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 including "*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 A 1.1.2** to **Table A 1.1.15**. These data are supplemented by two demonstration tables, **Table A 1.1.16** and **Table A 1.1.17**, showing trial outputs from a more disaggregated Key Category Analysis being developed following the methodology set out in the IPCC 2006 Guidelines.
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 A 1.2.1**.

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.

The UK completes both quantitative and qualitative KCAs.

[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".

We have used the method set out in Section 7.2 of the IPCC Good Practice Guidance (2000) (*Determining national key source categories*) to quantitatively determine the key source categories. A Tier 2 key category analysis (KCA) has been completed which takes into account the uncertainties associated with the emission factors, activity data or emissions.

In the 2014 NIR, the quantitative KCA has been supplemented using the methodology set out in Section 4.3.1 of the 2006 IPCC Guidelines Volume 1 General Guidance and Reporting (*Approach 1 to identify key categories*). This methodology has been used to provide a more disaggregated key category analysis – to the third level of IPCC subcategory (e.g. 1A1). **The method is still under development, to be included in complete format for the 2015 submission and the results shown here are indicative only**.

The method used in the qualitative KCA is described below, and further descriptions of the methods the UK uses to quantitatively determine key categories are given later in this section.

Qualitative analysis used to identify Key Categories
Following IPCC good practice, a qualitative analysis of the inventory has been made to identify any additional key source categories, which may not have been identified using the quantitative analysis. 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.

In addition, external recommendation has also been used as an additional criterion to identify key categories.

The results of this qualitative analysis are summarised in **Table A 1.1.1**. Initial indications are that we do not expect further additional source categories to be identified following this qualitative assessment, but this is kept under review.

Table A 1.1.1 Qualitative Key Category Analysis

	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*."

Quantitative Tier 2 KCA following IPCC 2000 Good Practice Guidance

A key category analysis has been completed for both level and trend. This KCA has been created using the IPCC GPG Tier 2 methodology, which takes into account uncertainties. 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 results of the key category analysis with and without LULUCF, for the base year and the latest reported year, are summarised by sector and gas in **Table A 1.1.12** to **Table A 1.1.15**. The tables indicate 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 1.1.2** to **Table A 1.1.7**. 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 1.1.8** to **Table A 1.1.11**. 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**.

Quantitative Approach 1 KCA following IPCC 2006 Guidelines

The methodology set out in Section 4.3.1 of the 2006 IPCC Guidelines Volume 1 General Guidance and Reporting (*Approach 1 to identify key categories*) has been used to provide a more disaggregated key category analysis – to the third level of IPCC subcategory (e.g. 1A1). The results are shown in **Table A 1.1.16** to **Table A 1.1.17**.
The method is still under development, and the results are indicative only.

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**. The numbers have been compared with **Table A 1.1.5** Key category analysis for the latest reported year (2012) based on level of emissions (including LULUCF).

Article 3.3 Afforestation and Reforestation (CO_2): The associated UNFCCC category 5A (-16 723 Gg CO_2) is a key category and the AR component (forest planted since 1990) is key on its own (i.e. its category contribution (-2 918 Gg CO_2) is greater than the smallest UNFCCC key category (2B5 Non-energy use of products)). 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 (11 173, -7 728 and 6 376 Gg CO_2 respectively). However, the Deforestation category contribution (1 045 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 (-16 723 Gg CO_2). The Forest Management category contribution (-14 626 Gg CO_2) is also greater than other categories in the UNFCCC key category analysis.

These categories have all had major recalculations this year due to the move to using the CARBINE carbon accounting model for forest carbon stock change modelling, the inclusion of all pre-1921 forest and increased deforestation rates from 2000 onwards (described in **Chapter 7**).

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

The uncertainty analysis is 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 1.1.2 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. 2012	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)	Level / Sum(Level)*100 %	Cumulative %
4D	Agricultural Soils	N2O	33708.74	27098.13	259.00	0.11138	39.60226	
6A	Solid Waste Disposal	CH4	43035.56	18566.63	48.38	0.02656	9.44502	49.04728
2B	Adipic Acid Production	N2O	20737.34	0.00	100.02	0.02646	9.40837	58.45565
1A(stationary)	Oil	CO2	96218.15	51576.83	14.16	0.01738	6.17921	64.63486
4B	Manure Management	N2O	3435.87	2737.21	254.00	0.01113	3.95866	68.59352
1A1&1A2&1A4&1A5	Other Combustion	N2O	4640.11	3212.94	177.10	0.01048	3.72749	72.32101
5B	5B LULUCF	CO2	15783.60	11172.67	50.01	0.01007	3.58045	75.90146
6B	Wastewater Handling	N2O	1165.05	1181.53	401.12	0.00596	2.11982	78.02127
5C	5C LULUCF	CO2	-6300.72	-7728.45	70.01	0.00563	2.00081	80.02209
5A	5A LULUCF	CO2	-15901.55	-16723.02	25.02	0.00508	1.80468	81.82677
2B	Nitric Acid Production	N2O	3903.85	60.76	100.50	0.00501	1.77962	83.60639
4A	Enteric Fermentation	CH4	19017.19	15652.02	20.00	0.00485	1.72527	85.33166
1A3b	Gasoline/ LPG	CO2	75568.67	40767.96	4.83	0.00465	1.65423	86.98589
5E	5E LULUCF	CO2	6893.22	6375.92	50.01	0.00440	1.56370	88.54959
1A	Coal	CO2	248181.59	144938.39	1.28	0.00407	1.44568	89.99527
4B	Manure Management	CH4	9002.22	6638.46	30.00	0.00345	1.22503	91.22030
1B1	Mining & Solid Fuel Transformation	CH4	18302.23	1985.76	88.34	0.00304	1.08008	92.30038
2	Industrial Processes	HFC	15326.15	14132.10	15.03	0.00294	1.04511	93.34549
1B2	Production, Refining & Distribution of Oil & Natu	CH4	10359.12	5215.48	24.71	0.00223	0.79366	94.13915
1A	Natural Gas	CO2	108305.60	154921.53	1.58	0.00218	0.77679	94.91593
1A3b	Gasoline/ LPG	N2O	897.45	181.01	170.00	0.00195	0.69205	95.60798
2B5	Non-energy use of products	CO2	1350.49	1709.26	111.80	0.00193	0.68489	96.29287
1B	Oil & Natural Gas	CO2	5777.92	3550.45	17.15	0.00126	0.44946	96.74233
1A	All Fuel	CH4	1860.64	912.30	50.00	0.00119	0.42202	97.16434
6B	Wastewater Handling	CH4	1685.62	1634.44	50.01	0.00108	0.38238	97.54672
1A3b	DERV	CO2	32995.99	67125.68	2.33	0.00098	0.34812	97.89484
1A3b	DERV	N2O	290.88	723.46	170.00	0.00063	0.22431	98.11915
6C	Waste Incineration	CO2	1292.36	270.65	29.91	0.00049	0.17532	98.29448
5B	5B LULUCF	N2O	769.94	572.96	50.01	0.00049	0.17466	98.46914
2A1	Cement Production	CO2	7295.26	3715.53	5.10	0.00047	0.16873	98.63787
1A3a	Aviation Fuel	CO2	1654.84	1829.04	20.27	0.00043	0.15216	98.79003
1A3b	Gasoline/ LPG	CH4	529.76	37.80	50.00	0.00034	0.12016	98.91019
5D	5D LULUCF	CO2	481.73	359.24	50.01	0.00031	0.10928	99.01946
2	Industrial Processes	SF6	1200.93	507.95	17.03	0.00026	0.09277	99.11223
4F	Field Burning	N2O	79.31	0.00	231.35	0.00023	0.08323	99.19546
2A7	Other Mineral Use	CO2	556.43	429.47	32.02	0.00023	0.08081	99.27627
2C1	Iron&Steel Production	CO2	2340.71	923.76	6.60	0.00020	0.07012	99.34638
1A4	Peat	CO2	475.59	50.29	31.62	0.00019	0.06822	99.41460
4F	Field Burning	CH4	265.91	0.00	55.90	0.00019	0.06743	99.48203
6C	Waste Incineration	N2O	56.89	45.73	230.11	0.00017	0.05938	99.54141
1A	Lubricant	CO2	386.90	160.77	30.07	0.00015	0.05277	99.59418
2	Industrial Processes	PFC	391.02	206.09	22.02	0.00011	0.03906	99.63324
2A3	Limestone & Dolomite use	CO2	1190.62	1178.37	7.07	0.00011	0.03819	99.67143
2A2	Lime Production	CO2	1462.36	1177.78	5.10	0.00010	0.03382	99.70525
6C	Waste Incineration	CH4	134.43	5.39	50.49	0.00009	0.03079	99.73604
1A3d	Marine Fuel	CO2	2168.02	2243.23	2.69	0.00007	0.02650	99.76254
1A3b	DERV	CH4	107.28	16.82	50.01	0.00007	0.02434	99.78687
1B	Solid Fuel Transformation	CO2	855.03	226.98	6.02	0.00007	0.02335	99.81022
1A	Other (waste)	CO2	234.97	2680.13	21.11	0.00006	0.02250	99.83272
2B	Chemical Industry	CH4	169.43	82.32	28.28	0.00006	0.02174	99.85446
1B2	Oil & Natural Gas	N2O	42.40	40.59	111.16	0.00006	0.02138	99.87583
1A3	Other Diesel	N2O	32.63	62.41	140.01	0.00006	0.02072	99.89656
1A3	Other Diesel	CO2	1679.92	2495.94	2.70	0.00006	0.02059	99.91715
2B	Ammonia Production	CO2	1431.17	948.39	2.92	0.00005	0.01893	99.93607
1A3a	Aviation Fuel	N2O	16.29	18.01	171.17	0.00004	0.01265	99.94872
2A7	Other Mineral Use	CH4	23.60	3.34	101.98	0.00003	0.01092	99.95964
1A3d	Marine Fuel	N2O	16.91	17.47	140.01	0.00003	0.01074	99.97038
5G	5G LULUCF	CO2	59.16	-1168.32	30.02	0.00002	0.00806	99.97844
1A4	Petroleum Coke	CO2	76.75	460.47	20.22	0.00002	0.00704	99.98548
5A	5A LULUCF	N2O	54.16	69.40	20.02	0.00001	0.00492	99.99039
2C	Iron & Steel	N2O	7.25	3.28	118.00	0.00001	0.00388	99.99428
5C2	5C2 LULUCF	N2O	14.39	25.39	20.02	0.00000	0.00131	99.99558
5C2	5C2 LULUCF	CH4	12.39	41.32	20.02	0.00000	0.00113	99.99671
1A3a	Aviation Fuel	CH4	3.57	0.75	53.85	0.00000	0.00087	99.99758
1A3	Other Diesel	CH4	2.31	2.30	50.03	0.00000	0.00052	99.99811
5E2	5E2 LULUCF	CH4	4.95	6.62	20.02	0.00000	0.00045	99.99855
1A3d	Marine Fuel	CH4	1.87	4.07	50.03	0.00000	0.00042	99.99898
5D	5D LULUCF	N2O	3.98	0.52	20.02	0.00000	0.00036	99.99934
5A	5A LULUCF	CH4	3.12	16.48	20.02	0.00000	0.00028	99.99962
2C	Iron & Steel Production	CH4	1.09	0.49	50.00	0.00000	0.00025	99.99987
1B1	Coke Oven Gas	N2O	0.12	0.02	118.00	0.00000	0.00006	99.99993
5E2	5E2 LULUCF	N2O	0.50	0.67	20.02	0.00000	0.00005	99.99998
5B	5B LULUCF	CH4	0.09	0.22	50.01	0.00000	0.00002	100.00000
1A	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
1A3c	Coal	CO2	0.00	42.73	6.02	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
1A3c	Coal	CH4	0.00	0.85	50.00	0.00000	0.00000	100.00000
1A3c	Coal	N2O	0.00	0.10	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	5G LULUCF	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -- >	783,829.33	577,433.23		0.28	100.00	

Table A 1.1.3 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. 2012	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)	Level / Sum(Level)*100 %	Cumulative %
4D	Agricultural Soils	N2O	33708.74	27098.13	259.00	0.11165	43.63893	
6A	Solid Waste Disposal	CH4	43035.56	18566.63	48.38	0.02663	10.40775	54.04668
2B	Adipic Acid Production	N2O	20737.34	0.00	100.02	0.02653	10.36737	64.41405
1A(stationary)	Oil	CO2	96218.15	51576.83	14.16	0.01742	6.80906	71.22310
4B	Manure Management	N2O	3435.87	2737.21	254.00	0.01116	4.36217	75.58527
1A1&1A2&1A4&1A5	Other Combustion	N2O	4640.11	3212.94	177.10	0.01051	4.10743	79.69271
6B	Wastewater Handling	N2O	1165.05	1181.53	401.12	0.00598	2.33589	82.02859
2B	Nitric Acid Production	N2O	3903.85	60.76	100.50	0.00502	1.96102	83.98961
4A	Enteric Fermentation	CH4	19017.19	15652.02	20.00	0.00486	1.90112	85.89074
1A3b	Gasoline/ LPG	CO2	75568.67	40767.96	4.83	0.00466	1.82284	87.71358
1A	Coal	CO2	248181.59	144938.39	1.28	0.00408	1.59304	89.30662
4B	Manure Management	CH4	9002.22	6638.46	30.00	0.00345	1.34990	90.65652
1B1	Mining & Solid Fuel Transformation	CH4	18302.23	1985.76	89.62	0.00305	1.19017	91.84669
2	Industrial Processes	HFC	15326.15	14132.10	15.03	0.00295	1.15164	92.99833
1B2	Production, Refining & Distribution of Oil & Natu	CH4	10359.12	5215.48	25.07	0.00224	0.87455	93.87288
1A	Natural Gas	CO2	108305.60	154921.53	1.58	0.00219	0.85596	94.72884
1A3b	Gasoline/ LPG	N2O	897.45	181.01	170.00	0.00195	0.76259	95.49143
2B5	Non-energy use of products	CO2	1350.49	1709.26	111.80	0.00193	0.75470	96.24613
1B	Oil & Natural Gas	CO2	5777.92	3550.45	17.15	0.00127	0.49527	96.74141
1A	All Fuel	CH4	1860.64	912.30	50.00	0.00119	0.46503	97.20644
6B	Wastewater Handling	CH4	1685.62	1634.44	50.01	0.00108	0.42135	97.62779
1A3b	DERV	CO2	32995.99	67125.68	2.33	0.00098	0.38361	98.01140
1A3b	DERV	N2O	290.88	723.46	170.00	0.00063	0.24718	98.25857
6C	Waste Incineration	CO2	1292.36	270.65	29.91	0.00049	0.19320	98.45177
2A1	Cement Production	CO2	7295.26	3715.53	5.10	0.00048	0.18593	98.63770
1A3a	Aviation Fuel	CO2	1654.84	1829.04	20.27	0.00043	0.16767	98.80537
1A3b	Gasoline/ LPG	CH4	529.76	37.80	50.00	0.00034	0.13240	98.93777
2	Industrial Processes	SF6	1200.93	507.95	17.03	0.00026	0.10222	99.04000
4F	Field Burning	N2O	79.31	0.00	231.35	0.00023	0.09172	99.13171
2A7	Other Mineral Use	CO2	556.43	429.47	32.02	0.00023	0.08904	99.22076
2C1	Iron&Steel Production	CO2	2340.71	923.76	6.60	0.00020	0.07726	99.29802
1A4	Peat	CO2	475.59	50.29	31.62	0.00019	0.07517	99.37319
4F	Field Burning	CH4	265.91	0.00	55.90	0.00019	0.07430	99.44749
6C	Waste Incineration	N2O	56.89	45.73	230.11	0.00017	0.06544	99.51293
1A	Lubricant	CO2	386.90	160.77	30.07	0.00015	0.05814	99.57107
2	Industrial Processes	PFC	391.02	206.09	22.02	0.00011	0.04304	99.61411
2A3	Limestone & Dolomite use	CO2	1190.62	1178.37	7.07	0.00011	0.04208	99.65619
2A2	Lime Production	CO2	1462.36	1177.78	5.10	0.00010	0.03727	99.69346
6C	Waste Incineration	CH4	134.43	5.39	50.49	0.00009	0.03393	99.72739
1A3d	Marine Fuel	CO2	2168.02	2243.23	2.69	0.00007	0.02920	99.75659
1A3b	DERV	CH4	107.28	16.82	50.01	0.00007	0.02682	99.78340
1B	Solid Fuel Transformation	CO2	855.03	226.98	6.02	0.00007	0.02573	99.80914
1A	Other (waste)	CO2	234.97	2680.13	21.11	0.00006	0.02479	99.83393
2B	Chemical Industry	CH4	169.43	82.32	28.28	0.00006	0.02395	99.85788
1B2	Oil & Natural Gas	N2O	42.40	40.59	111.16	0.00006	0.02356	99.88144
1A3	Other Diesel	N2O	32.63	62.41	140.01	0.00006	0.02284	99.90427
1A3	Other Diesel	CO2	1679.92	2495.94	2.70	0.00006	0.02269	99.92696
2B	Ammonia Production	CO2	1431.17	948.39	2.92	0.00005	0.02086	99.94781
1A3a	Aviation Fuel	N2O	16.29	18.01	171.17	0.00004	0.01394	99.96175
2A7	Other Mineral Use	CH4	23.60	3.34	101.98	0.00003	0.01203	99.97378
1A3d	Marine Fuel	N2O	16.91	17.47	140.01	0.00003	0.01184	99.98562
1A4	Petroleum Coke	CO2	76.75	460.47	20.22	0.00002	0.00776	99.99338
2C	Iron & Steel	N2O	7.25	3.28	118.00	0.00001	0.00428	99.99765
1A3a	Aviation Fuel	CH4	3.57	0.75	53.85	0.00000	0.00096	99.99861
1A3	Other Diesel	CH4	2.31	2.30	50.03	0.00000	0.00058	99.99919
1A3d	Marine Fuel	CH4	1.87	4.07	50.03	0.00000	0.00047	99.99966
2C	Iron & Steel Production	CH4	1.09	0.49	50.00	0.00000	0.00027	99.99993
1B1	Coke Oven Gas	N2O	0.12	0.02	118.00	0.00000	0.00007	100.00000
1A	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
1A3c	Coal	CO2	0.00	42.73	6.02	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
5A	5A LULUCF	CO2	0.00	0.00	25.02	0.00000	0.00000	100.00000
5B	5B LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C	5C LULUCF	CO2	0.00	0.00	70.01	0.00000	0.00000	100.00000
5D	5D LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5E	5E LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5G	5G LULUCF	CO2	0.00	0.00	30.02	0.00000	0.00000	100.00000
1A3c	Coal	CH4	0.00	0.85	50.00	0.00000	0.00000	100.00000
5A	5A LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	5B LULUCF	CH4	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	5C2 LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	5E2 LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
1A3c	Coal	N2O	0.00	0.10	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	5A LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	5B LULUCF	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	5C2 LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5D	5D LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	5E2 LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5G	5G LULUCF	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	781,950.36	584,411.63		0.26	100.00	

Table A 1.1.4 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. 2012	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)	Level / Sum(Level)*100 %	Cumulative %
4D	Agricultural Soils	N2O	33708.74	27098.13	259.00	0.11183	39.67584	
6A	Solid Waste Disposal	CH4	43035.56	18566.63	48.38	0.02667	9.46256	49.13840
2B	Adipic Acid Production	N2O	20737.34	0.00	100.02	0.02657	9.42585	58.56426
1A(stationary)	Oil	CO2	96218.15	51576.83	14.16	0.01745	6.19069	64.75494
4B	Manure Management	N2O	3435.87	2737.21	254.00	0.01118	3.96602	68.72096
1A1&1A2&1A4&1A5	Other Combustion	N2O	4640.11	3212.94	177.10	0.01053	3.73442	72.45538
5B	5B LULUCF	CO2	15783.60	11172.67	50.01	0.01011	3.58710	76.04248
6B	Wastewater Handling	N2O	1165.05	1181.53	401.12	0.00599	2.12375	78.16623
5C	5C LULUCF	CO2	-6300.72	-7728.45	70.01	0.00565	2.00453	80.17076
5A	5A LULUCF	CO2	-15901.55	-16723.02	25.02	0.00510	1.80804	81.97880
2B	Nitric Acid Production	N2O	3903.85	60.76	100.50	0.00503	1.78293	83.76173
4A	Enteric Fermentation	CH4	19017.19	15652.02	20.00	0.00487	1.72847	85.49020
1A3b	Gasoline/ LPG	CO2	75568.67	40767.96	4.83	0.00467	1.65730	87.14750
5E	5E LULUCF	CO2	6893.22	6375.92	50.01	0.00442	1.56661	88.71411
1A	Coal	CO2	248181.59	144938.39	1.28	0.00408	1.44837	90.16248
4B	Manure Management	CH4	9002.22	6638.46	30.00	0.00346	1.22731	91.38979
1B1	Mining & Solid Fuel Transformation	CH4	18302.23	1985.76	88.69	0.00305	1.08208	92.47187
1B2	Production, Refining & Distribution of Oil & Natu	CH4	10359.12	5215.48	24.81	0.00224	0.79513	93.26700
1A	Natural Gas	CO2	108305.60	154921.53	1.58	0.00219	0.77823	94.04523
2	Industrial Processes	HFC	11384.05	14132.10	15.03	0.00219	0.77774	94.82296
1A3b	Gasoline/ LPG	N2O	897.45	181.01	170.00	0.00195	0.69333	95.51629
2B5	Non-energy use of products	CO2	1350.49	1709.26	111.80	0.00193	0.68616	96.20246
1B	Oil & Natural Gas	CO2	5777.92	3550.45	17.15	0.00127	0.45029	96.65275
1A	All Fuel	CH4	1860.64	912.30	50.00	0.00119	0.42280	97.07555
6B	Wastewater Handling	CH4	1685.62	1634.44	50.01	0.00108	0.38309	97.45864
1A3b	DERV	CO2	32995.99	67125.68	2.33	0.00098	0.34877	97.80741
1A3b	DERV	N2O	290.88	723.46	170.00	0.00063	0.22473	98.03214
6C	Waste Incineration	CO2	1292.36	270.65	29.91	0.00050	0.17565	98.20779
5B	5B LULUCF	N2O	769.94	572.96	50.01	0.00049	0.17498	98.38277
2A1	Cement Production	CO2	7295.26	3715.53	5.10	0.00048	0.16905	98.55182
1A3a	Aviation Fuel	CO2	1654.84	1829.04	20.27	0.00043	0.15244	98.70426
2	Industrial Processes	PFC	1390.69	206.09	22.02	0.00039	0.13918	98.84344
1A3b	Gasoline/ LPG	CH4	529.76	37.80	50.00	0.00034	0.12038	98.96382
5D	5D LULUCF	CO2	481.73	359.24	50.01	0.00031	0.10948	99.07330
4F	Field Burning	N2O	79.31	0.00	231.35	0.00024	0.08339	99.15669
2A7	Other Mineral Use	CO2	556.43	429.47	32.02	0.00023	0.08096	99.23764
2	Industrial Processes	SF6	987.40	507.95	17.03	0.00022	0.07641	99.31406
2C1	Iron&Steel Production	CO2	2340.71	923.76	6.60	0.00020	0.07025	99.38430
1A4	Peat	CO2	475.59	50.29	31.62	0.00019	0.06835	99.45265
4F	Field Burning	CH4	265.91	0.00	55.90	0.00019	0.06755	99.52020
6C	Waste Incineration	N2O	56.89	45.73	230.11	0.00017	0.05949	99.57969
1A	Lubricant	CO2	386.90	160.77	30.07	0.00015	0.05286	99.63256
2A3	Limestone & Dolomite use	CO2	1190.62	1178.37	7.07	0.00011	0.03826	99.67082
2A2	Lime Production	CO2	1462.36	1177.78	5.10	0.00010	0.03389	99.70470
6C	Waste Incineration	CH4	134.43	5.39	50.49	0.00009	0.03084	99.73555
1A3d	Marine Fuel	CO2	2168.02	2243.23	2.69	0.00007	0.02655	99.76210
1A3b	DERV	CH4	107.28	16.82	50.01	0.00007	0.02438	99.78648
1B	Solid Fuel Transformation	CO2	855.03	226.98	6.02	0.00007	0.02339	99.80987
1A	Other (waste)	CO2	234.97	2680.13	21.11	0.00006	0.02254	99.83241
2B	Chemical Industry	CH4	169.43	82.32	28.28	0.00006	0.02178	99.85419
1B2	Oil & Natural Gas	N2O	42.40	40.59	111.16	0.00006	0.02142	99.87560
1A3	Other Diesel	N2O	32.63	62.41	140.01	0.00006	0.02076	99.89636
1A3	Other Diesel	CO2	1679.92	2495.94	2.70	0.00006	0.02063	99.91699
2B	Ammonia Production	CO2	1431.17	948.39	2.92	0.00005	0.01896	99.93595
1A3a	Aviation Fuel	N2O	16.29	18.01	171.17	0.00004	0.01267	99.94863
2A7	Other Mineral Use	CH4	23.60	3.34	101.98	0.00003	0.01094	99.95956
1A3d	Marine Fuel	N2O	16.91	17.47	140.01	0.00003	0.01076	99.97032
5G	5G LULUCF	CO2	59.16	-1168.32	30.02	0.00002	0.00807	99.97840
1A4	Petroleum Coke	CO2	76.75	460.47	20.22	0.00002	0.00705	99.98545
5A	5A LULUCF	N2O	54.16	69.40	20.02	0.00001	0.00493	99.99038
2C	Iron & Steel	N2O	7.25	3.28	118.00	0.00001	0.00389	99.99426
5C2	5C2 LULUCF	N2O	14.39	25.39	20.02	0.00000	0.00131	99.99557
5C2	5C2 LULUCF	CH4	12.39	41.32	20.02	0.00000	0.00113	99.99670
1A3a	Aviation Fuel	CH4	3.57	0.75	53.85	0.00000	0.00087	99.99758
1A3	Other Diesel	CH4	2.31	2.30	50.03	0.00000	0.00053	99.99810
5E2	5E2 LULUCF	CH4	4.95	6.62	20.02	0.00000	0.00045	99.99855
1A3d	Marine Fuel	CH4	1.87	4.07	50.03	0.00000	0.00042	99.99898
5D	5D LULUCF	N2O	3.98	0.52	20.02	0.00000	0.00036	99.99934
5A	5A LULUCF	CH4	3.12	16.48	20.02	0.00000	0.00028	99.99962
2C	Iron & Steel Production	CH4	1.09	0.49	50.00	0.00000	0.00025	99.99987
1B1	Coke Oven Gas	N2O	0.12	0.02	118.00	0.00000	0.00006	99.99993
5E2	5E2 LULUCF	N2O	0.50	0.67	20.02	0.00000	0.00005	99.99998
5B	5B LULUCF	CH4	0.09	0.22	50.01	0.00000	0.00002	100.00000
1A	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
1A3c	Coal	CO2	0.00	42.73	6.02	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
1A3c	Coal	CH4	0.00	0.85	50.00	0.00000	0.00000	100.00000
1A3c	Coal	N2O	0.00	0.10	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	5G LULUCF	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	780,673.37	577,433.23		0.28	100.00	

Table A 1.1.5 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. 2012	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)	Level / Sum(Level)*100 %	Cumulative %
4D	Agricultural Soils	N2O	33708.74	27098.13	259.00	0.11210	43.72829	
6A	Solid Waste Disposal	CH4	43035.56	18566.63	48.38	0.02674	10.42906	54.15735
2B	Adipic Acid Production	N2O	20737.34	0.00	100.02	0.02663	10.38860	64.54595
1A(stationary)	Oil	CO2	96218.15	51576.83	14.16	0.01749	6.82300	71.36895
4B	Manure Management	N2O	3435.87	2737.21	254.00	0.01121	4.37110	75.74005
1A1&1A2&1A4&1A5	Other Combustion	N2O	4640.11	3212.94	177.10	0.01055	4.11584	79.85589
6B	Wastewater Handling	N2O	1165.05	1181.53	401.12	0.00600	2.34067	82.19656
2B	Nitric Acid Production	N2O	3903.85	60.76	100.50	0.00504	1.96504	84.16160
4A	Enteric Fermentation	CH4	19017.19	15652.02	20.00	0.00488	1.90502	86.06662
1A3b	Gasoline/ LPG	CO2	75568.67	40767.96	4.83	0.00468	1.82658	87.89319
1A	Coal	CO2	248181.59	144938.39	1.28	0.00409	1.59630	89.48949
4B	Manure Management	CH4	9002.22	6638.46	30.00	0.00347	1.35266	90.84216
1B1	Mining & Solid Fuel Transformation	CH4	18302.23	1985.76	89.98	0.00306	1.19260	92.03476
1B2	Production, Refining & Distribution of Oil & Natu	CH4	10359.12	5215.48	25.17	0.00225	0.87635	92.91111
1A	Natural Gas	CO2	108305.60	154921.53	1.58	0.00220	0.85772	93.76882
2	Industrial Processes	HFC	11384.05	14132.10	15.03	0.00220	0.85717	94.62600
1A3b	Gasoline/ LPG	N2O	897.45	181.01	170.00	0.00196	0.76415	95.39015
2B5	Non-energy use of products	CO2	1350.49	1709.26	111.80	0.00194	0.75625	96.14639
1B	Oil & Natural Gas	CO2	5777.92	3550.45	17.15	0.00127	0.49629	96.64268
1A	All Fuel	CH4	1860.64	912.30	50.00	0.00119	0.46598	97.10866
6B	Wastewater Handling	CH4	1685.62	1634.44	50.01	0.00108	0.42221	97.53088
1A3b	DERV	CO2	32995.99	67125.68	2.33	0.00099	0.38439	97.91527
1A3b	DERV	N2O	290.88	723.46	170.00	0.00063	0.24768	98.16295
6C	Waste Incineration	CO2	1292.36	270.65	29.91	0.00050	0.19359	98.35655
2A1	Cement Production	CO2	7295.26	3715.53	5.10	0.00048	0.18631	98.54286
1A3a	Aviation Fuel	CO2	1654.84	1829.04	20.27	0.00043	0.16801	98.71087
2	Industrial Processes	PFC	1390.69	206.09	22.02	0.00039	0.15340	98.86427
1A3b	Gasoline/ LPG	CH4	529.76	37.80	50.00	0.00034	0.13268	98.99694
4F	Field Burning	N2O	79.31	0.00	231.35	0.00024	0.09190	99.08885
2A7	Other Mineral Use	CO2	556.43	429.47	32.02	0.00023	0.08923	99.17807
2	Industrial Processes	SF6	987.40	507.95	17.03	0.00022	0.08422	99.26229
2C1	Iron&Steel Production	CO2	2340.71	923.76	6.60	0.00020	0.07742	99.33971
1A4	Peat	CO2	475.59	50.29	31.62	0.00019	0.07533	99.41504
4F	Field Burning	CH4	265.91	0.00	55.90	0.00019	0.07445	99.48949
6C	Waste Incineration	N2O	56.89	45.73	230.11	0.00017	0.06557	99.55506
1A	Lubricant	CO2	386.90	160.77	30.07	0.00015	0.05826	99.61332
2A3	Limestone & Dolomite use	CO2	1190.62	1178.37	7.07	0.00011	0.04217	99.65549
2A2	Lime Production	CO2	1462.36	1177.78	5.10	0.00010	0.03735	99.69284
6C	Waste Incineration	CH4	134.43	5.39	50.49	0.00009	0.03399	99.72683
1A3d	Marine Fuel	CO2	2168.02	2243.23	2.69	0.00008	0.02926	99.75609
1A3b	DERV	CH4	107.28	16.82	50.01	0.00007	0.02687	99.78296
1B	Solid Fuel Transformation	CO2	855.03	226.98	6.02	0.00007	0.02578	99.80875
1A	Other (waste)	CO2	234.97	2680.13	21.11	0.00006	0.02484	99.83359
2B	Chemical Industry	CH4	169.43	82.32	28.28	0.00006	0.02400	99.85759
1B2	Oil & Natural Gas	N2O	42.40	40.59	111.16	0.00006	0.02360	99.88119
1A3	Other Diesel	N2O	32.63	62.41	140.01	0.00006	0.02288	99.90407
1A3	Other Diesel	CO2	1679.92	2495.94	2.70	0.00006	0.02273	99.92681
2B	Ammonia Production	CO2	1431.17	948.39	2.92	0.00005	0.02090	99.94771
1A3a	Aviation Fuel	N2O	16.29	18.01	171.17	0.00004	0.01397	99.96167
2A7	Other Mineral Use	CH4	23.60	3.34	101.98	0.00003	0.01206	99.97373
1A3d	Marine Fuel	N2O	16.91	17.47	140.01	0.00003	0.01186	99.98559
1A4	Petroleum Coke	CO2	76.75	460.47	20.22	0.00002	0.00777	99.99336
2C	Iron & Steel	N2O	7.25	3.28	118.00	0.00001	0.00428	99.99765
1A3a	Aviation Fuel	CH4	3.57	0.75	53.85	0.00000	0.00096	99.99861
1A3	Other Diesel	CH4	2.31	2.30	50.03	0.00000	0.00058	99.99919
1A3d	Marine Fuel	CH4	1.87	4.07	50.03	0.00000	0.00047	99.99966
2C	Iron & Steel Production	CH4	1.09	0.49	50.00	0.00000	0.00027	99.99993
1B1	Coke Oven Gas	N2O	0.12	0.02	118.00	0.00000	0.00007	100.00000
1A	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
1A3c	Coal	CO2	0.00	42.73	6.02	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
5A	5A LULUCF	CO2	0.00	0.00	25.02	0.00000	0.00000	100.00000
5B	5B LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C	5C LULUCF	CO2	0.00	0.00	70.01	0.00000	0.00000	100.00000
5D	5D LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5E	5E LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5G	5G LULUCF	CO2	0.00	0.00	30.02	0.00000	0.00000	100.00000
1A3c	Coal	CH4	0.00	0.85	50.00	0.00000	0.00000	100.00000
5A	5A LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	5B LULUCF	CH4	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	5C2 LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	5E2 LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
1A3c	Coal	N2O	0.00	0.10	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	5A LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	5B LULUCF	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	5C2 LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5D	5D LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	5E2 LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5G	5G LULUCF	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -- >	778,794.40	584,411.63		0.26	100.00	

Table A 1.1.6 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. 2012	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)	Level / Sum(Level)*100 %	Cumulative %
4D	Agricultural Soils	N2O	33708.74	27098.13	259.00	0.12155	47.71469	
6A	Solid Waste Disposal	CH4	43035.56	18566.63	48.38	0.01556	6.10722	53.82191
1A(stationary)	Oil	CO2	96218.15	51576.83	14.16	0.01265	4.96439	58.78630
4B	Manure Management	N2O	3435.87	2737.21	254.00	0.01204	4.72667	63.51297
1A1&1A2&1A4&1A5	Other Combustion	N2O	4640.11	3212.94	177.10	0.00985	3.86835	67.38132
5B	5B LULUCF	CO2	15783.60	11172.67	50.01	0.00968	3.79860	71.17992
5C	5C LULUCF	CO2	-6300.72	-7728.45	70.01	0.00937	3.67828	74.85820
6B	Wastewater Handling	N2O	1165.05	1181.53	401.12	0.00821	3.22206	78.08026
5A	5A LULUCF	CO2	-15901.55	-16723.02	25.02	0.00725	2.84454	80.92479
5E	5E LULUCF	CO2	6893.22	6375.92	50.01	0.00552	2.16775	83.09255
4A	Enteric Fermentation	CH4	19017.19	15652.02	20.00	0.00542	2.12822	85.22076
1A	Natural Gas	CO2	108305.60	154921.53	1.58	0.00424	1.66532	86.88608
2	Industrial Processes	HFC	11384.05	14132.10	15.03	0.00368	1.44434	88.33042
4B	Manure Management	CH4	9002.22	6638.46	30.00	0.00345	1.35394	89.68437
1A3b	Gasoline/ LPG	CO2	75568.67	40767.96	4.83	0.00341	1.33754	91.02191
2B5	Non-energy use of products	CO2	1350.49	1709.26	111.80	0.00331	1.29919	92.32110
1A	Coal	CO2	248181.59	144938.39	1.28	0.00322	1.26538	93.58649
1A3b	DERV	CO2	32995.99	67125.68	2.33	0.00270	1.06144	94.64793
1A3b	DERV	N2O	290.88	723.46	170.00	0.00213	0.83614	95.48407
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10359.12	5215.48	17.54	0.00158	0.62198	96.10605
6B	Wastewater Handling	CH4	1685.62	1634.44	50.01	0.00142	0.55569	96.66175
1B	Oil & Natural Gas	CO2	5777.92	3550.45	17.15	0.00105	0.41394	97.07569
1A	Other (waste)	CO2	234.97	2680.13	21.11	0.00098	0.38462	97.46030
1A	All Fuel	CH4	1860.64	912.30	50.00	0.00079	0.31013	97.77043
1A3a	Aviation Fuel	CO2	1654.84	1829.04	20.27	0.00064	0.25206	98.02249
5G	5G LULUCF	CO2	59.16	-1168.32	30.02	0.00061	0.23841	98.26090
1A3b	Gasoline/ LPG	N2O	897.45	181.01	170.00	0.00053	0.20920	98.47010
5B	5B LULUCF	N2O	769.94	572.96	50.01	0.00050	0.19480	98.66490
1B1	Mining & Solid Fuel Transformation	CH4	18302.23	1985.76	13.07	0.00045	0.17646	98.84136
2A1	Cement Production	CO2	7295.26	3715.53	5.10	0.00033	0.12880	98.97016
5D	5D LULUCF	CO2	481.73	359.24	50.01	0.00031	0.12214	99.09230
2A7	Other Mineral Use	CO2	556.43	429.47	32.02	0.00024	0.09348	99.18578
6C	Waste Incineration	N2O	56.89	45.73	230.11	0.00018	0.07154	99.25732
1A4	Petroleum Coke	CO2	76.75	460.47	20.22	0.00016	0.06331	99.32063
1A3	Other Diesel	N2O	32.63	62.41	140.01	0.00015	0.05941	99.38004
2	Industrial Processes	SF6	987.40	507.95	17.03	0.00015	0.05881	99.43885
2A3	Limestone & Dolomite use	CO2	1190.62	1178.37	7.07	0.00014	0.05665	99.49550
6C	Waste Incineration	CO2	1292.36	270.65	29.91	0.00014	0.05503	99.55053
1A3	Other Diesel	CO2	1679.92	2495.94	2.70	0.00012	0.04585	99.59637
2B	Nitric Acid Production	N2O	3903.85	60.76	100.50	0.00011	0.04151	99.63789
2C1	Iron&Steel Production	CO2	2340.71	923.76	6.60	0.00011	0.04147	99.67936
1A3d	Marine Fuel	CO2	2168.02	2243.23	2.69	0.00010	0.04109	99.72045
2A2	Lime Production	CO2	1462.36	1177.78	5.10	0.00010	0.04083	99.76128
1A	Lubricant	CO2	386.90	160.77	30.07	0.00008	0.03286	99.79414
2	Industrial Processes	PFC	1390.69	206.09	22.02	0.00008	0.03086	99.82500
1B2	Oil & Natural Gas	N2O	42.40	40.59	111.16	0.00008	0.03067	99.85567
1A3a	Aviation Fuel	N2O	16.29	18.01	171.17	0.00005	0.02095	99.87662
2B	Ammonia Production	CO2	1431.17	948.39	2.92	0.00005	0.01880	99.89542
1A3d	Marine Fuel	N2O	16.91	17.47	140.01	0.00004	0.01663	99.91205
2B	Chemical Industry	CH4	169.43	82.32	28.28	0.00004	0.01583	99.92788
1A3b	Gasoline/ LPG	CH4	529.76	37.80	50.00	0.00003	0.01285	99.94073
1A4	Peat	CO2	475.59	50.29	31.62	0.00003	0.01081	99.95154
5A	5A LULUCF	N2O	54.16	69.40	20.02	0.00002	0.00945	99.96099
1B	Solid Fuel Transformation	CO2	855.03	226.98	6.02	0.00002	0.00929	99.97028
1A3b	DERV	CH4	107.28	16.82	50.01	0.00001	0.00572	99.97600
5C2	5C2 LULUCF	CH4	12.39	41.32	20.02	0.00001	0.00562	99.98163
5C2	5C2 LULUCF	N2O	14.39	25.39	20.02	0.00001	0.00346	99.98508
2C	Iron & Steel	N2O	7.25	3.28	118.00	0.00001	0.00263	99.98771
2A7	Other Mineral Use	CH4	23.60	3.34	101.98	0.00001	0.00232	99.99003
5A	5A LULUCF	CH4	3.12	16.48	20.02	0.00001	0.00224	99.99227
6C	Waste Incineration	CH4	134.43	5.39	50.49	0.00000	0.00185	99.99412
1A3c	Coal	CO2	0.00	42.73	6.02	0.00000	0.00175	99.99587
1A3d	Marine Fuel	CH4	1.87	4.07	50.03	0.00000	0.00138	99.99725
5E2	5E2 LULUCF	CH4	4.95	6.62	20.02	0.00000	0.00090	99.99815
1A3	Other Diesel	CH4	2.31	2.30	50.03	0.00000	0.00078	99.99894
1A3c	Coal	CH4	0.00	0.85	50.00	0.00000	0.00029	99.99922
1A3a	Aviation Fuel	CH4	3.57	0.75	53.85	0.00000	0.00027	99.99950
2C	Iron & Steel Production	CH4	1.09	0.49	50.00	0.00000	0.00017	99.99967
5E2	5E2 LULUCF	N2O	0.50	0.67	20.02	0.00000	0.00009	99.99976
1A3c	Coal	N2O	0.00	0.10	118.00	0.00000	0.00008	99.99984
5B	5B LULUCF	CH4	0.09	0.22	50.01	0.00000	0.00007	99.99991
5D	5D LULUCF	N2O	3.98	0.52	20.02	0.00000	0.00007	99.99998
1B1	Coke Oven Gas	N2O	0.12	0.02	118.00	0.00000	0.00002	100.00000
1A	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
4F	Field Burning	CH4	265.91	0.00	55.90	0.00000	0.00000	100.00000
2B	Adipic Acid Production	N2O	20737.34	0.00	100.02	0.00000	0.00000	100.00000
4F	Field Burning	N2O	79.31	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 -->	780,673.37	577,433.23		0.25	100.00	

Table A 1.1.7 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. 2012	Combined uncertainty range as a % of source category	Level Parameter (used to order sources)	Level / Sum(Level)*100 %	Cumulative %
4D	Agricultural Soils	N2O	33708.74	27098.13	259.00	0.12009	54.88638	
6A	Solid Waste Disposal	CH4	43035.56	18566.63	48.38	0.01537	7.02516	61.91154
1A(stationary)	Oil	CO2	96218.15	51576.83	14.16	0.01250	5.71056	67.62209
4B	Manure Management	N2O	3435.87	2737.21	254.00	0.01190	5.43711	73.05920
1A1&1A2&1A4&1A5	Other Combustion	N2O	4640.11	3212.94	177.10	0.00974	4.44978	77.50898
6B	Wastewater Handling	N2O	1165.05	1181.53	401.12	0.00811	3.70634	81.21532
4A	Enteric Fermentation	CH4	19017.19	15652.02	20.00	0.00536	2.44809	83.66342
1A	Natural Gas	CO2	108305.60	154921.53	1.58	0.00419	1.91562	85.57904
2	Industrial Processes	HFC	11384.05	14132.10	15.03	0.00364	1.66143	87.24047
4B	Manure Management	CH4	9002.22	6638.46	30.00	0.00341	1.55745	88.79792
1A3b	Gasoline/ LPG	CO2	75568.67	40767.96	4.83	0.00337	1.53858	90.33650
2B5	Non-energy use of products	CO2	1350.49	1709.26	111.80	0.00327	1.49447	91.83097
1A	Coal	CO2	248181.59	144938.39	1.28	0.00318	1.45557	93.28654
1A3b	DERV	CO2	32995.99	67125.68	2.33	0.00267	1.22098	94.50752
1A3b	DERV	N2O	290.88	723.46	170.00	0.00210	0.96182	95.46934
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10359.12	5215.48	17.54	0.00157	0.71547	96.18481
6B	Wastewater Handling	CH4	1685.62	1634.44	50.01	0.00140	0.63922	96.82402
1B	Oil & Natural Gas	CO2	5777.92	3550.45	17.15	0.00104	0.47616	97.30018
1A	Other (waste)	CO2	234.97	2680.13	21.11	0.00097	0.44243	97.74261
1A	All Fuel	CH4	1860.64	912.30	50.00	0.00078	0.35674	98.09935
1A3a	Aviation Fuel	CO2	1654.84	1829.04	20.27	0.00063	0.28994	98.38929
1A3b	Gasoline/ LPG	N2O	897.45	181.01	170.00	0.00053	0.24064	98.62993
1B1	Mining & Solid Fuel Transformation	CH4	18302.23	1985.76	13.07	0.00044	0.20299	98.83291
2A1	Cement Production	CO2	7295.26	3715.53	5.10	0.00032	0.14816	98.98107
2A7	Other Mineral Use	CO2	556.43	429.47	32.02	0.00024	0.10753	99.08860
6C	Waste Incineration	N2O	56.89	45.73	230.11	0.00018	0.08230	99.17090
1A4	Petroleum Coke	CO2	76.75	460.47	20.22	0.00016	0.07283	99.24372
1A3	Other Diesel	N2O	32.63	62.41	140.01	0.00015	0.06834	99.31206
2	Industrial Processes	SF6	987.40	507.95	17.03	0.00015	0.06765	99.37971
2A3	Limestone & Dolomite use	CO2	1190.62	1178.37	7.07	0.00014	0.06516	99.44487
6C	Waste Incineration	CO2	1292.36	270.65	29.91	0.00014	0.06330	99.50817
1A3	Other Diesel	CO2	1679.92	2495.94	2.70	0.00012	0.05274	99.56091
2B	Nitric Acid Production	N2O	3903.85	60.76	100.50	0.00010	0.04775	99.60866
2C1	Iron&Steel Production	CO2	2340.71	923.76	6.60	0.00010	0.04771	99.65637
1A3d	Marine Fuel	CO2	2168.02	2243.23	2.69	0.00010	0.04727	99.70364
2A2	Lime Production	CO2	1462.36	1177.78	5.10	0.00010	0.04696	99.75060
1A	Lubricant	CO2	386.90	160.77	30.07	0.00008	0.03780	99.78840
2	Industrial Processes	PFC	1390.69	206.09	22.02	0.00008	0.03549	99.82390
1B2	Oil & Natural Gas	N2O	42.40	40.59	111.16	0.00008	0.03528	99.85918
1A3a	Aviation Fuel	N2O	16.29	18.01	171.17	0.00005	0.02410	99.88328
2B	Ammonia Production	CO2	1431.17	948.39	2.92	0.00005	0.02162	99.90490
1A3d	Marine Fuel	N2O	16.91	17.47	140.01	0.00004	0.01913	99.92404
2B	Chemical Industry	CH4	169.43	82.32	28.28	0.00004	0.01821	99.94225
1A3b	Gasoline/ LPG	CH4	529.76	37.80	50.00	0.00003	0.01478	99.95703
1A4	Peat	CO2	475.59	50.29	31.62	0.00003	0.01244	99.96946
1B	Solid Fuel Transformation	CO2	855.03	226.98	6.02	0.00002	0.01069	99.98015
1A3b	DERV	CH4	107.28	16.82	50.01	0.00001	0.00658	99.98673
2C	Iron & Steel	N2O	7.25	3.28	118.00	0.00001	0.00303	99.98975
2A7	Other Mineral Use	CH4	23.60	3.34	101.98	0.00001	0.00266	99.99242
6C	Waste Incineration	CH4	134.43	5.39	50.49	0.00000	0.00213	99.99454
1A3c	Coal	CO2	0.00	42.73	6.02	0.00000	0.00201	99.99656
1A3d	Marine Fuel	CH4	1.87	4.07	50.03	0.00000	0.00159	99.99815
1A3	Other Diesel	CH4	2.31	2.30	50.03	0.00000	0.00090	99.99905
1A3c	Coal	CH4	0.00	0.85	50.00	0.00000	0.00033	99.99938
1A3a	Aviation Fuel	CH4	3.57	0.75	53.85	0.00000	0.00031	99.99969
2C	Iron & Steel Production	CH4	1.09	0.49	50.00	0.00000	0.00019	99.99989
1A3c	Coal	N2O	0.00	0.10	118.00	0.00000	0.00009	99.99998
1B1	Coke Oven Gas	N2O	0.12	0.02	118.00	0.00000	0.00002	100.00000
1A	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
5A	5A LULUCF	CO2	0.00	0.00	25.02	0.00000	0.00000	100.00000
5B	5B LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C	5C LULUCF	CO2	0.00	0.00	70.01	0.00000	0.00000	100.00000
5D	5D LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5E	5E LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5G	5G LULUCF	CO2	0.00	0.00	30.02	0.00000	0.00000	100.00000
4F	Field Burning	CH4	265.91	0.00	55.90	0.00000	0.00000	100.00000
5A	5A LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	5B LULUCF	CH4	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	5C2 LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	5E2 LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
2B	Adipic Acid Production	N2O	20737.34	0.00	100.02	0.00000	0.00000	100.00000
4F	Field Burning	N2O	79.31	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	5A LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	5B LULUCF	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	5C2 LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5D	5D LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	5E2 LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5G	5G LULUCF	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -- >	778,794.40	584,411.63		0.22	100.00	

Table A 1.1.8 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. 2012	Combined uncertainty range as a % of source category	Trend Parameter (used to order sources)	Trend / Sum(Trend)*100 %	Cumulative %
4D	Agricultural Soils	N2O	33708.74	27098.13	259.00	0.03573	44.50713	
6B	Wastewater Handling	N2O	1165.05	1181.53	401.12	0.01223	15.23234	59.73947
6A	Solid Waste Disposal	CH4	43035.56	18566.63	48.38	0.00723	9.00649	68.74596
2B	Nitric Acid Production	N2O	3903.85	60.76	100.50	0.00668	8.32687	77.07283
1A3b	DERV	N2O	290.88	723.46	170.00	0.00346	4.30959	81.38242
1A3b	Gasoline/ LPG	N2O	897.45	181.01	170.00	0.00326	4.06368	85.44610
4B	Manure Management	N2O	3435.87	2737.21	254.00	0.00313	3.89353	89.33963
2B5	Non-energy use of products	CO2	1350.49	1709.26	111.80	0.00210	2.61517	91.95480
1A1&1A2&1A4&1A5	Other Combustion	N2O	4640.11	3212.94	177.10	0.00151	1.88618	93.84098
1A(stationary)	Oil	CO2	96218.15	51576.83	14.16	0.00091	1.13329	94.97427
5E	5E LULUCF	CO2	6893.22	6375.92	50.01	0.00076	0.95057	95.92484
1B1	Mining & Solid Fuel Transformation	CH4	18302.23	1985.76	13.07	0.00046	0.57246	96.49729
1A	All Fuel	CH4	1860.64	912.30	50.00	0.00027	0.33565	96.83295
5B	5B LULUCF	CO2	15783.60	11172.67	50.01	0.00027	0.33314	97.16609
1A	Other (waste)	CO2	234.97	2680.13	21.11	0.00026	0.32715	97.49324
6B	Wastewater Handling	CH4	1685.62	1634.44	50.01	0.00023	0.28761	97.78085
1A3b	Gasoline/ LPG	CH4	529.76	37.80	50.00	0.00021	0.25809	98.03894
1A3	Other Diesel	N2O	32.63	62.41	140.01	0.00018	0.22031	98.25925
4A	Enteric Fermentation	CH4	19017.19	15652.02	20.00	0.00015	0.19240	98.45165
2	Industrial Processes	HFC	15326.15	14132.10	15.03	0.00015	0.18808	98.63972
6C	Waste Incineration	CO2	1292.36	270.65	29.91	0.00014	0.17850	98.81822
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10359.12	5215.48	17.54	0.00014	0.17285	98.99108
1A3b	Gasoline/ LPG	CO2	75568.67	40767.96	4.83	0.00008	0.10164	99.09272
1A4	Peat	CO2	475.59	50.29	31.62	0.00007	0.08788	99.18060
1A3a	Aviation Fuel	CO2	1654.84	1829.04	20.27	0.00006	0.07340	99.25399
6C	Waste Incineration	CH4	134.43	5.39	50.49	0.00006	0.06991	99.32390
1A3b	DERV	CO2	32995.99	67125.68	2.33	0.00005	0.06784	99.39174
1B	Oil & Natural Gas	CO2	5777.92	3550.45	17.15	0.00005	0.06081	99.45255
6C	Waste Incineration	N2O	56.89	45.73	230.11	0.00005	0.05927	99.51182
1A	Natural Gas	CO2	108305.60	154921.53	1.58	0.00004	0.05501	99.56683
1A3a	Aviation Fuel	N2O	16.29	18.01	171.17	0.00004	0.05152	99.61835
1A4	Petroleum Coke	CO2	76.75	460.47	20.22	0.00004	0.04838	99.66674
1A3b	DERV	CH4	107.28	16.82	50.01	0.00004	0.04556	99.71230
2A7	Other Mineral Use	CH4	23.60	3.34	101.98	0.00003	0.04278	99.75508
1B2	Oil & Natural Gas	N2O	42.40	40.59	111.16	0.00003	0.03384	99.78893
1A	Lubricant	CO2	386.90	160.77	30.07	0.00003	0.03289	99.82182
2	Industrial Processes	SF6	1200.93	507.95	17.03	0.00003	0.03200	99.85382
1A3d	Marine Fuel	N2O	16.91	17.47	140.01	0.00002	0.02880	99.88262
1A	Coal	CO2	248181.59	144938.39	1.28	0.00001	0.01830	99.90092
2A1	Cement Production	CO2	7295.26	3715.53	5.10	0.00001	0.01263	99.91355
2	Industrial Processes	PFC	391.02	206.09	22.02	0.00001	0.01164	99.92519
2C1	Iron&Steel Production	CO2	2340.71	923.76	6.60	0.00001	0.01022	99.93542
2B	Chemical Industry	CH4	169.43	82.32	28.28	0.00001	0.00995	99.94537
2C	Iron & Steel	N2O	7.25	3.28	118.00	0.00001	0.00841	99.95378
2A7	Other Mineral Use	CO2	556.43	429.47	32.02	0.00000	0.00587	99.95965
2A3	Limestone & Dolomite use	CO2	1190.62	1178.37	7.07	0.00000	0.00441	99.96406
1B	Solid Fuel Transformation	CO2	855.03	226.98	6.02	0.00000	0.00428	99.96834
5B	5B LULUCF	N2O	769.94	572.96	50.01	0.00000	0.00422	99.97255
5C2	5C2 LULUCF	CH4	12.39	41.32	20.02	0.00000	0.00378	99.97633
5A	5A LULUCF	N2O	54.16	69.40	20.02	0.00000	0.00346	99.97980
5D	5D LULUCF	CO2	481.73	359.24	50.01	0.00000	0.00320	99.98299
1A3	Other Diesel	CO2	1679.92	2495.94	2.70	0.00000	0.00269	99.98568
1A3d	Marine Fuel	CH4	1.87	4.07	50.03	0.00000	0.00197	99.98766
4B	Manure Management	CH4	9002.22	6638.46	30.00	0.00000	0.00176	99.98942
5C2	5C2 LULUCF	N2O	14.39	25.39	20.02	0.00000	0.00174	99.99116
5A	5A LULUCF	CH4	3.12	16.48	20.02	0.00000	0.00166	99.99282
1A3a	Aviation Fuel	CH4	3.57	0.75	53.85	0.00000	0.00160	99.99442
1A3d	Marine Fuel	CO2	2168.02	2243.23	2.69	0.00000	0.00137	99.99580
2A2	Lime Production	CO2	1462.36	1177.78	5.10	0.00000	0.00077	99.99656
1A3c	Coal	CH4	0.00	0.85	50.00	0.00000	0.00062	99.99718
1A3c	Coal	CO2	0.00	42.73	6.02	0.00000	0.00045	99.99763
1A3	Other Diesel	CH4	2.31	2.30	50.03	0.00000	0.00044	99.99807
1A3c	Coal	N2O	0.00	0.10	118.00	0.00000	0.00041	99.99848
5E2	5E2 LULUCF	CH4	4.95	6.62	20.02	0.00000	0.00035	99.99883
5D	5D LULUCF	N2O	3.98	0.52	20.02	0.00000	0.00028	99.99911
2B	Ammonia Production	CO2	1431.17	948.39	2.92	0.00000	0.00026	99.99938
1B1	Coke Oven Gas	N2O	0.12	0.02	118.00	0.00000	0.00025	99.99963
2C	Iron & Steel Production	CH4	1.09	0.49	50.00	0.00000	0.00023	99.99986
5B	5B LULUCF	CH4	0.09	0.22	50.01	0.00000	0.00011	99.99996
5E2	5E2 LULUCF	N2O	0.50	0.67	20.02	0.00000	0.00004	100.00000
1A	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
5A	5A LULUCF	CO2	-15901.55	-16723.02	25.02	0.00000	0.00000	100.00000
5C	5C LULUCF	CO2	-6300.72	-7728.45	70.01	0.00000	0.00000	100.00000
5G	5G LULUCF	CO2	59.16	-1168.32	30.02	0.00000	0.00000	100.00000
4F	Field Burning	CH4	265.91	0.00	55.90	0.00000	0.00000	100.00000
2B	Adipic Acid Production	N2O	20737.34	0.00	100.02	0.00000	0.00000	100.00000
4F	Field Burning	N2O	79.31	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 -->	783,829.33	577,433.23		0.08	100.00	

Table A 1.1.9 Key Category Analysis based on 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. 2012	Combined uncertainty range as a % of source category	Trend Parameter (used to order sources)	Trend / Sum(Trend)*100 %	Cumulative %
4D	Agricultural Soils	N2O	33708.74	27098.13	259.00	0.02926	40.98841	
6B	Wastewater Handling	N2O	1165.05	1181.53	401.12	0.01145	16.03972	57.02813
6A	Solid Waste Disposal	CH4	43035.56	18566.63	48.38	0.00729	10.20965	67.23779
2B	Nitric Acid Production	N2O	3903.85	60.76	100.50	0.00661	9.25499	76.49278
1A3b	DERV	N2O	290.88	723.46	170.00	0.00335	4.69110	81.18388
1A3b	Gasoline/ LPG	N2O	897.45	181.01	170.00	0.00324	4.53959	85.72347
4B	Manure Management	N2O	3435.87	2737.21	254.00	0.00250	3.50387	89.22734
2B5	Non-energy use of products	CO2	1350.49	1709.26	111.80	0.00200	2.80628	92.03362
1A1&1A2&1A4&1A5	Other Combustion	N2O	4640.11	3212.94	177.10	0.00183	2.56498	94.59860
1A(stationary)	Oil	CO2	96218.15	51576.83	14.16	0.00093	1.30736	95.90596
1B1	Mining & Solid Fuel Transformation	CH4	18302.23	1985.76	13.07	0.00046	0.63759	96.54355
1A	All Fuel	CH4	1860.64	912.30	50.00	0.00027	0.38357	96.92712
1A	Other (waste)	CO2	234.97	2680.13	21.11	0.00026	0.35794	97.28507
6B	Wastewater Handling	CH4	1685.62	1634.44	50.01	0.00021	0.30054	97.58560
1A3b	Gasoline/ LPG	CH4	529.76	37.80	50.00	0.00021	0.28720	97.87281
1A3	Other Diesel	N2O	32.63	62.41	140.01	0.00017	0.23910	98.11190
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10359.12	5215.48	17.54	0.00014	0.20002	98.31193
6C	Waste Incineration	CO2	1292.36	270.65	29.91	0.00014	0.19946	98.51139
2	Industrial Processes	HFC	15326.15	14132.10	15.03	0.00014	0.19410	98.70549
4A	Enteric Fermentation	CH4	19017.19	15652.02	20.00	0.00013	0.18463	98.89012
1A3b	Gasoline/ LPG	CO2	75568.67	40767.96	4.83	0.00008	0.11736	99.00747
1A4	Peat	CO2	475.59	50.29	31.62	0.00007	0.09788	99.10535
1A3a	Aviation Fuel	CO2	1654.84	1829.04	20.27	0.00006	0.07805	99.18341
6C	Waste Incineration	CH4	134.43	5.39	50.49	0.00006	0.07774	99.26115
1A3b	DERV	CO2	32995.99	67125.68	2.33	0.00005	0.07369	99.33483
1B	Oil & Natural Gas	CO2	5777.92	3550.45	17.15	0.00005	0.07243	99.40726
1A	Natural Gas	CO2	108305.60	154921.53	1.58	0.00004	0.05932	99.46659
1A3a	Aviation Fuel	N2O	16.29	18.01	171.17	0.00004	0.05479	99.52138
6C	Waste Incineration	N2O	56.89	45.73	230.11	0.00004	0.05458	99.57595
1A4	Petroleum Coke	CO2	76.75	460.47	20.22	0.00004	0.05288	99.62884
1A3b	DERV	CH4	107.28	16.82	50.01	0.00004	0.05082	99.67966
2A7	Other Mineral Use	CH4	23.60	3.34	101.98	0.00003	0.04770	99.72736
1A	Lubricant	CO2	386.90	160.77	30.07	0.00003	0.03723	99.76458
2	Industrial Processes	SF6	1200.93	507.95	17.03	0.00003	0.03624	99.80082
1B2	Oil & Natural Gas	N2O	42.40	40.59	111.16	0.00003	0.03527	99.83609
1A3d	Marine Fuel	N2O	16.91	17.47	140.01	0.00002	0.03040	99.86649
4B	Manure Management	CH4	9002.22	6638.46	30.00	0.00002	0.02586	99.89236
1A	Coal	CO2	248181.59	144938.39	1.28	0.00002	0.02145	99.91380
2A1	Cement Production	CO2	7295.26	3715.53	5.10	0.00001	0.01448	99.92829
2	Industrial Processes	PFC	391.02	206.09	22.02	0.00001	0.01340	99.94169
2C1	Iron&Steel Production	CO2	2340.71	923.76	6.60	0.00001	0.01155	99.95324
2B	Chemical Industry	CH4	169.43	82.32	28.28	0.00001	0.01137	99.96460
2C	Iron & Steel	N2O	7.25	3.28	118.00	0.00001	0.00955	99.97416
1B	Solid Fuel Transformation	CO2	855.03	226.98	6.02	0.00000	0.00479	99.97895
2A3	Limestone & Dolomite use	CO2	1190.62	1178.37	7.07	0.00000	0.00463	99.98358
2A7	Other Mineral Use	CO2	556.43	429.47	32.02	0.00000	0.00447	99.98805
1A3	Other Diesel	CO2	1679.92	2495.94	2.70	0.00000	0.00290	99.99095
1A3d	Marine Fuel	CH4	1.87	4.07	50.03	0.00000	0.00214	99.99310
1A3a	Aviation Fuel	CH4	3.57	0.75	53.85	0.00000	0.00179	99.99489
1A3d	Marine Fuel	CO2	2168.02	2243.23	2.69	0.00000	0.00145	99.99634
2A2	Lime Production	CO2	1462.36	1177.78	5.10	0.00000	0.00071	99.99705
1A3c	Coal	CH4	0.00	0.85	50.00	0.00000	0.00068	99.99773
1A3c	Coal	CO2	0.00	42.73	6.02	0.00000	0.00050	99.99822
1A3	Other Diesel	CH4	2.31	2.30	50.03	0.00000	0.00046	99.99868
1A3c	Coal	N2O	0.00	0.10	118.00	0.00000	0.00045	99.99913
2B	Ammonia Production	CO2	1431.17	948.39	2.92	0.00000	0.00033	99.99946
1B1	Coke Oven Gas	N2O	0.12	0.02	118.00	0.00000	0.00028	99.99974
2C	Iron & Steel Production	CH4	1.09	0.49	50.00	0.00000	0.00026	100.00000
1A	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
5A	5A LULUCF	CO2	0.00	0.00	25.02	0.00000	0.00000	100.00000
5B	5B LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C	5C LULUCF	CO2	0.00	0.00	70.01	0.00000	0.00000	100.00000
5D	5D LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5E	5E LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5G	5G LULUCF	CO2	0.00	0.00	30.02	0.00000	0.00000	100.00000
4F	Field Burning	CH4	265.91	0.00	55.90	0.00000	0.00000	100.00000
5A	5A LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	5B LULUCF	CH4	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	5C2 LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	5E2 LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
2B	Adipic Acid Production	N2O	20737.34	0.00	100.02	0.00000	0.00000	100.00000
4F	Field Burning	N2O	79.31	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	5A LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	5B LULUCF	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	5C2 LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5D	5D LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	5E2 LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5G	5G LULUCF	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	781,950.36	584,411.63		0.07	100.00	

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

IPCC category	Source category	Gas	Emissions Gg CO2 equiv. 1990	Year Y emissions Gg CO2 equiv. 2012	Combined uncertainty range as a % of source category	Trend Parameter (used to order sources)	Trend / Sum(Trend)*100 %	Cumulative %
4D	Agricultural Soils	N2O	33708.74	27098.13	259.00	0.03401	43.29678	
6B	Wastewater Handling	N2O	1165.05	1181.53	401.12	0.01205	15.33875	58.63553
6A	Solid Waste Disposal	CH4	43035.56	18566.63	48.38	0.00727	9.25725	67.89278
2B	Nitric Acid Production	N2O	3903.85	60.76	100.50	0.00668	8.51102	76.40381
1A3b	DERV	N2O	290.88	723.46	170.00	0.00344	4.37932	80.78312
1A3b	Gasoline/ LPG	N2O	897.45	181.01	170.00	0.00327	4.15950	84.94262
4B	Manure Management	N2O	3435.87	2737.21	254.00	0.00296	3.76646	88.70908
2B5	Non-energy use of products	CO2	1350.49	1709.26	111.80	0.00208	2.64703	91.35611
1A1&1A2&1A4&1A5	Other Combustion	N2O	4640.11	3212.94	177.10	0.00161	2.04916	93.40527
1A(stationary)	Oil	CO2	96218.15	51576.83	14.16	0.00092	1.17071	94.57598
5E	5E LULUCF	CO2	6893.22	6375.92	50.01	0.00075	0.95229	95.52827
1B1	Mining & Solid Fuel Transformation	CH4	18302.23	1985.76	13.07	0.00046	0.58546	96.11373
2	Industrial Processes	HFC	11384.05	14132.10	15.03	0.00030	0.38481	96.49855
5B	5B LULUCF	CO2	15783.60	11172.67	50.01	0.00029	0.37415	96.87270
1A	All Fuel	CH4	1860.64	912.30	50.00	0.00027	0.34580	97.21850
1A	Other (waste)	CO2	234.97	2680.13	21.11	0.00026	0.33292	97.55141
6B	Wastewater Handling	CH4	1685.62	1634.44	50.01	0.00023	0.28902	97.84043
1A3b	Gasoline/ LPG	CH4	529.76	37.80	50.00	0.00021	0.26388	98.10432
1A3	Other Diesel	N2O	32.63	62.41	140.01	0.00018	0.22369	98.32801
4A	Enteric Fermentation	CH4	19017.19	15652.02	20.00	0.00015	0.18909	98.51710
6C	Waste Incineration	CO2	1292.36	270.65	29.91	0.00014	0.18272	98.69983
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10359.12	5215.48	17.54	0.00014	0.17872	98.87855
2	Industrial Processes	PFC	1390.69	206.09	22.02	0.00009	0.11892	98.99747
1A3b	Gasoline/ LPG	CO2	75568.67	40767.96	4.83	0.00008	0.10502	99.10249
1A4	Peat	CO2	475.59	50.29	31.62	0.00007	0.08988	99.19237
1A3a	Aviation Fuel	CO2	1654.84	1829.04	20.27	0.00006	0.07411	99.26648
6C	Waste Incineration	CH4	134.43	5.39	50.49	0.00006	0.07147	99.33794
1A3b	DERV	CO2	32995.99	67125.68	2.33	0.00005	0.06890	99.40684
1B	Oil & Natural Gas	CO2	5777.92	3550.45	17.15	0.00005	0.06341	99.47025
6C	Waste Incineration	N2O	56.89	45.73	230.11	0.00005	0.05765	99.52790
1A	Natural Gas	CO2	108305.60	154921.53	1.58	0.00004	0.05576	99.58366
1A3a	Aviation Fuel	N2O	16.29	18.01	171.17	0.00004	0.05202	99.63568
1A4	Petroleum Coke	CO2	76.75	460.47	20.22	0.00004	0.04922	99.68490
1A3b	DERV	CH4	107.28	16.82	50.01	0.00004	0.04662	99.73152
2A7	Other Mineral Use	CH4	23.60	3.34	101.98	0.00003	0.04377	99.77529
1B2	Oil & Natural Gas	N2O	42.40	40.59	111.16	0.00003	0.03398	99.80927
1A	Lubricant	CO2	386.90	160.77	30.07	0.00003	0.03379	99.84307
1A3d	Marine Fuel	N2O	16.91	17.47	140.01	0.00002	0.02902	99.87209
2	Industrial Processes	SF6	987.40	507.95	17.03	0.00002	0.01923	99.89131
1A	Coal	CO2	248181.59	144938.39	1.28	0.00001	0.01899	99.91030
2A1	Cement Production	CO2	7295.26	3715.53	5.10	0.00001	0.01303	99.92333
2C1	Iron&Steel Production	CO2	2340.71	923.76	6.60	0.00001	0.01050	99.93383
2B	Chemical Industry	CH4	169.43	82.32	28.28	0.00001	0.01025	99.94408
2C	Iron & Steel	N2O	7.25	3.28	118.00	0.00001	0.00865	99.95273
2A7	Other Mineral Use	CO2	556.43	429.47	32.02	0.00000	0.00547	99.95820
4B	Manure Management	CH4	9002.22	6638.46	30.00	0.00000	0.00540	99.96360
2A3	Limestone & Dolomite use	CO2	1190.62	1178.37	7.07	0.00000	0.00444	99.96803
1B	Solid Fuel Transformation	CO2	855.03	226.98	6.02	0.00000	0.00438	99.97242
5C2	5C2 LULUCF	CH4	12.39	41.32	20.02	0.00000	0.00384	99.97626
5A	5A LULUCF	N2O	54.16	69.40	20.02	0.00000	0.00351	99.97977
1A3	Other Diesel	CO2	1679.92	2495.94	2.70	0.00000	0.00273	99.98249
5B	5B LULUCF	N2O	769.94	572.96	50.01	0.00000	0.00258	99.98508
5D	5D LULUCF	CO2	481.73	359.24	50.01	0.00000	0.00218	99.98726
1A3d	Marine Fuel	CH4	1.87	4.07	50.03	0.00000	0.00200	99.98927
5C2	5C2 LULUCF	N2O	14.39	25.39	20.02	0.00000	0.00176	99.99103
5A	5A LULUCF	CH4	3.12	16.48	20.02	0.00000	0.00169	99.99272
1A3a	Aviation Fuel	CH4	3.57	0.75	53.85	0.00000	0.00164	99.99436
1A3d	Marine Fuel	CO2	2168.02	2243.23	2.69	0.00000	0.00138	99.99575
2A2	Lime Production	CO2	1462.36	1177.78	5.10	0.00000	0.00075	99.99649
1A3c	Coal	CH4	0.00	0.85	50.00	0.00000	0.00063	99.99712
1A3c	Coal	CO2	0.00	42.73	6.02	0.00000	0.00046	99.99758
1A3	Other Diesel	CH4	2.31	2.30	50.03	0.00000	0.00044	99.99803
1A3c	Coal	N2O	0.00	0.10	118.00	0.00000	0.00041	99.99844
5E2	5E2 LULUCF	CH4	4.95	6.62	20.02	0.00000	0.00035	99.99879
5D	5D LULUCF	N2O	3.98	0.52	20.02	0.00000	0.00029	99.99908
2B	Ammonia Production	CO2	1431.17	948.39	2.92	0.00000	0.00028	99.99936
1B1	Coke Oven Gas	N2O	0.12	0.02	118.00	0.00000	0.00026	99.99962
2C	Iron & Steel Production	CH4	1.09	0.49	50.00	0.00000	0.00023	99.99985
5B	5B LULUCF	CH4	0.09	0.22	50.01	0.00000	0.00011	99.99996
5E2	5E2 LULUCF	N2O	0.50	0.67	20.02	0.00000	0.00004	100.00000
1A	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
5A	5A LULUCF	CO2	-15901.55	-16723.02	25.02	0.00000	0.00000	100.00000
5C	5C LULUCF	CO2	-6300.72	-7728.45	70.01	0.00000	0.00000	100.00000
5G	5G LULUCF	CO2	59.16	-1168.32	30.02	0.00000	0.00000	100.00000
4F	Field Burning	CH4	265.91	0.00	55.90	0.00000	0.00000	100.00000
2B	Adipic Acid Production	N2O	20737.34	0.00	100.02	0.00000	0.00000	100.00000
4F	Field Burning	N2O	79.31	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 -->	780,673.37	577,433.23		0.08	100.00	

Table A 1.1.11 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. 2012	Combined uncertainty range as a % of source category	Trend Parameter (used to order sources)	Trend / Sum(Trend)*100 %	Cumulative %
4D	Agricultural Soils	N2O	33708.74	27098.13	259.00	0.02758	39.57344	
6B	Wastewater Handling	N2O	1165.05	1181.53	401.12	0.01127	16.17715	55.75059
6A	Solid Waste Disposal	CH4	43035.56	18566.63	48.38	0.00733	10.51522	66.26581
2B	Nitric Acid Production	N2O	3903.85	60.76	100.50	0.00661	9.48056	75.74637
1A3b	DERV	N2O	290.88	723.46	170.00	0.00333	4.77730	80.52367
1A3b	Gasoline/ LPG	N2O	897.45	181.01	170.00	0.00325	4.65677	85.18043
4B	Manure Management	N2O	3435.87	2737.21	254.00	0.00234	3.35480	88.53523
2B5	Non-energy use of products	CO2	1350.49	1709.26	111.80	0.00198	2.84610	91.38133
1A1&1A2&1A4&1A5	Other Combustion	N2O	4640.11	3212.94	177.10	0.00192	2.76089	94.14222
1A(stationary)	Oil	CO2	96218.15	51576.83	14.16	0.00094	1.35282	95.49503
1B1	Mining & Solid Fuel Transformation	CH4	18302.23	1985.76	13.07	0.00046	0.65351	96.14854
2	Industrial Processes	HFC	11384.05	14132.10	15.03	0.00029	0.41334	96.56188
1A	All Fuel	CH4	1860.64	912.30	50.00	0.00028	0.39591	96.95779
1A	Other (waste)	CO2	234.97	2680.13	21.11	0.00025	0.36505	97.32284
6B	Wastewater Handling	CH4	1685.62	1634.44	50.01	0.00021	0.30241	97.62526
1A3b	Gasoline/ LPG	CH4	529.76	37.80	50.00	0.00021	0.29430	97.91956
1A3	Other Diesel	N2O	32.63	62.41	140.01	0.00017	0.24328	98.16284
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH4	10359.12	5215.48	17.54	0.00014	0.20715	98.36999
6C	Waste Incineration	CO2	1292.36	270.65	29.91	0.00014	0.20463	98.57462
4A	Enteric Fermentation	CH4	19017.19	15652.02	20.00	0.00013	0.18081	98.75542
2	Industrial Processes	PFC	1390.69	206.09	22.02	0.00009	0.13291	98.88833
1A3b	Gasoline/ LPG	CO2	75568.67	40767.96	4.83	0.00008	0.12146	99.00980
1A4	Peat	CO2	475.59	50.29	31.62	0.00007	0.10032	99.11012
6C	Waste Incineration	CH4	134.43	5.39	50.49	0.00006	0.07965	99.18976
1A3a	Aviation Fuel	CO2	1654.84	1829.04	20.27	0.00006	0.07895	99.26872
1B	Oil & Natural Gas	CO2	5777.92	3550.45	17.15	0.00005	0.07557	99.34429
1A3b	DERV	CO2	32995.99	67125.68	2.33	0.00005	0.07500	99.41929
1A	Natural Gas	CO2	108305.60	154921.53	1.58	0.00004	0.06025	99.47953
1A3a	Aviation Fuel	N2O	16.29	18.01	171.17	0.00004	0.05542	99.53496
1A4	Petroleum Coke	CO2	76.75	460.47	20.22	0.00004	0.05392	99.58887
6C	Waste Incineration	N2O	56.89	45.73	230.11	0.00004	0.05269	99.64156
1A3b	DERV	CH4	107.28	16.82	50.01	0.00004	0.05211	99.69368
2A7	Other Mineral Use	CH4	23.60	3.34	101.98	0.00003	0.04890	99.74258
1A	Lubricant	CO2	386.90	160.77	30.07	0.00003	0.03832	99.78090
1B2	Oil & Natural Gas	N2O	42.40	40.59	111.16	0.00002	0.03546	99.81636
4B	Manure Management	CH4	9002.22	6638.46	30.00	0.00002	0.03441	99.85078
1A3d	Marine Fuel	N2O	16.91	17.47	140.01	0.00002	0.03068	99.88146
1A	Coal	CO2	248181.59	144938.39	1.28	0.00002	0.02229	99.90375
2	Industrial Processes	SF6	987.40	507.95	17.03	0.00002	0.02211	99.92586
2A1	Cement Production	CO2	7295.26	3715.53	5.10	0.00001	0.01496	99.94082
2C1	Iron&Steel Production	CO2	2340.71	923.76	6.60	0.00001	0.01188	99.95270
2B	Chemical Industry	CH4	169.43	82.32	28.28	0.00001	0.01173	99.96443
2C	Iron & Steel	N2O	7.25	3.28	118.00	0.00001	0.00985	99.97428
1B	Solid Fuel Transformation	CO2	855.03	226.98	6.02	0.00000	0.00492	99.97920
2A3	Limestone & Dolomite use	CO2	1190.62	1178.37	7.07	0.00000	0.00466	99.98386
2A7	Other Mineral Use	CO2	556.43	429.47	32.02	0.00000	0.00400	99.98786
1A3	Other Diesel	CO2	1679.92	2495.94	2.70	0.00000	0.00295	99.99081
1A3d	Marine Fuel	CH4	1.87	4.07	50.03	0.00000	0.00218	99.99299
1A3a	Aviation Fuel	CH4	3.57	0.75	53.85	0.00000	0.00184	99.99483
1A3d	Marine Fuel	CO2	2168.02	2243.23	2.69	0.00000	0.00146	99.99629
1A3c	Coal	CH4	0.00	0.85	50.00	0.00000	0.00069	99.99699
2A2	Lime Production	CO2	1462.36	1177.78	5.10	0.00000	0.00068	99.99767
1A3c	Coal	CO2	0.00	42.73	6.02	0.00000	0.00051	99.99818
1A3	Other Diesel	CH4	2.31	2.30	50.03	0.00000	0.00047	99.99864
1A3c	Coal	N2O	0.00	0.10	118.00	0.00000	0.00046	99.99910
2B	Ammonia Production	CO2	1431.17	948.39	2.92	0.00000	0.00035	99.99945
1B1	Coke Oven Gas	N2O	0.12	0.02	118.00	0.00000	0.00029	99.99973
2C	Iron & Steel Production	CH4	1.09	0.49	50.00	0.00000	0.00027	100.00000
1A	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
1A4	Combined Fuel	CO2	0.00	0.00	21.21	0.00000	0.00000	100.00000
5A	5A LULUCF	CO2	0.00	0.00	25.02	0.00000	0.00000	100.00000
5B	5B LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C	5C LULUCF	CO2	0.00	0.00	70.01	0.00000	0.00000	100.00000
5D	5D LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5E	5E LULUCF	CO2	0.00	0.00	50.01	0.00000	0.00000	100.00000
5G	5G LULUCF	CO2	0.00	0.00	30.02	0.00000	0.00000	100.00000
4F	Field Burning	CH4	265.91	0.00	55.90	0.00000	0.00000	100.00000
5A	5A LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	5B LULUCF	CH4	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	5C2 LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	5E2 LULUCF	CH4	0.00	0.00	20.02	0.00000	0.00000	100.00000
2B	Adipic Acid Production	N2O	20737.34	0.00	100.02	0.00000	0.00000	100.00000
4F	Field Burning	N2O	79.31	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	5A LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5B	5B LULUCF	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
5C2	5C2 LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5D	5D LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5E2	5E2 LULUCF	N2O	0.00	0.00	20.02	0.00000	0.00000	100.00000
5G	5G LULUCF	N2O	0.00	0.00	50.01	0.00000	0.00000	100.00000
		Sum -->	778,794.40	584,411.63		0.07	100.00	

Table A 1.1.12 Key Source Category Analysis summary for base 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	CO_2	Yes	Level	
1A(stationary)	Oil	CO_2	Yes	Level	
1A	Natural Gas	CO_2	Yes	Level	
1A	Other (waste)	CO_2			
1A	Lubricant	CO_2			
1A3a	Aviation Fuel	CO_2			
1A3b	DERV	CO_2			
1A3b	Gasoline/ LPG	CO_2	Yes	Level	
1A3d	Marine Fuel	CO_2			
1A3	Other Diesel	CO_2			
1A4	Peat	CO_2			
1A4	Petroleum Coke	CO_2			
1B	Solid Fuel Transformation	CO_2			
1B	Oil & Natural Gas	CO_2			
2A1	Cement Production	CO_2			
2A2	Lime Production	CO_2			
2A3	Limestone & Dolomite use	CO_2			
2A7	Other Mineral Use	CO_2			
2B	Ammonia Production	CO_2			
2B5	Non-energy use of products	CO_2			
2C1	Iron&Steel Production	CO_2			
5A	5A LULUCF	CO_2	Yes	Level	
5B	5B LULUCF	CO_2	Yes	Level	
5C	5C LULUCF	CO_2	Yes	Level	
5E	5E LULUCF	CO_2	Yes	Level	
5G	5G LULUCF	CO_2			
6C	Waste Incineration	CO_2			
7C	Other	CO_2			
1A	All Fuel	CH_4			
1A3a	Aviation Fuel	CH_4			
1A3b	DERV	CH_4			
1A3b	Gasoline/ LPG	CH_4			
1A3d	Marine Fuel	CH_4			
1A3	Other Diesel	CH_4			
1B1	Mining & Solid Fuel Transformation	CH_4	Yes	Level	
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH_4	Yes	Level	
2A7	Other Mineral Use	CH_4			
2B	Chemical Industry	CH_4			
2C	Iron & Steel Production	CH_4			
4A	Enteric Fermentation	CH_4	Yes	Level	
4B	Manure Management	CH_4	Yes	Level	
4F	Field Burning	CH_4			
5C2	5C2 LULUCF	CH_4			
5E2	5E2 LULUCF	CH_4			
6A	Solid Waste Disposal	CH_4	Yes	Level	high uncertainty
6B	Wastewater Handling	CH_4			
6C	Waste Incineration	CH_4			
1A1&1A2&1A4&1A5	Other Combustion	N_2O	Yes	Level	
1A3a	Aviation Fuel	N_2O			
1A3b	DERV	N_2O			
1A3b	Gasoline/ LPG	N_2O	Yes	Level	
1A3d	Marine Fuel	N_2O			
1A3	Other Diesel	N_2O			
1B1	Coke Oven Gas	N_2O			
1B2	Oil & Natural Gas	N_2O			
2B	Adipic Acid Production	N_2O	Yes	Level	
2B	Nitric Acid Production	N_2O	Yes	Level	
2C	Iron & Steel	N_2O			
4B	Manure Management	N_2O	Yes	Level	high uncertainty
4D	Agricultural Soils	N_2O	Yes	Level	high uncertainty
4F	Field Burning	N_2O			
5C2	5C2 LULUCF	N_2O			
5E2	5E2 LULUCF	N_2O			
6B	Wastewater Handling	N_2O	Yes	Level	
6C	Waste Incineration	N_2O			
2	Industrial Processes	HFC	Yes	Level	
2	Industrial Processes	PFC			
2	Industrial Processes	SF_6			

Table A 1.1.13 Key Source Category Analysis summary for 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	CO_2	Yes	Level	
1A(stationary)	Oil	CO_2	Yes	Level	
1A	Natural Gas	CO_2	Yes	Level	
1A	Other (waste)	CO_2			
1A	Lubricant	CO_2			
1A3a	Aviation Fuel	CO_2			
1A3b	DERV	CO_2			
1A3b	Gasoline/ LPG	CO_2	Yes	Level	
1A3d	Marine Fuel	CO_2			
1A3	Other Diesel	CO_2			
1A4	Peat	CO_2			
1A4	Petroleum Coke	CO_2			
1B	Solid Fuel Transformation	CO_2			
1B	Oil & Natural Gas	CO_2			
2A1	Cement Production	CO_2			
2A2	Lime Production	CO_2			
2A3	Limestone & Dolomite use	CO_2			
2A7	Other Mineral Use	CO_2			
2B	Ammonia Production	CO_2			
2B5	Non-energy use of products	CO_2			
2C1	Iron&Steel Production	CO_2			
5A	5A LULUCF	CO_2			
5B	5B LULUCF	CO_2			
5C	5C LULUCF	CO_2			
5E	5E LULUCF	CO_2			
5G	5G LULUCF	CO_2			
6C	Waste Incineration	CO_2			
7C	Other	CO_2			
1A	All Fuel	CH_4			
1A3a	Aviation Fuel	CH_4			
1A3b	DERV	CH_4			
1A3b	Gasoline/ LPG	CH_4			
1A3d	Marine Fuel	CH_4			
1A3	Other Diesel	CH_4			
1B1	Mining & Solid Fuel Transformation	CH_4	Yes	Level	
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH_4	Yes	Level	
2A7	Other Mineral Use	CH_4			
2B	Chemical Industry	CH_4			
2C	Iron & Steel Production	CH_4			
4A	Enteric Fermentation	CH_4	Yes	Level	
4B	Manure Management	CH_4	Yes	Level	
4F	Field Burning	CH_4			
5C2	5C2 LULUCF	CH_4			
5E2	5E2 LULUCF	CH_4			
6A	Solid Waste Disposal	CH_4	Yes	Level	high uncertainty
6B	Wastewater Handling	CH_4			
6C	Waste Incineration	CH_4			
1A1&1A2&1A4&1A5	Other Combustion	N_2O	Yes	Level	
1A3a	Aviation Fuel	N_2O			
1A3b	DERV	N_2O			
1A3b	Gasoline/ LPG	N_2O	Yes	Level	
1A3d	Marine Fuel	N_2O			
1A3	Other Diesel	N_2O			
1B1	Coke Oven Gas	N_2O			
1B2	Oil & Natural Gas	N_2O			
2B	Adipic Acid Production	N_2O	Yes	Level	
2B	Nitric Acid Production	N_2O	Yes	Level	
2C	Iron & Steel	N_2O			
4B	Manure Management	N_2O	Yes	Level	high uncertainty
4D	Agricultural Soils	N_2O	Yes	Level	high uncertainty
4F	Field Burning	N_2O			
5C2	5C2 LULUCF	N_2O			
5E2	5E2 LULUCF	N_2O			
6B	Wastewater Handling	N_2O	Yes	Level	
6C	Waste Incineration	N_2O			
2	Industrial Processes	HFC	Yes	Level	
2	Industrial Processes	PFC			
2	Industrial Processes	SF_6			

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

Quantitative Method Used: Approach 1 (Error propagation approach)					
A		B	C	D	E
IPCC Source Categories		Gas	Category Key Source Category	If Column C is Yes, Criteria for Identification	Comments
1A	Coal	CO_2	Yes	Level	
1A(stationary)	Oil	CO_2	Yes	Level, Trend	
1A	Natural Gas	CO_2	Yes	Level	
1A	Other (waste)	CO_2			
1A	Lubricant	CO_2			
1A3a	Aviation Fuel	CO_2			
1A3b	DERV	CO_2	Yes	Level	
1A3b	Gasoline/ LPG	CO_2	Yes	Level	
1A3d	Marine Fuel	CO_2			
1A3	Other Diesel	CO_2			
1A4	Peat	CO_2			
1A4	Petroleum Coke	CO_2			
1B	Solid Fuel Transformation	CO_2			
1B	Oil & Natural Gas	CO_2			
2A1	Cement Production	CO_2			
2A2	Lime Production	CO_2			
2A3	Limestone & Dolomite use	CO_2			
2A7	Other Mineral Use	CO_2			
2B	Ammonia Production	CO_2			
2B5	Non-energy use of products	CO_2	Yes	Level, Trend	
2C1	Iron&Steel Production	CO_2			
5A	5A LULUCF	CO_2	Yes	Level	
5B	5B LULUCF	CO_2	Yes	Level	
5C	5C LULUCF	CO_2	Yes	Level	
5E	5E LULUCF	CO_2	Yes	Level, Trend	
5G	5G LULUCF	CO_2			
6C	Waste Incineration	CO_2			
7C	Other	CO_2			
1A	All Fuel	CH_4			
1A3a	Aviation Fuel	CH_4			
1A3b	DERV	CH_4			
1A3b	Gasoline/ LPG	CH_4			
1A3d	Marine Fuel	CH_4			
1A3	Other Diesel	CH_4			
1B1	Mining & Solid Fuel Transformation	CH_4			
1B2	Production, Refining & Distribution of Oil & Natural Gas	CH_4			
2A7	Fletton Bricks	CH_4			
2B	Chemical Industry	CH_4			
2C	Iron & Steel Production	CH_4			
4A	Enteric Fermentation	CH_4	Yes	Level	
4B	Manure Management	CH_4	Yes	Level	
4F	Field Burning	CH_4			
5C2	5C2 LULUCF	CH_4			
5E2	5E2 LULUCF	CH_4			
6A	Solid Waste Disposal	CH_4	Yes	Level, Trend	high uncertainty
6B	Wastewater Handling	CH_4			
6C	Waste Incineration	CH_4			
1A1&1A2&1A4&1A5	Other Combustion	N_2O	Yes	Level, Trend	
1A3a	Aviation Fuel	N_2O			
1A3b	DERV	N_2O	Yes	Level, Trend	
1A3b	Gasoline/ LPG	N_2O	Yes	Trend	
1A3d	Marine Fuel	N_2O			
1A3	Other Diesel	N_2O			
1B1	Coke Oven Gas	N_2O			
1B2	Oil & Natural Gas	N_2O			
2B	Adipic Acid Production	N_2O			
2B	Nitric Acid Production	N_2O	Yes	Trend	
2C	Iron & Steel	N_2O			
4B	Manure Management	N_2O	Yes	Level, Trend	high uncertainty
4D	Agricultural Soils	N_2O	Yes	Level, Trend	high uncertainty
4F	Field Burning	N_2O			
5C2	5C2 LULUCF	N_2O			
5E2	5E2 LULUCF	N_2O			
6B	Wastewater Handling	N_2O	Yes	Level, Trend	
6C	Waste Incineration	N_2O			
2	Industrial Processes	HFC	Yes	Level	
2	Industrial Processes	PFC			
2	Industrial Processes	SF_6			

Table A 1.1.15 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	CO_2		Level	
1A(stationary)	Oil	CO_2		Level, Trend	
1A	Natural Gas	CO_2		Level	
1A	Other (waste)	CO_2			
1A	Lubricant	CO_2			
1A3a	Aviation Fuel	CO_2			
1A3b	DERV	CO_2		Level	
1A3b	Gasoline/ LPG	CO_2		Level	
1A3d	Marine Fuel	CO_2			
1A3	Other Diesel	CO_2			
1A4	Peat	CO_2			
1A4	Petroleum Coke	CO_2			
1B	Solid Fuel Transformation	CO_2			
1B	Oil & Natural Gas	CO_2			
2A1	Cement Production	CO_2			
2A2	Lime Production	CO_2			
2A3	Limestone & Dolomite use	CO_2			
2A7	Other Mineral Use	CO_2			
2B	Ammonia Production	CO_2			
2B5	Non-energy use of products	CO_2		Level, Trend	
2C1	Iron&Steel Production	CO_2			
5A	5A LULUCF	CO_2			
5B	5B LULUCF	CO_2			
5C	5C LULUCF	CO_2			
5E	5E LULUCF	CO_2			
5G	5G LULUCF	CO_2			
6C	Waste Incineration	CO_2			
7C	Other	CO_2			
1A	All Fuel	CH_4			
1A3a	Aviation Fuel	CH_4			
1A3b	DERV	CH_4			
1A3b	Gasoline/ LPG	CH_4			
1A3d	Marine Fuel	CH_4			
1A3	Other Diesel	CH_4			
1B1	Mining & Solid Fuel Transformation	CH_4			
1B2	Oil & Natural Gas	CH_4			
2A7	Fletton Bricks	CH_4			
2B	Chemical Industry	CH_4			
2C	Iron & Steel Production	CH_4			
4A	Enteric Fermentation	CH_4		Level	
4B	Manure Management	CH_4		Level	
4F	Field Burning	CH_4			
5C2	5C2 LULUCF	CH_4			
5E2	5E2 LULUCF	CH_4			
6A	Solid Waste Disposal	CH_4		Level, Trend	high uncertainty
6B	Wastewater Handling	CH_4			
6C	Waste Incineration	CH_4			
1A1&1A2&1A4&1A5	Other Combustion	N_2O		Level, Trend	
1A3a	Aviation Fuel	N_2O			
1A3b	DERV	N_2O		Level, Trend	
1A3b	Gasoline/ LPG	N_2O		Trend	
1A3d	Marine Fuel	N_2O			
1A3	Other Diesel	N_2O			
1B1	Coke Oven Gas	N_2O			
1B2	Oil & Natural Gas	N_2O			
2B	Adipic Acid Production	N_2O			
2B	Nitric Acid Production	N_2O		Trend	
2C	Iron & Steel	N_2O			
4B	Manure Management	N_2O		Level, Trend	high uncertainty
4D	Agricultural Soils	N_2O		Level, Trend	high uncertainty
4F	Field Burning	N_2O			
5C2	5C2 LULUCF	N_2O			
5E2	5E2 LULUCF	N_2O			
6B	Wastewater Handling	N_2O		Level, Trend	
6C	Waste Incineration	N_2O			
2	Industrial Processes	HFC		Level	
2	Industrial Processes	PFC			
2	Industrial Processes	SF_6			

Table A 1.1.16 Key Source Category Analysis – further disaggregation – for the latest reported year (including LULUCF). Note – indicative only.

IPCC Category Code	IPCC Category	Greenhouse Gas	Emissions (Gg CO2 eq) 2012	Absolute Value of Emissions (Gg CO2 eq) 2012	Level Assessment	Cumulative Total of Level
1A1	Other_Bituminous_Coal	CO2	120716.89	120716.89	0.1920	
1A4	Natural_Gas	CO2	81875.79	81875.79	0.1302	0.3223
1A3b	Gas/Diesel_Oil	CO2	67125.68	67125.68	0.1068	0.4290
1A1	Natural_Gas	CO2	45224.54	45224.54	0.0719	0.5010
1A3b	Motor_Gasoline	CO2	40493.73	40493.73	0.0644	0.5654
1A2	Natural_Gas	CO2	27655.23	27655.23	0.0440	0.6094
4D	non-fuel_combustion	N2O	27098.13	27098.13	0.0431	0.6525
6A	non-fuel_combustion	CH4	18566.63	18566.63	0.0295	0.6820
5A	non-fuel_combustion	CO2	-16723.02	16723.02	0.0266	0.7086
4A	non-fuel_combustion	CH4	15652.02	15652.02	0.0249	0.7335
2	All	HFC	14132.10	14132.10	0.0225	0.7560
5B	non-fuel_combustion	CO2	11172.67	11172.67	0.0178	0.7738
1A2	Blast_Furnace_Gas	CO2	10137.35	10137.35	0.0161	0.7899
1A1	Refinery_Gas	CO2	8764.47	8764.47	0.0139	0.8038
1A2	Other_Bituminous_Coal	CO2	7791.66	7791.66	0.0124	0.8162
5C	non-fuel_combustion	CO2	-7728.45	7728.45	0.0123	0.8285
4B	non-fuel_combustion	CH4	6638.46	6638.46	0.0106	0.8391
5E	non-fuel_combustion	CO2	6375.92	6375.92	0.0101	0.8492
1A4	Other_Kerosene	CO2	6295.06	6295.06	0.0100	0.8592
1A1	Petroleum_Coke	CO2	5827.42	5827.42	0.0093	0.8685
1A2	Gas/Diesel_Oil	CO2	5260.28	5260.28	0.0084	0.8769
1A4	Gas/Diesel_Oil	CO2	4515.99	4515.99	0.0072	0.8840
1A2	Other_Kerosene	CO2	4188.94	4188.94	0.0067	0.8907
1B2b	natural gas	CH4	3978.82	3978.82	0.0063	0.8970
2A1	non-fuel_combustion	CO2	3715.53	3715.53	0.0059	0.9029
1B2c	non-fuel_combustion	CO2	3266.47	3266.47	0.0052	0.9081
1A2	Refinery_Gas	CO2	3153.06	3153.06	0.0050	0.9132
1A1	Gas/Diesel_Oil	CO2	2831.07	2831.07	0.0045	0.9177
4B	non-fuel_combustion	N2O	2737.21	2737.21	0.0044	0.9220
1A1	Residual_Fuel_Oil	CO2	2567.34	2567.34	0.0041	0.9261
1A3	Gas/Diesel_Oil	CO2	2495.94	2495.94	0.0040	0.9301
1A1	Municipal_Solid_Waste	CO2	2344.01	2344.01	0.0037	0.9338
1A2	Liquefied_Petroleum_Gas	CO2	2065.27	2065.27	0.0033	0.9371
1B1	non-fuel_combustion	CH4	1982.53	1982.53	0.0032	0.9402
1A3d	Gas/Diesel_Oil	CO2	1927.34	1927.34	0.0031	0.9433
1A5	Jet_Gasoline	CO2	1791.57	1791.57	0.0028	0.9461
1A3	Jet_Gasoline	CO2	1775.44	1775.44	0.0028	0.9490
2B5	NEU	CO2	1709.26	1709.26	0.0027	0.9517
1A1	All Fuel (coal assumed)	N2O	1648.18	1648.18	0.0026	0.9543
6B	non-fuel_combustion	CH4	1634.44	1634.44	0.0026	0.9569
1A4	Other_Bituminous_Coal	CO2	1541.64	1541.64	0.0025	0.9594
1A2	Coke_Oven_Coke	CO2	1442.84	1442.84	0.0023	0.9617
6B	non-fuel_combustion	N2O	1181.53	1181.53	0.0019	0.9635
2A3	non-fuel_combustion	CO2	1178.37	1178.37	0.0019	0.9654
2A2	non-fuel_combustion	CO2	1177.78	1177.78	0.0019	0.9673
5G	non-fuel_combustion	CO2	-1168.32	1168.32	0.0019	0.9691
1B2c	flaring	CH4	1033.75	1033.75	0.0016	0.9708
2B	Natural_Gas	CO2	948.39	948.39	0.0015	0.9723
1A2	All Fuel (coal assumed)	N2O	910.01	910.01	0.0014	0.9737
1A4	Liquefied_Petroleum_Gas	CO2	894.99	894.99	0.0014	0.9752
2C	Blast_Furnace_Gas	CO2	807.73	807.73	0.0013	0.9765
1A2	Coke_Oven_Gas	CO2	762.29	762.29	0.0012	0.9777
1A5	Gas/Diesel_Oil	CO2	730.63	730.63	0.0012	0.9788
1A3b	Gas/Diesel_Oil	N2O	723.46	723.46	0.0012	0.9800
1A4	Patent_Fuel	CO2	717.14	717.14	0.0011	0.9811
1A1	Blast_Furnace_Gas	CO2	663.77	663.77	0.0011	0.9822
1A4	All Fuel (coal assumed)	N2O	631.44	631.44	0.0010	0.9832
1A4	Anthracite	CO2	609.31	609.31	0.0010	0.9841
5B	non-fuel_combustion	N2O	572.96	572.96	0.0009	0.9851
1A4	All Fuel	CH4	572.47	572.47	0.0009	0.9860
1A2	Residual_Fuel_Oil	CO2	543.57	543.57	0.0009	0.9868
1A1	Coke_Oven_Gas	CO2	534.43	534.43	0.0009	0.9877
2	All	SF6	507.95	507.95	0.0008	0.9885
1A2	Motor_Gasoline	CO2	506.51	506.51	0.0008	0.9893
1A4	Petroleum_Coke	CO2	460.47	460.47	0.0007	0.9900
2A7	non-fuel_combustion	CO2	429.47	429.47	0.0007	0.9907
1A4	Residual_Fuel_Oil	CO2	420.84	420.84	0.0007	0.9914

1A2	Lubricants	CO2	378.50	378.50	0.0006	0.9920
5D	non-fuel_combustion	CO2	359.24	359.24	0.0006	0.9926
1A4	Motor_Gasoline	CO2	333.96	333.96	0.0005	0.9931
1A3d	Residual_Fuel_Oil	CO2	315.89	315.89	0.0005	0.9936
1A3b	Liquefied_Petroleum_Gas	CO2	274.23	274.23	0.0004	0.9940
1B2b	non-fuel_combustion	CO2	248.55	248.55	0.0004	0.9944
1A2	Petroleum_Coke	CO2	230.11	230.11	0.0004	0.9948
1A1	All Fuel	CH4	214.31	214.31	0.0003	0.9951
2	All	PFC	206.09	206.09	0.0003	0.9955
1A2	Other_Oil:_Other	CO2	203.50	203.50	0.0003	0.9958
1B2a	oil	CH4	202.90	202.90	0.0003	0.9961
1B1	Other_Bituminous_Coal	CO2	200.18	200.18	0.0003	0.9964
1A3b	Motor_Gasoline	N2O	179.15	179.15	0.0003	0.9967
1A2	Scrap_Tyres	CO2	172.26	172.26	0.0003	0.9970
6C	Chemical_Waste	CO2	167.53	167.53	0.0003	0.9972
1A2	Municipal_Solid_Waste	CO2	163.86	163.86	0.0003	0.9975
1A1	Colliery_Methane	CO2	161.77	161.77	0.0003	0.9978
1A2	All Fuel	CH4	124.04	124.04	0.0002	0.9980
2C	non-fuel_combustion	CO2	116.03	116.03	0.0002	0.9981
1A3b	Lubricants	CO2	98.63	98.63	0.0002	0.9983
6C	Clinical	CO2	84.66	84.66	0.0001	0.9984
2B	non-fuel_combustion	CH4	82.32	82.32	0.0001	0.9986
5A	non-fuel_combustion	N2O	69.40	69.40	0.0001	0.9987
1A1	Liquefied_Petroleum_Gas	CO2	66.24	66.24	0.0001	0.9988
1A3	Gas/Diesel_Oil	N2O	62.41	62.41	0.0001	0.9989
2B2	Nitric Acid	N2O	60.76	60.76	0.0001	0.9990
1A3d	Lubricants	CO2	55.96	55.96	0.0001	0.9991
1A3	Aviation_Gasoline	CO2	53.60	53.60	0.0001	0.9992
1A4	Peat	CO2	50.29	50.29	0.0001	0.9992
6C	Municipal_Solid_Waste	N2O	45.73	45.73	0.0001	0.9993
1A3	Other_Bituminous_Coal	CO2	42.73	42.73	0.0001	0.9994
5C	non-fuel_combustion	CH4	41.32	41.32	0.0001	0.9994
1B2c	Flaring	N2O	39.39	39.39	0.0001	0.9995
1A3b	Motor_Gasoline	CH4	37.38	37.38	0.0001	0.9996
1B2a	non-fuel_combustion	CO2	35.43	35.43	0.0001	0.9996
1B1	Coke_Oven_Gas	CO2	26.80	26.80	0.0000	0.9997
5C	non-fuel_combustion	N2O	25.39	25.39	0.0000	0.9997
1A5	All Fuel (jet gasoline)	N2O	23.31	23.31	0.0000	0.9997
1A4	Coke_Oven_Coke	CO2	21.07	21.07	0.0000	0.9998
6C	Municipal_Solid_Waste	CO2	18.46	18.46	0.0000	0.9998
1A3	Jet Gasoline	N2O	17.47	17.47	0.0000	0.9998
1A3b	Gas/Diesel_Oil	CH4	16.82	16.82	0.0000	0.9999
5A	non-fuel_combustion	CH4	16.48	16.48	0.0000	0.9999
1A3d	Gas/Diesel_Oil	N2O	15.04	15.04	0.0000	0.9999
1A1	Other_Kerosene	CO2	7.51	7.51	0.0000	0.9999
5E	non-fuel_combustion	CH4	6.62	6.62	0.0000	0.9999
1A4	Lubricants	CO2	6.18	6.18	0.0000	0.9999
1A2	Colliery_Methane	CO2	4.20	4.20	0.0000	0.9999
1A3d	Gas/Diesel_Oil	CH4	3.96	3.96	0.0000	1.0000
2A7	Fletton bricks	CH4	3.34	3.34	0.0000	1.0000
2C	Iron_And_Steel	N2O	3.28	3.28	0.0000	1.0000
6C	MSW	CH4	3.27	3.27	0.0000	1.0000
1B1	Wood	CH4	3.21	3.21	0.0000	1.0000
1A3d	Residual_Fuel_Oil	N2O	2.43	2.43	0.0000	1.0000
1A3	Gas/Diesel_Oil	CH4	2.30	2.30	0.0000	1.0000
6C	non-fuel_combustion	CH4	2.11	2.11	0.0000	1.0000
1A3b	Liquefied_Petroleum_Gas	N2O	1.85	1.85	0.0000	1.0000
1A5	All Fuel	CH4	1.47	1.47	0.0000	1.0000
1B2b	Gas Production - Offshore Well Tes	N2O	0.92	0.92	0.0000	1.0000
1A3	Other_Bituminous_Coal	CH4	0.85	0.85	0.0000	1.0000
5E	non-fuel_combustion	N2O	0.67	0.67	0.0000	1.0000
1A3	Aviation Gasoline	N2O	0.53	0.53	0.0000	1.0000
5D	non-fuel_combustion	N2O	0.52	0.52	0.0000	1.0000
1A3	Jet Gasoline	CH4	0.48	0.48	0.0000	1.0000
2C	non-fuel_combustion	CH4	0.43	0.43	0.0000	1.0000
1A3b	Liquefied_Petroleum_Gas	CH4	0.42	0.42	0.0000	1.0000
1B2a	Oil Production - Well Testing	N2O	0.28	0.28	0.0000	1.0000
1A3	Aviation Gasoline	CH4	0.27	0.27	0.0000	1.0000
5B	non-fuel_combustion	CH4	0.22	0.22	0.0000	1.0000
1A3d	Residual_Fuel_Oil	CH4	0.10	0.10	0.0000	1.0000
1A3	Other_Bituminous_Coal	N2O	0.10	0.10	0.0000	1.0000
2C	Blast_Furnace_Gas	CH4	0.06	0.06	0.0000	1.0000
1B1	coke production	N2O	0.02	0.02	0.0000	1.0000
1B1	Coke_Oven_Gas	CH4	0.02	0.02	0.0000	1.0000

Table A 1.1.17 Key Source Category Analysis – further disaggregation – based on trend in emissions (from 1990 to latest reported year, including LULUCF). Note – indicative only.

IPCC Category Code	IPCC Category	Greenhouse Gas	Emissions (Gg CO2 eq) 1990	Emissions (Gg CO2 eq) 2012	Trend Assessment	% Contribution to Trend	Cumulative Total of Trend
1A3b	Gas/Diesel_Oil	CO2	32995.99	67125.68	0.051216423	13.84%	
1A1	Natural_Gas	CO2	9001.53	45224.54	0.046589956	12.59%	26.4%
1A4	Natural_Gas	CO2	70382.63	81875.79	0.034942642	9.44%	35.9%
1A1	Other_Bituminous_Coal	CO2	183432.78	120716.89	0.021247914	5.74%	41.6%
1A1	Residual_Fuel_Oil	CO2	26474.71	2567.34	0.021071824	5.69%	47.3%
1A3b	Motor_Gasoline	CO2	75568.67	40493.73	0.019949913	5.39%	52.7%
2B3	Adipic Acid	N2O	20737.34	0.00	0.018942632	5.12%	57.8%
6A	non-fuel_combustion	CH4	43035.56	18566.63	0.016808172	4.54%	62.3%
1B1	non-fuel_combustion	CH4	18302.07	1982.53	0.014315275	3.87%	66.2%
1A2	Residual_Fuel_Oil	CO2	13120.67	543.57	0.011326325	3.06%	69.3%
1A2	Other_Bituminous_Coal	CO2	19523.59	7791.66	0.008390375	2.27%	71.5%
1A4	Other_Bituminous_Coal	CO2	10497.53	1541.64	0.00772055	2.09%	73.6%
1A2	Natural_Gas	CO2	28638.02	27655.23	0.007358788	1.99%	75.6%
2	All	HFC	11384.05	14132.10	0.006729384	1.82%	77.4%
1A1	Petroleum_Coke	CO2	3328.16	5827.42	0.00402275	1.09%	78.5%
1A2	Gas/Diesel_Oil	CO2	11162.05	5260.28	0.003820543	1.03%	79.5%
1A2	Other_Kerosene	CO2	1439.40	4188.94	0.003762193	1.02%	80.6%
5A	non-fuel_combustion	CO2	-15901.55	-16723.02	0.003751812	1.01%	81.6%
1A2	Coke_Oven_Coke	CO2	5759.92	1442.84	0.003512688	0.95%	82.5%
2B2	Nitric Acid	N2O	3903.85	60.76	0.00349235	0.94%	83.5%
1A1	Refinery_Gas	CO2	8072.55	8764.47	0.003248685	0.88%	84.3%
1A4	Other_Kerosene	CO2	5047.16	6295.06	0.0030193	0.82%	85.2%
1B2b	natural gas	CH4	8540.82	3978.82	0.002979293	0.80%	86.0%
1A2	Blast_Furnace_Gas	CO2	16497.71	10137.35	0.002783374	0.75%	86.7%
1A1	Municipal_Solid_Waste	CO2	233.89	2344.01	0.002627303	0.71%	87.4%
1A4	Anthracite	CO2	3555.10	609.31	0.002508941	0.68%	88.1%
1A4	Residual_Fuel_Oil	CO2	3182.18	420.84	0.002396723	0.65%	88.7%
1A4	Gas/Diesel_Oil	CO2	8417.53	4515.99	0.00221563	0.60%	89.3%
2A1	non-fuel_combustion	CO2	7295.26	3715.53	0.00216065	0.58%	89.9%
1A4	Patent_Fuel	CO2	3261.70	717.14	0.002110245	0.57%	90.5%
4D	non-fuel_combustion	N2O	33708.74	27098.13	0.002051694	0.55%	91.1%
4A	non-fuel_combustion	CH4	19017.19	15652.02	0.001599004	0.43%	91.5%
1A1	Gas/Diesel_Oil	CO2	2029.94	2831.07	0.001577013	0.43%	91.9%
1A4	Coke_Oven_Coke	CO2	1736.09	21.07	0.001560307	0.42%	92.3%
1A3	Gas/Diesel_Oil	CO2	1679.92	2495.94	0.001490568	0.40%	92.7%
5G	non-fuel_combustion	CO2	59.16	-1168.32	0.001470052	0.40%	93.1%
5E	non-fuel_combustion	CO2	6893.22	6375.92	0.001431007	0.39%	93.5%
1A3d	Gas/Diesel_Oil	CO2	1024.67	1927.34	0.001399963	0.38%	93.9%
1A5	Jet_Gasoline	CO2	3888.14	1791.57	0.001380245	0.37%	94.3%
1A2	Refinery_Gas	CO2	3034.53	3153.06	0.00104963	0.28%	94.6%
2	All	PFC	1390.69	206.09	0.001020547	0.28%	94.8%
5B	non-fuel_combustion	CO2	15783.60	11172.67	0.00087626	0.24%	95.1%
2B5	NEU	CO2	1350.49	1709.26	0.000838026	0.23%	95.3%
1B2a	non-fuel_combustion	CO2	859.18	35.43	0.000741881	0.20%	95.5%
1A2	Liquefied_Petroleum_Gas	CO2	1945.97	2065.27	0.000725567	0.20%	95.7%
1A3	Jet_Gasoline	CO2	1577.65	1775.44	0.000710728	0.19%	95.9%
1A4	All Fuel	CH4	1537.07	572.47	0.000710202	0.19%	96.1%
2C	Blast_Furnace_Gas	CO2	1836.67	807.73	0.00069874	0.19%	96.3%
1A3d	Residual_Fuel_Oil	CO2	1143.35	315.89	0.000661545	0.18%	96.4%
1A2	Coke_Oven_Gas	CO2	1683.39	762.29	0.000613803	0.17%	96.6%
1A3b	Gas/Diesel_Oil	N2O	290.88	723.46	0.000611127	0.17%	96.8%
1B2b	non-fuel_combustion	CO2	998.73	248.55	0.000611052	0.17%	96.9%
1A3b	Motor_Gasoline	N2O	897.45	179.15	0.000602644	0.16%	97.1%
6C	Municipal_Solid_Waste	CO2	672.92	18.46	0.000592309	0.16%	97.3%
1A4	Petroleum_Coke	CO2	76.75	460.47	0.000487995	0.13%	97.4%
6B	non-fuel_combustion	CH4	1685.62	1634.44	0.000441213	0.12%	97.5%
1A3b	Motor_Gasoline	CH4	529.76	37.38	0.000438615	0.12%	97.6%
1B1	Other_Bituminous_Coal	CO2	720.24	200.18	0.000415289	0.11%	97.7%
1A5	Gas/Diesel_Oil	CO2	1396.68	730.63	0.000390269	0.11%	97.8%
1B2c	non-fuel_combustion	CO2	3920.01	3266.47	0.00037823	0.10%	97.9%
1A4	Peat	CO2	475.59	50.29	0.000373481	0.10%	98.0%
6B	non-fuel_combustion	N2O	1165.05	1181.53	0.000367799	0.10%	98.1%
2A3	non-fuel_combustion	CO2	1190.62	1178.37	0.000340613	0.09%	98.2%
1A3b	Liquefied_Petroleum_Gas	CO2	0.00	274.23	0.000332369	0.09%	98.3%
1A2	All Fuel (coal assumed)	N2O	1567.51	910.01	0.000328917	0.09%	98.4%
2C	non-fuel_combustion	CO2	504.04	116.03	0.000319787	0.09%	98.5%
1A1	Orimulsion	CO2	339.58	0.00	0.00031019	0.08%	98.6%
2	All	SF6	987.40	507.95	0.000286312	0.08%	98.7%
1A1	Blast_Furnace_Gas	CO2	1180.35	663.77	0.000273708	0.07%	98.7%
4F	non-fuel_combustion	CH4	265.91	0.00	0.000242899	0.07%	98.8%
1A2	Scrap_Tyres	CO2	1.07	172.26	0.000207803	0.06%	98.9%
1A2	Municipal_Solid_Waste	CO2	0.00	163.86	0.000198603	0.05%	98.9%

1A2	Lubricants	CO2	699.11	378.50	0.000179863	0.05%	99.0%
4B	non-fuel_combustion	N2O	3435.87	2737.21	0.000179006	0.05%	99.0%
4B	non-fuel_combustion	CH4	9002.22	6638.46	0.000177266	0.05%	99.1%
1A2	Other_Oil:_Other	CO2	84.04	203.50	0.000169874	0.05%	99.1%
6C	Clinical	CO2	292.63	84.66	0.000164698	0.04%	99.2%
1A2	Patent_Fuel	CO2	179.83	0.00	0.000164262	0.04%	99.2%
1A2	Motor_Gasoline	CO2	493.16	506.51	0.000163411	0.04%	99.2%
2B	Natural_Gas	CO2	1431.17	948.39	0.00015785	0.04%	99.3%
1A4	Motor_Gasoline	CO2	275.65	333.96	0.000152961	0.04%	99.3%
5C	non-fuel_combustion	CO2	-6300.72	-7728.45	0.000150663	0.04%	99.4%
1A1	Coke_Oven_Gas	CO2	873.59	534.43	0.000150249	0.04%	99.4%
1A4	Liquefied_Petroleum_Gas	CO2	1046.61	894.99	0.000128695	0.03%	99.4%
1B2a	oil	CH4	409.65	202.90	0.000128273	0.03%	99.5%
1A1	Liquefied_Petroleum_Gas	CO2	227.93	66.24	0.000127922	0.03%	99.5%
1A1	All Fuel (coal assumed)	N2O	2052.28	1648.18	0.000122939	0.03%	99.5%
1A4	All Fuel (coal assumed)	N2O	971.18	631.44	0.000121823	0.03%	99.6%
1A3b	Lubricants	CO2	262.77	98.63	0.000120484	0.03%	99.6%
6C	MSW	CH4	132.34	3.27	0.000116919	0.03%	99.6%
1A1	All Fuel	CH4	167.87	214.31	0.000106407	0.03%	99.7%
6C	Chemical_Waste	CO2	326.81	167.53	9.54778E-05	0.03%	99.7%
2A2	non-fuel_combustion	CO2	1462.36	1177.78	9.16779E-05	0.02%	99.7%
1A2	Colliery_Methane	CO2	105.48	4.20	9.1266E-05	0.02%	99.7%
1B1	Coke_Oven_Gas	CO2	134.78	26.80	9.06363E-05	0.02%	99.8%
1A3b	Gas/Diesel_Oil	CH4	107.28	16.82	7.76051E-05	0.02%	99.8%
1A1	Naphtha	CO2	81.41	0.00	7.43686E-05	0.02%	99.8%
4F	non-fuel_combustion	N2O	79.31	0.00	7.24476E-05	0.02%	99.8%
1A2	Petroleum_Coke	CO2	369.36	230.11	5.85065E-05	0.02%	99.8%
1A1	Other_Oil:_Other	CO2	61.60	0.00	5.62688E-05	0.02%	99.9%
2B	non-fuel_combustion	CH4	169.43	82.32	5.49839E-05	0.01%	99.9%
1A3	Other_Bituminous_Coal	CO2	0.00	42.73	5.17875E-05	0.01%	99.9%
1A3	Gas/Diesel_Oil	N2O	32.63	62.41	4.58398E-05	0.01%	99.9%
5C	non-fuel_combustion	CH4	12.39	41.32	3.87574E-05	0.01%	99.9%
5A	non-fuel_combustion	N2O	54.16	69.40	3.46417E-05	0.01%	99.9%
1B2c	flaring	CH4	1408.65	1033.75	3.38263E-05	0.01%	99.9%
1A1	Colliery_Methane	CO2	177.93	161.77	3.35268E-05	0.01%	99.9%
1A3d	Lubricants	CO2	107.51	55.96	3.03804E-05	0.01%	99.9%
5C	non-fuel_combustion	N2O	14.39	25.39	1.76285E-05	0.00%	100.0%
2A7	Fletton bricks	CH4	23.60	3.34	1.75112E-05	0.00%	100.0%
5A	non-fuel_combustion	CH4	3.12	16.48	1.71136E-05	0.00%	100.0%
1A5	All Fuel (jet gasoline)	N2O	49.14	23.31	1.66303E-05	0.00%	100.0%
1B2c	Flaring	N2O	38.33	39.39	1.27325E-05	0.00%	100.0%
2A7	non-fuel_combustion	CO2	556.43	429.47	1.22472E-05	0.00%	100.0%
1A2	All Fuel	CH4	152.57	124.04	1.09729E-05	0.00%	100.0%
1A3d	Gas/Diesel_Oil	N2O	7.99	15.04	1.09327E-05	0.00%	100.0%
1A1	Other_Kerosene	CO2	0.00	7.51	9.10717E-06	0.00%	100.0%
5B	non-fuel_combustion	N2O	769.94	572.96	8.87731E-06	0.00%	100.0%
1A4	Lubricants	CO2	16.62	6.18	7.69332E-06	0.00%	100.0%
1A3	Jet Gasoline	N2O	15.53	17.47	6.99521E-06	0.00%	100.0%
1A3	Aviation_Gasoline	CO2	77.18	53.60	5.53412E-06	0.00%	100.0%
1A3d	Residual_Fuel_Oil	N2O	8.92	2.43	5.20162E-06	0.00%	100.0%
5D	non-fuel_combustion	CO2	481.73	359.24	4.62862E-06	0.00%	100.0%
1B1	Wood	CH4	0.09	3.21	3.81362E-06	0.00%	100.0%
5E	non-fuel_combustion	CH4	4.95	6.62	3.50479E-06	0.00%	100.0%
6C	Municipal_Solid_Waste	N2O	56.89	45.73	3.46073E-06	0.00%	100.0%
1A3d	Gas/Diesel_Oil	CH4	1.49	3.96	3.44428E-06	0.00%	100.0%
5D	non-fuel_combustion	N2O	3.98	0.52	3.00686E-06	0.00%	100.0%
2C	Iron_And_Steel	N2O	7.25	3.28	2.64789E-06	0.00%	100.0%
1A3b	Liquefied_Petroleum_Gas	N2O	0.00	1.85	2.24615E-06	0.00%	100.0%
1A3	Jet Gasoline	CH4	2.68	0.48	1.8669E-06	0.00%	100.0%
1B2a	Oil Production - Well Testing	N2O	2.07	0.28	1.55981E-06	0.00%	100.0%
1A5	All Fuel	CH4	3.14	1.47	1.07846E-06	0.00%	100.0%
1A3	Other_Bituminous_Coal	CH4	0.00	0.85	1.0251E-06	0.00%	100.0%
1B2b	Gas Production - Offshore Well T	N2O	1.99	0.92	7.10116E-07	0.00%	100.0%
1A3	Gas/Diesel_Oil	CH4	2.31	2.30	6.79546E-07	0.00%	100.0%
6C	non-fuel_combustion	CH4	2.10	2.11	6.46946E-07	0.00%	100.0%
1A3b	Liquefied_Petroleum_Gas	CH4	0.00	0.42	5.12592E-07	0.00%	100.0%
1A3	Aviation Gasoline	CH4	0.89	0.27	4.93388E-07	0.00%	100.0%
5E	non-fuel_combustion	N2O	0.50	0.67	3.55694E-07	0.00%	100.0%
2C	non-fuel_combustion	CH4	0.95	0.43	3.48602E-07	0.00%	100.0%
1A3d	Residual_Fuel_Oil	CH4	0.38	0.10	2.2023E-07	0.00%	100.0%
5B	non-fuel_combustion	CH4	0.09	0.22	1.76427E-07	0.00%	100.0%
1A3	Other_Bituminous_Coal	N2O	0.00	0.10	1.21059E-07	0.00%	100.0%
1B1	coke production	N2O	0.12	0.02	7.69814E-08	0.00%	100.0%
1A3	Aviation Gasoline	N2O	0.76	0.53	5.3248E-08	0.00%	100.0%
1B1	Coke_Oven_Gas	CH4	0.08	0.02	5.21487E-08	0.00%	100.0%
2C	Blast_Furnace_Gas	CH4	0.14	0.06	5.07226E-08	0.00%	100.0%
1A1	Coke_Oven_Coke	CO2	0.00	0.00	0	0.00%	100.0%

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-2014-2012-v1.2.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	Yes	Associated UNFCCC category (5A2) is key	The associated UNFCCC inventory category is a key category and the Afforestation and Reforestation category contribution is greater than the smallest UNFCCC key category.

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 categories (5C and 5E) are key	The Deforestation category contribution is smaller than the smallest UNFCCC key category but the associated UNFCCC categories (5C Grassland and 5E Settlements) are key categories. Therefore this is a key category (IPCC good practice guidance for LULUCF section 5.4.4).
Forest Management	CO_2	Conversion to forest land	Yes	Associated UNFCCC category (5A2) is key	The associated UNFCCC inventory category is a key category and the Forest Management category contribution is greater than the smallest UNFCCC key category.

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

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

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

A3 ANNEX 3: Other Detailed Methodological Descriptions for individual source or sink categories, including for KP-LULUCF activities.

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

This Annex provides background information on the fuels used in the UK GHG inventory, mapping between IPCC and NAEI source categories 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, 2013), 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 Peat	Anthracite Coal[2] Coal Slurry[3] Coke Solid Smokeless Fuel (SSF) Coke Oven Gas Blast Furnace Gas Peat
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 Liquid Biofuels Biogas

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 in the basic combustion module for the industrial, commercial, domestic, and transport sectors are shown in **Table A 3.2.2** to **Table A 3.2.5**. 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 EMEP/EEA guidance documents, 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, (2013). 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 2012

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]	1.264[g]
Burning Oil	Domestic	kg/t	859[a]	0.462[g]	0.0277[g]	3.23[l]	1.85[l]	0.047[f]	0.672[z]
Burning Oil	Other Industry	kg/t	859[a]	0.0924[g]	0.0277[g]	3.33[l]	0.19[l]	0.028[e]	0.672[z]
Burning Oil	Public Service, Railways (Stationary)	kg/t	859[a]	0.462[g]	0.0277[g]	0	0	0.047[f]	0.672[z]
Burning Oil	Miscellaneous	kg/t	859[a]	0.462[g]	0.0277[g]	0	0	0.047[f]	0.672[z]
Gas Oil	Cement	kg/t	870[bc]	0.0910[g]	0.0273[g]	NE	NE	NE	NE
Gas Oil	Chemicals (combustion)	kg/t	870[a]	0.0910[g]	0.0273[g]	14.41[l]	3.99[l]	0.028[f]	0.61[z]
Gas Oil	Domestic	kg/t	870[a]	0.455[g]	0.0273[g]	3.19[l]	1.82[l]	0.047[f]	0.61[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, 20.00[av]
Gas Oil	Iron & Steel	kg/t	870[a]	0.091[g]	0.027[g]	9.79[l]	3.11[l]	0.028[f]	0.61[z]
Gas Oil	Refineries	kg/t	870[a]	0.136[g]	0.027[g]	23.24[k]	0.24[i]	0.028[f]	0.61[z]
Gas Oil	Other Industry	kg/t	870[a]	0.091[g]	0.027[g]	14.41[l]	3.99[l]	0.028[f]	0.61[z]
Gas Oil	Public Service	kg/t	870[a]	0.455[g]	0.027[g]	2.44[l]	0.375[l]	0.047[f]	0.61[z]
Gas Oil	Pulp, Paper and Print (combustion)	kg/t	870[a]	0.091[g]	0.027[g]	14.41[l]	3.99[l]	0.028[f]	0.61[z]
Gas Oil	Miscellaneous	kg/t	870[a]	0.455[g]	0.027[g]	2.69[l]	0.375[l]	0.047[f]	0.61[z]
Fuel Oil	Agriculture	kg/t	879[a]	0.433[g]	0.026[g]	7.69[l]	0.307[l]	0.138[f]	14.16[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]	11.14[l]	2.25[l]	0.034[f]	14.16[z]
Fuel Oil	Public Service	kg/t	879[a]	0.433[g]	0.026[g]	7.07[l]	0.664[l]	0.138[f]	14.16[z]
Fuel Oil	Pulp, Paper and Print (combustion)	kg/t	879[a]	0.087[g]	0.026[g]	11.14[l]	2.25[l]	0.034[f]	14.16[z]
Fuel Oil	Miscellaneous	kg/t	879[a]	0.433[g]	0.026[g]	7.18[l]	0.535[l]	0.138[f]	14.16[z]
Fuel Oil	Coastal Shipping, International Marine	kg/t	879[a]	0.05[ap]	0.08[ap]	70.57, 77.71[av]	7.4[ap]	3.52, 2.92[av]	17.6, 32.6[av]

Fuel	Source	Units	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Fuel Oil	Domestic	kg/t	879[a]	0.433[g]	0.026[g]	0[l]	0[l]	0.138[f]	14.16[z]
Fuel Oil	Iron & Steel	kg/t	879[a]	0.087[g]	0.026[g]	6.98[l]	0.683[l]	0.034[f]	14.16[z]
Fuel Oil	Railways (Stationary)	kg/t	879[a]	0.433[g]	0.026[g]	7.01[l]	0.664[l]	0.138[f]	14.16[z]
Fuel Oil	Other Industry	kg/t	879[a]	0.087[g]	0.026[g]	11.14[l]	2.25[l]	0.034[f]	14.16[z]
Fuel Oil	Refineries (Combustion)	kg/t	888[at]	0.13[g]	0.026[g]	2.43[ag]	0.81[ag]	0.034[f]	44.02[ag]
Lubricants	Other Industry	kg/t	865[x]	0.091[e]	0.027[e]	23.24[k]	0.253[f]	0.133[f]	11.41[x]
Petrol	Refineries	kg/t	855[a]	0.138[an]	0.028[g]	23.70[k]	0.24[e]	0.028[e]	0.011[z]
Naphtha	Refineries (Combustion)	kg/t	854[a]	0.129[g]	0.026[g]	23.70[k]	0.24[i]	0.028[f]	0.2[ax]
Waste oils	Cement (Combustion)	kg/t	C	C	C	C	C	C	C
Waste solvent	Cement (Combustion	kg/t	C	C	C	C	C	C	C
Petroleum Coke	Domestic	kg/t	837[a]	NE	NE	3.95[ap]	2.25[ap]	4.9[am]	142.4[as]
Petroleum Coke	Refineries	kg/t	930[a]	0.107[g]	0.281[w]	4.99[ag]	0.969[ag]	0.082[k]	21.09[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	16226[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	16226[a]	0.892[f]	0.100[g]	62.18[f]	15.11[f]	3.78[f]	0
LPG	Power stations	g/GJ Gross	16226[a]	0.892[f]	0.100[g]	62.18[f]	15.11[f]	3.78[f]	0
LPG	Refineries – combustion	g/GJ Gross	16226[a]	0.892[f]	0.100[g]	62.18[f]	15.11[f]	3.78[f]	0
LPG	Upstream oil and gas production - combustion at gas separation plant	g/GJ Gross	16226[a]	22.42[aw]	4.40[aw]	171.0[aw]	58.52[aw]	1.69[aw]	3.82[aw]
OPG	Gas production	g/GJ Gross	13937[at]	1.00[g]	NE	74.00[k]	2.37[i]	3.78[f]	0

Fuel	Source	Units	C^{aj}	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
OPG	Refineries (Combustion)	g/GJ Gross	13937[at]	1.000[g]	NE	59.93[ag]	14.82[ag]	3.78[f]	0
OPG	Other Industry	g/GJ Gross	13937[at]	5.000[g]	0.100[g]	74.00[k]	2.37[i]	3.78[f]	0
OPG	Upstream oil and gas production - combustion at gas separation plant	g/GJ Gross	16800[g]	22.42[aw]	4.40[aw]	171.0[aw]	58.52[aw]	1.69[aw]	3.82[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 2012

Fuel	Source	Units	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Coal	Agriculture	kg/t	673.9[ao]	0.011[o]	0.146[w]	4.75[l]	8.25[l]	0.05[o]	14.98[aa]
Coal	Collieries	kg/t	668.6[ao]	0.011[o]	0.148[w]	4.75[l]	8.25[l]	0.05[o]	15.49[aa]
Coal	Domestic	kg/t	676.2[ao]	15.7[o]	0.122[w]	2.34[l]	160.0[l]	14.00	19.06[aa]
Coal	Iron and Steel (Combustion)	kg/t	693.8[ao]	0.011[o]	0.237[w]	1.23[l]	0.534[l]	0.05[o]	14.98[aa]
Coal	Lime Production (Combustion)	kg/t	725.6[at]	0.011[o]	0.214[w]	170.9[v]	10.67[v]	0.05[o]	14.98[aa]
Coal	Miscellaneous	kg/t	631.9[ao]	0.011[o]	0.147[w]	5.55[l]	8.63[l]	0.05[o]	14.98[aa]
Coal	Public Service	kg/t	631.9[ao]	0.011[o]	0.147[w]	4.65[l]	7.06[l]	0.05[o]	14.98[aa]
Coal	Other Industry	kg/t	636.9[ao]	0.011[o]	0.214[w]	4.22[l]	1.93[l]	0.05[o]	14.98[aa]
Coal	Railways	kg/t	723.4[ao]	0.011[o]	0.147[m]	4.65[l]	7.06[l]	0.05[o]	14.98[aa]
Coal	Autogenerators	kg/t	594.9[ao]	0.02[o]	0.066[w]	5.21[l]	3.91[l]	0.03[o]	14.98[aa]
Coal	Cement production (combustion)	kg/t	C	C	C	C	C	C	C
Anthracite	Domestic	kg/t	835.8[ao]	2[o]	0.142[w]	3.47[k]	173.5[k]	1.7[o]	15.57[aa]
Coke	Agriculture	kg/t	820.9[r]	0.011[p]	0.150[w]	0	0	0.05[p]	19[ab]
Coke	SSF Production	kg/t	820.9[r]	0.011[p]	0.230[w]	NE	NE	0.05[p]	19[ab]
Coke	Domestic	kg/t	820.9[r]	5.8[o]	0.117[w]	3.04[l]	118.6[l]	4.9[o]	15.57[aa]
Coke	I&S[ak] (Sinter Plant)	kg/t	820.9[r]	1.33[ae]	0.230[w]	13.37[ae]	316.4[ae]	0.389[ae]	17.77[ae]
Coke	I&S[ak] (Combustion)	kg/t	820.9[r]	0.011[p]	0.230[w]	0.867[l]	226.2[l]	0.05[p]	19[ab]
Coke	Other Industry	kg/t	820.9[r]	0.011[p]	0.230[w]	0	0	0.05[p]	19[ab]
Coke	Railways	kg/t	820.9[r]	0.011[p]	0.150[w]	0	0	0.05[p]	19[ab]
Coke	Miscellaneous; Public Service	kg/t	820.9[r]	0.011[p]	0.150[w]	0	0	0.05[p]	19[ab]
Peat	Domestic	kg/t	370.0[g]	4.17[g]	0.056[g]	0.695[g]	69.5[g]	7.07[g]	0.108[f]

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]	5.64[k]	30.4[k]	0.05[p]	19[ab]
SSF	Domestic	kg/t	774.2[n]	5.8[o]	0.120[w]	3.26[k]	173.5[k]	4.9[o]	16[ab]
SSF	Other Industry	kg/t	766.3[n]	0.011[o]	0.237[w]	5.64[k]	30.4[k]	0.05[p]	19[ab]
Blast Furnace Gas	Coke Production	g/GJ Gross	74862[r]	1.00[k]	0.100[k]	23.2[k]	29.00[k]	23.00[k]	0
Blast Furnace Gas	I&S[ak] (Combustion), I&S[ak] (Flaring)	g/GJ Gross	74862[r]	1.00[k]	0.100[k]	23.2[k]	29.00[k]	23.00[k]	0
Blast Furnace Gas	Blast Furnaces	g/GJ Gross	74862[r]	1.00[k]	0.100[k]	23.2[k]	29.00[k]	23.00[k]	0
Coke Oven Gas	Other Sources	g/GJ Gross	10590[r]	1.11[k]	0.111[k]	74.00[k]	29.00[k]	23.00[k]	239.7[v]
Coke Oven Gas	I&S[ak] Blast Furnaces	g/GJ Gross	10590[r]	1.11[k]	0.111[k]	74.00[k]	29.00[k]	23.00[k]	239.7[v]
Coke Oven Gas	Coke Production	g/GJ Gross	10590[r]	1.11[k]	0.111[k]	74.00[k]	29.00[k]	23.00[k]	239.7[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 2012 (g/GJ gross)

Fuel	Source	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Natural Gas	Agriculture	13924[ao]	5.00[g]	0.100[g]	39.23[l]	2.13[l]	2.23[f]	0
Natural Gas	Miscellaneous	13924[ao]	5.00[g]	0.100[g]	50.56[l]	9.94[l]	2.23[f]	0
Natural Gas	Public Service	13924[ao]	5.00[g]	0.100[g]	53.50[l]	11.18[l]	2.23[f]	0
Natural Gas	Coke Production, SSF Production	13924[ao]	1.00[g]	0.100[g]	74.00[k]	2.37[l]	2.23[f]	0
Natural Gas	Refineries	13667[at]	1.00[g]	0.100[g]	74.00[k]	2.37[l]	2.23[f]	0
Natural Gas	Blast Furnaces	13924[ao]	5.00[g]	0.100[g]	23.23[v]	2.37[l]	2.23[f]	0
Natural Gas	Domestic	13924[ao]	5.00[g]	0.100[g]	21.57[l]	30.80[l]	2.23[f]	0
Natural Gas	Gas Production	13924[ao]	1.00[g]	0.100[g]	83.19[aw]	17.36[l]	2.23[f]	0
Natural Gas	Oil Production	15189[aw]	22.42[aw]	4.40[aw]	171.0[aw]	58.52[aw]	1.69[aw]	3.82[aw]
Natural Gas	I&S[ak]	13924[ao]	5.00[g]	0.100[g]	190.6[l]	180.1[l]	2.23[f]	0
Natural Gas	Railways	13924[ao]	5.00[g]	0.100[g]	74.00[k]	2.37[i]	2.23[f]	0
Natural Gas	Other Industry	13924[ao]	5.00[g]	0.100[g]	105.5[l]	94.60[l]	2.23[f]	0
Natural Gas	Nuclear Fuel Production, Collieries	13924[ao]	1.00[g]	0.100[g]	105.5[l]	94.60[l]	2.23[f]	0
Natural Gas	Autogenerators	13924[ao]	5.00[g]	0.100[g]	105.5[l]	17.17[l]	2.23[f]	0
Natural Gas	Ammonia (Combustion)	13924[ao]	5.00[g]	0.100[g]	111.9[d]	NE	2.23[f]	0
Colliery Methane	Other Industry, collieries	17668[at]	5.00[g]	0.100[g]	74.00[k]	2.37[i]	2.23[f]	0
Colliery Methane	Coke Production, Gas Production	17668[at]	5.00[g]	0.100[g]	74.00[k]	2.37[i]	2.23[f]	0

Table A 3.2.5 Emission Factors for the Combustion of other fuels and biomass 2012

Fuel	Source	Units	C[aj]	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
MSW	Miscellaneous	Kg/tonne	92.12[ah]	2.85[g]	0.038[g]	0.904[v]	0.090[v]	0.007[v]	0.022[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	439.8[g]	4.74[g]	0.063[g]	1.58[g]	79[g]	9.48[g]	NE
Wood	Domestic	Kg/tonne	386.9[g]	4.17[g]	0.056[g]	0.695[k]	69.5[k]	7.07[k]	0.108[f]
Wood	Other industry	Kg/tonne	381.4[g]	0.411[g]	0.055[g]	1.25[k]	68.5[k]	0.388[k]	0.128[f]
Sewage Gas	Public Services	g/GJ Gross	27404[g]	5.00[g]	0.100[g]	239.8[bb]	7.10[f]	2.42[f]	NE
Landfill Gas	Miscellaneous	g/GJ Gross	27404[g]	5.00[g]	0.100[g]	239.8[ba]	122.4[f]	3.62[f]	27.56

Footnotes to **Table A 3.2.2** to **Table A 3.2.5**:

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	Data supplied by Plant Operators at BP, Kemira Growhow, Kemira and Terra Nitrogen (2006-2013)
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-EEA Guidebook (2013)
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, 2013)
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 (2013) and Tata Steel (2013)
af	UKPIA (2004)
ag	Ricardo-AEA estimate based on data from Environment Agency (2013), UKPIA, DUKES, and other sources
ah	Carbon EF based on carbon content of waste
aj	Emission factor as mass carbon per unit fuel consumption, carbon emissions from biomass combustion reported as a memo item
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, 2007)

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 2013, DECC Offshore Inspectorate
ax	UKPIA, Pers. Comm., 2000
ay	Loader *et al* (2008)
az	As for domestic wood
ba	Amec, (2011)
bb	As for landfill gas
bc	Mineral Products Association (2013)
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 2012

Source	Unit	CO_2 [1,2]	CH_4	N_2O	NO_X	CO	NMVOC	SO_2
Coal	kt/Mt	611.5[s]	0.02[e]	0.063[l]	4.28[n]	0.787[n]	0.023[n]	4.08[n]
Petroleum Coke	kt/Mt	866.9[s]	0.107[q]	0.087[l]	2.98[n]	6.59[n]	0.020[n]	12.64[n]
Burning Oil	kt/Mt	859[a]	0.139[j]	0.028[j]	2.98[n]	6.59[n]	0.020[n]	12.64[n]
Fuel Oil	kt/Mt	874.7[s]	0.13[h]	0.026[h]	12.4[n]	1.62[n]	0.052[n]	9.71[n]
Gas Oil	kt/Mt	870[a]	0.136[h]	0.027[h]	15.66[n]	1.27[n]	0.274[n]	5.38[n]
Natural gas	g/GJ Gross	13848[s]	1.00[h]	0.100[h]	29.94[n]	17.14[n]	0.904[n]	0.119[n]
MSW	kt/Mt	92.1[t]	0.285[h]	0.038[h]	0.904[n]	0.090[n]	0.007[n]	0.022[n]
Poultry Litter	kt/Mt	266.4[o]	0.324[h]	0.043[h]	0.830[n]	0.304[n]	0.041[n]	0.122[n]
Sewage Gas	g/GJ Gross	27404[h]	1.00[h]	0.100[h]	239.8[u]	7.10[k]	2.42[k]	NE
Waste Oils	kt/Mt	864.8[b]	0.13[h]	0.026[h]	12.4[n]	1.62[n]	0.052[n]	9.71[n]
Landfill gas	g/GJ Gross	27404[h]	1.00[h]	0.100[h]	239.8[u]	122.4[k]	3.62[k]	27.56[v]
Wood	kt/Mt	309.0[h]	0.279[h]	0.037[h]	1.18[n]	8.04[n]	0.115[n]	0.121[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-EEA Guidebook (2013)
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, 20132013), Scottish Pollutant Release inventory (SEPA, 20132013), Northern Ireland Pollution Inventory (NEA, 2013, 2013) and direct communications with plant operators (Pers. Comms., 20132013)
o Environment Agency (20132013)
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)
V Gregory (2002)
NE Not Estimated

A3.2.2 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, 2013). 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, but where alternative data sources provide supplementary data to inform energy use and emission estimates.
The reasons for any deviations from use of DUKES data in the inventory are discussed within the source category methodological descriptions in Section 3 of the main report. The fuel reconciliation tables below show how the deviations are applied and how the energy data for the major fuels in the UK inventory are reconciled against the energy demand data from DUKES. The tables show:

(i) where fuels are re-allocated between sectors, but the overall annual fuel consumption across all UK sectors is kept consistent with the data in DUKES, and
(ii) where deviations are made to DUKES figures for total UK consumption of a given fuel, and in which source categories these deviations are made.

The inventory agency presents data below for the 2012 fuel allocations for coal, natural gas, fuel oil, gas oil (including DERV) and petroleum gases (LPG, OPG). Together these fuels constitute around 83% of the UK inventory 1A sector emissions total in 2012.

A3.2.2.1 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 2012.

Table A 3.2.7 Fuel reconciliation - coal use in 2012 (Mtonnes)

DUKES Category	DUKES	GHGI	Difference	GHGI category	CRF	Comment
Major power producers	**53.837**	**53.837**	**0.000**	Power stations	1A1a	
Blast furnaces	**0.987**	**0.987**	**0.000**	Blast furnaces	2C1	
Coal extraction	**0.004**	**0.004**	**0.000**	Collieries - combustion	1A1c	
		0.570		Autogenerators	1A2f	
		0.499		Autogenerators - exported to grid	1A2f	
Autogenerators	**1.069**	**1.069**	**0.000**			
Patent fuel manufacture etc.	**0.332**	**0.332**	**0.000**	Solid smokeless fuel production	1B1b	
Coke manufacture	5.079	4.831		Coke Production	1B1b	Operator data for 2012 updates data in DUKES
Iron and steel	0.051	0.051		Iron & steel - combustion plant	1A2a	
Non-ferrous metals	0.038	0.038		Non-Ferrous Metal	1A2b	
Chemicals	0.474	0.474		Chemicals	1A2c	
Paper, printing etc	0.126	0.126		Pulp, Paper and Print	1A2d	
Food, beverages etc	0.068	0.068		Food & drink, tobacco	1A2e	
Other industry	1.306					
		1.017		Other industrial combustion	1A2f	Includes small re-

DUKES Category	DUKES	GHGI	Difference	GHGI category	CRF	Comment
						allocation to re-balance the change to coke manufacture data
		0.498		Cement production - combustion	1A2f	Operator data
		0.038		Lime production - non decarbonising	1A2f	EU ETS
Industry + Coke total	**7.141**	**7.141**	**0.000**			
Rail	**0.016**	**0.016**	**0.000**	Rail	1A3c	
Domestic - anthracite	**0.199**	**0.199**	**0.000**	Domestic combustion - anthracite	1A4b	
		0.472		Domestic combustion - UK	1A4b	
		0.003		Domestic combustion - crown dependencies	1A4b	
Domestic - coal	**0.475**	**0.475**	**0.000**			
Agriculture	**0.001**	**0.001**	**0.000**	Agriculture - stationary combustion	1A4c	
Commercial	0.007					
Miscellaneous	0.006					
	0.013	**0.013**	**0.000**	Miscellaneous combustion	1A4a	
Public administration	**0.142**	**0.142**	**0.000**	Public sector combustion	1A4a	
TOTAL	**64.206**	**64.206**	**0.000**			

Notes: Sequences of shaded rows indicate categories which are grouped for purposes of data reconciliation, and should be considered together.

A3.2.2.2 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 2012 (Mtherms)

DUKES Category	DUKES	GHGI	Difference	GHGI Category	CRF	Comment
Major power producers	**6224**	**6224**	**0**	Power stations	1A1a	
		566		Autogenerators	1A2f	
		495		Autogenerators - exported to grid	1A2f	
		0		Railways - stationary combustion	1A4a	
Autogenerators	**1062**	**1062**	**0**			
Coal extraction	**1**	**1**	**0**	Collieries - combustion	1A1c	
		1177		Upstream oil production	1A1c	
		476		Upstream gas production	1A1c	
Oil and gas extraction	**1654**	**1654**	**0**			
Petroleum refineries	**203**	**203**	**0**	Refineries - combustion	1A1b	
Blast furnaces	**9**	**9**	**0**	Blast furnaces	1A2a	
		159		Gas production	1A1c	EU ETS
		0		Nuclear fuel production	1A1c	

DUKES Category	DUKES	GHGI	Difference	GHGI Category	CRF	Comment
Other energy industries	122					
Non-ferrous metals	103	103		Non-Ferrous Metal	1A2b	
Chemicals	909	909		Chemicals	1A2c	
Paper, printing, etc	473	473		Pulp, Paper and Print	1A2d	
Food, beverages, etc	777	777		Food & drink, tobacco	1A2e	
		116		Ammonia production	1A2c	Operator's data
Other industry	1723					
		1457		Other industrial combustion	1A2f	
		47		Lime production	1A2f	EU ETS
		2		Cement production	1A2f	Operator's data
		176		Ammonia production – feedstock use of gas	2B2	
Non-energy use	203	90		Non-energy use (stored carbon)		
Other energy, industry except iron and steel, plus non-energy use	**4309**	**4309**	**0**			
Iron and steel	**179**	**179**	**0**	Iron and steel - combustion plant	1A2a	
Domestic	**11570**	**11570**	**0**	Domestic combustion	1A4b	
Public administration	**1782**	**1782**	**0**	Public sector combustion	1A4a	
Commercial	1408					
Miscellaneous	377					
	1785	**1785**	**0**	Miscellaneous combustion	1A4a	
Agriculture	**52**	**52**	**0**	Agriculture - stationary	1A4c	
Autogenerators (colliery methane)	21					
Coal extraction (colliery methane)	3					
	24	**24**	**0**	Collieries – combustion (colliery methane)	1A1c	
Total	**28854**	**28855**	**-1**			(rounding)

Notes: Sequences of shaded rows indicate categories which are grouped for purposes of data reconciliation, and should be considered together.
1 Mtherm = 105.51 TJ

A3.2.2.3 Fuel Oil

Fuel oil data are 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 2012 (Mtonnes)

DUKES Category	DUKES	GHGI	Difference	GHGI Category	CRF	Comment
Major power producers	0.261					
		0.263		Power Stations - UK	1A1a	EU ETS data
		0.052		Power Stations - crown dependencies	1A1a	Local data sets
Autogenerators	0.074					

DUKES Category	DUKES	GHGI	Difference	GHGI Category	CRF	Comment
Iron and steel	0.006	0.028		Iron and steel - combustion plant	1A2a	Includes estimate for autogenerators
Non-ferrous metals	0.001	0.001		Non-Ferrous Metal	1A2b	
Chemicals	0.033	0.033		Chemicals	1A2c	
Paper, printing etc.	0.006	0.006		Pulp, Paper and Print	1A2d	
Food, beverages etc.	0.050	0.050		Food & drink, tobacco	1A2e	
Other industry	0.051					
		0.050		Other industrial combustion	1A2f	Reduced to offset increase in 1A1a; includes autogenerators
		0.000		Cement production - combustion	1A2f	Operator's data
	0.483	**0.484**	**-0.001**			
Petroleum refineries	**0.348**	**0.348**	**0.000**	Refineries - combustion	1A1b	
Agriculture	**0.014**	**0.014**	**0.000**	Agriculture - stationary combustion	1A4c	
Domestic	**0.000**	**0.000**	**0.000**	Domestic combustion	1A4b	
Commercial	0.043					
Miscellaneous	0.012					
		0.046		Miscellaneous combustion - UK	1A4a	
		0.008		Miscellaneous combustion - crown dependencies	1A4a	Local data sets
	0.055	**0.055**	**0.000**			
Public administration	**0.036**	**0.036**	**0.000**	Public sector combustion	1A4a	
National navigation	0.147	0.080		Shipping - coastal	1A3d	Revised UK/international split
		0.008		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	1.483	1.540		Shipping - international IPCC definition		Revised UK/international split
	1.629	**1.629**	**0.000**			
Total	**2.565**	**2.566**	**-0.001**			

Notes: Sequences of shaded rows indicate categories which are grouped for purposes of data reconciliation, and should be considered together.

A3.2.2.4 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 2012 (Mtonnes)

DUKES Category	DUKES	GHGI	Difference	GHGI Category	CRF	Comment
Refinery	**0.000**	**0.000**	**0.000**	Refineries	1A1b	
Major power producers	0.041					
		0.048		Power stations - UK	1A1a	EU ETS
		0.005		Power stations - CDs	1A1a	Local data sets
Autogenerators	0.014					
Iron and steel	0.000	0.002		Iron and steel	1A2a	Includes autogenerators
Non-ferrous metals	0.000	0.000		Non-Ferrous Metal	1A2b	Reduced to offset higher consumption elsewhere
Chemicals	0.020	0.008		Chemicals	1A2c	
Paper, printing etc.	0.057	0.002		Pulp, Paper and Print	1A2d	
Food, beverages etc.	0.385	0.011		Food, drink, tobacco	1A2e	
Other industry	1.381					
		0.030		Other industry UK	1A2f	Reduced to offset higher consumption elsewhere
		0.000		Other industry CDs	1A2f	Local data sets
		0.006		Cement production	1A2f	Operator's data
		0.139		Aircraft - support vehicles	1A3e	Bottom up model
		1.340		Industrial off-road	1A2fii	Bottom up model
Commercial	0.319					
Miscellaneous	0.223					
		0.023		Miscellaneous (UK)	1A4a	Reduced to offset higher consumption elsewhere
		0.010		Miscellaneous (CDs)	1A4a	
Public	0.260	0.022		Public sector	1A4a	
Agriculture	0.151					
		1.168		Agriculture - mobile	1A4c	Bottom up model
Rail	0.605					
		0.643		Railways	1A3c	Bottom up model
	3.457	**3.458**	**-0.001**			
		0.045		Upstream gas	1A1c	
		0.563		Upstream oil	1A1c	
Oil & gas	**0.608**	**0.608**	**0.000**			
National navigation	0.163	0.315		Shipping - coastal	1A3d	Revised UK/int'l split
		0.040		Fishing vessels	1A4c	
		0.229		Shipping - naval	1A3d	From MoD
		0.097		Motorboats	1A3d	Bottom up model
		0.002		Inland goods-carrying vessels	1A3d	Bottom up model
Marine bunkers	1.644	1.123		Shipping - int'l IPCC definition		Revised UK/int'l split
	1.806	**1.806**	**0.000**			
		0.010		House and garden machinery - DERV	1A4b	Bottom up model

DUKES Category	DUKES	GHGI	Difference	GHGI Category	CRF	Comment
		0.252		Industrial off-road mobile machinery - DERV	1A2fii	Bottom up model
		0.002		Sailing boats with auxiliary engines	1A3d	Bottom up model
		0.095		Motorboats / workboats	1A3d	Bottom up model
		21.134		Road transport - UK	1A3b	Reduced to offset data for off-road and other sources
		0.044		Road transport - CDs	1A3b	Local data sets
Road	**21.538**	**21.538**	**0.000**			
		0.132		Domestic (UK)	1A4b	
		0.007		Domestic (CDs)	1A4b	Local data sets
Domestic	**0.140**	**0.140**	**0.000**			
Total	**27.549**	**27.550**	**0.000**			

Notes: Sequences of shaded rows indicate categories which are grouped for purposes of data reconciliation, and should be considered together.

A3.2.2.5 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 2012 (Mtherms)

DUKES Sector	DUKES	GHGI	Difference	GHGI sector	CRF	Comment
Petroleum refineries, other gases	1074					
Autogenerators, other gases	111					
	1186	**1485**	-300	Refineries, OPG	1A1b	EU ETS higher than DUKES
Petroleum refineries, propane	**5**	**5**	0	Refineries, LPG	1A1b	
Iron & steel industry, propane	**1**	**1**	0	Iron & steel combustion, LPG	1A2a	
Industry (excluding iron & steel), propane	228					
Industry, butane	48					
Agriculture, propane	51					
Agriculture, butane	0					
		326		Industrial combustion, LPG - UK	1A2f	
		1		Industrial combustion, LPG - crown dependencies	1A2f	

DUKES Sector	DUKES	GHGI	Difference	GHGI sector	CRF	Comment
	326	**326**	0			
Industry, ethane & other gases	**0**	**585**	-585	Chemicals, OPG	1A2c	EU ETS higher than DUKES
Road, propane	**44**	**44**	0	Road transport - all vehicles LPG use	1A3b	
Domestic, propane	127					
Domestic, butane	13					
		131		Domestic combustion, LPG - UK	1A4b	
		9		Domestic combustion, LPG - crown dependencies	1A4b	
	139	**139**	0			
(excluded from DUKES)		**116**	-116	Gas separation plant, OPG	1A1c	EEMS. Outside scope of DUKES
(excluded from DUKES)		**6**	-6	Gas separation plant, LPG	1A1c	EEMS. Outside scope of DUKES
Total	**1701**	**2707**	**-1007**			LPG and OPG data from EEMS, EU ETS

Notes: Sequences of shaded rows indicate categories which are grouped for purposes of data reconciliation, and should be considered together.
1 Mtherm = 105.51 TJ

A3.2.3 Transport (1A3)

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

A3.2.4 Fugitive Emissions from Fuels (1B)

A3.2.4.1 Solid Fuels (1B1)

A3.2.4.1.1 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

Year	Deep Mined	Coal Storage & Transport[a]	Licensed Mine[c]	Open Cast[c]
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
2011	8.7[b]	1.16	-	0.34
2012	10.6[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

A3.2.4.1.2 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 for Coke and Solid Smokeless Fuel Production

	Units	CH_4	CO	NO_x	SO_2	NMVOC
Coke	kt/Mt coke made	0.0802[a]	2.35[c]	-	1.63[c]	0.0285[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 2012 based on Environment Agency (2013)
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

A3.2.4.2 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.

A3.2.4.2.1 *Oil & Gas Production: Flaring*

The activity data and implied emission factors are given below in **Table A 3.2.14** and **Table A 3.2.15**.

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	0.0091	0.00033	0.00007
2011	1305	2.59	0.0094	0.0014	0.0065	0.0078	0.00031	0.00010
2012	1156	2.60	0.0106	0.0014	0.0063	0.0117	0.00078	0.00010

There have been no significant recalculations since the previous submission.

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 (2013).

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	0.0012	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	184	2.10	0.0090	0.0015	0.0063	0.0028	0.00002	0.00008
2011	115	2.40	0.0094	0.0018	0.0057	0.0052	0.00001	0.00007
2012	107	2.31	0.0099	0.0014	0.0056	0.0040	0.00002	0.00007

Main revisions since previous submission:

- Activity data and emission estimates have been revised for 2010 and 2011 due to revision to source allocation for reported emissions at onshore terminals (Barrow, CATS). Detailed EUETS data have been reviewed and the allocation between flaring and combustion sources corrected. Flaring emissions are now slightly lower than in the 2013 submission, with combustion sources (reported in 1A1c) slightly higher for those years.

A3.2.4.2.2 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, 2013). Data from 1998-2012 are based on detailed operator returns, whilst 1990-1997 data are calculated using emission factors from 1998 and activity data based on DECC DUKES activity data (DECC, 2013). This is 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 1990-2012 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
2012	1177	5.88	2.4	18.0	6.2	0.18	0.40	0.46
2011	1274	5.85	1.9	16.0	6.3	0.09	0.33	0.46
2010	1469	5.78	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	1725	5.85	1.8	17.4	6.0	0.10	0.25	0.44
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

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
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

The main revision since the previous submission is:

- Correction to data in 2006 to re-allocate gas use and emissions between oil production sources and gas production sources, to account for gas use at four gas production sites (Ravenspurn, LOGGS, Viking B and Trent). This has led to a small decrease in emissions from oil production gas use, and a small increase in emissions from gas production gas use (see **Table A 3.2.17** below.)

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
2012	476	5.94	2.41	12.0	6.45	0.10	0.03	0.49
2011	540	5.78	4.35	17.5	8.39	0.43	0.10	0.48
2010	616	5.72	5.36	16.2	6.56	0.42	0.07	0.44
2009	609	5.72	4.33	15.7	7.18	0.44	0.08	0.49
2008	623	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	638	5.76	3.71	18.4	6.74	0.37	0.01	0.50
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.

There is a notable reduction in the methane IEF derived from the operator-reported data between 2011 and 2012. The gas combustion emissions are reported for gas use in a range of different devices, dominated by gas use in either turbines or in engines. The methane implied emission factors for emissions reported from gas engines are notably higher than those from turbines; and in years up to 2012 there was a higher reporting of gas use in engines, especially for a number of gas-producing sites that have ceased (or greatly reduced) production in 2012 (including: Grove Wellhead, Clipper and Chiswick platforms). Therefore, the higher proportion of gas use in turbines in 2012 leads to a lower methane IEF overall for 2012 compared to recent years. This feature of the gas use in engines and turbines also impacts upon the trends in IEFs for other pollutants, including: CO, NOx, NMVOC.

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 1990-2012 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
2012	0.563	3.19	0.130	32.1	6.47	0.95	2.38	0.172
2011	0.494	3.19	0.130	32.2	6.47	0.95	2.38	0.220
2010	0.463	3.19	0.130	32.2	6.47	0.95	2.38	0.220
2009	0.439	3.19	0.158	31.0	6.45	0.89	2.87	0.209
2008	0.443	3.19	0.161	31.9	6.88	0.95	2.75	0.194
2007	0.385	3.19	0.112	30.3	5.99	0.85	2.80	0.194
2006	0.412	3.19	0.077	27.7	5.07	0.77	3.43	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	5.72	0.84	4.40	0.217
2003	0.464	3.19	0.095	30.0	5.86	0.85	3.17	0.217
2002	0.509	3.19	0.087	33.0	6.44	0.92	3.05	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	0.502	3.19	0.097	34.1	7.56	1.03	3.33	0.361
1998	0.506	3.19	0.097	34.1	7.56	1.03	3.33	0.361
1997	0.489	3.19	0.097	34.1	7.56	1.03	3.33	0.361
1996	0.495	3.19	0.097	34.1	7.56	1.03	3.33	0.361
1995	0.495	3.19	0.097	34.1	7.56	1.03	3.33	0.361
1994	0.482	3.19	0.097	34.1	7.56	1.03	3.33	0.361
1993	0.382	3.19	0.097	34.1	7.56	1.03	3.33	0.361
1992	0.359	3.19	0.097	34.1	7.56	1.03	3.33	0.361
1991	0.348	3.19	0.097	34.1	7.56	1.03	3.33	0.361
1990	0.349	3.19	0.097	34.1	7.56	1.03	3.33	0.361

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
2012	0.0449	3.19	0.283	45.0	12.0	1.77	3.04	0.181
2011	0.0384	3.19	0.283	45.0	12.0	1.77	3.04	0.181
2010	0.0292	3.19	0.283	45.0	12.0	1.77	3.04	0.181
2009	0.0149	3.19	0.134	37.2	7.1	1.17	2.93	0.195
2008	0.0204	3.19	0.131	40.6	9.1	1.42	3.03	0.164
2007	0.0190	3.19	0.089	36.5	8.2	1.11	3.17	0.198
2006	0.0181	3.19	0.101	28.1	8.2	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	2.67	0.220
2001	0.0180	3.19	0.128	43.2	10.4	1.39	2.13	0.220
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.

A3.2.4.2.3 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, 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
2012	11.0	3.20	25.0	3.70	18.0	25.0	0.011	0.081
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

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
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, 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
2012	36.7	2.80	45.0	1.20	6.7	5.0	0.013	0.081
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
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

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
1990	225.5	2.69	15.7	22.0	11.2	6.73	15.9	0.029

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, 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
2012	46,920	0.007	0.42	7,704	0.061	1.23
2011	48,377	0.010	0.43	8,697	0.104	1.12
2010	59,766	0.009	0.44	10,840	0.071	1.18
2009	62,903	0.009	0.44	11,938	0.080	1.41
2008	58,460	0.010	0.65	14,011	0.095	1.45
2007	55,782	0.013	0.71	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	37,679	0.079	1.39
2002	82,464	0.012	0.86	42,303	0.113	1.65
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

The main revision since the previous submission is:

- Correction to oil loading at onshore sites to take account of reported emissions within IPPC/EPR regulatory mechanisms for the loading installations at terminals. For some sites there are separate permits (and therefore separate reported emissions) for the oil loading / unloading at oil storage sites, and the oil terminal itself. For one site in Scotland, the emissions from the loading area and storage tanks site were previously misallocated to other industrial sources in the UK inventory. This correction has led to small increases in methane and NMVOC emissions in 1B2 from 2007 onwards.

A3.2.4.2.4 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	78.9[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]
2012	80.0[5]	3.38[5]	13.9[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 (2013).
6 Extrapolated back from the 2004 analysis by network operators

The basis for the country-specific emission factors applied to the open-cast coal mining activity in the UK is clarified here.

A UK industry research study provides data on the methane content of open-cast coal samples from the three main UK open-cast coal producing regions (Williams, 1993), and this report is the basis for the estimates within the UK GHG inventory.

The emission factor is derived from compositional analysis of fresh coal core samples from the three main UK open-cast coal producing regions: Lancashire, South Wales and Leicestershire. The emission factor is based on the total methane content of the samples, and is likely to be an over-estimate of total methane emissions, as some residual methane will be retained within the coal structure to the point of combustion, especially where the coal is not processed to fine coal, and instead used as lump coal in larger grates, e.g. within residential and some commercial sectors. The emission factor is based on UK coal samples and therefore is regarded as more appropriate to use than IPCC defaults, as the data are more representative of the UK coal seams, depths and typical coal composition and permeability. Note also that whilst the UK reference is from 1993, the IPCC defaults are also based on a range of studies from around 1989-1993, and the IPCC GLs also note that there is a limited dataset on methane emission factors from open cast coal globally. The UK EF is of the same order of magnitude as the IPCC defaults and we regard it as a more accurate factor to use. There has not been any recent review of open cast coal mine methane content, however we also note that the estimates for 1990 and 2011 are 0.02% and 0.01% of the total UK GHG inventory, and therefore to fund additional coal sampling and analysis is a very low priority in the context of the overall UK GHGI improvement programme. The inventory agency has contacted a number of the main UK open cast coal mine operators during late 2013 / early 2014, since the ERT provided its feedback from the 2013 centralised review. However no new data has become available for inclusion in the UK inventory at this time, partly due to severe economic conditions in the UK industry leading to a number of company closures, We will continue to seek any new data or feedback on the current factor from the industry, as part of the 2015 submission compilation programme.

A3.2.3.2.3 Oil & Gas Production: Well testing

In both cases, for 1B2ai (oil) and 1B2bi (gas), the only emissions reported in the UK inventory are the well testing emissions reported within the EEMS regulatory reporting system. Venting and fugitives are not significant for exploration operations, including well testing. There is no direct venting of unburnt gas during an oil well test. Direct venting during well testing would be a safety hazard, and this accounts for the very limited amount reported. All production would be flared during an oil well test, and would normally be flared rather than vented during a gas well test. Accidental releases are not included in reports to DECC, but have to be reported (not quantified emissions, just instances of accidental releases) to the UK Health and Safety Executive. There is no reason to expect a steady relationship in the well testing totals, but CO_2 emissions will be significantly greater than CH_4. Note also that the reporting in the EEMS system of fugitive and venting emissions is not aligned to the overall stage in "oil and gas exploration and production"; operators report lines for all emissions of fugitive and venting emissions aggregated in (typically) one line per installation per year (some installations provide a breakdown of venting emissions into: maintenance, operational, emergency), not disaggregated by process stage. Venting and fugitives are only really significant for production operations. Inventory agency quality checking of the data from the EEMS system includes review at a site-by-site level of the completeness of reporting across the time series. Where periodic gaps in data reporting for a site / installation are evident, we use IPCC GPG techniques (interpolation, extrapolation or use of other installation activity as a surrogate) to address reporting gaps. This does in some instances impact upon estimates of "fugitives", and given the periodic, non-routine nature of fugitive emissions this need to address gaps in EEMS data introduces uncertainty, but we consider it to be the best use of UK-specific reporting systems.

A3.3 INDUSTRIAL PROCESSES (CRF SECTOR 2)

A3.3.1 Potential Emissions of Halocarbons and SF_6

The UK reports both actual and potential emissions of fluorinated gases within IPCC source category 2F, Consumption of Halocarbons and SF_6.

- Actual emissions are estimates of the emission of a gas to atmosphere in a given year.
- Potential emissions are estimated as the apparent consumption of fluid in a given year (IPCC, 1997). Apparent consumption is based on data on annual production, imports, exports and destruction of fluid. Hence, it is assumed that the entire emission occurs in the year of use rather than presenting estimates that reflect fluid leakage over the lifetime of a piece of equipment.

Potential emissions provide a convenient benchmark to compare emissions between countries and are simpler to estimate. Potential F-gas emissions are not reported for other Industrial Processes, such as from metal processes (2C) or halocarbon production (2E).

This annex provides an insight into the methods used to estimate potential emissions of F-gases within the UK GHG inventory, presenting information by source category.

Potential emissions are in effect the apparent consumption of a fluid in a particular year. The IPCC (1997) Tier 1 methodology defines a mass balance on the production, imports, exports and disposal of a fluid on a national basis. A further refinement is to include the total fluid exported and imported in products, e.g. refrigerators and aerosol cans. Potential emissions differ from actual emissions in that no account is made of the fluid that is stored in products and is emitted over a long period of time.

It is not possible to report potential emissions for all sources in the UK inventory, as for some emission sources the information is confidential. However, estimates of the total GWP of potential emissions in the main IPCC categories are reported below.

A3.3.1.1 2F1, Refrigeration and Air Conditioning Equipment

Potential as well as actual emissions are reported from this category. Potential emissions are estimated based on the size of the bank and summed across all HFCs (ICF, 2011).

A3.3.1.2 2F2, Foam Blowing

Potential as well as actual emissions are reported from this category. Potential emissions are estimated as the apparent consumption of fluid in a given year (following IPCC guidance). Apparent consumption is based on data on annual production, imports, exports and destruction of fluid. Hence, it is assumed that the entire emission occurs in the year of use rather than presenting estimates that reflect fluid leakage over the lifetime of a piece of equipment. A further refinement is to include the total fluid exported and imported in products. Potential emissions differ from actual emissions in that no account is made of the fluid that is stored in products and which is emitted over a long period of time.

In this inventory, potential emissions were estimated from the same data used to calculate the actual emissions. This was the annual consumption of fluid by each product sector and the amounts imported and exported into each product sector. Thus it was possible to estimate the annual amount of fluid consumed by each product sector and process that contributes to emissions.

A3.3.1.3 2F3, Fire Extinguishers

Potential as well as actual emissions are reported from this category. Potential emissions are estimated as the apparent consumption of fluid in a given year (following IPCC guidance). Apparent consumption is based on data on annual production, imports, exports and destruction of fluid. Hence, it is assumed that the entire emission occurs in the year of use rather than presenting estimates that reflect fluid leakage over the lifetime of a piece of equipment. A further refinement is to include the total fluid exported and imported in products. Potential emissions differ from actual emissions in that no account is made of the fluid that is stored in products and which is emitted over a long period of time.

In this inventory, potential emissions were estimated from the same data used to calculate the actual emissions. This was the annual consumption of fluid by each product sector and the amounts imported and exported into each product sector. Thus it was possible to estimate the annual amount of fluid consumed by each product sector and process that contributes to emissions.

A3.3.1.4 2F4, Aerosols / Metered Dose Inhalers

The IPCC (2000) states emissions from these sources are considered as “prompt” – because the initial charge is used after the first year or two after manufacture. Therefore it is assumed that potential emissions are equal to actual emissions for this source category.

A3.3.1.5 2F5, Solvents

Potential as well as actual emissions are reported from this category. The IPCC (2000) states emissions from these sources are considered as” prompt” – because the 100% of the solvent is used after first year or two after production. Therefore it is assumed that potential emissions are equal to actual emissions for this source category.

A3.3.1.6 2F7, Semiconductor Manufacture

Potential as well as actual emissions are reported from this category. Potential emissions are estimated based on the assumptions that all the fluid available for consumption is a given year is released in that year. Potential emissions from this category are aggregated with emissions from other categories reported in 2F9 to preserve the commercial confidentiality of emissions from the use of training shoes.

A3.3.1.7 2F8, Electrical Equipment / Electrical Insulation

Potential as well as actual emissions are reported from this category. Potential emissions have been estimated as consumption, which has been defined as the sum of SF_6 used for new equipment (bank size increase) plus SF_6 used for top up to offset emissions. Potential emissions from this category are aggregated with emissions from other categories reported in 2F9 to preserve the commercial confidentiality of emissions from the use of training shoes.

A3.3.1.8 2F9, Training shoes

Potential as well as actual emissions are reported from this category. Potential emissions are estimated on the assumption that all the SF_6 consumed to manufacture the shoes in a given year is released in that year. These estimates of emissions are commercially confidential, and so they are aggregated with emissions from other categories reported in 2F9.

A3.3.1.9 2F9, One Component Foams

Potential as well as actual emissions are reported from this category. Potential emissions have been set equal to actual emissions in all years in the time series. Potential emissions from this category are aggregated with emissions from other categories reported in 2F9 to preserve the commercial confidentiality of emissions from the use of training shoes.

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 2012 by Animal Type[a]

Animal type	Number
Cattle:	
Dairy cows	1,811,646
Beef cows	1,657,244
Dairy heifers	398,539
Beef heifers	309,200
Dairy replacements >1 year	518,151
Beef all others >1 year	2,299,997
Dairy calves <1 year	509,605
Beef calves <1 year	2,395,793
Pigs:	
Sows	356,738
Gilts	150,461
Boars	16,072
Fattening & other pigs 80 - >110 kg	685,945
Fattening & other pigs 50-80 kg	968,767
Other pigs 20-50 kg	1,129,535
Pigs < 20 kg	1,173,386
Sheep:	
Breeding sheep	15,621,363
Other sheep	364,138
Lambs < 1 year	16,229,415
Goats	97,802
Deer	31,152
Horses	1,023,615
Poultry:	
Growing pullets	9,092,157
Laying fowls	27,553,475
Breeding flock	9,987,314
Table chicken	102,557,948
Turkeys	3,759,454
Total other poultry	7,110,850

[a] 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: England: https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june; Scotland: http://www.scotland.gov.uk/Publications/2012/09/1148/downloads; Wales: http://wales.gov.uk/statistics-and-research/survey-agricultural-horticulture/?lang=en and John Bleasdale, Welsh

Government; Northern Ireland: http://www.dardni.gov.uk/june-agricultural-census-final-results and Paul Caskie, DARDNI)

Table A 3.5.2 Trends in Livestock Numbers (‘000s) 1990-2012

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
2012	1.812	8,089	4,481	32,215	160,061

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: **England:** https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june; **Scotland:** http://www.scotland.gov.uk/Publications/2012/09/1148/downloads; **Wales:** http://wales.gov.uk/statistics-and-research/survey-agricultural-horticulture/?lang=en and John Bleasdale, Welsh Government; **Northern Ireland:** http://www.dardni.gov.uk/june-agricultural-census-final-results and Paul Caskie, DARDNI)

Table A 3.5.3 Methane Emission Factors for Livestock Emissions for 2012

Animal type	Enteric methane[a] kg CH_4/head/year	Methane from manures[a, b] kg CH_4/head/year
Cattle:		
Dairy cows[ef]	110.7[b]	42.1
Beef cows[f]	50.5[b]	13.0
Dairy heifers	48	21.7
Beef heifers	48	17.3
Dairy replacements >1 year	48	21.7
Beef all others >1 year	48	17.3
Dairy calves<1 year	32.8	15.6
Beef calves <1 year	32.8	11.0
Pigs:		
Sows	1.5	12.7
Gilts	1.5	12.7
Boars	1.5	12.7
Fattening & other pigs 80 - >110 kg	1.5	21.0
Fattening & other pigs 50-80 kg	1.5	21.0
Other pigs 20-50 kg	1.5	21.0
Pigs <20 kg	1.5	17.1
Sheep:		
Breeding sheep	8	0.48
Other sheep	4[d]	0.24[d]
Lambs < 1 year	2.2[cg]	0.13[cg]
Goats	5	0.48
Horses	18	1.4
Deer:		
Stags & hinds	10.4[c]	0.26[c]
Calves	5.2[c]	0.13[c]
Poultry:		
Growing pullets	NE	0.117
Laying fowls	NE	0.114
Breeding flock	NE	0.117
Table chicken	NE	0.117
Turkeys	NE	0.116
Total other poultry	NE	0.117

[a]IPCC (1997)all manure EF's are tier 2 (with the exception of deer)
[b]Emission factor for the year 2012 (with the exception of deer)
[c] Sneath, RW, Chadwick DR, Phillips VR & Pain BF (1997), A UK Inventory of Methane/Nitrous Oxide Emissions from Farmed Livestock. Contract reports (2) to MAFF, projects WA0604/5, SRI, IGER & ADAS
[d]Factor quoted assumes animal lives for 6 months, animals are slaughtered at some stage during the year.
[e]% time spent grazing revised from 43% to 45% for dairy cows and 54% to 65% for beef cows (from Farm Practices Survey https://www.gov.uk/government/collections/farm-practices-survey)
[f]IPCC 2000 methodology
[g]Factor quoted assumes animal lives for 8.1 months (Wheeler, Wright & Phillips (2012). More robust evidence on the average age of OK lambs at slaughter. ADAS report)

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	87.5	33.9
1991	571	5133	4.04	87.5	34.6
1992	585	5237	4.06	89.3	34.6
1993	585	5259	4.07	89.6	34.7
1994	580	5300	4.05	89.5	34.7
1995	583	5398	4.05	90.5	35.1
1996	599	5545	4.08	92.8	35.9
1997	600	5790	4.07	94.8	36.7
1998	604	5775	4.07	94.9	36.8
1999	608	5964	4.03	96.5	37.4
2000	612	5979	4.03	96.8	37.5
2001	617	6346	4.01	100.0	38.7
2002	621	6493	3.97	101.2	39.1
2003	625	6621	3.96	102.4	39.5
2004	629	6763	4.00	104.1	40.0
2005	633	6986	4.02	106.3	40.8
2006	641	6977	4.04	106.9	41.0
2007	652	6913	4.06	107.1	41.0
2008	644	6943	4.06	106.9	40.8
2009	643	7031	3.99	107.1	40.8
2010	653	7273	3.95	109.3	41.6
2011	646	7528	4.06	111.9	42.6
2012	637	7445	4.07	110.7	42.1

[a]In 2012, animals spent 46% of the year grazing on good quality pasture, the rest of the time they were confined in animal housing.
Gestation period 281 days
Methane conversion rate 6%
Ash content of manure 8%
[b]Values from carcase weight data from slaughter survey (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/207799/slaughter-dataset-20jun13.xls) corrected by 1/0.48
[c]IPCC 2000 methodology
[d]Milk yield from https://www.gov.uk/government/publications/agriculture-in-the-united-kingdom-2012

Table A 3.5.5 Energy and digestibility coefficients of ruminant feeds

Energy and energy digestibility coefficients of ruminant feeds (MAFF, 1990)							
		GE (MJ/kg ODM)	DE (MJ/kg ODM)	DE/GE (%)	Proportion assumed in average annual diet.	GE (MJ/kg ODM) (weighted)	DE (MJ/kg ODM) (weighted)
Forages	Barley straw	18.4	8.2	44.6			
	Fresh grass (grazed) - all species	18.7	13.8	73.8	0.4	7.48	5.52
	Grass hay	18.4	10.7	58.2			
	Grass silage	19.0	13.6	71.6	0.5	9.5	6.8
	Grass silage (big bale)	18.9	12.7	67.2			
	Maize silage	18.2	11.7	64.3	0.1	1.82	1.17
	Totals				**1.0**	**18.80**	**13.49**
Concentrate energy feeds	Barley grain	18.4	15.8	85.9	0.38	6.992	6.004
	Citrus pulp	17.5	15.0	85.7			
	Fodder beet (fresh)	16.0	14.1	88.1			
	Maize gluten feed	19.2	15.8	82.3	0.05	0.96	0.79
	Oats	19.6	14.6	74.5			
	Rice bran (extracted)	16.7	NA				
	Sugar beet pulp (molassed)	17.1	15.0	87.7	0.05	0.855	0.75
	Wheat feed	19.1	14.3	74.9	0.1	1.91	1.43
	Wheat grain	18.3	16.4	89.6	0.08	1.464	1.312
Protein feeds	Brewers grains	20.9	NA				
	Cottonseed meal	20.4	13.9	68.1			
	Distillers grains (wheat)	21.7	15.8	72.8			
	Field beans						
	Field peas	18.5	NA				
	Rapeseed meal	19.7	15.2	77.2	0.2	3.94	3.04
	Soya bean meal	19.6	16.0	81.6	0.05	0.98	0.8
	Sunflower meal	19.5	12.8	65.6	0.04	0.78	0.512
Vitamins and minerals		0.0	0.0		0.05	0	0
	Totals				**1.00**	**17.88**	**14.64**

Table A 3.5.6 Calculation of digestibility[a]

1	***Total annual energy requirement for 'average' UK dairy cow***		
	Assumed parameters - 7,000 litres, 600 kg live weight		
	MElactation (MJ)	36050	- Derived from 'Feed into Milk' (2004) - See also Alderman and Cottrill (1993)
	MEpregnancy (MJ)	2400	
	MEmaintenance (MJ)	28760	
	Annual ME requirement (MJ)	67210	Sum of MElactation+ MEpregnancy+ MEmaintenance
	Annual DE requirement (MJ)	82975	Assuming ME = 0.81 x DE (factor from Alderman, 1982)
2	***Energy supplied from concentrate feed***		
	Average annual milk yield (litres)	7000	
	Average concentrate use (kg FW/litre)	0.28	From Nix, 2009
	Annual concentrate use (kg FW)	1960	
	Annual concentrate use (kg DM)	1705.2	Assumes DM content of concentrate of 87% (MAFF, 1990)
	GE supplied by concentrates (MJ)	30491	Calculated from values given in MAFF, 1990 (see **Table A 3.5.5**)
	DE supplied by concentrates (MJ)	24961	Calculated from values given in MAFF, 1990 (see **Table A 3.5.5**)
3	***Remaining energy supplied from forage***		
	DE to be supplied by forage (MJ)	58015	
	Forage DM required (Kg)	4301	Proportion concentrate in diet 28%[a]
	GE supplied by forage (MJ)	80851	Proportion forage in diet 72%[a]
4	***Diet digestibility***		
	Total GE intake (MJ)	111341	
	Total DE intake (MJ)	82975	
	Digestibility (ME/GE), %	74.52341	

[a]See explanation of calculations in main chapter section 6.2.2.1

Feed into Milk: Agnew, R. E., Yan, T., France, J., Kebreab, E. and Thomas, C. (2004). Energy requirement and supply. In: ed. C. Thomas, Feed into milk: a new applied feeding system for dairy cows, pp.11-20. Nottingham University Press, Nottingham, UK.
Alderman, G and Cottrill, B (1993) Energy and Protein Requirements of Ruminants: An Advisory Manual prepared by the AFRC Technical Committee on Responses to Nutrients. CAB International.
Alderman G (1982) Comparison of rations calculated in different systems. In: Feed Evaluation and Protein Requirement Systems for Ruminants. Eds. Jarrige R and Alderman G. CEC Luxembourg, pp 238-296.

Nix 2009: Nix, J. (2009). Farm Management Pocketbook 2009.
MAFF (1990), UK Tables of nutritive value and chemical composition of feedingstuffs. Rowett Research Services Ltd, Greenburn Road, Bucksburn, Aberdeen, AB2 9SB, UK

Table A 3.5.7 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	222.42
1991	39.13	3.00	43.40	3.91	0.54	0.35	222.37
1992	39.84	3.06	44.39	3.98	0.54	0.35	226.90
1993	39.86	3.06	44.64	3.99	0.54	0.35	227.57
1994	39.61	3.04	44.87	3.96	0.54	0.35	227.43
1995	39.76	3.05	45.70	3.98	0.54	0.35	229.92
1996	40.54	3.11	47.12	4.05	0.54	0.35	235.74
1997	40.61	3.11	49.14	4.06	0.54	0.35	240.98
1998	40.82	3.13	49.02	4.08	0.54	0.35	241.26
1999	41.02	3.15	50.36	4.10	0.54	0.35	245.19
2000	41.22	3.16	50.49	4.12	0.54	0.35	246.09
2001	41.47	3.18	53.41	4.15	0.54	0.35	254.10
2002	41.67	3.20	54.40	4.17	0.54	0.35	257.15
2003	41.88	3.21	55.40	4.19	0.54	0.35	260.22
2004	42.08	3.23	56.88	4.21	0.54	0.35	264.50
2005	42.28	3.24	58.91	4.23	0.54	0.35	270.13
2006	42.69	3.27	58.99	4.27	0.54	0.35	271.52
2007	43.23	3.32	58.60	4.32	0.54	0.35	272.13
2008	42.84	3.29	58.85	4.28	0.54	0.35	271.64
2009	42.80	3.28	59.06	4.28	0.54	0.35	272.03
2010	43.29	3.32	60.77	4.33	0.54	0.35	277.71
2011	42.94	3.29	63.81	4.29	0.54	0.35	284.27
2012	42.47	3.26	63.19	4.25	0.54	0.35	281.34

Table A 3.5.8 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

	Equation[d]	Beef cows	Others>1	Others<1
$NE_{pregnancy}$ (Net energy for pregnancy), MJ/d	2000GPG Eq4.8	3.54	2.70	0.00
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)		13.0[a]	6.0	2.96

[a]Digestible energy 65% (expert opinion, B. Cottrill, ADAS), Ash content of manure 8.0% (IPCC, 1997), Methane producing capacity of manure 0.17 m^3 kg VS^{-1} (IPCC, 1997)
[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 (expert opinion, Defra)
[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% (IPCC 1997)
[g]Time spent grazing is 45% and 65% for dairy and beef cattle respectively (Farm Practices Survey https://www.gov.uk/government/collections/farm-practices-survey)

A3.5.2 Manure Management (4B)

A3.5.2.1 Methane emissions from animal manures

Table A 3.5.9 Methane conversion factors for Manure Management Systems in the UK

Manure Handling System	Methane Conversion Factor %[a]
Liquid	39
Daily spread	0.1
Deep litter	39
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 3.5.10 Nitrogen Excretion Factors, kg N hd^{-1} year^{-1} for livestock in the UK (1990-2012)[a]

Animal type	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cattle:															
Dairy cows	97	100	106	110	112	113	115	117	117	117	117	118	121	123	123
Beef cows	79	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	67
Beef heifers	56	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	53
Beef all others >1 year	53	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	38
Beef calves <1 year	38	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	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	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	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	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	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	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	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	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	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	2.40

Animal type	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Goats	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6
Deer:															
Stags	13	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	13
Horses	50	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	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	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	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	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	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	1.71

[a]Cottrill and Smith , (2006) Defra Final report, Project WT0715NVZ, ‘Nitrogen output of livestock excreta

Table A 3.5.11 Distribution of Animal Waste Management Systems used for Different Animal types, 2012[a]

Animal Type	Liquid System	Daily Spread	Deep litter	Pasture Range and Paddock	Poultry without bedding	Poultry with bedding	Inciner-ation
Cattle:							
Dairy cows	41.0	4.6	9.3	45.1	NA	NA	NA
Beef cows	5.6	0.6	28.4	65.4	NA	NA	NA
Dairy heifers	9.8	1.1	20.2	69.0	NA	NA	NA
Beef heifers	5.6	0.6	28.4	65.4	NA	NA	NA
Dairy replacements >1 year	9.8	1.1	20.2	69.0	NA	NA	NA
Beef all others >1 year	5.6	0.6	28.4	65.4	NA	NA	NA
Dairy calves<1 year	0.0	0.0	45.2	54.8	NA	NA	NA
Beef calves <1 year	0.0	0.0	45.2	54.8	NA	NA	NA
Pigs:							
Sows	37.7	0.0	20.3	42.0	NA	NA	NA
Gilts	37.7	0.0	20.3	42.0	NA	NA	NA
Boars	37.7	0.0	20.3	42.0	NA	NA	NA
Fattening & other pigs 80 - >110 kg	35.3	0.0	62.7	2.0	NA	NA	NA
Fattening & other pigs 50-80 kg	35.3	0.0	62.7	2.0	NA	NA	NA
Other pigs 20-50 kg	35.3	0.0	62.7	2.0	NA	NA	NA
Pigs <20 kg	45.0	0.0	34.0	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	Deep litter	Pasture Range and Paddock	Poultry without bedding	Poultry with bedding	Inciner-ation
Stags[b]	0.0	0.0	0.0	100.0	NA	NA	NA
Hinds & Calves[b]	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	0.0	NA	1.2	0.0	98.8	0.0
Laying fowls	NA	0.0	NA	8.8	91.2	0.0	0.0
Breeding flock	NA	0.0	NA	0.2	0.0	99.8	0.0
Table chicken	NA	0.0	NA	1.0	0.0	67.6	31.5
Turkeys	NA	0.0	NA	3.6	0.0	96.4	0.0
Total other poultry	NA	0.0	NA	2.0	0.0	98.0	0.0

[a] Misselbrook, T.H., Chadwick, D.R., Gilhespy, S.L., Chambers, B.J., Smith, K.A., Willliams, J., Dragosits, U. (2011) Inventory of Ammonia Emissions from UK Agriculture, 2010. Defra contract AC0112, Inventory submission report September 2011
[b] Sneath, RW, Chadwick DR, Phillips VR & Pain BF (1997), A UK Inventory of Methane/Nitrous Oxide Emissions from Farmed Livestock. Contract reports (2) to MAFF, projects WA0604/5, SRI, IGER & ADAS

Table A 3.5.12 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
Deep litter	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 3.5.13 Areas of UK Crops and quantities of fertiliser applied for 2012[a]

Crop Type	Crop area, ha	Fertiliser, ktN
Winter wheat	1,991,875	366.1
Spring barley	617,518	61.2
Winter barley	384,666	55.3
Oats	121,923	11.4
Rye, triticale & mixed corn	25,933	1.3
Maize	157,718	6.1
Maincrop potatoes	148,771	20.1
Sugar beet	120,081	11.4
Oilseed rape	755,579	140.3
Peas (green)	31,905	0.0
Peas (dry)	24,193	0.0
Broad beans	1,193	0.0
Beans (human consumption)	7	0.0
Beans (animal consumption)	95,873	0.0
Rootcrops for stockfeed	33,171	2.7
Leafy forage crops	4,361	0.2
Other forage crops	22,191	0.7
Vegetable (brassicae)	2,863	0.5
Vegetables (other)	87,897	5.6
Soft fruit	9,327	0.2
Top fruit	24,185	1.5
Hops	0	0.0
Linseed	27,932	2.4
Other tillage	45,865	1.0
Grass under 5 years	1,356,614	126.3
Permanent grass	5,938,057	309.0

[a]Data includes England, Wales, Scotland and Northern Ireland, June survey results: England: https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june; Scotland: http://www.scotland.gov.uk/Publications/2012/09/1148/downloads; Wales:

http://wales.gov.uk/statistics-and-research/survey-agricultural-horticulture/?lang=en and John Bleasdale, Welsh Government; Northern Ireland: http://www.dardni.gov.uk/june-agricultural-census-final-results and Paul Caskie, DARDNI); BSFP (2013). British Survey of Fertiliser Practice: Fertiliser Use on Farm Crops for Crop Year 2012, The BSFP Authority, Peterborough. Data for preceding years comes from earlier versions of the same publication.

Table A 3.5.14 Trends in area grown ('000 ha) and N fertiliser applied (kg/ha) for the major UK crops, 1990-2012[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
2012	1,992	183.8	618	99.1	385	143.8	149	135.1	756	185.7	1,357	93.1	5,938	52.0

[a]Data includes England, Wales, Scotland and Northern Ireland, June survey results: England: https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june; Scotland: http://www.scotland.gov.uk/Publications/2012/09/1148/downloads; Wales: http://wales.gov.uk/statistics-and-research/survey-agricultural-horticulture/?lang=en and John Bleasdale, Welsh Government; Northern Ireland: http://www.dardni.gov.uk/june-agricultural-census-final-results and Paul Caskie, DARDNI); BSFP. British Survey of Fertiliser Practice: Fertiliser Use on Farm Crops for Crop Years from 1990 to 2012, The BSFP Authority, Peterborough. Data for preceding years comes from earlier versions of the same publication.

A3.5.3.2 Biological Fixation of Nitrogen by crops

Table A 3.5.15 Dry Mass Content and Residue Fraction of UK Crops for 2012

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), Personal communications from M Rose, Land Management Improvement Division
[b] Burton (1982), Post-Harvest Physiology of Crops, Longman, London, ISBN 0-582-46038-7; Nix, J (1997), Farm Management Pocket Book 1998, 28th ed., Wye College Press, Ashford, UK
[c]Hops dry mass from Brewers Licensed Retail Association (1998), expert opinion R Gerry (MAFF). Estimate of dry matter content of hops
[d]Field beans dry mass from PGRE (1998), expert opinion R Gerry (MAFF). Estimate of dry matter content of field beans

A3.5.3.3 Crop Residues

Table A 3.5.16 Production of UK Crops for 2012[a]

Crop Type	Crop production, kt
Broad Beans	11.3
Field Beans	336.0
Peas green for market	5.9
Peas green for processing	126.6
All peas harvested dry	26.6
Rye, mixed corn, triticale	105.0
Wheat	13,260
Oats	627.2
Barley	5,522
OSR	2,556
Linseed	42.0
Maize	3,785
Sugar beet	7,291
Hops	0
Potatoes	4,694
Total roots & onions	1,215
Total brassicas	466.2
Total others	348.1
Phaseolus beans	14.2

[a]Data includes England, Wales, Scotland and Northern Ireland (Tom Johnson, DEFRA (England & Wales), Helen McAfee, The Scottish Government and Conor McCormack, DARDNI)

A3.5.3.4 Histosols.

Total area 1500 km^2 (see **Table A 3.6.26**).

A3.5.3.5 Grazing Animals.

See **Table A 3.5.1**, **Table A 3.5.8** and **Table A 3.5.9** for parameters used in calculations.

A3.5.3.6 Organic Fertilizers.

See **Table A 3.5.1**, **Table A 3.5.8** and **Table A 3.5.9** for activity data.

A3.5.3.7 Application of sewage sludge to land

Table A 3.5.17 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	582,711	0.330	0.066	0.247
2001	837,676	0.474	0.095	0.355
2002	896,490	0.507	0.101	0.380
2003	1,059,890	0.600	0.120	0.450
2004	1,120,676	0.634	0.127	0.475
2005	1,221,080	0.691	0.138	0.518
2006	1,252,822	0.709	0.142	0.532
2007	1,295,260	0.733	0.147	0.550
2008	1,404,160	0.794	0.159	0.596
2009	1,311,280	0.742	0.148	0.556
2010	1,320,635	0.747	0.149	0.560
2011	1,337,149	0.756	0.151	0.567
2012	1,288,134	0.729	0.146	0.547

[a]Data includes England, Wales, Scotland and Northern Ireland, see data sources in Waste sector section 6B2

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

Table A 3.5.18 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), Compilation of Air Pollutant Emission Factors, volume 1, 5th ed., AP-42, United States Environmental Protection Agency, North Carolina

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 in the UK is calculated by a carbon accounting model, CARBINE, as gains and losses in pools of carbon in standing trees, litter and soil in conifer and broadleaf forests and in harvested wood products. Restocking is assumed in all forests. The method is Tier 3, as defined by IPCC (2006).

CARBINE uses as input data estimates of stand structure and growth obtained from yield tables that are applied at the stand level (Edwards and Christie, 1981). When stand-level carbon estimates are combined with area/age-class information, forest and national carbon stocks can be estimated. CARBINE can be used to estimate historical forest carbon stocks, as well as current and future carbon stocks under different forest area and management scenarios. Using one set of yield tables assumes the same growth rates/patterns occur at any time: historic, current or future. This means that changes that might affect growth rate or form are excluded, such as the improvement of planting material or better site quality. Carbon stock changes are inferred from differences in carbon stock estimates at different times. The model can represent all of the introduced and native plantation and naturally-occurring species relevant to the UK.

The model as used for this inventory consists of three sub-models or ‘compartments’ which estimate carbon stocks in the forest, soil, and wood products respectively. The forest carbon sub-model is further compartmentalised to represent fractions due to tree stems, branches, foliage, and roots. The impact of different forest management regimes can be assessed for the range of tree species, yield classes and management regimes represented in published yield tables (Edwards and Christie, 1981). At present not all of these are implemented in CARBINE. Currently the model contains the tables for 19 different tree species (Norway spruce, Sitka spruce, Scots pine, Corsican pine, Lodgepole pine, European larch, Japanese larch, Douglas fir, Grand fir, Noble fir, Western Red cedar, Western hemlock, Oak, Beech, Nothofagus, Poplar and a combined model table that covers Sycamore, Ash and Birch). Yield tables were extrapolated where necessary to cover longer rotations and management and yield in non-clearfell and un-thinned forests. All areas for a species are assumed to have been planted at the same spacing.

Increases in stemwood volume were based on standard yield tables. These tables do not provide information for years prior to the first table age so a function was developed to bridge the gap. The pattern fitted to the stemwood volume between planting and first table age from the yield tables follows a smooth curve from planting which connects to a linear function at a point determined algorithmically. This linear function then bridges the gap up to the first age in the yield table.

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 sitka spruce (P. Sitchensis) are given in **Table A 3.6.1.**

Table A 3.6.1 Main parameters for forest carbon flow model used to estimate carbon uptake by planting of forests of Sitka spruce (P. Sitchensis), yield class 12.

	P. sitchensis
Time of maximum mean annual increment (years)	60
Initial spacing (m)	2
First table age	20
Year of first thinning	25
Stemwood density (oven dried tonnes m^{-3})	0.33
Stemwood conversion loss	10%
% Branchwood left in forest	100%
% Branchwood harvested for fuel	0%
% fuel from bark	30%
% non-fuel products from bark	70%
% small roundwood (underbark) used as fuel	20%
% Pallets and fencing from small roundwoood (under bark)	20%
% Paper from small roundwood (under bark)	35%
% Particleboard etc from small roundwood (under bark)	25%
% Fuel from sawlogs (under bark)	30%
% Pallets and fencing from sawlogs (under bark)	0%
% Particleboard from sawlogs (under bark)	40%
% Structural timber from sawlogs (under bark)	30%
Root:Stem ratio	0.49
Crown:Stem ratio	0.32
Underbark/overbark ratio at 15cm DBH (varies with DBH)	0.9
Ratio of thinned stem volume that is sawlog at 15cm DBH (varies with DBH)	0.05

CARBINE includes a module for representing accumulation and loss of carbon in dead wood and litter. Tree mortality is accounted for implicitly in the standard Forestry Commission growth and yield tables (Edwards and Christie, 1981), and explicit estimates are included in models for unthinned stands, where mortality levels are high. The annual deadwood volume estimates need to be accumulated over an appropriate period to give the total stem volume in dead wood for a given stand age, to allow for the time taken for dead trees to decay. In the current version of CARBINE, the carbon in standing dead wood at any time step is calculated as a weighted sum of the carbon in trees that have died in the current year and the preceding 33 years. The weighting function has the exponential form

$$w_D(T) = -0.10554 + 1.10554 \times 0.93148T$$

where $w_D(T)$ is the fraction of dead wood remaining and T is the time in years since the material entered the dead wood pool. If T > 33 years then w(T) is set to zero.

Root and branch wood volume associated with dead trees is estimated in the same way as for living stem wood.

Standing dead wood is regarded as distinct from other forms of dead wood, which effectively form part of the litter pool. An assumption is made that 5% of the carbon in standing dead wood is transferred to the litter pool; implicitly all other losses as standing deadwood degrades involve oxidation of carbon to the atmosphere as CO_2.

The other significant input of carbon to the dead wood and litter pool is due to harvesting operations (as part of either thinning or clearfelling). The carbon in roots of harvested trees is assumed to all enter the litter pool. The harvesting of stem wood is assumed to involve a conversion loss equivalent to 10% of standing stem volume, which also enters the litter pool. It is difficult to make robust assumptions about the fate of branch wood and foliage at time of harvesting. In many situations, this material will be left on site to deteriorate and decay. Sometimes it is possible that branch wood remaining after clearfelling may be deliberately burned. There is also an increasing trend towards active harvesting of branch wood (or at least some proportion of it) to supply biomass to the Energy sector. For this inventory the assumption has been made that none of branch wood is harvested but is left to degrade and decay on site as part of the litter pool.

It is assumed in the CARBINE model that harvested material from thinning and felling is made into wood products. This is described further in **Section 0**. The net change in the carbon in this pool of wood products is reported in Category 5G.

Carbon entering the litter pool is assumed to be transferred to the soil or to be released to the atmosphere as CO_2. Emissions to the atmosphere are assumed to follow a Weibull 'hazard' function, such that 50% of the material has been lost after 20 years and 95% of the material has been lost after 40 years. The Weibull function has the form

$$w_L(T) = \exp(-(T/B)C)$$

where $w_L(T)$ is the fraction of material remaining, T is the time in years since the material entered the litter pool and B and C are constant parameters of the equation. Transfer from the litter pool to soil occurs with 1.6% of the remaining litter being added to the soil carbon pool at each time step.

CARBINE contains a very basic soil sub-model to estimate carbon stocks and stock changes in this pool which runs independently of the forest sub-model. Initial soil carbon is estimated based on land use/cover and soil texture (sand, loam, clay and peat). Changes in soil carbon are assumed to take place in response to land-use change and the magnitude and timecourse are estimated according to soil type (texture) and major land use category. This information is based on RothC, a UK soil carbon model, and published literature (Coleman et al., 1997).The estimates for these soil texture classes are then combined to give estimates for an "organic" and "mineral" soil for conifers. This combination of soil texture classes, and the CARBINE soil carbon model more generally, was parameterised for this inventory to give similar results to the CFlow soil carbon model (UK Greenhouse Gas Inventory, 1990-2011, Annex 3.6).

CARBINE contains a basic soil sub-model to estimate carbon stocks and stock changes in this pool which runs independently of the forest sub-model. Initial soil carbon is estimated based on land use/cover and soil texture (sand, loam, clay and peat). Changes in soil carbon are assumed to take place in response to land-use change and the magnitude and time course are estimated according to soil type (texture) and major land use category. This information is based on RothC, a UK soil carbon model, and published literature (Coleman et al., 1997).The estimates for these soil texture classes are then combined to give estimates for an organic and a mineral soil for conifers. This combination of soil texture classes, and the CARBINE soil carbon model more generally, was parameterised for this inventory to give similar results to the CFlow soil carbon model (UK Greenhouse Gas Inventory, 1990-2011, Annex 3.6).

Wood products are represented as long-lived and short-lived sawn timber, particleboard and paper. Carbon in harvested stemwood is allocated to these wood product categories using an assortment forecasting model that accounts for variation in product out-turn due to tree species and tree size class distribution at time of harvest (Rollinson and Gay, 1983). Wood products in primary use are assumed to decay over time with no account taken of carbon stocks in landfill or greenhouse gas emissions (due to wood products) from landfill. Further discussion of how the CARBINE output for harvested wood products is included in the inventory is given in **Section 0**)

The forest data for the inventory have been estimated by using data from the Forestry Commission planting statistics and the National Inventory of Woodlands and Trees. In order to assign species and growth rates to forest in the UK we used information from the subcompartment database (the Forestry Commission database of information on the growth rate and management of all GB public forest estate; see **Section 7.2.4**) on the species and growth rates of forests in the public forest estate to create a distribution of species and yield class. It was assumed that the private sector forests would follow the same distribution.

Management of forests are represented as one of four options: Clearfell with thinnnings, clearfell without thinnings, managed but not clearfelled and not used for timber production. The forests used for timber production also have a rotation length assigned. For the clearfell forests restocking occurs after the rotation length. For non-clearfell productive woodlands it is assumed there is a 30 year overlap of restocking and non-restocked trees. It was assumed that the private sector distribution of managed forests between clearfell with thinnings, without thinnings and non-clearfell would follow the same pattern as for the public forest estate. The percentage of private sector woodlands that are not managed for timber production was estimated separately for conifer and broadleaves using information from the woodland grant scheme (to give areas definitely in production) and comparing the CARBINE timber production estimates to the timber production statistics

The rotation lengths are based on the time of maximum mean annual stem volume increment. A range of rotations lengths were generated around this value to even out felling events. An assumption was also made that managed Sitka spruce that was not thinned would be on a considerably shorter rotation. The most likely reason for managed Sitka spruce not being thinned would be the threat of windblow, as this was widely planted on upland sites. This was necessary for the algorithm to be able to successfully assign areas of forest to planting years.

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 2005 and have now started to decrease gradually, reflecting the reduction in afforestation rate after the 1970s. This afforestation is all on ground that has not been wooded for many decades.

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 census (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). 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). For this inventory submission the assumption was made that any forest area in the inventory planted post-1920 that is not in the new planting record must be restocking. Forests planted pre-1920 were assumed to have been on land that has been forest since time immemorial. In both cases the forest area was assumed to have been restocked twice and had been managed in the same fashion and on the same rotation. The only exception to this was where the data indicated that some of the forest area that had been felled at some point in the past was no longer utilised for timber production. The assumption was made that forest had previously been felled on a rotation that felled at the time of maximum mean annual increment.

Where areas of new planting for a year are greater than the area implied by the inventory as still standing, it was assumed to have been restocked. This gave an indication of the maximum length of some of the rotations that had been applied. As an example, if the area in the inventory for 35 years before the base year is 2kha and the new planting record indicates that 3kha were afforested that year, then 1kha of the new planting must have been restocked. The rotation length for this area must also be a maximum of 35 years, otherwise it would not have been felled.

The planting data used as input to the CARBINE model comes from both planting statistics and estimates of historical planting year. National planting statistics from 1921 to the present are provided by the Forestry Commission for England, Scotland and Wales and from 1900 to the present by the Northern Ireland Forest Service. For the purposes of this inventory we assumed that the National Inventory of Woodlands and Trees survey gives a distribution of all the forest area by broad age classes for a base year of 2000, separately for conifers and broadleaves for England, Scotland and Wales. To obtain the area of woodland planted pre-1920 it was necessary to create an algorithm to remove the area of new planting from the age class distribution. The species were then allocated to this “residual distribution’ by starting in the base year of 2000 and allocating the shortest rotations first. For all the UK countries the new planting records was assigned based on the percentage of area previous allocated to each species and management. Conifer planting on organic soil is a subset of total conifer planting. All broadleaf planting is assumed to be on non-organic soil. The afforestation rates for each planting type in the UK have been calculated from the planting data and are shown in **Table A 3.6.2.**

Table A 3.6.2 Afforestation rate of conifers and broadleaves in the United Kingdom since 1500

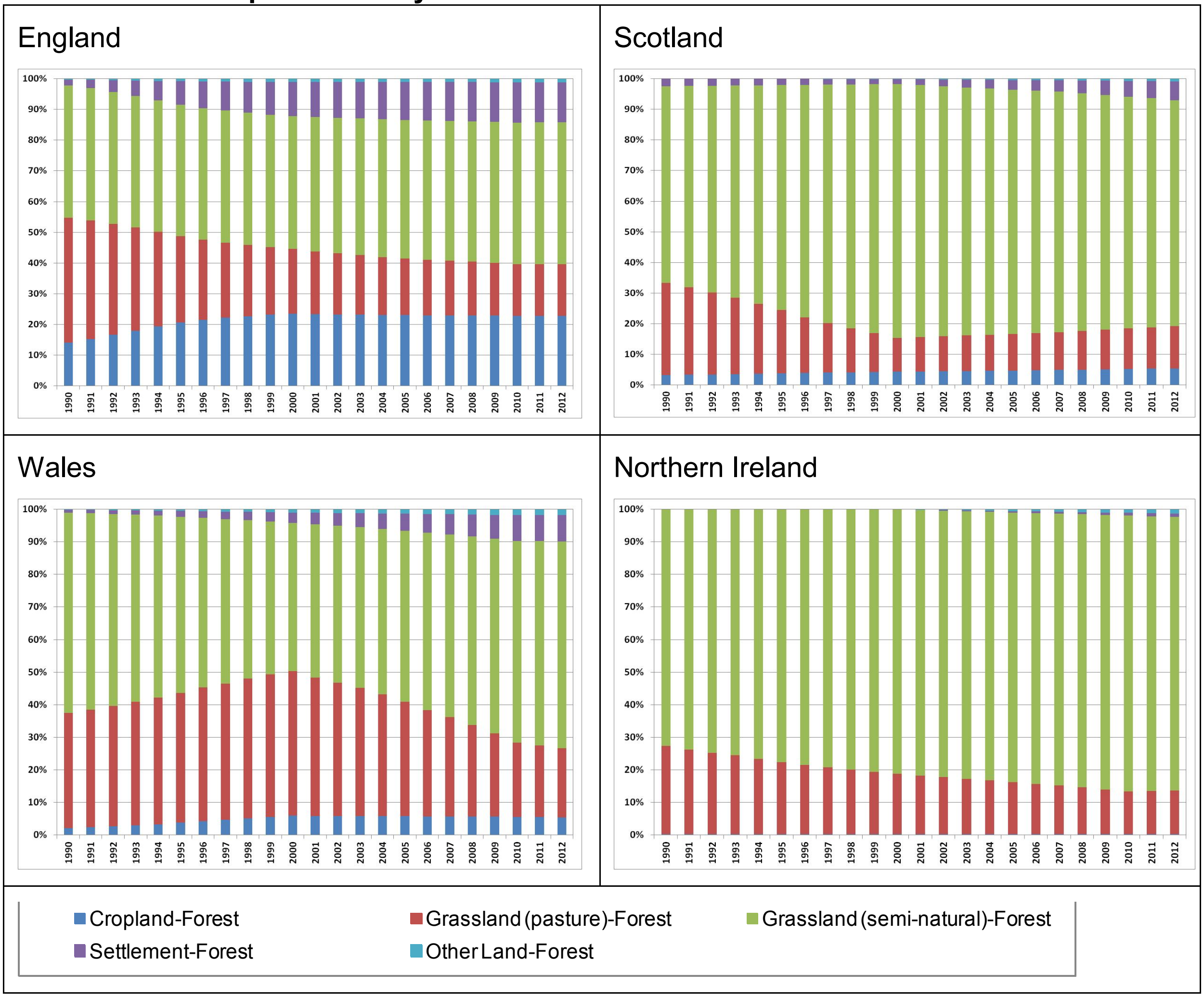
Period	Planting rate (k ha a^{-1})		
	Conifers on all soil types	Conifers on organic soil	Broadleaves
1501-1600	0.01	0.00	0.00
1601-1700	0.14	0.00	0.41
1701-1750	0.50	0.00	3.48
1751-1800	0.91	0.00	6.24
1801-1850	1.04	0.00	2.53
1851-1900	0.87	0.00	1.91
1901-1910	0.58	0.00	0.79
1911-1920	0.34	0.00	0.25
1921-1930	5.45	0.53	2.44
1931-1940	7.46	0.73	2.13
1941-1950	7.43	0.91	2.22
1951-1960	21.66	3.29	3.09
1961-1970	30.08	5.57	2.55
1971-1980	31.92	6.94	1.12

Period	Planting rate (k ha a^{-1})		
1981-1990	22.69	5.31	2.12
1991	13.46	6.54	13.69
1992	11.56	5.51	13.20
1993	10.08	4.94	18.16
1994	7.39	3.67	22.69
1995	9.45	4.38	21.60
1996	7.42	3.56	18.51
1997	7.72	3.50	19.75
1998	6.98	2.99	19.85
1999	6.63	2.77	20.72
2000	6.52	2.63	22.74
2001	4.90	1.89	27.68
2002	3.89	1.46	21.01
2003	3.75	1.38	19.87
2004	2.92	1.08	18.88
2005	2.10	0.70	19.74
2006	1.14	0.38	15.32
2007	2.13	0.66	17.38
2008	0.85	0.28	13.33
2009	1.21	0.34	10.44
2010	0.54	0.13	9.80
2011	1.55	0.37	13.28
2012	3.45	0.92	18.49

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 *et al.* 2012). This work is described in **Section A3.6.1.3**.

The CARBINE model output was post-processed using 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 1990-2012



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.

The CARBINE model has not yet been implemented for forest in the Isle of Man and Guernsey (Crown Dependencies of the UK) and instead the CFlow model is used as it was in previous submissions (UK Greenhouse Gas Inventory, 1990-2011, Annex 3.6).

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 CARBINE model (see **Table A 3.6.2**) for 5.A.2. Land converted to Forest land.

Where fertilisation occurs, 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 Estimates of forest planting on organic soils and N_2O emissions from drainage on forest soils

Work on developing this method was undertaken by Forest Research in 2012 (Yamulki *et al.* 2012), using new GIS data on forest planting in England, Wales and Scotland. Comparable data were 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 Digitised mapping by Forestry Commission soil surveyors	Scottish soil map (SSofS, 1984) Soil maps created priori to afforestation using the FC soil classification system
Forest Cover		
England, Scotland &Wales		National Forest Inventory woodlands map, Whitton, 2011

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%.

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.

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

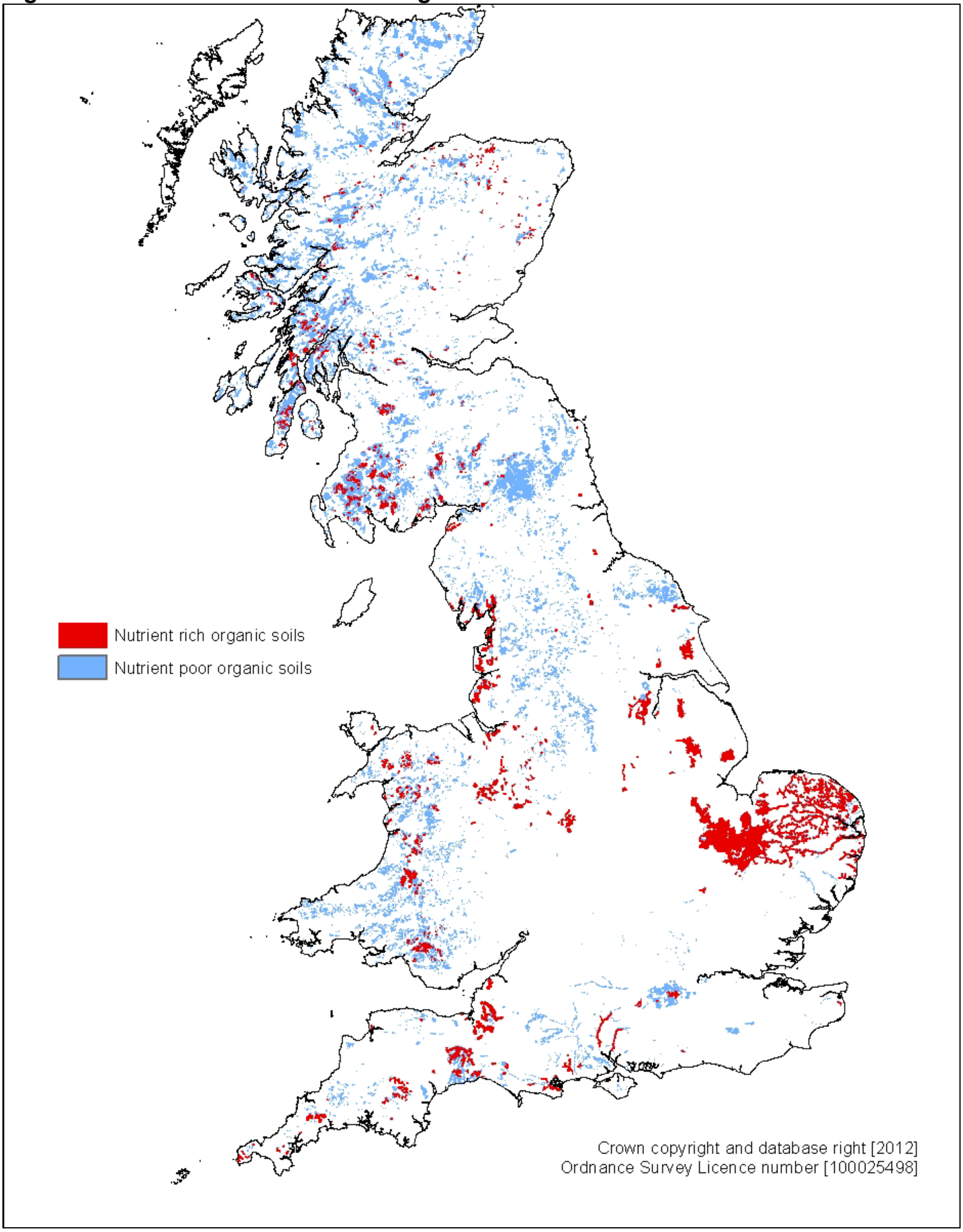


Table A 3.6.5 Areas (kha) of forest cover on mineral, organic nutrient rich and organic nutrient poor soils in Scotland, Wales and England.

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.

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 policy 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 policy was followed.

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

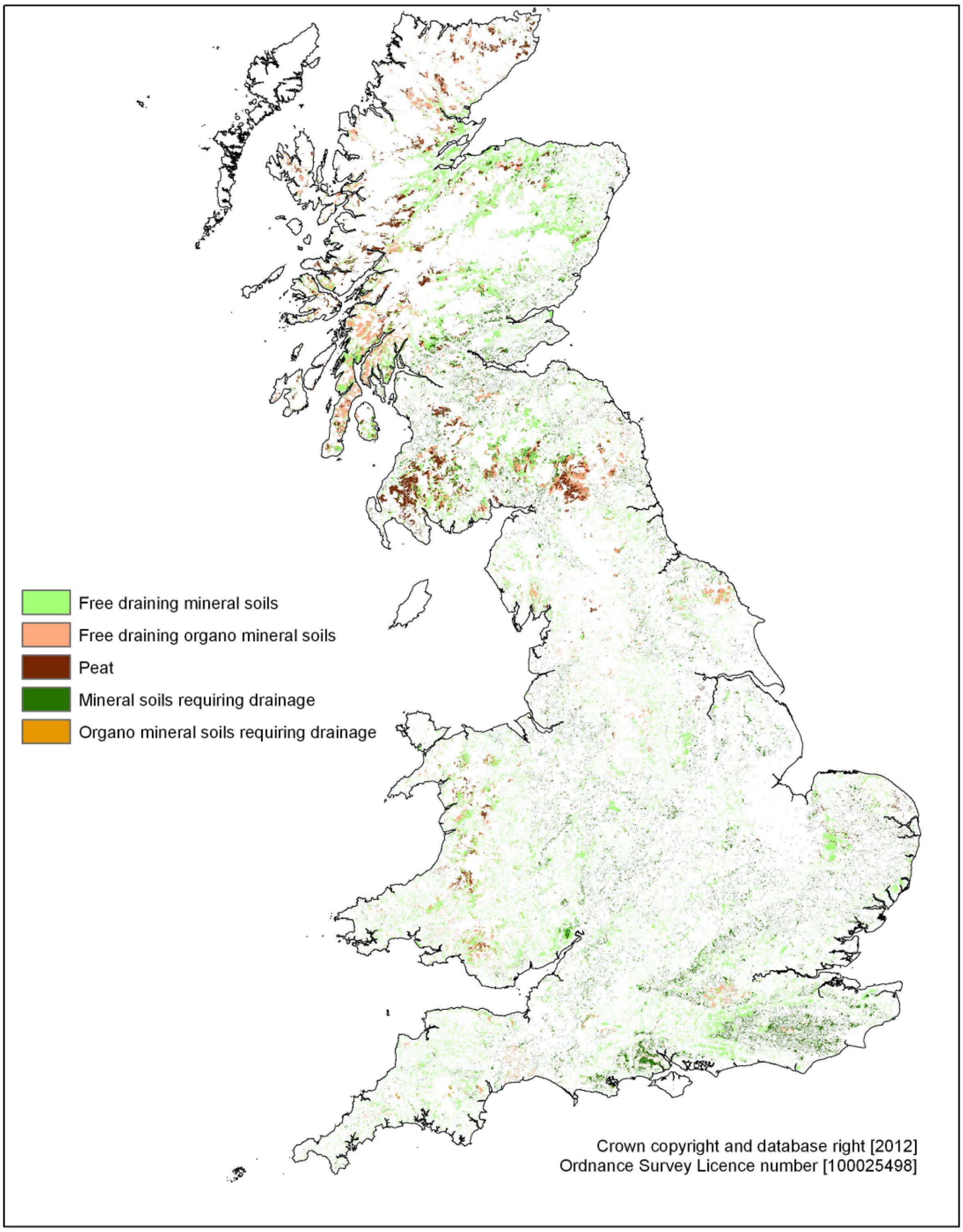
- **Impeded soils**
  - Man-made soils
  - Ironpan soils
  - Ironpan on induration
  - Indurated gley soils
- **Impervious soils**
  - Brown earths with slight gleying
  - Man-made soils (clayey)
  - Surface water gleys
  - Brown gley
  - Peaty gleys
  - Podzolic gleys
  - Groundwater gleys

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

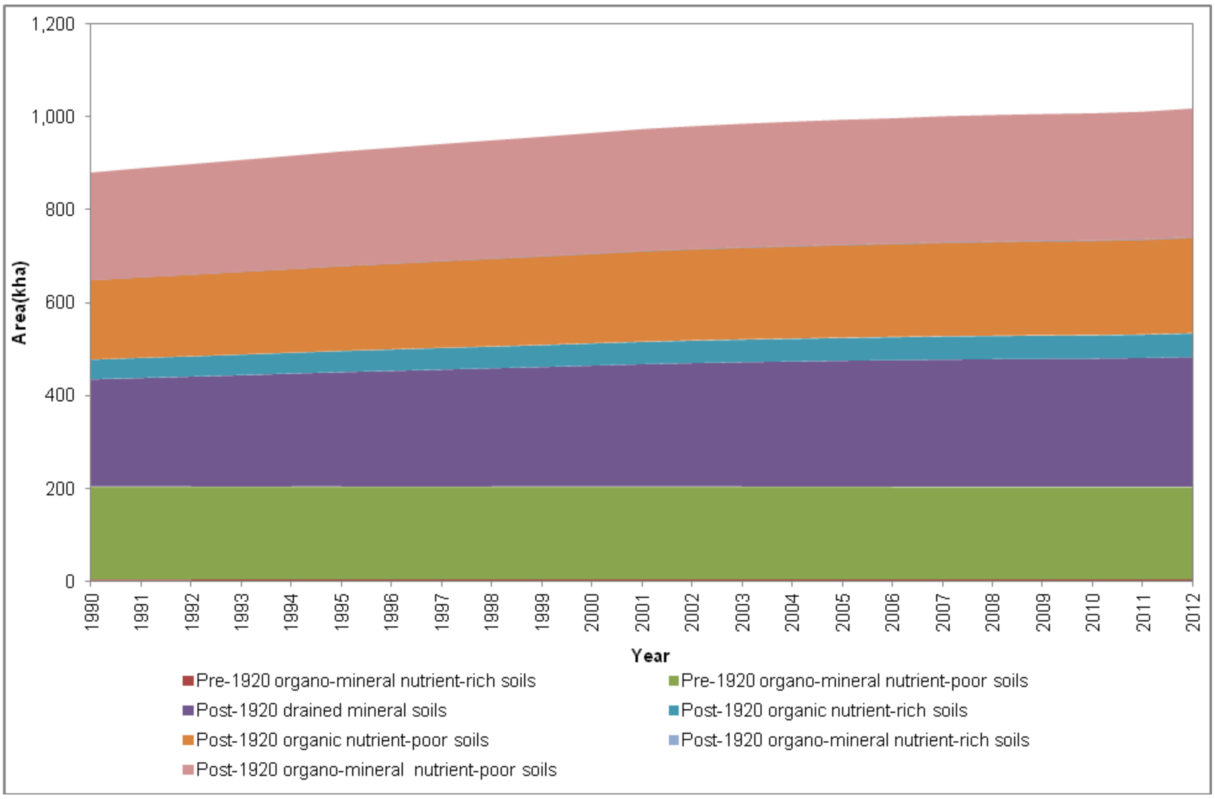
* We assumed that all forest areas on soils classed as 'Water' in the national soil map are on undrained mineral soils.

Figure A 3.6.3 Extent of forest drainage



For inventory reporting it is assumed that no forest planting occurred on organic soils or mineral soils requiring drainage before 1920. Forest areas (as reported in the CRF) are 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 are 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, 1990-2012



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*. 2009) 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 Guidance for Agriculture, Forestry and Other Land Uses (IPCC 2006) 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			

CROPLAND	GRASSLAND	FORESTLAND	SETTLEMENTS (URBAN)	OTHER
	Bogs			
	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 1990-2012 is given in **Table 7.1** in **Section 7.1.1**.

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
2008-2012	*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.

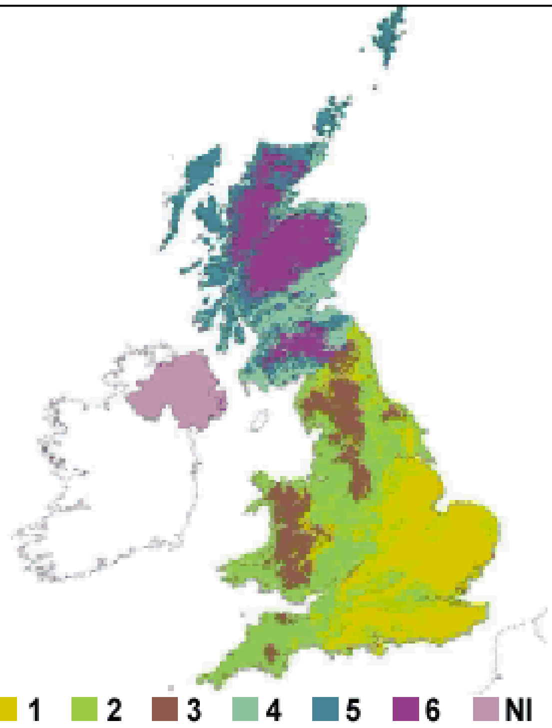
Year or Period	Method	Change matrix data
1950 – 1969	Extrapolation and ratio method	NICS1990->NICS1998
1970 – 1989	Land use areas and ratio method	NICS1990->NICS1998
1990 – 1998	Measured LUC matrix	NICS1990->NICS1998
1999-2007	Measured LUC matrix	NICS1998->NICS2007
2008-2012	*Extrapolated*	NICS1998->NICS2007

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. **Table A 3.6.11** 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-Table** A 3.6.15.

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 3.6.17**.

Table A 3.6.16 Rates of change of soil carbon for land use change transitions.

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

("Fast" & "Slow" refer to 99% of change occurring in times shown in **Table A 3.6.17**)

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 CARBINE 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 1990-2012 inventory use 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) and the 1990-2012 inventory uses the same model results as the 1990-2011 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 other than Forest is assigned by expert judgement based on the work of Milne and Brown (1997) and these are shown in **Table A 3.6.18**. Five basic land uses were assigned initial biomass carbon densities, and then the relative occurrences of these land uses in the four countries of the UK were used to calculate mean densities for each of the IPCC types, Cropland, Grassland and Settlements.

Living biomass carbon stocks and Dead Organic Matter (DOM) stocks on Forest Land are modelled using CARBINE and used to calculate changes in carbon stocks due to conversions to and from Forest Land. When land which is deforested to another land use, it is assumed that all living biomass and DOM is either converted to Harvested Wood Products or burnt on site in the year in which deforestation takes place. Increase in biomass carbon and DOM stocks on afforested land is modelled in CARBINE. Full details of CARBINE modelling of carbon stocks on Forest Land are given in **Annex Section A3.6.1.1.**

The mean biomass carbon densities for each land type were further weighted by the relative proportions of change occurring between non-Forest land types (**Table A 3.6.19-Table A 3.6.22),** 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

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

(Transitions to and from Forestland are considered elsewhere)

Table A 3.6.20 Weighted average change in equilibrium biomass carbon density (kg m^{-2}) for changes between different land types in Scotland.

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

(Transitions to and from Forestland are considered elsewhere)

Table A 3.6.21 Weighted average change in equilibrium biomass carbon density (kg m^{-2}) for changes between different land types in Wales.

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

(Transitions to and from Forestland are considered elsewhere)

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.

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

(Transitions to and from Forestland are considered elsewhere)

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. Their 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 **A3.6.2**.

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 yr $^{-1}$ 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 Forest 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 A3.6.2.1**) 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 Forest conversion compared with the extent estimated by the Forestry Commission. This is due to differences in Forest definitions, amongst other causes.

In order to improve the estimation of deforestation known to be occurring, the deforestation estimates from 2000 onwards were updated for this inventory submission using expert opinion from representatives of the devolved administrations (Forestry Commission and Natural Resources Wales).

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 Forest 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.

Table A 3.6.23 Countryside Survey data for Forest 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	Forest to Natural Grassland	5.600	4.418	1.099	0.171	0.61	0.86	0.72
	Forest to Pasture Grassland	3.081	0.608	0.418	0.086	0.33	0.14	0.28
	Forest to Cropland	0.545	0.097	0.019	0.008	0.06	0.00	0.00
	Forest to Settlements	1.242	0.293	0.132	0.072			
	Forest to Other Land	0.169	0.231	0.058	0.025			
1999-2007	Forest to Natural Grassland	2.656	10.327	0.120	0.209	0.86	0.98	0.42
	Forest to Pasture Grassland	0.277	0.186	0.162	0.102	0.09	0.02	0.58
	Forest to Cropland	0.141	0.006	0.001	0.001	0.05	0.00	0.00
	Forests to Settlements	0.617	0.098	0.095	0.142			
	Forest to Other Land	0.430	0.695	0.374	0.027			

[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

Table A 3.6.24 "Discounted" Forest 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]

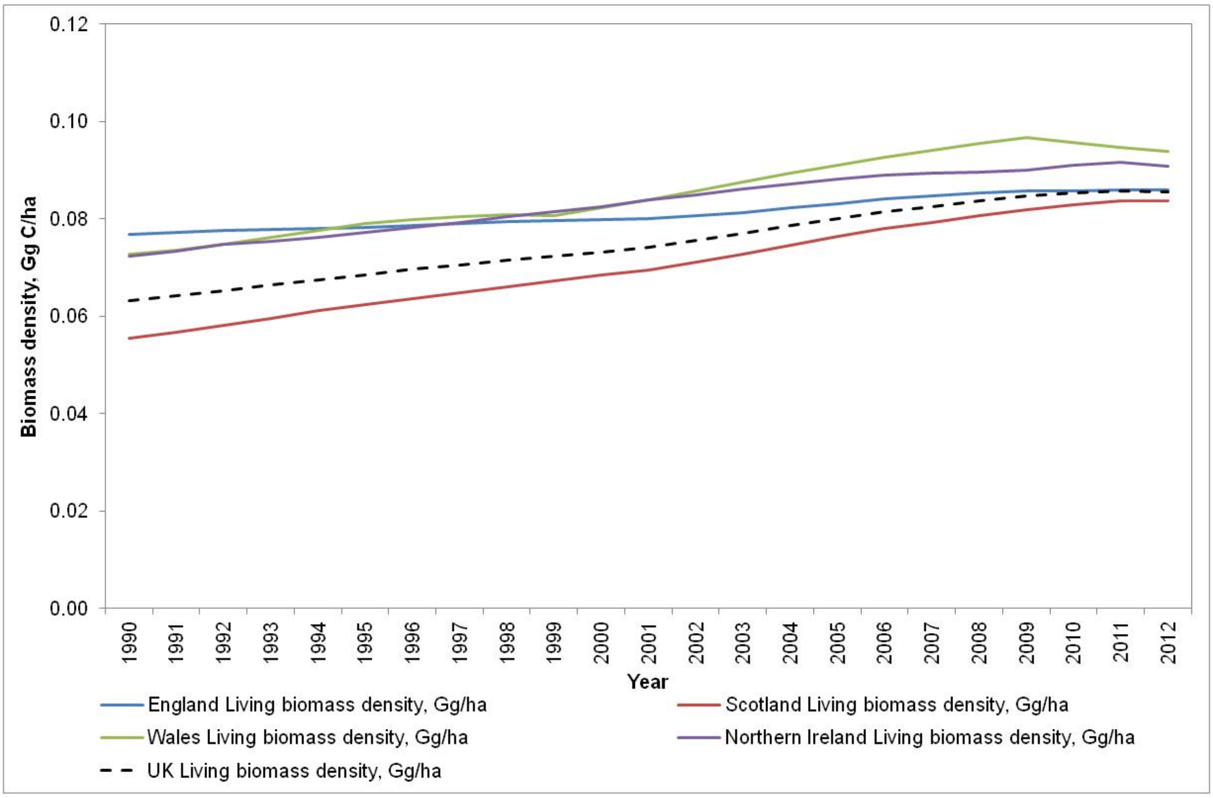
[a] Unconditional felling licence data used for "discounting"
[b] Land Use Change Statistics used for "discounting"
[c] England discount ratio used
[d] Wales discount ratio used

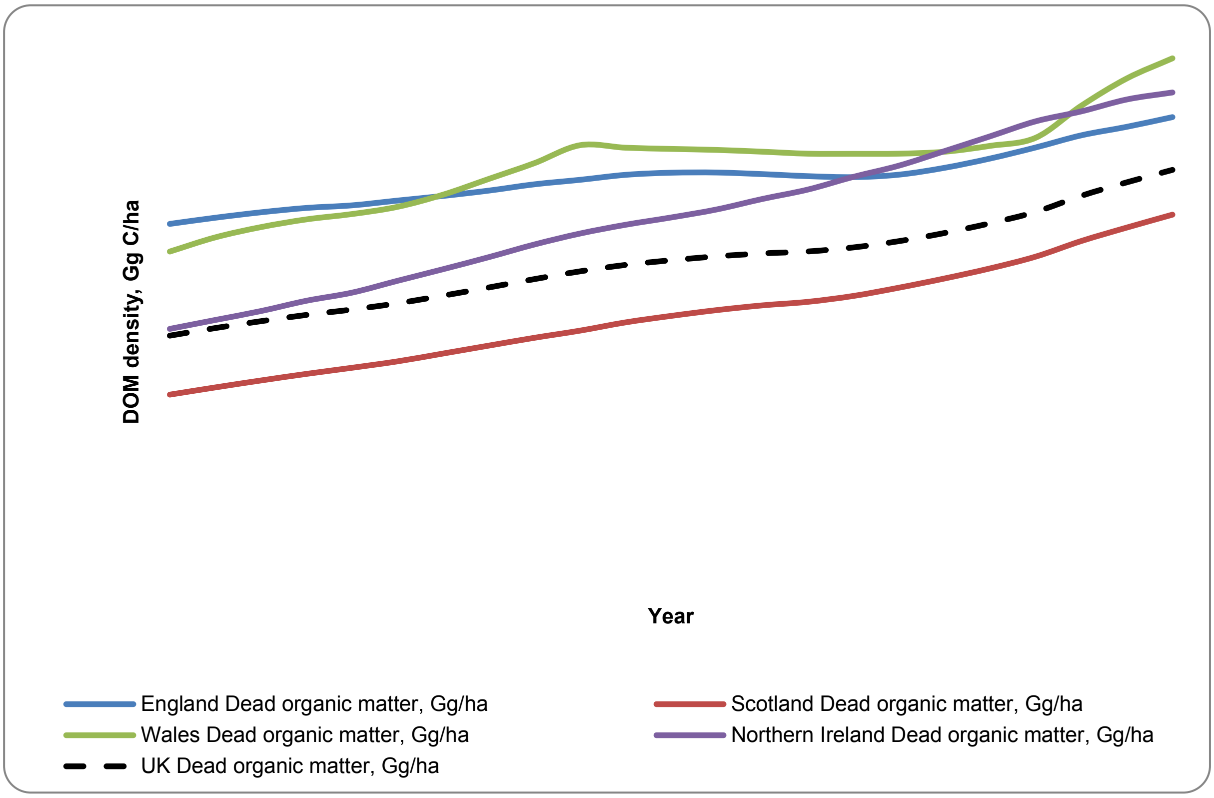
A3.6.4.3 Estimation of emissions

Soil carbon stock changes are estimated using the dynamic soil carbon model described in section A.3.6.2. When deforestation occurs it is assumed that 60% of the standing biomass is removed as timber products and the remainder is burnt. Country-specific forest biomass densities for living and dead organic matter from CARBINE are used (**Figure A 3.6.6**). 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 CARBINE to model emission from HWP (described in **Section 0**).

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, 1990-2012. Living densities (top) and dead organic matter – litter and dead wood (bottom).





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

A3.6.5.1 Activity dataset

Until 2010 only wildfires on Forest land were reported due to a lack of activity data for wildfires on other land use categories. Data on Forest wildfires prior to 2010 come from the Forestry Commission and the Forest Service of Northern Ireland.

In 2010 the Fire and Rescue Service began recording wildfires in England, Scotland and Wales on a new Incidence and Reporting Systems (IRS) which includes wildfires on all land use categories To provide data on non-Forest wildfires prior to 2010, thermal anomaly data for 2010 from the NASA-operated MODerate Resolution Imaging Spectroradiometer (MODIS) was from the Fire Information Resource Management System (FIRMS) and allocated to land uses using the proportions of fire on each land use type from the Fire and Rescue Service IRS data. The smallest thermal anomaly which can be reliably detected by MODIS is 25 ha, so for consistency a 25 ha threshold was set for reporting wildfires logged on the IRS.

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 84% of the wildfire-burnt area in England, 94% in Scotland and 66% in Wales. The

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 the IRS land type classification suggests that they occur on grassy areas within Settlements and there is not a separate reporting field for wildfires in Settlements in the CRF.

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

LULUCF sub-category	Forest	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

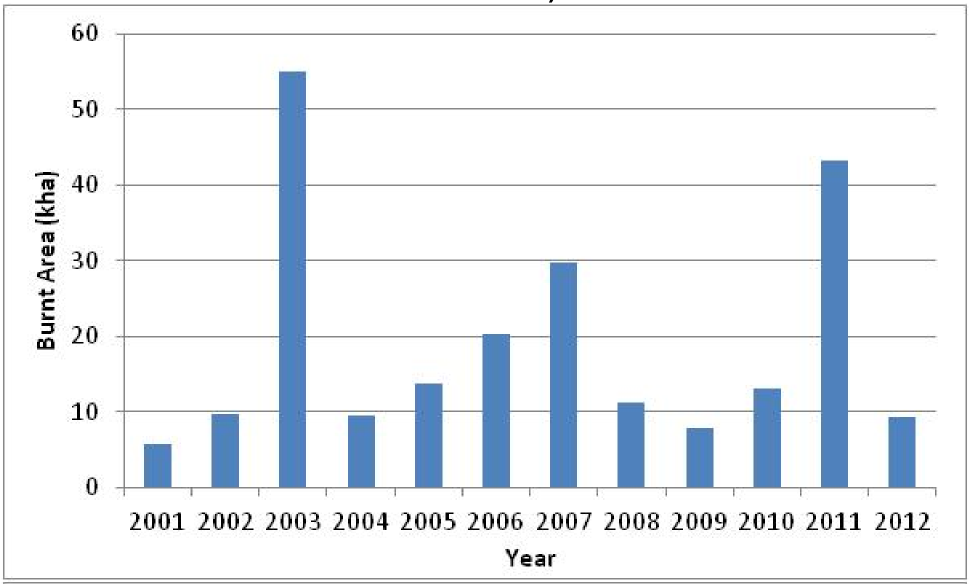
A time series of wildfire-burnt areas for each non-forest land use type was constructed for 1990-2011 (**Figure A 3.6.8**). For non-forest wildfires for England, Scotland and Wales the IRS burnt areas were used for 2010-2011 and the burnt area estimated from thermal anomalies (using equation 1). For 1990-2000 the average annual burnt area 2001-2011 was used.

In Northern Ireland, where no IRS data were available, it was assumed that the heathland and grassland burning rates were in the same proportions as the Scottish burning rates, using the area of heathland and grassland from the 2007 Northern Ireland Countryside Survey.

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 proportion of private-owned forest that was burnt each year was assumed to be the same as the percentage of the state forest that was burnt each year.

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 does 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 area of FIRMS thermal anomalies for GB for 2001-2012 (thermal anomalies were filtered to exclude those recorded over urban/industrial areas).



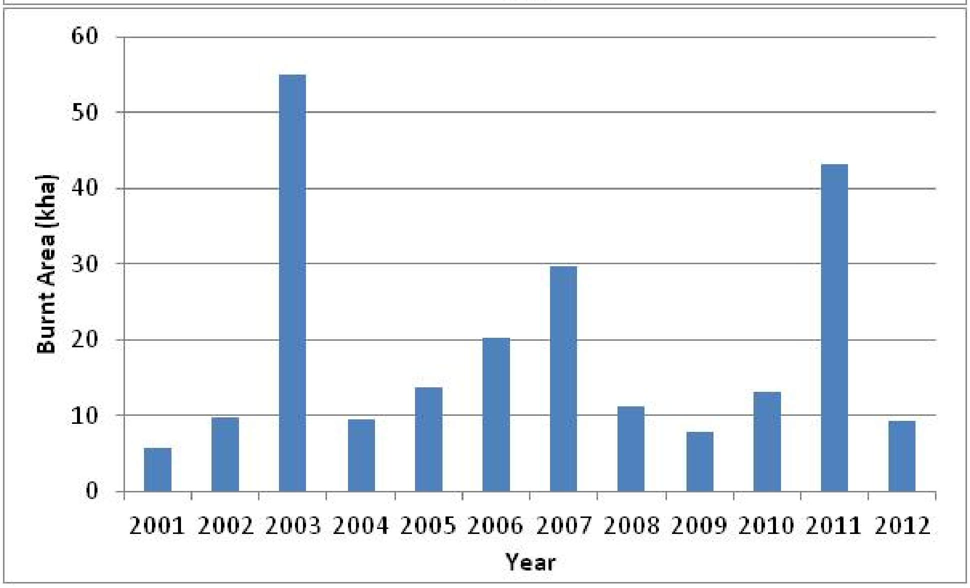
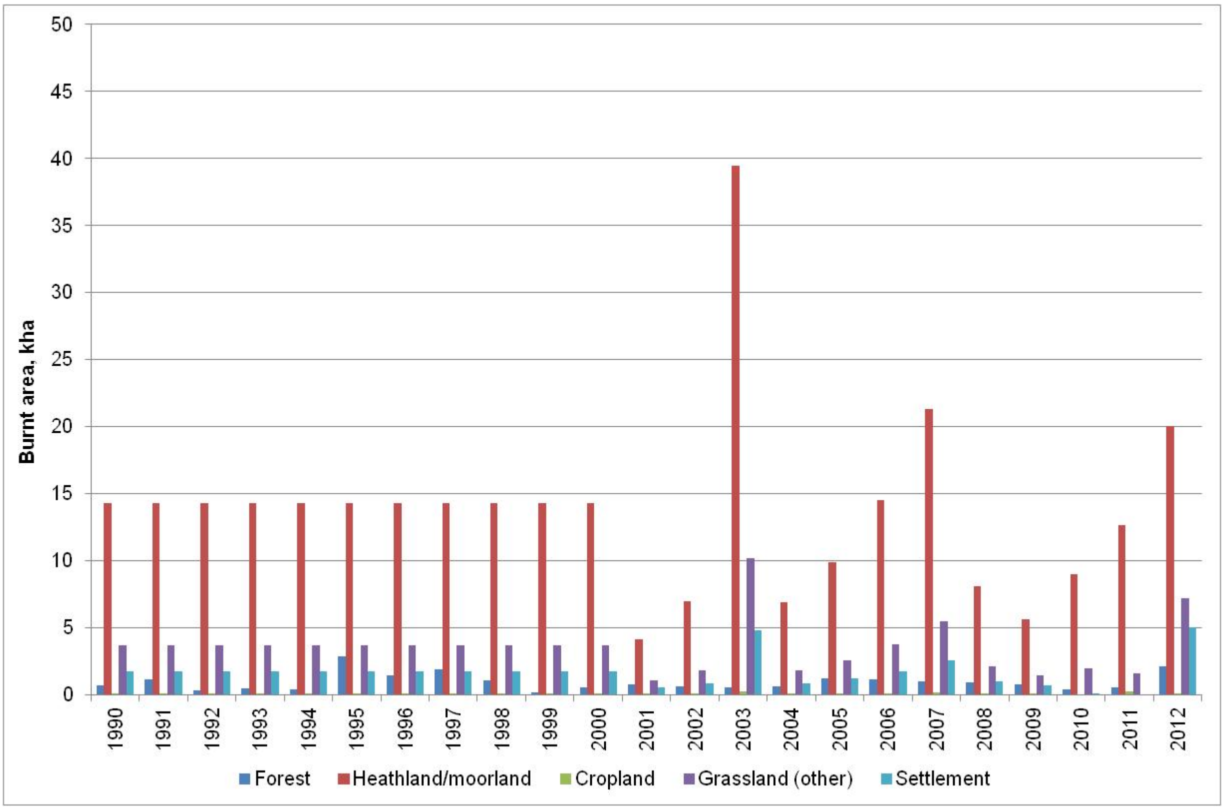
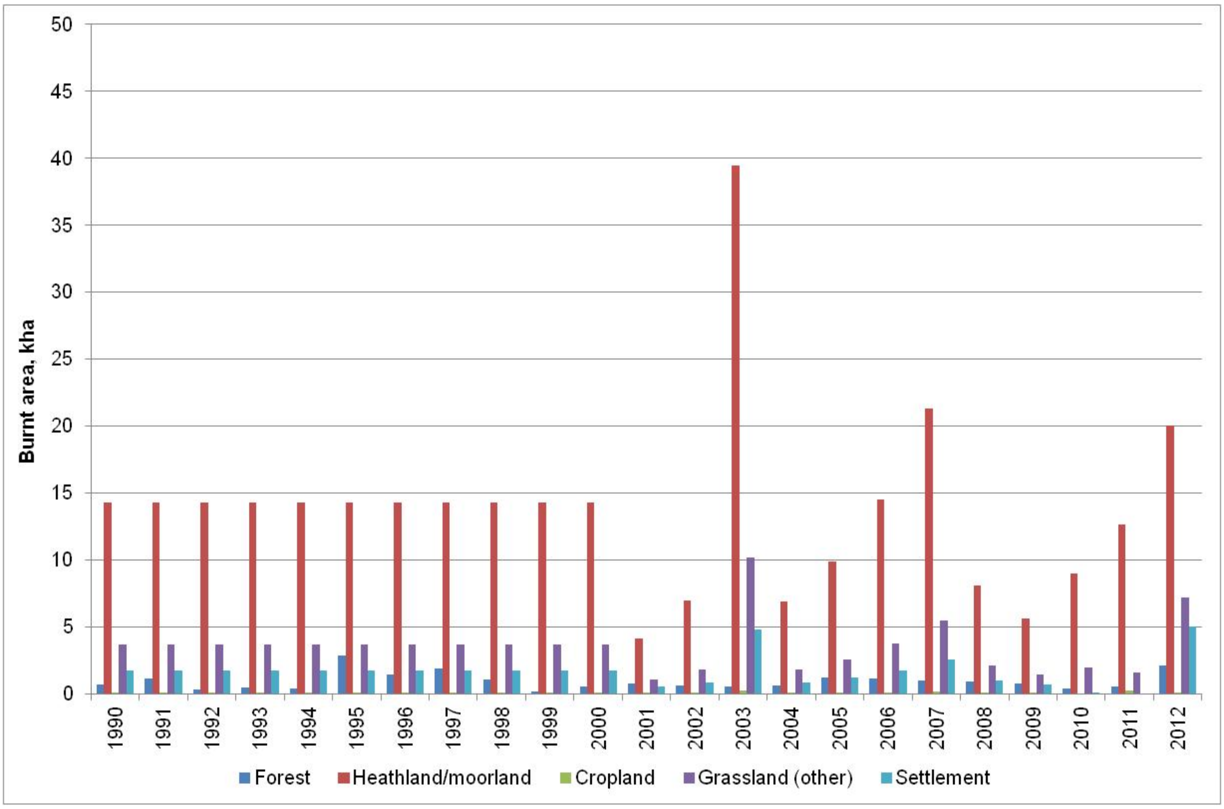


Figure A 3.6.7 shows the temporal pattern of FIRMS thermal anomalies, with peaks in hot dry years such as 2003. The FIRMS data used only includes thermal anomalies for March – August for each year, only March –August were used as these are the months where the IRS database recorded fires greater than 25ha. Some FIRMS thermal anomalies were recorded outwith these months due to FIRMS detecting both controlled burns and some fires less than 25ha in size which are not included in the IRS data.

Figure A 3.6.8 Time series of wildfire burnt areas in the UK 1990-2012





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.

As more IRS data becomes available it will be possible to increase confidence in the relationship between fires detected by FIRMS and fires of 25ha logged in the IRS. This may allow FIRMS data to be extrapolated to fires covering less than 25 ha the inventory in future. However, there would need to be reasonable confidence that the ratio of large to small fires used was valid and also some investigation of whether the distribution of small fires across land use classes was the same as that of larger fires.

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 savannah and grassland EFS for other grassland and settlements.

Country-specific biomass and Dead Organic Matter densities from the CARBINE model 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 2013b) (available from 1994, sourced from BGS for 1990-1994). 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 2013b) 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 and an estimate has been included for the first time in the 1990-2012 inventory 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 2012). 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 2012). The annual percentages of arable and grassland areas receiving lime in Great Britain for 1994-2012 were obtained from the Fertiliser Statistics Report (Agricultural Industries Confederation

2006), and the British Survey of Fertiliser Practice (BSFP 2012). 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 2011 figures were used for 2012.

In the 1990-2012 inventory, an estimate for LimeX data was added following 2012 UNFCCC Review. LimeX is a by-product of sugar production, sold to farmers as liming and therefore not included in BGS data on quarried liming products. As the timeseries is commercially confidential, so an approximate annual as value quoted on British Sugar website was added to the timeseries. LimeX is made up of two products of different limestone content and the median value of these was used to calculate tonnages, as data on quantities of each sold is confidential.

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 2006 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	$24 \times 10^7\ m^2$ (24,000 ha)	21%	480	0.0127	307	1280
'Thin' peat	$126 \times 10^7\ m^2$ (126,000 ha)	12%	480	0.0019	138	109
Total	**$150 \times 10^7\ m^2$ (150 kha)**				**445**	**297**

The emissions trend 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 follows an exponential decay and 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 soil 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 2012 was assumed to be the same as that for 2008-2011.

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	

End use	Method	Area in 1990-1991, ha	Area in 2007-2008, ha
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**). This method was repeated to check for updates to the data in 2013 for the 1990-2012 inventory and no changes to extraction site status or updated imagery were found since the 2010 data. 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 2013b). 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, m^3 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

Year	England		Scotland	
	Horticultural	Fuel	Horticultural	Fuel
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	41,000	243,000	21,000
2009	476,000	0	390,000	21,000
2010	456,000	1,000	527,000	21,000
2011	429,000	0	369,000	26,000
2012*	429,000	0	369,000	0

* The latest statistics were not published in time for inclusion in this submission, so the volumes for 2012 were carried forward from 2011

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 (Thomson et al, 2011). 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. CARBINE then applies a forest management regime as given in input to the model. 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.

At thinning and harvest, the CARBINE model allocates merchantable stem volume to various wood products, while the remainder is transferred to the waste pool. The 'end-use' wood products represented are:

- Long-lived sawn timber
- Short-lived sawn timber
- Particleboard
- Paper.

During wood processing, conversion losses are assumed and enter the waste stream and decay within a year. The amount of carbon allocated to the raw stemwood product, categories of each of the wood products is estimated by first inputting the merchantable stem carbon derived from the forest yield model to a stand volume assortment forecasting model which estimates the volume allocated to sawn timber, roundwood and waste. This is implemented in CARBINE as a set of functions derived from the output of a more general and flexible assortment forecasting program known as ASORT (Rollinson and Gay, 1983). Having allocated some of the stem carbon to sawn timber, roundwood and waste, fractions of the first two categories are further allocated, in different proportions, to the four 'end-use' wood product categories specified above. The proportions differ depending on the species harvested. This information is based on expert opinion rather than data or scientific research. A carbon retention curve is used to estimate product decay and return of carbon to the atmosphere. Each wood product category has its own carbon retention curve based on estimated service lives, taking into account not just the decay rate of wood products but the service life as influenced by socio-economic factors. The functions are used to calculate the amount of carbon retained in wood products in successive years after harvest. CARBINE does not include a compartment which represents the carbon dynamics of wood products disposed of to landfill.

Timber produced as a result of Forest conversion to Cropland, Grassland or Settlement is also added to the HWP pool. Changes in carbon stocks are estimated using CARBINE and all products are assumed to decay in the year of deforestation.

CARBINE assumes that any harvested wood products make a contribution that is additional to current consumption. In reality, it is likely that some products manufactured will merely replace other wood products, hence there may be less change in carbon stocks than is predicted by the models. How long the model continues to overestimate stocks will be affected by product service lives and the period over which the model is run.

The CARBINE method follows the Production Approach to HWP accounting described in the IPCC Guidelines (2006) .

According to this method the total HWP pool from UK forests has been gradually increasing since 1990, driven by historical expansion of the forest area and the resulting history of production harvesting (and thinning).

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 2012 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, for information on CFlow model please refer to 1990-2011 NIR).The assumptions and factors used for the estimation of emissions are given in **Table A 3.6.31** and **Table A** 3.6.32. 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 until 2011

Territory	LULUCF category	Time period	Reference
	5E	1991-1994	Isle of Man Ecological Habitat Survey, Phase 1 Report (Sayle et al, 1995)
Guernsey	5A	1990-2010	FAO Global Forest Resources Assessment 2010: Guernsey
	5A, 5B, 5C, 5E	1998/9, 2005, 2010	Guernsey Habitat Survey Sustainable Guernsey 2005, 2009, Guernsey Facts and Figures 2011
Jersey	5A	1990-2010	FAO Global Forest Resources Assessment 2010: Jersey
	5A, 5B, 5C, 5E	2006, 2008-2012	Jersey In Figures 2006/2008/2009/2010/2011/2012
Falkland Islands	5A	1990-2011	Department of Mineral Resources, personal communication FAO Global Forest Resources Assessment 2010: Falkland Islands
	5B, 5C	1991-2012	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	Default EF = 12% tC/t limestone applied, application rate 0.28 t/ha	Default EF = 12% tC/t limestone applied. Average 0.116 t/ha	No liming

Land Use category	Sub-category	Isle of Man	Guernsey	Jersey	Falkland Islands
		applied to cropland and improved grassland	for cropland	lime applied to cropland	
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)
	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	Default . SOC = 95	Default . SOC = 95	N/A

Land Use category	Sub-category	Isle of Man	Guernsey	Jersey	Falkland Islands
		tC/ha, assume conversion from cropland, no change due to change from other land	tC/ha, assume conversion from settlement, assume same soil C as for cropland	tC/ha, assume conversion from cropland, no change due to change from other land	
	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
	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

Land Use category	Sub-category	Isle of Man	Guernsey	Jersey	Falkland Islands
	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

In the 1990-2012 inventory there has been methodological improvement in the categorisation of Grassland and Other Land for the Crown Dependencies of the Isle of Man and Jersey and the Overseas Territory of the Falkland Islands.

Previous LULUCF inventories classified uncategorised land as Other Land, however in line with UNFCCC Review recommendations for UK land use this is now classed as Grassland. This change in land use classification has caused a change in emissions trend for these countries, as Grassland has soil carbon stocks which can be released when land is converted to Cropland or Settlement whereas Other Land does not.

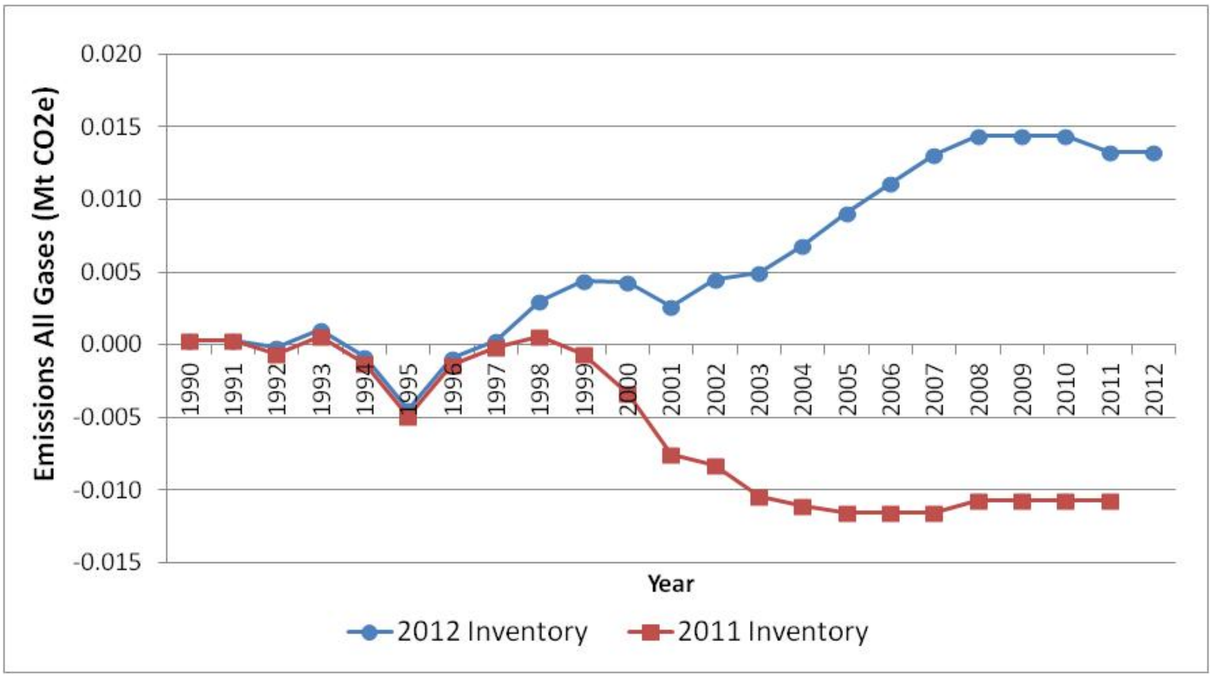
Emissions from the Isle of Man, Jersey and the Falklands now follow a similar trend to Guernsey data, which are based on a full Habitat Survey with no Other land. This is an improvement to previous estimates, however estimates continue to have high uncertainty and may not capture all relevant activities.

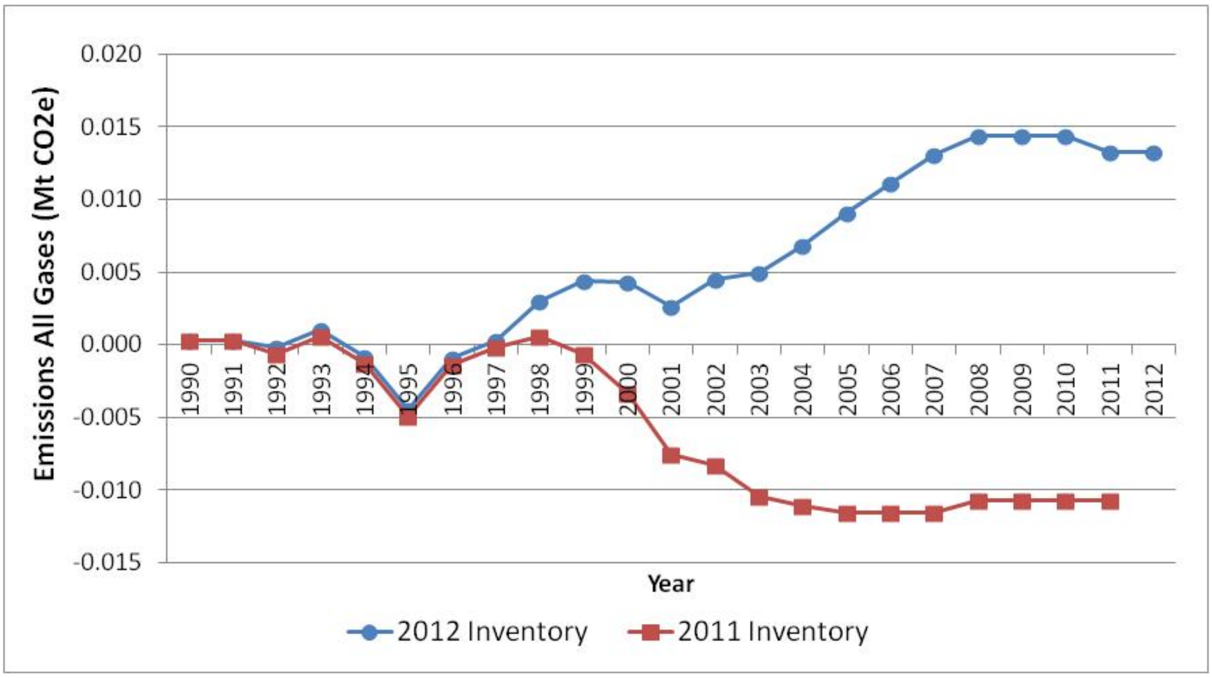
For Jersey, net emissions of GHGs from LULUCF were updated for the 1990 to 2012 inventory, using updated activity data, and ensuring the Tier 1 methodology was applied consistently. For Grassland area the timeseries trend is identical but there is a small increase in total area which is consistent with change from use of Other Land as a buffer to use of

Grassland as a buffer. There has been no change to the Cropland area timeseries. For Settlement area there was a step change in 2007-2008 values, which has now been removed by use of linear interpolation. This now consistent with methodology applied to the UK for LULUCF. This results in a change in the emissions trend from 1997 from becoming a sink to becoming a source and increasing to a peak in 2008-2010 (**This is because** the previous categorisation as Other Land past inventories recorded no emissions from Settlement creation, as new Settlement was established on Other land which has no soil carbon, therefore no soil carbon losses were recorded for Land converted to Settlement in Jersey, and Settlement creation appeared to act as a small sink because of the carbon stocks in Settlement soils. The revised classification of unassigned land as Grassland means that it is now deemed to have stocks of soil carbon which are released when the land is converted to Settlement. The revised emissions timeseries shows a trend of increasing emissions resulting from Grassland to Settlement conversion. In previous inventories, this trend was masked because no carbon stocks are released when Other Land is converted to Settlement.Figure A 3.6.9).

This is because the previous categorisation as Other Land past inventories recorded no emissions from Settlement creation, as new Settlement was established on Other land which has no soil carbon, therefore no soil carbon losses were recorded for Land converted to Settlement in Jersey, and Settlement creation appeared to act as a small sink because of the carbon stocks in Settlement soils. The revised classification of unassigned land as Grassland means that it is now deemed to have stocks of soil carbon which are released when the land is converted to Settlement. The revised emissions timeseries shows a trend of increasing emissions resulting from Grassland to Settlement conversion. In previous inventories, this trend was masked because no carbon stocks are released when Other Land is converted to Settlement.

Figure A 3.6.9 LULUCF sector emissions for all gases from Jersey for 1990-2012 inventory compared with the 1990-2011 inventory.

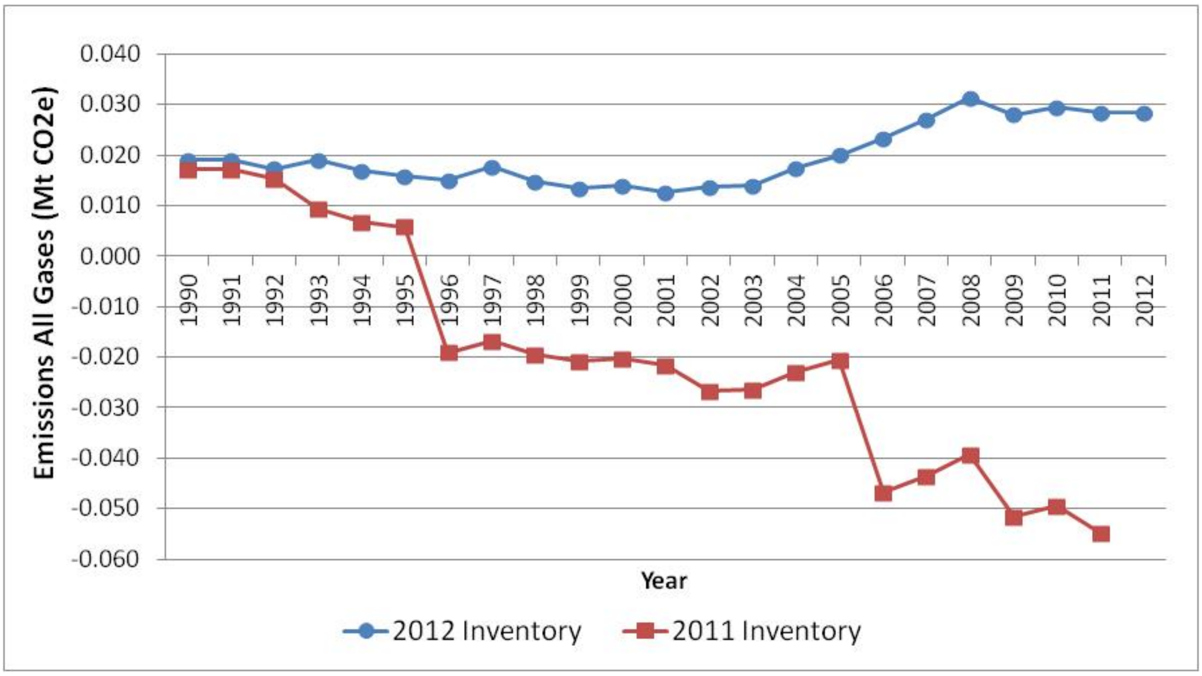


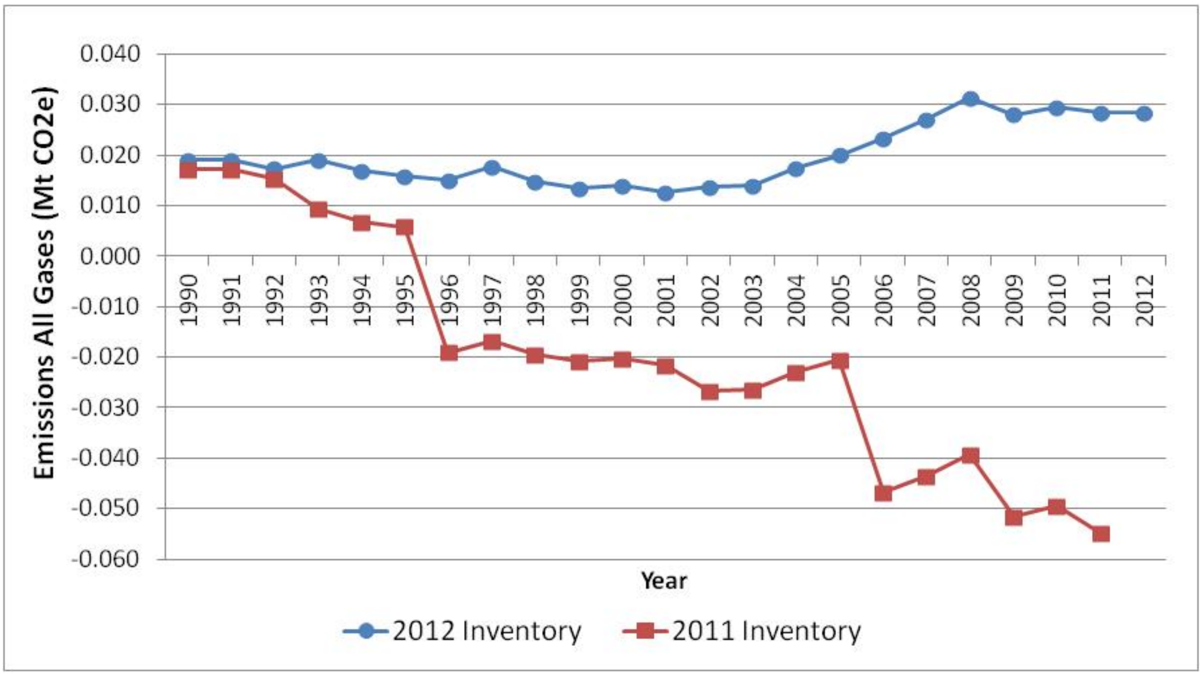


For the Isle of Man, net emissions of GHGs from LULUCF were updated for the 1990 to 2012 inventory, using updated activity data, and ensuring the Tier 1 methodology (for non-forest land use) was applied consistently. For the Grassland area there is a slight increase in values across the timeseries is consistent with change from use of Other Land as a buffer to use of Grassland as a buffer. The timeseries for Cropland and Settlement areas are identical to those in previous inventories. The change in the Grassland/Other Land classification results in a change in the emissions trend from 1995 from becoming a sink to becoming a source and increasing to a peak in 2008 (**Figure A 3.6.10**).

As for Jersey, this change in the trend due to the change from in Other Land categorisation, which means that instead of new Settlement being created from Other land which does not entail the release of soil carbon, it is built on Grassland which leads to the release of soil carbon stocks. The revised emissions timeseries highlights a trend of increasing emissions as a result of Grassland to Settlement conversion. In previous inventory years, this trend was masked because no carbon stocks are released when Other Land is converted to Settlement.

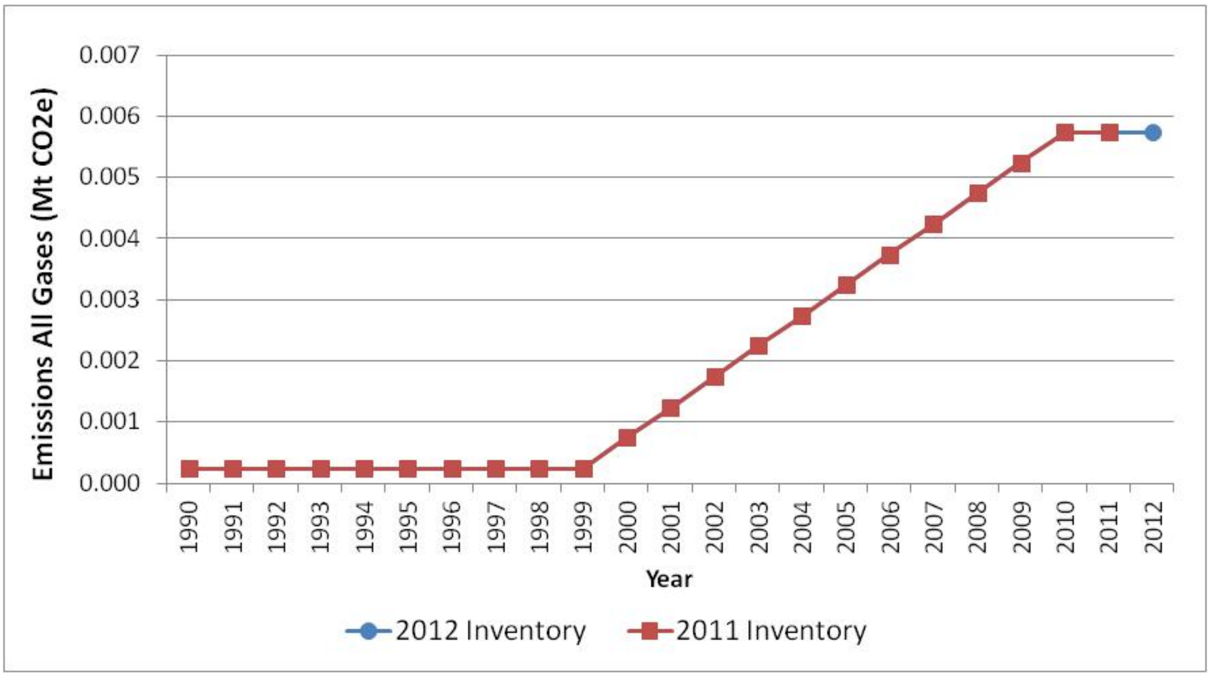
Figure A 3.6.10 LULUCF sector emissions for all gases from the Isle of Man for 1990-2012 inventory compared with the 1990-2011 inventory.

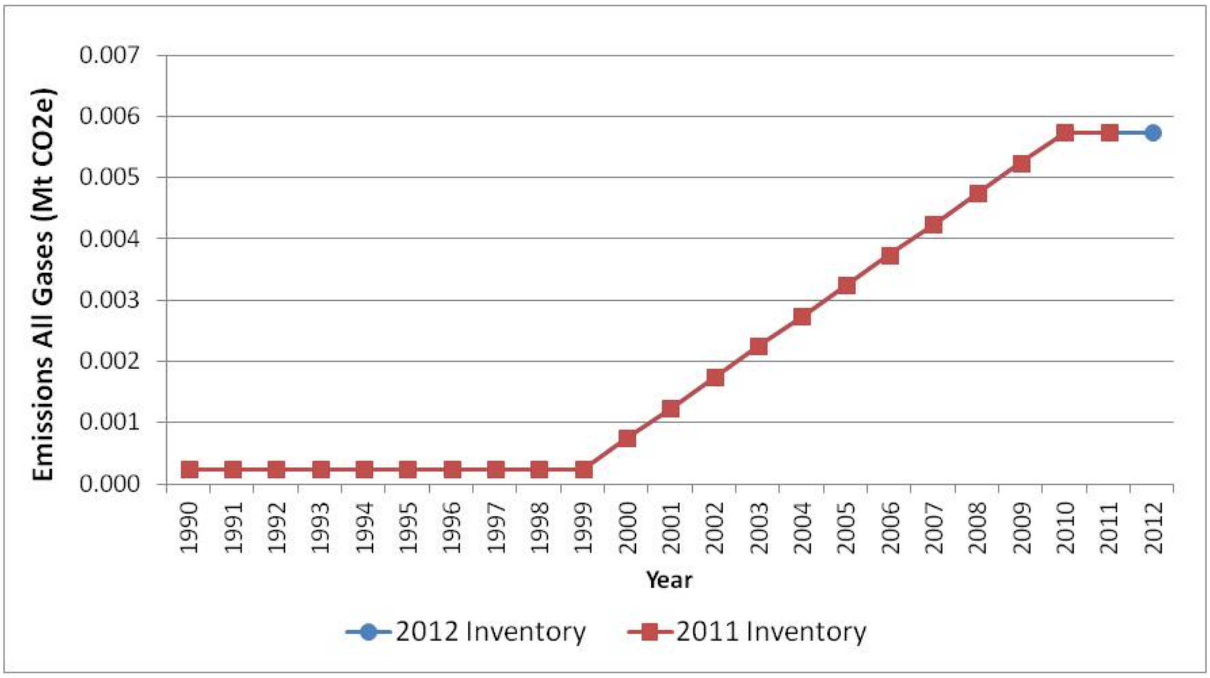




For Guernsey, net emissions of GHGs from LULUCF were updated for the 1990 to 2012 inventory, using updated activity data, and ensuring the Tier 1 methodology was applied consistently. Carbon stock changes due to afforestation were also modelled using the Tier 3 CFlow model (1990-2011 NIR, The more comprehensive model CARBINE has not yet been included in the OT and CD inventories). The LULUCF sector in Guernsey is a small source, due to conversion to Settlement and conversion to and liming of Cropland (**Figure A 3.6.11**). The emissions trend for the other Crown Dependencies and associated land use changes now match the trend seen in the Guernsey emissions, i.e. a steady increase in emissions from the late 1990s as a result of Grassland converted to Settlements.

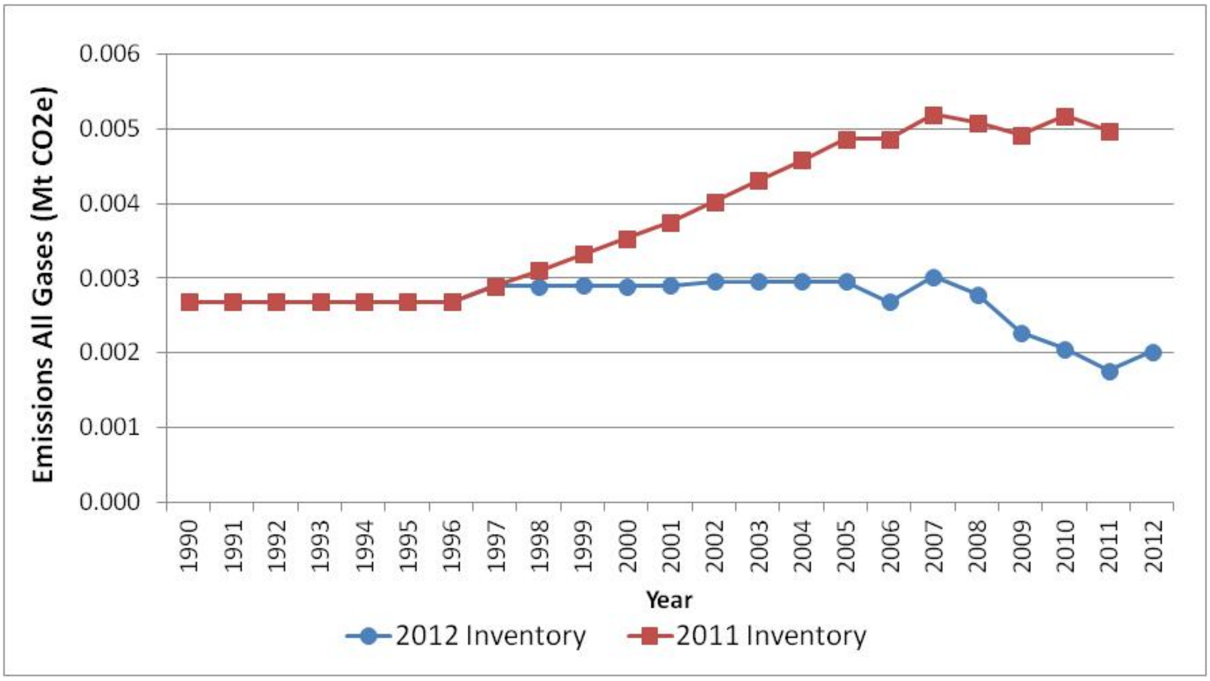
Figure A 3.6.11 LULUCF sector emissions for all gases from Guernsey for 1990-2012 inventory compared with the 1990-2011 inventory.

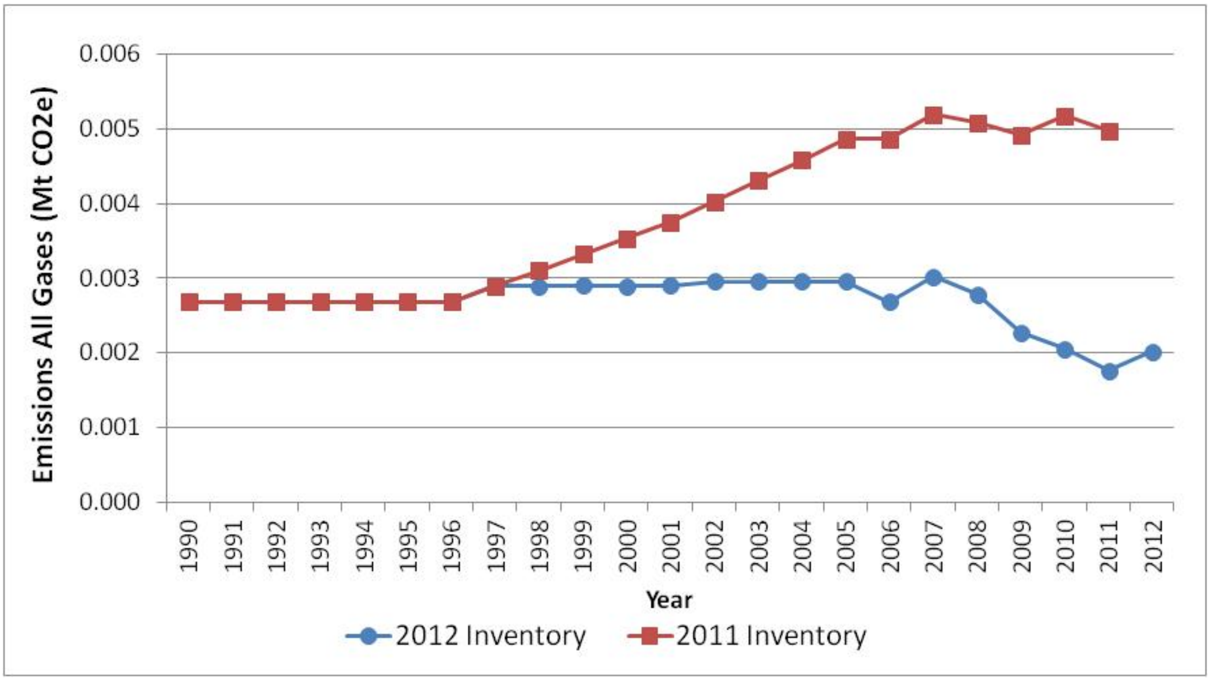




The Falklands Grassland area has a small change in timeseries, due to the inclusion of unfarmed agricultural land which fluctuates annually in the Grassland category in the 1990-2012 Inventory. In previous inventories this was included in the Other Land category due to the way the source data was collected. Cropland and Settlement areas have identical timeseries to previous inventories, except for change to 2011 value for Cropland due to updated source data. The change in Grassland/Other Land classification results in a change in the emissions trend from 1997 (**Figure A 3.6.12**). The revised emissions have reduced as there is no fluctuation in conversions from Grassland to Other Land and back to Grassland. The emissions timeseries shows a trend in emissions as a result of Grassland to Settlement conversion. In previous inventory years, this trend was masked because no carbon stocks are released when Other Land is converted to Settlement.

Figure A 3.6.12 LULUCF sector emissions for all gases from the Falklands for 1990-2012 inventory compared with the 1990-2011 inventory.





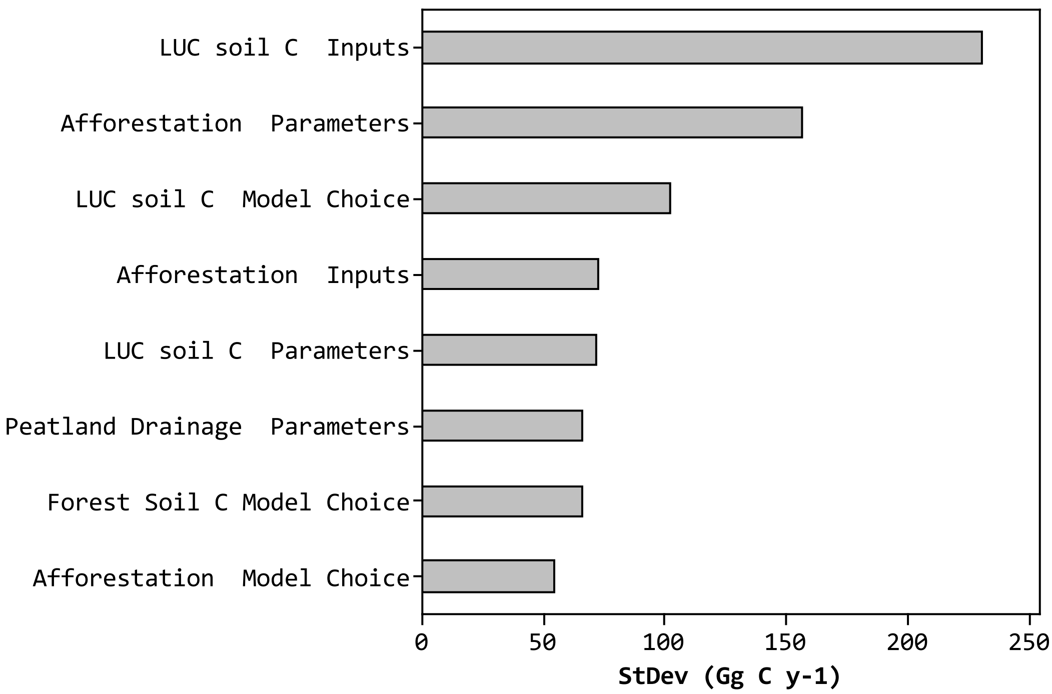
A3.6.13 Uncertainty analysis of the LULUCF sector

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 was central to the forestry sector of the inventory in previous submissions. 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. Although this analysis was carried out for the CFlow model, which is no longer used, it is likely to be applicable to the CARBINE model as both are similar forest carbon accounting models.

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 3.6.13**). 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 3.6.13 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. This has been addressed in this inventory submission as, with the move to CARBINE, 19 tree species are now modelled instead of the two used in previous submissions. 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**. 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 3.7.2**. The amounts of methane generated, recovered, used for power generation, flared, oxidised and emitted to the atmosphere from 1990 to 2012 are also shown.

Table A 3.7.1 Waste composition data

Local Authority controlled waste					C&I				
Material	Waste composition (2012)	DDOC			Material	Waste composition (2012)	DDOC		
		RDO	MDO	SDO			RDO	MDO	SDO
Paper	9.0%	0.00%	15.70%	0.42%	Paper and Card	6.4%	0.00%	15.70%	0.42%
Card	4.4%	0.00%	14.78%	0.39%	Food and Abattoir	9.7%	6.45%	1.95%	0.15%
Nappies	4.8%	0.00%	4.30%	0.00%	Food effluent	0.0%	0.00%	6.76%	0.00%
Textiles (and footwear)	4.1%	0.00%	6.67%	0.00%	Misc Comb	1.4%	0.00%	11.00%	0.00%
Misc. Combustible	4.6%	0.00%	11.00%	0.00%	Furniture	0.1%	0.00%	5.18%	0.04%
Wood	2.9%	0.00%	11.84%	0.69%	Garden	2.4%	3.74%	4.40%	0.58%
Food	32.4%	6.74%	2.60%	0.17%	Sewage sludge	0.4%	2.31%	0.00%	0.00%
Garden	3.3%	3.74%	4.40%	0.58%	Textiles / Carpet and Underlay	0.6%	0.00%	6.67%	0.00%
Soil and other organic	3.7%	0.00%	0.27%	0.00%	Wood	4.0%	0.00%	11.84%	0.69%
Furniture	2.1%	0.00%	5.18%	0.04%	Sanitary	0.1%	0.00%	4.30%	0.00%
Mattresses	0.5%	0.00%	6.67%	0.00%					
Other (as 100% inert)	28.4%	0.00%	0.00%	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 3.7.2** 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 3.7.2 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	58.33	2,539	273	11%	33	1%	240	9%	227	9%	2,039	80%
1991	18.84	73.97	92.80	56.50	2,586	316	12%	50	2%	266	10%	227	9%	2,043	79%
1992	19.47	73.30	92.77	54.68	2,631	466	18%	90	3%	376	14%	216	8%	1,948	74%
1993	20.09	72.62	92.72	52.83	2,673	466	17%	107	4%	359	13%	221	8%	1,986	74%
1994	20.71	71.95	92.66	51.00	2,713	467	17%	124	5%	342	13%	225	8%	2,022	75%
1995	26.46	71.28	97.74	54.29	2,769	447	16%	135	5%	312	11%	232	8%	2,090	75%
1996	25.75	70.61	96.36	51.11	2,813	503	18%	170	6%	333	12%	231	8%	2,079	74%
1997	26.98	69.82	96.80	49.86	2,855	589	21%	220	8%	369	13%	227	8%	2,039	71%
1998	26.67	67.44	94.11	49.29	2,889	694	24%	284	10%	410	14%	219	8%	1,975	68%
1999	27.56	66.36	93.92	49.59	2,918	917	31%	409	14%	508	17%	200	7%	1,801	62%
2000	27.57	65.37	92.94	50.02	2,946	1090	37%	525	18%	565	19%	186	6%	1,670	57%
2001	28.06	61.74	89.81	50.35	2,972	1162	39%	602	20%	561	19%	181	6%	1,629	55%
2002	27.63	64.17	91.79	49.42	2,991	1161	39%	643	21%	518	17%	183	6%	1,647	55%
2003	26.24	65.56	91.80	46.54	2,993	1334	45%	786	26%	547	18%	166	6%	1,493	50%
2004	25.05	63.10	88.15	43.83	2,979	1536	52%	961	32%	575	19%	144	5%	1,299	44%
2005	22.66	60.13	82.79	39.94	2,947	1557	53%	1,030	35%	527	18%	139	5%	1,252	42%
2006	21.33	55.67	77.01	36.83	2,900	1523	53%	1,062	37%	461	16%	138	5%	1,240	43%

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

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	%
2007	19.72	51.53	71.25	34.41	2,843	1530	54%	1,122	39%	408	14%	131	5%	1,182	42%
2008	17.63	47.56	65.19	30.97	2,774	1475	53%	1,135	41%	340	12%	130	5%	1,169	42%
2009	16.35	43.70	60.05	28.24	2,689	1469	55%	1,183	44%	286	11%	122	5%	1,098	41%
2010	14.39	39.72	54.11	24.94	2,595	1537	59%	1,209	47%	328	13%	106	4%	953	37%
2011	12.83	35.75	48.58	22.05	2,495	1464	59%	1,222	49%	242	10%	103	4%	928	37%
2012	11.42	31.77	43.19	19.30	2,390	1412	59%	1,237	52%	175	7%	98	4%	880	37%

Notes

a. Methane generated is based on the corrected MELMod 2011 v1-1 UK model.
b. Methane captured is the sum of methane used for power generation and methane flared.
c. Methane used for power generation is calculated from official figures on landfill gas electricity generation (Digest of UK Energy Statistics (DUKES, 2013)), 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 calculated from data provided by the Environment Agency at regulatory sites for 2009, 2010, 2011 and 2012, and from an independent report on installed flare capacity for 1990. Data for intervening years is interpolated between the values for 1990 and 2009.
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).

A3.7.2 Wastewater Handling (6B)

Table A 3.7.3 UK Industrial Waste Water Treatment Activity Data (6B1) (covers 1990, 1995, 2000, 2005, 2010, 2011 and 2012)

Sector	Units	1990	1995	2000	2005	2010	2011	2012
Organic chemical production	Mg	1,617,087	1,617,087	1,750,566	1,752,100	1,486,677	1,571,417	1,479,243

Sector	Units	1990	1995	2000	2005	2010	2011	2012
Milk-processing	PE	1,464,380	1,464,380	1,464,380	625,516	623,756	679,894	691,745
Manufacture of fruit and vegetable products	PE	1,144,564	1,144,564	1,144,564	1,472,785	1,495,227	1,318,790	1,227,581
Potato-processing	PE	302,037	302,037	302,037	388,651	394,573	348,013	323,944
Meat industry	PE	623,348	623,348	623,348	619,058	638,245	625,480	635,053
Breweries	PE	94,000	94,000	104,311	109,216	108,616	144,785	126,103
Production of alcohol and alcoholic beverages	PE	1,930,727	1,930,727	1,930,727	2,021,519	2,010,402	2,679,866	2,334,077
Manufacture of animal feed from plant products	PE	476,000	476,000	476,000	302,014	377,152	384,696	363,952
Manufacture of gelatine and of glue from hides, skin and bones	PE	13,315	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	286,854	249,841
Fish-processing industry	PE	18,000	18,000	18,000	6,014	6,105	6,331	6,362
Total Food and Drink	**PE**	**6,273,037**	**6,273,037**	**6,283,348**	**5,774,471**	**5,882,585**	**6,488,023**	**5,971,973**

Notes:

1) PE = Population Equivalents

2) PRODCOM data (Office of National Statistics, 2013) 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.

3) 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 or for land reclamation are derived and applied across the time series of activity data.

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 response to the implementation of the Urban Waste Water Treatment Directive, which banned sewage disposal direct to sea.

Table A 3.7.4 UK Domestic and Commercial Waste Water Treatment Activity Data (6B2): Total Sludge, Population Equivalents, Composting, Farmland Disposal and Land Reclamation

	Total Sludge	Population Equivalents	Composting	Farmland Disposal	Land Reclamation
Units→	**(kt dry solids)**	**(000 people)**	**(kt dry solids)**	**(kt dry solids)**	**(kt dry solids)**
1990	1,076	73,092	0	499	0
1991	1,072	73,092	0	507	0
1992	1,019	73,092	0	482	0
1993	1,014	73,092	0	502	0
1994	1,039	73,092	0	504	0
1995	1,120	73,092	0	548	0
1996	1,078	73,092	0	535	0
1997	1,038	73,092	0	725	5
1998	1,057	73,092	0	597	4
1999	1,126	73,092	0	582	27
2000	1,108	73,092	9.2	583	27
2001	1,541	73,092	5.8	838	29
2002	1,599	73,092	7.3	896	151
2003	1,653	73,119	14.4	1060	155
2004	1,759	72,896	19.0	1121	198
2005	1,770	72,851	13.5	1221	96

	Total Sludge	Population Equivalents	Composting	Farmland Disposal	Land Reclamation
Units→	(kt dry solids)	(000 people)	(kt dry solids)	(kt dry solids)	(kt dry solids)
2006	1,792	72,808	16.1	1253	62
2007	1,817	70,633	16.3	1295	78
2008	1,815	69,875	14.5	1404	51
2009	1,706	68,379	26.0	1311	56
2010	1,690	69,063	16.6	1321	37
2011	1,767	71,275	19.7	1337	89
2012	1,675	69,452	19.4	1288	52

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.

In previous submissions, the activity data for sludge disposed to land reclamation was included within the data for farmland disposal. In order to enable greater transparency of the activity data for sewage sludge disposal to agricultural land (the N_2O emissions for which are reported in 4D), we have split out the data reported by water companies for disposal to land reclamation. The same methane factor is applied to land reclamation activity data as that for agricultural land within the UKWIR toolkit, and in the UK GHGI.

Table A 3.7.5 UK Domestic and Commercial Waste Water Treatment Emission Factors (6B2): Treatment, Digestion, Composting, Farmland Disposal, Land Reclamation, and overall 6B2 IEF

	Treatment	Digestion	Composting	Farmland Disposal, Land Reclamation	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	1,517	12,941
2000	2,730	145	2,553	1,527	13,131
2001	2,731	145	2,553	1,488	10,435
2002	2,731	145	2,553	1,326	10,221
2003	2,730	145	2,553	1,362	10,152
2004	2,729	145	2,553	1,327	9,748
2005	2,729	145	2,553	1,460	9,788

	Treatment	Digestion	Composting	Farmland Disposal, Land Reclamation	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)
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	2,531	1,554	9,731
2012	2,723	146	2,401	1,753	10,190

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 3.7.6 UK Domestic and Commercial Waste Water Treatment Emission Estimates (6B2): Treatment, Digestion, Composting, Farmland Disposal, Land Reclamation and Total B2 estimates

	Treatment	Digestion	Composting	Farmland Disposal	Land Reclamation	TOTAL
Units→	(kg CH_4)	(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	-	1,122,575	7,742	14,533,965
1998	2,887,127	10,568,731	-	922,630	6,185	14,384,674
1999	3,073,581	10,568,731	-	883,589	40,218	14,566,119
2000	3,024,077	10,568,731	23,387	889,539	40,471	14,546,205
2001	4,209,250	10,568,731	14,757	1,246,109	42,739	16,081,586
2002	4,365,851	10,568,731	18,638	1,188,427	200,239	16,341,887
2003	4,512,888	10,578,892	36,766	1,444,078	211,797	16,784,421
2004	4,800,381	10,546,192	48,510	1,486,757	262,803	17,144,643
2005	4,830,943	10,540,026	34,493	1,783,378	140,067	17,328,908
2006	4,889,224	10,538,545	41,026	1,928,542	94,732	17,492,070
2007	4,962,695	10,227,949	41,617	1,950,692	117,169	17,300,121
2008	4,952,514	10,118,071	37,021	2,210,124	80,745	17,398,475
2009	4,655,140	9,904,730	66,459	1,971,173	83,736	16,681,238
2010	4,620,623	9,693,655	37,983	2,050,659	57,964	16,460,883
2011	4,842,585	10,087,468	49,804	2,077,936	138,142	17,195,935
2012	4,561,923	10,115,566	46,519	2,257,679	91,438	17,073,125

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.

Water company reporting of emissions to the inventory agency is not comprehensive across all companies and all years. Emissions data are only available from 2009 onwards, and the emission factors derived from 2009 activity and emissions data are applied to earlier years. Furthermore, not all UK water companies provide activity and emissions data to the inventory agency. In recent years, extensive stakeholder consultation with the industry has gradually increased the reporting by water companies, and in 2013 nine out of twelve UK water companies provided methane emission estimates that have been used in the UK inventory compilation, although only six companies also provided activity data; no data (for 2012) were reported by Thames Water or Northumbrian, Essex and Suffolk Water, which together account for around a third of UK water treatment and sewage sludge treatment and disposal activity. In earlier years (i.e. for 2009 to 2011 data), around half of the UK water companies have provided emissions data.

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. Where emissions data are reported in the absence of any activity data, then the inventory agency derives an estimate for the activity data for that source, using the industry aggregate IEF.

The methane emission factors for 2009 and earlier years 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; *(For 2012 data, United Utilities have also provided emissions data.)*
- ***Treatment***: Scottish Water, Northern Ireland Water, Yorkshire & York, South West, Thames; *(For 2012, emissions data have also been provided by Anglian and HPL, Dwr Cymru, United Utilities, Severn Trent, Southern and Wessex Water, but no emissions data were provided by NI water.)*
- ***Composting***: Scottish Water, Northern Ireland Water, Yorkshire & York, South West, Thames; *(For 2012, United Utilities have also provided emissions data. Based on the data returns it is evident that not all UK water companies use composting as a sewage sludge disposal option.)*
- ***Agricultural Land Disposal***: Scottish Water, Northern Ireland Water, Yorkshire & York, Anglian and HPL, South West, Thames; *(For 2012, emissions data have also been provided by United Utilities, but no emissions data were provided by NI water or Thames Water.)*

The inventory agency notes that there is a limited time series of emissions and activity data from which to derive UK-specific emission factors. Improvements in the completeness of water company reporting will reduce uncertainties in the derived country-specific, source-specific emission factors as the dataset increases. Progress has been made during 2013 with more water companies providing emissions data; the 2012 data returns cover over 65% of total UK water treatment activity. More complete company reporting is anticipated for 2013 data onwards, via a new industry reporting template that has been drafted for integration into the UKWIR tool. Despite the limited current dataset, the country-specific factors used are regarded as the best available data upon which to base the UK estimates, as they reflect the country-specific waste water and sludge treatment activities, input volumes and organic loading, as well as the UK-specific stock of treatment facilities and disposal options. There is also good consistency across the emission factors derived from the different water companies.

The emission factors derived from 2009 data are based on data from five 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 2012, the source accounts for 27% of total methane emissions from the sector. The company-specific factors exhibit a greater range of 2468 - 3273 kg CH_4/ktonne, with a standard deviation that is 10% of the mean.

- 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 used that year show reasonable consistency, ranging from 104-157 kg CH_4/ktonne, with a standard deviation that is 17% of the mean. In 2012, the source also accounts for 59% of estimated sector emissions; the range of reported emission factors is larger, ranging from 64 to 209 kg CH_4/ktonne, with a standard deviation of 37% of the mean. The underlying information from the UKWIR toolkit returns indicates that the company with the lowest emission factor is the company that has the highest percentage use of advanced digestion technology. The capture and recovery of methane from these systems leads to lower emissions; we note therefore, that the range of emission factors does not necessarily indicate a greater level of uncertainty in the country-specific aggregate factor for this source.

- Across the time series, the overall contribution of emissions from composting activities is less than 1% of total sector emission estimates, and the reporting of activity and emissions from this sludge disposal option is very limited. The range of emission factors reported by all companies since 2009 are within the range 1011 to 2553 kg CH_4/ktonne, with a standard deviation that is 34% of the mean.

- 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 863-2,350 kg CH_4/ktonne, with a standard deviation that is 33% of the mean. In 2012 this source is estimated to account for 13% of sector emissions. Company emission factors range from 1573 to 3435 kg CH_4/ktonne, with a standard deviation that is 30% of the mean. The variability in data for this source in part 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. The increase in overall emission factor in 2012 reflects a higher emission factor reported by one company (i.e. a higher EF compared to previous submissions by that company and in comparison to other company data since 2009) which has provided data that indicates that in 2012 90% of sludge disposals to land were raw or raw limed sludge (rather than digested, composted or dried sludge disposal to land which are also treatment / disposal routes commonly used in the UK). This source remains a priority for further research to access more data to improve the UK estimates.

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 to two-thirds of the UK water industry across recent years. The bullet-points above indicate that for the treatment and digestion emission sources together (which comprise around 86% of total estimated methane emissions in 2012), 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 more data are needed to reduce uncertainties.

During 2013, the inventory agency met with UK water company Carbon Managers, authors of the UKWIR tool and DECC to seek further data from water companies and to agree on a new reporting template for water companies to use in future years (via the UKWIR tool). As a result, more data on water company emissions have been available to the inventory agency in 2012, and we anticipate more complete, consistent reporting for 2013 data onwards. As the available dataset grows, the inventory agency will review the company-specific reporting from 2013 onwards to re-assess the applicability of emission factors for each source across the time series.

A3.7.3 Waste Incineration (6C)

Table A 3.7.7 Activity Data: UK Waste Incineration 1990-2012

	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	1.310	0.270	0.289	0.082
1996	1.428	0.250	0.288	0.088
1997	0.088	0.230	0.287	0.081
1998	0.089	0.236	0.287	0.185
1999	0.089	0.242	0.286	0.186
2000	0.092	0.248	0.285	0.188
2001	0.068	0.254	0.285	0.189
2002	0.068	0.260	0.284	0.191
2003	0.068	0.224	0.257	0.192
2004	0.068	0.188	0.231	0.194
2005	0.068	0.152	0.204	0.195
2006	0.068	0.115	0.177	0.196
2007	0.070	0.124	0.163	0.191
2008	0.068	0.131	0.136	0.168
2009	0.064	0.122	0.127	0.175
2010	0.065	0.127	0.140	0.183
2011	0.055	0.113	0.139	0.176
2012	0.055	0.101	0.134	0.161

Table A 3.7.8 Emissions Data: UK Waste Incineration 1990-2012

Year	Chemical Waste Incineration	Accidental Fires	MSW Incineration	Clinical Waste Incineration	Sewage Sludge Incineration	Total
Carbon Dioxide (kt CO_2)						
1990	326.81	NE	672.92	292.63	NA	**1292.36**
1995	325.31	NE	345.86	225.75	NA	**896.91**
2000	277.68	NE	18.97	207.35	NA	**504.00**
2005	251.19	NE	20.97	126.70	NA	**398.87**
2010	169.82	NE	22.31	106.06	NA	**298.20**
2011	174.41	NE	18.47	94.65	NA	**287.53**
2012	167.53	NE	18.46	84.66	NA	**270.65**

Year	Chemical Waste Incineration	Accidental Fires	MSW Incineration	Clinical Waste Incineration	Sewage Sludge Incineration	Total
Methane (kt CH_4)						
1990	NE	0.06	6.30	0.01	0.03	**6.40**
1995	NE	0.07	3.73	0.01	0.03	**3.84**
2000	NE	0.08	0.26	0.00	0.07	**0.42**
2005	NE	0.06	0.19	0.00	0.08	**0.34**
2010	NE	0.04	0.18	0.00	0.07	**0.30**
2011	NE	0.04	0.16	0.00	0.07	**0.26**
2012	NE	0.04	0.16	0.00	0.06	**0.26**
Nitrous oxide (kt N_2O)						
1990	0.03	NE	0.08	0.01	0.06	**0.18**
1995	0.03	NE	0.05	0.01	0.07	**0.15**
2000	0.03	NE	0.00	0.01	0.15	**0.19**
2005	0.02	NE	0.00	0.00	0.16	**0.18**
2010	0.01	NE	0.00	0.00	0.15	**0.17**
2011	0.01	NE	0.00	0.00	0.14	**0.16**
2012	0.01	NE	0.00	0.00	0.13	**0.15**

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	2012
1. Energy	1.46	1.52	1.57	1.54	1.57	1.62	1.74	1.81	1.88	1.76	1.63	1.39	1.44	1.32	1.29	1.42	1.42	1.52	1.47	1.44	1.43	1.37	1.49
2. Industrial Process	0.0001	0.0002	0.0002	0.001	0.003	0.01	0.01	0.01	0.02	0.02	0.03	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.07	0.07
3. Solvents and Other Product Use																							
4. Agriculture	0.16	0.17	0.17	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.16	0.12	0.11	0.11	0.14	0.16	0.15	0.15	0.14	0.13	0.14
5. LULUCF	-0.02	-0.02	-0.02	-0.02	-0.03	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02	-0.03	-0.02	-0.02	-0.02	-0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01
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	0.04
7. Other																							
Total	**1.74**	**1.81**	**1.86**	**1.81**	**1.84**	**1.89**	**2.02**	**2.10**	**2.18**	**2.07**	**1.90**	**1.66**	**1.70**	**1.53**	**1.48**	**1.64**	**1.68**	**1.79**	**1.75**	**1.71**	**1.69**	**1.63**	**1.74**

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

Fuel	Fuel Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
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	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	0.09	0.09	0.09	0.08	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	0.38	0.42
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	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	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	0.19	0.15	0.15	0.11	0.10	0.18
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	0.09	0.08	0.07
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	28.22
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	25.31	31.35	101.94	98.56	111.48	117.32	119.88	135.02	135.54	136.05
Petrol	Mt	0.24	0.24	0.24	0.23	0.23	0.23	0.26	0.25	0.25	0.25	0.22	0.24	0.22	0.22	0.22	0.22	0.21	0.21	0.20	0.20	0.20	0.19	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	0.00

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

Livestock Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
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	11,189
Non dairy	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	27,941
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	135,052
Goats	333	332	331	338	349	347	325	333	352	359	376	373	339	210	177	201	298	303	314	304	288	301	312
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	2,350
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	865
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	57,424	60,642	52,792	54,400	52,152	55,874

Table A 3.8.4 Isle of Man, Guernsey and Jersey – Total emissions from Agricultural Soils (kg N_2O-N)

Territory	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Isle of Man	27,461	28,295	29,129	26,663	26,796	27,191	27,187	27,320	28,849	29,140	28,792	27,867	27,881	20,189	20,039	20,225	24,749	27,822	28,095	25,989	24,856	23,741	24,289
Guernsey	3,956	3,956	3,956	3,956	3,956	3,956	3,246	3,246	3,246	3,246	3,218	2,908	2,781	2,792	2,751	2,879	2,885	2,881	2,878	2,874	2,871	2,825	2,840
Jersey	6,850	6,850	6,844	6,855	6,831	6,783	6,814	6,825	6,832	6,816	6,883	6,638	5,965	5,525	5,269	5,186	5,506	5,673	4,992	4,935	4,956	4,880	4,933

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	2012
1. Energy	1.10	1.06	1.05	1.07	1.08	1.08	1.07	1.08	1.18	1.15	1.17	1.26	1.27	1.27	1.36	1.38	1.45	1.56	1.40	1.38	1.38	1.42	1.30
2. Industrial Process	0.0001	0.0001	0.0001	0.001	0.002	0.003	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
3. Solvents and Other Product Use																							
4. Agriculture	0.23	0.23	0.23	0.23	0.23	0.22	0.23	0.23	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.19	0.20	0.19	0.19	0.18	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	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.00	0.00	0.00	0.00	0.002	0.00
6. Waste	0.10	0.09	0.08	0.07	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.07	0.09	0.09	0.09	0.10	0.09	0.09	0.09	0.09
7. Other																							
Total	**1.42**	**1.38**	**1.36**	**1.37**	**1.37**	**1.38**	**1.38**	**1.39**	**1.49**	**1.46**	**1.47**	**1.57**	**1.58**	**1.58**	**1.67**	**1.69**	**1.77**	**1.88**	**1.72**	**1.69**	**1.68**	**1.72**	**1.60**

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

Fuel	Fuel Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
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	0.00
Aviation turbine fuel	Mt	0.27	0.23	0.19	0.19	0.19	0.19	0.20	0.18	0.20	0.17	0.20	0.20	0.19	0.19	0.20	0.19	0.24	0.23	0.23	0.21	0.22	0.20	0.19
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	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	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	0.09
Fuel oil	Mt	0.21	0.21	0.22	0.22	0.22	0.22	0.23	0.23	0.24	0.24	0.37	0.38	0.39	0.40	0.41	0.41	0.42	0.42	0.43	0.42	0.43	0.43	0.45
Gas oil	Mt	0.41	0.41	0.42	0.43	0.45	0.46	0.46	0.48	0.50	0.52	0.43	0.45	0.47	0.49	0.45	0.48	0.53	0.56	0.55	0.55	0.55	0.60	0.58
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	11.25	12.26	12.78	12.54	13.12	12.86	14.02	14.50	14.50	15.07	15.10
MSW	Mt	0.00	0.00	0.00	0.00	0.00	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.21	0.21	0.19	0.19	0.16	0.16
Natural gas	Mth	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.11	1.14	1.17	1.20	1.23	1.26	1.26	1.26	1.58	1.67	1.79	1.60	1.27	1.87	1.62	1.73
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	0.14

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

Livestock Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
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	10,628
Non-dairy Cattle	5,645	5,549	5,385	5,491	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	5,994
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	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	9,426
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	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	2,303
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	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	243

Table A 3.8.9 Cayman Islands, Falklands Islands, Bermuda and Montserrat – Total emissions from Agricultural Soils (kg N_2O-N)

Territory	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Bermuda	277	280	283	287	290	293	293	293	293	294	294	294	294	294	294	294	294	294	294	294	294	294	294
Cayman Islands	118	118	105	93	95	96	97	98	99	100	101	102	103	104	105	106	193	206	192	212	174	167	147
Falkland Islands	529	519	513	506	483	467	506	473	511	494	498	636	455	393	404	462	438	397	405	255	344	244	244
Montserrat	4,631	4,662	4,723	4,768	4,791	4,791	4,791	4,791	4,791	4,791	4,791	4,775	4,775	4,775	4,775	4,775	4,769	4,830	4,830	4,830	4,830	4,830	4,830

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	2012
Cayman Islands	382	498	589	530	555	629	603	580	640	636	669	717	660	808	464	445	438	414	362	415	448	448	448
Bermuda	4,256	4,357	4,394	4,485	4,634	4,505	4,249	4,788	4,393	4,576	4,419	4,851	4,202	4,342	4,203	3,876	4,093	4,684	4,665	4,986	4,640	4,640	4,640
Montserrat	1,231	1,250	1,361	1,184	1,359	1,404	1,591	1,576	1,650	1,742	1,843	1,956	1,896	2,212	2,279	2,104	1,975	1,910	1,821	1,974	1,862	1,862	1,862

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	2012
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	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	2012
1. Energy	0.186	0.194	0.200	0.177	0.193	0.186	0.176	0.187	0.189	0.199	0.205	0.208	0.199	0.204	0.219	0.231	0.226	0.219	0.237	0.249	0.243	0.236	0.225
2. Industrial Process	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.002	0.003	0.004	0.004	0.005	0.006	0.006	0.006	0.007	0.008	0.008	0.008	0.009	0.152
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	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	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	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	0.001	0.002	0.000	0.000
7. Other	0	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**	**0.198**	**0.207**	**0.215**	**0.212**	**0.203**	**0.209**	**0.225**	**0.237**	**0.233**	**0.226**	**0.245**	**0.257**	**0.253**	**0.245**	**0.377**

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	2012
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	0.008
Charcoal	Mt	0.000	0.000	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	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	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	0.017
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	0.037
MSW	Mt	0.016	0.016	0.016	0.016	0.019	0.019	0.019	0.019	0.020	0.020	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Natural gas	Mth	37.4	44.5	40.5	42.4	38.5	38.9	47.0	37.5	41.0	43.3	44.3	46.1	38.2	41.7	40.7	37.6	32.3	29.4	28.7	23.8	28.4	20.2	24.2
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	0.004
Clinical waste	Mt	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	0.001	0.002	0.000	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 2% 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.

In presenting the comparison between the Reference Approach and the Sectoral Approach the UK inventory agency has compared the Reference Approach outputs against the emissions total of sector 1A only from the Sectoral Approach. This provides the simplest verification of the energy emission estimates in the national inventory total, and does not take account of any emissions derived from the NEU allocations from non-energy sources (such as from industrial process, product use or waste degradation / incineration sources).

A4.1.1 Improvement of the Reference Approach Method

A number of improvements to the Reference Approach calculations were implemented during the latest inventory cycle, to improve the accuracy, completeness and transparency of the data; this was following UNFCCC ERT recommendations from the in-country review in

September 2012, centralised review in 2013 and advice from two Lead Reviewers engaged by DECC in an inventory improvement programme project in 2013-14 (Ricardo-AEA, 2014b).

A4.1.1.1 Natural Gas Carbon Storage Fraction

The UNFCCC expert review of September 2013 recommended that the carbon stored fraction be revised to “1” in the Reference Approach, as the RA-SA comparison only considers emissions in the Energy sector 1A of the Sectoral Approach, whilst all emissions from natural gas use as a feedstock are reported in 2B1. We have therefore revised the natural gas feedstock data in the Reference Approach calculations, to be consistent with the Sectoral Approach for this source, and we have altered the carbon stored fraction to “1”, as advised by the ERT.

A4.1.1.2 Approach to use IPCC Default Carbon Storage Fractions

In the 2013 submission, the UK inventory agency had implemented changes to the RA carbon stored fractions for chemical feedstock commodities (ethane, naphtha and LPG) aimed at amending the RA outputs to match the known emissions from the use of by-product gases in petrochemical production facilities, the activity data for which are not included in the UK energy balance (i.e. 100% of the feedstock is reported in DUKES as NEU). However, in the analysis in the 2013 submission, the inventory agency had taken consideration of emissions from feedstock chemicals in ALL sources in the UK inventory (i.e. including emissions from chemical product use, degradation and disposal / incineration) rather than just the emissions in Energy 1A, and this led to a misleading RA-SA comparison.

Following review of the available UK data and the approach by other reporting Parties, and based on advice from UNFCCC Lead Reviewers (Ricardo-AEA, 2014b) we have revised our approach to estimating and reporting the Reference Approach estimates. The UK inventory RA now applies the IPCC default carbon stored fractions for commodities including: naphtha, ethane, LPG, gas oil, lubricants, coking coal (coal oils and tars). These have replaced the country-specific carbon stored fractions that were used in the 2013 submission. This new approach is more transparent, simpler and provides a more objective comparison to the UK’s Sectoral Approach.

Furthermore, the UK inventory agency has conducted sensitivity analysis, using country-specific stored carbon factors in the Reference Approach, and the observed difference in the RA-SA comparison is almost negligible compared to the use of the IPCC defaults. In both the base year and the latest year, for example, the % difference in total emissions between the RA and SA is within 0.3% whether the IPCC defaults or the UK factors are applied.

The default and country-specific carbon storage fractions are as follows for 2012:

• Naphtha	0.75 (IPCC default)	0.66 (UK-specific)
• Lubricants	0.50 (IPCC default)	0.54 (UK-specific)
• Bitumen	1.00 (IPCC default)	1.00 (UK-specific)
• Coking coal	0.75 (IPCC default)	1.00 (UK-specific)
• Natural Gas	1.00 (ERT recommendation)	1.00 (ERT)
• Gas Oil	0.50 (IPCC default)	0.66 (UK-specific)
• LPG	0.80 (IPCC default)	0.66 (UK-specific)
• Ethane	0.80 (IPCC default)	0.66 (UK-specific)
• Petroleum coke	1.00 (Assumed no 1A emissions)	1.00 (UK-specific)
• Other oil	1.00 (IPCC default)	1.00 (UK-specific)

The carbon storage fractions that are predominantly IPCC defaults in the list above are those that have been used in the CRF reporting of the RA estimates. For further details of the comparison of the outcomes of the RA using the two approaches – *IPCC defaults versus UK-specific carbon storage fractions* – see **Table A4.1.3** below.

The additional dataset for RA estimates using an alternative method (i.e. to apply estimated country-specific carbon storage fractions in the RA analysis) shows that the difference between that approach and applying the IPCC default factors in the RA (which is the dataset reported within the CRF) is very small indeed. Overall the two approaches show very close consistency, and are generally within a few kt CO_2 of each other in each year. This illustrates that that the method selection for the RA in the UK inventory (i.e. to use the simple, comparable approach of using the default IPCC carbon storage fractions) is defensible and does not impact significantly on the RA-SA comparison.

A4.1.1.3 Reporting of Petroleum Coke data

The Reference Approach data entries for petroleum coke have been revised and updated in accordance with advice provided by two Lead Reviewers engaged on inventory improvement research by DECC. The inventory agency has corrected the NEU allocation for petcoke to align with the sectoral approach, i.e. to amend the NEU input to the RA to reflect known uses of petcoke as a fuel in the UK that are not reported in DUKES. A stored carbon fraction of 1.0 for the remaining NEU allocation has been applied, following consultation with the DECC DUKES team, which has confirmed that the source data on petcoke sales and imports indicates that the remaining NEU petcoke is not used in combustion activities.

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 2% lower to 2% higher than the comparable bottom-up emission totals of the Sectoral Approach.

A4.2.1 Statistical Differences in Energy Balance Data

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, 2013), 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 solid and liquid fuels.

A4.2.2 Application of Carbon Factors: Aggregated (RA) vs. Detailed (SA)

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.

A4.2.3 Assumptions for Non Energy Use of Fuels

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. In the 2014 submission, the UK inventory agency has followed the 1996 IPCC Guidelines and applied default carbon stored factors for each commodity within the estimates presented for the Reference Approach. These assumptions applied within the estimation of carbon stored from non-energy fuel use introduce uncertainty to the Reference Approach emission data. This method difference is likely to have a very small overall impact on the RA-SA comparison compared to the other methodological differences outlined above.

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

Table 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.

The table presents the comparison between the Reference Approach that has been reported in the CRF, which uses the IPCC default carbon storage fractions, and also against a second set of calculated Reference Approach estimates which uses country-specific storage fractions for most commodities.

The overall comparison between the (as reported) Reference Approach (RA) and the Sectoral Approach (SA) indicates that in most years the RA estimates are slightly lower than the SA estimates. In 1990 the RA estimates are 98.5% of the SA, and in 2012 the RA estimates are 99.3% of the SA. Across the time series the average is that the RA estimates are 99.6% that of the SA.

The trend in the SA shows a slightly greater overall reduction than the RA, by around 5 $MtCO_2$.

The RA-SA comparison shows very close consistency between the two datasets for the UK, and provides verification of the reported SA emission estimates for 1A.

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

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Sectoral Approach 1A (Mt CO_2)	567.9	577.4	561.3	547.3	539.9	529.7	549.8	527.8	532.9	526.8	535.9	547.9
Reference Approach (IPCC defaults, as reported) (Mt CO_2)	559.4	576.2	565.0	546.4	540.9	537.3	548.1	523.1	531.4	528.6	540.3	547.4
Reference Approach (CS Storage Fractions) (Mt CO_2)	558.0	574.1	562.8	544.7	538.9	535.4	546.3	521.1	529.5	526.3	538.9	547.3
RA/SA (IPCC defaults, as reported) %	98.5%	99.8%	100.7%	99.8%	100.2%	101.4%	99.7%	99.1%	99.7%	100.3%	100.8%	99.9%
RA/SA (CS storage fractions) %	98.2%	99.4%	100.3%	99.5%	99.8%	101.1%	99.4%	98.7%	99.4%	99.9%	100.6%	99.9%

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Trend
Sectoral Approach 1A (Mt CO_2)	532.2	542.5	543.8	540.1	541.5	533.3	517.6	472.7	489.4	449.1	469.3	*-98.7*
Reference Approach IPCC defaults, as reported) (Mt CO_2)	527.2	533.0	534.9	540.1	537.8	526.3	513.8	470.5	485.7	445.5	466.0	*-93.4*
Reference Approach CS Storage Fractions (Mt CO_2)	526.9	532.4	534.8	539.8	536.8	526.3	513.7	470.6	486.2	446.1	466.9	*-91.1*
RA/SA (IPCC defaults, as reported) %	99.1%	98.2%	98.4%	100.0%	99.3%	98.7%	99.3%	99.5%	99.2%	99.2%	99.3%	*(99.6% average)*
RA/SA (CS storage fractions) %	99.0%	98.1%	98.3%	99.9%	99.1%	98.7%	99.2%	99.6%	99.4%	99.3%	99.5%	*(99.4% average)*

The lightly shaded rows of data are not reported as part of the UK inventory submission, but are presented here to illustrate the impact of method choice for carbon storage fractions in the Reference Approach methodology in the UK. The shaded rows apply estimated country-specific carbon storage fractions, whereas the submitted Reference Approach estimates applied the IPCC default carbon storage fractions

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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		The UK does not report emissions from this source. This has been discussed with the UNFCCC ERT. There is no clear guidance provided in the 1996 GLs on estimating CO_2 from NMVOC. The guidance about whether to include emissions of carbon in the form of VOCs in national totals is not prescriptive. Neither the UNFCCC reporting guidelines, nor the 1996 IPCC GLs clearly state that indirect CO_2 from NMVOCs should be included in totals.
CO_2	5. Land-Use Change and Forestry	5C1 Grassland remaining Grassland (emissions from wildfires)	Grass is assumed to be replaced by regrowth within a year, according to T1 methodology.
CO_2	6. Waste	6A1 Managed Waste disposal on land	Emissions from CO_2 in this category are assumed to be biogenic in origin and therefore not counted towards the total
CO_2	6. Waste	6C2 Accidental 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

GHG	CRF sector	Source/sink category	Reason
N_2O	1. Energy	1C2 Multilateral Operations	Data unavailable – this is a memo item so does not affect the national total.
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. Emissions from this source are considered negligible (and therefore not a key category). Believed to be very small and very uncertain
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 – Emissions from this source are considered negligible (and therefore not a key category)
N_2O	3. Solvent and Other Product Use	3D5 Wood Preservation	Data not readily available. Emissions are believed to be negligible.
N_2O	3. Solvent and Other Product Use	3D5 – printing industry	Data not readily available. Emissions are believed to be negligible.
N_2O	3. Solvent and Other Product Use	3D5 – other non-specified	Data not readily available. Emissions are believed to be negligible.
N_2O	3. Solvent and Other Product Use	3D5 – Seed oil extraction	Data not readily available. Emissions are believed to be negligible.
N_2O	3. Solvent and Other Product Use	3D5 – Non-aerosol consumer products	Data not readily available. Emissions are believed to be negligible.
N_2O	3. Solvent and Other Product Use	3D5 – Agrochemicals use	Data not readily available. Emissions are believed to be negligible.
N_2O	3. Solvent and Other Product Use	3D5 – Glue manufacturing	Data not readily available. Emissions are believed to be negligible.
N_2O	3. Solvent and Other Product Use	3D5 – Surface coating	Data not readily available. Emissions are believed to be negligible.
N_2O	3. Solvent and Other Product Use	3D5 - Aerosols	Data not readily available. Emissions are believed to be negligible.
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	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-	Nitrogen fertilizer is only applied to newly planted forests in the UK (not

GHG	CRF sector	Source/sink category	Reason
		Forest Management	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-CO_2 emissions from HWP
CH_4	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
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.

A further review of the uncertainty parameters used within the industrial processes sector was carried out in 2010; the recommendations from this review were included in the 2011 submission of the NIR. The review followed recommendations from the UNFCCC ERT.

In 2013, a review was carried out of the uncertainty parameters ascribed to activity data, emission factors or emissions in the following sectors: energy (selection of subcategories), industry (selection of subcategories), agriculture (all subcategories), LULUCF (cropland, grassland & settlements) and waste (selection of categories). Changes were made to the uncertainty parameters in both the error propagation and Monte Carlo model, ensuring the parameters used were the same in both approaches where possible. Methodological changes were made to the error propagation method to optimise the use of the emission factor uncertainty data where categories are aggregated. Changes were made to the Monte Carlo model to integrate new UK specific uncertainty data about the probability distribution functions associated with emissions in some categories of the agriculture sector.

The overall method used to estimate uncertainties is described below, and the work to improve the accuracy of the uncertainty analysis continues. The key category analysis used data from the uncertainty analysis, and the results of the key category analysis are given in **Annex 1**.

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, with one log-logistic PDF. The parameters of the PDFs were set by analysing the available data on emission factors and activity data, and 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 at least 20,000 times, such that the emission calculations performed produced a converged output distribution.
- The distribution of errors in the parameter values was calculated from the difference between 2.5 and 97.5 percentile values in the distribution, as a percentage of the distribution mean.
- 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.
- The uncertainty in the trend between 1990 and the latest reported year, according to gas, was also estimated.

A7.1.2 Summary of Recent Improvements to the Monte Carlo Model

In 2013, changes were made to the Monte Carlo model to integrate new UK specific uncertainty data to activity data, emission factors or emissions. The PDFs ascribed to each category in the model were also reviewed, and the PDFs associated with emissions in some categories of the agriculture sector were changed.

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

Four main changes have been introduced into the model for the 2014 submission:

- Uncertainty parameters ascribed to activity data, emission factors or emissions in the following sectors were updated in the model: energy (selection of subcategories), industry (selection of subcategories), agriculture (all subcategories), LULUCF (cropland, grassland & settlements) and waste (selection of categories). Several sources of data were used: DECC DUKES publication, EU ETS detailed returns, and expert elicitation.
- The PDF for category 4D agricultural soils was changed, using information based on recent UK research.
- Uncertainties introduced on trends, 1990 and the latest inventory totals are calculated from the difference between 2.5 and 97.5 percentiles as a percentage of the trend, 1990 or latest inventory year annual emission distribution mean. This is in contrast to

previous versions of these data in which uncertainties were calculated from the standard deviation of the results, and is considered an improvement on the previous approach particularly in relation to non-normally distributed uncertainties, for which the standard deviation is less convergent than the 95 percentile confidence limits. The impact of this change is most notable for IPCC sectors 4D and 6B2, for which uncertainties follow log-normal and log-logistic distribution functions respectively. The measure of uncertainty expressed for 2012 total emissions is reduced by this change from 95% to 82% for 'Agriculture - N_2O' (IPCC sectors 4B12-14 & 4D), and from 260% to 189% for 6B2. Similarly, the uncertainty expressed for N_2O and Agriculture total emissions is reduced when derived via this approach, from 82% to 69% and 53% to 44% respectively.

- For LULUCF, the calculation of the ‘Range of likely % change’ in these results is based on the difference between 1990 and 2012 emissions in each iteration as a percentage of the average 1990 emission across all iterations. The previous approach, which calculated the percentage change from 1990 to the latest year in each iteration, led to non-convergence of results for the trend in LULUCF emissions, where statistical characteristics were dominated by iterations with 1990 emissions close to zero resulting in disproportionately high percentage changes.

A7.1.4 Methodological details of the Monte Carlo model

A7.1.4.1 Uncertainty Distributions

A7.1.4.1.1 Distributions

Nearly all of the distributions of emissions from sources in the inventory are modelled used normal or log normal distributions, with one log-logistic PDF and one custom PDF. The log-logistic function was provided by Rothamsted Research for N_2O emissions from agricultural soils, and is based on the data presented in Milne *et al.* (2014).

A7.1.4.1.2 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.

A7.1.4.2 Correlations

The Monte Carlo model contains a number of correlations. Omitting these correlations will not affect uncertainties on emission totals in 1990 or the latest inventory year, but would lead to the uncertainties on trends being overestimated, by negating the dependence on base year emissions in the methodology for estimating subsequent emissions. 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.

A7.1.4.2.1 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. 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.

All correlations in the LULUCF sector were reviewed (see 2008 NIR for full details) and the revised and assumptions have been implemented in the current Monte Carlo model. This review found that the emission sources and carbon sinks in this sector were not correlated with each other, but were correlated across inventory years.

A7.1.4.2.2 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.

A7.1.4.2.3 Simulation Method

Following recommendations in the 2006 IPCC Guidelines, the model uses a true Monte Carlo sampling method.

A7.1.4.2.4 Treatment of categories where emissions are zero

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 from 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.

A7.1.4.2.5 Aggregation of categories

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.

A7.1.4.3 F-gas uncertainties

Estimated emissions and projections of F-gases were 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. Uncertainties from the Refrigeration and Air Conditioning (RAC) sector were taken from ICF (2011).

A7.1.5 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 reported emissions totals, but are not expected to match exactly.

b) *Inter-comparison between the output of the error propagation and Monte Carlo models*
A formal check to compare the output of the error propagation and Monte Carlo model is completed. 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 $\frac{(97.5 percentile - 2.5 percentile)}{2 \times \mu}$

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 approximately the same results. However, when a distribution is skewed the first method converges to a much lower precision, since the variance is dominated by outliers. The overall uncertainty quoted in **Table A 7.3.1** is calculated using the second method so that uncertainties in sectors that show a skewed distribution (such as agricultural soils and N_2O) are better represented.

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, and that convergence of the distributions is being achieved. 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 considering the data in the EU ETS returns, and 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.

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 are taken from the EU ETS return and the activity data are calculated based on an estimate of the emission factor. Petroleum coke use for residential combustion from 2011 NIR onwards is based on new data supplied by one of the UK's suppliers of petroleum coke as fuel.

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.
- 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		2012	
Fuel		Activity uncertainty (%)	Emission factor uncertainty (%)	Activity uncertainty (%)	Emission factor uncertainty (%)
Anthracite		1.5	6	0.5 (r)	6
Aviation spirit		20	3.3	20	3.3
Aviation turbine fuel		20	3.3	20	3.3
Blast furnace gas		1.5	6	0.5 (r)	6
Burning oil		6	2	6 (r)	2
Chemical waste		10 (r)	30 (r)	10 (r)	30 (r)
Clinical waste		5 (r)	20	5 (r)	20
Clinker production		1 (r)	5	1 (r)	5
Coal		1.5	1 to 6 (r)	0.5 (r)	1 to 6 (r)
Coke		3	3	0.5 (r)	3 to 6 (r)
Coke oven gas		1.5	6	0.5 (r)	6
Colliery methane		5	5	5	5
DERV		1.8	2.1	1.0 (r)	2.1
Dolomite – glass		20	25 (r)	20	25 (r)
Dolomite – sinter, BOF		5	5	5	5
Exploration drilling	1B2a	16 (r)	6 (r)	16 (r)	6 (r)
	1B2b	1 (r)	20 (r)	1 (r)	20 (r)
Fuel oil		5.5 to 19.7 (r)	1.7 to 2 (r)	1.3 to 19.7 (r)	1.7 to 2 (r)
Fletton bricks		20	25 (r)	20	25 (r)
Gas oil		1.8	2.1	1 to 1.7 (r)	2.1 (r)
Limestone – glass		20 (r)	25 (r)	20 (r)	25 (r)
Limestone - sinter		5	5	5	5
Limestone – lime		10 (r)	5 (r)	1 (r)	5 (r)
LPG		41.1 (r)	3	0.5 (r)	3
Lubricants		25 to 30 (r)	2 to 5 (r)	25 to 30 (r)	2 to 5 (r)
MSW		1 to 7 (r)	5 to 20 (r)	1 to 7 (r)	5 to 20 (r)
Naphtha		7.3	3	not used	not used
Natural gas		2.8	1.5	0.5 to 2.5 (r)	1.5
OPG		50	20	25 to 50 (r)	15 to 20 (r)
Orimulsion		1	2	not used	not used
Peat		30 (r)	10	30 (r)	10
Petrol		1	4.8	0.5 (r)	4.8
Petroleum coke	1A1	not used	not used	10 (r)	3
	1A2	7.8	3	1.5	3
	1A4	20	3	20	3
Petroleum waxes		50	100	50	100
Refinery miscellaneous		11.9	3	not used	not used
Soda ash		20 (r)	25 (r)	20 (r)	25 (r)
Scrap tyres		15	10	15	10
SSF		3.3 to 10 (r)	3	2 (r)	3
Waste		not used	not used	1	5 (r)
Waste oils		5.5 (r)	1.7 (r)	1 to 1.3 (r)	1.7 to 3 (r)
Waste solvent		1	50	1	3 (r)

Notes

1. Uncertainties expressed as 2s/E 0.5*R/E where R is the difference between 2.5 and 97.5 percentiles and E is the mean.

Not used = Fuel not used
(r) revised in comparison to previous NIR

Table A 7.2.2 Uncertainties in the activity data and emission factors for "non-fuels" used in the carbon dioxide inventory

		1990			2012		
Sector	Sources	Activity uncertainty (%)	Emission factor uncertainty (%)	Uncertainty in emission (%)	Activity uncertainty (%)	Emission factor uncertainty (%)	Uncertainty in emission (%)
1B2a	Offshore oil and gas - processes	16 (r)	6 (r)	‡	16 (r)	6 (r)	‡
1B2b	Offshore oil and gas		20	-	1	20	-
1B2c_Flaring	Offshore oil and gas - flaring	16	6	‡	16	6	‡
1B2c_Venting	Offshore oil and gas - venting	16	6	‡	16	6	‡
2B1	Ammonia production - feedstock use of gas	2.8	1.5		0.1	2.5 (r)	
5A	5A2 Forest Land - biomass burning; 5A2 Land converted to forest land	-	-	25	-	-	25
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
2B5	Carbon in detergents	50	100	-	50	100	-
2B5	Carbon in pesticides	50	100	-	50	100	-
2A3	Gypsum produced	n/a	n/a	-	5 (r)	5	‡
2C3	Primary aluminium production	1	20(r)	‡	1	20 (r)	‡
2C1	Steel production (electric arc and oxygen converters)	1	20	‡	1	20	‡

Notes

1. Uncertainties expressed as 0.5*R/E where R is the difference between 2.5 and 97.5 percentiles and E is the mean.

‡ input parameters were uncertainties of activity data and emission factors

(r) revised in comparison to previous NIR

A7.2.1.3 Uncertainty in the Emissions

The overall uncertainty was estimated at approximately **2% in 2012**.
The central estimate of total CO_2 emissions in 2012 was estimated as 475,702 Gg. The Monte Carlo analysis suggested that there is a 95% probability that CO_2 emissions in 2012 were between 466,476 Gg and 484,885 Gg.

A7.2.1.4 Uncertainty in the Trend

The uncertainty in the trend between 1990 and 2012 was estimated. In running this simulation it was necessary to make assumptions about the degree of correlation between sources in 1990 and 2012. 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 (e.g. 1990 5A CO_2 with 2012 5A CO_2);
- 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 2012 were between **18% and 21%** 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, unless different scopes of activities are included for different pollutants 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

Activity	IPCC Sector	1990		2012	
		Activity %	Emission Factor %	Activity %	Emission Factor %
Anthracite	1A4b	1.5	50	0.5	50
Aviation spirit	1A3a	20	50	20	50
	1A5b			0.5	50
Aviation turbine fuel	1A3a	20	50	20	50
	1A5b	1.5	50	0.5	50
Barley residue	4F1	25	50		
Biogas	1A2f			0.5	50
Biomass	1A2f			0.5	50
Blast furnace gas	1A1c	1.5	50	0.5	50
	1A2a	1.5	50	0.5	50
	2C1	1.5	50	0.5	50
Burning oil	1A1a			0.5	50
	1A2f	1.5	50	0.5	50
	1A4a	1.5	50		
	1A4b	1.5	50	0.5	50
	1A4c	1.5	50		
Charcoal	1A4b	1.5	50	0.5	50
Charcoal produced	1B1b	10	50	10	50
Clinical waste	6C	5	50	5	50
Coal	1A1a	1.5	50	0.5	50
	1A1c	1.5	50	0.5	50
	1A2a	1.5	50	0.5	50
	1A2b	1.5	50	0.5	50
	1A2c	1.5	50	0.5	50
	1A2d	1.5	50	0.5	50
	1A2e	1.5	50	0.5	50
	1A2f	1.5	50	0.5	50
	1A3c			0.5	50
	1A4a	1.5	50	0.5	50
	1A4b	1.5	50	0.5	50
	1A4c	1.5	50	0.5	50
Coal produced	1B1a	0.5	13	0.5	13
Coke	1A2a	1.5	50	0.5	50
	1A2f	1.5	50	0.5	50
	1A4a	1.5	50		
	1A4b	1.5	50	0.5	50
Coke oven gas	1A1c	1.5	50	0.5	50
	1A2a	1.5	50	0.5	50

Activity	IPCC Sector	1990		2012	
		Activity %	Emission Factor %	Activity %	Emission Factor %
	1A2f	1.5	50	0.5	50
	1B1b	1.5	50	0.5	50
Coke produced	1B1b	0.5	13	0.5	13
Colliery methane	1A1c	1.5	50	0.5	50
	1A2f	1.5	50	0.5	50
Crude oil	1B2a	16	20	16	20
Deep mined coal production	1B1a	0.5	13	0.5	13
DERV	1A2f	1.5	50	0.5	50
	1A3b	1.8	50	1	50
	1A3d	1.8	50	1.7	50
	1A4b	1.5	50	0.5	50
Ethylene	2B5	20	20	20	20
Exploration drilling :no of wells	1B2a	16	20	16	20
	1B2b	1	15	1	15
Fletton bricks	2A7	20	100	20	100
Fuel oil	1A1a	1.5	50	0.5	50
	1A1b	1.5	50	0.5	50
	1A2a	1.5	50	0.5	50
	1A2b	1.5	50	0.5	50
	1A2c	1.5	50	0.5	50
	1A2d	1.5	50	0.5	50
	1A2e	1.5	50	0.5	50
	1A2f	1.5	50	0.5	50
	1A3d	19.7	50	19.7	50
	1A4a	1.5	50	0.5	50
	1A4b	1.5	50		
	1A4c	1.5	50	0.5	50
Gas oil	1A1a	1.5	50	0.5	50
	1A1b	1.5	50		
	1A1c	1.5	50	0.5	50
	1A2a	1.5	50	0.5	50
	1A2b	1.5	50	0.5	50
	1A2c	1.5	50	0.5	50
	1A2d	1.5	50	0.5	50
	1A2e	1.5	50	0.5	50
	1A2f	1.5	50	0.5	50
	1A3c	1.8	50	1.7	50
	1A3d	1.8	50	1.7	50
	1A3e	1.8	50	1.7	50
	1A4a	1.5	50	0.5	50
	1A4b	1.5	50	0.5	50
	1A4c	1.5	50	0.5	50

Activity	IPCC Sector	1990		2012	
		Activity %	Emission Factor %	Activity %	Emission Factor %
	1A5b	1.5	50	0.5	50
Landfill gas	1A1a	1.5	50	0.5	50
Linseed residue	4F5	25	50		
Liquid bio-fuels	1A1a			0.5	50
LPG	1A1b	1.5	50	0.5	50
	1A1c	1.5	50	0.5	50
	1A2a	1.5	50	0.5	50
	1A2f	1.5	50	0.5	50
	1A3b			0.5	50
	1A4b	1.5	50	0.5	50
Lubricants	1A2f	1.5	50	0.5	50
Mass burnt	6C	5	50	5	50
Methanol	2B5	20	20		
MSW	1A1a	1.5	50	0.5	50
	6C	7	50	7	50
Naphtha	1A1b	1.5	50		
Natural gas	1A1a	1.5	50	0.5	50
	1A1b	1.5	50	0.5	50
	1A1c	1.5	50	0.5	50
	1A2a	1.5	50	0.5	50
	1A2b	1.5	50	0.5	50
	1A2c	1.5	50	0.5	50
	1A2d	1.5	50	0.5	50
	1A2e	1.5	50	0.5	50
	1A2f	1.5	50	0.5	50
	1A4a	1.5	50	0.5	50
	1A4b	1.5	50	0.5	50
	1A4c	1.5	50	0.5	50
Natural Gas (leakage at point of use)	1B2b	1	15	1	15
Natural Gas (transmission leakage)	1B2b	1	15	1	15
Natural gas supply	1B2b	1	15	1	15
Oats residue	4F1	25	50		
Oil production	1B2a	16	20	16	20
OPG	1A1b	1.5	50	0.5	50
	1A1c	1.5	50	0.5	50
	1A2c	1.5	50	0.5	50
	1A2f	1.5	50		
Orimulsion	1A1a	1.5	50		
Peat	1A4b	1.5	50	0.5	50
Petrol	1A2f	1.5	50	0.5	50
	1A3b	1	50	0.5	50

Activity	IPCC Sector	1990		2012	
		Activity %	Emission Factor %	Activity %	Emission Factor %
	1A3d	1.8	50	1.7	50
	1A4b	1.5	50	0.5	50
	1A4c	1.5	50	0.5	50
Poultry litter	1A1a			0.5	50
Process emission	2B5	20	20	20	20
Refinery miscellaneous	1A1b	1.5	50		
Scrap tyres	1A2f	1.5	50	0.5	50
Sewage gas	1A1a	1.5	50	0.5	50
Sewage sludge combustion	6C	5	50	5	50
SSF	1A2f	1.5	50		
	1A4b	1.5	50	0.5	50
SSF produced	1B1b	0.5	13	0.5	13
Steel production (electric arc)	2C1	1	50	0.1	50
Straw	1A1a			0.5	50
	1A4c	1.5	50	0.5	50
Waste oils	1A1a	1.5	50	0.5	50
	1A2f			0.5	50
Wheat residue	4F1	25	50		
Wood	1A1a			0.5	50
	1A2f	1.5	50	0.5	50
	1A4b	1.5	50	0.5	50

1 Skewed distribution
2 Various uncertainties for different types of main and service
* See text

Fuel combustion uncertainties expressed as 0.5*R/E where R is the difference between 2.5 and 97.5 percentiles and E is the mean.
Uncertainties in the activity data for fuels burnt are reported in **Table A 7.2.1**.

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 for distributions with uncertainty greater than 50%.

A7.2.2.3 Uncertainty in the Emissions

The overall uncertainty was estimated as approximately **20% in 2012**.
The central estimate of total CH_4 emissions in 2012 was estimated as 50,842 Gg CO_2 equivalent. The Monte Carlo analysis suggested that there is a 95% probability that CH_4 emissions in 2012 were between 42,371 and 62,769 Gg CO_2 equivalent.

A7.2.2.4 Uncertainty in the Trend

The uncertainty in the trend between 1990 and 2012 was estimated. In running this simulation it was necessary to make assumptions about the degree of correlation between sources in 1990 and 2012. 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 57% hence the degree of correlation was 43%;
- Offshore emissions are not correlated across years since they are based on separate studies using emission factors that reflected the processes in use at the time;
- Gas leakage emissions were partially correlated across years. As a simple estimate it was assumed that the degree of correlation should reflect the reduction in emissions. Emissions have reduced by 53% hence the degree of correlation was 47%; and
- Emissions from deep mines were not correlated across years as they were based on different studies, and a different selection of mines. Open cast and coal storage and transport were correlated since they are based on default emission factors.

This analysis indicates that there is a 95% probability that methane emissions in 2012 were between **41% and 59%** 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 (IPCC category 4D) uses a log-logistic distribution defined such that the 97.5 percentile is greater than the 2.5 percentile by a factor of around 4.2-4.3. These parameterised functions have been defined and provided by Rothamsted Research (from research based on Milne *et al.*, 2014) as the best possible fit to the expected distribution of uncertainties in 1990 and 2010 emissions, and are normalised in the Approach 2 methodology such that the resultant mean is consistent with the current inventory emissions in 1990 and the most recent year.

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

Activity	IPCC Sector	1990		2012	
		Activity %	Emission Factor %	Activity %	Emission Factor %
Acid production	2B2	10	100	10	100
Adipic acid produced	2B3	2	100		
Anthracite	1A4b	1.5	149	0.5	149
Aviation spirit	1A3a	20	170	20	170
	1A5b			10	170
Aviation turbine fuel	1A3a	20	170	20	170
	1A5b	10	170	10	170
Barley residue	4F1	25	230		
Biogas	1A2f			0.5	118
Biomass	1A2f			0.5	118
Blast furnace gas	1A1c	1.5	195	0.5	195
	1A2a	1.5	118	0.5	118
	2C1	1.5	118	0.5	118
Burning oil	1A1a			0.5	195
	1A2f	1.5	118	0.5	118
	1A4a	1.5	149		
	1A4b	1.5	149	0.5	149
	1A4c	1.5	149		
Charcoal	1A4b	1.5	149	0.5	149
Chemical waste	6C	7	230	7	230
Clinical waste	6C	7	230	7	230
Coal	1A1a	1.5	195	0.5	195
	1A1c	1.5	195	0.5	195
	1A2a	1.5	118	0.5	118
	1A2b	1.5	118	0.5	118
	1A2c	1.5	118	0.5	118
	1A2d	1.5	118	0.5	118
	1A2e	1.5	118	0.5	118
	1A2f	1.5	118	0.5	118
	1A3c			0.5	118
	1A4a	1.5	149	0.5	149
	1A4b	1.5	149	0.5	149
	1A4c	1.5	149	0.5	149
Coke	1A2a	1.5	118	0.5	118
	1A2f	1.5	118	0.5	118
	1A4a	1.5	149		
	1A4b	1.5	149	0.5	149
Coke oven gas	1A1c	1.5	195	0.5	195
	1A2a	1.5	118	0.5	118
	1A2f	1.5	118	0.5	118
	1B1b	1.5	118	0.5	118

Activity	IPCC Sector	1990		2012	
		Activity %	Emission Factor %	Activity %	Emission Factor %
Colliery methane	1A1c	1.5	195	0.5	195
	1A2f	1.5	118	0.5	118
DERV	1A2f	1.5	118	0.5	118
	1A3b	1.8	170	1	170
	1A3d	1.8	140	1.7	140
	1A4b	1.5	149	0.5	149
Exploration drilling :no of wells	1B2a	16	110	16	110
	1B2b	16	110	16	110
Fuel oil	1A1a	1.5	195	0.5	195
	1A1b	1.5	195	0.5	195
	1A2a	1.5	118	0.5	118
	1A2b	1.5	118	0.5	118
	1A2c	1.5	118	0.5	118
	1A2d	1.5	118	0.5	118
	1A2e	1.5	118	0.5	118
	1A2f	1.5	118	0.5	118
	1A3d	19.7	140	19.7	140
	1A4a	1.5	149	0.5	149
	1A4b	1.5	149		
	1A4c	1.5	149	0.5	149
Gas oil	1A1a	1.5	195	0.5	195
	1A1b	1.5	195		
	1A1c	1.5	195	0.5	195
	1A2a	1.5	118	0.5	118
	1A2b	1.5	118	0.5	118
	1A2c	1.5	118	0.5	118
	1A2d	1.5	118	0.5	118
	1A2e	1.5	118	0.5	118
	1A2f	1.5	118	0.5	118
	1A3c	1.8	140	1.7	140
	1A3d	1.8	140	1.7	140
	1A3e	1.8	140	1.7	140
	1A4a	1.5	149	0.5	149
	1A4b	1.5	149	0.5	149
	1A4c	1.5	149	0.5	149
	1A5b	10	170	10	170
Landfill gas	1A1a	1.5	195	0.5	195
Linseed residue	4F5	25	230		
Liquid bio-fuels	1A1a			0.5	195
LPG	1A1b	1.5	195	0.5	195
	1A1c	1.5	195	0.5	195
	1A2a	1.5	118	0.5	118
	1A2f	1.5	118	0.5	118

Activity	IPCC Sector	1990		2012	
		Activity %	Emission Factor %	Activity %	Emission Factor %
	1A3b			0.5	170
	1A4b	1.5	149	0.5	149
Lubricants	1A2f	1.5	118	0.5	118
MSW	1A1a	1.5	195	0.5	195
	6C	7	230	7	230
Naphtha	1A1b	1.5	195		
Natural gas	1A1a	1.5	195	0.5	195
	1A1b	1.5	195	0.5	195
	1A1c	1.5	195	0.5	195
	1A2a	1.5	118	0.5	118
	1A2b	1.5	118	0.5	118
	1A2c	1.5	118	0.5	118
	1A2d	1.5	118	0.5	118
	1A2e	1.5	118	0.5	118
	1A2f	1.5	118	0.5	118
	1A4a	1.5	149	0.5	149
	1A4b	1.5	149	0.5	149
	1A4c	1.5	149	0.5	149
Oats residue	4F1	25	230		
OPG	1A1c	1.5	195	0.5	195
	1A2c	1.5	118	0.5	118
	1A2f	1.5	118		
Orimulsion	1A1a	1.5	195		
Peat	1A4b	1.5	149	0.5	149
Petrol	1A2f	1.5	118	0.5	118
	1A3b	1	170	0.5	170
	1A3d	1.8	140	1.7	140
	1A4b	1.5	149	0.5	149
	1A4c	1.5	149	0.5	149
Poultry litter	1A1a			0.5	195
Refinery miscellaneous	1A1b	1.5	195		
Scrap tyres	1A2f	1.5	118	0.5	118
Sewage gas	1A1a	1.5	195	0.5	195
Sewage sludge combustion	6C	7	230	7	230
SSF	1A2f	1.5	118		
	1A4b	1.5	149	0.5	149
Steel production (electric arc)	2C1	1.5	118	0.5	118
Straw	1A1a			0.5	195
	1A4c	1.5	149	0.5	149
Waste	1A2f			0.5	118
Waste oils	1A1a	1.5	195	0.5	195
	1A2f			0.5	118
Waste solvent	1A2f			0.5	118

Activity	IPCC Sector	1990		2012	
		Activity %	Emission Factor %	Activity %	Emission Factor %
Wheat residue	4F1	25	230		
Wood	1A1a			0.5	195
	1A2f	1.5	118	0.5	118
	1A4b	1.5	149	0.5	149

Notes

1 Uncertainties expressed as 0.5*R/E where R is the difference between 2.5 and 97.5 percentiles and E is the mean.

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**.

A7.2.3.3 Uncertainty in the Emissions

The central estimate of total N_2O emissions in 2012 was estimated as 36,114 Gg CO_2 equivalent. The Monte Carlo analysis suggested that 95% of the values were between 20,907 and 70,710 Gg CO_2 equivalent.

A7.2.3.4 Uncertainty in the Trend

The uncertainty in the trend between 1990 and 2012 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 2012 compared with 1990 – only 2 of the original 8 units 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 2012 were between **35% and 64%** 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

2012

- 6% for HFCs

- 21% for PFCs
- 13% for SF_6

A7.2.4.3 Uncertainty in the Trend

This analysis indicates that there is a 95% probability that emissions in 2012 differed from those in 1990 by the following percentages

- +11% to +40% for HFCs
- -82% to -88% for PFCs
- -32% to -56% 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 **6%** in 1990 and **5%** in 2012.

A7.3.2 Uncertainty in the Trend

This analysis indicates that there is a 95% probability that the total GWP GHG emissions in 2012 were between 24% and 29% 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.

Table A 7.3.1 Summary of Monte Carlo Uncertainty Estimates

IPCC Source Category	Gas	1990 Emissions	2012 Emissions	Range of uncertainty in 1990 emissions		Uncertainty introduced on national total in 1990	Range of uncertainty in 2012 emissions		Uncertainty introduced on national total in 2012	% change in emissions between 2012 and 1990	Range of likely % change between 2012 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)	592,522	475,702	580,141	605,382	2%	466,476	484,885	2%	-20%	-21%	-18%
	CH_4	104,484	50,842	85,598	131,167	22%	42,371	62,769	20%	-51%	-59%	-41%
	N_2O	69,954	36,114	45,894	115,725	50%	20,907	70,710	69%	-49%	-64%	-35%
	HFC	11,382	14,134	10,260	12,503	10%	13,264	15,000	6%	24%	11%	40%
	PFC	1,402	208	1,335	1,468	5%	164	252	21%	-85%	-88%	-82%
	SF_6	988	542	823	1,153	17%	469	615	13%	-45%	-56%	-32%
	All	780,731	577,542	744,953	833,957	6%	556,150	614,010	5%	-26%	-29%	-24%

Uncertainty calculated as 0.5*R/E where R is the difference between 2.5 and 97.5 percentiles and E is the mean calculated in the simulation.
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 and removals 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	2012 Emissions	Uncertainty in 2012 emissions as % of emissions in category		Uncertainty Introduced on national total in 2012	% change in emissions between 1990 and 2012	Range of likely % change between 1990 and 2012	
				2.5 percentile	97.5 percentile			2.5 percentile	97.5 percentile
1A1a	GWP weighted total	205,952	160,604	158,844	162,695	1.2%	-22%	-24%	-20%
1A1b	GWP weighted total	17,661	15,868	13,591	18,329	14.9%	-10%	-30%	18%
1A1c	GWP weighted total	14,125	15,096	14,786	15,461	2.2%	7%	2%	12%
1A2a	GWP weighted total	24,148	13,470	12,867	14,073	4.5%	-44%	-48%	-41%
1A2b	GWP weighted total	1,151	651	640	661	1.6%	-43%	-45%	-42%
1A2c	GWP weighted total	15,582	9,967	9,023	11,015	10.0%	-36%	-44%	-26%
1A2d	GWP weighted total	4,607	2,882	2,837	2,925	1.5%	-37%	-39%	-35%
1A2e	GWP weighted total	7,604	4,557	4,491	4,623	1.4%	-40%	-42%	-38%
1A2f	GWP weighted total	53,367	34,168	33,605	34,836	1.8%	-36%	-38%	-34%
1A3a	GWP weighted total	1,674	1,848	1,490	2,205	19.3%	10%	-16%	45%
1A3b	GWP weighted total	110,647	108,953	106,489	111,423	2.3%	-2%	-5%	3%
1A3c	GWP weighted total	1,461	2,103	2,056	2,149	2.2%	44%	39%	49%
1A3d	GWP weighted total	2,294	2,321	2,283	2,359	1.6%	1%	-3%	5%
1A3e	GWP weighted total	254	501	464	568	10.4%	97%	70%	129%
1A4a	GWP weighted total	25,061	20,210	19,990	20,433	1.1%	-19%	-21%	-17%
1A4b	GWP weighted total	79,579	74,006	72,955	75,068	1.4%	-7%	-10%	-4%
1A4c	GWP weighted total	5,836	4,731	4,413	5,309	9.5%	-19%	-29%	-7%
1A5b	GWP weighted total	5,336	2,548	2,185	2,909	14.2%	-52%	-61%	-41%
1B1a	GWP weighted total	17,214	1,595	1,420	1,772	11.0%	-91%	-92%	-89%
1B1b	GWP weighted total	870	237	225	249	5.1%	-73%	-75%	-71%
1B1c	GWP weighted total	1,075	381	332	429	12.7%	-65%	-70%	-57%
1B2a	GWP weighted total	1,271	239	204	275	14.8%	-81%	-84%	-77%
1B2b	GWP weighted total	9,542	4,228	4,179	4,277	1.2%	-56%	-57%	-55%

IPCC Source Category	Gas	1990 Emissions	2012 Emissions	Uncertainty in 2012 emissions as % of emissions in category		Uncertainty Introduced on national total in 2012	% change in emissions between 1990 and 2012	Range of likely % change between 1990 and 2012	
				2.5 percentile	97.5 percentile			2.5 percentile	97.5 percentile
1B2ci	GWP weighted total	885	763	580	961	24.9%	-14%	-40%	23%
1B2cii	GWP weighted total	4,482	3,579	3,077	4,097	14.3%	-20%	-35%	-1%
2A1	GWP weighted total	7,295	3,716	3,531	3,901	5.0%	-49%	-50%	-48%
2A2	GWP weighted total	1,462	1,178	941	1,418	20.3%	-19%	-39%	7%
2A3	GWP weighted total	1,191	1,179	1,077	1,282	8.7%	-1%	-16%	19%
2A7	GWP weighted total	580	433	362	509	17.0%	-25%	-37%	-11%
2B1	GWP weighted total	1,431	948	934	963	1.6%	-34%	-36%	-31%
2B2	GWP weighted total	3,900	61	29	114	69.8%	-98%	-99%	-96%
2B3	GWP weighted total	20,736	0	0	0	n/a	-100%	-100%	-100%
2B5	GWP weighted total	1,520	1,790	809	3,465	74.2%	18%	-56%	202%
2C1	GWP weighted total	1,899	835	787	883	5.8%	-56%	-60%	-52%
2C3	GWP weighted total	1,783	134	114	154	14.9%	-92%	-94%	-91%
2C4	GWP weighted total	406	163	132	195	19.4%	-60%	-71%	-41%
2E1	GWP weighted total	11,372	54	49	60	9.8%	-100%	-100%	-99%
2E2	GWP weighted total	11	87	74	100	14.8%	701%	549%	888%
2F1	GWP weighted total	0	11,440	10,638	12,245	7.0%	n/a	n/a	n/a
2F2	GWP weighted total	0	328	232	423	29.2%	n/a	n/a	n/a
2F3	GWP weighted total	0	212	170	253	19.6%	n/a	n/a	n/a
2F4	GWP weighted total	10	1,991	1,688	2,295	15.3%	19187%	15008%	24884%
2F5	GWP weighted total	0	107	81	133	24.4%	n/a	n/a	n/a
2F9	GWP weighted total	640	460	383	538	16.9%	-28%	-44%	-8%
3	GWP weighted total	0	0	0	0	n/a	n/a	n/a	n/a
4A1	GWP weighted total	13,740	11,609	9,326	13,849	19.5%	-16%	-36%	12%
4A10	GWP weighted total	9	6	5	7	19.6%	-34%	-50%	-13%

IPCC Source Category	Gas	1990 Emissions	2012 Emissions	Uncertainty in 2012 emissions as % of emissions in category 2.5 percentile	97.5 percentile	Uncertainty Introduced on national total in 2012	% change in emissions between 1990 and 2012	Range of likely % change between 1990 and 2012 2.5 percentile	97.5 percentile
4A3	GWP weighted total	4,813	3,499	2,811	4,185	19.6%	-27%	-45%	-4%
4A4	GWP weighted total	11	11	9	14	19.7%	2%	-23%	36%
4A6	GWP weighted total	217	389	313	465	19.6%	79%	35%	138%
4A8	GWP weighted total	238	141	114	169	19.6%	-41%	-55%	-21%
4B1	GWP weighted total	5,055	4,219	2,994	5,452	29.1%	-17%	-46%	29%
4B3	GWP weighted total	288	209	148	271	29.2%	-27%	-53%	12%
4B4	GWP weighted total	1	1	1	1	29.6%	1%	-35%	56%
4B6	GWP weighted total	17	30	21	39	29.2%	79%	16%	175%
4B8	GWP weighted total	3,325	1,790	1,265	2,317	29.4%	-46%	-65%	-17%
4B9	GWP weighted total	315	391	275	507	29.6%	24%	-20%	90%
4B10	GWP weighted total	0	0	0	0	29.5%	-34%	-57%	1%
Agriculture - N_2O	GWP weighted total	37,224	29,895	15,112	64,305	82.3%	-20%	-21%	-19%
4F1	GWP weighted total	343	0	0	0	n/a	n/a	n/a	n/a
4F5	GWP weighted total	2	0	0	0	n/a	n/a	n/a	n/a
5A	GWP weighted total	-15,843	-16,636	-20,746	-12,512	-24.7%	5%	4%	6%
5B	GWP weighted total	16,567	11,756	7,911	16,859	38.1%	-29%	-30%	-28%
5C	GWP weighted total	-6,268	-7,654	-12,555	-4,376	-53.4%	22%	20%	24%
5D	GWP weighted total	485	360	237	523	39.8%	-26%	-27%	-25%
5E	GWP weighted total	6,897	6,381	4,220	9,281	39.7%	-7%	-9%	-6%
5G	GWP weighted total	59	-1,196	-1,654	-902	-31.5%	-2121%	-4062%	-1277%
6A1	GWP weighted total	42,984	18,579	10,654	30,252	52.7%	-57%	-72%	-34%
6B1	GWP weighted total	1,377	1,265	831	1,844	40.0%	-8%	-48%	60%
6B2	GWP weighted total	1,478	1,555	401	6,278	189.0%	5%	-15%	49%

IPCC Source Category	Gas	1990 Emissions	2012 Emissions	Uncertainty in 2012 emissions as % of emissions in category		Uncertainty Introduced on national total in 2012	% change in emissions between 1990 and 2012	Range of likely % change between 1990 and 2012	
				2.5 percentile	97.5 percentile			2.5 percentile	97.5 percentile
6C	GWP weighted total	1,483	322	255	406	23.5%	-78%	-83%	-72%
Grand Total	GWP weighted total	780,731	577,542	556,150	614,010	5.0%	-26%	-29%	-24%

Note: Although the range of likely trend for some sectors are large (e.g. ~1000% for 2F4), these are small in comparison to the trend from 1990 to 2012 (~20,000%). Such instances arise where 1990 emissions are orders of magnitude lower than 2012 emissions.

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 and removals 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 **Table A 7.5.1-Table A 7.5.4**. 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. (Please also refer to the section "*A7.5.2 Review of Changes Made to the Error Propagation Model since the last NIR"*.)

A7.5.1 Review of Recent Improvements to the Error Propagation Model

- **2006 NIR.** 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.
- **2006 NIR.** 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[5] 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

[5] 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.

historic estimates of supply and demand which will then alter the uncertainty calculated from previous data.

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

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

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

- **2006 NIR.** 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 have 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
- **2006 NIR.** 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
- **2006 NIR.** 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

- **2006 NIR.** 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
- **2006 NIR.** 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

Two updates were made to the model following a peer review of the model (Abbott, 2014):

- Uncertainty parameters ascribed to activity data, emission factors or emissions in the following sectors were updated: energy (selection of subcategories), industry (selection of subcategories), agriculture (all subcategories) and waste (categories relating to waste combustion). Several sources of data were used: DECC DUKES publication, EU ETS detailed returns, and expert elicitation.

- Methodological changes were made to the error propagation method to optimise the use of the emission factor uncertainty data where categories are aggregated. In our uncertainty analysis, we used an aggregated emission factor uncertainty for each fuel type. The aggregated emission factor was selected as the most representative value from the component sectors. We have improved on this by calculating the aggregate emission factor uncertainties as:

$$U_f = \sqrt{\frac{\sum_i U_{fi}^2 E_i^2}{\sum_i E_i^2}}$$

where U_f are the emission factor uncertainties and E are the emissions from the component sectors, i.

A7.5.3 Uncertainty in the Emissions

The error propagation analysis, **including** LULUCF emissions, suggests an uncertainty of 13% in the combined GWP total emission in the latest reported year.

The error propagation analysis, **excluding** LULUCF emissions, suggests an uncertainty of 12% 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 2.6% in the trend between the base year and the latest reported year.

The analysis, **excluding** LULUCF emissions, estimates an uncertainty of 2.6% 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, and additionally, the method described in Section 4.3.1 of the 2006 IPCC Guidelines Volume 1 General Guidance and Reporting (*Approach 1 to identify key categorie*s).
The results of this key category 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	Emissions 1990 Gg CO2 equiv	Year Y emissions 2012 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	248182	144938	0.5	1.1828513	1.284	0.322337	-0.049328	0.185658	-0.058348	0.131280	0.143663
1A(stationary)	Oil	CO2	96218	51577	10.58184063	9.4060149	14.158	1.264603	-0.025065	0.066067	-0.235765	0.988693	1.016415
1A	Natural Gas	CO2	108306	154922	0.5	1.5000209	1.581	0.424214	0.095698	0.198446	0.143548	0.140323	0.200740
1A	Other (waste)	CO2	235	2680	7	19.914373	21.109	0.097976	0.003210	0.003433	0.063935	0.033986	0.072406
1A	Lubricant	CO2	387	161	30	2	30.067	0.008371	-0.000161	0.000206	-0.000321	0.008737	0.008743
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	1655	1829	20	3.3	20.270	0.064207	0.000775	0.002343	0.002557	0.066267	0.066317
1A3b	DERV	CO2	32996	67126	1	2.1	2.326	0.270387	0.054699	0.085984	0.114867	0.121600	0.167275
1A3b	Gasoline/ LPG	CO2	75569	40768	0.5	4.7999329	4.826	0.340719	-0.019358	0.052222	-0.092919	0.036926	0.099987
1A3c	Coal	CO2	0	43	0.5	6	6.021	0.000446	0.000055	0.000055	0.000328	0.000039	0.000331
1A3d	Marine Fuel	CO2	2168	2243	1.7	2.0905113	2.694	0.010468	0.000819	0.002873	0.001713	0.006908	0.007117
1A3	Other Diesel	CO2	1680	2496	1.7	2.1	2.702	0.011679	0.001605	0.003197	0.003371	0.007687	0.008393
1A4	Peat	CO2	476	50	30	10	31.623	0.002754	-0.000386	0.000064	-0.003862	0.002733	0.004731
1A4	Petroleum Coke	CO2	77	460	20	3	20.224	0.016127	0.000517	0.000590	0.001551	0.016683	0.016755
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	855	227	0.5	6	6.021	0.002367	-0.000519	0.000291	-0.003116	0.000206	0.003123
1B	Oil & Natural Gas	CO2	5778	3550	16	6.1721264	17.149	0.105445	-0.000926	0.004548	-0.005718	0.102908	0.103067
2A1	Cement Production	CO2	7295	3716	1	5	5.099	0.032810	-0.002152	0.004759	-0.010762	0.006731	0.012694
2A2	Lime Production	CO2	1462	1178	1	5	5.099	0.010400	0.000123	0.001509	0.000616	0.002134	0.002221
2A3	Limestone & Dolomite use	CO2	1191	1178	5	5	7.071	0.014430	0.000381	0.001509	0.001907	0.010673	0.010842
2A7	Other Mineral Use	CO2	556	429	20	25	32.016	0.023812	0.000023	0.000550	0.000573	0.015560	0.015570
2B	Ammonia Production	CO2	1431	948	2.5	1.5	2.915	0.004788	-0.000141	0.001215	-0.000212	0.004295	0.004300
2B5	Non-energy use of products	CO2	1350	1709	50	100	111.803	0.330950	0.000910	0.002189	0.090991	0.154819	0.179578
2C1	Iron&Steel Production	CO2	2341	924	0.5	6.5847951	6.604	0.010564	-0.001034	0.001183	-0.006811	0.000837	0.006863
5A	5A LUCF	CO2	-15902	-16723	1	25	25.020	-0.724603	-0.006356	-0.021421	-0.158910	-0.030294	0.161772
5B	5B LUCF	CO2	15784	11173	1	50	50.010	0.967636	-0.000643	0.014312	-0.032135	0.020240	0.037977
5C	5C LUCF	CO2	-6301	-7728	1	70	70.007	-0.936986	-0.003930	-0.009900	-0.275124	-0.014000	0.275480
5D	5D LUCF	CO2	482	359	1	50	50.010	0.031113	0.000004	0.000460	0.000188	0.000651	0.000677
5E	5E LUCF	CO2	6893	6376	1	50	50.010	0.552202	0.001636	0.008167	0.081799	0.011550	0.082610
5G	5G LUCF	CO2	59	-1168	1	30	30.017	-0.060733	-0.001553	-0.001497	-0.046578	-0.002116	0.046626
6C	Waste Incineration	CO2	1292	271	10	28.18643	29.908	0.014018	-0.000878	0.000347	-0.024741	0.004903	0.025222
		CO2 Total	592,514.77	475,711.68									
1A	All Fuel	CH4	1860.640808	912.2978436	0.5	50	50.002	0.079000	-0.000594	0.001169	-0.029714	0.000826	0.029725
1A3a	Aviation Fuel	CH4	3.574412817	0.746511366	20	50	53.852	0.000070	-0.000002	0.000001	-0.000122	0.000027	0.000124
1A3b	DERV	CH4	107.2756433	16.82037759	1	50	50.010	0.001457	-0.000080	0.000022	-0.004005	0.000030	0.004005
1A3b	Gasoline/ LPG	CH4	529.7646953	37.79991574	0.5	50	50.002	0.003273	-0.000454	0.000048	-0.022676	0.000034	0.022676
1A3c	Coal	CH4	0	0.845783647	0.5	50	50.002	0.000073	0.000001	0.000001	0.000054	0.000001	0.000054
1A3d	Marine Fuel	CH4	1.86600767	4.066447002	1.7	50	50.029	0.000352	0.000003	0.000005	0.000172	0.000013	0.000173
1A3	Other Diesel	CH4	2.311216186	2.302576437	1.7	50	50.029	0.000199	0.000001	0.000003	0.000038	0.000007	0.000039
1B1	Coal Mining	CH4	18302.067	1982.530	0.5	13	13.010	0.044667	-0.014798	0.002540	-0.192369	0.001796	0.192377
	Solid Fuel Transformation	CH4	0.078	0.016	0.5	50	50.002	0.000001	0.000000	0.000000	-0.000003	0.000000	0.000003
	Wood	CH4	0.086	3.211	10	50	50.990	0.000284	0.000004	0.000004	0.000202	0.000058	0.000210
1B2	Natural Gas Transmission	CH4	8540.816	3978.821	1	15	15.033	0.103587	-0.002995	0.005097	-0.044927	0.007208	0.045502
	Offshore Oil& Gas	CH4	1818.301	1236.657	16	20	25.612	0.054853	-0.000139	0.001584	-0.002774	0.035844	0.035951
2A7	Other Mineral Use	CH4	23.602	3.340	20	100	101.980	0.000590	-0.000018	0.000004	-0.001808	0.000121	0.001812
2B	Chemical Industry	CH4	169.425	82.325	20	20	28.284	0.004032	-0.000055	0.000105	-0.001101	0.002983	0.003180
2C	Iron & Steel Production	CH4	1.092	0.494	0.5	50	50.002	0.000043	0.000000	0.000001	-0.000020	0.000000	0.000020
4A	Enteric Fermentation	CH4	19017.193	15652.021	0.1	20	20.000	0.542131	0.002031	0.020049	0.040615	0.002835	0.040714
4B	Manure Management	CH4	9002.219	6638.459	0.1	30	30.000	0.344897	-0.000026	0.008504	-0.000773	0.001203	0.001430
4F	Field Burning	CH4	265.912	0.000	25	50	55.902	0.000000	-0.000252	0.000000	-0.012597	0.000000	0.012597
5A	5A LUCF	CH4	3.125	16.475	1	20	20.025	0.000571	0.000018	0.000021	0.000363	0.000030	0.000364
5B	5B LUCF	CH4	0.093	0.216	1	50	50.010	0.000019	0.000000	0.000000	0.000009	0.000000	0.000009
5C2	5C2 LUCF	CH4	12.393	41.318	1	20	20.025	0.001433	0.000041	0.000053	0.000824	0.000075	0.000827
5E2	5E2 LUCF	CH4	4.945	6.619	1	20	20.025	0.000230	0.000004	0.000008	0.000076	0.000012	0.000077
6A	Solid Waste Disposal	CH4	43035.561	18566.628	15	46	48.384	1.555722	-0.016982	0.023783	-0.781194	0.504510	0.929943
6B	Wastewater Handling	CH4	1685.617	1634.437	1	50	50.010	0.141554	0.000497	0.002094	0.024828	0.002961	0.025003
6C	Waste Incineration	CH4	134.433	5.385	7	50	50.488	0.000471	-0.000120	0.000007	-0.006024	0.000068	0.006024
		CH4 total	104,522.39	50,823.83									

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

	Source Category	Gas	Emissions 1990 Gg CO2 equiv	Year Y emissions 2012 Gg CO2 equiv	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty range as % of national total in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced trend in total emissions by source category
					%	%	%	%	%	%	%	%	%
	A	B	C	D	E	F	G	H	I	J	K	L	M
1A1&1A2&1A4&1A5	Other Combustion	N2O	4640.115	3212.941	0.5	177.09714	177.098	0.985404	-0.000281	0.004116	-0.049716	0.002910	0.049801
1A3a	Aviation Fuel	N2O	16.291	18.006	20	170	171.172	0.005338	0.000008	0.000023	0.001297	0.000652	0.001452
1A3b	DERV	N2O	290.884	723.459	1	170	170.003	0.212994	0.000651	0.000927	0.110688	0.001311	0.110696
1A3b	Gasoline/ LPG	N2O	897.450	181.007	0.5	170	170.001	0.053290	-0.000618	0.000232	-0.105134	0.000164	0.105134
1A3c	Coal	N2O	0.000	0.100	0.5	118	118.001	0.000020	0.000000	0.000000	0.000015	0.000000	0.000015
1A3d	Marine Fuel	N2O	16.912	17.475	1.7	140	140.010	0.004237	0.000006	0.000022	0.000890	0.000054	0.000892
1A3	Other Diesel	N2O	32.630	62.414	1.7	140	140.010	0.015133	0.000049	0.000080	0.006865	0.000192	0.006867
1B1	Coke Oven Gas	N2O	0.116	0.024	0.5	118	118.001	0.000005	0.000000	0.000000	-0.000009	0.000000	0.000009
1B2	Oil & Natural Gas	N2O	42.396	40.585	16	110	111.158	0.007813	0.000012	0.000052	0.001300	0.001176	0.001753
2B	Adipic Acid Production	N2O	20737.345	0.000	2	100	100.020	0.000000	-0.019643	0.000000	-1.964268	0.000000	1.964268
2B	Nitric Acid Production	N2O	3903.850	60.760	10	100	100.499	0.010575	-0.003621	0.000078	-0.362075	0.001101	0.362077
2C	Iron & Steel	N2O	7.250	3.279	0.5	118	118.001	0.000670	-0.000003	0.000004	-0.000315	0.000003	0.000315
4B	Manure Management	N2O	3435.870	2737.212	1	254	254.002	1.204048	0.000251	0.003506	0.063714	0.004959	0.063907
4D	Agricultural Soils	N2O	33708.738	27098.125	1	259	259.002	12.154594	0.002772	0.034711	0.717995	0.049089	0.719672
4F	Field Burning	N2O	79.312	0.000	25	230	231.355	0.000000	-0.000075	0.000000	-0.017283	0.000000	0.017283
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	54.157	69.399	1	20	20.025	0.002407	0.000038	0.000089	0.000752	0.000126	0.000762
5B	5B LUCF	N2O	769.939	572.957	1	50	50.010	0.049622	0.000004	0.000734	0.000222	0.001038	0.001061
5C2	5C2 LUCF	N2O	14.385	25.387	1	20	20.025	0.000880	0.000019	0.000033	0.000378	0.000046	0.000381
5D2	5D2 LUCF	N2O	3.982	0.520	1	20	20.025	0.000018	-0.000003	0.000001	-0.000062	0.000001	0.000062
5E2	5E2 LUCF	N2O	0.502	0.672	1	20	20.025	0.000023	0.000000	0.000001	0.000008	0.000001	0.000008
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	1181.527	10	401	401.125	0.820770	0.000410	0.001513	0.164259	0.021404	0.165648
6C	Waste Incineration	N2O	56.892	45.734	7	230	230.106	0.018225	0.000005	0.000059	0.001076	0.000580	0.001222
		N2O Total	69,874.07	36,051.58									
2	Industrial Processes	HFC	11384	14132	1	15	15.033	0.367925	0.007315	0.018102	0.109731	0.025601	0.112678
2	Industrial Processes	PFC	1391	206	1	22	22.023	0.007860	-0.001054	0.000264	-0.023180	0.000373	0.023183
2	Industrial Processes	SF6	987	508	1	17	17.029	0.014980	-0.000285	0.000651	-0.004843	0.000920	0.004929
		Halocarbon & SF6 Total	13,762.14	14,846.14									
	TOTALS	GWP	780,673.37	577,433.23									
	Total Uncertainties%							12.6					2.61

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

	Source Category (Analysis without LULUCF)	Gas	Emissions 1990 Gg CO2 equiv	Year Y emissions 2012 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	248182	144938	0.5	1.1828513	1.284	0.318488	-0.052860	0.186106	-0.062526	0.131597	0.145696
1A(stationary)	Oil	CO2	96218	51577	10.58184063	9.4060149	14.158	1.249503	-0.026452	0.066226	-0.248804	0.991078	1.021832
1A	Natural Gas	CO2	108306	154922	0.5	1.5000209	1.581	0.419149	0.094436	0.198925	0.141656	0.140661	0.199629
1A	Other (waste)	CO2	235	2680	7	19.914373	21.109	0.096806	0.003215	0.003441	0.064024	0.034068	0.072524
1A	Lubricant	CO2	387	161	30	2	30.067	0.008271	-0.000166	0.000206	-0.000333	0.008758	0.008765
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	1655	1829	20	3.3	20.270	0.063441	0.000754	0.002349	0.002488	0.066427	0.066474
1A3b	DERV	CO2	32996	67126	1	2.1	2.326	0.267158	0.054376	0.086192	0.114189	0.121894	0.167024
1A3b	Gasoline/ LPG	CO2	75569	40768	0.5	4.7999329	4.826	0.336650	-0.020447	0.052348	-0.098143	0.037015	0.104891
1A3c	Coal	CO2	0	43	0.5	6	6.021	0.000440	0.000055	0.000055	0.000329	0.000039	0.000331
1A3d	Marine Fuel	CO2	2168	2243	1.7	2.0905113	2.694	0.010343	0.000791	0.002880	0.001654	0.006925	0.007120
1A3	Other Diesel	CO2	1680	2496	1.7	2.1	2.702	0.011539	0.001586	0.003205	0.003331	0.007705	0.008394
1A4	Peat	CO2	476	50	30	10	31.623	0.002721	-0.000394	0.000065	-0.003937	0.002739	0.004796
1A4	Petroleum Coke	CO2	77	460	20	3	20.224	0.015935	0.000517	0.000591	0.001552	0.016724	0.016795
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	855	227	0.5	6	6.021	0.002338	-0.000532	0.000291	-0.003194	0.000206	0.003201
1B	Oil & Natural Gas	CO2	5778	3550	16	6.1721264	17.149	0.104186	-0.001008	0.004559	-0.006224	0.103156	0.103344
2A1	Cement Production	CO2	7295	3716	1	5	5.099	0.032418	-0.002258	0.004771	-0.011291	0.006747	0.013154
2A2	Lime Production	CO2	1462	1178	1	5	5.099	0.010276	0.000103	0.001512	0.000516	0.002139	0.002200
2A3	Limestone & Dolomite use	CO2	1191	1178	5	5	7.071	0.014258	0.000366	0.001513	0.001829	0.010699	0.010854
2A7	Other Mineral Use	CO2	556	429	20	25	32.016	0.023527	0.000015	0.000551	0.000383	0.015597	0.015602
2B	Ammonia Production	CO2	1431	948	2.5	1.5	2.915	0.004731	-0.000161	0.001218	-0.000242	0.004305	0.004312
2B5	Non-energy use of products	CO2	1350	1709	50	100	111.803	0.326998	0.000893	0.002195	0.089348	0.155193	0.179075
2C1	Iron&Steel Production	CO2	2341	924	0.5	6.5847951	6.604	0.010438	-0.001069	0.001186	-0.007041	0.000839	0.007090
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	271	10	28.18643	29.908	0.013851	-0.000898	0.000348	-0.025303	0.004915	0.025776
		CO2 Total	591,499.32	483,423.63									
1A	All Fuel	CH4	1860.640808	912.2978436	0.5	50	50.002	0.078057	-0.000621	0.001171	-0.031069	0.000828	0.031080
1A3a	Aviation Fuel	CH4	3.574412817	0.746511366	20	50	53.852	0.000069	-0.000002	0.000001	-0.000124	0.000027	0.000127
1A3b	DERV	CH4	107.2756433	16.82037759	1	50	50.010	0.001439	-0.000082	0.000022	-0.004088	0.000031	0.004088
1A3b	Gasoline/ LPG	CH4	529.7646953	37.79991574	0.5	50	50.002	0.003234	-0.000462	0.000049	-0.023096	0.000034	0.023096
1A3c	Coal	CH4	0	0.845783647	0.5	50	50.002	0.000072	0.000001	0.000001	0.000054	0.000001	0.000054
1A3d	Marine Fuel	CH4	1.86600767	4.066447002	1.7	50	50.029	0.000348	0.000003	0.000005	0.000171	0.000013	0.000172
1A3	Other Diesel	CH4	2.311216186	2.302576437	1.7	50	50.029	0.000197	0.000001	0.000003	0.000036	0.000007	0.000037
1B1	Coal Mining	CH4	18302.067	1982.530	0.5	13	13.010	0.044133	-0.015086	0.002546	-0.196114	0.001800	0.196123
	Solid Fuel Transformation	CH4	0.078	0.016	0.5	50	50.002	0.000001	0.000000	0.000000	-0.000003	0.000000	0.000003
	Wood	CH4	0.086	3.211	10	50	50.990	0.000280	0.000004	0.000004	0.000202	0.000058	0.000210
1B2	Natural Gas Transmission	CH4	8540.816	3978.821	1	15	15.033	0.102350	-0.003120	0.005109	-0.046803	0.007225	0.047357
	Offshore Oil& Gas	CH4	1818.301	1236.657	16	20	25.612	0.054198	-0.000164	0.001588	-0.003282	0.035930	0.036080
2A7	Other Mineral Use	CH4	23.602	3.340	20	100	101.980	0.000583	-0.000018	0.000004	-0.001845	0.000121	0.001849
2B	Chemical Industry	CH4	169.425	82.325	20	20	28.284	0.003984	-0.000058	0.000106	-0.001151	0.002990	0.003204
2C	Iron & Steel Production	CH4	1.092	0.494	0.5	50	50.002	0.000042	0.000000	0.000001	-0.000021	0.000000	0.000021
4A	Enteric Fermentation	CH4	19017.193	15652.021	0.1	20	20.000	0.535657	0.001773	0.020098	0.035467	0.002842	0.035581
4B	Manure Management	CH4	9002.219	6638.459	0.1	30	30.000	0.340778	-0.000150	0.008524	-0.004501	0.001205	0.004660
4F	Field Burning	CH4	265.912	0.000	25	50	55.902	0.000000	-0.000256	0.000000	-0.012811	0.000000	0.012811
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	43035.561	18566.628	15	46	48.384	1.537145	-0.017617	0.023840	-0.810376	0.505727	0.955232
6B	Wastewater Handling	CH4	1685.617	1634.437	1	50	50.010	0.139864	0.000474	0.002099	0.023725	0.002968	0.023910
6C	Waste Incineration	CH4	134.433	5.385	7	50	50.488	0.000465	-0.000123	0.000007	-0.006131	0.000068	0.006131
		CH4 total	104,501.84	50,759.20									

Table A 7.5.4 Summary of error propagation uncertainty estimates excluding LULUCF, base year to the latest reported year (continued)

	Source Category	Gas	Emissions 1990	Year Y emissions 2012	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	4640.115	3212.941	0.5	177.09714	177.098	0.973637	-0.000345	0.004126	-0.061173	0.002917	0.061242
1A3a	Aviation Fuel	N2O	16.291	18.006	20	170	171.172	0.005274	0.000007	0.000023	0.001262	0.000654	0.001421
1A3b	DERV	N2O	290.884	723.459	1	170	170.003	0.210451	0.000649	0.000929	0.110273	0.001314	0.110281
1A3b	Gasoline/ LPG	N2O	897.450	181.007	0.5	170	170.001	0.052654	-0.000632	0.000232	-0.107493	0.000164	0.107493
1A3c	Coal	N2O	0.000	0.100	0.5	118	118.001	0.000020	0.000000	0.000000	0.000015	0.000000	0.000015
1A3d	Marine Fuel	N2O	16.912	17.475	1.7	140	140.010	0.004186	0.000006	0.000022	0.000860	0.000054	0.000862
1A3	Other Diesel	N2O	32.630	62.414	1.7	140	140.010	0.014953	0.000049	0.000080	0.006818	0.000193	0.006821
1B1	Coke Oven Gas	N2O	0.116	0.024	0.5	118	118.001	0.000005	0.000000	0.000000	-0.000010	0.000000	0.000010
1B2	Oil & Natural Gas	N2O	42.396	40.585	16	110	111.158	0.007719	0.000011	0.000052	0.001239	0.001179	0.001710
2B	Adipic Acid Production	N2O	20737.345	0.000	2	100	100.020	0.000000	-0.019976	0.000000	-1.997610	0.000000	1.997610
2B	Nitric Acid Production	N2O	3903.850	60.760	10	100	100.499	0.010449	-0.003683	0.000078	-0.368334	0.001103	0.368336
2C	Iron & Steel	N2O	7.250	3.279	0.5	118	118.001	0.000662	-0.000003	0.000004	-0.000327	0.000003	0.000327
4B	Manure Management	N2O	3435.870	2737.212	1	254	254.002	1.189670	0.000204	0.003515	0.051827	0.004971	0.052065
4D	Agricultural Soils	N2O	33708.738	27098.125	1	259	259.002	12.009458	0.002314	0.034795	0.599323	0.049208	0.601340
4F	Field Burning	N2O	79.312	0.000	25	230	231.355	0.000000	-0.000076	0.000000	-0.017577	0.000000	0.017577
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	1181.527	10	401	401.125	0.810969	0.000395	0.001517	0.158210	0.021455	0.159658
6C	Waste Incineration	N2O	56.892	45.734	7	230	230.106	0.018007	0.000004	0.000059	0.000898	0.000581	0.001070
		N2O Total	69,031.10	35,382.65									
2	Industrial Processes	HFC	11384	14132	1	15	15.033	0.363532	0.007176	0.018146	0.107640	0.025662	0.110657
2	Industrial Processes	PFC	1391	206	1	22	22.023	0.007766	-0.001075	0.000265	-0.023658	0.000374	0.023661
2	Industrial Processes	SF6	987	508	1	17	17.029	0.014801	-0.000299	0.000652	-0.005086	0.000922	0.005169
		Halocarbon & SF6 Total	13,762.14	14,846.14									
	TOTALS	GWP	778,794.40	584,411.63									
	Total Uncertainties%							12.3					2.59

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 2012.

Furthermore, the uncertainty assumed for agriculture sectors 4B12, 4B14, 4B14 and 4D differs significantly between the two approaches, due to the introduction of a custom PDF in the Monte Carlo analysis for these sectors.

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 2012)
	1990	**2012**	
Error propagation	783,829	577,433	5.2
Monte Carlo	780,731	577,542	5.1[a]

Notes

CI Confidence Interval

[a] 2.5th percentile, -29%, 97.5th percentile, -24%. 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 (MHD) on the west coast of Ireland. The station reports high-frequency mole fractions of the key greenhouse gases and is under the supervision of Prof. Simon O'Doherty of the University of Bristol (O'Doherty *et al.* 2004). DECC extended the measurement programme in 2011 with three new tall tower stations across the UK (UK DECC network): Tacolneston (TAC) near Norwich; Ridge Hill (RGL) near Hereford; Tall Tower Angus (TTA) near Dundee.

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 MHD at the time of each observation. By estimating and removing the underlying *baseline* trends (Northern Hemisphere mid-latitude atmospheric mole fractions 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 MHD 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 MHD observations (Manning et al 2003, 2011).

In the work presented this Chapter both the NAME baseline trends and the UK emission estimates are presented. InTEM estimates using only MHD data are presented along with the estimates made using the full UK DECC network. When only MHD data are used the temporal resolution of the inversion is three years, however with the additional data from the other UK stations the inversion time resolution is improved to one-year. The geographical spread of the UK DECC network allows the spatial distribution of the emissions across the UK to be better constrained within InTEM. 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 monthly mean mole fraction 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) with other sources including geological seeps and freshwater. 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 MHD, a peat bog area, the influence of observations taken when local emissions will be significant (low wind speeds and low boundary layer heights) has been reduced within InTEM

The GHGI trend is consistently downwards whereas the median of the InTEM estimates, after a rapid fall, shows only a very modest decline from 1992 onwards (**Figure A 8.2.2**).

Figure A 8.2.1 Monthly Northern Hemisphere trend in methane estimated from MHD observations (ppb). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.

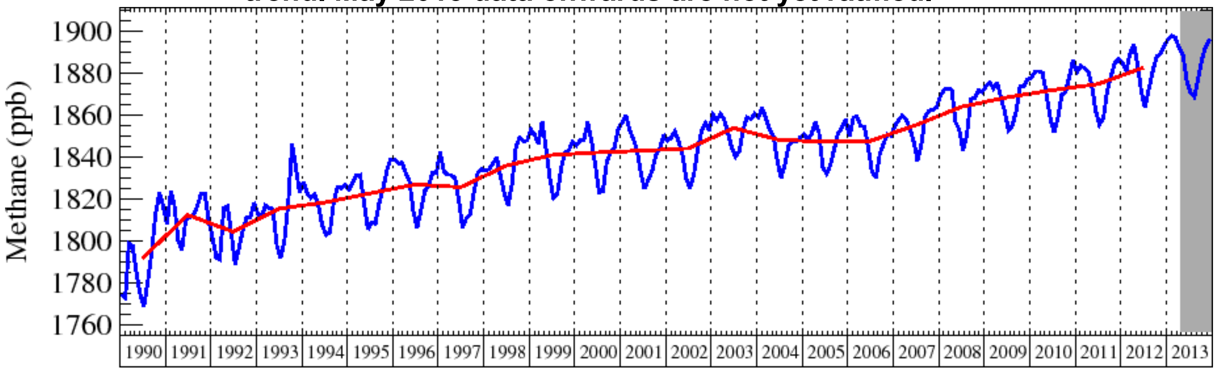


Figure A 8.2.2 Verification of the UK emission inventory estimates for methane in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM (GHGI) uncertainties are shown with the black (red) whisker lines.

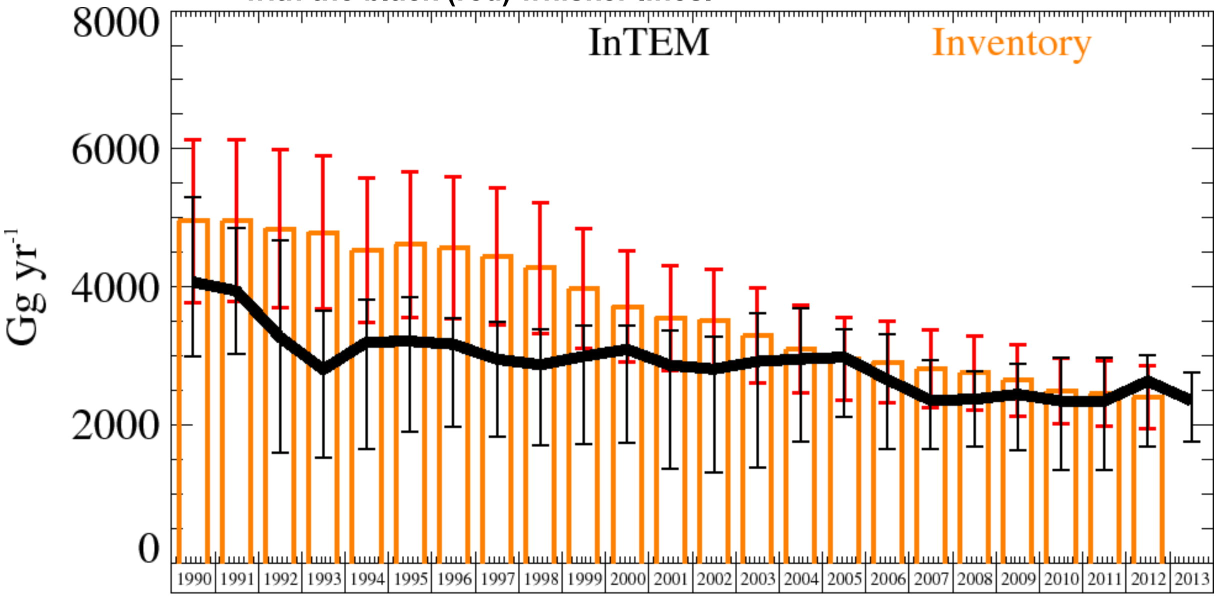
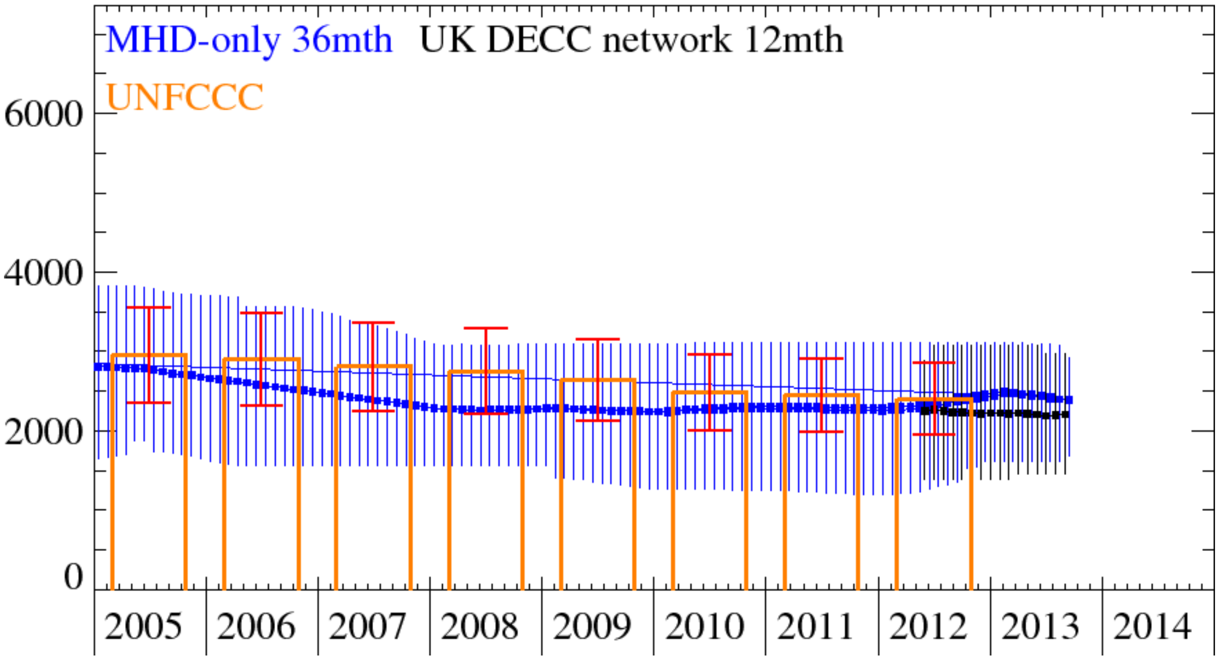


Figure A 8.2.3 **Verification of the UK emission inventory estimates for methane in Gg yr^{-1} for 2005-2013. GHGI estimates are shown in orange. Monthly InTEM MHD-only estimates are shown in blue. Monthly InTEM all-data estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.**



A8.3 NITROUS OXIDE

Figure A 8.3.1 shows the baseline atmospheric mole fraction 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 through biological process such as nitrification and denitrification (~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 GHGI estimates up to 2011. The trends in the time-series are in good agreement up to 2011 with 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. In 2012 and 2013 InTEM emissions have risen, this is seen both when using only MHD observations and when observations from the whole UK DECC network are used. Although the emission uncertainties of both InTEM and GHGI are significant, the latter are considerably larger.

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 MHD observations (ppb). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.

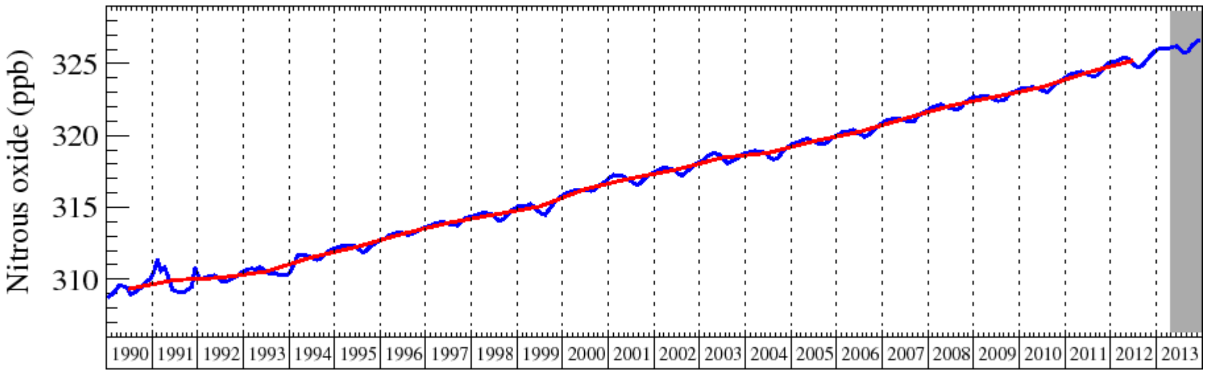


Figure A 8.3.2 Verification of the UK emission inventory estimates for nitrous oxide in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM (GHGI) uncertainties are shown with the black (red) whisker lines.

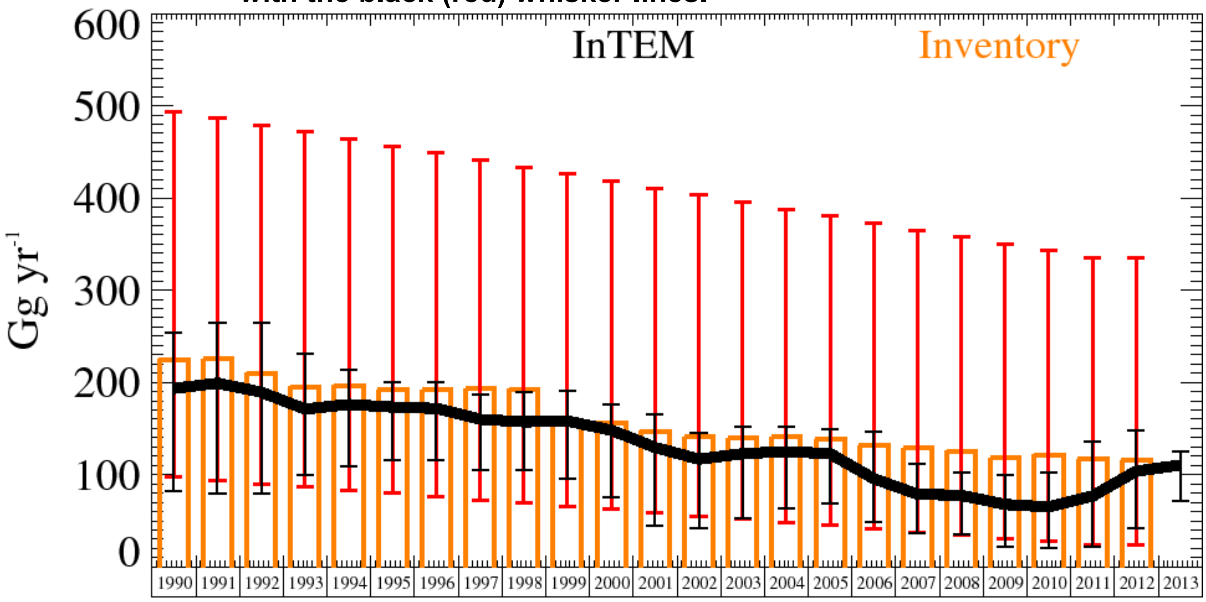
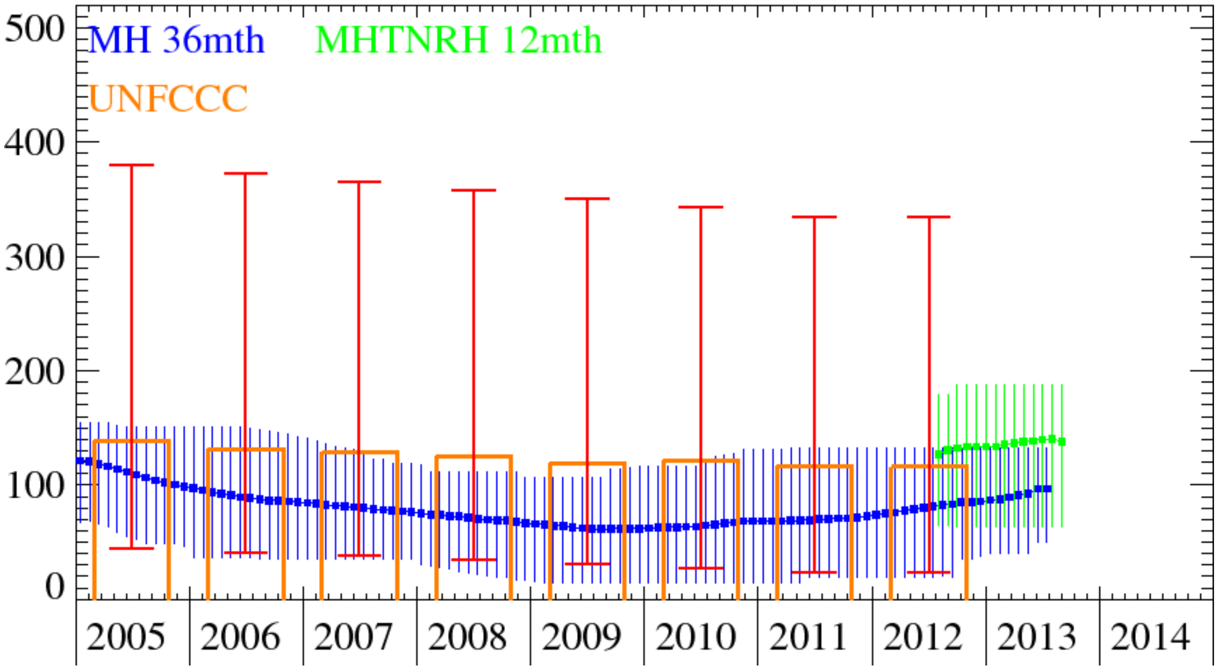


Figure A 8.3.3 Verification of the UK emission inventory estimates for nitrous oxide in Gg yr^{-1} for 2005-2013. GHGI estimates are shown in orange. Monthly InTEM MHD-only estimates are shown in blue. Monthly InTEM all-data estimates are shown in green. InTEM and GHGI uncertainties are shown as whisker lines.



A8.4 HYDROFLUOROCARBONS

A8.4.1 HFC-134a

Figure A 8.4.1 shows the baseline atmospheric mole fraction of the most widely used HFC, 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 MHD observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.

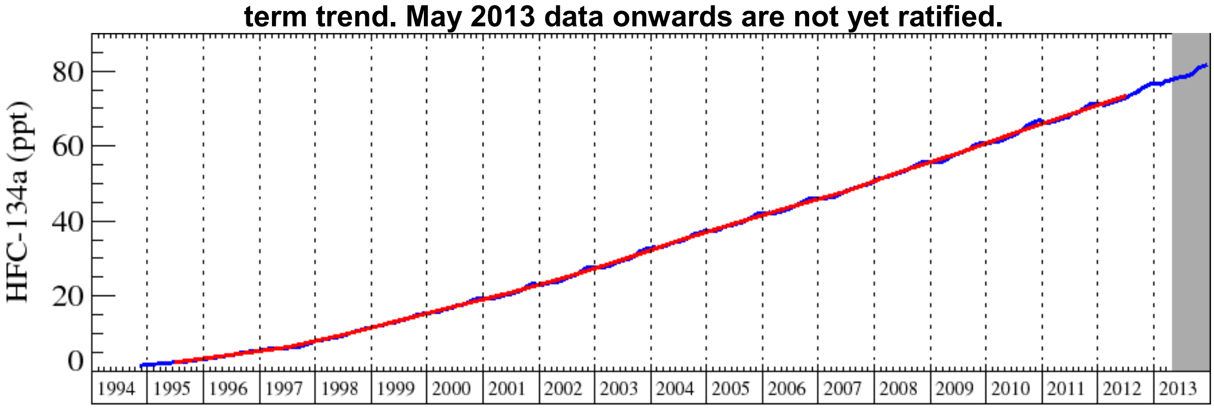


Figure A 8.4.2 shows the InTEM and GHGI emission estimates for the UK for HFC-134a for the period 1990 onwards. The GHGI shows a stronger increase in emission compared to the InTEM estimates. The InTEM estimates have risen at about 50% of the rate of the GHGI.

From the late 1990s onwards there is poor agreement between the GHGI and InTEM, with the InTEM estimates being about 60% of the GHGI estimates and well outside both uncertainty ranges. A similar result is obtained when the TAC observations are included within InTEM. GHGI and InTEM both show the UK reducing its emissions from a peak in 2009.

Figure A 8.4.2 Verification of the UK emission inventory estimates for HFC-134a in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.

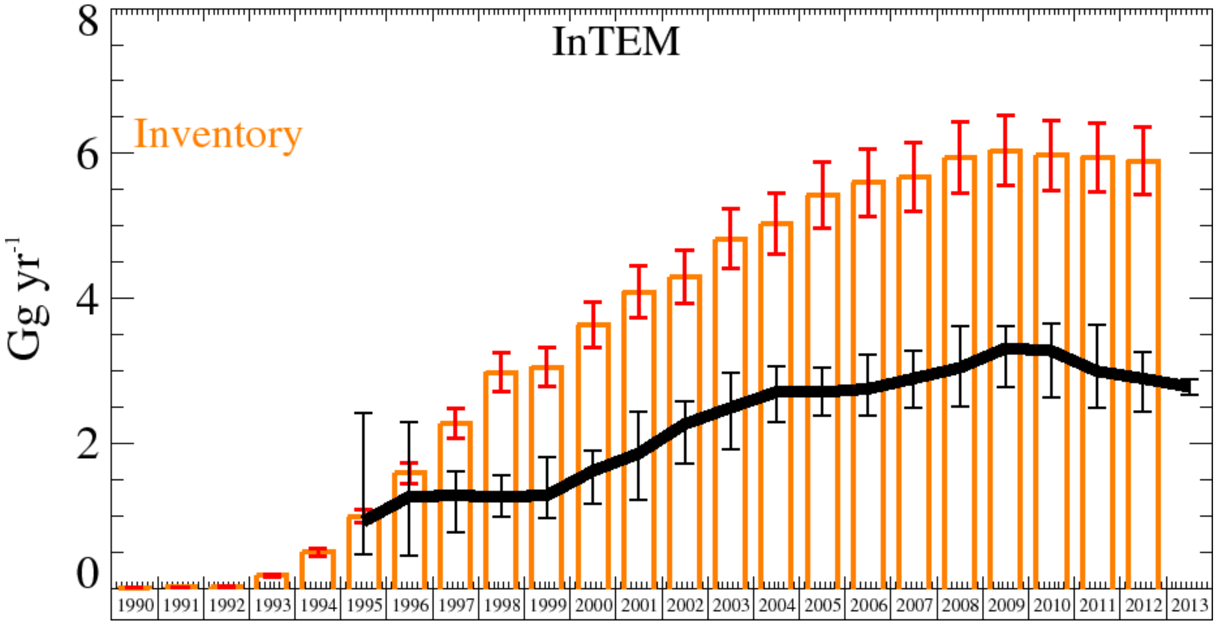
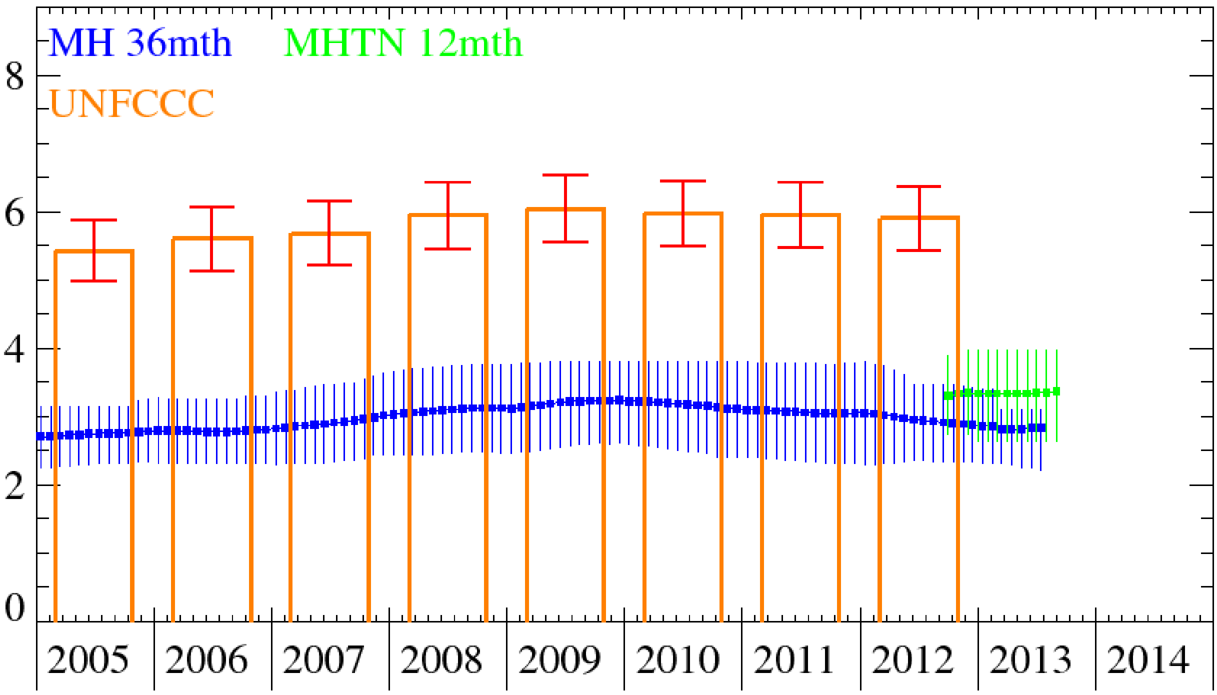


Figure A 8.4.3 **Verification of the UK emission inventory estimates for HFC-134a in Gg yr-1 for 2005-2013. GHGI estimates are shown in orange. Monthly InTEM MHD-only estimates are shown in blue. Monthly InTEM all-data estimates are shown in green. InTEM and GHGI uncertainties are shown as whisker lines.**



A8.4.2 HFC-152a

Figure A 8.4.4 shows the baseline atmospheric mole fraction 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 8.4.4 **Monthly Northern Hemisphere trend in HFC-152a estimated from MHD observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.**

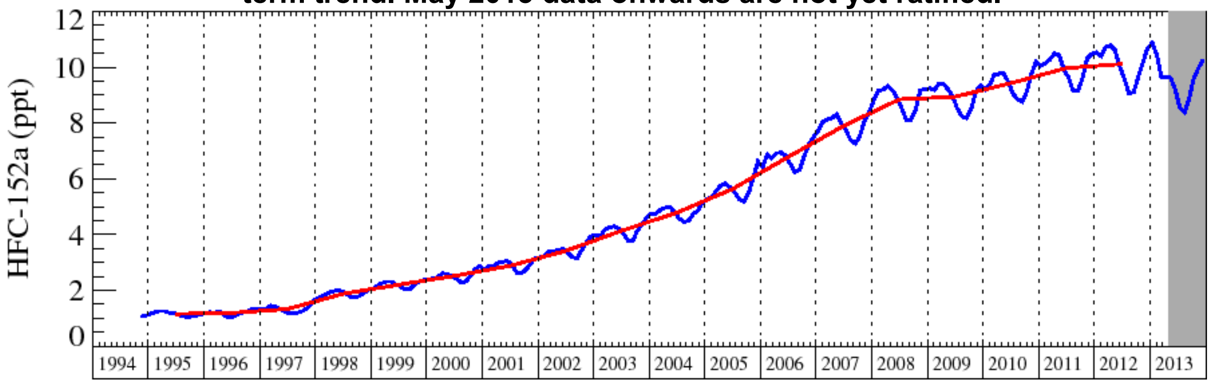


Figure A 8.4.5 shows the InTEM and the GHGI emission estimates for the UK for HFC-152a for the period 1990 onwards. From 2002-2008 the GHGI estimates are significantly larger than those estimated through the inversion modelling. From 2009 onwards the agreement between the 2 methods is good and consistently falls with the uncertainty ranges of both.

Figure A 8.4.5 Verification of the UK emission inventory estimates for HFC-152a in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.

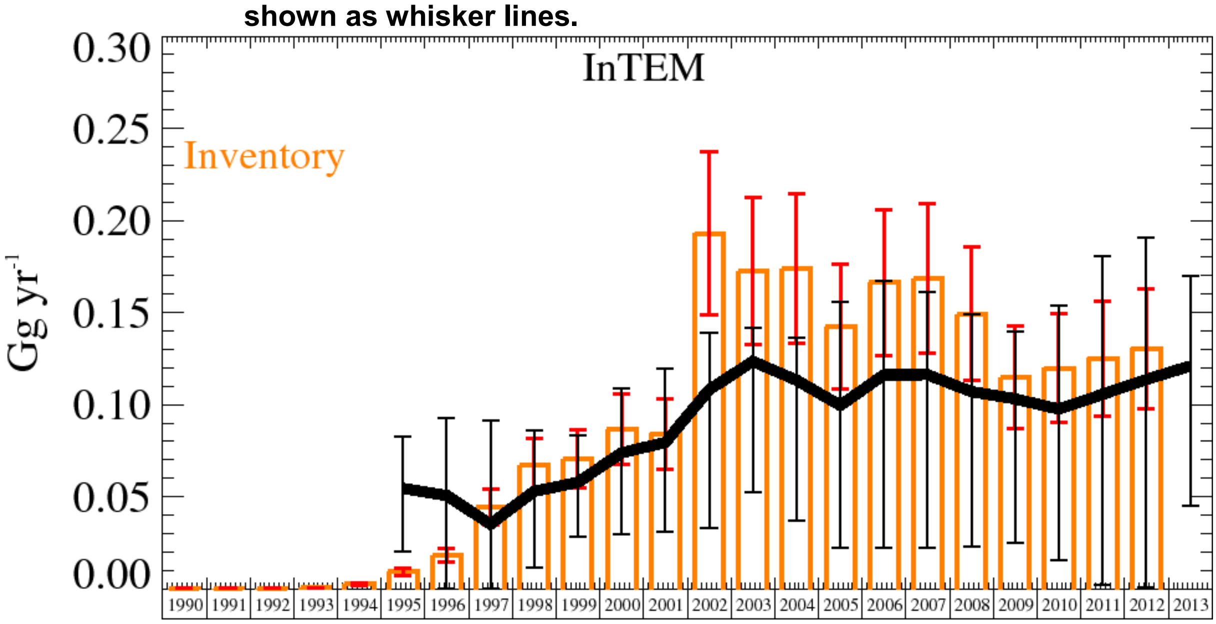
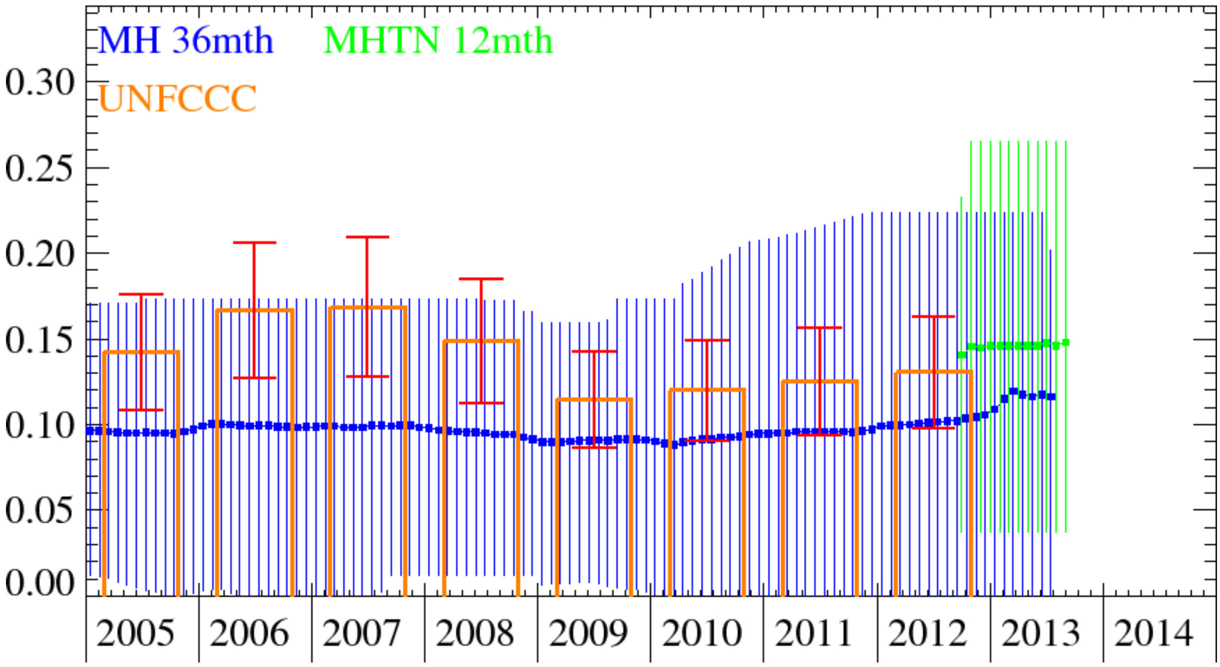


Figure A 8.4.6 Verification of the UK emission inventory estimates for HFC-152a in Gg yr^{-1} for 2005-2013. GHGI estimates are shown in orange. Monthly InTEM MHD-only estimates are shown in blue. Monthly InTEM all-data estimates are shown in green. InTEM and GHGI uncertainties are shown as whisker lines.



A8.4.3 HFC-125

Figure A 8.4.7 shows the baseline atmospheric mole fraction 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 8.4.8**. Both estimates suggest that the emissions of HFC-125 from the UK have increased significantly from the mid-1990s. The agreement between the 2 methods is excellent up until 2009 when InTEM reaches its peak. From 2010 The InTEM estimates show a modest decline in sharp contrast to the strongly increasing GHGI. By 2012 the difference between the GHGI and InTEM estimates is approximately 0.2 Gg yr^{-1} (20%).

Figure A 8.4.7 Monthly Northern Hemisphere trend in HFC-125 estimated from MHD observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.

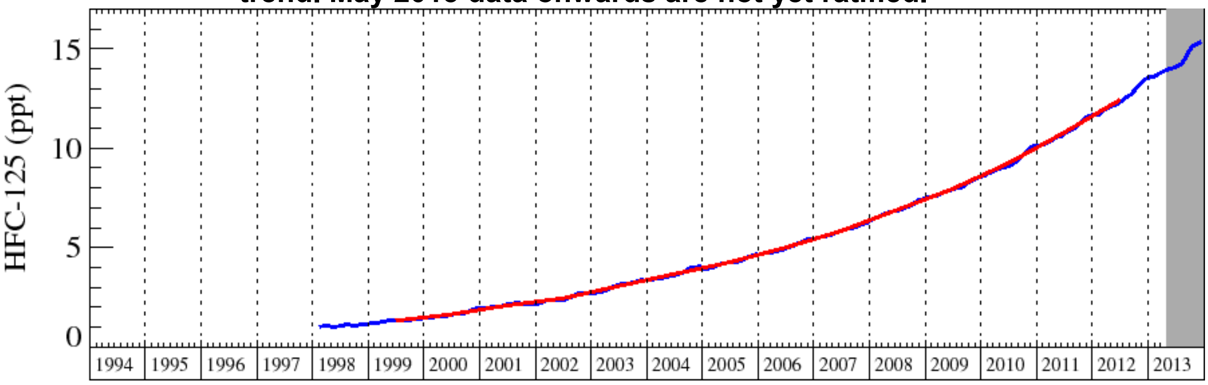


Figure A 8.4.8 Verification of the UK emission inventory estimates for HFC-125 in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.

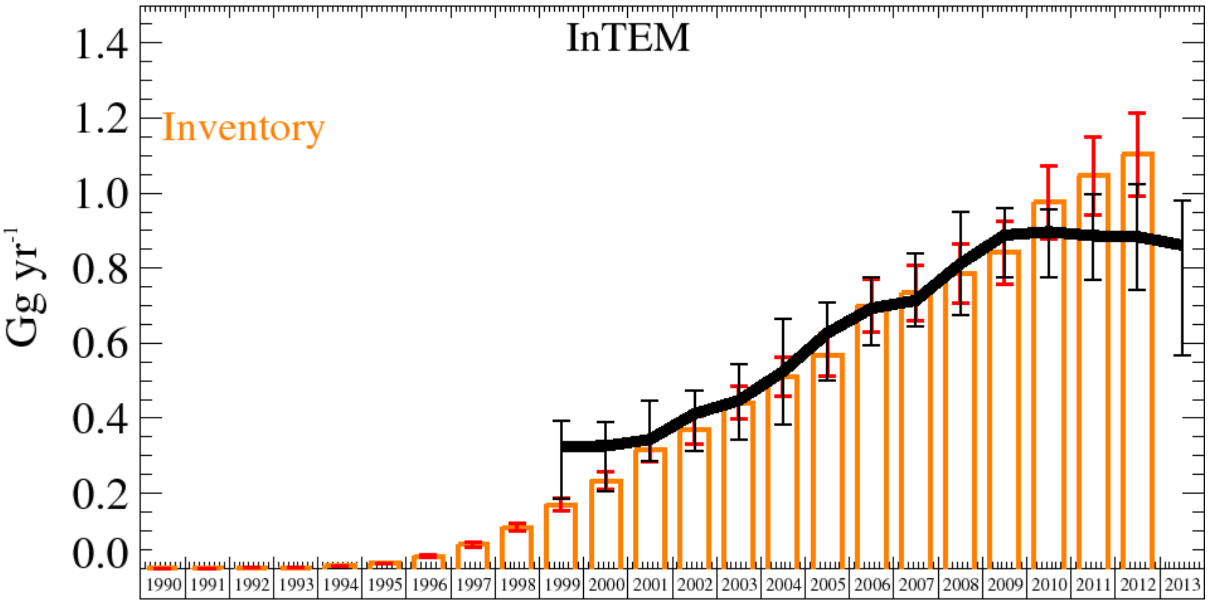
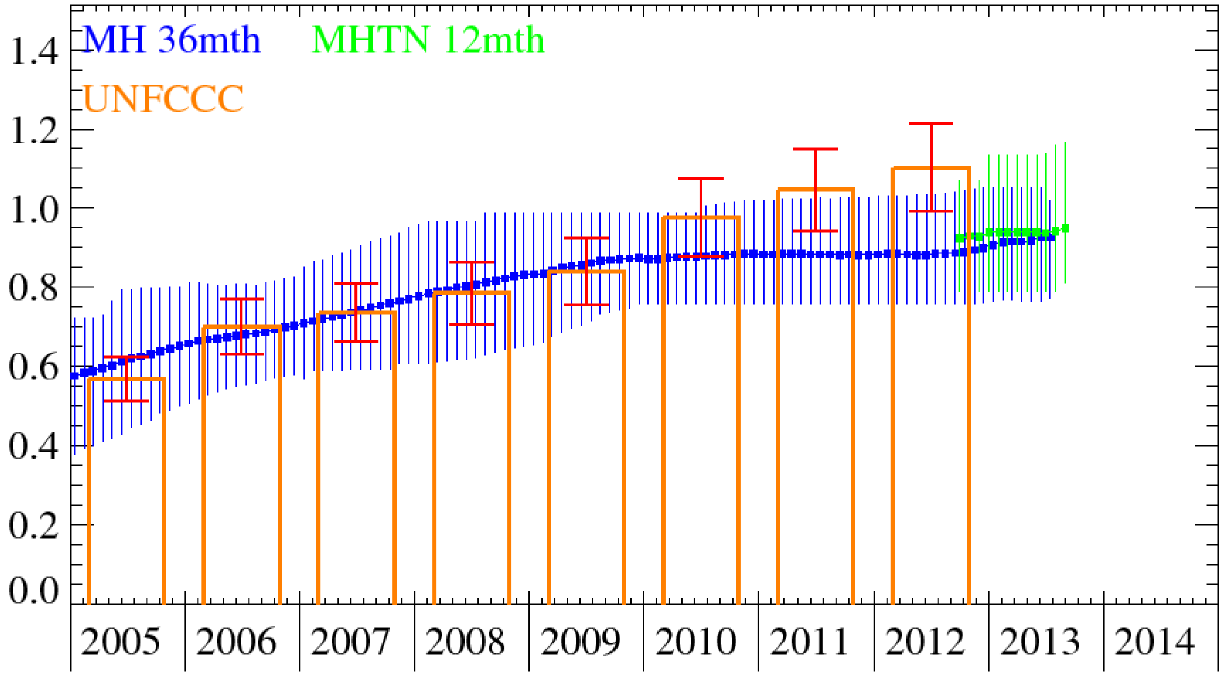


Figure A 8.4.9 **Verification of the UK emission inventory estimates for HFC-125 in Gg yr^{-1} for 2005-2013. GHGI estimates are shown in orange. Monthly InTEM MHD-only estimates are shown in blue. Monthly InTEM all-data estimates are shown in green. InTEM and GHGI uncertainties are shown as whisker lines.**



A8.4.4 HFC-143a

Figure A 8.4.10 shows the baseline atmospheric mole fraction 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 8.4.11** 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 InTEM estimates are consistently higher than the GHGI estimates, with the uncertainty ranges not overlapping until 2010.

Figure A 8.4.10 **Monthly Northern Hemisphere trend in HFC-143a estimated from MHD observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.**

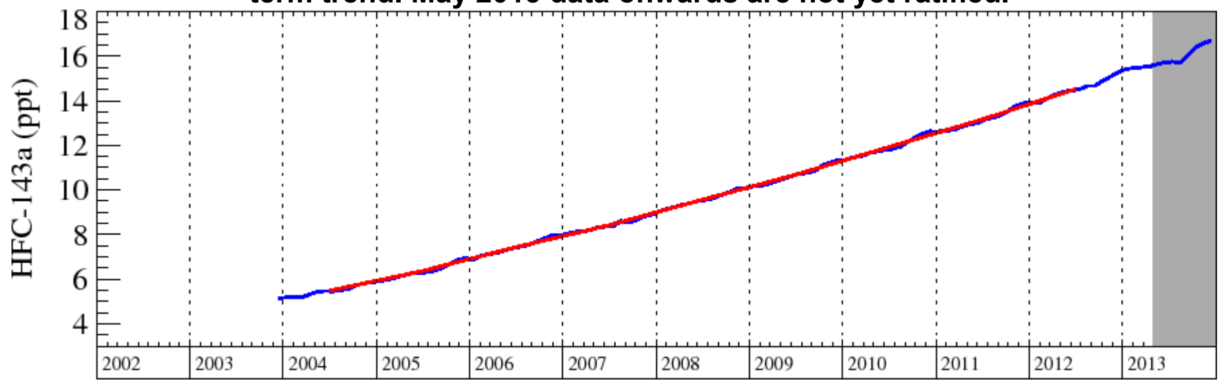


Figure A 8.4.11 **Verification of the UK emission inventory estimates for HFC-143a in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.**

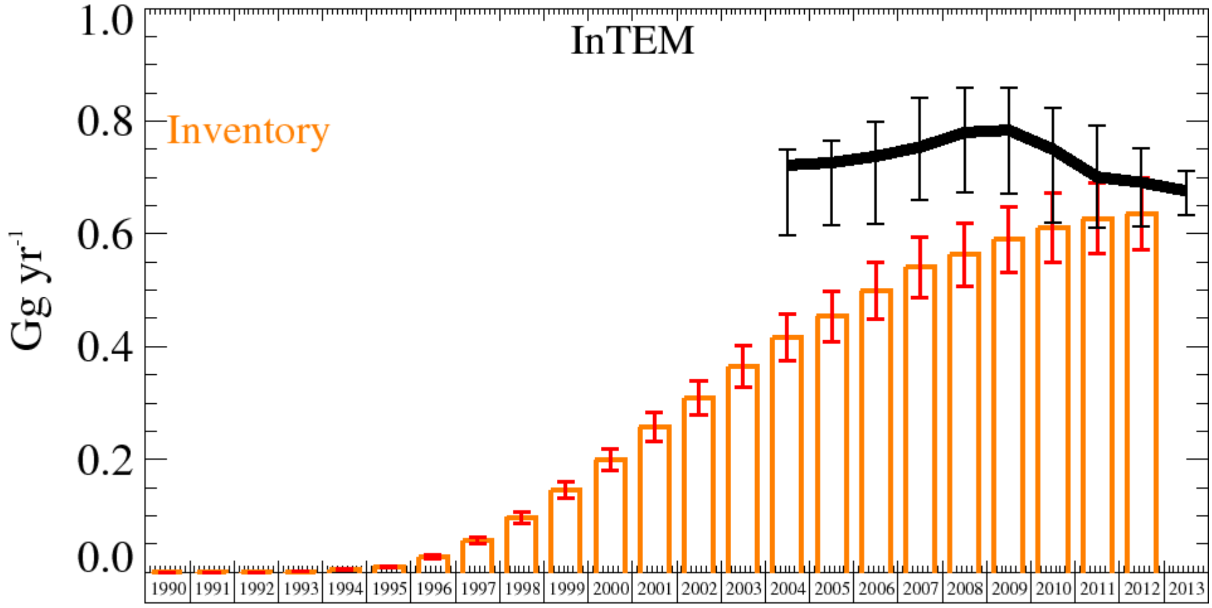
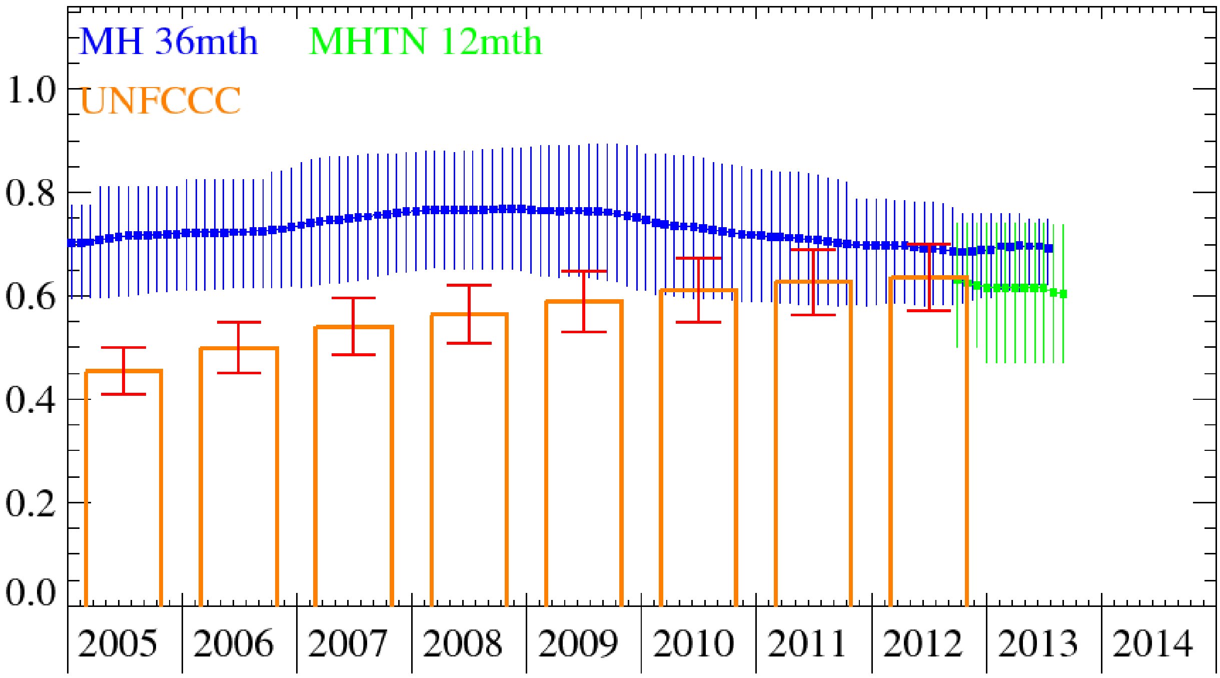


Figure A 8.4.12 **Verification of the UK emission inventory estimates for HFC-143a in Gg yr^{-1} for 2005-2013. GHGI estimates are shown in orange. Monthly InTEM MHD-only estimates are shown in blue. Monthly InTEM all-data estimates are shown in green. InTEM and GHGI uncertainties are shown as whisker lines.**



A8.4.5 HFC-23

Figure A 8.4.13 shows the baseline atmospheric mole fraction of HFC-23 from 2008 onwards. The annual trend is monotonic and positive at around 0.5 ppt/yr.

InTEM emission estimates for the UK for HFC-23 for 2008-2010 agree, within the uncertainty range, with the recent low emissions estimated by the GHGI (**Figure A 8.4.15**).

Figure A 8.4.13 Monthly Northern Hemisphere trend in HFC-23 estimated from MHD observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.

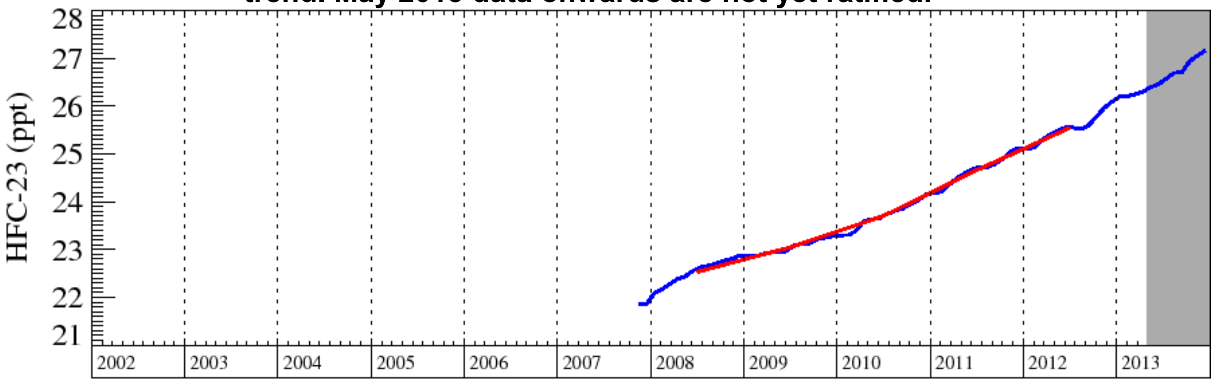


Figure A 8.4.14 Verification of the UK emission inventory estimates for HFC-23 in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.

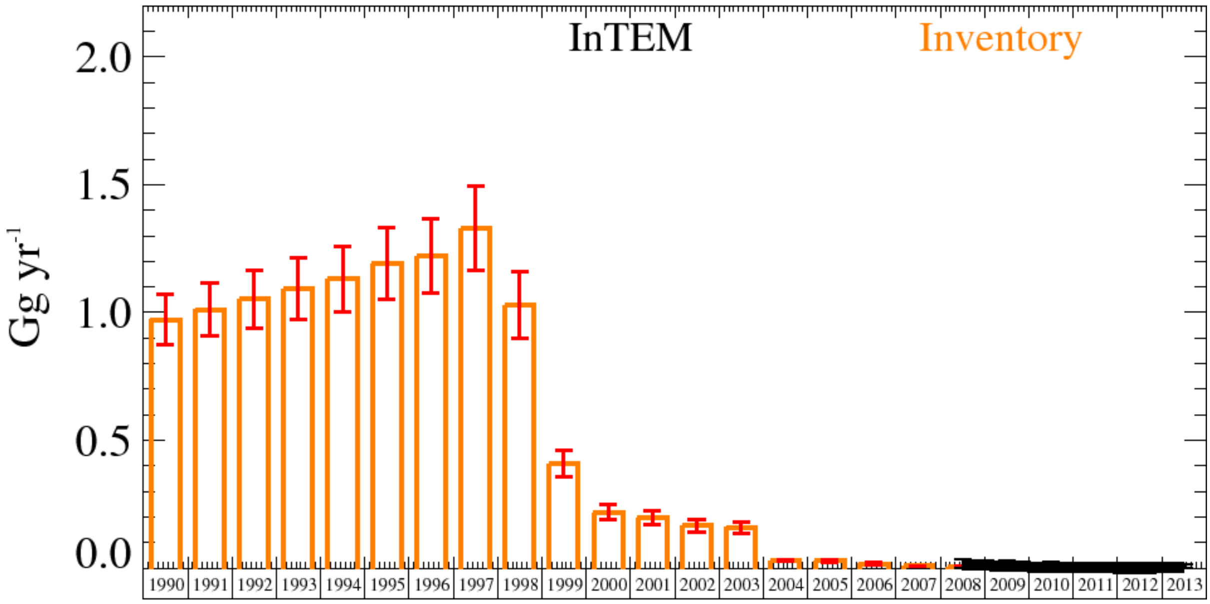
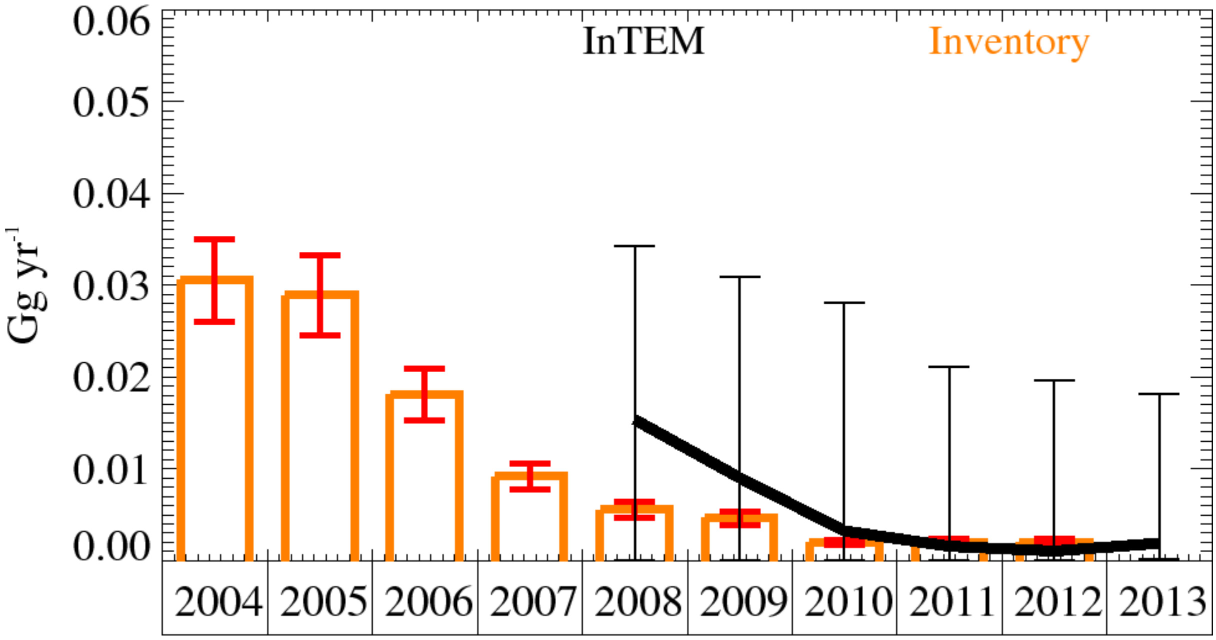


Figure A 8.4.15 Verification of the UK emission inventory estimates for HFC-23 in Gg yr^{-1} zoomed in for 2004-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.



A8.4.6 HFC-32

Figure A 8.4.16 shows the baseline atmospheric mole fraction 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 8.4.17**. The InTEM emission estimates are lower than the GHGI estimates. Both trends are positive however the rate of increase of the GHGI is larger than the InTEM. By 2012 the difference in estimated emissions is significant at more than 30%.

Figure A 8.4.16 Monthly Northern Hemisphere trend in HFC-32 estimated from MHD observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.

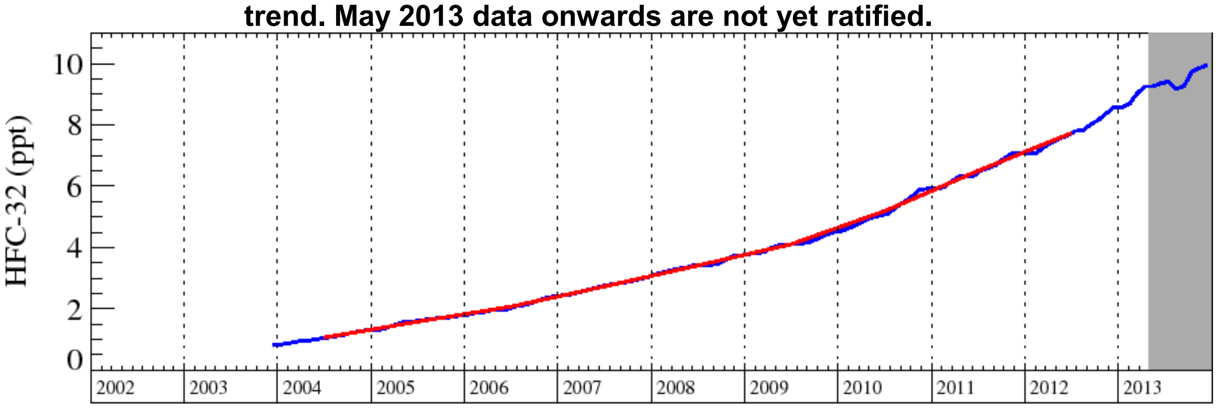
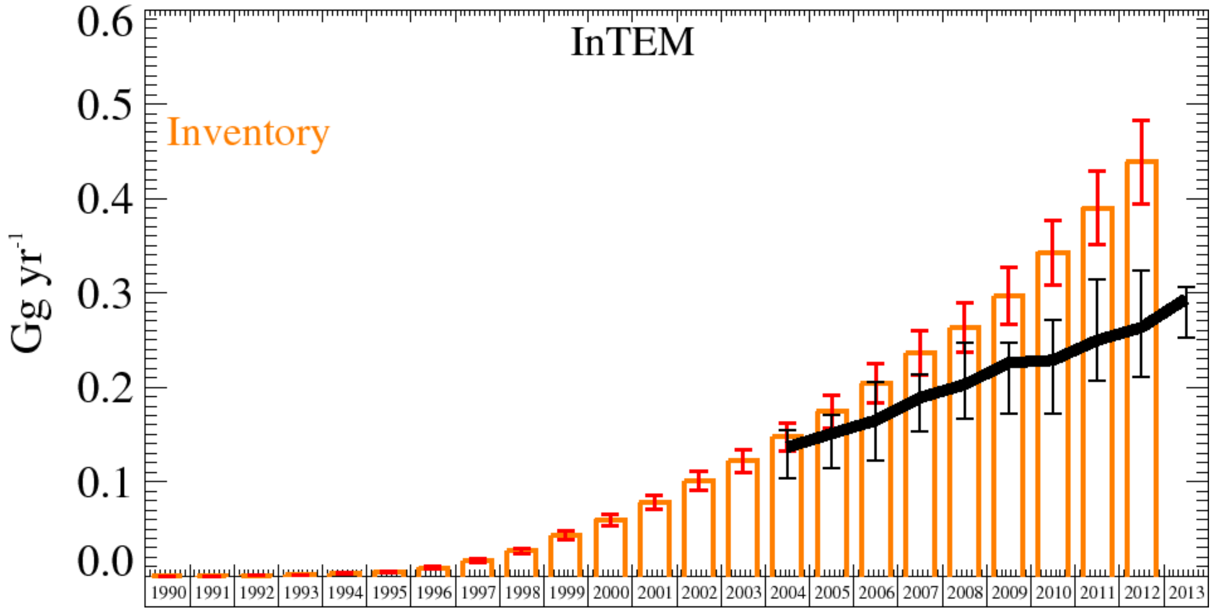


Figure A 8.4.17 Verification of the UK emission inventory estimates for HFC-32 in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.



A8.4.7 HFC-4310mee

Figure A 8.4.18 shows the baseline atmospheric mole fraction of HFC-4310mee from 2010 onwards. There is little discernible trend. The GHGI estimates are considerably larger (factor of 8) than those obtained through inversion modelling.

Figure A 8.4.18 Monthly Northern Hemisphere trend in HFC-4310mee estimated from MHD observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.

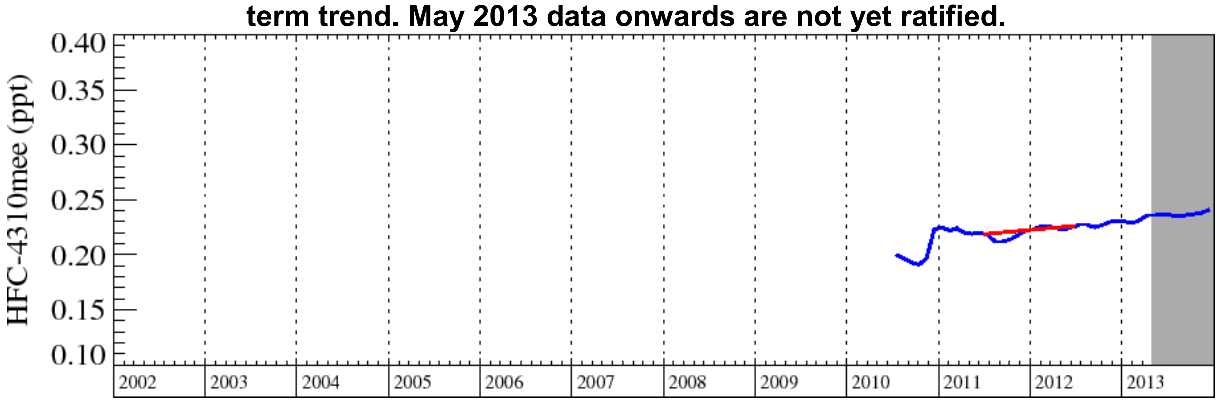


Figure A 8.4.19 Verification of the UK emission inventory estimates for HFC-4310mee in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.

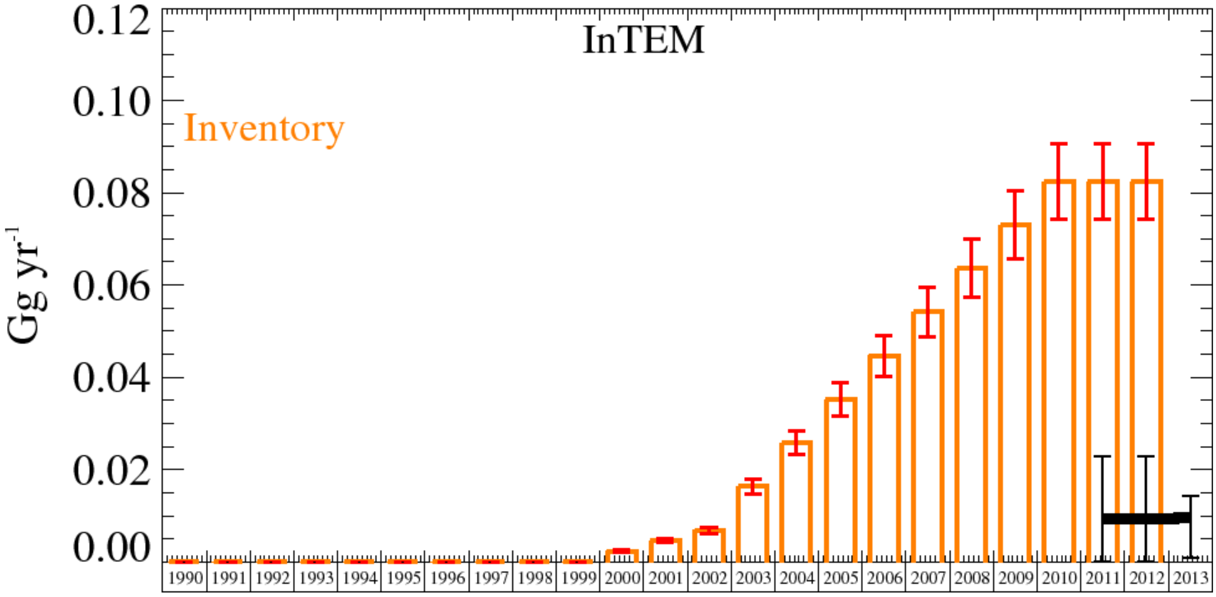
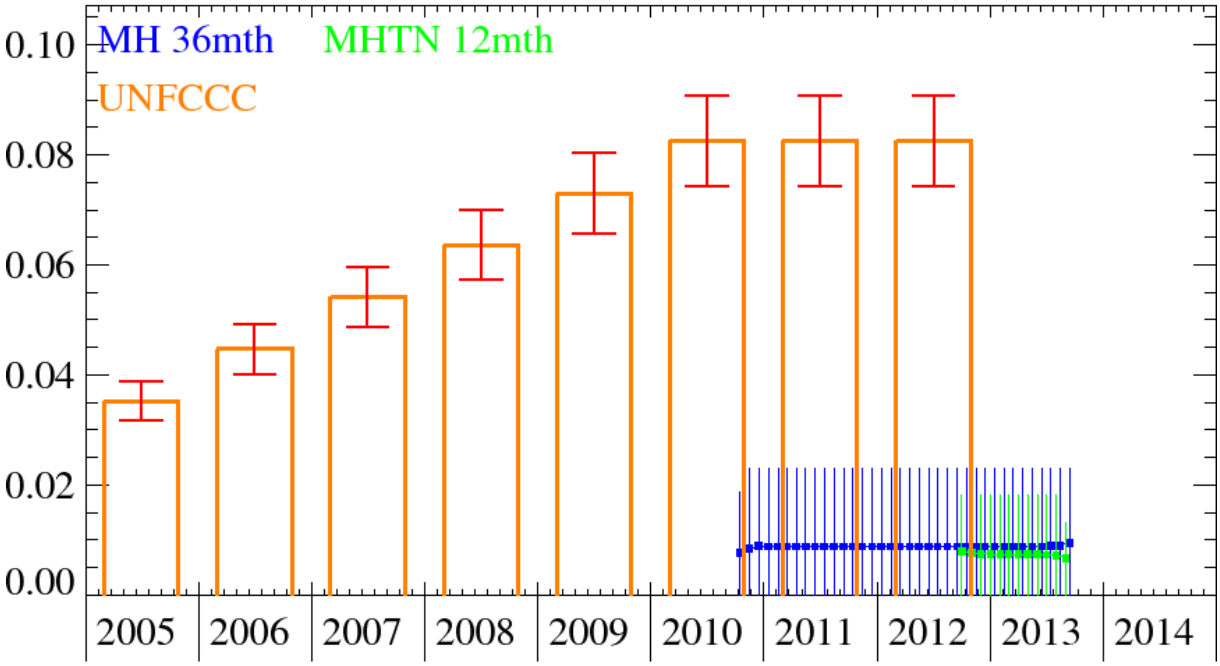


Figure A 8.4.20 Verification of the UK emission inventory estimates for HFC-4310mee in Gg yr^{-1} for 2005-2013. GHGI estimates are shown in orange. Monthly InTEM MHD-only estimates are shown in blue. Monthly InTEM all-data estimates are shown in green. InTEM and GHGI uncertainties are shown as whisker lines.



A8.4.8 HFC-227ea

Figure A 8.4.21 shows the baseline atmospheric mole fraction of HFC-227ea from 2007 onwards. There is positive trend of ~0.08 ppt yr^{-1}. The GHGI estimates are about double those obtained through inversion modelling.

Figure A 8.4.21 Monthly Northern Hemisphere trend in HFC-227ea estimated from MHD observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.

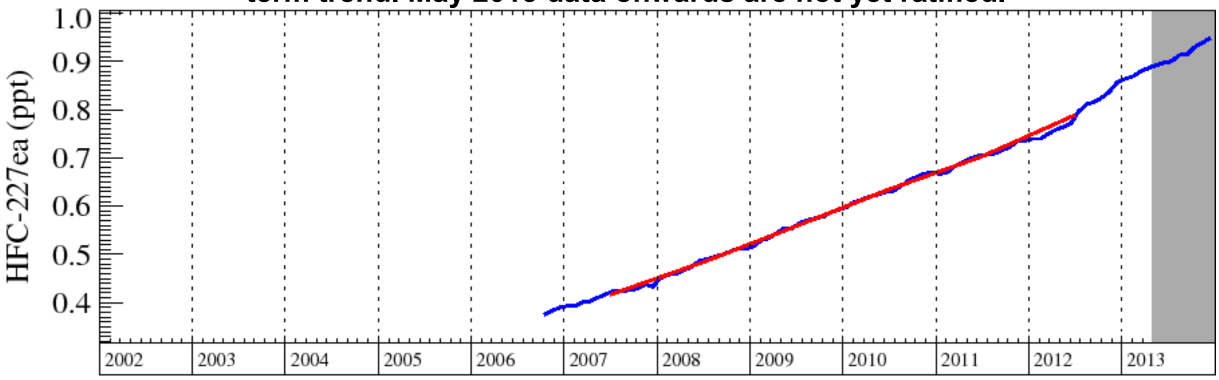


Figure A 8.4.22 Verification of the UK emission inventory estimates for HFC-227ea in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.

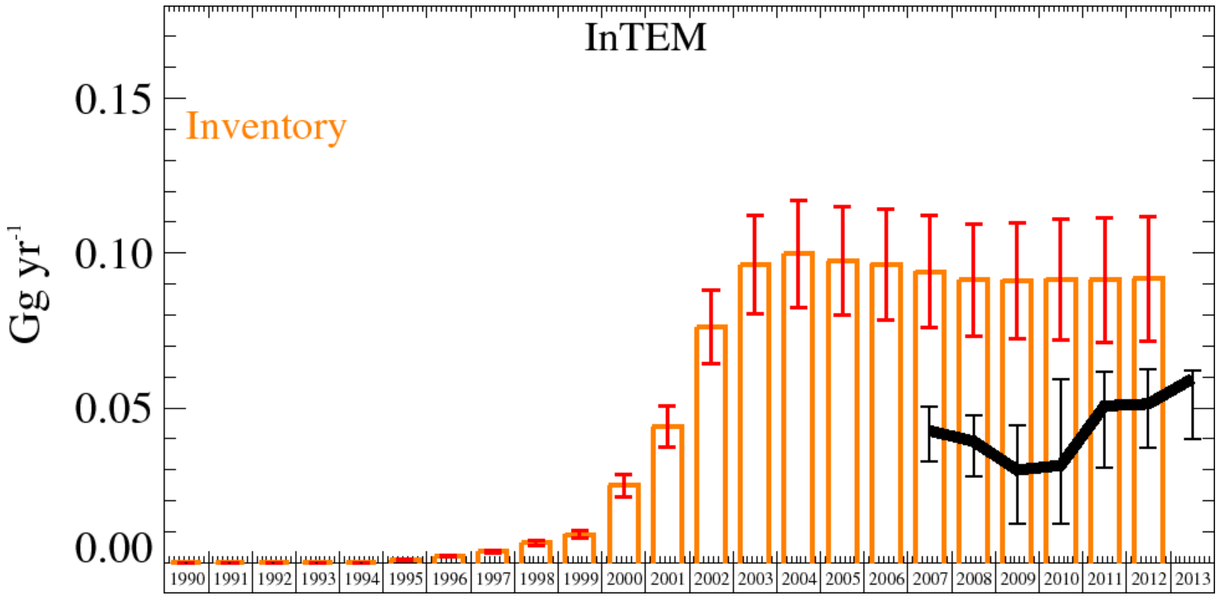
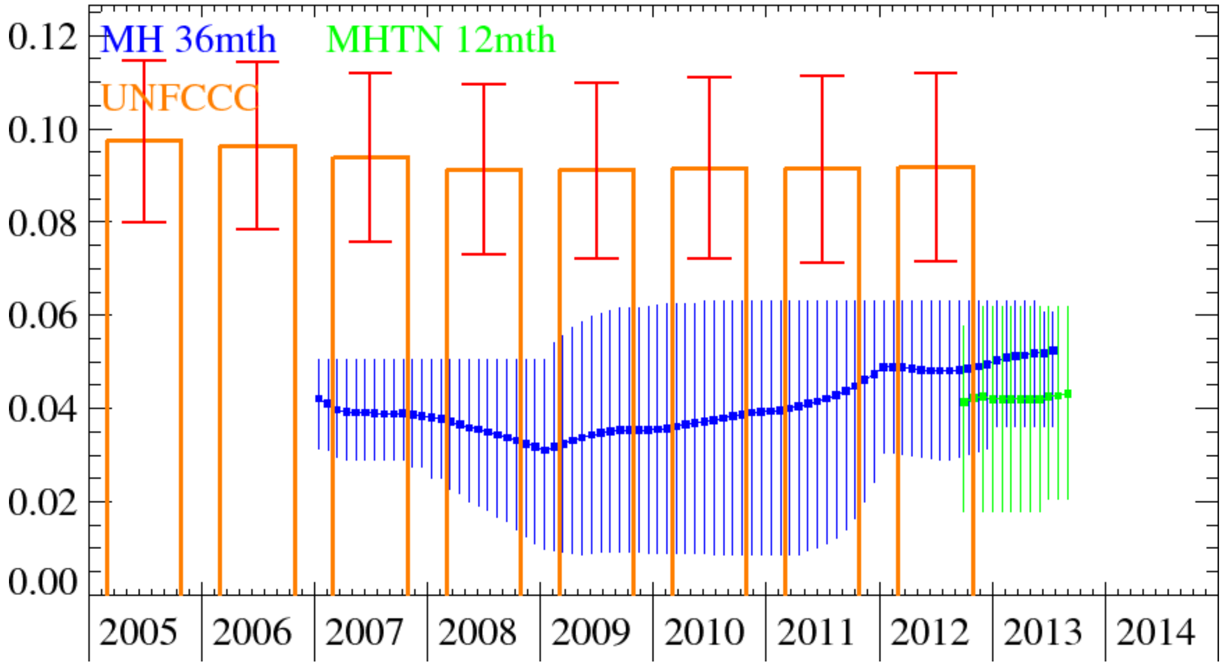


Figure A 8.4.23 Verification of the UK emission inventory estimates for HFC-227ea in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. Monthly InTEM MHD-only estimates are shown in blue. Monthly InTEM all-data estimates are shown in green. InTEM and GHGI uncertainties are shown as whisker lines.



A8.5 PERFLUOROCARBONS

A8.5.1 PFC-14

Figure A 8.5.1 shows the baseline atmospheric mole fraction of PFC-14 from 2004 onwards. The annual trend is monotonic and positive at around 0.7 ppt/yr. Within the uncertainty ranges of the InTEM and GHGI estimates, the UK emissions agree. The sharp drop in emissions in 2012 in the GHGI is mirrored by InTEM, this reflects the closure of the last significant aluminium production plant in the UK. The InTEM uncertainty ranges are large for PFC-14 because the vast majority of emissions come from point sources (smelters) which are not well captured in the large area averages within InTEM. If prior knowledge of the point sources are included within InTEM the uncertainty ranges are considerably reduced.

Figure A 8.5.1 Monthly Northern Hemisphere trend in PFC-14 estimated from MHD observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.

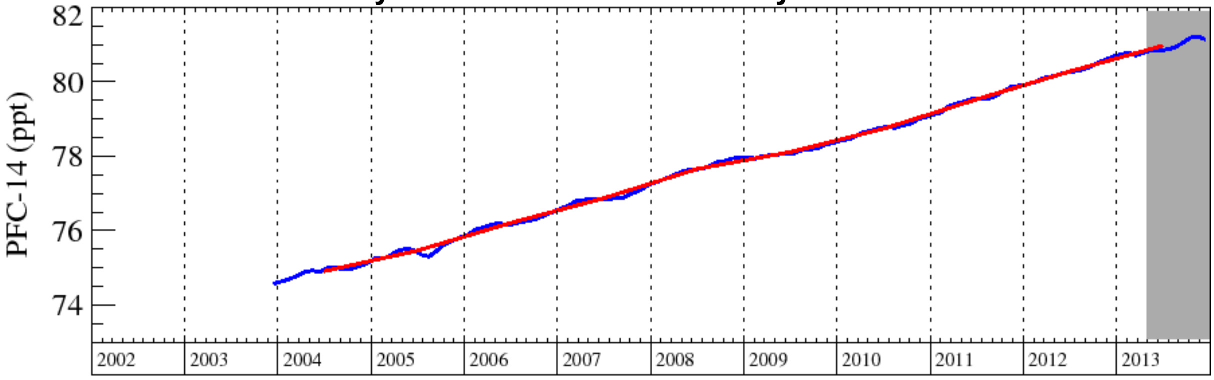


Figure A 8.5.2 Verification of the UK emission inventory estimates for PFC-14 in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.

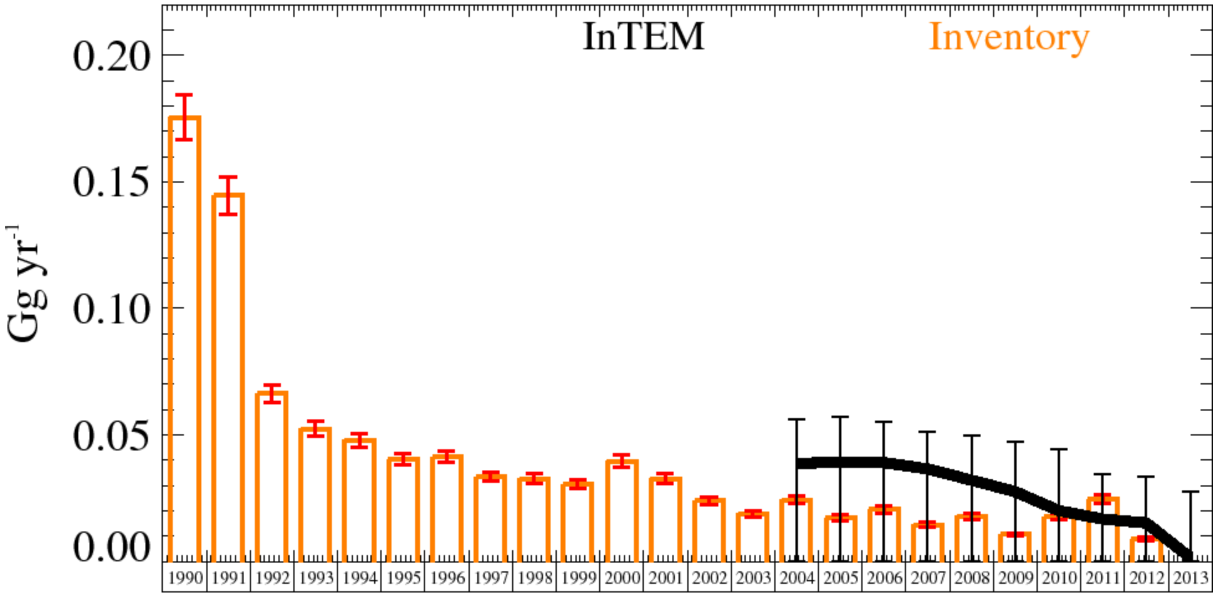
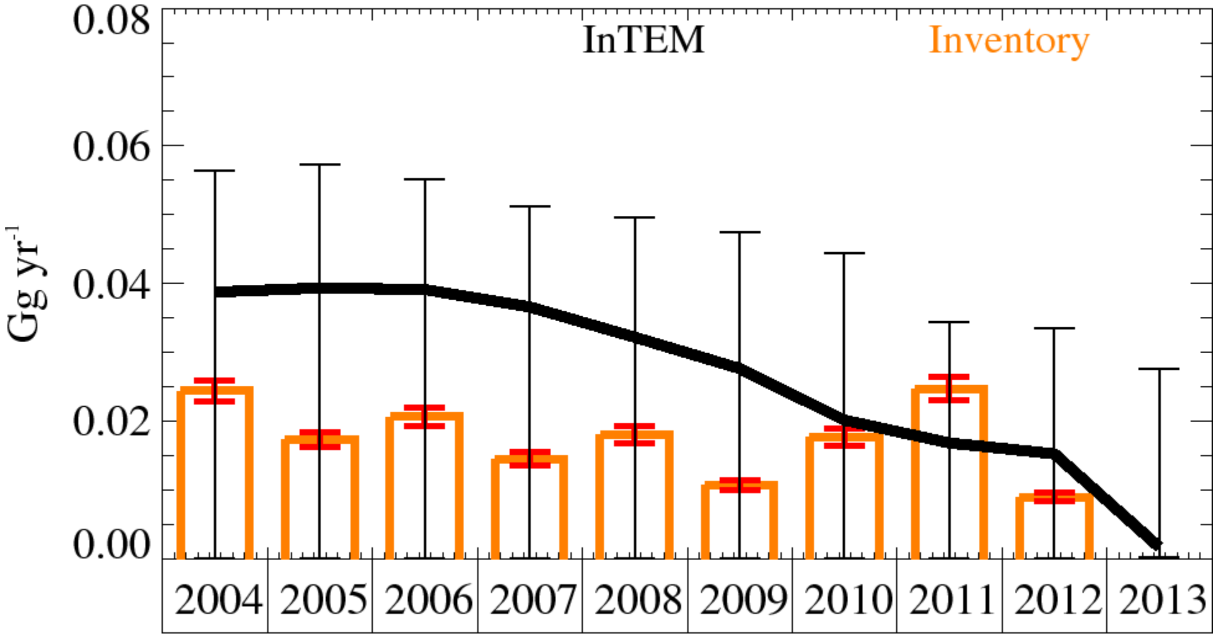


Figure A 8.5.3 Verification of the UK emission inventory estimates for PFC-14 in Gg yr^{-1} for zoomed in 2004-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.



A8.5.2 PFC-116

Figure A 8.5.4 shows the baseline atmospheric mole fraction 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 1.5.5) given the significant uncertainties in the InTEM solutions.

Figure A 8.5.4 Monthly Northern Hemisphere trend in PFC-116 estimated from MHD observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.

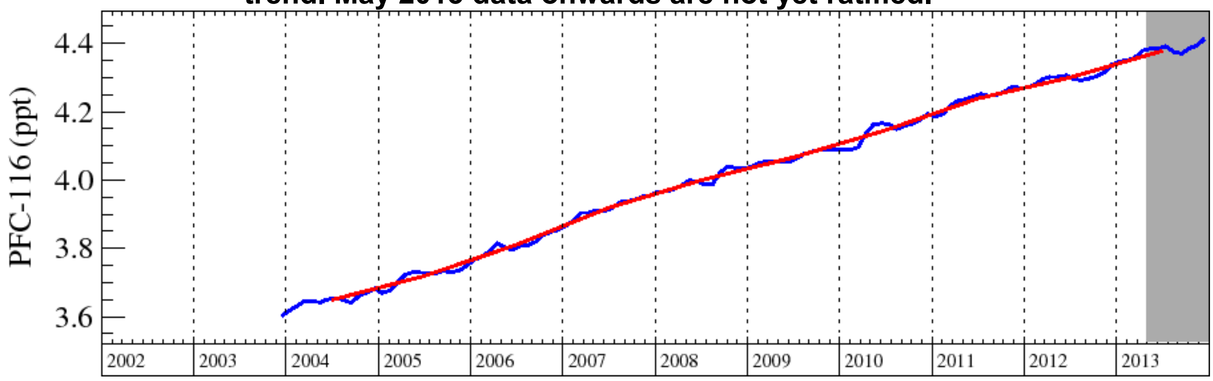


Figure A 8.5.5 Verification of the UK emission inventory estimates for PFC-116 in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.

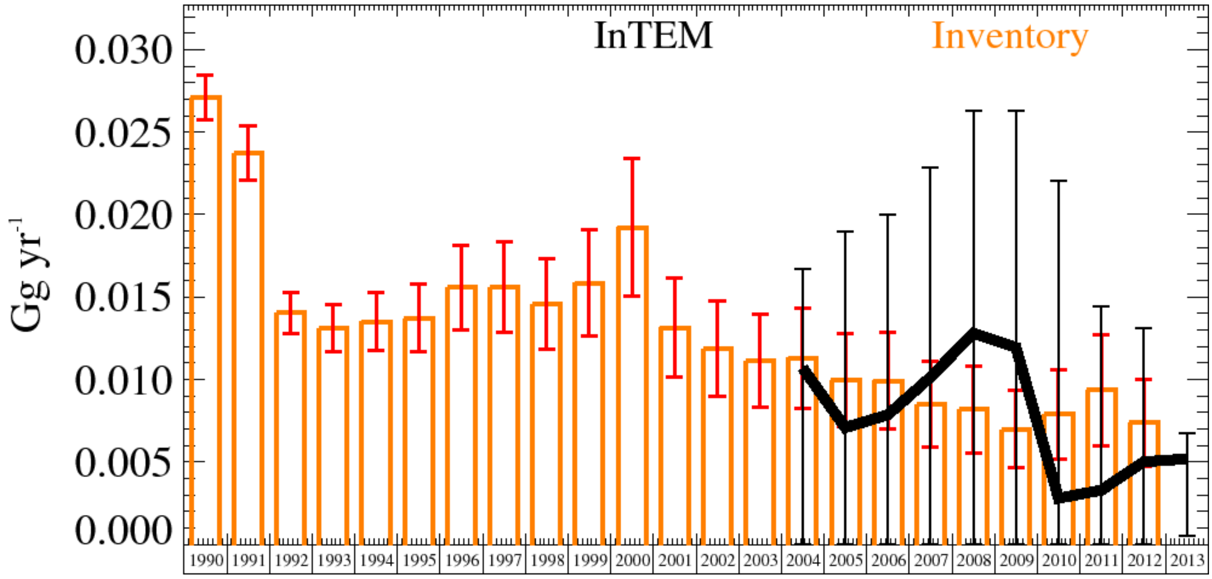
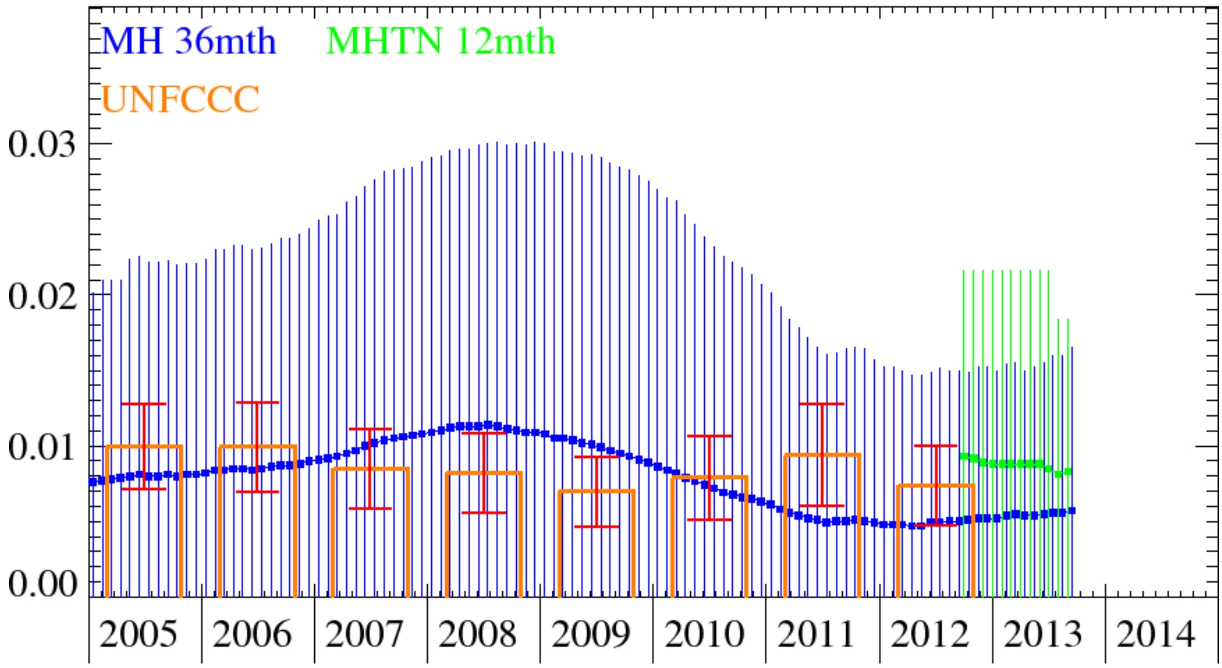


Figure A 8.5.6 Verification of the UK emission inventory estimates for PFC-116 in Gg yr^{-1} for 2005-2013. GHGI estimates are shown in orange. Monthly InTEM MHD-only estimates are shown in blue. Monthly InTEM all-data estimates are shown in green. InTEM and GHGI uncertainties are shown as whisker lines.



A8.5.3 PFC-218

Figure A 8.5.7 shows the baseline atmospheric mole fraction of PFC-218 from 2004 onwards. The annual trend is monotonic and positive at around 0.02 ppt/yr.

The median UK InTEM estimates are higher than those reported in the GHGI (**Figure A 8.5.8**). However within the uncertainty ranges of the InTEM results, two methods agree. Similar to PFC-14, without prior knowledge of the point source nature of the PFC-218 emissions, InTEM struggles to constrain the emissions.

Figure A 8.5.7 Monthly Northern Hemisphere trend in PFC-218 estimated from MHD observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.

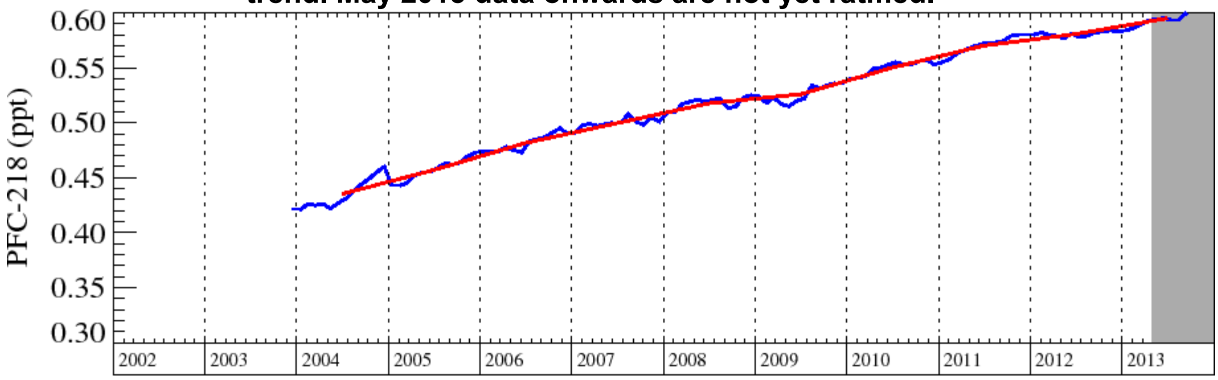


Figure A 8.5.8 Verification of the UK emission inventory estimates for PFC-218 in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.

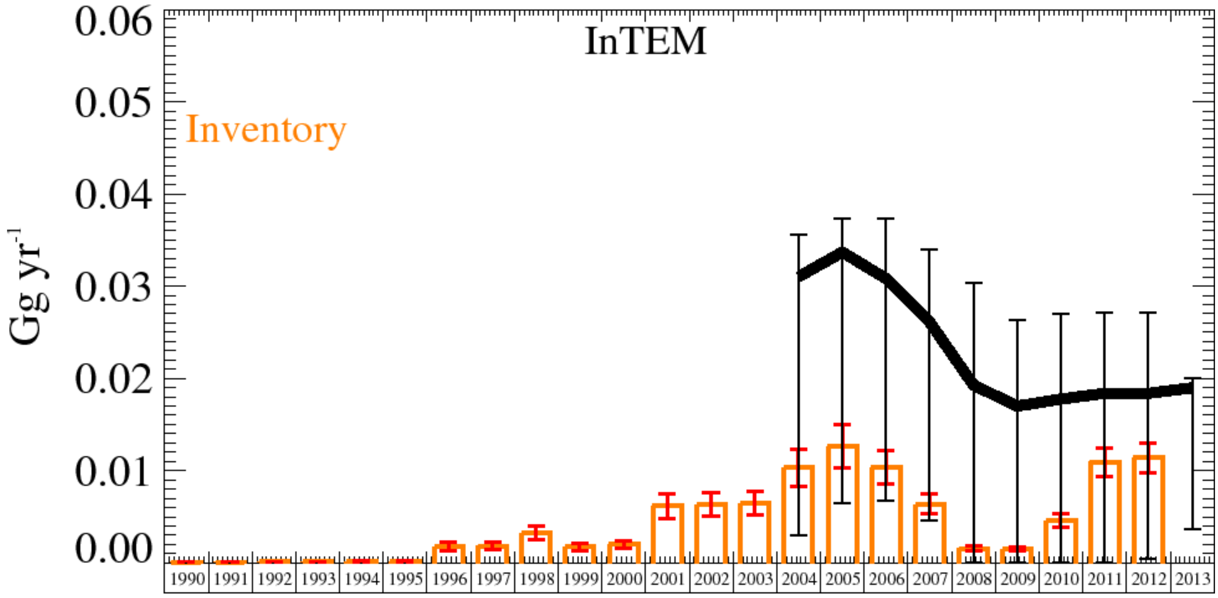
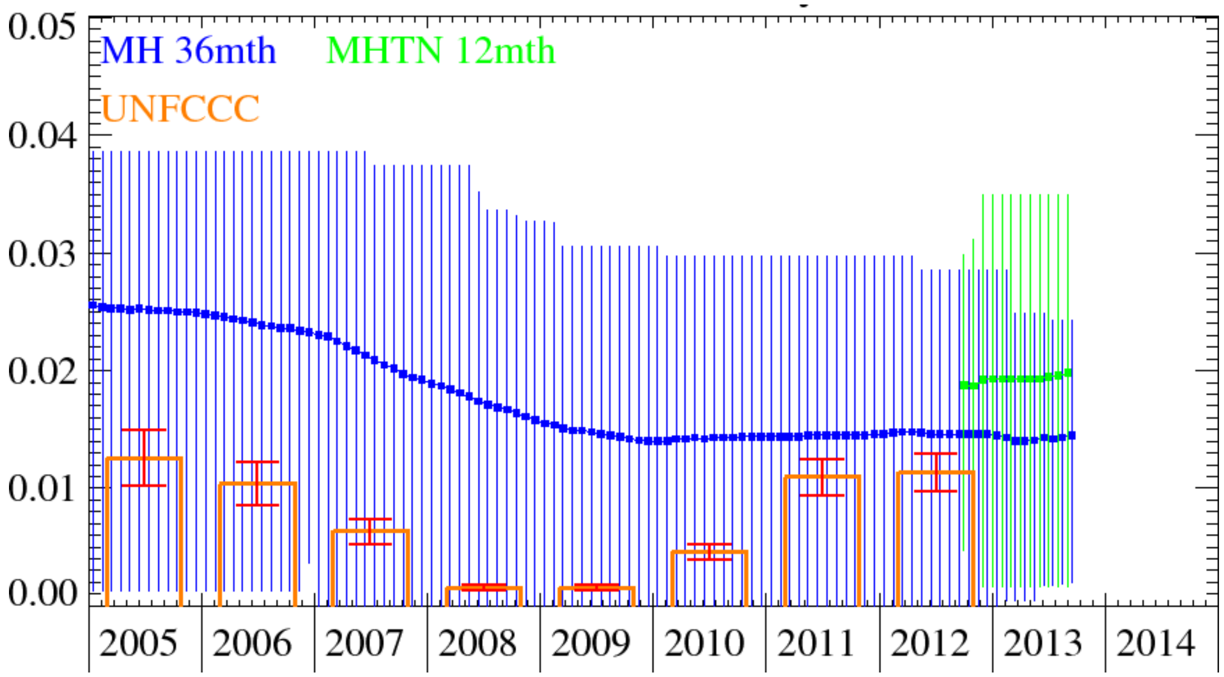


Figure A 8.5.9 **Verification of the UK emission inventory estimates for PFC-218 in Gg yr^{-1} for 2005-2013. GHGI estimates are shown in orange. Monthly InTEM MHD-only estimates are shown in blue. Monthly InTEM all-data estimates are shown in green. InTEM and GHGI uncertainties are shown as whisker lines.**



A8.6 SULPHUR HEXAFLUORIDE

Figure A 8.6.1 shows the baseline atmospheric mole fraction 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 0.02 Gg yr^{-1} (~30%), (**Figure A 8.6.2**) although the InTEM uncertainty ranges do incorporate the GHGI estimates.

Figure A 8.6.1 **Monthly Northern Hemisphere trend in SF_6 estimated from MHD observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.**

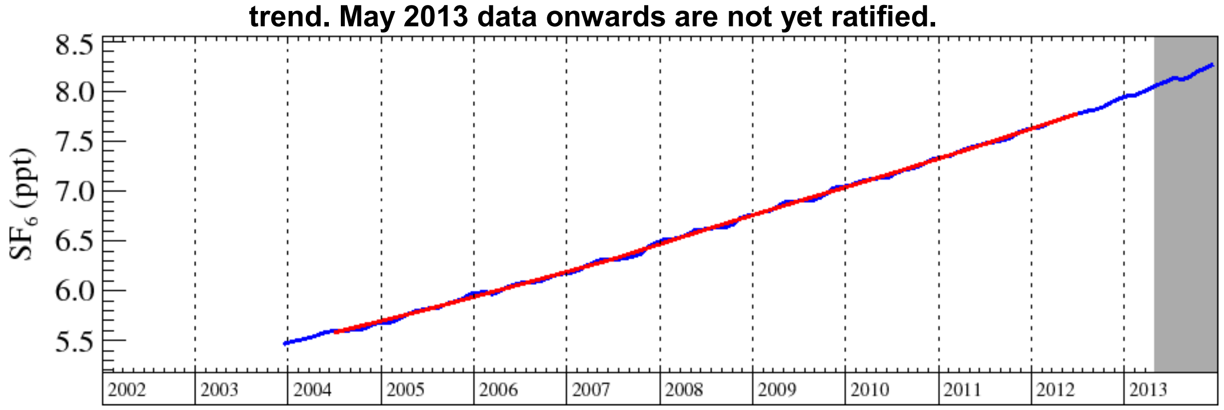


Figure A 8.6.2 **Verification of the UK emission inventory estimates for SF_6 in Gg yr^{-1} for 1990-2013. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.**

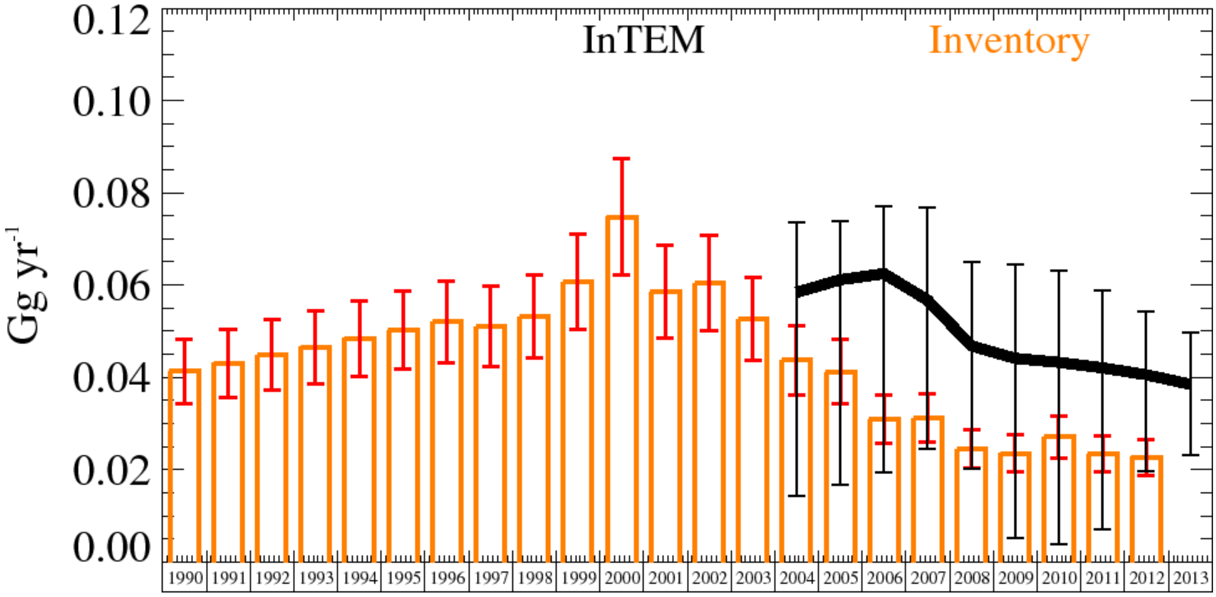
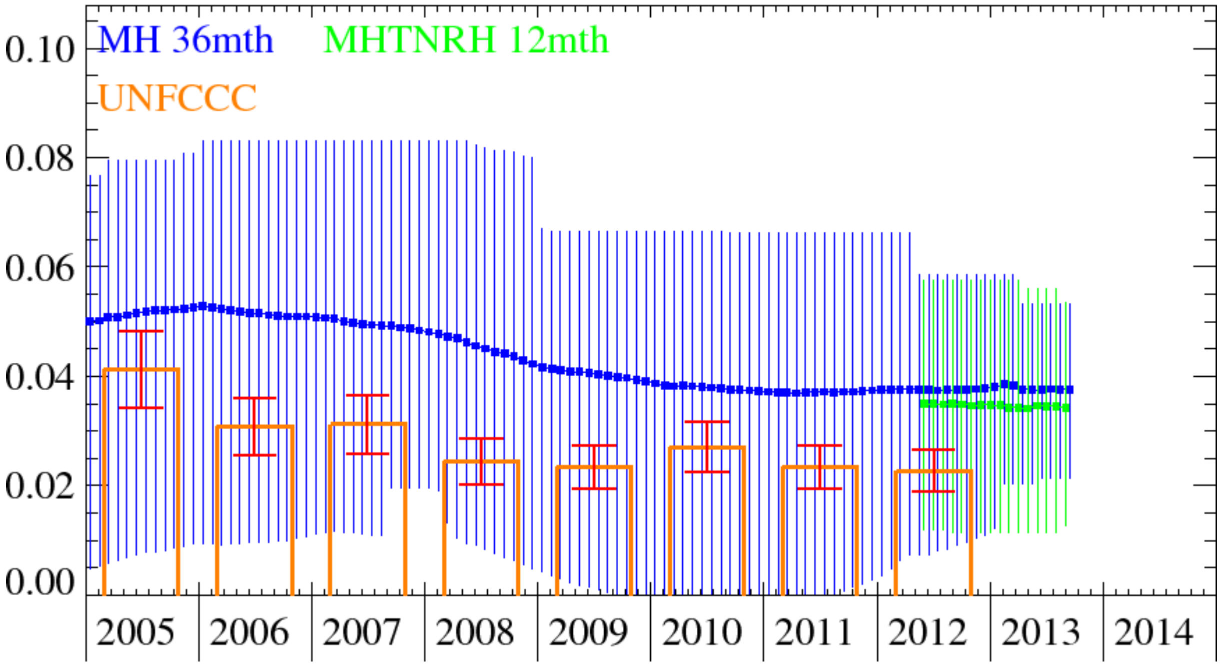


Figure A 8.6.3 **Verification of the UK emission inventory estimates for SF_6 in Gg yr^{-1} for 2005-2013. GHGI estimates are shown in orange. Monthly InTEM MHD-only estimates are shown in blue. Monthly InTEM all-data estimates are shown in green. InTEM and GHGI uncertainties are shown as whisker lines.**



A8.7 CARBON DIOXIDE

High precision, high frequency measurements of CO_2 are also made at MHD. 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 Monthly Northern Hemisphere trend in CO_2 estimated from MHD observations (ppt). Red line denotes the de-seasonalised long-term trend. May 2013 data onwards are not yet ratified.

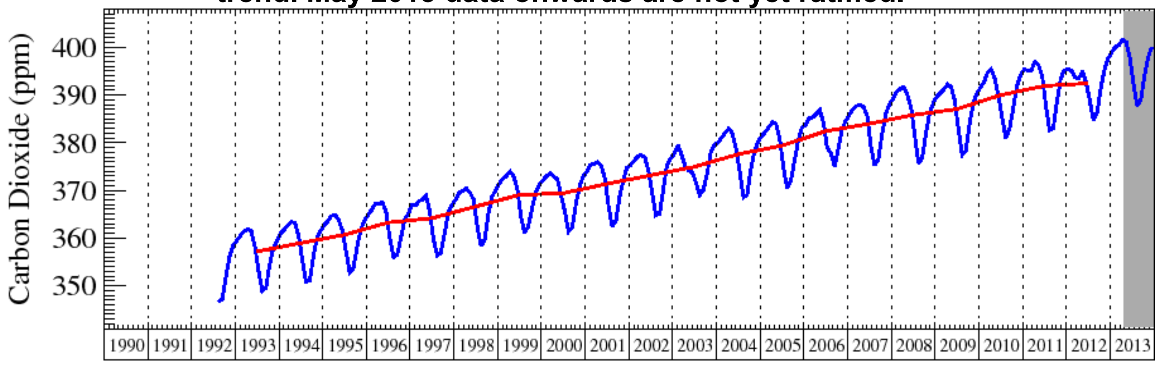
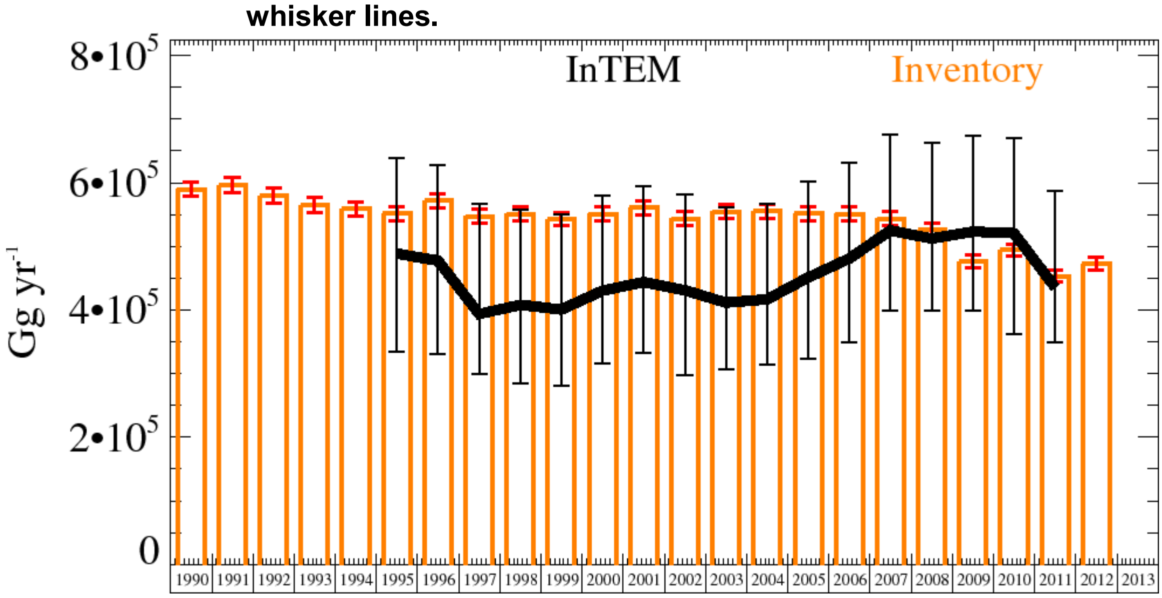


Figure A 8.7.2 Verification of the UK emission inventory estimates for CO_2 in Gg yr^{-1} for 1990-2012. GHGI estimates are shown in orange. InTEM estimates are shown in black. InTEM and GHGI uncertainties are shown as whisker lines.



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.

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 (after removal of the CO_2 emissions estimated to be released from power stations – these are assumed to emit little CO due to abatement technologies). The InTEM uncertainties have been arbitrarily increased to a minimum of ±200,000 Gg yr^{-1} to reflect the fact that the CO_2:CO ratio is variable across applications across the UK. The estimated uncertainties in the inventory 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 emission estimates.

A9 ANNEX 9: Analysis of EU ETS Data

A9.1 INTRODUCTION

This annex summarises the analysis of the 2012 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.

During 2013, DECC commissioned a study to review the EUETS dataset and identify any new data sources that could be used to help improve the accuracy of the UK inventory, especially focussing on the iron and steel sector, and to identify emissions from the use of feedstock process off-gases or carbon-containing residues that are not reported within the UK energy balance. This study (Ricardo-AEA, 2014) has led to a number of revisions to the UK inventory, through analysis of the EUETS data, and through extensive stakeholder consultation with operators of sites where emission sources were identified as potential gaps or inconsistencies in the inventory.

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

- In the 2012 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 chemical and 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, and from combustion of carbon-containing process residues. Analysis of "fuel gas" calorific values and carbon content has helped to inform the calculations to estimate emissions from NGL-derived gases and other residues, 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 8 years' worth of data on fuel use and emissions across major UK industrial plant, for 2005-2012.

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[6] emissions data only, and the growing need to understand the UK non-traded sector emissions for future reporting under the Effort Sharing Decision.

[6] 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.

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

In the 1990-2012 inventory cycle, the inventory agency has updated and extended the EU ETS analysis conducted for inventory compilation, using the 2012 EU ETS dataset. This annex presents a comprehensive review of the eight 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.

The inventory agency has also been provided with full details of the 2011-2012 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 where data reporting discrepancies have been identified from previous work. For those sectors where EU ETS are used in the GHGI, it is important to review emission factors from all major installations to ensure that any outliers are identified and checked prior to their inclusion in inventory calculations.

Wherever possible, consistent assumptions are made when interpreting data across all years of the EU ETS. For instance ensuring that each site is allocated to the same inventory sector in each year, and that there is consistency in the way in which site-specific names for fuels are interpreted across the entire period. The information on the EU ETS method "Tier" used for each of the data dictates whether they are used in inventory compilation. The highest tier EU ETS data are assumed to be subject to the lowest level of uncertainty, and so only tier 3 and tier 4 data are used. Occasionally there are internal inconsistencies in the EU ETS data between the data on consumption of a given fuel and emissions from the use of that fuel. These need to be resolved before the data can be used in the UK GHGI. As emissions data are verified, we cross-check the detailed emissions data against the final verified emissions for each site. As a general rule it is found that the most appropriate solution to inconsistencies is to assume that the EU ETS emissions data are correct, and that it is the activity data that need to be amended instead.

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 2012 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 five years' worth of Phase II data and hence the EU ETS dataset is now becoming a more useful 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 for the 2015 submission onwards.

- When using the EU ETS data, assumptions and interpretations are required to be made regarding the fuel types used by operators. Operators are free to describe fuels as they wish in their returns, rather than choosing from a specific list of fuels, and so assumptions occasionally need to be made where the fuel type used is not clear from the operator's description of it. This issue was more significant in the earlier years of EU ETS reporting, with operators often using terms such as "Fuel 1". The assumption then made about fuel type was based both on the other data the operator provided on the fuel such as calorific value, but also by comparison with later data for the same site, since operators now tend to use standard fuel names.

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 more limited use, mainly providing a de-minimis fuel consumption figure 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. As a general rule, those energy-intensive sectors with near 100% coverage in EU ETS also report a very high proportion of emission factor data at Tier 3. Those sectors with incomplete coverage tend to report most emission factor data below Tier 3.

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.

A9.3 DATA PROCESSING

DECC provided the detailed EU ETS regulator data from the Environment Agency, Scottish Environment Protection Agency and Northern Ireland Environment Agency during May 2013, and the inventory agency industrial emissions analysts progressed the analysis, combining the datasets to generate a UK-wide EU ETS dataset. The work built on analysis conducted in previous years, as the EU ETS has been in place since 2005, but this latest analysis, while focussing on the 2012 submissions, did involve review of the complete 8-years of data, 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 2012 EU ETS data which had to be allocated to DUKES' sectors, and all of the fuel data for 2012 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 2012 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. In cases where these residual emissions are large, then these are 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. Minor residual emissions are ignored for the purposes of the analysis reported here.

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 2013 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 2012, as published within DUKES 2013.

The EU ETS data for offshore oil and gas installations was provided in May 2013 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 8 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 indication 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 2012 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		2012	
	EU ETS	UK total	EU ETS	UK total
Power stations (fossil fuel, > 75MWe)	60	60	63	63
Power stations (fossil fuel, < 75MWe)	23	27	36	43
Power stations (nuclear)	12	12	9	9
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]	12	200[a]
Combustion – other industry	171	5000[a]	~400	5000[a]
Combustion – commercial sector	28	1000[a]	45	1000[a]
Combustion – public sector	169	1000[a]	122	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 seven stations are not included in the EU ETS data for 2012 (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 2012. 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, recent detailed analysis, including the collection of other industry data, has allowed for far greater use of EU ETS data for the latest inventory, compared with previous versions.

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 misreporting 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 misallocation 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	-	4647	108%	352	1491
					EU ETS / GHGI (%)		
2005	5006.7	4974	99.3%	5096	98%	-89	1228
2006	4910.2	4677	95.3%	4395	112%	515	1585
2007	4856.8	4828	99.4%	4402	110%	455	1441
2008	4708.7	4660	99.0%	4260	111%	449	1692
2009	4491.6	4423	98.5%	3963	113%	529	1630
2010	4465.8	4441	99.4%	4032	111%	434	1640
2011	4739.0	4194	88.5%	4110	115%	629	1774
2012	4287.0	3968	92.6%	3846	111%	441	1485

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 and 2012 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 reported 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 2012, 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 misallocation of gas use, rather than a gap in reported gas use. For 2005 to 2012, 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 35 of the larger gas compressor, LNG terminals 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 misinterpreted 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 1990-2012 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
2012		100	611.9
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
2012		99	874.7
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
2012		100	1.461
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
2012		0[b]	-

[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.
[b] Plant now operated as a power station and included in the figures for power stations burning coal

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.

A few power stations burn small quantities of petroleum coke as well as coal. One supplies data to ETS for coal/petroleum coke blends i.e. there are no separate emissions data or carbon factors for the coal and the petroleum coke at that site. We therefore back-calculate the coal IEF in those blends by using an assumed default for the petcoke carbon content and more detailed activity data on the constituents of the fuel blends, obtained directly from the operator.

The EU ETS based emission factors presented above for power stations are 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		85	877.6
2012		80	887.6
2005	OPG	60	1.495
2006		58	1.469

Year	Fuel	% Tier 3	Average Carbon Emission Factor (Tier 3 sites only)
2007		69	1.582
2008		82	1.483
2009		81	1.489
2010		82	1.501
2011		67	1.453
2012		64	1.470
2005	Natural Gas	0	n/a
2006		43	1.460
2007		45	1.462
2008		98	1.475
2009		98	1.480
2010		93	1.467
2011		81	1.447
2012		63	1.442

There has been a significant drop in the proportion of Tier 3 reporting for all three fuels since 2010, which will adversely affect the quality of the emission factors, although coverage is still in excess of 50% for all fuels.

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 2011-2012 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 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 2012 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 2005-2010, 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 for those years.

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		100	6.873
2007		99	6.916
2008		97	6.905
2009		97	6.990
2010		100	6.929
2011		94	6.990
2012		96	6.815
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
2012		100	1.094
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
2012		64	1.443
2005	Fuel oil	0	-
2006		0	-
2007		0	-
2008		84	878.3
2009		89	884.7
2010		83	887.6
2011		88	888.7
2012		67	877.2

Much of the ETS data for coke ovens and steelworks are now used in the GHGI, although not the emission factors shown above. Instead, the Inventory Agency have used the EU ETS data and other detailed, site-specific and fuel-specific data, provided by the process operators to refine the carbon balance model used to generate emission estimates for the sector. Details of the revisions to the carbon balance model can be found in the research report from the 2013-2014 inventory improvement programme (Ricardo-AEA, 2014)

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
2012		100	662.4
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
2012		100	770.2

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 2008-2012 are closer, with a narrower (4%) 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 less than 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 2008-2012

	2008	2009	2010	2011	2012
GHGI CO_2 emissions (kt)	8294	5686	5788	6130	5557
Sum of EU ETS CO_2 emissions (kt)	8259	5647	5754	6087	5556
EU ETS / GHGI	99.6%	99.3%	99.4%	99.3%	100.0%

*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
2012		100	725.6

*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

Year	Activity	EU ETS
2007		201.3
2008		195.6
2009		195.0
2010		194.0
2011		195.6
2012		195.7

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	656.9
2011		96	596.5	636.7
2012		96	605.8	636.9
2005	Fuel oil	17	864.7	879.0
2006		27	865.3	879.0

Year	**Fuel**	**% Tier 3**	**Average Carbon Emission Factor (Tier 3 sites only)**	**GHGI Carbon Emission Factor**
2007		44	872.3	879.0
2008		24	871.4	879.0
2009		39	871.3	879.0
2010		40	873.0	879.0
2011		49	874.2	879.0
2012		48	875.1	879.0
2005	Natural gas	13	1.593	1.478
2006		33	1.449	1.478
2007		43	1.468	1.477
2008		33	1.505	1.474
2009		46	1.496	1.474
2010		50	1.494	1.472
2011		46	1.469	1.468
2012		42	1.471	1.469

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 (2005-2012) 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 a Department of Energy and Climate Change's National Statistics release[7]. The geographical coverage of these estimates differs from the UNFCCC and EUMM coverage, with the totals including emissions from the UK and the UK's Crown Dependencies only. 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

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

Table A 10.1.1 Summary table of GHG (Including net emissions/removals from LULUCF) emissions by NC Category (Mt CO_2eq) – National Statistics coverage (UK and Crown Dependencies)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Energy Supply	272.39	270.07	258.93	241.12	233.18	233.98	234.93	218.82	222.07	209.52	218.43	227.64
Transport	121.57	119.78	121.09	122.42	122.87	122.12	126.50	127.81	126.78	127.80	126.72	126.70
Residential	80.79	89.58	86.93	90.94	86.53	82.28	93.88	87.33	89.85	89.37	89.72	92.07
Business	116.03	120.16	115.70	114.23	113.44	110.75	112.99	110.16	110.44	113.41	115.04	115.00
Public	13.14	13.99	14.63	13.30	12.95	12.78	13.82	13.47	12.47	12.24	11.50	11.99
Industrial Process	54.80	52.73	47.37	43.74	45.75	45.20	45.99	47.13	44.10	27.08	24.90	22.46
Agriculture	71.08	70.95	70.78	70.12	70.53	70.09	70.72	71.04	70.38	69.57	66.85	63.56
Land Use Change	1.88	1.80	1.30	0.49	0.55	1.49	0.75	0.39	-0.65	-1.15	-2.10	-3.12
Waste Management	47.27	47.36	45.36	46.04	46.59	47.89	47.72	46.38	45.09	41.43	38.76	37.91
Total	778.93	786.41	762.10	742.40	732.38	726.57	747.29	722.53	720.54	689.28	689.81	694.20

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Energy Supply	224.85	230.83	229.77	228.31	234.83	229.09	222.10	198.89	204.41	190.80	202.02
Transport	129.14	128.64	129.80	130.56	131.04	134.08	126.64	121.76	120.18	118.50	117.98
Residential	88.55	89.57	90.98	87.04	84.43	80.66	82.58	77.34	89.19	69.04	77.52
Business	105.07	108.13	107.40	108.43	105.90	104.92	100.67	89.69	90.31	85.88	86.68
Public	10.19	10.20	11.14	11.05	10.05	9.33	9.93	9.76	10.49	9.74	10.15
Industrial Process	19.40	20.21	19.71	19.06	17.65	19.03	17.22	10.92	11.82	10.27	9.80
Agriculture	63.31	62.66	62.51	61.95	60.01	58.40	57.59	56.70	57.52	57.24	56.59
Land Use Change	-4.04	-4.24	-5.19	-5.68	-6.21	-6.54	-6.86	-6.94	-7.25	-7.49	-6.98
Waste Management	38.24	34.90	30.81	29.79	29.48	28.29	27.92	26.22	23.15	22.70	21.62
Total	674.70	680.90	676.95	670.51	667.18	657.26	637.77	584.35	599.82	556.68	575.37

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	2001
CO_2	591.10	597.89	580.92	566.36	560.37	552.91	573.53	548.64	552.47	544.57	552.19	562.33
CH_4	104.25	104.41	101.96	100.81	95.35	97.12	95.97	93.38	89.99	83.79	78.24	74.79
N_2O	69.81	70.05	65.23	60.61	61.09	59.56	59.50	59.94	59.76	49.25	48.28	45.58
HFCs	11.38	11.86	12.35	13.02	13.93	15.32	16.56	18.95	16.66	9.87	8.85	9.71
PFCs	1.40	1.17	0.57	0.49	0.49	0.46	0.48	0.40	0.39	0.37	0.46	0.38
SF_6	0.99	1.03	1.07	1.11	1.16	1.20	1.25	1.22	1.27	1.45	1.79	1.40
Total	778.93	786.41	762.10	742.40	732.38	726.57	747.29	722.53	720.54	689.28	689.81	694.20

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO_2	545.07	555.56	556.22	552.83	552.25	544.92	527.29	477.94	495.23	454.03	474.05
CH_4	74.00	69.33	65.12	62.27	61.24	59.17	57.96	55.74	52.50	51.69	50.63
N_2O	43.77	43.26	43.82	42.90	40.75	40.03	39.00	36.83	37.70	36.29	35.99
HFCs	10.10	11.21	10.40	11.22	11.90	12.18	12.74	13.14	13.53	13.79	13.95
PFCs	0.32	0.28	0.34	0.30	0.30	0.22	0.20	0.15	0.22	0.33	0.21
SF_6	1.44	1.26	1.05	0.99	0.74	0.75	0.58	0.56	0.65	0.56	0.54
Total	674.70	680.90	676.95	670.51	667.18	657.26	637.77	584.35	599.82	556.68	575.37

A10.2 CARBON BUDGETS

As part of the Climate Change Act 2008[8], the UK committed to reducing greenhouse gas emissions by at least 80 per cent by 2050 (relative to 1990), with an interim target of reducing greenhouse gas emissions by at least 34 per cent by 2020, also relative to 1990.

These targets along with the legally binding five-year carbon budgets (which set the trajectory to reaching the targets by placing a restriction on the total amount of greenhouse gases the UK can emit over the five-year period) are on a UK only basis, thus excluding Crown Dependencies and Overseas Territories.

Summary statistics for the UK only are presented below. The final 2012 UK GHG emissions statistical release included an update of the UK's performance against the first carbon budget. The release can be found at: https://www.gov.uk/government/publications/final-uk-emissions-estimates

[8] http://www.legislation.gov.uk/ukpga/2008/27/contents

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**	**2001**
Energy Supply	271.86	269.51	258.28	240.51	232.56	233.33	234.28	218.22	221.43	208.87	217.94	227.43
Transport	121.08	119.30	120.62	121.94	122.39	121.63	125.95	127.26	126.22	127.24	126.16	126.12
Residential	80.48	89.26	86.62	90.62	86.21	81.95	93.53	86.88	89.39	88.98	89.32	91.69
Business	115.82	119.93	115.49	114.01	113.22	110.51	112.72	109.85	110.12	113.14	114.73	114.64
Public	13.14	13.99	14.63	13.30	12.95	12.78	13.82	13.47	12.47	12.24	11.50	11.99
Industrial Process	54.80	52.73	47.37	43.74	45.75	45.20	45.99	47.13	44.10	27.08	24.90	22.46
Agriculture	70.92	70.78	70.61	69.96	70.36	69.92	70.56	70.88	70.21	69.40	66.68	63.40
Land Use Change	1.89	1.82	1.32	0.51	0.57	1.52	0.78	0.41	-0.63	-1.12	-2.07	-3.09
Waste Management	47.13	47.22	45.22	45.91	46.46	47.76	47.58	46.25	44.95	41.30	38.66	37.82
Total	777.11	784.53	760.17	740.52	730.47	724.60	745.19	720.34	718.27	687.13	687.81	692.45

	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Energy Supply	224.64	230.68	229.59	228.04	234.52	228.74	221.73	198.52	204.06	190.47	201.60
Transport	128.58	128.07	129.23	129.99	130.49	133.51	126.09	121.23	119.65	117.96	117.45
Residential	88.12	89.16	90.62	86.64	84.05	80.28	82.19	76.96	88.80	68.66	77.12
Business	104.69	107.78	107.06	108.08	105.56	104.54	100.32	89.36	89.98	85.57	86.36
Public	10.19	10.20	11.14	11.05	10.05	9.33	9.93	9.76	10.49	9.74	10.15
Industrial Process	19.40	20.21	19.71	19.06	17.65	19.03	17.22	10.92	11.82	10.27	9.80
Agriculture	63.14	62.54	62.40	61.83	59.86	58.24	57.43	56.55	57.38	57.10	56.45
Land Use Change	-4.02	-4.22	-5.18	-5.67	-6.20	-6.55	-6.87	-6.95	-7.26	-7.50	-6.99
Waste Management	38.17	34.83	30.77	29.73	29.42	28.24	27.87	26.18	23.11	22.66	21.58
Total	672.90	679.26	675.35	668.76	665.40	655.36	635.91	582.54	598.02	554.94	573.52

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	2001
CO_2	589.61	596.34	579.32	564.79	558.77	551.27	571.77	546.80	550.55	542.76	550.50	560.89
CH_4	103.98	104.14	101.68	100.56	95.09	96.86	95.71	93.12	89.73	83.52	78.02	74.58
N_2O	69.75	69.99	65.17	60.55	61.03	59.50	59.44	59.88	59.69	49.18	48.22	45.52
HFCs	11.38	11.86	12.35	13.02	13.93	15.32	16.55	18.93	16.64	9.85	8.82	9.68
PFCs	1.40	1.17	0.57	0.49	0.49	0.46	0.48	0.40	0.39	0.37	0.46	0.38
SF_6	0.99	1.03	1.07	1.11	1.16	1.20	1.25	1.22	1.27	1.45	1.79	1.40
Total	777.11	784.53	760.17	740.52	730.47	724.60	745.19	720.34	718.27	687.13	687.81	692.45

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO_2	543.56	554.17	554.84	551.32	550.74	543.30	525.71	476.40	493.69	452.55	472.46
CH_4	73.81	69.18	65.00	62.13	61.08	59.01	57.80	55.59	52.36	51.55	50.49
N_2O	43.71	43.21	43.77	42.86	40.70	39.97	38.94	36.78	37.64	36.24	35.94
HFCs	10.06	11.16	10.36	11.17	11.84	12.12	12.67	13.08	13.46	13.71	13.88
PFCs	0.32	0.28	0.34	0.30	0.30	0.22	0.20	0.15	0.22	0.33	0.21
SF_6	1.44	1.26	1.04	0.98	0.74	0.75	0.58	0.56	0.65	0.56	0.54
Total	672.90	679.26	675.35	668.76	665.40	655.36	635.91	582.54	598.02	554.94	573.52

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 2012.

The final user sectoral categories used are consistent with those used in the National Communications (NC) to the UNFCCC. 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 1990-2012, inclusive. These data are updated annually to reflect revisions in the methods used to estimate emissions, and the availability of new information within the inventory. 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 or 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.

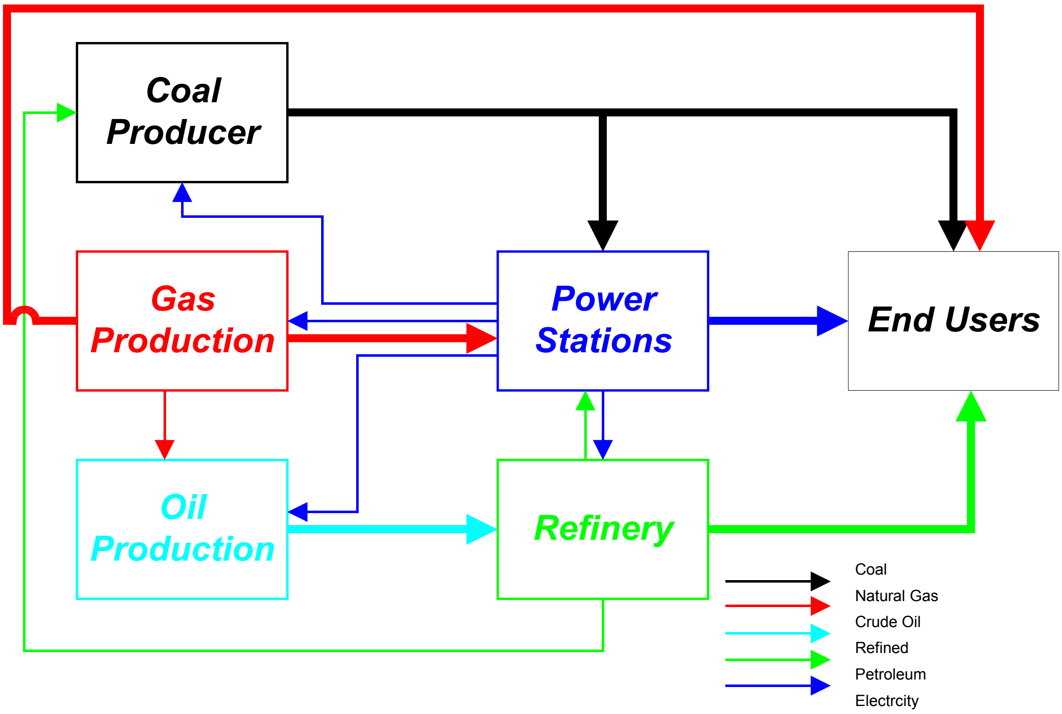
- Emissions in the **road transport** final user category include:
  1. Direct emissions from motor vehicle exhausts.
  2. Emissions from refineries producing motor fuels, including refining, storage, flaring and extraction of oil; and from the distribution and supply of motor fuels.

A11.3 OVERVIEW OF THE FINAL USER 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 A 11.3.1 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). This distribution is based on inventory fuel consumption data and DUKES electricity consumption data.
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 (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%) 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.

While a direct solution could possibly be used 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.

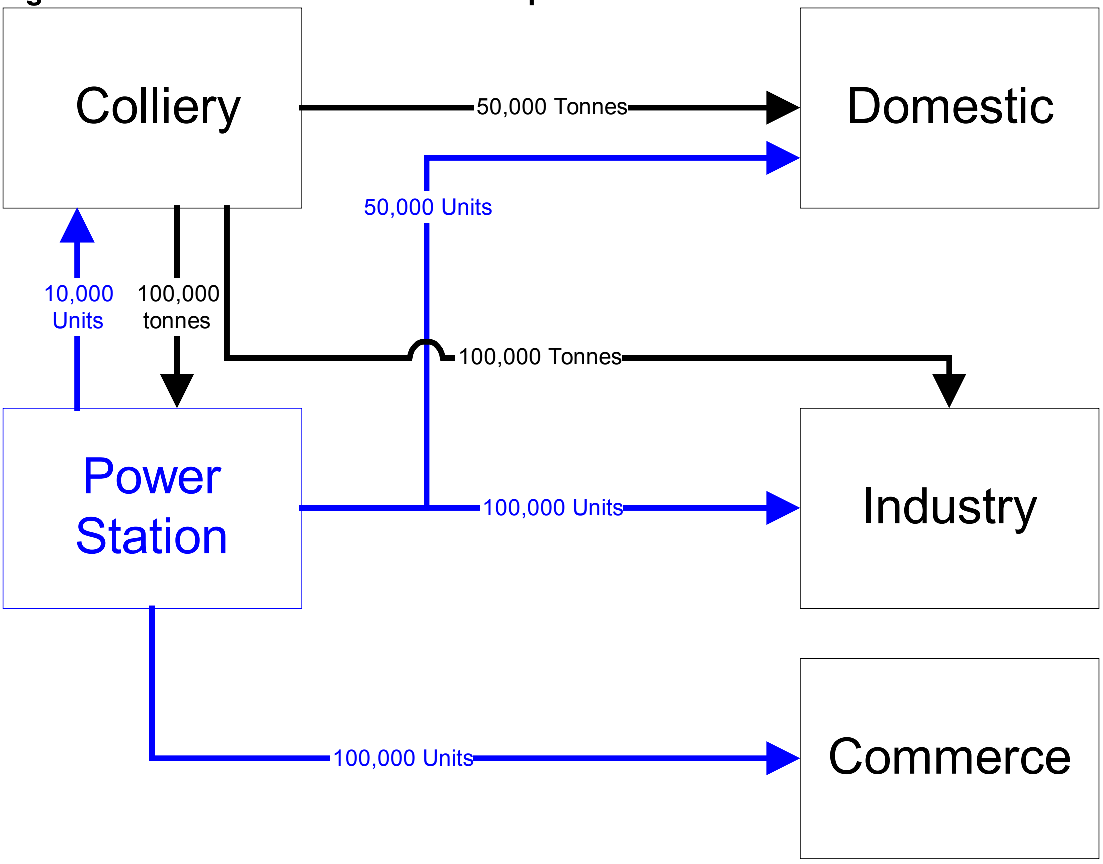
A11.4 EXAMPLE FINAL USER CALCULATION

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 A11.4.1**, 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	70,000	35,000	70,000	0	40.02	175,070
	Emissions after Iteration step	1	2,692	28	48,476	96,951	26,923	1.55	175,070
		2	1	1077	49,020	98,039	26,934	0.62	175,070
		3	41	1	49,227	98,454	27,348	0.02	175,070
		4	0	17	49,235	98,470	27,348	0.01	175,070
		5	1	0	49,238	98,477	27,355	0	175,070
		6	0	0	49,239	98,477	27,355	0	175,070

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 (175,070 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

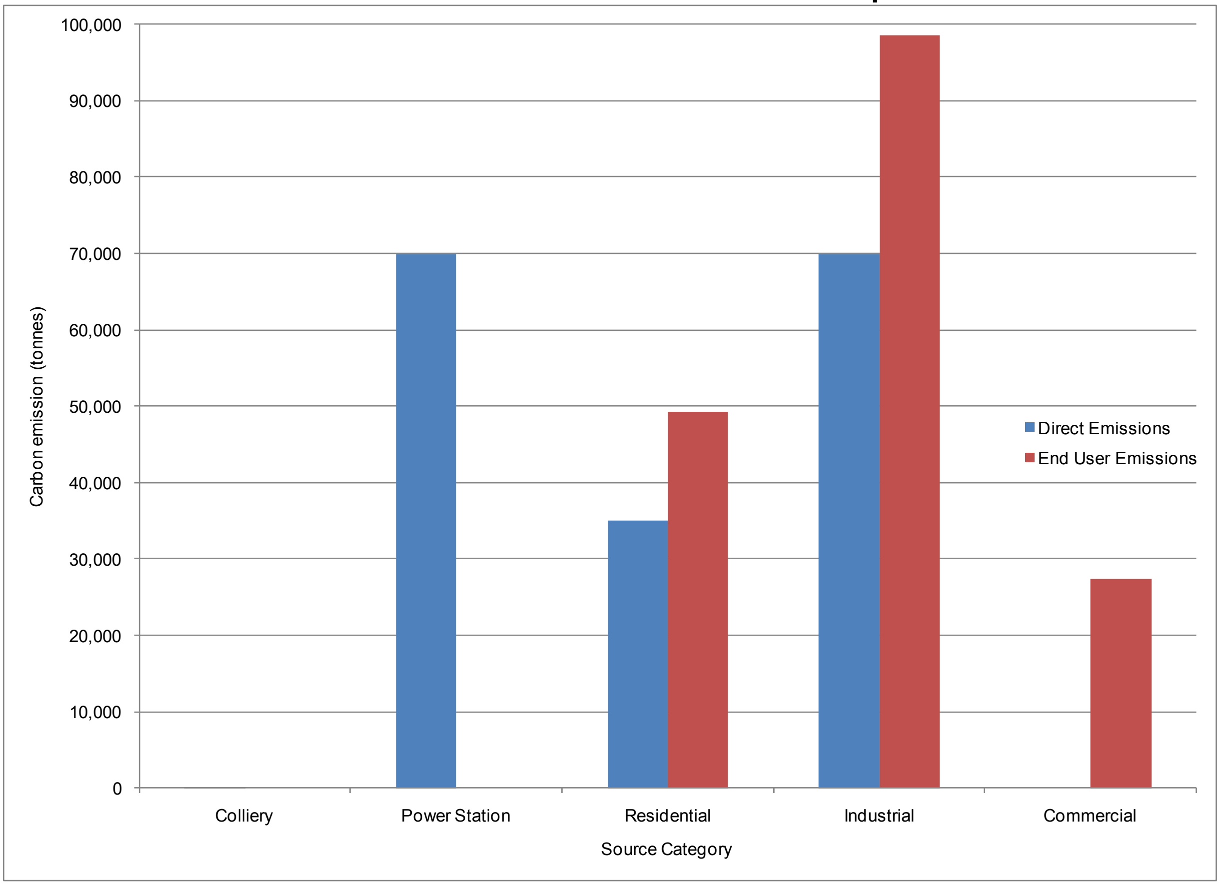


Figure A11.4.2 compares the quantities of direct and final user carbon emitted from each sector at the end of the final user calculation. The direct emissions of carbon are from the combustion of coal in the sectors. The direct and final user emissions are from two distinct calculations and must be considered 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 8 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
	Petroleum processes	Wide-cut gasoline
	Refineries – combustion	Vaporizing oil

Final user group	Emission sources to be reallocated to final users	Fuels used for redistribution
	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

		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 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 OPG
	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 Biogas

		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
			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 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
		SF6 used as a tracer gas	Non-fuel combustion
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 Liquid biofuels 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 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
			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
	1B2b_Distribution	Gas leakage	Natural Gas (leakage at point of use) Natural gas supply
	1B2b_Gas_Exploration	Upstream Gas Production - Offshore	Exploration drilling :no of wells

		Well Testing	
	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
	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
	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
	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 products	Carbon in detergents Petroleum waxes
	2F4_Aerosols	Aerosols - halocarbons	Non-fuel combustion
		Metered dose inhalers	Non-fuel combustion
	6C_Waste_Incineration	Accidental fires - vehicles	Mass burnt
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
		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
		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 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[12], 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

[12] 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	74.91	74.91	74.74	74.34	73.44	73.75	73.25	73.79	73.88	73.28	72.26	69.54
Business	249.69	248.49	246.60	232.48	223.44	217.31	215.55	216.69	207.95	208.51	206.91	215.36
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	9.15	9.15	10.12	10.89	12.25	12.56	13.27	14.51	15.83	15.63	13.90	12.98
Industrial Process	58.87	57.25	55.23	49.84	46.19	47.80	47.34	48.22	49.44	46.18	29.01	26.63
LULUCF	1.88	1.88	1.80	1.30	0.49	0.55	1.49	0.75	0.39	-0.65	-1.15	-2.10
Public	30.86	30.86	33.86	35.63	29.36	28.75	28.21	28.94	26.49	25.36	24.41	23.58
Residential	170.11	169.71	179.27	173.02	169.70	162.20	156.50	168.75	153.28	159.03	154.19	158.45
Transport	139.41	139.41	137.44	139.23	141.49	142.87	143.08	147.93	148.88	148.11	148.31	146.60
Waste Management	47.27	47.27	47.36	45.36	46.04	46.59	47.89	47.72	46.38	45.09	41.43	38.76
Total greenhouse gas emissions	**782.15**	**778.93**	**786.41**	**762.10**	**742.40**	**732.38**	**726.57**	**747.29**	**722.53**	**720.54**	**689.28**	**689.81**

Final user category	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Agriculture	66.53	66.22	65.58	65.37	64.71	62.84	61.17	60.29	59.12	60.07	59.68	59.14
Business	219.85	204.39	209.99	208.51	210.50	212.62	209.00	204.17	176.32	181.37	171.59	178.18
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	12.43	14.38	14.98	16.37	16.40	15.99	16.20	14.90	15.42	15.87	15.74	14.04
Industrial Process	23.86	20.64	21.22	20.59	19.68	18.51	19.80	17.92	11.89	12.60	11.03	10.56
LULUCF	-3.12	-4.04	-4.24	-5.19	-5.68	-6.21	-6.54	-6.86	-6.94	-7.25	-7.49	-6.98
Public	24.36	21.69	22.06	22.64	22.19	20.82	20.26	20.74	19.55	20.06	18.69	19.91
Residential	165.53	162.59	167.47	168.91	163.31	163.53	156.63	154.99	144.02	157.01	129.84	145.30
Transport	146.85	150.58	148.94	148.94	149.61	149.61	152.45	143.70	138.76	136.94	134.89	133.62
Waste Management	37.91	38.24	34.90	30.81	29.79	29.48	28.29	27.92	26.22	23.15	22.70	21.62
Total greenhouse gas emissions	**694.20**	**674.70**	**680.90**	**676.95**	**670.51**	**667.18**	**657.26**	**637.77**	**584.35**	**599.82**	**556.68**	**575.37**

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	232.10	232.10	230.48	216.76	208.26	204.58	201.66	203.10	194.30	195.20	193.90	201.79
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	8.46	8.46	9.41	10.16	11.49	11.79	12.46	13.69	14.96	14.80	13.19	12.32
Industrial Process	17.83	17.83	15.47	14.84	14.75	15.99	16.33	16.93	16.71	16.88	16.79	16.22
LULUCF	1.01	1.01	0.93	0.43	-0.38	-0.33	0.59	-0.14	-0.51	-1.54	-2.03	-2.99
Public	28.88	28.88	31.68	33.26	27.49	27.26	26.65	27.48	25.18	24.22	23.41	22.69
Residential	156.55	156.55	165.54	159.56	156.91	152.09	146.49	158.68	143.83	149.51	145.80	150.54
Transport	136.24	136.24	134.36	136.09	138.29	139.58	139.59	144.65	145.72	145.06	145.39	143.82
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	**591.10**	**591.10**	**597.89**	**580.92**	**566.36**	**560.37**	**552.91**	**573.53**	**548.64**	**552.47**	**544.57**	**552.19**

Final user category	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Agriculture	7.67	7.58	7.57	7.30	7.24	7.00	6.79	6.71	6.37	6.59	6.52	6.57
Business	205.90	189.91	195.25	193.25	195.10	197.01	192.97	187.95	160.18	164.83	154.91	161.27
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	11.83	13.73	14.34	15.64	15.76	15.39	15.56	14.33	14.77	15.26	15.00	13.38
Industrial Process	14.92	14.16	14.93	15.24	15.39	14.91	16.10	14.61	10.00	10.50	10.04	9.87
LULUCF	-3.98	-4.89	-5.14	-6.02	-6.51	-7.03	-7.37	-7.65	-7.71	-7.99	-8.20	-7.71
Public	23.53	20.93	21.37	21.95	21.56	20.25	19.73	20.21	19.01	19.54	18.17	19.35
Residential	157.72	155.13	160.23	161.81	156.45	156.87	150.43	148.90	138.04	150.97	124.24	139.23
Transport	144.22	148.01	146.56	146.63	147.47	147.56	150.39	141.93	137.01	135.26	133.09	131.83
Waste Management	0.51	0.51	0.46	0.43	0.38	0.30	0.33	0.28	0.27	0.27	0.27	0.25
Total greenhouse gas emissions	**562.33**	**545.07**	**555.56**	**556.22**	**552.83**	**552.25**	**544.92**	**527.29**	**477.94**	**495.23**	**454.03**	**474.05**

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	28.39	28.39	28.09	28.03	27.87	27.98	27.64	27.96	27.85	27.83	27.45	26.28
Business	13.22	13.22	12.96	12.57	11.96	9.14	9.91	9.12	8.78	7.80	6.82	6.30
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	0.59	0.59	0.60	0.62	0.64	0.63	0.66	0.65	0.68	0.64	0.54	0.49
Industrial Process	1.58	1.58	1.55	1.55	1.53	1.23	1.33	1.37	1.40	1.17	1.05	0.87
LULUCF	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.04
Public	1.78	1.78	1.97	2.16	1.70	1.33	1.42	1.32	1.20	1.03	0.89	0.79
Residential	12.20	12.20	12.73	12.51	11.89	9.17	8.86	8.55	7.49	6.97	6.20	5.52
Transport	1.70	1.70	1.63	1.65	1.59	1.51	1.50	1.42	1.31	1.23	1.13	1.01
Waste Management	44.76	44.76	44.85	42.85	43.62	44.34	45.77	45.56	44.63	43.29	39.69	36.94
Total greenhouse gas emissions	**104.25**	**104.25**	**104.41**	**101.96**	**100.81**	**95.35**	**97.12**	**95.97**	**93.38**	**89.99**	**83.79**	**78.24**

Final user category	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Agriculture	24.83	24.31	24.19	24.34	23.92	23.79	23.32	22.81	22.43	22.46	22.33	22.27
Business	5.80	5.52	4.88	4.62	4.06	3.77	3.52	3.41	3.18	3.05	3.05	2.93
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	0.45	0.48	0.46	0.55	0.45	0.42	0.47	0.41	0.48	0.45	0.56	0.48
Industrial Process	0.68	0.60	0.53	0.49	0.38	0.35	0.33	0.31	0.32	0.29	0.27	0.25
LULUCF	0.04	0.04	0.07	0.04	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.06
Public	0.73	0.67	0.60	0.61	0.54	0.48	0.45	0.45	0.46	0.44	0.44	0.47
Residential	5.21	5.04	4.59	4.51	4.01	3.80	3.61	3.48	3.45	3.55	3.14	3.46
Transport	0.96	0.92	0.83	0.82	0.69	0.64	0.68	0.58	0.62	0.54	0.63	0.57
Waste Management	36.10	36.43	33.18	29.14	28.16	27.93	26.74	26.47	24.75	21.66	21.24	20.14
Total greenhouse gas emissions	**74.79**	**74.00**	**69.33**	**65.12**	**62.27**	**61.24**	**59.17**	**57.96**	**55.74**	**52.50**	**51.69**	**50.63**

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	37.79	37.79	37.92	37.76	37.22	37.40	37.35	37.56	38.10	37.63	37.17	35.94
Business	2.53	2.53	2.46	2.39	2.21	2.19	2.14	2.05	1.93	1.91	1.84	1.89
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.09	0.09	0.10	0.11	0.13	0.14	0.15	0.16	0.18	0.19	0.17	0.17
Industrial Process	24.71	24.71	24.86	20.23	16.32	16.51	14.94	14.84	15.03	15.31	5.43	5.61
LULUCF	0.84	0.84	0.85	0.85	0.85	0.85	0.87	0.86	0.87	0.87	0.86	0.85
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	1.48	1.48	1.45	1.49	1.61	1.79	1.99	1.86	1.85	1.82	1.80	1.77
Waste Management	1.22	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	**69.81**	**69.81**	**70.05**	**65.23**	**60.61**	**61.09**	**59.56**	**59.50**	**59.94**	**59.76**	**49.25**	**48.28**

Final user category	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Agriculture	34.03	34.33	33.83	33.73	33.55	32.05	31.06	30.78	30.31	31.02	30.84	30.29
Business	1.96	1.92	1.90	1.86	1.95	1.93	1.91	1.75	1.44	1.49	1.39	1.59
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	0.15	0.18	0.17	0.18	0.19	0.19	0.17	0.16	0.17	0.16	0.18	0.17
Industrial Process	4.87	2.84	2.97	3.81	3.01	2.42	2.81	2.56	1.23	1.35	0.24	0.10
LULUCF	0.83	0.81	0.83	0.79	0.78	0.77	0.77	0.74	0.73	0.70	0.67	0.67
Public	0.10	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.09
Residential	0.67	0.66	0.66	0.64	0.63	0.66	0.61	0.57	0.53	0.55	0.52	0.64
Transport	1.67	1.65	1.56	1.49	1.45	1.41	1.38	1.18	1.13	1.13	1.18	1.21
Waste Management	1.30	1.29	1.26	1.24	1.25	1.24	1.23	1.17	1.20	1.22	1.20	1.22
Total greenhouse gas emissions	**45.58**	**43.77**	**43.26**	**43.82**	**42.90**	**40.75**	**40.03**	**39.00**	**36.83**	**37.70**	**36.29**	**35.99**