Annexes

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A1 ANNEX 1: Key Categories

This Annex was updated in the 2010 NIR to include the new information required for reporting under the Kyoto Protocol (decision 15/CMP.1). The table below contains the information that Annex 1 must contain, and the locations of this information in the Annex[1]. The text in italics refers to the elements which are required under the Kyoto Protocol.

Requirements	**Locations of the relevant information in this Annex**
Description of methodology used for identifying key categories, *including KP-LULUCF*	See sections immediately below "*General approach used to identify Key Categories*" and "*Approach used to identify KP-LULUCF Key Categories*".
Reference to the key category tables in the CRF	This Annex of the NIR presents detailed tables of information of the data derived from the key category analysis. These data are used to create the key category tables (Table 7) in the CRF.
Reference to the key category tables in the CRF, *including in the KP-LULUCF CRF tables*	This Annex of the NIR presents detailed tables of information of the data derived from the key category analysis. These data are used to create the key category KP-LULUCF tables (Table NIR 3) in the CRF.
Information on the level of disaggregation	The tables in this Annex contain information on the level of disaggregation used. The level of disaggregation follows IPCC Good Practice Guidance.
Tables 7.A1 - 7.A3 of the IPCC good practice guidance	The data requested in these Good Practice Guidance tables, including and excluding LULUCF, are provided in **Table A1.1.1** to **Table A1.1.14**.
Table NIR.3, as contained in the annex to decision 6/CMP.3	A facsimile of Table NIR 3, provided in the CRF, is given in **Table A1.2.1**.

A1.1 DESCRIPTION OF METHODOLOGY USED FOR IDENTIFYING KEY CATEGORIES

General approach used to identify Key Categories

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.

[1] The information in this table has been taken directly from the UNFCCC document "Annotated outline of the National Inventory Report including reporting elements under the Kyoto Protocol".

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 A 1.1.11** to **Table A 1.1.14**. A trend cannot be calculated for the base year alone, and so **Table A 1.1.11** and **Table A 1.1.12** 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 **Table A 7.6.1** to **Table** A 7.6.5 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 A 1.1.1**to **Table A 1.1.6**.

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 for the base year, 1990 and the latest reported year are shown in **Table A 1.1.7** and **Table A 1.1.10**. 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 2011 NIR.

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

Approach used to identify KP-LULUCF Key Categories

From the 2010 NIR onwards, the NIR contains a list of the Key Categories for Land Use, Land-Use Change and Forestry Activities under the Kyoto Protocol. The description below explains the Key Category analysis for Article 3.3 activities and any elected activities under Article 3.4

Three categories are considered to be key: Article 3.3 Afforestation and Reforestation (CO_2), Article 3.3 Deforestation (CO_2) and Article 3.4 Forest Management (CO_2). These have been assessed according to the IPCC good practice guidance for LULUCF section 5.4.4.

Article 3.3 Afforestation and Reforestation (CO_2): The associated UNFCCC category 5A (-13,627 Gg CO_2e) is a key category although the AR component (forest planted since 1990) is not key on its own (i.e. its category contribution (-2,766 Gg CO_2e) is smaller than the smallest UNFCCC key category (1A Coal)). Removals from this category are also predicted to increase over time as a result of tree planting schemes partially focussed on climate change mitigation.

Article 3.3 Deforestation (CO_2): The associated UNFCCC categories (5C and 5E) are key categories (-8,156 and 6,280 Gg CO_2e respectively). However, the Deforestation category contribution (615 Gg CO_2e) to these UNFCCC categories is smaller than the smallest UNFCCC key category (1A Coal). The data used in the calculation of deforestation emissions are the most uncertain of the data sources in the KP-LULUCF inventory and are a priority for improvement.

Article 3.4 Forest Management (CO_2): The associated UNFCCC category 5A is a key category (-13,627 Gg CO_2e). The Forest Management category contribution (-10,698 Gg CO_2e) is also greater than other categories in the UNFCCC key category.

These categories are the priority for improvement in the KP-LULUCF inventory, and there is ongoing development (described in **Chapter 7**).

Using the uncertainty analysis to plan improvements in the preparation of the inventory

The approach the UK takes to using the uncertainty analysis (both Approach 1 and Approach 2) to plan improvements in the preparation of the inventory is described in **Chapter 1**, **Section 1.2.2.4**.

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	2008			%	
4D	Agricultural Soils	N2O	30406.856	23322.159	424.001	0.1652078	50.99904	
6A	Solid Waste Disposal	CH4	49816.593	20288.285	48.384	0.0308864	9.53450	60.53354
1A(stationary)	Oil	CO2	92033	53791	15.133	0.0178465	5.50916	66.04270
4B	Manure Management	N2O	2759.235	2121.002	414.001	0.0146380	4.51870	70.56140
1A1&1A2&1A4&1A5	Other Combustion	N2O	4670.540	3325.662	195.000	0.0116706	3.60268	74.16409
2B	Nitric Acid Production	N2O	3903.850	1464.657	230.217	0.0115166	3.55512	77.71921
5B	5B LUCF	CO2	15822	15243	50.010	0.0101394	3.13000	80.84921
1A3b	Auto Fuel	CO2	109526	117555	4.482	0.0062907	1.94191	82.79112
5C	5C LUCF	CO2	-6130	-8156	70.007	0.0054994	1.69766	84.48878
6B	Wastewater Handling	N2O	1033.354	1243.539	401.125	0.0053115	1.63965	86.12843
4A	Enteric Fermentation	CH4	18527.713	15531.379	20.000	0.0047484	1.46582	87.59425
5E	5E LUCF	CO2	7074	6280	50.010	0.0045335	1.39948	88.99373
2B	Adipic Acid Production	N2O	20737.345	947.019	15.008	0.0039882	1.23114	90.22487
5A	5A LUCF	CO2	-12155	-13627	25.020	0.0038971	1.20301	91.42788
2	Industrial Processes	HFC	15480	11249	19	0.0037741	1.16505	92.59293
1A	Coal	CO2	248618	133606	1.077	0.0034313	1.05922	93.65214
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2792.377	68.774	0.0030501	0.94157	94.59371
1A3b	Auto Fuel	N2O	1172.211	1066.125	170.023	0.0025539	0.78838	95.38210
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5288.311	27.424	0.0023034	0.71106	96.09316
1A	Natural Gas	CO2	108920	200365	1.513	0.0021121	0.65200	96.74516
4B	Manure Management	CH4	3608.070	2856.681	30.000	0.0013870	0.42818	97.17333
1A	All Fuel	CH4	2065.099588	1076.734037	50.00159997	0.0013232	0.40846	97.58179
1B	Oil & Natural Gas	CO2	5778	4414	17.088	0.0012652	0.39056	97.97235
2B5	NEU	CO2	1563	1871	53.852	0.0010785	0.33293	98.30529
5G	5G LUCF	CO2	-1711	-1755	30	0.0006580	0.20314	98.50842
6B	Wastewater Handling	CH4	709.572	815.917	50.010	0.0004547	0.14037	98.64879
1A3b	Auto Fuel	CH4	634.8592178	127.667252	50.07833863	0.0004074	0.12576	98.77456
1A3	Other Diesel	N2O	224.533	315.668	140.010	0.0004028	0.12435	98.89891
1A3a	Aviation Fuel	CO2	1340	2177	20.270	0.0003481	0.10746	99.00638
6C	Waste Incineration	CO2	1207	418	21.190	0.0003276	0.10113	99.10750
2	Industrial Processes	SF6	1239	712	20	0.0003180	0.09817	99.20567
4F	Field Burning	N2O	77.762	0.000	231.355	0.0002305	0.07117	99.27684
2A1	Cement Production	CO2	7295	5203	2.417	0.0002259	0.06974	99.34658
1A4	Peat	CO2	477	461	31.623	0.0001933	0.05967	99.40624
4F	Field Burning	CH4	266.045	0.000	55.902	0.0001906	0.05883	99.46507
2C1	Iron&Steel Production	CO2	2309	3066	6.119	0.0001811	0.05589	99.52097
2B	Ammonia Production	CO2	1322	1108	10.112	0.0001713	0.05287	99.57383
2A7	Fletton Bricks	CO2	180	232	72.801	0.0001678	0.05180	99.62563
1A	Lubricant	CO2	387	199	30.067	0.0001491	0.04602	99.67165
6C	Waste Incineration	N2O	47.900	49.021	230.106	0.0001412	0.04360	99.71525
1A3d	Marine Fuel	CO2	4005	5283	2.202	0.0001130	0.03489	99.75014
6C	Waste Incineration	CH4	134.423	6.365	50.488	0.0000870	0.02685	99.77698
2A3	Limestone & Dolomite use	CO2	1285	1570	5.099	0.0000840	0.02593	99.80291
2A2	Lime Production	CO2	1192	876	5.099	0.0000779	0.02403	99.82694
1A3d	Marine Fuel	N2O	31.174	40.906	170.008	0.0000679	0.02096	99.84790
1B	Solid Fuel Transformation	CO2	856	132	6.013	0.0000660	0.02037	99.86828
2B	Chemical Industry	CH4	169.425	68.230	28.284	0.0000614	0.01896	99.88723
1B2	Oil & Natural Gas	N2O	42.396	32.034	111.158	0.0000604	0.01864	99.90587
2	Industrial Processes	PFC	462	209	10	0.0000595	0.01837	99.92424
1A	Other (waste)	CO2	212	1377	21.190	0.0000577	0.01781	99.94205
1A3	Other Diesel	CO2	1898	2652	2.202	0.0000536	0.01653	99.95858
2A4	Soda Ash Use	CO2	167	223	15.133	0.0000324	0.01002	99.96859
2A7	Fletton Bricks	CH4	23.602	16.461	101.980	0.0000308	0.00952	99.97811
1A3a	Aviation Fuel	N2O	13.196	21.437	171.172	0.0000289	0.00894	99.98705
2C	Iron & Steel	N2O	11.107	9.960	118.001	0.0000168	0.00518	99.99223
2C	Iron & Steel Production	CH4	16.357	20.390	50.002	0.0000105	0.00324	99.99547
1B1	Coke Oven Gas	N2O	2.085	0.922	118.001	0.0000032	0.00097	99.99644
5E2	5E2 LUCF	CH4	9.354	5.502	20.025	0.0000024	0.00074	99.99718
1A3a	Aviation Fuel	CH4	3.297458505	1.61055288	53.85164807	0.0000023	0.00070	99.99789
1A3	Other Diesel	CH4	3.163979778	4.050873262	50.02889165	0.0000020	0.00063	99.99851
5A	5A LUCF	N2O	6.852	2.440	20.025	0.0000018	0.00054	99.99905
5A	5A LUCF	CH4	4.298	14.504	20.025	0.0000011	0.00034	99.99940
1A3d	Marine Fuel	CH4	1.31985	1.731918161	50.02889165	0.0000008	0.00026	99.99966
5C2	5C2 LUCF	CH4	3.077	8.036	20.025	0.0000008	0.00024	99.99990
5E2	5E2 LUCF	N2O	0.949	0.558	20.025	0.0000002	0.00008	99.99998
5C2	5C2 LUCF	N2O	0.312	0.816	20.025	0.0000001	0.00002	100.00000
1A	Combined Fuel	CO2	0	0	21.213	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CO2	0	0	21.213	0.0000000	0.00000	100.00000
1A4	Combined Fuel	CO2	0	0	21.213	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CH4	0	0	33.54101966	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 -- >	780,383.39	629,622.16		0.3239	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. 1990 & 1995	Gg CO2 equiv. 2008			%	
4D	Agricultural Soils	N2O	30406.856	23322.159	424.001	0.1658294	55.21483	
6A	Solid Waste Disposal	CH4	49816.593	20288.285	48.384	0.0310026	10.32267	65.53749
1A(stationary)	Oil	CO2	92033	53791	15.133	0.0179137	5.96457	71.50206
4B	Manure Management	N2O	2759.235	2121.002	414.001	0.0146931	4.89224	76.39429
1A1&1A2&1A4&1A5	Other Combustion	N2O	4670.540	3325.662	195.000	0.0117145	3.90050	80.29479
2B	Nitric Acid Production	N2O	3903.850	1464.657	230.217	0.0115599	3.84900	84.14379
1A3b	Auto Fuel	CO2	109526	117555	4.482	0.0063144	2.10244	86.24623
6B	Wastewater Handling	N2O	1033.354	1243.539	401.125	0.0053315	1.77519	88.02143
4A	Enteric Fermentation	CH4	18527.713	15531.379	20.000	0.0047663	1.58699	89.60842
2B	Adipic Acid Production	N2O	20737.345	947.019	15.008	0.0040032	1.33292	90.94133
2	Industrial Processes	HFC	15480	11249	19	0.0037883	1.26135	92.20268
1A	Coal	CO2	248618	133606	1.077	0.0034442	1.14678	93.34946
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2792.377	69.251	0.0030616	1.01940	94.36887
1A3b	Auto Fuel	N2O	1172.211	1066.125	170.023	0.0025635	0.85355	95.22242
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5288.311	27.614	0.0023121	0.76984	95.99226
1A	Natural Gas	CO2	108920	200365	1.513	0.0021201	0.70590	96.69816
4B	Manure Management	CH4	3608.070	2856.681	30.000	0.0013923	0.46357	97.16173
1A	All Fuel	CH4	2065.099588	1076.734037	50.00159997	0.0013282	0.44222	97.60395
1B	Oil & Natural Gas	CO2	5778	4414	17.088	0.0012700	0.42285	98.02680
2B5	NEU	CO2	1563	1871	53.852	0.0010826	0.36046	98.38725
6B	Wastewater Handling	CH4	709.572	815.917	50.010	0.0004564	0.15197	98.53923
1A3b	Auto Fuel	CH4	634.8592178	127.667252	50.07833863	0.0004089	0.13616	98.67539
1A3	Other Diesel	N2O	224.533	315.668	140.010	0.0004044	0.13463	98.81002
1A3a	Aviation Fuel	CO2	1340	2177	20.270	0.0003494	0.11635	98.92637
6C	Waste Incineration	CO2	1207	418	21.190	0.0003288	0.10949	99.03586
2	Industrial Processes	SF6	1239	712	20	0.0003192	0.10628	99.14214
4F	Field Burning	N2O	77.762	0.000	231.355	0.0002314	0.07705	99.21919
2A1	Cement Production	CO2	7295	5203	2.417	0.0002268	0.07550	99.29469
1A4	Peat	CO2	477	461	31.623	0.0001940	0.06460	99.35929
4F	Field Burning	CH4	266.045	0.000	55.902	0.0001913	0.06369	99.42299
2C1	Iron&Steel Production	CO2	2309	3066	6.119	0.0001817	0.06051	99.48350
2B	Ammonia Production	CO2	1322	1108	10.112	0.0001719	0.05724	99.54074
2A7	Fletton Bricks	CO2	180	232	72.801	0.0001684	0.05608	99.59682
1A	Lubricant	CO2	387	199	30.067	0.0001496	0.04982	99.64664
6C	Waste Incineration	N2O	47.900	49.021	230.106	0.0001418	0.04720	99.69384
1A3d	Marine Fuel	CO2	4005	5283	2.202	0.0001134	0.03777	99.73161
6C	Waste Incineration	CH4	134.423	6.365	50.488	0.0000873	0.02907	99.76068
2A3	Limestone & Dolomite use	CO2	1285	1570	5.099	0.0000843	0.02807	99.78874
2A2	Lime Production	CO2	1192	876	5.099	0.0000781	0.02602	99.81476
1A3d	Marine Fuel	N2O	31.174	40.906	170.008	0.0000682	0.02270	99.83746
1B	Solid Fuel Transformation	CO2	856	132	6.013	0.0000662	0.02206	99.85952
2B	Chemical Industry	CH4	169.425	68.230	28.284	0.0000616	0.02052	99.88004
1B2	Oil & Natural Gas	N2O	42.396	32.034	111.158	0.0000606	0.02018	99.90022
2	Industrial Processes	PFC	462	209	10	0.0000597	0.01989	99.92011
1A	Other (waste)	CO2	212	1377	21.190	0.0000579	0.01928	99.93939
1A3	Other Diesel	CO2	1898	2652	2.202	0.0000538	0.01790	99.95728
2A4	Soda Ash Use	CO2	167	223	15.133	0.0000326	0.01084	99.96813
2A7	Fletton Bricks	CH4	23.602	16.461	101.980	0.0000310	0.01031	99.97844
1A3a	Aviation Fuel	N2O	13.196	21.437	171.172	0.0000291	0.00967	99.98811
2C	Iron & Steel	N2O	11.107	9.960	118.001	0.0000169	0.00561	99.99372
2C	Iron & Steel Production	CH4	16.357	20.390	50.002	0.0000105	0.00350	99.99723
1B1	Coke Oven Gas	N2O	2.085	0.922	118.001	0.0000032	0.00105	99.99828
1A3a	Aviation Fuel	CH4	3.297458505	1.61055288	53.85164807	0.0000023	0.00076	99.99904
1A3	Other Diesel	CH4	3.163979778	4.050873262	50.02889165	0.0000020	0.00068	99.99972
1A3d	Marine Fuel	CH4	1.31985	1.731918161	50.02889165	0.0000008	0.00028	100.00000
1A	Combined Fuel	CO2	0	0	21.213	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CO2	0	0	21.213	0.0000000	0.00000	100.00000
1A4	Combined Fuel	CO2	0	0	21.213	0.0000000	0.00000	100.00000
5A	5A LUCF	CO2	0	0	25.020	0.0000000	0.00000	100.00000
5B	5B LUCF	CO2	0	0	50.010	0.0000000	0.00000	100.00000
5C	5C LUCF	CO2	0	0	70.007	0.0000000	0.00000	100.00000
5E	5E LUCF	CO2	0	0	50.010	0.0000000	0.00000	100.00000
5G	5G LUCF	CO2	0	0	30	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CH4	0	0	33.54101966	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 -- >	777,458.32	631,605.24		0.3003	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	2008			%	
4D	Agricultural Soils	N2O	30406.856	23322.159	424.001	0.1659230	51.14602	
6A	Solid Waste Disposal	CH4	49816.593	20288.285	48.384	0.0310201	9.56198	60.70800
1A(stationary)	Oil	CO2	92033	53791	15.133	0.0179238	5.52503	66.23303
4B	Manure Management	N2O	2759.235	2121.002	414.001	0.0147014	4.53172	70.76476
1A1&1A2&1A4&1A5	Other Combustion	N2O	4670.540	3325.662	195.000	0.0117212	3.61307	74.37783
2B	Nitric Acid Production	N2O	3903.850	1464.657	230.217	0.0115664	3.56537	77.94319
5B	5B LUCF	CO2	15822	15243	50.010	0.0101833	3.13902	81.08221
1A3b	Auto Fuel	CO2	109526	117555	4.482	0.0063179	1.94751	83.02972
5C	5C LUCF	CO2	-6130	-8156	70.007	0.0055232	1.70255	84.73227
6B	Wastewater Handling	N2O	1033.354	1243.539	401.125	0.0053345	1.64438	86.37665
4A	Enteric Fermentation	CH4	18527.713	15531.379	20.000	0.0047690	1.47004	87.84670
5E	5E LUCF	CO2	7074	6280	50.010	0.0045531	1.40351	89.25021
2B	Adipic Acid Production	N2O	20737.345	947.019	15.008	0.0040055	1.23469	90.48490
5A	5A LUCF	CO2	-12155	-13627	25.020	0.0039139	1.20647	91.69137
1A	Coal	CO2	248618	133606	1.077	0.0034461	1.06227	92.75365
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2792.377	69.072	0.0030634	0.94428	93.69793
2	Industrial Processes	HFC	11386	11249	19	0.0027879	0.85938	94.55730
1A3b	Auto Fuel	N2O	1172.211	1066.125	170.023	0.0025650	0.79065	95.34796
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5288.311	27.543	0.0023134	0.71311	96.06107
1A	Natural Gas	CO2	108920	200365	1.513	0.0021213	0.65388	96.71495
4B	Manure Management	CH4	3608.070	2856.681	30.000	0.0013931	0.42941	97.14436
1A	All Fuel	CH4	2065.099588	1076.734037	50.00159997	0.0013289	0.40964	97.55400
1B	Oil & Natural Gas	CO2	5778	4414	17.088	0.0012707	0.39169	97.94568
2B5	NEU	CO2	1563	1871	53.852	0.0010832	0.33389	98.27958
5G	5G LUCF	CO2	-1711	-1755	30	0.0006609	0.20372	98.48330
6B	Wastewater Handling	CH4	709.572	815.917	50.010	0.0004567	0.14078	98.62407
1A3b	Auto Fuel	CH4	634.8592178	127.667252	50.07833863	0.0004092	0.12612	98.75020
1A3	Other Diesel	N2O	224.533	315.668	140.010	0.0004046	0.12471	98.87491
1A3a	Aviation Fuel	CO2	1340	2177	20.270	0.0003496	0.10777	98.98268
6C	Waste Incineration	CO2	1207	418	21.190	0.0003290	0.10142	99.08410
2	Industrial Processes	SF6	1030	712	20	0.0002654	0.08182	99.16592
4F	Field Burning	N2O	77.762	0.000	231.355	0.0002315	0.07137	99.23729
2A1	Cement Production	CO2	7295	5203	2.417	0.0002269	0.06994	99.30723
1A4	Peat	CO2	477	461	31.623	0.0001941	0.05984	99.36707
4F	Field Burning	CH4	266.045	0.000	55.902	0.0001914	0.05900	99.42607
2C1	Iron&Steel Production	CO2	2309	3066	6.119	0.0001818	0.05606	99.48213
2	Industrial Processes	PFC	1402	209	10	0.0001813	0.05588	99.53801
2B	Ammonia Production	CO2	1322	1108	10.112	0.0001720	0.05302	99.59103
2A7	Fletton Bricks	CO2	180	232	72.801	0.0001685	0.05195	99.64297
1A	Lubricant	CO2	387	199	30.067	0.0001497	0.04615	99.68912
6C	Waste Incineration	N2O	47.900	49.021	230.106	0.0001419	0.04373	99.73285
1A3d	Marine Fuel	CO2	4005	5283	2.202	0.0001135	0.03499	99.76784
6C	Waste Incineration	CH4	134.423	6.365	50.488	0.0000873	0.02692	99.79476
2A3	Limestone & Dolomite use	CO2	1285	1570	5.099	0.0000843	0.02600	99.82076
2A2	Lime Production	CO2	1192	876	5.099	0.0000782	0.02410	99.84486
1A3d	Marine Fuel	N2O	31.174	40.906	170.008	0.0000682	0.02102	99.86589
1B	Solid Fuel Transformation	CO2	856	132	6.013	0.0000663	0.02043	99.88632
2B	Chemical Industry	CH4	169.425	68.230	28.284	0.0000617	0.01901	99.90533
1B2	Oil & Natural Gas	N2O	42.396	32.034	111.158	0.0000607	0.01870	99.92402
1A	Other (waste)	CO2	212	1377	21.190	0.0000579	0.01786	99.94188
1A3	Other Diesel	CO2	1898	2652	2.202	0.0000538	0.01658	99.95846
2A4	Soda Ash Use	CO2	167	223	15.133	0.0000326	0.01004	99.96850
2A7	Fletton Bricks	CH4	23.602	16.461	101.980	0.0000310	0.00955	99.97805
1A3a	Aviation Fuel	N2O	13.196	21.437	171.172	0.0000291	0.00896	99.98701
2C	Iron & Steel	N2O	11.107	9.960	118.001	0.0000169	0.00520	99.99221
2C	Iron & Steel Production	CH4	16.357	20.390	50.002	0.0000105	0.00324	99.99546
1B1	Coke Oven Gas	N2O	2.085	0.922	118.001	0.0000032	0.00098	99.99643
5E2	5E2 LUCF	CH4	9.354	5.502	20.025	0.0000024	0.00074	99.99718
1A3a	Aviation Fuel	CH4	3.297458505	1.61055288	53.85164807	0.0000023	0.00070	99.99788
1A3	Other Diesel	CH4	3.163979778	4.050873262	50.02889165	0.0000020	0.00063	99.99851
5A	5A LUCF	N2O	6.852	2.440	20.025	0.0000018	0.00054	99.99905
5A	5A LUCF	CH4	4.298	14.504	20.025	0.0000011	0.00034	99.99939
1A3d	Marine Fuel	CH4	1.31985	1.731918161	50.02889165	0.0000008	0.00026	99.99966
5C2	5C2 LUCF	CH4	3.077	8.036	20.025	0.0000008	0.00024	99.99990
5E2	5E2 LUCF	N2O	0.949	0.558	20.025	0.0000002	0.00008	99.99998
5C2	5C2 LUCF	N2O	0.312	0.816	20.025	0.0000001	0.00002	100.00000
1A	Combined Fuel	CO2	0	0	21.213	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CO2	0	0	21.213	0.0000000	0.00000	100.00000
1A4	Combined Fuel	CO2	0	0	21.213	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CH4	0	0	33.54101966	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 -- >	777,019.42	629,622.16		0.3244	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	2008				%	
4D	Agricultural Soils	N2O	30406.856	23322.159	424.001	0.1665500		55.38715	
6A	Solid Waste Disposal	CH4	49816.593	20288.285	48.384	0.0311373		10.35488	65.74203
1A(stationary)	Oil	CO2	92033	53791	15.133	0.0179915		5.98318	71.72521
4B	Manure Management	N2O	2759.235	2121.002	414.001	0.0147569		4.90750	76.63272
1A1&1A2&1A4&1A5	Other Combustion	N2O	4670.540	3325.662	195.000	0.0117655		3.91267	80.54539
2B	Nitric Acid Production	N2O	3903.850	1464.657	230.217	0.0116101		3.86101	84.40640
1A3b	Auto Fuel	CO2	109526	117555	4.482	0.0063418		2.10900	86.51540
6B	Wastewater Handling	N2O	1033.354	1243.539	401.125	0.0053547		1.78073	88.29614
4A	Enteric Fermentation	CH4	18527.713	15531.379	20.000	0.0047870		1.59194	89.88808
2B	Adipic Acid Production	N2O	20737.345	947.019	15.008	0.0040206		1.33708	91.22516
1A	Coal	CO2	248618	133606	1.077	0.0034591		1.15036	92.37551
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2792.377	69.551	0.0030749		1.02258	93.39810
2	Industrial Processes	HFC	11386	11249	19	0.0027984		0.93064	94.32874
1A3b	Auto Fuel	N2O	1172.211	1066.125	170.023	0.0025747		0.85622	95.18495
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5288.311	27.734	0.0023221		0.77224	95.95719
1A	Natural Gas	CO2	108920	200365	1.513	0.0021293		0.70810	96.66530
4B	Manure Management	CH4	3608.070	2856.681	30.000	0.0013983		0.46502	97.13032
1A	All Fuel	CH4	2065.099588	1076.734037	50.00159997	0.0013339		0.44360	97.57392
1B	Oil & Natural Gas	CO2	5778	4414	17.088	0.0012755		0.42416	97.99808
2B5	NEU	CO2	1563	1871	53.852	0.0010873		0.36158	98.35967
6B	Wastewater Handling	CH4	709.572	815.917	50.010	0.0004584		0.15245	98.51211
1A3b	Auto Fuel	CH4	634.8592178	127.667252	50.07833863	0.0004107		0.13658	98.64870
1A3	Other Diesel	N2O	224.533	315.668	140.010	0.0004061		0.13505	98.78375
1A3a	Aviation Fuel	CO2	1340	2177	20.270	0.0003510		0.11671	98.90046
6C	Waste Incineration	CO2	1207	418	21.190	0.0003303		0.10983	99.01029
2	Industrial Processes	SF6	1030	712	20	0.0002664		0.08860	99.09890
4F	Field Burning	N2O	77.762	0.000	231.355	0.0002324		0.07729	99.17619
2A1	Cement Production	CO2	7295	5203	2.417	0.0002277		0.07574	99.25193
1A4	Peat	CO2	477	461	31.623	0.0001949		0.06480	99.31673
4F	Field Burning	CH4	266.045	0.000	55.902	0.0001921		0.06389	99.38062
2C1	Iron&Steel Production	CO2	2309	3066	6.119	0.0001825		0.06070	99.44132
2	Industrial Processes	PFC	1402	209	10	0.0001820		0.06051	99.50184
2B	Ammonia Production	CO2	1322	1108	10.112	0.0001726		0.05741	99.55925
2A7	Fletton Bricks	CO2	180	232	72.801	0.0001692		0.05625	99.61551
1A	Lubricant	CO2	387	199	30.067	0.0001503		0.04997	99.66548
6C	Waste Incineration	N2O	47.900	49.021	230.106	0.0001424		0.04735	99.71283
1A3d	Marine Fuel	CO2	4005	5283	2.202	0.0001139		0.03789	99.75072
6C	Waste Incineration	CH4	134.423	6.365	50.488	0.0000877		0.02916	99.77988
2A3	Limestone & Dolomite use	CO2	1285	1570	5.099	0.0000847		0.02816	99.80803
2A2	Lime Production	CO2	1192	876	5.099	0.0000785		0.02610	99.83413
1A3d	Marine Fuel	N2O	31.174	40.906	170.008	0.0000685		0.02277	99.85690
1B	Solid Fuel Transformation	CO2	856	132	6.013	0.0000665		0.02212	99.87903
2B	Chemical Industry	CH4	169.425	68.230	28.284	0.0000619		0.02059	99.89961
1B2	Oil & Natural Gas	N2O	42.396	32.034	111.158	0.0000609		0.02025	99.91986
1A	Other (waste)	CO2	212	1377	21.190	0.0000581		0.01934	99.93920
1A3	Other Diesel	CO2	1898	2652	2.202	0.0000540		0.01795	99.95715
2A4	Soda Ash Use	CO2	167	223	15.133	0.0000327		0.01088	99.96803
2A7	Fletton Bricks	CH4	23.602	16.461	101.980	0.0000311		0.01034	99.97837
1A3a	Aviation Fuel	N2O	13.196	21.437	171.172	0.0000292		0.00970	99.98807
2C	Iron & Steel	N2O	11.107	9.960	118.001	0.0000169		0.00563	99.99370
2C	Iron & Steel Production	CH4	16.357	20.390	50.002	0.0000106		0.00351	99.99722
1B1	Coke Oven Gas	N2O	2.085	0.922	118.001	0.0000032		0.00106	99.99827
1A3a	Aviation Fuel	CH4	3.297458505	1.61055288	53.85164807	0.0000023		0.00076	99.99904
1A3	Other Diesel	CH4	3.163979778	4.050873262	50.02889165	0.0000020		0.00068	99.99972
1A3d	Marine Fuel	CH4	1.31985	1.731918161	50.02889165	0.0000009		0.00028	100.00000
1A	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
1A4	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
5A	5A LUCF	CO2	0	0	25.020	0.0000000		0.00000	100.00000
5B	5B LUCF	CO2	0	0	50.010	0.0000000		0.00000	100.00000
5C	5C LUCF	CO2	0	0	70.007	0.0000000		0.00000	100.00000
5E	5E LUCF	CO2	0	0	50.010	0.0000000		0.00000	100.00000
5G	5G LUCF	CO2	0	0	30	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CH4	0	0	33.54101966	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 -- >	774,094.34	631,605.24		0.3007		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	Base year emissions	Year Y emissions	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)		Level / Sum(Level)*100
			Gg CO2 equiv.	Gg CO2 equiv.				
			1990 & 1995	2008				%
4D	Agricultural Soils	N2O	30406.856	23322.159	424.001	0.1570565		53.27789
6A	Solid Waste Disposal	CH4	49816.593	20288.285	48.384	0.0155907		5.28880
4B	Manure Management	N2O	2759.235	2121.002	414.001	0.0139464		4.73101
1A(stationary)	Oil	CO2	92033	53791	15.133	0.0129285		4.38570
5B	5B LUCF	CO2	15822	15243	50.010	0.0121076		4.10723
1A1&1A2&1A4&1A5	Other Combustion	N2O	4670.540	3325.662	195.000	0.0102999		3.49402
5C	5C LUCF	CO2	-6130	-8156	70.007	0.0090690		3.07645
1A3b	Auto Fuel	CO2	109526	117555	4.482	0.0083686		2.83885
6B	Wastewater Handling	N2O	1033.354	1243.539	401.125	0.0079224		2.68751
5A	5A LUCF	CO2	-12155	-13627	25.020	0.0054151		1.83694
2B	Nitric Acid Production	N2O	3903.850	1464.657	230.217	0.0053554		1.81671
5E	5E LUCF	CO2	7074	6280	50.010	0.0049883		1.69218
4A	Enteric Fermentation	CH4	18527.713	15531.379	20.000	0.0049336		1.67362
1A	Natural Gas	CO2	108920	200365	1.513	0.0048157		1.63362
2	Industrial Processes	HFC	15480	11249	19	0.0033994		1.15318
1A3b	Auto Fuel	N2O	1172.211	1066.125	170.023	0.0028790		0.97662
1A	Coal	CO2	248618	133606	1.077	0.0022855		0.77529
2B5	NEU	CO2	1563	1871	53.852	0.0015999		0.54273
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5288.311	16.944	0.0014231		0.48277
4B	Manure Management	CH4	3608.070	2856.681	30.000	0.0013611		0.46174
1B	Oil & Natural Gas	CO2	5778	4414	17.088	0.0011980		0.40639
1A	All Fuel	CH4	2065.099588	1076.734037	50.00159997	0.0008551		0.29007
5G	5G LUCF	CO2	-1711	-1755	30	0.0008369		0.28389
1A3	Other Diesel	N2O	224.533	315.668	140.010	0.0007020		0.23812
1A3a	Aviation Fuel	CO2	1340	2177	20.270	0.0007010		0.23780
6B	Wastewater Handling	CH4	709.572	815.917	50.010	0.0006481		0.21984
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2792.377	13.030	0.0005779		0.19603
1A	Other (waste)	CO2	212	1377	21.190	0.0004634		0.15721
2C1	Iron&Steel Production	CO2	2309	3066	6.119	0.0002980		0.10109
2A7	Fletton Bricks	CO2	180	232	72.801	0.0002679		0.09087
1A4	Peat	CO2	477	461	31.623	0.0002315		0.07853
2	Industrial Processes	SF6	1239	712	20	0.0002264		0.07680
2B	Adipic Acid Production	N2O	20737.345	947.019	15.008	0.0002257		0.07658
2A1	Cement Production	CO2	7295	5203	2.417	0.0001997		0.06774
1A3d	Marine Fuel	CO2	4005	5283	2.202	0.0001848		0.06268
6C	Waste Incineration	N2O	47.900	49.021	230.106	0.0001792		0.06077
2B	Ammonia Production	CO2	1322	1108	10.112	0.0001779		0.06036
6C	Waste Incineration	CO2	1207	418	21.190	0.0001408		0.04778
2A3	Limestone & Dolomite use	CO2	1285	1570	5.099	0.0001271		0.04312
1A3d	Marine Fuel	N2O	31.174	40.906	170.008	0.0001105		0.03747
1A3b	Auto Fuel	CH4	634.8592178	127.667252	50.07833863	0.0001015		0.03445
1A	Lubricant	CO2	387	199	30.067	0.0000949		0.03220
1A3	Other Diesel	CO2	1898	2652	2.202	0.0000927		0.03146
2A2	Lime Production	CO2	1192	876	5.099	0.0000709		0.02406
1A3a	Aviation Fuel	N2O	13.196	21.437	171.172	0.0000583		0.01977
1B2	Oil & Natural Gas	N2O	42.396	32.034	111.158	0.0000566		0.01918
2A4	Soda Ash Use	CO2	167	223	15.133	0.0000537		0.01822
2	Industrial Processes	PFC	462	209	10	0.0000334		0.01131
2B	Chemical Industry	CH4	169.425	68.230	28.284	0.0000307		0.01040
2A7	Fletton Bricks	CH4	23.602	16.461	101.980	0.0000267		0.00904
2C	Iron & Steel	N2O	11.107	9.960	118.001	0.0000187		0.00633
2C	Iron & Steel Production	CH4	16.357	20.390	50.002	0.0000162		0.00549
1B	Solid Fuel Transformation	CO2	856	132	6.013	0.0000126		0.00428
6C	Waste Incineration	CH4	134.423	6.365	50.488	0.0000051		0.00173
5A	5A LUCF	CH4	4.298	14.504	20.025	0.0000046		0.00156
1A3	Other Diesel	CH4	3.163979778	4.050873262	50.02889165	0.0000032		0.00109
5C2	5C2 LUCF	CH4	3.077	8.036	20.025	0.0000026		0.00087
5E2	5E2 LUCF	CH4	9.354	5.502	20.025	0.0000018		0.00059
1B1	Coke Oven Gas	N2O	2.085	0.922	118.001	0.0000017		0.00059
1A3a	Aviation Fuel	CH4	3.297458505	1.61055288	53.85164807	0.0000014		0.00047
1A3d	Marine Fuel	CH4	1.31985	1.731918161	50.02889165	0.0000014		0.00047
5A	5A LUCF	N2O	6.852	2.440	20.025	0.0000008		0.00026
5C2	5C2 LUCF	N2O	0.312	0.816	20.025	0.0000003		0.00009
5E2	5E2 LUCF	N2O	0.949	0.558	20.025	0.0000002		0.00006
1A	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000
1A3b	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000
1A4	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000
1A3b	Combined Fuel	CH4	0	0	33.54101966	0.0000000		0.00000
4F	Field Burning	CH4	266.045	0.000	55.902	0.0000000		0.00000
1A3b	Combined Fuel	N2O	0.000	0.000	33.541	0.0000000		0.00000
4F	Field Burning	N2O	77.762	0.000	231.355	0.0000000		0.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	50.990	0.0000000		0.00000
		Sum -- >	780,383.39	629,622.16		0.2948		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	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	2008			%	
4D	Agricultural Soils	N2O	30406.856	23322.159	424.001	0.1565633	59.86289	
6A	Solid Waste Disposal	CH4	49816.593	20288.285	48.384	0.0155418	5.94248	65.80537
4B	Manure Management	N2O	2759.235	2121.002	414.001	0.0139026	5.31575	71.12112
1A(stationary)	Oil	CO2	92033	53791	15.133	0.0128879	4.92776	76.04888
1A1&1A2&1A4&1A5	Other Combustion	N2O	4670.540	3325.662	195.000	0.0102676	3.92587	79.97474
1A3b	Auto Fuel	CO2	109526	117555	4.482	0.0083423	3.18973	83.16447
6B	Wastewater Handling	N2O	1033.354	1243.539	401.125	0.0078976	3.01968	86.18415
2B	Nitric Acid Production	N2O	3903.850	1464.657	230.217	0.0053386	2.04125	88.22539
4A	Enteric Fermentation	CH4	18527.713	15531.379	20.000	0.0049181	1.88047	90.10587
1A	Natural Gas	CO2	108920	200365	1.513	0.0048006	1.83553	91.94140
2	Industrial Processes	HFC	15480	11249	19	0.0033888	1.29571	93.23711
1A3b	Auto Fuel	N2O	1172.211	1066.125	170.023	0.0028699	1.09733	94.33444
1A	Coal	CO2	248618	133606	1.077	0.0022783	0.87111	95.20556
2B5	NEU	CO2	1563	1871	53.852	0.0015949	0.60981	95.81536
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5288.311	16.944	0.0014187	0.54244	96.35780
4B	Manure Management	CH4	3608.070	2856.681	30.000	0.0013569	0.51881	96.87661
1B	Oil & Natural Gas	CO2	5778	4414	17.088	0.0011942	0.45662	97.33322
1A	All Fuel	CH4	2065.099588	1076.734037	50.00159997	0.0008524	0.32592	97.65915
1A3	Other Diesel	N2O	224.533	315.668	140.010	0.0006998	0.26755	97.92670
1A3a	Aviation Fuel	CO2	1340	2177	20.270	0.0006988	0.26719	98.19389
6B	Wastewater Handling	CH4	709.572	815.917	50.010	0.0006460	0.24702	98.44090
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2792.377	13.030	0.0005761	0.22026	98.66116
1A	Other (waste)	CO2	212	1377	21.190	0.0004620	0.17664	98.83780
2C1	Iron&Steel Production	CO2	2309	3066	6.119	0.0002971	0.11358	98.95139
2A7	Fletton Bricks	CO2	180	232	72.801	0.0002670	0.10211	99.05349
1A4	Peat	CO2	477	461	31.623	0.0002308	0.08823	99.14173
2	Industrial Processes	SF6	1239	712	20	0.0002257	0.08630	99.22803
2B	Adipic Acid Production	N2O	20737.345	947.019	15.008	0.0002250	0.08604	99.31407
2A1	Cement Production	CO2	7295	5203	2.417	0.0001991	0.07611	99.39018
1A3d	Marine Fuel	CO2	4005	5283	2.202	0.0001842	0.07043	99.46061
6C	Waste Incineration	N2O	47.900	49.021	230.106	0.0001786	0.06829	99.52890
2B	Ammonia Production	CO2	1322	1108	10.112	0.0001774	0.06783	99.59672
6C	Waste Incineration	CO2	1207	418	21.190	0.0001404	0.05368	99.65040
2A3	Limestone & Dolomite use	CO2	1285	1570	5.099	0.0001267	0.04845	99.69886
1A3d	Marine Fuel	N2O	31.174	40.906	170.008	0.0001101	0.04210	99.74096
1A3b	Auto Fuel	CH4	634.8592178	127.667252	50.07833863	0.0001012	0.03870	99.77966
1A	Lubricant	CO2	387	199	30.067	0.0000946	0.03618	99.81584
1A3	Other Diesel	CO2	1898	2652	2.202	0.0000925	0.03535	99.85119
2A2	Lime Production	CO2	1192	876	5.099	0.0000707	0.02704	99.87823
1A3a	Aviation Fuel	N2O	13.196	21.437	171.172	0.0000581	0.02221	99.90044
1B2	Oil & Natural Gas	N2O	42.396	32.034	111.158	0.0000564	0.02156	99.92200
2A4	Soda Ash Use	CO2	167	223	15.133	0.0000535	0.02047	99.94247
2	Industrial Processes	PFC	462	209	10	0.0000333	0.01271	99.95518
2B	Chemical Industry	CH4	169.425	68.230	28.284	0.0000306	0.01168	99.96686
2A7	Fletton Bricks	CH4	23.602	16.461	101.980	0.0000266	0.01016	99.97703
2C	Iron & Steel	N2O	11.107	9.960	118.001	0.0000186	0.00711	99.98414
2C	Iron & Steel Production	CH4	16.357	20.390	50.002	0.0000161	0.00617	99.99031
1B	Solid Fuel Transformation	CO2	856	132	6.013	0.0000126	0.00481	99.99512
6C	Waste Incineration	CH4	134.423	6.365	50.488	0.0000051	0.00195	99.99707
1A3	Other Diesel	CH4	3.163979778	4.050873262	50.02889165	0.0000032	0.00123	99.99829
1B1	Coke Oven Gas	N2O	2.085	0.922	118.001	0.0000017	0.00066	99.99895
1A3a	Aviation Fuel	CH4	3.297458505	1.61055288	53.85164807	0.0000014	0.00053	99.99948
1A3d	Marine Fuel	CH4	1.31985	1.731918161	50.02889165	0.0000014	0.00052	100.00000
1A	Combined Fuel	CO2	0	0	21.213	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CO2	0	0	21.213	0.0000000	0.00000	100.00000
1A4	Combined Fuel	CO2	0	0	21.213	0.0000000	0.00000	100.00000
5A	5A LUCF	CO2	0	0	25.020	0.0000000	0.00000	100.00000
5B	5B LUCF	CO2	0	0	50.010	0.0000000	0.00000	100.00000
5C	5C LUCF	CO2	0	0	70.007	0.0000000	0.00000	100.00000
5E	5E LUCF	CO2	0	0	50.010	0.0000000	0.00000	100.00000
5G	5G LUCF	CO2	0	0	30	0.0000000	0.00000	100.00000
1A3b	Combined Fuel	CH4	0	0	33.54101966	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 -- >	777,458.32	631,605.24		0.2615	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. 2008				%	
4D	Agricultural Soils	N2O	30406.856	23322.159	424.001	0.0428375		44.42499	
2B	Nitric Acid Production	N2O	3903.850	1464.657	230.217	0.0175803		18.23183	62.65682
6B	Wastewater Handling	N2O	1033.354	1243.539	401.125	0.0129806		13.46168	76.11850
6A	Solid Waste Disposal	CH4	49816.593	20288.285	48.384	0.0091727		9.51261	85.63111
4B	Manure Management	N2O	2759.235	2121.002	414.001	0.0035488		3.68033	89.31144
1A1&1A2&1A4&1A5	Other Combustion	N2O	4670.540	3325.662	195.000	0.0033129		3.43571	92.74715
5B	5B LUCF	CO2	15822	15243	50.010	0.0012200		1.26519	94.01234
1A(stationary)	Oil	CO2	92033	53791	15.133	0.0009224		0.95662	94.96896
2B	Adipic Acid Production	N2O	20737.345	947.019	15.008	0.0006999		0.72583	95.69479
1A3b	Auto Fuel	N2O	1172.211	1066.125	170.023	0.0006850		0.71038	96.40517
1A3	Other Diesel	N2O	224.533	315.668	140.010	0.0005191		0.53831	96.94348
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2792.377	13.030	0.0003991		0.41387	97.35735
2B5	NEU	CO2	1563	1871	53.852	0.0003480		0.36089	97.71824
1A	All Fuel	CH4	2065.099588	1076.734037	50.00159997	0.0002901		0.30084	98.01909
5E	5E LUCF	CO2	7074	6280	50.010	0.0002819		0.29238	98.31146
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5288.311	16.944	0.0002142		0.22212	98.53358
1A3b	Auto Fuel	CH4	634.8592178	127.667252	50.07833863	0.0001898		0.19688	98.73045
6B	Wastewater Handling	CH4	709.572	815.917	50.010	0.0001198		0.12429	98.85474
1A3b	Auto Fuel	CO2	109526	117555	4.482	0.0001154		0.11971	98.97446
6C	Waste Incineration	N2O	47.900	49.021	230.106	0.0001081		0.11214	99.08660
1A	Other (waste)	CO2	212	1377	21.190	0.0001066		0.11051	99.19711
2A7	Fletton Bricks	CO2	180	232	72.801	0.0000903		0.09366	99.29077
1A3d	Marine Fuel	N2O	31.174	40.906	170.008	0.0000896		0.09296	99.38374
1A3a	Aviation Fuel	CO2	1340	2177	20.270	0.0000887		0.09194	99.47568
2	Industrial Processes	HFC	15480	11249	19	0.0000884		0.09163	99.56730
1A3a	Aviation Fuel	N2O	13.196	21.437	171.172	0.0000622		0.06454	99.63184
6C	Waste Incineration	CH4	134.423	6.365	50.488	0.0000512		0.05313	99.68497
1A	Natural Gas	CO2	108920	200365	1.513	0.0000507		0.05259	99.73756
6C	Waste Incineration	CO2	1207	418	21.190	0.0000491		0.05087	99.78843
4A	Enteric Fermentation	CH4	18527.713	15531.379	20.000	0.0000459		0.04761	99.83604
2	Industrial Processes	SF6	1239	712	20	0.0000227		0.02358	99.85961
1A	Lubricant	CO2	387	199	30.067	0.0000202		0.02092	99.88054
1A	Coal	CO2	248618	133606	1.077	0.0000153		0.01586	99.89640
1A4	Peat	CO2	477	461	31.623	0.0000150		0.01553	99.91193
1B	Oil & Natural Gas	CO2	5778	4414	17.088	0.0000142		0.01476	99.92669
2B	Chemical Industry	CH4	169.425	68.230	28.284	0.0000108		0.01118	99.93787
4B	Manure Management	CH4	3608.070	2856.681	30.000	0.0000096		0.00999	99.94786
2C1	Iron&Steel Production	CO2	2309	3066	6.119	0.0000089		0.00920	99.95705
2A7	Fletton Bricks	CH4	23.602	16.461	101.980	0.0000053		0.00548	99.96253
1B2	Oil & Natural Gas	N2O	42.396	32.034	111.158	0.0000053		0.00548	99.96801
2A4	Soda Ash Use	CO2	167	223	15.133	0.0000040		0.00414	99.97215
1B	Solid Fuel Transformation	CO2	856	132	6.013	0.0000040		0.00413	99.97628
2C	Iron & Steel Production	CH4	16.357	20.390	50.002	0.0000035		0.00367	99.97995
2	Industrial Processes	PFC	462	209	10	0.0000033		0.00338	99.98332
2C	Iron & Steel	N2O	11.107	9.960	118.001	0.0000027		0.00284	99.98616
2A3	Limestone & Dolomite use	CO2	1285	1570	5.099	0.0000027		0.00283	99.98899
1B1	Coke Oven Gas	N2O	2.085	0.922	118.001	0.0000021		0.00216	99.99115
1A3d	Marine Fuel	CO2	4005	5283	2.202	0.0000020		0.00203	99.99318
1A3	Other Diesel	CO2	1898	2652	2.202	0.0000011		0.00111	99.99429
5A	5A LUCF	CH4	4.298	14.504	20.025	0.0000009		0.00090	99.99520
2B	Ammonia Production	CO2	1322	1108	10.112	0.0000008		0.00087	99.99607
2A1	Cement Production	CO2	7295	5203	2.417	0.0000008		0.00081	99.99688
1A3	Other Diesel	CH4	3.163979778	4.050873262	50.02889165	0.0000007		0.00077	99.99765
1A3a	Aviation Fuel	CH4	3.297458505	1.61055288	53.85164807	0.0000006		0.00062	99.99827
5C2	5C2 LUCF	CH4	3.077	8.036	20.025	0.0000004		0.00045	99.99872
2A2	Lime Production	CO2	1192	876	5.099	0.0000004		0.00045	99.99918
1A3d	Marine Fuel	CH4	1.31985	1.731918161	50.02889165	0.0000003		0.00034	99.99952
5A	5A LUCF	N2O	6.852	2.440	20.025	0.0000002		0.00025	99.99977
5E2	5E2 LUCF	CH4	9.354	5.502	20.025	0.0000002		0.00017	99.99994
5C2	5C2 LUCF	N2O	0.312	0.816	20.025	0.0000000		0.00005	99.99998
5E2	5E2 LUCF	N2O	0.949	0.558	20.025	0.0000000		0.00002	100.00000
1A	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
1A4	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
5A	5A LUCF	CO2	-12155	-13627	25.020	0.0000000		0.00000	100.00000
5C	5C LUCF	CO2	-6130	-8156	70.007	0.0000000		0.00000	100.00000
5G	5G LUCF	CO2	-1711	-1755	30	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CH4	0	0	33.54101966	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 -- >	780,383.39	629,622.16		0.0964		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. 2008				%	
4D	Agricultural Soils	N2O	30406.856	23322.159	424.001	0.0483607		47.97879	
2B	Nitric Acid Production	N2O	3903.850	1464.657	230.217	0.0176299		17.49068	65.46946
6B	Wastewater Handling	N2O	1033.354	1243.539	401.125	0.0126699		12.56985	78.03932
6A	Solid Waste Disposal	CH4	49816.593	20288.285	48.384	0.0092080		9.13526	87.17458
4B	Manure Management	N2O	2759.235	2121.002	414.001	0.0040282		3.99641	91.17099
1A1&1A2&1A4&1A5	Other Combustion	N2O	4670.540	3325.662	195.000	0.0034732		3.44575	94.61674
1A(stationary)	Oil	CO2	92033	53791	15.133	0.0009362		0.92877	95.54552
2B	Adipic Acid Production	N2O	20737.345	947.019	15.008	0.0006980		0.69247	96.23799
1A3b	Auto Fuel	N2O	1172.211	1066.125	170.023	0.0006413		0.63619	96.87418
1A3	Other Diesel	N2O	224.533	315.668	140.010	0.0005091		0.50508	97.37926
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2792.377	13.030	0.0003985		0.39532	97.77458
2B5	NEU	CO2	1563	1871	53.852	0.0003396		0.33690	98.11148
1A	All Fuel	CH4	2065.099588	1076.734037	50.00159997	0.0002928		0.29050	98.40198
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5288.311	16.944	0.0002157		0.21397	98.61595
1A3b	Auto Fuel	CH4	634.8592178	127.667252	50.07833863	0.0001897		0.18818	98.80413
6B	Wastewater Handling	CH4	709.572	815.917	50.010	0.0001167		0.11580	98.91993
1A3b	Auto Fuel	CO2	109526	117555	4.482	0.0001119		0.11100	99.03093
1A	Other (waste)	CO2	212	1377	21.190	0.0001054		0.10456	99.13550
6C	Waste Incineration	N2O	47.900	49.021	230.106	0.0001043		0.10347	99.23896
2	Industrial Processes	HFC	15480	11249	19	0.0000936		0.09283	99.33179
2A7	Fletton Bricks	CO2	180	232	72.801	0.0000884		0.08768	99.41947
1A3d	Marine Fuel	N2O	31.174	40.906	170.008	0.0000878		0.08707	99.50654
1A3a	Aviation Fuel	CO2	1340	2177	20.270	0.0000872		0.08648	99.59303
1A3a	Aviation Fuel	N2O	13.196	21.437	171.172	0.0000612		0.06071	99.65373
6C	Waste Incineration	CH4	134.423	6.365	50.488	0.0000511		0.05068	99.70442
1A	Natural Gas	CO2	108920	200365	1.513	0.0000499		0.04954	99.75395
6C	Waste Incineration	CO2	1207	418	21.190	0.0000491		0.04876	99.80272
4A	Enteric Fermentation	CH4	18527.713	15531.379	20.000	0.0000374		0.03709	99.83980
2	Industrial Processes	SF6	1239	712	20	0.0000230		0.02287	99.86267
1A	Lubricant	CO2	387	199	30.067	0.0000204		0.02019	99.88286
1B	Oil & Natural Gas	CO2	5778	4414	17.088	0.0000159		0.01580	99.89867
1A	Coal	CO2	248618	133606	1.077	0.0000155		0.01533	99.91400
1A4	Peat	CO2	477	461	31.623	0.0000143		0.01419	99.92819
4B	Manure Management	CH4	3608.070	2856.681	30.000	0.0000131		0.01297	99.94116
2B	Chemical Industry	CH4	169.425	68.230	28.284	0.0000108		0.01074	99.95189
2C1	Iron&Steel Production	CO2	2309	3066	6.119	0.0000087		0.00862	99.96051
1B2	Oil & Natural Gas	N2O	42.396	32.034	111.158	0.0000058		0.00575	99.96627
2A7	Fletton Bricks	CH4	23.602	16.461	101.980	0.0000055		0.00546	99.97172
1B	Solid Fuel Transformation	CO2	856	132	6.013	0.0000040		0.00394	99.97566
2A4	Soda Ash Use	CO2	167	223	15.133	0.0000039		0.00388	99.97954
2C	Iron & Steel Production	CH4	16.357	20.390	50.002	0.0000035		0.00343	99.98297
2	Industrial Processes	PFC	462	209	10	0.0000033		0.00325	99.98622
2A3	Limestone & Dolomite use	CO2	1285	1570	5.099	0.0000027		0.00264	99.98886
2C	Iron & Steel	N2O	11.107	9.960	118.001	0.0000025		0.00252	99.99138
1B1	Coke Oven Gas	N2O	2.085	0.922	118.001	0.0000021		0.00208	99.99346
1A3d	Marine Fuel	CO2	4005	5283	2.202	0.0000019		0.00190	99.99537
1A3	Other Diesel	CO2	1898	2652	2.202	0.0000010		0.00104	99.99641
2A1	Cement Production	CO2	7295	5203	2.417	0.0000008		0.00082	99.99722
1A3	Other Diesel	CH4	3.163979778	4.050873262	50.02889165	0.0000007		0.00072	99.99794
2B	Ammonia Production	CO2	1322	1108	10.112	0.0000007		0.00068	99.99862
1A3a	Aviation Fuel	CH4	3.297458505	1.61055288	53.85164807	0.0000006		0.00060	99.99922
2A2	Lime Production	CO2	1192	876	5.099	0.0000005		0.00046	99.99968
1A3d	Marine Fuel	CH4	1.31985	1.731918161	50.02889165	0.0000003		0.00032	100.00000
1A	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
1A4	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
5A	5A LUCF	CO2	0	0	25.020	0.0000000		0.00000	100.00000
5B	5B LUCF	CO2	0	0	50.010	0.0000000		0.00000	100.00000
5C	5C LUCF	CO2	0	0	70.007	0.0000000		0.00000	100.00000
5E	5E LUCF	CO2	0	0	50.010	0.0000000		0.00000	100.00000
5G	5G LUCF	CO2	0	0	30	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CH4	0	0	33.54101966	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 -- >	777,458.32	631,605.24		0.1008		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.	Gg CO2 equiv.					
			1990	2008				%	
4D	Agricultural Soils	N2O	30406.856	23322.159	424.001	0.0463954		46.24965	
2B	Nitric Acid Production	N2O	3903.850	1464.657	230.217	0.0176462		17.59076	63.84041
6B	Wastewater Handling	N2O	1033.354	1243.539	401.125	0.0128109		12.77060	76.61101
6A	Solid Waste Disposal	CH4	49816.593	20288.285	48.384	0.0092130		9.18404	85.79505
4B	Manure Management	N2O	2759.235	2121.002	414.001	0.0038573		3.84518	89.64023
1A1&1A2&1A4&1A5	Other Combustion	N2O	4670.540	3325.662	195.000	0.0034203		3.40950	93.04974
5B	5B LUCF	CO2	15822	15243	50.010	0.0011876		1.18390	94.23363
1A(stationary)	Oil	CO2	92033	53791	15.133	0.0009329		0.92996	95.16360
2B	Adipic Acid Production	N2O	20737.345	947.019	15.008	0.0007001		0.69788	95.86147
1A3b	Auto Fuel	N2O	1172.211	1066.125	170.023	0.0006588		0.65677	96.51824
1A3	Other Diesel	N2O	224.533	315.668	140.010	0.0005138		0.51221	97.03045
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2792.377	13.030	0.0003995		0.39823	97.42868
2B5	NEU	CO2	1563	1871	53.852	0.0003434		0.34231	97.77099
1A	All Fuel	CH4	2065.099588	1076.734037	50.00159997	0.0002924		0.29146	98.06245
5E	5E LUCF	CO2	7074	6280	50.010	0.0002686		0.26776	98.33021
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5288.311	16.944	0.0002155		0.21486	98.54507
1A3b	Auto Fuel	CH4	634.8592178	127.667252	50.07833863	0.0001901		0.18952	98.73459
2	Industrial Processes	HFC	11386	11249	19	0.0001436		0.14314	98.87772
6B	Wastewater Handling	CH4	709.572	815.917	50.010	0.0001181		0.11774	98.99547
1A3b	Auto Fuel	CO2	109526	117555	4.482	0.0001134		0.11307	99.10854
1A	Other (waste)	CO2	212	1377	21.190	0.0001060		0.10571	99.21425
6C	Waste Incineration	N2O	47.900	49.021	230.106	0.0001059		0.10560	99.31985
2A7	Fletton Bricks	CO2	180	232	72.801	0.0000893		0.08899	99.40884
1A3d	Marine Fuel	N2O	31.174	40.906	170.008	0.0000886		0.08836	99.49720
1A3a	Aviation Fuel	CO2	1340	2177	20.270	0.0000879		0.08762	99.58482
1A3a	Aviation Fuel	N2O	13.196	21.437	171.172	0.0000617		0.06151	99.64633
6C	Waste Incineration	CH4	134.423	6.365	50.488	0.0000512		0.05108	99.69741
1A	Natural Gas	CO2	108920	200365	1.513	0.0000503		0.05016	99.74757
6C	Waste Incineration	CO2	1207	418	21.190	0.0000492		0.04905	99.79662
4A	Enteric Fermentation	CH4	18527.713	15531.379	20.000	0.0000406		0.04051	99.83713
1A	Lubricant	CO2	387	199	30.067	0.0000203		0.02026	99.85740
2	Industrial Processes	PFC	1402	209	10	0.0000183		0.01829	99.87568
1A	Coal	CO2	248618	133606	1.077	0.0000154		0.01538	99.89106
1B	Oil & Natural Gas	CO2	5778	4414	17.088	0.0000153		0.01528	99.90634
1A4	Peat	CO2	477	461	31.623	0.0000146		0.01454	99.92088
4B	Manure Management	CH4	3608.070	2856.681	30.000	0.0000118		0.01177	99.93265
2B	Chemical Industry	CH4	169.425	68.230	28.284	0.0000108		0.01079	99.94345
2	Industrial Processes	SF6	1030	712	20	0.0000096		0.00961	99.95306
2C1	Iron&Steel Production	CO2	2309	3066	6.119	0.0000088		0.00874	99.96181
1B2	Oil & Natural Gas	N2O	42.396	32.034	111.158	0.0000056		0.00560	99.96741
2A7	Fletton Bricks	CH4	23.602	16.461	101.980	0.0000054		0.00541	99.97282
1B	Solid Fuel Transformation	CO2	856	132	6.013	0.0000040		0.00397	99.97679
2A4	Soda Ash Use	CO2	167	223	15.133	0.0000039		0.00393	99.98072
2C	Iron & Steel Production	CH4	16.357	20.390	50.002	0.0000035		0.00349	99.98421
2A3	Limestone & Dolomite use	CO2	1285	1570	5.099	0.0000027		0.00268	99.98689
2C	Iron & Steel	N2O	11.107	9.960	118.001	0.0000026		0.00261	99.98950
1B1	Coke Oven Gas	N2O	2.085	0.922	118.001	0.0000021		0.00209	99.99159
1A3d	Marine Fuel	CO2	4005	5283	2.202	0.0000019		0.00193	99.99352
1A3	Other Diesel	CO2	1898	2652	2.202	0.0000011		0.00106	99.99458
5A	5A LUCF	CH4	4.298	14.504	20.025	0.0000009		0.00086	99.99544
2A1	Cement Production	CO2	7295	5203	2.417	0.0000008		0.00081	99.99625
2B	Ammonia Production	CO2	1322	1108	10.112	0.0000007		0.00074	99.99699
1A3	Other Diesel	CH4	3.163979778	4.050873262	50.02889165	0.0000007		0.00073	99.99772
1A3a	Aviation Fuel	CH4	3.297458505	1.61055288	53.85164807	0.0000006		0.00060	99.99832
2A2	Lime Production	CO2	1192	876	5.099	0.0000005		0.00046	99.99877
5C2	5C2 LUCF	CH4	3.077	8.036	20.025	0.0000004		0.00043	99.99921
1A3d	Marine Fuel	CH4	1.31985	1.731918161	50.02889165	0.0000003		0.00032	99.99953
5A	5A LUCF	N2O	6.852	2.440	20.025	0.0000002		0.00024	99.99978
5E2	5E2 LUCF	CH4	9.354	5.502	20.025	0.0000002		0.00016	99.99994
5C2	5C2 LUCF	N2O	0.312	0.816	20.025	0.0000000		0.00004	99.99998
5E2	5E2 LUCF	N2O	0.949	0.558	20.025	0.0000000		0.00002	100.00000
1A	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
1A4	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
5A	5A LUCF	CO2	-12155	-13627	25.020	0.0000000		0.00000	100.00000
5C	5C LUCF	CO2	-6130	-8156	70.007	0.0000000		0.00000	100.00000
5G	5G LUCF	CO2	-1711	-1755	30	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CH4	0	0	33.54101966	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 -- >	777,019.42	629,622.16		0.1003		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	2008				%	
4D	Agricultural Soils	N2O	30406.856	23322.159	424.001	0.0518963		49.56914	
2B	Nitric Acid Production	N2O	3903.850	1464.657	230.217	0.0176953		16.90185	66.47099
6B	Wastewater Handling	N2O	1033.354	1243.539	401.125	0.0125012		11.94059	78.41158
6A	Solid Waste Disposal	CH4	49816.593	20288.285	48.384	0.0092480		8.83332	87.24490
4B	Manure Management	N2O	2759.235	2121.002	414.001	0.0043348		4.14039	91.38529
1A1&1A2&1A4&1A5	Other Combustion	N2O	4670.540	3325.662	195.000	0.0035798		3.41929	94.80458
1A(stationary)	Oil	CO2	92033	53791	15.133	0.0009466		0.90411	95.70869
2B	Adipic Acid Production	N2O	20737.345	947.019	15.008	0.0006982		0.66686	96.37555
1A3b	Auto Fuel	N2O	1172.211	1066.125	170.023	0.0006153		0.58768	96.96323
1A3	Other Diesel	N2O	224.533	315.668	140.010	0.0005039		0.48128	97.44451
1B1	Mining & Solid Fuel Transformation	CH4	18289.709	2792.377	13.030	0.0003989		0.38098	97.82549
2B5	NEU	CO2	1563	1871	53.852	0.0003350		0.31999	98.14548
1A	All Fuel	CH4	2065.099588	1076.734037	50.00159997	0.0002951		0.28185	98.42733
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10304.011	5288.311	16.944	0.0002170		0.20730	98.63463
1A3b	Auto Fuel	CH4	634.8592178	127.667252	50.07833863	0.0001899		0.18143	98.81606
2	Industrial Processes	HFC	11386	11249	19	0.0001377		0.13148	98.94754
6B	Wastewater Handling	CH4	709.572	815.917	50.010	0.0001150		0.10984	99.05738
1A3b	Auto Fuel	CO2	109526	117555	4.482	0.0001099		0.10497	99.16234
1A	Other (waste)	CO2	212	1377	21.190	0.0001049		0.10017	99.26252
6C	Waste Incineration	N2O	47.900	49.021	230.106	0.0001021		0.09752	99.36004
2A7	Fletton Bricks	CO2	180	232	72.801	0.0000873		0.08342	99.44346
1A3d	Marine Fuel	N2O	31.174	40.906	170.008	0.0000868		0.08288	99.52634
1A3a	Aviation Fuel	CO2	1340	2177	20.270	0.0000864		0.08254	99.60888
1A3a	Aviation Fuel	N2O	13.196	21.437	171.172	0.0000607		0.05794	99.66682
6C	Waste Incineration	CH4	134.423	6.365	50.488	0.0000511		0.04881	99.71563
1A	Natural Gas	CO2	108920	200365	1.513	0.0000495		0.04732	99.76295
6C	Waste Incineration	CO2	1207	418	21.190	0.0000493		0.04710	99.81005
4A	Enteric Fermentation	CH4	18527.713	15531.379	20.000	0.0000321		0.03070	99.84075
1A	Lubricant	CO2	387	199	30.067	0.0000205		0.01959	99.86034
2	Industrial Processes	PFC	1402	209	10	0.0000183		0.01750	99.87783
1B	Oil & Natural Gas	CO2	5778	4414	17.088	0.0000170		0.01625	99.89409
1A	Coal	CO2	248618	133606	1.077	0.0000156		0.01489	99.90898
4B	Manure Management	CH4	3608.070	2856.681	30.000	0.0000152		0.01455	99.92353
1A4	Peat	CO2	477	461	31.623	0.0000139		0.01329	99.93682
2B	Chemical Industry	CH4	169.425	68.230	28.284	0.0000109		0.01038	99.94720
2	Industrial Processes	SF6	1030	712	20	0.0000100		0.00955	99.95675
2C1	Iron&Steel Production	CO2	2309	3066	6.119	0.0000086		0.00820	99.96495
1B2	Oil & Natural Gas	N2O	42.396	32.034	111.158	0.0000061		0.00586	99.97081
2A7	Fletton Bricks	CH4	23.602	16.461	101.980	0.0000056		0.00539	99.97620
1B	Solid Fuel Transformation	CO2	856	132	6.013	0.0000040		0.00380	99.98000
2A4	Soda Ash Use	CO2	167	223	15.133	0.0000039		0.00369	99.98369
2C	Iron & Steel Production	CH4	16.357	20.390	50.002	0.0000034		0.00326	99.98696
2A3	Limestone & Dolomite use	CO2	1285	1570	5.099	0.0000026		0.00251	99.98947
2C	Iron & Steel	N2O	11.107	9.960	118.001	0.0000024		0.00232	99.99178
1B1	Coke Oven Gas	N2O	2.085	0.922	118.001	0.0000021		0.00201	99.99379
1A3d	Marine Fuel	CO2	4005	5283	2.202	0.0000019		0.00181	99.99561
1A3	Other Diesel	CO2	1898	2652	2.202	0.0000010		0.00099	99.99660
2A1	Cement Production	CO2	7295	5203	2.417	0.0000008		0.00081	99.99741
1A3	Other Diesel	CH4	3.163979778	4.050873262	50.02889165	0.0000007		0.00068	99.99809
1A3a	Aviation Fuel	CH4	3.297458505	1.61055288	53.85164807	0.0000006		0.00058	99.99867
2B	Ammonia Production	CO2	1322	1108	10.112	0.0000006		0.00056	99.99923
2A2	Lime Production	CO2	1192	876	5.099	0.0000005		0.00046	99.99970
1A3d	Marine Fuel	CH4	1.31985	1.731918161	50.02889165	0.0000003		0.00030	100.00000
1A	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
1A4	Combined Fuel	CO2	0	0	21.213	0.0000000		0.00000	100.00000
5A	5A LUCF	CO2	0	0	25.020	0.0000000		0.00000	100.00000
5B	5B LUCF	CO2	0	0	50.010	0.0000000		0.00000	100.00000
5C	5C LUCF	CO2	0	0	70.007	0.0000000		0.00000	100.00000
5E	5E LUCF	CO2	0	0	50.010	0.0000000		0.00000	100.00000
5G	5G LUCF	CO2	0	0	30	0.0000000		0.00000	100.00000
1A3b	Combined Fuel	CH4	0	0	33.54101966	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 -- >	774,094.34	631,605.24		0.1047		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			

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
	IPCC Source Categories	Gas	Category Key Source Category	If Column C is Yes, Criteria for Identification	Comments
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			

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, Trend	
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	
1A3d	Marine Fuel	N2O			
1A3	Other Diesel	N2O			
1B1	Coke Oven Gas	N2O			
1B2	Oil & Natural Gas	N2O			
2B	Adipic Acid Production	N2O		Trend	
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, Trend	
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	
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			

A1.2 TABLE NIR 3, AS CONTAINED IN THE ANNEX TO DECISION 6/CMP.3

Table A 1.2.1 below is Table NIR 3, containing a summary overview for Key Categories for Land Use, Land-Use Change and Forestry Activities under the Kyoto Protocol[2]. The table is consistent with the data submitted in the UK's CRF submission in file <KP-GBE-2010-2008-v1.1.xls>.

Table A 1.2.1 Table NIR 3. Summary overview for Key Categories for Land Use, Land-Use Change and Forestry Activities under the Kyoto Protocol

KEY CATEGORIES OF EMISSIONS AND REMOVALS	GAS	CRITERIA USED FOR KEY CATEGORY IDENTIFICATION			COMMENTS[3]
		Associated category in UNFCCC inventory[1] is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory [1], [4] (including LULUCF)	Other[2]	
Specify key categories according to the national level of disaggregation used[1]					
Afforestation and Reforestation	CO_2	Conversion to Forest Land	No	Associated UNFCCC category (5A2) is key	The Afforestation and Reforestation category contribution is smaller than the smallest UNFCCC key category but the associated UNFCCC category (5A2 Land converted to Forest Land) is a key category. Therefore this is a key category (IPCC good practice guidance for LULUCF section 5.4.4).

2 Table NIR 3 can be found in FCCC/KP/CMP/2007/9/Add.2.

KEY CATEGORIES OF EMISSIONS AND REMOVALS	GAS	CRITERIA USED FOR KEY CATEGORY IDENTIFICATION			COMMENTS[3]
		Associated category in UNFCCC inventory[1] is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory [1], [4] (including LULUCF)	Other[2]	
Deforestation	CO_2	Conversion to Grassland; conversion to Settlements	No	Associated UNFCCC category (5C and 5E) are key)	The Deforestation category contribution is smaller than the smallest UNFCCC key category but the associated UNFCCC categories (5C Grassland and 5E Settlements) are key categories. Therefore this is a key category (IPCC good practice guidance for LULUCF section 5.4.4).
Forest Management	CO_2	Conversion to Forest Land	Yes	Associated UNFCCC category (5A2) is key	The associated UNFCCC inventory category is a key category and the Forest Management category contribution is greater than the smallest UNFCCC key category.

(1) See section 5.4 of the IPCC good practice guidance for LULUCF
(2) This should include qualitative consideration as per Section 5.4.3 of the IPCC Good Practice Guidance for LULUCF or any other criteria
(3) Describe the criteria identifying the category as key
(4) If the emissions or removals of the category exceed the emissions of the smallest category identified as key in the UNFCCC inventory (including LULUCF), Parties should indicate YES. If not, Parties should indicate NO

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 for individual source or sink categories, including for KP-LULUCF activities.

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 (DECC, 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 A 3.1.1** 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.

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.

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.

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.

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.

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

Slurry

This is a slurry of coal and water used in some power stations.

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.

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[3].

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

Table A 3.2.1 to **Table A 3.2.7** 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.

Table A 3.2.1 to **Table A 3.2.7** 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
2B2 Nitric Acid Production	Nitric Acid Production

IPCC Source Category	NAEI Source Category
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 DECC (2009). 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, 2009) are also used to generate emission factors.

Table A 3.3.1 to **Table A 3.3.4** 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 DECC (2009) 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 (DECC, 2009).

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. 85% of total GHG emissions are from the energy sector. 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 (DECC, 2009). 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. EU-ETS factors have continued to be used in the 2010 GHGI The sectors are listed below, along with the years for which EUETS data is used:

- Power Stations – coal – for 2005-2008
- Power Stations – fuel oil – for 2005-2008
- Power Stations – natural gas – for 2006 - 2008, (interpolated 2005)
- Power Stations – Petroleum Coke - 2005-2008
- Autogenerators – coal – 2005 - 2008
- Refineries – fuel oil - 2006 - 2008 (interpolated 2005)
- Refineries – Petroleum coke – 2005 – 2008

Although fuel use data are received directly from the cement industry, the data used is consistent with ETS data for coal, petroleum coke, gas oil, scrap tyres, waste oils and waste solvents for 2006-2008.

As data in the EU-ETS continues to improve in terms of its coverage of emissions from certain industries, the aim is to increase the use of the emission factors. In the next inventory, presented in 2011, it is hoped that the use of ETS data can continue to be expanded.

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 2008[1] (kg/t)

Fuel	Source	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
ATF	Aircraft Military	840[a]	0.103[ad]	0.1[g]	8.5[ad]	8.2[ad]	1.1[ad]	0.87[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]	3.34[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]	1.6[z]
Gas Oil	Domestic	870[a]	0.455[g]	0.0273[g]	3.19[l]	1.82[l]	0.047[f]	1.6[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]	20.80[l]	8.26[l]	0.028[f]	1.6[z]
Gas Oil	Refineries	870[a]	0.136[g]	0.0273[g]	4.55[k]	0.24[i]	0.028[f]	1.6[z]
Gas Oil	Other Industry	870[a]	0.0910[g]	0.0273[g]	4.84[l]	0.83[l]	0.028[f]	1.6[z]
Gas Oil	Public Service	870[a]	0.455[g]	0.0273[g]	2.44[l]	0.38[l]	0.047[f]	1.6[z]
Gas Oil	Miscellaneous	870[a]	0.455[g]	0.0273[g]	1.21[l]	0.16[l]	0.047[f]	1.6[z]
Fuel Oil	Agriculture	879[a]	0.433[g]	0.026[g]	7.69[l]	0.31[l]	0.14[f]	18.0[z]
Fuel Oil	Public Service	879[a]	0.433[g]	0.026[g]	7.35[l]	0.77[l]	0.14[f]	18.0[z]
Fuel Oil	Miscellaneous	879[a]	0.433[g]	0.026[g]	0.93[l]	0.038[l]	0.14[f]	18.0[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]	18.0[z]
Fuel Oil	Iron&Steel	879[a]	0.087[g]	0.026[g]	7.14	0.81[l]	0.035[f]	18.0[z]
Fuel Oil	Railways (Stationary)	879[a]	0.433[g]	0.026[g]	7.35[l]	0.77[l]	0.14[f]	18.0[z]
Fuel Oil	Other Industry	879[a]	0.087[g]	0.026[g]	10.56[l]	1.50[l]	0.035[f]	18.0[z]
Fuel Oil	Refineries (Combustion)	871.6[at]	0.130[g]	0.026[g]	3.69[ag]	0.66[ag]	0.035[f]	30.3[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]	0.138[an]	0.028[g]	4.62[k]	0.24[e]	0.028[e]	0.046[z]

Table A 3.3.2 Emission Factors for the Combustion of Coal for 2008[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]	17.3[aa]
Collieries	685.0[ao]	0.011[o]	0.148[w]	4.75[l]	8.25[l]	0.05[o]	22.0[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]	17.34[aa]
Lime Production (Combustion)	640.6[ao]	0.011[o]	0.214[w]	51.82[v]	7.81[v]	0.05[o]	17.34[aa]
Miscellaneous	710.0[ao]	0.011[o]	0.148[w]	4.74[l]	8.11[l]	0.05[o]	17.34[aa]
Public Service	710.0[ao]	0.011[o]	0.148[w]	4.71[l]	7.45[l]	0.05[o]	17.34[aa]
Other Industry	640.6[ao]	0.011[o]	0.214[w]	4.24[l]	2.03[l]	0.05[o]	17.34[aa]
Railways	710.0[ao]	0.011[o]	0.148[w]	4.71[l]	7.45[l]	0.05[o]	17.34[aa]
Autogenerators	581.3[at]	0.02[o]	0.0660[w]	5.57[l]	1.68[l]	0.03[o]	17.34[aa]

Table A 3.3.3 Emission Factors for the Combustion of Solid Fuels 2008[1] (kg/t)

Fuel	Source	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Anthracite	Domestic	840.0[ap]	2[o]	0.14[w]	3.47[k]	208.2[k]	1.7[o]	15.2[aa]
Coke	Agriculture	814.5[r]	0.011[p]	0.150[w]	5.15[l]	1.20[l]	0.05[p]	19[ab]
Coke	SSF Production	814.5r	0.011[p]	0.230[w]	IE	IE	0.05[p]	19[ab]
Coke	Domestic	814.5r	5.8[o]	0.117[w]	3.04[l]	118.6[l]	4.9[o]	15.2[aa]
Coke	I&S[ak] (Sinter Plant)	814.5r	1.52[ae]	0.230[w]	12.81[ae]	299[ae]	0.46[ae]	14.3[ae]
Coke	I&S[ak] (Combustion)	814.5r	0.011[p]	0.230[w]	0.87[l]	226[l]	0.05[p]	19[ab]
Coke	Other Industry	814.5r	0.011[p]	0.230[w]	5.15[l]	1.20[l]	0.05[p]	19[ab]
Coke	Railways	814.5r	0.011[p]	0.150[w]	5.15[l]	1.20[l]	0.05[p]	19[ab]
Coke	Miscellaneous; Public Service	814.5r	0.011[p]	0.150[w]	5.15[l]	1.20[l]	0.05[p]	19[ab]
MSW	Miscellaneous	75[ah]	2.85[g]	0.038[g]	0.90[v]	1.20[v]	0.0049[v]	0.089[v]
Petroleum Coke	Domestic	930[a]	NE	NE	3.95[k]	118[k]	4.9[am]	142.4[as]
Petroleum Coke	Refineries	930[at]	0.107[ai]	0.281[w]	6.67[ag]	1.17[ag]	0.054[ai]	34.8[ag]
Petroleum Coke	Cement Production – Combustion	819	0.107	0.143				
SSF	Miscellaneous; Public Service	766.3[n]	0.011[p]	0.151[w]	4.58[k]	124.4[k]	4.9[o]	16[ab]
SSF	Domestic	774.2[n]	5.8[o]	0.118[w]	3.05[k]	46.7[k]	0.05[p]	19[ab]
SSF	Other Industry	766.3[n]	0.011[p]	0.232[w]	4.58[g]	46.7[g]	0.05[g]	19
Straw	Agriculture	418[g]	4.5[g]	0.06[g]	1.5[k]	75[g]	9[k]	
Wood	Domestic	387[g]	4.17[g]	0.06[g]	0.7[k]	69.5[k]	23.6[o]	0.11[aa]

Table A 3.3.4 Emission Factors for the Combustion of Gaseous Fuels 2008[1] (g/GJ gross)

Fuel	Source	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Blast Furnace Gas	Coke Production	82137[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)	82137[r]	112[k]	2.0[k]	79[k]	39.5[k]	5.6[k]	0
Blast Furnace Gas	Blast Furnaces	82137[r]	112[k]	2.0[k]	50.7[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]	50.7[v]	40.0[k]	4.35[k]	280[v]
Coke Oven Gas	Coke Production	11089[r]	57.25[k]	2.0[k]	360[v]	40.0[k]	4.35[k]	280[v]
LPG	Domestic	16227[a]	0.889[f]	0.10[g]	62.1[f]	8.9[f]	3.77[f]	0
LPG	I&S[ak], Other Industry, Refineries, Gas Production	16227[a]	0.889[f]	0.10[g]	62.1[f]	15.1[f]	3.77[f]	0
Natural Gas	Agriculture	13975[r]	5.0[g]	0.10[g]	39.2[l]	2.13[l]	2.22[f]	0
Natural Gas	Miscellaneous	13975r	5.0[g]	0.10[g]	55.14[l]	10.8[l]	2.22[f]	0
Natural Gas	Public Service	13975r	5.0[g]	0.10[g]	58.7[l]	13.15[l]	2.22[f]	0
Natural Gas	Coke Production, SSF Prodn[al],	13975r	1.0[g]	0.10[g]	175.0[k]	2.37[l]	2.22[f]	0
Natural Gas	Refineries	13975r	1.0[g]	0.10[g]	70.0[k]	2.37[l]	2.22[f]	0
Natural Gas	Blast Furnaces	13975r	5.0[g]	0.10[g]	50.7[v]	2.37[l]	2.22[f]	0
Natural Gas	Domestic	13975r	5.0[g]	0.10[g]	69.2[l]	30.8[l]	2.22[f]	0
Natural Gas	Gas Prodn[al],	13975r	1.0[g]	0.10[g]	86.5[l]	17.4[l]	2.22[f]	0
Natural Gas	I&S[ak]	13975r	5.0[g]	0.10[g]	177.4[l]	167.6[l]	2.22[f]	0
Natural Gas	Railways	13975r	5.0[g]	0.10[g]	86.53[l]	33.8[l]	2.22[f]	0
Natural Gas	Other Industry	13975r	5.0[g]	0.10[g]	134.94[l]	63.5[l]	2.22[f]	0
Natural Gas	Nuclear Fuel Prodn[al], Collieries	13975r	1.0[g]	0.10[g]	134.94[l]	63.5[l]	2.22[f]	0

Fuel	Source	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Natural Gas	Autogenerators	13975r	5.0[g]	0.10[g]	68.4[l]	19.62[l]	2.22[f]	0
Natural Gas	Ammonia (Combustion)	13975r	5.0[g]	0.10[g]	146.1[d]	NE	2.22[f]	0
OPG	Gas production	15582a	1.0[g]	NE	70.0[k]	2.37[i]	3.77[f]	0
OPG	Refineries (Combustion)	15582a	1.0[g]	NE	91.0[ag]	12.0[z]	3.77[f]	0
OPG	Other Industry	15582a	5.0[g]	NE	70.0[k]	2.37[i]	3.77[f]	0
Colliery Methane	Other Industry	13933a	5.0[s]	0.10[g]	70.0[k]	2.37[i]	2.21[f]	0
Colliery Methane	Coke Production, Gas Production	13933a	1.0[s]	0.10[g]	70.0[k]	2.37[i]	2.21[f]	0
Sewage Gas	Public Services	27405g	5.0[g]	0.10[g]	66.78[f]	7.1[f]	2.42[f]	0
Landfill Gas	Miscellaneous	27405g	5.0[g]	0.10[g]	39.0[f]	122.4[f]	3.62[f]	0

Footnotes to **Tables A 3.3.1** to **A 3.3.4**:

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 (2009), Invista (2009), BP Chemicals (2009)
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 estimate based on disaggregation of UK fuel use by sector and device type with application of literature-based emission factors or data reported in the Pollution Inventory for each disaggregated sector/device combination (2009)
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, 2009)
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 DECC, (2009). The values of the conversion factors used in the calculations are given in **Table A 3.3.5.**

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* (DECC, 2009) 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[4].

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

Table A 3.3.6 Emission Factors for Power Stations in 2008 [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	614[s]	0.02[e]	0.063[l]	4.51[n]	0.612[n]	0.0231[n]	4.26[n]
Petroleum Coke	Kt/Mt	625 [a]	0.107[q]	0.087[r]	3.06[n]	12.1[n]	0.025[n]	8.88[n]
Fuel Oil	Kt/Mt	869.5[s]	0.130[h]	0.0260[h]	10.96[n]	1.09[n]	0.0515[n]	12.94[n]
Gas Oil	Kt/Mt	870[a]	0.136[h]	0.0273[h]	13.37[n]	39.1[n]	0.336[n]	7.87[n]
Burning Oil	Kt/Mt				3.08[n]	11.02[n]	1.034[n]	0.041[n]
Natural gas	Kt/Mth	1.499[s]	0.000106[h]	1.06E-05[h]	0.00417[n]	0.00094[n]	0.000170[n]	4.04E-05[n]
MSW	Kt/Mt	75[d]	0.285[h]	0.038[h]	0.902[o]	0.0983[o]	0.00488[o]	0.0888[o]
Sour gas	Kt/Mth	1.916[c]	0.000106[h]	1.06E-05[h]	0.0[n]	0.0[o]	0.0[n]	0.0[n]
Poultry Litter	Kt/Mt	NE	0.283[h]	0.0378[j]	0.854[n]	0.412[o]	0.0230[o]	0.326[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	10.96[n]	1.09[n]	0.0545[n]	12.24[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 **Table A 3.3.6** (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, 2009), SEPA's Scottish Pollutant Release inventory (SEPA, 2009), NI DoE's Inventory of Sources and Releases list (NI DoE, 2009) and direct communications with plant operators (Pers. Comms., 2009)
o	Environment Agency (2009)
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 A 3.3.6**. 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 2009). 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 manufacturer's 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 (DECC, 2009) on the amount of waste used in heat and electricity generation and the emissions from the incinerators (Environment Agency, 2009). 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.

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 (2009) 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 (DECC, 2009). 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). DECC (2009) 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 A 3.3.1**. 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 (DECC, 2009), 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, 2009) 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 **Table A 3.3.1 - Table A 3.3.4**. The fuel consumption for these categories are taken from DECC (2009). 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 **Table A 3.3.1 - Table A 3.3.4**. 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. In 2007, these recommendations for Heathrow were incorporated into the UK inventory. For the 2008 inventory these recommendations were incorporated into the UK inventory for all airports, along with further recommendations relating to: the effects of aircraft speed on take-off emissions; engine spool-up at take-off; the interpolation to intermediate thrust settings; hold times; taxiing thrust and times; engine deterioration and APU emission indices and running times.

For arrivals, 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. For the 2008 inventory these recommendations were incorporated into the UK inventory for all airports, along with further recommendations relating to: the interpolation to intermediate thrust settings; approach thrusts and times; taxiing thrust and times; engine deterioration and APU emission indices and running times.

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. In 2008 there are reductions in both emissions and aircraft movements, in line with the economic downturn.

A3.3.5.1.2 Emission Reporting Categories for Civil Aviation

Table A 3.3.7 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. The data covered all Air transport Movements (ATMs) excluding air-taxi.

The CAA also compiles summary statistics at reporting airports, which include air-taxi and non-ATMs.

A summary of aircraft movement data is given in **Table A 3.3.8**.

- **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 has been given in ONS (1995) and MOD (2005a) and is assumed to be aviation turbine fuel. A revised, but consistent time series of military aviation fuel was provided by the Safety, Sustainable Development and Continuity Division of the Defence Fuels Group of the MoD (MoD, 2009) covering each financial year from 2003/04 to 2007/08. Figures for 2008/09 were not complete so data for 2007/08 were used. Adjustments were made to the data to derive figures on a calendar year basis.

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
2008	776.4	438.9	1534.6	158.6

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 2008 (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 (2009)
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-CO2 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 A 3.3.10)**. 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 DECC 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, having first scaled up the emissions and fuel consumption to account for air-taxi and non-ATMs. The scaling is done separately for each airport to reflect the different fractions of air-taxi and non-ATMs at each airport and the different impacts on domestic and international emissions. The ATF fuel consumptions presented in DECC 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 DECC 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 DECC 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.

DECC have confirmed estimates in DUKES exclude Gibraltar and the other UK overseas territories. The DECC 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 DECC (2009). Emission factors are reported in **Table A 3.3.1** to **Table A 3.3.4**.

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 in 2007 and 2008 was estimated on the basis of reported train kilometres travelled. 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 a slight increase in 2008 in comparison to 2007.

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 (2009) http://www.rail-reg.gov.uk/upload/pdf/YEARBOOK0809-v22.pdf;
- Assumed mix of locomotives for each category; and,
- Fuel consumption factors for different types of locomotive (LRC (1998), BR (1994) and Hawkins & Coad (2004)).

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 A 3.3.11** 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 and CO with the emission factors for both categories increasing slightly from the values used in 2007. 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 decreased from 2.67 kt/ Mt fuel in 2007 to 1.63 kt/ Mt fuel in 2008 in line with UKPIA's Table of the S-content in fuels in 2008 (UKPIA, 2009).

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

	C[1]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Freight	870	0.17	1.2	80.1	8.9	4.5	1.63
Intercity	870	0.22	1.2	42.2	13.2	5.7	1.63
Regional	870	0.38	1.2	33.1	36.7	6.4	1.63

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 2008 inventory

There have been a number of significant improvements made to the road transport inventory, combining methodological changes with new emission factors and in some cases revised activity data. These improvements supplement the ones that were initiated last year following release of new emission factors, further research on the activity data in relation to the UK fleet and intensive discussions with officials at the Department for Transport (DfT) during 2009. The key changes are summarised as follows:

- Use of a new set of functions relating fuel consumption factors (in g fuel/km) to average speed for a wide range of vehicle classes following research carried out by TRL on behalf of DfT and published in 2009.
- Adoption of a new method for normalising petrol and diesel fuel consumption calculated using a detailed bottom-up method based on fuel consumption factors and vehicle km data with the figures published in DUKES. This effects the allocation of fuel consumption and hence CO_2 emissions between vehicle types, but not the overall CO_2 inventory for road transport.

- Use of a new set of functions relating emission factors for methane, NMVOCs and CO to average speed for a wide range of vehicle classes following research carried out by TRL on behalf of DfT and published in 2009. These were combined with functions and data used to take account of the change in emission factor with accumulated vehicle mileage (age). Provisional new emission factors for NO_x from the same data source had been adopted in the 2007 inventory and these were slightly revised on final publication of the new factors.
- Revisions to the vehicle survival rates assumed in the model affecting the turnover and mix of different vehicle classes in the fleet. This followed research carried out for Defra on vehicle licensing data. This was combined with analysis of the fleet composition for the more detailed categories of vehicles covered by the new DfT/TRL emission factors.
- Major changes in the assumptions made about the proportion of petrol vehicles with failed catalyst systems in the fleet, based on new evidence obtained from DfT suggesting a higher rate of failure than had previously been assumed.
- Minor revisions to the vehicle km activity data for cars and vans in Northern Ireland. This was based on new information from the Department of Regional Development in N Ireland on the structure of the car and LGV vehicle fleet there.
- Changes in the methodology for estimating cold start emissions following the recommendations of the study by TRL published in 2009.
- Changes in the assumptions on average trip length required for the calculation of cold start emissions and evaporative losses from vehicles following a review of trip data held by the Department for Transport.

For CO_2, these changes have only affected the distribution of fuel consumption and hence CO_2 emissions between vehicle types, but the total CO_2 emissions from 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 methods, 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 DECC and corrected for consumption by off-road vehicles and the very small amount of fuel consumed by the Crown Dependencies included in DUKES (emissions from the Crown Dependencies are calculated elsewhere).

In 2008, 16.68 Mtonnes of petrol and 20.61 Mtonnes of diesel fuel (DERV) were consumed in the UK (a very small proportion of this was used in the Crown Dependencies). For both fuels, this is a decrease in consumption compared with 2007. It was estimated that of this, around 1.5% of petrol was consumed by off-road vehicles and machinery and 0.4% used in the Crown Dependencies, leaving 16.35 Mtonnes of petrol consumed by road vehicles in the UK in 2008. Around 0.05% of road diesel is estimated to be used by off-road vehicles and machinery (the bulk of these use gas oil) and 0.3% used in the Crown Dependencies, leaving 20.55 Mtonnes of diesel consumed by road vehicles in the UK in 2008.

According to figures in DUKES (DECC, 2009), 0.125 Mtonnes of LPG were used for transport in 2008, up from 0.119 Mtonnes the previous year and back to levels in 2006.

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 DECC refer only to mineral-based fuels (fossil fuels). According to statistics in DUKES and from HMRC (2009), an additional 0.16 Mtonnes bioethanol and 0.79 Mtonnes biodiesel were consumed in the UK in 2008. On a volume basis, this represents about 0.9% of all petrol and 3.5% of all diesel sold in the UK, respectively, and on an energy basis it is estimated that consumption of bioethanol and biodiesel displaced around 0.098 Mtonnes of mineral-based petrol (about 0.6% of total petrol that would have been consumed) and 0.685 Mtonnes of mineral-based diesel (about 3.2% of total diesel that would have been consumed). 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 A 3.3.12**. Values for SO_2 vary annually as the sulphur-content of fuels change, and are shown in **Table A 3.3.12** for 2008 fuels based on data from UKPIA (2009).

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

Fuel	C[a]	SO_2[b]
Petrol	855	0.047
Diesel	863	0.014

a Emission factor in kg carbon/tonne, based on UKPIA (2005)
b 2008 emission factor calculated from UKPIA (2009) – figures on the weighted average sulphur-content of fuels delivered in the UK in 2008

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 2008 inventory, a different procedure was used 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.

Fuel consumption factors for petrol and diesel vehicles

The important equations relating fuel consumption to average speed were updated and are based on the new fuel consumption-speed relationships for detailed categories of vehicles compiled by TRL on behalf of DfT. The factors themselves are available at http://www.dft.gov.uk/pgr/roads/environment/emissions/ together with appropriate documentation from TRL on how the emission factors were derived (see for example the report by Boulter et al. (2009) at http://www.dft.gov.uk/pgr/roads/environment/emissions/report-3.pdf. The TRL equations were derived from their large database of emission measurements compiled from different sources covering different vehicle types and drive cycles. The measurements were made on dynamometer test facilities under simulated real-world drive cycles.

For cars, LGVs and motorcycles, the speed-related fuel consumption factors in g fuel/km were used in combination with average speed, fleet composition and vehicle km data for different road types as described below. The fleet-average fuel consumption factors calculated for these vehicle types grouped into their respective Euro emission standards are shown in **Table A 3.3.13** for average speeds on urban, rural and motorway roads. The different emission standards are described in a later section.

Table A 3.3.13 Fuel Consumption Factors for Light Vehicles (in g fuel/km)

g fuel /km		Urban	Rural	Motorway
Petrol cars	Pre-Euro 1	66.4	62.8	69.1
	Euro 1	61.4	57.9	64.1
	Euro 2	58.8	55.3	61.5
	Euro 3	55.0	51.4	57.6
	Euro 4	50.8	47.2	53.4
Diesel cars	Pre-Euro 1	60.3	55.0	61.2
	Euro 1	58.5	53.2	59.4
	Euro 2	54.9	49.6	55.8
	Euro 3	50.2	44.9	51.1
	Euro 4	47.7	42.4	48.7
Petrol LGVs	Pre-Euro 1	68.7	64.1	70.0
	Euro 1	63.6	59.0	64.8
	Euro 2	60.9	56.3	62.1
	Euro 3	57.1	52.5	58.3
	Euro 4	52.3	47.7	53.6
Diesel LGV	Pre-Euro 1	61.9	68.4	91.9
	Euro 1	76.7	84.4	110.1
	Euro 2	71.5	77.5	106.0
	Euro 3	63.2	69.8	104.0
	Euro 4	63.2	69.8	104.0
Mopeds, <50cc, 2st	Pre-Euro 1	25.5		
	Euro 1	15.3		
	Euro 2	12.3		
	Euro 3	10.7		
Motorcycles, >50cc, 2st	Pre-Euro 1	27.5	30.2	
	Euro 1	25.3	27.8	
	Euro 2	25.3	27.8	
	Euro 3	25.3	27.8	

g fuel /km		Urban	Rural	Motorway
Motorcycles, >50cc, 4st	Pre-Euro 1	35.3	35.1	53.9
	Euro 1	33.5	33.2	46.9
	Euro 2	31.6	31.9	49.3
	Euro 3	31.6	31.9	49.3

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, 2009a). A time-series of mpg figures from 1989 to 2007 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 shape of the DfT/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 factor with speed and hence road type. As no figures were available from DfT for 2008, the mpg factors for 2008 were estimated on the basis of the trends in the composition of the HGV fleet and the DfT/TRL speed-related functions.

Table A 3.3.14 presents the fleet-averaged fuel consumption factors for rigid and articulated HGVs from 1990-2008 for urban, rural and motorway conditions based on the road freight statistics for HGVs up to 2007 published in DfT (2008a). These are revised from last year's version of the inventory because of combination with the new DfT/TRL speed related functions, but averaged over all road types, the factors are the same as in the previous inventory.

Table A 3.3.14 Average fuel consumption factors for HGVs (in g fuel/km) in the fleet based on DfT's road freight statistics

g fuel/km	Rigid HGVs			Artic HGVs		
	Urban	Rural	Motorway	Urban	Rural	Motorway
1990	271	221	228	437	337	344
1991	275	224	232	436	335	343
1992	276	224	232	432	333	341
1993	265	215	223	411	317	324
1994	256	209	216	405	312	319
1995	260	214	221	395	305	312
1996	255	211	218	387	299	306
1997	253	210	217	385	299	305
1998	243	202	209	367	285	292
1999	248	208	215	369	287	294
2000	247	208	215	369	287	294
2001	257	217	225	373	292	298
2002	250	212	219	371	290	296
2003	259	220	228	376	293	300
2004	250	213	220	362	283	289
2005	245	209	216	358	279	286
2006	252	214	222	361	281	287

g fuel/km	Rigid HGVs			Artic HGVs		
	Urban	**Rural**	**Motorway**	**Urban**	**Rural**	**Motorway**
2007	260	221	228	367	286	293
2008	261	221	229	368	286	293

For buses and coaches, the principal data source used was figures from DfT on the Bus Service Operators Grant system (BSOG). This is an audited subsidy, directly linked to the fuel consumed on local bus services. From BSOG financial figures, DfT were able to calculate the costs and hence quantity of fuel (in litres) used for local bus services going back to 1996 and using additional bus km data were able to derive implied fuel consumption factors for local service buses (DfT, 2009a). DfT believe this provides a relatively robust estimation of fuel consumption on local bus services and would be based on a larger evidence base than the DfT/TRL speed-related functions which are derived from a relatively small sample of buses and coaches tested. The BSOG data actually imply an increase in the average fuel consumption factor for local buses, i.e. a reduction in fuel efficiency over the period from 1996 to 2005/2006, which is now levelling off. The BSOG data were used to define the fuel consumption factor for buses in the inventory over an urban cycle. However, the BSOG data do not cover more rural bus services and coaches. For these, an approach similar to that used for HGVs was used by utilising the research-based, speed-related fuel consumption factors given by DfT/TRL in combination with the BSOG data. Using a combination of fleet composition data for different sizes of buses, the DfT/TRL functions were used to define how the fuel efficiency of the average bus and coach in the UK fleet varied with average speed and road type and year. The differences relative to the fuel efficiency factor for the average bus over an urban cycle were derived for the average bus on a rural cycle and the average coach on motorways. The relative differences were then applied to the BSOG-based urban bus factor to develop a series of internally consistent trends in bus and coach fuel consumption factor on urban, rural and motorway roads. As BSOG data were not available for the whole of 2008, trends in the average fuel consumption factor for urban buses implied by DfT/TRL functions for different bus classes and the change in the bus fleet between 2007 and 2008 were used to define a 2008/2007 fuel efficiency scaling factor which was applied to the BSOG factor for 2007 to give an estimate of fuel consumption factor for local buses in 2008.

Table A 3.3.15 presents the fleet-averaged fuel consumption factor for buses and coaches from 1990-2008 for urban, rural and motorway conditions based on this method.

Fuel reconciliation and normalisation
A model is used to calculate total petrol and diesel consumption by combining these factors with relevant traffic data (discussed in Section A3.3.5.3.1.). These "bottom-up" calculated estimates of petrol and diesel consumption are then compared with DECC figures for total fuel consumption in the UK published in DUKES, adjusted for the small amount of consumption by off-road machinery and consumption in the Crown Dependencies. The bottom-up estimated fuel consumption differs from the DUKES-based figures and so it is necessary to adjust the calculated estimates for individual vehicle types by using a normalisation process to ensure the total consumption of petrol and diesel equals the DUKES-based figures. This is to comply with the UNFCCC reporting system which requires emissions of CO_2 to be based on fuel sales.

Figure A 3.3.1 shows the ratio of calculated fuel consumption to the figures in DUKES based on total fuel sales of petrol and diesel in the UK. The ratio fluctuates just above and below the 1 line, but the difference is never higher than 7%. In 2008, the bottom-up method underestimates petrol consumption by 5% and over-estimates diesel consumption by 2%. This is considered well within the uncertainty of the factors used to derive the bottom-up estimates.

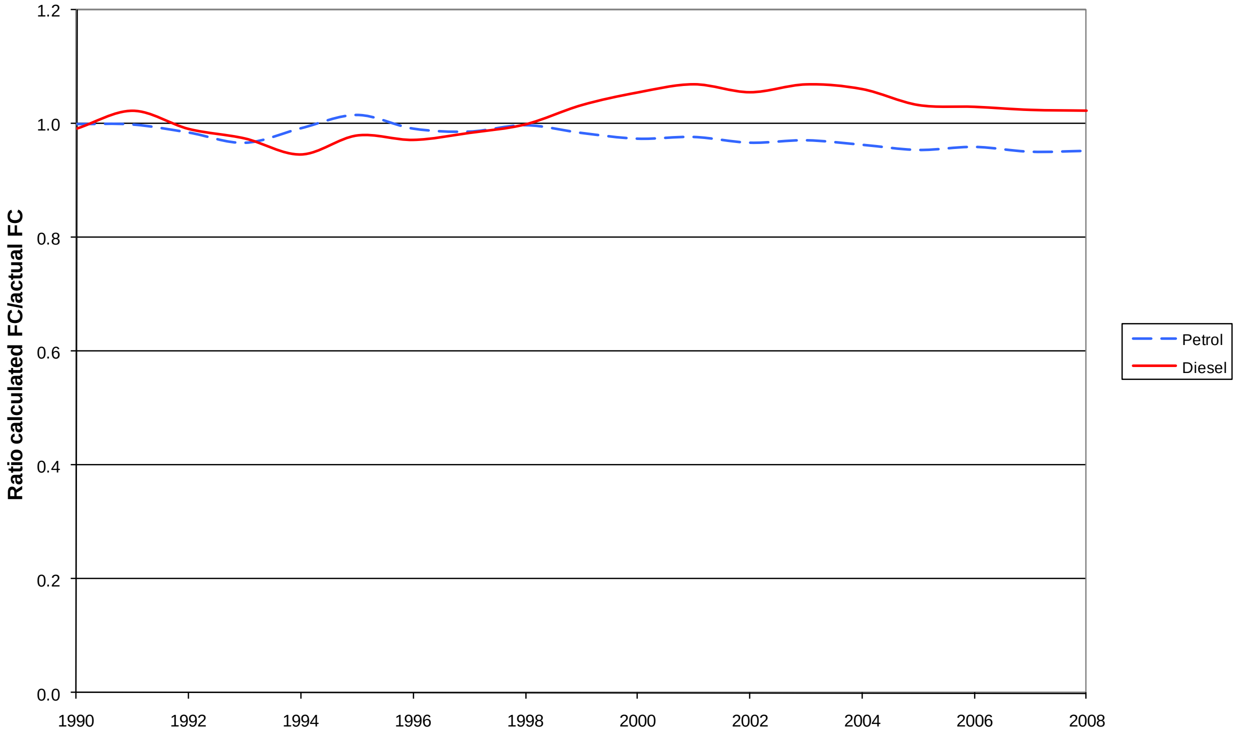
Table A 3.3.15 Average fuel consumption factors for buses and coaches (in g fuel/km) in the fleet based on DfT's BSOG data

g fuel/km	Urban	Rural	Motorway
1990	305	190	216
1991	305	190	216
1992	305	190	216
1993	304	190	216
1994	300	188	214
1995	296	185	212
1996	290	182	209
1997	289	182	210
1998	289	183	212
1999	300	191	222
2000	313	200	234
2001	314	201	236
2002	327	210	247
2003	342	220	259
2004	355	228	269
2005	370	237	280
2006	356	228	269
2007	350	224	264
2008	349	223	263

The 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.

For petrol, the fuel consumption calculated for each vehicle type consuming petrol is scaled up of down by the same proportion to make the total petrol consumption align with DUKES. So for example, the fuel consumption estimated for petrol cars, LGVs and motorcycles are all increased by 5% to align with fuel sales in 2008. 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.

Figure A 3.3.1 Ratio of calculated consumption of petrol and diesel fuel based on traffic movement and fuel consumption factors summed for different vehicle types to the DUKES figures for these fuels based on fuel sales in the UK.



For diesel, a number of different vehicle classes (cars, LGVs, HGVs and buses) all consume similar amounts of fuel. Either the fuel consumption for all diesel vehicles can be scaled to align with DUKES, as carried out for petrol normalisation, or that for specific vehicle types can be adjusted to bring the total in line with DUKES. Because all vehicle types make a similar contribution to diesel consumption, adjusting the calculated figures for all vehicle types by scaling can lead to distorted trends in the figures for specific vehicle types over a time-series. After discussions with officials at DfT, it was decided to retain the consumption for cars, LGVs and buses at the values calculated by the bottom-up approach and use HGVs to "carry the burden" of bringing the total diesel consumption in line with DUKES (DfT, 2009b). There were two main reasons for this. First, because HGVs are the largest overall consumer of diesel, this approach of correcting for the difference between calculated diesel consumption and fuel sales figures from DUKES (the difference being 0.46 Mtonnes or 2% in 2008) has a smaller effect on HGVs than other vehicle classes. A second reason is that a rationale can be given for HGVs leading to the overestimation of diesel consumption compared with sales since 1998 on the basis of "fuel tourism" effects. This is where vehicles consume fuel on UK roads that was purchased abroad. In this case, the fuel would not appear in the UK sales figures, but would be represented in consumption figures calculated from traffic movement data. Given the recent price differential between diesel sold in the UK and the rest of Europe and the amount of cross-border haulage operations, HGVs are believed to make a larger contribution to potential fuel tourism effects than any other class of vehicle. Furthermore, DfT were able to provide some data to back up this hypothesis. This included DfT estimates of the amount of fuel purchased abroad by UK vehicles and the kilometres travelled in the UK by foreign vehicles (DfT, 2009b). The figures suggested the total amount of fuel purchased abroad (and therefore not contributing to UK fuel sales in DUKES) by HGVs operating in the UK could be around 550 ktonnes compared with a gap of around 460 ktonnes in the estimate of total diesel consumption and the figures based on fuel sales in DUKES. This is at least consistent with a theory indicating HGV fuel tourism contributing to the gap and partial justification for adjusting the bottom-up estimated diesel consumption for HGVs to bring the total diesel consumption in line with DUKES. However, it is important to recognise that other factors including modelling uncertainty will also be playing a factor.

Emissions from LPG consumption

Total CO_2 emissions from vehicles running on LPG are estimated on the basis of national figures (from DUKES) 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 reliable 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. Figures from DUKES suggest that the consumption of LPG is around 0.3% of the total amount of petrol and diesel consumed by road transport and vehicle licensing data suggest less than 0.5% of all light duty vehicles run on LPG.

Emissions of CO_2 from LPG consumption are calculated from total consumption figures and carbon factors for LPG fuel.

Emissions from natural gas consumption

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 DECC 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 over a given distance. 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). A similar conclusion was reached in the recent review of emission modelling methodology carried out by TRL on behalf of DfT (Barlow and Boulter, 2009, see http://www.dft.gov.uk/pgr/roads/environment/emissions/report-2.pdf). 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 (vkm) 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, 2009c). The DfT Report "Transport

Statistics Great Britain" (DfT, 2009c) provides vehicle kilometres data up to 2008. Additional information discussed later was used to provide the breakdown in vkm for cars by fuel type.

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, 2008, 2009a). These provided a consistent time-series of vehicle km data for all years up to 2008. A slight revision was made to the vehicle km time-series for 1990-2007 due to new information from Northern Ireland about the split between cars and LGVs and the petrol/diesel car split for cars and LGVs in the traffic flow based on further interrogation by DRDNI of licensing data (DRDNI, 2009b).

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 2008 as shown in **Table A 3.3.16.**

Table A 3.3.16 UK vehicle km by road vehicles

Billion vkm		1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
Petrol cars	urban	142.9	139.7	139.1	138.7	140.0	136.1	133.7	129.7	127.5	125.0	120.6
	rural	138.2	128.1	127.2	127.3	127.0	124.4	122.5	118.4	117.0	113.4	109.5
	m-way	47.7	46.0	48.4	48.8	48.2	46.3	45.9	44.0	43.1	41.5	39.8
Diesel cars	urban	4.8	13.9	21.3	22.9	25.9	28.4	31.3	34.0	37.1	40.1	42.3
	rural	8.1	22.9	35.2	38.2	42.6	46.9	51.9	56.2	61.4	65.7	69.1
	m-way	4.2	11.9	19.1	20.8	23.0	24.9	27.7	29.8	32.4	34.4	36.1
Petrol LGVs	urban	11.2	7.7	4.4	3.7	3.0	2.6	2.3	2.0	1.9	1.8	1.6
	rural	11.5	8.4	4.8	4.1	3.7	3.2	2.7	2.3	2.3	2.2	2.0
	m-way	4.0	3.0	2.0	1.8	1.5	1.2	1.1	0.9	1.0	0.9	0.8
Diesel LGVs	urban	6.0	10.7	16.5	17.6	17.8	19.6	21.1	21.9	22.5	23.5	23.7
	rural	6.6	12.0	18.6	19.9	22.3	24.0	25.5	26.8	27.8	29.9	30.1
	m-way	2.1	4.1	7.6	8.3	8.5	9.1	10.0	10.5	11.0	11.6	11.6
Rigid HGVs	urban	4.7	4.4	4.2	4.2	4.1	4.3	4.4	4.3	4.2	4.0	4.0
	rural	7.5	7.0	7.6	7.6	8.1	8.3	8.2	8.2	8.3	8.5	8.3
	m-way	3.7	3.5	4.3	4.3	4.3	4.3	4.4	4.3	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	0.9
	rural	4.3	5.1	5.6	5.6	5.3	5.3	5.3	5.3	5.5	5.6	5.6
	m-way	4.7	5.6	7.0	7.0	7.5	7.4	8.0	7.9	8.0	8.3	8.0
Buses	urban	2.4	3.0	3.0	3.0	3.0	3.2	3.2	3.2	3.3	3.4	3.2
	rural	1.7	1.5	1.6	1.6	1.8	1.8	1.6	1.5	1.6	1.8	1.6
	m-way	0.6	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.6	0.6	0.5
M/cycle	urban	3.3	1.9	2.2	2.4	2.6	3.1	2.8	3.0	2.7	3.2	2.7
	rural	2.0	1.6	2.0	2.1	2.1	2.2	2.1	2.2	2.1	2.2	2.1
	m-way	0.3	0.3	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.5

<u>Vehicle speeds by road type</u>

Vehicle speed data are used to calculate emission factors from the emission factor-speed relationships available for different pollutants. Average speed data for traffic in a number of different areas were taken from the following main sources: Transport Statistics Great Britain (DfT, 2009c) provided averages of speeds in Central, Inner and Outer London surveyed at different times of day during 1990 to 2008. 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, 2008b) 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 A 3.3.17** shows the speeds used in the 2008 inventory for light duty vehicles, HGVs and buses.

Table A 3.3.17 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, size, 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, 2009d) provide the number of vehicles licensed on the road by fuel type. This information is combined with data on the relative mileage done by petrol and diesel cars

(DfT, 2008c, 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 3.3.16**.

The new DfT/TRL emission factors cover three engine size ranges for cars: <1400cc, 1400-2000cc and >2000cc. The vehicle licensing statistics have shown that there has been a growing trend in the sales of bigger and smaller engine-sized cars in recent years, in particular for diesel cars at the expense of medium-sized cars. The inventory uses the proportion of cars by engine size varying each year from 2000 onwards based on the vehicle licensing data (DfT, 2009d). 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, 2008c).

To utilise the new DfT/TRL emission factors, additional investigation had to be made in terms of the vehicle sizes in the fleet as the new emission factors cover three different weight classes of LGVs, eight different size classes of rigid HGVs, five different weight classes of artic HGVs, five different weight classes of buses and coaches and seven different engine types (2-stroke and 4-stroke) and size classes of mopeds and motorcycles. Information on the size fractions of these different vehicle types was obtained from vehicle licensing statistics and used to break down the vehicle km data. Some data were not available and assumptions were necessary in the case of buses, coaches and motorcycles. Only limited information on the sizes of buses and coaches by weight exists and it was assumed based on analysis of local bus operator information that 72% of all bus and coach km on urban and rural roads are done by buses, the remaining 28% by coaches, while on motorways all the bus and coach km are actually done by coaches. It was also assumed that mopeds (<50cc) operate only in urban areas, while the only motorcycles on motorways are the type more than 750cc, 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. Research on the motorcycle fleet indicated that 2-stroke motorcycles are confined to the <150cc class.

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 A 3.3.18** shows the regulations that have come into force up to 2008 for each vehicle type.

Table A 3.3.18 Vehicles types and regulation classes

Vehicle Type	Fuel	Regulation	Approx. date into service in UK
Cars	Petrol	Pre-Euro 1	
		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
		99/96/EC (Euro V)	1/10/2008
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

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: 2008” (DfT, 2009d) 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 2008 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 2008, 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. A more detailed examination of vehicle licensing data was undertaken since the last version of the inventory to refine the survival rate assumptions for use with the new emission factors. This has the effect of revising the turnover in the fleet and therefore the composition of the fleet by Euro standard. 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, 2009c). 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. The mix of petrol and diesel cars in the Northern Ireland fleet were revised since the last version of the inventory after DRDNI were able to further interrogate the licensing data held (DRDNI, 2009b).

Assumptions are made about the proportion of failing catalysts in the petrol car fleet.
A sensitive parameter in the emission calculations for petrol cars is the assumption made about the proportion of the fleet with catalyst systems that have failed, for example due to mechanical damage or failure of the lambda sensor. Following discussions with DfT since the last version of the inventory, these assumptions have been revised. It is now assumed that the failure rate is 5% per annum for all Euro standards and that up to 2008, only 20% of failed catalysts were rectified properly, but those that were rectified were done so within a year of failing. The revisions are based on new evidence on fitting of replacement catalysts. According to DfT there is evidence that a high proportion of replacement catalysts are not Type Approved and do not restore the emission performance of the vehicle to its original level (DfT 2009e). This is being addressed through the Regulations Controlling Sale and Installation of Replacement Catalytic Converters and Particle Filters for Light Vehicles for Euro 3 (or above) LDVs after June 2009.

Voluntary measures and retrofits to reduce emissions
The inventory takes account of the early introduction of certain emission 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, 2004). 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.

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.

Fuel quality
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.

Hot Emission Factors
The emission factors for all pollutants were reviewed and updated where necessary in light of the release of the new DfT/TRL emission factors in 2009 (Boulter et al, 2009).

The emission factors for N_2O for all vehicle types were updated in the previous version of the inventory using the latest recommendation of the Emissions Inventory Guidebook (EEA, 2007) derived from the COPERT 4 methodology "*Computer Programme to Calculate Emissions from Road Transport*". The DfT/TRL review recommended these emission factors continue to be used for the UK inventory.

For N_2O emissions from 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 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. The 2008 inventory used revised age-mileage functions provided by TRL to work out the accumulated mileage effects in the calculation of N_2O emission factors.

N_2O emissions were a problem with early generation petrol cars fitted with three-way catalysts, being formed as a by-product on the catalyst surface during the NO_x reduction process. 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 updated in line with the new speed-emission functions and road type factors from the 2009 DfT/TRL compilation. Full emission factor-speed relationships were available for cars and LGVs, whereas for HGVs, buses and motorcycles only single averaged factors for urban, rural and motorway roads were available. **Table A 3.3.23** summarises the CH_4 emission factor for all vehicle types and road conditions in mg/km.

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

Emission factors for NO_x were updated in the previous year's inventory using the preliminary DfT/TRL compilation of emission factors released in 2008 for consultation. The finalised set of emission factors for these and also for total hydrocarbons (THC), CO and other pollutants were published in 2009 and are used in the 2008 inventory. The emission factors are represented as equations relating emission factor in g/km to average speed (Boulter et al, 2009).

As stated earlier, the DfT/TRL emission factors are 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 are presented as a series of emission factor-speed relationships for vehicles normalised to an accumulated mileage of 50,000 kilometres. Scaling factors are 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 are 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. **Tables A 3.3.24-26** summarise the NO_x, CO and THC emission factors for all vehicle types under typical urban, rural and motorway road conditions in g/km normalised to 50,000km accumulated mileage and current fuels. These are derived from the tables at http://www.dft.gov.uk/pgr/roads/environment/emissions/ for detailed vehicle size classes and averaged according to the proportion of different vehicle sizes in the UK fleet according to vehicle licensing statistics. Factors for NMVOCs are derived by subtracting the calculated g/km factors for methane from the corresponding THC emission factors.

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 A 3.3.17**. 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.

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 TRL 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.

Various other assumptions and adjustments 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 (2009) 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 on these pollutants are generally rather small for these weak blends.

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 A 3.3.19**.

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 A 3.3.20**.

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

Cold start emissions are the excess emissions that occur when a vehicle is started with its engine below its normal operating temperature. The excess emissions occur from petrol and diesel vehicles because of the lower efficiency of the engine and the additional fuel used when it is cold, but more significantly for petrol cars, because the three-way catalyst does not function properly and reduce emissions from the tailpipe until it has reached its normal operating temperature.

Previously, the inventory used the COPERT II methodology (EEA, 1997) for estimating cold start emissions, but this was revised in light of a review of alternative methodologies and the recommendations made by TRL on behalf of DfT (Boulter and Latham, 2009). Their main conclusion was that the current inventory approach based on COPERT II ought to be updated to take into account new data and modelling approaches developed in the ARTEMIS programme and COPERT 4 (EEA, 2007). However, it was also acknowledged that such an update can only be undertaken once the ARTEMIS model and/or COPERT 4 have been finalised and that at the time of their study it was not possible to give definitive emission factors for all vehicle categories.

Boulter and Lathan (2009) also stated that it is possible that the incorporation of emission factors from different sources would increase the overall complexity of the UK inventory model, as each set of emission factors relates to a specific methodology. It was therefore necessary to check on progress made on completing the ARTEMIS and COPERT 4 methodologies and assess their complexities and input data requirements for national scale modelling.

The conclusion from this assessment of alternative methodologies was that neither ARTEMIS nor a new COPERT 4 was sufficiently well-developed for national scale modelling and that COPERT 4 referred to in CORINAIR Emissions Inventory Guidebooks still utilises the approach in COPERT III (EEA, 2000). COPERT III was developed in 2000 and is a methodology similar to the COPERT II methodology currently used in the UK inventory, but is rather more detailed in terms of vehicle classes and uses more up-to-date information including scaling factors for more recent Euro standards reflecting the faster warm-up times of catalysts on petrol cars. COPERT III is a trip-based methodology which like COPERT II uses the proportion of distance travelled on each trip with the engine cold and a ratio of cold/hot emission factor. Both of these are dependent on ambient temperature. Different cold/hot emission factor ratios are used for different vehicle types, Euro standards, technologies and pollutants.

Cold start emissions are calculated from the 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 III and were used with monthly average temperatures for central England based on historic trends in Met Office data.

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

β = 0.6474 - 0.02545 . l_{trip} - (0.00974 - 0.000385 . l_{trip}) . t_a
where

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

The method is sensitive to the choice of average trip length in the calculation. A review of average trip lengths was made, including those from the National Travel Survey, which highlighted the variability in average trip lengths available (DfT, 2007a). A key issue seems to be what the definition of a trip is according to motorist surveys. The mid-point seems to be a value of 10 km given for the UK in the CORINAIR Emissions Inventory Guidebook, so this figure was adopted (EEA, 2007).

The COPERT III method provides pollutant-specific reduction factors for β to take account of the effects of Euro 2 to Euro 4 technologies in reducing cold start emissions relative to Euro 1.
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 each Euro standard of petrol cars. 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 were estimated 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 1970-2008 were used for the calculations based on Met Office for Central England (CET data), the same data as used for the cold start calculations. 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 2008 was 68 kPa, 2kPa below the limit set by European Council Directive 98/70/EC for Member States with “arctic” summer conditions (UKPIA, 2009).

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 A 3.3.27**. 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 A 3.3.27** 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:

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

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
$F_{EUII-IV}$	=	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 A 3.3.27** give hot soak loss emissions in g/vehicle.trip for uncontrolled ($HS_{uncontrolled}$) and Euro 1 and Euro 2-4 canister controlled (HS_{EUI}, $HS_{EUII-IV}$) vehicles. Total annual hot soak losses were calculated from the equation:

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

where

VKM	=	total number of vehicle kilometres driven in the UK by the petrol vehicles (cars and LGVs)
l_{trip}	=	average trip length

The trip length of 10 km was revised from the value used in the previous version of the inventory for consistency with the method for cold start emissions.

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

The equations specified in **Table A 3.3.27** 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:

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

where

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

Methodologies for estimating evaporative emissions from vehicles were reviewed by TRL in 2009 and new methods based on COPERT 4 are planned to be introduced in the next version of the inventory.

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 CH4/km		Urban	Rural	Motorway
Petrol cars	Pre-Euro 1	73.0	21.8	57.7
	Euro 1	15.0	5.2	20.9
	Euro 2	15.8	9.6	9.7
	Euro 3	5.0	4.1	7.2
	Euro 4	1.3	1.0	1.8
Diesel cars	Pre-Euro 1	12.3	10.2	10.0
	Euro 1	6.1	6.3	6.2
	Euro 2	2.9	1.7	1.2
	Euro 3	1.4	1.1	1.1
	Euro 4	1.0	0.8	0.7
Petrol LGVs	Pre-Euro 1	73.0	21.8	57.7
	Euro 1	15.0	5.2	20.9
	Euro 2	15.8	9.6	9.7
	Euro 3	5.0	4.1	7.2
	Euro 4	1.3	1.0	1.8
Diesel LGV	Pre-Euro 1	11.8	4.0	22.0
	Euro 1	6.7	1.7	5.8
	Euro 2	2.9	1.7	1.2
	Euro 3	2.2	0.6	1.0
	Euro 4	1.5	0.4	0.7
Rigid HGVs	Pre-Euro I	185.5	50.2	43.6
	Euro I	85.0	23.0	20.0
	Euro II	54.4	20.0	18.6
	Euro III	47.6	21.4	18.2
	Euro IV	2.6	1.6	1.2
	Euro V	2.3	1.4	1.1
Artic HGVs	Pre-Euro I	381.8	174.5	152.7
	Euro I	175.0	80.0	70.0
	Euro II	112.0	69.6	65.1
	Euro III	98.0	74.4	63.7
	Euro IV	5.3	5.6	4.2
	Euro V	4.7	5.0	3.8
Buses & coaches	Pre-Euro I	381.8	174.5	152.7
	Euro I	175.0	80.0	70.0
	Euro II	113.8	52.0	45.5
	Euro III	103.3	47.2	41.3
	Euro IV	5.3	5.6	4.2
	Euro V	4.7	5.0	3.8
Mopeds, <50cc, 2st	Pre-Euro 1	219.0		
	Euro 1	43.8		
	Euro 2	24.1		
	Euro 3	19.7		
Motorcycles, >50cc, 2st	Pre-Euro 1	150.0	150.0	
	Euro 1	99.0	106.5	
	Euro 2	30.0	31.5	
	Euro 3	12.0	13.5	
Motorcycles, >50cc, 4st	Pre-Euro 1	200.0	200.0	200.0
	Euro 1	127.9	138.6	148.7
	Euro 2	126.7	93.1	107.1
	Euro 3	76.2	32.6	31.8

Table A 3.3.24 NOx Emission Factors for Road Transport (in g/km) normalised to 50,000 km accumulated mileage (where applicable).

g NOx (as NO2 eq)/km		Urban	Rural	Motorway
Petrol cars	Pre-Euro 1	1.558	1.982	2.600
	Euro 1	0.301	0.319	0.371
	Euro 2	0.143	0.154	0.189
	Euro 3	0.064	0.066	0.079
	Euro 4	0.046	0.043	0.045
Diesel cars	Pre-Euro 1	0.578	0.613	0.805
	Euro 1	0.523	0.550	0.809
	Euro 2	0.617	0.647	0.922
	Euro 3	0.477	0.491	0.660
	Euro 4	0.297	0.328	0.471
Petrol LGVs	Pre-Euro 1	1.496	2.025	2.731
	Euro 1	0.350	0.384	0.462
	Euro 2	0.091	0.089	0.123
	Euro 3	0.050	0.058	0.079
	Euro 4	0.034	0.028	0.025
Diesel LGV	Pre-Euro 1	1.649	1.769	2.353
	Euro 1	1.143	1.339	1.980
	Euro 2	1.247	1.491	2.260
	Euro 3	0.736	0.921	1.478
	Euro 4	0.368	0.461	0.739
Rigid HGVs	Pre-Euro I	8.094	8.229	8.717
	Euro I	5.400	5.540	5.810
	Euro II	5.675	5.738	5.959
	Euro III	4.431	4.390	4.572
	Euro IV	2.729	2.748	2.895
	Euro V	1.608	1.612	1.700
Artic HGVs	Pre-Euro I	14.440	13.426	14.223
	Euro I	10.122	9.430	9.987
	Euro II	10.440	9.714	10.296
	Euro III	8.267	7.654	8.113
	Euro IV	5.101	4.745	5.014
	Euro V	2.989	2.775	2.932
Buses & coaches	Pre-Euro I	11.182	10.106	10.199
	Euro I	7.471	6.658	7.663
	Euro II	7.977	7.047	8.288
	Euro III	6.431	5.366	6.573
	Euro IV	3.935	3.353	4.030
	Euro V	2.361	1.976	2.409
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	0.026	0.039	
	Euro 1	0.041	0.054	
	Euro 2	0.048	0.062	
	Euro 3	0.023	0.036	
Motorcycles, >50cc, 4st	Pre-Euro 1	0.223	0.446	0.569
	Euro 1	0.229	0.443	0.569
	Euro 2	0.127	0.306	0.664
	Euro 3	0.065	0.155	0.337

Table A 3.3.25 CO Emission Factors for Road Transport (in g/km) normalised to 50,000 km accumulated mileage (where applicable)

g CO/km		Urban	Rural	Motorway
Petrol cars	Pre-Euro 1	9.774	6.850	5.531
	Euro 1	2.423	1.637	3.132
	Euro 2	0.534	0.695	1.823
	Euro 3	0.230	0.615	1.583
	Euro 4	0.419	0.705	1.564
Diesel cars	Pre-Euro 1	0.583	0.434	0.361
	Euro 1	0.318	0.223	0.183
	Euro 2	0.193	0.118	0.079
	Euro 3	0.057	0.035	0.024
	Euro 4	0.052	0.030	0.016
Petrol LGVs	Pre-Euro 1	11.689	8.169	6.688
	Euro 1	3.098	3.245	4.807
	Euro 2	0.096	1.154	3.116
	Euro 3	0.406	0.767	2.215
	Euro 4	0.406	0.767	2.215
Diesel LGV	Pre-Euro 1	0.713	0.768	0.953
	Euro 1	0.547	0.456	0.425
	Euro 2	0.592	0.624	0.758
	Euro 3	0.174	0.132	0.120
	Euro 4	0.136	0.103	0.094
Rigid HGVs	Pre-Euro I	2.140	1.957	2.059
	Euro I	1.377	1.296	1.370
	Euro II	1.173	1.122	1.179
	Euro III	1.042	0.963	0.980
	Euro IV	0.567	0.497	0.547
	Euro V	0.078	0.072	0.074
Artic HGVs	Pre-Euro I	2.489	2.258	2.392
	Euro I	2.170	1.981	2.099
	Euro II	1.804	1.692	1.835
	Euro III	1.907	1.738	1.855
	Euro IV	0.340	0.311	0.340
	Euro V	0.134	0.120	0.128
Buses & coaches	Pre-Euro I	2.723	1.893	1.504
	Euro I	1.677	1.106	1.239
	Euro II	1.333	0.867	1.130
	Euro III	1.457	0.922	1.218
	Euro IV	0.127	0.084	0.090
	Euro V	0.129	0.085	0.092
Mopeds, <50cc, 2st	Pre-Euro 1	13.800		
	Euro 1	5.600		
	Euro 2	1.300		
	Euro 3	1.300		
Motorcycles, >50cc, 2st	Pre-Euro 1	16.081	23.667	
	Euro 1	10.608	15.616	
	Euro 2	8.392	12.352	
	Euro 3	4.634	6.818	
Motorcycles, >50cc, 4st	Pre-Euro 1	16.588	22.015	25.843
	Euro 1	10.083	17.564	15.740
	Euro 2	5.270	8.981	9.511
	Euro 3	2.909	4.957	5.252

Table A 3.3.26 THC Emission Factors for Road Transport (in g/km) normalised to 50,000 km accumulated mileage (where applicable). NMVOC emission factors are derived by subtracting methane factors from the THC factors

g HC/km		Urban	Rural	Motorway
Petrol cars	Pre-Euro 1	1.242	0.847	0.644
	Euro 1	0.124	0.091	0.115
	Euro 2	0.045	0.041	0.051
	Euro 3	0.020	0.020	0.027
	Euro 4	0.014	0.010	0.013
Diesel cars	Pre-Euro 1	0.124	0.093	0.076
	Euro 1	0.072	0.048	0.035
	Euro 2	0.054	0.039	0.031
	Euro 3	0.020	0.013	0.010
	Euro 4	0.018	0.015	0.013
Petrol LGVs	Pre-Euro 1	1.444	0.935	0.669
	Euro 1	0.190	0.128	0.151
	Euro 2	0.037	0.038	0.057
	Euro 3	0.028	0.028	0.039
	Euro 4	0.014	0.014	0.019
Diesel LGV	Pre-Euro 1	0.160	0.136	0.124
	Euro 1	0.083	0.057	0.042
	Euro 2	0.082	0.076	0.085
	Euro 3	0.034	0.025	0.024
	Euro 4	0.029	0.022	0.021
Rigid HGVs	Pre-Euro I	0.993	0.836	0.894
	Euro I	0.397	0.355	0.364
	Euro II	0.254	0.225	0.231
	Euro III	0.225	0.200	0.205
	Euro IV	0.011	0.010	0.010
	Euro V	0.011	0.010	0.010
Artic HGVs	Pre-Euro I	0.711	0.609	0.651
	Euro I	0.676	0.589	0.629
	Euro II	0.430	0.372	0.398
	Euro III	0.370	0.322	0.344
	Euro IV	0.018	0.016	0.017
	Euro V	0.019	0.016	0.017
Buses & coaches	Pre-Euro I	1.014	0.676	0.409
	Euro I	0.589	0.413	0.431
	Euro II	0.384	0.271	0.273
	Euro III	0.346	0.245	0.270
	Euro IV	0.018	0.012	0.013
	Euro V	0.018	0.012	0.014
Mopeds, <50cc, 2st	Pre-Euro 1	13.910		
	Euro 1	2.730		
	Euro 2	1.560		
	Euro 3	1.200		
Motorcycles, >50cc, 2st	Pre-Euro 1	7.407	8.113	
	Euro 1	2.341	3.273	
	Euro 2	1.243	1.738	
	Euro 3	0.777	1.084	
Motorcycles, >50cc, 4st	Pre-Euro 1	1.527	1.218	1.726
	Euro 1	0.853	0.753	0.807
	Euro 2	0.381	0.439	0.577
	Euro 3	0.238	0.275	0.362

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 A 3.3.1**.

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 DECC (2009);

(ii) Naval fuel consumption is assumed to be marine diesel oil (MOD, 2009). 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 A 3.3.1**.

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 DECC 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.[5]).

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.

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

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, 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.

Emissions from naval shipping have been revised due to the use of a revised, but consistent time series of naval fuel consumption (naval diesel and marine gas oil) from the Safety, Sustainable Development and Continuity Division of the Defence Fuels Group of the MoD (MoD, 2009). Fuel data for each financial year from 2003/04 to 2007/08 were provided. Figures for 2008/09 were not complete so data for 2007/08 were used. Adjustments were made to the data to derive figures on a calendar year basis. Fuel consumption for earlier years were re-scaled from the new 2003 figures on the basis of trends in data previously provided by the MoD.

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 DECC reported fuel use data and emission factors from **Table A 3.3.1**. 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 DECC 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 A 3.3.1**. 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 A3.2**. 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 DECC 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 2005-2008. For industrial machinery, manufacturing output statistics were used to scale 2005-2008 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 terminal passengers at UK airports were used.

A simple turnover model is used to characterise the population of each machinery type by age (year of manufacture/sale). For older units, 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). For equipment whose emissions are regulated by Directive 2002/88/EC or 2004/26/EC, the emission factors for a given unit were taken to be the maximum permitted by the directive at the year of manufacture. The emission regulations are quite complex in terms of how they apply to different machinery types and some updates were made to the inventory to give a better match of each of the 77 different machinery types to the relevant regulation in terms of implementation date and limit value.

The methodology follows the Tier 3 methodology described in the latest EMEP/CORINAIR emission inventory guidebook (EMEP/CORINAIR, 2009).

Aggregated emission factors for the four main off-road machinery categories in 2008 are shown in **Table A 3.3.28** by fuel type. The fleet-average (aggregated) emission factors for most machinery types are lower than in the 2007 inventory because of the expiry of old machinery and penetration of new machinery into the fleet as well as the reduction in the sulphur content of fuels.

Table A 3.3.28 Aggregate Emission Factors for Off-Road Source Categories in 2008 (t/kt fuel)

Source	Fuel	C[2]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2[3]
Domestic House&Garden	DERV	863	0.158	1.306	47.96	4.3	2.6	0.014
Domestic House&Garden	Petrol	855	1.210	0.031	4.02	667.9	74.9	0.048
Agricultural Power Units	Gas Oil	870	0.162	1.318	32.28	17.0	5.6	1.63
Agricultural Power Units	Petrol	855	2.175	0.015	1.45	716.3	248.6	0.048
Industrial Off-road	Gas Oil	870	0.154	1.306	38.02	16.6	6.3	1.63
Industrial Off-road	Petrol	855	3.809	0.051	6.16	1020.8	40.7	0.048
Aircraft Support	Gas Oil	870	0.164	1.337	31.25	12.5	5.3	1.63

1 Emission factors reported are for 2008
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 A 3.3.1.**

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 DECC (2009). 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 A 3.3.29**.

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
2008	7.61[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 1998-2008 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 A 3.3.29** 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 DUKES (2009).

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 A 3.3.30**.

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 A 3.3.30** and are based on US EPA (2009) 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 range of processes in use, these estimates will be very uncertain.

Data are available on the production of SSF and the fuels used (DECC, 2009). 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. This is done because DUKES does not seem to include any petroleum coke in its commodity balance tables and the SSF figures in DUKES must therefore exclude petroleum coke. 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]	1.91[c]	-	1.84[c]	0.0273[e]
Coke	kt/Mt coal consumed	-	-	0.02[b]		-
SSF	kt/Mt SSF made	0.0802[a]	0.0156[c]	0.0235[c]	-	0.0178[a]
SSF	kt/Mt coal consumed	-	-	-	3.59[d]	-

a EIPPCB, (2000)
b USEPA (2004)
c Factor for 2008 based on Environment Agency (2009)
d Based on mass balance.
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 1995-2008. 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. 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 and 2008 datasets, many of these problems have been resolved, as the DECC Oil & Gas team of regulators has engaged with several operators to identify and resolve reporting gaps and inconsistencies. One or two non-reporting sites for some sources are still evident, however.

To resolve these data gaps, the Inventory Agency agreed the following actions with DECC (Furneaux, 2009):

- Onshore & offshore loading: Three sites had omitted to report in 2008, and data have been extrapolated from earlier years;
- Onshore Fugitive sources: Several sites had omitted to report the quite minor fugitive emissions data estimates in 2008, and all of these were estimated based on extrapolation of previous data and comparison against PI/SPRI data;
- Onshore Own Gas use, flaring and fugitive emissions: One site had omitted to report in 2008; activity data were obtained and the emission factors from 2007 data used to provide the 2008 emission estimates.
- Direct Process emissions: One offshore site reported emissions that were identified as erroneous by the inventory agency. Consultation with the operator resolved this matter and led to revisions of the 2008 data from EEMS.

Some significant revisions to emissions data reporting methodology were 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.

Note that an additional source of GHG emissions from oil & gas exploration that is not included within the UK inventory is the release of methane-containing gases from underground reservoirs following drilling blowouts at the seabed. There has been some research evidence to suggest that a major blowout on the UK Continental Shelf occurred following drilling activity in November 1990, which has led to a release of methane-containing gases over many years. It is unknown whether this release is "additional" to background emissions from natural depressurisation of reservoirs through sea-bed pockmarks. These emissions are not reported within any regulatory system in the UK and no estimates of mass emissions have been made. This is an issue which DECC will consider for further investigation.

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, 2009). Data from 1995-2008 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 1999-2008, and on emission factors and production throughput data for 1990-1998.

The activity data and implied emission factors are given in **Table A 3.3.31**. The implied emission factors for 1997-2008 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

Year	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
2008	1449	2.53	0.0086	0.0013	0.0062	0.0085	0.00012	0.00007
2007	1671	2.52	0.0095	0.0012	0.0067	0.0076	0.00014	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 (2009).

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, 2009). Data from 1995-2008 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 1999-2008, and on emission factors and production throughput data for 1990-1998.

The activity data and implied emission factors are given in **Table A 3.3.32**. The implied emission factors for 1990-2008 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

Year	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
2008	2123	6.35	2.64	19.10	7.16	0.19	0.30	0.44
2007	2228	6.34	2.68	18.72	6.93	0.20	0.15	0.45
2006	2393	5.65	2.32	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, 2009). 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 1995-2008 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 1999-2008, and on emission factors and production throughput data for 1990-1998.

The activity data and implied emission factors are given in **Table A 3.3.33**.

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

Year	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
2008	20.4	2.98	36.1	2.31	11.74	13.9	0.012	0.080
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

Year	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
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
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, 2009) and previous industry studies by Oil & Gas UK (1998). Data from 1995-2008 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.

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, 2009). Data from 1995-2008 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 recent years, the methane and NMVOC data from operators appear to be incomplete in the EEMS dataset, most notably from ship loading emissions at BP sites (onshore terminals and offshore platforms). 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 considerable uncertainty. Some progress has been made through consultation with operators, and an ongoing study into data reporting at onshore terminals is expected to lead to better quality inventory data in future.

Activity data (tonnes oil loaded / unloaded) are 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 approach enables a transparent assessment of implied emission factors for 1998 onwards. Activity data for 1990-1997 are not available and are therefore estimated, but the emissions data are unchanged (as there is no new data on emissions during 1990-1997).

Emissions data from 1995-2008 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 A 3.3.35**.

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

Year	ONSHORE LOADING			OFFSHORE LOADING		
	Activity	CH_4	NMVOC	Activity	CH_4	NMVOC
	kt	t/kt	t/kt	kt	t/kt	t/kt
2008	52,100	0.011	0.71	16,850	0.107	1.25
2007	60,291	0.012	0.67	23,680	0.094	1.65
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
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

Year	ONSHORE LOADING			OFFSHORE LOADING		
	Activity	CH_4	NMVOC	Activity	CH_4	NMVOC
	kt	t/kt	t/kt	kt	t/kt	t/kt
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 natural gas leakage are provided by UK Transco, four companies (formed in 2005) that operate the low-pressure gas distribution networks within Great Britain, and also from Phoenix Gas in Northern Ireland. 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, Phoenix Gas); 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 etc.) is based on studies from British Gas in the early 1990s (British Gas, 1993; Williams, 1993). Emission estimates for 1997 to 2008 are derived from an industry leakage model; the data are provided independently by the gas network operators to mitigate commercial confidentiality concerns. 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 gas infrastructure in Northern Ireland is much newer than in the rest of the UK, as the gas pipeline (from Scotland) was only commissioned in 1999. Since then, the gas network has continued to develop across Northern Ireland. In this inventory, we have obtained estimates of the very small amount of annual leakage for the Northern Ireland grid for the first time, from the main gas operator (Phoenix Gas, 2009). Annual estimates from 2005 onwards have been provided, and the data for 1999 to 2004 have been extrapolated back from the 2005 figure.

The methane, CO_2 and NMVOC content of natural gas is shown in **Table A 3.3.36**. The methane and NMVOC 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. No gas composition data have been provided by Phoenix Gas and hence the UK average gas composition is assumed for Northern Ireland.

In the 1990-2008 inventory, estimates of emissions of CO_2 from gas leakage have been made for the first time. The CO_2 content of natural gas are included in the table below; the data from 2004 onwards have been derived from annual compositional analysis by gas network operators, whilst the 1990-2003 data have been extrapolated back from the 2004 figure. Further work is planned during the next inventory cycle to confirm the scope of the gas leakage estimates reported by the network operators, to determine whether leaks at the point of use are included; if such losses are not within the current estimates then separate estimates for emissions under 1B2bv “Other Leakage” will be made in the next inventory.

Table A 3.3.36 Methane, CO_2 and NMVOC Composition of Natural Gas

Period	CH_4 weight %	CO2 weight %	NMVOC weight %
1990-96[1]	84.3	3.95[6]	8.9
1997-99[2]	77.1	3.95[6]	14.7
2000[2]	77.6	3.95[6]	14.7
2001[2]	77.1	3.95[6]	14.8[3]
2002[2]	77.3	3.95[6]	15.0[3]
2003[2]	77.4	3.95[6]	15.2[3]
2004[2]	77.4	3.95[5]	15.3
2005[4]	77.9	3.65[5]	15.3
2006[5]	78.4	3.76[5]	15.0
2007[5]	78.2	3.64[5]	14.8
2008[5]	80.1	3.24[5]	13.5

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)
5 Gas compositional analysis provided by gas network operators: UKD, Scotia Gas, Northern Gas Networks, Wales and West (2009)
6 Extrapolated back from the 2004 analysis by network operators

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 (2009). 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 (2009), 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, 2009) 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 DECC (2009).

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 (2009) estimates for 1994-2008. 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, 2009). 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, 2009). 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 had been included in previous versions of the GHG inventory, e.g. carbon from chemical waste incinerators; most had not. A summary of the estimates of emitted/stored carbon was produced and these have been presented in a separate technical report[6]. 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:

[6] 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.

- 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.

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 other industry assume that waste oils are used by two sectors: roadstone coating plant and garages. In reality, other sectors may use waste oils as fuels, but no figures are available and the quantities are, in any case, likely to be small. The figures for power stations and other industrial use of waste lubricants reflect the fact that the Waste Incineration Directive (WID) 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 reporting requirements in the 2006 IPCC 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 DECC 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.

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.

A3.4 INDUSTRIAL PROCESSES (CRF SECTOR 2)

A3.4.1 Mineral Processes (2A)

A3.4.1.1 Cement Production (2A1)

Emission factors and activity data for the production of cement are commercially sensitive and therefore confidential.

A3.4.1.2 Lime Production (2A2)

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

Table A 3.4.1 Emission Factors for Lime Kilns based on Fuel Consumption, 2008

Fuel	C [a]	CH_4	N_2O	Units
Coal	641[b]	0.011[c]	0.214[e]	Kt / Mt fuel
Natural Gas	1.47[b]	0.00053[f]	1.06E-05[f]	Kt / Mtherm
Coke	815[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 3.4.2 Emission Factors for Lime Kilns, 2007: Indirect GHGs

Fuel	CO	NO_x	NMVOC	Units
Coal	7.81	51.8	0.05	Kt / Mt fuel
Natural Gas	0.0460	0.0314	2.34E-3	Kt / Mtherm
Coke	9.26	0.312	0.05	Kt / Mt fuel

A3.4.2 Chemical Industry (2B)

A3.4.2.1 Nitric Acid Production (2B2)

Table A 3.4.3 Summary of Nitric Acid Production in the UK, 1990-2008

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	0.807
1996	6	2.44	3.83	0.743
1997	6	2.35	3.78	0.902
1998	6	2.61	3.99	0.732
1999	6	2.44	6.29	0.913

Year	No of sites	Production (Mt 100% Nitric Acid)	Aggregate EF (kt N_2O / Mt Acid)	Aggregate EF (kt NO_X / Mt Acid)
2000	6	2.03	6.94	0.992
2001	5	1.65	6.62	0.662
2002	4	1.64	4.20	0.392
2003	4	1.71	4.38	0.431
2004	4	1.71	5.00	0.437
2005	4	1.71	3.80	0.373
2006	4	1.47	3.87	0.424
2007	4	1.61	3.54	0.380
2008	4	1.29	3.65	0.234

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 2008 was 82.1 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 (Corus, 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 A 3.4.3.4**. Data on iron production are reported in ISSB (2009).

Table A 3.4.4 Emission Factors for Blast Furnaces (BF), Electric Arc Furnaces (EAF) and Basic Oxygen Furnaces (BOF), 2008

	C [a]	CH_4	N_2O	NO_x	SO_2	NMVOC	CO	Units
Blast furnaces	IE	NE	NE	NE	0.102[b]	0.12[c]	2.26[b]	kt/Mt pig iron
Electric arc furnaces	2[d]	0.01[e]	0.005[e]	0.189[b]	0.170[b]	0.09[e]	0.779[b]	kt/Mt Steel
Basic oxygen furnaces	IE	NE	NE	0.0123[f]	IE	NE	7.37[b]	kt/Mt Steel
Losses of BFG/BOFG	8.67 [g]	NE	NE	NE	NE	NE	NE	kt/Mtherm gas
Slag processing	NE	NE	NE	NE	7.88E-6[b]	NE	NE	kt/Mt Pig iron

a Emission factor as kt carbon/unit activity
b Emission factor for 2008 based on data from Corus (2009) and data for non-Corus plant from EA (2009)
c IPCC (1997)
d Corus (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 Corus (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 A 3.4.5**.

Table A 3.4.5 Emission Factors for Aluminium Production, 2008

	C [a]	SO_2 [b]	NO_x [b]	CO [b]	Units
Prebake	420	14.8	0.896	102	Kt / Mt Al
Anode Baking	IE	0.952	0.262	3.82	Kt / Mt anode

a Emission factor as kt carbon per unit activity, Walker, 1997.
b Environment Agency Pollution Inventory (2009) and SEPA (2009)
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 3.4.6 NMVOC Emission Factors for Food and Drink Processing, 2008

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

Food/Drink	Process	Emission Factor	Units
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 (2010).

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 (2010).

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 (2F9A)

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 (2F9B)

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 A 3.6.1**) collected in the June Agricultural Census and published in Defra (2009a) and the appropriate emission factors. Data for earlier years are often revised so information was taken from the Defra agricultural statistics database.

Table A 3.6.2 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 base data and emission factors for cattle for 1990-2008 are given in **Table A 3.6.3** and **Table A 3.6.4**.

The main parameters involved in the calculation of the emissions factors for beef are shown in **Table A 3.6.5**. The emission factors for other cattle were also calculated using the IPCC Tier 2 procedure (**Table A 3.6.4**), but do not vary from year to year.

The data used to calculate emissions are summarised below.

Cattle weights

In the inventory the dairy cattle weights are slaughter weight data provided by Sarah Thompson, Defra. There is an increase in slaughter weights from 2004 (238kg) to 2005

(343kg). This increase was a result of the lifting of the Over Thirty Month rule[7], which is a measure to control the exposure of humans to the disease BSE; see **Table A 3.6.3** in Annex 3 for further details. A footnote to this table also includes the description of the method used to estimate live weight from slaughter weights.

Animal numbers

The national cattle numbers are sum of the regional cattle data (from the four constituent countries of the UK).

Animal numbers used to estimate the methane emissions are consistent with the numbers used to estimate N_2O emissions.

Milk yield

Calculation of milk yield for leap years is estimated from dividing the total by 365. Values of milk production are corrected by dairy herd to match values from regional totals.

Beef cattle

In the inventory a Tier 2 methodology is used for the calculation of the emissions from beef, but a time series of cattle weights were not available and so a constant weight is assumed of 500 kg.

Sheep

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 A 3.6.2** are reported on the basis that the animals are alive the whole year.

7 To be able to slaughter cattle aged over 30 months (OTM), abattoirs must be OTM approved by the Meat Hygiene Service (MHS). In the UK, it is an offence to slaughter OTM cattle in a non-OTM approved abattoir. It is also an offence to slaughter cattle which were born or reared in the UK before 1 August 1996 for human consumption in any abattoir.

Table A 3.6.1 Livestock Population Data for 2008 by Animal Type

Animal Type	Number
Cattle:	
Dairy Breeding Herd	1,908,945
Beef Herd[a]	1,670,142
Beef and others >1 year old[b]	5,361,344
Others < 1 year old	2,836,696
Pigs:	
All breeding pigs	494,564
Other pigs > 50 kg	1,782,077
Other pigs 20-50 kg	1,211,506
Pigs <20 kg	1,225,365
Sheep:	
Breeding sheep	15,616,234
Other sheep	940,537
Lambs < 1 year	16,574,319
Goats	96,156
Horses	370,225
Deer	31,386
Poultry:	
Broilers	109,858,933
Breeders	9,068,223
Layers	25,939,837
Growing Pullets	9,313,272
Ducks, geese and guinea fowl	2,276,537
Turkeys	5,532,316

[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 for 2008

Animal Type	Enteric methane[a] kg CH_4/head/year	Methane from manures[a] kg CH_4/head/year
Dairy Breeding Herd	108.9[b]	26.8[b]
Beef Herd	49.8[b]	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 2008
[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 (IPCC, 2000)

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	572	14.3	4.01	89.4	21.9
1991	571	14.2	4.04	89.3	21.9
1992	585	14.5	4.06	91.5	22.4
1993	585	14.7	4.07	91.9	22.6
1994	580	14.7	4.05	91.4	22.5
1995	583	15.0	4.05	92.6	22.7
1996	599	15.1	4.08	94.0	23.1
1997	491	15.9	4.07	90.0	22.1
1998	492	16.1	4.07	90.5	22.2
1999	506	16.4	4.03	92.0	22.6
2000	483	16.5	4.03	91.0	22.4
2001	488	16.7	4.01	91.6	22.5
2002	478	17.9	3.97	94.4	23.2
2003	467	18.3	3.96	94.8	23.3
2004	495	18.2	4.00	96.5	23.7
2005	714	18.8	4.02	111.6	27.4
2006	641	18.7	4.04	107.2	26.3
2007	652	19.1	4.06	109.5	26.9
2008	644	19.3	4.06	108.9	26.8

[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 revised in the 2008 inventory, values from carcase weight data from slaughter survey corrected by 1/0.48

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	54%	43-50%[d]	46%
GE (MJ/d)	126.4	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)	49.8[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) replaced in 2008 inventory by value calculated using Tier 2 methodology with constant animal weight values

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

Factor	Equation[a]	
Average Weight of Animal (kg)		500
NEm (Net energy for maintenance), MJ/d	4.1	35.4
NE_a (Net energy for activity), MJ/d[b]	4.2a	3.27
NE_l (Net energy for lactation), MJ/d	4.5a	0
$NE_{pregnancy}$ (Net energy for pregnancy), MJ/d	4.8	3.54
NE_{ma}/DE (Ratio available energy for maintenance in a diet to digestible energy consumed)	4.9	0.51
NE_{ga}/DE (Ratio available energy for growth in a diet to digestible energy consumed)	4.10	0.31
GE (Gross energy intake), MJ/d	4.11	126.4
EF enteric, kg CH_4/head/y[c]		49.8[d]
EF manure, kg CH_4/head/y		2.74

a From IPCC 2000 GPG
b Based on 17% of NEm, grazing factor of 0.085 introduced to account for proportion of time spent grazing/housed
c IPCC 1996 guidelines
d 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, 2009a) in the same way as the enteric emissions. The emission factors are listed in

Table A 3.6.2. 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 A 3.6.3** and **Table A 3.6.6** (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 A 3.6.4**.

Cattle weights

In the inventory the dairy cattle weights are slaughter weight data provided by Sarah Thompson, Defra. There is an increase in slaughter weights from 2004 (238kg) to 2005 (343kg). This increase was a result of the lifting of the Over Thirty Month rule[8], which is a measure to control the exposure of humans to the disease BSE; see **Table A 3.6.3** in **Annex 3** for further details. A footnote to this table also includes the description of the method used to estimate live weight from slaughter weights.

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)

[8] To be able to slaughter cattle aged over 30 months (OTM), abattoirs must be OTM approved by the Meat Hygiene Service (MHS). In the UK, it is an offence to slaughter OTM cattle in a non-OTM approved abattoir. It is also an offence to slaughter cattle which were born or reared in the UK before 1 August 1996 for human consumption in any abattoir.

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:

$$N_2O_{(AWMS)} = 44/28 \,.\, \sum N_{(T)} \,.\, Nex_{(T)} \,.\, AWMS_{(W)} \,.\, EF_3$$

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
EF3	=	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, 2009a). **Table A 3.6.7** shows emission factors for nitrogen excretion per head for domestic livestock in the UK (Nex) from Cottrill and Smith (ADAS).

Table A 3.6.7 Nitrogen Excretion Factors, kg N hd^{-1} $year^{-1}$ for livestock in the UK[a] (1990-2008)[b]

Animal Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Dairy Cows	97	97	98	98	99	100	101	104	104	106	106	110	112	113	114	115.1	116.2	117.3	118.4
Dairy heifers in calf	67	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	79
Other Cattle > 2 year	56	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	56
Other Cattle <1 year	38	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	3.6
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	9.3
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	14.82
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	17.78
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	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	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	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	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	0.44
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	1.04
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	0.73
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	1.67
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	1.80
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	0.33
Horses	50	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	13

[a] Cottrill and Smith, ADAS

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

The methodology assumes that 20% of the total manure N applied to soil 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.

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 A 3.6.8**. 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
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

Animal Type	Liquid System	Daily Spread	Solid Storage and Dry Lot[a]	Pasture Range and Paddock	Other[b]	Fuel
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 A 3.6.9 gives the N_2O emission factor for each animal waste management system ($EF3_{(AWMS)}$). 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:

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

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, 2009a) and fertilizer application rates (BSFP, 2009) as shown in **Table A 3.6.10**. **Figure A3.6.1** shows data compiled by the ONS (2009) 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 below shows the BSFP is 8.8% larger in average.

Table A 3.6.10 Areas of UK Crops and rates of fertiliser applied for 2008

Crop Type	Crop area, ha	Fertiliser rate, ktN
Winter wheat	2,080,210	370.0
Spring barley	615,621	58.1
Winter barley	416,412	56.2
Oats	135,022	11.3
Rye, triticale & mixed corn	24,983	1.7
Maize	152,702	6.4

Crop Type	Crop area, ha	Fertiliser rate, ktN
Maincrop potatoes	143,585	22.1
Sugar beet	119,654	10.3
Oilseed rape	598,148	113.5
Peas (green, human cons)	35,301	0.0
Peas (dry, human cons)	5,975	0.0
Peas, dry, animal cons)	23,901	0.0
Broad beans	425	0.0
Beans (human cons)	4	0.0
Beans (animal cons)	118,462	0.12
Rootcrops for stockfeed	35,159	1.9
Leafy forage crops	5,669	0.3
Other forage crops	27,266	0.0
Vegetables (brassicae)	29,206	3.5
Vegetables (other)	32,865	2.6
Soft fruit	9,585	0.3
Top fruit	23,901	1.1
Hops	1,100	0.0
Linseed	16,262	0.0
Other tillage	74,981	3.0
Grass under 5 years	1,140,964	110.8
Permanent grass	6,035,694	283.1

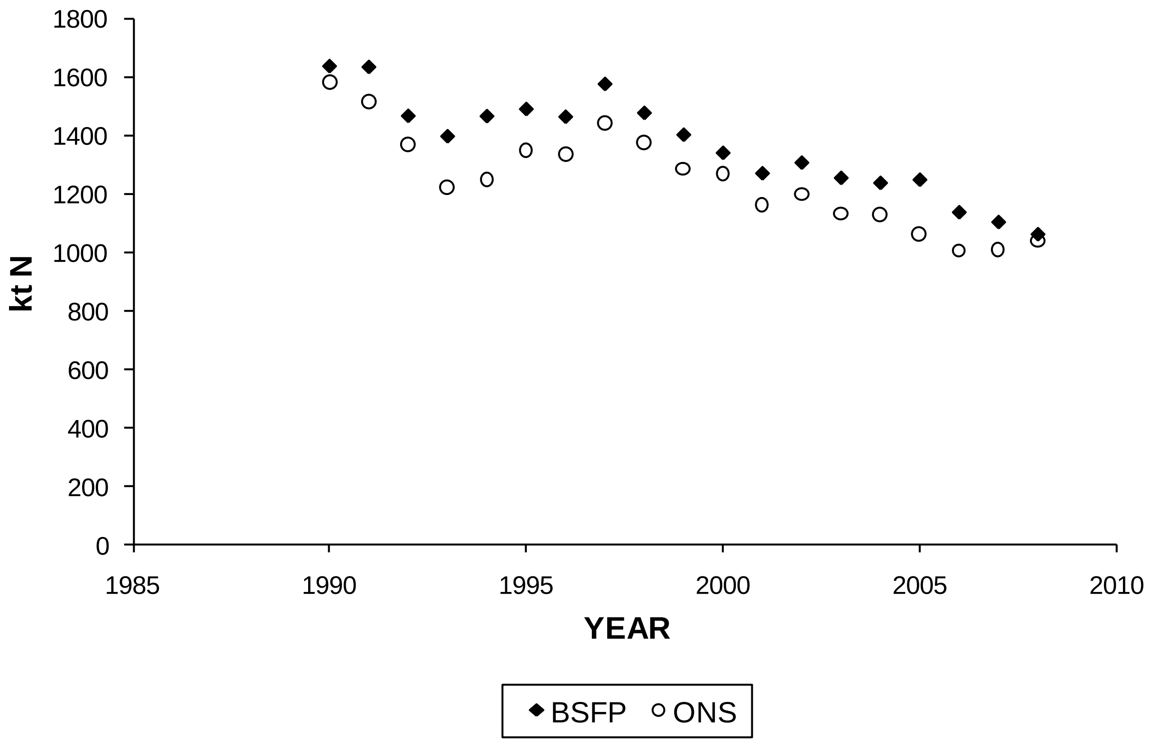


Figure A3.6.1. **Comparison of fertiliser data, sources BSFP and ONS**

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:

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

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 A 3.6.11**.

Table A 3.6.11 Dry Mass Content and Residue Fraction of UK Crops for 2008

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 (2009a, 2009b). 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:

$N_2O_{(CR)}$ = $\sum_i$ ($Crop_O$. $Res_{oi}/Crop_{oi}$. $FracDM_i$. $Frac_{(NCRO)}$. (1-$Frac_B$) + $\sum_j$ (2 . $Crop_{(BFj)}$. $FracDM_j$. $Frac_{(NCRBFj)}$) . (1-$Frac_{Rj}$) . (1-$Frac_{Bj}$))) . EF_1 . 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 (2009a, 2009b) and are shown in **Table A 3.6.12**. The dry mass fraction of crops and residue fraction are given in **Table A 3.6.11**. 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 for 2008

Crop Type	Crop production, kt
Broad beans	9.9
Field Beans	534.6
Peas green for market	5.9
Peas green for processing	153.1
All peas harvested dry	19.6
Rye, mixed corn, triticale	128.1
Wheat	17,227
Oats	783.9
Barley	6,143
OSR	1,974
Linseed	29.2
Maize	0
Sugar beet	7,500
Hops	0
Potatoes	5,986
Total roots & onions	1,233
Total brassicas	523.6
Total others	341.7
Phaseolus beans	15.8

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.

The methodology assumes that 20% of the total manure N applied to soil 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.

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 A 3.6.7** 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 A 3.6.7** 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:

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

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:

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

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
$Frac_{(GASM)}$	=	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:

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

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:

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

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 A 3.6.7** 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, 2009b) 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 are 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 2008 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 is 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 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).

In addition to these planted forests, there are about 828,000 ha of woodland planted prior to 1921 or not of commercial importance (in 1990). 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 in carbon balance (see the Forest land section in Chapter 7 for a discussion of this assumption).

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%	11.7%
1951-1960	21.66	3.06	3.09	16.0%	11.4%
1961-1970	30.08	5.28	2.55	22.7%	8.3%
1971-1980	31.38	7.61	1.14	22.4%	5.8%
1981-1990	22.31	6.05	2.19	19.0%	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	0.76	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%
2007	2.14	0.39	7.99	0.1%	0.7%
2008	0.86	0.14	6.12	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
1999-2008	*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
1999-2008	*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 3.7.12-15**.

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 A 3.7.17)

		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, and 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 (**Tables A 3.7.19-22**), 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 2003-2008 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 2008) 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 -2008 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 1990-2008 (* indicates an estimated area)

Year	Area burnt, ha Great Britain	Northern Ireland	UK	% UK forest area burnt
1990	185	127	312	0.0325%
1991	376*	88*	464	0.0486%
1992	92*	22*	114	0.0120%
1993	157*	37*	194	0.0206%
1994	123*	24	147	0.0158%
1995	1023*	16	1039	0.1127%
1996	466	94	560	0.0613%
1997	585	135	720	0.0796%
1998	310	22	332	0.0371%
1999	45	9	54	0.0061%
2000	165	6	171	0.0193%
2001	181	85	266	0.0309%
2002	141	85	226	0.0264%
2003	147	1	148	0.0175%
2004	146	91	237	0.0281%
2005	5*	75*	80*	0.0096%
2006	429*	3*	432*	0.0519%
2007	454*	55	508*	0.0614%
2008	427*	35	462*	0.0562%

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 2008.

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 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	88.190	71.395
1995	97.184	69.536	95.832	97.877	80.194
2000	100.937	79.324	101.856	106.700	88.069
2005	107.628	93.177	119.397	116.417	100.364
2008	111.051	100.740	128.328	118.490	106.776

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 2008) 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 1994-2008 were obtained from the Fertiliser Statistics Report (Agricultural Industries Confederation 2006), and the British Survey of Fertiliser Practice (BSFP 2009). These data are produced annually and used to update the inventory. 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	24x10^7 m^2 (24,000 ha)	21%	480	0.0127	307	1280
'Thin' peat	126x10^7 m^2 (126,000 ha)	12%	480	0.0019	138	109
Total	**150x10^7 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 2008 have been estimated from activity data taken from the Business Monitor of

Mineral Extraction in Great Britain (Office of National Statistics 2008). In Northern Ireland, new data on use of peat for horticultural use was not yet available so the contribution of emissions due to peat extraction was therefore incorporated as constant from 1990 to 2008. 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. Timber produced as a result of Forest conversion to Grassland or Settlement is also added to the HWP pool.

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 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 as this is not mandatory under the GPG). 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 2008 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
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
2008	0.050	0.002	0.044	5.109	1.898	0.267	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.

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 2008 figures have been rolled forward 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)

Details of activity data in terms of quantities of biodegradable waste sent to landfill are given in the chapter eight. This chapter provides further details on the methodology used to determine emission factors.

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 waste, on the basis that the biochemistry of individual fractions of waste in the US is comparable to the same fractions in the UK. This has approach been adapted to UK conditions and incorporated into (1) the Environment Agency's WISARD / WRATE life cycle assessment models (WS Atkins, 2000); (2) the HELGA framework model (Gregory et al., 1999) and (3) GasSim (Environment Agency, 2002).

Cellulose and hemi-cellulose make up approximately 91% of the degradable carbon in waste. Other degradable fractions which also make a small contribution (such as proteins and lipids) are not considered. 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 **Table A 3.8.1** and **Table A 3.8.2** 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 was 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 organic 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 utilisation for 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 A 3.8.3**). Collection efficiency at any site is limited to 75% over the lifetime of the site. 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.

A3.8.2.1 Gas Utilisation

Power generation is currently the dominant use for landfill gas in the UK and good data are available on this from official sources. There is growing interest in other uses for landfill gas, such as use as a vehicle fuel or injection into the gas grid (after clean-up), but these applications are currently at a very low level and have not been included.

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 DECC figures. In addition, LQM (2003) included data on utilisation prior to the first round of the Non Fossil Fuel Obligation (NFFO)[9] contracts (Richards and Aitchison, 1990). The five NFFO rounds (NFFO 1-5) 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). Renewables Obligation (RO)[10] replaced NFFO in 2002 and are now the main support scheme for renewable electricity projects in the UK. It places an obligation on UK suppliers of electricity to source an increasing proportion of their electricity from renewable sources.

This approach, comparing the trade association and Government data sources, provided a reasonable correlation, and so LQM was confident in the accuracy of its estimates of installed capacity at the time. 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 DECC.

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

[9] The Non Fossil Fuel Obligation (NFFO) was used in the UK to promote renewable electricity generation in the 1990s. There were five Orders made in England and Wales. NFFO Orders 1,2,3,4 and 5 were made in 1990, 1991, 1994, 1997 and 1998. From April 1st 2002 it has been replaced by the Renewables Obligation

[10] A Renewables Obligation Certificate (ROC) is a green certificate issued to an accredited generator for eligible renewable electricity generated within the United Kingdom and supplied to customers within the United Kingdom by a licensed electricity supplier. Landfill gas is eligible for Renewables Obligation Certificate.

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 A 3.8.3**). The downtime and replacement figures are LQM assessments following inquiries made as part of the 2002 survey.

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
2008	18.79	65.94	84.73	3642	2576	71	1164	31.96	1412	38.78	107	2.93	960

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 A 3.8.4.**

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 NI DoE, 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 North Wyke (formerly 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
2008	38.42	0.626

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 **Table A 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). Household intakes.

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	26.3
2001	26.2
2002	26.2
2003	26.0

Year	Protein consumption (kg/person/yr)
2004	26.0
2005	26.3
2006	26.1
2007	25.9
2008	25.9

The protein consumption in 2008 was not available when the 2008 estimates were being created, and so the estimate from 2007 was used. Defra have revised the time series of protein consumptions from 2000 to 2007.

A3.8.3.7 Work to improve the methodology

Review of the time series of protein consumptions
Currently the protein consumptions are used to estimate emissions are "household intakes". Defra now produce a time series of the estimates of the small amount of additional protein from consuming meals eaten outside the home; this intake is called "eating out intakes". This time series is only available from 2000 onwards. The sum of the "household intakes" and "eating out intakes" then provides the total protein consumption per year per person. The "eating out intakes" will be added to the "household intakes" protein consumption figures and a revised time series produced for the 2011 NIR. In addition, a method will be devised for producing a consistent time series of protein consumptions from 1990 onwards which overcomes the step change between 1996 and 1997. Following the UNFCCC ERT suggestion, we are investigating whether the protein consumptions in the years before 1997 can be extrapolated using a surrogate method that uses gross domestic product (GDP) or GDP per capita as a driver. Initial calculations suggest that a GDP metric may not be a suitable proxy for estimating protein consumption.

A preliminary analysis of the latest available time series of protein consumptions (available from January 2010) suggests that Defra may have removed the step change between 1996 and 1997. We will investigate this further in the 2011 NIR.

Improvements to generating estimates from wastewater treatment
Work continues to gain access to known data sources of information that might improve the estimates of emissions from all waste water treatment in the UK, and to help make our first estimates of emissions from industrial waste water treatment. The UK currently assumes that estimates of emission from industrial waste water treatment are small and may be partially included in other emissions from the Pollution Inventory which are included with industrial emissions.

We continue to have discussions with UK Water Industry Research (UK WIR) to improve the estimates of CH_4 and N_2O from waste water treatment. We have been able to establish that OFWAT (the economic regulator for the water and sewerage industry in England and Wales) still receive activity data within the "June Returns". Discussions still continue between UK WIR and the GHG inventory team to assign the "best estimates" of emission factors to activity data. These discussions are currently constrained as some of the data is commercially confidential. Defra are currently in further discussions with UK WIR on behalf of the GHG inventory team.

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 DECC. Emissions from non-fuel sources were introduced into the inventory at the same time as the estimates for the OTs.

For the 1990-2007 greenhouse gas inventory, submitted in 2010, a number of improvements were made to the method used to include emissions from the OTs and CDs in the UK inventory database. These changes were described in the 2010 NIR. These methods continue to be used.

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[11]. 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, although separate estimates of CD fuel combustion are also now made. 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.

11 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 A 3.9.3** and **Table A 3.9.5**.

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 A 3.9.2**. These data are supplied by energy statisticians and other government officials and are thought to be of good quality. Emissions are summarised in **Table A 3.9.3.**

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 2008 are the commercial and domestic sectors and road transport. Emissions from power generation make up 9% of total CO_2 emissions, much of Jersey's electricity is imported from France.

Agricultural activity is the main source of methane emissions, accounting for around 84% of total methane emissions in 2008. Waste is incinerated, and so there are no methane emissions from landfill sites. These emissions were estimated using emission factors from the GHGi, and the process for estimating emissions from waste incineration in Jersey was fully integrated with the UK spreadsheets this year.

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 and 2008 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 63% to total CO_2 emissions. Residential and commercial combustion are also significant sources, accounting for a further 39% of total emissions. Some minor industrial sources of combustion emissions also exist - the sewage treatment plant and quarries. Significant improvements have been made to estimates from fuel combustion in the Isle of Man for this inventory, to ensure that all fuels are covered, including the natural gas pipeline (this is additional to the fuel use presented in the UK energy statistics). Data received after the cut off date for the 1990-2007 inventory has been incorporated this year.

The most significant methane source is agriculture, which accounted for 96% of methane emissions in 2008. 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 are based on real data and emission factors sourced from the existing GHG inventory, and so estimates have a fairly low uncertainty. 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 2008 was power stations, showing an increase on emissions in 2007. The time series of emissions from power stations reflect the changing proportion of electricity imported from France. The next largest source is road transport, accounting for 27% of CO_2 emissions in 2008.

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 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	1990-2008 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	N_2O from manure management are based on a time series of UK emissions. Methane emissions based on IPCC guidelines	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**	**2008**
1. Energy	1.43	1.50	1.55	1.52	1.55	1.60	1.72	1.79	1.86	1.75	1.62	1.42	1.39	1.28	1.32	1.39	1.41	1.50	1.42
2. Industrial Processes	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.05
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	0.13	0.13
5. Land Use, Land Use Change and Forestry	-0.04	-0.03	-0.10	-0.04	-0.05	-0.06	-0.07	-0.08	-0.06	-0.05	-0.04	-0.05	-0.08	-0.05	-0.04	-0.05	-0.07	-0.07	-0.07
6. Waste	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.09	0.08	0.07	0.06	0.04	0.06	0.06	0.05	0.05
7. Other																			
Total	**1.66**	**1.75**	**1.72**	**1.74**	**1.76**	**1.82**	**1.93**	**1.99**	**2.10**	**2.00**	**1.83**	**1.61**	**1.55**	**1.43**	**1.45**	**1.54**	**1.56**	**1.66**	**1.58**

A3.9.2 Overseas Territories: Bermuda, Falklands Islands, Montserrat, the Cayman Islands and Gibraltar

Table A 3.9.4 summarises the methods used to estimate emissions from the Falklands Islands, Montserrat, the Cayman Islands and Bermuda. Emissions from some sources are not estimated due to lack of data. Emissions are summarised in **Table A 3.9.5**. The government of Bermuda has prepared its own GHG inventory estimates and methodological report for 1990 to 2000, and has provided more data for the estimates of emissions from 2001-2008, so **Table A 3.9.4** only refers to the methodologies used for the latter part of the time series for Bermuda, and the full time series for the Falkland Islands, Montserrat and the Cayman Islands.

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 certain years, so the time series was extrapolated back to 1990 based on population statistics. Vehicle numbers were not provided for all years, 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 has been uninhabitable during parts of the time series, 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

Continued improvements have been made to the data availability from the Cayman Islands, through closer collaboration with data providers. 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 64% of emissions in 2008. In last year's inventory, energy use at the desalination plant was assumed to be oil. This assumption has been corrected (the plant uses electricity). 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.

Data have now been supplied to improve estimated emission for 2001 to 2008. These data were supplied in the Compendium of Environmental Statistics, and have allowed improvements to emissions from this part of the time series.

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	1990-2008 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	2008
1. Energy	1.07	1.08	1.09	1.11	1.13	1.14	1.13	1.15	1.24	1.26	1.28	1.39	1.40	1.41	1.46	1.49	1.58	1.72	1.63
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	0.03	0.03	0.03	0.03
3. Solvent and Other Products Use																			
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	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	0.03
6. Waste	0.07	0.07	0.07	0.07	0.07	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13
7. Other																			
Total	**1.33**	**1.33**	**1.34**	**1.35**	**1.38**	**1.45**	**1.43**	**1.46**	**1.56**	**1.58**	**1.60**	**1.70**	**1.72**	**1.73**	**1.78**	**1.82**	**1.91**	**2.04**	**1.95**

A3.9.2.5 Gibraltar Emissions

A greenhouse gas inventory for Gibraltar has been created which contains annual emission estimates from 1990 to 2008 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 A 3.9.6** 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 A 3.9.7**.

No data were available to update the time series to 2008 and therefore estimates from 2007 have been used in place of 2008 data.

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 – 2008 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	2008
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	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	0.01
3. Solvent and Other Products Use																			
4. Agriculture																			
5. Land Use, Land Use Change and Forestry																			
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	0.00
7. Other																			
Total	**0.18**	**0.19**	**0.19**	**0.17**	**0.18**	**0.18**	**0.18**	**0.18**	**0.19**	**0.20**	**0.21**	**0.20**	**0.20**	**0.21**	**0.22**	**0.22**	**0.22**	**0.22**	**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’ DECC, 2009), 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 DECC 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 A 4.3.1 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	-1.3	0.1	1.0	0.5	0.6	2.2

Year	1996	1997	1998	1999	2000	2001
Percentage difference	0.4	0.1	0.9	1.5	2.3	0.9

Year	2002	2003	2004	2005	2006	2007	2008
Percentage difference	0.6	0.1	0.4	1.1	1.4	0.1	0.2

A5 ANNEX 5: Assessment of Completeness

A5.1 ASSESSMENT OF COMPLETENESS

Table A 5.1.1 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	1. Energy	1B2Bv(i) & (ii) Natural gas, other leakage	Emissions from these sources believed to be very small
CO_2	1. Energy	1A1a Other fuels, scrap tyres	Emissions below the reporting threshold and are therefore assumed to be negligible
CO_2	1. Energy	1A3B Road Transport, Gaseous fuels	No activity data available and emissions from this source believed to be very small
CO_2	1. Energy	1C2 Multilateral Operations	Data unavailable
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	2. Industrial Processes	2A5/6 Asphalt Roofing/Paving	No methodology available but considered negligible
CO_2	2. Industrial Processes	2C2 Ferroalloys Production	Source considered negligible in the UK
CO_2	2. Industrial Processes	2D2 Food and Drink	No appropriate data available
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	5. Land-Use Change and Forestry	5B2/5C1/5C2/5D/5F Biomass burning by Wildfires	There is no activity data available for wildfires on non forest land in the UK
CO_2	6. Waste	6A1 Managed Waste disposal on land	Emissions from CO2 in this category are assumed to be biogenic in origin and therefore not counted towards the total
CO_2	6. Waste	6C2 Additional fires (vehicles)	No suitable emission factor available
N_2O	1. Energy	1A1a Other fuels, scrap tyres	Emissions below the reporting threshold and are therefore assumed to be negligible
N_2O	1. Energy	1A3B Road Transport, Gaseous fuels	No activity data available and emissions from this source believed to be very small
N_2O	1. Energy	1A3B Road Transport, Liquid fuels, LPG	No suitable emission factor has been identified and emissions from this source are believed to be small
N_2O	1. Energy	1A3D Other liquid fuels, lubricants	No suitable emission factor has been identified and emissions from this source are believed to be small

GHG	CRF sector	Source/sink category	Reason
N_2O	1. Energy	1C1B, International bunkers, marine, lubricants	No suitable emission factor identified and emissions are thought to be negligible
N_2O	1. Energy	1A2F Other not specified, other fuels	Emissions from this source are believed to be very small
N_2O	1. Energy	1C2 Multilateral Operations	Data unavailable
N_2O	2. Industrial Processes	2A7 Glass Production	Data not available
N_2O	2. Industrial Processes	2A7 Fletton Brick Production	No suitable method for estimating emissions of N_2O from this source, but emission are thought to be negligible
N_2O	2. Industrial Processes	2A7 Asphalt	Data unavailable. Believed to be very small and very uncertain
N_2O	2. Industrial Processes	2B1 Ammonia Production	Emissions from this source are considered negligible
N_2O	3. Solvent and Other Product Use	3D Other –Anaesthesia	Activity not readily available – believed small
N_2O	4. Agriculture	4D4 other non-specified	There are currently no other sources at this time
N_2O	5. Land-Use Change and Forestry	5A N_2O emissions from drainage of soils	Methodology under consideration
N_2O	5. Land-Use Change and Forestry	5B2 N_2O 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	There is no activity data for wildfires from non forest land in the UK
N_2O	5. Land-Use Change and Forestry	5G Harvested wood products	No guidance available for calculating non CO_2 emissions from harvested wood products.
N_2O	6. Waste	6B1 Industrial Wastewater	No suitable activity data have been identified. Most waste water is treated in the public system – emissions from this source are believed to be very small
N_2O	6. Waste	6B2 Domestic and Commercial	No data are available to estimate emissions from this source. Emissions are believed to be small
N_2O	6. Waste	6C2 Chemical	High temperature combustion processes, methane and N2O emissions insignificant
N_2O	6. Waste	6C2 Accidental fires (vehicles)	No suitable emission factor available
CH_4	1. Energy	1B2Bv(i) & (ii) Natural gas, other leakage	Emissions believed to be very small
CH_4	1. Energy	1A1a Other fuels, scrap tyres	Emissions below the reporting threshold and are therefore assumed to be negligible
CH_4	1. Energy	1A3B Road Transport, Gaseous fuels	No activity data available and emissions from this source believed to be very small
CH_4	1. Energy	1A3B Road Transport, Liquid fuels, LPG	No suitable emission factor has been identified and emissions from this source are believed to be small
CH_4	1. Energy	1A3D Other liquid fuels, lubricants	No suitable emission factor has been identified and emissions from this source are believed to be small
	1. Energy	1C1B, International bunkers, marine, lubricants	No suitable emission factor identified and emissions are thought to be negligible
	1. Energy	1C2 Multilateral Operations	Data unavailable

GHG	CRF sector	Source/sink category	Reason
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	4. Agriculture	4D3 Indirect emissions	There are no known sources of methane from this
CH_4	4. Agriculture	4D4 Improved grassland	There are no known sources of methane from this
CH_4	5. Land-Use Change and Forestry	5A1 Forest Land remaining Forest Land	Reporting of these estimates is not mandatory
CH_4	5. Land-Use Change and Forestry	5B2/5C1/5C2/5D1/5D2/5F – Wildfires	There is no activity data for wildfires from non forest land in the UK
CH_4	5. Land-Use Change and Forestry	5G Harvested wood products	No guidance available on calculating non-CO2 emissions from HWP
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	2F9 Gibraltar F gas emissions	Data not available
SF_6	2.Industrial Processes	2C5. Non-ferrous metals	Separate estimate not currently made for this source
SF_6	2.Industrial Processes	2F9 Gibraltar F gas emissions	Data not available

A6 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 other useful reference information.

A6.1 ANNUAL INVENTORY SUBMISSION

No additional information.

A6.2 SUPPLEMENTARY INFORMATION UNDER ARTICLE 7, PARAGRAGH 1

A6.2.1 KP-LULUCF (accounting table, CRF and/or NIR tables)

No additional information.

A6.2.2 Standard electronic format (SEF) tables

The tables presented below are the tables for 2009. The data are given in standard electronic format (SEF). Further reference can be made to document SEF_GB_2010_2_18-8-40 27-4-2010.xls as part of the SIAR submission, Chapter 12.

Table A 6.2.1 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	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 of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	3453388806	NO	NO	25103406	NO	NO

Table A 6.2.2 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							2417	NO	NO	265170	NO	NO
Sub-total		NO	NO				2417	NO	NO	265170	NO	NO

Transaction type	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Retirement	260854974	48338	NO	4605119	NO	NO

Table A 6.2.3 Annual external transactions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Transfers and acquisitions												
CDM	NO	NO	NO	27103234	NO	NO	NO	NO	NO	NO	NO	NO
AT	2874178	NO	NO	493490	NO	NO	6355100	NO	NO	271585	NO	NO
BE	7574647	NO	NO	250078	NO	NO	900769	NO	NO	1322625	NO	NO
BG	NO	NO	NO	1	NO	NO	NO	45000	NO	140001	NO	NO
CZ	6099806	NO	NO	2094000	NO	NO	11983046	NO	NO	986756	NO	NO
DK	153044370	159735	NO	8540832	NO	NO	139226212	NO	NO	5723993	NO	NO
EE	283280	NO	NO	NO	NO	NO	150000	NO	NO	NO	NO	NO
FI	7022231	NO	NO	276000	NO	NO	4471738	NO	NO	1298333	NO	NO
FR	155605133	45001	NO	11143355	NO	NO	284367819	1	NO	12948458	NO	NO
DE	166839857	315544	NO	13647128	NO	NO	107520746	262618	NO	19880191	NO	NO
GR	763008	NO	NO	NO	NO	NO	20	NO	NO	1890	NO	NO
HU	5994148	22118	NO	NO	NO	NO	NO	NO	NO	952100	NO	NO
IE	2022744	NO	NO	1076505	NO	NO	2103192	NO	NO	5157595	NO	NO
IT	9606968	NO	NO	2366577	NO	NO	8551602	NO	NO	1833166	NO	NO
JP	NO	NO	NO	313785	NO	NO	108971	75250	NO	5256981	NO	NO
LV	341255	NO	NO	NO	NO	NO	70000	NO	NO	NO	NO	NO
LT	108056	NO	NO	NO	NO	NO	100000	109301	NO	NO	NO	NO
LU	10000	NO	NO	NO	NO	NO	10000	NO	NO	320286	NO	NO
NL	47045148	5750	NO	18100070	NO	NO	41938096	50000	NO	28381431	NO	NO
NZ	1000	98338	NO	401000	NO	NO	1000	NO	NO	500	NO	NO
NO	13000949	NO	NO	300000	NO	NO	3685523	NO	NO	322606	NO	NO
PL	3047178	NO	NO	3000	NO	NO	761042	NO	NO	802385	NO	NO
PT	1462794	NO	NO	225000	NO	NO	4162000	NO	NO	712960	NO	NO
RO	12782845	NO	NO	NO	NO	NO	332	NO	NO	461600	NO	NO
SK	3673782	NO	NO	1	NO	NO	1000	NO	NO	320215	NO	NO
SI	170000	NO	NO	200000	NO	NO	NO	NO	NO	154617	NO	NO
ES	22791958	NO	NO	2869643	NO	NO	5346884	NO	NO	5745771	NO	NO
SE	3126246	NO	NO	959755	NO	NO	356557	NO	NO	600228	NO	NO
CH	6583	667156	NO	38570894	NO	NO	1000	52006	NO	35735557	NO	NO
UA	105971	43006	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total	625404135	1356648	NO	128934348	NO	NO	622172649	594176	NO	129331830	NO	NO

Additional information

Independently verified ERUs								NO				

Table A 6.2.4 Total annual transactions

Total (Sum of tables 2a and 2b)	625404135	1356648	NO	128934348	NO	NO	622175066	594176	NO	129597000	NO	NO

Table A 6.2.5 Expiry, cancellation and replacement

Transaction or event type	Expiry, cancellation and requirement to replace		Replacement					
	Unit type		Unit 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 6.2.6 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	2956145800	NO	NO	23301	NO	NO
Entity holding accounts	239617021	714134	NO	19466508	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	2497	NO	NO	610996	NO	NO
Retirement account	260854974	48338	NO	4605119	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 of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	3456620292	762472	NO	24705924	NO	NO

Table A 6.2.7 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)	625404135	1356648	NO	128934348	NO	NO	622175066	594176	NO	129597000	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	820872772	1356648	NO	257708988	NO	NO	776335607	594176	NO	233614060	NO	NO
Total	4232953402	1356648	NO	257708988	NO	NO	776335607	594176	NO	233614060	NO	NO

Table A 6.2.8 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 6.2.9 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)	260854974	48338	NO	4605119	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	260854974	48338	NO	4605119	NO	NO

Table A 6.2.10 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

Table A 6.2.11 Memo item: Corrective transactions relating to replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Table A 6.2.12 Memo item: Corrective transactions relating to retirement

	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

A6.2.3 National system, including changes

Refer to document 'SIAR Reports 2009-GB v1.0.xls' as part of the SIAR submission, Chapter 12.

A6.2.4 National registry

No additional information.

A6.2.4.1 Changes to national registry

Refer to the following documents as part of the SIAR submission, Chapter 14:

1. Certification email from the EC.oft
2. Release Notes version 4.0.16.pdf
3. Release Notes version 4.1.16.pdf
4. Release Notes version 4.2.21.pdf
5. Test Report Version 4.1.pdf
6. Test Report Version 4.2.pdf
7. CITL Test Plan for Version 4.1.doc

A6.2.4.2 Reports:

No additional information.

A6.2.4.3 Publicly available information

No additional information.

A6.2.5 Adverse impacts under Article 3, paragraph 14 of the Kyoto Protocol

No additional information.

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 A 7.2.1** 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 DECC and reported 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[12], 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

[12] 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).

- 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.

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, 2008). This work also included an update to the uncertainty analysis, which has been taken into account in the overall 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.

A7.1.3 Review of changes made to the Monte Carlo model since the last NIR

Changes have been made to the treatment of uncertainties from petroleum coke combustion, due to new source data being used as the basis for the inventory. This is explained in **Section A7.2.1.1**.

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 exactly.

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 2008 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), and reviewed and updated in 2008 (Thomson, pers. comm. 2008). 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.

Emissions and activity data for petroleum coke are taken from a number of sources. In 2008, data for power stations, refineries and cement are taken from EU ETS returns. The total petroleum coke use in the inventory deviates from the energy statistics total, and as such it is not possible to correlate the uncertainties based on the statistical difference in the energy statistics for 2008. For refineries, the emissions data is taken from the EU ETS return and the activity data is calculated based on an estimate of the emission factor. Petroleum coke use for residential combustion is extrapolated from a limited data set, covering certain years only. This is therefore much more uncertain than the data for other source sectors. For 1990, the activity data is based on DUKES, but taken from the non-energy use line, and is therefore again, more uncertain than the statistical difference would imply.

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			2008		
Fuel		Activity uncertainty (%)	Emission factor uncertainty (%)	Uncertainty in emission (%)	Activity uncertainty (%)	Emission factor uncertainty (%)	Uncertainty in emission (%)
Anthracite		1.5	6	‡	0.4	6	‡
Aviation spirit		20	3.3	‡	3.4	3.3	‡
Aviation turbine fuel		20	3.3	‡	3.4	3.3	‡
Blast furnace gas		1.5	6	‡	0.4	6	‡
Burning oil		6	2	‡	1.4	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	‡	0.4	1	‡
Coke		3	3	‡	0.2	3	‡
Coke oven gas		1.5	6	‡	0.4	6	‡
Colliery methane		5	5	‡	5	5	‡
DERV		1.8	2.1	‡	0.4	2.1	‡
Dolomite		1	5	‡	1	5	‡
Exploration drilling		1	28	‡	1	28	‡
Fuel oil		5.5	1.7	‡	4.1	1.7	‡
Fletton bricks		20	70	‡	20	70	‡
Gas oil		1.8	1.4	‡	0.4	1.4	‡
Limestone		1	5	‡	1	5	‡
LPG		25.7	3	‡	2.7	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	‡	0.2	1.5	‡
OPG		1.4	3	‡	0.8	3	‡
Orimulsion		1	2	‡	not used	not used	‡
Peat		25	25	‡	25	25	‡
Petrol		1	4.8	‡	0.7	4.8	‡
Petroleum coke	1A1a	not used	not used	‡	0.75	3	‡
	1A1b	7.8	3	‡	‡	‡	5
	1A2f	25	3	‡	0.75	3	‡
	1A4b	50	3	‡	25	3	‡
Petroleum waxes		50	20	‡	50	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	‡	not used	not used	‡
SSF		3.3	3	‡	1.8	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			2008		
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 2008**.

The central estimate of total CO_2 emissions in 2008 was estimated as 534,507 Gg. The Monte Carlo analysis suggested that 95% of the values were between 525,908 Gg and 543,039 Gg.

A7.2.1.4 Uncertainty in the Trend

The uncertainty in the trend between 1990 and 2008 was estimated. In running this simulation it was necessary to make assumptions about the degree of correlation between sources in 1990 and 2008. 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 2008 were between **8% and 12%** 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 A 7.2.3**. The uncertainty on the activities for the fuels burnt are not pollutant specific, and are reported in **Table A 7.2.1**.

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			2008		
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	‡
Anthracite			50	‡		50	‡

		1990			2008		
Source	Reference	Activity %	Emission Factor %	Source Uncertainty %	Activity %	Emission Factor %	Source Uncertainty %
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 A 7.2.3** 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 2008**.

The central estimate of total CH_4 emissions in 2008 was estimated as 48,932 Gg CO_2 equivalent. The Monte Carlo analysis suggested that 95% of the values were between 40,968 and 59,042 Gg CO_2 equivalent.

A7.2.2.4 Uncertainty in the Trend

The uncertainty in the trend between 1990 and 2008 was estimated. In running this simulation it was necessary to make assumptions about the degree of correlation between sources in 1990 and 2008. 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 53% hence the degree of correlation was 47%; 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 2008 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 A** 7.2.4. The uncertainty for the fuels burnt are not pollutant specific and are reported in **Table A 7.2.1**. 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 Farming and Food Science Team 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			2008		
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 A 7.2.1**.

‡ 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 252% in 2008.

The central estimate of total N_2O emissions in 2008 was estimated as 33,843 Gg CO_2 equivalent. The Monte Carlo analysis suggested that 95% of the values were between 9,694 and 97,156 Gg CO_2 equivalent.

A7.2.3.4 Uncertainty in the Trend

The uncertainty in the trend between 1990 and 2008 was also estimated. In running this simulation it was necessary to make assumptions about the degree of correlation between sources in 1990 and 2008. 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 2008 compared with 1990 – only 4 of the original 8 sites are still operating in the latest inventory year, 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 2008 were between **33% and 73%** 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 are based on the recent study to update emissions and projections of F-gases (AEA, 2008).

A7.2.4.2 Uncertainty in the Emissions

The uncertainties were estimated as

1990 (1995)

- 15% (14%) for HFCs,
- 5% (7%) for PFCs
- 17% (17%) for SF_6

2008

- 25% for HFCs
- 24% for PFCs
- 16% for SF_6

A7.2.4.3 Uncertainty in the Trend

This analysis indicates that there is a 95% probability that emissions in 2008 differed from those in 1990 by the following percentages

- -24% to +24% for HFCs
- -88% to -82% for PFCs
- -43% to -16% 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 1990 and **14%** in 2008.

A7.3.2 Uncertainty in the Trend

This analysis indicates that there is a 95% probability that the total GWP GHG emissions in 2008 were between 17% and 21% below the level in 1990.

The uncertainty estimates for all gases are summarised in **Table A 7.3.1**. 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.

Table A 7.3.1 Summary of Monte Carlo Uncertainty Estimates 1990 - 2008

Gas	1990 Emissions	2008 Emissions	Uncertainty in 1990 emissions as % of emissions in category		Uncertainty introduced on national total in 1990	Uncertainty in 2008 emissions as % of emissions in category		Uncertainty introduced on national total in 2008	% change in emissions between 2008 and 1990	Range of likely % change between 2008 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)	593392	534507	583968	602799	2%	525908	543039	2%	-10%	-12%	-8%
CH_4	104600	48932	85578	129249	26%	40968	59042	23%	-53%	-56%	-50%
N_2O	65091	33843	32926	146033	177%	9694	97156	252%	-55%	-73%	-33%
HFC	11392	11231	9982	12804	15%	8939	13524	25%	-1%	-24%	24%
PFC	1402	209	1347	1457	5%	167	251	24%	-85%	-88%	-82%
SF_6	1030	712	886	1175	17%	617	807	16%	-30%	-43%	-16%
All	776907	629435	732259	860277	15%	598967	693325	14%	-19%	-21%	-17%

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 A 7.4.1 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 2008)**
	1990	**2008**	
Error propagation	777,019	629,622	4.7
Monte Carlo	776,907	629,435	4.2 [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 A 7.5.1**. 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 uncertainties for petroleum coke use have been reviewed and updated, in line with the different data sources used to produce the emissions estimates.

Table A 7.5.1 Sectoral Uncertainty Estimates

IPCC Source Category	Gas	1990 Emissions	2008 Emissions	Uncertainty in 2008 emissions as % of emissions in category		Uncertainty Introduced on national total in 2008	% change in emissions between 1990 and 2008	Range of likely % change between 1990 and 2008	
				2.5 percentile	97.5 percentile			2.5 percentile	97.5 percentile
1A1a	GWP weighted total	206,431	175,272	173,827	176,825	1%	-15%	-17%	-14%
1A1b	GWP weighted total	18,391	15,353	15,056	15,648	2%	-17%	-19%	-14%
1A1c	GWP weighted total	14,097	16,949	16,708	17,219	2%	20%	17%	24%
1A2a	GWP weighted total	24,450	18,270	17,592	18,942	5%	-25%	-29%	-21%
1A2f	GWP weighted total	76,485	58,612	57,911	59,507	2%	-23%	-25%	-22%
1A3a	GWP weighted total	1,356	2,201	2,119	2,284	5%	64%	39%	93%
1A3b	GWP weighted total	111,610	118,866	116,474	121,217	2%	7%	3%	10%
1A3c	GWP weighted total	1,871	2,424	2,279	2,647	10%	30%	16%	44%
1A3d	GWP weighted total	4,145	5,395	5,307	5,485	2%	30%	27%	33%
1A3e	GWP weighted total	254	549	513	604	11%	117%	91%	143%
1A4a	GWP weighted total	25,669	21,894	21,633	22,155	1%	-15%	-16%	-13%
1A4b	GWP weighted total	80,353	80,026	79,169	80,887	1%	0%	-3%	2%
1A4c	GWP weighted total	5,758	4,650	4,385	5,054	9%	-19%	-27%	-10%
1A5b	GWP weighted total	5,337	2,970	2,888	3,054	3%	-44%	-51%	-36%
1B1a	GWP weighted total	18,274	2,783	2,585	2,983	9%	-85%	-86%	-83%
1B1b	GWP weighted total	877	143	138	147	4%	-84%	-84%	-83%
1B2a	GWP weighted total	2,783	916	758	1,073	21%	-67%	-74%	-59%
1B2b	GWP weighted total	7,973	4,342	4,321	4,363	1%	-46%	-46%	-45%
1B2c_Flaring	GWP weighted total	4,485	3,955	3,442	4,478	16%	-11%	-27%	6%
1B2c_Venting	GWP weighted total	884	522	416	634	25%	-40%	-56%	-21%
2A1	GWP weighted total	7,294	5,202	5,099	5,305	2%	-29%	-31%	-27%
2A2	GWP weighted total	1,192	876	839	912	5%	-26%	-31%	-22%
2A3	GWP weighted total	1,286	1,570	1,533	1,607	3%	22%	18%	27%
2A4	GWP weighted total	167	223	196	251	15%	34%	12%	60%
2A7	GWP weighted total	203	249	155	374	55%	31%	-34%	126%
2B1	GWP weighted total	1,321	1,108	1,094	1,122	2%	-16%	-19%	-14%

IPCC Source Category	Gas	1990 Emissions	2008 Emissions	Uncertainty in 2008 emissions as % of emissions in category		Uncertainty Introduced on national total in 2008	% change in emissions between 1990 and 2008	Range of likely % change between 1990 and 2008	
				2.5 percentile	97.5 percentile			2.5 percentile	97.5 percentile
2B2	GWP weighted total	3,902	1,452	453	3,253	132%	-47%	-91%	50%
2B3	GWP weighted total	20,726	946	830	1,064	15%	-95%	-96%	-95%
2B5	GWP weighted total	1,730	1,937	1,283	2,629	42%	16%	-31%	79%
2C1	GWP weighted total	1,886	2,593	2,467	2,720	6%	38%	28%	47%
2C3	GWP weighted total	1,783	621	593	650	6%	-65%	-67%	-63%
2E1	GWP weighted total	11,380	126	111	141	15%	-99%	-99%	-99%
2E2	GWP weighted total	11	12	10	13	15%	8%	-10%	27%
2F1	GWP weighted total	0	7,306	5,058	9,564	38%	3900936%	2378898%	5930683%
2F2	GWP weighted total	0	408	306	510	30%	NA	NA	NA
2F3	GWP weighted total	0	200	167	233	20%	NA	NA	NA
2F4	GWP weighted total	12	3,016	2,588	3,440	17%	25600%	20621%	31270%
2F5	GWP weighted total	0	83	66	100	25%	NA	NA	NA
2F8	GWP weighted total	662	769	668	872	16%	17%	NA	NA
4A1	GWP weighted total	13,704	11,874	9,934	13,816	20%	-12%	-32%	10%
4A10	GWP weighted total	9	6	5	7	20%	-33%	-48%	-16%
4A3	GWP weighted total	4,503	3,369	2,817	3,924	20%	-24%	-41%	-5%
4A4	GWP weighted total	12	10	9	12	20%	-14%	-33%	8%
4A6	GWP weighted total	77	141	117	164	20%	84%	44%	130%
4A8	GWP weighted total	238	149	124	173	20%	-37%	-51%	-21%
4B1	GWP weighted total	2,149	1,799	1,347	2,249	30%	-14%	-42%	21%
4B3	GWP weighted total	109	81	61	102	30%	-23%	-48%	7%
4B4	GWP weighted total	0	0	0	0	30%	7%	-27%	51%
4B6	GWP weighted total	6	11	8	14	31%	86%	26%	161%
4B8	GWP weighted total	1,120	699	522	874	31%	-36%	-57%	-10%
4B9	GWP weighted total	224	266	200	333	31%	21%	-18%	70%
4B9a	GWP weighted total	0	0	0	0	30%	-32%	-54%	-4%
Agriculture - N2O	GWP weighted total	33,107	25,344	1,863	88,490	336%	-23%	-24%	-22%

IPCC Source Category	Gas	1990 Emissions	2008 Emissions	Uncertainty in 2008 emissions as % of emissions in category		Uncertainty Introduced on national total in 2008	% change in emissions between 1990 and 2008	Range of likely % change between 1990 and 2008	
				2.5 percentile	97.5 percentile			2.5 percentile	97.5 percentile
5A	GWP weighted total	-12,135	-13,629	-16,413	-10,815	-25%	14%	-16%	52%
5B	GWP weighted total	15,786	15,207	8,989	21,443	50%	2%	-48%	73%
5C	GWP weighted total	-6,122	-8,157	-11,452	-5,553	-45%	43%	-23%	137%
5E	GWP weighted total	7,082	6,290	3,731	8,903	50%	-8%	-50%	44%
5G	GWP weighted total	-1,712	-1,755	-2,189	-1,321	-30%	5%	-28%	46%
6A1	GWP weighted total	49,794	20,279	12,649	30,176	54%	-59%	-59%	-59%
6B2	GWP weighted total	1,761	2,046	790	5,010	201%	19%	-19%	66%
6C	GWP weighted total	1,388	474	416	545	17%	-66%	-71%	-59%
Grand Total	GWP weighted total	776,910	629,406	599,148	693,523	14%	-19%	-21%	-17%

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[13] 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.

[13] 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.

This large year-to-year variability is in part controlled by the historical revisions to the energy statistics that the 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.

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 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 DECC 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.

A7.6.2 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.

A7.6.3 Uncertainty in the Emissions

The error propagation analysis, **including** LULUCF emissions, suggests an uncertainty of 16% in the combined GWP total emission in 2008, the latest reported inventory year in this NIR; GWP emission uncertainty of 16% in the 2007 inventory, reported in the 2009 NIR.

The error propagation analysis, **excluding** LULUCF emissions, suggests an uncertainty of 16% in the combined GWP total emission in 2008, the latest reported inventory year in this NIR; GWP emission uncertainty of 16% in the 2007 inventory, reported in the 2009 NIR.

A7.6.4 Uncertainty in the Trend

The analysis, **including** LULUCF emissions, estimates an uncertainty of 2.3% in the trend between the base year and 2008, the latest reported inventory year in this NIR; trend uncertainty of 2.4% in the 2007 inventory, reported in the 2009 NIR.

The analysis, **excluding** LULUCF emissions, estimates an uncertainty of 2.3% in the trend between the base year and 2008, the latest reported inventory year in this NIR; trend uncertainty of 2.5% in the 2007 inventory, reported in the 2009 NIR.

A7.6.5 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**.

A7.6.6 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	BaseYear Emissions 1990 & 1995 Gg CO2 equiv	Year Y emissions 2008 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 %
	A	B	C	D	E	F	G	H	I	J	K	L
1A	Coal	CO2	248618	133606	0.4	1	1.077	0.228546	-0.085560	0.171205	-0.085560	0.096848
1A(stationary)	Oil	CO2	92033	53791	15	2	15.133	1.292849	-0.026190	0.068929	-0.052380	1.462205
1A	Natural Gas	CO2	108920	200365	0.2	1.5	1.513	0.481571	0.143943	0.256753	0.215914	0.072621
1A	Other (waste)	CO2	212	1377	7	20	21.190	0.046343	0.001545	0.001765	0.030899	0.017468
1A	Lubricant	CO2	387	199	30	2	30.067	0.009492	-0.000145	0.000255	-0.000291	0.010807
1A	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000
1A3a	Aviation Fuel	CO2	1340	2177	20	3.3	20.270	0.070099	0.001404	0.002790	0.004635	0.078916
1A3b	Auto Fuel	CO2	109526	117555	2.8	3.5	4.482	0.836858	0.037350	0.150638	0.130726	0.596495
1A3b	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000
1A3d	Marine Fuel	CO2	4005	5283	1.7	1.4	2.202	0.018479	0.002629	0.006770	0.003681	0.016276
1A3	Other Diesel	CO2	1898	2652	1.7	1.4	2.202	0.009275	0.001436	0.003398	0.002010	0.008169
1A4	Peat	CO2	477	461	30	10	31.623	0.023149	0.000097	0.000591	0.000975	0.025058
1A4	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000
1B	Solid Fuel Transformation	CO2	856	132	0.4	6	6.013	0.001261	-0.000716	0.000169	-0.004297	0.000096
1B	Oil & Natural Gas	CO2	5778	4414	16	6	17.088	0.119798	-0.000317	0.005656	-0.001904	0.127986
2A1	Cement Production	CO2	7295	5203	1	2.2	2.417	0.019968	-0.000876	0.006667	-0.001926	0.009428
2A2	Lime Production	CO2	1192	876	1	5	5.099	0.007093	-0.000110	0.001122	-0.000548	0.001587
2A3	Limestone & Dolomite use	CO2	1285	1570	1	5	5.099	0.012712	0.000683	0.002011	0.003413	0.002845
2A4	Soda Ash Use	CO2	167	223	15	2	15.133	0.005371	0.000113	0.000286	0.000227	0.006075
2A7	Fletton Bricks	CO2	180	232	20	70	72.801	0.026789	0.000111	0.000297	0.007765	0.008397
2B	Ammonia Production	CO2	1322	1108	10	1.5	10.112	0.017795	0.000053	0.001420	0.000080	0.020079
2B5	NEU	CO2	1563	1871	50	20	53.852	0.159989	0.000781	0.002397	0.015622	0.169491
2C1	Iron&Steel Production	CO2	2309	3066	1.2	6	6.119	0.029800	0.001542	0.003929	0.009251	0.006668
5A	5A LUCF	CO2	-12155	-13627	1	25	25.020	-0.541505	-0.004896	-0.017462	-0.122395	-0.024695
5B	5B LUCF	CO2	15822	15243	1	50	50.010	1.210761	0.003175	0.019533	0.158732	0.027624
5C	5C LUCF	CO2	-6130	-8156	1	70	70.007	-0.906900	-0.004114	-0.010452	-0.287989	-0.014781
5E	5E LUCF	CO2	7074	6280	1	50	50.010	0.498835	0.000734	0.008048	0.036686	0.011381
5G	5G LUCF	CO2	-1711	-1755	1	30	30.017	-0.083687	-0.000481	-0.002249	-0.014420	-0.003181
6C	Waste Incineration	CO2	1207	418	7	20	21.190	0.014084	-0.000711	0.000536	-0.014222	0.005309
		CO2 Total	593,470.62	534,563.72								
1A	All Fuel	CH4	2065.099588	1076.734037	0.4	50	50.002	0.085509	-0.000755	0.001380	-0.037763	0.000781
1A3a	Aviation Fuel	CH4	3.297458505	1.61055288	20	50	53.852	0.000138	-0.000001	0.000002	-0.000067	0.000058
1A3b	Auto Fuel	CH4	634.8592178	127.667252	2.8	50	50.078	0.010154	-0.000493	0.000164	-0.024638	0.000648
1A3b	Combined Fuel	CH4	0	0	15	30	33.541	0.000000	0.000000	0.000000	0.000000	0.000000
1A3d	Marine Fuel	CH4	1.31985	1.731918161	1.7	50	50.029	0.000138	0.000001	0.000002	0.000043	0.000005
1A3	Other Diesel	CH4	3.163979778	4.050873262	1.7	50	50.029	0.000322	0.000002	0.000005	0.000096	0.000012
1B1	Coal Mining	CH4	18285.666	2790.590	0.4	13	13.006	0.057645	-0.015325	0.003576	-0.199230	0.002023
	Solid Fuel Transformation	CH4	4.043	1.788	0.4	50	50.002	0.000142	-0.000002	0.000002	-0.000094	0.000001
1B2	Natural Gas Transmission	CH4	7954.835	4333.268	1	15	15.033	0.103464	-0.002671	0.005553	-0.040068	0.007853
	Offshore Oil& Gas	CH4	2349.176	955.043	16	20	25.612	0.038850	-0.001205	0.001224	-0.024098	0.027692
2A7	Fletton Bricks	CH4	23.602	16.461	20	100	101.980	0.002666	-0.000003	0.000021	-0.000331	0.000597
2B	Chemical Industry	CH4	169.425	68.230	20	20	28.284	0.003065	-0.000088	0.000087	-0.001755	0.002473
2C	Iron & Steel Production	CH4	16.357	20.390	0.4	50	50.002	0.001619	0.000009	0.000026	0.000461	0.000015
4A	Enteric Fermentation	CH4	18527.713	15531.379	0.1	20	20.000	0.493362	0.000747	0.019902	0.014938	0.002815
4B	Manure Management	CH4	3608.070	2856.681	0.1	30	30.000	0.136115	-0.000070	0.003661	-0.002089	0.000518
4F	Field Burning	CH4	266.045	0.000	25	50	55.902	0.000000	-0.000275	0.000000	-0.013753	0.000000
5A	5A LUCF	CH4	4.298	14.504	1	20	20.025	0.000461	0.000014	0.000019	0.000283	0.000026
5C2	5C2 LUCF	CH4	3.077	8.036	1	20	20.025	0.000256	0.000007	0.000010	0.000142	0.000015
5E2	5E2 LUCF	CH4	9.354	5.502	1	20	20.025	0.000175	-0.000003	0.000007	-0.000052	0.000010
6A	Solid Waste Disposal	CH4	49816.593	20288.285	15	46	48.384	1.559072	-0.025490	0.025998	-1.172518	0.551498
6B	Wastewater Handling	CH4	709.572	815.917	1	50	50.010	0.064807	0.000312	0.001046	0.015596	0.001479
6C	Waste Incineration	CH4	134.423	6.365	7	50	50.488	0.000510	-0.000131	0.000008	-0.006541	0.000081
		CH4 total	104,589.99	48,924.23								

Table A 7.6.2 Summary of error propagation uncertainty estimates including LULUCF, base year to the latest reported year (continued)

	Source Category	Gas	BaseYear Emissions 1990 & 1995 Gg CO2 equiv	Year Y emissions 2008 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 %
	A	B	C	D	E	F	G	H	I	J	K	L
1A1&1A2&1A4&1A5	Other Combustion	N2O	4670.540	3325.662	0.4	195	195.000	1.029991	-0.000567	0.004262	-0.110585	0.002411
1A3a	Aviation Fuel	N2O	13.196	21.437	20	170	171.172	0.005828	0.000014	0.000027	0.002350	0.000777
1A3b	Auto Fuel	N2O	1172.211	1066.125	2.8	170	170.023	0.287896	0.000154	0.001366	0.026221	0.005410
1A3b	Combined Fuel	N2O	0.000	0.000	15	30	33.541	0.000000	0.000000	0.000000	0.000000	0.000000
1A3d	Marine Fuel	N2O	31.174	40.906	1.7	170	170.008	0.011045	0.000020	0.000052	0.003432	0.000126
1A3	Other Diesel	N2O	224.533	315.668	1.7	140	140.010	0.070196	0.000172	0.000405	0.024131	0.000972
1B1	Coke Oven Gas	N2O	2.085	0.922	0.4	118	118.001	0.000173	-0.000001	0.000001	-0.000115	0.000001
1B2	Oil & Natural Gas	N2O	42.396	32.034	16	110	111.158	0.005655	-0.000003	0.000041	-0.000306	0.000929
2B	Adipic Acid Production	N2O	20737.345	947.019	0.5	15	15.008	0.022574	-0.020221	0.001214	-0.303311	0.000858
2B	Nitric Acid Production	N2O	3903.850	1464.657	10	230	230.217	0.535542	-0.002159	0.001877	-0.496594	0.026543
2C	Iron & Steel	N2O	11.107	9.960	0.4	118	118.001	0.001867	0.000001	0.000013	0.000151	0.000007
4B	Manure Management	N2O	2759.235	2121.002	1	414	414.001	1.394642	-0.000135	0.002718	-0.055797	0.003844
4D	Agricultural Soils	N2O	30406.856	23322.159	1	424	424.001	15.705646	-0.001550	0.029886	-0.657402	0.042264
4F	Field Burning	N2O	77.762	0.000	25	230	231.355	0.000000	-0.000080	0.000000	-0.018491	0.000000
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	10	50	50.990	0.000000	0.000000	0.000000	0.000000	0.000000
5A	5A LUCF	N2O	6.852	2.440	1	20	20.025	0.000078	-0.000004	0.000003	-0.000079	0.000004
5C2	5C2 LUCF	N2O	0.312	0.816	1	20	20.025	0.000026	0.000001	0.000001	0.000014	0.000001
5E2	5E2 LUCF	N2O	0.949	0.558	1	20	20.025	0.000018	0.000000	0.000001	-0.000005	0.000001
6B	Wastewater Handling	N2O	1033.354	1243.539	10	401	401.125	0.792243	0.000525	0.001593	0.210581	0.022535
6C	Waste Incineration	N2O	47.900	49.021	7	230	230.106	0.017915	0.000013	0.000063	0.003057	0.000622
		N2O Total	65,141.66	33,963.92								
2	Industrial Processes	HFC	15480	11249	1	19	19.026	0.339942	-0.001588	0.014415	-0.030180	0.020386
2	Industrial Processes	PFC	462	209	1	10	10.050	0.003335	-0.000210	0.000268	-0.002099	0.000379
2	Industrial Processes	SF6	1239	712	1	20	20.025	0.022641	-0.000369	0.000912	-0.007381	0.001290
		Halocarbon & SF6 Total	17,181.13	12,170.28								
	TOTALS	GWP	780,383.39	629,622.16								
	Total Uncertainties%							16.1				

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	BaseYear Emissions 1990 & 1995 Gg CO2 equiv	Year Y emissions 2008 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 %
	A	B	C	D	E	F	G	H	I	J	K	L
1A	Coal	CO2	248618	133606	0.4	1	1.077	0.227828	-0.087662	0.171849	-0.087662	0.097213
1A(stationary)	Oil	CO2	92033	53791	15	2	15.133	1.288789	-0.026949	0.069188	-0.053898	1.467706
1A	Natural Gas	CO2	108920	200365	0.2	1.5	1.513	0.480059	0.143702	0.257719	0.215553	0.072894
1A	Other (waste)	CO2	212	1377	7	20	21.190	0.046198	0.001549	0.001771	0.030985	0.017534
1A	Lubricant	CO2	387	199	30	2	30.067	0.009463	-0.000149	0.000256	-0.000297	0.010848
1A	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000
1A3a	Aviation Fuel	CO2	1340	2177	20	3.3	20.270	0.069879	0.001400	0.002801	0.004620	0.079213
1A3b	Auto Fuel	CO2	109526	117555	2.8	3.5	4.482	0.834230	0.036705	0.151204	0.128467	0.598739
1A3b	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000
1A3d	Marine Fuel	CO2	4005	5283	1.7	1.4	2.202	0.018421	0.002610	0.006795	0.003655	0.016337
1A3	Other Diesel	CO2	1898	2652	1.7	1.4	2.202	0.009246	0.001428	0.003411	0.001999	0.008200
1A4	Peat	CO2	477	461	30	10	31.623	0.023076	0.000094	0.000593	0.000944	0.025152
1A4	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000
1B	Solid Fuel Transformation	CO2	856	132	0.4	6	6.013	0.001257	-0.000725	0.000170	-0.004351	0.000096
1B	Oil & Natural Gas	CO2	5778	4414	16	6	17.088	0.119422	-0.000360	0.005678	-0.002160	0.128468
2A1	Cement Production	CO2	7295	5203	1	2.2	2.417	0.019906	-0.000931	0.006692	-0.002049	0.009464
2A2	Lime Production	CO2	1192	876	1	5	5.099	0.007071	-0.000119	0.001127	-0.000593	0.001593
2A3	Limestone & Dolomite use	CO2	1285	1570	1	5	5.099	0.012672	0.000676	0.002019	0.003379	0.002855
2A4	Soda Ash Use	CO2	167	223	15	2	15.133	0.005354	0.000113	0.000287	0.000225	0.006098
2A7	Fletton Bricks	CO2	180	232	20	70	72.801	0.026705	0.000110	0.000298	0.007704	0.008429
2B	Ammonia Production	CO2	1322	1108	10	1.5	10.112	0.017739	0.000044	0.001425	0.000066	0.020155
2B5	NEU	CO2	1563	1871	50	20	53.852	0.159487	0.000773	0.002406	0.015456	0.170129
2C1	Iron&Steel Production	CO2	2309	3066	1.2	6	6.119	0.029706	0.001531	0.003944	0.009186	0.006693
5A	5A LUCF	CO2	0	0	1	25	25.020	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
5C	5C LUCF	CO2	0	0	1	70	70.007	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
5G	5G LUCF	CO2	0	0	1	30	30.017	0.000000	0.000000	0.000000	0.000000	0.000000
6C	Waste Incineration	CO2	1207	418	7	20	21.190	0.014040	-0.000722	0.000538	-0.014449	0.005329
		CO2 Total	590,570.39	536,578.66								
1A	All Fuel	CH4	2065.099588	1076.734037	0.4	50	50.002	0.085241	-0.000773	0.001385	-0.038647	0.000783
1A3a	Aviation Fuel	CH4	3.297458505	1.61055288	20	50	53.852	0.000137	-0.000001	0.000002	-0.000069	0.000059
1A3b	Auto Fuel	CH4	634.8592178	127.667252	2.8	50	50.078	0.010122	-0.000499	0.000164	-0.024959	0.000650
1A3b	Combined Fuel	CH4	0	0	15	30	33.541	0.000000	0.000000	0.000000	0.000000	0.000000
1A3d	Marine Fuel	CH4	1.31985	1.731918161	1.7	50	50.029	0.000137	0.000001	0.000002	0.000042	0.000005
1A3	Other Diesel	CH4	3.163979778	4.050873262	1.7	50	50.029	0.000321	0.000002	0.000005	0.000095	0.000013
1B1	Coal Mining	CH4	18285.666	2790.590	0.4	13	13.006	0.057464	-0.015514	0.003589	-0.201687	0.002030
	Solid Fuel Transformation	CH4	4.043	1.788	0.4	50	50.002	0.000142	-0.000002	0.000002	-0.000096	0.000001
1B2	Natural Gas Transmission	CH4	7954.835	4333.268	1	15	15.033	0.103139	-0.002738	0.005574	-0.041076	0.007882
	Offshore Oil& Gas	CH4	2349.176	955.043	16	20	25.612	0.038728	-0.001226	0.001228	-0.024526	0.027796
2A7	Fletton Bricks	CH4	23.602	16.461	20	100	101.980	0.002658	-0.000003	0.000021	-0.000349	0.000599
2B	Chemical Industry	CH4	169.425	68.230	20	20	28.284	0.003055	-0.000089	0.000088	-0.001786	0.002482
2C	Iron & Steel Production	CH4	16.357	20.390	0.4	50	50.002	0.001614	0.000009	0.000026	0.000457	0.000015
4A	Enteric Fermentation	CH4	18527.713	15531.379	0.1	20	20.000	0.491813	0.000617	0.019977	0.012332	0.002825
4B	Manure Management	CH4	3608.070	2856.681	0.1	30	30.000	0.135687	-0.000096	0.003674	-0.002875	0.000520
4F	Field Burning	CH4	266.045	0.000	25	50	55.902	0.000000	-0.000278	0.000000	-0.013900	0.000000
5A	5A LUCF	CH4	0.000	0.000	1	20	20.025	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
5E2	5E2 LUCF	CH4	0.000	0.000	1	20	20.025	0.000000	0.000000	0.000000	0.000000	0.000000
6A	Solid Waste Disposal	CH4	49816.593	20288.285	15	46	48.384	1.554176	-0.025943	0.026096	-1.193382	0.553572
6B	Wastewater Handling	CH4	709.572	815.917	1	50	50.010	0.064604	0.000308	0.001049	0.015400	0.001484
6C	Waste Incineration	CH4	134.423	6.365	7	50	50.488	0.000509	-0.000132	0.000008	-0.006614	0.000081
		CH4 total	104,573.26	48,896.19								

Table A 7.6.4 Summary of error propagation uncertainty estimates excluding LULUCF, base year to the latest reported year (continued)

	Source Category	Gas	BaseYear Emissions 1990 & 1995	Year Y emissions 2008	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
			Gg CO2 equiv	Gg CO2 equiv	%	%	%	%	%	%	%	%
	A	B	C	D	E	F	G	H	I	J	K	L
1A1&1A2&1A4&1A5	Other Combustion	N2O	4670.540	3325.662	0.4	195	195.000	1.026758	-0.000603	0.004278	-0.117544	0.002420
1A3a	Aviation Fuel	N2O	13.196	21.437	20	170	171.172	0.005810	0.000014	0.000028	0.002343	0.000780
1A3b	Auto Fuel	N2O	1172.211	1066.125	2.8	170	170.023	0.286992	0.000146	0.001371	0.024888	0.005430
1A3b	Combined Fuel	N2O	0.000	0.000	15	30	33.541	0.000000	0.000000	0.000000	0.000000	0.000000
1A3d	Marine Fuel	N2O	31.174	40.906	1.7	170	170.008	0.011011	0.000020	0.000053	0.003407	0.000126
1A3	Other Diesel	N2O	224.533	315.668	1.7	140	140.010	0.069975	0.000171	0.000406	0.023996	0.000976
1B1	Coke Oven Gas	N2O	2.085	0.922	0.4	118	118.001	0.000172	-0.000001	0.000001	-0.000117	0.000001
1B2	Oil & Natural Gas	N2O	42.396	32.034	16	110	111.158	0.005638	-0.000003	0.000041	-0.000341	0.000932
2B	Adipic Acid Production	N2O	20737.345	947.019	0.5	15	15.008	0.022503	-0.020446	0.001218	-0.306686	0.000861
2B	Nitric Acid Production	N2O	3903.850	1464.657	10	230	230.217	0.533861	-0.002195	0.001884	-0.504913	0.026642
2C	Iron & Steel	N2O	11.107	9.960	0.4	118	118.001	0.001861	0.000001	0.000013	0.000142	0.000007
4B	Manure Management	N2O	2759.235	2121.002	1	414	414.001	1.390263	-0.000155	0.002728	-0.064214	0.003858
4D	Agricultural Soils	N2O	30406.856	23322.159	1	424	424.001	15.656335	-0.001775	0.029998	-0.752474	0.042424
4F	Field Burning	N2O	77.762	0.000	25	230	231.355	0.000000	-0.000081	0.000000	-0.018689	0.000000
4G	OvTerr Agriculture N2O (all)	N2O	0.000	0.000	10	50	50.990	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
5C2	5C2 LUCF	N2O	0.000	0.000	1	20	20.025	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
6B	Wastewater Handling	N2O	1033.354	1243.539	10	401	401.125	0.789756	0.000520	0.001599	0.208396	0.022620
6C	Waste Incineration	N2O	47.900	49.021	7	230	230.106	0.017859	0.000013	0.000063	0.002990	0.000624
		N2O Total	65,133.54	33,960.11								
2	Industrial Processes	HFC	15480	11249	1	19	19.026	0.338875	-0.001706	0.014470	-0.032406	0.020463
2	Industrial Processes	PFC	462	209	1	10	10.050	0.003325	-0.000214	0.000269	-0.002140	0.000380
2	Industrial Processes	SF6	1239	712	1	20	20.025	0.022570	-0.000379	0.000916	-0.007587	0.001295
		Halocarbon & SF6 Total	17,181.13	12,170.28								
	TOTALS	GWP	777,458.32	631,605.24								
	Total Uncertainties%							16.0				

Table A 7.6.5 Summary of error propagation uncertainty estimates excluding LULUCF, base year to the latest reported year (continued)

	Source Category	Gas	Emissions 1990 Gg CO2	Year Y emissions 2007 Gg CO2	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
			equiv	equiv	%	%	%	%	%	%	%	%	%
	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: IPCC Sectoral Tables of GHG Emissions

The tables in this Annex present summary data for UK greenhouse gas emissions for the years 1990-2008, 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.

A8.1 SUMMARY TABLES

Tables A8.1.1 to **A8.1.19** present UK GHG emissions as summary reports for national greenhouse gas inventories (IPCC Table 7A).

Table A 8.1.1 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[1]		PFCs[1]		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		**591,622.30**	**4,959.26**	**209.88**	**11.88**	**11,385.55**	**73.47**	**1,401.47**	**0.10**	**0.04**	**2,747.22**	**9,001.57**	**2,564.20**	**3,714.90**
1. Energy		**572,173.65**	**1,490.18**	**19.85**							**2,718.50**	**8,423.59**	**1,580.94**	**3,652.78**
A. Fuel Combustion	Reference Approach [2]	564,153.25												
	Sectoral Approach [2]	565,539.30	128.57	19.70							2,704.58	8,363.75	1,024.88	3,624.32
1. Energy Industries		236,075.50	9.65	6.54							846.10	133.03	8.31	2,872.28
2. Manufacturing Industries and Construction		98,891.95	15.42	5.23							404.79	731.77	28.21	416.76
3. Transport		116,434.52	30.31	4.65							1,196.40	6,309.51	880.64	94.00
4. Other Sectors		108,852.50	73.04	3.13							215.11	1,176.08	104.82	231.96
5. Other		5,284.82	0.15	0.16							42.18	13.37	2.89	9.33
B. Fugitive Emissions from Fuels		6,634.35	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		5,777.94	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**	**1,401.47**	**0.10**	**0.04**	**13.33**	**281.62**	**259.57**	**54.80**
A. Mineral Products		10,119.29	1.12	NE							NE	5.31	13.08	4.27
B. Chemical Industry		2,884.58	8.07	79.49	NO	NO	NO	NO	NO	NO	8.49	82.11	167.12	41.60
C. Metal Production		2,309.27	0.78	0.04				1,332.75		0.02	4.85	194.20	2.05	8.94
D. Other Production [3]		NE									NE	NE	77.33	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	57.82	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		**NE**		**NE,NO**							**NO**	**NO**	**667.39**	**NO**
4. Agriculture			**1,055.41**	**107.01**							**9.07**	**266.04**	**26.06**	**NO**
A. Enteric Fermentation			871.98											
B. Manure Management			170.76	8.67									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[4]			NE	98.09									NE	
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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	[5]	**2,929.06**	**0.80**	**0.03**							**0.20**	**6.97**	**NA,NO**	**NA**
A. Forest Land	[5]	-12,155.07	0.20	0.02							0.05	1.79	NO	
B. Cropland	[5]	15,822.10	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	[5]	-6,130.33	0.15	0.00							0.04	1.28	NO	
D. Wetlands	[5]	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	[5]	7,074.34	0.45	0.00							0.11	3.90	NO	
F. Other Land	[5]	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	[5]	-1,681.97	NE	NE							NE	NE	NA	NA
6. Waste		**1,206.44**	**2,402.90**	**3.47**							**6.12**	**23.34**	**30.24**	**7.32**
A. Solid Waste Disposal on Land	[6]	NA,NE,NO	2,363.11								NA,NE,NO	NA,NE,NO	23.63	
B. Waste-water Handling			33.38	3.31							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	[6]	1,206.44	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)*** [7]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [8]														
International Bunkers		**22,281.78**	**0.40**	**0.66**							**228.51**	**28.58**	**12.88**	**91.96**
Aviation		15,601.49	0.29	0.50							75.07	12.88	5.45	2.97
Marine		6,680.29	0.10	0.17							153.45	15.71	7.43	88.99
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**2,980.26**												

Table A 8.1.2 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[1]		PFCs[1]		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		**598,889.41**	**4,923.07**	**209.70**	**11.88**	**11,853.64**	**82.77**	**1,170.74**	**0.10**	**0.05**	**2,700.75**	**9,211.35**	**2,501.26**	**3,613.60**
1. Energy		**581,632.59**	**1,507.30**	**19.77**							**2,674.86**	**8,680.32**	**1,569.37**	**3,553.33**
A. Fuel Combustion	Reference Approach [2]	580,813.89												
	Sectoral Approach [2]	575,399.63	131.49	19.63							2,661.26	8,597.73	1,023.22	3,528.15
1. Energy Industries		236,171.89	9.67	6.54							802.20	132.64	8.23	2,762.77
2. Manufacturing Industries and Construction		98,830.04	15.19	5.10							389.37	684.28	26.70	429.66
3. Transport		115,905.59	30.09	4.64							1,199.97	6,485.17	878.11	91.38
4. Other Sectors		120,199.69	76.43	3.22							229.03	1,284.87	107.58	234.67
5. Other		4,292.42	0.12	0.13							40.69	10.77	2.59	9.68
B. Fugitive Emissions from Fuels		6,232.97	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		5,713.55	480.59	0.14							13.19	46.97	545.85	7.69
2. Industrial Processes		**13,215.55**	**9.48**	**80.02**	**11.88**	**11,853.64**	**82.77**	**1,170.74**	**0.10**	**0.05**	**11.84**	**271.98**	**248.74**	**53.07**
A. Mineral Products		8,611.32	0.91	NE							NE	4.31	12.62	3.46
B. Chemical Industry		2,920.52	8.03	79.99	NO	NO	NO	NO	NO	NO	7.68	80.28	156.98	40.98
C. Metal Production		1,683.72	0.53	0.03				1,095.57		0.02	4.16	187.39	1.92	8.63
D. Other Production [3]		NE									NE	NE	77.22	NE
E. Production of Halocarbons and SF_6						11,841.76		10.91		NA,NO				
F. Consumption of Halocarbons and SF_6					11.88	11.89	82.77	64.26	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		**NE**		**NE,NO**							**NO**	**NO**	**630.72**	**NO**
4. Agriculture			**1,039.26**	**106.45**							**7.76**	**227.78**	**22.52**	**NO**
A. Enteric Fermentation			858.90											
B. Manure Management			169.52	8.67									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[4]			NE	97.57									NE	
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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	(5)	**2,840.89**	**0.90**	**0.03**							**0.22**	**7.91**	**NA,NO**	**NA**
A. Forest Land	(5)	-12,635.55	0.35	0.02							0.09	3.02	NO	
B. Cropland	(5)	15,978.23	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	(5)	-6,074.88	0.16	0.00							0.04	1.37	NO	
D. Wetlands	(5)	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	(5)	6,989.43	0.40	0.00							0.10	3.52	NO	
F. Other Land	(5)	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	(5)	-1,416.34	NE	NE							NE	NE	NA	NA
6. Waste		**1,200.38**	**2,366.12**	**3.43**							**6.07**	**23.35**	**29.92**	**7.20**
A. Solid Waste Disposal on Land	(6)	NA,NE,NO	2,328.51								NA,NE,NO	NA,NE,NO	23.29	
B. Waste-water Handling			31.27	3.28							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	(6)	1,200.38	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)*** [7]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [8]														
International Bunkers		**21,784.53**	**0.34**	**0.65**							**221.42**	**27.30**	**11.88**	**88.09**
Aviation		15,324.15	0.24	0.49							72.81	12.09	4.68	3.89
Marine		6,460.38	0.10	0.16							148.60	15.21	7.19	84.20
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**3,138.43**												

Table A 8.1.3 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[1]		PFCs[1]		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		**581,664.61**	**4,850.51**	**188.44**	**13.02**	**12,323.11**	**93.79**	**573.24**	**0.10**	**0.05**	**2,588.43**	**8,804.68**	**2,441.72**	**3,434.66**
1. Energy		**565,768.91**	**1,487.21**	**19.39**							**2,565.79**	**8,348.26**	**1,550.40**	**3,377.93**
A. Fuel Combustion	Reference Approach [2]	569,528.11												
	Sectoral Approach [2]	559,181.57	123.90	19.24							2,552.28	8,293.61	1,000.16	3,353.98
1. Energy Industries		224,934.56	9.70	6.26							733.22	130.21	7.86	2,560.94
2. Manufacturing Industries and Construction		95,808.12	14.50	5.13							379.21	694.25	26.43	462.60
3. Transport		117,174.11	29.09	4.64							1,176.24	6,303.34	859.25	94.47
4. Other Sectors		117,177.98	70.50	3.09							225.68	1,155.55	104.18	226.82
5. Other		4,086.79	0.11	0.12							37.93	10.26	2.44	9.15
B. Fugitive Emissions from Fuels		6,587.34	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		6,137.34	476.14	0.15							13.16	22.20	549.96	7.91
2. Industrial Processes		**12,451.74**	**9.92**	**65.07**	**13.02**	**12,323.11**	**93.79**	**573.24**	**0.10**	**0.05**	**10.97**	**262.46**	**247.14**	**49.66**
A. Mineral Products		8,023.20	0.82	NE							NE	3.85	12.54	3.10
B. Chemical Industry		2,978.08	8.64	65.04	NO	NO	NO	NO	NO	NO	6.87	79.60	155.37	38.42
C. Metal Production		1,450.46	0.46	0.03				490.38		0.02	4.10	179.00	1.89	8.15
D. Other Production [3]		NE									NE	NE	77.34	NE
E. Production of Halocarbons and SF_6						12,310.08		10.96		NA,NO				
F. Consumption of Halocarbons and SF_6					13.02	13.03	93.79	71.89	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		**NE**		**NE,NO**							**NO**	**NO**	**598.13**	**NO**
4. Agriculture			**1,042.10**	**100.50**							**5.63**	**165.25**	**16.72**	**NO**
A. Enteric Fermentation			864.79											
B. Manure Management			169.44	8.06									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[4]			NE	92.28									NE	
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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	(5)	**2,284.79**	**0.62**	**0.03**							**0.15**	**5.41**	**NA,NO**	**NA**
A. Forest Land	(5)	-13,320.03	0.09	0.02							0.02	0.77	NO	
B. Cropland	(5)	15,983.46	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	(5)	-6,177.50	0.17	0.00							0.04	1.50	NO	
D. Wetlands	(5)	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	(5)	6,907.44	0.36	0.00							0.09	3.15	NO	
F. Other Land	(5)	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	(5)	-1,108.57	NE	NE							NE	NE	NA	NA
6. Waste		**1,159.17**	**2,310.66**	**3.46**							**5.88**	**23.31**	**29.33**	**7.07**
A. Solid Waste Disposal on Land	(6)	NA,NE,NO	2,269.81								NA,NE,NO	NA,NE,NO	22.70	
B. Waste-water Handling			34.76	3.32							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	(6)	1,159.17	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)*** [7]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [8]														
International Bunkers		**23,693.74**	**0.34**	**0.71**							**235.61**	**28.94**	**12.20**	**92.34**
Aviation		16,942.82	0.23	0.54							79.60	12.97	4.64	5.38
Marine		6,750.92	0.11	0.17							156.01	15.97	7.55	86.96
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**3,553.92**												

Table A 8.1.4 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[1]		PFCs[1]		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		**566,629.11**	**4,705.36**	**173.36**	**628.47**	**13,121.18**	**106.82**	**489.51**	**0.10**	**0.05**	**2,441.92**	**8,462.04**	**2,326.83**	**3,104.70**
1. Energy		**551,989.72**	**1,409.60**	**18.73**							**2,425.93**	**8,161.57**	**1,474.51**	**3,051.89**
A. Fuel Combustion	Reference Approach (2)	552,182.63												
	Sectoral Approach (2)	545,084.58	121.77	18.57							2,412.40	8,108.05	944.83	3,028.32
1. Energy Industries		207,098.36	9.90	5.51							632.48	120.43	7.73	2,226.77
2. Manufacturing Industries and Construction		94,973.50	14.52	4.92							380.07	692.43	26.75	459.35
3. Transport		118,267.37	27.56	4.87							1,135.33	6,018.74	804.66	92.03
4. Other Sectors		120,604.42	69.68	3.15							229.44	1,266.01	103.35	242.06
5. Other		4,140.93	0.12	0.12							35.09	10.44	2.34	8.10
B. Fugitive Emissions from Fuels		6,905.14	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		6,560.31	462.19	0.16							13.14	23.15	529.42	8.13
2. Industrial Processes		**12,439.90**	**8.71**	**52.44**	**628.47**	**13,121.18**	**106.82**	**489.51**	**0.10**	**0.05**	**10.25**	**268.16**	**241.41**	**47.46**
A. Mineral Products		8,053.44	0.69	NE							NE	3.24	12.09	2.61
B. Chemical Industry		3,021.49	7.59	52.42	NO	NO	NO	NO	NO	NO	6.06	81.76	149.63	36.66
C. Metal Production		1,364.97	0.44	0.03				381.33		0.02	4.20	183.16	1.89	8.19
D. Other Production (3)		NE									NE	NE	77.80	NE
E. Production of Halocarbons and SF_6						12,779.93		27.23		NA,NO				
F. Consumption of Halocarbons and SF_6					628.47	341.25	106.82	80.96	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		**NE**		**NE,NO**							**NO**	**NO**	**581.64**	**NO**
4. Agriculture			**1,034.85**	**98.72**							**0.12**	**3.53**	**0.47**	**NO**
A. Enteric Fermentation			863.95											
B. Manure Management			170.73	8.13									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils(4)			NE	90.59									NE	
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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	(5)	**1,123.70**	**0.63**	**0.02**							**0.16**	**5.48**	**NA,NO**	**NA**
A. Forest Land	(5)	-13,678.57	0.15	0.02							0.04	1.35	NO	
B. Cropland	(5)	15,566.14	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	(5)	-6,609.50	0.13	0.00							0.03	1.15	NO	
D. Wetlands	(5)	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	(5)	6,848.20	0.34	0.00							0.08	2.99	NO	
F. Other Land	(5)	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	(5)	-1,002.57	NE	NE							NE	NE	NA	NA
6. Waste		**1,075.80**	**2,251.57**	**3.44**							**5.46**	**23.30**	**28.80**	**5.36**
A. Solid Waste Disposal on Land	(6)	NA,NE,NO	2,211.71								NA,NE,NO	NA,NE,NO	22.12	
B. Waste-water Handling			34.46	3.30							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	(6)	1,075.80	5.41	0.15							5.46	23.30	6.68	5.36
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)* (7)		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: (8)														
International Bunkers		**24,832.29**	**0.33**	**0.74**							**239.34**	**29.62**	**12.21**	**91.47**
Aviation		18,148.90	0.22	0.58							85.16	13.83	4.75	4.61
Marine		6,683.39	0.11	0.17							154.18	15.78	7.46	86.86
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**3,705.44**												

Table A 8.1.5 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[1]		PFCs[1]		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		**560,553.17**	**4,372.68**	**177.07**	**2,513.56**	**14,049.99**	**122.25**	**485.88**	**0.09**	**0.05**	**2,355.66**	**8,002.53**	**2,262.88**	**2,658.80**
1. Energy		**544,986.74**	**1,113.93**	**19.12**							**2,341.43**	**7,700.02**	**1,422.91**	**2,603.88**
A. Fuel Combustion	Reference Approach (2)	545,963.45												
	Sectoral Approach (2)	537,863.50	108.05	18.95							2,327.89	7,645.18	889.05	2,581.22
1. Energy Industries		204,353.46	11.30	5.46							597.36	131.24	8.58	1,885.19
2. Manufacturing Industries and Construction		95,457.12	15.25	4.95							392.54	741.82	28.65	386.33
3. Transport		118,417.88	25.74	5.43							1,081.12	5,642.70	758.22	95.36
4. Other Sectors		115,675.24	55.64	2.99							224.02	1,119.41	91.38	206.61
5. Other		3,959.80	0.11	0.12							32.84	10.00	2.21	7.72
B. Fugitive Emissions from Fuels		7,123.23	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		6,959.98	458.16	0.16							13.10	24.01	533.60	8.35
2. Industrial Processes		**13,728.38**	**10.28**	**53.05**	**2,513.56**	**14,049.99**	**122.25**	**485.88**	**0.09**	**0.05**	**9.58**	**274.54**	**234.70**	**50.54**
A. Mineral Products		9,029.83	0.77	NE							NE	3.65	12.61	5.45
B. Chemical Industry		3,059.19	8.95	53.02	NO	NO	NO	NO	NO	NO	5.26	86.46	141.31	36.99
C. Metal Production		1,639.35	0.56	0.03				345.16		0.02	4.32	184.43	1.95	8.09
D. Other Production (3)		NE									NE	NE	78.83	NE
E. Production of Halocarbons and SF_6						13,264.93		49.01		NA,NO				
F. Consumption of Halocarbons and SF_6					2,513.56	785.06	122.25	91.71	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		**NE**		**NE,NO**							**NO**	**NO**	**576.96**	**NO**
4. Agriculture			**1,040.51**	**101.18**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			868.57											
B. Manure Management			171.94	8.27									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils(4)			NE	92.91									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	(5)	**916.58**	**0.61**	**0.02**							**0.15**	**5.32**	**NA,NO**	**NA**
A. Forest Land	(5)	-14,164.06	0.12	0.01							0.03	1.07	NO	
B. Cropland	(5)	15,618.32	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	(5)	-6,547.73	0.14	0.00							0.03	1.22	NO	
D. Wetlands	(5)	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	(5)	6,803.12	0.35	0.00							0.09	3.03	NO	
F. Other Land	(5)	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	(5)	-793.07	NE	NE							NE	NE	NA	NA
6. Waste		**921.47**	**2,207.36**	**3.70**							**4.50**	**22.64**	**28.31**	**4.38**
A. Solid Waste Disposal on Land	(6)	NA,NE,NO	2,167.42								NA,NE,NO	NA,NE,NO	21.67	
B. Waste-water Handling			35.96	3.58							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	(6)	921.47	3.98	0.12							4.50	22.64	6.64	4.38
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)* (7)		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: (8)														
International Bunkers		**25,149.23**	**0.30**	**0.76**							**233.04**	**28.42**	**11.62**	**83.24**
Aviation		18,897.62	0.20	0.60							88.74	13.66	4.64	6.00
Marine		6,251.61	0.10	0.16							144.30	14.77	6.99	77.24
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**4,914.03**												

Table A 8.1.6 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[(1)]		PFCs[(1)]		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		**551,702.87**	**4,329.41**	**172.58**	**5,472.03**	**15,467.98**	**140.50**	**461.90**	**0.10**	**0.05**	**2,250.87**	**7,490.49**	**2,082.95**	**2,351.65**
1. Energy		**535,429.66**	**1,155.46**	**19.57**							**2,239.45**	**7,173.49**	**1,276.68**	**2,289.80**
A. Fuel Combustion	Reference Approach [(2)]	543,527.74												
	Sectoral Approach [(2)]	526,774.12	93.62	19.37							2,225.10	7,118.43	821.82	2,272.40
1. Energy Industries		201,959.66	11.33	5.35							564.11	130.14	8.92	1,720.30
2. Manufacturing Industries and Construction		92,088.69	15.53	4.81							374.79	747.77	29.14	301.23
3. Transport		117,407.51	23.92	6.31							1,035.56	5,358.65	701.87	82.90
4. Other Sectors		111,432.09	42.74	2.77							217.61	872.07	79.69	160.33
5. Other		3,886.18	0.11	0.12							33.03	9.80	2.20	7.64
B. Fugitive Emissions from Fuels		8,655.54	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		8,429.70	462.19	0.20							13.88	24.17	454.59	6.61
2. Industrial Processes		**14,159.18**	**8.31**	**47.99**	**5,472.03**	**15,467.98**	**140.50**	**461.90**	**0.10**	**0.05**	**6.94**	**282.38**	**241.82**	**57.56**
A. Mineral Products		9,155.67	0.77	NE							NE	3.64	11.93	9.67
B. Chemical Industry		3,065.28	6.84	47.95	NO	NO	NO	NO	NO	NO	2.40	88.58	149.07	39.80
C. Metal Production		1,938.24	0.70	0.03				286.29		0.02	4.54	190.16	2.02	8.09
D. Other Production [(3)]		NE									NE	NE	78.80	NE
E. Production of Halocarbons and SF_6						13,980.68		70.79		NA,NO				
F. Consumption of Halocarbons and SF_6					5,472.03	1,487.30	140.50	104.83	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		**NE**		**NE,NO**							**NO**	**NO**	**536.84**	**NO**
4. Agriculture			**1,027.49**	**101.54**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			859.35											
B. Manure Management			168.15	8.09									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[(4)]			NE	93.45									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	(5)	**1,242.37**	**1.41**	**0.02**							**0.35**	**12.31**	**NA,NO**	**NA**
A. Forest Land	(5)	-13,727.88	0.96	0.02							0.24	8.38	NO	
B. Cropland	(5)	15,749.94	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	(5)	-6,460.78	0.16	0.00							0.04	1.36	NO	
D. Wetlands	(5)	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	(5)	6,722.26	0.29	0.00							0.07	2.57	NO	
F. Other Land	(5)	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	(5)	-1,041.17	NE	NE							NE	NE	NA	NA
6. Waste		**871.66**	**2,136.74**	**3.47**							**4.12**	**22.31**	**27.61**	**4.29**
A. Solid Waste Disposal on Land	(6)	NA,NE,NO	2,098.76								NA,NE,NO	NA,NE,NO	20.99	
B. Waste-water Handling			34.33	3.35							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	(6)	871.66	3.65	0.12							4.12	22.31	6.62	4.29
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)*** [(7)]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [(8)]														
International Bunkers		**26,798.92**	**0.30**	**0.81**							**248.82**	**29.86**	**12.25**	**92.98**
Aviation		20,089.05	0.20	0.64							94.28	14.04	4.77	5.10
Marine		6,709.87	0.11	0.17							154.55	15.82	7.48	87.88
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**5,239.55**												

Table A 8.1.7 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[1]		PFCs[1]		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		**573,836.98**	**4,216.64**	**172.21**	**9,232.59**	**16,660.88**	**162.12**	**479.90**	**0.06**	**0.05**	**2,179.97**	**7,542.01**	**1,990.65**	**2,029.10**
1. Energy		**557,207.88**	**1,101.73**	**18.92**							**2,168.70**	**7,228.10**	**1,202.40**	**1,969.61**
A. Fuel Combustion	Reference Approach [2]	555,841.20												
	Sectoral Approach [2]	547,928.15	96.47	18.72							2,157.29	7,174.07	774.04	1,951.00
1. Energy Industries		204,077.30	12.14	5.16							524.34	130.81	9.57	1,472.78
2. Manufacturing Industries and Construction		93,191.89	16.03	4.69							349.26	767.12	29.33	238.21
3. Transport		122,195.59	22.37	5.91							1,016.07	5,376.15	651.14	70.00
4. Other Sectors		124,658.38	45.82	2.84							234.56	890.40	81.81	162.32
5. Other		3,804.99	0.11	0.11							33.05	9.59	2.18	7.69
B. Fugitive Emissions from Fuels		9,279.73	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		8,912.96	449.05	0.20							10.95	23.16	428.09	7.12
2. Industrial Processes		**14,742.07**	**9.51**	**47.69**	**9,232.59**	**16,660.88**	**162.12**	**479.90**	**0.06**	**0.05**	**6.67**	**282.12**	**235.69**	**56.63**
A. Mineral Products		9,443.12	0.72	NE							NE	3.40	10.69	10.16
B. Chemical Industry		3,073.51	8.00	47.65	NO	NO	NO	NO	NO	NO	2.25	85.69	141.91	38.16
C. Metal Production		2,225.44	0.79	0.03				282.17		0.02	4.42	193.03	2.07	8.30
D. Other Production [3]		NE									NE	NE	81.01	NE
E. Production of Halocarbons and SF_6						14,320.56		77.13		NA,NO				
F. Consumption of Halocarbons and SF_6					9,232.59	2,340.32	162.12	120.61	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		**NE**		**NE,NO**							**NO**	**NO**	**525.67**	**NO**
4. Agriculture			**1,037.93**	**101.99**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			868.57											
B. Manure Management			169.36	8.07									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[4]			NE	93.92									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	(5)	**1,000.44**	**1.02**	**0.02**							**0.25**	**8.91**	**NA,NO**	**NA**
A. Forest Land	(5)	-13,604.66	0.50	0.01							0.12	4.36	NO	
B. Cropland	(5)	15,787.97	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	(5)	-6,704.72	0.18	0.00							0.05	1.60	NO	
D. Wetlands	(5)	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	(5)	6,707.07	0.34	0.00							0.08	2.96	NO	
F. Other Land	(5)	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	(5)	-1,185.22	NE	NE							NE	NE	NA	NA
6. Waste		**886.60**	**2,066.45**	**3.59**							**4.36**	**22.88**	**26.90**	**2.87**
A. Solid Waste Disposal on Land	(6)	NA,NE,NO	2,027.19								NA,NE,NO	NA,NE,NO	20.27	
B. Waste-water Handling			35.27	3.46							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	(6)	886.60	3.99	0.13							4.36	22.88	6.63	2.87
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)*** [7]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [8]														
International Bunkers		**28,587.63**	**0.31**	**0.86**							**269.23**	**31.94**	**13.14**	**100.95**
Aviation		21,254.34	0.20	0.67							100.14	14.64	4.95	5.40
Marine		7,333.29	0.12	0.18							169.10	17.31	8.19	95.55
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**5,478.57**												

Table A 8.1.8 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[1]		PFCs[1]		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		**550,034.46**	**3,967.05**	**175.66**	**14,047.63**	**18,996.05**	**187.70**	**398.06**	**0.05**	**0.05**	**2,043.78**	**7,048.27**	**1,918.40**	**1,652.14**
1. Energy		**533,976.88**	**1,048.39**	**18.29**							**2,034.36**	**6,726.67**	**1,164.33**	**1,591.31**
A. Fuel Combustion	Reference Approach (2)	532,199.01												
	Sectoral Approach (2)	526,525.64	91.75	18.11							2,029.58	6,677.45	715.00	1,572.48
1. Energy Industries		190,870.14	12.23	4.70							440.75	71.06	7.54	1,143.68
2. Manufacturing Industries and Construction		93,137.55	16.63	4.56							345.46	756.11	29.51	218.76
3. Transport		123,643.02	20.60	5.95							986.67	5,019.75	596.54	57.95
4. Other Sectors		115,244.21	42.19	2.79							222.65	821.42	79.23	143.86
5. Other		3,630.71	0.10	0.11							34.06	9.11	2.18	8.23
B. Fugitive Emissions from Fuels		7,451.24	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		6,991.61	423.96	0.18							4.40	18.36	449.06	7.44
2. Industrial Processes		**14,863.76**	**8.02**	**48.29**	**14,047.63**	**18,996.05**	**187.70**	**398.06**	**0.05**	**0.05**	**7.17**	**289.31**	**217.46**	**59.71**
A. Mineral Products		10,289.48	0.71	NE							NE	3.35	10.13	13.41
B. Chemical Industry		2,612.38	6.62	48.26	NO	NO	NO	NO	NO	NO	2.60	86.59	125.75	35.62
C. Metal Production		1,961.90	0.69	0.03				220.26		0.02	4.57	199.37	2.12	10.68
D. Other Production (3)		NE									NE	NE	79.46	NE
E. Production of Halocarbons and SF_6						15,622.21		38.32		NA,NO				
F. Consumption of Halocarbons and SF_6					14,047.63	3,373.83	187.70	139.48	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		**NE**		**NE,NO**							**NO**	**NO**	**511.36**	**NO**
4. Agriculture			**1,006.92**	**105.14**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			840.24											
B. Manure Management			166.68	8.15									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils(4)			NE	96.99									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	(5)	**693.15**	**1.20**	**0.02**							**0.30**	**10.48**	**NA,NO**	**NA**
A. Forest Land	(5)	-13,360.12	0.65	0.01							0.16	5.72	NO	
B. Cropland	(5)	15,529.82	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	(5)	-6,821.67	0.15	0.00							0.04	1.33	NO	
D. Wetlands	(5)	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	(5)	6,709.90	0.39	0.00							0.10	3.44	NO	
F. Other Land	(5)	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	(5)	-1,364.77	NE	NE							NE	NE	NA	NA
6. Waste		**500.66**	**1,902.53**	**3.92**							**1.95**	**21.80**	**25.25**	**1.12**
A. Solid Waste Disposal on Land	(6)	NA,NE,NO	1,866.16								NA,NE,NO	NA,NE,NO	18.66	
B. Waste-water Handling			36.21	3.85							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	(6)	500.66	0.16	0.07							1.95	21.80	6.59	1.12
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)*** (7)		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: (8)														
International Bunkers		**30,823.07**	**0.33**	**0.92**							**295.37**	**34.57**	**14.33**	**119.67**
Aviation		22,599.66	0.20	0.72							106.31	15.22	5.17	7.18
Marine		8,223.40	0.13	0.21							189.06	19.35	9.15	112.49
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**5,761.72**												

Table A 8.1.9 Summary Report For National Greenhouse Gas Inventories (IPCC TABLE 7A) – 1998

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		Net CO_2 emissions/removals (Gg)	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
				CO_2 equivalent (Gg)					(Gg)					
Total National Emissions and Removals		**551,983.79**	**3,760.87**	**173.79**	**19,752.40**	**16,751.54**	**193.40**	**388.14**	**0.05**	**0.05**	**2,002.64**	**6,761.55**	**1,788.08**	**1,621.52**
1. Energy		**536,554.01**	**961.49**	**18.38**							**1,994.35**	**6,464.54**	**1,063.02**	**1,561.23**
A. Fuel Combustion	Reference Approach [2]	539,256.02												
	Sectoral Approach [2]	529,474.28	92.36	18.20							1,990.12	6,416.11	656.83	1,550.40
1. Energy Industries		195,511.76	13.45	4.94							443.11	88.58	4.93	1,187.53
2. Manufacturing Industries and Construction		91,364.72	16.09	4.44							341.56	721.20	29.40	185.68
3. Transport		122,866.51	18.94	6.02							958.04	4,822.83	540.91	50.80
4. Other Sectors		116,537.29	43.80	2.69							221.63	775.43	79.84	120.37
5. Other		3,194.00	0.09	0.10							25.79	8.07	1.76	6.03
B. Fugitive Emissions from Fuels		7,079.73	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		6,921.31	414.65	0.18							3.84	17.68	405.93	1.37
2. Industrial Processes		**14,847.54**	**6.14**	**49.19**	**19,752.40**	**16,751.54**	**193.40**	**388.14**	**0.05**	**0.05**	**6.15**	**265.63**	**206.07**	**59.06**
A. Mineral Products		10,248.30	0.71	NE							NE	3.35	9.93	13.09
B. Chemical Industry		2,812.40	4.80	49.16	NO	NO	NO	NO	NO	NO	2.49	69.03	114.75	36.53
C. Metal Production		1,786.83	0.63	0.03				208.07		0.02	3.66	193.25	2.02	9.44
D. Other Production [3]		NE									NE	NE	79.36	NE
E. Production of Halocarbons and SF_6						12,117.13		42.50		NA,NO				
F. Consumption of Halocarbons and SF_6					19,752.40	4,634.41	193.40	137.57	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		**NE**		**NE,NO**							**NO**	**NO**	**494.84**	**NO**
4. Agriculture			**1,006.97**	**102.24**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			839.55											
B. Manure Management			167.42	8.38									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[4]			NE	93.87									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	[5]	**77.02**	**0.91**	**0.02**							**0.23**	**7.94**	**NA,NO**	**NA**
A. Forest Land	[5]	-13,321.59	0.36	0.01							0.09	3.17	NO	
B. Cropland	[5]	15,417.91	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	[5]	-7,219.86	0.16	0.00							0.04	1.39	NO	
D. Wetlands	[5]	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	[5]	6,669.02	0.39	0.00							0.10	3.38	NO	
F. Other Land	[5]	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	[5]	-1,468.47	NE	NE							NE	NE	NA	NA
6. Waste		**505.23**	**1,785.36**	**3.96**							**1.91**	**23.45**	**24.15**	**1.23**
A. Solid Waste Disposal on Land	[6]	NA,NE,NO	1,748.00								NA,NE,NO	NA,NE,NO	17.48	
B. Waste-water Handling			37.15	3.80							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	[6]	505.23	0.20	0.16							1.91	23.45	6.67	1.23
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)*** [7]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [8]														
International Bunkers		**34,143.41**	**0.34**	**1.02**							**324.02**	**37.77**	**15.55**	**121.35**
Aviation		25,169.66	0.20	0.80							117.84	16.67	5.57	7.99
Marine		8,973.75	0.14	0.22							206.18	21.10	9.98	113.35
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**5,823.07**												

Table A 8.1.10 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[(1)]		PFCs[(1)]		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		**541,602.25**	**3,514.04**	**139.48**	**25,164.85**	**9,949.39**	**224.58**	**367.55**	**0.05**	**0.06**	**1,905.15**	**6,392.14**	**1,608.61**	**1,210.08**
1. Energy		**526,599.53**	**869.55**	**17.87**							**1,896.83**	**6,078.55**	**958.20**	**1,160.07**
A. Fuel Combustion	Reference Approach [(2)]	533,688.97												
	Sectoral Approach [(2)]	520,561.92	93.06	17.70							1,892.25	6,040.58	600.32	1,150.33
1. Energy Industries		185,686.09	13.19	4.47							397.89	80.95	4.96	875.48
2. Manufacturing Industries and Construction		91,984.78	15.73	4.43							328.71	703.49	28.93	146.53
3. Transport		123,679.15	17.32	6.04							918.52	4,491.67	483.61	38.63
4. Other Sectors		116,062.26	46.73	2.66							219.68	756.54	81.02	83.37
5. Other		3,149.63	0.09	0.09							27.45	7.93	1.81	6.32
B. Fugitive Emissions from Fuels		6,037.61	776.50	0.17							4.59	37.97	357.88	9.74
1. Solid Fuels		112.08	380.84	0.00							0.32	23.94	0.26	8.01
2. Oil and Natural Gas		5,925.53	395.66	0.17							4.27	14.03	357.62	1.73
2. Industrial Processes		**14,740.26**	**5.35**	**17.31**	**25,164.85**	**9,949.39**	**224.58**	**367.55**	**0.05**	**0.06**	**6.30**	**282.73**	**166.41**	**48.58**
A. Mineral Products		9,802.72	0.59	NE							NE	1.56	8.57	8.94
B. Chemical Industry		2,846.55	4.03	17.28	NO	NO	NO	NO	NO	NO	2.69	65.91	75.17	31.30
C. Metal Production		2,090.98	0.73	0.03				187.75		0.03	3.61	215.26	1.93	8.34
D. Other Production [(3)]		NE									NE	NE	80.75	NE
E. Production of Halocarbons and SF_6						4,881.55		19.50		NA,NO				
F. Consumption of Halocarbons and SF_6					25,164.85	5,067.84	224.58	160.30	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		**NE**		**NE,NO**							**NO**	**NO**	**461.37**	**NO**
4. Agriculture			**1,004.08**	**100.45**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			841.44											
B. Manure Management			162.63	8.67									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[(4)]			NE	91.78									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	(5)	**-201.67**	**0.83**	**0.01**							**0.21**	**7.28**	**NA,NO**	**NA**
A. Forest Land	(5)	-13,489.27	0.06	0.01							0.01	0.50	NO	
B. Cropland	(5)	15,320.53	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	(5)	-7,124.11	0.39	0.00							0.10	3.43	NO	
D. Wetlands	(5)	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	(5)	6,604.51	0.38	0.00							0.10	3.35	NO	
F. Other Land	(5)	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	(5)	-1,513.34	NE	NE							NE	NE	NA	NA
6. Waste		**464.13**	**1,634.23**	**3.83**							**1.81**	**23.58**	**22.63**	**1.44**
A. Solid Waste Disposal on Land	(6)	NA,NE,NO	1,598.00								NA,NE,NO	NA,NE,NO	15.98	
B. Waste-water Handling			36.02	3.68							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	(6)	464.13	0.22	0.16							1.81	23.58	6.65	1.44
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)*** [(7)]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [(8)]														
International Bunkers		**33,834.64**	**0.27**	**1.03**							**276.49**	**32.83**	**12.96**	**87.59**
Aviation		27,331.24	0.17	0.87							126.24	17.45	5.69	6.07
Marine		6,503.39	0.10	0.16							150.25	15.38	7.27	81.52
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**6,410.95**												

Table A 8.1.11 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[1]		PFCs[1]		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		**549,839.35**	**3,298.13**	**136.26**	**32,187.62**	**8,635.71**	**260.51**	**466.40**	**0.08**	**0.08**	**1,872.64**	**5,636.32**	**1,485.80**	**1,226.08**
1. Energy		**535,411.78**	**791.44**	**18.01**							**1,864.58**	**5,318.98**	**872.36**	**1,183.91**
A. Fuel Combustion	Reference Approach [2]	547,133.20												
	Sectoral Approach [2]	529,677.39	79.47	17.85							1,861.38	5,281.56	516.55	1,175.04
1. Energy Industries		196,354.91	12.48	4.93							429.09	92.18	6.03	933.24
2. Manufacturing Industries and Construction		91,741.57	15.16	4.33							316.62	587.70	28.41	132.08
3. Transport		122,985.87	15.20	5.99							874.91	3,933.47	408.88	29.20
4. Other Sectors		115,678.74	36.55	2.51							214.34	660.88	71.51	74.37
5. Other		2,916.31	0.08	0.09							26.42	7.33	1.71	6.16
B. Fugitive Emissions from Fuels		5,734.39	711.97	0.15							3.20	37.42	355.81	8.86
1. Solid Fuels		102.36	333.43	0.00							0.31	24.42	0.20	7.31
2. Oil and Natural Gas		5,632.02	378.54	0.15							2.89	13.00	355.61	1.55
2. Industrial Processes		**14,296.50**	**5.04**	**17.90**	**32,187.62**	**8,635.71**	**260.51**	**466.40**	**0.08**	**0.08**	**5.91**	**283.46**	**160.79**	**40.99**
A. Mineral Products		9,284.93	0.59	NE							NE	2.75	9.79	10.51
B. Chemical Industry		3,028.83	3.78	17.87	NO	NO	NO	NO	NO	NO	2.43	82.93	70.23	22.94
C. Metal Production		1,982.75	0.68	0.03				257.46		0.05	3.48	197.78	1.77	7.53
D. Other Production [3]		NE									NE	NE	79.00	NE
E. Production of Halocarbons and SF_6						2,619.64		23.08		NA,NO				
F. Consumption of Halocarbons and SF_6					32,187.62	6,016.07	260.51	185.86	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		**NE**		**NE,NO**							**NO**	**NO**	**430.98**	**NO**
4. Agriculture			**962.35**	**96.30**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			809.08											
B. Manure Management			153.27	7.97									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[4]			NE	88.34									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	(5)	**-339.40**	**1.19**	**0.02**							**0.29**	**10.37**	**NA,NO**	**NA**
A. Forest Land	(5)	-13,755.67	0.20	0.01							0.05	1.75	NO	
B. Cropland	(5)	15,339.05	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	(5)	-7,221.51	0.59	0.00							0.15	5.15	NO	
D. Wetlands	(5)	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	(5)	6,566.69	0.40	0.00							0.10	3.47	NO	
F. Other Land	(5)	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	(5)	-1,267.95	NE	NE							NE	NE	NA	NA
6. Waste		**470.47**	**1,538.11**	**4.03**							**1.86**	**23.51**	**21.67**	**1.18**
A. Solid Waste Disposal on Land	(6)	NA,NE,NO	1,501.00								NA,NE,NO	NA,NE,NO	15.01	
B. Waste-water Handling			36.89	3.87							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	(6)	470.47	0.23	0.16							1.86	23.51	6.66	1.18
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)*** [7]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [8]														
International Bunkers		**35,861.82**	**0.23**	**1.10**							**270.37**	**31.94**	**12.36**	**75.63**
Aviation		30,139.08	0.14	0.96							137.77	18.37	5.94	6.89
Marine		5,722.74	0.09	0.14							132.60	13.57	6.42	68.74
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**6,572.84**												

Table A 8.1.12 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[1]		PFCs[1]		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		**561,479.64**	**3,012.00**	**128.33**	**38,763.19**	**9,271.81**	**157.40**	**386.43**	**0.07**	**0.06**	**1,830.05**	**5,254.52**	**1,389.20**	**1,104.31**
1. Energy		**548,372.90**	**756.75**	**18.03**							**1,822.61**	**4,923.85**	**803.75**	**1,068.30**
A. Fuel Combustion	Reference Approach [2]	552,408.38												
	Sectoral Approach [2]	542,441.96	73.95	17.88							1,819.23	4,897.15	454.48	1,058.52
1. Energy Industries		206,934.00	13.32	5.21							455.50	92.14	5.31	829.85
2. Manufacturing Industries and Construction		91,464.50	14.01	4.33							303.96	620.75	28.37	135.45
3. Transport		122,591.71	13.13	5.78							818.92	3,529.74	351.29	23.15
4. Other Sectors		118,529.85	33.41	2.48							215.96	647.16	67.86	64.31
5. Other		2,921.90	0.08	0.09							24.91	7.37	1.66	5.76
B. Fugitive Emissions from Fuels		5,930.94	682.80	0.15							3.38	26.70	349.27	9.78
1. Solid Fuels		101.68	301.86	0.00							0.25	13.68	0.17	8.16
2. Oil and Natural Gas		5,829.26	380.94	0.15							3.13	13.01	349.09	1.62
2. Industrial Processes		**13,074.89**	**4.46**	**15.54**	**38,763.19**	**9,271.81**	**157.40**	**386.43**	**0.07**	**0.06**	**4.64**	**272.96**	**151.07**	**33.69**
A. Mineral Products		8,442.73	0.58	NE							NE	2.54	9.22	9.07
B. Chemical Industry		3,117.14	3.46	15.52	NO	NO	NO	NO	NO	NO	1.62	81.89	60.02	16.83
C. Metal Production		1,515.02	0.42	0.02				217.59		0.03	3.02	188.53	1.58	7.79
D. Other Production [3]		NE									NE	NE	80.26	NE
E. Production of Halocarbons and SF_6						2,387.42		54.05		NA,NO				
F. Consumption of Halocarbons and SF_6					38,763.19	6,884.39	157.40	114.80	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		**NE**		**NE,NO**							**NO**	**NO**	**414.69**	**NO**
4. Agriculture			**904.02**	**90.69**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			758.33											
B. Manure Management			145.69	7.76									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[4]			NE	82.93									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	(5)	**-460.44**	**1.47**	**0.02**							**0.37**	**12.90**	**NA,NO**	**NA**
A. Forest Land	(5)	-14,280.31	0.28	0.01							0.07	2.42	NO	
B. Cropland	(5)	15,286.51	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	(5)	-7,175.80	0.77	0.01							0.19	6.78	NO	
D. Wetlands	(5)	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	(5)	6,543.35	0.42	0.00							0.11	3.71	NO	
F. Other Land	(5)	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	(5)	-834.18	NE	NE							NE	NE	NA	NA
6. Waste		**492.28**	**1,345.29**	**4.04**							**2.44**	**44.81**	**19.69**	**2.33**
A. Solid Waste Disposal on Land	(6)	NA,NE,NO	1,308.00								NA,NE,NO	NA,NE,NO	13.08	
B. Waste-water Handling			37.13	3.89							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	(6)	492.28	0.16	0.16							2.44	44.81	6.61	2.33
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other *(please specify)* [7]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [8]														
International Bunkers		**35,793.35**	**0.22**	**1.09**							**281.88**	**32.45**	**12.77**	**77.25**
Aviation		29,374.46	0.12	0.93							133.45	17.26	5.58	7.46
Marine		6,418.89	0.10	0.16							148.43	15.19	7.19	69.79
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**7,261.41**												

Table A 8.1.13 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[1]		PFCs[1]		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		**543,914.91**	**2,868.50**	**122.69**	**46,918.86**	**9,747.64**	**154.38**	**320.66**	**0.07**	**0.06**	**1,729.89**	**4,627.90**	**1,314.58**	**977.38**
1. Energy		**531,912.37**	**738.03**	**17.76**							**1,725.36**	**4,370.43**	**742.53**	**945.11**
A. Fuel Combustion	Reference Approach [2]	534,017.48												
	Sectoral Approach [2]	526,255.71	66.50	17.61							1,721.63	4,350.84	403.85	938.10
1. Energy Industries		204,296.70	13.68	5.24							442.30	88.88	6.13	751.01
2. Manufacturing Industries and Construction		83,140.42	12.85	4.26							284.24	567.68	27.67	115.60
3. Transport		124,626.22	11.75	5.65							766.83	3,146.57	305.54	20.71
4. Other Sectors		111,135.74	28.14	2.36							204.52	539.98	62.85	45.53
5. Other		3,056.63	0.09	0.09							23.75	7.74	1.65	5.25
B. Fugitive Emissions from Fuels		5,656.66	671.53	0.15							3.73	19.59	338.68	7.01
1. Solid Fuels		107.95	301.96	0.00							0.26	7.11	0.13	5.81
2. Oil and Natural Gas		5,548.71	369.56	0.14							3.46	12.48	338.55	1.21
2. Industrial Processes		**12,488.78**	**4.35**	**8.61**	**46,918.86**	**9,747.64**	**154.38**	**320.66**	**0.07**	**0.06**	**2.43**	**222.83**	**150.89**	**31.33**
A. Mineral Products		8,287.39	0.59	NE							NE	2.53	9.60	12.00
B. Chemical Industry		3,029.91	3.47	8.60	NO	NO	NO	NO	NO	NO	1.09	39.41	60.06	13.07
C. Metal Production		1,171.48	0.29	0.02				150.49		0.04	1.34	180.89	1.36	6.26
D. Other Production [3]		NE									NE	NE	79.87	NE
E. Production of Halocarbons and SF_6						2,034.23		57.35		NA,NO				
F. Consumption of Halocarbons and SF_6					46,918.86	7,713.41	154.38	112.82	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		**NE**		**NE,NO**							**NO**	**NO**	**402.63**	**NO**
4. Agriculture			**892.34**	**92.24**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			749.35											
B. Manure Management			142.99	7.46									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[4]			NE	84.79									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	[5]	**-977.58**	**1.27**	**0.02**							**0.32**	**11.11**	**NA,NO**	**NA**
A. Forest Land	[5]	-14,986.41	0.23	0.01							0.06	2.05	NO	
B. Cropland	[5]	15,312.53	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	[5]	-7,511.91	0.67	0.00							0.17	5.89	NO	
D. Wetlands	[5]	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	[5]	6,475.07	0.36	0.00							0.09	3.17	NO	
F. Other Land	[5]	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	[5]	-266.86	NE	NE							NE	NE	NA	NA
6. Waste		**491.34**	**1,232.51**	**4.06**							**1.78**	**23.54**	**18.53**	**0.93**
A. Solid Waste Disposal on Land	[6]	NA,NE,NO	1,195.00								NA,NE,NO	NA,NE,NO	11.95	
B. Waste-water Handling			37.35	3.91							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	[6]	491.34	0.16	0.16							1.78	23.54	6.58	0.93
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)*** [7]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [8]														
International Bunkers		**34,207.02**	**0.19**	**1.05**							**254.51**	**29.74**	**11.56**	**67.20**
Aviation		28,858.25	0.11	0.92							129.95	16.99	5.53	6.05
Marine		5,348.77	0.08	0.13							124.56	12.75	6.03	61.15
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**7,632.72**												

Table A 8.1.14 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[1]		PFCs[1]		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		**555,710.43**	**2,584.17**	**120.84**	**53,012.63**	**10,466.83**	**157.57**	**277.33**	**0.06**	**0.06**	**1,748.29**	**4,160.46**	**1,198.36**	**967.92**
1. Energy		**542,976.77**	**598.50**	**17.59**							**1,743.55**	**3,977.74**	**636.43**	**933.24**
A. Fuel Combustion	Reference Approach [2]	543,563.07												
	Sectoral Approach [2]	537,602.87	63.93	17.47							1,740.62	3,956.29	364.68	924.72
1. Energy Industries		211,832.90	12.99	5.29							469.96	96.49	5.07	743.72
2. Manufacturing Industries and Construction		84,248.68	13.70	4.25							280.00	548.35	27.51	104.28
3. Transport		126,043.19	10.57	5.52							762.36	2,822.13	269.07	30.91
4. Other Sectors		112,315.93	26.57	2.30							202.40	481.34	61.27	39.92
5. Other		3,162.18	0.09	0.09							25.89	7.99	1.75	5.89
B. Fugitive Emissions from Fuels		5,373.90	534.58	0.13							2.93	21.44	271.76	8.51
1. Solid Fuels		111.87	259.87	0.00							0.28	10.74	0.12	7.28
2. Oil and Natural Gas		5,262.03	274.71	0.12							2.65	10.70	271.64	1.23
2. Industrial Processes		**13,291.52**	**5.56**	**9.10**	**53,012.63**	**10,466.83**	**157.57**	**277.33**	**0.06**	**0.06**	**2.63**	**148.63**	**146.72**	**33.75**
A. Mineral Products		8,473.91	0.62	NE							NE	2.67	9.24	16.37
B. Chemical Industry		2,970.13	4.35	9.08	NO	NO	NO	NO	NO	NO	1.19	37.00	55.71	9.90
C. Metal Production		1,847.49	0.59	0.02				110.91		0.03	1.44	108.95	1.57	7.49
D. Other Production [3]		NE									NE	NE	80.21	NE
E. Production of Halocarbons and SF_6						1,981.33		55.71		NA,NO				
F. Consumption of Halocarbons and SF_6					53,012.63	8,485.49	157.57	110.71	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		**NE**		**NE,NO**							**NO**	**NO**	**398.16**	**NO**
4. Agriculture			**893.17**	**90.08**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			753.26											
B. Manure Management			139.91	7.34									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[4]			NE	82.75									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	[5]	**-1,029.54**	**1.21**	**0.02**							**0.30**	**10.58**	**NA,NO**	**NA**
A. Forest Land	[5]	-15,595.04	0.20	0.01							0.05	1.73	NO	
B. Cropland	[5]	15,384.30	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	[5]	-7,320.91	0.63	0.00							0.16	5.55	NO	
D. Wetlands	[5]	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	[5]	6,459.86	0.38	0.00							0.09	3.30	NO	
F. Other Land	[5]	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	[5]	42.25	NE	NE							NE	NE	NA	NA
6. Waste		**471.68**	**1,085.73**	**4.04**							**1.80**	**23.51**	**17.05**	**0.93**
A. Solid Waste Disposal on Land	[6]	NA,NE,NO	1,048.00								NA,NE,NO	NA,NE,NO	10.48	
B. Waste-water Handling			37.58	3.89							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	[6]	471.68	0.16	0.16							1.80	23.51	6.57	0.93
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)*** [7]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [8]														
International Bunkers		**34,333.27**	**0.18**	**1.06**							**244.89**	**28.57**	**11.00**	**68.37**
Aviation		29,544.62	0.10	0.94							132.78	17.09	5.58	7.13
Marine		4,788.65	0.07	0.12							112.11	11.47	5.43	61.24
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**8,483.78**												

Table A 8.1.15 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[1]		PFCs[1]		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		**555,288.14**	**2,504.53**	**122.58**	**55,902.85**	**9,607.77**	**157.74**	**342.42**	**0.05**	**0.05**	**1,703.51**	**3,860.05**	**1,125.80**	**813.01**
1. Energy		**542,837.73**	**583.04**	**17.36**							**1,698.49**	**3,685.06**	**576.07**	**779.45**
A. Fuel Combustion	Reference Approach [2]	545,422.53												
	Sectoral Approach [2]	537,558.21	62.07	17.23							1,695.56	3,667.54	329.77	769.50
1. Energy Industries		210,075.26	13.50	5.11							451.14	96.96	5.90	583.81
2. Manufacturing Industries and Construction		82,746.12	13.36	4.34							280.91	578.85	28.08	105.81
3. Transport		127,384.93	9.52	5.45							735.58	2,530.24	233.42	37.49
4. Other Sectors		114,299.14	25.61	2.24							200.48	453.83	60.58	35.93
5. Other		3,052.75	0.08	0.09							27.45	7.67	1.79	6.46
B. Fugitive Emissions from Fuels		5,279.52	520.97	0.13							2.92	17.51	246.29	9.95
1. Solid Fuels		168.08	234.90	0.01							0.36	6.61	0.10	8.60
2. Oil and Natural Gas		5,111.43	286.08	0.13							2.56	10.90	246.20	1.35
2. Industrial Processes		**13,748.58**	**5.36**	**11.53**	**55,902.85**	**9,607.77**	**157.74**	**342.42**	**0.05**	**0.05**	**2.95**	**141.27**	**136.32**	**32.65**
A. Mineral Products		8,619.05	0.61	NE							NE	2.61	9.36	16.55
B. Chemical Industry		3,076.03	4.09	11.51	NO	NO	NO	NO	NO	NO	1.30	28.81	45.25	8.72
C. Metal Production		2,053.49	0.66	0.03				153.04		0.02	1.65	109.85	1.62	7.38
D. Other Production [3]		NE									NE	NE	80.09	NE
E. Production of Halocarbons and SF_6						444.68		90.23		NA,NO				
F. Consumption of Halocarbons and SF_6					55,902.85	9,161.91	157.74	99.15	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		**NE**		**NE,NO**							**NO**	**NO**	**397.00**	**NO**
4. Agriculture			**899.99**	**89.62**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			759.15											
B. Manure Management			140.84	7.19									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[4]			NA,NE	82.43									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	[5]	**-1,770.93**	**1.18**	**0.01**							**0.29**	**10.36**	**NA,NO**	**NA**
A. Forest Land	[5]	-16,238.04	0.26	0.01							0.06	2.29	NO	
B. Cropland	[5]	15,315.52	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	[5]	-7,640.19	0.57	0.00							0.14	4.95	NO	
D. Wetlands	[5]	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	[5]	6,423.66	0.36	0.00							0.09	3.13	NO	
F. Other Land	[5]	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	[5]	368.12	NE	NE							NE	NE	NA	NA
6. Waste		**472.76**	**1,014.95**	**4.06**							**1.78**	**23.36**	**16.42**	**0.91**
A. Solid Waste Disposal on Land	[6]	NA,NE,NO	977.00								NA,NE,NO	NA,NE,NO	9.77	
B. Waste-water Handling			37.80	3.90							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	[6]	472.76	0.14	0.16							1.78	23.36	6.65	0.91
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)*** [7]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [8]														
International Bunkers		**38,124.78**	**0.19**	**1.17**							**278.58**	**31.88**	**12.38**	**80.41**
Aviation		32,399.22	0.10	1.03							145.11	18.22	5.92	8.43
Marine		5,725.56	0.09	0.14							133.47	13.66	6.46	71.97
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**9,596.11**												

Table A 8.1.16 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[1]		PFCs[1]		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		**552,824.35**	**2,446.18**	**118.83**	**59,602.06**	**10,411.15**	**146.95**	**261.42**	**0.05**	**0.05**	**1,677.21**	**3,463.93**	**1,068.14**	**687.17**
1. Energy		**540,345.93**	**527.44**	**17.39**							**1,672.60**	**3,289.66**	**522.99**	**653.48**
A. Fuel Combustion	Reference Approach [2]	546,555.35												
	Sectoral Approach [2]	534,475.55	58.37	17.24							1,669.46	3,271.13	297.71	644.55
1. Energy Industries		210,597.62	13.00	5.29							465.66	101.38	5.35	462.40
2. Manufacturing Industries and Construction		82,579.36	13.08	4.38							274.26	557.06	28.05	103.96
3. Transport		128,703.17	8.61	5.32							714.09	2,218.46	203.28	43.16
4. Other Sectors		109,859.50	23.60	2.18							190.79	387.35	59.43	29.23
5. Other		2,735.89	0.07	0.08							24.65	6.88	1.60	5.80
B. Fugitive Emissions from Fuels		5,870.38	469.07	0.15							3.14	18.53	225.29	8.93
1. Solid Fuels		111.98	194.71	0.00							0.24	6.13	0.11	7.67
2. Oil and Natural Gas		5,758.40	274.36	0.15							2.90	12.40	225.18	1.26
2. Industrial Processes		**13,945.96**	**4.88**	**9.05**	**59,602.06**	**10,411.15**	**146.95**	**261.42**	**0.05**	**0.05**	**2.61**	**142.68**	**131.34**	**32.77**
A. Mineral Products		8,512.42	0.51	NE							NE	4.28	9.62	17.25
B. Chemical Industry		2,975.66	3.52	9.02	NO	NO	NO	NO	NO	NO	1.04	25.09	41.73	7.14
C. Metal Production		2,457.89	0.84	0.03				60.02		0.01	1.57	113.31	1.59	8.39
D. Other Production [3]		NE									NE	NE	78.41	NE
E. Production of Halocarbons and SF_6						442.32		110.28		NA,NO				
F. Consumption of Halocarbons and SF_6					59,602.06	9,966.92	146.95	91.13	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		**NE**		**NE,NO**							**NO**	**NO**	**397.47**	**NO**
4. Agriculture			**910.75**	**88.25**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			768.18											
B. Manure Management			142.57	6.99									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[4]			NA,NE	81.26									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	[5]	**-1,937.37**	**0.95**	**0.01**							**0.24**	**8.29**	**NA,NO**	**NA**
A. Forest Land	[5]	-15,721.42	0.06	0.01							0.01	0.49	NO	
B. Cropland	[5]	15,233.03	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	[5]	-7,686.91	0.57	0.00							0.14	4.99	NO	
D. Wetlands	[5]	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	[5]	6,371.88	0.32	0.00							0.08	2.81	NO	
F. Other Land	[5]	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	[5]	-133.94	NE	NE							NE	NE	NA	NA
6. Waste		**469.83**	**1,002.16**	**4.13**							**1.76**	**23.29**	**16.33**	**0.91**
A. Solid Waste Disposal on Land	[6]	NA,NE,NO	964.00								NA,NE,NO	NA,NE,NO	9.64	
B. Waste-water Handling			38.03	3.98							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	[6]	469.83	0.14	0.16							1.76	23.29	6.69	0.91
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)*** [7]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [8]														
International Bunkers		**40,847.99**	**0.19**	**1.26**							**290.83**	**33.18**	**12.85**	**86.55**
Aviation		35,117.74	0.10	1.11							156.92	19.47	6.37	9.14
Marine		5,730.25	0.09	0.14							133.91	13.71	6.48	77.40
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**10,763.14**												

Table A 8.1.17 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[1]		PFCs[1]		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		**550,305.84**	**2,398.07**	**113.58**	**62,492.76**	**10,765.69**	**146.10**	**305.85**	**0.04**	**0.04**	**1,649.05**	**3,257.83**	**1,026.54**	**669.01**
1. Energy		**538,275.17**	**495.39**	**17.36**							**1,644.77**	**3,044.23**	**489.01**	**636.01**
A. Fuel Combustion	Reference Approach (2)	546,338.45												
	Sectoral Approach (2)	533,242.74	56.51	17.23							1,642.00	3,023.61	275.37	627.31
1. Energy Industries		214,242.50	11.20	5.47							471.16	102.22	6.07	440.46
2. Manufacturing Industries and Construction		80,586.05	13.21	4.33							260.43	557.01	26.84	95.26
3. Transport		130,381.02	7.92	5.27							708.16	1,980.61	181.04	56.06
4. Other Sectors		105,211.33	24.10	2.07							177.78	376.65	59.81	29.72
5. Other		2,821.83	0.08	0.08							24.47	7.11	1.62	5.79
B. Fugitive Emissions from Fuels		5,032.44	438.88	0.13							2.78	20.63	213.64	8.70
1. Solid Fuels		138.77	180.42	0.00							0.26	10.01	0.13	7.75
2. Oil and Natural Gas		4,893.66	258.46	0.12							2.51	10.62	213.51	0.95
2. Industrial Processes		**13,417.45**	**4.70**	**7.65**	**62,492.76**	**10,765.69**	**146.10**	**305.85**	**0.04**	**0.04**	**2.31**	**178.00**	**122.58**	**32.10**
A. Mineral Products		8,571.22	0.83	NE							NE	4.67	9.59	18.39
B. Chemical Industry		2,719.78	3.21	7.62	NO	NO	NO	NO	NO	NO	1.00	26.10	33.58	5.67
C. Metal Production		2,126.45	0.66	0.02				128.38		0.01	1.31	147.24	1.64	8.04
D. Other Production (3)		NE									NE	NE	77.77	NE
E. Production of Halocarbons and SF_6						387.47		90.23		NA,NO				
F. Consumption of Halocarbons and SF_6					62,492.76	10,376.04	146.10	87.24	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		**NE**		**NE,NO**							**NO**	**NO**	**398.58**	**NO**
4. Agriculture			**893.27**	**84.43**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			752.50											
B. Manure Management			140.78	6.90									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils(4)			NA,NE	77.53									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	(5)	**-1,821.41**	**1.42**	**0.01**							**0.35**	**12.40**	**NA,NO**	**NA**
A. Forest Land	(5)	-15,090.61	0.64	0.01							0.16	5.58	NO	
B. Cropland	(5)	15,279.27	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	(5)	-7,786.25	0.51	0.00							0.13	4.48	NO	
D. Wetlands	(5)	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	(5)	6,312.72	0.27	0.00							0.07	2.34	NO	
F. Other Land	(5)	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	(5)	-536.54	NE	NE							NE	NE	NA	NA
6. Waste		**434.63**	**1,003.29**	**4.13**							**1.62**	**23.19**	**16.38**	**0.90**
A. Solid Waste Disposal on Land	(6)	NA,NE,NO	965.00								NA,NE,NO	NA,NE,NO	9.65	
B. Waste-water Handling			38.16	3.98							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	(6)	434.63	0.13	0.16							1.62	23.19	6.73	0.90
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)*** (7)		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: (8)														
International Bunkers		**42,248.48**	**0.21**	**1.30**							**314.63**	**35.55**	**14.01**	**99.11**
Aviation		35,557.55	0.10	1.13							159.08	19.63	6.48	10.95
Marine		6,690.94	0.10	0.17							155.55	15.92	7.53	88.16
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**10,850.07**												

Table A 8.1.18 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[1]		PFCs[1]		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		**542,409.17**	**2,339.12**	**111.91**	**64,919.02**	**10,931.31**	**148.36**	**221.02**	**0.04**	**0.03**	**1,552.10**	**3,040.15**	**1,010.01**	**594.69**
1. Energy		**529,180.14**	**443.64**	**16.81**							**1,547.68**	**2,825.98**	**474.50**	**564.17**
A. Fuel Combustion	Reference Approach [2]	531,150.57												
	Sectoral Approach [2]	523,964.36	57.59	16.68							1,545.23	2,804.13	255.92	553.06
1. Energy Industries		210,395.96	11.77	5.10							438.04	103.68	5.27	369.50
2. Manufacturing Industries and Construction		78,907.94	12.92	4.34							255.94	539.59	26.93	92.42
3. Transport		130,825.46	7.19	5.15							658.75	1,763.26	160.90	53.97
4. Other Sectors		100,960.35	25.62	2.00							167.30	390.37	61.15	31.25
5. Other		2,874.64	0.08	0.09							25.20	7.24	1.66	5.92
B. Fugitive Emissions from Fuels		5,215.79	386.06	0.13							2.45	21.85	218.59	11.11
1. Solid Fuels		137.96	126.20	0.00							0.25	10.52	0.13	10.68
2. Oil and Natural Gas		5,077.83	259.86	0.13							2.19	11.33	218.46	0.43
2. Industrial Processes		**14,664.56**	**5.38**	**8.91**	**64,919.02**	**10,931.31**	**148.36**	**221.02**	**0.04**	**0.03**	**2.49**	**178.42**	**121.78**	**29.61**
A. Mineral Products		8,937.73	0.88	NE							NE	3.45	9.97	15.86
B. Chemical Industry		3,067.18	3.63	8.88	NO	NO	NO	NO	NO	NO	1.07	29.03	31.28	5.80
C. Metal Production		2,659.65	0.87	0.03				83.43		0.01	1.42	145.94	1.70	7.95
D. Other Production [3]		NE									NE	NE	78.83	NE
E. Production of Halocarbons and SF_6						175.60		54.56		NA,NO				
F. Consumption of Halocarbons and SF_6					64,919.02	10,753.37	148.36	83.02	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		**NE**		**NE,NO**							**NO**	**NO**	**397.50**	**NO**
4. Agriculture			**887.25**	**82.06**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			748.72											
B. Manure Management			138.53	6.82									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[4]			NA,NE	75.23									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	[5]	**-1,886.45**	**1.44**	**0.01**							**0.36**	**12.64**	**NA,NO**	**NA**
A. Forest Land	[5]	-14,173.62	0.73	0.01							0.18	6.37	NO	
B. Cropland	[5]	15,350.53	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	[5]	-8,091.31	0.43	0.00							0.11	3.78	NO	
D. Wetlands	[5]	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	[5]	6,312.64	0.29	0.00							0.07	2.49	NO	
F. Other Land	[5]	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	[5]	-1,284.70	NE	NE							NE	NE	NA	NA
6. Waste		**450.93**	**1,001.42**	**4.12**							**1.57**	**23.11**	**16.23**	**0.91**
A. Solid Waste Disposal on Land	[6]	NA,NE,NO	963.00								NA,NE,NO	NA,NE,NO	9.63	
B. Waste-water Handling			38.29	3.96							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	[6]	450.93	0.13	0.16							1.57	23.11	6.60	0.91
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)*** [7]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [8]														
International Bunkers		**42,149.64**	**0.20**	**1.29**							**314.69**	**35.45**	**14.03**	**103.47**
Aviation		35,408.44	0.10	1.12							158.11	19.42	6.45	9.77
Marine		6,741.20	0.10	0.17							156.57	16.03	7.58	93.69
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**11,592.68**												

Table A 8.1.19 Summary Report For National Greenhouse Gas Inventories (IPCC TABLE 7A) – 2008

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		Net CO_2 emissions/removals	CH_4	N_2O	HFCs[1]		PFCs[1]		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		**531,719.59**	**2,312.87**	**109.31**	**68,835.86**	**11,168.86**	**150.70**	**208.95**	**0.03**	**0.03**	**1,398.95**	**2,816.42**	**940.05**	**511.98**
1. Energy		**519,143.56**	**442.31**	**15.47**							**1,394.74**	**2,618.28**	**419.97**	**481.89**
A. Fuel Combustion	Reference Approach [2]	522,298.88												
	Sectoral Approach [2]	514,597.49	57.52	15.37							1,392.35	2,600.20	236.02	470.81
1. Energy Industries		204,700.48	11.58	4.75							353.43	100.06	4.68	290.22
2. Manufacturing Industries and Construction		75,319.86	11.93	3.87							227.57	486.40	23.72	84.62
3. Transport		126,900.46	6.36	4.66							619.83	1,594.80	143.19	57.45
4. Other Sectors		104,736.21	27.56	2.01							165.98	411.53	62.74	32.53
5. Other		2,940.47	0.08	0.09							25.55	7.41	1.69	5.99
B. Fugitive Emissions from Fuels		4,546.06	384.79	0.11							2.39	18.08	183.94	11.08
1. Solid Fuels		132.01	132.97	0.00							0.24	8.40	0.13	9.57
2. Oil and Natural Gas		4,414.05	251.82	0.10							2.15	9.68	183.81	1.52
2. Industrial Processes		**14,148.20**	**5.00**	**7.81**	**68,835.86**	**11,168.86**	**150.70**	**208.95**	**0.03**	**0.03**	**2.40**	**163.34**	**119.30**	**29.18**
A. Mineral Products		8,103.25	0.78	NE							NE	4.47	9.83	17.14
B. Chemical Industry		2,978.56	3.25	7.78	NO	NO	NO	NO	NO	NO	0.69	21.20	27.12	4.22
C. Metal Production		3,066.39	0.97	0.03				118.40		0.00	1.71	137.67	1.61	7.83
D. Other Production [3]		NE									NE	NE	80.75	NE
E. Production of Halocarbons and SF_6						125.86		11.67		NA,NO				
F. Consumption of Halocarbons and SF_6					68,835.86	11,016.77	150.70	78.88	0.03	0.03				
G. Other		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use		**NE**		**NE,NO**							**NO**	**NO**	**384.59**	**NO**
4. Agriculture			**866.15**	**81.87**							**NA,NO**	**NA,NO**	**NA,NE,NO**	**NO**
A. Enteric Fermentation			730.99											
B. Manure Management			135.16	6.63									NO	
C. Rice Cultivation			NA,NO										NA,NO	
D. Agricultural Soils[4]			NA,NE	75.23									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	NA							NA	NA	NA	NO
5. Land Use, Land-Use Change and Forestry	[5]	**-1,973.77**	**1.34**	**0.01**							**0.33**	**11.68**	**NA,NO**	**NA**
A. Forest Land	[5]	-13,626.85	0.69	0.01							0.17	6.04	NO	
B. Cropland	[5]	15,243.39	NA,NE,NO	NA,NE,NO							NO	NO	NO	
C. Grassland	[5]	-8,156.37	0.38	0.00							0.10	3.35	NO	
D. Wetlands	[5]	IE,NE,NO	IE,NE,NO	IE,NE,NO							NO	NO	NO	
E. Settlements	[5]	6,280.29	0.26	0.00							0.07	2.29	NO	
F. Other Land	[5]	NE,NO	NE,NO	NE,NO							NO	NO	NO	
G. Other	[5]	-1,714.23	NE	NE							NE	NE	NA	NA
6. Waste		**401.60**	**998.07**	**4.15**							**1.48**	**23.11**	**16.19**	**0.91**
A. Solid Waste Disposal on Land	[6]	NA,NE,NO	959.53								NA,NE,NO	NA,NE,NO	9.60	
B. Waste-water Handling			38.42	3.99							NA,NE	NA,NE	NA,NE	
C. Waste Incineration	[6]	401.60	0.13	0.16							1.48	23.11	6.60	0.91
D. Other		NA	NA	NA							NA	NA	NA	NA
7. Other ***(please specify)*** [7]		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [8]														
International Bunkers		**41,552.61**	**0.21**	**1.27**							**324.36**	**36.25**	**14.54**	**122.21**
Aviation		34,094.38	0.09	1.08							151.86	18.59	6.19	9.41
Marine		7,458.23	0.12	0.19							172.50	17.66	8.35	112.80
Multilateral Operations		**NE**	**NE**	**NE**							**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass		**12,461.37**												

A9 ANNEX 9: Additional Information Quantitative Discussion of 2008 Inventory

This Annex discusses the emission estimates made in the 1990-2008 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.

A9.1 ENERGY SECTOR (1)

Figure A 9.1.1 and **Figure A 9.1.2** show both emissions of direct and indirect Greenhouse Gases for the Energy sector (category 1) in the UK for the years 1990-2008. Emissions from direct greenhouse gases in this sector have declined 12% since 1990, with a decrease of 1.95% between 2007 and 2008 continuing this trend.

Table A 9.1.1 to **Table A** 9.1.4 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 2008.

A9.1.1 Carbon Dioxide

Analysing emissions by pollutant shows that 98% of total net CO_2 emissions in 2008 came from the Energy sector (**Table A 9.1.4**), 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 9% since 1990 (**Table A 9.1.1**) and have also shown a decrease of 1.9% between 2007 and 2008 (**Table A 9.1.2**).

Energy industries (category 1A1) were responsible for 39% of the sector's CO_2 emissions in 2008 (**Table A 9.1.3**). There has been an overall decline in emissions from this sector of 13% since 1990 (**Table A 9.1.1**). 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 – there has been a shift towards electricity generation in the UK using CCGT power stations rather than coal-fired power stations, and the CCGT stations operate at a higher thermal efficiency (in 2008, the CCGTs operated at 52% efficiency, whilst coal-fired stations operated at 36% efficiency).[14] 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 3% decrease from 2007 to 2008, due to a significant decrease in the amount of coal used for electricity generation in 2008.

[14] Plant loads, demand and efficiency, Table 5.10, DECC (2009)

Emissions of from category 1A2 – Manufacturing Industries and Construction contributed 14% (**Table A 9.1.4**) to overall net CO_2 emissions in the UK in 2008. Since 1990, these emissions have declined by 24%, (**Table A 9.1.1**) mostly as a result of a decline in the emissions from the Iron and steel industry. This sector has seen a significant decrease in 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 9% since 1990 (**Table A 9.1.1**). In 2008, this sector contributed 24% (**Table A 9.1.4**) to overall CO_2 emissions within the UK. Emissions from transport are dominated by road transport (1A3b), which in 2008 contributed 92% to the total emissions from transport. Since 1990, emissions from road transport have increased by 7%. Emissions from domestic aviation have more than doubled since 1990, but has shown a decrease of 14% 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 4% since 1990 (**Table A 9.1.1**). During this period, residential emissions have increased by 1% and emissions from the commercial/institutional subsector have decreased by 15%. Fuel consumption data since 1990 indicates a general trend in fuel switching in these sectors, away from more carbon-intensive fuels such as coal, coke, fuel oil and gas oil, towards burning oil and natural gas. This shift has partly been driven by fuel prices but also through the growth of the UK gas supply network (most notably in Northern Ireland). Note, however, that between 2007 and 2008, commercial/institutional and residential emissions increased by 6% and 3% respectively.

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 1990-2008, although they only contribute a small percentage towards emissions from the energy sector.

A9.1.2 Methane

In 2008, 19% (see **Table A 9.1.4**) of total methane emissions came from the energy sector, the majority (57%, **Table A 9.1.3**) from fugitive emissions from oil and natural gas (1B2). Emissions from this category have decreased by 49% since 1990 (**Table A 9.1.1**). 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.

A9.1.3 Nitrous Oxide

The energy sector accounted for 14% of total N_2O emissions in the UK during 2008. Of this, a majority (31%, **Table A 9.1.3**) arose from energy industries (1A1). Within this category, emissions from public electricity production have shown a 38% decrease, whilst emissions from petroleum refining have increased by 16%. Emissions from 1A1c (Manufacture of Solid Fuels and Other Energy Industries) have increased by 26% between 1990 and 2008. N_2O

emissions have decreased overall by 48% since 1990. Over this period the use of coal has decreased and the use of natural gas increased.

The other major contribution towards N_2O emissions within the energy sector is the transport sector (1A3) (30%, **Table A 9.1.3**). Between 1990 and 1999, emissions increased by 30% due to the increasing numbers of petrol driven cars fitted with early generation 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. Since then, emission factors have been declining with successive Euro standards, presumably due to better catalyst formulations as well as reductions in fuel sulphur content. The overall change in the N_2O emissions from the transport sector between 1990 and 2008 is actually 0.2% (**Table A 9.1.1**).

A9.1.4 Nitrogen Oxides

In 2008, over 99% of NO_x emissions in the UK came from the energy sector. Since 1990 emissions from this sector have decreased by 49% (**Table A 9.1.1**), 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 2008, emissions from transport contributed 44% (**Table A 9.1.4**) to the total emissions of NO_x in the UK, with 32% 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 A 9.1.1**) 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 25% (**Table A 9.1.4**) to total NO_x emissions in the UK during 2008. Between 1990 and 2008, emissions from this sector decreased by 58% (**Table A 9.1.1**). The main reason for this was a decrease in emissions from public electricity and heat (1A1a) of 64%. 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 44% (**Table A 9.1.1**) since 1990. In 2008, emissions from this sector contributed 16% (**Table A 9.1.4**) 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.

A9.1.5 Carbon Monoxide

Emissions of carbon monoxide from the energy sector contributed 93% (**Table A 9.1.4**) to overall UK CO emissions in 2008. Of this, 61% of emissions (**Table A 9.1.3**) occur from the transport sector. Since 1990, emissions from 1A3 have declined by 75% (**Table A 9.1.1**), 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 17% (**Table A 9.1.4**) to overall emissions of CO in 2008. 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.

A9.1.6 Non Methane Volatile Organic Compounds

In 2008, 45% (**Table A 9.1.4**) 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 19% (**Table A 9.1.4**) towards the overall UK emissions of NMVOCs in 2008. 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 15% (**Table A 9.1.4**) to overall emissions of NMVOC in the UK in 2008. Since 1990, emissions from this sector have decreased by 84% (**Table A 9.1.1**) due to the increased use of three way catalysts on petrol cars.

A9.1.7 Sulphur Dioxide

94% (**Table A 9.1.4)** of emissions of sulphur dioxide came from the energy sector in 2008. 60% (**Table A 9.1.3**) 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 92%. 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 A9.1.1**) than conventional coal and oil stations and have negligible SO_2 emissions.

Emissions from Manufacturing, Industry and Construction were responsible for 16% (**Table** A 9.1.4) of UK emissions of SO_2 in 2008. Since 1990, emissions from this sector have declined by 80% (**Table A 9.1.1**). 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 A 9.1.1 UK emissions of direct greenhouse gases from IPCC sector 1, 1990-2008

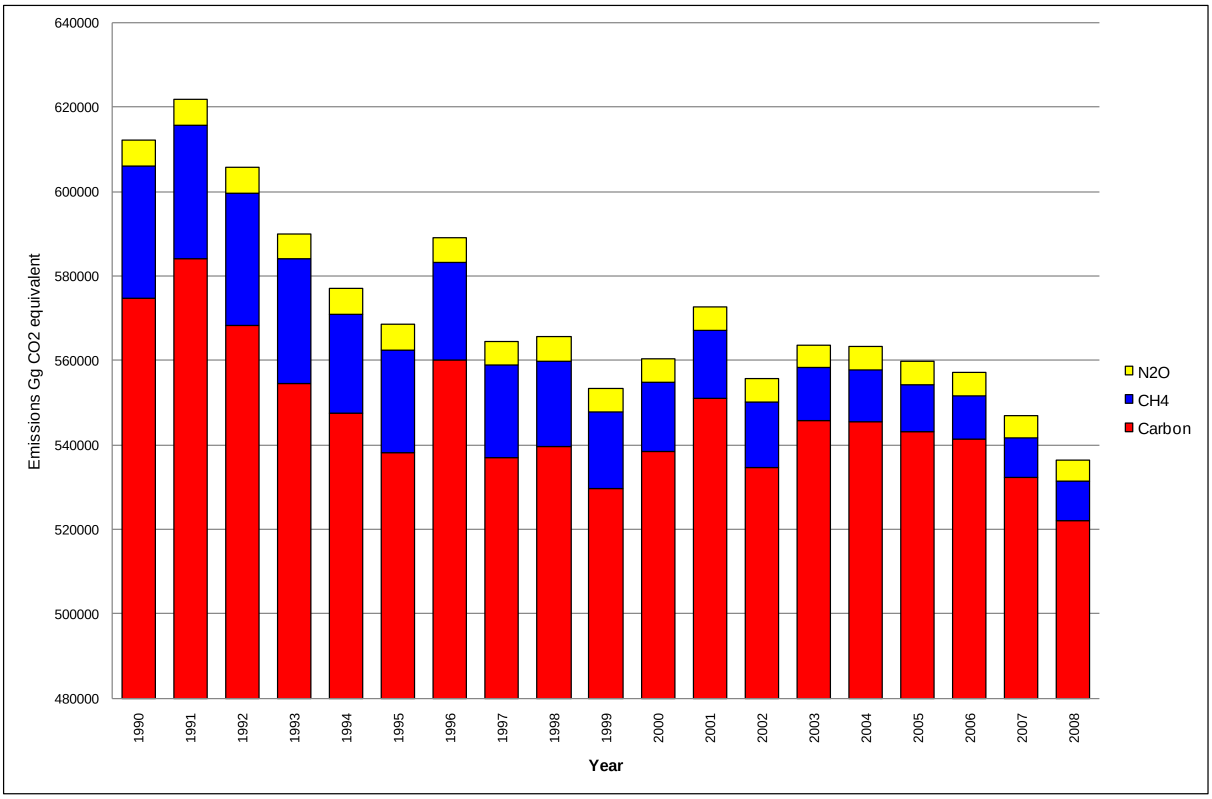


Figure A 9.1.2 UK emissions of Indirect Greenhouse Gases from IPCC sector 1, 1990-2008

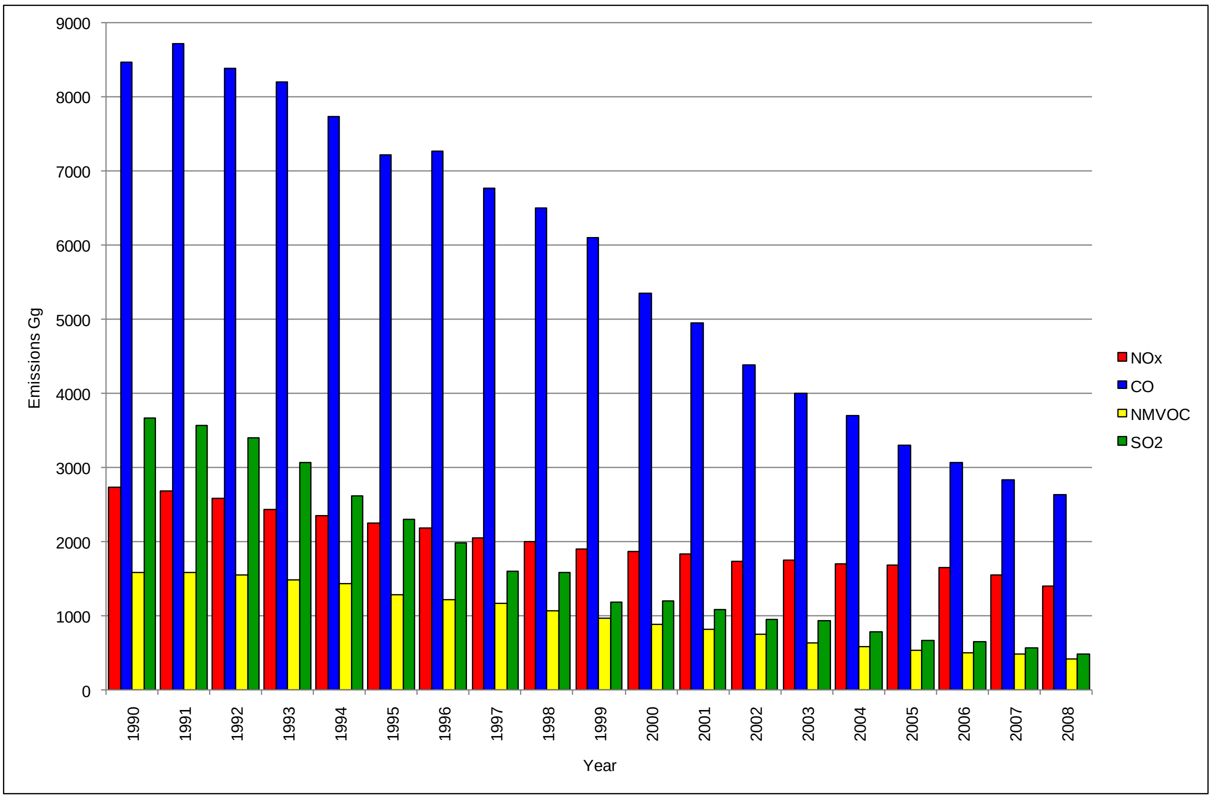


Table A 9.1.1 % Changes from 1990 to 2008 in Sector 1

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
1A1	-13%	20%	-27%	-58%	-25%	-44%	-90%
1A2	-24%	-23%	-26%	-44%	-34%	-16%	-80%
1A3	9%	-79%	0%	-48%	-75%	-84%	-39%
1A4	-4%	-62%	-36%	-23%	-65%	-40%	-86%
1A5	-44%	-46%	-45%	-39%	-45%	-42%	-36%
1B1	-85%	-85%	-56%	-58%	-78%	-61%	-54%
1B2	-24%	-49%	-24%	-84%	-55%	-67%	-80%
Overall	**-9%**	**-70%**	**-22%**	**-49%**	**-69%**	**-73%**	**-87%**

Table A 9.1.2 % Changes from 2007 to 2008 in Sector 1

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
1A1	-3%	-2%	-7%	-19%	-3%	-11%	-21%
1A2	-5%	-8%	-11%	-11%	-10%	-12%	-8%
1A3	-3%	-12%	-10%	-6%	-10%	-11%	6%
1A4	4%	7%	0%	-1%	5%	3%	3%
1A5	2%	3%	2%	1%	2%	2%	1%
1B1	-4%	5%	-7%	-3%	-20%	2%	-10%
1B2	-13%	-3%	-19%	-2%	-15%	-16%	255%
Overall	**-1.9%**	**-0.3%**	**-8%**	**-10%**	**-7%**	**-11%**	**-15%**

Table A 9.1.3 % Contribution to Sector 1

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
1A1	39%	3%	31%	25%	4%	1%	60%
1A2	14%	3%	25%	16%	18%	6%	17%
1A3	24%	1%	30%	44%	61%	34%	12%
1A4	20%	6%	13%	12%	16%	15%	7%
1A5	1%	0%	1%	2%	0%	0%	1%
1B1	0%	30%	0%	0%	0%	0%	2%
1B2	1%	57%	1%	0%	0%	44%	0%

Table A 9.1.4 % Contribution to Overall Pollutant Emissions

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
1A1	39%	0%	4%	25%	4%	1%	57%
1A2	14%	1%	4%	16%	17%	3%	16%
1A3	24%	0%	4%	44%	57%	15%	11%
1A4	20%	1%	2%	12%	15%	7%	6%
1A5	1%	0%	0%	2%	0%	0%	1%
1B1	0%	6%	0%	0%	0%	0%	2%
1B2	1%	11%	0%	0%	0%	19%	0%
Overall	**98%**	**19%**	**14%**	**100%**	**93%**	**45%**	**94%**

A9.2 INDUSTRIAL PROCESSES SECTOR (2)

Figure A 9.2.1 and **Figure A 9.2.2** show both emissions of direct and indirect Greenhouse Gases for the UK industrial processes sector in 1990-2008. Emissions from direct Greenhouse gases within this sector have decreased by 47% since 1990. **Table A 9.2.1** to **Table A 9.2.4** 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 2008.

A9.2.1 Carbon Dioxide

The industrial processes sector is not a major source of emissions in the UK for carbon dioxide. In 2008, just 2.4% (**Table A 9.2.4**) of UK emissions originated from this sector.

A9.2.2 Methane

Emissions of methane from the industrial processes sector are very small and have a negligible effect on overall methane emissions in the UK.

A9.2.3 Nitrous Oxide

In 2008, 7% (**Table A 9.2.4**) of N_2O emissions in the UK came from the industrial processes sector. Between 1990 and 2008, emissions from this sector declined by an estimated 90% (**Table A 9.2.1**) 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.

A9.2.4 Hydrofluorocarbons

Table A 9.2.4 shows that the industrial processes sector was responsible for 100% of emissions of HFCs in the UK in 2008. Since 1990, emissions of HFCs have decreased by 1% (**Table A 9.2.1**). The largest contribution to this sector in 2008 arises from category 2F1 – refrigeration and air conditioning equipment. In 2008, these contributed 65% (**Table A 9.2.4**) 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 (27%, **Table A 9.2.4**) 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 A 9.2.4**), by-product emissions (2%, **Table A 9.2.4**) and fire extinguishers (2%, **Table A 9.2.4**). A small emission also arises from the use of HFCs as a cover gas in aluminium and magnesium foundries.

A9.2.5 Perfluorocarbons

In 2008, 100% (**Table A 9.2.4**) of PFC emissions came from the industrial processes sector. Since 1990, emissions from this sector have declined by 85% (**Table A 9.2.1**). Within this sector, the main contribution to emissions comes from aluminium production (57%, **Table A 9.2.4**). 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 91% decrease (**Table A 9.2.1**) due to significant improvements in process control and an increase in the rate of aluminium recycling.

The next largest source is 2F9, which includes a range of sources including the semiconductor and electronics industries. In 2008, this sector contributed 31% (**Table A 9.2.4**) to overall PFC emissions in the UK .The remaining contribution arises from fugitive emissions from PFC manufacture. In 2008, this contributed 6% (**Table A 9.2.4**) to overall PFC totals in the UK.

A9.2.6 Sulphur Hexaflouride

In 2008, the industrial processes sector contributed 100% (**Table A 9.2.4**) of emissions of SF_6 in the UK. Emissions arise from two main sectors. The use of SF_6 in magnesium foundries contributed 12% (**Table A 9.2.4**) towards total emissions in 2008. Emissions from 2F8 – Other contributed 87% (**Table A 9.2.4**) 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 31% (**Table A 9.2.1**).

A9.2.7 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 A 9.2.4**).

A9.2.8 Carbon Monoxide

During 2008, emissions from the industrial sector contributed 6% (**Table A 9.2.4**) 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 A 9.2.3**. Since 1990, emissions from this sector have decreased by 42% (**Table A 9.2.1**).

A9.2.9 Non Methane Volatile Organic Compounds

In 2008, emissions from the industrial processes sector contributed 13% (**Table A 9.2.4**) 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.

A9.2.10 Sulphur Dioxide

In 2008, SO_2 emissions from the industrial processes sector contributed just 6% (**Table A 9.2.4**) 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 47% (**Table A 9.2.1**).

Figure A 9.2.1 Emissions of direct greenhouse gases from IPCC sector 2, 1990-2008

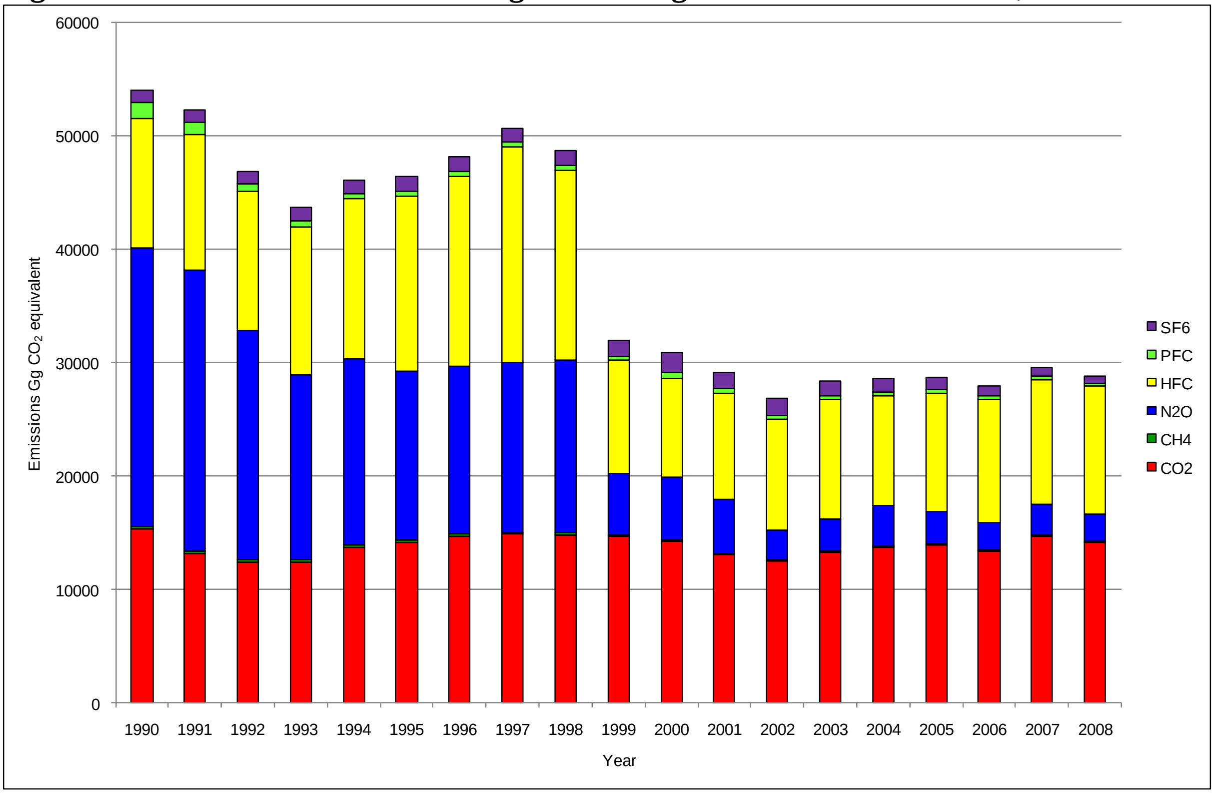


Figure A 9.2.2 Emissions of indirect greenhouse gases from IPCC sector 2, 1990-2008

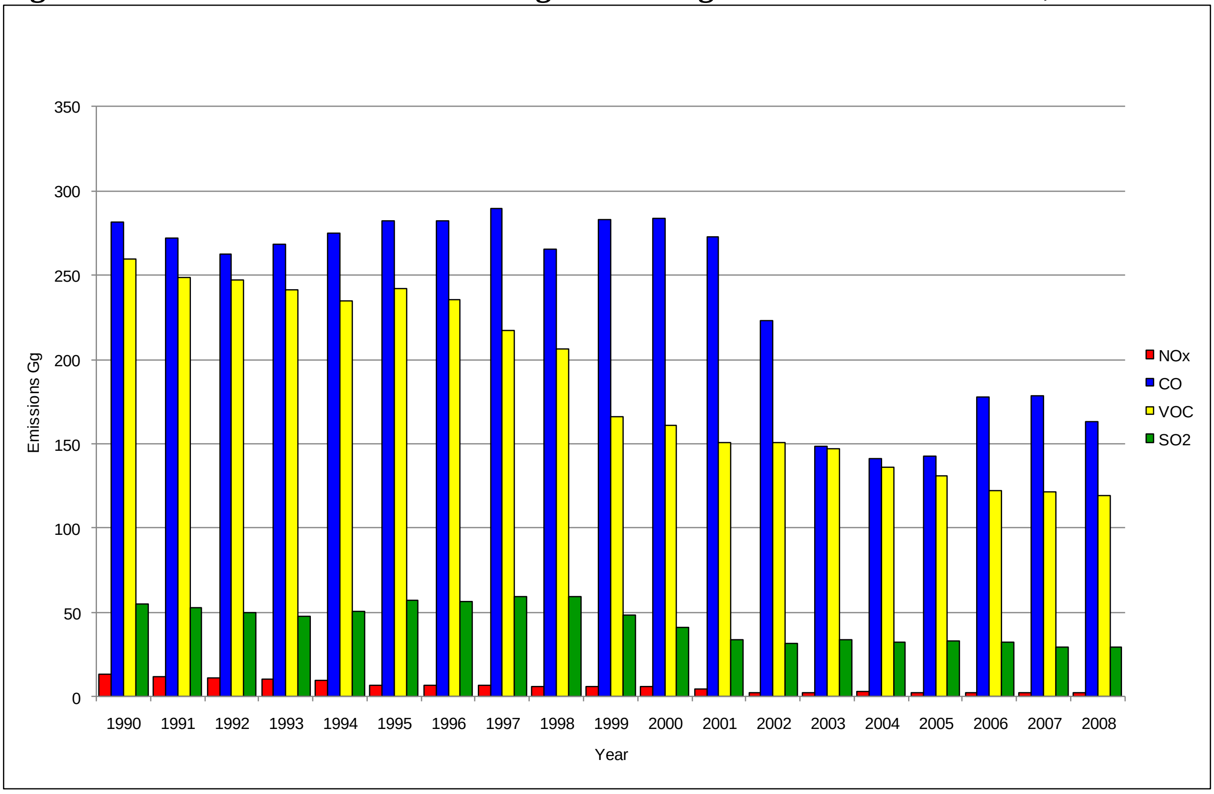


Table A 9.2.1 % Changes from 1990 to 2008 in Sector 2

	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NOx	CO	NMVOC	SO_2
2A1	-29%									
2A2	-26%									
2A3	22%									
2A4	34%									
2A5										
2A6									-30%	
2A7	29%	-30%						-16%	-9%	302 %
2B1	-16%									
2B2			-62%				-96%			
2B3			-95%							
2B4										
2B5	20%	-60%					0%	-74%	-84%	-90%
2C1	38%	25%	-10%				-66%	-18%	-22%	-49%
2C2										
2C3	12%				-91%		-61%	56%		22%
2C4						-79%				
2C5								-98%		-30%
2D1									-96%	
2D2									10%	
2E1				-99%						
2E2					7%					
2E3										
2F1				147506%	1896%					
2F2										
2F3										
2F4				25405%						
2F5										
2F8										
2F9					31%	3%				
2G										
Overall	**-8%**	**-50%**	**-90%**	**-1%**	**-85%**	**-31%**	**-82%**	**-42%**	**-54%**	**-47%**

Table A 9.2.2 % Changes from 2007 to 2008 in Sector 2

	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NOx	CO	NMVOC	SO_2
2A1	-15%									
2A2	0%									
2A3	1%									
2A4	4%									
2A5										
2A6									11%	
2A7	28%	-11%						30%	-22%	8%
2B1	-8%									
2B2			-17%				-50%			
2B3			-4%							
2B4										
2B5	1%	-10%					-16%	-27%	-13%	-27%
2C1	22%	12%	6%				30%	-6%	-6%	-6%
2C2										
2C3	-10%				42%		-5%	-6%		-3%
2C4				1022%		-41%				
2C5								35%		14%
2D1									0%	
2D2									2%	
2E1				-28%						
2E2					-79%					
2E3										
2F1				4%	-3%	-11%				
2F2				-4%						
2F3				1%	-63%					
2F4				0%						
2F5				17%						
2F8										
2F9				-40%	-4%	-3%				
2G										
Overall	**-4%**	**-7%**	**-12%**	**2%**	**-5%**	**-10%**	**-3%**	**-8%**	**-2%**	**-1%**

Table A 9.2.3 % Contribution to Sector 2

	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NOx	CO	NMVOC	SO_2
2A1	37%									
2A2	6%									
2A3	11%									
2A4	2%									
2A5										
2A6									6%	
2A7	2%	16%						3%	2%	59%
2B1	8%									
2B2			60%				13%			
2B3			39%							
2B4										
2B5	13%	65%					16%	13%	23%	14%
2C1	18%	19%	0%				57%	63%	1%	5%
2C2										
2C3	4%				57%		14%	21%		17%
2C4				0%		12%				
2C5								1%		4%
2D1									0%	
2D2									68%	
2E1				1%						
2E2					6%					
2E3										
2F1				65%	1%	0%				
2F2				4%						
2F3				2%	0%					
2F4				27%						
2F5				1%	0%					
2F8										
2F9				1%	36%	87%				
2G										

Table A 9.2.4 % 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			4%				0%			
2B3			3%							
2B4										
2B5	0%	0%					0%	1%	3%	1%
2C1	0%	0%	0%				0%	4%	0%	0%
2C2										
2C3	0%				57%		0%	1%		1%
2C4				0%		12%				
2C5								0%		0%
2D1									0%	
2D2									9%	
2E1				1%						
2E2					6%					
2E3										
2F1				65%	1%	0%				
2F2				4%						
2F3				2%	0%					
2F4				27%						
2F5				1%	0%					
2F8										
2F9				1%	36%	87%				
2G										
Overall	**2.4%**	**0.21%**	**7%**	**100%**	**100%**	**100%**	**0.17%**	**6%**	**13%**	**6%**

A9.3 SOLVENTS AND OTHER PRODUCT USE SECTOR (3)

Only emissions of NMVOCs occur from the solvents category. **Figure A 9.3.1** displays total NMVOC emissions for 1990-2008. **Table A 9.3.1 - Table A 9.3.4** 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 2008. Emissions from this sector contribute 37% to overall emissions of NMVOC in the UK (**Table A 9.3.4**), and since 1990 emissions have declined by 42% (**Table A 9.3.1**).

The largest source of emissions within the solvents sector is category 3D (solvent and other product use: other), contributing 61% of NMVOC emissions in this sector (**Table A 9.3.3**).

Figure A 9.3.1 Emissions of NMVOC from IPCC Sector 3, 1990-2008

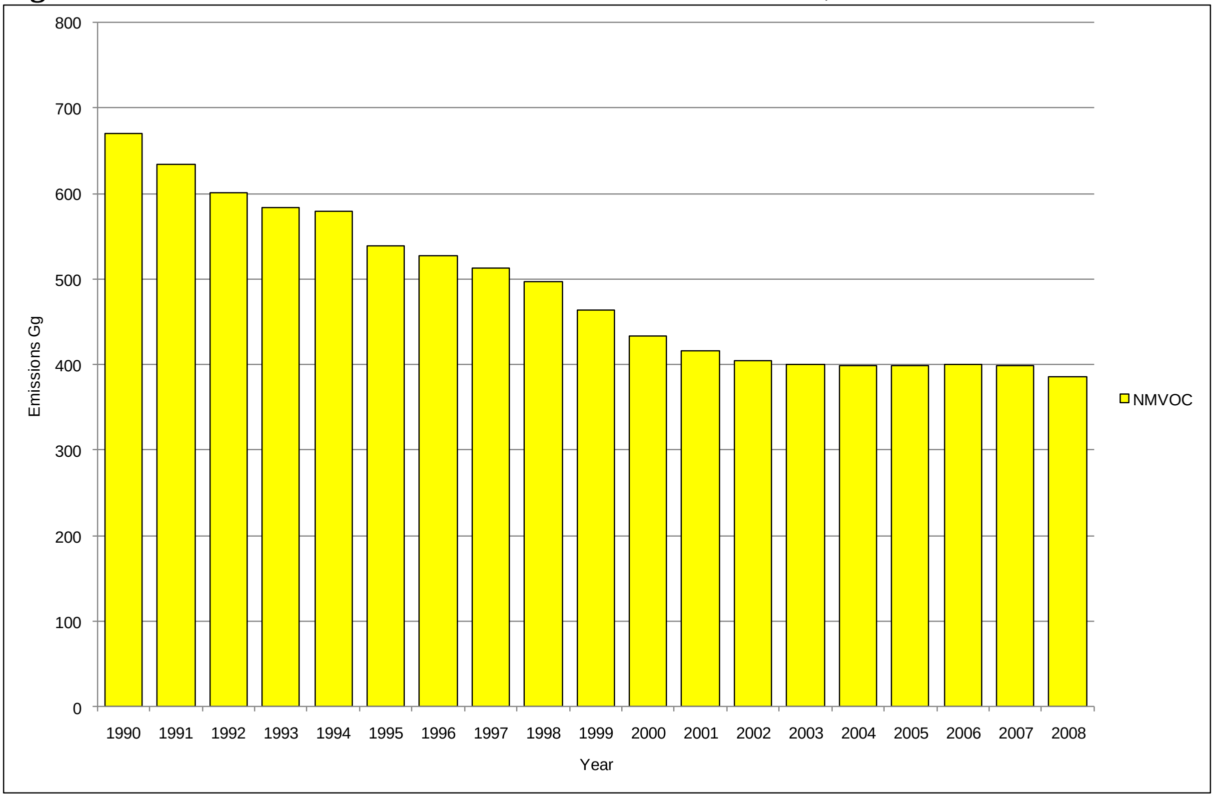


Table A 9.3.1 % Changes 1990-2008 within Sector 3

	NMVOC
3A	-48%
3B	-65%
3C	-72%
3D	-28%
Overall	**-42%**

Table A 9.3.2 % Changes 2007-2008 within Sector 3

	NMVOC
3A	-8%
3B	-1%
3C	-3%
3D	-1%
Overall	**-3.24%**

Table A 9.3.3 % Contribution to Sector 3

	NMVOC
3A	28%
3B	8%
3C	4%
3D	61%

Table A 9.3.4 % Contribution to Overall Pollutant Emissions

	NMVOC
3A	10%
3B	3%
3C	1%
3D	22%
Overall	**37%**

A9.4 AGRICULTURE SECTOR (4)

Figure A 9.4.1 and **Figure A 9.4.2** show both emissions of direct and indirect greenhouse gases for the agricultural sector (category 4) in the UK for the years 1990-2008. Emissions of direct greenhouse gases from this sector have decreased by 21% since 1990.

Table A 9.4.1-Table A 9.4.4 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 2008.

A9.4.1 Methane

Agriculture is the second largest source of methane in the UK, and in 2008 emissions from this sector totalled 38% (**Table A 9.4.4**) of the UK total. Since 1990, methane emissions from agriculture have declined by 18% (**Table A 9.4.1**). 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 A 9.4.3**), and 24% of total methane emissions in 2008 (**Table A 9.4.4**). Since 1990, emissions from this sector have declined by 13% (**Table A 9.4.1**) and this is due to a decline in cattle numbers over this period.

A9.4.2 Nitrous Oxide

In 2008, nitrous oxide emissions from agriculture contributed 75% (**Table A 9.4.4**) to the UK total emission. Of this, 92% (**Table A 9.4.3**) came from the agricultural soils sector, 4D. Since 1990, emissions of N_2O from the agricultural sector have declined by 23% (**Table A 9.4.1**), driven by a fall in synthetic fertiliser application and a decline in animal population over this period.

A9.4.3 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.

A9.4.4 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.

A9.4.5 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 A 9.4.1 Emissions of direct greenhouse gases from IPCC sector 4, 1990-2008

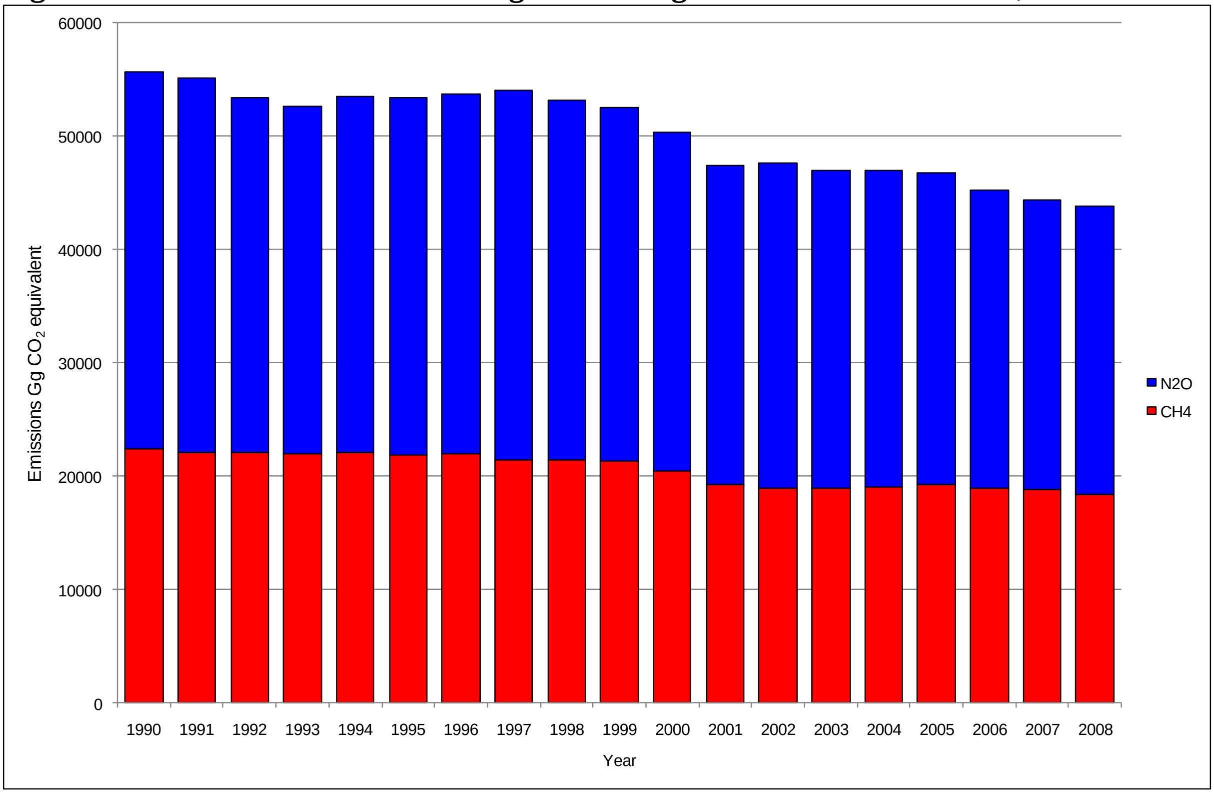


Figure A 9.4.2 Emissions of indirect greenhouse gases from IPCC sector 4, 1990-2008

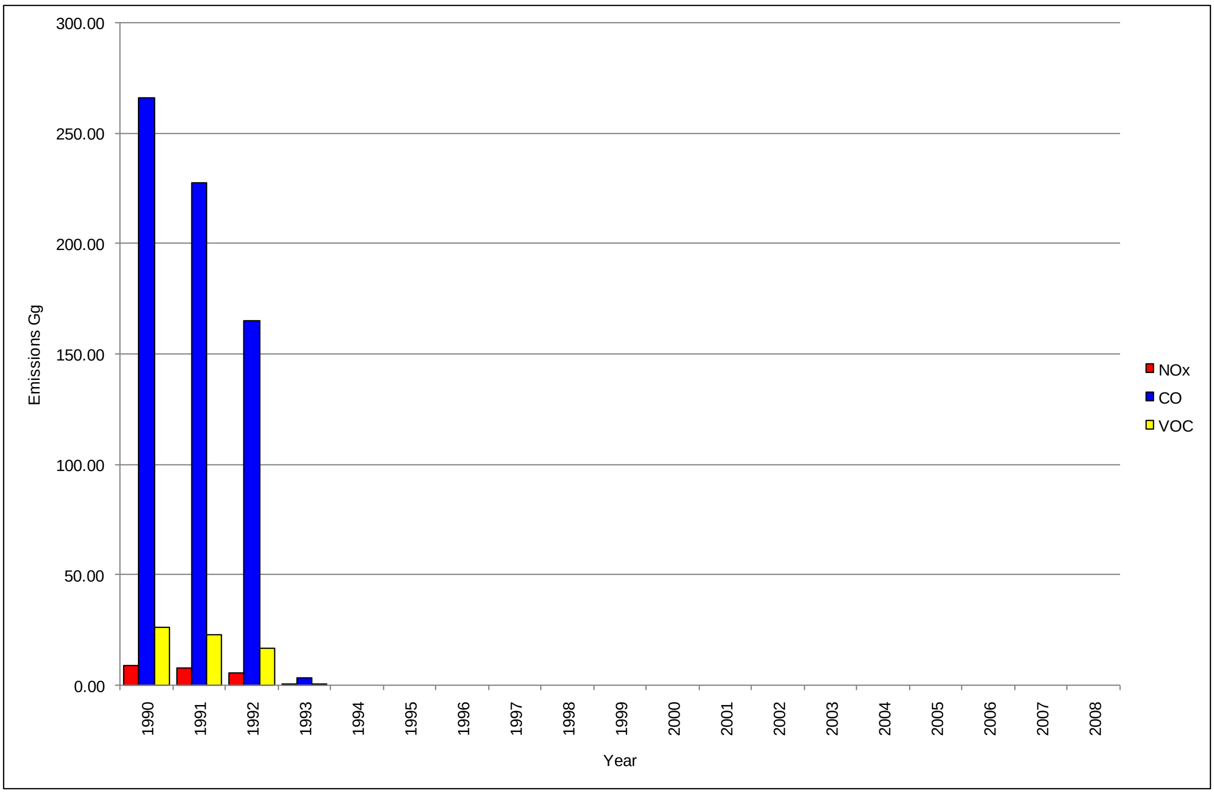


Table A 9.4.1 % Changes 1990-2008 within Sector 4

	CH_4	N_2O	NO_x	CO	NMVOC
4A1	-13%				
4A2					
4A3	-25%				
4A4	-15%				
4A5					
4A6	82%				
4A7					
4A8	-38%				
4A9					
4A10	-34%				
4B1	-16%				
4B2					
4B3	-25%				
4B4	5%				
4B5					
4B6	82%				
4B7					
4B8	-38%				
4B9	19%				
4B10	-34%				
4B11					
4B12		-23%			
4B13		-22%			
4B14		-26%			
4C					
4D		-23%			
4E					
4F1	-100%	-100%	-100%	-100%	-100%
4F2					
4F3					
4F4					
4F5	-100%	-100%	-100%	-100%	-100%
4G					
Overall	**-18%**	**-23%**	**-100%**	**-100%**	**-100%**

Table A 9.4.2 % Changes 2007-2008 within Sector 4

	CH_4	N_2O	Nox	CO	NMVOC
4A1	-2%				
4A2					
4A3	-3%				
4A4	1%				
4A5					
4A6	-3%				
4A7					
4A8	-3%				
4A9					
4A10	1%				
4B1	-3%				
4B2					
4B3	-3%				
4B4	19%				
4B5					
4B6	-3%				
4B7					
4B8	-3%				
4B9	-1%				
4B10	1%				
4B11					
4B12		-2%			
4B13		-2%			
4B14		-4%			
4C					
4D		0%			
4E					
4F1					
4F2					
4F3					
4F4					
4F5					
4G					
Overall	**-2%**	**0%**			

Table A 9.4.3 % Contribution to Sector 4

	CH_4	N_2O	NOx	CO	NMVOC
4A1	64%				
4A2					
4A3	18%				
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	0%				
4B11					
4B12		0%			
4B13		6%			
4B14		2%			
4C					
4D		92%			
4E					
4F1	0%	0%			
4F2					
4F3					
4F4					
4F5	0%	0%			
4G					

Table A 9.4.4 % 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	0%				
4B11					
4B12		0%			
4B13		4%			
4B14		2%			
4D		69%			
4E					
4F1	0%	0%	0%	0%	0%
4F2					
4F3					
4F4					
4F5	0%	0%	0%	0%	0%
4G					
Overall	**38%**	**75%**	**0%**	**0%**	**0%**

A9.5 LAND USE, LAND USE CHANGE AND FORESTRY (5)

Figure A 9.5.1 and **Figure A 9.5.2** 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 1990-2008.

Table A 9.5.1 and **Table A 9.5.2** summarise the changes observed through the time series for each pollutant.

A9.5.1 Carbon Dioxide

Figure A 9.5.1 shows net emissions/removals of carbon dioxide. In 1990, the UK was a net source of CO_2 from LULUCF activities. In 2008, the UK was a net sink, therefore showing a decrease in emissions of 169%.

A9.5.2 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 decreased by 8% since 2007 (**Table A 9.5.2**), although have increased overall by 68% since 1990 (**Table A 9.5.1**).

A9.5.3 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 53% since 1990 (**Table A 9.5.1**), and shown a decline of 11% since 2007 (**Table A 9.5.2**).

A9.5.4 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 8% since 2007 (**Table A 9.5.2**), and have increased overall by 68% since 1990 (**Table A 9.5.1**).

A9.5.5 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 A 9.5.1 Net emissions/removals of direct greenhouse gases from IPCC sector 5, 1990-2008

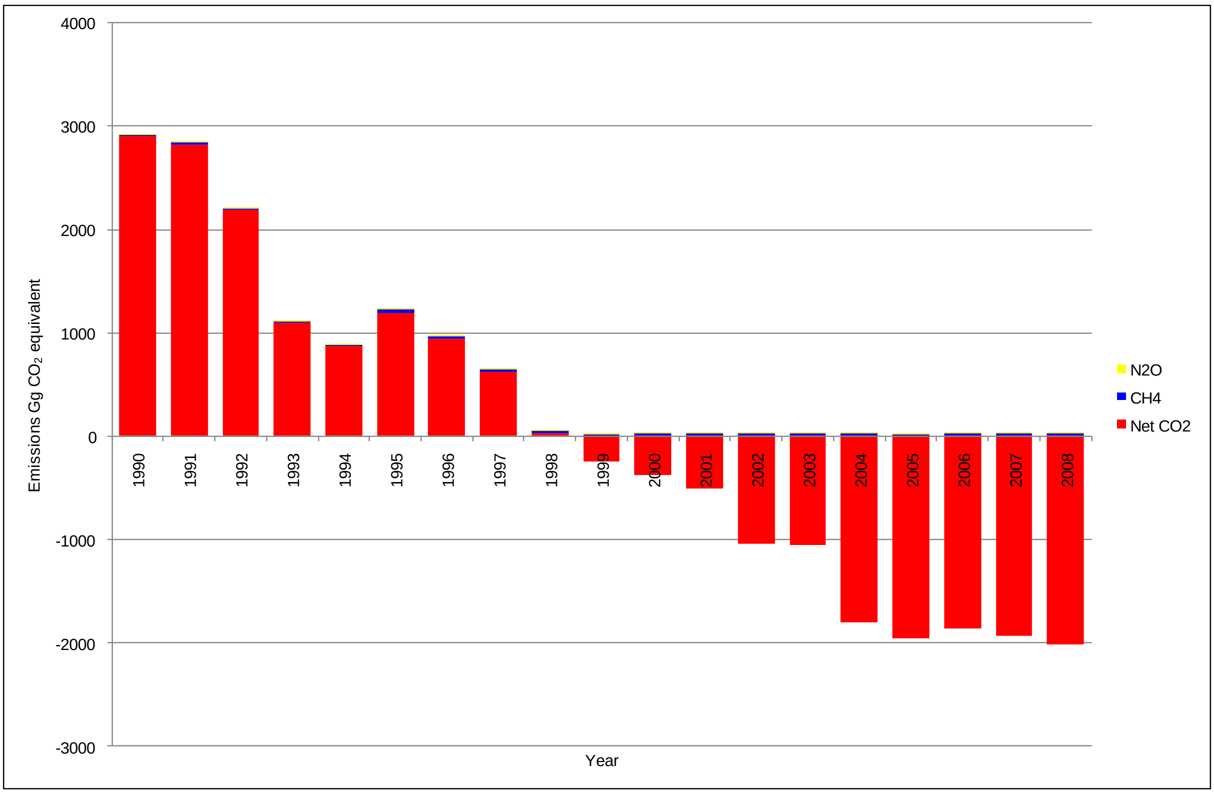


Figure A 9.5.2 Emissions of indirect greenhouse gases from IPCC sector 5, 1990-2008

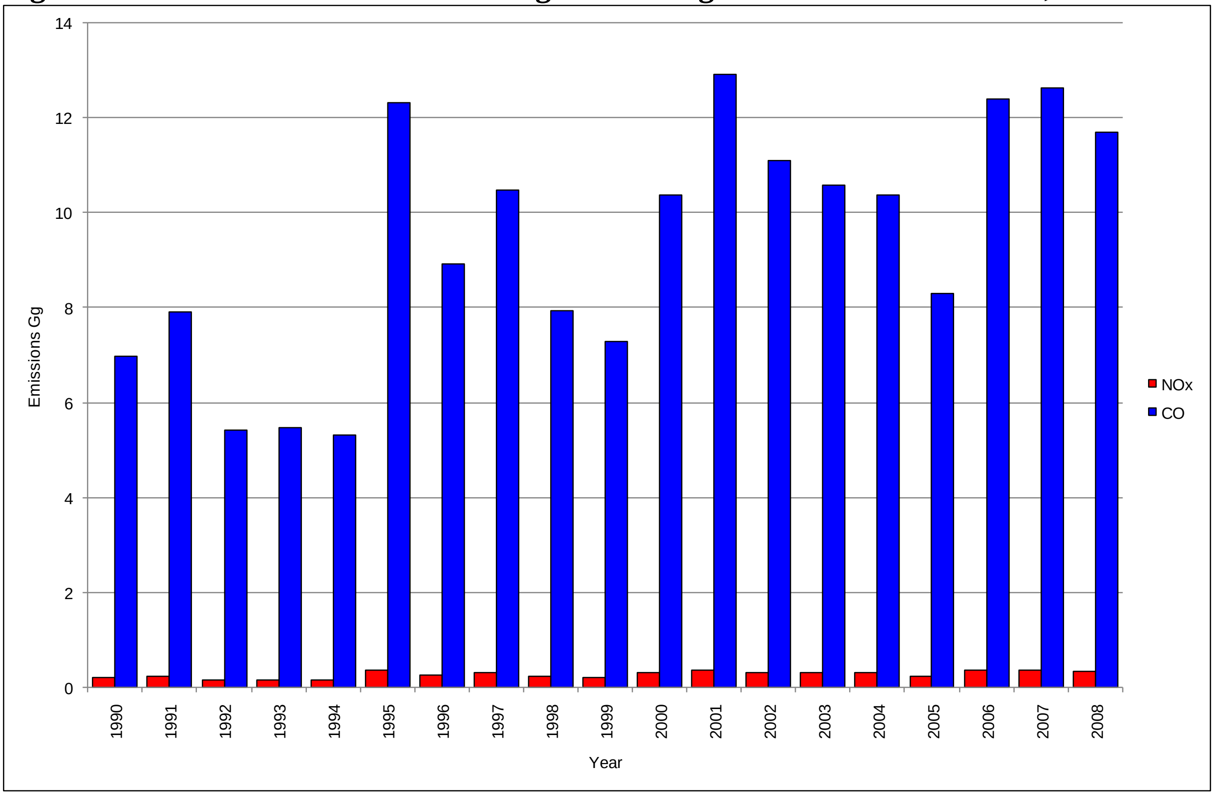


Table A 9.5.1 % Changes 1990-2008 within Sector 5

	CO_2	CH_4	N_2O	NOx	CO
5A	12%	237%	-64%	237%	237%
5B	-4%				
5C	33%	161%	161%	161%	161%
5D					
5E	-11%	-41%	-41%	-41%	-41%
5F					
5G	3%				
Overall	**-169%**	**68%**	**-53%**	**68%**	**68%**

Table A 9.5.2 % Changes 2007-2008 within Sector 5

	CO_2	CH_4	N_2O	NOx	CO
5A	-4%	-5%	-12%	-5%	-5%
5B	-1%				
5C	1%	-11%	-11%	-11%	-11%
5D					
5E	-1%	-8%	-8%	-8%	-8%
5F					
5G	32%				
Overall	**5%**	**-8%**	**-11%**	**-8%**	**-8%**

A9.6 WASTE (6)

Figure A 9.6.1 and **Figure A 9.6.2** show emissions of both direct and indirect greenhouse gases from the waste category (sector 6) in the UK for the years 1990-2008. 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.

Table A 9.6.1 to **Table A 9.6.4** 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 2008.

A9.6.1 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 A 9.6.4**). Since 1990, CO_2 emissions arising from the waste sector have decreased by 65% (**Table A 9.6.1**) and have shown a decrease of 11% since 2007 (**Table A 9.6.2**).

A9.6.2 Methane

Emissions of methane from the waste sector accounted for around 43% (**Table A 9.6.4**) of total CH_4 emissions in the UK during 2008. 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 A 9.6.3**). 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 A 9.6.1**) 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.

A9.6.3 Nitrous Oxide

Nearly all nitrous oxide waste emissions in the UK occur from the wastewater handling sector (see **Table A 9.6.3**). Since 1990, N_2O emissions from this sector have increased by 20% **Table A 9.6.1**). Overall, this sector contributes just 4% (**Table A 9.6.4**) to overall nitrous oxide emissions.

A9.6.4 Nitrogen Oxides

Emissions of NO_x from the waste category have a negligible effect on overall UK emissions.

A9.6.5 Carbon Monoxide

Emissions of CO from the waste category have a negligible effect on overall UK emissions, contributing around 1% during 2008 (**Table A 9.6.4**).

A9.6.6 Non-Methane Volatile Organic Compounds

Emissions of NMVOC from the waste category have a very small influence 2%,(**Table A 9.6.4**) on overall UK emissions.

A9.6.7 Sulphur Dioxide

Emissions of SO_2 from the waste category have a negligible effect on overall UK emissions.

Figure A 9.6.1 Emissions of direct greenhouse gases from IPCC sector 6, 1990-2008

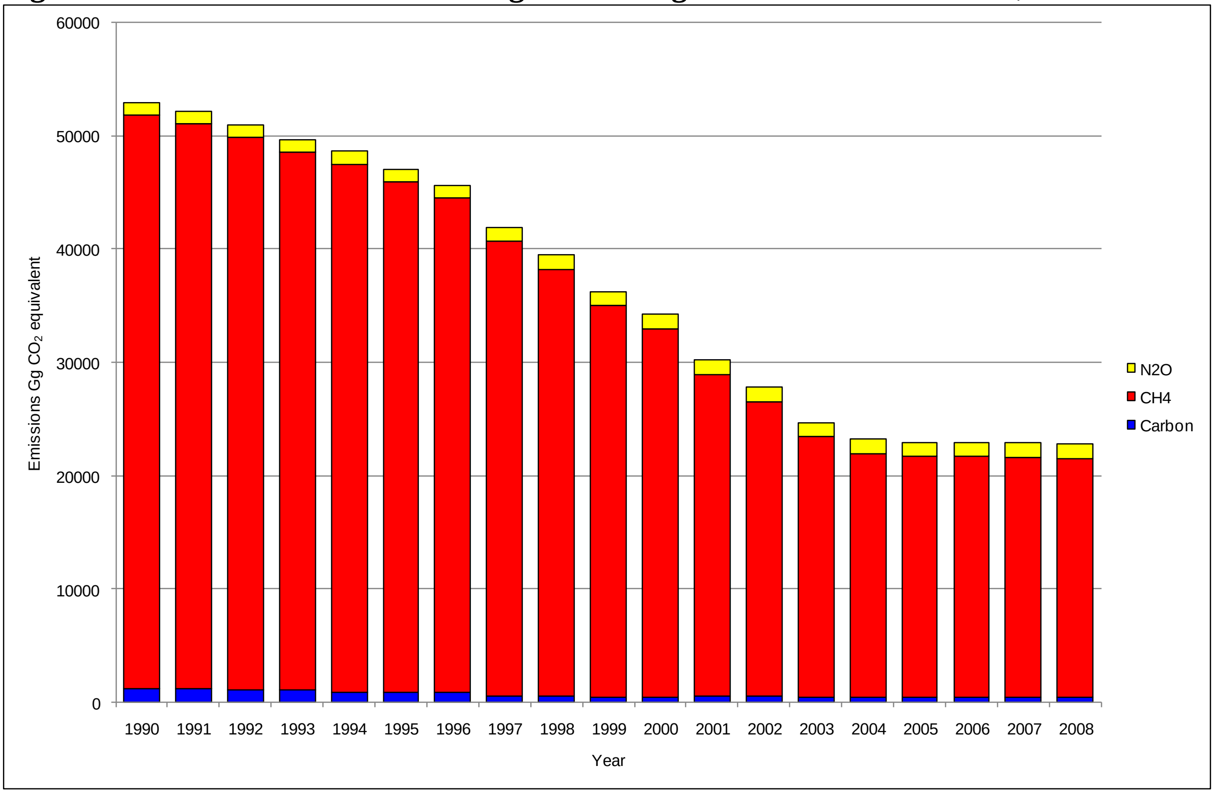


Figure A 9.6.2 Emissions of indirect greenhouse gases from IPCC sector 6, 1990-2008

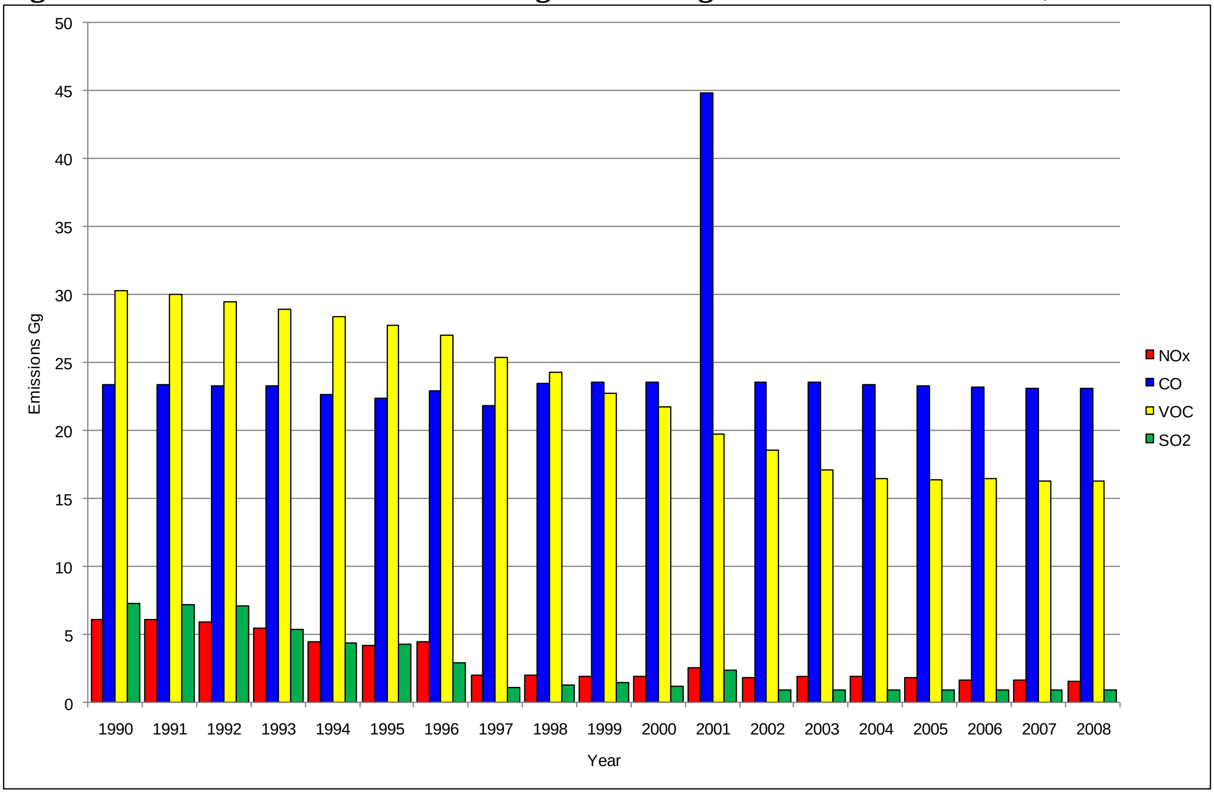


Table A 9.6.1 % Changes 1990-2008 within Sector 6

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
6A1		-59%				-59%	
6B2		15%	20%				
6C	-65%	-95%	2%	-75%	-1%	0%	-88%
Overall	**-65%**	**-58%**	**20%**	**-75%**	**-1%**	**-46%**	**-88%**

Table A 9.6.2 % Changes 2007-2008 within Sector 6

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
6A1		-0.4%				-0.4%	
6B2		0.3%	0.7%				
6C	-11%	0.2%	0.0%	-6%	0.0%	0.0%	-0.8%
Overall	**-10.5%**	**-0.3%**	**0.6%**	**-6.0%**	**0.0%**	**-0.2%**	**-0.8%**

Table A 9.6.3 % 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 9.6.4 % Contribution to Overall Pollutant Emissions

	CO_2	CH_4	N_2O	NOx	CO	NMVOC	SO_2
6A1		41%				1%	
6B2		2%	4%				
6C	0.1%	0.0%	0.1%	0.1%	1%	1%	0.2%
Overall	**0.08%**	**43%**	**4%**	**0.11%**	**1%**	**2%**	**0.18%**

A10 ANNEX 10: Verification

This Annex discusses the verification of the UK estimates of the Kyoto Gases.

A10.1 MODELLING APPROACH USED FOR THE VERIFICATION OF THE UK GHGI

In order to provide some verification of the UK Greenhouse Gas Inventory (GHGI), DECC (Department of Energy and Climate Change) 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 (O'Doherty *et al.* 2004).

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. 2007) driven by 3D synoptic meteorology from the ECMWF (ERA-Interim) (1995-2002) and the Met Offices's numerical weather prediction model (2003-2009) to generate so called air-history maps. The air-history maps represent the recent 12-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 three-year period (Jan'95-Dec'97, Feb'95-Jan'98,… Dec'06-Nov'09). The uncertainty ranges have been estimated by solving eacyh 3-yr period multiple times (26) with a random noise perturbation (based on the std of the points classed as baseline) applied to the observations. The annual estimates have been calculated by taking the median of the solutions with the full year represented in the solution period.

A10.2 METHANE

In **Table A 10.2.1** the emission estimates made for the UK with the NAME-inversion methodology are compared to the GHGI emission estimates for the period 1995-2008 inclusive.

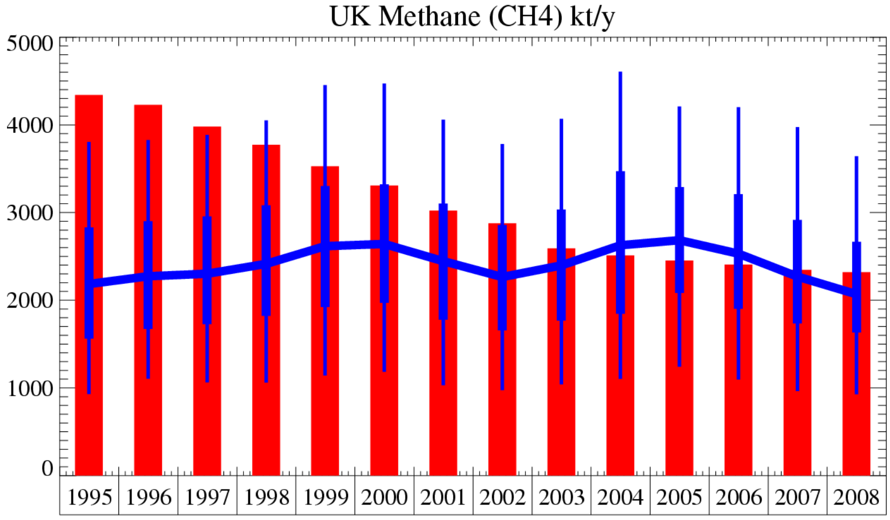
Methane has a natural (biogenic) component and it is estimated that 22% of the annual global emission is released from wetlands (Nilsson *et al*. 2001). Usually natural emissions are strongly dependent on a range of meteorological factors such as temperature and diurnal, annual, growth and decay cycles. 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 A 10.2.1**). The agreement from 2003 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.

Table A 10.2.1 Verification of the UK emission inventory estimates for CH4 in Gg yr-1 for 1995-2008. NAME-inversion uncertainties are shown in plot below.

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CH_4 – NAME	2180	2270	2300	2410	2620	2640	2450	2270	2400	2630	2680	2530	2270	2070
CH_4 – GHGI	4341	4228	3979	3773	3526	3308	3021	2877	2591	2510	2452	2405	2346	2320

Figure A 10.2.1 Verification of the UK emission inventory estimates for methane in Gg yr-1 for 1995-2008. GHGI estimates are shown in red. NAME-inversion estimates are shown in blue. NAME-inversion uncertainties are shown with the blue whisker lines showing 5th, 25th, median, 75th and 95th percentiles. Note: kt yr-1 is equivalent to 1 Gg yr-1.



A10.3 NITROUS OXIDE

The main activities in Europe resulting in the release of nitrous oxide are agricultural practices resulting in emissions from 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.

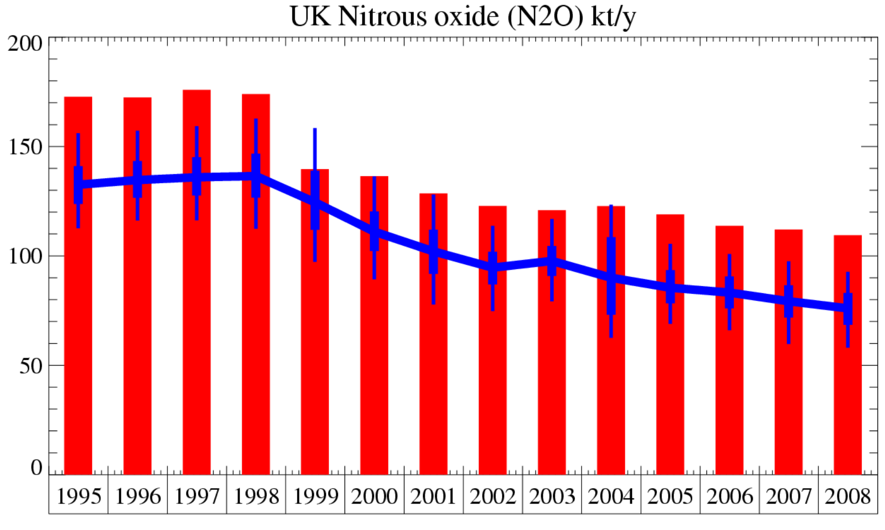
Table A 10.3.1 shows the NAME-inversion and GHGI emission estimates for the UK for nitrous oxide for the period 1995-2008. The median NAME-inversion estimates are approximately 15% lower than the GHGI estimates throughout the whole time period. The trends in the time-series are in good agreement. Both show declining UK totals (**Figure** A 10.3.1). The GHGI estimates show a sharp decline (40 Gg) between 1998 and 1999 in line with the introduction of the clean technology at an adipic acid plant in Wilton, north east England. It is estimated to have cut its emissions of N_2O by 90%, from 46 thousand tonne yr^{-1} to around 6 thousand tonne yr^{-1} (DEFRA, 2000).

The nature of the nitrous oxide emissions challenges the NAME technique assumption of uniformity of release both in time and space. 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 10.3.1 Verification of the UK emission inventory estimates for N_2O in Gg yr^{-1} for 1995-2008. NAME uncertainty shown on figure below.

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
N_2O -NAME	133	135	136	136	125	111	102	95	98	90	85	83	79	76
N_2O- GHGI	173	172	176	174	140	136	128	123	121	123	119	114	112	109

Figure A 10.3.1 Verification of the UK emission inventory estimates for nitrous oxide in Gg yr^{-1} for 1995-2008. GHGI estimates are shown in red. NAME-inversion estimates are shown in blue. NAME-inversion uncertainties are shown with the blue whisker lines showing 5th, 25th, median, 75th and 95th percentiles.



A10.4 HYDROFLUOROCARBONS

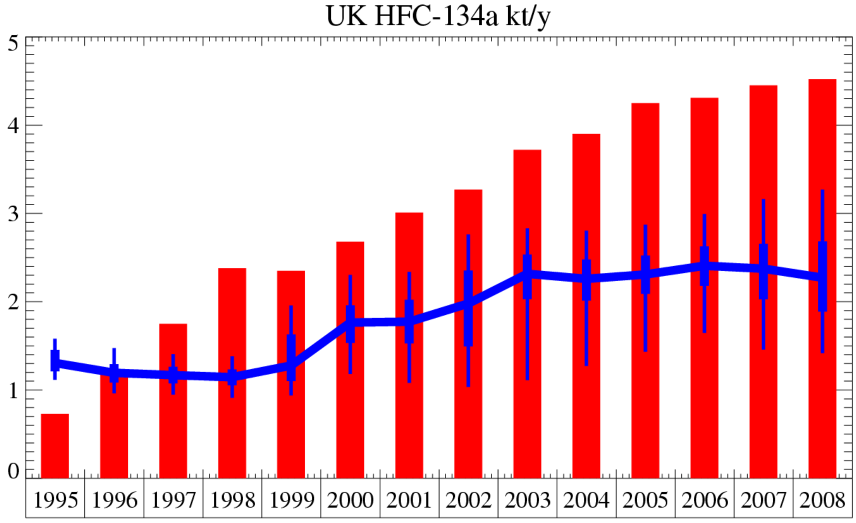
A10.4.1 HFC-134a

Table A 10.4.1 shows the NAME-inversion and GHGI emission estimates for the UK for HFC-134a for the period 1995-2008. The GHGI shows an earlier increase in emission compared to the NAME-inversion estimates. The NAME-inversion estimates begin their rise in 1999-2000 whereas the GHGI estimates began to rise from 1995 (**Figure A 10.4.1**). From 2003 onwards the NAME-inversion estimates show little change, whereas the GHGI estimates continue to rise.

Table A 10.4.1 Verification of the UK emission inventory estimates for HFC-134a in Gg yr^{-1} for 1995-2008. The NAME-inversion uncertainties are shown in the figure below.

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
HFC-134a –NAME	1.3	1.2	1.2	1.1	1.3	1.8	1.8	2.0	2.3	2.3	2.3	2.4	2.4	2.3
HFC-134a – GHGI	0.7	1.2	1.8	2.4	2.4	2.7	3.0	3.3	3.7	3.9	4.3	4.3	4.5	4.5

Figure A 10.4.1 Verification of the UK emission inventory estimates for HFC-134a in Gg yr^{-1} for 1995-2008. GHGI estimates are shown in red. NAME-inversion estimates are shown in blue. NAME-inversion uncertainties are shown with the blue whisker lines showing 5th, 25th, median, 75th and 95th percentiles.



A10.4.2 HFC-152a

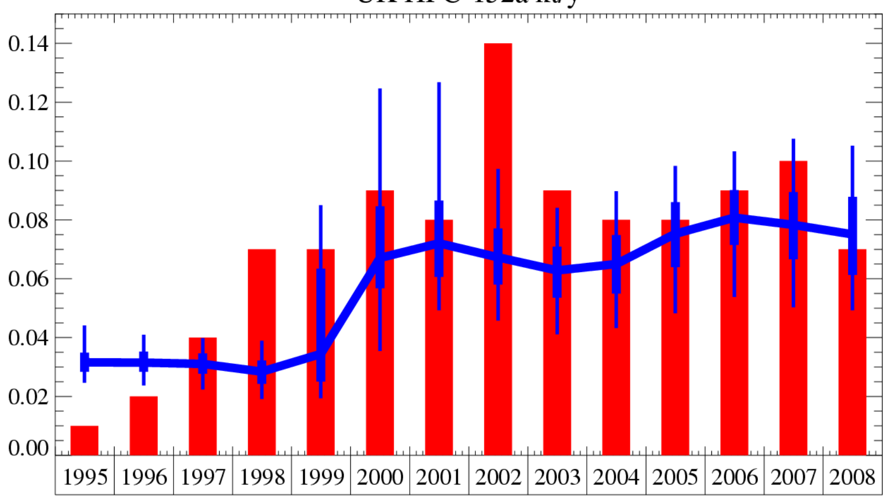
Table A 10.4.2 and

Figure A 10.4.2 show the NAME and the GHGI emission estimates for the UK for HFC-152a for the period 1995-2008. The agreement between the two datasets is generally good except for 1998 and 2002 when the GHGI estimates are considerably higher.

Table A 10.4.2 Verification of the UK emission inventory estimates for HFC-152a in Gg yr^{-1} for 1995-2008. The NAME-inversion uncertainties are shown in the figure below.

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
HFC-152a –NAME	0.03	0.03	0.03	0.03	0.03	0.07	0.07	0.07	0.06	0.07	0.08	0.08	0.08	0.08
HFC-152a – GHGI	0.01	0.02	0.04	0.07	0.07	0.09	0.08	0.14	0.09	0.08	0.08	0.09	0.10	0.07

Figure A 10.4.2 Verification of the UK emission inventory estimates for HFC-152a in Gg yr-1 for 1995-2008. GHGI estimates are shown in red. NAME-inversion estimates are shown in blue. NAME-inversion uncertainties are shown with the blue whisker lines showing 5th, 25th, median, 75th and 95th percentiles.



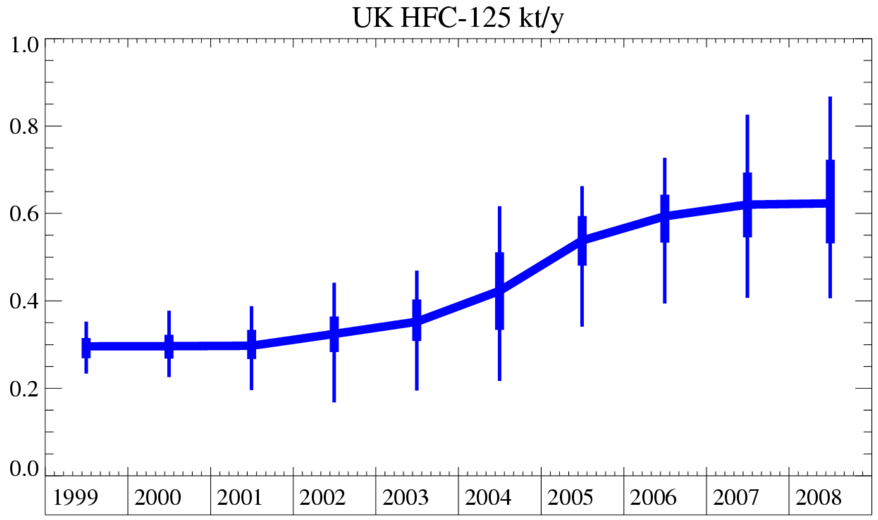
A10.4.3 HFC-125

NAME-inversion emission estimates for the UK for HFC-125 for the period 1999-2008 are shown below in **Table A 10.4.3**. The estimates suggest that the emissions of HFC-125 from the UK increased significantly between 2003 and 2006.

Table A 10.4.3 Verification of the UK emission inventory estimates for HFC-125 in Gg yr-1 for 1999-2008. The NAME-inversion uncertainties are shown in the figure below.

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
HFC-125 – NAME					0.30	0.30	0.30	0.32	0.35	0.42	0.54	0.59	0.62	0.62

Figure A 10.4.3 Verification of the UK emission inventory estimates for HFC-125 in Gg yr-1 for 1995-2008. GHGI estimates are shown in red. NAME-inversion estimates are shown in blue. NAME-inversion uncertainties are shown with the blue whisker lines showing 5th, 25th, median, 75th and 95th percentiles.



A10.4.4 HFC-365mfc

NAME emission estimates for the UK for HFC-365mfc for the period 2004-2008 are shown below in **Table A 10.4.4**. The estimates show a rise and then a fall in the emissions.

Table A 10.4.4 Verification of the UK emission inventory estimates for HFC-365mfc in Gg yr^{-1} for 2004-2008. The NAME-inversion estimates have a calculated uncertainty of ±0.15 Gg yr^{-1} (25th -75th uncertainty range).

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
HFC-365mfc –NAME										0.58	0.57	0.51	0.32	0.15

A10.4.5 HFC-143a

NAME-inversion emission estimates for the UK for HFC-143a for the period 2004-2008 are shown below in **Table A 10.4.5**. The estimates suggest that the emissions of HFC-125 from the UK have been increasing.

Table A 10.4.5 Verification of the UK emission inventory estimates for HFC-143a in Gg yr-1 for 2004-2008. The NAME-inversion estimates have a calculated uncertainty of ±0.12 Gg yr^{-1} (25th -75th uncertainty range).

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
HFC-143a – NAME										0.50	0.55	0.57	0.59	0.60

A10.4.6 HFC-23

NAME-inversion emission estimates for the UK for HFC-23 for 2008 are shown below in **Table A 10.4.6**.

Table A 10.4.6 Verification of the UK emission inventory estimates for HFC-23 in Gg yr^{-1} for 2008. The NAME-inversion estimates have a calculated uncertainty of ±0.01 Gg yr^{-1} (25^{th} -75^{th} uncertainty range).

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
HFC-23 – NAME														0.01

A10.4.7 HFC-32

NAME-inversion emission estimates for the UK for HFC-32 for 2004-2008 are shown below in **Table A 10.4.7**. The emissions are estimated to be rising steadily.

Table A 10.4.7 Verification of the UK emission inventory estimates for HFC-32 in Gg yr^{-1} for 2004-2008. The NAME estimates have a calculated error of ±0.03 Gg yr^{-1}.

Gas	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
HFC-32 – NAME										0.13	0.14	0.14	0.16	0.17

A11 ANNEX 11: Analysis of EU ETS Data

A11.1 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 4 years' worth of data on fuel use and emissions across major UK industrial plant, for 2005-2008.

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.

EU ETS 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 were included in the UK Emission Trading Scheme (UK ETS), or which had a Climate Change Agreement (CCA) could 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 gave 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 is available. Note however, that emissions from smaller combustion devices in the industrial, commercial and public sectors will not be reported, since they are outside the scope of the EU ETS. 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 should be covered for several major industrial sectors:

- Power stations;
- Oil refineries;
- Coke ovens;
- Integrated steelworks;
- Cement kilns; and
- Lime kilns.

In the case of coke ovens and integrated steelworks, 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. 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 for these sectors. The EU ETS data has, however, been useful as a quality check for the use of fuels within the iron and steel sector.

This annex summarises what data are available in the 2005 to 2008 EU ETS datasets for power stations and refineries, and identifies which EU ETS fuel quality data (i.e. CO_2 emission factors) have been used within the GHGI. Data for the ‘other industrial combustion’ sector are also briefly described as an example of an area of the GHGI where use of EU ETS data is more problematic.

A11.2 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 11.2.1.** 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 11.2.1 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).

A11.3 ANALYSIS OF EU ETS DATA FOR POWER STATIONS

Table A 11.3.1 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 11.3.1 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)
2005	Coal	99	615.6
2006		100	615.6
2007		100	615.4
2008		100	614.0
2005	Fuel oil / Waste oil[a]	68	860.2
2006		66	873.3
2007		68	871.2
2008		92	869.5
2005	Natural gas	52	1.459
2006		76	1.475
2007		95	1.471
2008		97	1.499
2005	Coal - autogenerators	100	594.3
2006		100	596.3
2007		100	594.5
2008		100	581.3

[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 EU ETS data shown are regarded as good quality data, 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.

A11.4 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 11.4.1 and Table A 11.4.2.** 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 11.4.1 EU ETS Data for Fuel Oil & OPG burnt at Refineries (Emission Factors in ktonne / Mtonne for Fuel Oil and ktonne / Mtherm for OPG)

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 sites only)
2005	Fuel Oil	26	861.0
2006		68	873.7
2007		79	877.2
2008		91	871.6
2005	OPG	75	1.525
2006		53	1.483
2007		69	1.673
2008		82	1.483

Table A 11.4.2 EU ETS Derived Data for Carbon Emissions from Petroleum Coke burnt at Refineries (in Mtonnes)

Year	Fuel	% Tier 3	Emission from EUETS	Emission, based on DUKES[b]
2005	Petroleum Coke	-[a]	1.273	1.123
2006		-[a]	1.338	1.263
2007		-[a]	1.350	1.212
2008		-[a]	1.235	1.271

[a] It was unclear from the data received how much of the emission was based on a Tier 3 approach.
[b] Using an emission factor of 930 kt/Mt of petroleum coke burnt (figure suggested by the refinery industry).

Emission factors for fuel oil generated from EU ETS data have been adopted in the GHGI, with the exception of data for 2005, where Tier 3 methods were used for only 26% of fuel.

Carbon factors can be derived for OPG based on quite high levels of Tier 3 reporting, and there was in addition considerable uncertainty regarding the allocation of EU ETS fuels to the OPG fuel category. The emission factors are surprisingly variable and, for this reason, these data have not been used. Consultation with the industry is required to establish whether the large year-on-year changes in carbon factors is realistic for this fuel.

Emission data for petroleum coke are significantly higher in 2005-2007 than would be obtained using DUKES activity data, and an appropriate emission factor. This is especially noticeable for 2005 and 2007, where the petroleum coke consumption given in DUKES would have to be more than 100% carbon in order to generate the carbon emissions given in the EU ETS. Consultation with energy statisticians has identified that the figures given in DUKES are subject to considerable uncertainty and, as a result, the EU ETS data have been used instead.

A11.5 ANALYSIS OF EUETS DATA FOR INDUSTRIAL COMBUSTION SOURCES

Table A 11.5.1 gives data for industrial combustion of coal, fuel oil and natural gas.

Table A 11.5.1 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)**	**GHGI Carbon Emission Factor**
2005	Coal	98	607.1	631.1
2006		98	603.0	631.1
2007		99	613.5	645.4
2008		94	596.8	640.6
2005	Fuel oil	17	864.7	879.0
2006		27	865.3	879.0
2007		20	865.7	879.0
2008		18	870.7	879.0
2005	Natural gas	14	1.455	1.478
2006		31	1.470	1.478
2007		40	1.466	1.477
2008		31	1.523	1.474

At first sight, the data for coal looks like it should be reliable enough to be used in the GHGI with 94% 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.

A12 ANNEX 12: UK Domestic Emissions Reporting Requirements

In addition to the reporting requirements of the UNFCCC, Kyoto Protocol and EUMM, UK Greenhouse Gas Inventory statistics are published annually in the Department of Energy and Climate Change's statistical release. The geographical coverage of these estimates differs from the UNFCCC and EUMM coverage, with the totals only including emissions from the UK and the UK's Crown Dependencies. Summary tables of these data are presented below. The data are presented in the nine categories used for the UK's National Communications to the UNFCCC (NC Categories).

A12.1 NATIONAL STATISTICS

Table A 12.1.1 Summary table of GHG emissions by NC Category (Mt CO2eq) – National Statistics coverage

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Energy Supply	274.0	274.0	262.9	243.5	235.2	235.6	237.1	220.9	223.4	210.5
Transport	124.7	123.1	124.2	125.4	125.5	124.7	129.3	130.5	129.3	130.0
Residential	81.5	90.2	87.5	91.5	86.9	82.6	94.1	87.6	90.3	89.3
Business	111.0	113.0	108.7	109.0	109.5	106.9	109.5	108.1	107.5	109.1
Public	13.6	14.5	15.1	13.8	13.4	13.2	14.3	13.9	12.7	12.4
Industrial Processes	54.3	52.4	46.9	43.3	45.2	44.7	45.6	47.1	43.8	26.9
Agriculture	61.3	60.8	59.1	58.4	59.3	59.1	59.6	59.8	58.7	58.1
Land Use Change	2.9	2.8	2.2	1.1	0.9	1.2	1.0	0.6	0.0	-0.2
Waste Management	52.9	52.1	50.9	49.5	48.5	46.9	45.5	41.8	39.3	36.1
Total	**776.1**	**782.9**	**757.5**	**735.5**	**724.6**	**714.9**	**735.9**	**710.2**	**705.1**	**672.2**

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Energy Supply	219.5	229.5	226.4	230.7	228.6	228.7	231.0	226.2	219.7
Transport	129.0	128.5	130.5	131.7	132.9	133.8	135.5	136.0	131.9
Residential	90.1	92.4	88.9	90.1	91.7	88.2	85.1	81.8	84.4
Business	110.0	110.5	101.1	103.2	102.0	101.9	99.6	98.3	95.7
Public	11.7	12.1	10.3	10.2	11.1	11.0	10.5	9.6	10.2
Industrial Processes	24.4	21.8	18.4	19.2	18.7	17.8	16.5	18.0	16.7
Agriculture	55.5	52.6	52.8	52.1	52.0	51.8	49.9	48.9	48.4
Land Use Change	-0.4	-0.5	-1.0	-1.0	-1.8	-2.0	-1.9	-1.9	-2.0
Waste Management	34.1	30.1	27.7	24.6	23.1	22.9	22.8	22.8	22.7
Grand Total	**673.9**	**677.0**	**655.1**	**660.7**	**658.2**	**654.1**	**649.2**	**639.6**	**627.6**

Table A 12.1.2 Summary table of GHG emissions by Gas (Mt CO2eq) – National Statistics coverage

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2	592.8	600.2	582.9	567.9	561.8	553.1	575.3	551.5	553.6	543.1
CH_4	104.4	103.6	102.1	99.1	92.1	91.2	88.8	83.5	79.2	74.0
N_2O	65.1	65.0	58.5	53.8	54.9	53.5	53.4	54.5	53.9	43.3
HFCs	11.4	11.9	12.3	13.1	14.1	15.5	16.7	19.0	16.8	10.0
PFCs	1.4	1.2	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4
SF_6	1.0	1.1	1.1	1.2	1.2	1.2	1.3	1.2	1.3	1.4
Grand Total	**776.1**	**782.9**	**757.5**	**735.5**	**724.6**	**714.9**	**735.9**	**710.2**	**705.1**	**672.2**

	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO_2	551.2	562.6	545.0	556.7	556.3	553.9	551.4	543.6	532.8
CH_4	69.5	63.4	60.4	54.4	52.7	51.5	50.5	49.3	48.7
N_2O	42.3	39.8	38.1	37.5	38.0	36.9	35.2	34.7	33.9
HFCs	8.7	9.3	9.8	10.5	9.6	10.4	10.8	11.0	11.2
PFCs	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2
SF_6	1.8	1.4	1.5	1.3	1.1	1.1	0.9	0.8	0.7
Grand Total	**673.9**	**677.0**	**655.1**	**660.7**	**658.2**	**654.1**	**649.2**	**639.6**	**627.6**

A12.2 CARBON BUDGETS

The UK's Climate Change Act includes legally binding targets for the UK to reduce its greenhouse gas emissions by at least 80 per cent by 2050, and by at least 34 per cent by 2020, both below base year levels. It also establishes a system of binding five-year carbon budgets to set the trajectory towards these targets. The geographical coverage of the Act and the carbon budgets is UK only. Summary statistics for the UK only are presented below.

Table A 12.2.1 Summary table of GHG emissions by NC Category (Mt CO_2eq) – UK only

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Energy Supply	273.5	273.5	262.2	242.9	234.6	234.9	236.5	220.3	222.8	209.8
Transport	124.3	122.8	123.8	125.0	125.1	124.3	128.9	130.1	128.9	129.6
Residential	81.2	89.9	87.2	91.2	86.6	82.2	93.8	87.1	89.9	89.0
Business	110.8	112.7	108.4	108.8	109.3	106.6	109.2	107.7	107.2	108.8
Public	13.6	14.5	15.1	13.8	13.4	13.2	14.3	13.9	12.7	12.4
Industrial Processes	54.3	52.4	46.9	43.3	45.2	44.7	45.6	47.1	43.8	26.9
Agriculture	61.1	60.7	58.9	58.2	59.2	59.0	59.4	59.6	58.5	57.9
Land Use Change	3.0	2.9	2.3	1.1	0.9	1.3	1.0	0.7	0.1	-0.2
Waste Management	52.7	51.9	50.7	49.4	48.4	46.8	45.4	41.7	39.2	36.0
Grand Total	**774.5**	**781.2**	**755.8**	**733.8**	**722.8**	**713.1**	**734.0**	**708.2**	**703.1**	**670.2**

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Energy Supply	219.0	229.2	226.1	230.5	228.4	228.4	230.7	225.8	219.3
Transport	128.5	128.0	130.1	131.2	132.4	133.3	135.0	135.5	131.4
Residential	89.7	92.0	88.6	89.7	91.3	87.9	84.7	81.4	84.0
Business	109.6	110.1	100.7	102.9	101.7	101.6	99.3	97.9	95.4
Public	11.7	12.1	10.3	10.2	11.1	11.0	10.5	9.6	10.2
Industrial Processes	24.4	21.8	18.4	19.2	18.7	17.8	16.5	18.0	16.7
Agriculture	55.4	52.5	52.7	52.0	51.9	51.7	49.8	48.8	48.3
Land Use Change	-0.3	-0.4	-0.9	-1.0	-1.7	-1.9	-1.8	-1.9	-1.9
Waste Management	34.0	30.0	27.6	24.5	23.0	22.8	22.8	22.8	22.6
Grand Total	**672.0**	**675.4**	**653.6**	**659.3**	**656.7**	**652.6**	**647.6**	**637.9**	**626.0**

Table A 12.2.2 Summary table of GHG emissions by Gas (Mt CO2eq) – UK Only

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2	591.4	598.7	581.5	566.5	560.4	551.5	573.7	549.9	551.8	541.4
CH_4	104.1	103.4	101.9	98.8	91.8	90.9	88.5	83.3	79.0	73.8
N_2O	65.1	65.0	58.4	53.7	54.9	53.5	53.4	54.5	53.9	43.2
HFCs	11.4	11.9	12.3	13.1	14.0	15.5	16.7	19.0	16.7	9.9
PFCs	1.4	1.2	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4
SF_6	1.0	1.1	1.1	1.2	1.2	1.2	1.3	1.2	1.3	1.4
Grand Total	**774.5**	**781.2**	**755.8**	**733.8**	**722.8**	**713.1**	**734.0**	**708.2**	**703.1**	**670.2**

	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO_2	549.6	561.3	543.7	555.5	555.1	552.6	550.1	542.2	531.5
CH_4	69.3	63.3	60.2	54.3	52.6	51.4	50.4	49.1	48.6
N_2O	42.2	39.8	38.0	37.5	38.0	36.8	35.2	34.7	33.9
HFCs	8.6	9.3	9.7	10.5	9.6	10.4	10.8	10.9	11.2
PFCs	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2
SF_6	1.8	1.4	1.5	1.3	1.1	1.1	0.9	0.8	0.7
Grand Total	**672.0**	**675.4**	**653.6**	**659.3**	**656.7**	**652.6**	**647.6**	**637.9**	**626.0**

UK Domestic Emissions Reporting Requirements A12

A13 Annex 13: End User Emissions

A13.1 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[15].

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.

A13.2 DEFINITION OF FINAL USERS

The final user[16] 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:

- Emissions in the **residential** final user category include:

[15] See page 84 of UNFCCC Guidelines contained in FCCC/CP/1999/7 available at: http://unfccc.int/resource/docs/cop5/07.pdf

[16] 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.

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.

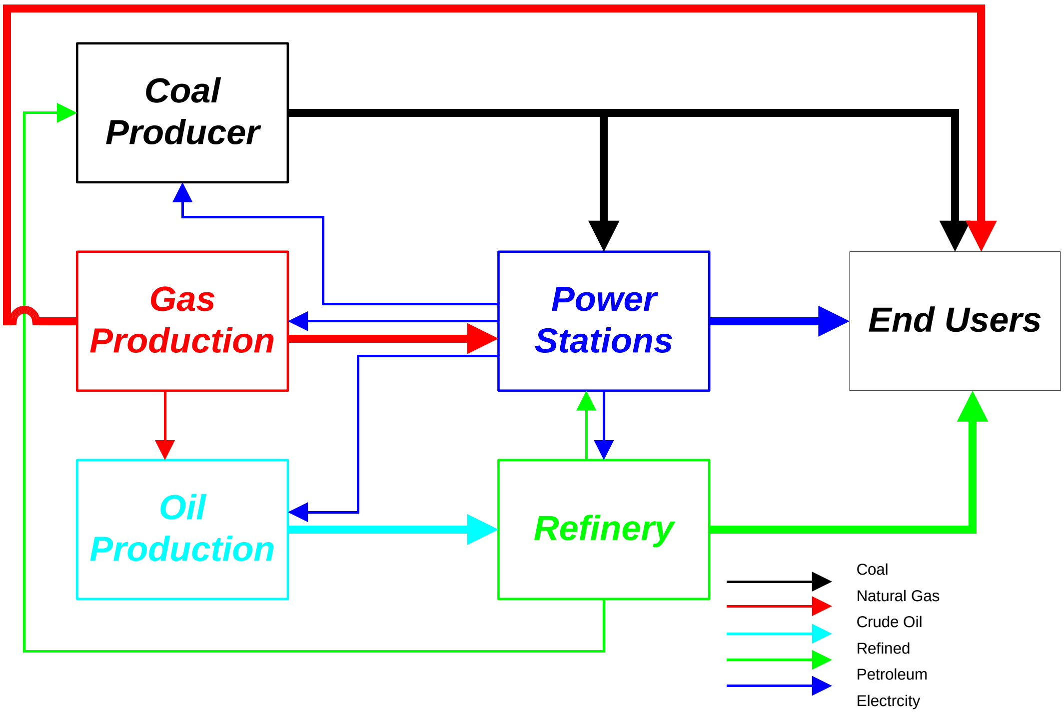
- Emissions in the **road transport** final user category include:
  1. Direct emissions from motor vehicle exhausts.
  2. Emissions refineries producing motor fuels, including refining, storage, flaring and extraction of oil; and from the distribution and supply of motor fuels.

A13.3 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 A13.3.1 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 A 13.3.1 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[17] 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%)[18] 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.

[17] 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.

[18] In the model used to determine emissions from final users, the value of this percentage can 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.

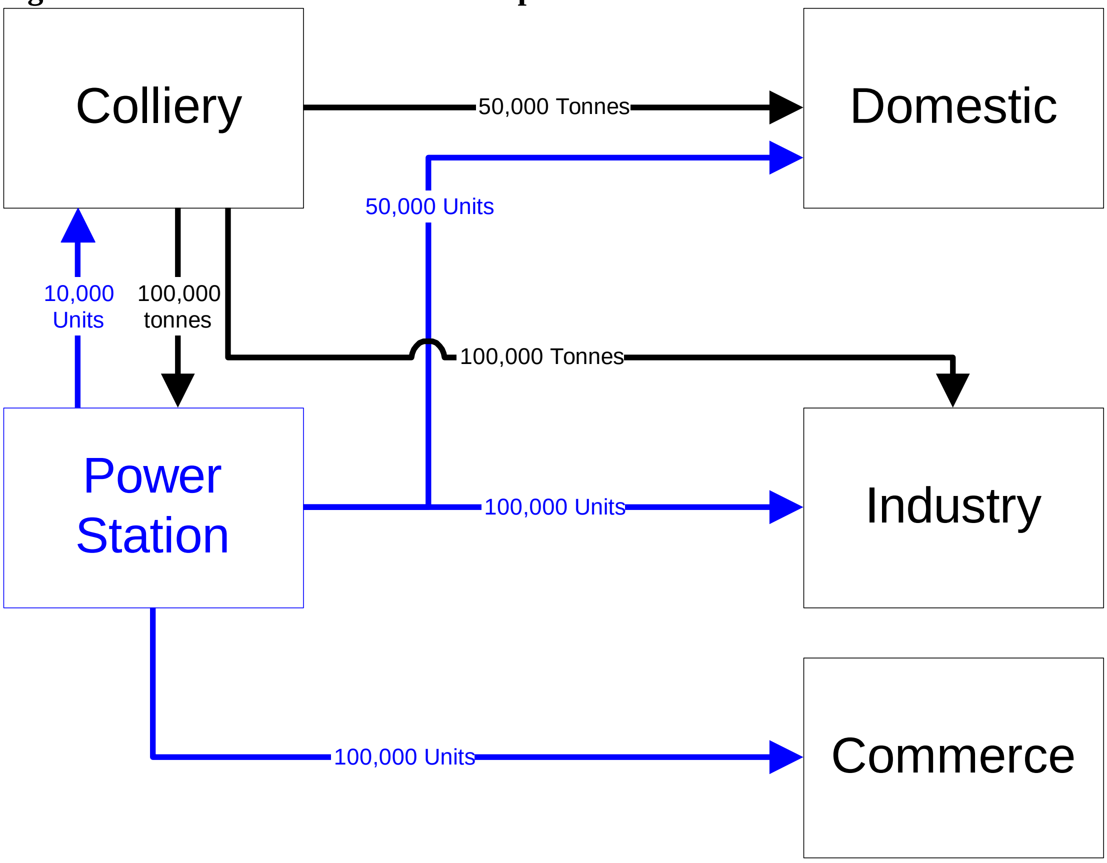
A13.4 EXAMPLE FINAL USER CALCULATION

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 A13.4.1** 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 A 13.4.1 Fuel use in the example calculation



In **Figure A13.4.1**, 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 A13.4.1 summarises the outputs during this example final user calculation.

Table A 13.4.1 Example of the outputs during a final user calculation

			Sector					**Unallocated emissions as percentage of total emission**	**Total emission of SO_2 (tonnes)**
			Colliery	**Power Station**	**Residential**	**Industrial**	**Commercial**		
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 A 13.4.2 Comparison of 'direct' and final user emissions of sulphur dioxide according the sectors considered in the final user example

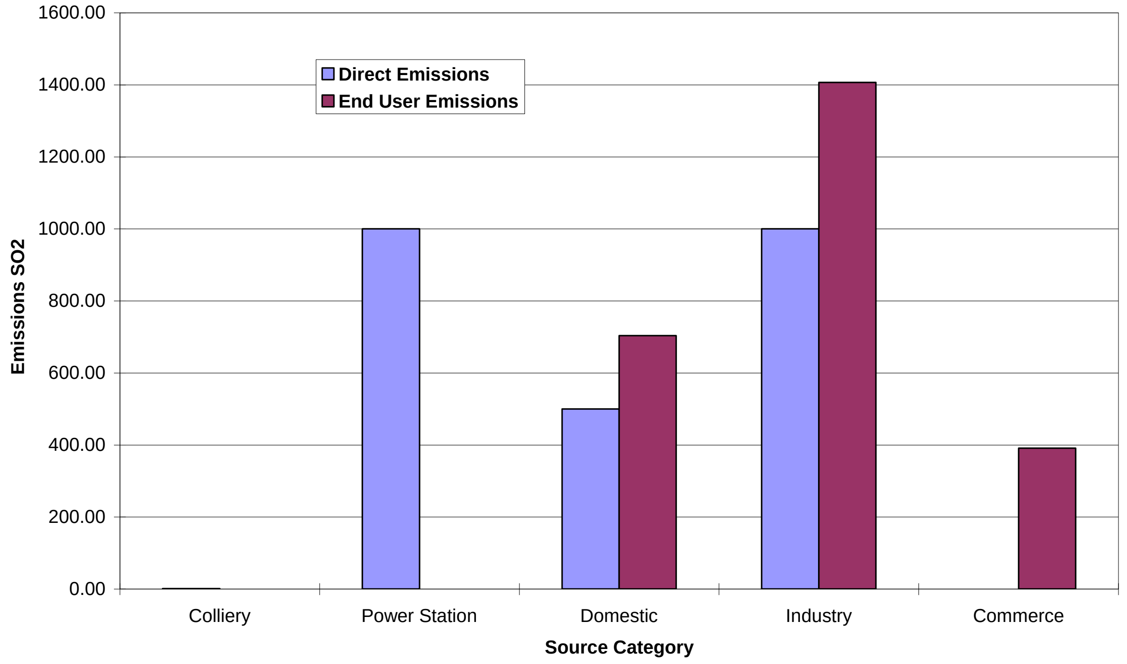


Figure A13.4.2 compares the quantities of direct and final user sulphur dioxide emitted from each sector at the end of the final user calculation. The direct emissions of sulphur dioxide are from the combustion of coal in the sectors. The direct and final user emissions are from two distinct calculations 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.

A13.5 FINAL USER CALCULATION METHODOLOGY FOR THE UK GREENHOUSE GAS INVENTORY

The approach divides fuel user emissions into 7 categories (see column 1 of **Table A13.5.1**). 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 13.5.1: 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 13.5.2: 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

NCFormat	IPCC	SourceName	ActivityName
		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
	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
Agriculture Total			
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

NCFormat	IPCC	SourceName	ActivityName
			Waste
			Waste oils
			Waste solvent
		Lime production - non decarbonising	Coal
			Coke
			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

NCFormat	IPCC	SourceName	ActivityName
	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
			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
Business Total			
Energy Supply	1A1a_Public_Electricity&Heat_Production	Power stations	Coal
			Fuel oil
			Gas oil

NCFormat	IPCC	SourceName	ActivityName
			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
		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
Energy Supply Total			
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

NCFormat	IPCC	SourceName	ActivityName
Exports Total			
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
	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

NCFormat	IPCC	SourceName	ActivityName
Industrial Process Total			
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
	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
Land Use Change Total			
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
Public Total			
Residential	1A4b_Residential	Domestic combustion	Anthracite
			Burning oil
			Coal
			Coke
			Fuel oil
			Gas oil

NCFormat	IPCC	SourceName	ActivityName
			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
Residential Total			
Transport	1A3aii_Civil_Aviation_Domestic	Aircraft - domestic cruise	Aviation spirit
			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 -	Petrol

NCFormat	IPCC	SourceName	ActivityName
		urban driving	
		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
		Road transport - mopeds (<50cc 2st) - urban driving	Petrol
		Road transport - motorcycle (>50cc 2st) - rural driving	Petrol

NCFormat	IPCC	SourceName	ActivityName
		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
Transport Total			
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
Waste Management Total			

A13.6 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.

Notes

- LULUCF Land Use Land Use Change and Forestry

Table A 13.6.1: 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	8.81	8.81	8.84	8.66	8.42	8.44	8.34	8.36	7.98	7.87	7.68	7.37
Methane	22.56	22.56	22.23	22.28	22.11	22.17	21.91	22.11	21.45	21.44	21.36	20.47
Nitrous oxide	33.83	33.83	33.65	31.81	31.25	32.01	32.12	32.27	33.25	32.34	31.77	30.47
HFCs												
PFCs												
SF_6												
Total greenhouse gas emissions	65.20	65.20	64.72	62.75	61.78	62.62	62.38	62.74	62.68	61.65	60.81	58.30

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007	2008
Carbon dioxide	7.71	7.66	7.59	7.50	7.41	7.13	6.91	6.81
Methane	19.24	19.00	18.96	19.10	19.32	18.96	18.83	18.38
Nitrous oxide	28.72	29.20	28.52	28.35	27.93	26.72	25.97	25.90
HFCs								
PFCs								
SF_6								
Total greenhouse gas emissions	55.67	55.86	55.07	54.95	54.66	52.81	51.70	51.09

Table A 13.6.2: 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	227.47	227.47	224.73	211.06	203.95	200.98	197.61	199.03	191.88	191.79	188.96	196.35
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	2.25	2.23	2.17	2.08	1.96	1.93	1.85	1.89
HFCs	1.09	0.00	0.00	0.00	0.31	0.67	1.09	1.57	2.02	2.54	3.14	3.80
PFCs	0.10	0.06	0.06	0.07	0.08	0.09	0.10	0.12	0.14	0.14	0.16	0.19
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	245.12	243.77	240.78	226.70	219.27	213.88	211.73	212.86	205.87	205.33	202.23	209.81

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007	2008
Carbon dioxide	201.58	188.43	194.90	192.62	192.59	194.46	190.47	184.57
Methane	6.53	6.49	5.27	5.01	4.56	4.28	3.64	3.65
Nitrous oxide	1.94	1.89	1.92	1.93	1.97	2.01	1.96	1.77
HFCs	4.48	5.39	5.87	6.51	6.98	7.40	7.78	8.05
PFCs	0.11	0.11	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	0.62
Total greenhouse gas emissions	215.31	202.98	208.72	206.91	207.04	208.94	204.57	198.74

Table A 13.6.3: 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	14.39	14.29	15.45	15.83	16.48	16.68	16.59	16.51	15.67
Methane	1.69	1.69	1.64	1.64	1.62	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	49.51	45.84	47.37	46.96	47.89	49.52	46.00	28.87	26.25

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007	2008
Carbon dioxide	14.20	13.19	13.99	14.32	14.34	13.79	15.14	14.24
Methane	0.76	0.67	0.60	0.57	0.49	0.45	0.40	0.42
Nitrous oxide	4.88	2.73	2.89	3.64	2.87	2.43	2.82	2.47
HFCs	2.39	2.03	1.98	0.45	0.44	0.39	0.18	0.15
PFCs	0.27	0.21	0.17	0.24	0.17	0.22	0.14	0.13
SF_6	0.76	0.85	0.67	0.39	0.25	0.18	0.15	0.09
Total greenhouse gas emissions	23.25	19.68	20.31	19.61	18.57	17.46	18.83	17.51

Table A 13.6.4: 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	2.89	2.89	2.81	2.18	1.08	0.86	1.19	0.93	0.61	0.02	-0.25	-0.38
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	2.91	2.91	2.83	2.20	1.10	0.88	1.22	0.96	0.64	0.04	-0.23	-0.35

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007	2008
Carbon dioxide	-0.51	-1.05	-1.08	-1.81	-1.98	-1.89	-1.96	-2.04
Methane	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03
Nitrous oxide	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFCs								
PFCs								
SF_6								
Total greenhouse gas emissions	-0.47	-1.02	-1.05	-1.78	-1.96	-1.86	-1.92	-2.01

Table A 13.6.5: 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	29.25	29.25	32.33	33.90	27.85	27.56	26.76	27.63	25.19	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	31.19	31.19	34.47	36.21	29.67	29.00	28.26	29.05	26.50	25.15	24.22	23.31

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007	2008
Carbon dioxide	23.12	20.69	20.80	21.58	21.43	21.43	20.58	20.80
Methane	0.80	0.76	0.59	0.60	0.56	0.53	0.45	0.46
Nitrous oxide	0.09	0.08	0.08	0.08	0.08	0.09	0.08	0.08
HFCs								
PFCs								
SF_6								
Total greenhouse gas emissions	24.01	21.53	21.47	22.26	22.07	22.04	21.11	21.33

Table A 13.6.6: 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	155.85	155.85	165.61	159.43	155.60	150.39	143.90	155.99	141.36	147.12	142.53	147.07
Methane	11.65	11.65	12.18	11.93	11.39	8.75	8.45	8.28	7.43	7.03	6.50	5.80
Nitrous oxide	0.92	0.92	0.96	0.90	0.83	0.78	0.70	0.68	0.58	0.61	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	168.82	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	2008
Carbon dioxide	153.84	148.35	151.82	153.03	148.88	148.74	143.04	145.68
Methane	5.64	5.56	4.36	4.27	3.92	3.73	3.29	3.40
Nitrous oxide	0.61	0.55	0.57	0.55	0.54	0.58	0.54	0.53
HFCs	2.43	2.35	2.65	2.68	3.02	3.01	3.01	3.01
PFCs								
SF_6								
Total greenhouse gas emissions	162.52	156.82	159.39	160.53	156.37	156.07	149.88	152.62

Table A 13.6.7: 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	140.76	140.76	139.16	140.86	142.83	144.02	144.30	150.11	150.44	149.19	149.22	148.08
Methane	2.21	2.21	2.10	2.11	1.98	1.95	2.02	1.88	1.76	1.68	1.46	1.36
Nitrous oxide	1.68	1.68	1.67	1.67	1.75	1.94	2.23	2.12	2.13	2.17	2.18	2.18
HFCs												
PFCs												
SF_6												
Total greenhouse gas emissions	144.65	144.65	142.93	144.64	146.56	147.91	148.56	154.12	154.33	153.05	152.87	151.63

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007	2008
Carbon dioxide	148.29	151.40	151.91	151.17	152.82	151.89	152.66	147.65
Methane	1.38	1.24	1.09	1.05	0.91	0.83	0.90	0.80
Nitrous oxide	2.12	2.12	2.04	1.98	1.95	1.92	1.87	1.69
HFCs								
PFCs								
SF_6								
Total greenhouse gas emissions	151.78	154.76	155.04	154.20	155.69	154.64	155.43	150.14

Table A 13.6.8: 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	44.99	43.52	40.08	37.62	34.44	32.38
Nitrous oxide	1.08	1.08	1.07	1.08	1.07	1.15	1.08	1.12	1.22	1.23	1.19	1.25
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	39.35	36.09	34.10

Greenhouse Gas	2001	2002	2003	2004	2005	2006	2007	2008
Carbon dioxide	0.49	0.49	0.47	0.47	0.47	0.43	0.45	0.40
Methane	28.33	25.94	22.86	21.35	21.09	21.12	21.08	21.00
Nitrous oxide	1.26	1.26	1.26	1.26	1.29	1.29	1.28	1.29
HFCs								
PFCs								
SF_6								
Total greenhouse gas emissions	30.08	27.70	24.59	23.08	22.85	22.84	22.81	22.69

Table A 13.6.9: 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	65.20	65.20	64.72	62.75	61.78	62.62	62.38	62.74	62.68	61.65	60.81	58.30
Business	245.12	243.77	240.78	226.70	219.27	213.88	211.73	212.86	205.87	205.33	202.23	209.81
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	10.30	10.30	11.39	12.32	13.90	14.32	15.44	17.05	18.15	17.70	15.78	15.15
Industrial Process	58.42	56.80	54.98	49.51	45.84	47.37	46.96	47.89	49.52	46.00	28.87	26.25
Public	31.19	31.19	34.47	36.21	29.67	29.00	28.26	29.05	26.50	25.15	24.22	23.31
Residential	168.82	168.43	178.75	172.27	167.86	160.03	153.45	165.74	150.74	156.87	151.53	155.67
Transport	144.65	144.65	142.93	144.64	146.56	147.91	148.56	154.12	154.33	153.05	152.87	151.63
Waste Management	52.87	52.87	52.08	50.89	49.55	48.54	46.94	45.52	41.79	39.35	36.09	34.10
LULUCF	2.91	2.91	2.83	2.20	1.10	0.88	1.22	0.96	0.64	0.04	-0.23	-0.35
Overseas Territories	1.51	1.50	1.52	1.53	1.52	1.56	1.63	1.61	1.65	1.74	1.78	1.81
Total greenhouse gas emissions	781.00	777.63	784.46	759.03	737.06	726.13	716.55	737.54	711.87	706.89	673.95	675.67

Final user category	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Agriculture	55.67	55.86	55.07	54.95	54.66	52.81	51.70	51.09
Business	215.31	202.98	208.72	206.91	207.04	208.94	204.57	198.74
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	14.85	16.82	17.19	18.44	18.85	16.22	17.20	15.51
Industrial Process	23.25	19.68	20.31	19.61	18.57	17.46	18.83	17.51
Public	24.01	21.53	21.47	22.26	22.07	22.04	21.11	21.33
Residential	162.52	156.82	159.39	160.53	156.37	156.07	149.88	152.62
Transport	151.78	154.76	155.04	154.20	155.69	154.64	155.43	150.14
Waste Management	30.08	27.70	24.59	23.08	22.85	22.84	22.81	22.69
LULUCF	-0.47	-1.02	-1.05	-1.78	-1.96	-1.86	-1.92	-2.01
Overseas Territories	1.91	1.92	1.94	2.00	2.04	2.13	2.26	2.17
Total greenhouse gas emissions	678.91	657.04	662.67	660.19	656.17	651.29	641.87	629.79

Table A 13.6.10: Final user emissions, Carbon, $MtCO_2$ equivalent

Final user category	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Agriculture	8.81	8.81	8.84	8.66	8.42	8.44	8.34	8.36	7.98	7.87	7.68	7.37
Business	227.47	227.47	224.73	211.06	203.95	200.98	197.61	199.03	191.88	191.79	188.96	196.35
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	9.33	9.33	10.39	11.27	12.82	13.23	14.25	15.87	16.91	16.50	14.80	14.20
Industrial Process	17.25	17.25	15.09	14.39	14.29	15.45	15.83	16.48	16.68	16.59	16.51	15.67
Public	29.25	29.25	32.33	33.90	27.85	27.56	26.76	27.63	25.19	24.01	23.19	22.39
Residential	155.85	155.85	165.61	159.43	155.60	150.39	143.90	155.99	141.36	147.12	142.53	147.07
Transport	140.76	140.76	139.16	140.86	142.83	144.02	144.30	150.11	150.44	149.19	149.22	148.08
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	2.89	2.89	2.81	2.18	1.08	0.86	1.19	0.93	0.61	0.02	-0.25	-0.38
Overseas Territories	1.25	1.25	1.27	1.29	1.28	1.31	1.34	1.33	1.36	1.45	1.48	1.51
Total greenhouse gas emissions	594.07	594.07	601.42	584.19	569.20	563.16	554.39	576.62	552.90	555.04	544.57	552.71

Final user category	2001	2002	2003	2004	2005	2006	2007	2008
Agriculture	7.71	7.66	7.59	7.50	7.41	7.13	6.91	6.81
Business	201.58	188.43	194.90	192.62	192.59	194.46	190.47	184.57
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	13.92	15.86	16.33	17.47	17.98	15.43	16.33	14.74
Industrial Process	14.20	13.19	13.99	14.32	14.34	13.79	15.14	14.24
Public	23.12	20.69	20.80	21.58	21.43	21.43	20.58	20.80
Residential	153.84	148.35	151.82	153.03	148.88	148.74	143.04	145.68
Transport	148.29	151.40	151.91	151.17	152.82	151.89	152.66	147.65
Waste Management	0.49	0.49	0.47	0.47	0.47	0.43	0.45	0.40
LULUCF	-0.51	-1.05	-1.08	-1.81	-1.98	-1.89	-1.96	-2.04
Overseas Territories	1.60	1.62	1.65	1.70	1.75	1.84	1.98	1.89
Total greenhouse gas emissions	564.25	546.65	558.38	558.04	555.69	553.26	545.59	534.73

Table A 13.6.11: Final user emissions, Methane, $MtCO_2$ equivalent

Final user category	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Agriculture	22.56	22.56	22.23	22.28	22.11	22.17	21.91	22.11	21.45	21.44	21.36	20.47
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	0.89	0.93	0.95	0.95	1.03	1.00	1.05	0.99	0.79	0.74
Industrial Process	1.69	1.69	1.64	1.64	1.62	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	11.65	11.65	12.18	11.93	11.39	8.75	8.45	8.28	7.43	7.03	6.50	5.80
Transport	2.21	2.21	2.10	2.11	1.98	1.95	2.02	1.88	1.76	1.68	1.46	1.36
Waste Management	50.59	50.59	49.82	48.66	47.40	46.48	44.99	43.52	40.08	37.62	34.44	32.38
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	0.23	0.23	0.23	0.23	0.23	0.24
Total greenhouse gas emissions	104.60	104.60	103.84	102.32	99.25	92.27	91.40	89.02	83.78	79.46	74.27	69.69

Final user category	2001	2002	2003	2004	2005	2006	2007	2008
Agriculture	19.24	19.00	18.96	19.10	19.32	18.96	18.83	18.38
Business	6.53	6.49	5.27	5.01	4.56	4.28	3.64	3.65
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.74	0.72	0.65	0.74	0.63	0.57	0.66	0.58
Industrial Process	0.76	0.67	0.60	0.57	0.49	0.45	0.40	0.42
Public	0.80	0.76	0.59	0.60	0.56	0.53	0.45	0.46
Residential	5.64	5.56	4.36	4.27	3.92	3.73	3.29	3.40
Transport	1.38	1.24	1.09	1.05	0.91	0.83	0.90	0.80
Waste Management	28.33	25.94	22.86	21.35	21.09	21.12	21.08	21.00
LULUCF	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03
Overseas Territories	0.23	0.23	0.22	0.22	0.21	0.21	0.21	0.21
Total greenhouse gas emissions	63.67	60.63	54.63	52.93	51.71	50.72	49.48	48.93

Table A 13.6.12: 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	33.83	33.83	33.65	31.81	31.25	32.01	32.12	32.27	33.25	32.34	31.77	30.47
Business	2.58	2.58	2.50	2.43	2.25	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	0.20
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	0.61	0.55	0.57
Transport	1.68	1.68	1.67	1.67	1.75	1.94	2.23	2.12	2.13	2.17	2.18	2.18
Waste Management	1.08	1.08	1.07	1.08	1.07	1.15	1.08	1.12	1.22	1.23	1.19	1.25
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	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Total greenhouse gas emissions	65.14	65.14	65.09	58.50	53.82	54.97	53.58	53.47	54.54	53.96	43.32	42.33

Final user category	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Agriculture	28.72	29.20	28.52	28.35	27.93	26.72	25.97	25.90
Business	1.94	1.89	1.92	1.93	1.97	2.01	1.96	1.77
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.19	0.24	0.21	0.23	0.24	0.21	0.21	0.19
Industrial Process	4.88	2.73	2.89	3.64	2.87	2.43	2.82	2.47
Public	0.09	0.08	0.08	0.08	0.08	0.09	0.08	0.08
Residential	0.61	0.55	0.57	0.55	0.54	0.58	0.54	0.53
Transport	2.12	2.12	2.04	1.98	1.95	1.92	1.87	1.69
Waste Management	1.26	1.26	1.26	1.26	1.29	1.29	1.28	1.29
LULUCF	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overseas Territories	0.05	0.05	0.04	0.05	0.04	0.04	0.04	0.04
Total greenhouse gas emissions	39.87	38.12	37.54	38.08	36.91	35.29	34.77	33.96

Table A 13.6.13: 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	1.09	0.00	0.00	0.00	0.31	0.67	1.09	1.57	2.02	2.54	3.14	3.80
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	15.48	11.39	11.85	12.32	13.12	14.06	15.48	16.68	19.02	16.78	9.99	8.68

Final user category	2001	2002	2003	2004	2005	2006	2007	2008
Agriculture								
Business	4.48	5.39	5.87	6.51	6.98	7.40	7.78	8.05
Energy Supply								
Exports								
Industrial Process	2.39	2.03	1.98	0.45	0.44	0.39	0.18	0.15
Public								
Residential	2.43	2.35	2.65	2.68	3.02	3.01	3.01	3.01
Transport								
Waste Management								
LULUCF								
Overseas Territories	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
Total greenhouse gas emissions	9.32	9.80	10.53	9.67	10.48	10.84	11.01	11.25

Table A 13.6.14: 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	0.10	0.06	0.06	0.07	0.08	0.09	0.10	0.12	0.14	0.14	0.16	0.19
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	0.46	1.40	1.17	0.57	0.49	0.49	0.46	0.48	0.40	0.39	0.37	0.47

Final user category	2001	2002	2003	2004	2005	2006	2007	2008
Agriculture								
Business	0.11	0.11	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	0.13
Public								
Residential								
Transport								
Waste Management								
LULUCF								
Overseas Territories	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total greenhouse gas emissions	0.39	0.32	0.28	0.34	0.26	0.31	0.22	0.21

Table A 13.6.15: 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**	**2008**
Agriculture								
Business	0.67	0.66	0.65	0.74	0.86	0.69	0.64	0.62
Energy Supply								
Exports								
Industrial Process	0.76	0.85	0.67	0.39	0.25	0.18	0.15	0.09
Public								
Residential								
Transport								
Waste Management								
LULUCF								
Overseas Territories	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total greenhouse gas emissions	1.43	1.51	1.32	1.13	1.11	0.87	0.79	0.71