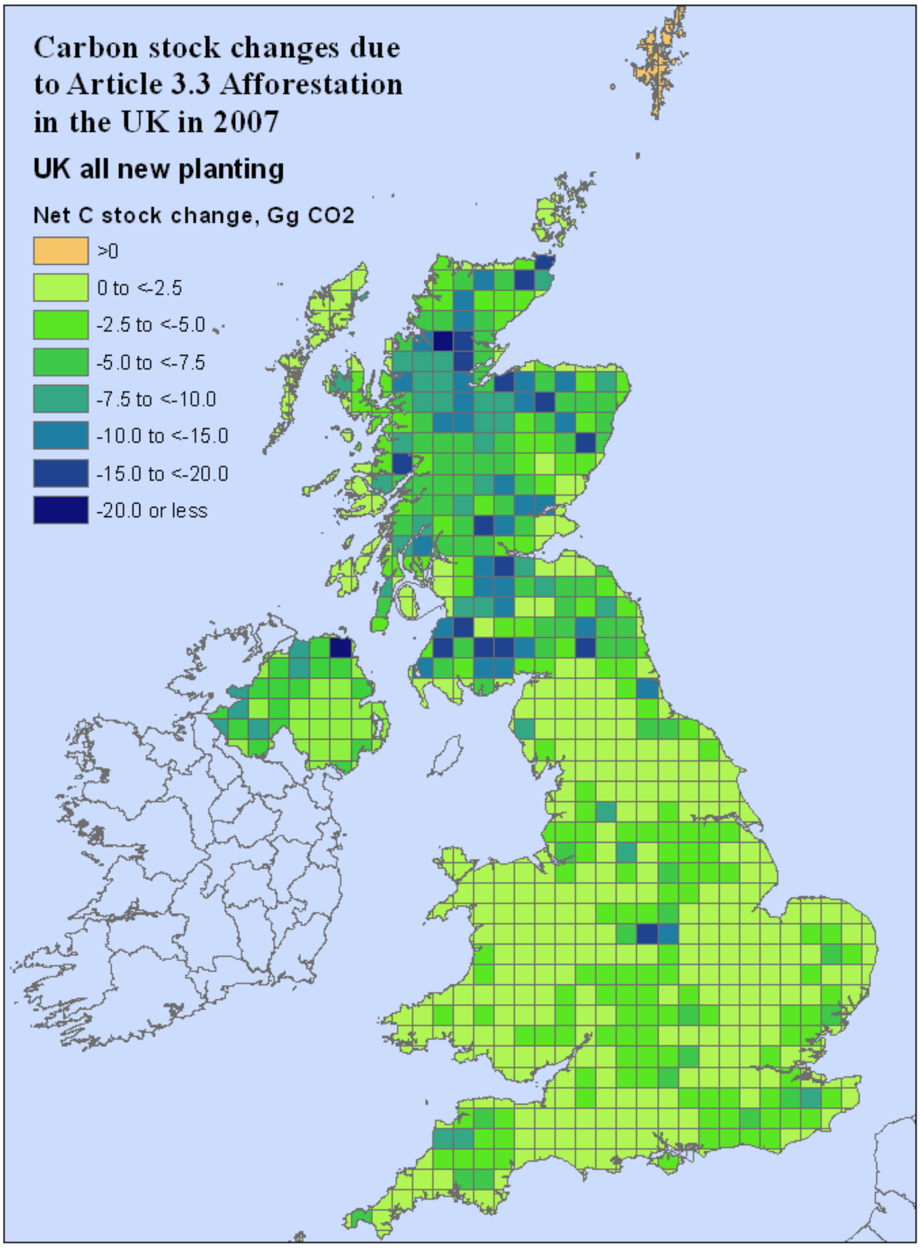

Figure A10- 3: Carbon stock changes due to Article 3.3 Afforestation in the UK 1990-2007, Gg CO_2

A10.3.1.2 Justification for omitting pools or fluxes

The below-ground biomass and dead wood carbon pools are currently not reported separately but included in the soil and litter carbon pools respectively. It may be possible to modify the C-Flow model so that it produces estimates for these carbon pools for future reporting.

The area included in Forest Management only includes those areas of forest that were newly planted between 1921 and 1990 (1394 kha or c.50% of the UK forest area). The area of forest established before 1920 (c. 820 kha) is reported in the CRF for the national greenhouse gas inventory but is assumed to be in carbon balance, i.e. zero flux. Uncertainty as to the management and date of first establishment of pre-1921 woodlands (which are predominantly broadleaf) makes it difficult to estimate appropriate model parameters. The omission of pre-1920 forests will have no effect on the number of credits that the UK can claim under Article 3.4, as these are capped for the first commitment period.

Nitrous oxide emissions from N fertilization of newly planted forest land on poor soils are now included (see the NIR for further details). The Forestry Commission has estimated liming of forests and N fertilisation of established forest land to be negligible due to economic factors, so emissions from these activities are not currently estimated. Emissions of N_2O from areas in Forest Management due to the drainage of soils are not currently estimated, although a methodology is under consideration (NIR Annex 3.7).

Emissions of greenhouse gases due to biomass burning are estimated for Deforestation. Hopefully, biomass burning will diminish as the use of woodfuel as a source of bioenergy becomes more commonplace. Emissions due to forest wildfires are now included (see the NIR for further details). At present, it is assumed that all wildfires occur on Forest Management land. Assessing the impact of wildfires on AR forests is methodologically complex under the UK's current approach and wildfires would only affect a very small area of AR land area (less than 1% since 1990) if the burnt areas are distributed in proportion to forest. It can be assumed that wildfires will not result in permanent deforestation. This area will be kept under review.

A10.3.1.3 Factoring out

The CFlow model in principle assumes constant weather and management conditions and therefore 'factoring out' of such influences is not required.

A10.3.1.4 Recalculations since last submission

Emissions from N fertilisation of newly planted forests and emissions from forest wildfires have been included. Carbon stock changes in afforested soils are now calculated differently as a result of the disaggregation of the C-Flow model from national to 20km scale. At the national scale a simple country-specific model is used to split new planting between organic and mineral soils. The disaggregated version of C-Flow uses the Defra soil carbon database (Bradley et al. 2005) to estimate the proportion of planting on organic or mineral soils in each 20km square. As a result the model assigns less planting to organic soils (particularly in Scotland), which results in a small reduction in the soil carbon stock change compared with previous estimates (3-10 Gg CO_2 in 2000-2006).

A10.3.1.5 Uncertainty estimates

To be decided. A full uncertainty analysis of the LULUCF sector in the UNFCCC greenhouse gas inventory will be completed by 2009: improved uncertainty estimates for Article 3.3 and 3.4 activities will be derived from this work.

A10.3.1.6 Information on other methodological issues

Measurement intervals. Emissions and removals are reported annually but compiled from data sources with different measurement intervals. For Afforestation/ Reforestation land the national planting statistics are produced annually and disaggregated to the 20km scale using regional datasets. The regional datasets are also produced annually but there are discrepancies between the national and regional planting totals that have yet to be resolved, hence the continued use of the more reliable national dataset. The statistics are reported by planting year, which runs from the 1st April of the previous year to the 31st March of the reported year, i.e. the 2001 planting year was 1st April 2000 to 31st March 2001. These statistics are adjusted to calendar years in order to be compliant with the Kyoto Protocol regulations. This adjustment has the effect of slightly smoothing the planting series and has no effect on the area of forest planted overall. The annual planting series drives the model C-Flow, which produces outputs at the annual scale (see NIR Annex 3.7. for more detail). The Deforestation activity data is estimated using a five year running mean. The Forest Management areas come from the annual national planting statistics. The estimated numbers will be verified using the NIWT (1995-1998) and preliminary results from NIWT2 (2009-2017).

Choice of methods. The methods used to estimate emissions and removals from Deforestation and Forest Management activities are the same as those used in the UNFCCC inventory. Developments in the methods used for Kyoto Protocol reporting will be incorporated into the UNFCCC inventory reporting in due course.

Disturbances. Emissions from forest wildfires were included in the UNFCCC inventory for the first time in 2008. Data is available on fire damage to state-managed forests and extrapolated to privately-managed forests (see the NIR for further details on the method and assumptions). There is no data available on the type of forest burnt by wildfires (species or age) or wildfire locations within each country of the UK. Wildfires are not assumed to result in a permanent change in land use. Damage from windblow is not reported in the UNFCCC inventory, although it does occur in the UK (FAO, 2005; Forestry Commission, 2002). There are currently insufficient data to include the effects of these disturbances in the inventory although this is being kept under review and a methodology will be developed in time.

Inter-annual variability. The method used to estimate emissions and removals from AR and FM is based on the C-Flow model. This model is not sensitive to inter-annual variation in environmental conditions so these will not affect the annual growth and decay rates. There is an ongoing research project to look at the variation in management conditions across the UK forest estate and over time. The area burnt in wildfires does show inter-annual variation and this is included in the emissions methodology. Where data is missing from the annual time series a Burg regression equation is used to extrapolate the trend over the previous ten years.

A10.3.1.7 Accounting issues

Not applicable for this submission.

A10.3.2 Article 3.3

A10.3.2.1 Information that demonstrates that activities began after 1990 and before 2012 and are directly human-induced

Under the current methodology, the Forestry Commission and the Forest Service of Northern Ireland provide annual data on new planting (on land that has not previously been forested). This information is provided for each country in the UK and the time series extends back before 1990. Data are provided for both state and private woodlands: the private woodland planting is divided between grant-aided and non-grant-aided. Estimates of non-grant-aided woodland planting and restocking are reported annually, for inclusion in planting statistics, although the Forestry Commission have doubts about their completeness and accuracy Their assessment is that non-grant-aided new woodland has arisen by natural regeneration and is all broadleaved. This assumption can be verified against the NIWT2 at a later date. Only state and grant-aided woodland areas are currently included in the assessment of Article 3.3 activities as these are directly human-induced.

A10.3.2.2 Information on how harvesting or forest disturbance followed by re establishment is distinguished from deforestation

The data sources used for estimating Deforestation do not allow for confusion between harvesting or forest disturbance and deforestation. The unconditional felling licences used for the estimation of rural deforestation are only given when no restocking will occur, and the survey of land converted to developed use describes the conversion of forest land to the settlement category, which precludes re-establishment. The NIWT2, which will be partially completed by the end of the first commitment period, will be used to verify deforestation estimates made using these data sources.

A10.3.2.3 Information on the size and location of forest areas that have lost forest cover but are not yet classified as deforested

Restocking is assumed for forest areas that have lost forest cover through harvesting or forest disturbance, unless there is deforestation as described above. As such, information on the size and location of forest areas that have lost forest cover is not explicitly collected. However, it should be possible to assess such areas through the comparison of the NIWT and NIWT2 at the end of the first commitment period.

A10.3.3 Article 3.4

A10.3.3.1 Information that demonstrates that activities have occurred since 1990 and are human-induced

All managed forests (planted between 1921 and 1989) are included in this category. The C-Flow model is used to calculate emissions from this forest area after 1990 that have arisen from thinning, harvesting and restocking. A current research project is examining the impact of management upon carbon stock changes in UK forests in more detail.

A10.3.3.2 Information relating to Forest Management: (i) that the forest definition is consistent; and (ii) that forest management is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological, economic and social functions of the forest in a sustainable manner

Data used for estimating emissions from Forest Management is supplied by the Forestry Commission and complies with their definition of forest land, which is the one used for Article 3.3 and 3.4 activities.

The UK has a system of certification for sustainable woodland management under the Forest Stewardship Council (FSC). Forest statistics published in 2006 by the Forestry Commission record that 73% of softwood removals in 2005 were from certified sources. Such removals will almost entirely come from post-1920 conifer woodland reported under Forest Management. The management practices in certified woodlands are reviewed annually. All state-owned forests are certified and an increasing proportion of non-state-owned woodlands are becoming certified. The total certified area in March 2007 was 1276 kha (Forestry Commission, 2007). This does not include all woodland that is managed in a sustainable manner, such as smaller or non-timber producing woodlands where certification is not considered worthwhile. In particular, it may omit many broadleaved woodlands even though they are managed for their social and environmental benefits (Forestry Commission, 2002). In the UK's country report to the Global Forest Resource Assessment 2005 (FAO, 2005) 83% of UK forests are managed for production, 18% are managed for conservation of biodiversity (these have protected status) and 55% have a social service function (public access).

A10.4 OTHER INFORMATION

A10.4.1 Key category analysis

At present all categories relating to Article 3.3 and Forest Management under Article 3.4 are considered to be key categories. Afforestation and Reforestation activities are a component of the key UNFCCC category 5A2 and removals from this category are also likely to increase over time as a result of tree planting schemes partially focussed on climate change mitigation. Deforestation is the only significant net source in the Kyoto Protocol inventory and the data used in the reporting of deforestation are probably the most uncertain of the data sources used. Forest Management is the majority component of the key UNFCCC category 5A2 and is therefore a key category based on contribution alone.

A10.5 INFORMATION RELATING TO ARTICLE 6

Not applicable to UK forests.

A11 Annex 11: End User Emissions

A11.1 INTRODUCTION

This Annex explains the concept of a final user or end user, summarises the final user calculation methodology with examples, and contains tables of greenhouse gas emissions according to final user from 1990 to 2007.

The final user sectoral categories used are consistent with those used in the National Communications (NC) to the FCCC. The sectoral categories in the NC are derived from the UNFCCC reporting guidelines on national communications[10].

The purpose of the final user calculations is to allocate emissions from fuel and electricity producers to the energy users - this allows the emission estimates for a consumer of energy to include the emissions from the production of the fuel or electricity they use.

The UNFCCC does not require final user data to be included in the UK's National Inventory Report. These data have been included to provide DECC with information for their policy support needs.

The tables in this Annex present summary data for UK greenhouse gas emissions for the years 1990-2007, inclusive. These data are updated annually to reflect revisions in the methods used to estimate emissions, and the availability of new information. These recalculations are applied retrospectively to earlier years to ensure a consistent time series and this accounts for any differences in data published in previous reports.

Emissions from the UK Overseas Territories have been included in the totals as a separate row. There is not enough information available to reallocate emissions from energy supply in the Overseas Territories.

A11.2 DEFINITION OF FINAL USERS

The final user[11] or end user calculations allocate emissions from fuel producers to fuel users. The final user calculation therefore allows estimates to be made of emissions for a consumer of fuel, which also include the emissions from producing the fuel the consumer has used

The emissions included in the final user categories can be illustrated with an example of two final users - the residential sector and road transport:

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[10] See page 84 of UNFCCC Guidelines contained in FCCC/CP/1999/7 available at: http://unfccc.int/resource/docs/cop5/07.pdf

[11] A final user is a consumer of fuel for useful energy. A 'fuel producer' is someone who extracts, processes and converts fuels for the end use of final users. Clearly there can be some overlap of these categories but here the fuel uses categories of the UK DECC publication DUKES are used, which enable a distinction to be made.

- Emissions in the **residential** final user category include:
  1. Direct emissions from domestic premises, for example, from burning gas, coal or oil for space heating.

  2. Emissions from power stations generating the electricity used by domestic consumers; emissions from refineries including refining, storage, flaring and extraction; emissions from coal mines (including emissions due to fuel use in the mining industry itself and fugitive emissions of methane from the mines); and emissions from the extraction, storage and distribution of mains gas.

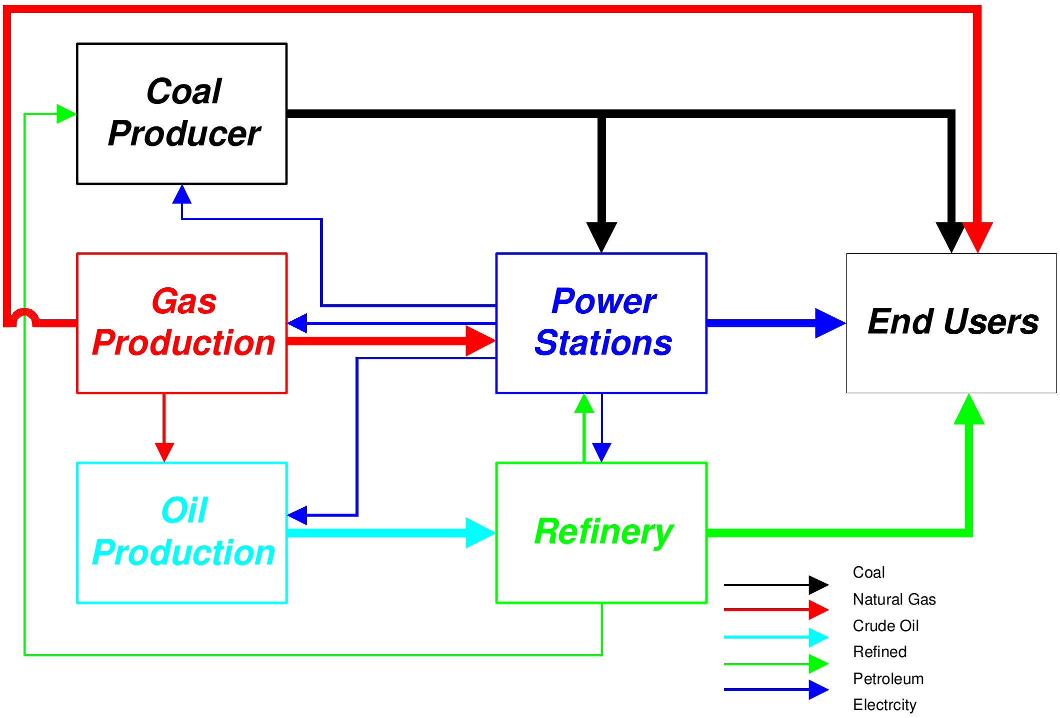
- Emissions in the **road transport** final user category include:
  1. Direct emissions from motor vehicle exhausts.
  2. Emissions refineries producing motor fuels, including refining, storage, flaring and extraction of oil; and from the distribution and supply of motor fuels.

A11.3 OVERVIEW OF THE FINAL USERS CALCULATIONS

As fuel and electricity producers use energy from other producers, they are allocated emissions from each other and these have to then be reallocated to final users. This circularity results in an iterative approach being used to estimate emissions from categories of final users.

Figure A11.1 shows a simplified view of the energy flows in the UK (the fuels used in the greenhouse gas inventory have hundreds of uses). This figure shows that while final users consuming electricity are responsible for a proportion of the emissions from power stations they are also responsible for emissions from collieries, and some of these emissions in turn come from electricity generated in power stations and from refineries.

Figure A11.1: Simplified fuel flows for a final user calculation.



The approach for estimating end user emissions is summarised in the three steps below:

1. Emissions are calculated for each sector for each fuel.
2. Emissions from fuel and electricity producers are then distributed to those sectors that use the fuel according to the energy content[12] of the fuel they use (these sectors can include other fuel producers).
3. By this stage in the calculation, emissions from final users will have increased and those from fuel and electricity producers will have decreased. The sum of emissions from fuel producers and power stations in a particular year as a percentage of the total emissions is then calculated. If this percentage, for any year, exceeds a predetermined value (e.g. 1% or 0.01%)[13] the process continues at Step 2. If this percentage matches or is less than the predetermined value, the calculation is finished.

Convergence of this iterative approach is likely, as the fuel flows to the final users are much greater than fuel flows amongst the fuel producers.

12 If calorific data for the fuels is not available then the mass of fuel is used instead. This is the case for years prior to 1990.

13 In the model used to determine emissions from final users, the value of this percentage cane be adjusted. The tables presented later in this Appendix were calculated for a convergence at 0.001%.

While a direct solution could possibly be used (for example, after defining a system of linear equations and solving by an inverse matrix or Gaussian elimination) it was decided to base the calculation on an iterative approach because:

- This can be implemented in the database structures already in existence for the UK greenhouse gas inventory;
- It can handle a wide range of flows and loops that occur without any of the limits that other approaches may incur; and
- The same code will cover all likely situations and will be driven by tabular data stored in the database.

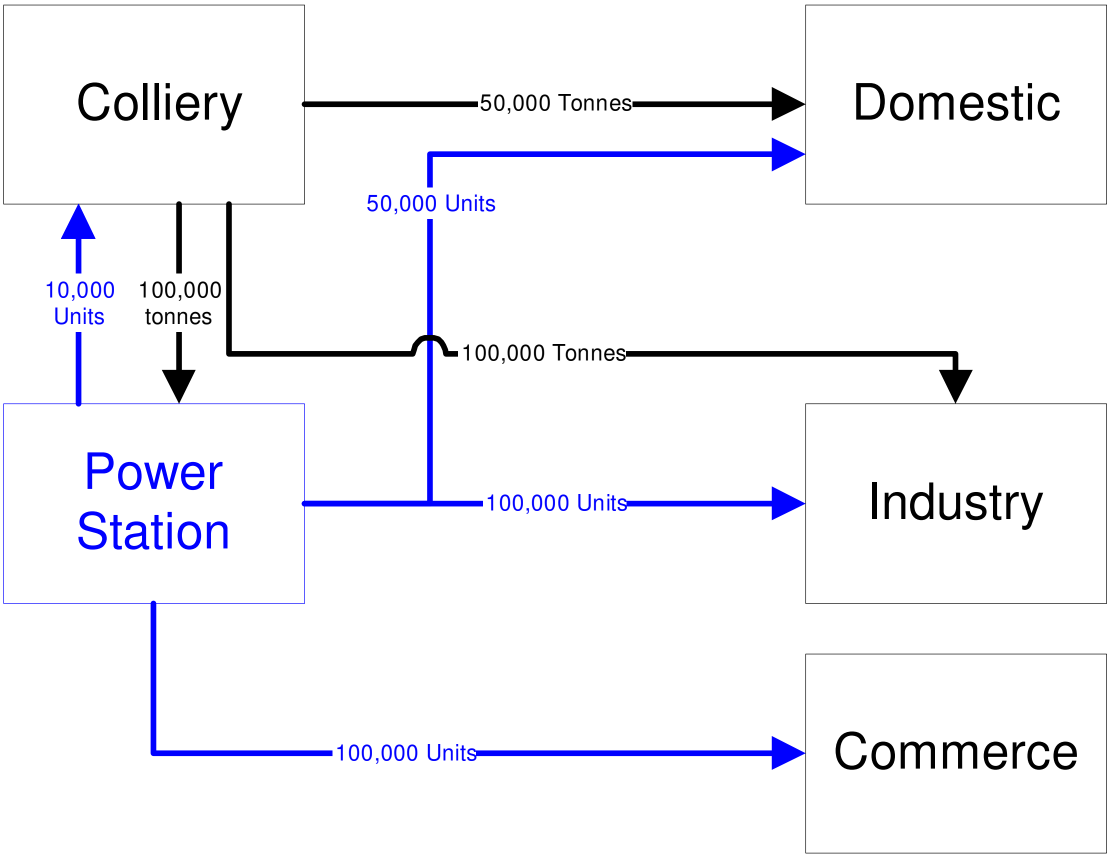
A11.4 EXAMPLE FINAL USER CALCULATION

The following example illustrates the methodology used to calculate emissions according to final users. The units in this example are arbitrary and sulphur dioxide has been used in the example.

The example in **Figure A11.2** has two fuel producers, *power stations* and *collieries*, and three final users, *residential*, *industry* and *commercial*. The following assumptions have been made for simplicity:

- The only fuels used are coal and electricity;
- Coal is the only source of sulphur dioxide emissions (released from burning coal in power stations to produce electricity and from burning coal in the home for space heating); and
- Commerce uses no coal and so has zero ‘direct’ emissions.

Figure A11.2: Fuel use in the example calculation



In **Figure A11.2**, the tonnes refer to tonnes of coal burnt (black arrows), and the units refer to units of electricity consumed (blue arrows).

In this example the coal extracted by the colliery is burnt in the power station to produce electricity for the final users. Industrial and residential users also directly burn coal. Although the colliery uses electricity produced by the power station, it is not considered to be a final user. The colliery is a ‘fuel producer’ as it is part of the chain that extracts, processes and converts fuels for the final users.

Table A11.4.1 summarises the outputs during this example final user calculation.

Table A 11.4.1 Example of the outputs during a final user calculation

			Sector						
			Colliery	**Power Station**	**Residential**	**Industrial**	**Commercial**	**Unallocated emissions as percentage of total emission**	**Total emission of SO_2 (tonnes)**
Coal use (tonnes)	Mass		100	100,000	50,000	100,000	0		
	Energy content		25,000	25,000,000	12,500,000	25,000,000	0		
Electricity use (arbitrary units)	Energy units		10,000		50,000	100,000	100,000		
Emissions of SO_2 (tonnes)	Initial		1.00	1000.00	500.00	1000.00	0.00	40.02	2501.00
	Emissions after Iteration step	1	38.46	0.40	692.51	1385.02	384.62	1.55	2501.00
		2	0.02	15.38	700.28	1400.55	384.77	0.62	2501.00
		3	0.59	0.01	703.24	1406.48	390.69	0.02	2501.00
		4	0.00	0.24	703.36	1406.72	390.69	0.01	2501.00
		5	0.01	0.00	703.40	1406.81	390.78	0.00	2501.00
		6	0.00	0.00	703.41	1406.81	390.78	0.00	2501.00

The initial sulphur dioxide emissions are 1% of the mass of coal burnt. The emissions from the power stations are distributed to the other sectors by using the factor:

- (Electricity used by that sector)/(total electricity used minus own use by power stations);

Similarly for the colliery emissions the following factor is used; and

- (Energy of coal used by that sector)/(total energy of coal consumed used minus own use by collieries).

At the end of iteration step one, the commerce sector has 384.62 tonnes of sulphur dioxide emissions allocated to it, mainly from derived from power stations. Emissions allocated to the residential and industry sectors have also increased over their initial allocations. However collieries and power stations still have some emissions allocated to them (these come from each other) and so the reallocation process is repeated to reduce these allocations to zero – these two sectors are not final users. The total unallocated (in this example, equal to the total emissions from collieries and power stations) falls in each iteration until the emissions are consistently allocated across the sectors. In this example, six iterations are needed to achieve a consistent allocation across the sectors.

The sum of emissions allocated to the sectors (2501.00 tonnes of sulphur dioxide) remains unchanged from the initial allocation to the allocation in the sixth iteration. This check is an important quality control measure to ensure all emissions are accounted for during the final user calculations.

Figure A11.3: Comparison of 'direct' and final user emissions of sulphur dioxide according the sectors considered in the final user example

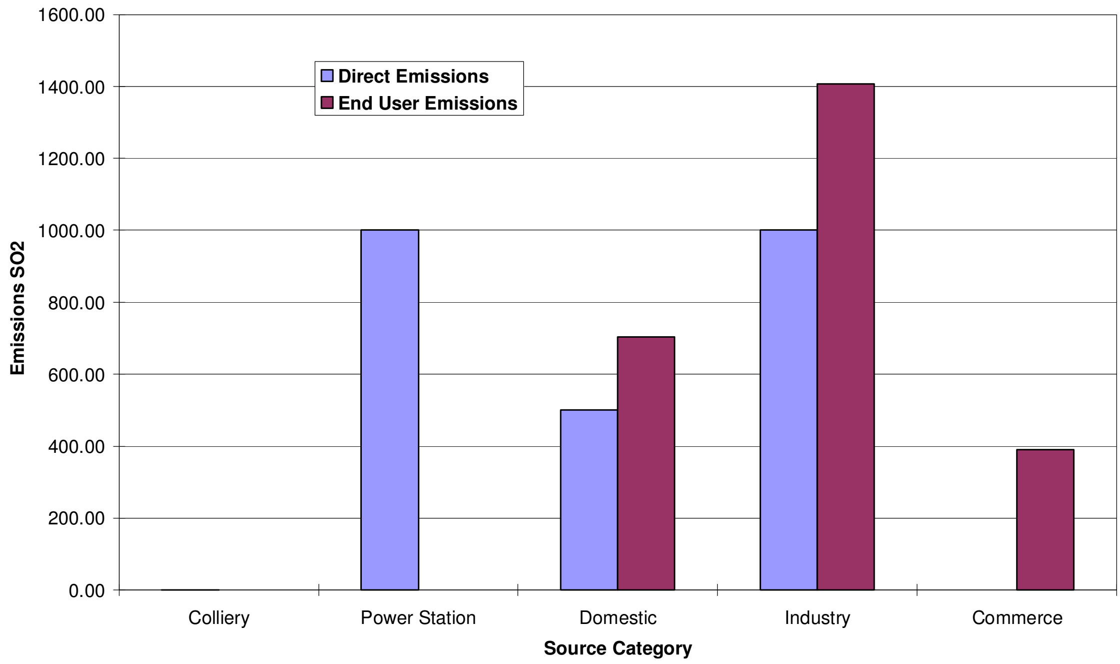


Figure A11.3 compares the quantities of direct and final user sulphur dioxide emitted from each sector at the end of the final user calculation. The direct emissions of sulphur dioxide are from the combustion of coal in the sectors. The direct and final user emissions are from two distinct calculations and must be considered independently – in other words, the direct and final user emissions in each sector must not be summed. The sum of all the direct emissions and the sum of the final user emissions, are identical.

There are relatively large direct emissions of sulphur dioxide from power stations, residential and industry sectors. The final user emissions from the power stations and the colliery are zero because these two sectors are not final users. The sulphur dioxide emissions from these two sectors have been reallocated to the residential, industrial and commercial sectors. This reallocation means the final user emissions for the residential and industrial sectors are greater than their 'direct' emissions.

A11.5 FINAL USER CALCULATION METHODOLOGY FOR THE UK GREENHOUSE GAS INVENTORY

The approach divides fuel user emissions into 7 categories (see column 1 of **Table A11.5.1**). For each of these groups, source categories are distributed by the total energy consumption of a group of fuels. For example, for the coal group, the emissions of four source categories are distributed to final users according to the energy use of anthracite and coal combined.

Table A 11.5.1: Sources reallocated to final users and the fuels used

Final user group	Emission sources to be reallocated to final users	Fuels used for redistribution
1. Coke	Gasification processes	Coke
	Coke production	
2. Coal	Coal storage & transport	Coal
	Collieries	Anthracite
	Deep-mined coal	
	Open-cast coal	
3. Natural gas	Gas separation plant (combustion)	Natural gas
	Gas leakage	
	Gas production	
4. Electricity	Nuclear fuel production	Electricity
	Power stations	
5. Petroleum	Off shore flaring	Naphtha
	Offshore loading	Burning oil (premium)
	Offshore oil & gas (venting)	Burning oil
	Offshore oil & gas (well testing)	Aviation turbine fuel
	Offshore oil and gas	Aviation spirit
	Offshore own gas use	Derv
	Oil terminal storage	Fuel oil
	Onshore loading	Gas oil
	Petroleum processes	OPG
	Refineries (Combustion)	Refinery misc.
	Refineries (drainage)	Petrol
	Refineries (flares)	Petroleum coke
	Refineries (process)	Wide-cut gasoline
	Refineries (road/rail loading)	Vaporizing oil
	Refineries (tankage)	LPG
	Refinery (process)	
	Ship purging	
6. Solid Smokeless Fuels	Solid Smokeless fuel production	Solid Smokeless Fuels
7. Town gas	Town gas manufacture	Town gas

Comments on the calculation methodology used to allocate emissions according final users are listed below:

- Emissions are allocated to final users on the basis of the proportion of the total energy produced used by a given sector. This approach is followed to allow for sectors such as petroleum where different products are made in a refinery;
- Some emissions are allocated to an “exports” category. This is for emissions within the UK from producing fuels, (for example from a refinery or coal mine), which are subsequently exported or sent to bunkers for use outside the UK. Therefore these emissions are part of the UK inventory even if the use of the fuel produces emissions that cannot be included in the UK inventory because it takes place outside the UK;
- No allowance is made for the emission from the production of fuels or electricity outside the UK that are subsequently imported;
- Some of the output of a refinery is not used as a fuel but used as feedstock or lubricants. This is not currently treated separately and the emissions from their production (which are small) are allocated to users of petroleum fuels. This is partly due to lack of data in the database used to calculate the inventory, and partly due to the lack of a clear, transparent way of separating emissions from the production of fuels and from the production of non-fuel petroleum products; and
- Final user emissions are estimated for aviation in four categories: domestic take off and landing, international take off and landing, domestic cruise and international cruise. This enables both IPCC and UNECE categories to be estimated from the same final user calculation.

Our exact mapping of final user emissions to IPCC categories is shown in the following table. The NAEI source sectors and activity names are also shown, as it is necessary to subdivide some IPCC categories. This classification has been used to generate the final user tables for the greenhouse gases given in this section. As this table is for final users, no fuel producers are included in the table.

Table A 11.5.2: Final user category, IPCC sectors, and NAEI source names and activity names used in the emission calculation

NCFormat	IPCC	SourceName	ActivityName
Agriculture	1A4ci_Agriculture/Forestry/Fishing:Stationary	Agriculture - stationary combustion	Coal Fuel oil Natural gas Straw
	1A4cii_Agriculture/Forestry/Fishing:Off-road	Agricultural engines	Lubricants
		Agriculture - mobile machinery	Gas oil Petrol
	2B5_Chemical_Industry_Other	Agriculture - agrochemicals use	Carbon in pesticides
	4A10_Enteric_Fermentation_Deer	Agriculture livestock - deer enteric	Non-fuel combustion
	4A1a_Enteric_Fermentation_Dairy	Agriculture livestock - dairy cattle enteric	Non-fuel combustion
	4A1b_Enteric_Fermentation_Non-Dairy	Agriculture livestock - other cattle enteric	Non-fuel combustion
	4A3_Enteric_Fermentation_Sheep	Agriculture livestock - sheep enteric	Non-fuel combustion
	4A4_Enteric_Fermentation_Goats	Agriculture livestock - goats enteric	Non-fuel combustion
	4A6_Enteric_Fermentation_Horses	Agriculture livestock - horses enteric	Non-fuel combustion
	4A8_Enteric_Fermentation_Swine	Agriculture livestock - pigs enteric	Non-fuel combustion
	4B12_Liquid_Systems	Agriculture livestock - manure liquid systems	Non-fuel combustion
	4B13_Solid_Storage_and_Drylot	Agriculture livestock - manure solid storage and dry lot	Non-fuel combustion
	4B14_Other	Agriculture livestock - manure other	Non-fuel combustion
	4B1a_Manure_Management_Dairy	Agriculture livestock - dairy cattle wastes	Non-fuel combustion
	4B1b_Manure_Management_Non-Dairy	Agriculture livestock - other cattle wastes	Non-fuel combustion
	4B3_Manure_Management_Sheep	Agriculture livestock - sheep goats and deer wastes	Non-fuel combustion
	4B4_Manure_Management_Goats	Agriculture livestock - goats wastes	Non-fuel combustion
	4B6_Manure_Management_Horses	Agriculture livestock - horses wastes	Non-fuel combustion
	4B8_Manure_Management_Swine	Agriculture livestock - pigs wastes	Non-fuel combustion
	4B9_Manure_Management_Poultry	Agriculture livestock - broilers wastes	Non-fuel combustion
		Agriculture livestock - laying hens wastes	Non-fuel combustion
		Agriculture livestock - other poultry wastes	Non-fuel combustion
	4B9a_Manure_Management_Deer	Agriculture livestock - deer wastes	Non-fuel combustion
	4D_Agricultural_Soils	Agricultural soils	Non-fuel crops Non-fuel fertilizer

NCFormat	IPCC	SourceName	ActivityName
	4F1_Field_Burning_of_Agricultural_Residues	Field burning	Barley residue
			Oats residue
			Wheat residue
	4F5_Field_Burning_of_Agricultural_Residues	Field burning	Linseed residue
	non-IPCC	Agriculture - stationary combustion	Electricity
Business	1A2a_Manufacturing_Industry&Construction:I&S	Blast furnaces	Blast furnace gas
			Coke oven gas
			LPG
			Natural gas
		Iron and steel - combustion plant	Blast furnace gas
			Coal
			Coke
			Coke oven gas
			Fuel oil
			Gas oil
			LPG
			Natural gas
	1A2f_Manufacturing_Industry&Construction:Other	Ammonia production - combustion	Natural gas
		Autogenerators	Coal
			Natural gas
		Cement production - combustion	Coal
			Fuel oil
			Gas oil
			Natural gas
			Petroleum coke
			Scrap tyres
			Waste
			Waste oils
			Waste solvent
		Lime production - non decarbonising	Coal
			Coke

NCFormat	IPCC	SourceName	ActivityName
			Natural gas
		Other industrial combustion	Burning oil Coal Coke Coke oven gas Colliery methane Fuel oil Gas oil LPG Lubricants Natural gas OPG SSF Wood
	1A2fii_Manufacturing_Industry&Construction: Off-road	Industrial engines	Lubricants
		Industrial off-road mobile machinery	Gas oil Petrol
	1A4a_Commercial/Institutional	Miscellaneous industrial/commercial combustion	Coal Fuel oil Gas oil Landfill gas MSW Natural gas
	1A4ci_Agriculture/Forestry/Fishing:Stationary	Miscellaneous industrial/commercial combustion	Burning oil
	2B5_Carbon from NEU of products	Other industrial combustion	Energy recovery - chemical industry
	2C1_Iron&Steel	Blast furnaces	Coal
	2F1_Refrigeration_and_Air_Conditioning_Equipment	Commercial Refrigeration	Refrigeration and Air Conditioning - Disposal Refrigeration and Air Conditioning - Lifetime Refrigeration and Air Conditioning - Manufacture
		Domestic Refrigeration	Refrigeration and Air Conditioning - Disposal Refrigeration and Air Conditioning - Lifetime

NCFormat	IPCC	SourceName	ActivityName
			Refrigeration and Air Conditioning - Manufacture
		Industrial Refrigeration	Refrigeration and Air Conditioning - Lifetime Refrigeration and Air Conditioning - Manufacture
		Mobile Air Conditioning	Refrigeration and Air Conditioning - Lifetime Refrigeration and Air Conditioning - Manufacture
		Refrigerated Transport	Refrigeration and Air Conditioning - Disposal Refrigeration and Air Conditioning - Lifetime Refrigeration and Air Conditioning - Manufacture
		Stationary Air Conditioning	Refrigeration and Air Conditioning - Disposal Refrigeration and Air Conditioning - Lifetime Refrigeration and Air Conditioning - Manufacture
	2F2_Foam_Blowing	Foams	Non-fuel combustion
	2F3_Fire_Extinguishers	Firefighting	Non-fuel combustion
	2F5_Solvents	Precision cleaning - HFC	Non-fuel combustion
	2F8_Other_(one_component_foams)	One Component Foams	Non-fuel combustion
	2F8_Other_(semiconductors_electrical_sporting_goods)	Electrical insulation	Non-fuel combustion
		Electronics - PFC	Non-fuel combustion
		Electronics - SF6	Non-fuel combustion
		Sporting goods	Non-fuel combustion
	non-IPCC	Iron and steel - combustion plant	Electricity
		Miscellaneous industrial/commercial combustion	Electricity
		Other industrial combustion	Electricity
Energy Supply	1A1a_Public_Electricity&Heat_Production	Power stations	Coal Fuel oil Gas oil Natural gas Petroleum coke
	1A1b_Petroleum_Refining	Refineries - combustion	Natural gas
	1A1ci_Manufacture_of_Solid_Fuels-coke	Coke production	Natural gas
		Solid smokeless fuel production	Coke
	1A1cii_Other_Energy_Industries	Collieries - combustion	Natural gas

NCFormat	IPCC	SourceName	ActivityName
		Gas production	LPG
		Gas separation plant - combustion	LPG OPG
		Nuclear fuel production	Natural gas
		Offshore oil and gas - own gas combustion	Natural gas
	1B1b_Solid_Fuel_Transformation	Coke production	Coal
		Solid smokeless fuel production	Coal
	non-IPCC	Collieries - combustion	Electricity
		Gas production	Electricity
		Refineries - combustion	Electricity
Exports	1A3di_International_Marine	Shipping - international IPCC definition	Fuel oil Gas oil
	Aviation_Bunkers	Aircraft - international cruise	Aviation spirit Aviation turbine fuel
		Aircraft - international take off and landing	Aviation spirit Aviation turbine fuel
	non-IPCC	Exports	Aviation turbine fuel Burning oil Coke DERV Electricity Fuel oil Petrol SSF
Industrial Process	1A2a_Manufacturing_Industry&Construction:I&S	Sinter production	Coke
	2A1_Cement_Production	Cement - decarbonising	Clinker production
	2A2_Lime_Production	Lime production - decarbonising	Limestone
	2A3_Limestone_&_Dolomite_Use	Basic oxygen furnaces	Dolomite
		Glass - general	Dolomite Limestone
		Sinter production	Dolomite Limestone

NCFormat	IPCC	SourceName	ActivityName
	2A4_Soda_Ash_Production_&_Use	Glass - general	Soda ash
	2A7_(Fletton_Bricks)	Brick manufacture - Fletton	Fletton bricks
	2B1_Ammonia_Production	Ammonia production - feedstock use of gas	Natural gas
	2B2_Nitric_Acid_Production	Nitric acid production	Acid production
	2B3_Adipic_Acid_Production	Adipic acid production	Adipic acid produced
	2B5_Chemical_Industry_Other	Chemical industry - ethylene	Ethylene
		Chemical industry - general	Process emission
		Chemical industry - methanol	Methanol
	2C1_Iron&Steel	Blast furnaces	Coke Fuel oil
		Electric arc furnaces	Steel production (electric arc)
		Ladle arc furnaces	Steel production (electric arc) Steel production (oxygen converters)
	2C3_Aluminium_Production	Primary aluminium production - general	Primary aluminium production
		Primary aluminium production - PFC emissions	Primary aluminium production
	2C4_Cover_gas_used_in_Al_and_Mg_foundries	Magnesium cover gas	Non-fuel combustion
	2E1_Production_of_Halocarbons_and_Sulphur_Hexafluoride	Halocarbons production - by-product	Non-fuel combustion
	2E2_Production_of_Halocarbons_and_Sulphur_Hexafluoride	Halocarbons production - fugitive	Non-fuel combustion
	non-IPCC	Blast furnaces	Electricity
Land Use Change	5A_Forest Land (Biomass Burning - wildfires)	Forest Land - Biomass burning	Biomass
	5A2_Forest Land (N fertilisation)	Direct N2O emission from N fertilisation of forest land	Non-fuel combustion
	5A2_Land Converted to Forest Land	Land converted to Forest Land	Non-fuel combustion
	5B_Liming	Cropland - Liming	Dolomite Limestone
	5B1_Cropland Remaining Cropland	Cropland remaining Cropland	Non-fuel combustion
	5B2_Land Converted to Cropland	Land converted to Cropland	Non-fuel combustion
	5C_Grassland (Biomass burning - controlled)	Grassland - Biomass Burning	Biomass
	5C_Liming	Grassland - Liming	Dolomite Limestone
	5C1_Grassland Remaining Grassland	Grassland remaining Grassland	Non-fuel combustion

NCFormat	IPCC	SourceName	ActivityName
	5C2_Land converted to grassland	Land converted to Grassland	Non-fuel combustion
	5E_Settlements (Biomass burning - controlled)	Settlements - Biomass Burning	Biomass
	5E2_Land converted to settlements	Land converted to Settlements	Non-fuel combustion
	5G_Other (Harvested wood)	Harvested Wood Products	Non-fuel combustion
Public	1A4a_Commercial/Institutional	Public sector combustion	Burning oil Coal Coke Fuel oil Gas oil Natural gas Sewage gas
	non-IPCC	Public sector combustion	Electricity
Residential	1A4b_Residential	Domestic combustion	Anthracite Burning oil Coal Coke Fuel oil Gas oil LPG Natural gas Peat Petroleum coke SSF Wood
	1A4bii_Residential:Off-road	House and garden machinery	DERV Petrol
	2B5_Chemical_Industry_Other	Non-aerosol products - household products	Carbon in detergents Petroleum waxes
	2F4_Aerosols	Aerosols - halocarbons	Non-fuel combustion
		Metered dose inhalers	Non-fuel combustion
	6C_Waste_Incineration	Accidental fires - vehicles	Mass burnt
	non-IPCC	Domestic combustion	Electricity
Transport	1A3aii_Civil_Aviation_Domestic	Aircraft - domestic cruise	Aviation spirit

NCFormat	IPCC	SourceName	ActivityName
			Aviation turbine fuel
		Aircraft - domestic take off and landing	Aviation spirit Aviation turbine fuel
	1A3b_Road_Transportation	Road transport - all vehicles LPG use	LPG
		Road transport - buses and coaches - motorway driving	DERV
		Road transport - buses and coaches - rural driving	DERV
		Road transport - buses and coaches - urban driving	DERV
		Road transport - cars - motorway driving	DERV
		Road transport - cars - rural driving	DERV
		Road transport - cars - urban driving	DERV
		Road transport - cars non catalyst - motorway driving	Petrol
		Road transport - cars non catalyst - rural driving	Petrol
		Road transport - cars non catalyst - urban driving	Petrol
		Road transport - cars with catalysts - motorway driving	Petrol
		Road transport - cars with catalysts - rural driving	Petrol
		Road transport - cars with catalysts - urban driving	Petrol
		Road transport - HGV articulated - motorway driving	DERV
		Road transport - HGV articulated - rural driving	DERV
		Road transport - HGV articulated - urban driving	DERV
		Road transport - HGV rigid - motorway driving	DERV
		Road transport - HGV rigid - rural driving	DERV
		Road transport - HGV rigid - urban driving	DERV
		Road transport - LGVs - motorway driving	DERV
		Road transport - LGVs - rural driving	DERV
		Road transport - LGVs - urban driving	DERV
		Road transport - LGVs non catalyst - motorway driving	Petrol
		Road transport - LGVs non catalyst - rural driving	Petrol
		Road transport - LGVs non catalyst - urban driving	Petrol
		Road transport - LGVs with catalysts - motorway driving	Petrol
		Road transport - LGVs with catalysts - rural driving	Petrol
		Road transport - LGVs with catalysts - urban driving	Petrol

NCFormat	IPCC	SourceName	ActivityName
		Road transport - mopeds (<50cc 2st) - urban driving	Petrol
		Road transport - motorcycle (>50cc 2st) - rural driving	Petrol
		Road transport - motorcycle (>50cc 2st) - urban driving	Petrol
		Road transport - motorcycle (>50cc 4st) - motorway driving	Petrol
		Road transport - motorcycle (>50cc 4st) - rural driving	Petrol
		Road transport - motorcycle (>50cc 4st) - urban driving	Petrol
		Road vehicle engines	Lubricants
	1A3c_Railways	Railways - freight	Gas oil
		Railways - intercity	Gas oil
		Railways - regional	Gas oil
	1A3dii_National_Navigation	Marine engines	Lubricants
		Shipping - coastal	Fuel oil Gas oil
	1A3e_Other_Transportation	Aircraft - support vehicles	Gas oil
	1A4a_Commercial/Institutional	Railways - stationary combustion	Burning oil Coal Fuel oil Natural gas
	1A5b_Other:Mobile	Aircraft - military	Aviation turbine fuel
		Shipping - naval	Gas oil
	non-IPCC	Railways - regional	Electricity
Waste Management	6A1_Managed_Waste_Disposal_on_Land	Landfill	Non-fuel combustion
	6B2_Wastewater_Handling	Sewage sludge decomposition	Non-fuel domestic
	6C_Waste_Incineration	Incineration	MSW
		Incineration - chemical waste	Chemical waste
		Incineration - clinical waste	Clinical waste
		Incineration - sewage sludge	Sewage sludge combustion

A11.6 METHODOLOGICAL CHANGES

Two improvements have been made to the Final User calculation this year. The first is that all emissions from the Overseas Territories have been removed from the calculation. These emissions are added in as a separate row to balance the totals. This means that there are no significant emissions remaining in the Energy Supply sector (emissions from power stations in the OTs were not reallocated, since sufficient data were not available).

The second improvement has been to correct an over-allocation that had previously been made to road transport emissions. This had occurred where fuel use data is held in the database for the calculation of emissions from cold starts or dioxins, which is not additional to the fuel used to calculate emissions of greenhouse gases. By setting the GCV for the fuels used for these sources to zero, no emissions from refineries can be reallocated to these sources. The effect of this is that Energy Supply emissions allocated to road transport have been reduced, which means that more of these will be allocated to other oil users, for example in the residential and exports sectors.

A11.7 DETAILED EMISSIONS ACCORDING TO FINAL USER CATEGORIES

The final user categories in the data tables in this summary are those used in National Communications. The final user reallocation includes all emissions from the UK and Crown Dependencies. Emissions from the Overseas Territories are included in the totals, but not in the individual sectors.

The base year for hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride is 1995. For carbon dioxide, methane and nitrous oxide, the base year is 1990.

Table A 11.7.1: Final user emissions from Agriculture, by gas, $MtCO_2$ equivalent

Greenhouse Gas	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Carbon dioxide	8.77	8.77	8.80	8.62	8.38	8.40	8.30	8.32	7.94	7.82	7.64	7.32
Methane	22.40	22.40	22.07	22.13	21.95	22.01	21.75	21.90	21.68	21.62	21.48	20.70
Nitrous oxide	33.28	33.28	33.11	31.30	30.74	31.49	31.61	31.76	32.73	31.81	31.22	29.96
HFCs												
PFCs												
SF_6												
Total greenhouse gas emissions	64.45	64.45	63.97	62.05	61.07	61.89	61.65	61.98	62.35	61.26	60.34	57.99

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007
Carbon dioxide	7.66	7.62	7.55	7.45	7.23	7.04	6.66
Methane	19.49	19.30	19.29	19.33	18.84	18.81	18.42
Nitrous oxide	28.23	28.73	28.05	27.90	27.48	26.37	25.47
HFCs							
PFCs							
SF_6							
Total greenhouse gas emissions	55.39	55.64	54.89	54.68	53.55	52.22	50.55

Table A 11.7.2: Final user emissions from Business, by gas, $MtCO_2$ equivalent

Greenhouse Gas	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Carbon dioxide	227.49	227.49	224.75	211.07	203.96	200.96	197.58	199.00	191.86	191.76	188.93	196.33
Methane	13.06	13.06	12.83	12.44	11.93	9.15	9.94	9.23	9.07	8.14	7.38	6.87
Nitrous oxide	2.58	2.58	2.50	2.43	2.26	2.23	2.17	2.08	1.96	1.93	1.85	1.89
HFCs	1.20	0.00	0.00	0.00	0.20	0.67	1.20	1.84	2.56	3.36	4.24	5.11
PFCs	0.11	0.06	0.06	0.07	0.08	0.10	0.11	0.13	0.16	0.16	0.19	0.22
SF_6	0.81	0.60	0.65	0.70	0.74	0.76	0.81	0.84	0.80	0.79	0.74	0.71
Total greenhouse gas emissions	245.25	243.79	240.79	226.71	219.17	213.87	211.82	213.13	206.40	206.15	203.33	211.13

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007
Carbon dioxide	201.59	188.46	194.87	192.51	192.40	194.69	190.52
Methane	6.53	6.49	5.27	5.01	4.56	4.29	3.65
Nitrous oxide	1.96	1.89	1.92	1.91	1.94	2.01	1.95
HFCs	5.88	6.64	6.74	6.83	6.68	6.55	6.39
PFCs	0.15	0.11	0.10	0.09	0.09	0.08	0.08
SF6	0.67	0.66	0.65	0.74	0.86	0.69	0.64
Total greenhouse gas emissions	216.77	204.26	209.55	207.10	206.51	208.32	203.23

Table A 11.7.3: Final user emissions from Industrial Processes, by gas, $MtCO_2$ equivalent

Greenhouse Gas	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Carbon dioxide	17.25	17.25	15.09	14.38	14.29	15.45	15.83	16.48	16.68	16.59	16.42	15.59
Methane	1.69	1.69	1.64	1.64	1.61	1.32	1.41	1.45	1.48	1.25	1.14	0.98
Nitrous oxide	24.72	24.72	24.87	20.24	16.33	16.52	14.95	14.86	15.04	15.32	5.44	5.62
HFCs	13.98	11.37	11.84	12.31	12.78	13.26	13.98	14.32	15.62	12.12	4.88	2.62
PFCs	0.36	1.34	1.11	0.50	0.41	0.39	0.36	0.36	0.26	0.25	0.21	0.28
SF_6	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.47	0.69	1.09
Total greenhouse gas emissions	58.42	56.80	54.98	49.50	45.84	47.37	46.96	47.89	49.52	46.00	28.78	26.18

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007
Carbon dioxide	14.12	13.09	13.89	14.20	14.19	13.67	14.87
Methane	0.76	0.67	0.61	0.57	0.49	0.45	0.40
Nitrous oxide	4.88	2.73	2.89	3.64	2.87	2.43	2.82
HFCs	2.39	2.03	1.98	0.45	0.44	0.39	0.18
PFCs	0.27	0.21	0.17	0.24	0.17	0.22	0.14
SF_6	0.76	0.85	0.67	0.39	0.25	0.18	0.15
Total greenhouse gas emissions	23.17	19.57	20.20	19.48	18.42	17.34	18.56

Table A 11.7.4: Final user emissions from Land Use Land Use Change and Forestry, by gas, $MtCO_2$ equivalent

Greenhouse Gas	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Carbon dioxide	2.94	2.94	2.85	2.30	1.14	0.93	1.25	1.01	0.70	0.09	-0.19	-0.33
Methane	0.02	0.02	0.02	0.01	0.01	0.01	0.03	0.02	0.03	0.02	0.02	0.02
Nitrous oxide	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
HFCs												
PFCs												
SF_6												
Total greenhouse gas emissions	2.97	2.97	2.88	2.32	1.15	0.94	1.29	1.04	0.74	0.11	-0.17	-0.30

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007
Carbon dioxide	-0.45	-0.97	-1.01	-1.76	-1.90	-1.79	-1.79
Methane	0.03	0.03	0.03	0.02	0.02	0.03	0.03
Nitrous oxide	0.01	0.00	0.00	0.00	0.00	0.00	0.00
HFCs							
PFCs							
SF_6							
Total greenhouse gas emissions	-0.42	-0.94	-0.98	-1.73	-1.88	-1.75	-1.75

Table A 11.7.5: Final user emissions from Public Sector, by gas, $MtCO_2$ equivalent

Greenhouse Gas	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Carbon dioxide	29.24	29.24	32.32	33.89	27.84	27.55	26.74	27.61	25.18	24.01	23.19	22.39
Methane	1.74	1.74	1.93	2.10	1.66	1.29	1.37	1.29	1.20	1.04	0.94	0.83
Nitrous oxide	0.20	0.20	0.21	0.21	0.16	0.15	0.13	0.13	0.11	0.10	0.09	0.09
HFCs												
PFCs												
SF_6												
Total greenhouse gas emissions	31.18	31.18	34.46	36.20	29.66	28.99	28.24	29.03	26.48	25.15	24.22	23.31

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007
Carbon dioxide	23.12	20.70	20.81	21.60	21.46	21.42	20.34
Methane	0.80	0.76	0.59	0.60	0.56	0.53	0.44
Nitrous oxide	0.09	0.08	0.08	0.08	0.08	0.09	0.08
HFCs							
PFCs							
SF_6							
Total greenhouse gas emissions	24.01	21.54	21.48	22.28	22.10	22.03	20.86

Table A 11.7.6: Final user emissions from Residential, by gas, $MtCO_2$ equivalent

Greenhouse Gas	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Carbon dioxide	155.86	155.86	165.62	159.44	155.62	150.40	143.91	156.00	141.37	147.13	142.53	147.07
Methane	11.64	11.64	12.17	11.92	11.39	8.74	8.45	8.28	7.43	7.02	6.49	5.79
Nitrous oxide	0.92	0.92	0.96	0.90	0.83	0.78	0.70	0.68	0.58	0.60	0.55	0.57
HFCs	0.01	0.01	0.01	0.01	0.03	0.12	0.40	0.78	1.36	2.11	1.95	2.24
PFCs												
SF_6												
Total greenhouse gas emissions	168.43	168.43	178.76	172.27	167.86	160.04	153.46	165.74	150.74	156.87	151.52	155.67

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007
Carbon dioxide	153.83	148.33	151.83	153.01	148.72	148.27	142.25
Methane	5.64	5.55	4.35	4.27	3.92	3.72	3.28
Nitrous oxide	0.61	0.55	0.56	0.55	0.54	0.58	0.54
HFCs	2.43	2.35	2.65	2.68	3.02	3.01	3.01
PFCs							
SF_6							
Total greenhouse gas emissions	162.50	156.79	159.39	160.51	156.21	155.58	149.07

Table A 11.7.7: Final user emissions from Transport, by gas, $MtCO_2$ equivalent

Final user category	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Carbon dioxide	140.81	140.81	139.15	140.83	142.91	144.11	144.38	150.14	150.46	149.21	149.21	148.04
Methane	2.27	2.27	2.15	2.15	2.02	1.99	2.05	1.92	1.79	1.70	1.48	1.38
Nitrous oxide	1.69	1.69	1.68	1.73	1.95	2.36	2.90	2.23	2.26	2.31	2.32	2.32
HFCs												
PFCs												
SF_6												
Total greenhouse gas emissions	144.76	144.76	142.98	144.71	146.89	148.45	149.33	154.29	154.51	153.23	153.01	151.74

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007
Carbon dioxide	148.22	151.34	151.41	150.95	152.70	151.82	153.20
Methane	1.40	1.25	1.09	1.05	0.92	0.83	0.90
Nitrous oxide	2.24	2.22	2.13	2.06	2.00	1.96	1.89
HFCs							
PFCs							
SF_6							
Total greenhouse gas emissions	151.86	154.82	154.64	154.06	155.62	154.61	155.99

Table A 11.7.8: Final user emissions from Waste Management, by gas, $MtCO_2$ equivalent

Greenhouse Gas	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Carbon dioxide	1.20	1.20	1.20	1.15	1.07	0.92	0.87	0.88	0.50	0.50	0.46	0.46
Methane	50.59	50.59	49.82	48.66	47.40	46.48	45.00	43.52	40.08	37.61	34.45	32.37
Nitrous oxide	1.08	1.08	1.07	1.08	1.07	1.15	1.08	1.12	1.22	1.23	1.19	1.23
HFCs												
PFCs												
SF_6												
Total greenhouse gas emissions	52.87	52.87	52.08	50.89	49.55	48.54	46.94	45.52	41.79	39.34	36.11	34.06

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007
Carbon dioxide	0.49	0.49	0.47	0.47	0.47	0.43	0.45
Methane	28.34	25.94	22.86	21.34	21.10	21.12	21.08
Nitrous oxide	1.26	1.26	1.26	1.26	1.26	1.29	1.30
HFCs							
PFCs							
SF_6							
Total greenhouse gas emissions	30.09	27.69	24.59	23.07	22.84	22.84	22.83

Table A 11.7.9: Final user emissions from all National Communication categories, $MtCO_2$ equivalent

Final user category	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Agriculture	64.45	64.45	63.97	62.05	61.07	61.89	61.65	61.98	62.35	61.26	60.34	57.99
Business	245.3	243.8	240.8	226.7	219.2	213.9	211.8	213.1	206.4	206.1	203.3	211.1
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	10.31	10.31	11.41	12.34	13.90	14.32	15.44	17.06	18.17	17.72	15.80	15.17
Industrial Process	58.4	56.8	55.0	49.5	45.8	47.4	47.0	47.9	49.5	46.0	28.8	26.2
Public	31.18	31.18	34.46	36.20	29.66	28.99	28.24	29.03	26.48	25.15	24.22	23.31
Residential	168.43	168.43	178.76	172.27	167.86	160.04	153.46	165.74	150.74	156.87	151.52	155.67
Transport	144.76	144.76	142.98	144.71	146.89	148.45	149.33	154.29	154.51	153.23	153.01	151.74
Waste Management	52.87	52.87	52.08	50.89	49.55	48.54	46.94	45.52	41.79	39.34	36.11	34.06
LULUCF	2.97	2.97	2.88	2.32	1.15	0.94	1.29	1.04	0.74	0.11	-0.17	-0.30
Overseas Territories	1.56	1.55	1.59	1.61	1.63	1.68	1.67	1.67	1.73	1.83	1.85	1.89
Total greenhouse gas emissions	780.21	777.12	783.90	758.61	736.72	726.10	716.80	737.35	712.43	707.65	674.79	676.83

Final user category	2001	2002	2003	2004	2005	2006	2007
Agriculture	55.4	55.6	54.9	54.7	53.6	52.2	50.6
Business	216.8	204.3	209.5	207.1	206.5	208.3	203.2
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	14.88	16.84	17.27	18.48	18.76	16.28	16.90
Industrial Process	23.2	19.6	20.2	19.5	18.4	17.3	18.6
Public	24.01	21.54	21.48	22.28	22.10	22.03	20.86
Residential	162.50	156.79	159.39	160.51	156.21	155.58	149.07
Transport	151.86	154.82	154.64	154.06	155.62	154.61	155.99
Waste Management	30.09	27.69	24.59	23.07	22.84	22.84	22.83
LULUCF	-0.42	-0.94	-0.98	-1.73	-1.88	-1.75	-1.75
Overseas Territories	1.97	1.96	2.02	2.09	2.11	2.19	2.25
Total greenhouse gas emissions	680.23	658.17	663.05	660.01	654.23	649.66	638.49

Table A 11.7.10: Final user emissions, Carbon, $MtCO_2$ equivalent

Final user category	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Agriculture	8.77	8.77	8.80	8.62	8.38	8.40	8.30	8.32	7.94	7.82	7.64	7.32
Business	227.49	227.49	224.75	211.07	203.96	200.96	197.58	199.00	191.86	191.76	188.93	196.33
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	9.34	9.34	10.40	11.29	12.82	13.23	14.26	15.89	16.92	16.51	14.82	14.22
Industrial Process	17.25	17.25	15.09	14.38	14.29	15.45	15.83	16.48	16.68	16.59	16.42	15.59
Public	29.24	29.24	32.32	33.89	27.84	27.55	26.74	27.61	25.18	24.01	23.19	22.39
Residential	155.86	155.86	165.62	159.44	155.62	150.40	143.91	156.00	141.37	147.13	142.53	147.07
Transport	140.81	140.81	139.15	140.83	142.91	144.11	144.38	150.14	150.46	149.21	149.21	148.04
Waste Management	1.20	1.20	1.20	1.15	1.07	0.92	0.87	0.88	0.50	0.50	0.46	0.46
LULUCF	2.94	2.94	2.85	2.30	1.14	0.93	1.25	1.01	0.70	0.09	-0.19	-0.33
Overseas Territories	1.30	1.30	1.34	1.36	1.38	1.43	1.47	1.47	1.53	1.62	1.64	1.67
Total greenhouse gas emissions	594.19	594.19	601.51	584.33	569.40	563.36	554.59	576.80	553.12	555.24	544.64	552.77

Final user category	2001	2002	2003	2004	2005	2006	2007
Agriculture	7.66	7.62	7.55	7.45	7.23	7.04	6.66
Business	201.59	188.46	194.87	192.51	192.40	194.69	190.52
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	13.95	15.88	16.41	17.50	17.89	15.50	16.05
Industrial Process	14.12	13.09	13.89	14.20	14.19	13.67	14.87
Public	23.12	20.70	20.81	21.60	21.46	21.42	20.34
Residential	153.83	148.33	151.83	153.01	148.72	148.27	142.25
Transport	148.22	151.34	151.41	150.95	152.70	151.82	153.20
Waste Management	0.49	0.49	0.47	0.47	0.47	0.43	0.45
LULUCF	-0.45	-0.97	-1.01	-1.76	-1.90	-1.79	-1.79
Overseas Territories	1.75	1.75	1.81	1.88	1.91	1.99	2.06
Total greenhouse gas emissions	564.27	546.69	558.04	557.83	555.08	553.06	544.61

Table A 11.7.11: Final user emissions, Methane, $MtCO_2$ equivalent

Final user category	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Agriculture	22.40	22.40	22.07	22.13	21.95	22.01	21.75	21.90	21.68	21.62	21.48	20.70
Business	13.06	13.06	12.83	12.44	11.93	9.15	9.94	9.23	9.07	8.14	7.38	6.87
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.88	0.88	0.90	0.94	0.95	0.95	1.03	1.00	1.05	1.00	0.79	0.74
Industrial Process	1.69	1.69	1.64	1.64	1.61	1.32	1.41	1.45	1.48	1.25	1.14	0.98
Public	1.74	1.74	1.93	2.10	1.66	1.29	1.37	1.29	1.20	1.04	0.94	0.83
Residential	11.64	11.64	12.17	11.92	11.39	8.74	8.45	8.28	7.43	7.02	6.49	5.79
Transport	2.27	2.27	2.15	2.15	2.02	1.99	2.05	1.92	1.79	1.70	1.48	1.38
Waste Management	50.59	50.59	49.82	48.66	47.40	46.48	45.00	43.52	40.08	37.61	34.45	32.37
LULUCF	0.02	0.02	0.02	0.01	0.01	0.01	0.03	0.02	0.03	0.02	0.02	0.02
Overseas Territories	0.21	0.21	0.21	0.20	0.20	0.20	0.14	0.14	0.14	0.14	0.14	0.14
Total greenhouse gas emissions	104.49	104.49	103.72	102.20	99.13	92.14	91.16	88.75	83.94	79.56	74.32	69.84

Final user category	2001	2002	2003	2004	2005	2006	2007
Agriculture	19.49	19.30	19.29	19.33	18.84	18.81	18.42
Business	6.53	6.49	5.27	5.01	4.56	4.29	3.65
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.74	0.72	0.65	0.74	0.64	0.57	0.65
Industrial Process	0.76	0.67	0.61	0.57	0.49	0.45	0.40
Public	0.80	0.76	0.59	0.60	0.56	0.53	0.44
Residential	5.64	5.55	4.35	4.27	3.92	3.72	3.28
Transport	1.40	1.25	1.09	1.05	0.92	0.83	0.90
Waste Management	28.34	25.94	22.86	21.34	21.10	21.12	21.08
LULUCF	0.03	0.03	0.03	0.02	0.02	0.03	0.03
Overseas Territories	0.14	0.13	0.12	0.13	0.12	0.12	0.11
Total greenhouse gas emissions	63.85	60.84	54.86	53.05	51.15	50.47	48.97

Table A 11.7.12: Final user emissions, Nitrous Oxide, $MtCO_2$ equivalent

Final user category	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Agriculture	33.28	33.28	33.11	31.30	30.74	31.49	31.61	31.76	32.73	31.81	31.22	29.96
Business	2.58	2.58	2.50	2.43	2.26	2.23	2.17	2.08	1.96	1.93	1.85	1.89
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.10	0.10	0.11	0.12	0.13	0.14	0.16	0.18	0.20	0.21	0.20	0.21
Industrial Process	24.72	24.72	24.87	20.24	16.33	16.52	14.95	14.86	15.04	15.32	5.44	5.62
Public	0.20	0.20	0.21	0.21	0.16	0.15	0.13	0.13	0.11	0.10	0.09	0.09
Residential	0.92	0.92	0.96	0.90	0.83	0.78	0.70	0.68	0.58	0.60	0.55	0.57
Transport	1.69	1.69	1.68	1.73	1.95	2.36	2.90	2.23	2.26	2.31	2.32	2.32
Waste Management	1.08	1.08	1.07	1.08	1.07	1.15	1.08	1.12	1.22	1.23	1.19	1.23
LULUCF	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
Overseas Territories	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total greenhouse gas emissions	64.61	64.61	64.57	58.06	53.52	54.87	53.75	53.08	54.16	53.58	42.92	41.94

Final user category	2001	2002	2003	2004	2005	2006	2007
Agriculture	28.23	28.73	28.05	27.90	27.48	26.37	25.47
Business	1.96	1.89	1.92	1.91	1.94	2.01	1.95
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.19	0.24	0.22	0.23	0.23	0.21	0.20
Industrial Process	4.88	2.73	2.89	3.64	2.87	2.43	2.82
Public	0.09	0.08	0.08	0.08	0.08	0.09	0.08
Residential	0.61	0.55	0.56	0.55	0.54	0.58	0.54
Transport	2.24	2.22	2.13	2.06	2.00	1.96	1.89
Waste Management	1.26	1.26	1.26	1.26	1.26	1.29	1.30
LULUCF	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Overseas Territories	0.06	0.05	0.05	0.05	0.05	0.05	0.05
Total greenhouse gas emissions	39.53	37.76	37.17	37.68	36.46	34.98	34.29

Table A 11.7.13: Final user emissions, HFC, $MtCO_2$ equivalent

Final user category	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Agriculture												
Business	1.20	0.00	0.00	0.00	0.20	0.67	1.20	1.84	2.56	3.36	4.24	5.11
Energy Supply												
Exports												
Industrial Process	13.98	11.37	11.84	12.31	12.78	13.26	13.98	14.32	15.62	12.12	4.88	2.62
Public												
Residential	0.40	0.01	0.01	0.01	0.03	0.12	0.40	0.78	1.36	2.11	1.95	2.24
Transport												
Waste Management												
LULUCF												
Overseas Territories	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02
Total greenhouse gas emissions	15.59	11.39	11.85	12.32	13.01	14.06	15.59	16.96	19.56	17.60	11.09	9.99

Final user category	2001	2002	2003	2004	2005	2006	2007
Agriculture							
Business	5.88	6.64	6.74	6.83	6.68	6.55	6.39
Energy Supply							
Exports							
Industrial Process	2.39	2.03	1.98	0.45	0.44	0.39	0.18
Public							
Residential	2.43	2.35	2.65	2.68	3.02	3.01	3.01
Transport							
Waste Management							
LULUCF							
Overseas Territories	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Total greenhouse gas emissions	10.73	11.05	11.40	9.99	10.18	9.98	9.61

Table A 11.7.14: Final user emissions, PFC, $MtCO_2$ equivalent

Final user category	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Agriculture												
Business	0.11	0.06	0.06	0.07	0.08	0.10	0.11	0.13	0.16	0.16	0.19	0.22
Energy Supply												
Exports												
Industrial Process	0.36	1.34	1.11	0.50	0.41	0.39	0.36	0.36	0.26	0.25	0.21	0.28
Public												
Residential												
Transport												
Waste Management												
LULUCF												
Overseas Territories	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total greenhouse gas emissions	0.47	1.40	1.17	0.57	0.49	0.49	0.47	0.49	0.42	0.41	0.40	0.50

Final user category	2001	2002	2003	2004	2005	2006	2007
Agriculture							
Business	0.15	0.11	0.10	0.09	0.09	0.08	0.08
Energy Supply							
Exports							
Industrial Process	0.27	0.21	0.17	0.24	0.17	0.22	0.14
Public							
Residential							
Transport							
Waste Management							
LULUCF							
Overseas Territories	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total greenhouse gas emissions	0.42	0.31	0.26	0.33	0.25	0.3	1.3

Table A 11.7.15: Final user emissions, SF_6, $MtCO_2$ equivalent

Final user category	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Agriculture												
Business	0.81	0.60	0.65	0.70	0.74	0.76	0.81	0.84	0.80	0.79	0.74	0.71
Energy Supply												
Exports												
Industrial Process	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.47	0.69	1.09
Public												
Residential												
Transport												
Waste Management												
LULUCF												
Overseas Territories	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total greenhouse gas emissions	1.24	1.03	1.08	1.12	1.17	1.18	1.24	1.27	1.23	1.26	1.43	1.80

Final user category	2001	2002	2003	2004	2005	2006	2007
Agriculture							
Business	0.67	0.66	0.65	0.74	0.86	0.69	0.64
Energy Supply							
Exports							
Industrial Process	0.76	0.85	0.67	0.39	0.25	0.18	0.15
Public							
Residential							
Transport							
Waste Management							
LULUCF							
Overseas Territories	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total greenhouse gas emissions	1.43	1.51	1.32	1.13	1.11	0.87	0.79

A12 ANNEX 12: Analysis of EU ETS Data

A12.1 INTRODUCTION

The EU Emission Trading Scheme (EU ETS) provides a source of data that can be used to cross-check data held in the UK Greenhouse Gas Inventory (GHGI), and to inform the carbon contents of current UK fuels. The EU ETS has operated since 2005, and there are now 3 years' worth of data on fuel use and emissions across major UK industrial plant, for 2005, 2006 and 2007.

These processes are collectively responsible for a major proportion of UK emissions of carbon dioxide and so the EU ETS data has the potential to be an extremely important source of information to support the UK GHG inventory. However, operators of processes which are included in the UK Emission Trading Scheme (UK ETS), or which have a Climate Change Agreement (CCA) can choose to be exempt from the EU ETS. The UK ETS exemptions were valid until the end of 2006, whilst the CCA exemptions were valid until the end of 2007. These exemptions mean that the 2005 to 2007 EU ETS data gives an incomplete picture of total UK fuels consumed and carbon dioxide emitted by several major industrial sectors.

From the 2008 EU ETS dataset onwards, all of the major plant opt-outs will have ceased, and a more complete picture of fuel use and emissions across heavy industry in the UK will be available. The 2008 data are due to become available during Spring 2009. Note however, that emissions from smaller combustion devices in the industrial, commercial and public sectors will not be reported within EU ETS, due to the limited scope of EU ETS reporting. This limitation will continue to restrict how much of the EU ETS data can be used to cross-check and directly inform the GHGI. However, from the 2008 dataset onwards, 100% of sector emissions will be covered for several major industrial sectors:

- Power stations;
- Oil refineries;
- Coke ovens;
- Integrated steelworks;
- Cement kilns; and
- Lime kilns.

This annex examines what data are already available in 2005 to 2007 EU ETS datasets, and the use of EU ETS fuel quality data (i.e. CO_2 emission factors) within the GHGI. The data reported under the EU ETS includes quantities of fuels consumed, carbon contents, calorific values and emissions of CO_2. Data for individual installations are treated as commercially confidential by the UK regulatory authorities and so only aggregated emissions data are presented here.

A12.2 PROCESSING OF EU ETS DATA

In order to be able to compare EU ETS data with GHGI data it was necessary to:

1) allocate each of the installations named in the EU ETS dataset to one of the emission sectors reported in the GHGI; and
2) allocate each fuel used by each installation to one of the fuel types used in the GHGI.

Task 1 was straightforward, while the allocation of fuels to GHGI categories was, occasionally, quite uncertain. The uncertainties largely centred on the allocation of fuels to GHGI fuel categories such as LPG, OPG, gas oil and fuel oil, and were due to the use of abbreviations or other ambiguous names for fuels within the EU ETS reporting system. There were also some instances where gas oil was specified as the fuel, but where it was possible that fuel oil was actually used, and vice versa.

The level of coverage of the EU ETS data can be seen in **Table A 12.2.1.** The number of sites in each sector which are included in the ETS dataset for 2005 is given, together with AEA's estimate of the total number of installations in that sector throughout the UK.

Table A 12.2.1: Numbers of installations included in the EU ETS datasets

Sector	Number of installations	
	EU ETS data	UK total
Power stations (fossil fuel, > 75MWe)	61	61
Power stations (fossil fuel, < 75MWe)	21	30
Power stations (nuclear)	12	12
Coke ovens	4	4
Sinter plant	3	3
Blast furnaces	3	3
Cement kilns	4	15
Lime kilns	8	15
Refineries	12	12
Combustion – iron & steel industry	12	200[a]
Combustion – other industry	237	5000[a]
Combustion – commercial sector	23	1000[a]
Combustion – public sector	167	1000[a]

[a] These estimates are not intended to be particularly accurate but are 'order of magnitude' figures, offered in order to show that the number of installations in the UK is likely to be considerably higher than the number of installations reporting in the EU ETS at present.

Data were included for all coke ovens, refineries, sinter plant and blast furnaces. Power stations are divided into three categories in the table in order to show that, although 9 stations are not included in the EU ETS data, these are all small (in most cases, very small diesel-fired plant supplying electricity to Scottish islands). In comparison, coverage is quite poor for cement and lime kilns (presumably due to CCA participants opting out) and for combustion processes (due to CCA/UKETS opt-outs and the fact that numerous combustion plant are too small to be required to join the EU ETS).

A12.3 ANALYSIS OF EU ETS DATA FOR POWER STATIONS

Table A 12.3.1 summarises data given in the EU ETS datasets for the major fuels burnt by major power stations and coal burnt by autogenerators. The percentage of emissions that were based on use of Tier 3 emission factors is given (tier 3 factors are based on fuel analysis, and are therefore more reliable than emission factors based on default values). The table then gives the average emission factor for all EUETS emissions that were based on use of the Tier 3 factors. Finally, the carbon factor using the methodology used in the previous version of the GHGI is given for comparison.

Table A 12.3.1: EU ETS data for Coal, Fuel Oil and Natural Gas burnt at Power Stations and Autogenerators (Emission Factors in ktonne / Mtonne for Coal & Fuel Oil and ktonne / Mtherm for Natural Gas)

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 sites only)	2006 GHGI Carbon Emission Factor
2005	Coal	100	615.6	627.2
2006		100	615.6	627.2
2007		100	615.4	627.2
2005	Fuel oil / Waste oil[a]	68	860.2	879.0
2006		66	873.3	879.0
2007		68	871.2	879.0
2005	Natural gas	52	1.443	1.478
2006		76	1.462	1.478
2007		95	1.463	1.477
2005	Coal - autogenerators	100	594.3	631.1
2006		100	596.3	631.1
2007		100	594.5	645.4

[a] It is not possible to distinguish between fuel oil and waste oil in the EU ETS data, so all emissions have been reported under fuel oil.

The main point of note from the data presented in **Table A 12.3.1** is that the emission factors generated using the 2006 GHGI methodology are higher than those generated from the EU ETS dataset. The EU ETS data are generally very consistent across the three years for which data are available, with the exception of the 2005 data for fuel oil and natural gas. The data used in the 2006 GHGI were based on extrapolated information from operator-supplied data from a study that focussed on carbon emission factors in the power sector 2004. The EU ETS data shown are regarded as good quality data, and are assumed to be representative of the sector as a whole, since a high proportion of emissions are based on Tier 3 emission factors (i.e. verified emissions based on fuel analysis to ISO17025). The EU ETS based emission factors presented above have therefore been used directly as the emission factors in the GHGI, with the exception of the 2005 figure for gas, where Tier 3 factors were only used for about half of the sector's emissions.

A12.4 ANALYSIS OF EU ETS DATA FOR REFINERIES

Similar data to that shown in Table A 1.3.1 for power stations are shown for oil refineries in **Table A 12.4.1.** The main fuels in refineries are fuel oil and OPG and emissions also occur due to the burning off of 'petroleum coke' deposits on catalysts used in processes such as catalytic cracking. In the latter case, emissions in the EU ETS are not generally based on activity data and emission factors but are instead based on direct measurement of carbon emitted. This is due to the technical difficulty in measuring the quantity of petroleum coke burnt and the carbon content.

Table A 12.4.1: EU ETS Data for Fuel Oil, OPG and Petroleum Coke burnt at Refineries (Emission Factors in ktonne / Mtonne for Fuel Oil & Petroleum Coke and ktonne / Mtherm for OPG)

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 sites only)	2006 GHGI Carbon Emission Factor
2005	Fuel Oil	26	861.0	879.0
2006		68	873.7	879.0
2007		79	877.4	879.0
2005	OPG	69	1.526	1.644
2006		48	1.507	1.644
2007		60	1.519	1.644
2005	Petroleum Coke	-[a]	1054.2	930.0
2006		-[a]	985.8	930.0
2007		-[a]	1189.8	930.0

[a] It was unclear from the data received how much of the emission was based on a Tier 3 approach.

As with power stations, the emission factors generated from EU ETS data were generally lower than those obtained using the 2006 GHGI methodology. Only in the case of petroleum coke is this reversed, but here the EU ETS factors are significantly higher. The factors given in Table 1.14.1 are based on EU ETS carbon emissions and DUKES activity data (since no activity data can be given in EU ETS for this fuel). The emission factors generated for 2005 and 2007 are impossibly high, suggesting that petroleum coke is more than 100% carbon. At the time of inventory compilation, it was not certain whether this was more likely to be due to inaccuracies in DUKES or EUETS. However, due to the large difference in the numbers, a compromise approach was adopted of using the 2006 EU ETS figure in the GHGI and an emission factor of 1000 ktonnes/Mtonne for 2005 and 2007. Consultation with the industry and energy statisticians should allow full resolution of this issue for the next version of the inventory.

The emission factors for fuel oil are very similar to those generated using the previous GHGI methodology. Because of the high percentage of Tier 3 data in 2006 and 2007, the EU ETS data have been used in the GHGI, while the 2005 figure has not been used as only 26% Tier 3 coverage was not considered high enough to be representative for the sector.

Emission factors for OPG are significantly lower than those generated using the GHGI method. However, Tier 3 emission factors are not always used for the majority of emissions, and there was in addition considerable uncertainly regarding the allocation of EU ETS fuels to the OPG fuel category. The data have therefore not been used in the GHGI, but it is hoped that Tier 3 emission factors will be used for a much higher percentage of emissions in future EU ETS data sets, thereby improving confidence in the data and enabling their future use in the derivation of the GHGI estimates.

A12.5 ANALYSIS OF EU ETS DATA FOR INDUSTRIAL COMBUSTION SOURCES

Table A.12.5.1 gives data for industrial combustion of coal, fuel oil and natural gas.

Table A 12.5.1: EU ETS data for Coal, Fuel Oil and Natural Gas burnt by Industrial Combustion Plant (Emission Factors in ktonne / Mtonne for Coal & Fuel Oil and ktonne / Mtherm for Natural Gas)

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 sites only)	2006 GHGI Carbon Emission Factor
2005	Coal	98	607.1	631.1
2006		98	603.0	631.1
2007		99	613.5	645.4
2005	Fuel oil	14	864.7	879.0
2006		14	865.3	879.0
2007		17	865.7	879.0
2005	Natural gas	16	1.376	1.478
2006		30	1.470	1.478
2007		39	1.465	1.477

At first sight, the data for coal looks like it should be reliable enough to be used in the GHGI with 98% or more of emissions based on Tier 3 factors. However, it must be recalled that numerous smaller industrial consumers will not be represented in EU ETS and that the EU ETS data are not fully representative of UK fuels as a whole. This is also true for EU ETS data for fuel oil and natural gas but here, in addition, very little of the EU ETS data are based on Tier 3 factors. Therefore, none of the above data have been used directly in the compilation of the GHGI estimates, and the emission factors from the 2006 GHGI have been retained.

Within the iron & steel sector, the EU ETS reporting format does not provide a breakdown of emissions for the sectors reported within the GHGI; estimates of emissions from coke ovens, blast furnaces and sinter plants are not provided explicitly within the EU ETS. In addition, the scope of reporting of EU ETS does not cover 100% of iron & steel sites or activities, as some secondary steel processes are excluded from the scope of EU ETS reporting. These two factors make the analysis and comparison of the EU ETS and the GHGI estimates much more uncertain. The EU ETS data has, however, been useful as a quality check for the use of fuels within the iron and steel sector.

A13 ANNEX 13: Standard Electronic Format Tables of GHG Emissions

2008 was the first year the UK Registry was operating under the Kyoto Protocol rules. Connection was established during October 2008 and the reporting year ended on the 31st December 2008. The UK issued 3,412,080,630 AAUs under the Kyoto Protocol following agreement with the UNFCCC.

After establishing the connection to the ITL, the UK Registry was made available to EU ETS operators and market participants from late October 2008. During the remainder of the year, units were exchanged with 27 other Registries operating within the Kyoto rules as confirmed by the UNFCCC.

In total, the UK Registry received 195,468,637 AAUs and 128,774,640 CERs. Conversely, 154,160,461 AAUs and 103,671,234 CERs were externally transferred to other national registries. Account holders voluntarily cancelled 80 AAUs and 345,826 CERS. There were no transactions of any kind involving RMUs, ERUs tCERs or lCERs. All of these additions and subtractions were undertaken by account holders of person and operator holding accounts, i.e. the UK Government did not initiate any transactions or receive any units into Party Holding Accounts. The UK did not carry out any transactions in response to notifications, as none were received from the ITL.

The tables in this Annex present summary data for UK greenhouse gas emissions for the years 1990-2007, inclusive. The data are given in standard electronic format (SEF).

A13.1 SEF TABLES

Table A 13.1.1 Total quantities of Kyoto Protocol units by account type at beginning of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	NO	NO	NO	NO	NO	NO
Entity holding accounts	NO	NO	NO	NO	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	NO	NO	NO	NO	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal in storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification repor	NO	NO	NO	NO		NO
Total	NO	NO	NO	NO	NO	NO

Table A 13.1.2: Annual internal transactions

Transaction type	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Article 6 issuance and conversion												
Party-verified projects		NO					NO		NO			
Independently verifed projects		NO					NO		NO			
Article 3.3 and 3.4 issuance or cancellation												
3.3 Afforestation and reforestation			NO				NO	NO	NO	NO		
3.3 Deforestation			NO				NO	NO	NO	NO		
3.4 Forest management			NO				NO	NO	NO	NO		
3.4 Cropland management			NO				NO	NO	NO	NO		
3.4 Grazing land management			NO				NO	NO	NO	NO		
3.4 Revegetation			NO				NO	NO	NO	NO		
Article 12 afforestation and reforestation												
Replacement of expired tCERs							NO	NO	NO	NO	NO	
Replacement of expired lCERs							NO	NO	NO	NO		
Replacement for reversal of storage							NO	NO	NO	NO		NO
Replacement for non-submission of certification report							NO	NO	NO	NO		NO
Other cancellation							80	NO	NO	345826	NO	NO
Sub-total		NO	NO				80	NO	NO	345826	NO	NO

Transaction type	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Retirement	NO	NO	NO	NO	NO	NO

Table A 13.1.3: Annual external transactions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Transfers and acquisitions												
AT	5843000	NO	NO	NO	NO	NO	2282061	NO	NO	774000	NO	NO
BE	5885748	NO	NO	18533	NO	NO	127300	NO	NO	125609	NO	NO
CDM	NO	NO	NO	62161648	NO	NO	NO	NO	NO	NO	NO	NO
CH	NO	NO	NO	33433864	NO	NO	NO	NO	NO	45251255	NO	NO
CZ	11489825	NO	NO	NO	NO	NO	782000	NO	NO	1626050	NO	NO
DE	64352120	NO	NO	4620417	NO	NO	63038368	NO	NO	24017240	NO	NO
DK	22282192	NO	NO	5572000	NO	NO	19197293	NO	NO	3858432	NO	NO
EE	NO	NO	NO	NO	NO	NO	1149000	NO	NO	NO	NO	NO
ES	11243141	NO	NO	30000	NO	NO	10897316	NO	NO	2727817	NO	NO
EU	5627661	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
FI	5188331	NO	NO	72000	NO	NO	1660100	NO	NO	1246333	NO	NO
FR	29089813	NO	NO	8032882	NO	NO	15284836	NO	NO	9982330	NO	NO
GR	NO	NO	NO	945	NO	NO	42000	NO	NO	53945	NO	NO
IE	351449	NO	NO	NO	NO	NO	1296245	NO	NO	1182380	NO	NO
IT	1185263	NO	NO	6689921	NO	NO	12239997	NO	NO	3957262	NO	NO
JP	NO	NO	NO	593482	NO	NO	NO	NO	NO	2658703	NO	NO
LT	200506	NO	NO	NO	NO	NO	NO	NO	NO	221751	NO	NO
LU	99000	NO	NO	NO	NO	NO	NO	NO	NO	54551	NO	NO
LV	25476	NO	NO	NO	NO	NO	NO	NO	NO	20000	NO	NO
NL	27963194	NO	NO	7195948	NO	NO	25004610	NO	NO	5223648	NO	NO
NZ	NO	NO	NO	15000	NO	NO	NO	NO	NO	NO	NO	NO
PL	210000	NO	NO	NO	NO	NO	1073000	NO	NO	238000	NO	NO
PT	1457944	NO	NO	288000	NO	NO	NO	NO	NO	305000	NO	NO
RO	243002	NO	NO	NO	NO	NO	1	NO	NO	16600	NO	NO
SE	2654320	NO	NO	50000	NO	NO	86334	NO	NO	119328	NO	NO
SI	54617	NO	NO	NO	NO	NO	NO	NO	NO	11000	NO	NO
SK	22035	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total	195468637	NO	NO	128774640	NO	NO	154160461	NO	NO	103671234	NO	NO

Additional information

Independently verified ERUs								NO				

Table A 13.1.4: Total annual transactions

Total (Sum of tables 2a and 2b)	195468637	NO	NO	128774640	NO	NO	154160541	NO	NO	104017060	NO	NO

Table A 13.1.5: Expiry, cancellation and replacement

	Expiry, cancellation and requirement to replace		Replacement					
	Unit type		Unit type					
Transaction or event type	**tCERs**	**lCERs**	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Temporary CERs (tCERS)								
Expired in retirement and replacement accounts	NO							
Replacement of expired tCERs			NO	NO	NO	NO	NO	
Expired in holding accounts	NO							
Cancellation of tCERs expired in holding accounts	NO							
Long-term CERs (lCERs)								
Expired in retirement and replacement accounts		NO						
Replacement of expired lCERs			NO	NO	NO	NO		
Expired in holding accounts		NO						
Cancellation of lCERs expired in holding accounts		NO						
Subject to replacement for reversal of storage		NO						
Replacement for reversal of storage			NO	NO	NO	NO		NO
Subject to replacement for non-submission of certification report		NO						
Replacement for non-submission of certification report			NO	NO	NO	NO		NO
Total			NO	NO	NO	NO	NO	NO

Table A 13.1.6: Total quantities of Kyoto Protocol units by account type at end of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	3194708440	NO	NO	NO	NO	NO
Entity holding accounts	258680286	NO	NO	24757580	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	80	NO	NO	345826	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal in storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification repor	NO	NO	NO	NO		NO
Total	3453388806	NO	NO	25103406	NO	NO

Table A 13.1.7: Summary information on additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
Starting values	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Issuance pursuant to Article 3.7 and 3.8	3412080630											
Non-compliance cancellation							NO	NO	NO	NO		
Carry-over	NO	NO		NO								
Sub-total	3412080630	NO		NO			NO	NO	NO	NO		
Annual transactions												
Year 0 (2007)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 1 (2008)	195468637	NO	NO	128774640	NO	NO	154160541	NO	NO	104017060	NO	NO
Year 2 (2009)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 3 (2010)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total	195468637	NO	NO	128774640	NO	NO	154160541	NO	NO	104017060	NO	NO
Total	3607549267	NO	NO	128774640	NO	NO	154160541	NO	NO	104017060	NO	NO

Table A 13.1.8: Summary information on replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Previous CPs			NO	NO	NO	NO	NO	NO
Year 1 (2008)		NO	NO	NO	NO	NO	NO	NO
Year 2 (2009)		NO	NO	NO	NO	NO	NO	NO
Year 3 (2010)		NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)		NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO	NO	NO

Table A 13.1.9: Summary information on retirement

	Retirement					
	Unit type					
Year	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Year 1 (2008)	NO	NO	NO	NO	NO	NO
Year 2 (2009)	NO	NO	NO	NO	NO	NO
Year 3 (2010)	NO	NO	NO	NO	NO	NO
Year 4 (2011)	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO

Table A 13.1.10: Memo item: Corrective transactions relating to additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
NO TRANSACTION												

Table A 13.1.11: Memo item: Corrective transactions relating to replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
NO TRANSACTION								

Table A 13.1.12: Memo item: Corrective transactions relating to retirement

	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
NO TRANSACTION						

A14 ANNEX 14: Additional Reporting Requirements

For reporting during the Kyoto Commitment Period, additional information will be required in the NIR, specifically regarding KP-LULUCF activities, and registry information. The UNFCCC have provided a draft annotated outline to specify how the NIR should be structured to include this information.

A14.1 CONSIDERATION OF NEW REQUIREMENTS

Reporting under this new structure is not a requirement until the 2010 submission. However, the UK have considered and included some of the new data requirements, and the table below details which of the additional requirements are already included, and where they can be found. The NIR will be restructured in line with the new annotated outline for the 2010 submission. Table A14.1 is based on the annotated outline supplied by the UNFCCC, and additional requirements are highlighted in *italics*.

Table A 14.1.1: Consideration of additional reporting requirements

UNFCCC Annotated Outline	UK Comments
ES.1. Background information on greenhouse gas inventories, climate change and *supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol* (e.g., as it pertains to the national context, to provide information to the general public)	The Executive Summaries will be re-ordered in the 2010 NIR to follow the structure outlined here. The emissions and removals from KP-LULUCF activities are currently included in table ES.5.
ES.2. Summary of national emission and removal related trends, *and emission and removals from KP-LULUCF activities*	
ES.3. Overview of source and sink category emission estimates and trends, *including KP-LULUCF activities*	
ES.4. *Supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol*	
ES.5. Other information (e.g., indirect greenhouse gases)	
PART 1: ANNUAL INVENTORY SUBMISSION	
Chapter 1: Introduction	
1.1. Background information on greenhouse gas inventories, climate change and *supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol* (e.g., as it pertains to the national context, to provide information to the general public)	The additional requirements are already included in Chapter 1 of the UK NIR.
1.2. A description of the institutional arrangements for inventory preparation, *including the legal and procedural arrangements for inventory planning, preparation and management*	The additional requirements are already included in Chapter 1 of the UK NIR.
1.3. Inventory preparation	

UNFCCC Annotated Outline	UK Comments
1.4. Brief general description of methodologies and data sources used	
1.5. Brief description of key categories, *including for KP-LULUCF*	A Key Category Analysis including KP-LULUCF will be carried out for the 2010 inventory submission
1.6. Information on the QA/QC plan including verification and treatment of confidentiality issues where relevant	
1.7. General uncertainty evaluation, including data on the overall uncertainty for the inventory totals	
1.8. General assessment of the completeness (with reference to annex 5 of the structure of the national inventory report (NIR))	
Chapter 2: Trends in greenhouse gas emissions	
2.1. Description and interpretation of emission trends for aggregated greenhouse gas emissions	
2.2. Description and interpretation of emission trends by gas	
2.3. Description and interpretation of emission trends by category	
2.4. Description and interpretation of emission trends for indirect greenhouse gases and SO_2	
2.5. Description and interpretation of emission trends for KP-LULUCF inventory in aggregate and by activity, and by gas	Emissions trends including KP-LULUCF will be considered in the 2010 NIR.
Chapters 3–9: *(e.g. SECTOR NAME (CRF sector number))*	
X.1. Overview of sector (e.g., quantitative overview and description)	
X.2. Source category (CRF source category number)	
X.2.1. Source category description (e.g., characteristics of sources)	
X.2.2. Methodological issues (e.g., choice of methods/activity data/emission factors, assumptions, parameters and conventions underlying the emission and removal estimates – the rationale for their selection, any specific methodological issues (e.g. description of national methods))	
X.2.3. Uncertainties and time-series consistency	
X.2.4. Source-specific QA/QC and verification, if applicable	
X.2.5. Source-specific recalculations, if applicable, including changes made in response to the review process	
X.2.6. Source-specific planned improvements, if applicable (e.g., methodologies, activity data, emission factors, etc.), including those in response to the review process	
Chapter 9: Other (CRF sector 7) (if applicable)	
Chapter 10: Recalculations and improvements	
10.1. Explanations and justifications for recalculations, *including for KP-LULUCF inventory*	There have been no

UNFCCC Annotated Outline		UK Comments
10.2.	Implications for emission levels, *including on KP-LULUCF emission levels*	recalculations to the KP-LULUCF inventory this year
10.3.	Implications for emission trends, including time series consistency, *and also for the KP-LULUCF inventory*	
10.4.	Recalculations, including in response to the review process, and planned improvements to the inventory (e.g., institutional arrangements, inventory preparation), *including for KP-LULUCF inventory*	
PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1		
Chapter 11: KP-LULUCF		
11.1	*General information*	All of this information is currently presented in Annex 10. This will be moved to Chapter 11 of the main text in the 2010 NIR.
11.2	*Land-related information*	
11.3	*Activity-specific information*	
11.4	*Article 3.3*	
11.5	*Article 3.4*	
11.6	*Other information*	
11.7	*Information relating to Article 6*	
Chapter 12: Information on accounting of Kyoto units		
12.1	*Background information*	Information about the registry and accounting of Kyoto units is currently included in Chapter 1. Chapter 12 as outlined here will be included in the 2010 submission.
12.2	*Summary of information reported in the SEF tables*	
12.3	*Discrepancies and notifications*	
12.4	*Publicly accessible information*	
12.5	*Calculation of the commitment period reserve (CPR)*	
12.6	*KP-LULUCF accounting*	
Chapter 13: Information on changes in national system		This information is currently contained in Chapter 1. Chapter 13 will be included in the 2010 NIR.
Chapter 14: Information on changes in national registry		Any relevant information will be presented in the 2010 NIR.
Chapter 15: Information on minimization of adverse impacts in accordance with Article 3, paragraph 14		Included in Section 1.11
Chapter 16: Other information		
REFERENCES		
ANNEXES TO THE NATIONAL INVENTORY REPORT		
Annex 1: Key categories		
• Description of methodology used for identifying key categories, *including for KP-LULUCF.*		As discussed with reference to section 1.5.
• Reference to the key category tables in the CRF, *including in the KP-LULUCF CRF tables).*		
• Information on the level of disaggregation		

UNFCCC Annotated Outline	UK Comments
• Tables 7.A1 - 7.A3 of the IPCC good practice guidance	
• *Table NIR.3, as contained in the annex to decision 6/CMP.3.*	
Annex 2: Detailed discussion of methodology and data for estimating CO_2 emissions from fossil fuel combustion	
Annex 3: Other detailed methodological descriptions for individual source or sink categories, *including for KP-LULUCF activities*	Currently, Annex 10 contains all methods for KP-LULUCF activities. This will be moved to Chapter 11 in 2010 and it is unlikely that there will be any additional information to include in this Annex.
Annex 4: CO_2 reference approach and comparison with sectoral approach, and relevant information on the national energy balance	
Annex 5: Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded for the annual inventory submission *and also for the KP-LULUCF inventory*	This will be considered in the 2010 submission
Annex 6: Additional information to be considered as part of the annual inventory submission and the *supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol* or other useful reference information	
A.6.1: Annual inventory submission	
A.6.2: *Supplementary information under Article 7, paragraph 1*	SEF tables are currently presented in Annex 13. These can be moved to Annex 6 for the 2010 NIR. All other requirements will be considered in the 2010 NIR.
A.6.2.1 KP-LULUCF (accounting table, CRF and/or NIR tables)	
A.6.2.2 Standard electronic format (i.e. SEF tables)	
A.6.2.3 National system, including changes	
A.6.2.4 National registry	
6.2.4.1 Changes to national registry	
6.2.4.2 Reports:	
(i) list of discrepancies;	
(ii) notifications from EB of CDM (reversal of storage and failure of certification)	
(iii) non-replacements	
(iv) invalid units	
6.2.4.3 Publicly available information	
A.6.2.5 Adverse impacts under Article 3, paragraph 14 of the Kyoto Protocol	
Annex 7: Tables 6.1 and 6.2 of the IPCC good practice guidance	
Annex 8: Other annexes - (Any other relevant information – optional).	