Annexes

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A1 ANNEX 1: Key Categories

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 (decision 15/CMP.1).

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

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**.

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

[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".

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 7.5.1** to **Table A 7.5.4** using the same categorisation and the same estimates of uncertainty. The table indicates whether a key category arises from the level assessment or the trend assessment. The factors that make a source a key category are:

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

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

Both the level and the trend assessments have been completed, following the procedure set out in the IPCC Good Practice Guidance (2000). The emission estimates were taken from the current inventory.

The results of the level assessment with and without LULUCF for 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 to the latest reported year, and, 1990 to the latest reported year, are shown in **Table A 1.1.7** to **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.

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

Qualitative analysis used to identify key categories

Following IPCC good practice, a qualitative analysis of the inventory has been made to identify key source categories. The approach set out in section 7.2.2 of the IPCC Good Practice Guidance has been applied, using the four criteria set out in the guidance, to judge whether a category is a key category. The criteria are:

1. (Use of) mitigation techniques and technologies;
2. High expected emission growth;
3. High uncertainty;
4. Unexpectedly low or high emissions.

The results of this qualitative analysis are summarised below. Initial indications are that we do not expect further additional source categories to be identified following this qualitative assessment, but this will be kept under review.

	IPCC GPG qualitative key category criteria				Other criteria
Source category	(Use of) mitigation techniques and technologies	High expected emission growth	High uncertainty	Unexpectedly low or high emissions	
Cement Production (2A1)					X (see note a)

Notes

a Following UNFCCC Expert Review Team recommendation from the 2010 Centralised Review (FCCC/ARR/2010/GBR) to include this source category as a key category: "…*excluding uncertainties, this category is by far the most significant category within the industrial processes sector. The ERT recommends therefore, based on this quantitative and qualitative criterion, that the United Kingdom consider this category as key*."

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 (-10 569 Gg CO_2) is a key category although the AR component (forest planted since 1990) is not key on its own (i.e. its category contribution (-2 959 Gg CO_2) 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 (5B, 5C and 5E) are key categories (12 116, -8 541 and 6 216 Gg CO_2 respectively). However, the Deforestation category contribution (710 Gg CO_2) 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 (-10 569 Gg CO_2). The Forest Management category contribution (-7 498 Gg CO_2) 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 **Chapters 7 and 11**).

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

The uncertainty analysis should be used to prioritise and plan improvements. The approach the UK takes to achieve this 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 LULUCF)

IPCC category	Source category	Gas	Base year emissions Gg CO2 equiv. 1990 & 1995	Year Y emissions Gg CO2 equiv. 2010	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)	Level / Sum(Level)*100 %	Cumulative %
4D	Agricultural Soils	N2O	32825.07	26385.59	424.00	0.17973	53.82760	
6A	Solid Waste Disposal	CH4	43143.47	14767.00	48.38	0.02696	8.07324	61.90085
1A(stationary)	Oil	CO2	92867.52	53505.95	15.13	0.01815	5.43518	67.33602
1A1&1A2&1A4&1A5	Other Combustion	N2O	4829.07	3122.22	195.00	0.01216	3.64193	70.97795
2B	Nitric Acid Production	N2O	3903.85	1316.57	230.22	0.01161	3.47587	74.45382
4B	Manure Management	N2O	2053.05	1750.56	414.00	0.01098	3.28726	77.74108
5B	Cropland	CO2	15732.05	12115.71	50.01	0.01016	3.04281	80.78389
1A3b	Auto Fuel	CO2	108564.64	111579.17	4.48	0.00628	1.88196	82.66585
6B	Wastewater Handling	N2O	1164.86	1151.57	401.12	0.00603	1.80711	84.47295
5C	Grassland	CO2	-6261.11	-8541.00	70.01	0.00566	1.69522	86.16817
4A	Enteric Fermentation	CH4	18694.63	15385.93	20.00	0.00483	1.44605	87.61423
5E	Settlements	CO2	7011.87	6216.22	50.01	0.00453	1.35620	88.97043
2B	Adipic Acid Production	N2O	20737.34	0.00	15.01	0.00402	1.20370	90.17413
5A	Forest Land	CO2	-12155.07	-10568.81	25.02	0.00393	1.17619	91.35031
2	Industrial Processes	HFC	15327.65	14314.07	19.03	0.00377	1.12788	92.47819
1A	Coal	CO2	247785.08	114863.47	1.08	0.00345	1.03213	93.51033
1B1	Mining & Solid Fuel Transformation	CH4	18281.71	1799.47	100.77	0.00307	0.92018	94.43050
1A3b	Auto Fuel	N2O	1179.78	847.95	170.02	0.00259	0.77579	95.20629
1B2	Production, Refining & Distribution of Oil & Natu	CH4	10322.92	5191.29	25.61	0.00225	0.67454	95.88082
1A	Natural Gas	CO2	108956.17	197884.94	1.51	0.00213	0.63768	96.51850
4B	Manure Management	CH4	3585.62	2679.30	30.00	0.00139	0.41603	96.93453
1A	All Fuel	CH4	2077.99	1069.03	50.00	0.00134	0.40185	97.33637
1B	Oil & Natural Gas	CO2	5777.84	4388.43	17.09	0.00128	0.38185	97.71822
2B5	NEU	CO2	1562.92	1969.82	53.85	0.00109	0.32551	98.04373
5G	Other	CO2	-1727.33	-3985.06	30.02	0.00067	0.20053	98.24426
2A7	Fletton Bricks	CO2	539.42	530.66	72.80	0.00051	0.15188	98.39614
5B	Cropland	N2O	781.56	622.48	50.01	0.00050	0.15116	98.54730
1A3a	Aviation Fuel	CO2	1580.55	1990.63	20.27	0.00041	0.12391	98.67121
1A3b	Auto Fuel	CH4	634.83	71.41	50.08	0.00041	0.12295	98.79417
1A3	Other Diesel	N2O	191.40	282.12	140.01	0.00035	0.10364	98.89781
6C	Waste Incineration	CO2	1227.50	292.01	21.19	0.00034	0.10060	98.99840
2	Industrial Processes	SF6	1239.30	689.99	20.02	0.00032	0.09598	99.09438
5D	Wetlands	CO2	481.73	263.02	50.01	0.00031	0.09317	99.18756
4F	Field Burning	N2O	77.60	0.00	231.35	0.00023	0.06944	99.25699
2A1	Cement Production	CO2	7295.26	3792.01	2.42	0.00023	0.06818	99.32518
1A	Combined Fuel	CO2	801.51	867.86	21.21	0.00022	0.06576	99.39094
1A4	Peat	CO2	475.59	47.44	31.62	0.00019	0.05817	99.44910
4F	Field Burning	CH4	265.51	0.00	55.90	0.00019	0.05740	99.50650
2B	Ammonia Production	CO2	1431.17	978.43	10.11	0.00019	0.05597	99.56247
6B	Wastewater Handling	CH4	287.21	347.89	50.01	0.00019	0.05555	99.61802
2C1	Iron&Steel Production	CO2	2309.27	1747.34	6.12	0.00018	0.05465	99.67267
1A	Lubricant	CO2	386.90	225.28	30.07	0.00015	0.04499	99.71766
6C	Waste Incineration	N2O	47.90	47.25	230.11	0.00014	0.04263	99.76029
6C	Waste Incineration	CH4	134.43	6.25	50.49	0.00009	0.02625	99.78654
2A2	Lime Production	CO2	1206.41	233.70	5.10	0.00008	0.02379	99.81033
2A3	Limestone & Dolomite use	CO2	1125.28	920.77	5.10	0.00007	0.02219	99.83252
1B	Solid Fuel Transformation	CO2	856.42	219.64	6.01	0.00007	0.01992	99.85244
2B	Chemical Industry	CH4	169.43	73.50	28.28	0.00006	0.01853	99.87097
1B2	Oil & Natural Gas	N2O	42.40	46.17	111.16	0.00006	0.01823	99.88920
1A3d	Marine Fuel	CO2	2123.33	2264.57	2.20	0.00006	0.01809	99.90729
2	Industrial Processes	PFC	461.81	220.47	10.05	0.00006	0.01795	99.92524
1A	Other (waste)	CO2	212.42	1660.57	21.19	0.00006	0.01741	99.94264
1A3	Other Diesel	CO2	1613.78	2370.91	2.20	0.00005	0.01375	99.95639
1A3d	Marine Fuel	N2O	16.56	17.64	170.01	0.00004	0.01089	99.96728
1A3a	Aviation Fuel	N2O	15.56	19.60	171.17	0.00003	0.01030	99.97758
2A7	Fletton Bricks	CH4	23.60	5.63	101.98	0.00003	0.00931	99.98689
2C	Iron & Steel	N2O	11.11	6.72	118.00	0.00002	0.00507	99.99196
2C	Iron & Steel Production	CH4	16.36	11.81	50.00	0.00001	0.00316	99.99512
1B1	Coke Oven Gas	N2O	2.08	1.38	118.00	0.00000	0.00095	99.99607
5E2	Land converted to settlements	CH4	9.96	8.30	20.02	0.00000	0.00077	99.99684
1A3a	Aviation Fuel	CH4	3.30	1.11	53.85	0.00000	0.00069	99.99753
1A3	Other Diesel	CH4	3.11	3.78	50.03	0.00000	0.00060	99.99813
5A	Forest Land	N2O	5.57	1.92	20.02	0.00000	0.00043	99.99856
1A3d	Marine Fuel	CH4	1.85	3.91	50.03	0.00000	0.00036	99.99892
5A	Forest Land	CH4	4.30	8.17	20.02	0.00000	0.00033	99.99925
5D	Wetlands	N2O	3.98	0.50	20.02	0.00000	0.00031	99.99956
5C2	Land converted to grassland	CH4	3.90	11.74	20.02	0.00000	0.00030	99.99986
5E2	Land converted to settlements	N2O	1.01	0.84	20.02	0.00000	0.00008	99.99994
5C2	Land converted to grassland	N2O	0.40	1.19	20.02	0.00000	0.00003	99.99997
5B	Cropland	CH4	0.14	0.39	50.01	0.00000	0.00003	100.00000
1A3c	Coal	CO2	0.00	49.62	6.01	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
2A4	Soda Ash Use	CO2	0.00	0.00	15.13	0.00000	0.00000	100.00000
1A3c	Coal	CH4	0.00	0.99	50.00	0.00000	0.00000	100.00000
1A3c	Coal	N2O	0.00	0.12	118.00	0.00000	0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.00	0.00	50.99	0.00000	0.00000	100.00000
5G	Other	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	774,364.31	590,177.13		0.3339	100.00	

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

IPCC category	Source category	Gas	Base year emissions Gg CO2 equiv. 1990 & 1995	Year Y emissions Gg CO2 equiv. 2010	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)	Level / Sum(Level)*100 %	Cumulative %
4D	Agricultural Soils	N2O	32825.07	26385.59	424.00	0.18064	58.32919	
6A	Solid Waste Disposal	CH4	43143.47	14767.00	48.38	0.02709	8.74841	67.07760
1A(stationary)	Oil	CO2	92867.52	53505.95	15.13	0.01824	5.88972	72.96732
1A1&1A2&1A4&1A5	Other Combustion	N2O	4829.07	3122.22	195.00	0.01222	3.94650	76.91382
2B	Nitric Acid Production	N2O	3903.85	1316.57	230.22	0.01166	3.76655	80.68038
4B	Manure Management	N2O	2053.05	1750.56	414.00	0.01103	3.56217	84.24255
1A3b	Auto Fuel	CO2	108564.64	111579.17	4.48	0.00632	2.03935	86.28190
6B	Wastewater Handling	N2O	1164.86	1151.57	401.12	0.00606	1.95823	88.24013
4A	Enteric Fermentation	CH4	18694.63	15385.93	20.00	0.00485	1.56699	89.80712
2B	Adipic Acid Production	N2O	20737.34	0.00	15.01	0.00404	1.30436	91.11148
2	Industrial Processes	HFC	15327.65	14314.07	19.03	0.00379	1.22220	92.33369
1A	Coal	CO2	247785.08	114863.47	1.08	0.00346	1.11845	93.45214
1B1	Mining & Solid Fuel Transformation	CH4	18281.71	1799.47	101.94	0.00309	0.99713	94.44927
1A3b	Auto Fuel	N2O	1179.78	847.95	170.02	0.00260	0.84066	95.28993
1B2	Production, Refining & Distribution of Oil & Natu	CH4	10322.92	5191.29	25.90	0.00226	0.73095	96.02088
1A	Natural Gas	CO2	108956.17	197884.94	1.51	0.00214	0.69101	96.71189
4B	Manure Management	CH4	3585.62	2679.30	30.00	0.00140	0.45082	97.16270
1A	All Fuel	CH4	2077.99	1069.03	50.00	0.00135	0.43545	97.59816
1B	Oil & Natural Gas	CO2	5777.84	4388.43	17.09	0.00128	0.41378	98.01194
2B5	NEU	CO2	1562.92	1969.82	53.85	0.00109	0.35273	98.36467
2A7	Fletton Bricks	CO2	539.42	530.66	72.80	0.00051	0.16458	98.52925
1A3a	Aviation Fuel	CO2	1580.55	1990.63	20.27	0.00042	0.13427	98.66352
1A3b	Auto Fuel	CH4	634.83	71.41	50.08	0.00041	0.13324	98.79676
1A3	Other Diesel	N2O	191.40	282.12	140.01	0.00035	0.11231	98.90907
6C	Waste Incineration	CO2	1227.50	292.01	21.19	0.00034	0.10901	99.01808
2	Industrial Processes	SF6	1239.30	689.99	20.02	0.00032	0.10401	99.12208
4F	Field Burning	N2O	77.60	0.00	231.35	0.00023	0.07524	99.19733
2A1	Cement Production	CO2	7295.26	3792.01	2.42	0.00023	0.07389	99.27121
1A	Combined Fuel	CO2	801.51	867.86	21.21	0.00022	0.07126	99.34247
1A4	Peat	CO2	475.59	47.44	31.62	0.00020	0.06303	99.40550
4F	Field Burning	CH4	265.51	0.00	55.90	0.00019	0.06220	99.46770
2B	Ammonia Production	CO2	1431.17	978.43	10.11	0.00019	0.06065	99.52836
6B	Wastewater Handling	CH4	287.21	347.89	50.01	0.00019	0.06020	99.58855
2C1	Iron&Steel Production	CO2	2309.27	1747.34	6.12	0.00018	0.05922	99.64777
1A	Lubricant	CO2	386.90	225.28	30.07	0.00015	0.04875	99.69652
6C	Waste Incineration	N2O	47.90	47.25	230.11	0.00014	0.04620	99.74272
6C	Waste Incineration	CH4	134.43	6.25	50.49	0.00009	0.02844	99.77116
2A2	Lime Production	CO2	1206.41	233.70	5.10	0.00008	0.02578	99.79694
2A3	Limestone & Dolomite use	CO2	1125.28	920.77	5.10	0.00007	0.02405	99.82099
1B	Solid Fuel Transformation	CO2	856.42	219.64	6.01	0.00007	0.02158	99.84257
2B	Chemical Industry	CH4	169.43	73.50	28.28	0.00006	0.02008	99.86266
1B2	Oil & Natural Gas	N2O	42.40	46.17	111.16	0.00006	0.01975	99.88241
1A3d	Marine Fuel	CO2	2123.33	2264.57	2.20	0.00006	0.01960	99.90201
2	Industrial Processes	PFC	461.81	220.47	10.05	0.00006	0.01945	99.92146
1A	Other (waste)	CO2	212.42	1660.57	21.19	0.00006	0.01886	99.94032
1A3	Other Diesel	CO2	1613.78	2370.91	2.20	0.00005	0.01489	99.95521
1A3d	Marine Fuel	N2O	16.56	17.64	170.01	0.00004	0.01180	99.96702
1A3a	Aviation Fuel	N2O	15.56	19.60	171.17	0.00003	0.01116	99.97818
2A7	Fletton Bricks	CH4	23.60	5.63	101.98	0.00003	0.01009	99.98826
2C	Iron & Steel	N2O	11.11	6.72	118.00	0.00002	0.00549	99.99376
2C	Iron & Steel Production	CH4	16.36	11.81	50.00	0.00001	0.00343	99.99718
1B1	Coke Oven Gas	N2O	2.08	1.38	118.00	0.00000	0.00103	99.99822
1A3a	Aviation Fuel	CH4	3.30	1.11	53.85	0.00000	0.00074	99.99896
1A3	Other Diesel	CH4	3.11	3.78	50.03	0.00000	0.00065	99.99961
1A3d	Marine Fuel	CH4	1.85	3.91	50.03	0.00000	0.00039	100.00000
1A3c	Coal	CO2	0.00	49.62	6.01	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
2A4	Soda Ash Use	CO2	0.00	0.00	15.13	0.00000	0.00000	100.00000
5A	Forest land	CO2	0.00	0.00	25.02	0.00000	0.00000	100.00000
5B	Cropland	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C	Grassland	CO2	0.00	0.00	70.01	0.00000	0.00000	100.00000
5D	Wetlands	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5E	Settlements	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5G	Other	CO2	0.00	0.00	30.02	0.00000	0.00000	100.00000
1A3c	Coal	CH4	0.00	0.99	50.00	0.00000	0.00000	100.00000
5A	Forest land	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	Cropland	CH4	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	Land converted to grassland	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	Land converted to settlements	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
1A3c	Coal	N2O	0.00	0.12	118.00	0.00000	0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.00	0.00	50.99	0.00000	0.00000	100.00000
5A	Forest land	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	Cropland	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	Land converted to grassland	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5D	Wetlands	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	Land converted to settlements	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5G	Other	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	770,471.37	594,021.50		0.3097	100.00	

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

IPCC category	Source category	Gas	Emissions Gg CO2 equiv. 1990	Year Y emissions Gg CO2 equiv. 2010	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)	Level / Sum(Level)*100 %	Cumulative %
4D	Agricultural Soils	N2O	32825.07	26385.59	424.00	0.18048	53.97320	
6A	Solid Waste Disposal	CH4	43143.47	14767.00	48.38	0.02707	8.09508	62.06828
1A(stationary)	Oil	CO2	92867.52	53505.95	15.13	0.01822	5.44988	67.51816
1A1&1A2&1A4&1A5	Other Combustion	N2O	4829.07	3122.22	195.00	0.01221	3.65178	71.16994
2B	Nitric Acid Production	N2O	3903.85	1316.57	230.22	0.01165	3.48527	74.65521
4B	Manure Management	N2O	2053.05	1750.56	414.00	0.01102	3.29615	77.95136
5B	Cropland	CO2	15732.05	12115.71	50.01	0.01020	3.05104	81.00240
1A3b	Auto Fuel	CO2	108564.64	111579.17	4.48	0.00631	1.88705	82.88945
6B	Wastewater Handling	N2O	1164.86	1151.57	401.12	0.00606	1.81199	84.70144
5C	Grassland	CO2	-6261.11	-8541.00	70.01	0.00568	1.69981	86.40125
4A	Enteric Fermentation	CH4	18694.63	15385.93	20.00	0.00485	1.44997	87.85122
5E	Settlements	CO2	7011.87	6216.22	50.01	0.00455	1.35987	89.21108
2B	Adipic Acid Production	N2O	20737.34	0.00	15.01	0.00404	1.20695	90.41804
5A	Forest Land	CO2	-12155.07	-10568.81	25.02	0.00394	1.17937	91.59741
1A	Coal	CO2	247785.08	114863.47	1.08	0.00346	1.03493	92.63233
1B1	Mining & Solid Fuel Transformation	CH4	18281.71	1799.47	101.19	0.00309	0.92267	93.55500
2	Industrial Processes	HFC	11385.62	14314.07	19.03	0.00281	0.84007	94.39507
1A3b	Auto Fuel	N2O	1179.78	847.95	170.02	0.00260	0.77788	95.17295
1B2	Production, Refining & Distribution of Oil & Natu	CH4	10322.92	5191.29	25.71	0.00226	0.67636	95.84931
1A	Natural Gas	CO2	108956.17	197884.94	1.51	0.00214	0.63940	96.48872
4B	Manure Management	CH4	3585.62	2679.30	30.00	0.00139	0.41715	96.90587
1A	All Fuel	CH4	2077.99	1069.03	50.00	0.00135	0.40293	97.30880
1B	Oil & Natural Gas	CO2	5777.84	4388.43	17.09	0.00128	0.38288	97.69168
2B5	NEU	CO2	1562.92	1969.82	53.85	0.00109	0.32639	98.01807
5G	Other	CO2	-1727.33	-3985.06	30.02	0.00067	0.20107	98.21914
2A7	Fletton Bricks	CO2	539.42	530.66	72.80	0.00051	0.15229	98.37143
5B	Cropland	N2O	781.56	622.48	50.01	0.00051	0.15157	98.52300
1A3a	Aviation Fuel	CO2	1580.55	1990.63	20.27	0.00042	0.12424	98.64725
1A3b	Auto Fuel	CH4	634.83	71.41	50.08	0.00041	0.12329	98.77053
1A3	Other Diesel	N2O	191.40	282.12	140.01	0.00035	0.10392	98.87446
6C	Waste Incineration	CO2	1227.50	292.01	21.19	0.00034	0.10087	98.97532
5D	Wetlands	CO2	481.73	263.02	50.01	0.00031	0.09342	99.06875
2	Industrial Processes	SF6	1029.95	689.99	20.02	0.00027	0.07998	99.14873
4F	Field Burning	N2O	77.60	0.00	231.35	0.00023	0.06963	99.21836
2A1	Cement Production	CO2	7295.26	3792.01	2.42	0.00023	0.06837	99.28673
1A	Combined Fuel	CO2	801.51	867.86	21.21	0.00022	0.06594	99.35266
1A4	Peat	CO2	475.59	47.44	31.62	0.00020	0.05832	99.41098
4F	Field Burning	CH4	265.51	0.00	55.90	0.00019	0.05756	99.46854
2B	Ammonia Production	CO2	1431.17	978.43	10.11	0.00019	0.05612	99.52466
6B	Wastewater Handling	CH4	287.21	347.89	50.01	0.00019	0.05570	99.58036
2C1	Iron&Steel Production	CO2	2309.27	1747.34	6.12	0.00018	0.05480	99.63516
2	Industrial Processes	PFC	1401.60	220.47	10.05	0.00018	0.05462	99.68979
1A	Lubricant	CO2	386.90	225.28	30.07	0.00015	0.04511	99.73490
6C	Waste Incineration	N2O	47.90	47.25	230.11	0.00014	0.04275	99.77764
6C	Waste Incineration	CH4	134.43	6.25	50.49	0.00009	0.02632	99.80396
2A2	Lime Production	CO2	1206.41	233.70	5.10	0.00008	0.02386	99.82782
2A3	Limestone & Dolomite use	CO2	1125.28	920.77	5.10	0.00007	0.02225	99.85007
1B	Solid Fuel Transformation	CO2	856.42	219.64	6.01	0.00007	0.01997	99.87004
2B	Chemical Industry	CH4	169.43	73.50	28.28	0.00006	0.01858	99.88862
1B2	Oil & Natural Gas	N2O	42.40	46.17	111.16	0.00006	0.01828	99.90690
1A3d	Marine Fuel	CO2	2123.33	2264.57	2.20	0.00006	0.01813	99.92503
1A	Other (waste)	CO2	212.42	1660.57	21.19	0.00006	0.01746	99.94249
1A3	Other Diesel	CO2	1613.78	2370.91	2.20	0.00005	0.01378	99.95627
1A3d	Marine Fuel	N2O	16.56	17.64	170.01	0.00004	0.01092	99.96719
1A3a	Aviation Fuel	N2O	15.56	19.60	171.17	0.00003	0.01033	99.97752
2A7	Fletton Bricks	CH4	23.60	5.63	101.98	0.00003	0.00933	99.98685
2C	Iron & Steel	N2O	11.11	6.72	118.00	0.00002	0.00508	99.99194
2C	Iron & Steel Production	CH4	16.36	11.81	50.00	0.00001	0.00317	99.99511
1B1	Coke Oven Gas	N2O	2.08	1.38	118.00	0.00000	0.00095	99.99606
5E2	Land converted to settlements	CH4	9.96	8.30	20.02	0.00000	0.00077	99.99683
1A3a	Aviation Fuel	CH4	3.30	1.11	53.85	0.00000	0.00069	99.99752
1A3	Other Diesel	CH4	3.11	3.78	50.03	0.00000	0.00060	99.99813
5A	Forest Land	N2O	5.57	1.92	20.02	0.00000	0.00043	99.99856
1A3d	Marine Fuel	CH4	1.85	3.91	50.03	0.00000	0.00036	99.99892
5A	Forest Land	CH4	4.30	8.17	20.02	0.00000	0.00033	99.99925
5D	Wetlands	N2O	3.98	0.50	20.02	0.00000	0.00031	99.99956
5C2	Land converted to grassland	CH4	3.90	11.74	20.02	0.00000	0.00030	99.99986
5E2	Land converted to settlements	N2O	1.01	0.84	20.02	0.00000	0.00008	99.99994
5C2	Land converted to grassland	N2O	0.40	1.19	20.02	0.00000	0.00003	99.99997
5B	Cropland	CH4	0.14	0.39	50.01	0.00000	0.00003	100.00000
1A3c	Coal	CO2	0.00	49.62	6.01	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
2A4	Soda Ash Use	CO2	0.00	0.00	15.13	0.00000	0.00000	100.00000
1A3c	Coal	CH4	0.00	0.99	50.00	0.00000	0.00000	100.00000
1A3c	Coal	N2O	0.00	0.12	118.00	0.00000	0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.00	0.00	50.99	0.00000	0.00000	100.00000
5G	Other	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	771,152.71	590,177.13		0.3344	100.00	

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

IPCC category	Source category	Gas	Emissions Gg CO2 equiv. 1990	Year Y emissions Gg CO2 equiv. 2010	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)	Level / Sum(Level)*100 %	Cumulative %
4D	Agricultural Soils	N2O	32825.07	26385.59	424.00	0.18140	58.50020	
6A	Solid Waste Disposal	CH4	43143.47	14767.00	48.38	0.02721	8.77406	67.27425
1A(stationary)	Oil	CO2	92867.52	53505.95	15.13	0.01832	5.90699	73.18124
1A1&1A2&1A4&1A5	Other Combustion	N2O	4829.07	3122.22	195.00	0.01227	3.95807	77.13932
2B	Nitric Acid Production	N2O	3903.85	1316.57	230.22	0.01171	3.77760	80.91691
4B	Manure Management	N2O	2053.05	1750.56	414.00	0.01108	3.57261	84.48953
1A3b	Auto Fuel	CO2	108564.64	111579.17	4.48	0.00634	2.04533	86.53485
6B	Wastewater Handling	N2O	1164.86	1151.57	401.12	0.00609	1.96398	88.49883
4A	Enteric Fermentation	CH4	18694.63	15385.93	20.00	0.00487	1.57158	90.07041
2B	Adipic Acid Production	N2O	20737.34	0.00	15.01	0.00406	1.30819	91.37860
1A	Coal	CO2	247785.08	114863.47	1.08	0.00348	1.12173	92.50033
1B1	Mining & Solid Fuel Transformation	CH4	18281.71	1799.47	102.37	0.00310	1.00005	93.50038
2	Industrial Processes	HFC	11385.62	14314.07	19.03	0.00282	0.91053	94.41092
1A3b	Auto Fuel	N2O	1179.78	847.95	170.02	0.00261	0.84313	95.25405
1B2	Production, Refining & Distribution of Oil & Natu	CH4	10322.92	5191.29	26.01	0.00227	0.73309	95.98713
1A	Natural Gas	CO2	108956.17	197884.94	1.51	0.00215	0.69303	96.68017
4B	Manure Management	CH4	3585.62	2679.30	30.00	0.00140	0.45214	97.13231
1A	All Fuel	CH4	2077.99	1069.03	50.00	0.00135	0.43673	97.56904
1B	Oil & Natural Gas	CO2	5777.84	4388.43	17.09	0.00129	0.41499	97.98403
2B5	NEU	CO2	1562.92	1969.82	53.85	0.00110	0.35377	98.33780
2A7	Fletton Bricks	CO2	539.42	530.66	72.80	0.00051	0.16506	98.50286
1A3a	Aviation Fuel	CO2	1580.55	1990.63	20.27	0.00042	0.13467	98.63753
1A3b	Auto Fuel	CH4	634.83	71.41	50.08	0.00041	0.13363	98.77115
1A3	Other Diesel	N2O	191.40	282.12	140.01	0.00035	0.11264	98.88379
6C	Waste Incineration	CO2	1227.50	292.01	21.19	0.00034	0.10933	98.99312
2	Industrial Processes	SF6	1029.95	689.99	20.02	0.00027	0.08669	99.07981
4F	Field Burning	N2O	77.60	0.00	231.35	0.00023	0.07547	99.15528
2A1	Cement Production	CO2	7295.26	3792.01	2.42	0.00023	0.07410	99.22938
1A	Combined Fuel	CO2	801.51	867.86	21.21	0.00022	0.07147	99.30085
1A4	Peat	CO2	475.59	47.44	31.62	0.00020	0.06321	99.36406
4F	Field Burning	CH4	265.51	0.00	55.90	0.00019	0.06239	99.42645
2B	Ammonia Production	CO2	1431.17	978.43	10.11	0.00019	0.06083	99.48727
6B	Wastewater Handling	CH4	287.21	347.89	50.01	0.00019	0.06037	99.54765
2C1	Iron&Steel Production	CO2	2309.27	1747.34	6.12	0.00018	0.05939	99.60704
2	Industrial Processes	PFC	1401.60	220.47	10.05	0.00018	0.05921	99.66625
1A	Lubricant	CO2	386.90	225.28	30.07	0.00015	0.04889	99.71514
6C	Waste Incineration	N2O	47.90	47.25	230.11	0.00014	0.04633	99.76147
6C	Waste Incineration	CH4	134.43	6.25	50.49	0.00009	0.02853	99.79000
2A2	Lime Production	CO2	1206.41	233.70	5.10	0.00008	0.02586	99.81586
2A3	Limestone & Dolomite use	CO2	1125.28	920.77	5.10	0.00007	0.02412	99.83997
1B	Solid Fuel Transformation	CO2	856.42	219.64	6.01	0.00007	0.02165	99.86162
2B	Chemical Industry	CH4	169.43	73.50	28.28	0.00006	0.02014	99.88176
1B2	Oil & Natural Gas	N2O	42.40	46.17	111.16	0.00006	0.01981	99.90157
1A3d	Marine Fuel	CO2	2123.33	2264.57	2.20	0.00006	0.01966	99.92123
1A	Other (waste)	CO2	212.42	1660.57	21.19	0.00006	0.01892	99.94015
1A3	Other Diesel	CO2	1613.78	2370.91	2.20	0.00005	0.01494	99.95508
1A3d	Marine Fuel	N2O	16.56	17.64	170.01	0.00004	0.01183	99.96692
1A3a	Aviation Fuel	N2O	15.56	19.60	171.17	0.00003	0.01119	99.97811
2A7	Fletton Bricks	CH4	23.60	5.63	101.98	0.00003	0.01012	99.98823
2C	Iron & Steel	N2O	11.11	6.72	118.00	0.00002	0.00551	99.99374
2C	Iron & Steel Production	CH4	16.36	11.81	50.00	0.00001	0.00344	99.99718
1B1	Coke Oven Gas	N2O	2.08	1.38	118.00	0.00000	0.00103	99.99821
1A3a	Aviation Fuel	CH4	3.30	1.11	53.85	0.00000	0.00075	99.99896
1A3	Other Diesel	CH4	3.11	3.78	50.03	0.00000	0.00065	99.99961
1A3d	Marine Fuel	CH4	1.85	3.91	50.03	0.00000	0.00039	100.00000
1A3c	Coal	CO2	0.00	49.62	6.01	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
2A4	Soda Ash Use	CO2	0.00	0.00	15.13	0.00000	0.00000	100.00000
5A	Forest land	CO2	0.00	0.00	25.02	0.00000	0.00000	100.00000
5B	Cropland	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C	Grassland	CO2	0.00	0.00	70.01	0.00000	0.00000	100.00000
5D	Wetlands	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5E	Settlements	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5G	Other	CO2	0.00	0.00	30.02	0.00000	0.00000	100.00000
1A3c	Coal	CH4	0.00	0.99	50.00	0.00000	0.00000	100.00000
5A	Forest land	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	Cropland	CH4	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	Land converted to grassland	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	Land converted to settlements	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
1A3c	Coal	N2O	0.00	0.12	118.00	0.00000	0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.00	0.00	50.99	0.00000	0.00000	100.00000
5A	Forest land	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	Cropland	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	Land converted to grassland	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5D	Wetlands	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	Land converted to settlements	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5G	Other	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	767,259.76	594,021.50		0.3101	100.00	

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

IPCC category	Source category	Gas	Emissions Gg CO2 equiv. 1990	Year Y emissions Gg CO2 equiv. 2010	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)	Level / Sum(Level)*100 %	Cumulative %
4D	Agricultural Soils	N2O	32825.07	26385.59	424.00	0.18956	58.49079	
1A(stationary)	Oil	CO2	92867.52	53505.95	15.13	0.01372	4.23324	62.72403
4B	Manure Management	N2O	2053.05	1750.56	414.00	0.01228	3.78907	66.51310
6A	Solid Waste Disposal	CH4	43143.47	14767.00	48.38	0.01211	3.73548	70.24858
1A1&1A2&1A4&1A5	Other Combustion	N2O	4829.07	3122.22	195.00	0.01032	3.18312	73.43170
5B	Cropland	CO2	15732.05	12115.71	50.01	0.01027	3.16781	76.59952
5C	Grassland	CO2	-6261.11	-8541.00	70.01	0.01013	3.12611	79.72563
1A3b	Auto Fuel	CO2	108564.64	111579.17	4.48	0.00847	2.61473	82.34036
6B	Wastewater Handling	N2O	1164.86	1151.57	401.12	0.00783	2.41502	84.75538
5E	Settlements	CO2	7011.87	6216.22	50.01	0.00527	1.62531	86.38069
4A	Enteric Fermentation	CH4	18694.63	15385.93	20.00	0.00521	1.60884	87.98953
2B	Nitric Acid Production	N2O	3903.85	1316.57	230.22	0.00514	1.58466	89.57419
1A	Natural Gas	CO2	108956.17	197884.94	1.51	0.00507	1.56561	91.13980
2	Industrial Processes	HFC	11385.62	14314.07	19.03	0.00461	1.42387	92.56367
5A	Forest land	CO2	-12155.07	-10568.81	25.02	0.00448	1.38250	93.94618
1A3b	Auto Fuel	N2O	1179.78	847.95	170.02	0.00244	0.75376	94.69994
1A	Coal	CO2	247785.08	114863.47	1.08	0.00210	0.64679	95.34673
5G	Other	CO2	-1727.33	-3985.06	30.02	0.00203	0.62539	95.97212
2B5	NEU	CO2	1562.92	1969.82	53.85	0.00180	0.55460	96.52672
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10322.92	5191.29	17.08	0.00150	0.46353	96.99025
4B	Manure Management	CH4	3585.62	2679.30	30.00	0.00136	0.42024	97.41049
1B	Oil & Natural Gas	CO2	5777.84	4388.43	17.09	0.00127	0.39206	97.80255
1A	All Fuel	CH4	2077.99	1069.03	50.00	0.00091	0.27946	98.08202
1A3a	Aviation Fuel	CO2	1580.55	1990.63	20.27	0.00068	0.21096	98.29298
1A3	Other Diesel	N2O	191.40	282.12	140.01	0.00067	0.20651	98.49949
2A7	Fletton Bricks	CO2	539.42	530.66	72.80	0.00065	0.20198	98.70147
1A	Other (waste)	CO2	212.42	1660.57	21.19	0.00060	0.18396	98.88544
5B	Cropland	N2O	781.56	622.48	50.01	0.00053	0.16275	99.04819
1B1	Mining & Solid Fuel Transformation	CH4	18281.71	1799.47	13.06	0.00040	0.12288	99.17107
1A	Combined Fuel	CO2	801.51	867.86	21.21	0.00031	0.09625	99.26732
6B	Wastewater Handling	CH4	287.21	347.89	50.01	0.00029	0.09096	99.35828
2	Industrial Processes	SF6	1029.95	689.99	20.02	0.00023	0.07224	99.43052
5D	Wetlands	CO2	481.73	263.02	50.01	0.00022	0.06877	99.49929
6C	Waste Incineration	N2O	47.90	47.25	230.11	0.00018	0.05684	99.55613
2C1	Iron&Steel Production	CO2	2309.27	1747.34	6.12	0.00018	0.05590	99.61203
2B	Ammonia Production	CO2	1431.17	978.43	10.11	0.00017	0.05173	99.66376
2A1	Cement Production	CO2	7295.26	3792.01	2.42	0.00016	0.04791	99.71167
1A	Lubricant	CO2	386.90	225.28	30.07	0.00011	0.03541	99.74708
6C	Waste Incineration	CO2	1227.50	292.01	21.19	0.00010	0.03235	99.77943
1A3	Other Diesel	CO2	1613.78	2370.91	2.20	0.00009	0.02730	99.80673
1B2	Oil & Natural Gas	N2O	42.40	46.17	111.16	0.00009	0.02683	99.83356
1A3d	Marine Fuel	CO2	2123.33	2264.57	2.20	0.00008	0.02607	99.85964
2A3	Limestone & Dolomite use	CO2	1125.28	920.77	5.10	0.00008	0.02455	99.88418
1A3b	Auto Fuel	CH4	634.83	71.41	50.08	0.00006	0.01870	99.90288
1A3a	Aviation Fuel	N2O	15.56	19.60	171.17	0.00006	0.01754	99.92042
1A3d	Marine Fuel	N2O	16.56	17.64	170.01	0.00005	0.01568	99.93610
2	Industrial Processes	PFC	1401.60	220.47	10.05	0.00004	0.01158	99.94768
2B	Chemical Industry	CH4	169.43	73.50	28.28	0.00004	0.01087	99.95855
1A4	Peat	CO2	475.59	47.44	31.62	0.00003	0.00784	99.96639
1B	Solid Fuel Transformation	CO2	856.42	219.64	6.01	0.00002	0.00691	99.97330
2A2	Lime Production	CO2	1206.41	233.70	5.10	0.00002	0.00623	99.97953
2C	Iron & Steel	N2O	11.11	6.72	118.00	0.00001	0.00414	99.98367
2C	Iron & Steel Production	CH4	16.36	11.81	50.00	0.00001	0.00309	99.98676
2A7	Fletton Bricks	CH4	23.60	5.63	101.98	0.00001	0.00300	99.98976
6C	Waste Incineration	CH4	134.43	6.25	50.49	0.00001	0.00165	99.99141
1A3c	Coal	CO2	0.00	49.62	6.01	0.00001	0.00156	99.99297
5C2	Land converted to grassland	CH4	3.90	11.74	20.02	0.00000	0.00123	99.99420
1A3d	Marine Fuel	CH4	1.85	3.91	50.03	0.00000	0.00102	99.99523
1A3	Other Diesel	CH4	3.11	3.78	50.03	0.00000	0.00099	99.99621
5E2	Land converted to settlements	CH4	9.96	8.30	20.02	0.00000	0.00087	99.99708
5A	Forest land	CH4	4.30	8.17	20.02	0.00000	0.00086	99.99794
1B1	Coke Oven Gas	N2O	2.08	1.38	118.00	0.00000	0.00085	99.99879
1A3a	Aviation Fuel	CH4	3.30	1.11	53.85	0.00000	0.00031	99.99910
1A3c	Coal	CH4	0.00	0.99	50.00	0.00000	0.00026	99.99936
5A	Forest land	N2O	5.57	1.92	20.02	0.00000	0.00020	99.99956
5C2	Land converted to grassland	N2O	0.40	1.19	20.02	0.00000	0.00012	99.99968
5B	Cropland	CH4	0.14	0.39	50.01	0.00000	0.00010	99.99979
5E2	Land converted to settlements	N2O	1.01	0.84	20.02	0.00000	0.00009	99.99988
1A3c	Coal	N2O	0.00	0.12	118.00	0.00000	0.00007	99.99995
5D	Wetlands	N2O	3.98	0.50	20.02	0.00000	0.00005	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
2A4	Soda Ash Use	CO2	0.00	0.00	15.13	0.00000	0.00000	100.00000
4F	Field Burning	CH4	265.51	0.00	55.90	0.00000	0.00000	100.00000
2B	Adipic Acid Production	N2O	20737.34	0.00	15.01	0.00000	0.00000	100.00000
4F	Field Burning	N2O	77.60	0.00	231.35	0.00000	0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.00	0.00	50.99	0.00000	0.00000	100.00000
5G	Other	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	771,152.71	590,177.13		0.32	100.00	

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

IPCC category	Source category	Gas	Emissions Gg CO2 equiv. 1990	Year Y emissions Gg CO2 equiv. 2010	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)	Level / Sum(Level)*100 %	Cumulative %
4D	Agricultural Soils	N2O	32825.07	26385.59	424.00	0.18834	65.10709	
1A(stationary)	Oil	CO2	92867.52	53505.95	15.13	0.01363	4.71210	69.81918
4B	Manure Management	N2O	2053.05	1750.56	414.00	0.01220	4.21768	74.03686
6A	Solid Waste Disposal	CH4	43143.47	14767.00	48.38	0.01203	4.15803	78.19489
1A1&1A2&1A4&1A5	Other Combustion	N2O	4829.07	3122.22	195.00	0.01025	3.54319	81.73807
1A3b	Auto Fuel	CO2	108564.64	111579.17	4.48	0.00842	2.91050	84.64857
6B	Wastewater Handling	N2O	1164.86	1151.57	401.12	0.00778	2.68821	87.33678
4A	Enteric Fermentation	CH4	18694.63	15385.93	20.00	0.00518	1.79083	89.12760
2B	Nitric Acid Production	N2O	3903.85	1316.57	230.22	0.00510	1.76391	90.89151
1A	Natural Gas	CO2	108956.17	197884.94	1.51	0.00504	1.74271	92.63422
2	Industrial Processes	HFC	11385.62	14314.07	19.03	0.00458	1.58494	94.21916
1A3b	Auto Fuel	N2O	1179.78	847.95	170.02	0.00243	0.83902	95.05818
1A	Coal	CO2	247785.08	114863.47	1.08	0.00208	0.71995	95.77813
2B5	NEU	CO2	1562.92	1969.82	53.85	0.00179	0.61733	96.39547
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10322.92	5191.29	17.08	0.00149	0.51596	96.91143
4B	Manure Management	CH4	3585.62	2679.30	30.00	0.00135	0.46778	97.37921
1B	Oil & Natural Gas	CO2	5777.84	4388.43	17.09	0.00126	0.43641	97.81562
1A	All Fuel	CH4	2077.99	1069.03	50.00	0.00090	0.31108	98.12669
1A3a	Aviation Fuel	CO2	1580.55	1990.63	20.27	0.00068	0.23483	98.36152
1A3	Other Diesel	N2O	191.40	282.12	140.01	0.00066	0.22987	98.59140
2A7	Fletton Bricks	CO2	539.42	530.66	72.80	0.00065	0.22483	98.81622
1A	Other (waste)	CO2	212.42	1660.57	21.19	0.00059	0.20477	99.02099
1B1	Mining & Solid Fuel Transformation	CH4	18281.71	1799.47	13.06	0.00040	0.13678	99.15777
1A	Combined Fuel	CO2	801.51	867.86	21.21	0.00031	0.10714	99.26491
6B	Wastewater Handling	CH4	287.21	347.89	50.01	0.00029	0.10125	99.36616
2	Industrial Processes	SF6	1029.95	689.99	20.02	0.00023	0.08041	99.44657
6C	Waste Incineration	N2O	47.90	47.25	230.11	0.00018	0.06327	99.50984
2C1	Iron&Steel Production	CO2	2309.27	1747.34	6.12	0.00018	0.06222	99.57207
2B	Ammonia Production	CO2	1431.17	978.43	10.11	0.00017	0.05758	99.62964
2A1	Cement Production	CO2	7295.26	3792.01	2.42	0.00015	0.05333	99.68297
1A	Lubricant	CO2	386.90	225.28	30.07	0.00011	0.03942	99.72239
6C	Waste Incineration	CO2	1227.50	292.01	21.19	0.00010	0.03601	99.75840
1A3	Other Diesel	CO2	1613.78	2370.91	2.20	0.00009	0.03039	99.78879
1B2	Oil & Natural Gas	N2O	42.40	46.17	111.16	0.00009	0.02987	99.81866
1A3d	Marine Fuel	CO2	2123.33	2264.57	2.20	0.00008	0.02902	99.84768
2A3	Limestone & Dolomite use	CO2	1125.28	920.77	5.10	0.00008	0.02732	99.87500
1A3b	Auto Fuel	CH4	634.83	71.41	50.08	0.00006	0.02081	99.89582
1A3a	Aviation Fuel	N2O	15.56	19.60	171.17	0.00006	0.01952	99.91534
1A3d	Marine Fuel	N2O	16.56	17.64	170.01	0.00005	0.01745	99.93279
2	Industrial Processes	PFC	1401.60	220.47	10.05	0.00004	0.01289	99.94569
2B	Chemical Industry	CH4	169.43	73.50	28.28	0.00003	0.01210	99.95778
1A4	Peat	CO2	475.59	47.44	31.62	0.00003	0.00873	99.96651
1B	Solid Fuel Transformation	CO2	856.42	219.64	6.01	0.00002	0.00769	99.97420
2A2	Lime Production	CO2	1206.41	233.70	5.10	0.00002	0.00694	99.98113
2C	Iron & Steel	N2O	11.11	6.72	118.00	0.00001	0.00461	99.98575
2C	Iron & Steel Production	CH4	16.36	11.81	50.00	0.00001	0.00344	99.98918
2A7	Fletton Bricks	CH4	23.60	5.63	101.98	0.00001	0.00334	99.99253
6C	Waste Incineration	CH4	134.43	6.25	50.49	0.00001	0.00184	99.99436
1A3c	Coal	CO2	0.00	49.62	6.01	0.00001	0.00174	99.99610
1A3d	Marine Fuel	CH4	1.85	3.91	50.03	0.00000	0.00114	99.99724
1A3	Other Diesel	CH4	3.11	3.78	50.03	0.00000	0.00110	99.99834
1B1	Coke Oven Gas	N2O	2.08	1.38	118.00	0.00000	0.00095	99.99928
1A3a	Aviation Fuel	CH4	3.30	1.11	53.85	0.00000	0.00035	99.99963
1A3c	Coal	CH4	0.00	0.99	50.00	0.00000	0.00029	99.99992
1A3c	Coal	N2O	0.00	0.12	118.00	0.00000	0.00008	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
2A4	Soda Ash Use	CO2	0.00	0.00	15.13	0.00000	0.00000	100.00000
5A	Forest land	CO2	0.00	0.00	25.02	0.00000	0.00000	100.00000
5B	Cropland	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C	Grassland	CO2	0.00	0.00	70.01	0.00000	0.00000	100.00000
5D	Wetlands	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5E	Settlements	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5G	Other	CO2	0.00	0.00	30.02	0.00000	0.00000	100.00000
4F	Field Burning	CH4	265.51	0.00	55.90	0.00000	0.00000	100.00000
5A	Forest land	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	Cropland	CH4	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	Land converted to grassland	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	Land converted to settlements	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
2B	Adipic Acid Production	N2O	20737.34	0.00	15.01	0.00000	0.00000	100.00000
4F	Field Burning	N2O	77.60	0.00	231.35	0.00000	0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.00	0.00	50.99	0.00000	0.00000	100.00000
5A	Forest land	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	Cropland	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	Land converted to grassland	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5D	Wetlands	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	Land converted to settlements	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5G	Other	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	767,259.76	594,021.50		0.29	100.00	

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

IPCC category	Source category	Gas	Base year emissions Gg CO2 equiv. 1990 & 1995	Year Y emissions Gg CO2 equiv. 2010	Combined uncertainty range as a % of source category	Trend Parameter (used to order sources)	Trend / Sum(Trend)*100 %	Cumulative %
4D	Agricultural Soils	N2O	32825.07	26385.59	424.00	0.05468	49.48703	
2B	Nitric Acid Production	N2O	3903.85	1316.57	230.22	0.01954	17.68764	67.17468
6B	Wastewater Handling	N2O	1164.86	1151.57	401.12	0.00944	8.53920	75.71387
6A	Solid Waste Disposal	CH4	43143.47	14767.00	48.38	0.00943	8.53195	84.24582
4B	Manure Management	N2O	2053.05	1750.56	414.00	0.00708	6.40864	90.65446
1A1&1A2&1A4&1A5	Other Combustion	N2O	4829.07	3122.22	195.00	0.00472	4.27071	94.92516
1A(stationary)	Oil	CO2	92867.52	53505.95	15.13	0.00088	0.79581	95.72097
1A3	Other Diesel	N2O	191.40	282.12	140.01	0.00059	0.53736	96.25833
2B5	NEU	CO2	1562.92	1969.82	53.85	0.00050	0.45432	96.71265
5E	Settlements	CO2	7011.87	6216.22	50.01	0.00048	0.43887	97.15152
1B1	Mining & Solid Fuel Transformation	CH4	18281.71	1799.47	13.06	0.00046	0.41316	97.56468
1A3b	Auto Fuel	N2O	1179.78	847.95	170.02	0.00033	0.29786	97.86254
1A	All Fuel	CH4	2077.99	1069.03	50.00	0.00029	0.25890	98.12145
1A3b	Auto Fuel	CH4	634.83	71.41	50.08	0.00023	0.20809	98.32954
2	Industrial Processes	HFC	15327.65	14314.07	19.03	0.00021	0.19171	98.52125
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10322.92	5191.29	17.08	0.00017	0.15467	98.67593
1A	Other (waste)	CO2	212.42	1660.57	21.19	0.00015	0.13539	98.81131
2A7	Fletton Bricks	CO2	539.42	530.66	72.80	0.00014	0.12747	98.93878
1A3b	Auto Fuel	CO2	108564.64	111579.17	4.48	0.00013	0.11656	99.05535
6C	Waste Incineration	N2O	47.90	47.25	230.11	0.00013	0.11441	99.16976
4A	Enteric Fermentation	CH4	18694.63	15385.93	20.00	0.00010	0.09158	99.26134
1A3a	Aviation Fuel	CO2	1580.55	1990.63	20.27	0.00007	0.06498	99.32632
6B	Wastewater Handling	CH4	287.21	347.89	50.01	0.00007	0.06491	99.39123
1A4	Peat	CO2	475.59	47.44	31.62	0.00007	0.06338	99.45461
5B	Cropland	CO2	15732.05	12115.71	50.01	0.00007	0.06321	99.51783
6C	Waste Incineration	CO2	1227.50	292.01	21.19	0.00006	0.05813	99.57596
1A	Natural Gas	CO2	108956.17	197884.94	1.51	0.00006	0.05291	99.62887
5D	Wetlands	CO2	481.73	263.02	50.01	0.00006	0.05240	99.68127
6C	Waste Incineration	CH4	134.43	6.25	50.49	0.00005	0.04934	99.73061
1A3a	Aviation Fuel	N2O	15.56	19.60	171.17	0.00005	0.04561	99.77623
1B2	Oil & Natural Gas	N2O	42.40	46.17	111.16	0.00004	0.03446	99.81069
1A3d	Marine Fuel	N2O	16.56	17.64	170.01	0.00003	0.02918	99.83987
2A7	Fletton Bricks	CH4	23.60	5.63	101.98	0.00003	0.02585	99.86572
1A	Combined Fuel	CO2	801.51	867.86	21.21	0.00003	0.02327	99.88899
2	Industrial Processes	SF6	1239.30	689.99	20.02	0.00002	0.02054	99.90953
1A	Coal	CO2	247785.08	114863.47	1.08	0.00002	0.01727	99.92680
5B	Cropland	N2O	781.56	622.48	50.01	0.00001	0.01349	99.94029
1A	Lubricant	CO2	386.90	225.28	30.07	0.00001	0.01266	99.95295
4B	Manure Management	CH4	3585.62	2679.30	30.00	0.00001	0.00968	99.96263
2B	Chemical Industry	CH4	169.43	73.50	28.28	0.00001	0.00895	99.97158
2C	Iron & Steel	N2O	11.11	6.72	118.00	0.00001	0.00490	99.97648
2A2	Lime Production	CO2	1206.41	233.70	5.10	0.00000	0.00359	99.98007
1B	Solid Fuel Transformation	CO2	856.42	219.64	6.01	0.00000	0.00315	99.98322
2	Industrial Processes	PFC	461.81	220.47	10.05	0.00000	0.00267	99.98589
2B	Ammonia Production	CO2	1431.17	978.43	10.11	0.00000	0.00231	99.98820
2A1	Cement Production	CO2	7295.26	3792.01	2.42	0.00000	0.00208	99.99028
1A3d	Marine Fuel	CH4	1.85	3.91	50.03	0.00000	0.00126	99.99154
1A3	Other Diesel	CO2	1613.78	2370.91	2.20	0.00000	0.00111	99.99265
1B	Oil & Natural Gas	CO2	5777.84	4388.43	17.09	0.00000	0.00089	99.99354
1A3a	Aviation Fuel	CH4	3.30	1.11	53.85	0.00000	0.00082	99.99436
1A3	Other Diesel	CH4	3.11	3.78	50.03	0.00000	0.00071	99.99507
5C2	Land converted to grassland	CH4	3.90	11.74	20.02	0.00000	0.00071	99.99577
1A3d	Marine Fuel	CO2	2123.33	2264.57	2.20	0.00000	0.00063	99.99640
1B1	Coke Oven Gas	N2O	2.08	1.38	118.00	0.00000	0.00059	99.99699
1A3c	Coal	CH4	0.00	0.99	50.00	0.00000	0.00050	99.99749
5A	Forest land	CH4	4.30	8.17	20.02	0.00000	0.00040	99.99789
1A3c	Coal	CO2	0.00	49.62	6.01	0.00000	0.00036	99.99825
2A3	Limestone & Dolomite use	CO2	1125.28	920.77	5.10	0.00000	0.00033	99.99858
2C	Iron & Steel Production	CH4	16.36	11.81	50.00	0.00000	0.00033	99.99891
1A3c	Coal	N2O	0.00	0.12	118.00	0.00000	0.00033	99.99923
5D	Wetlands	N2O	3.98	0.50	20.02	0.00000	0.00020	99.99944
5A	Forest land	N2O	5.57	1.92	20.02	0.00000	0.00019	99.99962
5B	Cropland	CH4	0.14	0.39	50.01	0.00000	0.00015	99.99977
2C1	Iron&Steel Production	CO2	2309.27	1747.34	6.12	0.00000	0.00010	99.99987
5C2	Land converted to grassland	N2O	0.40	1.19	20.02	0.00000	0.00007	99.99994
5E2	Land converted to settlements	CH4	9.96	8.30	20.02	0.00000	0.00006	99.99999
5E2	Land converted to settlements	N2O	1.01	0.84	20.02	0.00000	0.00001	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
2A4	Soda Ash Use	CO2	0.00	0.00	15.13	0.00000	0.00000	100.00000
5A	Forest land	CO2	-12155.07	-10568.81	25.02	0.00000	0.00000	100.00000
5C	Grassland	CO2	-6261.11	-8541.00	70.01	0.00000	0.00000	100.00000
5G	Other	CO2	-1727.33	-3985.06	30.02	0.00000	0.00000	100.00000
4F	Field Burning	CH4	265.51	0.00	55.90	0.00000	0.00000	100.00000
2B	Adipic Acid Production	N2O	20737.34	0.00	15.01	0.00000	0.00000	100.00000
4F	Field Burning	N2O	77.60	0.00	231.35	0.00000	0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.00	0.00	50.99	0.00000	0.00000	100.00000
5G	Other	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	774,364.31	590,177.13		0.11	100.00	

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

IPCC category	Source category	Gas	Base year emissions Gg CO2 equiv. 1990 & 1995	Year Y emissions Gg CO2 equiv. 2010	Combined uncertainty range as a % of source category	Trend Parameter (used to order sources)	Trend / Sum(Trend)*100 %	Cumulative %
4D	Agricultural Soils	N2O	32825.07	26385.59	424.00	0.04231	43.84539	
2B	Nitric Acid Production	N2O	3903.85	1316.57	230.22	0.01960	20.30373	64.14912
6A	Solid Waste Disposal	CH4	43143.47	14767.00	48.38	0.00945	9.79626	73.94538
6B	Wastewater Handling	N2O	1164.86	1151.57	401.12	0.00891	9.22752	83.17289
4B	Manure Management	N2O	2053.05	1750.56	414.00	0.00628	6.50274	89.67564
1A1&1A2&1A4&1A5	Other Combustion	N2O	4829.07	3122.22	195.00	0.00499	5.16972	94.84536
1A(stationary)	Oil	CO2	92867.52	53505.95	15.13	0.00090	0.93743	95.78279
1A3	Other Diesel	N2O	191.40	282.12	140.01	0.00058	0.59676	96.37955
2B5	NEU	CO2	1562.92	1969.82	53.85	0.00048	0.50182	96.88137
1B1	Mining & Solid Fuel Transformation	CH4	18281.71	1799.47	13.06	0.00045	0.47080	97.35217
1A3b	Auto Fuel	N2O	1179.78	847.95	170.02	0.00039	0.40316	97.75534
1A	All Fuel	CH4	2077.99	1069.03	50.00	0.00029	0.30153	98.05687
1A3b	Auto Fuel	CH4	634.83	71.41	50.08	0.00023	0.23719	98.29406
2	Industrial Processes	HFC	15327.65	14314.07	19.03	0.00020	0.20448	98.49854
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10322.92	5191.29	17.08	0.00017	0.18016	98.67870
1A	Other (waste)	CO2	212.42	1660.57	21.19	0.00015	0.15205	98.83075
2A7	Fletton Bricks	CO2	539.42	530.66	72.80	0.00013	0.13763	98.96838
1A3b	Auto Fuel	CO2	108564.64	111579.17	4.48	0.00012	0.12671	99.09509
6C	Waste Incineration	N2O	47.90	47.25	230.11	0.00012	0.12359	99.21868
4A	Enteric Fermentation	CH4	18694.63	15385.93	20.00	0.00008	0.08803	99.30670
1A4	Peat	CO2	475.59	47.44	31.62	0.00007	0.07223	99.37893
1A3a	Aviation Fuel	CO2	1580.55	1990.63	20.27	0.00007	0.07177	99.45070
6B	Wastewater Handling	CH4	287.21	347.89	50.01	0.00007	0.07156	99.52226
6C	Waste Incineration	CO2	1227.50	292.01	21.19	0.00006	0.06648	99.58873
1A	Natural Gas	CO2	108956.17	197884.94	1.51	0.00006	0.05900	99.64773
6C	Waste Incineration	CH4	134.43	6.25	50.49	0.00005	0.05617	99.70390
1A3a	Aviation Fuel	N2O	15.56	19.60	171.17	0.00005	0.05038	99.75429
1B2	Oil & Natural Gas	N2O	42.40	46.17	111.16	0.00004	0.03771	99.79199
1A3d	Marine Fuel	N2O	16.56	17.64	170.01	0.00003	0.03186	99.82385
2A7	Fletton Bricks	CH4	23.60	5.63	101.98	0.00003	0.02956	99.85341
1A	Combined Fuel	CO2	801.51	867.86	21.21	0.00002	0.02544	99.87886
2	Industrial Processes	SF6	1239.30	689.99	20.02	0.00002	0.02409	99.90294
1A	Coal	CO2	247785.08	114863.47	1.08	0.00002	0.01999	99.92293
4B	Manure Management	CH4	3585.62	2679.30	30.00	0.00002	0.01734	99.94027
1A	Lubricant	CO2	386.90	225.28	30.07	0.00001	0.01493	99.95521
2B	Chemical Industry	CH4	169.43	73.50	28.28	0.00001	0.01034	99.96555
2C	Iron & Steel	N2O	11.11	6.72	118.00	0.00001	0.00582	99.97136
1B	Oil & Natural Gas	CO2	5777.84	4388.43	17.09	0.00000	0.00437	99.97574
2A2	Lime Production	CO2	1206.41	233.70	5.10	0.00000	0.00410	99.97983
1B	Solid Fuel Transformation	CO2	856.42	219.64	6.01	0.00000	0.00360	99.98344
2	Industrial Processes	PFC	461.81	220.47	10.05	0.00000	0.00310	99.98654
2B	Ammonia Production	CO2	1431.17	978.43	10.11	0.00000	0.00289	99.98943
2A1	Cement Production	CO2	7295.26	3792.01	2.42	0.00000	0.00242	99.99185
1A3d	Marine Fuel	CH4	1.85	3.91	50.03	0.00000	0.00141	99.99326
1A3	Other Diesel	CO2	1613.78	2370.91	2.20	0.00000	0.00124	99.99449
1A3a	Aviation Fuel	CH4	3.30	1.11	53.85	0.00000	0.00094	99.99543
1A3	Other Diesel	CH4	3.11	3.78	50.03	0.00000	0.00078	99.99621
1B1	Coke Oven Gas	N2O	2.08	1.38	118.00	0.00000	0.00072	99.99694
1A3d	Marine Fuel	CO2	2123.33	2264.57	2.20	0.00000	0.00069	99.99762
1A3c	Coal	CH4	0.00	0.99	50.00	0.00000	0.00056	99.99818
2C	Iron & Steel Production	CH4	16.36	11.81	50.00	0.00000	0.00045	99.99863
1A3c	Coal	CO2	0.00	49.62	6.01	0.00000	0.00041	99.99904
1A3c	Coal	N2O	0.00	0.12	118.00	0.00000	0.00037	99.99941
2A3	Limestone & Dolomite use	CO2	1125.28	920.77	5.10	0.00000	0.00031	99.99972
2C1	Iron&Steel Production	CO2	2309.27	1747.34	6.12	0.00000	0.00028	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
2A4	Soda Ash Use	CO2	0.00	0.00	15.13	0.00000	0.00000	100.00000
5A	Forest land	CO2	0.00	0.00	25.02	0.00000	0.00000	100.00000
5B	Cropland	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C	Grassland	CO2	0.00	0.00	70.01	0.00000	0.00000	100.00000
5D	Wetlands	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5E	Settlements	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5G	Other	CO2	0.00	0.00	30.02	0.00000	0.00000	100.00000
4F	Field Burning	CH4	265.51	0.00	55.90	0.00000	0.00000	100.00000
5A	Forest land	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	Cropland	CH4	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	Land converted to grassland	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	Land converted to settlements	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
2B	Adipic Acid Production	N2O	20737.34	0.00	15.01	0.00000	0.00000	100.00000
4F	Field Burning	N2O	77.60	0.00	231.35	0.00000	0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.00	0.00	50.99	0.00000	0.00000	100.00000
5A	Forest land	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	Cropland	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	Land converted to grassland	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5D	Wetlands	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	Land converted to settlements	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5G	Other	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	770,471.37	594,021.50		0.10	100.00	

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

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IPCC category	Source category	Gas	Emissions Gg CO2 equiv. 1990	Year Y emissions Gg CO2 equiv. 2010	Combined uncertainty range as a % of source category	Trend Parameter (used to order sources)	Trend / Sum(Trend)*100 %	Cumulative %
4D	Agricultural Soils	N2O	32825.07	26385.59	424.00	0.05031	47.41899	
2B	Nitric Acid Production	N2O	3903.85	1316.57	230.22	0.01961	18.48260	65.90158
6A	Solid Waste Disposal	CH4	43143.47	14767.00	48.38	0.00946	8.91620	74.81778
6B	Wastewater Handling	N2O	1164.86	1151.57	401.12	0.00926	8.73267	83.55045
4B	Manure Management	N2O	2053.05	1750.56	414.00	0.00680	6.41393	89.96438
1A1&1A2&1A4&1A5	Other Combustion	N2O	4829.07	3122.22	195.00	0.00483	4.55119	94.51557
1A(stationary)	Oil	CO2	92867.52	53505.95	15.13	0.00089	0.83950	95.35507
1A3	Other Diesel	N2O	191.40	282.12	140.01	0.00059	0.55486	95.90993
2B5	NEU	CO2	1562.92	1969.82	53.85	0.00050	0.46822	96.37815
5E	5E LULUCF	CO2	7011.87	6216.22	50.01	0.00047	0.44358	96.82172
1B1	Mining & Solid Fuel Transformation	CH4	18281.71	1799.47	13.06	0.00046	0.43058	97.25230
2	Industrial Processes	HFC	11385.62	14314.07	19.03	0.00045	0.42307	97.67537
1A3b	Auto Fuel	N2O	1179.78	847.95	170.02	0.00035	0.33153	98.00690
1A	All Fuel	CH4	2077.99	1069.03	50.00	0.00029	0.27198	98.27888
1A3b	Auto Fuel	CH4	634.83	71.41	50.08	0.00023	0.21689	98.49577
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10322.92	5191.29	17.08	0.00017	0.16249	98.65826
1A	Other (waste)	CO2	212.42	1660.57	21.19	0.00015	0.14036	98.79862
2A7	Fletton Bricks	CO2	539.42	530.66	72.80	0.00014	0.13032	98.92894
1A3b	Auto Fuel	CO2	108564.64	111579.17	4.48	0.00013	0.11945	99.04839
6C	Waste Incineration	N2O	47.90	47.25	230.11	0.00012	0.11699	99.16538
4A	Enteric Fermentation	CH4	18694.63	15385.93	20.00	0.00010	0.09003	99.25541
1A3a	Aviation Fuel	CO2	1580.55	1990.63	20.27	0.00007	0.06697	99.32238
6B	Wastewater Handling	CH4	287.21	347.89	50.01	0.00007	0.06685	99.38923
1A4	Peat	CO2	475.59	47.44	31.62	0.00007	0.06606	99.45529
6C	Waste Incineration	CO2	1227.50	292.01	21.19	0.00006	0.06066	99.51595
5D	5D LULUCF	CO2	481.73	263.02	50.01	0.00006	0.05514	99.57109
1A	Natural Gas	CO2	108956.17	197884.94	1.51	0.00006	0.05472	99.62581
6C	Waste Incineration	CH4	134.43	6.25	50.49	0.00005	0.05140	99.67721
1A3a	Aviation Fuel	N2O	15.56	19.60	171.17	0.00005	0.04701	99.72422
5B	5B LULUCF	CO2	15732.05	12115.71	50.01	0.00004	0.03950	99.76372
1B2	Oil & Natural Gas	N2O	42.40	46.17	111.16	0.00004	0.03540	99.79912
1A3d	Marine Fuel	N2O	16.56	17.64	170.01	0.00003	0.02995	99.82907
2A7	Fletton Bricks	CH4	23.60	5.63	101.98	0.00003	0.02698	99.85605
1A	Combined Fuel	CO2	801.51	867.86	21.21	0.00003	0.02389	99.87994
1A	Coal	CO2	247785.08	114863.47	1.08	0.00002	0.01810	99.89804
2	Industrial Processes	PFC	1401.60	220.47	10.05	0.00002	0.01796	99.91600
1A	Lubricant	CO2	386.90	225.28	30.07	0.00001	0.01336	99.92936
5B	5B LULUCF	N2O	781.56	622.48	50.01	0.00001	0.01270	99.94207
4B	Manure Management	CH4	3585.62	2679.30	30.00	0.00001	0.01218	99.95424
2B	Chemical Industry	CH4	169.43	73.50	28.28	0.00001	0.00938	99.96362
2	Industrial Processes	SF6	1029.95	689.99	20.02	0.00001	0.00822	99.97184
2C	Iron & Steel	N2O	11.11	6.72	118.00	0.00001	0.00518	99.97702
2A2	Lime Production	CO2	1206.41	233.70	5.10	0.00000	0.00374	99.98077
1B	Solid Fuel Transformation	CO2	856.42	219.64	6.01	0.00000	0.00329	99.98405
2B	Ammonia Production	CO2	1431.17	978.43	10.11	0.00000	0.00249	99.98655
2A1	Cement Production	CO2	7295.26	3792.01	2.42	0.00000	0.00218	99.98873
1B	Oil & Natural Gas	CO2	5777.84	4388.43	17.09	0.00000	0.00204	99.99077
1A3d	Marine Fuel	CH4	1.85	3.91	50.03	0.00000	0.00130	99.99207
1A3	Other Diesel	CO2	1613.78	2370.91	2.20	0.00000	0.00115	99.99322
1A3a	Aviation Fuel	CH4	3.30	1.11	53.85	0.00000	0.00085	99.99408
5C2	5C2 LULUCF	CH4	3.90	11.74	20.02	0.00000	0.00073	99.99481
1A3	Other Diesel	CH4	3.11	3.78	50.03	0.00000	0.00073	99.99554
1A3d	Marine Fuel	CO2	2123.33	2264.57	2.20	0.00000	0.00065	99.99619
1B1	Coke Oven Gas	N2O	2.08	1.38	118.00	0.00000	0.00063	99.99682
1A3c	Coal	CH4	0.00	0.99	50.00	0.00000	0.00051	99.99733
5A	5A LULUCF	CH4	4.30	8.17	20.02	0.00000	0.00041	99.99774
1A3c	Coal	CO2	0.00	49.62	6.01	0.00000	0.00037	99.99812
2C	Iron & Steel Production	CH4	16.36	11.81	50.00	0.00000	0.00037	99.99848
1A3c	Coal	N2O	0.00	0.12	118.00	0.00000	0.00034	99.99882
2A3	Limestone & Dolomite use	CO2	1125.28	920.77	5.10	0.00000	0.00032	99.99915
5D	5D LULUCF	N2O	3.98	0.50	20.02	0.00000	0.00021	99.99936
5A	5A LULUCF	N2O	5.57	1.92	20.02	0.00000	0.00020	99.99956
2C1	Iron&Steel Production	CO2	2309.27	1747.34	6.12	0.00000	0.00016	99.99971
5B	5B LULUCF	CH4	0.14	0.39	50.01	0.00000	0.00015	99.99986
5C2	5C2 LULUCF	N2O	0.40	1.19	20.02	0.00000	0.00007	99.99994
5E2	5E2 LULUCF	CH4	9.96	8.30	20.02	0.00000	0.00006	99.99999
5E2	5E2 LULUCF	N2O	1.01	0.84	20.02	0.00000	0.00001	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
2A4	Soda Ash Use	CO2	0.00	0.00	15.13	0.00000	0.00000	100.00000
5A	5A LULUCF	CO2	-12155.07	-10568.81	25.02	0.00000	0.00000	100.00000
5C	5C LULUCF	CO2	-6261.11	-8541.00	70.01	0.00000	0.00000	100.00000
5G	5G LULUCF	CO2	-1727.33	-3985.06	30.02	0.00000	0.00000	100.00000
4F	Field Burning	CH4	265.51	0.00	55.90	0.00000	0.00000	100.00000
2B	Adipic Acid Production	N2O	20737.34	0.00	15.01	0.00000	0.00000	100.00000
4F	Field Burning	N2O	77.60	0.00	231.35	0.00000	0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.00	0.00	50.99	0.00000	0.00000	100.00000
5G	5G LULUCF	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	771,152.71	590,177.13		0.11	100.00	

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

IPCC category	Source category	Gas	Emissions Gg CO2 equiv. 1990	Year Y emissions Gg CO2 equiv. 2010	Combined uncertainty range as a % of source category	Trend Parameter (used to order sources)	Trend / Sum(Trend)*100 %	Cumulative %
4D	Agricultural Soils	N2O	32825.07	26385.59	424.00	0.03800	41.20952	
2B	Nitric Acid Production	N2O	3903.85	1316.57	230.22	0.01966	21.32027	62.52979
6A	Solid Waste Disposal	CH4	43143.47	14767.00	48.38	0.00949	10.28761	72.81740
6B	Wastewater Handling	N2O	1164.86	1151.57	401.12	0.00874	9.47531	82.29271
4B	Manure Management	N2O	2053.05	1750.56	414.00	0.00600	6.51008	88.80279
1A1&1A2&1A4&1A5	Other Combustion	N2O	4829.07	3122.22	195.00	0.00510	5.52820	94.33100
1A(stationary)	Oil	CO2	92867.52	53505.95	15.13	0.00092	0.99328	95.32428
1A3	Other Diesel	N2O	191.40	282.12	140.01	0.00057	0.61915	95.94343
2B5	NEU	CO2	1562.92	1969.82	53.85	0.00048	0.51961	96.46303
1B1	Mining & Solid Fuel Transformation	CH4	18281.71	1799.47	13.06	0.00045	0.49309	96.95612
2	Industrial Processes	HFC	11385.62	14314.07	19.03	0.00043	0.46945	97.42557
1A3b	Auto Fuel	N2O	1179.78	847.95	170.02	0.00041	0.44618	97.87174
1A	All Fuel	CH4	2077.99	1069.03	50.00	0.00029	0.31824	98.18999
1A3b	Auto Fuel	CH4	634.83	71.41	50.08	0.00023	0.24844	98.43842
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10322.92	5191.29	17.08	0.00018	0.19015	98.62858
1A	Other (waste)	CO2	212.42	1660.57	21.19	0.00015	0.15841	98.78699
2A7	Fletton Bricks	CO2	539.42	530.66	72.80	0.00013	0.14127	98.92826
1A3b	Auto Fuel	CO2	108564.64	111579.17	4.48	0.00012	0.13041	99.05868
6C	Waste Incineration	N2O	47.90	47.25	230.11	0.00012	0.12688	99.18556
4A	Enteric Fermentation	CH4	18694.63	15385.93	20.00	0.00008	0.08606	99.27162
1A4	Peat	CO2	475.59	47.44	31.62	0.00007	0.07564	99.34726
1A3a	Aviation Fuel	CO2	1580.55	1990.63	20.27	0.00007	0.07431	99.42158
6B	Wastewater Handling	CH4	287.21	347.89	50.01	0.00007	0.07404	99.49562
6C	Waste Incineration	CO2	1227.50	292.01	21.19	0.00006	0.06971	99.56532
1A	Natural Gas	CO2	108956.17	197884.94	1.51	0.00006	0.06131	99.62663
6C	Waste Incineration	CH4	134.43	6.25	50.49	0.00005	0.05881	99.68544
1A3a	Aviation Fuel	N2O	15.56	19.60	171.17	0.00005	0.05217	99.73761
1B2	Oil & Natural Gas	N2O	42.40	46.17	111.16	0.00004	0.03890	99.77651
1A3d	Marine Fuel	N2O	16.56	17.64	170.01	0.00003	0.03284	99.80935
2A7	Fletton Bricks	CH4	23.60	5.63	101.98	0.00003	0.03100	99.84035
1A	Combined Fuel	CO2	801.51	867.86	21.21	0.00002	0.02624	99.86660
1A	Coal	CO2	247785.08	114863.47	1.08	0.00002	0.02106	99.88765
2	Industrial Processes	PFC	1401.60	220.47	10.05	0.00002	0.02059	99.90825
4B	Manure Management	CH4	3585.62	2679.30	30.00	0.00002	0.02053	99.92878
1A	Lubricant	CO2	386.90	225.28	30.07	0.00001	0.01583	99.94461
2B	Chemical Industry	CH4	169.43	73.50	28.28	0.00001	0.01088	99.95549
2	Industrial Processes	SF6	1029.95	689.99	20.02	0.00001	0.01016	99.96565
2C	Iron & Steel	N2O	11.11	6.72	118.00	0.00001	0.00618	99.97183
1B	Oil & Natural Gas	CO2	5777.84	4388.43	17.09	0.00001	0.00584	99.97767
2A2	Lime Production	CO2	1206.41	233.70	5.10	0.00000	0.00429	99.98196
1B	Solid Fuel Transformation	CO2	856.42	219.64	6.01	0.00000	0.00378	99.98574
2B	Ammonia Production	CO2	1431.17	978.43	10.11	0.00000	0.00312	99.98887
2A1	Cement Production	CO2	7295.26	3792.01	2.42	0.00000	0.00256	99.99142
1A3d	Marine Fuel	CH4	1.85	3.91	50.03	0.00000	0.00146	99.99289
1A3	Other Diesel	CO2	1613.78	2370.91	2.20	0.00000	0.00128	99.99417
1A3a	Aviation Fuel	CH4	3.30	1.11	53.85	0.00000	0.00099	99.99516
1A3	Other Diesel	CH4	3.11	3.78	50.03	0.00000	0.00081	99.99596
1B1	Coke Oven Gas	N2O	2.08	1.38	118.00	0.00000	0.00078	99.99674
1A3d	Marine Fuel	CO2	2123.33	2264.57	2.20	0.00000	0.00071	99.99745
1A3c	Coal	CH4	0.00	0.99	50.00	0.00000	0.00058	99.99803
2C	Iron & Steel Production	CH4	16.36	11.81	50.00	0.00000	0.00050	99.99853
1A3c	Coal	CO2	0.00	49.62	6.01	0.00000	0.00042	99.99896
1A3c	Coal	N2O	0.00	0.12	118.00	0.00000	0.00038	99.99934
2C1	Iron&Steel Production	CO2	2309.27	1747.34	6.12	0.00000	0.00036	99.99970
2A3	Limestone & Dolomite use	CO2	1125.28	920.77	5.10	0.00000	0.00030	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
2A4	Soda Ash Use	CO2	0.00	0.00	15.13	0.00000	0.00000	100.00000
5A	Forest land	CO2	0.00	0.00	25.02	0.00000	0.00000	100.00000
5B	Cropland	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C	Grassland	CO2	0.00	0.00	70.01	0.00000	0.00000	100.00000
5D	Wetlands	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5E	Settlements	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5G	Other	CO2	0.00	0.00	30.02	0.00000	0.00000	100.00000
4F	Field Burning	CH4	265.51	0.00	55.90	0.00000	0.00000	100.00000
5A	Forest land	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	Cropland	CH4	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	Land converted to grassland	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	Land converted to settlements	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
2B	Adipic Acid Production	N2O	20737.34	0.00	15.01	0.00000	0.00000	100.00000
4F	Field Burning	N2O	77.60	0.00	231.35	0.00000	0.00000	100.00000
4G	OvTerr Agriculture N2O (all)	N2O	0.00	0.00	50.99	0.00000	0.00000	100.00000
5A	Forest land	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	Cropland	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	Land converted to grassland	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5D	Wetlands	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	Land converted to settlements	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5G	Other	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	767,259.76	594,021.50		0.09	100.00	

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
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		Qualitative	
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 LULUCF	CO2		Level	
5B	5B LULUCF	CO2		Level	
5C	5C LULUCF	CO2		Level	
5E	5E LULUCF	CO2		Level	
5G	5G LULUCF	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	Mining & Solid Fuel Transformation	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 LULUCF	CH4			
5E2	5E2 LULUCF	CH4			
6A	Solid Waste Disposal	CH4		Level	high uncertainty
6B	Wastewater Handling	CH4			
6C	Waste Incineration	CH4			
1A1&1A2&1A4&1A	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 LULUCF	N2O			
5E2	5E2 LULUCF	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		Qualitative	
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 LULUCF	CO2			
5B	5B LULUCF	CO2			
5C	5C LULUCF	CO2			
5E	5E LULUCF	CO2			
5G	5G LULUCF	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	Mining & Solid Fuel Transformation	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 LULUCF	CH4			
5E2	5E2 LULUCF	CH4			
6A	Solid Waste Disposal	CH4		Level	high uncertainty
6B	Wastewater Handling	CH4			
6C	Waste Incineration	CH4			
1A1&1A2&1A4&1A	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 LULUCF	N2O			
5E2	5E2 LULUCF	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 IPCC Source Categories		B Gas	C Category Key Source Category	D If Column C is Yes, Criteria for Identification	E Comments
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		Qualitative	
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 LULUCF	CO2		Level	
5B	5B LULUCF	CO2		Level	
5C	5C LULUCF	CO2		Level	
5E	5E LULUCF	CO2		Level	
5G	5G LULUCF	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	Mining & Solid Fuel Transformation	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 LULUCF	CH4			
5E2	5E2 LULUCF	CH4			
6A	Solid Waste Disposal	CH4		Level, Trend	high uncertainty
6B	Wastewater Handling	CH4			
6C	Waste Incineration	CH4			
1A1&1A2&1A4&1A	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 LULUCF	N2O			
5E2	5E2 LULUCF	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
IPCC Source Categories		Gas	Category Key Source Category	If Column C is Yes, Criteria for Identification	Comments
1A	Coal	CO2			
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		Qualitative	
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 LULUCF	CO2			
5B	5B LULUCF	CO2			
5C	5C LULUCF	CO2			
5E	5E LULUCF	CO2			
5G	5G LULUCF	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	Mining & Solid Fuel Transformation	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 LULUCF	CH4			
5E2	5E2 LULUCF	CH4			
6A	Solid Waste Disposal	CH4		Level, Trend	high uncertainty
6B	Wastewater Handling	CH4			
6C	Waste Incineration	CH4			
1A1&1A2&1A4&1A	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 LULUCF	N2O			
5E2	5E2 LULUCF	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-GBR-2013-2011-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 (5A) is key	The Afforestation and Reforestation category contribution is smaller than the smallest UNFCCC key category but the associated UNFCCC category (5A 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 (5B, 5C and 5E) are key)	The Deforestation category contribution is smaller than the smallest UNFCCC key category but the associated UNFCCC categories (5B Cropland, 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 (5A) 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 and 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, 2012), 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, waste solvents, general wastes, 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 .

Table A 3.1.1 Mapping of fuels used in IPCC and the NAEI

	IPCC	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 Charcoal	Wood Straw Poultry Litter, Meat & bone meal Landfill Gas Sewage Gas Charcoal

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 ENERGY (CRF SECTOR 1)

Most emissions from energy sources are calculated using the 'basic combustion module (see Section 3.2.6.2.1 of the main report), which involves the calculation of emissions from each source, as the product of fuel consumption data and an emission factor. The emission factors used throughout the energy sector within the inventory are shown in
Table A 3.2.2 to **Table A 3.2.5** and **Table A 3.2.6** 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 (2012) are reported in terms of energy content on a gross basis. The tables are grouped into solid, liquid, gas and biomass/other based on the IPCC definitions of the fuels.

The NAEI database stores 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, (2011). The values of the conversion factors used in the calculations are given in **Table A 3.2.1.**

Table A 3.2.1 Conversion Factors for Gross to Net Energy Consumption

Fuel	Conversion Factor
Other Gaseous Fuels	0.90
Solid and Liquid Fuels	0.95
LPG and OPG	0.92
Blast Furnace Gas	1.00

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.

Table A 3.2.2 Emission Factors for the Combustion of Liquid Fuels for 2011

Fuel	Source	Units	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
ATF	Aircraft Military	kg/t	859[a]	0.103[g]	0.1[g]	8.5[g]	8.2[g]	1.1[g]	0.84[g]
Burning Oil	Domestic	kg/t	859[a]	0.462[g]	0.0277[g]	3.23[l]	1.85[l]	0.047[f]	0.534[z]
Burning Oil	Other Industry	kg/t	859[a]	0.0924[g]	0.0277[g]	3.33[l]	0.19[l]	0.028[e]	0.534[z]
Burning Oil	Public Service, Railways (Stationary)	kg/t	859[a]	0.462[g]	0.0277[g]	0	0	0.047[f]	0.534[z]
Burning Oil	Miscellaneous	kg/t	859[a]	0.462[g]	0.0277[g]	0	0	0.047[f]	0.534[z]
Burning Oil	Power stations	kg/t	859[a]	0.139[g]	0.0277[g]	2.54[ag]	2.07 [ag]	0.041 [ag]	0.534[z]
Gas Oil	Cement	kg/t	870[a]	0.0910[g]	0.0273[g]	NE	NE	NE	NE
Gas Oil	Chemicals (combustion)	kg/t	870[a]	0.0910[g]	0.0273[g]	6.02[l]	1.56[l]	0.028[f]	0.76[z]
Gas Oil	Domestic	kg/t	870[a]	0.455[g]	0.0273[g]	3.19[l]	1.82[l]	0.047[f]	0.76[z]
Gas Oil	Fishing, Coastal Shipping, Naval, International Marine	kg/t	870[a]	0.05[ap]	0.08 [ap]	57.97, 64.44, 69.33, 69.33[av]	7.4[ap]	2.04, 2.82, 2.74, 2.74[av]	2.02, 20.00, 20.00, 20.5[av]
Gas Oil	Iron&Steel	kg/t	870[a]	0.091[g]	0.0273[g]	9.79[l]	3.42[l]	0.028[f]	0.76[z]
Gas Oil	Refineries	kg/t	870[a]	0.136[g]	0.0273[g]	4.53[k]	0.24[i]	0.028[f]	0.76[z]
Gas Oil	Other Industry	kg/t	870[a]	0.091[g]	0.0273[g]	6.02[l]	1.56[l]	0.028[f]	0.76[z]
Gas Oil	Public Service	kg/t	870[a]	0.455[g]	0.0273[g]	2.44[l]	0.38[l]	0.047[f]	0.76[z]
Gas Oil	Pulp, Paper and Print (combustion)	kg/t	870[a]	0.091[g]	0.0273[g]	6.02[l]	1.56[l]	0.028[f]	0.76[z]
Gas Oil	Miscellaneous	kg/t	870[a]	0.455[g]	0.0273[g]	1.65[l]	0.213[l]	0.047[f]	0.76[z]
Fuel Oil	Agriculture	kg/t	879[a]	0.433[g]	0.026[g]	7.69[l]	0.31[l]	0.138[f]	15.05[z]
Fuel Oil	Cement	kg/t	879[a]	0.087[g]	0.026[g]	NE	NE	NE	NE
Fuel Oil	Chemicals (combustion)	kg/t	879[a]	0.087[g]	0.026[g]	12.15[l]	1.86[l]	0.034[f]	15.05[z]
Fuel Oil	Public Service	kg/t	879[a]	0.433[g]	0.026[g]	6.93[l]	0.80[l]	0.138[f]	15.05[z]
Fuel Oil	Pulp, Paper and Print (combustion)	kg/t	879[a]	0.087[g]	0.026[g]	12.15[l]	1.86[l]	0.034[f]	15.05[z]
Fuel Oil	Miscellaneous	kg/t	879[a]	0.433[g]	0.026[g]	1.91[l]	0.08[l]	0.138[f]	15.05[z]
Fuel Oil	Coastal Shipping,	kg/t	879[a]	0.05[ap]	0.08[ap]	70.57,	7.4[ap]	3.517,	17.60[av],

Fuel	Source	Units	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	International Marine					77.71[av]		2.924[av]	27.60[av]
Fuel Oil	Domestic	kg/t	879[a]	0.433[g]	0.026[g]	0[ap]	0[ap]	0.138[f]	15.05[z]
Fuel Oil	Iron&Steel	kg/t	879[a]	0.087[g]	0.026[g]	7.01[l]	0.80[l]	0.034[f]	15.05[z]
Fuel Oil	Railways (Stationary)	kg/t	879[a]	0.433[g]	0.026[g]	7.21[l]	0.76[l]	0.138[f]	15.05[z]
Fuel Oil	Other Industry	kg/t	879[a]	0.087[g]	0.026[g]	12.15[l]	1.86[l]	0.034[f]	15.05[z]
Fuel Oil	Refineries (Combustion)	kg/t	878[at]	0.130[g]	0.026[g]	2.47[ag]	0.79[ag]	0.034[f]	29.67[ag]
Lubricants	Other Industry	kg/t	865[x]	0.091[e]	0.027[e]	4.53[k]	0.25[f]	0.133[f]	11.41[x]
Petrol	Refineries	kg/t	855[a]	0.138[an]	0.028[g]	4.62[k]	0.24[e]	0.028[e]	0.01[z]
Naphtha	Refineries (Combustion)	kg/t	854[a]	0.129[g]	0.026[g]	4.62[k]	0.24[i]	0.028[f]	0.2[ax]
Waste oils	Cement (Combustion)	kg/t	C	C	C	C	C	C	C
Waste oils	Power stations	kg/t	865[x]	0.130[g]	0.026[g]	12.22[ag]	1.47[ag]	0.11[ag]	10.38[ag]
Waste solvent	Cement (Combustion	kg/t	C	C	C	C	C	C	C
Petroleum Coke	Domestic	kg/t	837[ay]	NE	NE	3.95[az]	158[az]	4.9[az]	142.4[az]
Petroleum Coke	Refineries	kg/t	930[at]	0.107[g]	0.281[w]	5.38[ag]	1.48[ag]	0.054[k]	27.15[ag]
Petroleum Coke	Cement Production –Combustion	kg/t	C	C	C	C	C	C	C
Petroleum Coke	Other Industry	kg/t	C	C	C	C	C	C	C
LPG	Domestic	g/GJ Gross	16227[a]	0.892[f]	0.100[g]	62.19[f]	8.89[f]	3.78[f]	0
LPG	I&S[ak], Other Industry, Refineries,	g/GJ Gross	16227[a]	0.892[f]	0.100[g]	62.19[f]	15.11[f]	3.78[f]	0
LPG	Power stations	g/GJ Gross	16227[a]	0.892[f]	0.100[g]	62.19[f]	15.11[f]	3.78[f]	0
LPG	Refineries – combustion	g/GJ Gross	16227[a]	0.892[f]	0.100[g]	62.19[f]	15.11[f]	3.78[f]	0
LPG	Upstream oil and gas production - combustion at gas separation	g/GJ Gross	16227[a]	17.904[aw]	4.34[aw]	151.37[aw]	59.92[aw]	0.81[aw]	3.15[aw]

Fuel	Source	Units	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	plant								
OPG	Gas production	g/GJ Gross	13914[at]	1.000[g]	NE	70.00[k]	2.37[i]	3.78[f]	0
OPG	Refineries (Combustion)	g/GJ Gross	13914[at]	1.000[g]	NE	70.81[ag]	14.13[z]	3.78[f]	0
OPG	Other Industry	g/GJ Gross	13914[at]	5.000[g]	0.100[g]	70.00[k]	2.37[i]	3.78[f]	0
OPG	Upstream oil and gas production - combustion at gas separation plant	g/GJ Gross	13914[at]	17.904[aw]	4.34[aw]	151.37[aw]	59.92[aw]	0.81[aw]	3.15[aw]

Note: Emission factors on an energy basis are presented in CD-ROM/excel file which accompanies this report.

Table A 3.2.3 Emission Factors for the Combustion of Solid fuels for 2011

Fuel	Source	Units	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Coal	Agriculture	kg/t	672.7[ao]	0.011[o]	0.146[w]	4.75[l]	8.25[l]	0.05[o]	16.64[aa]
Coal	Collieries	kg/t	668.6[ao]	0.011[o]	0.148[w]	4.75[l]	8.25[l]	0.05[o]	19.09[aa]
Coal	Domestic	kg/t	677.6[ao]	15.7[o]	0.122[w]	2.34[l]	159.96[l]	14.00[o]	16.62[aa]
Coal	Iron and Steel (Combustion)	kg/t	716.7[ao]	0.011[o]	0.237[w]	1.23	0.53	0.05[o]	16.64[aa]
Coal	Lime Production (Combustion)	kg/t	703.9[at]	0.011[o]	0.214[w]	75.51[v]	6.38[v]	0.05[o]	16.64[aa]
Coal	Miscellaneous	kg/t	633.2[ao]	0.011[o]	0.147[w]	5.49[l]	8.57[l]	0.05[o]	16.64[aa]
Coal	Public Service	kg/t	633.2[ao]	0.011[o]	0.147[w]	4.65[l]	6.90[l]	0.05[o]	16.64[aa]
Coal	Other Industry	kg/t	636.7[ao]	0.011[o]	0.214[w]	4.19[l]	1.82[l]	0.05[o]	16.64[aa]
Coal	Railways	kg/t	726.8[ao]	0.011[o]	0.147[m]	4.65[l]	6.90[l]	0.05[o]	16.64[aa]
Coal	Autogenerators	kg/t	594.9[ao]	0.020[o]	0.066[w]	5.22[l]	3.99[l]	0.03[o]	16.64[aa]
Coal	Cement production (combustion)	kg/t	C	C	C	C	C	C	C
Anthracite	Domestic	kg/t	816.1[ao]	2.00[o]	0.142[w]	3.47[k]	208.2[k]	1.7[o]	15.45[aa]
Coke	Agriculture	kg/t	847.2[r]	0.011[p]	0.150[w]	0	0	0.05[p]	19.0[ab]
Coke	SSF Production	kg/t	847.2[r]	0.011[p]	0.230[w]	NE	NE	0.05[p]	19.0[ab]
Coke	Domestic	kg/t	847.2[r]	5.8[o]	0.117[w]	2.57[l]	100.18[l]	4.9[o]	12.87[aa]
Coke	I&S[ak] (Sinter Plant)	kg/t	847.2[r]	1.39[ae]	0.230[w]	14.85[ae]	308.96[ae]	0.44[ae]	19.07[ae]
Coke	I&S[ak] (Combustion)	kg/t	847.2[r]	0.011[p]	0.230[w]	0.90[l]	234.4[l]	0.05[p]	19.0[ab]
Coke	Other Industry	kg/t	847.2[r]	0.011[p]	0.230[w]	0	0	0.05[p]	19.0[ab]
Coke	Railways	kg/t	847.2[r]	0.011[p]	0.150[w]	0	0	0.05[p]	19.0[ab]
Coke	Miscellaneous; Public Service	kg/t	847.2[r]	0.011[p]	0.150[w]	0	0	0.05[p]	19.0[ab]
Peat	Domestic	kg/t	370.0[g]	4.17[g]	0.056[g]	0.70[g]	69.5[g]	7.07[g]	NE

Fuel	Source	Units	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
SSF	Miscellaneous; Public Service	kg/t	766.3[n]	0.011[o]	0.155[w]	4.89[k]	48.9[k]	0.05[p]	19.00[ab]
SSF	Domestic	kg/t	774.2[n]	5.8[o]	0.120[w]	3.26[k]	130.4[k]	4.9[o]	16.00[ab]
SSF	Other Industry	kg/t	766.3[n]	0.011[o]	0.237[w]	4.89[k]	48.9[k]	0.05[p]	19.00[ab]
Blast Furnace Gas	Coke Production	g/GJ Gross	78437[r]	112.01[k]	2.00[k]	79.0[k]	39.5[k]	5.60[k]	0
Blast Furnace Gas	I&S[ak] (Combustion), I&S[ak] (Flaring)	g/GJ Gross	78437[r]	112.01[k]	2.00[k]	79.0[k]	39.5[k]	5.60[k]	0
Blast Furnace Gas	Blast Furnaces	g/GJ Gross	78437[r]	112.01[k]	2.00[k]	19.0[ae]	39.5[k]	5.60[k]	0
Coke Oven Gas	Other Sources	g/GJ Gross	11083[r]	57.25[k]	2.00[k]	80.5[k]	40.0[k]	4.35[k]	230.7[v]
Coke Oven Gas	I&S[ak] Blast Furnaces	g/GJ Gross	11083[r]	57.25[k]	2.00[k]	80.5[k]	40.0[k]	4.35[k]	230.7[v]
Coke Oven Gas	Coke Production	g/GJ Gross	11083[r]	57.25[k]	2.00[k]	335.23[ae]	40.0[k]	4.35[k]	230.7[v]

Note: Emission factors on an energy basis are presented in CD-ROM/Excel file which accompanies this submission.

Table A 3.2.4 Emission Factors for the Combustion of Gaseous Fuels 2011 (g/GJ gross)

Fuel	Source	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Natural Gas	Agriculture	13918[ao]	5.0[g]	0.10[g]	39.2[l]	2.13[l]	2.23[f]	0
Natural Gas	Miscellaneous	13918[ao]	5.0[g]	0.10[g]	55.5[l]	10.34[l]	2.23[f]	0
Natural Gas	Public Service	13918[ao]	5.0[g]	0.10[g]	59.3[l]	12.59[l]	2.23[f]	0
Natural Gas	Coke Production, SSF Prodn[al],	13918[ao]	1.0[g]	0.10[g]	175.0[k]	2.37[l]	2.23[f]	0
Natural Gas	Refineries	13713[at]	1.0[g]	0.10[g]	70.0[k]	2.37[l]	2.23[f]	0
Natural Gas	Blast Furnaces	13918[ao]	5.0[g]	0.10[g]	19.04[v]	2.37[l]	2.23[f]	0
Natural Gas	Domestic	13918[ao]	5.0[g]	0.10[g]	21.9[l]	30.8[l]	2.23[f]	0
Natural Gas	Gas Prodn[al],	13918[ao]	1.0[g]	0.10[g]	83.6[aw]	17.4[l]	2.23[f]	0
Natural Gas	Oil Prodn[al]	15118[aw]	17.9[aw]	4.34[aw]	151.4[aw]	59.9[aw]	0.81[aw]	3.15[aw]
Natural Gas	I&S[ak]	13918[ao]	5.0[g]	0.10[g]	185.0[l]	175.3[l]	2.23[f]	0
Natural Gas	Railways	13918[ao]	5.0[g]	0.10[g]	83.6[l]	33.8[l]	2.23[f]	0
Natural Gas	Other Industry	13918[ao]	5.0[g]	0.10[g]	90.3[l]	82.3[l]	2.23[f]	0
Natural Gas	Nuclear Fuel Prodn[al], Collieries	13918[ao]	1.0[g]	0.10[g]	90.3[l]	82.3[l]	2.23[f]	0
Natural Gas	Autogenerators	13918[ao]	5.0[g]	0.10[g]	90.3[l]	19.2[l]	2.23[f]	0
Natural Gas	Ammonia (Combustion)	13918[ao]	5.0[g]	0.10[g]	123.4[d]	NE	2.23[f]	0
Colliery Methane	Other Industry, collieries	17407[at]	5.0[s]	0.10[g]	70.0[k]	2.37[i]	2.23[f]	0
Colliery Methane	Coke Production, Gas Production	17407[at]	1.0[s]	0.10[g]	70.0[k]	2.37[i]	2.23[f]	0

Table A 3.2.5 Emission Factors for the Combustion of other fuels and biomass 2011

Fuel	Source	Units	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
MSW	Miscellaneous	Kg/tonne	94[ah]	2.85[g]	0.038[g]	1.02[v]	0.065[v]	0.0045[v]	0.029[v]
Scrap tyres	Cement (combustion)	Kg/tonne	C	C	C	C	C	C	C
Waste	Cement (combustion)	Kg/tonne	C	C	C	C	C	C	C
Straw	Agriculture	Kg/tonne	440[g]	4.7[g]	0.06[g]	1.6[k]	79[g]	9.5[k]	
Wood	Domestic	Kg/tonne	387[g]	4.17[g]	0.06[g]	0.7[k]	69.5[k]	7.1[k]	0.11[f]
Wood	Other industry	Kg/tonne	381[g]	0.41[g]	0.05[g]	2.06[k]	68.5[k]	0.39[k]	0.13[f]
Sewage Gas	Public Services	g/GJ Gross	27406[g]	5.0[g]	0.10[g]	239.8[bb]	7.1[f]	2.42[f]	27.57
Landfill Gas	Miscellaneous	g/GJ Gross	27406[g]	5.0[g]	0.10[g]	239.8[ba]	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: GrowHow (2011), Invista (2011), BP Chemicals (2011)
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 (now Ricardo-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
r	Ricardo-AEA 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, 2011)
w	Fynes *et al* (1994)
x	Passant (2004)
y	UKPIA (1989)
z	Emission factor derived from data supplied by UKPIA (2006 onwards)
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	Ricardo-AEA estimate based on data from Environment Agency (2012) and Corus (2012)
af	UKPIA (2004)
ag	Ricardo-AEA estimate based on data from Environment Agency (2012), UKPIA, DUKES, and other sources
ah	Carbon EF based on carbon content of waste
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	Ricardo-AEA estimate based on carbon factors review
ap	EMEP/CORINAIR
aq	Ricardo-AEA 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
au	Data supplied directly by the British Cement Association (BCA)

av UK Ship Emissions Inventory (Entec, 2010)
aw EEMS 2008 to 2011, DECC Oil and Gas
ax UKPIA, Pers. Comm., 2000
ay Loader *et al* (2008)
az As for domestic wood
ba Amec, (2011)
bb As for landfill gas
C Confidential
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.

A3.2.1 Energy Industries (1A1)

A3.2.1.1 Electricity Generation

Table A 3.2.6 Emission Factors for Power Stations in 2011

Source	Unit	CO_2[1,2]	CH_4	N_2O	NO_X	CO	NMVOC	SO_2
Coal	kt/Mt	609[s]	0.02[e]	0.063[l]	4.25[n]	0.69[n]	0.021[n]	3.93[n]
Petroleum Coke	kt/Mt	867[s]	0.107[n]	0.087[n]	2.98[n]	6.59[n]	0.020[n]	12.64[n]
Burning Oil	kt/Mt	859[a]	0.139[j]	0.0277[j]	2.54[n]	2.07[n]	0.041[n]	0.12[n]
Fuel Oil	kt/Mt	874[s]	0.130[h]	0.026[h]	12.22[n]	1.47[n]	0.107[n]	10.38[n]
Gas Oil	kt/Mt	870[a]	0.136[h]	0.0273[h]	8.14[n]	1.48[n]	0.098[n]	13.615[n]
Natural gas	g/GJ Gross	13815[s]	1.00[h]	0.10[h]	29.38[n]	13.11[n]	1.11[n]	0.43[n]
MSW	kt/Mt	94[t]	0.285[h]	0.038[h]	1.02[n]	0.065[n]	0.0045[n]	0.0289[n]
Poultry Litter	kt/Mt	265	0.284[h]	0.0379[h]	0.797[n]	0.365[n]	0.0412[n]	0.165[n]
Sewage Gas	g/GJ Gross	27406	1.00[h]	0.10[h]	239.81[u]	7.10[k]	2.42[k]	NE
Waste Oils	kt/Mt	864.8[b]	0.130[h]	0.026[h]	12.22[n]	1.47[n]	0.107[n]	10.377[n]
Landfill gas	g/GJ Gross	27406	1.00[h]	0.10[h]	239.81[u]	122.44[k]	2.42[k]	NE
Wood	kt/Mt	309	0.279[h]	0.0372[h]	1.43[n]	10.73[n]	0.169[n]	0.011[n]

[A time series of carbon emission factors can be found in the background energy tables on the accompanying CD, or in the Excel tables accompanying the report on the NAEI website]

Footnotes to **Energy Industries (**1A1)
A3.2.1.2 Electricity Generation

Table A 3.2.6 (Emission Factors for Power Stations)

1 Emission factor as mass carbon/ unit fuel consumption
2 Emissions of carbon from biomass combustion reported as a memo item
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, 2011), SEPA's Scottish Pollutant Release inventory (SEPA, 2011), NI DoE's Inventory of Sources and Releases list (NI DoE, 2011) and direct communications with plant operators (Pers. Comms., 2011)
o Environment Agency (2011)
p USEPA (1997)
q IPCC (2006)
r Based on Fynes, G. & Sage, P.W (1994)
s Based on EU ETS data
t Carbon EF based on carbon content of waste
u Amec (2011)
NE Not Estimated

A3.2.1 Reallocations of energy data and differences from UK energy statistics

The main source of energy consumption data used in the UK inventory is the Digest of UK Energy Statistics (DECC, 2012). This annual publication gives detailed sectoral energy consumption broken down by fuel type, and covering the entire time period covered by the inventory. In many cases, these data are used directly in the inventory without modification. However, there are instances where the activity data used in the inventory are not based directly on DUKES data, where alternative data sources provide supplementary data to inform energy use and emission estimates.

The detail of any modifications within the inventory energy sector estimates to DUKES data (e.g. additional detail to estimate fuel use in mobile and stationary appliances) or deviations from DUKES (e.g. where other evidence indicates that the DUKES fuel use data are incorrect) are discussed within the source category methodological descriptions in Section 3 of the main report.

The fuel reconciliation tables below present an overview of the inventory fuel data, showing how the use of energy data for the major fuels in the UK inventory are reconciled against the source data from DUKES.

In order to aid transparency of the UK inventory totals and fuel re-allocations across all source categories, these tables aim to provide a top-level summary of:

(i) where fuel re-allocations occur but the overall annual fuel consumption is kept consistent with the DUKES totals, and

(ii) where deviations from DUKES fuel use totals for a given fuel are made, and in which source categories these deviations are made.

The inventory agency presents data below for the 2011 fuel allocations for coal, natural gas, fuel oil, gas oil (including DERV) and petroleum gases (LPG, OPG). Together these fuels constitute around 82% of the UK inventory 1A sector emissions total in 2011.

A3.2.1.1 Coal

Total industrial coal use within the GHG inventory is consistent with the DUKES total. However, there is an apparent step change in the amount of fuel allocated to other industries within DUKES between 1999 and 2000. In addition, between 1997 and 1999, the total coal use allocated to 1A2f is less than the independent estimates for cement and lime production used within the inventory. Cement and lime production would fall into the 1A2f category for IPCC reporting. Therefore Inventory Agency estimates have been made to construct a consistent time series for coal use. In the most part, coal use is consistent with the DUKES data. The table below compares inventory estimates with DUKES estimates for 2011.

Table A 3.2.7 Fuel reconciliation - coal use in 2011 (Mtonnes)

DUKES Category	DUKES	GHGI	Difference	GHGI category	CRF	Comment
Major power producers	**40.566**	**40.566**	**0.000**	Power stations	1A1a	
Coke manufacture	**5.398**	**5.398**	**0.000**	Coke production	1B1b	
Blast furnaces	**0.995**	**0.995**	**0.000**	Blast furnaces	2C1	
Coal extraction	**0.004**	**0.004**	**0.000**	Collieries - combustion	1A1c	
		0.695		Autogenerators	1A2f	
		0.596		Autogenerators - exported to grid	1A2f	
Autogenerators	**1.291**	**1.291**	**0.000**			
Patent fuel manufacture etc.	**0.331**	**0.331**	**0.000**	Solid smokeless fuel production	1B1b	
Iron and steel	0.053	0.053		Iron & steel - combustion plant	1A2a	
Non-ferrous metals	0.040	0.040		Non-Ferrous Metal	1A2b	
Chemicals	0.360	0.360		Chemicals	1A2c	
Paper, printing etc	0.129	0.129		Pulp, Paper and Print	1A2d	
Food, beverages etc	0.070	0.070		Food & drink, tobacco	1A2e	
Other industry	1.375					

DUKES Category	DUKES	GHGI	Difference	GHGI category	CRF	Comment
		0.697		Other industrial combustion	1A2f	
		0.604		Cement production - combustion	1A2f	Operator's data
		0.073		Lime production - non decarbonising	1A2f	EU ETS
Industry total	**2.026**	**2.026**	**0.000**			
Rail	**0.015**	**0.015**	**0.000**	Rail	1A3c	
Domestic - anthracite	**0.215**	**0.215**	**0.000**	Domestic combustion - anthracite	1A4b	
		0.498		Domestic combustion - UK	1A4b	
		0.003		Domestic combustion - crown dependencies	1A4b	
Domestic - coal	**0.501**	**0.501**	**0.000**			
Agriculture	**0.001**	**0.001**	**0.000**	Agriculture - stationary combustion	1A4c	
Commercial	0.008					
Miscellaneous	0.007					
	0.015	**0.015**	**0.000**	Miscellaneous combustion	1A4a	
Public administration	**0.156**	**0.156**	**0.000**	Public sector combustion	1A4a	
TOTAL	**51.514**	**51.514**	**0.000**			

Notes: Shaded rows are grouped and should be considered together

A3.2.1.1.1 Natural Gas

Data for natural gas use is largely taken directly from DUKES. Operator estimates for ammonia production (both fuel and feedstock), and ETS data for gas separation plant lead to minor reallocations of the DUKES data, these are summarised below.

Table A 3.2.8 Fuel reconciliation – natural gas use in 2011 (Mtherms)

DUKES Category	DUKES	GHGI	Difference	GHGI Category	CRF	Comment
Major power producers	**9404**	**9404**	**0**	Power stations	1A1a	
		571		Autogenerators	1A2f	
		490		Autogenerators - exported to grid	1A2f	
		0		Railways - stationary combustion	1A4a	
Autogenerators	**1062**	**1062**	**0**			
		1274		Upstream oil production	1A1c	
		540		Upstream gas production	1A1c	
Oil and gas extraction	**1814**	**1814**	**0**			
Petroleum refineries	**200**	**200**	**0**	Refineries - combustion	1A1b	
Blast furnaces	**15**	**15**	**0**	Blast furnaces	1A2a	
		209		Gas production	1A1c	EU ETS
		0		Nuclear fuel production	1A1c	
Other energy industries	**67**	**209**	**-143**			EU ETS data higher than DUKES
Non-ferrous metals	99	99		Non-Ferrous Metal	1A2b	
Chemicals	1159					

DUKES Category	DUKES	GHGI	Difference	GHGI Category	CRF	Comment
		1159		Chemicals	1A2c	
		74		Ammonia production	1A2c	Operator's data
Paper, printing, etc	571	571		Pulp, Paper and Print	1A2d	
Food, beverages, etc	834	834		Food & drink, tobacco	1A2e	
Other industry	1844					
		1649		Other industrial combustion	1A2f	Reduced to offset increase in 1A1c, 1A2c and difference between DUKES and operators' non-energy use data
		47		Lime production		EU ETS
		3		Cement production		Operator's data
All industry except iron and steel	**4507**	**4436**	**71**			See 1A2f line
Iron and steel	**210**	**210**	**0**	Iron and steel - combustion plant	1A2a	
Domestic	**9997**	**9997**	**0**	Domestic combustion	1A4b	
Public administration	**1208**	**1208**	**0**	Public sector combustion	1A4a	
Commercial	1094					
Miscellaneous	496					
	1590	**1590**	**0**	Miscellaneous combustion	1A4a	
Agriculture	**62**	**62**	**0**	Agriculture - stationary	1A4c	
Non-energy use	**275**	**203**	**72**	Ammonia production - feedstock use of gas	2B2	Operator's data lower than DUKES
Total	**30409**	**30410**	**-1**			(rounding)

Notes: Shaded rows are grouped and should be considered together
1 Mtherm = 105.51 TJ

A3.2.1.1.2 Fuel Oil

Fuel oil data is largely taken directly from DUKES, with a small modification to account for additional fuel use in power stations over and above the DUKES estimates. In addition, the UK uses a different split between international and domestic shipping. These modifications are summarised below.

Table A 3.2.9 Fuel reconciliation – Fuel oils use in 2011 (Mtonnes)

DUKES Category	DUKES	GHGI	Difference	GHGI Category	CRF	Comment
Major power producers	0.255					
		0.287		Power Stations - UK	1A1a	EUETS data
		0.021		Power Stations - crown dependencies	1A1a	Local data sets
Autogenerators	0.119					
Coke manufacture	0.000					

DUKES Category	DUKES	GHGI	Difference	GHGI Category	CRF	Comment
Iron and steel	0.008	0.045		Iron and steel - combustion plant	1A2a	Includes estimate for autogenerators
Non-ferrous metals	0.008	0.008		Non-Ferrous Metal	1A2b	
Chemicals	0.037	0.037		Chemicals	1A2c	
Paper, printing etc	0.014	0.014		Pulp, Paper and Print	1A2d	
Food, beverages etc	0.025	0.025		Food & drink, tobacco	1A2e	
Other industry	0.084					
		0.114		Other industrial combustion	1A2f	Reduced to offset increase in 1A1a; includes autogenerators
		0.000		Cement production - combustion	1A2f	Operator's data
	0.551	**0.551**	**0.000**			
Blast furnaces	**0.000**	**0.000**	**0.000**	Blast furnaces	2C1	
Petroleum refineries	**0.660**	**0.660**	**0.000**	Refineries - combustion	1A1b	
Agriculture	**0.016**	**0.016**	**0.000**	Agriculture - stationary combustion	1A4c	
Domestic	**0.000**	**0.000**	**0.000**	Domestic combustion	1A4b	
Commercial	0.061					
Miscellaneous	0.021					
		0.077		Miscellaneous combustion - UK	1A4a	
		0.005		Miscellaneous combustion - crown dependencies	1A4a	Local data sets
	0.081	**0.081**	**0.000**			
Public administration	**0.068**	**0.068**	**0.000**	Public sector combustion	1A4a	
National navigation	0.695	0.088		Shipping - coastal	1A3d	Revised UK/international split
		0.009		Shipping between UK and Gibraltar	1A3d	Revised UK/international split
		0.001		Shipping between UK and other overseas territories	1A3d	Revised UK/international split
Marine bunkers	1.543	2.139		Shipping - international IPCC definition		Revised UK/international split
	2.238	**2.238**	**0.000**			
Total	**3.614**	**3.614**	**0.000**			

Notes: Shaded rows are grouped and should be considered together

A3.2.1.1.3 Gas Oil

The GHGI makes specific estimates for a number of sources including off road machinery, inland waterways, shipping, rail and power stations. The total gas oil use is normalised to the total fuel use in DUKES, modified for the inventory split between domestic and international shipping. These reallocations are set out below.

Table A 3.2.10 Fuel reconciliation – Gas oil use in 2011 (Mtonnes)

DUKES Category	DUKES	GHGI	Difference	GHGI Category	CRF	Comment
Refinery	**0.000**	**0.000**	**0.000**	Refineries	1A1b	
Major power producers	0.041					
		0.044		Power stations - UK	1A1a	EU ETS
		0.007		Power stations - CDs	1A1a	Local data sets
Autogenerators	0.016					
Iron and steel	0.000	0.002		Iron and steel	1A2a	Includes autogenerators
Non-ferrous metals	0.015	0.000		Non-Ferrous Metal	1A2b	Reduced to offset higher consumption elsewhere
Chemicals	0.080	0.002		Chemicals	1A2c	
Paper, printing etc	0.024	0.001		Pulp, Paper and Print	1A2d	
Food, beverages etc	0.168	0.006		Food, drink, tobacco	1A2e	
Other industry	1.555					
		0.044		Other industry UK	1A2f	Reduced to offset higher consumption elsewhere
		0.000		Other industry CDs	1A2f	Local data sets
		0.005		Cement production	1A2f	Operator's data
		0.138		Aircraft - support vehicles	1A3e	Bottom up model
		1.392		Industrial off-road	1A2fii	Bottom up model
Commercial	0.342					
Miscellaneous	0.218					
		0.014		Miscellaneous (CDs)	1A4a	
		0.015		Miscellaneous (UK)	1A4a	Reduced to offset higher consumption elsewhere
Public	0.273	0.011		Public sector	1A4a	
Agriculture	0.153					
		1.168		Agriculture - mobile	1A4c	Bottom up model
Rail	0.601					
		0.638		Railways	1A3c	Bottom up model
	3.488	**3.488**	**0.000**			
		0.038		Upstream gas	1A1c	
		0.489		Upstream oil	1A1c	
Oil & gas	**0.527**	**0.527**	**0.000**			
National navigation	0.810	0.342		Shipping - coastal	1A3d	Revised UK/int'l split
		0.037		Fishing vessels	1A4c	
		0.252		Shipping - naval	1A3d	From MoD
		0.099		Motorboats	1A3d	Bottom up model
		0.002		Inland goods-carrying vessels	1A3d	Bottom up model
Marine bunkers	0.753	0.832		Shipping - int'l IPCC definition		Revised UK/int'l split
	1.563	**1.563**	**0.000**			
		0.010		House and garden machinery - DERV	1A4b	Bottom up model

DUKES Category	DUKES	GHGI	Difference	GHGI Category	CRF	Comment
		0.281		Industrial off-road mobile machinery - DERV	1A2fii	Bottom up model
		0.002		Sailing boats with auxiliary engines	1A3d	Bottom up model
		0.093		Motorboats / workboats	1A3d	Bottom up model
		20.561		Road transport - UK	1A3b	Reduced to offset data for off-road and other sources
		0.044		Road transport - CDs	1A3b	Local data sets
Road	**20.991**	**20.991**	**0.000**			
		0.134		Domestic (UK)	1A4b	
		0.008		Domestic (CDs)	1A4b	Local data sets
Domestic	**0.142**	**0.142**	**0.000**			
Total	**26.710**	**26.711**	**0.000**			

Notes: Shaded rows are grouped and should be considered together

A3.2.1.1.4 Petroleum gases

For petroleum gases (LPG, OPG), a number of gaps in the UK energy statistics have been identified and as such, the total fuel use in the inventory is greater than the national statistics. These modifications to the energy balance are set out in the table below. They mostly relate to refineries, use of feedstock as fuel in the petrochemicals sector, and fuel use for offshore oil and gas production.

Table A 3.2.11 Fuel reconciliation – Use of petroleum gases in 2011 (Mtherms)

DUKES Sector	DUKES	GHGI	Difference	GHGI sector	CRF	Comment
Petroleum refineries, other gases	1078					
Autogenerators, other gases	165					
Heat generation, propane	3					
	1245	**1682**	-437	Refineries, OPG	1A1b	EU ETS higher than DUKES
Petroleum refineries, propane	**0**	**0**	0	Refineries, LPG	1A1b	
Industry, propane	202					
Industry, butane	174					
Agriculture, propane	47					
Agriculture, butane	0					
		422		Industrial combustion, LPG - UK	1A2f	
		1		Industrial combustion, LPG - crown dependencies	1A2f	
	423	**423**	0			
Industry, ethane & other gases	**0**	**575**	-575	Other industrial combustion, OPG	1A2f	EU ETS higher than DUKES
Road, propane	**46**	**46**	0	Road transport - all vehicles LPG use	1A3b	

DUKES Sector	DUKES	GHGI	Difference	GHGI sector	CRF	Comment
Domestic, propane	122					
Domestic, butane	12					
		124		Domestic combustion, LPG - UK	1A4b	
		10		Domestic combustion, LPG - crown dependencies	1A4b	
	134	**134**	0			
(excluded from DUKES)		**135**	-135	Gas separation plant, OPG	1A1c	EEMS. Outside scope of DUKES
(excluded from DUKES)		**7**	-7	Gas separation plant, LPG	1A1c	EEMS. Outside scope of DUKES
Total	**1848**	**3002**	**-1154**			LPG and OPG data from EEMS, EUETS

Notes: Shaded rows are grouped and should be considered together
1 Mtherm = 105.51 TJ

A3.2.2 Transport (1A3)

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

A3.2.3 Fugitive Emissions From fuels (1B)

A3.2.3.1 Solid Fuels (1B1)

A3.2.3.1.1 Coal Mining

The emission factors used are shown in **Table A 3.2.12**.

Table A 3.2.12 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	12.4[b]	1.16	-	0.34
2006	10.5[b]	1.16	-	0.34
2007	9.9[b]	1.16	-	0.34
2008	9.3[b]	1.16	-	0.34
2009	10.3[b]	1.16	-	0.34
2010	9.4 [b]	1.16	-	0.34

Year	Deep Mined	Coal Storage & Transport[a]	Licensed Mine[c]	Open Cast[c]
2011	8.7[b]	1.16	-	0.34

[a] Bennet *et al* (1995)
[b] Factor based on colliery operator data, predominantly from UK Coal and the UK Coal Authority
[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

A3.2.3.1.2 Solid Fuel Transformation

Emissions of non-CO_2 pollutants from SSF plant are estimated on the basis of total production of SSF. The emission factors used are given in **Table A 3.2.13** and are based on US EPA (2010) factors for coke ovens.

Table A 3.2.13 Emission Factors Used for Coke and Solid Smokeless Fuel Production

	Units	CH_4	CO	NO_x	SO_2	NMVOC
Coke	kt/Mt coke made	0.0802[a]	2.18[c]	-	2.58[c]	0.0274[e]
Coke	kt/Mt coal consumed	-	-	0.02[b]		-
SSF	kt/Mt SSF made	0.0802[a]	0.02[c]	0.0220[c]	-	0.0178[a]
SSF	kt/Mt coal consumed	-	-	-	3.20[d]	-

a EIPPCB, (2000)
b USEPA (2004)
c Factor for 2010 based on Environment Agency (2011)
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

A3.2.3.2 Oil and Natural Gas (1B2)

In the NAEI, upstream oil and gas emissions are estimated in the following categories each with its own methodology:

- Oil & Gas Production: Flaring
- Oil & Gas Production: Well testing
- Oil & Gas Production: Venting
- Oil & Gas Production: Process Emissions (including fugitive emissions)
- Offshore Oil Loading
- Onshore Oil Loading
- Oil Terminal Storage
- Oil and Gas Production: Fuel combustion (reported under 1A1c Other Energy Industries)
- Gas Separation Plant (Combustion) (reported under 1A1c Other Energy Industries)

The mapping of these sources to IPCC source categories is described in the main report **Section 3.3.2**. Activity data are reported in the CRF Background Table 1B2, however in many cases these data are not used to calculate the emissions, but are provided for comparison with other inventories.

A3.2.3.2.1 Oil & Gas Production: Flaring

The activity data and implied emission factors are given below in **Table 3.3.9 and Table 3.3.10**.

Table A 3.2.14 Oil Production Flaring: Activity Data & Implied Emission Factors

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
1990	2627	1.43	0.0091	0.0009	0.0058	0.0085	0.00004	0.00005
1991	2381	1.56	0.0095	0.0010	0.0064	0.0097	0.00005	0.00005
1992	2321	1.72	0.0098	0.0011	0.0068	0.0101	0.00005	0.00005
1993	2315	1.85	0.0090	0.0011	0.0071	0.0103	0.00005	0.00006
1994	3087	1.47	0.0067	0.0008	0.0056	0.0079	0.00004	0.00005
1995	2246	2.39	0.0100	0.0013	0.0073	0.0095	0.00014	0.00008
1996	2388	2.27	0.0097	0.0013	0.0069	0.0090	0.00013	0.00007
1997	1996	2.70	0.0104	0.0015	0.0073	0.0093	0.00013	0.00008
1998	2008	2.70	0.0104	0.0014	0.0070	0.0093	0.00014	0.00008
1999	1820	2.66	0.0107	0.0016	0.0068	0.0080	0.00028	0.00009
2000	1664	2.54	0.0115	0.0012	0.0066	0.0068	0.00019	0.00008
2001	1747	2.64	0.0101	0.0013	0.0068	0.0072	0.00021	0.00008
2002	1600	2.67	0.0100	0.0016	0.0068	0.0073	0.00016	0.00008
2003	1418	2.66	0.0103	0.0013	0.0068	0.0070	0.00017	0.00008
2004	1439	2.66	0.0099	0.0013	0.0067	0.0071	0.00022	0.00008
2005	1634	2.65	0.0096	0.0013	0.0067	0.0083	0.00016	0.00008
2006	1404	2.59	0.0100	0.0013	0.0068	0.0076	0.00014	0.00008
2007	1489	2.60	0.0098	0.0014	0.0067	0.0082	0.00012	0.00008
2008	1275	2.59	0.0089	0.0013	0.0062	0.0089	0.00028	0.00007
2009	1279	2.62	0.0092	0.0013	0.0066	0.0092	0.00017	0.00007
2010	1317	2.64	0.0097	0.0014	0.0060	0.0090	0.00033	0.00007
2011	1305	2.59	0.0094	0.0014	0.0065	0.0078	0.00031	0.00010

Main revisions since previous submission:

- From 2000 onwards, re-allocation (correction) of East Brae platform from Oil to Gas, hence lower AD and emissions than in previous submission for oil production flaring.
- 2002-5 revisions to site estimates to increase emissions, addressing under-reports at a number of sites (Anasuria, Magnus, MacCulloch).

Note that an estimate of NMVOC emissions from refinery flares is also reported in 1B2ci Venting and Flaring: Oil. This is based on estimates supplied by UKPIA (2012).

Table A 3.2.15 Gas Production Flaring: Activity Data & Implied Emission Factors

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
1990	111	1.43	0.0091	0.0009	0.0058	0.0085	0.00004	0.00005
1991	100	1.56	0.0095	0.0010	0.0064	0.0097	0.00005	0.00005
1992	98	1.72	0.0098	0.0011	0.0068	0.0101	0.00005	0.00005
1993	98	1.85	0.0090	0.0011	0.0071	0.0103	0.00005	0.00006
1994	130	1.47	0.0067	0.0008	0.0056	0.0079	0.00004	0.00005
1995	95	2.39	0.0100	0.0013	0.0073	0.0095	0.00014	0.00008
1996	101	2.27	0.0097	0.0013	0.0069	0.0090	0.00013	0.00007
1997	84	2.68	0.0177	0.0015	0.0073	0.0021	0.00013	0.00008
1998	84	2.68	0.0177	0.0014	0.0070	0.0021	0.00014	0.00008
1999	90	2.65	0.0123	0.0016	0.0085	0.0051	0.00028	0.00009
2000	283	2.24	0.0073	0.0010	0.0051	0.0030	0.00019	0.00006
2001	204	2.24	0.0056	0.0012	0.0051	0.0033	0.00021	0.00006
2002	154	2.32	0.0065	0.0011	0.0066	0.0043	0.00002	0.00008
2003	107	2.28	0.0078	0.0012	0.0065	0.0041	0.00002	0.00008
2004	149	2.29	0.0087	0.0012	0.0067	0.0033	0.00002	0.00008
2005	159	2.23	0.0073	0.0012	0.0066	0.0029	0.00002	0.00008
2006	156	2.18	0.0093	0.0012	0.0067	0.0030	0.00001	0.00008
2007	184	1.93	0.0072	0.0012	0.0066	0.0035	0.00001	0.00008
2008	161	2.03	0.0080	0.0013	0.0064	0.0038	0.00002	0.00008
2009	186	1.98	0.0083	0.0012	0.0066	0.0036	0.00001	0.00008
2010	194	2.12	0.0116	0.0019	0.0060	0.0027	0.00002	0.00031
2011	114	2.38	0.0130	0.0013	0.0057	0.0053	0.00003	0.00051

Main revisions since previous submission:

- Data revised for 1999-2004 to address reporting gaps for a number of sites (Armada, Scoter, Shearwater platform), e.g. where platforms had started production but not previously reported to EEMS.

A3.2.3.2.2 Oil & Gas Production: Fuel Combustion

This refers to the use of unrefined natural gas and gas oil on offshore platforms and onshore terminals as a fuel in heaters, boilers, turbines and reciprocating engines. Gas and gas oil combustion emission data for CO_2, SO_2, NO_x, CO, NMVOC, and CH_4 are taken from the EEMS dataset (DECC, 2012). Data from 1998-2011 are based on detailed operator returns, whilst 1990-1997 data are calculated using emission factors from 1998 and activity data derived based on DECC DUKES activity data (DECC, 2012) modified to address an under-report during 1990-2000 inclusive for gas use at a number of UK oil and gas terminals (Personal communication, DECC, 2012).

EEMS data provide activity data for gas use in mass terms, whilst the DECC time series of gas use in the upstream oil and gas sector is presented in energy terms. The EEMS data are available from 1998 onwards (1996, 1997 EEMS data appear to be incomplete and are therefore disregarded for this source), whilst the DECC DUKES data are available from 1990 onwards, but are incomplete prior to the introduction of a new reporting system in 2001.

The inventory agency used the average energy (DUKES):mass (EEMS) relationship during 2001-2005 inclusive to back-calculate an "adjusted" activity in energy terms for 1998-2000 inclusive. Compared to the reported data in DUKES, these were found to be higher by 8%, 16% and 18% respectively. It was assumed therefore that the 1990-1997 data were under-reported by around 14%, and a new time-series of activity data estimated on this basis.

Previous analysis for the 1990-1997 dataset was rendered obsolete by the identification of the gap in UK energy statistics, and hence the implied emission factors from 1998 have been used to generate the emission estimates from 1990 to 1997 inclusive, assuming the same oil:gas split in emissions as within the 1998 EEMS dataset.

The activity data and implied emission factors for natural gas use are given below in **Table A 3.2.16** and **Table A 3.2.17**. The implied emission factors for 1990-2011 are reported as tonne pollutant per Mtherm gas used.

Table A 3.2.16 Oil Production Own Gas Use: Activity Data & Implied Emission Factors

Year	Activity	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
2011	1274	5.85	1.9	16.0	6.3	0.09	0.33	0.46
2010	1472	5.77	1.8	15.7	6.0	0.08	1.01	0.38
2009	1476	5.86	2.2	17.6	6.4	0.14	0.34	0.42
2008	1468	6.05	2.0	18.8	6.4	0.12	0.72	0.40
2007	1575	5.93	2.2	17.2	6.3	0.13	0.16	0.40
2006	1780	5.85	1.8	16.9	5.9	0.10	0.24	0.42
2005	1745	5.78	1.8	17.9	6.1	0.16	0.17	0.44
2004	1842	5.79	2.1	17.3	6.0	0.17	0.19	0.44
2003	1815	6.11	2.2	17.8	6.3	0.14	0.25	0.47
2002	1867	6.30	2.3	18.8	6.3	0.14	0.25	0.49
2001	1786	5.93	2.4	14.5	6.3	0.18	0.16	0.46
2000	1828	5.90	2.4	14.8	6.3	0.18	0.16	0.48
1999	1847	6.04	2.3	14.0	6.2	0.17	0.20	0.44
1998	1809	6.13	2.3	16.0	6.3	0.16	0.34	0.47
1997	1696	6.13	2.3	16.0	6.3	0.16	0.34	0.47
1996	1626	6.13	2.3	16.0	6.3	0.16	0.34	0.47
1995	1433	6.13	2.3	16.0	6.3	0.16	0.34	0.47
1994	1404	6.13	2.3	16.0	6.3	0.16	0.34	0.47
1993	1183	6.13	2.3	16.0	6.3	0.16	0.34	0.47
1992	1120	6.13	2.3	16.0	6.3	0.16	0.34	0.47
1991	1053	6.13	2.3	16.0	6.3	0.16	0.34	0.47
1990	1013	6.13	2.3	16.0	6.3	0.16	0.34	0.47

Main revisions since previous submission:

- From 2000 onwards, re-allocation (correction) of East Brae platform from Oil to Gas, hence lower AD and emissions than in previous submission for oil production own gas use.
- Revision to activity data time series from 1990-2000 inclusive, to address under-report in UK energy statistics.

- Revision to method to use 2008 IEFs for all years 1990-1997, due to activity data gap rendering previous analysis obsolete.

Table A 3.2.17 Gas Production Own Gas Use: Activity Data & Implied Emission Factors

Year	Activity	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
2011	540	5.78	4.29	17.5	8.40	0.35	0.10	0.48
2010	613	5.71	5.34	16.2	6.94	0.41	0.07	0.44
2009	609	5.72	4.33	15.7	7.18	0.44	0.08	0.49
2008	624	5.89	3.74	15.0	8.01	0.34	0.07	0.47
2007	617	5.85	3.43	19.2	7.11	0.35	0.08	0.48
2006	583	5.76	3.74	17.9	6.51	0.39	0.01	0.49
2005	759	5.68	5.11	23.0	7.48	0.60	0.06	0.52
2004	812	5.67	4.58	21.8	7.18	0.52	0.05	0.51
2003	807	5.96	4.08	20.1	7.47	0.43	0.05	0.53
2002	841	6.40	4.69	22.8	7.60	0.51	0.04	0.75
2001	892	5.95	3.37	14.7	6.77	0.32	0.03	0.51
2000	807	6.07	2.73	15.7	6.57	0.21	0.03	0.50
1999	721	6.07	4.30	20.3	7.14	0.47	0.07	0.50
1998	613	6.17	3.83	18.7	7.11	0.39	0.10	0.56
1997	575	6.17	3.83	18.7	7.11	0.39	0.10	0.56
1996	551	6.17	3.83	18.7	7.11	0.39	0.10	0.56
1995	486	6.17	3.83	18.7	7.11	0.39	0.10	0.56
1994	476	6.17	3.83	18.7	7.11	0.39	0.10	0.56
1993	401	6.17	3.83	18.7	7.11	0.39	0.10	0.56
1992	380	6.17	3.83	18.7	7.11	0.39	0.10	0.56
1991	357	6.17	3.83	18.7	7.11	0.39	0.10	0.56
1990	344	6.17	3.83	18.7	7.11	0.39	0.10	0.56

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

- Oil & Gas Production, fuel combustion: natural gas;
- Gas separation plant: LPG; and
- Gas separation plant: OPG.

Emissions are reported under 1A1cii Other Energy Industries.

The activity data and implied emission factors for gas oil use are given below in **Table A 3.2.18 and Table A 3.2.19**. The implied emission factors for 1990-2011 are reported as kilotonne pollutant per megatonne gas oil 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 3.2.18 Oil Production, Gas Oil: Activity Data & Implied Emission Factors

Year	Activity	CO_2	CH_4	NO_x	CO	NMVOC	SO_2	N_2O
	Mt	Mt/Mt	kt/Mt	kt/Mt	kt/Mt	kt/Mt	kt/Mt	kt/Mt
2011	0.489	3.19	0.308	32.1	6.66	0.97	2.22	0.199
2010	0.463	3.19	0.130	32.2	6.49	0.95	2.38	0.172
2009	0.435	3.19	0.158	31.0	6.44	0.89	2.87	0.209
2008	0.451	3.19	0.157	31.0	6.71	0.92	2.68	0.190
2007	0.385	3.19	0.928	30.3	6.07	0.89	2.80	0.193
2006	0.412	3.19	0.146	27.7	5.06	0.77	3.42	0.214
2005	0.459	3.19	0.087	31.6	6.53	0.94	4.03	0.216
2004	0.432	3.19	0.080	29.7	5.69	0.84	4.28	0.217
2003	0.464	3.19	0.096	30.0	5.89	0.85	3.11	0.217
2002	0.509	3.19	0.087	33.0	6.48	0.92	2.99	0.214
2001	0.558	3.19	0.116	31.5	7.10	1.04	2.95	0.217
2000	0.513	3.19	0.105	34.4	7.85	1.38	3.10	0.219
1999	0.555	3.19	0.098	34.2	7.60	1.04	3.37	0.353
1998	0.506	3.19	0.098	34.2	7.60	1.04	3.37	0.353
1997	0.489	3.19	0.098	34.2	7.60	1.04	3.37	0.353
1996	0.495	3.19	0.098	34.2	7.60	1.04	3.37	0.353
1995	0.495	3.19	0.098	34.2	7.60	1.04	3.37	0.353
1994	0.482	3.19	0.098	34.2	7.60	1.04	3.37	0.353
1993	0.382	3.19	0.098	34.2	7.60	1.04	3.37	0.353
1992	0.359	3.19	0.098	34.2	7.60	1.04	3.37	0.353
1991	0.348	3.19	0.098	34.2	7.60	1.04	3.37	0.353
1990	0.349	3.19	0.098	34.2	7.60	1.04	3.37	0.353

Table A 3.2.19 Gas Production, Gas Oil: Activity Data & Implied Emission Factors

Year	Activity	CO_2	CH_4	NO_x	CO	NMVOC	SO_2	N_2O
	Mt	Mt/Mt	kt/Mt	kt/Mt	kt/Mt	kt/Mt	kt/Mt	kt/Mt
2011	0.0376	3.19	0.355	44.4	10.6	1.61	3.19	0.480
2010	0.0292	3.19	0.283	45.0	12.0	1.77	3.04	0.181
2009	0.0147	3.19	0.142	37.2	7.09	1.17	2.93	0.195
2008	0.0202	3.19	0.121	38.4	8.75	1.32	3.03	0.164
2007	0.0190	3.19	0.097	36.5	8.21	1.11	3.17	0.198
2006	0.0178	3.19	0.107	27.7	8.18	1.11	3.24	0.218
2005	0.0163	3.19	0.120	41.1	11.3	1.39	3.70	0.221
2004	0.0164	3.19	0.150	48.2	14.9	1.67	3.78	0.227
2003	0.0226	3.19	0.154	49.5	13.2	1.70	3.46	0.215
2002	0.0218	3.19	0.139	46.3	11.5	1.52	4.66	0.384
2001	0.0180	3.19	0.126	42.5	10.2	1.37	2.13	0.218
2000	0.0140	3.19	0.144	48.1	12.0	1.59	3.15	0.220
1999	0.0172	3.19	0.148	49.1	12.3	1.57	3.55	0.220
1998	0.0192	3.19	0.148	49.1	12.3	1.57	3.55	0.220
1997	0.0183	3.19	0.148	49.1	12.3	1.57	3.55	0.220
1996	0.0179	3.19	0.148	49.1	12.3	1.57	3.55	0.220
1995	0.0151	3.19	0.148	49.1	12.3	1.57	3.55	0.220
1994	0.0137	3.19	0.148	49.1	12.3	1.57	3.55	0.220
1993	0.0129	3.19	0.148	49.1	12.3	1.57	3.55	0.220
1992	0.0109	3.19	0.148	49.1	12.3	1.57	3.55	0.220
1991	0.0108	3.19	0.148	49.1	12.3	1.57	3.55	0.220
1990	0.0097	3.19	0.148	49.1	12.3	1.57	3.55	0.220

Emissions are reported under 1A1cii Other Energy Industries.

A3.2.3.2.3 Oil & Gas Production: Well Testing

The activity data and implied emission factors are given below in **Table A 3.2.20 and Table A 3.2.21**. Oil production well testing emissions are reported under 1B2ai, whilst gas production well testing emissions are reported under 1B2bi.

Table A 3.2.20 Oil Production Well Testing: Activity Data and Implied Emission Factors

Year	Activity	CO_2	CH_4	NO_x	CO	NMVOC	SO_2	N_2O
	ktonnes	kt/kt	t/kt	t/kt	t/kt	t/kt	t/kt	t/kt
2011	13.3	3.20	25.0	3.70	18.0	25.0	0.013	0.081
2010	10.3	3.20	25.0	3.70	18.0	25.0	0.013	0.081
2009	33.2	3.20	25.0	3.70	18.0	25.0	0.013	0.081
2008	9.5	3.20	25.0	3.70	18.0	25.0	0.013	0.080
2007	11.1	3.20	25.0	3.70	18.0	25.0	0.013	0.080
2006	12.6	3.20	25.0	3.70	18.0	25.0	0.012	0.080
2005	20.5	3.20	25.0	3.70	18.0	25.0	0.013	0.081
2004	13.2	3.20	25.0	3.70	18.0	25.0	0.013	0.081
2003	15.4	3.20	25.0	3.70	18.0	25.0	0.013	0.081
2002	29.2	3.20	25.0	3.70	18.0	25.0	0.013	0.081
2001	21.4	3.20	25.0	3.70	18.0	25.0	0.013	0.081
2000	27.5	3.20	25.0	3.70	18.0	25.0	0.013	0.081
1999	37.5	3.20	25.1	3.68	17.9	24.9	0.013	0.081
1998	111.5	3.19	24.2	3.63	17.7	22.9	0.013	0.081
1997	107.8	3.19	34.8	2.59	13.3	15.0	29.9	0.081
1996	107.2	3.19	36.9	2.74	14.1	15.8	31.6	0.085
1995	102.5	3.19	34.8	2.59	13.3	14.9	29.8	0.081
1994	282.5	3.19	11.2	17.9	10.4	6.09	14.2	0.029
1993	265.6	3.19	11.9	19.1	10.6	6.37	14.7	0.029
1992	248.7	3.19	14.0	20.4	10.9	6.68	15.2	0.029
1991	231.8	3.19	14.9	22.0	67.7	7.04	15.9	0.029
1990	234.4	3.19	15.7	22.0	11.2	6.73	15.9	0.029

Table A 3.2.21 Gas Production Well Testing: Activity Data and Implied Emission Factors

Year	Activity	CO_2	CH_4	NO_x	CO	NMVOC	SO_2	N_2O
	ktonnes	kt/kt	t/kt	t/kt	t/kt	t/kt	t/kt	t/kt
2011	12.1	2.80	45.0	1.20	6.7	5.0	0.012	0.080
2010	17.9	2.80	45.0	1.20	6.7	5.0	0.012	0.081
2009	22.9	2.80	45.0	1.20	6.7	5.0	0.013	0.080
2008	11.3	2.80	45.0	1.20	6.7	5.0	0.011	0.080
2007	13.2	2.80	45.0	1.20	6.7	5.0	0.011	0.080
2006	15.0	2.80	45.0	1.20	6.7	5.0	0.011	0.080
2005	19.7	2.80	45.0	1.20	6.7	5.0	0.013	0.081
2004	30.1	2.83	43.7	1.36	7.4	6.3	0.013	0.081
2003	29.7	2.83	43.6	1.38	7.5	6.4	0.013	0.081
2002	19.1	2.81	44.5	1.26	7.0	5.5	0.013	0.081
2001	14.0	2.88	41.2	1.67	8.8	8.8	0.013	0.081
2000	17.2	2.91	39.3	1.92	9.9	10.7	0.013	0.081

Year	Activity	CO_2	CH_4	NO_x	CO	NMVOC	SO_2	N_2O
	ktonnes	kt/kt	t/kt	t/kt	t/kt	t/kt	t/kt	t/kt
1999	32.9	2.80	45.0	1.20	6.7	5.0	0.013	0.081
1998	107.2	2.69	45.0	1.50	8.7	5.0	0.013	0.081
1997	103.7	2.69	34.8	2.59	13.3	15.0	29.9	0.081
1996	103.1	2.69	36.9	2.74	14.1	15.8	31.6	0.085
1995	98.6	2.69	34.8	2.59	13.3	14.9	29.8	0.081
1994	271.7	2.69	11.2	17.9	10.4	6.09	14.2	0.029
1993	255.5	2.69	11.9	19.1	10.6	6.37	14.7	0.029
1992	239.2	2.69	14.0	20.4	10.9	6.68	15.2	0.029
1991	223.0	2.69	14.9	22.0	67.7	7.04	15.9	0.029
1990	225.5	2.69	15.7	22.0	11.2	6.73	15.9	0.029

A3.2.3.2.4 Oil Loading Emissions

The activity data and implied emission factors are given in **Table A 3.2.22**.

Table A 3.2.22 Crude Oil Loading, Onshore and Offshore: Activity Data and Implied Emission Factors

Year	ONSHORE LOADING			OFFSHORE LOADING		
	Activity	CH_4	NMVOC	Activity	CH_4	NMVOC
	kt	t/kt	t/kt	kt	t/kt	t/kt
2011	29,014	0.016	0.30	8,697	0.104	1.12
2010	33,101	0.016	0.69	10,840	0.071	1.18
2009	32,161	0.017	0.75	11,938	0.080	1.41
2008	36,795	0.015	0.96	14,011	0.095	1.45
2007	60,291	0.012	0.67	20,401	0.106	1.60
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
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

A3.2.3.2.5 Leakage from the Gas Transmission and Distribution System

The calculation of the reported UK average gas composition is derived from the sum-product of the annual Local Distribution Zone (LDZ) compositional data and the estimated gas consumption through each of the LDZs, to provide an average gas composition for Great Britain which is then applied across the UK.

Table A 3.2.23 Methane, Carbon Dioxide and NMVOC Composition of Natural Gas

Year	CH_4 weight %	CO_2 weight %	NMVOC weight %
1990-96	84.3[1]	3.92[6]	8.9[1]
1997-99	77.1[2]	3.92[6]	14.7[2]
2000	77.6[2]	3.92[6]	14.7[2]
2001	76.3[2]	3.92[6]	14.8[3]
2002	77.3[2]	3.92[6]	15.0[3]
2003	77.4[2]	3.92[6]	15.2[3]
2004	77.6[5]	3.92[5]	15.3[5]
2005	78.1[5]	3.60[5]	15.2[5]
2006	78.6[5]	3.70[5]	14.9[5]
2007	78.3[5]	3.74[5]	14.8[5]
2008	79.0[5]	3.62[5]	14.4[5]
2009	79.2[5]	3.45[5]	14.7[5]
2010	79.9[5]	3.02[5]	14.4[5]
2011	80.5[5]	2.71[5]	14.2[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 (2012). The 2010 CO_2 factor was previously submitted as 3.01%, due to a rounding error.
6 Extrapolated back from the 2004 analysis by network operators

A3.3 INDUSTRIAL PROCESSES (CRF SECTOR 2)

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

A3.4 SOLVENT AND OTHER PRODUCT USE (CRF SECTOR 3)

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

A3.5 AGRICULTURE (CRF SECTOR 4)

A3.5.1 Enteric Fermentation (4A)

Table A 3.5.1 Livestock Population Data for 2011 by Animal Type[a]

Animal type	Number
Cattle:	
Dairy cows	1,813,998
Beef cows	1,674,748
Dairy heifers	413,782
Beef heifers	336,481
Dairy replacements >1 year	503,632
Beef all others >1 year	2,344,187
Dairy calves <1 year	510,266
Beef calves <1 year	2,336,345
Pigs:	
Sows	361,788
Gilts	145,201
Boars	16,464
Fattening & other pigs 80 - >110 kg	673,813
Fattening & other pigs 50-80 kg	960,014
Other pigs 20-50 kg	1,112,034
Pigs < 20 kg	1,171,317
Sheep:	
Breeding sheep	15,246,209
Other sheep	398,258
Lambs < 1 year	15,989,501
Goats	
Deer	32,618
Horses	312,915
Poultry:	
Growing pullets	9,244,749
Laying fowls	29,112,264
Breeding flock	10,252,531
Table chicken	102,461,001
Turkeys	3,940,455
Total other poultry	7,540,155

[a]Data includes England, Wales, Scotland and Northern Ireland

Table A 3.5.2 Trends in Livestock Numbers ('000s) 1990-2011

Year	Dairy cows	Other cattle	Pigs	Sheep	Poultry
1990	2,848	9,344	7,548	44,469	127,952
1991	2,771	9,232	7,695	44,166	140,947
1992	2,683	9,242	7,707	44,540	137,613
1993	2,668	9,183	7,853	44,436	144,171
1994	2,716	9,238	7,892	43,813	140,447
1995	2,603	9,254	7,627	43,304	142,267
1996	2,587	9,452	7,590	42,086	148,936
1997	2,478	9,154	8,072	42,823	179,460
1998	2,439	9,080	8,146	44,471	165,087
1999	2,440	8,983	7,284	44,656	165,157
2000	2,336	8,799	6,482	42,264	169,773
2001	2,251	8,351	5,845	36,716	179,880
2002	2,227	8,118	5,588	35,834	168,996
2003	2,191	8,317	5,046	35,812	178,818
2004	2,129	8,459	5,159	35,817	181,759
2005	2,060	8,380	4,862	35,416	173,909
2006	2,054	8,269	4,933	34,722	173,081
2007	1,954	8,350	4,834	33,946	167,667
2008	1,909	8,198	4,714	33,131	166,200
2009	1,857	8,169	4,724	32,038	159,288
2010	1,847	8,262	4,468	31,086	163,842
2011	1,814	8,119	4,441	31,634	162,551

Data derived as sum of totals for each Devolved Administration (i.e. England, Wales, Scotland and Northern Ireland), obtained from Devolved Administration statistical publications (June survey results)

Table A 3.5.3 Methane Emission Factors for Livestock Emissions for 2011

Animal type	Enteric methane[a] kg CH_4/head/year	Methane from manures[ab] kg CH_4/head/year
Cattle:		
Dairy cows[ef]	111.0[b]	31.8
Beef cows[f]	50.5[b]	2.5
Dairy heifers	48	7.7
Beef heifers	48	3.3
Dairy replacements >1 year	48	7.7
Beef all others >1 year	48	3.3
Dairy calves<1 year	32.8	0.7
Beef calves <1 year	32.8	0.5
Pigs:		
Sows	1.5	4.0
Gilts	1.5	4.0
Boars	1.5	4.0
Fattening & other pigs 80 - >110 kg	1.5	5.6
Fattening & other pigs 50-80 kg	1.5	5.6
Other pigs 20-50 kg	1.5	5.6
Pigs <20 kg	1.5	5.9
Sheep:		
Breeding sheep	8	0.19
Other sheep	8[d]	0.19[d]
Lambs < 1 year	2.2[cg]	0.05[cg]
Goats	5	0.12
Horses	18	1.4
Deer:		
Stags & hinds	10.4[c]	0.26[c]
Calves	5.2[c]	0.13[c]
Poultry:		
Growing pullets	NE	0.063
Laying fowls	NE	0.064
Breeding flock	NE	0.063
Table chicken	NE	0.082
Turkeys	NE	0.063
Total other poultry	NE	0.063

[a]IPCC (1997)all manure EF's are tier 2 (with the exception of deer)
[b]Emission factor for the year 2011 (with the exception of deer)
[c]Sneath et al. (1997)
[d]Factor quoted assumes animal lives for a year; emission calculation assumes animal lives for 6 months
[e]% time spent grazing revised from 43% to 45% for dairy cows and 54% to 65% for beef cows (linked to AWMS data)
[f]IPCC 2000 methodology
[g]Factor quoted assumes animal lives for 8.1 months

Table A 3.5.4 Dairy Cows Methane Emission Factors[a]

Year	Average weight of cow (kg)[b]	Average milk yield per dairy cow (litres per annum)[d]	Average fat content (%)	Enteric emission factor (kg CH_4/head/y)[c]	Manure emission factor (kg CH_4/head/y)
1990	572	5151	4.01	86.8	20.0
1991	571	5133	4.04	86.8	20.4
1992	585	5237	4.06	88.6	20.4
1993	585	5259	4.07	88.8	20.5
1994	580	5300	4.05	88.8	20.5
1995	583	5398	4.05	89.7	20.7
1996	599	5545	4.08	92.0	21.2
1997	600	5790	4.07	94.1	21.7
1998	604	5775	4.07	94.2	21.7
1999	608	5964	4.03	95.7	22.1
2000	612	5979	4.03	96.0	22.2
2001	617	6346	4.01	99.2	23.4
2002	621	6493	3.97	100.4	24.3
2003	625	6621	3.96	101.6	25.1
2004	629	6763	4.00	103.2	26.1
2005	633	6986	4.02	105.4	27.3
2006	641	6977	4.04	106.0	28.0
2007	652	6913	4.06	106.2	28.7
2008	644	6943	4.06	106.0	29.2
2009	643	7031	3.99	106.2	29.9
2010	653	7273	3.95	108.4	31.1
2011	646	7533	4.06	111.0	31.8

[a]In 2011, 46% of animals graze on good quality pasture, rest confined
Gestation period 281 days
Digestible energy 75% (Bruce Cottrill, ADAS, pers. comm.)
Methane conversion rate 6%
Ash content of manure 8%
[b]Values from carcase weight data from slaughter survey corrected by 1/0.48
[c]IPCC 2000 methodology
[d]Milk yield from http://www.defra.gov.uk/statistics/files/defra-stats-foodfarm-crosscutting-auk-auk2011-120709.pdf

Table A 3.5.5 Parameters used in the calculations of gross energy for dairy cows Tier 2 emission factors

Year	NE_m (Net energy for maintenance), MJ/d (eq. 4.1)	NE_{feed} (Energy to obtain food), MJ/d (eq 4.2a)	NE_l (Net energy for lactation), MJ/d (eq. 4.5a)	$NE_{pregnancy}$ (Net energy for pregnancy) MJ/d (eq. 4.8)	NE_{ma}/DE (Ratio available energy for maintenance in a diet to digestible energy consumed) (eq. 4.9)	NE_{ga}/DE (Ratio available energy for growth in a diet to digestible energy consumed) (eq. 4.10)	GE (Gross energy intake), MJ/d (eq. 4.11)
1990	39.17	3.00	43.38	3.92	0.54	0.35	220.59
1991	39.13	3.00	43.40	3.91	0.54	0.35	220.54
1992	39.84	3.06	44.39	3.98	0.54	0.35	225.04
1993	39.86	3.06	44.64	3.99	0.54	0.35	225.70
1994	39.61	3.04	44.87	3.96	0.54	0.35	225.56
1995	39.76	3.05	45.70	3.98	0.54	0.35	228.03
1996	40.54	3.11	47.12	4.05	0.54	0.35	233.80
1997	40.61	3.11	49.14	4.06	0.54	0.35	239.00
1998	40.82	3.13	49.02	4.08	0.54	0.35	239.27
1999	41.02	3.15	50.36	4.10	0.54	0.35	243.17
2000	41.22	3.16	50.49	4.12	0.54	0.35	244.07
2001	41.47	3.18	53.41	4.15	0.54	0.35	252.01
2002	41.67	3.20	54.40	4.17	0.54	0.35	255.03
2003	41.88	3.21	55.40	4.19	0.54	0.35	258.08
2004	42.08	3.23	56.88	4.21	0.54	0.35	262.33
2005	42.28	3.24	58.91	4.23	0.54	0.35	267.91
2006	42.69	3.27	58.99	4.27	0.54	0.35	269.29
2007	43.23	3.32	58.60	4.32	0.54	0.35	269.90
2008	42.84	3.29	58.85	4.28	0.54	0.35	269.40
2009	42.80	3.28	59.06	4.28	0.54	0.35	269.80
2010	43.29	3.32	60.77	4.33	0.54	0.35	275.43
2011	42.94	3.29	63.86	4.29	0.54	0.35	282.04

Feed digestibility was 75 % according to Bruce Cottrill, ADAS, *pers. comm.*

Table A 3.5.6 Parameters used in the calculation of the Methane Emission Factors[a] for beef cows and other cattle

	Equation[d]	Beef cows	Others>1	Others<1
Average weight of animal (kg)		500	400-500	180
Time spent grazing (%)		65	43-50[g]	46
NE_m (Net energy for maintenance), MJ/d	2000GPG Eq4.1	35.4	33.2	15.8
NE_a (Net energy for activity), MJ/d[e]	2000GPG Eq4.2a	3.94	0.00	0.00
NE_l (Net energy for lactation), MJ/d	2000GPG Eq4.5a	0.0	0.0	0.0
$NE_{pregnancy}$ (Net energy for pregnancy), MJ/d	2000GPG Eq4.8	3.54	2.70	0.00

	Equation[d]	Beef cows	Others>1	Others<1
NE_{ma}/DE (Ratio available energy for maintenance in a diet to digestible energy consumed)	2000GPG Eq4.9	0.51	0.51	0.51
NE_{ga}/DE (Ratio available energy for growth in a diet to digestible energy consumed)	2000GPG Eq4.10	0.31	0.31	0.31
GE (gross energy intake), MJ/d[b]	2000GPG Eq4.11	128.4	123.3	83.4[e]
Daily weight gain (kg day^{-1})		0	0.3	0.6
Enteric Emission Factor (kg CH_4/head/y)[f]		50.5[c]	48.0	32.8
Manure Emission Factor (kg CH_4/head/y)		2.5[a]	6.0	2.96

[a]Digestible energy 65%, Ash content of manure 8.0%, Methane producing capacity of manure 0.17 m3/kg VS
[b]Calculated following IPCC guidelines
[c]IPCC (1997) default (48 kg/head/y) replaced in 2008 inventory onwards by value calculated using Tier 2 methodology with constant animal weight values
[d]From IPCC 2000 GPG
[e]Based on 17% of NEm, grazing factor of 0.35 introduced to account for proportion of time spent grazing/housed
[f]Methane conversion rate is 6%
[g]Time spent grazing is 45% and 65% for dairy and beef cattle respectively

A3.5.2 Manure Management (4B)

A3.5.2.1 Methane emissions from animal manures

Table A 3.5.7 Methane conversion factors for Manure Management Systems in the UK

Manure Handling System	Methane Conversion Factor %[a]
Liquid	39
Daily spread	0.1
Solid storage and drylot	1
Pasture range and paddock	1
Poultry manure - with bedding	1.5
Poultry manure - without bedding	1.5

[a] IPCC (2000)

A3.5.2.2 Nitrous Oxide emissions from Animal Waste Management Systems

Table A 3.5.8 Nitrogen Excretion Factors, kg N hd^{-1} year^{-1} for livestock in the UK (1990-2011)[a]

Animal type	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Cattle:														
Dairy cows	97	100	106	110	112	113	115	117	117	117	117	118	121	121
Beef cows	79	79	79	79	79	79	79	79	79	79	79	79	79	79
Dairy heifers	67	67	67	67	67	67	67	67	67	67	67	67	67	67
Beef heifers	56	56	56	56	56	56	56	56	56	56	56	56	56	56
Dairy replacements >1 year	53	53	53	53	53	53	53	53	53	53	53	53	53	53
Beef all others >1 year	53	53	53	53	53	53	53	53	53	53	53	53	53	53
Dairy calves<1 year	38	38	38	38	38	38	38	38	38	38	38	38	38	38
Beef calves <1 year	38	38	38	38	38	38	38	38	38	38	38	38	38	38
Pigs:														
Sows	23.6	22.5	21.4	21.2	20.9	20.7	20.5	20.1	19.7	19.3	18.9	18.5	18.1	18.1
Gilts	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
Boars	28.8	27.4	26.1	25.8	25.5	25.3	25.0	24.5	23.9	23.4	22.9	22.3	21.8	21.8
Fattening & other pigs 80 - >110 kg	20.2	19.3	18.4	18.2	18.0	17.8	17.6	17.2	16.9	16.5	16.1	15.8	15.4	15.4
Fattening & other pigs 50-80 kg	17.5	16.7	15.9	15.7	15.5	15.4	15.2	14.9	14.6	14.3	13.9	13.6	13.3	13.3
Other pigs 20-50 kg	11.7	11.2	10.6	10.5	10.4	10.3	10.2	10.0	9.8	9.6	9.3	9.1	8.9	8.9
Pigs <20 kg	4.6	4.4	4.2	4.1	4.1	4.0	4.0	3.9	3.8	3.7	3.6	3.5	3.4	3.4
Sheep:														
Breeding sheep	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Other sheep	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Lambs < 1 year	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40

Animal type	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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
Deer:														
Stags	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Hinds & Calves	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Horses	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Poultry:														
Growing pullets	0.42	0.39	0.36	0.36	0.35	0.35	0.34	0.34	0.34	0.34	0.33	0.33	0.33	0.33
Laying fowls	0.89	0.85	0.81	0.80	0.80	0.79	0.78	0.77	0.75	0.74	0.72	0.71	0.70	0.70
Breeding flock	1.16	1.13	1.10	1.10	1.09	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.02
Table chicken	0.64	0.59	0.55	0.54	0.53	0.52	0.51	0.49	0.47	0.46	0.44	0.42	0.40	0.40
Turkeys	1.50	1.59	1.68	1.70	1.71	1.73	1.75	1.76	1.77	1.79	1.80	1.81	1.82	1.82
Total other poultry	1.30	1.41	1.52	1.54	1.56	1.58	1.60	1.62	1.64	1.66	1.67	1.69	1.71	1.71

[a]Cottrill and Smith (2006)

Table A 3.5.9 Distribution of Animal Waste Management Systems used for Different Animal types, 2011[a]

Animal Type	Liquid System	Daily Spread	Solid Storage and Dry Lot[b]	Pasture Range and Paddock	Poultry without bedding	Poultry with bedding	Inciner-ation
Cattle:							
Dairy cows	38.3	13.0	3.6	45.1	NA	NA	NA
Beef cows	4.7	14.2	15.7	65.4	NA	NA	NA
Dairy heifers	9.1	9.0	12.9	69.0	NA	NA	NA
Beef heifers	4.7	14.2	15.7	65.4	NA	NA	NA
Dairy replacements >1 year	9.1	9.0	12.9	69.0	NA	NA	NA
Beef all others >1 year	4.7	14.2	15.7	65.4	NA	NA	NA
Dairy calves<1 year	0.0	14.0	31.2	54.8	NA	NA	NA
Beef calves <1 year	0.0	14.0	31.2	54.8	NA	NA	NA
Pigs:							
Sows	16.8	17.1	24.2	42.0	NA	NA	NA
Gilts	16.8	17.1	24.2	42.0	NA	NA	NA
Boars	16.8	17.1	24.2	42.0	NA	NA	NA
Fattening & other pigs 80 - >110 kg	24.8	29.0	44.2	2.0	NA	NA	NA
Fattening & other pigs 50-80 kg	24.8	29.0	44.2	2.0	NA	NA	NA
Other pigs 20-50 kg	24.8	29.0	44.2	2.0	NA	NA	NA
Pigs <20 kg	26.3	23.1	29.7	21.0	NA	NA	NA
Sheep:							
Breeding sheep	0.0	0.0	4.2	95.8	NA	NA	NA
Other sheep	0.0	0.0	4.2	95.8	NA	NA	NA
Lambs < 1 year	0.0	0.0	4.2	95.8	NA	NA	NA
Goats	0.0	0.0	8.2	91.8	NA	NA	NA
Deer:							

Animal Type	Liquid System	Daily Spread	Solid Storage and Dry Lot[b]	Pasture Range and Paddock	Poultry without bedding	Poultry with bedding	Inciner-ation
Stags[c]	0.0	0.0	0.0	100.0	NA	NA	NA
Hinds & Calves[c]	0.0	0.0	24.9	75.1	NA	NA	NA
Horses	0.0	0.0	0.0	100.0	NA	NA	NA
Poultry:							
Growing pullets	NA	49.4	NA	1.2	0.0	49.4	0.0
Laying fowls	NA	45.6	NA	8.8	45.6	0.0	0.0
Breeding flock	NA	49.9	NA	0.2	0.0	49.9	0.0
Table chicken	NA	32.3	NA	0.9	0.0	32.3	34.5
Turkeys	NA	48.2	NA	3.6	0.0	48.2	0.0
Total other poultry	NA	49.0	NA	2.0	0.0	49.0	0.0

[a]Misselbrook et al., 2011
[b]Farmyard manure
[c]Sneath et al. (1997)

Table A 3.5.10 Nitrous Oxide Emission Factors for Animal Waste Handling Systems[a]

Waste Handling System	Emission Factor (EF_3), kg N_2O 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
Poultry manure - with bedding[c]	0.02
Poultry manure - without bedding[c]	0.005

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

A3.5.3 Agricultural Soils (4D)

A3.5.3.1 Inorganic Fertiliser

Table A 3.5.11 Areas of UK Crops and quantities of fertiliser applied for 2011[a]

Crop Type	Crop area, ha	Fertiliser, ktN
Winter wheat	1,969,383	379.8
Spring barley	611,079	61.7
Winter barley	358,676	51.0
Oats	108,604	10.4
Rye, triticale & mixed corn	27,454	1.1
Maize	164,430	7.9
Maincrop potatoes	146,123	23.2
Sugar beet	112,715	10.0
Oilseed rape	704,559	138.4
Peas (green)	33,528	0.0
Peas (dry)	29,900	0.1
Broad beans	997	0.0
Beans (human consumption)	5	0.0
Beans (animal consumption)	125,418	0.0
Rootcrops for stockfeed	33,225	2.7
Leafy forage crops	3,838	0.3
Other forage crops	21,184	0.9
Vegetable (brassicae)	3,097	0.5
Vegetables (other)	91,535	7.4
Soft fruit	9,723	0.3
Top fruit	23,665	1.0
Hops	0	0.0
Linseed	36,459	3.2
Other tillage	45,330	1.4
Grass under 5 years	1,277,840	118.4
Permanent grass	6,017,874	316.7

[a]Data includes England, Wales, Scotland and Northern Ireland

Table A 3.5.12 Trends in area grown ('000 ha) and N fertiliser applied (kg/ha) for the major UK crops, 1990-2011[a]

Year	Winter wheat		Spring barley		Winter barley		Maincrop potatoes		Oilseed rape		Grass leys (<5yrs)		Permanent grassland	
	'000 ha	kg/ha N	'000 ha	kg/ha N	'000 ha	kg/ha N	'000 ha	kg/ha N	'000 ha	kg/ha N	'000 ha	kg/ha N	'000 ha	kg/ha N
1990	2,014	182.9	635	90.1	882	139.8	177	182.3	390	225.5	1,721	157.5	5,531	107.9
1991	1,980	187.9	552	93.2	841	141.8	177	177.4	440	206.4	1,698	163.3	5,577	107.0
1992	2,066	187.9	515	93.2	784	141.8	181	177.7	421	206.3	1,680	163.0	5,506	106.7
1993	1,759	188.0	518	93.6	650	141.8	171	177.8	377	206.2	1,684	163.2	5,487	107.5
1994	1,811	187.9	483	93.5	628	141.8	165	177.1	404	206.1	1,577	163.2	5,555	108.9
1995	1,859	192.9	504	97.1	689	144.2	172	173.7	354	187.4	1,521	168.8	5,573	108.4
1996	1,977	187.3	518	94.0	749	139.6	177	179.0	357	189.8	1,513	159.1	5,539	104.7
1997	2,034	187.3	518	94.0	839	139.8	166	180.0	445	189.9	1,516	158.2	5,468	103.4
1998	2,045	181.7	484	91.0	769	135.5	164	186.3	506	192.4	1,417	149.7	5,551	101.7
1999	1,847	185.0	631	98.7	548	142.3	178	151.1	417	196.5	1,341	175.4	5,635	99.9
2000	2,086	188.2	539	106.1	589	146.4	166	153.6	332	190.0	1,340	143.2	5,547	91.9
2001	1,635	185.1	783	109.0	462	143.8	165	150.8	404	196.3	1,320	134.9	5,766	88.5
2002	1,996	192.9	555	108.1	546	153.5	158	161.4	357	202.0	1,357	137.2	5,698	81.5
2003	1,836	197.0	621	106.6	455	148.5	145	142.6	460	194.7	1,315	129.0	5,864	78.2
2004	1,990	196.6	587	103.5	420	145.6	148	163.1	498	197.3	1,361	117.0	5,799	73.4
2005	1,870	195.0	553	101.0	384	142.1	137	159.7	588	200.2	1,308	113.6	5,887	83.2
2006	1,836	191.7	494	100.3	388	136.9	140	140.1	568	191.3	1,252	103.9	6,146	67.1
2007	1,830	189.9	515	97.8	383	135.9	140	127.3	674	189.6	1,291	97.9	6,139	60.4
2008	2,080	177.9	616	94.1	416	134.9	144	152.8	598	189.7	1,256	94.5	6,210	49.1
2009	1,814	187.2	749	100.2	411	139.5	147	161.0	581	182.3	1,262	88.7	6,223	53.0
2010	1,939	193.1	539	98.0	383	142.8	138	134.1	642	196.5	1,232	100.2	6,066	57.5
2011	1,969	192.8	611	101.0	359	142.3	146	158.5	705	196.5	1,278	92.7	6,018	52.6

[a]Data includes England, Wales, Scotland and Northern Ireland

A3.5.3.2 Biological Fixation of Nitrogen by crops

Table A 3.5.13 Dry Mass Content and Residue Fraction of UK Crops for 2011

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	0.91a	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)
[c]Hops dry mass from Brewers Licensed Retail Association (1998)
[d]Field beans dry mass from PGRE (1998)

A3.5.3.3 Crop Residues

Table A 3.5.14 Production of UK Crops for 2011[a]

Crop Type	Crop production, kt
Broad Beans	11.9
Field Beans	418.8
Peas green for market	0.0
Peas green for processing	178.5
All peas harvested dry	49.2
Rye, mixed corn, triticale	121.1
Wheat	15,257
Oats	613.4
Barley	5,494
OSR	2,758
Linseed	71.0
Maize	5459
Sugar beet	8,504
Hops	0
Potatoes	6,416
Total roots & onions	1,177
Total brassicas	499.2
Total others	369.7
Phaseolus beans	15.2

[a]Data includes England, Wales, Scotland and Northern Ireland

A3.5.3.4 Histosols.

Total area 1500 km^2 (Brown et al., 2012, Table A.3.6.27).

A3.5.3.5 Grazing Animals.

See Tables A 3.5.1, 3.5.8, A 3.5.9 for activity data

A3.5.3.6 Organic Fertilizers.

See Tables A 3.5.1, 3.5.8, A 3.5.9 for activity data

A3.5.3.7 Application of sewage sludge to land

Table A 3.5.15 Nitrous oxide emissions from sewage sludge (kt N_2O/yr)[a]

Year	Application of sewage sludge to land (t DM/yr)	Direct N_2O	Indirect N_2O from atmospheric deposition	Indirect N_2O from leaching and runoff
1990	499,000	0.282	0.056	0.212
1995	548,000	0.310	0.062	0.233
2000	582,261	0.329	0.066	0.247
2001	837,476	0.474	0.095	0.355
2002	843,020	0.477	0.095	0.358
2003	1,180,700	0.668	0.134	0.501
2004	1,231,800	0.697	0.139	0.523
2005	1,260,420	0.713	0.143	0.535
2006	1,313,488	0.743	0.149	0.557
2007	1,295,260	0.733	0.147	0.550
2008	1,170,397	0.662	0.132	0.497
2009	1,143,456	0.647	0.129	0.485
2010	1,084,942	0.614	0.123	0.460
2011	1,166,906	0.660	0.132	0.495

[a]Data includes England, Wales, Scotland and Northern Ireland

A3.5.4 Field Burning of Agricultural Residues (4F)

Table A 3.5.16 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)

A3.6 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**.

A3.6.1 Carbon stock changes due to afforestation and forest management (5A)

A3.6.1.1 The carbon accounting model CFlow and forestry activity data

Carbon uptake by the forests planted since 1921 is calculated by a carbon accounting model, CFlow (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 are 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.

The estimates described here use the combined area of new private and state planting from 1921 to 2011 for England, Scotland, Wales and Northern Ireland sub-divided into conifers and broadleaves. The model is also used for forest in the Isle of Man and Guernsey (Crown Dependencies of the UK). Restocking is dealt with in the model through the second and subsequent rotations, which occur after clearfelling at the time of Maximum Area Increment (MAI). 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 have therefore been estimated by assuming all conifers in Great Britain followed the growth pattern of Yield Class 12 $m^3\ ha^{-1}\ a^{-1}$. In Northern Ireland Yield Class 14 $m^3\ ha^{-1}\ a^{-1}$ was used, based on the original assumptions by Cannell and Dewar (1995). Milne *et al*. (1998) 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) that gives a species breakdown 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 3.6.1 Afforestation rate and age distribution of conifers and broadleaves in the United Kingdom since 1921 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 latest National Forest Inventory will not be completed until 2014/15. 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 1,195,000 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 actively managed, but overall this category is assumed to be in carbon balance, either equilibrium or steady-cyclic. See the Forest land section in Chapter 7 for a discussion of this assumption.

Table A 3.6.1 Afforestation rate and age distribution of conifers and broadleaves in the United Kingdom since 1921

Period	Planting rate (kha a^{-1})			Age distribution	
	Conifers on all soil types	Conifers on organic soil	Broadleaves	Conifers	Broadleaves
1921-1930	5.43	0.54	2.44	1.2%	7.2%
1931-1940	7.46	0.79	2.13	2.2%	7.8%
1941-1950	7.43	0.97	2.22	5.3%	10.9%
1951-1960	21.66	3.27	3.09	13.9%	10.6%
1961-1970	30.08	5.54	2.55	19.8%	7.7%
1971-1980	31.38	6.91	1.14	19.5%	5.4%
1981-1990	22.31	5.28	2.19	16.8%	4.6%
1991	13.46	3.26	6.71	1.4%	1.0%
1992	11.56	2.74	6.48	1.4%	1.0%
1993	10.06	2.46	8.87	1.3%	1.2%
1994	7.39	1.83	11.16	1.1%	1.4%
1995	9.44	2.18	10.47	1.2%	1.2%
1996	7.42	1.77	8.93	1.1%	1.0%
1997	7.72	1.74	9.46	1.1%	1.1%
1998	6.98	1.49	9.67	1.1%	1.1%
1999	6.63	1.38	10.12	1.1%	1.1%
2000	6.53	1.31	10.91	1.1%	1.2%
2001	4.90	0.94	13.46	1.0%	1.4%
2002	3.89	0.73	10.03	0.9%	1.1%
2003	3.75	0.69	9.36	0.9%	1.0%
2004	2.92	0.54	8.88	0.9%	1.0%
2005	2.10	0.35	9.25	0.9%	1.1%
2006	1.14	0.19	7.12	0.8%	0.9%
2007	2.14	0.33	8.14	1.0%	1.0%
2008	0.86	0.14	6.11	0.9%	0.9%
2009	1.22	0.17	4.80	0.8%	0.8%
2010	0.54	0.07	4.60	0.7%	0.7%
2011	1.55	0.18	6.64	0.7%	0.9%

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.

The proportion of forest planting on mineral and organic soils was re-assessed in 2012, as part of the work to estimate N_2O emissions due to drainage on forest soils (Yamulki and Broadmeadow, 2012). This work is described below.

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 3.6.2.**

The parameters controlling the transfer of carbon into the litter pools and its subsequent decay are given in **Table A 3.6.2**. 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 3.6.2 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

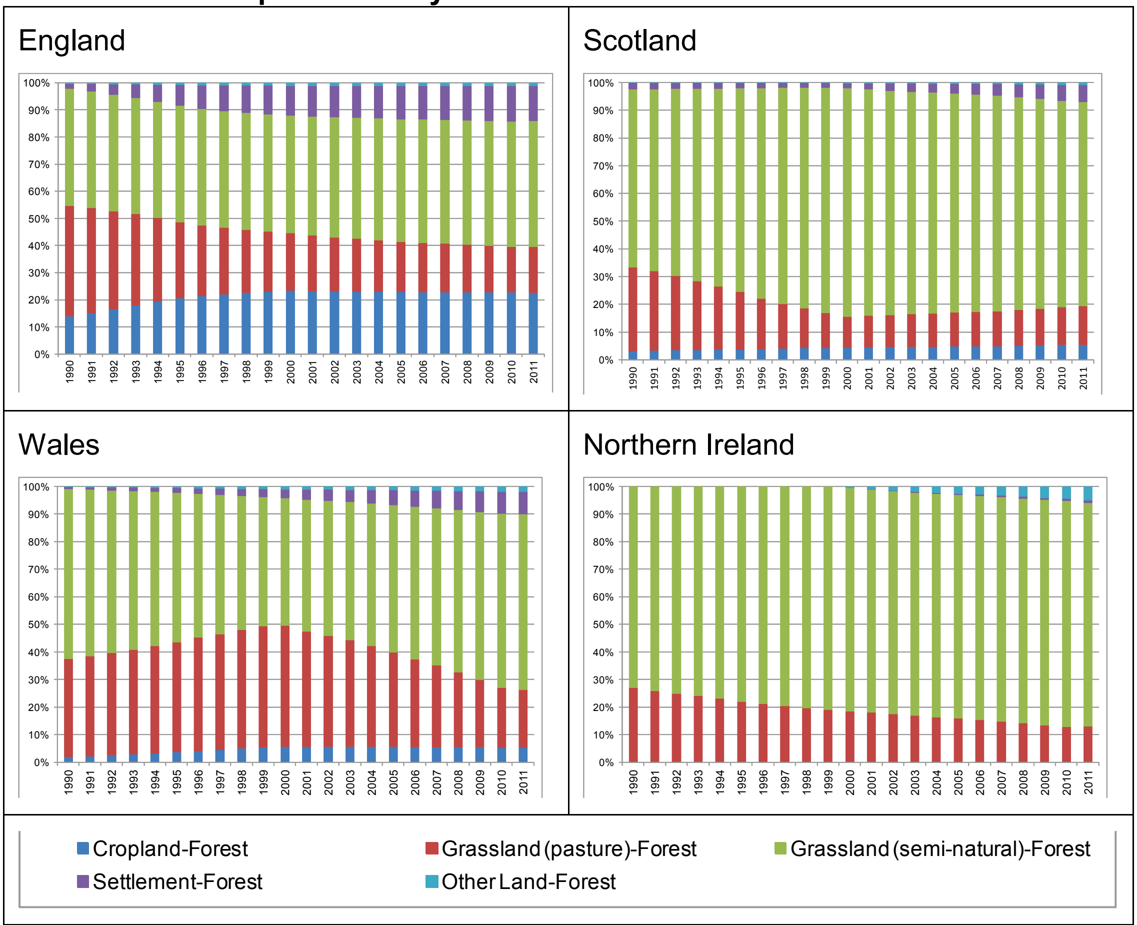
Estimates of carbon losses from the afforested soils are based on measurements taken at deep peat moorland locations, covering afforestation of peat from 1 to 9 years previously and at a 26 year old conifer forest (Hargreaves *et al*. 2003). These measurements suggest that long term losses from afforested peatlands settle 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.

The C-Flow model was originally spreadsheet-based but has been translated into Matlab (Mathworks 2010) scripts. This allows greater flexibility for further model development, integration with other parts of the LULUCF inventory and partitioning of results according to the required output (UNFCCC inventory, KP-LULUCF inventory, national/regional). The C-Flow model outputs were restructured in 2010 to use the IPCC default 20-year transition period for land converted to forest to move into the Forest remaining Forest category. The area within the Land converted to Forest Land sub-category is split between cropland, pasture grassland, semi-natural grassland, settlement and other areas. This split is based on the relative proportions of historical land use change from these categories to forest. The proportions for each country change over time because the 20-year transition period has a different start date for each inventory year (**Figure A 3.6.1**).

Figure A 3.6.1 Proportional land use contribution to forest conversion in the previous 20 years 1990-2011



The area and carbon stock changes in the Forest remaining Forest category are adjusted to take account of losses of forest converted to other land use categories, as these losses are not reflected in the statistics published by the Forestry Commission. Implied carbon stock changes per unit area are calculated using the unadjusted forest area and carbon stock changes. The forest area is then adjusted to reflect losses due to forest conversion and multiplied by the implied carbon stock change to obtain the adjusted carbon stock change.

It is assumed in the C-Flow model that harvested material from thinning and felling is made into wood products. This is described further in Section A3.6.11. The net change in the carbon in this pool of wood products is reported in Category 5G.

A3.6.1.2 Nitrogen fertilization of forest land

Nitrogen fertilization 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 C-Flow 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. The emission factor for N_2O of applied nitrogen fertiliser is the default value of 1% used in the IPCC 2006 Guidelines. Emissions of N_2O from N fertilisation of forests have fallen since 1990 due to reduced rates of new forest planting.

A3.6.1.3 New estimates of forest planting on organic soils and N_2O emissions from drainage on forest soils

This work was undertaken by Forest Research (Yamulki and Broadmeadow 2012), using new GIS data on forest planting in England, Wales and Scotland. Unfortunately, comparable data was not available for Northern Ireland.

The area of forest in each country was classified using GIS according to 1) forest canopy cover (i.e. high forest, young forest, felled, open areas within forest and water); 2) forest soil type (i.e. organic, organo-mineral, mineral); 3) forest soil nutrient status (i.e. nutrient poor and nutrient rich) and 4) forest soil drainage (i.e. drained and not-drained). The spatial datasets used for the analysis of forest area classification are shown in Table A.3.6.3.

Table A 3.6.3 Source data used for forest area classification

Soil Data		
Country	**Peatland map – name**	**Original data sources**
England	Peat_Natural_England_Oct08 Natural England, 2010	National Soil Map NSRI 2005 Biodiversity Action Plan - Priority Habitat Inventory mapping, Natural England 2008 BGS DiGMapGB-50 dataset Superficial Geology, British Geological Society
Wales	SHEP_BGS_HofW_FCSS Forest Research, Vanguelova et al., 2011	National Soils Map 2005 Habitats of Wales CCW BGS DiGMapGB-50 Superficial Geology Forestry Commission digitised soil mapping 2011
Scotland	JHI_Soils_Peat_Depth_250k	Scottish soil map (SSofS, 1984)

Soil Data		
Country	**Peatland map – name**	**Original data sources**
	Digitised mapping by Forestry Commission soil surveyors	Soil maps created priori to afforestation using the FC soil classification system
Forest Cover		
England, Scotland &Wales		National Forest Inventory woodlands map, Whitton, 2011

1- Forest area per country (England, Scotland and Wales) classified as high forest, young forest, felled, and open areas within forest.

The area of forest cover was determined using the interpreted forest type data in the National Forest Inventory (NFI) woodland map (Whitton 2011). The NFI woodland map categories were amalgamated to create four forest canopy classes plus open ground with forest. This data represents the best available spatial data of woodland cover and is based on ortho-rectified Ordnance Survey imagery obtained between 2000 and 2009 (2006 in Wales). Although the dates are not consistent between countries, the photographic images used to create the digital map were less than 3 years old. The map includes all woodland greater than 0.5 ha in size with, or with the potential to achieve, tree canopy density of >20%.

2- Stratification of forest area into mineral, shallow peaty soil (organo-mineral), deep peaty soil and water

A recently published JNCC report, contains an improved map of peat and peaty soils in the UK (JNCC 2011). This was used with the NFO woodland map to assess the soil type of afforested areas (Table A 3.6.4).

Table A 3.6.4 Area of forest soils, kha

Soil Type	Scotland	Wales	England
Mineral	794.795	220.747	1073.459
Shallow Peaty Soils/ Organo-mineral soils & Soils with peaty pockets *	237.074	57.579	123.370
Deep Peaty soils/ Peat	232.683	17.962	51.785
'Water' **	4.219	0.218	

*In England buried peat which outcrops occasionally has been mapped as the 'peaty pockets' soil type which typically are non peaty soils or shallow organic soils with significant pockets of deeper peat.

** Water area (high forest, young forest and felled); these are areas of forest which are located on land which is classed as water in the national soil map. The aerial photographs (NFI) show that there is woodland so it is obviously not water but we have no soils information for that land, the soils maps are crude and in Scotland in particular the inland water bodies and coast are rather roughly drawn.

3- Stratification of soil type by nutrient status

The classification of organic soils according to their nutrient status (Figure A 3.6.2, Table A 3.6.5) was based on the FC Ecological Site Classification (ESC) system (Pyatt et al., 2001). In ESC soil types are divided into six soil nutrient regime classes [very poor, poor, medium, rich, very rich and carbonate], in terms of the availability of N, P, K and pH. For this project nutrient-rich soils were taken to be those with a Soil Nutrient Regime (SNR) of Medium, Rich or Very Rich where as those with a SNR of Poor or Very Poor were classed as nutrient-poor soils. The soil type nutrient classification was applied to national soil maps (Soil Survey of Scotland and the Soil Survey of England & Wales) and the forest soil types of the FC soil classification.

Figure A 3.6.2 Nutrient status of organic soils

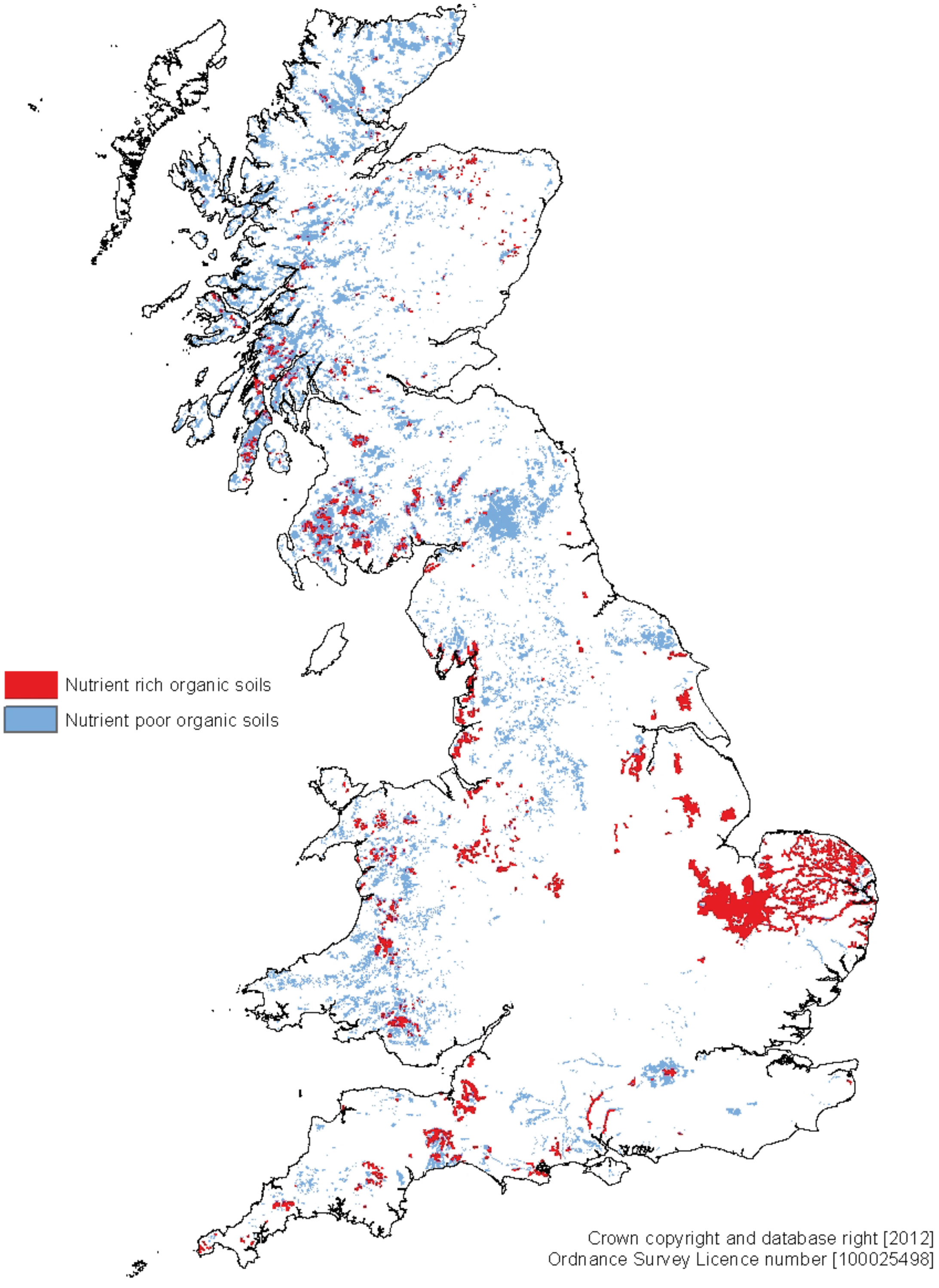


Table A 3.6.5 Areas (kha) of forest cover on mineral, organic nutrient rich and organic nutrient poor soils in Scotland, Wales and England.

Forest Cover	Scotland	Wales	England*
Mineral soils			
High Forest	679.597	198.341	1,009.369
Young trees	75.490	14.400	59.129
Felled	36.336	7,760	7.825
'Water'	2.564	0.184	
Organic (peat) nutrient-rich soils			
High Forest	9.221	4.382	15.818
Young trees	1.576	1.003	0.481
Felled	0.774	0.728	0.128
'Water'	0.079		
Organic (peat) nutrient-poor soils			
High Forest	186.346	9.249	28.259
Young trees	30.559	1.649	4.818
Felled	11.622	9.600	2.253
'Water'	0.579	0.002	
Peaty (organo-mineral) nutrient-rich soils			
High Forest		0.221	5.678
Young trees		0.051	0.144
Felled		0.046	0.065
'Water'		0.002	
Peaty (organo-mineral) nutrient-poor soils			
High Forest	190.379	44.930	98.802
Young trees	33.127	7.821	13.632
Felled	9.564	4.735	5.102
'Water'	0.976	0.029	

* For England the soil nutrient classification was based on NATMAP soil map only as the FC soil survey data was not available.

4- Stratification of mineral soils into free draining mineral soils (which were assumed to be not artificially drained) and imperfectly draining/impeded mineral soils (which were assumed to be artificially drained) based on the current guidance and policy for forest operations and management. We assumed all forest on organic soils is cultivated prior to planting and therefore effectively drained (Table A 3.6.6, Figure A 3.6.3).

The current policy is to carry out the minimum drainage necessary to remove excess water which may limit the growth and damaging the health and stability of tree crops. The purpose of the drains is to prevent water standing in plough furrows, to provide an outlet for water running off the site that controls run-off and minimises soil erosion. The guidance indicates that intensive drainage is often inappropriate and that very wet areas may be best left unplanted to form an open wetland habitat. Trees in very wet areas may become the centre of wind throw and the returns from drainage in terms of increased yield are modest and uncertain. In our analysis of forest drainage we assumed that the guidance was followed.

The mineral soils types described as requiring drainage (Forest Enterprise 1993) are the impeded and impervious soils:

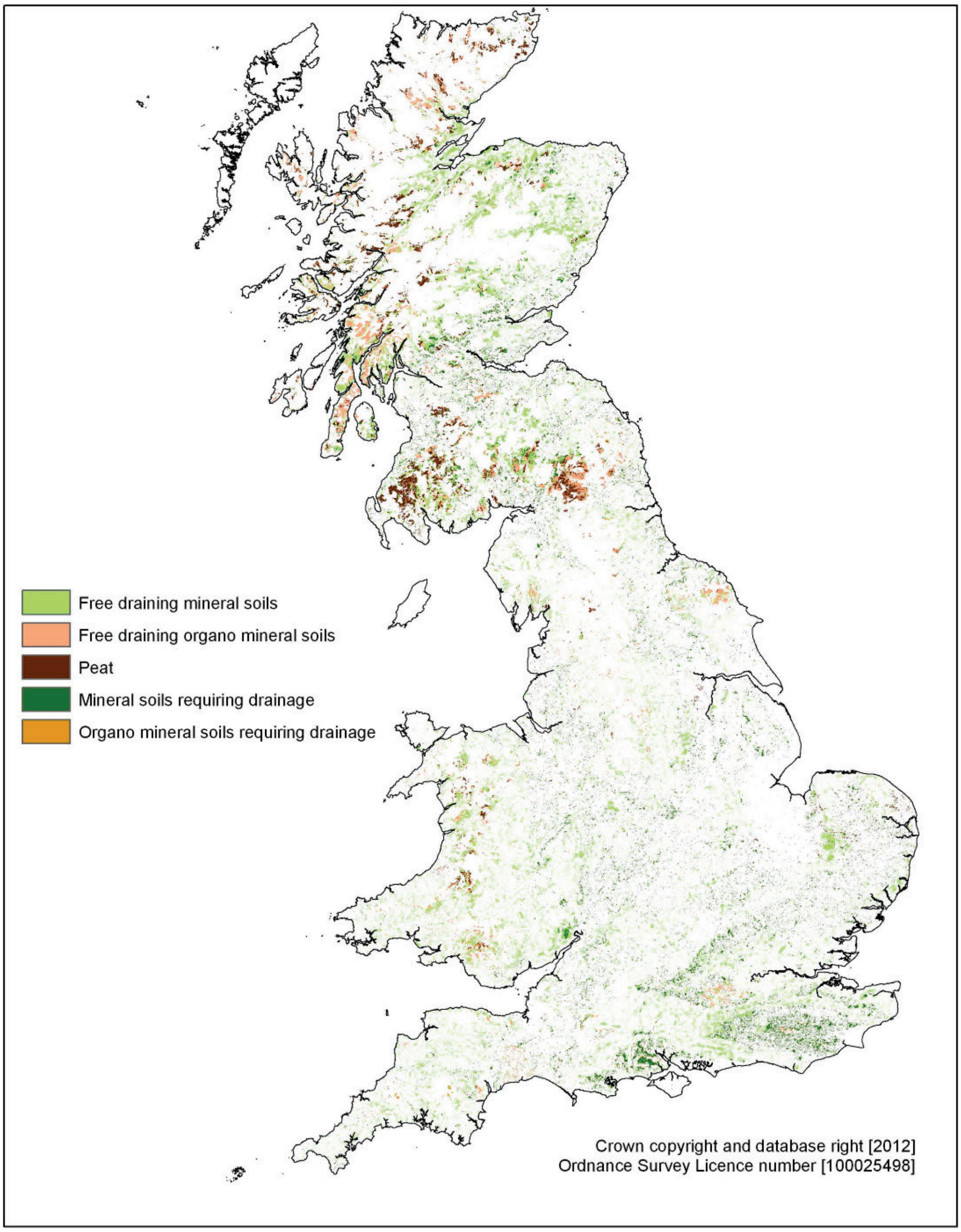
- **Impeded soils**
  - Man-made soils
  - Ironpan soils
  - Ironpan on induration
  - Indurated gley soils
- **Impervious soils**
  - Brown earths with slight gleying
  - Man-made soils (clayey)
  - Surface water gleys
  - Brown gley
  - Peaty gleys
  - Podzolic gleys
  - Groundwater gleys

Table A 3.6.6 Forest areas (kha) on mineral soils per country classified based on drainage status.

Forest type	Scotland	Wales	England
Free draining mineral soils (i.e. Not Drained)	544.063	191.991	676.082
High Forest	54.048	14.159	39.702
Young Trees	28.597	7.726	5.806
Felled		0.009	1.338
Open within Forest	2.564	0.184	
'Water'	626.708	213.876	721.590
Sum of forest area	544.063	191.991	676.082
Imperfectly draining/impeded mineral soils i.e. Drained			
High Forest	138.200	6.502	328.687
Young Trees	21.839	0.279	19.115
Felled	8.044	0.078	2.019
Open within Forest	0.004	0.003	0.710
'Water'			
Sum of forest area	168.083	6.859	349.821

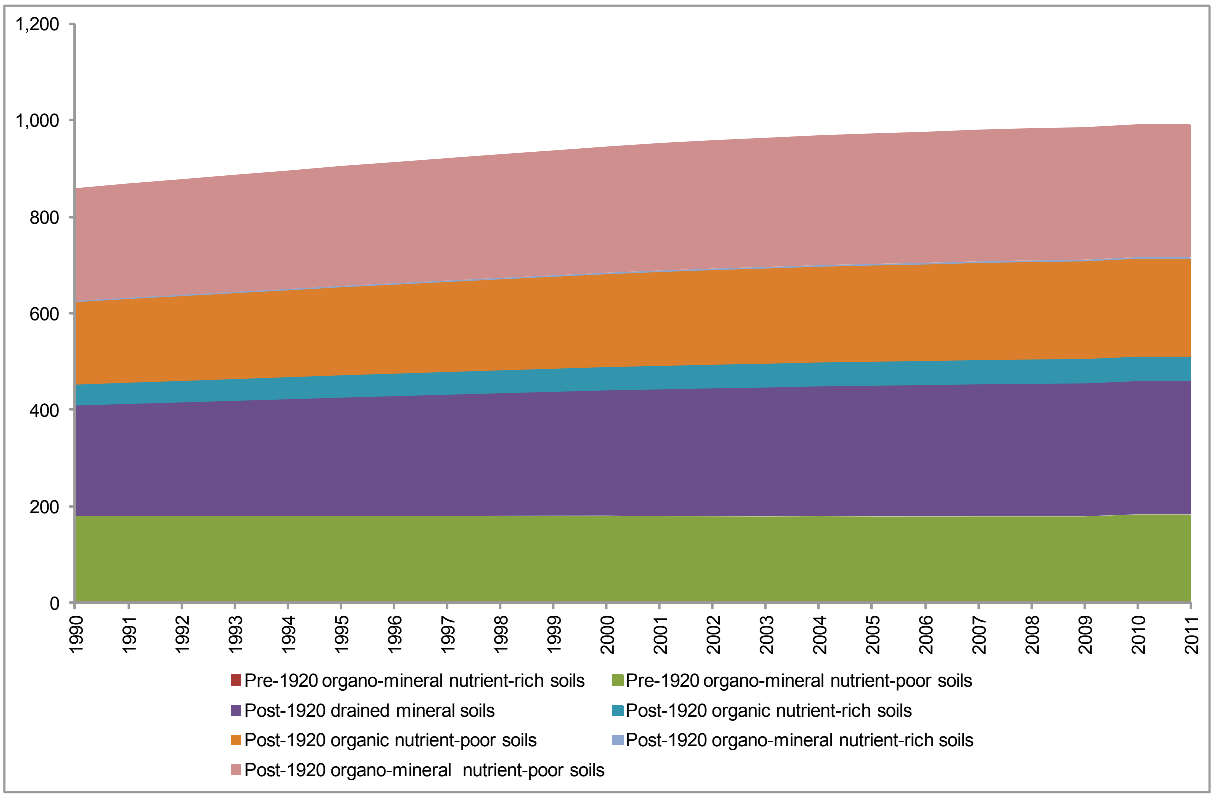
* We assumed that all forest areas on soils classed as 'Water' in the national soil map are on undrained mineral soils.

Figure A 3.6.3 Extent of forest drainage



For inventory reporting it was assumed that no forest planting occurred on organic soils or mineral soils requiring drainage before 1920. Forest areas (as reported in the CRF) were split between mineral/organo-mineral/organic soils and nutrient-rich/nutrient-poor status based on the work described above (Figure A.3.6.4). N_2O emissions were then estimated using the IPCC default emission factors for drained mineral, nutrient-rich organic and nutrient-poor organic soils (IPCC, 2003).

Figure A 3.6.4 Area of forest soils requiring drainage, 1990-2011



The total annual N_2O emissions for UK Mineral, Organo-mineral, Organic (peat) forest soils and felling (based on Morison et al. 2012) was equivalent to 1.85 kt N_2O yr^{-1} (1.18 kt N_2O-N yr^{-1}). N-deposition and N fertilisation is already included in the annual N_2O emission data for UK, so this value is slightly higher than the 1.72 kt N_2O yr^{-1} estimate based on the default IPCC EFs. Pending the availability of more detailed country-specific emission factors, the IPCC default EFs have been used to estimate N_2O emissions from drainage in the GHGI. Distinguishing between EFs for forest on nutrient rich and nutrient poor soils should have little effect on the inventory as the majority of forest land was classified as nutrient-poor soil; However, it will be important to derive accurate EFs for forest area on organic and organo-mineral soils as the current IPCC Tier 1 methodology does not distinguish between these categories due to lack of accurate EFs.

A3.6.2 Land Use Change and Soils (5B, 5C, 5E)

Changes in soil carbon due to land use change are modelled with a dynamic model of carbon stock change which is driven by matrices of change calculated from land surveys.

A3.6.2.1 Land Use Change Matrices

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, 1998 (Haines-Young *et al*. 2000) and 2007 (Smart *et al*. 2010) are used.

In Northern Ireland, matrices were calculated from the Northern Ireland Countryside Surveys of 1990, 1998 (Cooper and McCann 2002) and 2007 (Cooper, McCann and Rogers 2009). 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 estimated for 1970-79 and 1980-89 using area data. The relationship between the matrix of land use transitions and initial area from recent countryside surveys is assumed to be the same as the relationship between the matrix and area data for each of the 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 types of land for descriptive purposes: Forest, Grassland, Cropland, Settlements, Wetlands and Other Land. Only areas undergoing active commercial peat extraction and areas of inland water are reported under Wetlands in the current inventory, so the remaining land in the UK has been placed into the five other types. The more detailed habitats for the two surveys in Great Britain were combined as shown in Table A 3.6.7 for the Monitoring Landscape Change dataset and Table A 3.6.8 for the Countryside Survey dataset.

Table A 3.6.7 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 3.6.8 Grouping of Countryside Survey Broad Habitat types for soil carbon change modelling

CROPLAND	GRASSLAND	FORESTLAND	SETTLEMENTS (URBAN)	OTHER
Arable and horticulture	Improved grassland	Broadleaved, mixed and yew woodland	Built up areas and gardens	Inland rock
	Neutral grassland	Coniferous woodland	Unsurveyed urban land	Supra littoral rock
	Calcareous grassland		Boundary and linear features	Littoral rock
	Acid grassland			Standing open water and canals
	Bracken			Rivers and streams
	Dwarf shrub heath			Sea
	Fen, marsh, swamp			
	Bogs			

CROPLAND	GRASSLAND	FORESTLAND	SETTLEMENTS (URBAN)	OTHER
	Montane			
	Supra littoral sediment			
	Littoral sediment			

The area data used between 1947 and 2007 are shown in Table A 3.6.9 and Table A 3.6.10. 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. The full set of annual land use change matrices 1990-2001 is given in Table 7.1 in Chapter 7.

Table A 3.6.9 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
1999-2007	Measured LUC matrix	CS1998->CS2007
2008-2010	*Extrapolated*	CS1998->CS2007

Table A 3.6.10 Sources of land use change data in Northern Ireland for different periods in estimation of changes in soil carbon.

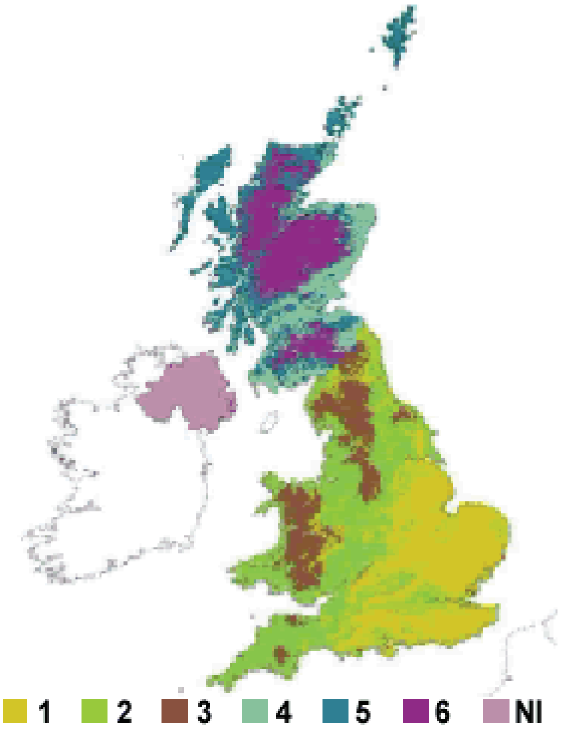
Year or Period	Method	Change matrix data
1950 – 1969	Extrapolation and ratio method	NICS1990->NICS1998
1970 – 1989	Land use areas and ratio method	NICS1990->NICS1998
1990 – 1998	Measured LUC matrix	NICS1990->NICS1998
1999-2007	Measured LUC matrix	NICS1998->NICS2007
2008-2010	*Extrapolated*	NICS1998->NICS2007

NICS = Northern Ireland Countryside Survey

The transitions between habitat types in the Countryside Surveys for the latest survey (2007) were calculated with Geographical Information System software (arcGIS). We identified 544 Countryside Survey squares of Great Britain that coincided between the 1998 and 2007 surveys. Survey square locations are confidential. For each coincident square, we calculated the area that changed from one habitat type in 1998 to another in 2007. There are 47 broad habitats described by the Countryside Survey. Individual surveyed squares contain a subset of these habitats and changes between habitats are called transitions. Each coincident survey square also has a 'land class' assigned to it that does not change between survey years. There are currently 45 land classes in the Land Classification of Great Britain. Land classes represent the stratification of environments across the UK. A simplified picture of the stratification is shown in Figure A.3.6.5.

Transitions between broad habitats were grouped by land class. The ratio of the total area of each land class to the total area sampled within each land class is calculated so that the transitions can be up-scaled to the land class areas. Transitions can then be extracted at various scales i.e. UK or Devolved Authorities scale or 20 km by 20 km squares. These scales are required by the soil carbon and non-forest biomass models.

Figure A 3.6.5 Stratification of environments across the UK with areas 1 to 6 based on the underlying Land Classification (45 classes).



1. Easterly lowlands (England/ Wales)
2. Westerly lowlands (England/ Wales)
3. Uplands (England/ Wales)
4. Lowlands (Scotland)
5. Intermediate uplands and islands (Scotland)
6. True uplands (Scotland)
7. Northern Ireland

A3.6.2.2 Soils modelling

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. **Error! Reference source not found.** shows total stock of soil carbon (1990) for different land types in the four devolved areas of the UK.

Table A 3.6.11 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, we calculate the change in equilibrium carbon density from the initial to the final land use during a transition. 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 land use data (1990 to 1998) is used in the weighting (this will be updated). The averages calculated are presented in Table A 3.6.12-15**.**

Table A 3.6.12 Weighted average change in equilibrium soil carbon density (t ha-1) 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 3.6.13 Weighted average change in equilibrium soil carbon density (t ha-1) 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 3.6.14 Weighted average change in equilibrium soil carbon density (t ha-1) 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 3.6.15 Weighted average change in equilibrium soil carbon density (t ha-1) 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 3.6.16). 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 3.6.16.

Table A 3.6.16 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 3.6.17)

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

Table A 3.6.17 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_0) 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.

For the 2011 inventory, the soil carbon model was run at 20x20km scale i.e. the carbon stock change in soils is calculated for a 20 x 20 km grid covering the UK. Previously, modelling has been carried out at national scales using land use change matrices, spatially disaggregated to England Scotland Wales and Northern Ireland. We are moving towards modelling at finer spatial scales and then summing to obtain carbon fluxes at Devolved Authority scales for the National Inventory.

A3.6.3 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 3.6.19. 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 (Table A 3.6.18 - 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 3.6.18 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 3.6.19 Weighted average change in equilibrium biomass carbon density (kg m-2) 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 3.6.20 Weighted average change in equilibrium biomass carbon density (kg m-2) 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 3.6.21 Weighted average change in equilibrium biomass carbon density (kg m-2) 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 3.6.22 Weighted average change in equilibrium biomass carbon density (kg m-2) 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

A3.6.4 Carbon stock changes and biomass burning emissions due to Deforestation (5B, 5C, 5E, 5G)

Deforestation is an activity that cuts across LULUCF categories, affecting net emissions and removals in all the land use categories except 5D Wetlands. The process of land use change affects carbon stock changes in biomass and soil, and the woody material left after felling either moves into the harvested wood products pool or is assumed to be burnt on-site, resulting in immediate biomass burning emissions.

Levy and Milne (2004) discuss methods for estimating deforestation since 1990 using a number of data sources. This approach of combining Forestry Commission felling licence data for rural areas with Ordnance Survey data for non-rural areas has been expanded to include new sources of information and to improve coverage of all countries in the UK. Deforestation before 1990 (which contributes to soil carbon stock changes from historical land use change) is estimated from the land use change matrices described in **A3.7.2**.

A3.6.4.1 Activity datasets

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 but sometimes by natural regeneration. 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. A felling licence is not required only under certain conditions (http://www.forestry.gov.uk/forestry/INFD-6DFKW6), e.g. if felling is allowed as part of planning permission (for building work) or for service maintenance (for gas, water, electricity). Most unconditional felling licence applications are for small areas (6.8 ±19.2 ha), but their summation gives some indication of areas deforested. In previous years these areas have not been published, but figures from the Forestry Commission were collated for England. Spatial datasets are now available (http://www.forestry.gov.uk/datadownload) for England (2000-present), Scotland (1999-present) and Wales (1996-present).

Felling for urban development (with no requirement to restock) can be allowed under planning permission but only local planning authorities hold documentation for this, 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 to the Department of Communities and Local Government (DCLG) (http://www.communities.gov.uk/planningandbuilding/planningbuilding/planningstatistics/landusechange/). DCLG provide an extract of this dataset, listing annual land use change from forestry and woodland to developed land uses (1990-2008 in the latest submission). This dataset comes 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 is applied to the data to smooth out the between-year variation appropriately, to give a suitable estimate with annual resolution.

The Countryside Survey land use change matrix (**section A3.7.2**) gives estimates of forest conversion to other land use categories for all countries in the UK for 1990-1998 and 1999-2007. There are known issues with Countryside Survey over-estimating the extent of woodland conversion compared with the extent estimated by the Forestry Commission. This is due to differences in woodland definitions, amongst other causes.

A3.6.4.2 Compilation of activity datasets

The deforestation activity dataset is compiled from the felling licence and DCLG datasets as far as possible, using Countryside Survey (CS) data to fill gaps in the time series, to estimate deforestation in Northern Ireland (for which no direct data is available) and to estimate the conversion to different land use categories[3]. The DCLG data is used to estimate the area of Forest Land converted to Settlement (5.E.2.1). The unconditional felling licence data is used to estimate the area of Forest Land converted to Cropland (5.B.2.1) and of Forest Land converted to Grassland (5.C.2.1). The split between the Cropland and Grassland categories is based on the proportional split between forest to grassland conversion and forest to cropland conversion in the most recent Countryside Surveys. Only England has any post-1990 forest to cropland conversion: the estimated areas in Scotland, Wales and Northern Ireland are so small that they are thought to be due to survey classification error than genuine land use change.

The CS data is used to estimate the relative split of woodland conversion between grassland, cropland and settlements (Table A 3.6.23), using other known data (e.g. felling licences) to 'discount' the CS areas where datasets overlap in time (Table A 3.6.24). There is no non-CS data for Northern Ireland so the discount rates for England or Wales are used, depending on availability. The 1990-98 discount rates are also applied to the pre-1990 CS land use change estimates. These changes in the method compared to previously have led to average increase of 0.27 kha a^{-1} (1990-2010) in the estimated area of deforestation in the UK, with a cumulative area of 26.3 kha in 2009 compared to an estimate of 20.9 kha in the 2009 inventory.

The annual area of forest converted to other land uses is removed from the area of 5A1 Forest Land remaining Forest Land to maintain consistency in the land area matrix.

[3] Discussion with Northern Ireland experts confirmed that there are no direct and comprehensive datasets on woodland loss available. 127 ha of deforestation between 2000 and 2006 is recorded in Environmental Impact Assessments but these do not cover all developments. A new Forestry Act has now introduced felling licences, so it may be possible to obtain direct data in the future.

Table A 3.6.23 Countryside Survey data for woodland conversion

	Countryside Survey land use change	Annual rate of change, kha/yr				Grassland/Cropland fractional split		
		England	Scotland	Wales	N Ireland	England	Scotland	Wales
1990-1998	Woods to Natural Grassland	5.600	4.418	1.099	0.171	0.61	0.86	0.72
	Woods to Pasture Grassland	3.081	0.608	0.418	0.086	0.33	0.14	0.28
	Woods to Cropland	0.545	0.097	0.019	0.008	0.06	0.00	0.00
	Woods to Settlements	1.242	0.293	0.132	0.072			
	Woods to Other Land	0.169	0.231	0.058	0.025			
1999-2007	Woods to Natural Grassland	2.656	10.327	0.120	0.209	0.86	0.98	0.42
	Woods to Pasture Grassland	0.277	0.186	0.162	0.102	0.09	0.02	0.58
	Woods to Cropland	0.141	0.006	0.001	0.001	0.05	0.00	0.00
	Woods to Settlements	0.617	0.098	0.095	0.142			
	Woods to Other Land	0.430	0.695	0.374	0.027			

Table A 3.6.24 "Discounted" woodland conversion rates

		"Discount" ratio			Estimated annual rate of change, kha/yr			
		England	Scotland	Wales	England	Scotland	Wales	N Ireland
1990-1998	Grassland & Cropland	2%[a]			0.159	0.088[c]	0.026[c]	0.005[c]
	Settlements & Other Land	28%[b]			0.390	0.145[c]	0.052[c]	0.027[c]
1999-2007	Grassland & Cropland	20%[a]	2%[a]	15%[a]	0.602	0.262	0.041	0.045[d]
	Settlements & Other Land	28%[b]			0.296	0.224[c]	0.133[c]	0.048[c]

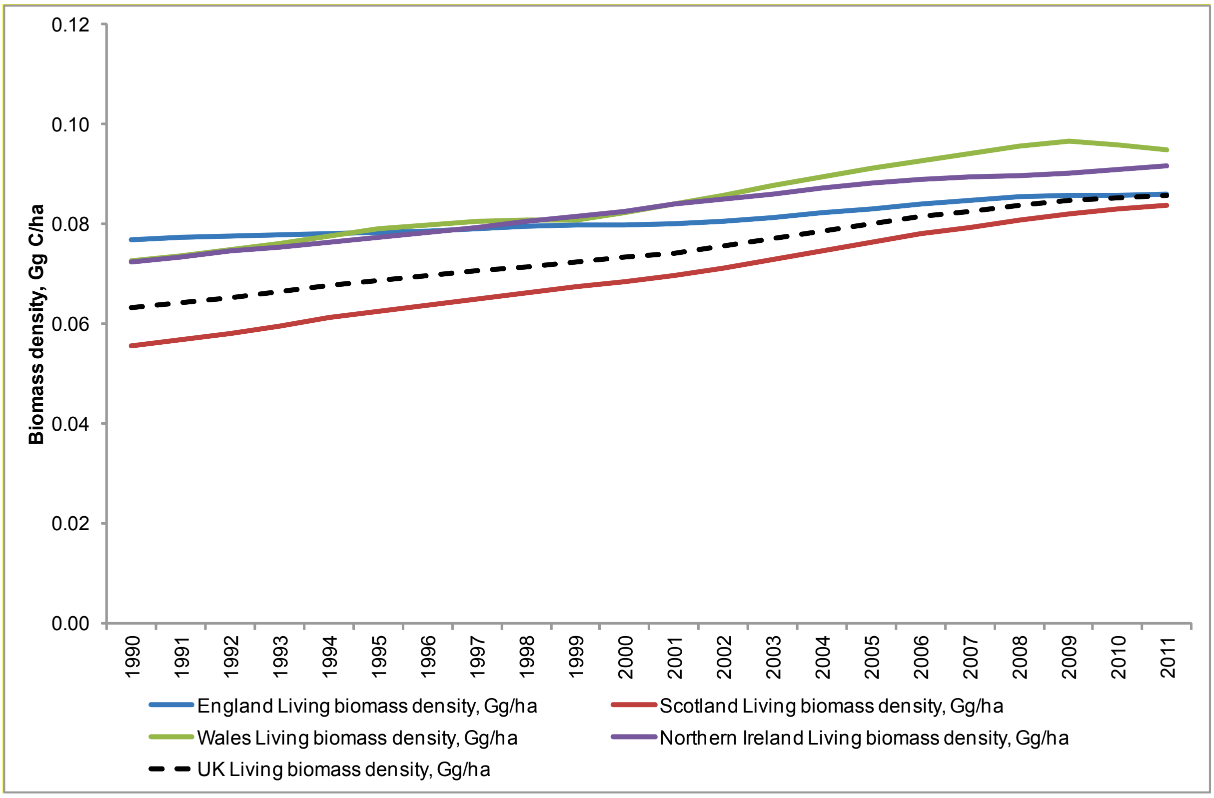
[a] Unconditional felling licence data used for "discounting"
[b] Land Use Change Statistics used for "discounting"
[c] England discount ratio used
[d] Wales discount ratio used

A3.6.4.3 Estimation of emissions

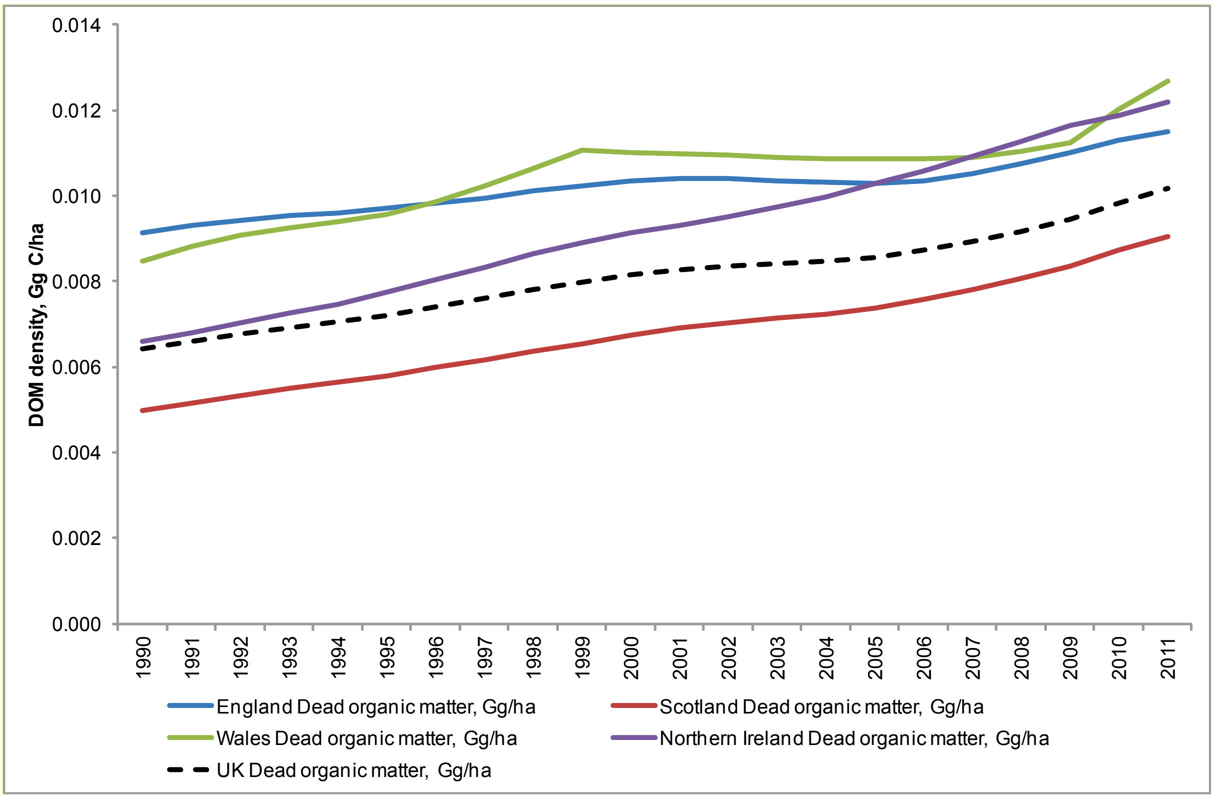
Soil carbon stock changes are estimated using the dynamic soil carbon model described in section A.3.7.2. When deforestation it is assumed that 60% of the standing biomass is removed as timber products and the remainder is burnt. Previously a standing biomass of 240 tonnes ha-1 (broadleaved timber) was assumed. This has now been replaced by country-specific forest biomass densities for living and dead organic matter (Figure A.3.6.6), which has resulted in lower estimates of the amount of biomass burnt. Biomass losses are reported in the relevant carbon stock change tables (assuming a carbon fraction of 0.5). The carbon removed as timber is reported as harvested wood products (HWP) in 5G, using a lookup table of HWP carbon flux in the years following felling (described in section A.3.7.10).

Direct and indirect greenhouse gas emissions from associated biomass burning is estimated using the Tier 1 methodology described in the IPCC 1996 guidelines (IPCC 1997 a, b, c). Only immediate losses are considered because sites are normally completely cleared for development, leaving no debris to decay.

Figure A 3.6.6 Country-specific biomass densities for biomass burning, 1990-2011



Country-specific living biomass densities



Country-specific dead organic matter (litter and dead wood) densities

A3.6.5 Biomass Burning – Forest and Non-Forest Wildfires (5A, 5B, 5C)

A3.6.5.1 Activity dataset

Non-forest wildfires are reported for the first time in the 1990-2011 inventory, and the time series for forest wildfires has been updated. This is because a new activity dataset has become available: the Fire and Rescue Service Incidence and Reporting Systems (IRS), covering England, Scotland and Wales. The IRS database contains 30 attributes for each fire to which a fire appliance was called, including date, spatial location, property type description (e.g. heathland and moorland, standing crop) and an estimate of the area burnt. This dataset is available from 1st April 2009. The original dataset had >126,000 fire records but 99% of these fires were less than 1 ha in size. A burnt area threshold of 25 hectares was used to extract a subset of the IRS database: this was estimated to capture 87% of the wildfire-burnt area in England, 93% in Scotland and 50% in Wales.

It was assumed that all fires in the IRS database were wildfires: even if they started as controlled burning, the need for a fire appliance call-out indicates that they are no longer under control. The IRS property type descriptions were assigned to LULUCF sub-categories (Table A 3.6.25). There is a very small area of wildfires that occur on Settlement types, and these are included in the Grassland category, as there is not a separate reporting filed in the CRF.

Table A 3.6.25 IRS database property type descriptions by LULUCF sub-category

LULUCF sub-category	Woodland	Cropland	Grassland	Settlement
IRS property type description	Woodland/forest - conifers/softwood	Straw/stubble burning	Heathland or moorland	Domestic garden (vegetation not equipment)
	Woodland/forest - broadleaf/hardwood	Stacked/baled crop	Grassland, pasture, grazing etc	Park
		Nurseries, market garden	Scrub land	Roadside vegetation
		Standing crop	Tree scrub	Railway trackside vegetation
				Wasteland
				Canal/riverbank vegetation

Thermal anomaly data for 2010 from the NASA-operated MODerate Resolution Imaging Spectroradiometer (MODIS) was obtained from the Fire Information for Resource Management System (FIRMS) for comparison with the IRS dataset. Thermal anomalies usually represent active fires, but may detect industrial heart sources, although these are typically masked out by the thermal anomaly processing chain. The IRS data set records 89 fires > 25ha occurring in 2010. The FIRMS data set records 335 fire detections for the same period, however, the FIRMS detections may contain multiple detections for a single fire event and the FIRMS detections are for a single 1km pixel, and do not have a straightforward conversion to burnt area. Searching the IRS and FIRMS data sets for temporally and spatially coincident events (using a 2km buffer around the IRS data) suggests that 22 fires were recorded by both the IRS and FIRMS systems. There are wide discrepancies between the two datasets, reflecting their different natures. The IRS data set records fires where a fire service response was required, so do not record controlled burning, unless the fire gets out of control. The FIRMS data set however, responds to anomalous heat signatures, so records controlled and uncontrolled fires, however, it is only able to detect fires under cloud-free or light cloud conditions. It is also only able to detect fires alight at the time of the satellite overpass. The FIRMS data is more likely to detect larger fires than smaller ones, probably due to the stronger heat signature and the longer burn time that larger fires tend to exhibit. Consequently, the IRS and FIRMS thermal anomalies give a very different perspective on the extent, timing and duration of fire events in the UK. However, the datasets did show correlation (R^2= 70-81%), which enabled an empirical relationship to be derived to extend the burnt area record back to 2001.

Figure A 3.6.7 Annual number of FIRMS thermal anomalies for GB for 2001-2011 (thermal anomalies were filtered to exclude those recorded over urban/industrial areas).

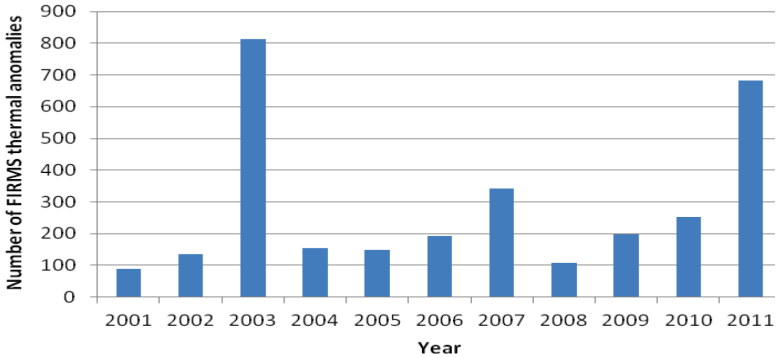


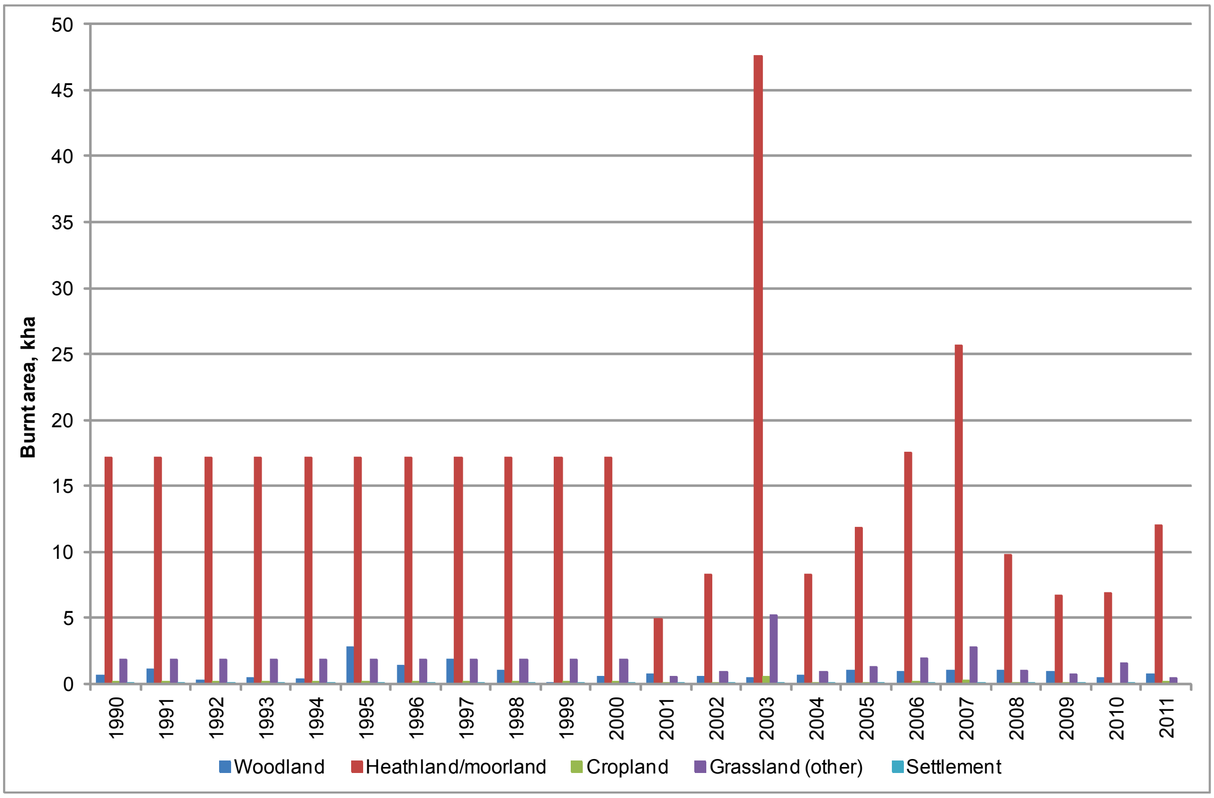
Figure A 3.6.7 shows the temporal pattern of FIRMS thermal anomalies, with peaks in hot dry years such as 2003. Applying equation 1 (correlation between IRS burnt area and FIRMS thermal anomalies) to the number of thermal anomalies produces the burnt area time series back to 2001.

Burnt area estimate (ha) = 71.587TA – 549.7 (Eq.1)

Where TA is the monthly number of FIRMS thermal anomalies. The equation was applied to the number of thermal anomalies for March – August for each year, only March –August were used as these are the months where the IRS database recorded fires greater than 25ha. FIRMS thermal anomalies are recorded for a wider range of months than the IRS fires > 25ha this will partly be due to FIRMS detecting both controlled burns and fires less than 25ha in size.

A time series of wildfire-burnt areas for each land use type was constructed for 1990-2011 (Figure A 3.6.8). For non-forest wildfires for England, Scotland and Wales the annual average burnt area 2001-2011 was used for 1990-2000, the estimated burnt area (using equation 1) was used for 2001-2009 and the IRS burnt areas were used for 2010-2011. In Northern Ireland, where no IRS data was available, it was assumed that the heathland and grassland burning rates were proportional to the Scottish burning rate, using the area of heathland and grassland from the Northern Ireland Countryside Survey (2007). Estimates of the forest 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). There is a gap in the time series 2005-2010 for Great Britain but areas of forest wildfires are reported annually for Northern Ireland. The gap was filled using the annual average areas burnt 1995-2005. These areas refer only to fire damage in state forests; no information is collected on fire damage in privately owned forests. 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.

Figure A 3.6.8 Time series of wildfire burnt areas in the UK 1990-2011



The IRS database is manually completed by fire service personnel and requires some subjective judgement by the people involved. This is likely to lead to non-systematic differences in the accuracy and precision of the data. The accuracy of the locations is variable, but an assessment of a number of the larger fires suggests that the land cover type attribute is reliable. The accuracy of the burnt area estimates could not be validated using aerial photography as the available imagery was not recent enough. Landsat images were used, however, it was still difficult to find cloud-free, pre- and post-fire images for fires in 2010. In addition Landsat & has been affected by image ‘striping’ since 2003, which affects the quality of the images and causes some data loss. There are issues with re-ignited fires or additional fires in the same area being logged in the database as separate events. Overall, the uncertainty associated with this dataset is high but should be re-assessed once a longer time series is available.

A3.6.5.2 Estimation of emissions

The IPCC Tier 1 method is used for estimating emissions of CO_2 and non-CO_2 gases from wildfires (IPCC 2006). The *Calluna* heath fuel biomass consumption factor and grassland emission factors are used for heathland and moorland fires, the agricultural residues EFs for cropland and the savanna and grassland EFS for other grassland and settlements. Country-specific biomass densities are used for estimating fuel consumption in forest fires (as discussed in the deforestation methodology section) and the ‘extra tropical forest’ EFs in the 2006 Guidelines. Emissions from all wildfires are reported under the ‘Land remaining Land’ categories (i.e. 5A1, 5B1 and 5C1) and IE reporting under 5A2, 5B2 and 5C2.

A3.6.6 Liming of Agricultural Soils (5B1, 5C1)

A3.6.6.1 Activity data

The amount of lime, dolomite and chalk produced for agricultural use annually in Great Britain is reported in the Annual Minerals Raised Inquiry (ONS 2010) (available from 1994). All such minerals are assumed to be used within Great Britain in the year of production. 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 2010) 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 LULUCF sector. The amount of lime purchased annually for agricultural use in Northern Ireland is reported in the Northern Ireland Statistical review (Department of Agriculture and Rural Development 2011). It is assumed that this is all limestone, as there are limestone deposits but no dolomite deposits in Northern Ireland.

In the UK lime is applied to both grassland and cropland. Totals areas of grassland and cropland are obtained from the annual agricultural census data (Defra 2011). The annual percentages of arable and grassland areas receiving lime in Great Britain for 1994-2010 were obtained from the Fertiliser Statistics Report (Agricultural Industries Confederation 2006), and the British Survey of Fertiliser Practice (BSFP 2011). Percentages for 1990-1993 were assumed to be equal to those for 1994. The latest statistics were not published in time for inclusion in the inventory so the 2010 figures were used for 2011.

A3.6.6.2 Estimation of emissions

The method for estimating CO_2 emissions due to the application of lime and related compounds is that described in the IPCC 1996 Guidelines. The percentages of grassland and cropland where agricultural lime is applied are used to split CO_2 emissions between the Cropland and Grassland categories. 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.

A3.6.7 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.3.6.26. 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 3.6.26 Area and carbon loss rates of UK fen wetland in 1990

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

The emissions trend since 1990 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). A current project is looking at extending this methodology to other parts of the UK if suitable activity data is available.

A3.6.8 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).

A3.6.9 Emissions of N_2O due to disturbance associated with land use conversion to Cropland

N_2O emissions due to disturbance associated with land use conversion to cropland are reported in Table 5(III). The Tier 1 methodology described in the IPCC 2006 Guidelines is used. The activity data are the areas and soil carbon stock changes reported in 5B2 Land converted to Cropland. Some C:N ratios for UK soil/vegetation combinations are published in the Countryside Survey (with values of 11.7 to 13.4) but only for the top 15cm of soil. However, the soil carbon stock changes reported in the inventory are from the top 1m of soil, so these C:N ratios were not felt to be applicable. Therefore, the IPCC default C:N ratio of 15 is used for estimating mineralised N. The emission factor of 1% in the 2006 Guidelines was used to estimate N_2O emissions from mineralised N.

A3.6.10 On-site and off-site emissions from peat extraction (5D)

On-site emissions of CO_2 and N_2O from peat extraction activities (for energy and horticultural use) and off-site emissions of CO_2 from the decomposition of horticultural peat are reported in category 5D.

A3.6.10.1 Activity datasets

Separate activity datasets have been compiled for Northern Ireland and for Great Britain (England, Scotland and Wales). Information for Northern Ireland is taken from papers by

Cruikshank and Tomlinson (1997) and Tomlinson (2010). These provide estimates of the extent of peat extraction in 1990-1991 and 2007-2008 by different methods (mechanical extraction, sod-cutting and hand-cutting) and by different end uses (fuel or horticultural peat) (Table A 3.6.27). Estimates for 1992-2006 were interpolated and the estimate for 2010 was assumed to be the same as that for 2008.

Table A 3.6.27 Activity data for peat extraction sites in Northern Ireland

End use	Method	Area in 1990-1991, ha	Area in 2007-2008, ha
Fuel	Mechanical	3855	329
Fuel	Hand-cutting	107	16
Horticultural	57% vacuum harvesting, 22% mechanical extraction, 18% sod cutting, 3% turfs	576	
Horticultural	95% vacuum harvesting, 5% mechanical extraction		689

For Great Britain areas undergoing peat extraction in 1991 were calculated using the GB area of peat with planning permission (7598 ha) and splitting it between the three countries in proportion to their production volume in 1991 (for both horticultural and fuel peat). Areas of extraction in 2002, 2005 and 2010 (Table A 3.6.28) were estimated using the Directory of Mines and Quarries point locations with Google Earth imagery (see **Chapter 7**, **Section 7.5.2**). Extraction sites were defined as any sites recorded as producing peat for horticultural or for energy use in the Directory of Mines and Quarries (Cameron *et al.* 2010): so any sites abandoned since 2002 (where a change of land use cannot be identified) are still estimated to be producing on-site emissions, in line with good practice guidance. A time series was constructed using linear interpolation. The extraction area (active and abandoned) declined between 1991 and 2009 by 18% in England and 60% on fuel sites in Scotland but increased by 16% on horticultural sites in Scotland. This area was assumed to be converted to Grassland. There is no reported peat production in Wales but five sites are recorded in the Directory of Mines and Quarries (the only site that is visible in the Google Earth imagery is very close to the English border and it is possible that any production from this site is reported in the England production totals). The area of these sites was used for the whole of the time period. A small area of land conversion to Wetland (<0.14 kha) was recorded (assumed to be all from Grassland).

Table A 3.6.28 Activity data for peat extraction sites in England, Scotland and Wales

Country	Area in 1991, ha	Area in 2002, ha	Area in 2005, ha	Area in 2010, ha
England	5854	4785	4785	4794
Scotland	1734	1471	1471	1585
Horticultural	*1174*	*1285*	*1285*	*1362*
Fuel	*560*	*186*	*186*	*223*
Wales	482	482	482	482

Annual production in Great Britain is inferred from extractor sales by volume as published in the "Annual Minerals Raised Inquiry" report (ONS 2010). This gives a breakdown for horticultural and other uses of peat (assumed to be fuel) for English regions and for Scotland (no peat extraction is reported in Wales) (Table A 3.6.29). Annual production is highly variable because extraction methods depend on suitable summer weather for drying peat.

Table A 3.6.29 Annual peat production, m3 for England and Scotland (from Annual Minerals Raised Inquiry/Mineral Extraction in Great Britain reports)

Year	England		Scotland	
	Horticultural	Fuel	Horticultural	Fuel
1990	1,116,940	2,727	293,170	93,163
1991	1,202,000	2,000	241,000	115,000
1992	1,079,000	4,000	332,000	91,000
1993	1,069,820	2,180	306,511	73,489
1994	1,375,000	1,000	498,000	108,000
1995	1,578,000	2,000	657,000	44,000
1996	1,313,000	2,000	517,000	53,000
1997	1,227,000	2,000	332,000	59,000
1998	936,000	0	107,000	32,000
1999	1,224,000	0	392,000	37,000
2000	1,258,000	1,000	336,000	31,000
2001	1,459,000	1,000	325,000	30,000
2002	856,000	1,000	107,000	10,000
2003	1,227,000	1,000	741,000	38,000
2004	902,000	1,000	338,000	21,000
2005	927,000	1,000	556,000	21,000
2006	856,000	1,000	712,000	24,000
2007	654,000	0	221,000	10,000
2008	455,000	0	243,000	16,630
2009	476,000	0	390,000	21,000
2010	456,000	1,000	527,000	21,000
2011*	456,000	1,000	527,000	21,000

* The latest statistics were not published in time for inclusion in this submission, so the volumes for 2011 were carried forward from 2010

A3.6.10.2 Estimation of emissions

Default on-site emission factors for Tier 1 reporting (IPCC 2006) are used to estimate emissions. Peat extracted for horticultural use is inferred to be from oligotrophic (nutrient-poor) bogs. Peat for fuel is inferred to be from mineratrophic (nutrient-rich) fens or bogs. On-site emissions of CO_2 and N_2O from drainage are reported.

A value of 0.0641 tonnes C m^{-3} is used for Great Britain to estimate emissions from extracted horticultural peat volumes based on previous work by Dinsmore (in review). This is higher than the previously used factor of 0.0557 (Cruikshank and Tomlinson 1997) but slightly lower than the default emission factor of 0.07 tonnes C m^{-3} air-dry peat for nutrient-poor peats.

Tomlinson (2010) gives production estimates of horticultural peat production for Northern Ireland for 1990/91 and 2007/2008. These have been interpolated to produce a time series. The total emission from horticultural peat production is the sum of emissions from vacuum harvesting production, sod extraction production and mechanical extraction production.

Emissions from vacuum harvesting production =
area * annual depth of extraction * carbon fraction by volume
where
Annual depth of extraction by vacuum harvesting, m/ha = 0.1
Carbon fraction of air-dry peat by volume, tonnes C/m3 air-dry peat = 0.0641

Emissions from sod extraction production =
area * sod extraction rate * % dry matter for sods * mean % C
where
Sod extraction rate, tonnes/ha/yr = 200

Sod extraction, mean % dry matter = 35%
Mean % carbon = 49%

Emissions from mechanical extraction production =
area * extraction rate * % dry matter for mechanical extraction * mean % C
where
The mechanical extraction rate was estimated to be 206.45 tonnes/ha in 1990/91 and 243.06 tonnes/ha in 2007/08 (Tomlinson 2010).
Mechanical extraction, mean % dry matter = 67%
Mean % carbon = 49%

A3.6.11 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 Cropland, 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.

A3.6.12 Methods for the Overseas Territories (OTs) and Crown Dependencies (CDs)

The OTs and CDs were contacted for any updates in datasets in 2011 to refresh the LULUCF estimates for this submission. This work builds on an MSc project to calculate LULUCF net emissions/removals for the OTs and CDs 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 (6 km^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 (Table A 3.6.30). 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 and Guernsey (using the C-Flow model also used for the UK).The assumptions and factors used for the estimation of emissions are given in Tables A.3.7.31 and A.3.7.32. The estimates have high uncertainty and may not capture all relevant activities.

Table A 3.6.30 Information sources for estimating LULUCF emissions from the Overseas Territories and Crown Dependencies

Territory	LULUCF category	Time period	Reference
Isle of Man	5A	1970-2011	Personal communication from Isle of Man Department of Agriculture, Fisheries and Forestry (Peter Williamson) FAO (2010) Global Forest Resources Assessment: Isle of Man
	5B, 5C	2002-2011	Isle of Man Agricultural and Horticultural Census: completed by all farmland occupiers on an annual basis
	5E	1991-1994	Isle of Man Ecological Habitat Survey, Phase 1 Report (Sayle et al, 1995)
Guernsey	5A	1990-2010	FAO (2010) Global Forest Resources Assessment: Guernsey
	5A, 5B, 5C, 5E	1998/9, 2005, 2010	Guernsey Habitat Survey Sustainable Guernsey 2005, 2009, Guernsey Facts and Figures 2011

Territory	LULUCF category	Time period	Reference
Jersey	5A	1990-2010	FAO (2010) Global Forest Resources Assessment: Jersey
	5A, 5B, 5C, 5E	2006, 2008-2011	Jersey In Figures 2008/2009/2010/2011
Falkland Islands	5A	1990-2011	Department of Mineral Resources, personal communication FAO (2010) Global Forest Resources Assessment: Falkland Islands
	5B, 5C	1991-2011	Falkland Islands Agricultural Statistics
	5E	1990-2005	Falkland Islands Environment and Planning Department, personal communication

Table A 3.6.31 Assumptions used in applying the Tier 1 methodology to the Overseas Territories and Crown Dependencies

Land Use category	Sub-category	Isle of Man	Guernsey	Jersey	Falkland Islands
Forest land fluxes	Living biomass	From C-Flow model	From C-Flow model	Assumed in equilibrium	No forest on Falklands
	Dead organic matter	From C-Flow model	From C-Flow model	Assumed in equilibrium	No forest on Falklands
	Mineral soils	From C-Flow model	From C-Flow model	Assumed in equilibrium	No forest on Falklands
	Organic soils	From C-Flow model	From C-Flow model	Assumed in equilibrium	No forest on Falklands
Crop remaining crop	Living biomass	N/A. Only for perennial crops	N/A. Only for perennial crops	N/A. Only for perennial crops	N/A. Only for perennial crops
	Dead organic matter	N/A	N/A	N/A	N/A
	Mineral soils	No change in SOC	No change in SOC	No change in SOC	N/A
	Organic soils	N/A	N/A	N/A	Default
	Liming	Default EF = 12% tC/t limestone applied. Average 0.15 t/ha lime applied to cropland and improved grassland	Default EF = 12% tC/t limestone applied, application rate 0.28 t/ha for cropland	Default EF = 12% tC/t limestone applied. Average 0.116 t/ha lime applied to cropland	No liming
Land converted to Crop	Living biomass	Use Wales values, grass to crop (-0.5 tC/ha)	Use England values, grass to crop (-0.5 tC/ha)	Use England values, grass to crop (-0.5 tC/ha)	Use Wales values, grass to crop (-0.5 tC/ha)

Land Use category	Sub-category	Isle of Man	Guernsey	Jersey	Falkland Islands
	Dead organic matter	N/A	N/A	N/A	N/A
	Mineral soils	Default . SOC = 95 tC/ha, assume conversion from natural grassland	Default . SOC = 95 tC/ha, assume conversion from natural grassland	Default . SOC = 95 tC/ha, assume conversion from natural grassland	N/A
	Organic soils	N/A	N/A	N/A	Default
	N_2O emissions	Default	Default	Default	N/A
Grass remaining grass	Living biomass	N/A	N/A	N/A	N/A
	Dead organic matter	N/A	N/A	N/A	N/A
	Mineral soils	No change in SOC	No change in SOC	No change in SOC	N/A
	Organic soils	N/A	N/A		Assume no soil C stock change
	Liming	Default EF = 12% tC/t limestone applied	Default EF = 12% tC/t limestone applied, application rate 0.28 t/ha for improved grassland	Not applied	No liming
Land converted to grass	Living biomass	Use Wales values, crop to pasture grass (-0.5 tC/ha)	Use England values, settlement to pasture grass (-1.8 tC/ha)	Use England values, crop to pasture grass (-0.5 tC/ha)	Use Wales values, crop to pasture grass (-0.5 tC/ha)
	Dead organic matter	N/A	N/A	N/A	N/A
	Mineral soils	Default . SOC = 95 tC/ha, assume conversion from cropland, no change due to change from other land	Default . SOC = 95 tC/ha, assume conversion from settlement, assume same soil C as for cropland	Default . SOC = 95 tC/ha, assume conversion from cropland, no change due to change from other land	N/A
	Organic soils	N/A	N/A	N/A	Default
Settlements remaining Settlements	Living biomass	N/A	N/A	N/A	N/A
	Dead organic matter	N/A	N/A	N/A	N/A
	Mineral soils	N/A	N/A	N/A	N/A

Land Use category	Sub-category	Isle of Man	Guernsey	Jersey	Falkland Islands
	Organic soils	N/A	N/A	N/A	N/A
Land converted to Settlements	Living biomass	Use Wales values, grass to settlement (-0.8 tC/ha)	Use England values, grass to settlement (-0.8 tC/ha)	Use England values, grass to settlement (-0.8 tC/ha)	Use Wales values, grass to settlement (-0.8 tC/ha)
	Dead organic matter	N/A	N/A	N/A	N/A
	Mineral soils	Default . SOC = 95 tC/ha, assume conversion from grassland and all soil C lost	N/A	Default . SOC = 95 tC/ha, assume conversion from grassland and all soil C lost	N/A
	Organic soils	N/A	N/A	N/A	Default - assume cropland
Other land remaining other land	Living biomass	N/A	N/A	N/A	N/A
	Dead organic matter	N/A	N/A	N/A	N/A
	Mineral soils	N/A	N/A	N/A	N/A
	Organic soils	N/A	N/A	N/A	N/A
Land converted to other land	Living biomass	N/A	N/A	N/A	N/A
	Dead organic matter	N/A	N/A	N/A	N/A
	Mineral soils	N/A	Assume no change in soil stocks	N/A	N/A
	Organic soils	N/A	N/A	N/A	N/A
Harvested wood products		From C-Flow model	From C-Flow model	N/A	N/A

Table A 3.6.32 Tier 1 factors used for estimating LULUCF emissions from Overseas Territories and Crown Dependencies

	Factor	Isle of Man/ Guernsey/ Jersey	Falkland Islands
Biomass carbon densities, tC/ha	Cropland	1.5	1.5
	Grassland	2	2
	Pasture Grassland	1	1
	Settlements	2.8	2.8
	Soil C density	95	87
	Grass Flu	1	1
	Grass Fmg	1	1
	Grass Fi	1.4	1.4
	Crop Flu	0.71	0.71
	Crop Fmg	1	1
	Crop Fi	1.2	1.2
	C/N ratio kg N_2O-N/kg N	15	15
	N_2O EF	0.01	0.01
	Limestone EF	0.12	0.12
	Cropland Organic soils EF, tC/ha/yr		-1
	Grassland Organic soils EF, tC/ha/yr		-0.25

A3.6.13 Uncertainty analysis of the LULUCF sector

The purpose of carrying out uncertainty analysis within the LULUCF inventory is to quantify where the largest sources of errors lie, and to identify areas to be targeted in future work so as to reduce the uncertainties. Previous work focused on sensitivity analysis of the CFLOW model, which is central to the forestry sector of the inventory. In the 1990-2010 inventory report the work was extended to encompass the whole of the existing inventory methodology, applying uncertainty quantification more widely and rigorously to all model parameters and empirical conversion factors, and to quantify the impact of those uncertainties on the inventory.

The results of the simulations including both input and parameter uncertainty are that the area undergoing land use change is the single biggest uncertainty in the inventory, followed by uncertainty in the forest model parameters and the choice of model for the change in soil carbon following land use change (Figure A 3.6.9). The next five terms are all of a similar magnitude. Full details of the methodology and results are in the 1990-2010 inventory report.

The uncertainty in the land use change areas is being addressed by the development of a new vector-based approach (see Chapter 7, section 1.1), combining multiple sources of land use data.

Figure A 3.6.9 The largest uncertainties in the LULUCF inventory, in terms of standard deviation in the output distributions

Parameterisation of the forest model is the second largest source of uncertainty. This suggests that further forest growth data may be needed to constrain these parameters. The choice of soil carbon model and its parameters are also important, because the time course of the flux following land use change may be quite different, depending on the equations used to represent this, and how carbon is distributed between fast- and slow-turnover pools. The choice of forest model is less important, largely because all the UK forest models are based on the same yield table data.

A3.7 WASTE (CRF SECTOR 6)

A3.7.1 Solid Waste Disposal on Land (6A)

The assumed waste composition is set out in **Table A 3.7.1.1**. This table also sets out the assumed DDOC content of the waste.

The model allocates waste to two types of landfill – old, closed sites which last received waste in 1979, and modern engineered landfills that came into operation from 1980. Only these latter sites have gas management systems. The old closed sites have no gas control. The distribution of waste between these types of site is the same as used for compiling the previous NIR.

The quantities of Local Authority controlled and Commercial & Industrial waste sent to landfill are shown in **Table A 3.7.1.2**, updated to include data for 2011. The amounts of methane generated, recovered, used for power generation, flared, oxidised and emitted to the atmosphere from 1990 to 2011 are also shown.

Table A 3.7.1.1 Waste composition data

Local Authority controlled waste					C&I				
Material	**Waste composition (2011)**	**DDOC**			**Material**	**Waste composition (2011)**	**DDOC**		
		RDO	**MDO**	**SDO**			**RDO**	**MDO**	**SDO**
Paper	9.9%	0.00%	15.70%	0.42%	Commercial	0%	n/a		
Card	4.7%	0.00%	14.78%	0.39%	Paper and Card	7.3%	0.00%	15.70%	0.42%
Nappies	4.6%	0.00%	4.30%	0.00%	General industrial waste	0%	n/a		
Textiles (and footwear)	4.1%	0.00%	6.67%	0.00%	Food and Abattoir	9.5%	6.45%	1.95%	0.15%
Misc. Combustible	4.4%	0.00%	11.00%	0.00%	Food effluent	0.1%	0.00%	6.76%	0.00%
Wood	2.8%	0.00%	11.84%	0.69%	C&D	0%	n/a		
Food	31.8%	6.74%	2.60%	0.17%	Misc processes	0%	n/a		
Garden	3.1%	3.74%	4.40%	0.58%	Other waste	0%	n/a		
Soil and other organic	3.5%	0.00%	0.27%	0.00%	Misc Comb	1.6%	0.00%	11.00%	0.00%
Furniture	2.1%	0.00%	5.18%	0.04%	Furniture	0.1%	0.00%	5.18%	0.04%
Mattresses	0.5%	0.00%	6.67%	0.00%	Garden	2.2%	3.74%	4.40%	0.58%
Material 1 (not used)	0%	n/a			Sewage sludge	0%	n/a		
Material 2 (not used)	0%	n/a			Textiles / Carpet and Underlay	0.7%	0.00%	6.67%	0.00%
Non-inert Fines	0%	n/a			Wood	4.2%	0.00%	11.84%	0.69%
Other (as 100% inert)	28.5%	0.00%	0.00%	0.00%	Sanitary	0.1%	0.00%	4.30%	0.00%

Notes:

a. DDOC values for Local Authority controlled waste and Commercial & Industrial waste since 1997
b. Furniture in LA-managed waste is assumed to be 62% wood and 5% textile on fresh mass basis.
c. Mattresses are assumed to be 50% textiles on fresh mass basis. Excluding non-biodegradable component).
d. “Other” is assumed to be 100% inert – i.e. non-biodegradable.
e. Furniture in C&I waste is assumed to be 50% wood on fresh mass basis.

A3.7.1.1 Methane emission

The right-most column of **Table A.3.7.1.2** shows the current NIR estimate of methane emitted from UK landfills, according to the approach outlined in **Chapter 8**, taking account of recovery and oxidation.

Table A 3.7.1.2 Amount of waste landfilled and methane generated, captured, utilised, flared, oxidised and emitted.

Year	Waste Landfilled (Mt)			Waste reported in CRF[4]	Methane generated	Methane captured		Methane used for power generation		Methane flared		Residual methane oxidised		Methane emitted	
	MSW	C&I	MSW+ C&I	Mt	kt	kt	%	kt	%	kt	%	kt	%	kt	%
1990	18.19	74.64	92.83	58.30	2,539	267	11%	33	1%	234	9%	227	8.9%	2,044	81%
1991	18.84	73.97	92.80	56.49	2,586	361	14%	50	2%	311	12%	223	8.6%	2,003	77%
1992	19.47	73.30	92.77	54.67	2,631	474	18%	90	3%	383	15%	216	8.2%	1,941	74%
1993	20.09	72.62	92.72	52.83	2,673	583	22%	107	4%	476	18%	209	7.8%	1,881	70%
1994	20.71	71.95	92.66	50.99	2,713	677	25%	124	5%	553	20%	204	7.5%	1,832	68%
1995	26.46	71.28	97.74	54.29	2,769	789	29%	135	5%	655	24%	198	7.1%	1,781	64%
1996	25.75	70.61	96.36	51.12	2,813	892	32%	170	6%	722	26%	192	6.8%	1,729	61%
1997	26.98	69.82	96.80	49.79	2,855	1,071	38%	220	8%	851	30%	178	6.2%	1,605	56%
1998	26.67	67.44	94.11	49.22	2,888	1,215	42%	284	10%	931	32%	167	5.8%	1,506	52%
1999	27.56	66.36	93.92	49.51	2,918	1,386	48%	409	14%	978	34%	153	5.2%	1,378	47%
2000	27.57	65.37	92.94	49.99	2,946	1,509	51%	525	18%	983	33%	144	4.9%	1,293	44%
2001	28.06	61.74	89.81	50.28	2,972	1,717	58%	602	20%	1,115	38%	126	4.2%	1,130	38%
2002	27.63	64.17	91.79	49.35	2,991	1,846	62%	643	21%	1,203	40%	114	3.8%	1,030	34%
2003	26.24	65.56	91.80	46.45	2,992	1,993	67%	786	26%	1,206	40%	100	3.3%	900	30%
2004	25.05	63.10	88.15	43.75	2,979	2,056	69%	961	32%	1,095	37%	92	3.1%	831	28%
2005	22.66	60.13	82.79	39.84	2,947	2,050	70%	1,030	35%	1,021	35%	90	3.0%	807	27%
2006	21.33	55.67	77.01	36.81	2,900	2,020	70%	1,062	37%	958	33%	88	3.0%	792	27%
2007	19.72	51.53	71.25	34.38	2,843	1,984	70%	1,122	39%	861	30%	86	3.0%	774	27%
2008	17.63	47.56	65.19	30.95	2,774	1,938	70%	1,142	41%	796	29%	84	3.0%	752	27%
2009	15.96	43.69	59.65	27.85	2,693	1,884	70%	1,189	44%	696	26%	81	3.0%	727	27%
2010	13.30	39.73	53.03	23.86	2,598	1,821	70%	1,203	47%	612	24%	78	3.0%	699	27%
2011	13.40	35.76	49.16	22.63	2,503	1,757	70%	1195	48%	562	22%	75	3.0%	671	27%

[4] Waste reported in the CRF does not include inert C&I waste.

Notes

a. Methane generated is based on the corrected MELMod 2011 v1-1 UK model.
b. Methane captured is based on the gas collection efficiency averaged over modern and closed landfills as described in the 2008 NIR.
c. Methane used for power generation is calculated from official figures on landfill gas electricity generation (Digest of UK Energy Statistics (DUKES, 2012)), in MWh/year, assuming a net calorific value for methane of 50 GJ/tonnes and a conversion efficiency between methane use and electricity export of 30%, which includes parasitic losses and on-site use of electricity, eg for gas blowers, leachate treatment and site offices.
d. Methane flared is estimated the difference between methane captured and methane used for power generation. It includes minor uses such as direct use and vehicle fuel.
e. Methane oxidised is based on the IPCC default oxidation factor of 10%, applied to methane remaining after subtraction of the amount captured.
f. Methane emitted = (methane generated – methane captured) x (1-oxidation factor). Oxidation factor=0.1.

A3.7.2 Wastewater Handling (6B)

Table A 3.8.2.1 UK Industrial Waste Water Treatment Activity Data (6B1): 1990, 1995, 2000, 2005, 2010, 2011

Sector	Units	1990	1995	2000	2005	2010	2011
Organic chemical production	Mg	1,617,087	1,617,087	1,750,566	1,752,100	1,486,677	1,486,677
Milk-processing	PE	1,464,380	1,464,380	1,464,380	625,516	623,756	623,756
Manufacture of fruit and vegetable products	PE	1,144,564	1,144,564	1,144,564	1,472,785	1,495,227	1,495,227
Potato-processing	PE	302,037	302,037	302,037	388,651	394,573	394,573
Meat industry	PE	623,348	623,348	623,348	619,058	638,245	638,245
Breweries	PE	94,000	94,000	104,311	109,216	108,616	108,616
Production of alcohol and alcoholic beverages	PE	1,930,727	1,930,727	1,930,727	2,021,519	2,010,402	2,010,402
Manufacture of animal feed from plant products	PE	476,000	476,000	476,000	302,014	377,152	377,152
Manufacture of gelatine and of glue from hides, skin and bones	PE	13,315	13,315	13,315	13,315	13,315	13,315
Malt-houses	PE	206,666	206,666	206,666	216,384	215,194	215,194
Fish-processing industry	PE	18,000	18,000	18,000	6,014	6,105	6,105
Total Food and Drink	**PE**	**6,273,037**	**6,273,037**	**6,283,348**	**5,774,471**	**5,882,585**	**5,882,585**

Notes:

1) PE = Population Equivalents
2) Data on industrial activity for 2011 were not available from the Office of National Statistics in time for inventory preparation, and therefore 2010 activity data have been used for 2011 also for all sectors.
3) PRODCOM data (Office of National Statistics, 2012) provides activity data for organic chemical production in 2009. The estimates of production in all other years in the UK are estimated, scaled from the 2009 value using Office of National Statistics Index of Production (IoP) for other years.
   i.e. Production in Year XXXX = Production in 2009 × IoP (Year XXXX) ÷ IoP (2009)
   1997 is the earliest year for IoP data, and hence the value for 1997 is used as the best estimate for all years 1990-1997 inclusive.
4) The total organic loads for all sub-sections of the UK food and drink industry are provided for 2002 in a Defra report (link below). As for organic chemical production, the estimates for other years across the time series have been scaled using Office of National Statistics Index of Production for other years. As above, 1997 is earliest year for IoP data and hence the 1997 value is used for all years 1990-1997 inclusive.
   http://www.defra.gov.uk/publications/files/pb6655-uk-sewage-treatment-020424.pdf

6B2 Domestic and Commercial Waste Water Handling and Sludge Disposal

As outlined in the main report **Section 8.3.2**, UK-specific emission factors are applied to the time series of activity data on water treatment and sewage sludge treatment and disposal. These factors are derived from UK water industry emissions data reported to the inventory agency, which in turn have been calculated using a spreadsheet tool developed by UK Water Industry Research (UKWIR), which all UK water companies utilise. The UKWIR tool provides emission factors for sub-processes within the industry, enabling water companies to calculate their methane emissions based on their company-specific stock of water treatment equipment and effluent inputs to individual water treatment works. From the aggregated industry reported emissions and activity data, country-specific implied emission factors for digestion, water and sludge treatment, composting and disposal to farmland are derived and applied across the time series of activity data.

Water company reporting of emissions to the inventory agency is not comprehensive; emissions data are only available from 2009 onwards, and not all UK water companies currently provide emissions data to the inventory agency. The inventory agency note that there is a limited dataset from which to derive UK-specific emission factors, despite extensive stakeholder consultation with industry contacts in recent years. However, there is good consistency across the emission factors derived from the different water companies and the data are based on UK-specific water treatment facilities, effluent inputs and treatment / disposal activities, and therefore are regarded as the best available data upon which to derive inventory estimates.

For each source, where there is a company-specific emission factor this is applied to the activity data across all years of the time series, and where there is no company-specific factor, the UK-wide aggregate factor from reporting companies is applied to the activity data. This approach leads to small variations in the industry-wide country-specific factors that are reported in the tables below, as the contribution to total emissions varies over time as different companies adopt different treatment and disposal practices, evident through the activity data time series.

The methane emission factors are calculated using emissions and activity data reported by the following UK water companies:

- ***Digestion***: Scottish Water, Yorkshire & York, Anglian and HPL, South West, Thames;
- ***Treatment***: Scottish Water, Northern Ireland Water, Yorkshire & York, South West, Thames;
- ***Composting***: Scottish Water, Northern Ireland Water, Yorkshire & York, South West, Thames;
- ***Agricultural Land Disposal***: Scottish Water, Northern Ireland Water, Yorkshire & York, Anglian and HPL, South West, Thames;

The activity data, emission factors and emissions totals for each source and the overall UK estimates are presented in the tables below. The step-change in activity data in 2000 to 2001 reflects the changes in the UK water industry practices to increase the level of sewage sludge treatment and disposal by non-sea-disposal methods, in reaction to the implementation of the Urban Waste Water Treatment Directive, which banned sewage disposal direct to sea.

Table A 3.8.2.2 UK Domestic and Commercial Waste Water Treatment Activity Data (6B2): Total Sludge, Population Equivalents, Composting and Farmland Disposal

	Total Sludge	Population Equivalents	Composting	Farmland Disposal
Units→	**(kt dry solids)**	**(000 people)**	**(kt dry solids)**	**(kt dry solids)**
1990	1,076	73,092	0	499
1991	1,072	73,092	0	507
1992	1,019	73,092	0	482
1993	1,014	73,092	0	502
1994	1,039	73,092	0	504
1995	1,120	73,092	0	548
1996	1,078	73,092	0	535
1997	1,038	73,092	0	730
1998	1,057	73,092	0	601
1999	1,126	73,092	0	608
2000	1,108	73,092	9.2	608
2001	1,541	73,092	5.8	865
2002	1,599	73,092	7.3	1047
2003	1,653	73,119	14.4	1214
2004	1,759	72,896	19.0	1318
2005	1,770	72,851	13.5	1317
2006	1,792	72,808	16.1	1314
2007	1,817	70,633	16.3	1373
2008	1,815	69,875	14.5	1456
2009	1,706	68,379	26.0	1367
2010	1,690	69,063	16.6	1358
2011	1,767	71,275	19.3	1407

Note that there are no reported data for Population Equivalents prior to 2002, and therefore the 2002 data are applied back to 1990.
In the CRF table 6.Bs1, the activity data for the UK are the "Total Sludge" data, as shown above in the first column of activity data.

Table A 3.8.2.3 UK Domestic and Commercial Waste Water Treatment Emission Factors (6B2): Treatment, Digestion, Composting and Farmland Disposal, and the Implied Emission Factor for 6B2 overall

	Treatment	Digestion	Composting	Farmland Disposal	Overall IEF
Units→	**(kg CH_4 / kt dry solids)**	**(kg CH_4 / 000 people)**	**(kg CH_4 / kt dry solids)**	**(kg CH_4 / kt dry solids)**	**(kg CH_4 / kt dry solids)**
1990	2,728	145	n/a	1,597	13,291
1991	2,729	145	n/a	1,596	13,342
1992	2,729	145	n/a	1,593	13,854
1993	2,729	145	n/a	1,592	13,940
1994	2,729	145	n/a	1,598	13,676
1995	2,729	145	n/a	1,599	12,947
1996	2,728	145	n/a	1,618	13,335
1997	2,732	145	n/a	1,548	14,007
1998	2,732	145	n/a	1,546	13,612
1999	2,731	145	n/a	1,519	12,941
2000	2,730	145	2,553	1,529	13,131
2001	2,731	145	2,553	1,489	10,435
2002	2,731	145	2,553	1,327	10,221
2003	2,730	145	2,553	1,364	10,152
2004	2,729	145	2,553	1,328	9,748

	Treatment	Digestion	Composting	Farmland Disposal	Overall IEF
Units→	**(kg CH_4 / kt dry solids)**	**(kg CH_4 / 000 people)**	**(kg CH_4 / kt dry solids)**	**(kg CH_4 / kt dry solids)**	**(kg CH_4 / kt dry solids)**
2005	2,729	145	2,553	1,461	9,788
2006	2,728	145	2,553	1,539	9,759
2007	2,732	145	2,553	1,506	9,523
2008	2,729	145	2,553	1,574	9,587
2009	2,729	145	2,553	1,503	9,780
2010	2,735	140	2,290	1,553	9,742
2011	2,740	142	2,584	1,575	9,731

Note that the 6B2 overall IEF in the right hand column is derived from the sum of all emission estimates divided by the "total sludge" activity data in Table A.3.8.2.2.

Table A 3.8.2.4 UK Domestic and Commercial Waste Water Treatment Emission Estimates (6B2): Treatment, Population Equivalents, Composting and Farmland Disposal, and the Implied Emission Factor for 6B2 overall

	Treatment	Digestion	Composting	Farmland Disposal	TOTAL
Units→	**(kg CH_4)**	**(kg CH_4)**	**(kg CH_4)**	**(kg CH_4)**	**(kg CH_4)**
1990	2,935,716	10,568,731	-	796,812	14,301,259
1991	2,925,010	10,568,731	-	809,395	14,303,136
1992	2,780,871	10,568,731	-	767,829	14,117,431
1993	2,767,214	10,568,731	-	799,285	14,135,230
1994	2,835,186	10,568,731	-	805,425	14,209,342
1995	3,056,342	10,568,731	-	876,126	14,501,199
1996	2,941,242	10,568,731	-	865,408	14,375,381
1997	2,834,917	10,568,731	-	1,130,317	14,533,965
1998	2,887,127	10,568,731	-	928,815	14,384,674
1999	3,073,581	10,568,731	-	923,806	14,566,119
2000	3,024,077	10,568,731	23,387	930,010	14,546,205
2001	4,209,250	10,568,731	14,757	1,288,848	16,081,586
2002	4,365,851	10,568,731	18,638	1,388,666	16,341,887
2003	4,512,888	10,578,892	36,766	1,655,876	16,784,421
2004	4,800,381	10,546,192	48,510	1,749,560	17,144,643
2005	4,830,943	10,540,026	34,493	1,923,445	17,328,908
2006	4,889,224	10,538,545	41,026	2,023,274	17,492,070
2007	4,962,695	10,227,949	41,617	2,067,860	17,300,121
2008	4,952,514	10,118,071	37,021	2,290,870	17,398,475
2009	4,655,140	9,904,730	66,459	2,054,909	16,681,238
2010	4,620,623	9,693,655	37,983	2,108,622	16,460,883
2011	4,842,585	10,087,468	49,804	2,216,078	17,195,935

Note that the total emissions presented in the right hand column above are the data reported in the CRF table 6.Bs1, for total 6B2 source category emissions.

In the review of the 2011 UK GHG inventory submission, the UNFCCC ERT questioned the accuracy of the source estimates due to uncertainty regarding the applicability of factors derived from one year and from only a sub-set of the UK water industry and then applied to water industry operations throughout the time series. Whilst the estimates are somewhat uncertain and further work is needed to consult across the industry to seek out additional data and to improve the method, we remain confident that the method is an improvement compared to the previous approach which used data from a 1996 study, based on information from the early 1990s and then extrapolated the emission estimates forward based on population trends.

The emission factors derived from 2009 data are based on data from 5 UK water companies that in 2009 managed the disposal of 53% of the total volume of sewage sludge arisings.

- In 2009, the treatment emissions are estimated to account for 28% of the total methane emissions from the sector and the company-specific factors show close agreement, ranging from 2532-2834 kg CH_4/ktonne, with a standard deviation that is 5% of the mean figure.
- In 2009, the digestion emissions are estimated to account for 59% of the total methane emissions from the sector and the five company-specific factors show reasonable consistency, ranging from 104-157 kg CH_4/ktonne, with a standard deviation that is 17% of the mean.
- The emission factor for composting is derived from data from a single water company that reported data for 2009. In 2009, the composting emissions are estimated to account for less than 1% of the total methane emissions from the sector.
- In 2009, the disposal to agriculture emissions are estimated to account for 12% of the total methane emissions from the sector but the five company-specific factors show wide variability, ranging from 863-2350 kg CH_4/ktonne, with a standard deviation that is 33% of the mean. In part this reflects the different types of disposal to agriculture that are conducted by water companies, as in some cases the sludge is pre-treated or dried prior to application to land and the resultant emissions vary as a result of this treatment. However, the variability in reported data also indicates higher uncertainty for this source, and therefore further consultation with the water industry is on-going to seek out a more comprehensive dataset for this source.

The inventory estimates for methane are uncertain due to the limited dataset available to the inventory agency, but the method does utilise emission factors derived from country-specific research and that reflect company-specific waste water treatment and disposal systems, albeit from around half of the UK water industry. The bullet-points above indicate that for the treatment and digestion emission sources together (which comprise around 88% of total estimated methane emissions in 2009), the level of uncertainty in the average UK emission factors is relatively low. We note, however, that the uncertainty in the emission estimates for other sources, notably disposal to agriculture, are higher and these data are subject to on-going industry consultation in order to seek out a more comprehensive dataset.

During 2012, the inventory agency met with UK water company Carbon Managers to request activity and emissions data from across the non-reporting water companies. In addition, the inventory agency met with water reporting experts within the Environment Agency of England and Wales to research available data for activities and emissions in both the industrial (6B1) and municipal (6B2) waste water treatment sectors. The detailed activity data of treatment and sludge disposal activity is no longer (since 2009) a mandatory requirement of annual reporting by water companies to UK regulators of the industry (OFWAT, Water Commissioner for Scotland, UREGNI). The inventory agency is working with regulators to seek alternative industry data and to research options for implementing new data gathering mechanisms to underpin improvements to inventory compilation methods.

A3.7.3 Waste Incineration (6C)

Table A 3.7.3 Activity Data: UK Waste Incineration 1990-2011

	Municipal Waste Incineration (Mt)	Clinical Waste Incineration (Mt)	Industrial Waste Incineration (Mt)	Sewage Sludge Incineration (Mt)
1990	2.211	0.350	0.290	0.075
1991	2.189	0.350	0.290	0.069
1992	2.100	0.330	0.290	0.072
1993	1.858	0.310	0.290	0.084
1994	1.360	0.290	0.289	0.072
1995	1.299	0.270	0.289	0.082
1996	1.417	0.250	0.288	0.088
1997	0.078	0.230	0.287	0.081
1998	0.079	0.236	0.287	0.185
1999	0.079	0.242	0.286	0.186
2000	0.084	0.248	0.285	0.188
2001	0.060	0.254	0.285	0.189
2002	0.061	0.260	0.284	0.191
2003	0.061	0.224	0.257	0.192
2004	0.061	0.188	0.231	0.194
2005	0.061	0.152	0.204	0.195
2006	0.061	0.115	0.177	0.196
2007	0.062	0.124	0.163	0.191
2008	0.062	0.131	0.136	0.168
2009	0.062	0.122	0.127	0.175
2010	0.063	0.127	0.140	0.183
2011	0.062	0.112	0.139	0.176

A3.8 DATA FOR THE UK'S CROWN DEPENDENCIES AND OVERSEAS TERRITORIES

Table A 3.8.1 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	2009	2010	2011
1. Energy	1.45	1.51	1.56	1.53	1.56	1.62	1.73	1.80	1.87	1.75	1.63	1.39	1.44	1.31	1.33	1.42	1.42	1.52	1.42	1.44	1.42	1.41
2. Industrial Process	0.0001	0.0002	0.0002	0.001	0.003	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.07
3. Solvents and Other Product Use																						
4. Agriculture	0.17	0.17	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.18	0.17	0.17	0.12	0.12	0.12	0.15	0.16	0.16	0.15	0.14	0.14
5. LULUCF	-0.02	-0.02	-0.02	-0.03	-0.04	-0.04	-0.06	-0.06	-0.06	-0.06	-0.07	-0.07	-0.07	-0.08	-0.07	-0.07	-0.10	-0.09	-0.09	-0.10	-0.09	-0.10
6. Waste	0.14	0.14	0.14	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.09	0.09	0.07	0.07	0.04	0.06	0.06	0.05	0.05	0.05	0.04	0.04
7. Other																						
Total	**1.74**	**1.81**	**1.85**	**1.80**	**1.83**	**1.88**	**1.98**	**2.06**	**2.14**	**2.02**	**1.86**	**1.61**	**1.65**	**1.47**	**1.47**	**1.58**	**1.59**	**1.70**	**1.61**	**1.61**	**1.58**	**1.56**

Table A 3.8.2 Isle of Man, Guernsey and Jersey – Fuel use data

Sector	Fuel Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Aviation spirit	Mt	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	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Aviation turbine fuel	Mt	0.07	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.09	0.09	0.08	0.08	0.08
Burning oil	Mt	0.22	0.25	0.23	0.23	0.25	0.26	0.30	0.35	0.34	0.30	0.35	0.30	0.38	0.39	0.36	0.37	0.36	0.37	0.37	0.38	0.40	0.40
Coal	Mt	0.12	0.12	0.10	0.11	0.10	0.10	0.10	0.09	0.07	0.05	0.04	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
DERV	Mt	0.07	0.08	0.08	0.08	0.09	0.09	0.11	0.12	0.13	0.12	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.13
Fuel oil	Mt	0.48	0.51	0.58	0.55	0.57	0.59	0.59	0.55	0.59	0.59	0.45	0.26	0.21	0.09	0.11	0.09	0.14	0.18	0.10	0.15	0.10	0.08
Gas oil	Mt	0.12	0.12	0.13	0.12	0.12	0.13	0.13	0.15	0.19	0.13	0.12	0.13	0.18	0.15	0.14	0.14	0.12	0.13	0.12	0.11	0.10	0.09
LPG	Mth	25.65	27.50	24.11	24.93	24.37	25.37	28.63	60.01	60.97	60.47	60.57	59.47	58.49	54.68	37.82	38.72	36.47	34.76	34.54	34.31	34.90	30.99
Natural gas	Mth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.86	57.12	101.94	98.56	111.48	117.32	119.88	135.02	150.16
Petrol	Mt	0.23	0.23	0.23	0.23	0.23	0.22	0.26	0.24	0.24	0.23	0.21	0.24	0.22	0.22	0.22	0.22	0.21	0.21	0.20	0.20	0.20	0.19
Wood	Mt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A 3.8.3 Isle of Man, Guernsey and Jersey – Animal numbers

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Dairy	15,888	15,888	15,888	15,682	15,477	15,729	14,990	15,330	15,890	15,950	16,186	15,416	14,525	15,426	14,590	14,335	14,138	13,140	12,593	11,658	11,455	10,944
Non-dairy Cattle	28,663	30,164	31,665	27,134	27,710	28,333	28,346	27,049	28,639	29,292	29,176	28,562	28,438	13,873	14,828	15,562	24,089	32,449	32,615	30,147	28,615	27,137
Sheep	151,764	150,972	150,180	154,483	161,798	160,228	157,432	162,159	174,345	178,705	176,259	168,867	171,264	91,952	85,521	90,536	137,438	146,560	149,642	145,962	138,251	134,963
Goats	333	332	331	338	349	347	325	333	352	359	376	373	339	210	177	201	298	303	314	304	288	301
Horses	1,928	1,928	1,928	1,928	1,928	1,928	1,928	1,928	1,928	1,928	1,928	1,928	1,928	1,928	1,928	1,965	2,358	2,097	2,243	2,301	2,379	2,346
Pigs	4,854	5,774	6,694	5,419	5,037	5,411	5,130	6,714	7,071	6,449	4,609	3,413	3,578	1,337	1,391	1,148	1,310	1,457	1,239	1,420	1,114	920
Poultry	84,048	77,855	71,662	76,675	73,469	46,481	60,080	58,356	54,552	51,071	46,448	42,295	46,091	50,217	48,087	58,160	58,229	53,424	52,642	40,792	38,400	36,152

Table A 3.8.4 Isle of Man, Guernsey and Jersey – Total emissions from Agricultural Soils (kg N2O-N)

Territory	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Isle of Man	26,856	27,691	28,525	26,075	26,213	26,617	26,621	26,730	28,293	28,600	28,246	27,336	27,359	19,689	19,525	19,706	24,216	27,271	27,525	25,486	24,356	23,185
Guernsey	4,054	4,054	4,054	4,054	4,054	4,054	3,344	3,344	3,344	3,344	3,311	2,997	2,865	2,871	2,824	2,948	2,949	2,916	2,884	2,852	2,819	2,773
Jersey	6,391	6,391	6,391	6,391	6,391	6,391	6,391	6,391	6,391	6,391	6,494	6,304	5,640	5,229	4,982	4,904	5,224	5,391	4,762	4,704	4,726	4,660

Table A 3.8.5 Isle of Man, Guernsey and Jersey – Amount of synthetic fertilizer applied

Country	kg N applied
Isle of Man	2,831,800
Guernsey	279,267
Jersey	558,533

Table A 3.8.6 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	2009	2010	2011
1. Energy	1.21	1.19	1.18	1.21	1.22	1.23	1.23	1.24	1.34	1.32	1.34	1.44	1.45	1.45	1.54	1.59	1.68	1.81	1.61	1.55	1.63	1.64
2. Industrial Process	0.0001	0.0001	0.0002	0.001	0.002	0.004	0.01	0.01	0.02	0.02	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.08	0.08
3. Solvents and Other Product Use																						
4. Agriculture	0.23	0.22	0.23	0.23	0.23	0.22	0.23	0.22	0.22	0.21	0.21	0.21	0.20	0.20	0.20	0.19	0.19	0.19	0.19	0.18	0.18	0.18
5. LULUCF	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.01	0.01	0.00	0.01	0.005
6. Waste	0.10	0.09	0.07	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.08
7. Other																						
Total	**1.54**	**1.50**	**1.49**	**1.50**	**1.50**	**1.52**	**1.52**	**1.54**	**1.65**	**1.62**	**1.65**	**1.75**	**1.76**	**1.77**	**1.86**	**1.93**	**2.03**	**2.15**	**1.96**	**1.89**	**1.98**	**1.99**

Table A 3.8.7 Cayman Islands, Falklands Islands, Bermuda and Montserrat – Fuel use data

Sector	Fuel Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Aviation spirit	Mt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aviation turbine fuel	Mt	0.26	0.22	0.19	0.19	0.19	0.19	0.20	0.18	0.20	0.17	0.20	0.19	0.19	0.19	0.20	0.19	0.24	0.23	0.23	0.21	0.22	0.21
Burning oil	Mt	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	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Clinical waste	Mt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DERV	Mt	0.16	0.15	0.15	0.14	0.14	0.13	0.13	0.12	0.15	0.12	0.11	0.15	0.14	0.10	0.18	0.24	0.23	0.28	0.13	0.10	0.10	0.14
Fuel oil	Mt	0.30	0.30	0.31	0.32	0.33	0.34	0.34	0.36	0.38	0.40	0.53	0.55	0.56	0.59	0.56	0.59	0.64	0.67	0.67	0.67	0.66	0.71
Gas oil	Mt	0.26	0.26	0.26	0.27	0.27	0.27	0.27	0.26	0.27	0.27	0.17	0.18	0.18	0.19	0.19	0.20	0.20	0.20	0.20	0.20	0.20	0.20
LPG	Mth	7.59	7.62	7.66	7.70	7.75	7.79	7.54	7.38	7.03	7.15	7.26	7.31	8.25	8.51	8.60	8.67	8.74	9.00	9.08	9.18	9.08	9.28
MSW	Mt	0.00	0.00	0.00	0.00	0.00	0.17	0.17	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.19	0.19	0.19	0.19
Natural gas	Mth	67.57	70.77	73.97	77.17	80.37	83.57	86.78	89.14	91.50	93.86	96.22	98.59	101.23	101.23	101.23	126.50	133.47	143.43	127.90	101.72	150.20	129.90
Petrol	Mt	0.20	0.20	0.20	0.20	0.21	0.21	0.21	0.21	0.22	0.23	0.22	0.23	0.22	0.22	0.25	0.18	0.17	0.20	0.19	0.21	0.20	0.18

Table A 3.8.8 Cayman Islands, Falklands Islands, Bermuda and Montserrat – Animal numbers

OTs	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Dairy Cattle	10,862	10,840	10,928	11,015	10,964	10,931	11,016	10,945	11,026	10,992	11,054	11,387	10,972	10,818	10,845	10,999	10,954	10,970	11,002	10,668	10,833	10,628
Non-dairy Cattle	5,645	5,549	5,385	4,118	5,437	5,286	5,635	5,321	5,653	5,498	5,748	5,540	6,063	6,692	7,472	6,988	7,433	7,290	6,934	6,601	6,145	6,271
Sheep	733,949	717,255	725,952	731,602	722,271	690,456	712,219	712,396	712,782	674,605	647,525	617,625	588,157	591,267	585,564	538,251	534,809	514,885	509,520	483,425	492,865	491,575
Goats	7,507	7,607	7,871	7,958	8,232	8,342	8,452	8,561	8,671	8,781	8,891	9,001	9,111	9,220	9,330	9,440	9,290	9,892	10,043	9,703	9,347	9,511
Horses	2,500	2,451	2,327	2,354	2,414	2,319	2,235	2,233	2,290	2,048	1,994	2,009	1,910	1,903	1,787	1,844	1,794	1,700	1,717	1,669	1,644	1,623
Swine	2,116	2,136	2,078	2,020	2,313	2,332	2,330	2,329	2,327	2,326	2,155	2,009	2,029	2,049	2,023	1,980	2,421	2,623	2,515	2,652	2,528	2,423
Poultry	45,319	50,319	52,919	52,919	49,419	49,555	49,692	49,828	49,964	50,101	50,714	50,264	50,261	50,645	50,831	50,525	51,363	50,160	49,714	49,814	50,014	50,024
Deer	155	155	155	155	155	155	155	155	155	155	155	155	155	155	155	155	155	155	169	184	184	243

Table A 3.8.9 Cayman Islands, Falklands Islands, Bermuda and Montserrat – Total emissions from Agricultural Soils (kg N2O-N)

Territory	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Cayman Islands	118	118	105	88	95	96	97	98	99	100	101	102	103	104	105	106	193	206	192	212	174	167
Falklands	529	519	513	506	483	467	506	473	511	494	498	636	455	393	404	462	438	397	405	255	344	244
Bermuda	277	280	283	287	290	293	293	293	293	294	294	294	294	294	294	294	294	294	294	294	294	294
Montserrat *	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8

Table A 3.8.10 Cayman Islands, Falklands Islands, Bermuda and Montserrat - Amount of synthetic fertilizer applied

Country	kg N applied
Cayman Islands	5,400
Falklands	0
Bermuda	1,480
Montserrat	6,000

Table A 3.8.11 Cayman Islands, Falklands Islands, Bermuda and Montserrat – Production of non-N-fixing crops (tonnes)

Territory	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
total *	5,869	6,105	6,344	6,199	6,548	6,538	6,443	6,944	6,683	6,954	6,931	7,524	6,758	7,362	6,946	6,425	6,506	7,008	6,848	7,375	6,950	6,950

* Data have been collected to allow a disaggregation of emission estimates by territory and are in place to be included in the 2014 submission.

Table A 3.8.12 Montserrat – Production of N-fixing crops (tonnes)

Production of N-fixing crops (tonnes)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Montserrat	0.26	0.32	0.34	0.32	0.32	0.42	0.50	0.44	0.38	0.40	0.42	0.38	0.42	0.44	0.46	0.36	0.30	0.28	0.26	0.40	0.40	0.40

Table A 3.8.13 Gibraltar – 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	2009	2010	2011
1. Energy	0.186	0.194	0.199	0.177	0.193	0.186	0.176	0.187	0.189	0.199	0.205	0.208	0.199	0.203	0.219	0.231	0.226	0.219	0.237	0.249	0.244	0.238
2. Industrial Process	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.003	0.003	0.004	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.009
3. Solvents and Other Product Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. LULUCF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. Waste	0.006	0.006	0.006	0.007	0.008	0.006	0.006	0.006	0.006	0.006	0.007	0	0	0	0	0	0	0	0	0.0008	0.0015	0.0003
7. Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0.192**	**0.201**	**0.206**	**0.184**	**0.201**	**0.193**	**0.184**	**0.194**	**0.197**	**0.207**	**0.215**	**0.212**	**0.204**	**0.209**	**0.225**	**0.237**	**0.233**	**0.226**	**0.244**	**0.258**	**0.253**	**0.247**

Table A 3.8.14 Gibraltar – Fuel use data

Sector	Fuel Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Aviation turbine fuel	Mt	0.010	0.009	0.009	0.009	0.009	0.008	0.007	0.007	0.007	0.006	0.007	0.007	0.007	0.007	0.008	0.009	0.008	0.006	0.008	0.008	0.007	0.009
Charcoal	Mt	0	0	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DERV	Mt	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.004	0.005	0.004	0.004	0.003	0.004	0.004	0.004	0.004
Fuel oil	Mt	0.023	0.023	0.022	0.022	0.022	0.021	0.020	0.022	0.022	0.023	0.024	0.024	0.019	0.019	0.019	0.021	0.021	0.019	0.020	0.020	0.018	0.018
Gas oil	Mt	0.020	0.023	0.025	0.019	0.024	0.024	0.023	0.024	0.025	0.026	0.026	0.027	0.029	0.029	0.031	0.033	0.033	0.035	0.038	0.040	0.041	0.038
MSW	Mt	0.016	0.016	0.016	0.016	0.019	0.019	0.019	0.019	0.020	0.020	0.024	0	0	0	0	0	0	0	0	0	0	0
Natural gas	Mth	0.748	0.732	0.722	0.703	0.641	0.618	0.691	0.621	0.620	0.611	0.612	0.637	0.616	0.625	0.628	0.590	0.554	0.526	0.549	0.521	0.622	0.481
Petrol	Mt	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Clinical waste	Mt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.002	0.000

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 is compiled using a detailed Sectoral Approach methodology, to produce sector-specific inventories of the 10 pollutants in accordance with the IPCC reporting format. These UK GHGI emission estimates are based on bottom-up activity data, including:

- national energy statistics that present annual consumption of primary and secondary fuels within different economic sectors in the UK; and
- a wide range of other statistical datasets (e.g. raw material extraction and use, production statistics for minerals, metals, glass, cement, specific chemicals, waste statistics, livestock and crop data, land use survey information) to generate estimates of non-combustion emissions from other known sources.

To provide a comparison against the detailed Sectoral Approach inventory estimates, the inventory agency also calculates alternative UK emission estimates for carbon dioxide from energy sources in the UK, using the IPCC Reference Approach. This is a top-down inventory compilation method, which calculates emission estimates from National Statistics on production, imports, exports, stock changes and non-energy uses of fossil fuels: crude oil, natural gas and solid fuels.

The Reference Approach inventory method utilises different sections of the UK national energy statistics, combining aggregated data on fuel inputs and outputs from the overall UK economy, using top-level data on oils, gas and solid fuels to assess the UK carbon balance for combustion sources. This more simplistic, non-source-specific methodology provides a very useful quality check against the more rigorous Sectoral Approach. The Reference Approach typically produces UK CO_2 emission estimates that are between 1% lower to 2% higher than the more detailed Sectoral Approach, due to statistical differences between production-side and demand-side fuel estimates within national energy statistics, and the more aggregated approach to applying emission factors to activity data across fuel types.

The Reference Approach calculations have been revised during the latest inventory cycle, to improve the accuracy, completeness and transparency of the data; this was following UNFCCC ERT recommendations and discussions with the UNFCCC Expert Review Team at the in-country review in September 2012:

- A correction has been made to add data on Natural Gas Liquids imports to Reference Approach estimates. NGL import data have been evident in the UK energy balance for 2007 onwards, but previously had been omitted in error from the Reference Approach energy balance for petroleum fuels;
- Import and export data for petroleum coke in 1990-1994 have been revised in the Reference Approach calculations to match those used in the Sectoral Approach, to

provide a consistent method for the petroleum coke estimates across all years and remove a known difference between the Reference and Sectoral Approaches;

- Activity data for natural gas use as a feedstock has been revised in the Sectoral Approach to reflect revisions in operator data from 1997 onwards, following clarifications of the use of natural gas in combustion and as a feedstock in ammonia production (2B1). The feedstock data in the Reference Approach calculations have been revised to be consistent with the Sectoral Approach for this source;
- The full time series of feedstock and non-energy use of fuels has been revised and updated in the Reference Approach, to provide annual estimates of carbon stored that are consistent with the Sectoral Approach. This has coincided with a review of the use of feedstock chemicals as energy sources in UK industrial production. This review led to an increase across the time series in UK GHGI estimates reported in 1A2f of the Sectoral Approach, due to increased activity data for Other Petroleum Gas use as a fuel in several industries. We have revised the Reference Approach estimates and calculated annual carbon storage fractions for each fuel, to remove known reasons for difference with the Sectoral Approach estimates. The inventory agency has also completed the Additional Information CRF table 1Ad, to present the associated CO_2 emission estimates from energy use of fuels that are reported in energy statistics as non-energy use, and to indicate the IPCC sectors where those emissions are included in the UK GHGI Sectoral Approach;
- The overall comparison of emissions totals for Reference Approach and Sectoral Approach has been amended to match that calculated in the CRF table 1Ac. Table A4.3.1 below presents the comparison between Reference Approach totals and the Sectoral Approach estimates for sources in IPCC sector 1A only.
- Data on marine bunker use of gas oil have been revised across the time series, compared to the 1990-2010 inventory, due to small revisions to gas oil allocations from recent research into shipping, inland waterways and fishing vessels.

A4.2 DISCREPANCIES BETWEEN THE IPCC REFERENCE AND SECTORAL APPROACH

The IPCC Reference Approach total can be compared with the IPCC Table 1A Total; the IPCC Reference Approach CO_2 estimates typically range between 1% lower to 2 % higher than the comparable bottom-up emission totals of the Sectoral Approach.

The IPCC Reference Approach is based on statistics of production, imports, exports, stock changes and non-energy use of fuels whilst the Sectoral Approach uses fuel consumption data by source sector. The two sets of statistics can be related using mass balances (see the publication ‘Digest of UK Energy Statistics’ DECC, 2012), but these show that some fuel is unaccounted for. This unaccounted fuel is reported in DUKES as statistical differences, which 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, for total supply and also for each fuel.

Nevertheless a proportion of the difference between the Reference Approach and the Sectoral Approach totals will be accounted for by statistical differences, particularly for liquid fuels.

Note that:

1. The Sectoral Approach only includes emissions from the non-energy use of fuel where they can be specifically identified and estimated, for example within industrial processes including: ammonia production, petrochemical production, fertiliser 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 by difference, based on (i) total reported non-energy use of fuels in the UK energy balance, and (ii) Sectoral Approach estimates of carbon released from feedstock fuels. This is straightforward for some fuels such as natural gas where there are a limited number of known uses of gas as a feedstock chemical with associated combustion and process releases. However, there are a number of emission sources in the UK GHGI Sectoral Approach that cannot be allocated to a specific fuel in the UK energy balance, for example where carbon from chemical industry feedstocks is ultimately released via combustion, waste incineration, or from release of CO_2 in use of products such as pesticides and detergents. In these instances, the total annual emission estimates from all such sources have been aggregated and then estimates of feedstock use across a group of chemical feedstock fuels (i.e. ethane, propane, butane, naphtha) have been calculated at an aggregated level. These assumptions applied within the estimation of carbon stored from non-energy fuel use introduce uncertainty to the Reference Approach emission data.

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, stock changes and non-energy uses 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 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, and hence the estimates from the Reference Approach are associated with higher uncertainty.

A4.3 TIME SERIES OF DIFFERENCES IN THE IPCC REFERENCE AND SECTORAL INVENTORIES

Table A 4.3.1 shows the percentage differences in CO_2 emissions from fuel combustion sources between the IPCC Reference Approach and the UK GHGI (Sectoral Approach) IPCC sector 1A, for each year since 1990.

In most years, the percentage difference is a small positive number, indicating that the Reference Approach estimates are slightly higher than the Sectoral Approach.

Table A 4.3.1 Modified comparison of the IPCC Reference Approach and the Sectoral Approach (% total CO_2)

Year	1990	1991	1992	1993	1994	1995
Percentage difference	-1.1	0.1	1.2	0.3	0.7	1.9

Year	1996	1997	1998	1999	2000	2001
Percentage difference	0.0	-0.7	-0.1	0.6	1.3	0.6

Year	2002	2003	2004	2005	2006	2007
Percentage difference	-0.2	-1.1	-0.7	0.9	0.7	0.4

Year	2008	2009	2010	2011
Percentage difference	0.8	1.1	0.5	1.0

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	1C2 Multilateral Operations	Data unavailable – this is a memo item so does not affect the national total.
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
CO_2	5. Land-Use Change and Forestry	5C1 Grassland remaining Grassland	Emissions believed small (and therefore not a key category).
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
CO_2	KP LULUCF	KP A.1.2 Units of land harvested since the beginning of the commitment period	Assumed not to occur in this commitment period as forest management cycles operate on long time scales
CO_2	KP LULUCF	5(KP-II)4 Carbon emissions from lime application-Afforestation/Reforestation	No lime is applied to forests in the UK
CO_2	KP LULUCF	5(KP-II)4 Carbon emissions from lime application- Forest Management	No lime is applied to forests in the UK
CO_2	KP LULUCF	5(KP-II)5 GHG emissions from biomass burning-Afforestation/Reforestation/Forest Management-Controlled burning	Controlled burning for forest management purposes does not occur in the UK
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 (and therefore not a key category)
N_2O	2. Industrial Processes	2A7 Asphalt	Data unavailable. Believed to be very small and very uncertain

GHG	CRF sector	Source/sink category	Reason
N_2O	2. Industrial Processes	2B1 Ammonia Production	Emissions from this source are considered negligible (and therefore not a key category)
N_2O	3. Solvent and Other Product Use	3D Other –Anaesthesia	Activity not readily available – believed small (and therefore not a key category).
N_2O	5. Land-Use Change and Forestry	5D2 Land converted to Wetlands	No data available
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 waste water	No data are available to estimate emissions from this source. Emissions are believed to be 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 Accidental fires (vehicles)	No suitable emission factor available
N_2O	KP LULUCF	KP A.1.2 Units of land harvested since the beginning of the commitment period	Assumed not to occur in this commitment period as forest management cycles operate on long time scales
N_2O	KP LULUCF	5(KP-II)1 Direct N_2O emissions from N fertilisation-Forest Management	Nitrogen fertilizer is only applied to newly planted forests in the UK (not established forests)
N_2O	KP LULUCF	5(KP-II)5 GHG emissions from biomass burning-Afforestation/Reforestation/Forest Management-Controlled burning	Controlled burning for forest management purposes does not occur in the UK
CH_4	1. Energy	1C2 Multilateral Operations	Data unavailable. This is a memo item and therefore does not affect the national total.
CH_4	2. Industrial Processes	2C3 Aluminium	Methodology not available but considered negligible (and therefore not a key category)
CH_4	4. Agriculture	4D3 Indirect emissions	There are no known sources of methane from this
CH_4	5. Land-Use Change and Forestry	5A1 Forest Land remaining Forest Land, 5D2 Land converted to wetlands	No data to allow emissions calculation
CH_4	5. Land-Use Change and Forestry	5G Harvested wood products	No guidance available on calculating non-CO2 emissions from HWP
CH_4	5. Land-Use Change and Forestry	5G Harvested wood products	No guidance available on calculating non-CO_2 emissions from HWP
CH_4	KP LULUCF	KP A.1.2 Units of land harvested since the beginning of the commitment	Assumed not to occur in this commitment period as forest management cycles operate on long

GHG	CRF sector	Source/sink category	Reason
		period	time scales
CH_4	KP LULUCF	5(KP-II)5 GHG emissions from biomass burning-Afforestation/Reforestation/Forest Management-Controlled burning	Controlled burning for forest management purposes does not occur in the UK

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

No additional information.

A7 ANNEX 7: Uncertainties

Uncertainty estimates are calculated using two methods: Approach 1 (error propagation) and Approach 2 (Monte Carlo simulation).

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. Estimated uncertainty presented in National Communication categories (which are consistent with the UK's Carbon Budgets sectors) are not reported here, since the categories are not consistent with the requirements of the UK's commitments under the UNFCCC and Kyoto Protocol.

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.

A further review of the uncertainty parameters used within the industrial processes sector has also been carried out; the recommendations from this review were included in the 2011 submission of the NIR. The review followed recommendations from the ERT.

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 a less marked 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 of the Monte Carlo uncertainty analysis used for the UK NIR. This review was commissioned following suggestions from a UNFCCC 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 UNFCCC comments from the Third Centralised Review, from recommendations made at the EU workshop on uncertainties in Greenhouse Gas Inventories[5], and by the IPCC 2006 Guidelines. A range of changes were made to the model to simplify its structure and review and improve the correlations used.

A7.1.2.1 Method Changes

A number of changes have been introduced to the Monte Carlo model, and these are listed below.

A7.1.2.1.1 Change of Simulation Method

Following recommendations in the 2006 IPCC Guidelines, the model now uses a true Monte Carlo sampling method as opposed to the Latin Hypercube method used previously. The revision makes very little difference to the uncertainties estimated by the model.

A7.1.2.1.2 Treatment of Zero Emissions

The original Monte Carlo model contained a number of sources where the emissions were zero, but uncertainties were still allocated to the activity data and emission factors. These zero emissions existed for several reasons:

- Emissions occurred in 1990 but were absent in later years;
  - The activity had been banned (for example, burning of agricultural straw residues);
  - Emissions had been transferred to another sector (for example MSW emissions from waste to IPCC category 6C to 1A1a.); and
- Because data had been included in the analysis for completeness where either the emission factor or the activity data were zero thus leading to a zero emission.

The estimated uncertainties were unaffected when the ‘zero emissions’ were removed from the model.

[5] 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).

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

Two changes to the uncertainty parameters have been introduced into the model for the 2013 submission:

- Based on new information from the main plant operator in the UK for HFC and HCFC production, the uncertainty estimate for this source has been revised for this submission. An uncertainty estimate of 10% has been applied to the emissions data for this source.
- For OPG use, additional OPG has been introduced into the inventory to cover use at petrochemical plants and to remove discrepancies between ETS and the UK energy statistics for refineries. Since the total now deviates from the energy statistics it is no longer appropriate to apply an uncertainty estimate based on the statistical difference from the energy statistics. An uncertainty estimate of 20% has been applied to the activity data in 2011 and 50% in 1990.

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 and after 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 2011 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 sections present the uncertainties in emissions, and the trend in emissions according to gas.

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), and the activity data uncertainty is estimated at 5%, based on expert judgment. 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 2010, 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 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 now based on new data supplied by one of the UK's suppliers of petroleum coke as fuel. The uncertainty parameters for this source have therefore been revised accordingly, since this source is considered to be less uncertain than the previously used data source.

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			2011		
Fuel		Activity uncertainty (%)	Emission factor uncertainty (%)	Uncertainty in emission (%)	Activity uncertainty (%)	Emission factor uncertainty (%)	Uncertainty in emission (%)
Anthracite		1.5	6	‡	0.2	6	‡
Aviation spirit		20	3.3	‡	20	3.3	‡
Aviation turbine fuel		20	3.3	‡	20	3.3	‡
Blast furnace gas		1.5	6	‡	0.2	6	‡
Burning oil		6	2	‡	0.9	2	‡
Chemical waste		50	100	‡	50	100	‡
Clinical waste		7	20	‡	7	20	‡
Clinker production		5	5	‡	5	5	‡
Coal		1.5	1	‡	0.2	1	‡
Coke		3	3	‡	0.2	3	‡
Coke oven gas		1.5	6	‡	0.2	6	‡
Colliery methane		5	5	‡	5	5	‡
DERV		1.8	2.1	‡	0.3	2.1	‡
Dolomite – glass		20	5	‡	20	5	‡
Dolomite – sinter, BOF		5	5	‡	5	5	‡
Exploration drilling		1	28	‡	1	28	‡
Fuel oil		5.5	1.7	‡	1.6	1.7	‡
Fletton bricks		20	70	‡	20	70	‡
Gas oil		1.8	1.4	‡	0.3	1.4	‡
Limestone – glass and lime		10	5	‡	15	5	‡
Limestone - sinter		5	5	‡	5	5	‡
LPG		25.7	3	‡	0.6	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	1.5	‡
OPG		50	20	‡	20	5	‡
Orimulsion		1	2	‡	not used	not used	‡
Peat		25	25	‡	25	25	‡
Petrol		1	4.8	‡	0.4	4.8	‡
Petroleum coke	1A1a	not used	not used	‡	0.75	3	‡
	1A1b	7.8	3	‡	‡	‡	5
	1A2f	25	3	‡	0.75	3	‡
	1A4b	20	3	‡	20	3	‡
Petroleum waxes		50	100	‡	50	100	‡
Refinery miscellaneous		11.9	3	‡	not used	not used	‡

	1990			2011		
Fuel	Activity uncertainty (%)	Emission factor uncertainty (%)	Uncertainty in emission (%)	Activity uncertainty (%)	Emission factor uncertainty (%)	Uncertainty in emission (%)
Soda ash	25	2	‡	15	2	‡
Scrap tyres	15	10	‡	15	10	‡
SSF	3.3	3	‡	1	3	‡
Waste	not used	not used		1	50	‡
Waste oils	20	5	‡	20	5	‡
Waste solvent	1	50	‡	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			2011		
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	2.8	1.5		0.1	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	50	100	-	50	100	-
	Carbon in pesticides	50	100	-	50	100	-
	Gypsum produced	n/a	n/a	-	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 at approximately **2% in 2011**.

The central estimate of total CO_2 emissions in 2011 was estimated as 460,656 Gg. The Monte Carlo analysis suggested that 95% of the values were between 452,992 Gg and 468,249 Gg.

A7.2.1.4 Uncertainty in the Trend

The uncertainty in the trend between 1990 and 2011 was estimated. In running this simulation it was necessary to make assumptions about the degree of correlation between sources in 1990 and 2011. 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 2011 were between **20% and 24%** 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			2011		
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	‡

		1990			2011		
Source	Reference	Activity %	Emission Factor %	Source Uncertainty %	Activity %	Emission Factor %	Source Uncertainty %
Town gas			50	‡		50	‡
Lubricants			50	‡		50	‡
Waste oils			50	‡		50	‡
Scrap tyres			50	‡		50	‡
Aviation spirit			50	‡		50	‡
Anthracite			50	‡		50	‡
Burning oil (premium)			50	‡		50	‡
Vaporising oil			50	‡		50	‡
Clinical waste			50	‡		50	‡
Poultry litter			50	‡		50	‡
Landfill gas			50	‡		50	‡
Sewage gas			50	‡		50	‡
Wood			50	‡		50	‡
Straw			50	‡		50	‡
Sewage sludge combustion			50	‡		50	‡
Field burning	*	25	50	‡	25	50	‡
Landfill	Brown *et al* 1999	-	-	~48[1]	-	-	~48[1]
Livestock: enteric	Williams, 1993	-	-	20	-	-	20
Livestock: wastes	Williams, 1993	-	-	30.5	-	-	30.5
Coal Mining	Bennett *et al*, 1995	-	-	13.3	-	-	13.3
Offshore	*	16	20	‡	16	20	‡
Gas Leakage	Williams, 1993	-	-	17-75[2]	-	-	17-75[2]
Chemical industry	*	20	20	‡	20	20	‡
Fletton bricks	*	20	100	‡	20	100	‡
Sewage sludge	Hobson *et al*, 1996	-	-	50	-	-	50

Notes

1 Skewed distribution
2 Various uncertainties for different types of main and service
* See text
‡ Input parameters were uncertainties of activity data and emission factors

Fuel combustion uncertainties expressed as 2s/E

Uncertainties in the activity data for fuels burnt are reported in **Table A7.2.1**.

The non-fuel combustion sources are mainly derived from the source documents for the estimates or from the Watt Committee Report (Williams, 1993). The uncertainty in offshore emissions was revised for the 2000 inventory using improved estimates of the activity data. The methane factors were assumed to have an uncertainty of 20% since the flaring factors are based on test measurements.

The sources quoted in **Table 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 approximately **19% in 2011**.

The central estimate of total CH_4 emissions in 2011 was estimated as 42,052 Gg CO_2 equivalent. The Monte Carlo analysis suggested that 95% of the values were between 36,317 and 49,303 Gg CO_2 equivalent.

A7.2.2.4 Uncertainty in the Trend

The uncertainty in the trend between 1990 and 2011 was estimated. In running this simulation it was necessary to make assumptions about the degree of correlation between sources in 1990 and 2011. 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 67% hence the degree of correlation was 33%;
- 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 51% hence the degree of correlation was 49%; 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 2011 were between **46% and 67%** 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.). Work is currently ongoing to refine the uncertainty estimates for this source, it is anticipated that this improvement will be introduced for the 2014 submission.

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			2011		
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]

	1990			2011		
Source	Activity %	Emission Factor %	Source Uncertainty %	Activity %	Emission Factor %	Source Uncertainty %
Adipic Acid	2	100		n/a	n/a	
Nitric Acid	10	100		2	50	

Notes

1 Expressed as 2s/E

2 With 97.5 percentile 100 times the 2.5 percentile and the mean of 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 central estimate of total N_2O emissions in 2011 was estimated as 34,424 Gg CO_2 equivalent. The Monte Carlo analysis suggested that 95% of the values were between 7,694 and 103,833 Gg CO_2 equivalent.

A7.2.3.4 Uncertainty in the Trend

The uncertainty in the trend between 1990 and 2011 was also estimated. In running this simulation it was necessary to make assumptions about the degree of correlation between sources across years. 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 2011 compared with 1990 – only 4 of the original 8 sites are still operating in the latest inventory year, all of which now have differing levels of abatement fitted.

This analysis indicates that there is a 95% probability that N_2O emissions in 2011 were between **32% and 79%** 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), for all sources except for refrigeration and air conditioning, and HFC/HCFC manufacture. For these sources, the uncertainty parameters were taken from ICF, 2011 and information from the HFC/HCFC plant operator.

A7.2.4.2 Uncertainty in the Emissions

The uncertainties were estimated as

1990 (1995)

- 10% (9%) for HFCs,
- 5% (7%) for PFCs
- 17% (17%) for SF_6

2011

- 7% for HFCs
- 17% for PFCs
- 7% for SF_6

A7.2.4.3 Uncertainty in the Trend

This analysis indicates that there is a 95% probability that emissions in 2011 differed from those in 1990 by the following percentages

- +17% to +42% for HFCs
- -73% to -80% for PFCs
- -28% to -52% 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 **17%** in 2011.

A7.3.2 Uncertainty in the Trend

This analysis indicates that there is a 95% probability that the total GWP GHG emissions in 2011 were between 26% and 31% 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

IPCC Source Category	Gas	1990 Emissions	2011 Emissions	Uncertainty in 1990 emissions as % of emissions in category		Uncertainty introduced on national total in 1990	Uncertainty in 2011 emissions as % of emissions in category		Uncertainty introduced on national total in 2011	% change in emissions between 2011 and 1990	Range of likely % change between 2011 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	%	%	%	%
TOTAL	CO_2 (net)	593,548	460,656	582,825	604,282	2%	452,992	468,249	2%	-22%	-24%	-20%
	CH_4	98,977	42,052	82,681	120,307	24%	36,317	49,303	19%	-57%	-67%	-46%
	N_2O	67,622	34,424	30,337	153,214		7,694	103,833		-57%	-79%	-32%
	HFC	11,386	14,649	10,443	12,323	10%	13,860	15,439	7%	29%	17%	42%
	PFC	1,402	325	1,347	1,457	5%	281	371	17%	-77%	-80%	-73%
	SF_6	1,029	607	885	1,175	17%	523	692	7%	-41%	-52%	-28%
	All	773,963	552,712	728,175	863,233	15%	521,788	622,359	17%	-29%	-31%	-26%

Notes

Uncertainty calculated as 2s/E where s is the standard deviation and E is the mean, calculated in the simulation.
The uncertainty for N_2O is not quoted because the distribution is highly skewed and the uncertainty 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 SECTORAL UNCERTAINTIES

A7.4.1 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 7.4.1**. We recommend that the estimates in the table are taken only as indicative, since the uncertainties for fuels are based on the overall statistical difference for the fuel total and does not take into account additional uncertainty at sector level. The estimates are presented in IPCC categories, which is consistent with the reporting format used within this submission to the UNFCCC.

A7.4.2 Review of Changes made to the Monte Carlo Model since the last NIR

No changes that are specific to the sectoral uncertainty analysis have been made. The changes made to the uncertainty parameters used to estimate the uncertainties by gas are all reflected within the sectoral analysis.

Table A 7.4.1 Sectoral Uncertainty Estimates

IPCC Source Category	Gas	1990 Emissions	2011 Emissions	Uncertainty in 2011 emissions as % of emissions in category		Uncertainty Introduced on national total in 2011	% change in emissions between 1990 and 2011	Range of likely % change between 1990 and 2011	
				2.5 percentile	97.5 percentile			2.5 percentile	97.5 percentile
1A1a	GWP weighted total	205,936	146,416	145,193	147,756	1%	-29%	-30%	-28%
1A1b	GWP weighted total	17,687	17,597	16,055	19,164	11%	1%	-18%	23%
1A1c	GWP weighted total	14,165	16,146	15,924	16,382	2%	14%	10%	19%
1A2a	GWP weighted total	24,016	12,740	12,283	13,200	4%	-47%	-50%	-44%
1A2f	GWP weighted total	55,428	39,449	38,758	40,195	2%	-29%	-31%	-26%
1A3a	GWP weighted total	1,600	1,953	1,641	2,269	20%	23%	-3%	54%
1A3b	GWP weighted total	110,634	109,222	107,205	111,227	2%	-1%	-5%	2%
1A3c	GWP weighted total	1,461	2,085	2,061	2,109	1%	43%	40%	46%
1A3d	GWP weighted total	2,294	2,449	2,423	2,476	1%	7%	4%	10%
1A3e	GWP weighted total	254	499	466	549	11%	97%	74%	122%
1A4a	GWP weighted total	25,049	16,139	15,952	16,326	1%	-36%	-37%	-34%
1A4b	GWP weighted total	79,668	65,633	64,941	66,327	1%	-18%	-19%	-16%
1A4c	GWP weighted total	5,837	4,787	4,514	5,200	9%	-18%	-26%	-9%
1A5b	GWP weighted total	5,337	2,776	2,450	3,106	14%	-48%	-56%	-38%
1B1a	GWP weighted total	17,206	1,593	1,444	1,744	11%	-91%	-92%	-89%
1B1b	GWP weighted total	878	274	267	280	3%	-69%	-70%	-68%
1B1c	GWP weighted total	1,075	388	345	431	13%	-64%	-69%	-58%
1B2a	GWP weighted total	1,269	485	419	551	17%	-61%	-69%	-53%
1B2b	GWP weighted total	9,542	4,183	4,129	4,238	2%	-56%	-57%	-55%
1B2ci	GWP weighted total	885	599	480	726	25%	-31%	-50%	-8%
1B2cii	GWP weighted total	4,484	4,000	3,522	4,489	15%	-10%	-25%	6%
2A1	GWP weighted total	7,292	4,096	3,862	4,337	7%	-44%	-48%	-39%

IPCC Source Category	Gas	1990 Emissions	2011 Emissions	Uncertainty in 2011 emissions as % of emissions in category		Uncertainty Introduced on national total in 2011	% change in emissions between 1990 and 2011	Range of likely % change between 1990 and 2011	
				2.5 percentile	97.5 percentile			2.5 percentile	97.5 percentile
2A2	GWP weighted total	1,436	1,135	988	1,283	16%	-21%	-33%	-7%
2A3	GWP weighted total	1,125	922	863	980	8%	-18%	-26%	-9%
2A7	GWP weighted total	580	493	444	548	13%	-14%	-30%	2%
2B1	GWP weighted total	1,431	643	635	650	1%	-55%	-56%	-54%
2B2	GWP weighted total	3,924	207	121	291	50%	-94%	-97%	-89%
2B3	GWP weighted total	20,658	0	0	0	n/a	-100%	-100%	-100%
2B5	GWP weighted total	1,730	1,987	1,083	3,262	70%	25%	-46%	134%
2C1	GWP weighted total	1,886	1,071	1,020	1,123	6%	-43%	-47%	-39%
2C3	GWP weighted total	1,783	491	460	521	7%	-72%	-74%	-71%
2E1	GWP weighted total	11,374	73	67	79	10%	-99%	-99%	-99%
2E2	GWP weighted total	11	87	77	98	15%	706%	571%	858%
2F1	GWP weighted total	0	11,219	10,552	11,881	7%	0%	n/a	n/a
2F2	GWP weighted total	0	312	235	389	30%	0%	n/a	n/a
2F3	GWP weighted total	0	207	173	241	20%	0%	n/a	n/a
2F4	GWP weighted total	12	2,717	2,295	3,136	19%	22947%	18269%	28254%
2F5	GWP weighted total	0	107	85	129	25%	0%	n/a	n/a
2F9	GWP weighted total	662	608	518	699	18%	-7%	-26%	14%
4A1	GWP weighted total	13,666	11,670	9,764	13,597	20%	-14%	-33%	8%
4A10	GWP weighted total	9	6	5	7	20%	-30%	-46%	-13%
4A3	GWP weighted total	4,811	3,427	2,869	3,994	20%	-28%	-44%	-10%
4A4	GWP weighted total	11	11	9	13	20%	0%	-22%	25%
4A6	GWP weighted total	78	120	100	139	20%	55%	21%	94%
4A8	GWP weighted total	238	140	117	163	20%	-41%	-53%	-26%

IPCC Source Category	Gas	1990 Emissions	2011 Emissions	Uncertainty in 2011 emissions as % of emissions in category		Uncertainty Introduced on national total in 2011	% change in emissions between 1990 and 2011	Range of likely % change between 1990 and 2011	
				2.5 percentile	97.5 percentile			2.5 percentile	97.5 percentile
4B1	GWP weighted total	1,687	1,699	1,274	2,126	31%	3%	-30%	44%
4B3	GWP weighted total	114	81	61	101	30%	-27%	-51%	2%
4B4	GWP weighted total	0	0	0	0	30%	2%	-31%	43%
4B6	GWP weighted total	6	9	7	12	30%	57%	6%	120%
4B8	GWP weighted total	1,497	512	384	640	30%	-65%	-76%	-51%
4B9	GWP weighted total	169	256	192	320	30%	56%	5%	119%
4B10	GWP weighted total	0	0	0	0	31%	-29%	-52%	-1%
Agriculture - N2O	GWP weighted total	34,816	28,365	2,137	97,305	336%	-18%	-20%	-17%
5A	GWP weighted total	-11,940	-10,148	-12,279	-8,047	-25%	-14%	-37%	14%
5B	GWP weighted total	16,532	11,983	7,271	16,630	48%	-24%	-60%	25%
5C	GWP weighted total	-6,296	-8,474	-11,939	-5,732	-45%	45%	-23%	141%
5D	GWP weighted total	485	402	236	570	51%	-10%	-56%	54%
5E	GWP weighted total	6,947	6,327	3,748	8,900	50%	-6%	-49%	47%
5G	GWP weighted total	-1,710	-3,400	-4,237	-2,562	-30%	104%	39%	185%
6A1	GWP weighted total	42,993	14,165	8,889	21,138	54%	-65%	-82%	-39%
6B1	GWP weighted total	1,373	1,267	740	1,790	50%	0%	-51%	75%
6B2	GWP weighted total	1,465	1,561	441	4,451	251%	11%	-14%	48%
6C	GWP weighted total	1,485	344	234	499	49%	-77%	-85%	-65%
Grand Total	GWP weighted total	773,852	552,714	521,935	622,292	17%	-29%	-31%	-26%

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.

A7.5 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.

A7.5.1 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[6] for fuel categories presented in the 1996 DTI DUKES. We have now chosen to use a 5-year rolling average since this is a time period short enough to allow a satisfactory estimate of the change in the variability in the supply and demand, but avoids the sometimes large year-to-year variability that can be a feature of the UK energy statistics.

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

[6] We have assumed that the distribution of errors in the parameter values was normal. The quoted range of possible error of uncertainty is taken as 2s, where s is the standard deviation. If the expected value of a parameter is E and the standard deviation is s, then the uncertainty is quoted as 2s/E expressed as a percentage. For a normal distribution the probability of the parameter being less than E-2s is 0.025 and the probability of the emission being less than E+2s is 0.975.

The uncertainty between supply and demand has been estimated for the following fuels:

- Coal
- Coke
- Petroleum coke
- Solid smokeless fuel
- Burning oil
- Fuel oil
- Gas oil
- Petrol
- Natural gas
- LPG
- OPG
- Naphtha
- Miscellaneous
- Blast furnace gas
- Coke oven gas

- In a few cases in this uncertainty analysis, types of fuels are grouped into one class: for example, oil in IPCC sector 1A used in stationary combustion; this oil is a combination of burning oil (minimal quantities used), fuel oil, and gas oil. In this case, and in other instances like it, we have used expert judgement to assign an uncertainty to a fuel class from the estimated uncertainties associated with individual fuels of that class. The uncertainties in the consumption of Aviation Turbine Fuel and Aviation Spirit has been reviewed and this is discussed below;

- We have reviewed the uncertainties associated with the emissions of HFC, PFC and SF_6 from industrial processes. The uncertainties associated with the total F-gas emissions has been assigned to the EF in the error propagation analysis since uncertainties are not known individually for the ADs and EFs as the emissions are produced from a model. The uncertainties used are weighted values, and reflect the individual uncertainties and the magnitude of emissions in each of the respective sectors;

- The LULUCF sectoral experts, CEH, have revised the uncertainties associated with emissions associated with Land Use Change and Forestry. The uncertainties associated with the emissions in each LULUCF category have been assigned to the EF in the error propagation analysis, since uncertainties are not known individually for the ADs and EFs as emissions are produced from a complicated model;

- We have reviewed the uncertainties associated with the consumptions of Aviation Turbine Fuel and Aviation Spirit

  For this review we contacted 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.

A7.5.2 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.

A7.5.3 Uncertainty in the Emissions

The error propagation analysis, **including** LULUCF emissions, suggests an uncertainty of 21% in the combined GWP total emission in the latest reported year.

The error propagation analysis, **excluding** LULUCF emissions, suggests an uncertainty of 21% in the combined GWP total emission in the latest reported year.

A7.5.4 Uncertainty in the Trend

The analysis, **including** LULUCF emissions, estimates an uncertainty of 3.3% in the trend between the base year and the latest reported year.

The analysis, **excluding** LULUCF emissions, estimates an uncertainty of 3.2% in the trend between the base year and the latest reported year.

A7.5.5 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**.

A7.5.6 Tables of uncertainty estimates from the error propagation approach

See overleaf.

Table A 7.5.1 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 2011 Gg CO2 equiv	Activity data uncertainty %	Emission factor uncertainty %	Combined uncertainty %	Combined uncertainty range as % of national total in year t %	Type A sensitivity %	Type B sensitivity %	Uncertainty in trend in national emissions introduced by emission factor uncertainty %	Uncertainty in trend in national emissions introduced by activity data uncertainty %	Uncertainty introduced trend in total emissions by source category %
	A	B	C	D	E	F	G	H	I	J	K	L	M
1A	Coal	CO2	247708	113724	0.4	1	1.077	0.221435	-0.080186	0.146293	-0.080186	0.082756	0.115232
1A(stationary)	Oil	CO2	96117	54196	15	2	15.133	1.482689	-0.018239	0.069717	-0.036478	1.478918	1.479368
1A	Natural Gas	CO2	107749	163701	0.2	1.5	1.513	0.447852	0.111802	0.210583	0.167703	0.059562	0.177966
1A	Other (waste)	CO2	235	2162	7	20	21.190	0.082832	0.002566	0.002782	0.051329	0.027536	0.058248
1A	Lubricant	CO2	387	191	30	2	30.067	0.010408	-0.000108	0.000246	-0.000216	0.010450	0.010452
1A	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1A3a	Aviation Fuel	CO2	1580	1935	20	3.3	20.270	0.070913	0.001043	0.002489	0.003441	0.070407	0.070491
1A3b	Auto Fuel	CO2	108565	108211	2.8	3.5	4.482	0.876853	0.039773	0.139201	0.139206	0.551208	0.568514
1A3c	Coal	CO2	0	41	0.4	6	6.013	0.000443	0.000052	0.000052	0.000315	0.000030	0.000316
1A3d	Marine Fuel	CO2	2168	2360	1.7	1.4	2.202	0.009397	0.001052	0.003036	0.001472	0.007300	0.007447
1A3	Other Diesel	CO2	1680	2477	1.7	2.1	2.702	0.012101	0.001649	0.003187	0.003463	0.007662	0.008408
1A4	Peat	CO2	476	48	30	10	31.623	0.002739	-0.000374	0.000062	-0.003737	0.002615	0.004561
1A4	Petroleum Coke	CO2	77	338	20	3	20.224	0.012346	0.000364	0.000434	0.001092	0.012286	0.012335
1A4	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1B	Solid Fuel Transformation	CO2	856	258	0.4	6	6.013	0.002808	-0.000452	0.000332	-0.002710	0.000188	0.002717
1B	Oil & Natural Gas	CO2	5778	4103	16	6	17.088	0.126743	-0.000011	0.005278	-0.000066	0.119419	0.119419
2A1	Cement Production	CO2	7295	4096	1	5	5.099	0.037754	-0.001409	0.005268	-0.007045	0.007451	0.010254
2A2	Lime Production	CO2	1436	1135	1	5	5.099	0.010462	0.000146	0.001460	0.000728	0.002065	0.002189
2A3	Limestone & Dolomite use	CO2	1125	922	5	5	7.071	0.011783	0.000156	0.001186	0.000778	0.008384	0.008420
2A7	Other Mineral Use	CO2	556	488	20	25	32.016	0.028239	0.000118	0.000628	0.002957	0.017751	0.017996
2B	Ammonia Production	CO2	1431	643	10	1.5	10.112	0.011746	-0.000483	0.000827	-0.000725	0.011689	0.011712
2B5	Non-energy use of products	CO2	1563	1917	50	100	111.803	0.387505	0.001036	0.002466	0.103559	0.174386	0.202818
2C1	Iron&Steel Production	CO2	2309	1384	1.2	6	6.119	0.015307	-0.000334	0.001780	-0.002002	0.003021	0.003624
5A	5A LUCF	CO2	-12002	-10222	1	25	25.020	-0.462352	-0.002163	-0.013149	-0.054086	-0.018595	0.057194
5B	5B LUCF	CO2	15753	11454	1	50	50.010	1.035591	0.000315	0.014735	0.015772	0.020838	0.026133
5C	5C LUCF	CO2	-6313	-8484	1	70	70.007	-1.073813	-0.005136	-0.010914	-0.359553	-0.015435	0.359884
5D	5D LUCF	CO2	482	403	1	50	50.010	0.036406	0.000077	0.000518	0.003853	0.000733	0.003922
5E	5E LUCF	CO2	6943	6320	1	50	50.010	0.571392	0.001775	0.008130	0.088745	0.011497	0.089487
5G	5G LUCF	CO2	-1711	-3402	1	30	30.017	-0.184601	-0.002810	-0.004376	-0.084307	-0.006189	0.084534
6C	Waste Incineration	CO2	1292	290	40	50	64.031	0.033544	-0.000810	0.000373	-0.040508	0.021086	0.045668
		CO2 Total	593,535.72	460,687.46									
1A	All Fuel	CH4	2074.54888	1023.931482	0.4	50	50.002	0.092559	-0.000582	0.001317	-0.029085	0.000745	0.029095
1A3a	Aviation Fuel	CH4	3.29913401	1.168204466	20	50	53.852	0.000114	-0.000002	0.000002	-0.000076	0.000043	0.000087
1A3b	Auto Fuel	CH4	634.5055988	61.07460148	2.8	50	50.078	0.005529	-0.000502	0.000079	-0.025111	0.000311	0.025112
1A3c	Coal	CH4	0	0.802802468	0.4	50	50.002	0.000073	0.000001	0.000001	0.000052	0.000001	0.000052
1A3d	Marine Fuel	CH4	1.86600767	4.064767145	1.7	50	50.029	0.000368	0.000004	0.000005	0.000176	0.000013	0.000176
1A3	Other Diesel	CH4	2.311216186	2.41187971	1.7	50	50.029	0.000218	0.000001	0.000003	0.000049	0.000007	0.000050
1B1	Coal Mining	CH4	17656.026	1980.346	0.4	13	13.006	0.046565	-0.013610	0.002547	-0.176936	0.001441	0.176942
	Solid Fuel Transformation	CH4	4.043	3.280	0.4	50	50.002	0.000297	0.000001	0.000004	0.000026	0.000002	0.000026
	Wood	CH4	0.086	3.212	10	50	50.990	0.000296	0.000004	0.000004	0.000203	0.000058	0.000211
1B2	Natural Gas Transmission	CH4	8541.423	4016.151	1	15	15.033	0.109152	-0.002652	0.005166	-0.039774	0.007306	0.040439
	Offshore Oil& Gas	CH4	1817.038	1087.940	16	20	25.612	0.050376	-0.000264	0.001400	-0.005273	0.031667	0.032103
2A7	Other Mineral Use	CH4	23.602	5.186	20	100	101.980	0.000956	-0.000015	0.000007	-0.001493	0.000189	0.001505
2B	Chemical Industry	CH4	169.425	72.844	20	20	28.284	0.003725	-0.000061	0.000094	-0.001227	0.002650	0.002921
2C	Iron & Steel Production	CH4	16.357	8.937	0.4	50	50.002	0.000808	-0.000003	0.000011	-0.000174	0.000007	0.000174
4A	Enteric Fermentation	CH4	18835.167	15376.703	0.1	20	20.000	0.555987	0.002539	0.019780	0.050788	0.002797	0.050865
4B	Manure Management	CH4	3475.662	2560.206	0.1	30	30.000	0.138856	0.000112	0.003293	0.003361	0.000466	0.003393
4F	Field Burning	CH4	265.912	0.000	25	50	55.902	0.000000	-0.000243	0.000000	-0.012170	0.000000	0.012170
5A	5A LUCF	CH4	4.300	7.032	1	20	20.025	0.000255	0.000005	0.000009	0.000102	0.000013	0.000103
5B	5B LUCF	CH4	0.143	0.289	1	50	50.010	0.000026	0.000000	0.000000	0.000012	0.000001	0.000012
5C2	5C2 LUCF	CH4	13.025	14.035	1	20	20.025	0.000508	0.000006	0.000018	0.000123	0.000026	0.000125
5E2	5E2 LUCF	CH4	6.643	7.143	1	20	20.025	0.000259	0.000003	0.000009	0.000062	0.000013	0.000063
6A	Solid Waste Disposal	CH4	43145.944	14171.059	15	46	48.384	1.239563	-0.021251	0.018229	-0.977567	0.386705	1.051275
6B	Wastewater Handling	CH4	1685.617	1639.922	1	50	50.010	0.148267	0.000567	0.002110	0.028333	0.002983	0.028490
6C	Waste Incineration	CH4	134.433	6.160	7	50	50.488	0.000562	-0.000115	0.000008	-0.005756	0.000078	0.005757
		CH4 total	98,511.38	42,053.90									

Table A 7.5.2 Summary of error propagation uncertainty estimates including LULUCF, base year to the latest reported year (continued)

	Source Category	Gas	BaseYear Emissions 1990 & 1995	Year Y emissions 2011	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
			Gg CO2 equiv	Gg CO2 equiv	%	%	%	%	%	%	%	%	%
	A	B	C	D	E	F	G	H	I	J	K	L	M
1A1&1A2&1A4&1A5	Other Combustion	N2O	4709.918	3001.375	0.4	195	195.000	1.058087	-0.000450	0.003861	-0.087783	0.002184	0.087810
1A3a	Aviation Fuel	N2O	15.559	19.050	20	170	171.172	0.005895	0.000010	0.000025	0.001745	0.000693	0.001878
1A3b	Auto Fuel	N2O	1179.802	848.165	2.8	170	170.023	0.260708	0.000011	0.001091	0.001897	0.004320	0.004719
1A3c	Coal	N2O	0.000	0.095	0.4	118	118.001	0.000020	0.000000	0.000000	0.000014	0.000000	0.000014
1A3d	Marine Fuel	N2O	16.912	18.381	1.7	170	170.008	0.005650	0.000008	0.000024	0.001388	0.000057	0.001389
1A3	Other Diesel	N2O	32.630	62.044	1.7	140	140.010	0.015705	0.000050	0.000080	0.006992	0.000192	0.006995
1B1	Coke Oven Gas	N2O	2.085	1.692	0.4	118	118.001	0.000361	0.000000	0.000002	0.000032	0.000001	0.000032
1B2	Oil & Natural Gas	N2O	42.396	60.718	16	110	111.158	0.012202	0.000039	0.000078	0.004323	0.001767	0.004670
2B	Adipic Acid Production	N2O	20737.345	0.000	2	100	100.020	0.000000	-0.018976	0.000000	-1.897642	0.000000	1.897642
2B	Nitric Acid Production	N2O	3903.850	206.770	10	100	100.499	0.037568	-0.003307	0.000266	-0.330715	0.003762	0.330737
2C	Iron & Steel	N2O	11.107	6.145	0.4	118	118.001	0.001311	-0.000002	0.000008	-0.000267	0.000004	0.000267
4B	Manure Management	N2O	2046.904	1721.945	1	414	414.001	1.288804	0.000341	0.002215	0.141376	0.003133	0.141411
4D	Agricultural Soils	N2O	33449.622	27015.695	1	424	424.001	20.708515	0.004133	0.034753	1.752582	0.049148	1.753271
4F	Field Burning	N2O	79.312	0.000	25	230	231.355	0.000000	-0.000073	0.000000	-0.016697	0.000000	0.016697
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	57.216	63.328	1	20	20.025	0.002293	0.000029	0.000081	0.000582	0.000115	0.000593
5B	5B LUCF	N2O	769.952	518.488	1	50	50.010	0.046877	-0.000038	0.000667	-0.001889	0.000943	0.002111
5C2	5C2 LUCF	N2O	14.431	10.072	1	20	20.025	0.000365	0.000000	0.000013	-0.000005	0.000018	0.000019
5D2	5D2 LUCF	N2O	3.982	0.509	1	20	20.025	0.000018	-0.000003	0.000001	-0.000060	0.000001	0.000060
5E2	5E2 LUCF	N2O	0.674	0.725	1	20	20.025	0.000026	0.000000	0.000001	0.000006	0.000001	0.000006
5G	5G LUCF	N2O	0.000	0.000	1	50	50.010	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6B	Wastewater Handling	N2O	1165.049	1205.967	10	401	401.125	0.874542	0.000485	0.001551	0.194457	0.021939	0.195691
6C	Waste Incineration	N2O	56.892	49.763	7	230	230.106	0.020701	0.000012	0.000064	0.002746	0.000634	0.002818
		N2O Total	68,295.64	34,810.93									
2	Industrial Processes	HFC	15328	14654	1	15	15.033	0.398266	0.004820	0.018851	0.072295	0.026659	0.077054
2	Industrial Processes	PFC	462	325	1	22	22.023	0.012952	-0.000004	0.000418	-0.000093	0.000592	0.000599
2	Industrial Processes	SF6	1239	607	1	17	17.029	0.018702	-0.000353	0.000781	-0.005999	0.001105	0.006100
		Halocarbon & SF6 Total	17,028.89	15,586.69									
	TOTALS	GWP	777,371.62	553,138.98									
	Total Uncertainties%							21.0					3.28

Table A 7.5.3 Summary of error propagation uncertainty estimates excluding LULUCF, base year to the latest reported year

	Source Category	Gas	BaseYear Emissions 1990 & 1995	Year Y emissions 2011	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
	(Analysis without LULUCF)												
			Gg CO2 equiv	Gg CO2 equiv	%	%	%	%	%	%	%	%	%
	A	B	C	D	E	F	G	H	I	J	K	L	M
1A	Coal	CO2	247708	113724	0.4	1	1.077	0.220118	-0.083150	0.147054	-0.083150	0.083186	0.117617
1A(stationary)	Oil	CO2	96117	54196	15	2	15.133	1.473871	-0.019324	0.070079	-0.038648	1.486610	1.487112
1A	Natural Gas	CO2	107749	163701	0.2	1.5	1.513	0.445189	0.111272	0.211678	0.166909	0.059872	0.177322
1A	Other (waste)	CO2	235	2162	7	20	21.190	0.082340	0.002577	0.002796	0.051547	0.027679	0.058508
1A	Lubricant	CO2	387	191	30	2	30.067	0.010346	-0.000112	0.000248	-0.000225	0.010505	0.010507
1A	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1A3a	Aviation Fuel	CO2	1580	1935	20	3.3	20.270	0.070492	0.001032	0.002502	0.003405	0.070773	0.070855
1A3b	Auto Fuel	CO2	108565	108211	2.8	3.5	4.482	0.871638	0.038861	0.139925	0.136014	0.554075	0.570525
1A3c	Coal	CO2	0	41	0.4	6	6.013	0.000440	0.000053	0.000053	0.000316	0.000030	0.000318
1A3d	Marine Fuel	CO2	2168	2360	1.7	1.4	2.202	0.009341	0.001035	0.003052	0.001449	0.007338	0.007479
1A3	Other Diesel	CO2	1680	2477	1.7	2.1	2.702	0.012029	0.001640	0.003203	0.003445	0.007701	0.008437
1A4	Peat	CO2	476	48	30	10	31.623	0.002723	-0.000381	0.000062	-0.003805	0.002628	0.004625
1A4	Petroleum Coke	CO2	77	338	20	3	20.224	0.012273	0.000365	0.000437	0.001096	0.012350	0.012399
1A4	Combined Fuel	CO2	0	0	15	15	21.213	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1B	Solid Fuel Transformation	CO2	856	258	0.4	6	6.013	0.002791	-0.000463	0.000334	-0.002777	0.000189	0.002784
1B	Oil & Natural Gas	CO2	5778	4103	16	6	17.088	0.125989	-0.000071	0.005305	-0.000424	0.120040	0.120041
2A1	Cement Production	CO2	7295	4096	1	5	5.099	0.037529	-0.001492	0.005296	-0.007458	0.007489	0.010569
2A2	Lime Production	CO2	1436	1135	1	5	5.099	0.010400	0.000132	0.001468	0.000658	0.002075	0.002177
2A3	Limestone & Dolomite use	CO2	1125	922	5	5	7.071	0.011712	0.000145	0.001192	0.000724	0.008427	0.008459
2A7	Other Mineral Use	CO2	556	488	20	25	32.016	0.028071	0.000113	0.000631	0.002829	0.017844	0.018067
2B	Ammonia Production	CO2	1431	643	10	1.5	10.112	0.011676	-0.000501	0.000831	-0.000751	0.011750	0.011774
2B5	Non-energy use of products	CO2	1563	1917	50	100	111.803	0.385200	0.001025	0.002479	0.102485	0.175293	0.203054
2C1	Iron&Steel Production	CO2	2309	1384	1.2	6	6.119	0.015216	-0.000359	0.001789	-0.002156	0.003036	0.003724
5A	5A LUCF	CO2	0	0	1	25	25.020	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5B	5B LUCF	CO2	0	0	1	50	50.010	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5C	5C LUCF	CO2	0	0	1	70	70.007	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5D	5D LUCF	CO2	0	0	1	50	50.010	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5E	5E LUCF	CO2	0	0	1	50	50.010	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5G	5G LUCF	CO2	0	0	1	30	30.017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6C	Waste Incineration	CO2	1292	290	40	50	64.031	0.033345	-0.000828	0.000375	-0.041386	0.021196	0.046498
		CO2 Total	590,383.88	464,618.44									
1A	All Fuel	CH4	2074.54888	1023.931482	0.4	50	50.002	0.092009	-0.000606	0.001324	-0.030307	0.000749	0.030316
1A3a	Aviation Fuel	CH4	3.29913401	1.168204466	20	50	53.852	0.000113	-0.000002	0.000002	-0.000078	0.000043	0.000089
1A3b	Auto Fuel	CH4	634.5055988	61.07460148	2.8	50	50.078	0.005496	-0.000511	0.000079	-0.025569	0.000313	0.025570
1A3c	Coal	CH4	0	0.802802468	0.4	50	50.002	0.000072	0.000001	0.000001	0.000052	0.000001	0.000052
1A3d	Marine Fuel	CH4	1.86600767	4.064767145	1.7	50	50.029	0.000365	0.000004	0.000005	0.000176	0.000013	0.000176
1A3	Other Diesel	CH4	2.311216186	2.41187971	1.7	50	50.029	0.000217	0.000001	0.000003	0.000048	0.000007	0.000049
1B1	Coal Mining	CH4	17656.026	1980.346	0.4	13	13.006	0.046288	-0.013863	0.002561	-0.180224	0.001449	0.180230
	Solid Fuel Transformation	CH4	4.043	3.280	0.4	50	50.002	0.000295	0.000000	0.000004	0.000024	0.000002	0.000024
	Wood	CH4	0.086	3.212	10	50	50.990	0.000294	0.000004	0.000004	0.000204	0.000059	0.000212
1B2	Natural Gas Transmission	CH4	8541.423	4016.151	1	15	15.033	0.108502	-0.002754	0.005193	-0.041303	0.007344	0.041951
	Offshore Oil& Gas	CH4	1817.038	1087.940	16	20	25.612	0.050076	-0.000284	0.001407	-0.005676	0.031832	0.032334
2A7	Other Mineral Use	CH4	23.602	5.186	20	100	101.980	0.000950	-0.000015	0.000007	-0.001525	0.000190	0.001537
2B	Chemical Industry	CH4	169.425	72.844	20	20	28.284	0.003703	-0.000063	0.000094	-0.001269	0.002664	0.002951
2C	Iron & Steel Production	CH4	16.357	8.937	0.4	50	50.002	0.000803	-0.000004	0.000012	-0.000183	0.000007	0.000183
4A	Enteric Fermentation	CH4	18835.167	15376.703	0.1	20	20.000	0.552680	0.002358	0.019883	0.047166	0.002812	0.047250
4B	Manure Management	CH4	3475.662	2560.206	0.1	30	30.000	0.138030	0.000077	0.003311	0.002303	0.000468	0.002350
4F	Field Burning	CH4	265.912	0.000	25	50	55.902	0.000000	-0.000247	0.000000	-0.012370	0.000000	0.012370
5A	5A LUCF	CH4	0.000	0.000	1	20	20.025	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5B	5B LUCF	CH4	0.000	0.000	1	50	50.010	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5C2	5C2 LUCF	CH4	0.000	0.000	1	20	20.025	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5E2	5E2 LUCF	CH4	0.000	0.000	1	20	20.025	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6A	Solid Waste Disposal	CH4	43145.944	14171.059	15	46	48.384	1.232191	-0.021807	0.018324	-1.003117	0.388716	1.075799
6B	Wastewater Handling	CH4	1685.617	1639.922	1	50	50.010	0.147386	0.000552	0.002121	0.027611	0.002999	0.027773
6C	Waste Incineration	CH4	134.433	6.160	7	50	50.488	0.000559	-0.000117	0.000008	-0.005856	0.000079	0.005856
		CH4 total	98,487.27	42,025.40									

Table A 7.5.4 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 2011	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
			Gg CO2 equiv	Gg CO2 equiv	%	%	%	%	%	%	%	%	%
	A	B	C	D	E	F	G	H	I	J	K	L	M
1A1&1A2&1A4&1A5	Other Combustion	N2O	4709.918	3001.375	0.4	195	195.000	1.051794	-0.000501	0.003881	-0.097716	0.002195	0.097741
1A3a	Aviation Fuel	N2O	15.559	19.050	20	170	171.172	0.005860	0.000010	0.000025	0.001727	0.000697	0.001862
1A3b	Auto Fuel	N2O	1179.802	848.165	2.8	170	170.023	0.259157	-0.000001	0.001097	-0.000162	0.004343	0.004346
1A3c	Coal	N2O	0.000	0.095	0.4	118	118.001	0.000020	0.000000	0.000000	0.000014	0.000000	0.000014
1A3d	Marine Fuel	N2O	16.912	18.381	1.7	170	170.008	0.005616	0.000008	0.000024	0.001366	0.000057	0.001367
1A3	Other Diesel	N2O	32.630	62.044	1.7	140	140.010	0.015611	0.000050	0.000080	0.006982	0.000193	0.006984
1B1	Coke Oven Gas	N2O	2.085	1.692	0.4	118	118.001	0.000359	0.000000	0.000002	0.000029	0.000001	0.000029
1B2	Oil & Natural Gas	N2O	42.396	60.718	16	110	111.158	0.012129	0.000039	0.000079	0.004297	0.001777	0.004650
2B	Adipic Acid Production	N2O	20737.345	0.000	2	100	100.020	0.000000	-0.019289	0.000000	-1.928901	0.000000	1.928901
2B	Nitric Acid Production	N2O	3903.850	206.770	10	100	100.499	0.037344	-0.003365	0.000267	-0.336463	0.003781	0.336485
2C	Iron & Steel	N2O	11.107	6.145	0.4	118	118.001	0.001303	-0.000002	0.000008	-0.000282	0.000004	0.000282
4B	Manure Management	N2O	2046.904	1721.945	1	414	414.001	1.281139	0.000322	0.002227	0.133367	0.003149	0.133404
4D	Agricultural Soils	N2O	33449.622	27015.695	1	424	424.001	20.585355	0.003810	0.034933	1.615409	0.049403	1.616164
4F	Field Burning	N2O	79.312	0.000	25	230	231.355	0.000000	-0.000074	0.000000	-0.016972	0.000000	0.016972
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
5B	5B LUCF	N2O	0.000	0.000	1	50	50.010	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
5D2	5D2 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
5G	5G LUCF	N2O	0.000	0.000	1	50	50.010	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6B	Wastewater Handling	N2O	1165.049	1205.967	10	401	401.125	0.869341	0.000475	0.001559	0.190647	0.022053	0.191919
6C	Waste Incineration	N2O	56.892	49.763	7	230	230.106	0.020578	0.000011	0.000064	0.002625	0.000637	0.002701
		N2O Total	67,449.38	34,217.81									
2	Industrial Processes	HFC	15328	14654	1	15	15.033	0.395898	0.004687	0.018949	0.070299	0.026797	0.075233
2	Industrial Processes	PFC	462	325	1	22	22.023	0.012875	-0.000009	0.000421	-0.000199	0.000595	0.000627
2	Industrial Processes	SF6	1239	607	1	17	17.029	0.018591	-0.000368	0.000786	-0.006248	0.001111	0.006346
		Halocarbon & SF6 Total	17,028.89	15,586.69									
	TOTALS	GWP	773,349.42	556,448.33									
	Total Uncertainties%							20.8					3.22

A7.6 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 7.6.1 shows differences in the trend uncertainty between the error propagation and Monte Carlo approaches. These differences probably arise from the improvements that were made to the Monte Carlo approach that have not yet been implemented into the error propagation approach, due to the timing of the updates. Other reasons why the two models do not give identical answers are that the error propagation approach only uses normal distributions, cannot account for different uncertainty parameters between the 1990 and the latest inventory year, cannot account for correlations within years, and automatically assumes a correlation between the emission factor uncertainty in 1990 and 2011.

The central estimates of emissions generated by the Monte Carlo model in 1990, and those in the latest inventory year, are very close. Mathematically we would not expect the central estimates from the two methods to be identical.

Table A 7.6.1 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 2011)
	1990	**2011**	
Error propagation	774,160	553,139	6.6
Monte Carlo	773,963	552,712	5.6[a]

Notes

CI Confidence Interval

[a] 2.5^{th} percentile, -26%, 97.5^{th} percentile, -21%. Difference between these values is the 95% Confidence Interval which assuming a normal distribution is equal to ±2 standard deviations on the central estimate.

[b] Net emissions, including emissions and removals from LULUCF

A8 ANNEX 8: Verification

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

A8.1 MODELLING APPROACH USED FOR THE VERIFICATION OF THE UK GHGI

In order to provide verification of the UK Greenhouse Gas Inventory (GHGI), DECC (Department of Energy and Climate Change) have established and maintained a high-quality remote 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 the University of Bristol (O'Doherty *et al.* 2004). DECC have now extended the measurement programme with three new stations across the UK (UK DECC network).

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 three-dimensional modelled meteorology to interpret the observations. NAME determines the history of the air arriving at Mace Head at the time of each observation. By estimating and removing the underlying *baseline* trends (Northern Hemisphere mid-latitude atmospheric concentrations where the short-term impact of regional pollution have been removed from the data) from the observations and by modelling where the air has passed over on route to Mace Head on a regional scale, estimates of UK emissions are made. A methodology called Inversion Technique for Emission Modelling (InTEM) has been developed that uses an iterative best-fit technique which searches a set of random emission maps to determine the one that most accurately mimics the Mace Head observations [Manning et al 2003, 2011].

In the work presented here both the NAME *baseline* trends and the UK emission estimates are presented. The 'top-down' InTEM estimates of UK emissions are compared to the 'bottom-up' GHGI estimates.

A8.2 METHANE

Figure A.8.2.1 shows the baseline atmospheric concentration of methane from 1990 onwards. The underlying trend is positive but there is strong year to year variability and a strong seasonal cycle.

In Figure A.8.2.2 the emission estimates made for the UK with the InTEM methodology are compared to the GHGI emission estimates for the period 1990 onwards.

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 (<5%, Bergamaschi *et al* 2005). 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 median of the InTEM estimates, after a rapid fall, shows only a very modest decline from 1992 onwards (**Figure A .8.1.2**). Except for a single year the uncertainties overlap and since 2000 the agreement is excellent. Prior to 2000 the GHGI estimates are larger than the median InTEM estimates.

Figure A 8.2.1 Monthly Northern Hemisphere trend in methane estimated from Mace Head observations (ppb). Red line denotes the de-seasonalised long-term trend. May 2012 data onwards are not yet ratified.

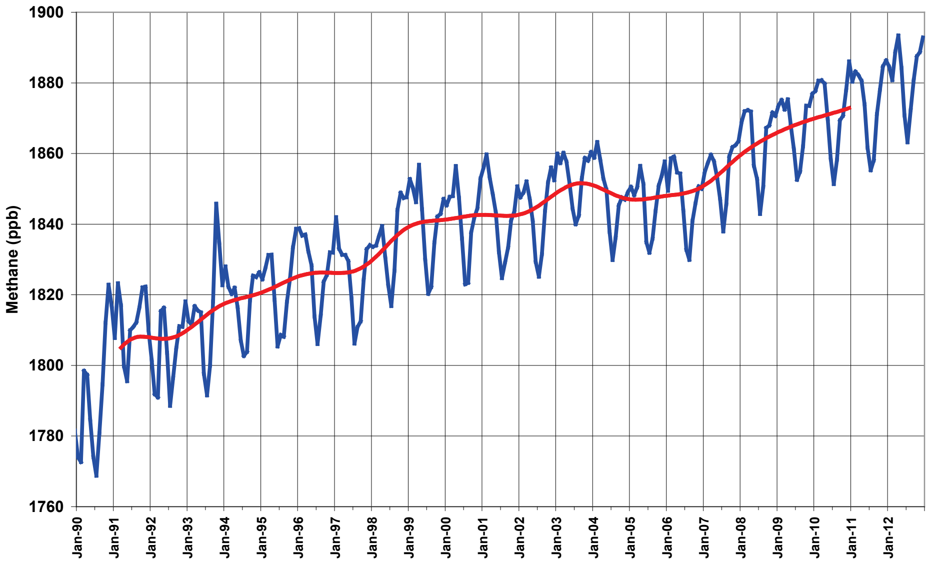
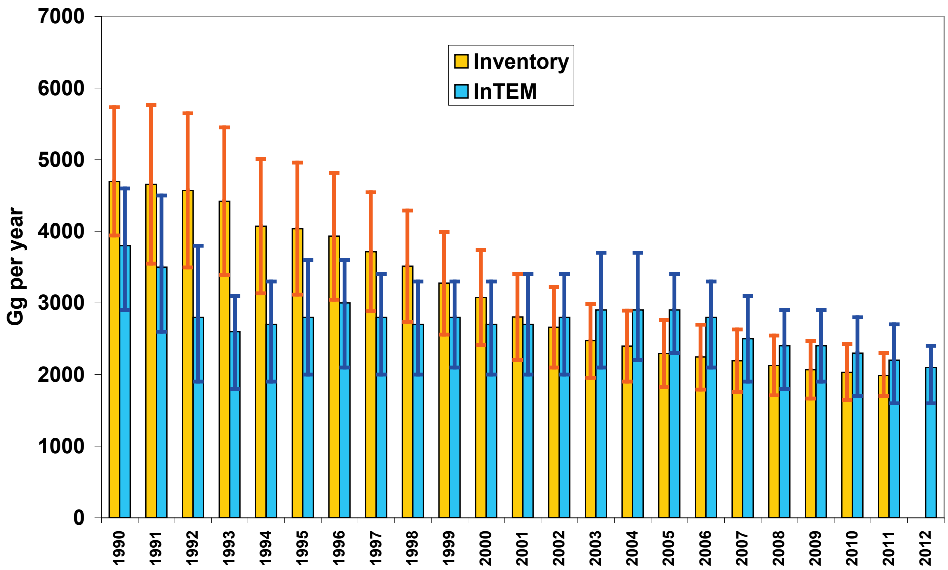


Figure A 8.2.2 Verification of the UK emission inventory estimates for methane in Gg yr^{-1} for 1990-2012. GHGI estimates are shown in orange. InTEM estimates are shown in blue. InTEM and GHGI uncertainties are shown as whisker lines.



A8.3 NITROUS OXIDE

Figure A 8.3.1 shows the baseline atmospheric concentration of nitrous oxide from 1990 onwards. The annual trend is monotonic and positive at ~0.7 ppb/yr.

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.

Figure A 8.3.2 shows the InTEM and GHGI emission estimates for the UK for nitrous oxide for the period 1990 onwards. The median InTEM estimates are approximately 10-40 kt lower than the most likely GHGI estimates throughout the whole time period, however given the significant uncertainties in the estimates, especially in the GHGI, the agreement is very good. The trends in the time-series are in excellent agreement. Both show declining UK totals. 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 InTEM estimates, with a longer averaging period, show a more gradual decline from 1998 to 2003 but the overall reduction is similar.

The nature of the nitrous oxide emissions challenges the InTEM 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.

Figure A 8.3.1 Monthly Northern Hemisphere trend in nitrous oxide estimated from Mace Head observations (ppb). Red line denotes the de-seasonalised long-term trend. May 2012 data onwards are not yet ratified.

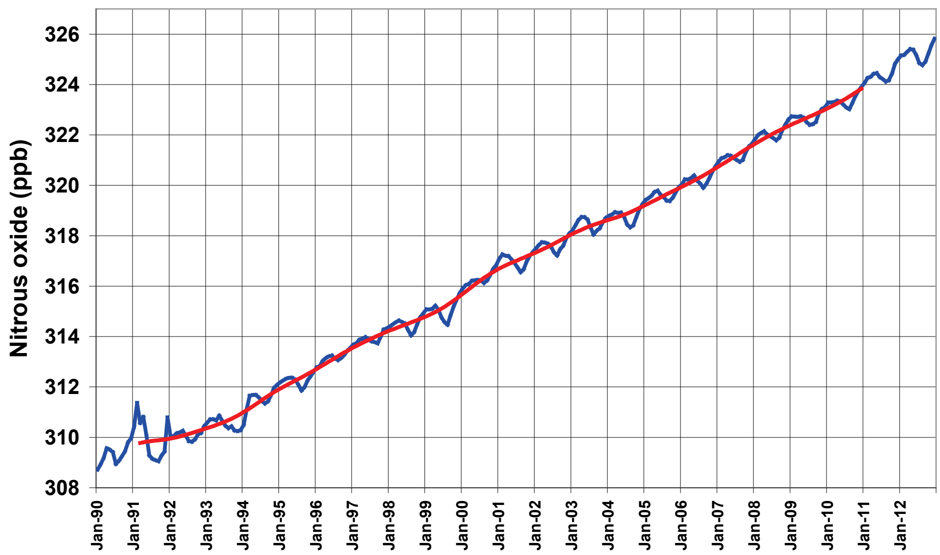
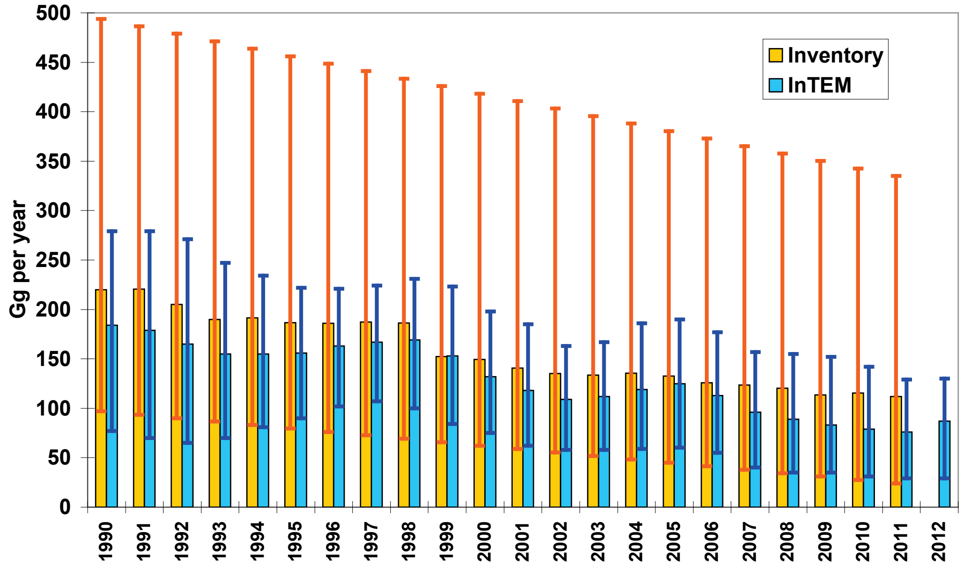


Figure A 8.3.2 **Verification of the UK emission inventory estimates for nitrous oxide in Gg yr^{-1} for 1990-2012. GHGI estimates are shown in orange. InTEM estimates are shown in blue. InTEM and GHGI uncertainties are shown as whisker lines.**



A8.4 HYDROFLUOROCARBONS

A8.4.1 HFC-134a

Figure A 8.4.1 shows the baseline atmospheric concentration of HFC-134a from 1995 onwards. The annual trend is monotonic and positive at over 4 ppt/yr.

Figure A 8.4.1 **Monthly Northern Hemisphere trend in HFC-134a estimated from Mace Head observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2012 data onwards are not yet ratified.**

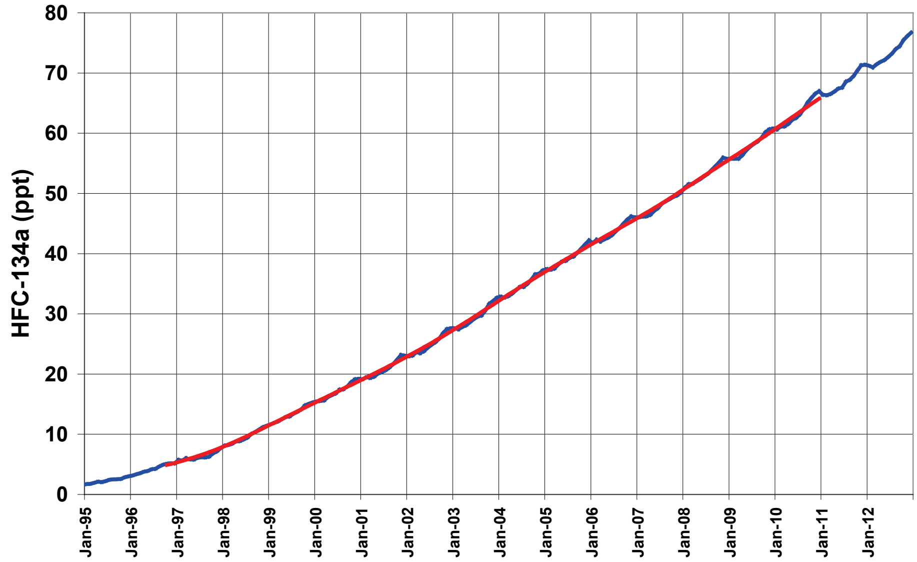
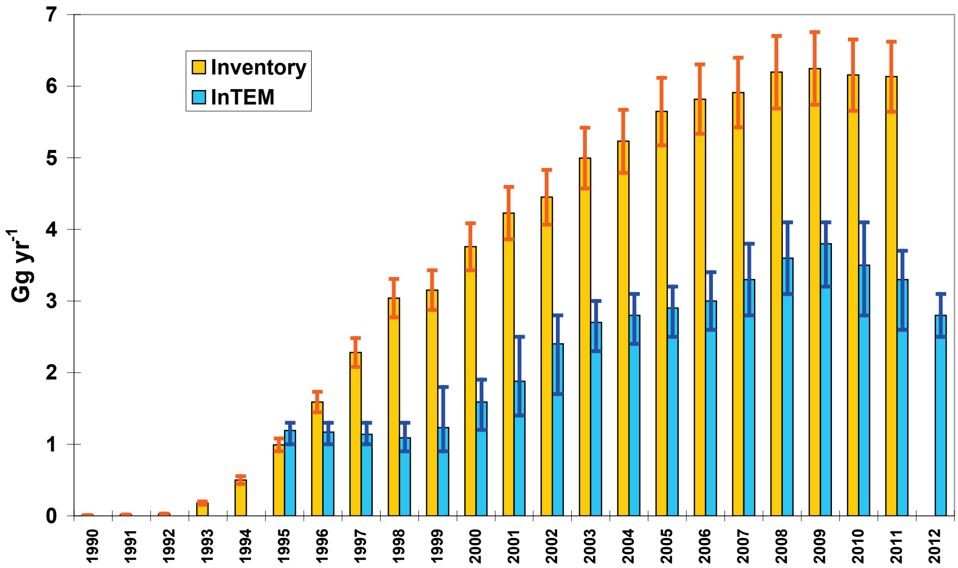


Figure A 8.4.2 shows the InTEM and GHGI emission estimates for the UK for HFC-134a for the period 1990 onwards. The GHGI shows an earlier increase in emission compared to the InTEM estimates. The InTEM estimates begin their rise in 1999-2000 whereas the GHGI estimates began to rise from 1994. From the late 1990s onwards there is poor agreement between the GHGI and InTEM, with the GHGI being about double the InTEM estimates and the uncertainties in both methods do not overlap.

Figure A 8.4.2 Verification of the UK emission inventory estimates for HFC-134a in Gg yr^{-1} for 1990-2012. GHGI estimates are shown in orange. InTEM estimates are shown in blue. InTEM and GHGI uncertainties are shown as whisker lines.



A8.4.2 HFC-152a

Figure A 8.4.3 shows the baseline atmospheric concentration of HFC-152a from 1995 onwards. The annual trend shows a strong rise from the mid-1990s until 2008 and then a much reduced annual increase.

Figure A 8.4.3 Monthly Northern Hemisphere trend in HFC-152a estimated from Mace Head observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2012 data onwards are not yet ratified.

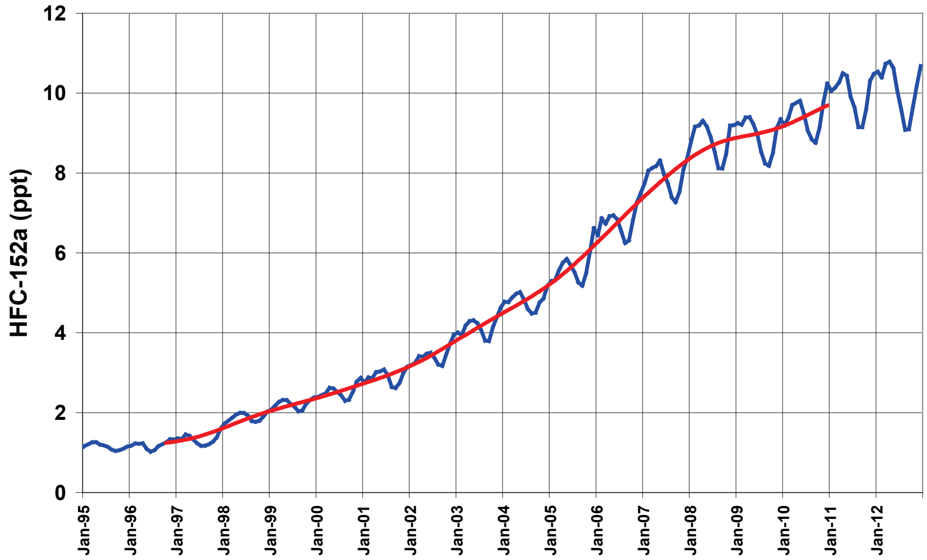
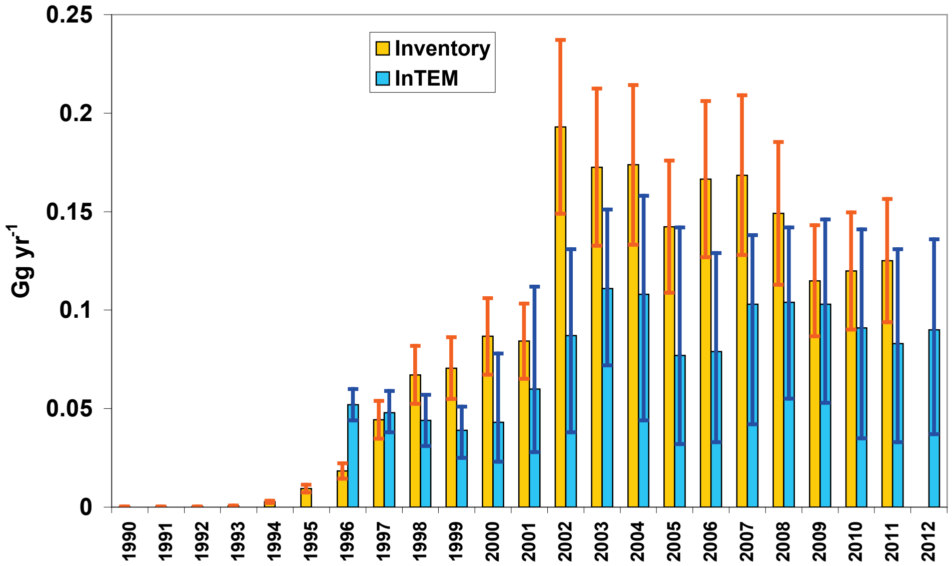


Figure A 8.4.4 shows the InTEM and the GHGI emission estimates for the UK for HFC-152a for the period 1990 onwards. The InTEM estimates have a tendency to be lower than the GHGI estimates but the uncertainties in both methods are significant and the majority overlap.

Figure A 8.4.4 Verification of the UK emission inventory estimates for HFC-152a in Gg yr^{-1} for 1990-2012. GHGI estimates are shown in orange. InTEM estimates are shown in blue. InTEM and GHGI uncertainties are shown as whisker lines.



A8.4.3 HFC-125

Figure A 8.4.5 shows the baseline atmospheric concentration of HFC-125 from 1998 onwards. The annual trend is monotonic and exponentially increasing.

InTEM emission estimates for the UK for HFC-125 for the period 1999 onwards are shown in Figure A 8.4.6. Both estimates suggest that the emissions of HFC-125 from the UK have increased significantly from the mid-1990s. The agreement between the two methods is excellent from 2000 up until 2009 where InTEM reaches its peak and then begins to decline, a pattern not seen in the GHGI.

Figure A 8.4.5 Monthly Northern Hemisphere trend in HFC-125 estimated from Mace Head observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2012 data onwards are not yet ratified.

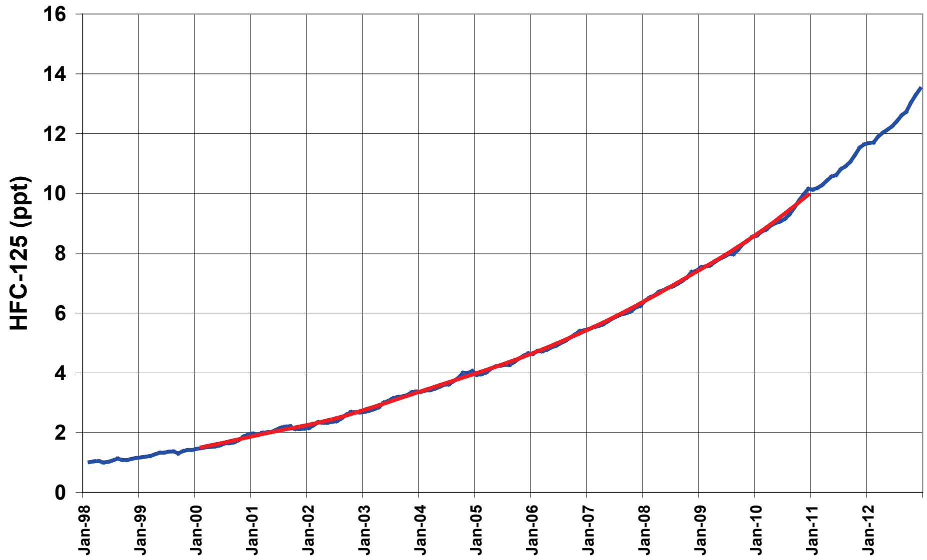
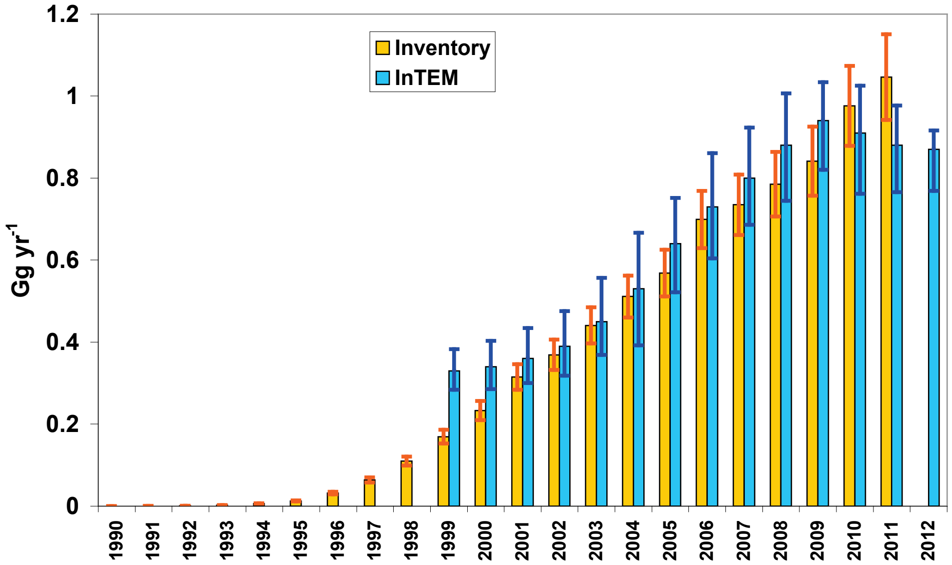


Figure A 8.4.6 Verification of the UK emission inventory estimates for HFC-125 in Gg yr^{-1} for 1990-2012. GHGI estimates are shown in orange. InTEM estimates are shown in blue. InTEM and GHGI uncertainties are shown as whisker lines.



A8.4.4 HFC-143a

Figure A 8.4.7 shows the baseline atmospheric concentration of HFC-143a from 2004 onwards. The annual trend is monotonic and positive at more than 1 ppt/yr.

InTEM emission estimates for the UK for HFC-143a for the period 2004 onwards are shown below in Figure A 8.4.8 and are compared to the GHGI estimates. UK emissions as estimated through the GHGI are increasing year on year from the early 1990s. The InTEM estimates show a rise 2004-2009 and then a decline. The uncertainty ranges of the two methods rarely overlap..

Figure A 8.4.7 Monthly Northern Hemisphere trend in HFC-143a estimated from Mace Head observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2012 data onwards are not yet ratified.

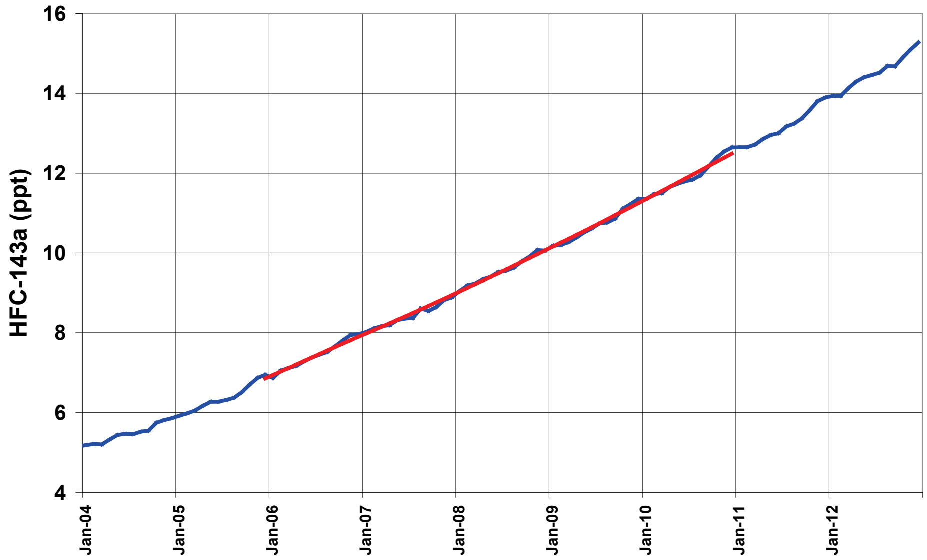
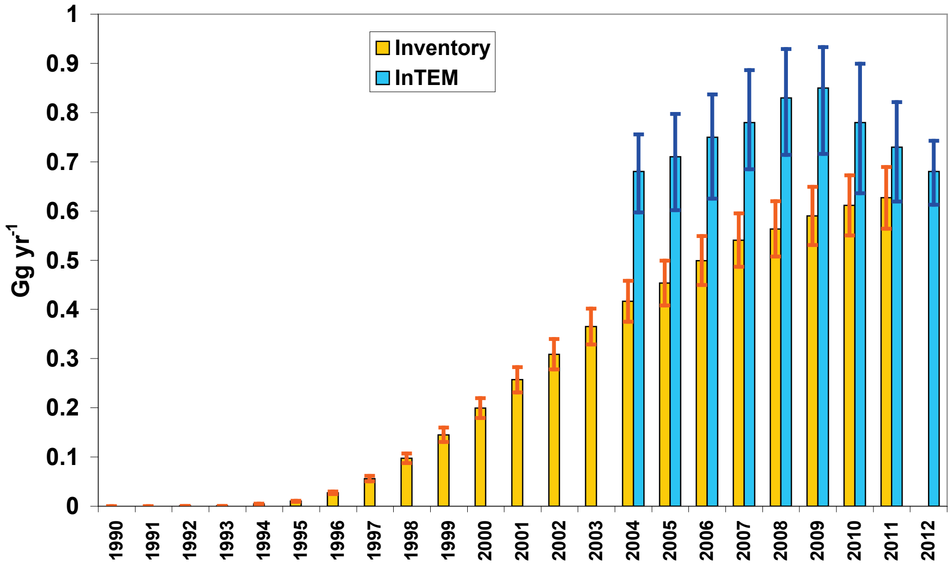


Figure A 8.4.8 Verification of the UK emission inventory estimates for HFC-143a in Gg yr^{-1} for 1990-2012. GHGI estimates are shown in orange. InTEM estimates are shown in blue. InTEM and GHGI uncertainties are shown as whisker lines.



A8.4.5 HFC-23

Figure A 8.4.9 shows the baseline atmospheric concentration of HFC-23 from 2008 onwards. The annual trend is monotonic and positive at around 0.5 ppt/yr.

The median InTEM emission estimates for the UK for HFC-23 are larger than the GHGI estimates but the InTEM uncertainties are significant and entirely encompass the GHGI estimates. (Figure A 8.4.10).

Figure A 8.4.9 Monthly Northern Hemisphere trend in HFC-23 estimated from Mace Head observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2012 data onwards are not yet ratified.

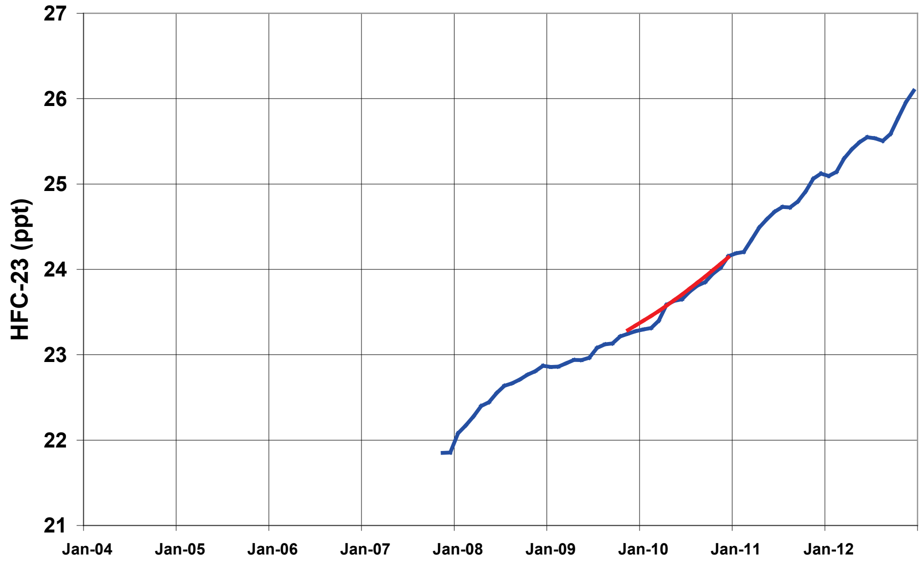
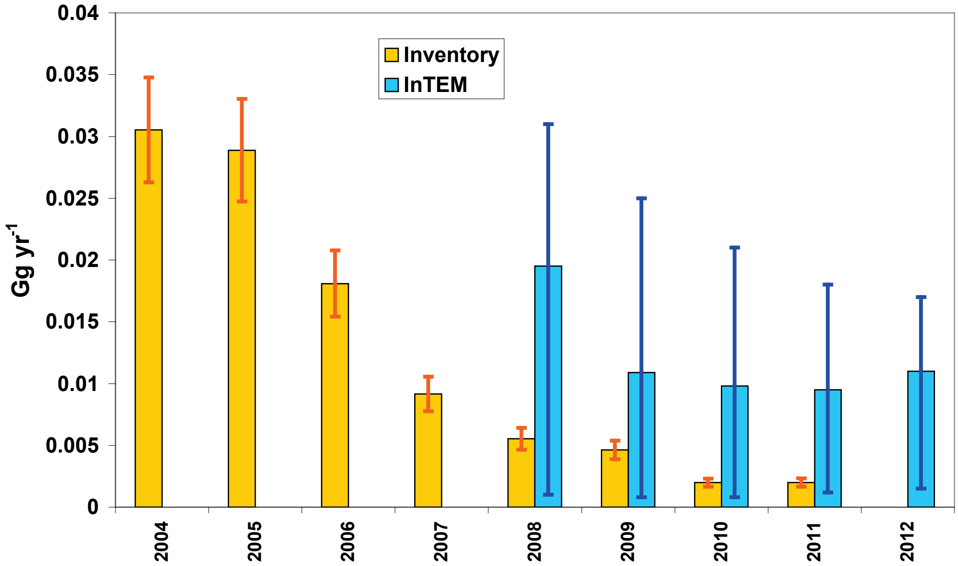


Figure A 8.4.10 Verification of the UK emission inventory estimates for HFC-23 in Gg yr^{-1} for 1990-2012. GHGI estimates are shown in orange. InTEM estimates are shown in blue. InTEM and GHGI uncertainties are shown as whisker lines.



A8.4.6 HFC-32

Figure A 8.4.11 shows the baseline atmospheric concentration of HFC-32 from 2004 onwards. The annual trend is monotonic and positive at around 0.7 ppt/yr.

InTEM emission estimates for the UK for HFC-32 for 2004 onwards are shown in Figure A 8.4.12. The median InTEM emission estimates are lower than the GHGI estimates but the trend agrees 2004-2009 and the uncertainties overlap. Post-2009 the InTEM estimates flatten and decline, and thereby diverge from the GHGI which continues to increase.

Figure A 8.4.11 Monthly Northern Hemisphere trend in HFC-32 estimated from Mace Head observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2012 data onwards are not yet ratified.

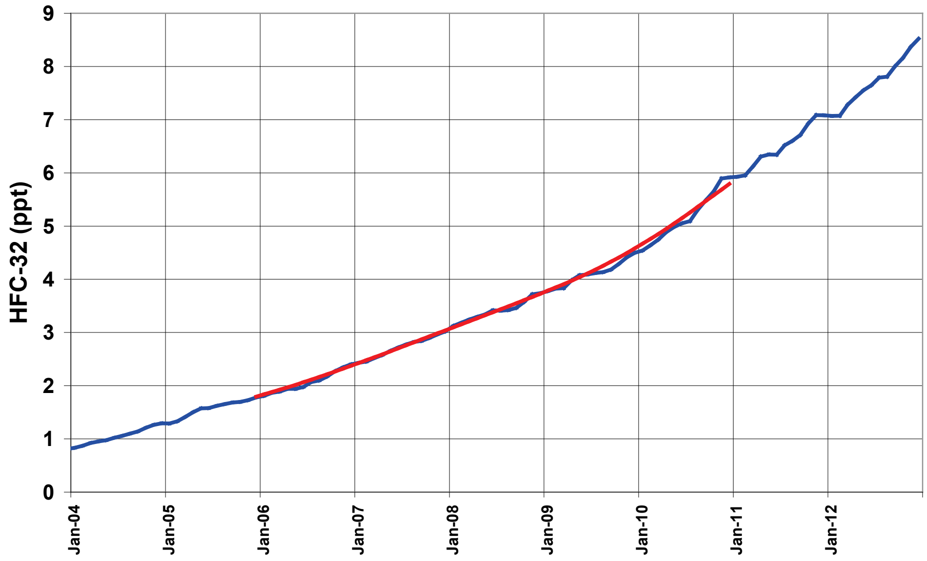
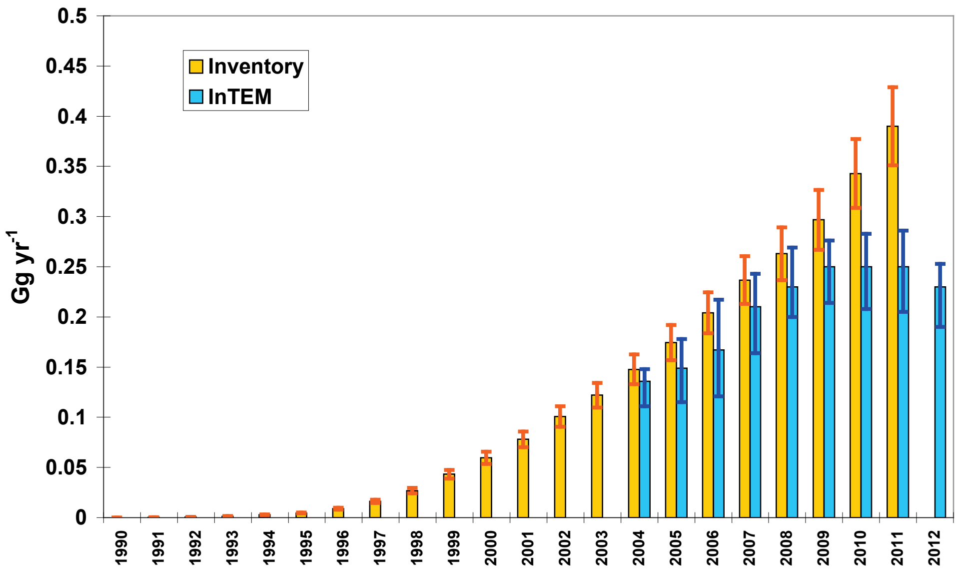


Figure A 8.4.12 Verification of the UK emission inventory estimates for HFC-32 in Gg yr^{-1} for 1990-2012. GHGI estimates are shown in orange. InTEM estimates are shown in blue. InTEM and GHGI uncertainties are shown as whisker lines.



A8.5 PERFLUOROCARBONS

A8.5.1 PFC-14

Figure A 8.5.1 shows the baseline atmospheric concentration of PFC-14 from 2004 onwards. The annual trend is monotonic and positive at around 0.7 ppt/yr.

Figure A 8.5.1 Monthly Northern Hemisphere trend in PFC-14 estimated from Mace Head observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2012 data onwards are not yet ratified.

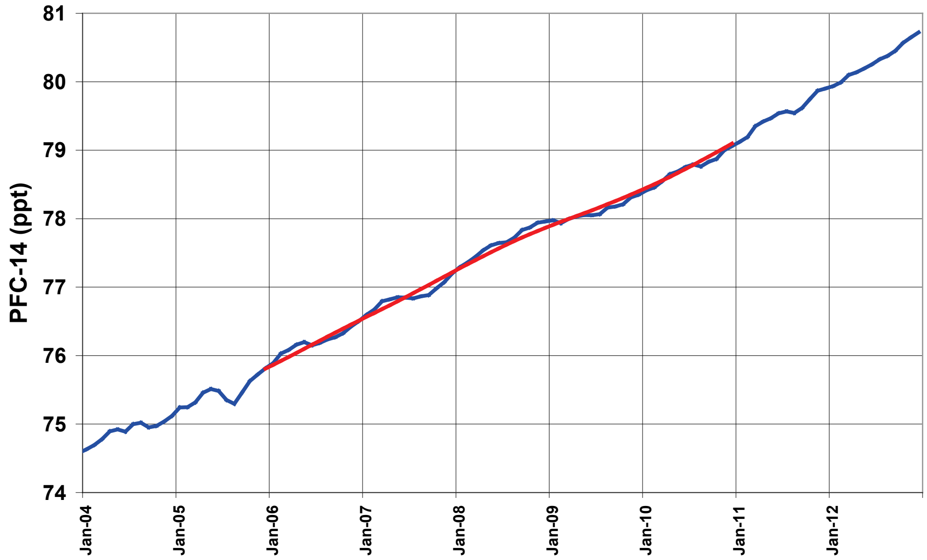
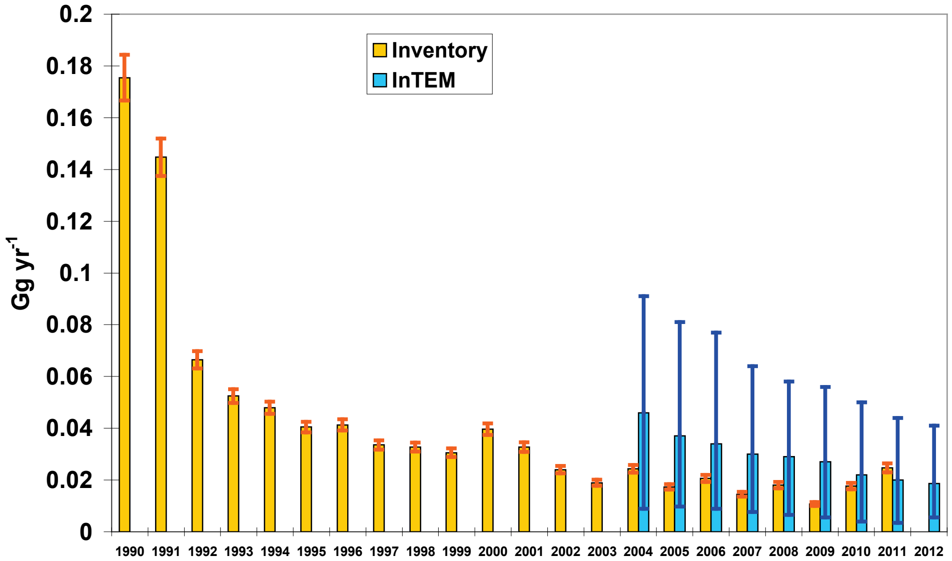


Figure A 8.5.2 Verification of the UK emission inventory estimates for PFC-14 in Gg yr^{-1} for 1990-2012. GHGI estimates are shown in orange. InTEM estimates are shown in blue. InTEM and GHGI uncertainties are shown as whisker lines.



The InTEM and GHGI estimates of UK emissions of PFC-14 are shown in Figure A 8.5.2. The median InTEM estimates are approximately double those reported in the GHGI between 2004 and 2008 however the InTEM uncertainty ranges are significant and encompass the GHGI estimates.

A8.5.2 PFC-116

Figure A 8.5.3 shows the baseline atmospheric concentration of PFC-116 from 2004 onwards. The annual trend is monotonic and positive at around 0.1 ppt/yr.

The UK InTEM estimates are consistent with those reported in the GHGI (Figure A 8.5.4) given the significant uncertainties in the InTEM solutions.

Figure A 8.5.3 Monthly Northern Hemisphere trend in PFC-116 estimated from Mace Head observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2012 data onwards are not yet ratified.

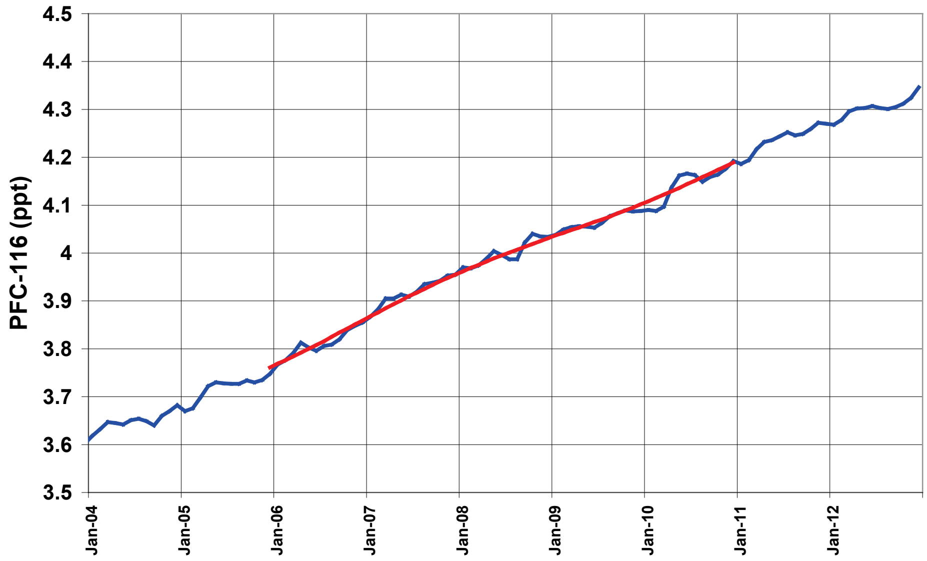
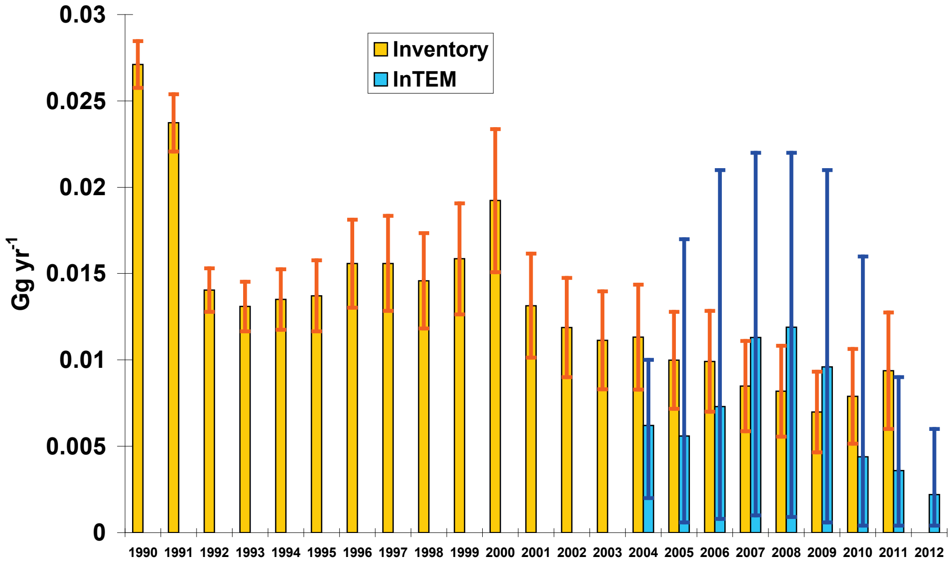


Figure A 8.5.4 Verification of the UK emission inventory estimates for PFC-116 in Gg yr-1 for 1990-2012. GHGI estimates are shown in orange. InTEM estimates are shown in blue. InTEM and GHGI uncertainties are shown as whisker lines.



A8.5.3 PFC-218

Figure A 8.5.5 shows the baseline atmospheric concentration of PFC-218 from 2004 onwards. The annual trend is monotonic and positive at around 0.02 ppt/yr.

The UK InTEM estimates are significantly higher than those reported in the GHGI (Figure A 8.5.6), however the InTEM uncertainties are significant and there is some overlap with the GHGI.

Figure A 8.5.5 Monthly Northern Hemisphere trend in PFC-218 estimated from Mace Head observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2012 data onwards are not yet ratified.

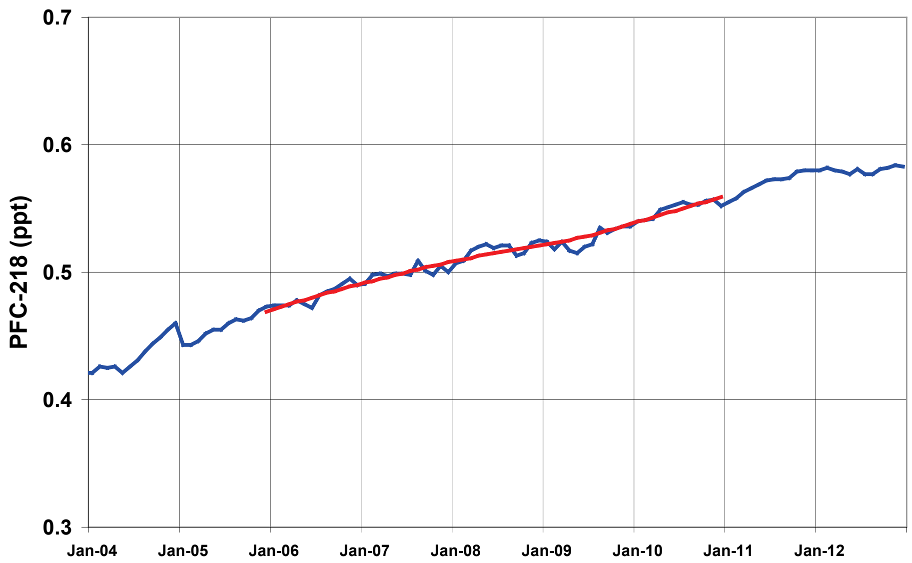
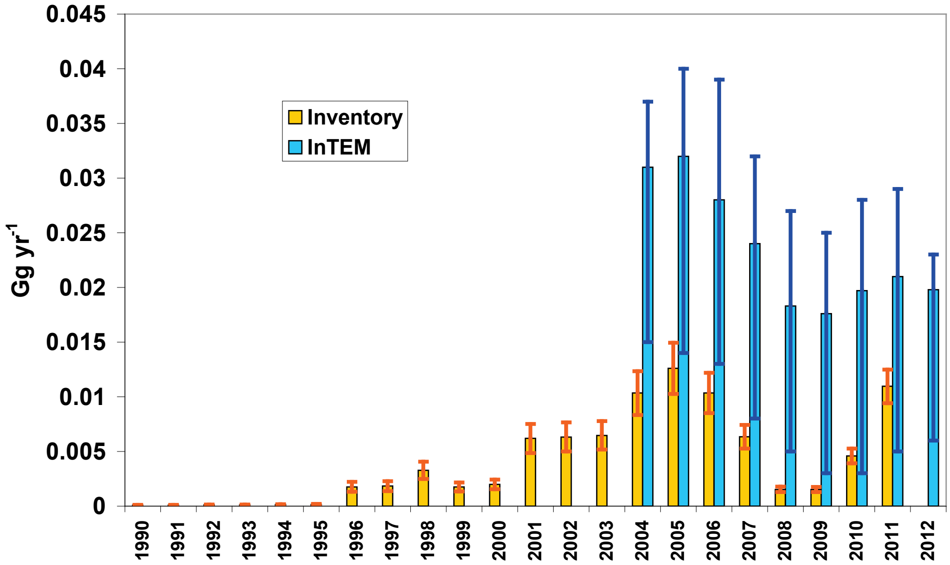


Figure A 8.5.6 Verification of the UK emission inventory estimates for PFC-218 in Gg yr^{-1} for 1990-2012. GHGI estimates are shown in orange. InTEM estimates are shown in blue. InTEM and GHGI uncertainties are shown as whisker lines.



A8.6 SULPHUR HEXAFLUORIDE

Figure A 8.6.1 shows the baseline atmospheric concentration of SF_6 from 2004 onwards. The annual trend is monotonic and positive at around 0.3 ppt/yr.

The median UK InTEM estimates are higher than those reported in the GHGI by about 0.01-0.02 Gg yr^{-1} (Figure A 8.6.2), however the InTEM uncertainties are significant and there is some overlap with the GHGI uncertainties.

Figure A 8.6.1 Monthly Northern Hemisphere trend in SF_6 estimated from Mace Head observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2012 data onwards are not yet ratified.

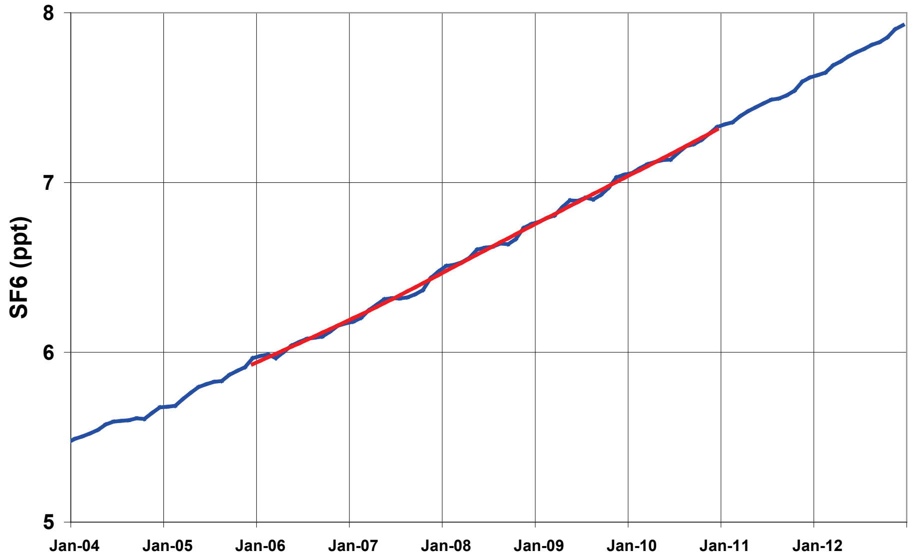
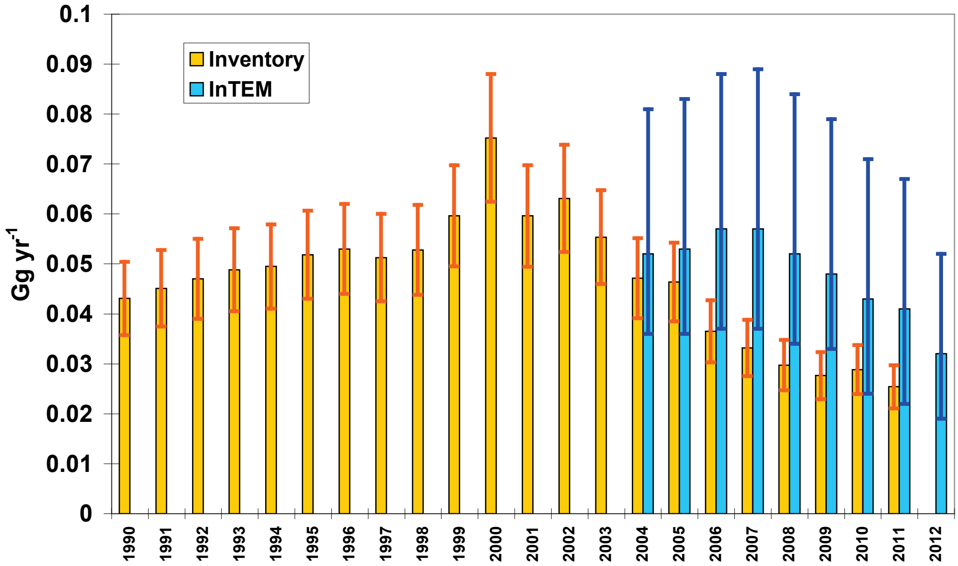


Figure A 8.6.2 Verification of the UK emission inventory estimates for SF_6 in Gg yr^{-1} for 1990-2012. GHGI estimates are shown in orange. InTEM estimates are shown in blue. InTEM and GHGI uncertainties are shown as whisker lines.



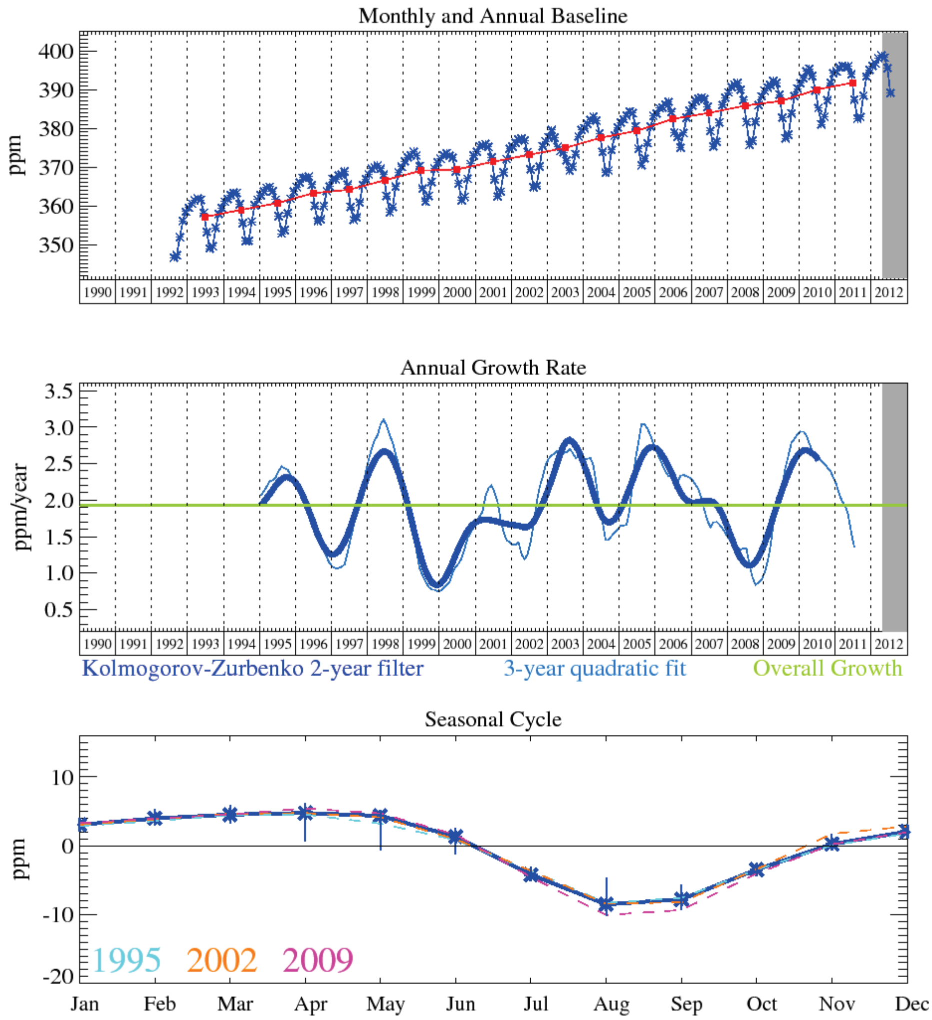
A8.7 CARBON DIOXIDE

High precision, high frequency measurements of CO_2 are also made at Mace Head. The CO_2 observed has three principle components:

1. Northern hemisphere baseline (Figure A 8.7.1).
2. Anthropogenic (man-made)

3. Biogenic (natural)

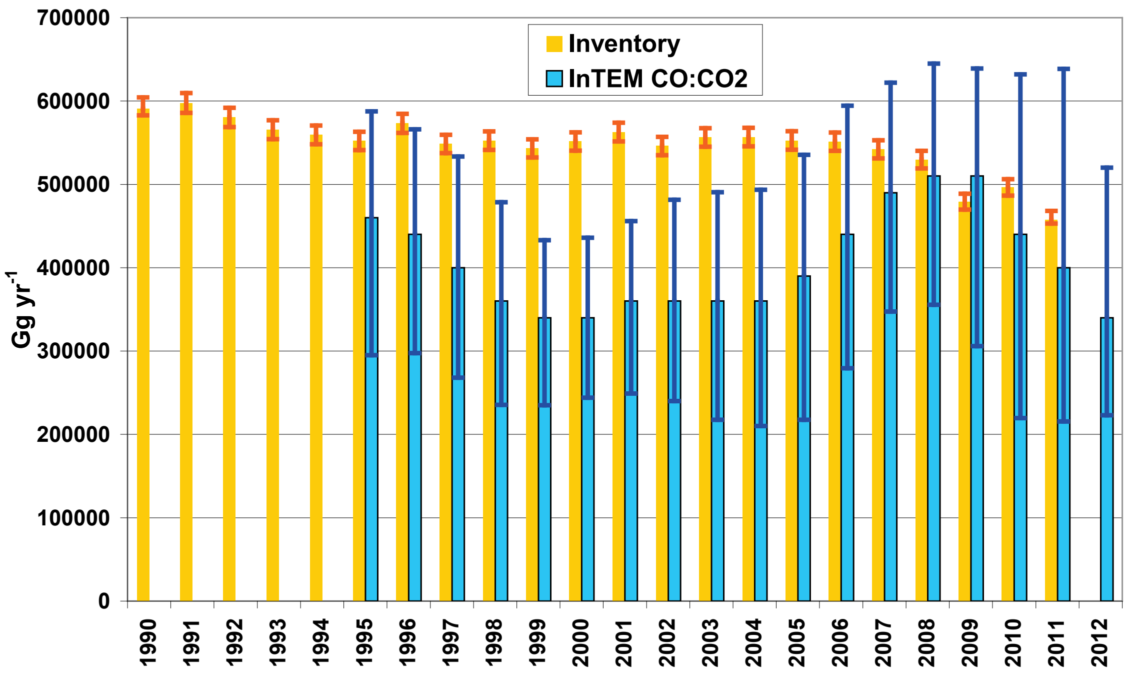
Figure A 8.7.1 Top plot: Monthly (blue) and annual (red) mid-latitude Northern Hemisphere baseline mass mixing ratio of CO_2. Middle plot: Annual growth rate of CO_2 in the Northern Hemisphere using two different methods, the green line shows the average growth over this period. Lower plot: The average (blue) seasonal cycle of CO_2, with year to year variability.



Plants both respire CO_2 and absorb it through photosynthesis. Therefore the CO_2 flux from vegetation has a diurnal and seasonal cycle and switches from positive to negative on a daily basis. This unknown natural (biogenic) component of the observed CO_2 is significant when compared to the anthropogenic (man-made) component and cannot be assumed negligible (except during the winter months). From the CO_2 observations it is not possible to distinguish between biogenic and anthropogenic CO_2. Therefore it is difficult to use the CO_2 observations directly in an inversion to estimate anthropogenic emissions. This is because the diurnally varying biogenic CO_2 flux is at odds with a key assumption of the inversion method, namely that emissions do not strongly vary in time over the inversion time-window. Methods are under development to attempt to over-come these challenges, such as: the use of isotopic observations; through ratios with respect to anthropogenic CO; and through the use of just the winter-time observations. The uncertainties associated with each of these methods are predicted to be significant.

Below (Figure A 8.7.2) are the preliminary results for UK emissions of CO_2 using the InTEM inversion results for CO. The InTEM CO emission maps have been scaled by the annually varying UK inventory ratio of CO_2:CO emissions. The InTEM uncertainties have been arbitrarily increased by 50% to reflect the fact that the CO_2:CO ratio is variable across applications across the UK. The estimated uncertainties in the inventory in 1990 and 2011 are also presented. It can be noted that the uncertainties in the InTEM results are considerably larger than the inventory uncertainties. Work is on-going to seek to improve our methods of verifying inventory CO_2 emissions estimates.

Figure A 8.7.2 Inventory (orange) and InTEM (blue) UK CO_2 emission estimates.



A8.8 FUTURE PLANS

The expanded UK DECC network of sensors will provide a significant increase in the number of observations of carbon dioxide, methane and nitrous oxide covering different spatial regions of the UK. These additional observations began in 2012 and will be included in future InTEM inversions. The improved spatial distribution of observations will increase the resolution of the inversion estimates and enable better quantification of the InTEM uncertainty.

A new UK university initiative called GAUGE has recently been launched that aims to improve the quantification of UK emissions of the principle greenhouse gases through inversion modelling. A range of inversion techniques will be included and will result in an improved understanding of the uncertainties related to inversion modelling.

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A9 ANNEX 9: Analysis of EU ETS Data

A9.1 INTRODUCTION

This annex summarises the analysis of the 2011 European Union Emissions Trading System (EU ETS) energy and emissions data that is used within the compilation of the UK GHG inventory. The EU ETS data are used to inform activity data estimates for heavy industry sectors, carbon dioxide emission factors of UK fuels within those sectors, and for comparison of fuel allocations to specific economic sectors against data presented in the *Digest of UK Energy Statistics* (DUKES), published by the Department of Energy and Climate Change (DECC).

The EU ETS data are used in the UK GHGI compilation as follows:

- EU ETS raw data on energy and emission estimates are processed and checked to enable integration of the activity data, implied emission factors and installation emission estimates as far as practicable within the UK GHG inventory compilation. Emission sources reported in EU ETS are allocated to inventory fuels and source codes, outliers are identified and clarifications of data inconsistencies are sought with the regulatory agencies;
- The verified EU ETS data provides up to date high quality fuel compositional analysis of UK fuels, and these data are used to improve inventory emission estimates across the highly energy intensive sources such as power stations, refineries, cement kilns, and oil and gas sources;
- EU ETS activity data are closely compared against the UK national energy balance (DUKES) published by DECC, and any inconsistencies are researched, seeking to resolve these through consultation with DECC wherever possible;
- The EU ETS dataset for offshore oil and gas installations are checked to assess data consistency in emissions reporting between the EU ETS and the (more comprehensive) EEMS dataset that is used within the UK GHGI compilation.
- Overall, the Inventory Agency approach seeks to minimise data discrepancies between EU ETS and the GHGI as far as practicable, in order that the derivation of traded and non-traded emission estimates from the UK GHGI are as accurate as possible. Close consistency between the EU ETS and GHGI is an important aspect of the development of a complete and consistent evidence base for policy development and tracking progress towards UK GHG reduction targets in the non-traded sector under the EU Effort Sharing Decision.

The key findings from the analysis and use of the EU ETS data include:

- In the 2011 EU ETS dataset, a very high coverage of Tier 3 emissions data is evident for all fuel use in the power sector, as well as for coal autogeneration, coal use in the lime sector, and refinery fuel oil and OPG use. All of the fuel quality data for these sources and fuels are therefore used within the UK GHGI, as the EU ETS fuel quality data is the most representative dataset available to inform UK carbon dioxide emission factors in the inventory;
- EU ETS emissions data from refineries are higher than estimates derived from DUKES activity data, with a discrepancy evident in OPG emissions. Comparison against data from the trade association, UKPIA, indicates that the EU ETS data are

correct, and therefore UK GHGI estimates are based on EU ETS data rather than refinery fuel use data reported in the UK energy balance;

- There are a range of other activity data discrepancies within the oil & gas, cement and lime, other industry and iron and steel sectors. Revisions to fuel allocations within the UK GHGI have been implemented for a number of sources, whilst further research is needed in some instances to clarify the issues where the reporting format of EU ETS does not map explicitly to energy balance and GHG inventory reporting requirements;
- EU ETS data for fuel use at petrochemical production facilities has helped to identify and quantify under-reports within the UK energy statistics for the combustion of gases that are derived from Natural Gas Liquid (NGL) feedstock to petrochemical production processes. Analysis of “fuel gas” calorific values and carbon content has helped to inform the calculations to estimate emissions from NGL-derived gases, to address the under-report in UK energy statistics and fill a reporting gap in previous inventory submissions.

A9.2 BACKGROUND

A9.2.1 EU ETS Data and GHG Inventories

The European Union Emissions Trading System (EU ETS) data provides annual estimates of fuel use and fuel quality data from the most energy intensive sites in the UK, and 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 7 years’ worth of data on fuel use and emissions across major UK industrial plant, for 2005-2011.

The data reported under the EU ETS includes quantities of fuels consumed, carbon contents, calorific values and emissions of carbon dioxide, all presented by installation and by emission source. Data for individual installations are treated as commercially confidential by the UK regulatory authorities and so only aggregated emissions data are reported in inventory outputs.

As part of the UK’s annual reporting requirements to the EUMM and UNFCCC, the UK must include a comparison of the EU ETS data against the national inventory dataset within the National Inventory Report. Furthermore, the analysis of the inventory against the EU ETS dataset is coming under increasing scrutiny due to the development of domestic GHG reduction targets that are based on non-traded[7] emissions data only, and the growing need to understand the UK non-traded sector emissions for future reporting under the Effort Sharing Decision.

The EU ETS dataset helps to improve the UK GHG inventory in a number of ways:

- Identifying new sources, therefore improving completeness;
- Helping assess true levels of uncertainty in fuel- and sector-specific data;
- Providing fuel quality data and oxidation factors for complex processes;
- Providing information on process-specific emissions that are not apparent from the national energy balances;

[7] All GHG emissions that are regulated within the EU ETS are defined as “traded” emissions, whilst all other GHG emissions are defined as “non-traded”. The EU Effort Sharing Decision will lead to the UK adopting a new target for GHG reductions by 2020 for all of the non-traded emissions (i.e. everything outside of EU ETS), and progress towards this target will be monitored through the UK GHG inventory.

- Reducing uncertainty in the GHGI; and
- Acting as a source of quality assurance to inventory data.

In the 1990-2011 inventory cycle, the inventory agency has updated and extended the EU ETS analysis conducted for inventory compilation, using the 2011 EU ETS dataset. This annex presents a comprehensive review of the seven years' of EU ETS data, indicating where the data have already been used in the improvement of the GHGI, as well as highlighting outstanding issues which could be investigated further, with potential for further revision and improvement of the GHGI.

In the 1990-2011 inventory cycle, for the first time the inventory agency has been provided with full details of the 2011 EU ETS data for all offshore oil and gas installations, which are regulated by the DECC Offshore Inspectorate. Access to these detailed data has enabled a more thorough review of the fuel/gas quality and reported emissions from combustion and flaring sources at offshore installations, and has directly improved the completeness and accuracy of the sector estimates within the UK GHGI.

The analysis of the EU ETS data for use in the UK GHGI necessitates a high level of detailed review of the available data, in order to ensure correct interpretation and application of the available data. The study team prioritises effort to the sources and sites that are the most significant in UK GHGI terms, and/or known data reporting discrepancies have been identified from previous work. For example, it is important to review emission factors from all major installations in a given sector to ensure that outliers are identified and checked prior to their inclusion in inventory calculations.

Wherever possible, consistent assumptions and allocations are applied across all years of the EU ETS, and the information on the EU ETS method "Tier" informs use of the data in inventory compilation. Where higher-Tier methods are used, a lower level of uncertainty in the EU ETS data is assumed. In most instances where calculations appear inconsistent between emissions data and activity data, it is assumed that the EU ETS emissions data are correct, and activity data are amended as appropriate.

A9.2.2 Scope of the UK EU ETS and Implications for the GHG Inventory

There are a number of limitations to the EU ETS data that affect the data usefulness in GHG inventory compilation, including:

- The EU ETS data are only available from 2005 onwards, whilst the UK GHG inventory reports emission trends back to 1990. The additional information that EU ETS provides (e.g. year-specific emission factors for many fuels in energy intensive sectors) helps to reduce the uncertainties in inventory emission estimates for the later years, but care is needed where revisions to the time series are made back to 2005. A consistent approach to inventory compilation across the time series is a key tenet of IPCC good practice guidance, and care is needed to ensure that the use of EU ETS data does not introduce a systematic reporting step-change in the UK GHGI;

- Further to this point, it is important to note that the scope of EU ETS reporting has evolved through the years, from Phase I (2005 to 2007) into Phase II (2008 to 2011 data). The comparability of EU ETS data for many sectors is poor between these two phases. For example, many cement kilns did not report to EU ETS until Phase II; several sectors including cement were reporting under Climate Change Agreements and were opted-out of EU ETS during Phase I. Therefore in several sectors, more complete coverage of EU ETS reporting is evident in Phase II and data from 2008 onwards are therefore much more useful for UK GHGI reporting. There are now four years' worth of Phase II data and hence the EU ETS dataset is now becoming a more robust dataset;

- In the UK during EU ETS Phases I and II, the regulators have adopted a "medium" definition of the term "combustion", and there are many sectors where fuel use in specific types of combustion unit have not been included in the EU ETS reporting scope. Examples of this include flaring on chemical sites, fuel use in heaters, dryers, fryers and stenters in industry sectors such as: chemicals, food and drink, textiles, paper and pulp. Hence the total fuel use and GHG emissions from these sectors are typically under-reported within the EU ETS, with many sites and sources excluded from the scope of EU ETS.

- Further to this point, Phase III of EU ETS from 2013 onwards will encompass a wider scope of reporting compared to Phase II (including the reporting of some non-CO_2 emissions), and hence additional data will become available to inform GHGI estimates in future years.

- When using the EU ETS data, assumptions and interpretations are required to be made regarding the fuel types used by operators. There is not a specific list of fuels to be selected from in operator returns and so assumptions occasionally need to be made where the fuel type used is not clear.

Note that:

- The direct use of EU ETS data (e.g. fuel use data by sector) to inform UK GHGI estimates is limited to where the EU ETS is known to cover close to 100% of sector installations. For example, the EU ETS is regarded as representative and almost 100% comprehensive in coverage of refineries, power stations, cement and lime kilns; for many other industrial sectors (such as chemicals, non-ferrous metals, food and drink, engineering) the EU ETS is not comprehensive and therefore the data are of limited use, other than to provide a de-minimis fuel use for these sectors;

- EU ETS Implied Emissions Factors (IEFs) can be used within the UK GHGI, but only where the evidence indicates that EU ETS data are representative of sector as whole and provides more comprehensive and accurate data than alternative sources. The key criteria to consider in the assessment of EU ETS IEF usefulness is the percentage of annual fuel use by sector where operator estimates use Tier 3 emission factors.

- Review of the EU ETS IEFs for different fuels across different sites provides a useful insight into the level of Tier 3 reporting within different sectors, the progression of higher-Tier reporting within EU ETS through the time series and the level of variability in fuel quality for the different major fuels in the UK.

A9.2.3 Limitations of EU ETS Data Integration with GHG Inventory: Autogeneration

It must, however, be noted that despite detailed research there remain some fundamental limitations in the use of EU ETS data within national inventories where the sector allocation of energy use and emissions cannot be resolved against the national energy statistics that underpin the GHG inventory compilation. One key example is that of the division between fuel use in autogeneration (or heat generation) and direct fuel use within a specific sector. For example, based on the data available from EU ETS, it is impossible to differentiate between gas use in autogeneration on a chemical installation, or gas use directly to heat chemical production processes. In this example, the allocation of EU ETS energy use and emissions between 1A2c (chemicals) and 1A2f (autogenerators) is uncertain, and therefore comparison of EU ETS and GHGI estimates is uncertain.

The EU ETS data are not sufficiently detailed and transparent to enable accurate allocation to either the chemicals sector or autogeneration, and the allocation of energy use in the UK energy statistics (which is based on annual surveys of fuel suppliers) is evidently different. The UK energy statistics are subject to some uncertainty, however small, and there is likely to be more uncertainty in estimates at industrial sector-level, rather than at more aggregated levels. For example, while fuel producers and suppliers will be able to quantify total fuel demand with a high level of certainty, it would be far more difficult for them to estimate fuel use by specific industrial sectors. This will be reflected in the quality of UK energy statistics which are used to estimate emissions from 1A2c etc. A significant proportion of fossil fuel use by the UK chemical industry is included in the EU ETS as many chemical processes will use sufficiently large combustion installations to exceed the threshold for EU ETS. Therefore it reasonable to assume that EU ETS emissions for chemicals should be similar in magnitude to those estimated from UK energy statistics and even, given the uncertainty in fuel allocation, to exceed them.

A9.2.4 Limitations of EU ETS Data Integration with GHG Inventory: Iron & Steel

EU ETS data for iron and steel producers have been analysed, however there are practical difficulties that have prevented much use of EU ETS data in the UK GHGI to date. For example, the reporting of emissions in the EU ETS does not always contain sufficient information to distinguish between fuels used directly in iron making and steelmaking, and fuels used for other purposes in steelworks (such as reheat furnaces). The data from EU ETS also focusses on the combustion of secondary fuels (such as coke, COG, BFG), whereas the national activity statistics from DECC provide the data for the primary fuel inputs to integrated steelworks (such as coking coal, gas, fuel oil). The EU ETS data are also insufficiently detailed to distinguish emissions from energy use and emissions from industrial processes at some steelworks.

These considerations mean that it is 1) difficult to reconcile the EU ETS data with the UK energy statistics and 2) difficult to directly use the EU ETS data to inform the UK energy statistics. The inventory agency consults with the team of UK energy statisticians in DECC to close out observed discrepancies between EU ETS and DUKES, e.g. for iron and steel flaring, anthracite use in sinter plant and coke oven coke activity data.

As a result of the points outlined above, GHGI emissions are still largely based on the use of UK energy statistics and literature-based emission factors. Consultation with process operators is aimed at improving the EU ETS data transparency and detail such that it can be used to a greater extent than at present if issues such as described above can be resolved. Note, however, that direct substitution of EU ETS data into the UK GHGI in preference to the DUKES data could introduce a double-count to the UK inventory, as the overall national fuel statistics are associated with low uncertainty and there is more likely to be a problem of sector allocation in national energy statistics than a gap.

A9.3 DATA PROCESSING

DECC provided the detailed EU ETS regulator data from the Environment Agency, Scottish Environment Protection Agency and Northern Ireland Environment Agency during April 2012, and the inventory agency industrial emissions analysts have progressed the analysis, combining the datasets to generate a UK-wide EU ETS dataset. This work builds on analysis conducted in previous years, as the EU ETS has been in place since 2005, but this present analysis has reviewed all 7 annual datasets, to ensure a consistent approach to the interpretation of energy and emissions data across the time series.

The initial step in the analysis is the allocation of all sites in the dataset to one of the economic sectors as reported within the DUKES Commodity Balance tables. Next, the reported fuels for every UK installation have to be allocated to one of the GHGI fuel names, which are also aligned with the fuel types reported within DUKES. This enables a direct comparison of EU ETS fuel totals against sector fuel allocations within DUKES and therefore used within the GHGI.

Most of the allocations have been made as part of previous years' work, and do not need to be revisited. There were a small number of new installations included in the 2011 EU ETS data which had to be allocated to DUKES' sectors, and all of the fuel data for 2011 also has had to be allocated to DUKES/GHGI fuel types. In a very small number of cases, we have revised data for earlier years, for example when it has become apparent that existing assumptions are likely to be incorrect. The allocation process does rely upon some expert judgement, with the Ricardo-AEA team using the reported EU ETS fuel names as well as the reported fuel quality data such as calorific values and carbon emission factors in order to make the fuel-type allocation for each entry in the EU ETS spreadsheet. But the allocation is, occasionally, quite uncertain, particularly with the allocation of petroleum-based fuels such as the GHGI fuel categories LPG, OPG, gas oil and fuel oil, often because of the use of abbreviations or other ambiguous names for fuels within the EU ETS reporting system. Cross-checking of data across the time series for each installation has been used to ensure as much consistency in fuel allocations as possible, although in some cases, operators of installations use different fuel terminology in different years.

The quality checking and allocation process is an open-ended task for such a large dataset, and hence the inventory agency focuses on the highest emitters and the known "problem" sites and fuel types. Where uncertainties arise in allocations, the most important allocation decisions are copied across to the DECC DUKES team, for their information and input, as ultimately the EU ETS analysis by the inventory agency is taken into account to some degree within the compilation of DUKES for the following year.

As a data verification step, the installation emissions (broken down by fuel) from the EU ETS regulator spreadsheets are then compared against the total installation emissions for 2011 on the Community Installation Transaction Log (CITL) which is a central website that holds the verified EU ETS emissions totals for all EU installations in the scheme. Each year we have noted that for some sites the regulator data does not match the CITL dataset, and therefore some "residual" emissions allocations are generated, from the difference between CITL and regulator information. These instances are then fed back to the regulator contacts, for their consideration and to request any insights into the likely fuels that the residual emissions should be allocated against.

A final data set is then available for fuel combustion emission sources, which includes the following data fields:

- GHGI Source Category;
- GHGI Fuel Category;
- Fuel Consumed;

- Fuel Calorific Value;
- Fuel Carbon Emission Factor; and
- Related Emissions of CO_2

The inventory agency then combines the data by sector and/or fuel category to provide data for comparison against GHGI emissions data, and energy statistics published in DUKES. In this way, the analysis can:

- provide improved CO_2 emission factors for highly energy-intensive industrial sectors covered by the GHGI through the use of verified data;
- provide a comparison with UK energy statistics, allowing the identification of inconsistencies between EU ETS and DUKES;
- Identify any emission sources that are not contained in the GHGI.

The analysis of the EU ETS data for all onshore facilities was completed by May 2012 and provided to the DECC team of energy statisticians, in time for them to consider the EU ETS dataset during compilation of the UK energy balance for 2011, as published within DUKES 2012.

The EU ETS data for offshore oil and gas installations was provided in October 2012 and were used directly in the compilation of emission estimates for the upstream oil and gas sector, after the UK energy balance had been compiled by DECC. Access to these EU ETS data for offshore facilities provided more fuel-specific information (GCV, carbon content) to help improve completeness and accuracy of the upstream oil and gas estimates in the UK GHGI, augmenting the EEMS dataset which is a more comprehensive dataset (i.e. EEMS covers more emission sources than EU ETS) but does not provide the same level of fuel-specific data.

A9.4 EU ETS DATA COVERAGE

The coverage of the EU ETS data has changed over the 7 years for which data are available. Major changes have been outlined in **Section A11.2.2**, and these changes in scope have an impact on the usefulness of data for some sectors, with data generally being more complete for Phase II of EU ETS, beginning in 2008. In addition, smaller combustion installations in the industrial, commercial and public sectors are outside the scope of EU ETS, and so for some source sectors in the GHGI, the EU ETS data only includes a small proportion of the sector and the EU ETS are not useful to directly inform the GHGI.

The following GHGI source sectors are well represented in the EU ETS data sets in the UK:

- Power stations, particularly those burning coal, gas, and fuel oil;
- Oil refineries;
- Coke ovens & Integrated steelworks;
- Cement kilns (from Phase II onwards); and
- Lime kilns (from Phase II onwards, and excluding kilns used in the Soda Ash industry).

However, GHGI sectors such as industrial combustion, autogeneration, and public sector combustion are only partially represented in the EU ETS data. An analysis of the actual level of coverage of the EU ETS data can be seen in **Table A 9.4.1** below. The number of sites in each sector which are included in the ETS dataset for 2005 and 2011 are given, together with the inventory agency's estimate of the total number of installations in that sector throughout the UK in those years.

Table A 9.4.1 Numbers of installations included in the EU ETS data

Sector	Number of installations			
	2005		2011	
	EU ETS	UK total	EU ETS	UK total
Power stations (fossil fuel, > 75MWe)	60	60	63	63
Power stations (fossil fuel, < 75MWe)	23	27	24	29
Power stations (nuclear)	12	12	10	10
Coke ovens	4	4	4	4
Sinter plant	3	3	3	3
Blast furnaces	3	3	3	3
Cement kilns	8	15	12	12
Lime kilns	4	17	13	15
Refineries	12	12	11	11
Combustion – iron & steel industry	11	200[a]	13	200[a]
Combustion – other industry	171	5000[a]	390	5000[a]
Combustion – commercial sector	28	1000[a]	39	1000[a]
Combustion – public sector	169	1000[a]	120	1000[a]

[a] These estimates are 'order of magnitude' figures, 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.

Data are included in EU ETS 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 five stations are not included in the EU ETS data for 2011 (4 in 2005), these are all small (in most cases, very small diesel-fired plant supplying electricity to Scottish islands). In comparison, coverage is quite poor in 2005 for cement and lime kilns (due to CCA participants opting out during Phase I) 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). All cement kilns and all but two lime kilns are included in 2011. The two excluded lime kilns are excluded on the basis that they are an integral part of installations for manufacturing soda ash, and these installations are not yet covered by EU ETS in the UK.

For most emission sources the level of detail given in the EU ETS data matches well with the structures of the GHGI, allowing comparison of like with like. Only in the case of coke ovens and integrated steelworks is this not the case, since the EU ETS reporting format does not provide a breakdown of emissions for the sectors reported within the GHGI: i.e. estimates of emissions from coke ovens, blast furnaces and sinter plants are not provided explicitly. However, for these sectors the EU ETS data has still been useful as a quality check for the overall use of fuels.

A9.5 EU ETS DATA USE IN THE UK GHGI

A9.5.1 Activity Data

A9.5.1.1 Crude Oil Refineries

The comparison of EU ETS emissions data against GHGI data based on DUKES fuel use allocations for petcoke, natural gas, fuel oil and OPG use is inconsistent to varying degrees in different years. Previous EU ETS analysis indicated that petcoke data in DUKES were too low; the DECC energy statistics team have investigated this matter with the refinery operators and have revised data for a number of sites that had been mis-reporting data through the DORS system used to compile DUKES. In recent years, therefore, the EU ETS and DUKES data are closely consistent for petcoke use by refineries.

Data inconsistencies between DUKES and EU ETS remain for other fuels, however. In some cases, this will be due to mis-allocation of fuel use data within the EU ETS analysis, where fuel names are unclear, e.g. “fuel gas” could be interpreted as refinery use of OPG or the use of natural gas as a support fuel within the refinery fuel gas system.

The fuel oil data in most years is around 10% higher in EU ETS than in DUKES. Natural gas is a relatively minor fuel in the sector; whilst the EU ETS allocations indicate an over-report in DUKES, there is considerable uncertainty over the allocations of gases in the EU ETS dataset, as noted above. The comparison of OPG data (even including the autogenerator allocation in DUKES within the refinery sector) indicates a considerable under-report in DUKES in all years, ranging from 23% to 35% across the time series. The petcoke data from 2007 onwards shows quite close consistency between EU ETS and DUKES. The alignment of GHGI emissions data with EU ETS sector data is achieved by using OPG activity data to deliver a consistent emissions dataset.

In the 1990-2009 GHGI cycle, the inconsistencies in the refinery sector were highlighted in the analysis of the ETS and non-ETS inventory data; the ETS emissions in 2009 for the sector as a whole were 11% higher than the estimates in the GHGI based on DUKES energy statistics. There is very low uncertainty regarding the scope of the refinery installations or the scope of EU ETS; the EU ETS data indicate that the GHG inventory previously included a large under-report for the refinery sector data. As a result of the analysis on the 1990-2009 inventory data, these discrepancies have been resolved.

Note that the GHGI estimates in the 1990-2009 cycle also included the assumption that all of the OPG allocation to “autogenerators” within the DUKES commodity balance tables (in the column “Other gases”) is used within the refinery sector. Consultation with the DECC DUKES team has indicated (Personal Communication, Evans, 2010) that the “Other gases” column in the Commodity Balance tables is the OPG on the refinery basis, with CHP plant on site allocated to the autogeneration line. We have therefore retained this assumption in the current analysis, including the autogenerator allocation of “other gases” within the refinery sector.

To resolve the refinery sector under-report, we have compared the GHGI data against EU ETS data, and also considered the total carbon dioxide emissions for the refinery sector provided annually by UKPIA. At the installation level, the UKPIA and EU ETS data show very close consistency for recent years. The close consistency of the EU ETS and UKPIA data further strengthens the case for using EU ETS data as the primary dataset to inform the UK GHG inventory, in preference to the DUKES energy statistics.

At the fuel-specific level, the greatest disparity is evident in the reporting of OPG use at refineries; the reporting disparity has therefore been resolved through a top-down emissions comparison between DUKES-derived data and EU ETS, with the difference between the two then allocated to OPG use in the UK GHGI. Total emissions for the sector are therefore aligned with EU ETS totals back to 2005.

Prior to 2005, there are no EU ETS data. The comparison of GHG emission estimates based on UK energy statistics compared to those directly from the trade association, UKPIA, show very close consistency for 2000 to 2003, but in 2004 the UKPIA emissions data are 8% higher than that derived from UK energy statistics. Taking a conservative approach, and considering the apparent under-report in UK energy statistics in later years, in the 1990-2010 GHGI cycle, the GHGI estimates were aligned with the (higher) UKPIA estimates, again applying a correction to the OPG allocation for the sector. We have retained this approach in the current inventory. No deviations from UK energy statistics have been made prior to 2004, as the data from UKPIA and GHGI estimates based on DUKES are closely consistent.

The time series of emissions data and the amended OPG activity data for the sector are shown below. (The year-specific Tier 3 implied emission factors for OPG are used to derive the additional activity data needed, with the 2004 data calculated using the 2005 EU ETS IEF for OPG.)

Table A 9.5.1 Refinery Emissions Data Comparison and Revision to OPG Activity

Year	EU ETS total	UKPIA total	UKPIA / EU ETS	GHGI (based on DUKES)	UKPIA / GHGI	Difference in emissions	Revised OPG use in GHGI
	kt C	kt C	%	kt C	%	kt C	Mth
2000	No data	4599	-	4528	102%	71	-
2001	No data	4535	-	4420	103%	115	-
2002	No data	4767	-	4917	97%	-150	-
2003	No data	4772	-	4741	101%	31	-
2004	No data	4999	-	4636	108%	364	1491
					EU ETS / GHGI (%)		
2005	5006.7	4974	99.3%	5084	99%	-77	1235
2006	4910.2	4677	95.3%	4385	112%	525	1593
2007	4856.8	4828	99.4%	4399	110%	457	1443
2008	4708.7	4660	99.0%	4306	109%	402	1614
2009	4491.6	4423	98.5%	3939	114%	553	1590
2010	4465.8	4441	99.4%	4072	110%	393	1562
2011	4739.0	4194	88.5%	4094	116%	645	1682

There is some level of uncertainty in the allocation of fuels in EU ETS to specific “DUKES” fuels, although the OPG use in refineries seems to be reported quite consistently as “Refinery Gas”, “Refinery Off-Gas”, or “OPG/RFG”. The DECC DUKES team have reviewed the year to year consistency of OPG use in refineries through the DORS system.

The 2011 data from UKPIA exclude emissions from one of the UK oil refineries and hence are an under-report for the sector. Through comparison of the UKPIA data, operator data from reporting to EU ETS and under IPPC regulation, we consider the EU ETS total in the table above to be the best available data for the sector.

A9.5.1.2 Oil & Gas Terminal OPG and LPG Use

The allocation of reported fuel use within EU ETS to map to UK energy balance fuel nomenclature is uncertain in some cases. Analysis of the EU ETS fuel use data does indicate that there are small amounts of these fuels being used in the upstream oil & gas sector that are not evident within DUKES.

The DECC DUKES team have noted previously (Personal communication, DECC, 2010) that some LPG and OPG fuels are abstracted from upstream oil and gas exploration and production sources, rather than purchased from other sources, and that no data have been collected for this source since DUKES last published data for these sources, for the year 2002.

Therefore, the data from the EU ETS from oil and gas processing terminals on LPG and OPG combustion are used directly within the UK GHG inventory for the Phase II years of 2008 to 2011, with estimates for 2003 to 2007 derived by interpolation between the EU ETS 2008 data and the DUKES 2002 data.

A9.5.1.3 Natural Gas Use by Downstream Gas Supply Installations

The EU ETS data includes natural gas use by large gas compressor and storage sites that operate on the UK gas transmission and distribution network, as well as the three operational LNG terminals and a small number of other downstream gas industry sites.

The gas use reported in EU ETS for these sites throughout Phase II has been notably higher than the allocation of gas within DUKES Commodity Balance table 4.2 (Energy Industry Use, Other). This has been evident in the traded / non-traded analysis for the gas supply sector in the UK and DA GHGI.

As this gas use arises from the downstream network, the inventory agency and the DECC DUKES team consider that the DUKES data indicate a small mis-allocation of gas use, rather than a gap in reported gas use. For 2005 to 2011, therefore, the EU ETS data for this source are used within the UK GHG inventory, and the overall gas use data are balanced by reducing the allocation of gas use to “other industrial combustion (IPCC source 1A2f); the EU ETS data since 2005 shows good consistency with the data from DUKES for earlier years.

Even the increase of gas use to this sector informed by EU ETS data is expected to be a small under-report for the sector as a whole, as the EU ETS scope only includes around 28 of the larger gas compressor and storage sites on the UK network, and it is likely that additional gas use on smaller sites also occurs. However, the inventory agency has no data to inform such estimates.

A9.5.1.4 Other Industry OPG use

There are a number of “other industry” sites where OPG use has been allocated by the inventory agency from EU ETS data, where the fuel is defined as either a specific gas (e.g. ethane, propane, butane) or more generic terms such as “OPG”, “High Pressure Refinery Gas”, “Low Pressure Refinery gas”, “fuel gas” or “RFG/OPG/ROG” within the EU ETS forms. The direct reference to refinery gases and the locations of the installations raises questions about how the fuel consumption is tracked and then reported within DUKES.

For a small number of sites, consultation with the DUKES team, regulators and operators has clarified that there is an under-report within DUKES and that the EU ETS energy and emissions data are the more accurate dataset and should be used in the UK GHGI. At some sites, energy supplier data returns to DECC have been mis-interpreted with gases allocated to non-energy uses in the UK energy balance, when in fact a higher proportion of petroleum-based gases are used in combustion.

Within the DUKES petroleum commodity balance tables, there is no allocation of OPG or other light hydrocarbons to these industrial combustion processes, but there is an allocation to non-energy use of these gases, as well as some OPG use reported in autogeneration. Based on the EU ETS evidence, some proportion of this non-energy use has been re-allocated to account for the GHG emissions from these facilities, to address this gap in the inventory totals.

In the 1990-2011 inventory cycle, EU ETS data for fuel use at petrochemical production facilities has helped to identify and quantify under-reports within the UK energy statistics for the combustion of gases that are derived from Natural Gas Liquid (NGL) feedstock to petrochemical production processes. Analysis of “fuel gas” calorific values and carbon content has helped to inform the calculations to estimate emissions from NGL-derived gases, to address the under-report in UK energy statistics and fill a reporting gap in previous inventory submissions.

A9.5.1.5 Other Processes

The EU ETS dataset contains some emission sources that are not included in the GHGI. These sources are individually small but the EU ETS data have been used to generate estimates of emissions included within the UK GHGI in this submission, including:

- Emissions from clays and brick making additives. The GHGI currently includes carbon emissions from carbonaceous material contained in the Lower Oxford Clay used in Fletton bricks, but does not include the less significant emissions from other types of clays used in Non-Fletton bricks and emissions from other additives;
- Emissions from additives used in steelmaking, such as scrap metals and alloys;
- Emissions from additives used in glassmaking, such as barium carbonate and calumite.

Emissions are only available back to 2005, and data for 2005-2007 are more limited in some cases due to the opting out of processes involved in Climate Change Agreements, but annual production estimates are available for all three sectors and have been used to construct a time series of emissions for inclusion in the UK GHGI.

A9.5.2 Implied Emission Factors

A9.5.2.1 Power Stations

Table A 9.5.2 summarises EU ETS data for fuels burnt by major power stations and coal burnt by autogenerators. The percentage of emissions based on 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), as well as the average emission factor for EU ETS emissions based on Tier 3 factors.

Table A 9.5.2 EU ETS data for Fuels used at Power Stations and Autogenerators (Emission Factors in kt / Mt for Coal & Fuel Oil, kt / Mth for Gases)

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 only)
2005	Coal	99	615.3
2006		100	615.0
2007		100	614.7
2008		100	612.4
2009		100	607.2
2010		100	609.0
2011		100	609.0
2005	Fuel oil / Waste oil[a]	59	860.2
2006		66	873.3
2007		70	871.1
2008		92	869.5
2009		97	872.7
2010		96	873.3
2011		95	873.9
2005	Natural gas	52	1.443
2006		76	1.465
2007		95	1.464
2008		97	1.467
2009		100	1.464
2010		99	1.460
2011		99	1.458
2005	Coal - autogenerators	100	594.3
2006		100	596.3
2007		100	594.5
2008		100	581.3
2009		100	600.6
2010		100	599.9
2011		100	594.9

[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 factors are also very consistent across the time-series, which would be expected for this sector. As shown in Section 3, the EU ETS data for power stations also cover almost all UK installations in this sector, and certainly cover all of the larger installations.

In the 1990-2011 inventory cycle, we have refined the analysis for coal-fired power stations, to separate out the reporting of coal and petcoke within fuel blends that are used at a small number of UK power stations. Reporting of fuel analysis and emissions for coal and petcoke blends is permitted within EU ETS reporting, and previous UK GHG inventory submissions have allocated all of the carbon emissions from the fuel blend data proportionately to both coal and petroleum coke i.e. those fuels are assumed to have the same carbon emission factor as the blend itself.. In the latest cycle we have back-calculated the coal IEF from those blends using an assumed default for petcoke carbon content and more detailed activity data on the constituents of the fuel blends, from operators. This has not affected the UK GHGI emissions total, but does enable us to present a more accurate IEF for both coal and petroleum coke use in power stations. As a result, the IEFs for coal in the table above are all fractionally lower than the data presented in previous submissions.

The EU ETS based emission factors presented above for power stations are therefore 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 reported in EU ETS. Small quantities of sour gas were burnt at one power station in 2005-2007 and 2009 and EU ETS Tier 3 emission factors are available and therefore used. [Due to the confidentiality of the data, the emission factors are not shown]. Prior to 2005, the emission factors for these sectors are based on the methodology established by Baggott *et al*, 2004, since it has been concluded that this represents the most reliable approach.

The EU ETS factors for coal-fired autogenerators are slightly different to the factors for the power stations in that, although the EU ETS data are exclusively Tier 3, they only represent about 80% of total fuel used by the sector.

A9.5.2.2 Crude Oil Refineries

The tables below summarise the EU ETS data for the major fuels burnt by refineries in the UK.

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. Refineries also use natural gas, although it is a relatively small source of emissions compared to other fuels.

Table A 9.5.3 Refinery EU ETS Data for Fuel Oil, OPG and Natural Gas (Emission Factors in kt / Mt for Fuel Oil and kt / Mth for OPG and Natural Gas)

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 sites only)
2005	Fuel Oil	25	861.0
2006		65	873.9
2007		79	877.4
2008		91	871.6
2009		91	876.2
2010		97	878.2
2011		83	879.6
2005	OPG	60	1.495
2006		58	1.469
2007		69	1.582
2008		82	1.483
2009		81	1.489

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 sites only)
2010		82	1.512
2011		68	1.468
2005	Natural Gas	0	n/a
2006		43	1.460
2007		45	1.462
2008		98	1.475
2009		98	1.480
2010[8]		93	1.467
2011		81	1.447

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 25% of fuel. Carbon factors can be derived for **OPG** based on moderate levels of Tier 3 reporting for 2005-2007 and 2011 but levels of more than 80% for 2008-2010. There is some uncertainty regarding the allocation of EU ETS fuels to the OPG fuel category, and the derived emission factors do cover a wider spread of values than for many other fuels in EU ETS. However, this perhaps reflects the nature of this fuel, and the data for all seven years have been used in the inventory.

Carbon factors for natural gas are based on a low % of Tier 3 reporting until 2008; in 2008 to 2010 over 90% of gas use is reported at Tier 3 and 81% in 2011. Within the UK GHGI, the EU ETS factors for 2008 to 2011 are used directly, whilst emission factors for earlier years are derived from gas network operator gas compositional analysis.

EU ETS emission data for **petroleum coke** are higher in 2005-2008, 2011 and lower in 2009 and 2010, when compared against the estimates derived from DUKES activity data and the industry-recommended emission factor. This is especially noticeable for 2005, 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 DECC energy statisticians has identified that the figures given in DUKES are subject to uncertainty and hence the EU ETS data are used directly within the UK GHGI.

A9.5.2.3 Integrated Steelworks & Coke Ovens

Table A 9.5.4 summarises EU ETS data for the major fuels burnt at integrated steelworks and coke ovens. The data exclude one independent coke oven which calculates emissions using a detailed mass balance approach which makes it more difficult to assess the data in the same way as the other installations.

Table A 9.5.4 EU ETS data for Fuels used at Integrated Steelworks and Coke Ovens (Emission Factors in kt / Mt for Solid & Liquid Fuels, kt / Mth for Gases)

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 sites only)
2005	Blast furnace gas	0	-
2006		91	6.873

[8] Notably lower Tier 3 analysis and lower IEF, as one refinery reports at Tier 2 in 2010 that had previously reported at Tier 3.

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 sites only)
2007		90	6.920
2008		92	6.945
2009		92	7.029
2010		100	6.949
2011		94	6.990
2005	Coke oven gas	0	-
2006		0	-
2007		0	-
2008		56	1.093
2009		100	1.140
2010		100	1.117
2011		100	1.089
2005	Natural gas	0	-
2006		3	1.479
2007		2	1.478
2008		0	-
2009		58	1.425
2010		68	1.441
2011		64	1.441
2005	Fuel oil	0	-
2006		0	-
2007		0	-
2008		84	878.3
2009		89	884.7
2010		83	887.6
2011		88	888.7

With the exception of blast furnace gas, reporting of emission factors at Tier 3 has only predominated in the last few years of the time series. None of the data are currently used in the GHGI. In the case of natural gas, the derived emission factors are quite variable, and the level of Tier 3 reporting is particularly low. The factors for fuel oil for the period 2008-2011 are based on a much higher level of Tier 3 data, and are quite consistent.

Emission factors for blast furnace gas and coke oven gas are currently based on a carbon mass balance approach that utilises DUKES energy data and fixed/estimated carbon factors for selected input fuels such as coal, and selected outputs such as coke oven gas & pig iron, and then calculates the carbon content of coke oven coke, blast furnace gas, and basic oxygen furnace gas.

A9.5.2.4 Cement Kilns

Table A 9.5.5 summarises EU ETS data for the major fuels burnt at cement kilns.

Table A 9.5.5 EU ETS data for Fuels used at Cement Kilns (kt / Mt)

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 sites only)
2005	Coal	8	671.1
2006		100	546.2
2007		100	664.3
2008		100	655.8
2009		100	658.3
2010		100	637.7
2011		100	645.8
2005	Petroleum coke	-	-
2006		100	820.8
2007		100	830.2
2008		100	819.1
2009		100	796.8
2010		100	750.8
2011		100	738.4

The EU ETS dataset also provides a detailed breakdown of cement sector process emissions from the decarbonisation of raw materials during the clinker manufacturing process. These data are useful to compare against statistics provided by the Mineral Products Association (MPA) regarding clinker production and the non-combustion emissions associated with UK cement production.

The MPA data on clinker production are commercially confidential.

The two data sets show significant differences for 2005-2007; however the EU ETS data cover only a fraction of the sector, so differences might be expected. The coal IEF data for 2008-2011 are closer, with a narrow (3%) range. Because of the good agreement in both activity data and emission factors for 2008 onwards, the industry-wide estimates provided by the MPA and used within the GHGI show very close comparison with the EU ETS estimates, with the sum of the EU ETS data around 1% lower than those reported to the GHGI, as outlined below in **Table A 9.5.6**.

Table A 9.5.6 Comparison of Cement Sector Carbon Dioxide Emissions* within the UK GHGI and the EU ETS for 2008-2011

	2008	2009	2010	2011
GHGI CO_2 emissions (kt)	8294	5686	5788	6130
Sum of EU ETS CO_2 emissions (kt)	8259	5647	5754	6087
EU ETS / GHGI	99.6%	99.3%	99.4%	99.3%

*The data in this table include fuel combustion emissions (reported under IPCC 1A2f) and process emissions (reported under IPCC sector 2A1) from UK cement kilns.

A9.5.2.5 Lime Kilns

Table A 9.5.7 summarises data given in the EU ETS datasets for the major fuels burnt at lime kilns. Unlike cement kilns, which often burn a variety of fuels, many lime kilns burn just a single fuel, often natural gas. Coke oven coke is believed to be used in some lime kilns but these currently do not report in EU ETS, and hence do not appear in the tables below.

Table A 9.5.7 EU ETS data for Fuels used at Lime Kilns (Emission Factors in kt / Mt for Solid Fuels and kt / Mth for Gases)

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 sites only)
2005	Coal*	-	-
2006		-	-
2007		34	846.9
2008		79	701.4
2009		100	698.9
2010		100	634.4
2011		100	703.9

*Coal used in the lime industry in the UK includes a high proportion of anthracitic coal, and hence these IEFs are notably higher than for coal used in other sectors of UK industry.

The EU ETS data for lime kilns are variable across the time series, both in terms of the proportion of emissions based on Tier 3 factors, and in the emission factors themselves. EU ETS based factors are currently used for coal and petroleum coke from 2008 onwards, as the EU ETS data do include all lime kilns burning those fuels and almost all of those data are Tier 3 and hence are regarded as highly reliable.

EU ETS data for natural gas use in the lime industry does cover all installations burning this fuel, however the proportion of emissions based on Tier 3 factors is very low. Therefore the EU ETS emission factors are not used in the UK GHGI, and the emission factors for natural gas continue to be based on the methodology given in Baggott *et al,* 2004.

Table A 9.5.8 shows implied emission factors for process-related emissions from lime kilns that are used within the UK GHG inventory. The lime industry can be sub-divided into those installations where lime is the primary product, and carbon dioxide is an unwanted by-product; and those installations where both lime and carbon dioxide are utilised. The latter include kilns in the sugar industry (where carbon dioxide is used in the purification stages) and soda ash production (where carbon dioxide is combined with other chemicals to produce sodium carbonate), and in these kilns, the carbon dioxide from decarbonisation of the limestone or dolomite feedstock is assumed to be fully consumed in the process, rather than emitted to atmosphere. **Table A 9.5.8** therefore does not cover these installations. None of the emission factors in EU ETS are Tier 3, so the table shows the overall emission factors for all tiers of data.

Table A 9.5.8 EU ETS emission factor data for production of lime (kt / Mt lime produced)

Year	Activity	EU ETS
2005	Lime production	200.4
2006		201.2
2007		201.3

Year	Activity	EU ETS
2008		195.6
2009		195.0
2010		193.9
2011		195.3

These factors compare with a theoretical emission factor of 214 kt / Mt lime, assuming use of pure limestone. We note that the EU ETS factors are all lower than the theoretical emission factor based on the stoichiometry of the lime manufacturing process and this is despite some use of dolomitic limestone in the UK industry which would be expected to further increase the emission factor above the 214 kt/Mt lime factor. The EU ETS data are subject to third party verification, and therefore the emissions data are assumed to be accurate. It is assumed that the reason for this deviation from the theoretical emission factor is due to the production activity data being inflated by either the products containing some proportion of slaked lime (i.e. hydrated product and hence heavier than pure lime) and/or other additives to the lime product which increase the mass of the lime product.

A9.5.2.6 Other Industrial Combustion

Table A 9.5.9 summarises EU ETS data for coal, fuel oil and natural gas used by industrial combustion installations.

At first sight, the data for coal looks like it should be reliable enough to be used in the GHGI with 92% or more of emissions based on Tier 3 factors in each year. 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 – see **Section A 9.4** for details. 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 these data have been used directly in the compilation of the GHGI estimates.

Table A 9.5.9 EU ETS data for Coal, Fuel Oil and Natural Gas used by Industrial Combustion Plant (Emission Factors in kt / Mt for Coal & Fuel Oil, kt / Mth for Natural Gas)

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 sites only)	GHGI Carbon Emission Factor
2005	Coal	98	607.1	630.9
2006		98	603.0	631.7
2007		99	615.7	645.6
2008		94	598.6	639.7
2009		92	595.4	651.3
2010		92	589.0	657.0
2011		96	596.5	636.7
2005	Fuel oil	17	864.7	879.0
2006		27	865.3	879.0
2007		44	872.3	879.0
2008		24	871.4	879.0
2009		40	871.3	879.0

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 sites only)	GHGI Carbon Emission Factor
2010		40	873.0	879.0
2011		44	874.2	879.0
2005	Natural gas	13	1.593	1.478
2006		33	1.449	1.478
2007		42	1.468	1.477
2008		33	1.505	1.474
2009		46	1.495	1.474
2010		50	1.494	1.472
2011		49	1.444	1.468

Emission factors can also be derived from EU ETS where a high percentage of Tier 3 analysis is evident, for a number of other minor fuels. Due to the very low number of sites that report data for each fuel type, these EU ETS-derived emission factors are confidential and are not tabulated here. The source/activity combinations for which EU ETS emission factor data are used within the inventory are:

- Other industrial combustion / petroleum coke
- Other industrial combustion / waste solvents
- Other industrial combustion / colliery methane

The EU ETS-derived emission factors for colliery methane for each year (2005-11) are also applied to all other sources using these fuels.

A10 ANNEX 10: 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).

A10.1 NATIONAL STATISTICS

Table A 10.1.1 Summary table of GHG emissions by NC Category (Mt CO_2eq) – National Statistics coverage

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy Supply	272.45	270.13	258.99	241.17	233.24	234.03	235.02	218.90	222.16	209.72	218.46
Transport	121.48	119.71	120.99	122.26	122.75	122.07	126.41	127.72	126.72	127.74	126.65
Residential	80.76	89.57	86.92	90.93	86.52	82.27	93.88	87.37	90.07	89.72	90.16
Business	115.34	119.62	115.19	113.77	112.95	110.28	112.88	110.10	110.42	112.08	114.00
Public	13.13	13.98	14.63	13.30	12.95	12.78	13.82	13.47	12.47	12.20	11.50
Industrial Process	54.66	52.62	47.26	43.64	45.64	45.09	45.97	47.09	44.07	26.83	24.69
Agriculture	63.72	63.53	63.38	62.73	62.99	62.58	62.90	62.89	62.09	61.49	59.22
Land Use Change	4.02	4.13	3.35	2.32	2.13	3.28	2.59	2.44	1.53	1.00	0.42
Waste Management	47.38	46.50	45.22	43.83	42.60	41.41	40.36	37.28	35.24	32.55	30.84
Total	**772.94**	**779.80**	**755.93**	**733.96**	**721.76**	**713.79**	**733.81**	**707.26**	**704.77**	**673.33**	**675.95**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Energy Supply	227.66	224.88	230.86	229.90	227.52	232.83	227.11	221.94	198.69	204.28	190.95
Transport	126.64	129.08	128.59	129.75	130.30	131.10	132.38	126.60	121.73	120.14	118.45
Residential	92.57	89.11	90.22	91.70	87.84	85.23	81.48	83.39	78.07	89.88	69.65
Business	114.36	104.86	107.69	107.01	108.19	105.58	104.57	102.81	91.45	91.90	89.14
Public	11.99	10.19	10.20	11.14	11.05	10.05	9.33	9.36	8.26	8.42	7.14
Industrial Process	22.26	19.24	20.00	19.47	18.81	17.38	18.71	16.90	10.80	11.74	10.23
Agriculture	56.32	56.34	55.93	55.82	55.48	53.68	52.18	51.41	50.64	51.19	51.20
Land Use Change	-0.09	-0.99	-1.28	-2.39	-2.60	-2.99	-3.34	-3.79	-3.82	-3.67	-3.31
Waste Management	27.42	25.31	22.42	20.97	20.44	20.07	19.72	19.20	18.46	17.87	17.28
Total	**679.14**	**658.02**	**664.64**	**663.37**	**657.04**	**652.94**	**642.15**	**627.84**	**574.27**	**591.74**	**550.73**

Table A 10.1.2 Summary table of GHG emissions by Gas (Mt CO_2eq) – National Statistics coverage

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO_2	592.01	599.20	582.00	567.26	561.01	553.78	574.94	550.31	554.34	544.95	553.14
CH_4	98.89	98.08	96.31	93.09	85.74	85.04	82.81	78.28	74.04	69.04	64.81
N_2O	68.23	68.41	63.58	58.93	59.40	57.95	57.75	58.07	57.86	47.31	46.42
HFCs	11.39	11.86	12.35	13.02	13.93	15.32	16.56	18.98	16.88	10.24	9.31
PFCs	1.40	1.17	0.57	0.49	0.49	0.46	0.48	0.40	0.39	0.37	0.46
SF_6	1.03	1.08	1.12	1.17	1.18	1.24	1.27	1.23	1.26	1.43	1.80
Total	**772.94**	**779.80**	**755.93**	**733.96**	**721.76**	**713.79**	**733.81**	**707.26**	**704.77**	**673.33**	**675.95**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
CO_2	564.26	547.49	557.61	558.20	554.12	552.72	543.60	531.17	480.69	497.84	458.61
CH_4	59.13	56.06	52.06	50.49	48.30	47.29	46.17	44.83	43.53	42.83	41.88
N_2O	43.72	41.96	41.50	42.07	41.16	39.03	38.34	37.32	35.29	35.86	34.75
HFCs	10.23	10.69	11.88	11.15	12.04	12.72	13.03	13.61	13.95	14.30	14.57
PFCs	0.38	0.32	0.28	0.34	0.30	0.30	0.22	0.20	0.15	0.22	0.33
SF_6	1.42	1.51	1.32	1.13	1.11	0.87	0.79	0.71	0.66	0.69	0.61
Total	**679.14**	**658.02**	**664.64**	**663.37**	**657.04**	**652.94**	**642.15**	**627.84**	**574.27**	**591.74**	**550.73**

A10.2 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 10.2.1 Summary table of GHG emissions by NC Category (Mt CO_2eq) – UK only

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy Supply	271.92	269.57	258.33	240.56	232.61	233.38	234.37	218.30	221.52	209.07	217.97
Transport	121.00	119.24	120.52	121.79	122.28	121.59	125.86	127.18	126.16	127.20	126.09
Residential	80.45	89.25	86.61	90.62	86.21	81.94	93.53	86.92	89.61	89.33	89.76
Business	115.13	119.39	114.99	113.56	112.72	110.04	112.60	109.79	110.10	111.81	113.69
Public	13.13	13.98	14.63	13.30	12.95	12.78	13.82	13.47	12.47	12.20	11.50
Industrial Process	54.66	52.62	47.26	43.64	45.64	45.09	45.97	47.09	44.07	26.83	24.69
Agriculture	63.55	63.36	63.21	62.56	62.82	62.41	62.73	62.73	61.91	61.31	59.05
Land Use Change	4.04	4.15	3.38	2.35	2.16	3.32	2.65	2.50	1.59	1.06	0.49
Waste Management	47.24	46.36	45.08	43.70	42.47	41.28	40.22	37.14	35.10	32.42	30.75
Total	**771.12**	**777.92**	**754.01**	**732.08**	**719.86**	**711.84**	**731.75**	**705.12**	**702.55**	**671.23**	**673.99**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Energy Supply	227.45	224.67	230.72	229.67	227.26	232.51	226.76	221.62	198.30	203.92	190.59
Transport	126.07	128.52	128.03	129.18	129.73	130.55	131.82	126.06	121.20	119.61	117.92
Residential	92.19	88.68	89.80	91.34	87.44	84.85	81.09	83.00	77.69	89.48	69.26
Business	114.01	104.47	107.35	106.67	107.84	105.25	104.19	102.47	91.13	91.58	88.83
Public	11.99	10.19	10.20	11.14	11.05	10.05	9.33	9.36	8.26	8.42	7.14
Industrial Process	22.26	19.24	20.00	19.47	18.81	17.38	18.71	16.90	10.80	11.74	10.23
Agriculture	56.14	56.17	55.81	55.70	55.36	53.53	52.02	51.25	50.49	51.04	51.06
Land Use Change	-0.02	-0.92	-1.20	-2.32	-2.53	-2.89	-3.25	-3.71	-3.72	-3.58	-3.22
Waste Management	27.33	25.24	22.35	20.92	20.39	20.01	19.67	19.15	18.42	17.83	17.24
Total	**677.43**	**656.27**	**663.06**	**661.78**	**655.34**	**651.24**	**640.34**	**626.11**	**572.56**	**590.04**	**549.06**

Table A 10.2.2 Summary table of GHG emissions by Gas (Mt CO_2eq) – UK Only

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CO_2	590.52	597.65	580.41	565.71	559.44	552.16	573.22	548.51	552.47	543.20	551.50
CH_4	98.62	97.81	96.03	92.83	85.48	84.77	82.55	78.02	73.77	68.78	64.59
N_2O	68.16	68.35	63.52	58.87	59.34	57.89	57.69	58.00	57.79	47.24	46.36
HFCs	11.39	11.86	12.35	13.02	13.93	15.32	16.55	18.97	16.86	10.21	9.28
PFCs	1.40	1.17	0.57	0.49	0.49	0.46	0.48	0.40	0.39	0.37	0.46
SF_6	1.03	1.08	1.12	1.17	1.18	1.24	1.27	1.23	1.26	1.43	1.80
Total	**771.12**	**777.92**	**754.01**	**732.08**	**719.86**	**711.84**	**731.75**	**705.12**	**702.55**	**671.23**	**673.99**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
CO_2	562.86	546.04	556.28	556.84	552.67	551.30	542.08	529.74	479.26	496.42	457.20
CH_4	58.92	55.87	51.91	50.36	48.16	47.13	46.00	44.67	43.38	42.69	41.74
N_2O	43.65	41.89	41.44	42.02	41.11	38.97	38.28	37.26	35.23	35.80	34.69
HFCs	10.19	10.64	11.83	11.10	11.99	12.66	12.96	13.54	13.88	14.23	14.49
PFCs	0.38	0.32	0.28	0.34	0.30	0.30	0.22	0.20	0.15	0.22	0.33
SF_6	1.42	1.51	1.32	1.13	1.11	0.87	0.79	0.71	0.66	0.69	0.61
Total	**677.43**	**656.27**	**663.06**	**661.78**	**655.34**	**651.24**	**640.34**	**626.11**	**572.56**	**590.04**	**549.06**

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A11 ANNEX 11: End User Emissions

A11.1 INTRODUCTION

This Annex explains the concept of a final user or end user, summarises the final user calculation methodology with examples, and contains tables of greenhouse gas emissions according to final user from 1990 to 2011.

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[9].

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 1990-2011, 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 are not included in the calculations; there is not enough information available to reallocate emissions from energy supply. Emissions presented in this chapter show emissions from the UK and Crown Dependencies, consistent with the UK statistical release.

A11.2 DEFINITION OF FINAL USERS

The final user[10] 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:

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

[10] 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:

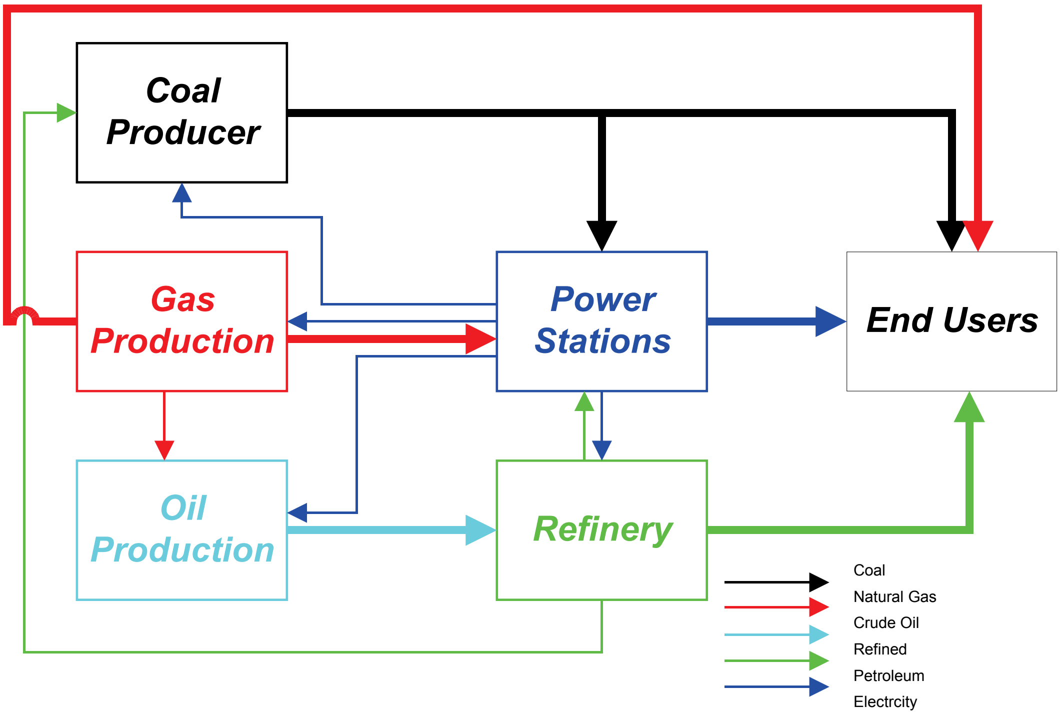
1. Direct emissions from motor vehicle exhausts.
2. Emissions refineries producing motor fuels, including refining, storage, flaring and extraction of oil; and from the distribution and supply of motor fuels.

A11.3 OVERVIEW OF THE FINAL USERS CALCULATIONS

As fuel and electricity producers use energy from other producers, they are allocated emissions from each other and these have to then be reallocated to final users. This circularity results in an iterative approach being used to estimate emissions from categories of final users.

Figure A11.3.1 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 11.3.1 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[11] 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%)[12] 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.

[11] 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.

[12] 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.

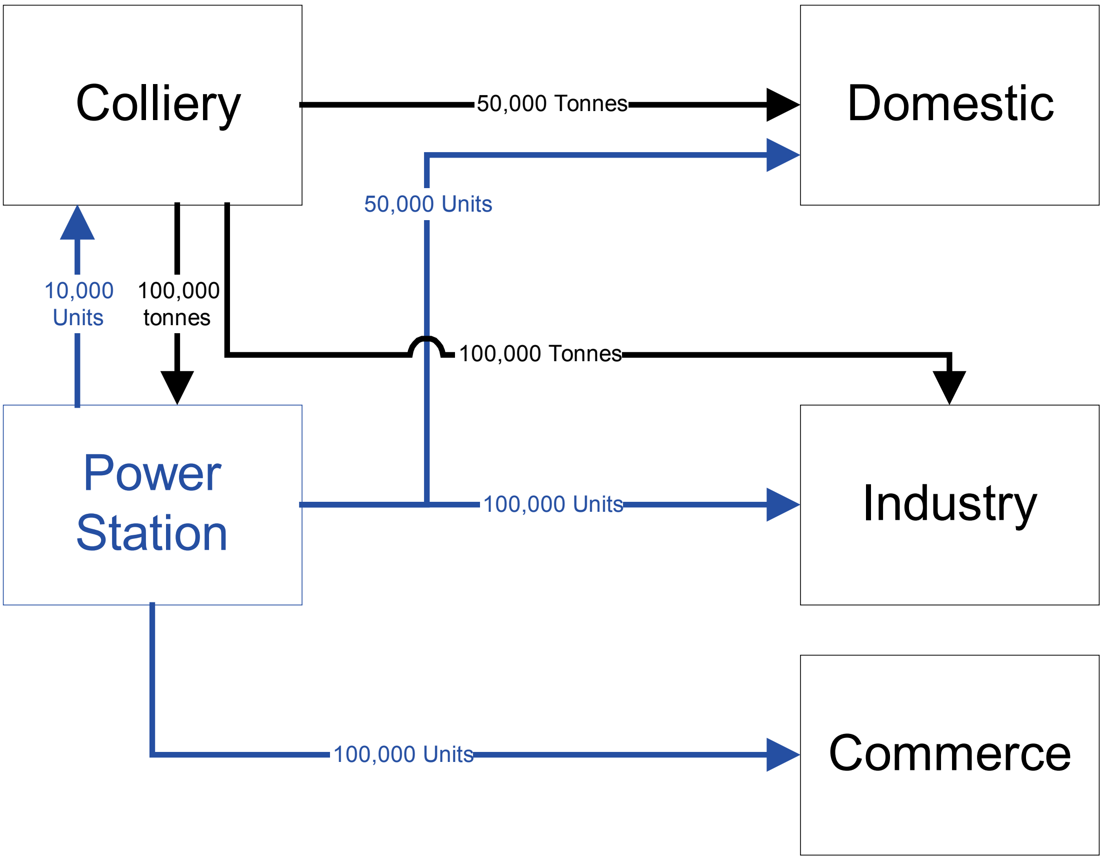
A11.4 EXAMPLE FINAL USER CALCULATION

The following example illustrates the methodology used to calculate emissions according to final users. The units in this example are arbitrary.

The example in **Figure A11.4.1** 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 carbon 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 11.4.1 Fuel use in the example calculation



In **Figure A 11.4.1**, 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 A11.4.1 summarises the outputs during this example final user calculation.

Table A 11.4.1 Example of the outputs during a final user calculation

			Sector						
			Colliery	**Power Station**	**Residential**	**Industrial**	**Commercial**	**Unallocated emissions as percentage of total emission**	**Total emission of carbon (tonnes)**
Coal use (tonnes)	Mass		100	100,000	50,000	100,000	0		
	Energy content		25,000	25,000,000	12,500,000	25,000,000	0		
Electricity use (arbitrary units)	Energy units		10,000		50,000	100,000	100,000		
Emissions of carbon (tonnes)	Initial		70	70000	35000	70000	0	40.02	175070
	Emissions after Iteration step	1	2692	28	48476	96951	26923	1.55	175070
		2	1	1077	49020	98039	26934	0.62	175070
		3	41	1	49227	98454	27348	0.02	175070
		4	0	17	49235	98470	27348	0.01	175070
		5	1	0	49238	98477	27355	0	175070
		6	0	0	49239	98477	27355	0	175070

The initial carbon emissions are 70% 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 26923 tonnes of carbon emissions allocated to it, mainly 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 (175070 tonnes of carbon) 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 11.4.2 Comparison of 'direct' and final user emissions of carbon according the sectors considered in the final user example

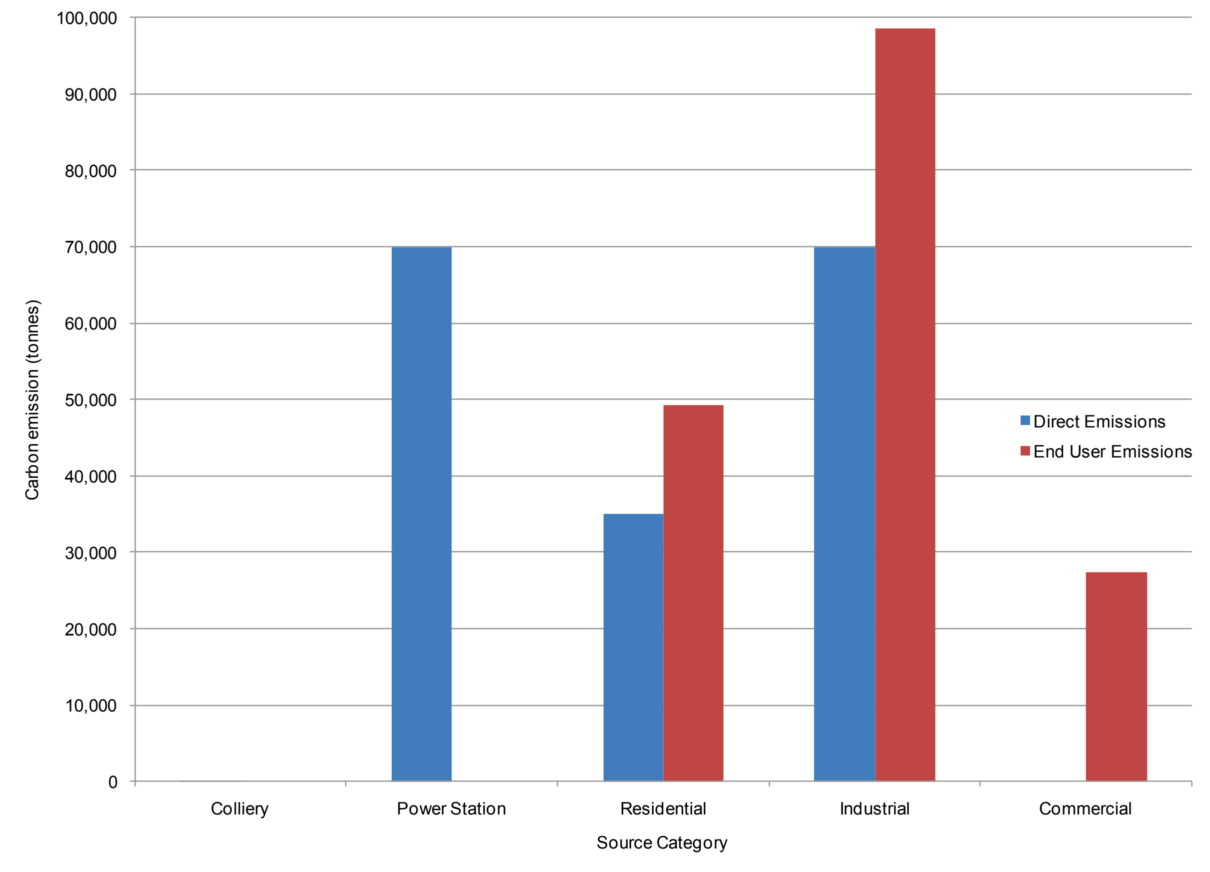


Figure A11.4.2 compares the quantities of direct and final user carbon emitted from each sector at the end of the final user calculation. The direct emissions of carbon are from the combustion of coal in the sectors. The direct and final user emissions are from two distinct calculations and must be considered 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 carbon 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 carbon emissions from these two sectors have been reallocated to the residential, industrial and commercial sectors. This reallocation means the final user emissions for the residential and industrial sectors are greater than their 'direct' emissions.

A11.5 FINAL USER CALCULATION METHODOLOGY FOR THE UK GREENHOUSE GAS INVENTORY

The approach divides fuel user emissions into 7 categories (see column 1 of **Table A11.5.1**). For each of these groups, source categories are distributed by the total energy consumption of a group of fuels. For example, for the coal group, the emissions of four source categories are distributed to final users according to the energy use of anthracite and coal combined.

Table A 11.5.1 Sources reallocated to final users and the fuels used

Final user group	Emission sources to be reallocated to final users	Fuels used for redistribution
1. Coke	Gasification processes	Coke
	Coke production	Blast furnace gas
	Iron and steel – flaring	
2. Coal	Closed Coal Mines	Coal
	Coal storage and transport	Anthracite
	Collieries - combustion	
	Deep-mined coal	
	Open-cast coal	
3. Natural gas	Gas leakage	Natural gas
	Gas production	
	Upstream Gas Production - flaring	
	Upstream Gas Production - fuel combustion	
	Upstream Gas Production - Gas terminal storage	
	Upstream Gas Production - Offshore Well Testing	
	Upstream Gas Production - process emissions	
	Upstream Gas Production - venting	
	Upstream Gas production - combustion at gas separation plant	
4. Electricity	Nuclear fuel production	Electricity
	Power stations	
	Autogeneration – exported to grid	
	Power stations - FGD	
5. Petroleum	Upstream Oil Production - gas combustion	Naphtha
	Upstream Oil Production - gas flaring	Burning oil (premium)
	Upstream Oil Production - gas venting	Burning oil
	Upstream Oil Production - Offshore Oil Loading	Aviation turbine fuel
	Upstream Oil Production - Offshore Well Testing	Aviation spirit
	Upstream Oil Production - Oil terminal storage	Derv
	Upstream Oil Production - Onshore Oil Loading	Fuel oil
	Upstream Oil Production - process emissions	Gas oil
	Petrol stations - petrol delivery	OPG
	Petrol stations - vehicle refuelling	Refinery misc.
	Petrol terminals - storage	Petrol
	Petrol terminals - tanker loading	Petroleum coke

Final user group	Emission sources to be reallocated to final users	Fuels used for redistribution
	Petroleum processes	Wide-cut gasoline
	Refineries - combustion	Vaporizing oil
	Refineries - drainage	LPG
	Refineries - flares	
	Refineries - general	
	Refineries - process	
	Refineries - road/rail loading	
	Refineries - tankage	
	Sea going vessel loading	
	Ship purging	
6. Solid Smokeless Fuels	Solid Smokeless fuel production	Solid Smokeless Fuels
7. Town gas	Town gas manufacture	Town gas
8. Charcoal	Charcoal production	Charcoal

Comments on the calculation methodology used to allocate emissions according final users are listed below:

- Emissions are allocated to final users on the basis of the proportion of the total energy produced used by a given sector. This approach is followed to allow for sectors such as petroleum where different products are made in a refinery;
- Some emissions are allocated to an “exports” category. This is for emissions within the UK from producing fuels, (for example from a refinery or coal mine), which are subsequently exported or sent to bunkers for use outside the UK. Therefore these emissions are part of the UK inventory even if the use of the fuel produces emissions that cannot be included in the UK inventory because it takes place outside the UK;
- No allowance is made for the emission from the production of fuels or electricity outside the UK that are subsequently imported;
- Some of the output of a refinery is not used as a fuel but used as feedstock or lubricants. This is not currently treated separately and the emissions from their production (which are small) are allocated to users of petroleum fuels. This is partly due to lack of data in the database used to calculate the inventory, and partly due to the lack of a clear, transparent way of separating emissions from the production of fuels and from the production of non-fuel petroleum products; and
- Final user emissions are estimated for aviation in four categories: domestic take off and landing, international take off and landing, domestic cruise and international cruise. This enables both IPCC and UNECE categories to be estimated from the same final user calculation.

Our exact mapping of final user emissions to IPCC categories is shown in the following table. The NAEI source sectors and activity names are also shown, as it is necessary to subdivide some IPCC categories. This classification has been used to generate the final user tables for the greenhouse gases given in this section. As this table is for final users, no fuel producers are included in the table.

Table A 11.5.2 Final user category, IPCC sectors, and NAEI source names and activity names used in the emission calculation

NC Category	IPCC Category	Source Name	Activity Name
Agriculture	1A4ci_Agriculture/Forestry/Fishing:Stationary	Agriculture - stationary combustion	Coal
			Coke
			Fuel oil
			Natural gas
			Straw
			Vaporising oil
		Miscellaneous industrial/commercial combustion	Burning oil
	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
	4B10_Manure_Management_Deer	Agriculture livestock - deer wastes	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	Non-fuel combustion

NC Category	IPCC Category	Source Name	Activity Name
		wastes	
	4B1b_Manure_Management_Non-Dairy	Agriculture livestock - other cattle wastes	Non-fuel combustion
	4B3_Manure_Management_Sheep	Agriculture livestock - sheep goats and deer wastes	Non-fuel combustion
	4B4_Manure_Management_Goats	Agriculture livestock - goats wastes	Non-fuel combustion
	4B6_Manure_Management_Horses	Agriculture livestock - horses wastes	Non-fuel combustion
	4B8_Manure_Management_Swine	Agriculture livestock - pigs wastes	Non-fuel combustion
	4B9_Manure_Management_Poultry	Agriculture livestock - broilers wastes	Non-fuel combustion
		Agriculture livestock - laying hens wastes	Non-fuel combustion
		Agriculture livestock - other poultry wastes	Non-fuel combustion
	4D_Agricultural_Soils	Agricultural soils	Non-fuel crops
			Non-fuel fertilizer
		OvTerr Agricultural Soils	Non-fuel combustion
	4F1_Field_Burning_of_Agricultural_Residues	Field burning	Barley residue
			Oats residue
			Wheat residue
	4F5_Field_Burning_of_Agricultural_Residues	Field burning	Linseed residue
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

NC Category	IPCC Category	Source Name	Activity Name
			Fuel oil Gas oil LPG Natural gas Town gas
	1A2b_Non-Ferrous_Metals	Non-Ferrous Metal (combustion)	Coal Fuel oil Gas oil Natural gas
	1A2c_Chemicals	Ammonia production - combustion	Natural gas
		Chemicals (combustion)	Coal Fuel oil Gas oil Natural gas
	1A2d_Pulp_Paper_Print	Pulp, Paper and Print (combustion)	Coal Fuel oil Gas oil Natural gas
	1A2e_Food_drink_tobacco	Food & drink, tobacco (combustion)	Coal Fuel oil Gas oil Natural gas
	1A2f	Other industrial combustion	Biomass
	1A2f_Manufacturing_Industry&Construction:Other	Autogeneration - exported to grid	Coal Natural gas
		Autogenerators	Coal Natural gas

NC Category	IPCC Category	Source Name	Activity Name
		Cement production - combustion	Coal
			Fuel oil
			Gas oil
			Natural gas
			Petroleum coke
			Scrap tyres
			Waste
			Waste oils
			Waste solvent
		Lime production - non decarbonising	Coal
			Coke
			Natural gas
		Other industrial combustion	Burning oil
			Coal
			Coke
			Coke oven gas
			Colliery methane
			Fuel oil
			Gas oil
			LPG
			Lubricants
			Natural gas
			OPG
			Petroleum coke
			SSF
			Town gas
			Waste solvent

NC Category	IPCC Category	Source Name	Activity Name
			Wood
	1A2fii_Manufacturing_Industry&Construction:Off-road	Industrial engines	Lubricants
		Industrial off-road mobile machinery	DERV
			Gas oil
			Petrol
	1A4a_Commercial/Institutional	Miscellaneous industrial/commercial combustion	Coal
			Coke
			Fuel oil
			Gas oil
			Natural gas
			SSF
			Town gas
	2B5_Carbon from NEU of products	Other industrial combustion	Energy recovery - chemical industry
	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 - Disposal

NC Category	IPCC Category	Source Name	Activity Name
			Refrigeration and Air Conditioning - Lifetime Refrigeration and Air Conditioning - Manufacture
		Mobile Air Conditioning	Refrigeration and Air Conditioning - Disposal 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	Other PFC use	Non-fuel combustion
		Precision cleaning - HFC	Non-fuel combustion
	2F9_Other_(one_component_foams)	One Component Foams	Non-fuel combustion
	2F9_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

NC Category	IPCC Category	Source Name	Activity Name
Energy Supply	1A1a_Public_Electricity&Heat_Production	Miscellaneous industrial/commercial combustion	Landfill gas
			MSW
		Power stations	Burning oil
			Coal
			Coke
			Fuel oil
			Gas oil
			Landfill gas
			LPG
			MSW
			Natural gas
			OPG
			Orimulsion
			Petroleum coke
			Poultry litter
			Scrap tyres
			Sewage gas
			Sour gas
			Straw
			Waste oils
			Wood
		Public sector combustion	Sewage gas
	1A1b_Petroleum_Refining	Refineries - combustion	Burning oil
			Fuel oil
			Gas oil
			LPG

NC Category	IPCC Category	Source Name	Activity Name
			Naphtha
			Natural gas
			OPG
			Petrol
			Petroleum coke
			Refinery miscellaneous
	1A1ci_Manufacture_of_Solid_Fuels-coke	Coke production	Blast furnace gas
			Coke oven gas
			Colliery methane
			Natural gas
		Solid smokeless fuel production	Coke
			Natural gas
	1A1cii_Other_Energy_Industries	Collieries - combustion	Coal
			Coke oven gas
			Colliery methane
			Natural gas
		Gas production	Colliery methane
			LPG
			Natural gas
			OPG
			Town gas
		Nuclear fuel production	Natural gas
		Town gas manufacture	Burning oil
			Coal
			Coke
			Coke oven gas
			LPG

NC Category	IPCC Category	Source Name	Activity Name
			Natural gas
		Upstream Gas Production - fuel combustion	Gas oil Natural gas
		Upstream Oil Production - fuel combustion	Gas oil Natural gas
		Upstream oil and gas production - combustion at gas separation plant	LPG OPG
	1B1a_Post-Mining_Activities	Coal storage and transport	Deep mined coal production
	1B1a_Surface_Mines	Open-cast coal	Coal produced
	1B1a_Underground_Mines	Deep-mined coal	Coal produced
	1B1b_Solid_Fuel_Transformation	Coke production	Coke produced
		Iron and steel - flaring	Coke oven gas
		Solid smokeless fuel production	Coal SSF produced
		Charcoal production	Charcoal
	1B1c_Closed_Coal_Mines	Closed Coal Mines	Non-fuel combustion
	1B2a_Oil_Exploration	Upstream Oil Production - Offshore Well Testing	Exploration drilling :no of wells
	1B2a_Oil_Other	Upstream Oil Production - Onshore Oil Loading	Crude oil
	1B2a_Oil_Production	Upstream Oil Production - process emissions	Non-fuel combustion
	1B2a_Oil_Transport	Upstream Oil Production - Offshore Oil Loading	Crude oil
	1B2a_Refining/Storage	Petroleum processes	Oil production
		Upstream Oil Production - Oil terminal storage	Non-fuel combustion

NC Category	IPCC Category	Source Name	Activity Name
	1B2b_Distribution	Gas leakage	Natural Gas (leakage at point of use) Natural gas supply
	1B2b_Gas_Exploration	Upstream Gas Production - Offshore Well Testing	Exploration drilling :no of wells
	1B2b_Gas_Production	Upstream Gas Production - process emissions	Non-fuel combustion
		Upstream Gas Production - Gas terminal storage	Non-fuel combustion
	1B2b_Transmission	Gas leakage	Natural Gas (transmission leakage)
	1B2c_Flaring_Gas	Upstream Gas Production - flaring	Non-fuel combustion
	1B2ci_Venting_Gas	Upstream Gas Production - venting	Non-fuel combustion
	1B2ci_Venting_Oil	Upstream Oil Production - venting	Non-fuel combustion
	1B2cii_Flaring_Oil	Upstream Oil Production - flaring	Non-fuel combustion
	2A3_Limestone_&_Dolomite_Use	Power stations - FGD	Gypsum produced
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
		Sinter production	Dolomite Limestone
	2A7_(Fletton_Bricks)	Brick manufacture - Fletton	Fletton bricks
	2A7_Glass_Production	Glass - general	Dolomite Limestone Soda ash
	2B1_Ammonia_Production	Ammonia production - feedstock use of gas	Natural gas

NC Category	IPCC Category	Source Name	Activity Name
	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	Electric arc furnaces	Steel production (electric arc)
		Iron and steel - flaring	Blast furnace gas
		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
	3_Solvent_and_Other_Product_Use	Solvent use	Solvent use
Land Use Change	5A_Forest Land (Biomass Burning - wildfires)	Forest Land - Biomass Burning\Wildfires	Biomass
	5A_Forest Land (Drainage of soils)	Forest Land - Drainage of Organic Soils	Non-fuel combustion
	5A1_Forest Land Remaining Forest Land	Forest Land remaining Forest Land	Non-fuel combustion
	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_Cropland (Biomass Burning - controlled)	Cropland - Biomass Burning\Controlled Burning	Biomass

NC Category	IPCC Category	Source Name	Activity Name
	5B_Cropland (Biomass Burning - wildfires)	Cropland - Biomass Burning\Wildfires	Biomass
	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
	5B2_N2O emissions from disturbance associated with land-use conversion to cropland	N2O emissions from disturbance associated with land-use conversion to cropland	Non-fuel combustion
	5C_Grassland (Biomass burning - controlled)	Grassland - Biomass Burning\Controlled Burning	Biomass
	5C_Grassland (Biomass Burning - wildfires)	Grassland - Biomass Burning\Wildfires	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
	5D_Wetlands (Biomass burning - controlled)	Wetlands - Biomass Burning\Controlled Burning	Biomass
	5D_Wetlands (Biomass Burning - wildfires)	Wetlands - Biomass Burning\Wildfires	Biomass
	5D1_Wetlands remaining wetlands	Wetlands remaining Wetland	Non-fuel combustion
	5D2_Land converted to wetlands	Land converted to Wetland	Non-fuel combustion
	5D2_Non-CO2 emissions from drainage of soils and wetlands	Non-CO2 emissions from drainage of soils and wetlands	Non-fuel combustion
	5E_Settlements (Biomass burning - controlled)	Settlements - Biomass Burning\Controlled Burning	Biomass
	5E_Settlements (Biomass Burning - wildfires)	Settlements - Biomass Burning\Wildfires	Biomass
	5E1_Settlements remaining settlements	Settlements remaining Settlements	Non-fuel combustion
	5E2_Land converted to settlements	Land converted to Settlements	Non-fuel combustion
	5F_Other land (Biomass burning - controlled)	Other Land - Biomass Burning	Biomass

NC Category	IPCC Category	Source Name	Activity Name
	5F1_Other land remaining other land	Other Land remaining Other Land	Non-fuel combustion
	5F2_Land converted to other land	Land converted to Other Land	Non-fuel combustion
	5G_Other (Harvested wood)	Harvested Wood Products	Non-fuel combustion
Public	1A4a_Commercial/Institutional	Public sector combustion	Burning oil Coal Coke Fuel oil Gas oil Natural gas Town gas
Residential	1A4b_Residential	Domestic combustion	Anthracite Burning oil Coal Coke Fuel oil Gas oil LPG Natural gas Peat Petroleum coke SSF Town gas Wood Charcoal
	1A4bii_Residential:Off-road	House and garden machinery	DERV Petrol
	2B5_Chemical_Industry_Other	Non-aerosol products - household	Carbon in detergents

NC Category	IPCC Category	Source Name	Activity Name
		products	Petroleum waxes
	2F4_Aerosols	Aerosols - halocarbons	Non-fuel combustion
		Metered dose inhalers	Non-fuel combustion
	6C_Waste_Incineration	Accidental fires - vehicles	Mass burnt
Transport	1A3aii_Civil_Aviation_Domestic	Aircraft - domestic cruise	Aviation spirit
			Aviation turbine fuel
		Aircraft - domestic take off and landing	Aviation spirit
			Aviation turbine fuel
		Aircraft between UK and CDs - Cruise	Aviation spirit
			Aviation turbine fuel
		Aircraft between UK and CDs - TOL	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 - cold start	DERV
			Petrol
		Road transport - cars - motorway driving	DERV
			Petrol
		Road transport - cars - rural driving	DERV
			Petrol
		Road transport - cars - urban driving	DERV
			Petrol

NC Category	IPCC Category	Source Name	Activity Name
		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 - cold start	DERV
			Petrol
		Road transport - LGVs - motorway driving	DERV
			Petrol
		Road transport - LGVs - rural driving	DERV
			Petrol
		Road transport - LGVs - urban driving	DERV
			Petrol
		Road transport - mopeds (<50cc 2st) - urban driving	Petrol
		Road transport - motorcycle (>50cc 2st) - rural driving	Petrol
		Road transport - motorcycle (>50cc 2st) - urban driving	Petrol
		Road transport - motorcycle (>50cc 4st) - motorway driving	Petrol
		Road transport - motorcycle (>50cc 4st) - rural driving	Petrol

NC Category	IPCC Category	Source Name	Activity Name
		Road transport - motorcycle (>50cc 4st) - urban driving	Petrol
		Road vehicle engines	Lubricants
	1A3c_Railways	Rail - coal	Coal
		Railways - freight	Gas oil
		Railways - intercity	Gas oil
		Railways - regional	Gas oil
	1A3dii_National_Navigation	Inland goods-carrying vessels	DERV Gas oil Petrol
		Marine engines	Lubricants
		Motorboats / workboats (e.g. canal boats, dredgers, service boats, tourist boats, river boats)	DERV Gas oil Petrol
		Personal watercraft e.g. jet ski	DERV Gas oil Petrol
		Sailing boats with auxiliary engines	DERV Gas oil Petrol
		Shipping - coastal	Fuel oil Gas oil
	1A3e_Other_Transportation	Aircraft - support vehicles	Gas oil
	1A4a_Commercial/Institutional	Railways - stationary combustion	Burning oil Coal Coke

NC Category	IPCC Category	Source Name	Activity Name
			Fuel oil Natural gas
	1A4ciii_Fishing	Fishing vessels	Gas oil
	1A5b_Other:Mobile	Aircraft - military	Aviation spirit Aviation turbine fuel
		Shipping - naval	Gas oil
Waste Management	6A1_Managed_Waste_Disposal_on_Land	Landfill	Non-fuel combustion
	6B1_Industrial_Wastewater_Handling	Industrial Waste Water Treatment	Non-fuel combustion
	6B2_Wastewater_Handling	Sewage sludge decomposition	Non-fuel domestic
	6C_Waste_Incineration	Incineration	MSW
		Incineration - chemical waste	Chemical waste
		Incineration - clinical waste	Clinical waste
		Incineration - sewage sludge	Sewage sludge combustion

A11.6 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, this is the coverage used for the UK statistical release[13], where the final users data are presented in more detail.

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

[13] https://www.gov.uk/government/publications/final-uk-emissions-estimates

Table A 11.6.1 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	67.39	67.56	67.32	66.94	66.05	66.21	65.74	65.97	65.73	64.99	64.18	61.92
Business	248.86	247.67	245.94	231.85	222.88	216.70	214.96	216.49	207.83	208.43	205.47	214.22
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	9.21	9.21	10.17	10.96	12.32	12.63	13.34	14.58	15.90	15.71	14.06	13.06
Industrial Process	58.92	57.30	55.30	49.91	46.25	47.85	47.39	48.35	49.54	46.28	28.88	26.55
LULUCF	4.04	4.02	4.13	3.35	2.32	2.13	3.28	2.59	2.44	1.53	1.00	0.42
Public	30.85	30.85	33.85	35.62	29.35	28.75	28.20	28.93	26.49	25.36	24.36	23.57
Residential	170.05	169.66	179.23	172.98	169.66	162.16	156.46	168.73	153.30	159.23	154.52	158.87
Transport	139.31	139.31	137.35	139.10	141.30	142.72	143.00	147.80	148.76	148.00	148.30	146.49
Waste Management	47.24	47.38	46.50	45.22	43.83	42.60	41.41	40.36	37.28	35.24	32.55	30.84
Total greenhouse gas emissions	**775.85**	**772.94**	**779.80**	**755.93**	**733.96**	**721.76**	**713.79**	**733.81**	**707.26**	**704.77**	**673.33**	**675.95**

Final user category	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Agriculture	59.29	59.24	58.85	58.68	58.23	56.49	54.93	54.11	53.06	53.74	53.65
Business	219.17	204.14	209.48	208.09	210.15	211.96	208.44	206.41	178.16	182.98	174.99
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	12.51	14.46	15.07	16.47	16.17	15.40	15.54	14.86	15.36	15.85	15.79
Industrial Process	23.72	20.55	21.09	20.43	19.51	18.30	19.55	17.70	11.80	12.58	11.08
LULUCF	-0.09	-0.99	-1.28	-2.39	-2.60	-2.99	-3.34	-3.79	-3.82	-3.67	-3.31
Public	24.36	21.69	22.06	22.64	22.18	20.79	20.26	20.13	17.94	17.86	15.91
Residential	166.01	163.13	168.09	169.64	164.04	164.06	157.36	155.70	144.74	157.75	130.54
Transport	146.75	150.48	148.87	148.85	148.91	148.87	149.69	143.53	138.59	136.77	134.80
Waste Management	27.42	25.31	22.42	20.97	20.44	20.07	19.72	19.20	18.46	17.87	17.28
Total greenhouse gas emissions	**679.14**	**658.02**	**664.64**	**663.37**	**657.04**	**652.94**	**642.15**	**627.84**	**574.27**	**591.74**	**550.73**

Table A 11.6.2 Final user CO_2 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	8.74	8.74	8.73	8.55	8.35	8.37	8.26	8.27	7.93	7.82	7.64	7.32
Business	231.08	231.08	229.61	215.92	207.49	203.79	200.87	202.70	193.97	194.94	192.32	200.50
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	8.52	8.52	9.47	10.21	11.55	11.86	12.53	13.76	15.03	14.88	13.34	12.39
Industrial Process	17.72	17.72	15.39	14.77	14.68	15.92	16.26	16.94	16.70	16.87	16.54	16.00
LULUCF	3.17	3.15	3.25	2.48	1.45	1.25	2.38	1.70	1.55	0.65	0.12	-0.45
Public	28.87	28.87	31.67	33.25	27.49	27.26	26.65	27.48	25.18	24.22	23.37	22.69
Residential	156.51	156.51	165.51	159.54	156.89	152.06	146.47	158.67	143.82	149.50	145.77	150.49
Transport	136.15	136.15	134.27	136.00	138.17	139.48	139.50	144.55	145.63	144.96	145.37	143.71
Waste Management	1.29	1.29	1.30	1.27	1.19	1.02	0.87	0.87	0.52	0.52	0.48	0.49
Total greenhouse gas emissions	**592.03**	**592.01**	**599.20**	**582.00**	**567.26**	**561.01**	**553.78**	**574.94**	**550.31**	**554.34**	**544.95**	**553.14**

Final user category	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Agriculture	7.67	7.58	7.56	7.30	7.23	6.97	6.76	6.72	6.39	6.58	6.53
Business	205.05	189.47	194.53	192.59	194.46	196.01	192.09	189.72	161.59	166.09	157.86
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	11.90	13.80	14.43	15.74	15.53	14.81	14.91	14.29	14.72	15.24	15.09
Industrial Process	14.70	13.98	14.71	15.00	15.15	14.68	15.88	14.49	9.96	10.50	10.12
LULUCF	-0.92	-1.80	-2.13	-3.16	-3.36	-3.73	-4.08	-4.50	-4.51	-4.31	-3.94
Public	23.53	20.93	21.36	21.95	21.55	20.22	19.72	19.62	17.45	17.40	15.48
Residential	157.69	155.08	160.18	161.80	156.38	156.60	150.30	148.76	137.95	150.94	124.14
Transport	144.12	147.92	146.49	146.56	146.80	146.85	147.69	141.79	136.87	135.13	133.07
Waste Management	0.51	0.51	0.46	0.43	0.38	0.30	0.33	0.28	0.27	0.27	0.27
Total greenhouse gas emissions	**564.26**	**547.49**	**557.61**	**558.20**	**554.12**	**552.72**	**543.60**	**531.17**	**480.69**	**497.84**	**458.61**

Table A 11.6.3 Final user CH_4 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	22.56	22.68	22.39	22.32	22.17	22.15	21.81	21.94	21.63	21.50	21.37	20.56
Business	13.34	13.34	13.09	12.69	12.09	9.26	10.04	9.27	8.94	7.95	6.96	6.45
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	0.60	0.60	0.60	0.63	0.64	0.64	0.67	0.66	0.69	0.64	0.55	0.50
Industrial Process	1.71	1.71	1.66	1.66	1.63	1.33	1.42	1.45	1.48	1.25	1.12	0.94
LULUCF	0.02	0.02	0.03	0.02	0.02	0.02	0.04	0.03	0.03	0.03	0.02	0.03
Public	1.78	1.78	1.97	2.15	1.70	1.33	1.41	1.32	1.20	1.03	0.89	0.79
Residential	12.19	12.19	12.72	12.50	11.88	9.16	8.85	8.54	7.48	6.97	6.19	5.51
Transport	1.70	1.70	1.63	1.63	1.56	1.49	1.50	1.41	1.31	1.23	1.12	1.01
Waste Management	44.74	44.87	44.00	42.70	41.41	40.35	39.29	38.20	35.52	33.44	30.81	29.03
Total greenhouse gas emissions	**98.64**	**98.89**	**98.08**	**96.31**	**93.09**	**85.74**	**85.04**	**82.81**	**78.28**	**74.04**	**69.04**	**64.81**

Final user category	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Agriculture	19.48	19.16	19.22	19.38	19.13	19.09	18.68	18.26	17.93	18.01	17.93
Business	5.93	5.64	5.02	4.75	4.20	3.91	3.67	3.57	3.32	3.19	3.24
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.46	0.48	0.46	0.55	0.45	0.43	0.48	0.41	0.47	0.45	0.52
Industrial Process	0.72	0.63	0.57	0.53	0.43	0.39	0.38	0.36	0.35	0.34	0.30
LULUCF	0.03	0.03	0.06	0.03	0.04	0.03	0.04	0.03	0.03	0.02	0.03
Public	0.73	0.67	0.60	0.60	0.54	0.48	0.45	0.43	0.42	0.39	0.37
Residential	5.20	5.03	4.59	4.50	4.00	3.79	3.62	3.47	3.46	3.55	3.16
Transport	0.96	0.91	0.82	0.82	0.68	0.64	0.67	0.57	0.60	0.53	0.58
Waste Management	25.61	23.49	20.73	19.31	18.83	18.53	18.17	17.71	16.96	16.34	15.76
Total greenhouse gas emissions	**59.13**	**56.06**	**52.06**	**50.49**	**48.30**	**47.29**	**46.17**	**44.83**	**43.53**	**42.83**	**41.88**

Table A 11.6.4 Final user N_2O 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	36.09	36.14	36.20	36.07	35.53	35.69	35.66	35.77	36.17	35.66	35.17	34.04
Business	2.59	2.59	2.52	2.45	2.27	2.25	2.20	2.11	1.99	1.97	1.89	1.94
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	0.09	0.09	0.10	0.11	0.13	0.14	0.15	0.16	0.18	0.19	0.17	0.17
Industrial Process	24.73	24.73	24.88	20.24	16.33	16.52	14.95	14.86	15.04	15.32	5.44	5.62
LULUCF	0.85	0.85	0.85	0.85	0.85	0.85	0.87	0.86	0.86	0.86	0.86	0.84
Public	0.20	0.20	0.21	0.22	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.10
Residential	0.95	0.95	0.99	0.93	0.87	0.82	0.74	0.73	0.63	0.65	0.60	0.62
Transport	1.47	1.47	1.45	1.47	1.56	1.75	2.01	1.84	1.83	1.82	1.80	1.77
Waste Management	1.21	1.22	1.21	1.25	1.24	1.24	1.25	1.29	1.24	1.28	1.27	1.33
Total greenhouse gas emissions	**68.17**	**68.23**	**68.41**	**63.58**	**58.93**	**59.40**	**57.95**	**57.75**	**58.07**	**57.86**	**47.31**	**46.42**

Final user category	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Agriculture	32.14	32.50	32.07	32.00	31.87	30.43	29.48	29.13	28.73	29.14	29.19
Business	2.00	1.96	1.94	1.90	1.99	1.96	1.95	1.85	1.54	1.57	1.52
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.15	0.18	0.17	0.18	0.18	0.17	0.15	0.16	0.17	0.16	0.18
Industrial Process	4.88	2.84	2.98	3.82	3.02	2.43	2.82	2.48	1.22	1.36	0.25
LULUCF	0.80	0.78	0.79	0.74	0.73	0.71	0.70	0.67	0.65	0.62	0.59
Public	0.10	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07
Residential	0.67	0.66	0.66	0.64	0.63	0.65	0.61	0.58	0.54	0.56	0.53
Transport	1.67	1.64	1.55	1.47	1.42	1.37	1.32	1.17	1.12	1.11	1.16
Waste Management	1.30	1.30	1.23	1.22	1.24	1.23	1.23	1.21	1.23	1.26	1.25
Total greenhouse gas emissions	**43.72**	**41.96**	**41.50**	**42.07**	**41.16**	**39.03**	**38.34**	**37.32**	**35.29**	**35.86**	**34.75**