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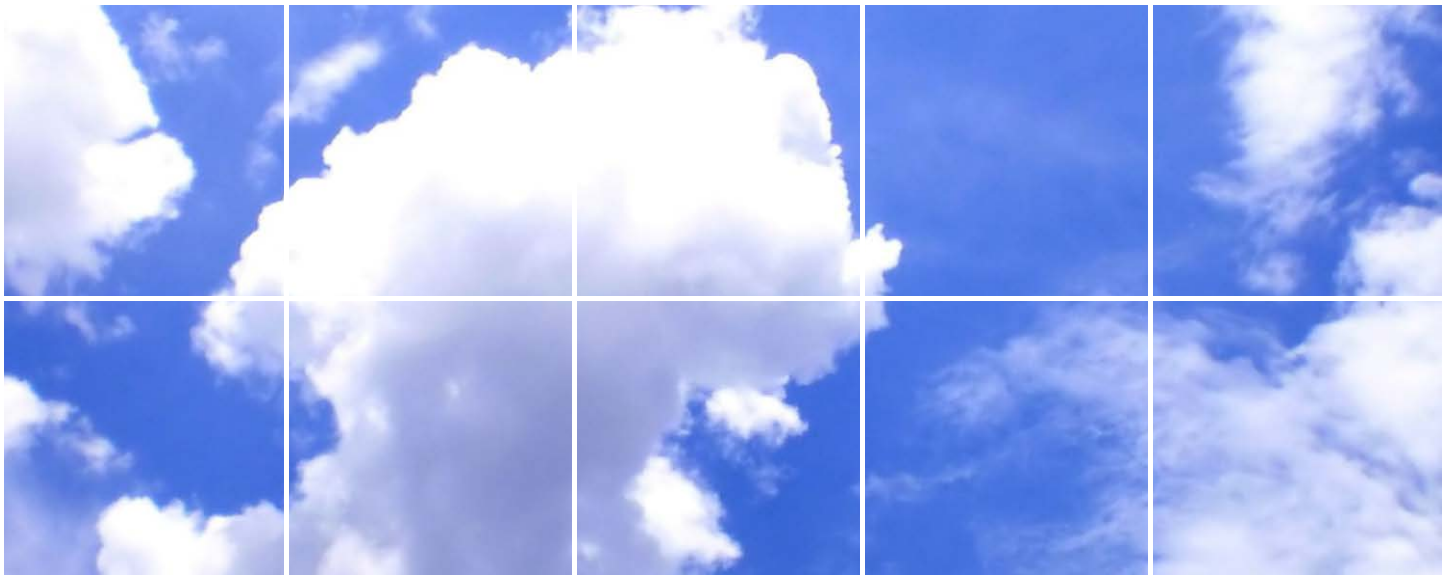

Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 - 2009

Report to the Department for Energy and Climate Change, The Scottish Government, The Welsh Government and The Northern Ireland Department of Environment.

September 2011

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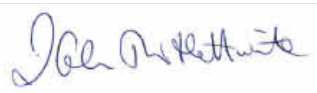
	Signature	
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Executive Summary

This report presents estimates of greenhouse gas (GHG) emission inventories for the constituent countries of the UK. Separate GHG emission inventories have been estimated for England, Scotland, Wales and Northern Ireland for the years 1990, 1995 and 1998 to 2009. The GHGs reported are:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF_6)

The estimates are consistent with the United Nations Framework Convention on Climate Change (FCCC) reporting guidelines and the 2009 UK Greenhouse Gas Inventory (MacCarthy et al., 2011). Emissions from offshore oil and gas exploration and production activities are not allocated to any country, and are reported separately within an "Unallocated" inventory category.

UK territorial coverage in this report excludes the Crown Dependencies of Jersey, Guernsey and Isle of Man, and also excludes emissions for those Overseas Territories joining UK instruments of ratification for the FCCC and the Kyoto Protocol namely: Cayman Islands, Falkland Islands, Bermuda, Montserrat and Gibraltar. The main focus of the report is emissions presented on a *by source* (emissions are allocated to the source sector in which they occur) basis, and figures and percentages within this report refer to this dataset, unless otherwise stated.

The DA inventory data presented in this report also exclude the emissions from international shipping and aviation; consistent with the UK GHG inventory reporting protocol, emissions from international shipping and aviation are reported only as "memo items" to the national inventory, and are excluded from national totals. Estimates of the DA emissions from international shipping and international aviation are provided separately in Appendix 3 of this report.

The UK distribution of regional net[1] greenhouse gas emissions in 2009, expressed in terms of global warming potentials (GWP), is[2] detailed below, in addition to the trends in emissions from the Base Year[3].

- England has a **77.6%** share of total net GHG emissions in **2009** and emissions have declined by **29.5%** since the Base Year.
- Scotland has an **8.6%** share of total net GHG emissions in **2009**, and the trend since the Base Year is a decline of **30.5%**.
- Wales has a **7.6%** share of total net GHG emissions in **2009** and emissions have declined by **23.3%** since the Base Year.
- Northern Ireland has a **3.5%** share of total net GHG emissions in **2009**, and the trend since the Base Year is a decline of **20.3%**.
- **2.8%** of the UK emissions total is unallocated in **2009.** Unallocated emissions have increased by **2.6%** since the Base Year.

Table ES1 presents emissions of the six GHGs in more detail for the base year and 2009. Tables ES2.1.1 to ES2.5.3 present the time series of emissions for each constituent country, and for unallocated emissions.

[1] Net emissions include removals in the LULUCF sector.
[2] The percentages presented in these figures are rounded to one decimal place, but are calculated from emission estimates calculated at full precision. Note that all percentages quoted in this report are based on net emission estimates held at full precision and they may differ slightly from those that can be calculated from summary tables presented in the report.
[3] Base years for UK greenhouse gas emissions are: 1990 for carbon dioxide, methane and nitrous oxide, 1995 for the fluorinated gases.

UK trends in emissions of GHGs over recent years are as follows:

- **Carbon dioxide**: Overall UK emissions have fallen by **19.7%** between 1990 and **2009**, mainly driven by the installation of combined cycle gas turbines (CCGT) in the power generation sector in England and reductions in carbon dioxide emissions from industry in England, Scotland and Wales.

- **Methane**: Overall UK emissions have fallen by **60.5%** between 1990 and **2009**, due primarily to significant reductions in methane emissions from waste disposal and coal mining.

- **Nitrous oxide**: Overall UK emissions have fallen by **49.0%** between 1990 and **2009,** driven predominantly by a large reduction in emissions following the installation of abatement measures at an adipic acid plant in England.

- **HFCs**: Overall UK emissions have fallen by **29.8%** between 1995 and **2009**, primarily due to improved emission abatement at HCFC production plant in England. Offsetting that reduction, there has been a rising trend in emissions across all countries from sources such as losses from refrigeration and air conditioning equipment and emissions from industrial aerosols and metered dose inhalers, although this is now beginning to level off.

- **PFCs**: Overall UK emissions have fallen by **68.2%** between 1995 and **2009**, mainly due to improved control measures in aluminium production in England and Wales and a reduction in aluminium production capacity in Scotland.

- **SF_6**: Overall UK emissions have decreased by **46.7%** between 1995 and **2009**. This is mostly due to decreases in emissions from the magnesium industry.

Data Sources and Inventory Methodology

In the compilation of GHG inventories for the constituent countries of the UK, where possible the same methodology has been used to calculate emission estimates as for the UK Inventory. However, for many emission sources the data available for constituent country emissions are less detailed than for the UK as a whole, and for some sources country-level data are not available at all.

In particular, complete sets of fuel consumption data are not available for England, Wales, Scotland or Northern Ireland. In order to make emission estimates for fuel consumption, therefore, the available data has been supplemented with surrogate statistics.

Sub-national energy statistics are published annually by the Department for Energy and Climate Change (DECC) within the quarterly *Energy Trends*[4] publication. These sub-national statistics are limited in their detail when compared to UK-level energy statistics (used in the UK GHG Inventory compilation), but do provide estimated fuel use data for England, Scotland, Wales and Northern Ireland for the following source sectors:

- Industry and Commercial
- Agriculture
- Residential

The DECC sub-national energy statistics have been developed in recent years to provide estimates of fuel use and carbon dioxide emissions data at Local Authority (LA) level across the UK. The latest available data include LA solid and liquid fuel use estimates for 2005 to 2008, with gas and electricity data also available up to 2009.

The DECC data at local and regional level are derived from analysis of gas and electricity meter point data, supplemented by additional research to estimate the distribution of solid fuels and petroleum-based fuels across the UK. Since the initial study and presentation of experimental data for 2003 and

[4] The latest available data are taken from the December 2010 Energy Trends: http://www.decc.gov.uk/en/content/cms/statistics/publications/trends/trends.aspx

2004, each annual revision to the local and regional data has included data improvements through targeted sector research. These DECC sub-national energy statistics continue to evolve and improve, reducing data inaccuracies, but nevertheless are subject to greater uncertainty and less detail than the UK energy statistics presented within Digest of UK Energy Statistics (DUKES) which are used to underpin the UK GHG inventory. However, they are regarded as the best dataset available to inform the patterns of fuel use across the Devolved Administrations (DA) and are therefore used to underpin the carbon dioxide emission estimates from fuel combustion sources within the inventories presented here, in conjunction with other data sources such as EU Emission Trading System (ETS) fuel use data for large industrial sites and other DA-specific energy data.

For other significant GHG emission sources there are more reliable and complete country level datasets available, although some of these are less detailed than data used for the UK Inventory:

- Industrial process emissions are based on plant operator estimates reported to environmental agencies under regulatory systems such as Integrated Pollution Prevention and Control (IPPC). Major sources include cement and lime kilns, iron and steelworks, aluminium and other non ferrous metal plant, chemical industries;

- Agricultural emissions are based on UK emission factors and annual survey data across each of the DAs including estimates of arable production and livestock numbers;

- Land Use, Land Use Change and Forestry (LULUCF) estimates are based on emission factors and regional survey data of land use, modelled to calculate GHG emissions and carbon fluxes between sources and sinks;

- Emissions from waste disposal activities are estimated based on modelled emissions from the UK GHG inventory, split out across the DAs based on local authority waste disposal activity reporting which provides an insight into the local shares of UK activity for recycling, landfilling, incineration and other treatment and disposal options.

As a result of the more limited DA-specific activity and emission factor data, the emission estimates for the England, Scotland, Wales and Northern Ireland inventories are subject to greater uncertainty than the equivalent UK estimates. Chapter 9 outlines the overall uncertainties of the DA GHG inventories.

Since the publication of the 1990-2008 GHG inventories for England, Scotland, Wales and Northern Ireland, some of the methodologies used to compile the inventories have been revised due to either changes within the UK GHG inventory compilation method, or the use of new or improved DA-specific data sources for a given source sector. Significant revisions have been made to DA estimates in the following categories; for details, see Chapter 7:

- Energy production
- Industrial fuel combustion
- Domestic fuel combustion
- Oil and gas sector
- Road transport
- Agriculture
- Land Use, Land Use Change & Forestry
- Waste management

Country-Specific Climate Change Commitments and Related Inventory Improvements

The climate change policy agenda has been changing rapidly at DA Government level within the UK in the last year, with significant new challenges to data management and reporting now developing through new legislation, strategy documents and policy instruments. The Climate Change (Scotland) Act (2009), the One Wales Commitment and the Climate Change Strategy for Wales (2010), and the Northern Ireland Greenhouse Gas Emissions Action Plan (2011), outline each of the DAs' aims and objectives in reducing GHG emissions.

Each of the devolved Governments tailors their climate change policy legislation and policies to target their specific local and regional priorities. The Climate Change (Scotland) Act outlines that the net Scottish GHG emissions account shall include all existing anthropogenic sources and sinks of emissions in Scotland, together with emissions from the traded sector[5], and also a "Scottish share" of GHG emissions from international shipping and international aviation. In contrast, the Welsh emissions account will exclude emissions from the traded sector and international transport sources, with specific sector targets to be established.

In view of these developing data requirements, a new programme of inventory improvement for the DAs has been implemented, with several new strands of research commissioned or planned to (i) meet the current and future reporting needs outlined in climate change legislation relevant to each DA, and (ii) improve the accuracy and sensitivity of estimates from source sectors where current GHG emission estimates are known to be most uncertain.

This report includes the results from a number of areas of research, including:

- A review of progress under the **DA GHG inventory improvement programme**, including an overview of the data availability for DA GHG inventory compilation, and summary of the main data revisions due to data and method improvements (Chapter 7);
- **Traded and Non-Traded GHG Emission Inventory Estimates** for England, Scotland, Wales and Northern Ireland in 2008 and 2009 (Chapter 8);
- Analysis of the **uncertainties in the reported trends** of GHG emission estimates for each DA (Chapter 9); and,
- **DA GHG emission estimates on an "end user" basis** (Chapter 10).

Traded and Non-Traded GHG Estimates

The 2009 EUETS data has been analysed and used to derive non-traded estimates for the DA GHG emission inventories, taking account of observed data discrepancies for specific IPCC sectors. The data are presented in an aggregated IPCC format, which enables more transparent comparison between the inventory and EUETS reporting formats. The findings for the 2009 dataset show that:

- Across the **UK**, the non-traded share of overall carbon dioxide emissions is ***50 %***;
- **England** has a high share of EUETS emissions within several sectors including iron and steelworks, power generation and public sector traded emissions. England non-traded emissions are estimated to be around ***55.1%*** of total carbon dioxide emissions in **2009**, a few percent higher than the UK average.
- In **Wales** the coverage of the EUETS is higher than the rest of the UK, reflecting the high share of heavy industry in Wales (e.g. emissions from power stations, refineries and integrated iron and steelworks). As a result, the non-traded share of the total carbon dioxide emissions in Wales in **2009** is only ***38.8%***;
- **Scotland** also has a higher than UK-average share of EUETS emissions, due to a high proportion of emissions from sectors such as refineries, chemicals and paper & pulp. The non-traded share of the total carbon dioxide emissions in Scotland in **2009** is ***40.3%***;
- **Northern Ireland** has much lower share of the EUETS emissions, reflecting the fact that there are no refineries, iron and steelworks or oil & gas terminals in Northern Ireland. The non-traded share of the Northern Ireland carbon dioxide emissions in **2009** is ***68.4%***.

DA GHG Estimates on an End User Basis

Analysis of emissions re-allocated across the DAs to represent consumption patterns rather than production patterns are presented within Chapter 10. In this analysis, all emissions associated with energy supply (e.g. power generation, coal mining, oil and gas extraction, refineries) are allocated to the final users of the energy. The emission trends derived from those calculations are summarised below, but it must be noted that there is a high level of uncertainty in the reported data, due to limited data availability on electricity generation and consumption, especially at the DA-level in 1990.

[5] The "traded sector" refers to emissions from installations that operate within the EU ETS, the EU-wide trading scheme that has been operational since 2005 and includes emissions from large energy consumers within the industrial and commercial sectors.

Considering the DA share of end user emission estimates, but discounting emissions associated with exported fuels, the emission estimates show that:

- **England** has a ***80.8%*** share of UK GHG emissions in **2009**, and the trend in emissions since the Base Year on an end user basis is ***-28.7%*** across all GHGs;
- **Scotland** has an ***8.6%*** share of UK GHG emissions in **2009**, and the trend in emissions since the Base Year on an end user basis is ***-35.7%*** across all GHGs;
- **Wales** has a ***6.8%*** share of UK GHG emissions in **2009**, and the trend in emissions since the Base Year on an end user basis is ***-32.3%*** across all GHGs;
- **Northern Ireland** has a ***3.8%*** share of UK GHG emissions in **2009,** and the trend in emissions since the Base Year on an end user basis is ***-17.6%*** across all GHGs.

Revisions and Updates to the Greenhouse Gas Inventories

Each year, the GHG inventories for England, Scotland, Wales and Northern Ireland are extended and updated. The time series of the inventories are extended by including a new inventory year – i.e. the previous inventory (published in September 2010) covered the years up to and including 2008, whilst this report gives emission estimates for the years up to and including 2009.

The inventories are also updated to take account of any amendments to core activity or emission factor data, and these amendments may result in revisions to emission estimates for a given year. Core energy statistics (mainly provided by DECC in their annual publication "The Digest of UK Energy Statistics") are revised annually and hence the data provided (e.g. for "coal used in energy generation in 2008") may be different in the latest edition of the Digest, compared to that used in the compilation of the previous inventory report. In addition, since the previous inventory report (2010), a more representative emission factor for one or more GHGs may have been derived for a given process. Use of a new emission factor in emission estimation calculations may lead to revisions of historic data. The nature of emission inventories is such that ongoing improvements to data collection or estimation techniques will inevitably lead to some revisions of historic data.

In addition, there may also be changes to the methodology used to allocate emissions to each of the DAs, especially where full and consistent sets of fuel use data are not available. For example, where emissions may previously have been allocated using surrogate statistics such as regional GVA or population, this methodology may be improved, should more suitable statistics become available.

Therefore, it is not appropriate to use data from previous reports and compare them with the figures in this report, without taking account of any changes to either the emission estimation methodology or the source data. There is normally a comment in the report to indicate where such changes have occurred.

Summary of Greenhouse Gas Emission Trends for the UK and Devolved Administrations

Table ES1 contains a summary of GHG emission trends for the UK and constituent countries. The following notes apply to this table:

- 1995 is used as the Base Year (BY) for emissions of HFCs, PFCs and SF_6 in the UK's Climate Change Programme, in accordance with Article 3.8 of the Kyoto Protocol;

- All of the carbon dioxide data are based on the net emissions of carbon dioxide (CO_2), including net emissions/removals of carbon dioxide in Land Use, Land Use Change and Forestry sectors; and

- The percentage changes presented in this chapter are calculated from emission estimates held at full precision within a database. The emissions quoted in Table ES1 and other tables relevant to this Chapter are values rounded from estimates in the database. The percentages and emissions totals that could be calculated from these tables may therefore differ slightly from percentages that have been calculated from the emission estimates held at full precision.

Emissions data at full precision can be found in the tables that accompany this report "DA_GHGi_1990-2009_Issue 1.xls"

Table ES1: Summary of Greenhouse Gas Emission Trends for UK and Devolved Administrations (as GWP-Equivalent Mass of Carbon Dioxide, CO_2e)

Table ES1								
Greenhouse Gas		Units	England	Scotland	Wales	Northern Ireland	Unallocated	UK
Carbon Dioxide CO_2	1990	kt CO_2e	465,169	50,191	43,157	16,532	13,087	588,136
	1990 Percentage	%	79.1%	8.5%	7.3%	2.8%	2.2%	100.0%
	2009	kt CO_2e	372,975	36,505	34,821	13,561	14,299	472,161
	2009 Percentage	%	79.0%	7.7%	7.4%	2.9%	3.0%	100.0%
	Percentage change from BY	%	-19.8%	-27.3%	-19.3%	-18.0%	9.3%	-19.7%
Methane CH_4	1990	kt CO_2e	83,811	11,784	8,230	4,445	1,855	110,125
	1990 Percentage	%	76.1%	10.7%	7.5%	4.0%	1.7%	100.0%
	2009	kt CO_2e	29,194	5,676	4,471	3,130	977	43,448
	2009 Percentage	%	67.2%	13.1%	10.3%	7.2%	2.2%	100.0%
	Percentage change from BY	%	-65.2%	-51.8%	-45.7%	-29.6%	-47.3%	-60.5%
Nitrous Oxide N_2O	1990	kt CO_2e	53,113	7,006	3,889	3,465	228	67,701
	1990 Percentage	%	78.5%	10.3%	5.7%	5.1%	0.3%	100.0%
	2009	kt CO_2e	23,977	4,938	2,792	2,527	288	34,521
	2009 Percentage	%	69.5%	14.3%	8.1%	7.3%	0.8%	100.0%
	Percentage change from BY	%	-54.9%	-29.5%	-28.2%	-27.1%	26.4%	-49.0%
HFCs	1995	kt CO_2e	15,215	128	66	38	0.0	15,447
	1995 Percentage	%	98.5%	0.8%	0.4%	0.2%	0.0%	100.0%
	2009	kt CO_2e	9,218	898	446	284	0.0	10,846
	2009 Percentage	%	85.0%	8.3%	4.1%	2.6%	0.0%	100.0%
	Percentage change from BY	%	-39.4%	602.7%	580.8%	639.3%	0.0%	-29.8%
PFCs	1995	kt CO_2e	227	87	147	1	0.0	462
	1995 Percentage	%	49.2%	18.8%	31.8%	0.1%	0.0%	100.0%
	2009	kt CO_2e	65	52	30	0	0.0	147
	2009 Percentage	%	44.4%	35.1%	20.4%	0.0%	0.0%	100.0%
	Percentage change from BY	%	-71.3%	-40.5%	-79.5%	-90.2%	0.0%	-68.2%
SF_6	1995	kt CO_2e	1,124	31	83	2	0.0	1,239
	1995 Percentage	%	90.7%	2.5%	6.7%	0.2%	0.0%	100.0%
	2009	kt CO_2e	566	48	41	6	0.0	661
	2009 Percentage	%	85.6%	7.3%	6.2%	0.9%	0.0%	100.0%
	Percentage change from BY	%	-49.6%	56.5%	-50.4%	200.9%	0.0%	-46.7%
Total	BY	kt CO_2e	618,659	69,227	55,572	24,483	15,169	783,110
	1990 Percentage	%	79.0%	8.8%	7.1%	3.1%	1.9%	100.0%
	2009	kt CO_2e	435,996	48,116	42,602	19,508	15,564	561,785
	2009 Percentage	%	77.6%	8.6%	7.6%	3.5%	2.8%	100.0%
	Percentage change from BY	%	-29.5%	-30.5%	-23.3%	-20.3%	2.6%	-28.3%

Tables ES2.1.1 and ES2.1.2 summarise the emissions of each of the GHGs for England expressed in terms of carbon dioxide and carbon equivalent, respectively.

Table ES2.1.1: England GHG Emissions by Gas, 1990 to 2009 (Mt CO_2e)

England	Mt CO_2e														
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	BY to 2009
Carbon Dioxide CO_2	465.2	424.3	421.7	413.9	417.7	431.2	424.8	434.8	432.9	432.2	425.3	424.1	412.3	373.0	**-19.8%**
Methane CH_4	83.8	67.2	56.2	52.2	48.3	43.8	41.6	36.5	34.7	33.2	32.3	30.8	30.0	29.2	**-65.2%**
Nitrous Oxide N_2O	53.1	42.2	42.3	31.9	31.5	29.1	28.1	27.7	28.6	27.6	26.1	26.2	25.8	24.0	**-54.9%**
HFCs	11.4	15.2	16.0	9.2	7.8	8.3	8.4	9.1	8.1	8.7	9.0	8.9	9.2	9.2	**-39.4%**
PFCs	1.0	0.2	0.2	0.2	0.3	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	**-71.3%**
SF_6	0.9	1.1	1.1	1.3	1.6	1.3	1.4	1.2	1.0	1.0	0.8	0.7	0.6	0.6	**-49.6%**
Total Net Emissions	**615.4**	**550.3**	**537.5**	**508.6**	**507.1**	**513.9**	**504.4**	**509.4**	**505.4**	**502.8**	**493.6**	**490.8**	**478.0**	**436.0**	**-29.5%**
Net CO_2 emissions from LULUCF	5.6	5.1	4.2	4.0	3.6	3.4	3.0	2.9	2.5	2.1	1.9	1.7	1.5	1.4	
Net CH_4 emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Net N_2O emissions from LULUCF	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	

Table ES2.1.2: England GHG Emissions by Gas, 1990 to 2009 (Mt Carbon equivalent)

England	Mt Carbon equivalent														
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	BY to 2009
Carbon	126.9	115.7	115.0	112.9	113.9	117.6	115.9	118.6	118.1	117.9	116.0	115.7	112.4	101.7	**-19.8%**
Methane CH_4	22.9	18.3	15.3	14.2	13.2	11.9	11.3	9.9	9.5	9.0	8.8	8.4	8.2	8.0	**-65.2%**
Nitrous Oxide N_2O	14.5	11.5	11.5	8.7	8.6	7.9	7.7	7.5	7.8	7.5	7.1	7.1	7.0	6.5	**-54.9%**
HFCs	3.1	4.1	4.4	2.5	2.1	2.3	2.3	2.5	2.2	2.4	2.5	2.4	2.5	2.5	**-39.4%**
PFCs	0.3	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	**-71.3%**
SF_6	0.3	0.3	0.3	0.3	0.4	0.3	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	**-49.6%**
Total Net Emissions	**167.8**	**150.1**	**146.6**	**138.7**	**138.3**	**140.1**	**137.6**	**138.9**	**137.8**	**137.1**	**134.6**	**133.9**	**130.4**	**118.9**	**-29.5%**
Net CO_2 emissions from LULUCF	1.5	1.4	1.1	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.5	0.5	0.4	0.4	
Net CH_4 emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Net N_2O emissions from LULUCF	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	

Table ES2.1.3: Aggregated Emission trends by National Communication sector for England (Mt CO_2e)

England	Aggregate Emission Trends by National Communication Sector (Mt CO_2e)													
NC Format	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1. Agriculture	39.9	38.1	37.4	37.2	35.7	33.2	33.5	32.9	33.0	32.9	31.6	31.3	31.4	31.0
2. Business	86.1	83.4	83.2	83.2	84.1	87.0	82.4	83.7	81.7	82.5	80.0	78.7	77.9	69.3
3. Energy Supply	211.4	167.6	154.9	145.9	150.2	159.1	160.8	167.1	164.4	165.9	165.9	167.0	159.7	141.1
4. Industrial Process	48.8	40.4	39.5	22.2	20.0	18.2	15.8	16.0	15.4	14.6	13.1	14.2	12.9	8.4
5. Land Use Change	5.9	5.4	4.5	4.3	4.0	3.7	3.3	3.2	2.7	2.4	2.2	2.0	1.8	1.7
6. Public	11.4	11.4	10.8	10.6	10.0	10.3	8.8	8.7	9.4	9.3	8.4	7.8	7.8	6.8
7. Residential	63.0	65.1	71.8	71.6	72.4	74.3	71.7	72.8	74.3	71.1	68.7	65.8	67.1	63.1
8. Transport	101.5	101.9	105.8	106.6	105.7	105.7	107.6	106.9	107.9	108.3	108.3	109.0	105.0	100.4
9. Waste Management	47.3	37.0	29.7	27.0	25.2	22.3	20.4	18.0	16.5	15.9	15.4	15.0	14.4	14.1
Total	**615.4**	**550.3**	**537.5**	**508.6**	**507.1**	**513.9**	**504.4**	**509.4**	**505.4**	**502.8**	**493.6**	**490.8**	**478.0**	**436.0**

[a] Solvents and other product use emissions occur as non-methane volatile organic compounds (NMVOC) and so do not appear in this table, which covers direct GHGs only.
[b] NC Format refers to National Communication Format used for reporting emissions to the UNFCCC

Tables ES2.2.1 and ES2.2.2 summarise the emissions of each of the GHGs for Scotland expressed in terms of carbon dioxide and carbon equivalent, respectively.

Table ES2. 2.1: Scotland GHG Emissions by Gas, 1990 to 2009 (Mt CO_2e)

Scotland	Mt CO_2e														
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	BY to 2009
Carbon Dioxide CO_2	50.2	49.4	49.9	47.0	49.3	49.4	46.0	45.9	43.6	42.5	45.9	42.0	40.0	36.5	**-27.3%**
Methane CH_4	11.8	10.1	9.0	8.2	7.9	7.2	6.7	6.1	6.1	6.1	6.0	6.0	5.9	5.7	**-51.8%**
Nitrous Oxide N_2O	7.0	6.3	6.2	6.0	5.8	5.8	5.7	5.6	5.5	5.3	5.3	5.0	4.9	4.9	**-29.5%**
HFCs	0.0	0.1	0.4	0.4	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	**602.7%**
PFCs	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**-40.5%**
SF_6	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	**56.5%**
Total (Net Emissions)	**69.1**	**66.1**	**65.6**	**61.8**	**63.7**	**63.0**	**59.2**	**58.5**	**56.0**	**54.8**	**58.1**	**53.9**	**51.8**	**48.1**	**-30.5%**
Net CO_2 Emissions from LULUCF	-2.4	-3.4	-3.6	-3.7	-3.9	-4.2	-4.5	-4.8	-5.3	-5.5	-5.5	-5.7	-5.9	-6.0	
Net CH_4 Emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Net N_2O Emissions from LULUCF	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	

Table ES2. 2.2: Scotland GHG Emissions by Gas, 1990 to 2009 (Mt Carbon equivalent)

Scotland	Mt Carbon equivalent														
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	BY to 2009
Carbon Dioxide CO_2	13.7	13.5	13.6	12.8	13.5	13.5	12.5	12.5	11.9	11.6	12.5	11.4	10.9	10.0	**-27.3%**
Methane CH_4	3.2	2.8	2.4	2.2	2.1	2.0	1.8	1.7	1.7	1.7	1.6	1.6	1.6	1.5	**-51.8%**
HFCs	1.9	1.7	1.7	1.6	1.6	1.6	1.6	1.5	1.5	1.4	1.4	1.4	1.3	1.3	**-29.5%**
Nitrous Oxide N_2O	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	**602.7%**
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**-40.5%**
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**56.5%**
Total Net Emissions	**18.8**	**18.0**	**17.9**	**16.9**	**17.4**	**17.2**	**16.1**	**16.0**	**15.3**	**15.0**	**15.9**	**14.7**	**14.1**	**13.1**	**-30.5%**
Net CO_2 emissions from LULUCF	-0.7	-0.9	-1.0	-1.0	-1.1	-1.1	-1.2	-1.3	-1.5	-1.5	-1.5	-1.5	-1.6	-1.6	
Net CH_4 emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Net N_2O emissions from LULUCF	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	

Table ES2.2.3: Aggregated Emission trends by National Communication sector for Scotland (Mt CO_2e)

Scotland	Aggregate Emission Trends by National Communication Sector (Mt CO_2e)													
NC Format	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1. Agriculture	10.1	9.7	9.6	9.4	9.1	8.8	8.8	8.8	8.6	8.5	8.3	8.1	7.9	7.9
2. Business	10.5	7.5	7.6	7.7	8.0	8.6	7.7	7.6	7.5	7.9	7.7	7.4	7.2	6.4
3. Energy Supply	22.2	26.4	26.2	23.1	25.9	25.3	23.3	23.4	21.6	20.5	24.4	21.1	19.6	18.2
4. Industrial Process	1.9	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.4
5. Land Use Change	-2.1	-3.0	-3.2	-3.3	-3.5	-3.8	-4.2	-4.4	-5.0	-5.2	-5.2	-5.4	-5.6	-5.7
6. Public	1.3	1.2	1.1	1.2	1.1	1.1	0.9	0.9	1.0	1.1	1.0	0.9	0.9	0.8
7. Residential	8.1	8.1	8.5	8.4	8.3	8.7	8.1	8.1	8.2	8.0	7.8	7.5	7.8	7.3
8. Transport	10.6	10.6	10.9	11.1	10.9	10.8	11.1	11.2	11.2	11.3	11.5	11.6	11.2	10.7
9. Waste Management	6.5	5.1	4.1	3.7	3.5	2.9	2.7	2.3	2.2	2.2	2.2	2.2	2.2	2.1
Total	**69.1**	**66.1**	**65.6**	**61.8**	**63.7**	**63.0**	**59.2**	**58.5**	**56.0**	**54.8**	**58.1**	**53.9**	**51.8**	**48.1**

[a] Solvents and other product use emissions occur as NMVOC and so do not appear in this table, which covers direct GHGs only.
[b] NC Format refers to National Communication Format used for reporting emissions to the UNFCCC.

Tables ES2.3.1 and ES2.3.2 summarise the emissions of each of the GHGs for Wales expressed in terms of carbon dioxide and carbon equivalent, respectively.

Table ES2.3.1: Wales GHG Emissions by Gas, 1990 to 2009 (Mt CO_2e)

Wales	Mt CO_2e														
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**BY to 2009**
Carbon Dioxide CO_2	43.2	40.8	43.1	44.3	46.4	43.9	37.4	38.5	42.0	40.5	41.9	39.2	41.6	34.8	**-19.3%**
Methane CH_4	8.2	6.8	6.1	5.9	5.7	5.2	5.1	5.0	5.0	5.1	4.8	4.6	4.4	4.5	**-45.7%**
Nitrous Oxide N_2O	3.9	3.9	4.0	3.9	3.6	3.5	3.3	3.4	3.3	3.4	3.2	3.0	2.8	2.8	**-28.2%**
HFCs	0.0	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	**580.8%**
PFCs	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.0	**NA**
SF_6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	**-50.4%**
Total Net Emissions	**55.7**	**51.7**	**53.5**	**54.5**	**56.2**	**53.1**	**46.4**	**47.4**	**50.9**	**49.5**	**50.4**	**47.3**	**49.3**	**42.6**	**-23.3%**
Net CO_2 emissions from LULUCF	-0.1	-0.1	0.0	0.1	0.0	0.0	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	
Net CH_4 emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Net N_2O emissions from LULUCF	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	

Table ES2.3.2: Wales GHG Emissions by Gas, 1990 to 2009 (Mt Carbon equivalent)

Wales	Mt Carbon equivalent														
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**BY to 2009**
Carbon Dioxide CO_2	11.8	11.1	11.7	12.1	12.7	12.0	10.2	10.5	11.5	11.0	11.4	10.7	11.3	9.5	**-19.3%**
Methane CH_4	2.2	1.8	1.7	1.6	1.5	1.4	1.4	1.4	1.4	1.4	1.3	1.2	1.2	1.2	**-45.7%**
Nitrous Oxide N_2O	1.1	1.1	1.1	1.1	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	**-28.2%**
HFCs	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**580.8%**
PFCs	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**NA**
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**-50.4%**
Total Net Emissions	**15.2**	**14.1**	**14.6**	**14.9**	**15.3**	**14.5**	**12.6**	**12.9**	**13.9**	**13.5**	**13.7**	**12.9**	**13.4**	**11.6**	**-23.3%**
Net CO_2 emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	
Net CH_4 emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Net N_2O emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Table ES2.3.3: Aggregated Emission trends by National Communication sector for Wales (Mt CO_2e)

Wales	Aggregate Emission Trends by National Communication Sector (Mt CO_2e)													
NC Format	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1. Agriculture	7.0	7.0	7.1	7.0	6.6	6.4	6.2	6.3	6.2	6.3	6.0	5.7	5.4	5.3
2. Business	13.2	14.4	15.1	16.5	16.3	13.3	9.3	10.4	11.1	10.3	10.8	10.6	10.1	8.1
3. Energy Supply	17.5	12.8	13.8	13.5	16.2	17.3	15.7	15.1	17.8	17.5	18.4	15.9	19.0	16.1
4. Industrial Process	2.9	3.0	2.9	3.1	3.2	2.4	1.9	2.5	2.6	2.4	2.5	2.7	2.5	1.4
5. Land Use Change	0.0	0.0	0.1	0.2	0.1	0.0	0.0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3
6. Public	0.8	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.4	0.4	0.4
7. Residential	5.0	5.1	5.6	5.5	5.3	5.4	5.1	5.1	5.2	4.9	4.8	4.5	4.7	4.4
8. Transport	6.2	6.1	6.3	6.3	6.2	6.2	6.4	6.4	6.5	6.5	6.6	6.6	6.4	6.2
9. Waste Management	3.2	2.5	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.2	1.1	1.1	1.0	1.0
Total	**55.7**	**51.7**	**53.5**	**54.5**	**56.2**	**53.1**	**46.4**	**47.4**	**50.9**	**49.5**	**50.4**	**47.3**	**49.3**	**42.6**

[a] Solvents and other product use emissions occur as NMVOC and so do not appear in this table, which covers direct GHGs only.
[b] NC Format refers to National Communication Format used for reporting emissions to the UNFCCC.

Tables ES2.4.1 and ES2.4.2 summarise the emissions of each of the GHGs for Northern Ireland expressed in terms of carbon dioxide and carbon equivalent, respectively.

Table ES2.4.1: Northern Ireland GHG Emissions by Gas, 1990 to 2009 (Mt CO_2e)

Northern Ireland	Mt CO_2e														
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	BY to 2009
Carbon Dioxide CO_2	16.5	16.7	16.2	16.4	16.3	16.7	15.1	15.1	15.1	15.9	16.4	15.1	15.2	13.6	**-18.0%**
Methane CH_4	4.4	4.0	3.8	3.7	3.5	3.4	3.3	3.2	3.1	3.2	3.2	3.2	3.1	3.1	**-29.6%**
Nitrous Oxide N_2O	3.5	3.5	3.7	3.7	3.5	3.5	3.0	3.0	2.9	2.7	2.7	2.6	2.6	2.5	**-27.1%**
HFCs	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	**639.3%**
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**-90.2%**
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**200.9%**
Total Net Emissions	**24.4**	**24.3**	**23.9**	**23.9**	**23.4**	**23.7**	**21.6**	**21.5**	**21.3**	**22.1**	**22.6**	**21.2**	**21.2**	**19.5**	**-20.3%**
Net CO_2 emissions from LULUCF	0.0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	
Net CH_4 emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Net N_2O emissions from LULUCF	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Table ES2.4.2: Northern Ireland GHG Emissions by Gas, 1990 to 2009 (Mt Carbon equivalent)

Northern Ireland	Mt Carbon equivalent														
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	BY to 2009
Carbon Dioxide CO_2	4.5	4.6	4.4	4.5	4.5	4.5	4.1	4.1	4.1	4.3	4.5	4.1	4.2	3.7	**-18.0%**
Methane CH_4	1.2	1.1	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	**-29.6%**
Nitrous Oxide N_2O	0.9	1.0	1.0	1.0	0.9	1.0	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	**-27.1%**
HFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**639.3%**
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**-90.2%**
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**200.9%**
Total Net Emissions	**6.7**	**6.6**	**6.5**	**6.5**	**6.4**	**6.5**	**5.9**	**5.9**	**5.8**	**6.0**	**6.2**	**5.8**	**5.8**	**5.3**	**-20.3%**
Net CO_2 emissions from LULUCF	0.0	0.0	0.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Net CH_4 emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Net N_2O emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Table ES2.4.3: Aggregated Emission trends by National Communication sector for Northern Ireland (Mt CO_2e)

Northern Ireland	Aggregate Emission Trends by National Communication Sector (Mt CO_2e)													
NC Format	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1. Agriculture	5.8	5.9	6.2	6.0	5.7	5.7	5.8	5.7	5.6	5.5	5.5	5.3	5.2	5.2
2. Business	2.4	2.2	1.8	1.9	1.9	2.0	1.6	1.7	1.8	2.1	2.1	2.1	2.0	1.8
3. Energy Supply	5.3	6.5	6.2	6.2	6.3	6.6	5.2	5.0	4.8	5.4	5.7	4.7	4.8	3.7
4. Industrial Process	0.8	0.8	0.8	0.9	0.7	0.6	0.2	0.2	0.2	0.4	0.4	0.5	0.4	0.2
5. Land Use Change	0.1	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1
6. Public	0.5	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
7. Residential	4.4	3.6	3.8	3.8	3.8	3.8	3.9	3.8	3.8	3.5	3.6	3.3	3.5	3.4
8. Transport	3.3	3.6	3.7	3.9	4.0	4.0	4.2	4.3	4.3	4.4	4.4	4.5	4.3	4.3
9. Waste Management	1.9	1.5	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Total	**24.4**	**24.3**	**23.9**	**23.9**	**23.4**	**23.7**	**21.6**	**21.5**	**21.3**	**22.1**	**22.6**	**21.2**	**21.2**	**19.5**

[a] Solvents and other product use emissions occur as NMVOC and so do not appear in this table, which covers direct GHGs only
[b] NC Format refers to National Communication Format used for reporting emissions to the UNFCCC.

Tables ES2.5.1 and ES2.5.2 summarise the Unallocated emissions of each of the GHGs expressed in terms of carbon dioxide and carbon equivalent, respectively.

Table ES2.5.1: Unallocated GHG Emissions by Gas, 1990 to 2009 (Mt CO_2e)

Unallocated	Mt CO_2e														
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	BY to 2009
Carbon Dioxide CO_2	13.1	17.8	18.9	18.8	17.9	18.7	18.9	17.8	17.6	17.2	15.3	15.8	14.5	14.3	**9.3%**
Methane CH_4	1.9	1.8	1.6	1.4	1.2	1.2	1.1	1.1	1.2	0.9	0.8	1.0	0.9	1.0	**-47.3%**
Nitrous Oxide N_2O	0.2	0.3	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	**26.4%**
HFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Net Emissions	**15.2**	**19.9**	**20.8**	**20.6**	**19.5**	**20.3**	**20.5**	**19.2**	**19.1**	**18.4**	**16.4**	**17.1**	**15.7**	**15.6**	**2.6%**
Net CO_2 emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Net CH_4 emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Net N_2O emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Table ES2.5.2: Unallocated GHG Emissions by Gas, 1990 to 2009 (Mt Carbon equivalent)

Unallocated	Mt Carbon equivalent														
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	BY to 2009
Carbon Dioxide CO_2	3.6	4.9	5.1	5.1	4.9	5.1	5.2	4.8	4.8	4.7	4.2	4.3	4.0	3.9	**9.3%**
Methane CH_4	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.3	**-47.3%**
Nitrous Oxide N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**26.4%**
HFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total Net Emissions	**4.1**	**5.4**	**5.7**	**5.6**	**5.3**	**5.5**	**5.6**	**5.2**	**5.2**	**5.0**	**4.5**	**4.7**	**4.3**	**4.2**	**2.6%**
Net CO_2 emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Net CH_4 emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Net N_2O emissions from LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Table ES2.5.3 Aggregated Emission trends by National Communication sector for unallocated emissions (Mt CO_2e)

Unallocated	Aggregate Emission Trends by National Communication Sector (Mt CO_2e)													
NC Format	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1. Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. Business	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3. Energy Supply	15.2	19.9	20.8	20.6	19.5	20.3	20.5	19.2	19.1	18.4	16.4	17.1	15.7	15.6
4. Industrial Process	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5. Land Use Change	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6. Public	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7. Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8. Transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9. Waste Management	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10. Exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**15.2**	**19.9**	**20.8**	**20.6**	**19.5**	**20.3**	**20.5**	**19.2**	**19.1**	**18.4**	**16.4**	**17.1**	**15.7**	**15.6**

[a] Solvents and other product use emissions occur as NMVOC and so do not appear in this table, which covers direct GHGs only.
[b] NC Format refers to National Communication Format used for reporting emissions to the UNFCCC.

Contacts

This work forms part of the Climate and Energy: Science and Analysis Research Programme of the Department for Energy and Climate Change. The land use, land use change and forestry estimates were provided by the Centre for Ecology and Hydrology (CEH) Edinburgh (Contract CPEG 1). Rothamsted Research provides the estimates of agricultural emissions under a separate contract to the Department for Environment, Food and Rural Affairs.

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A copy of this report and related data may be found on the website maintained by AEA for DECC: http://www.naei.defra.gov.uk

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Document Revision History	
Version	Comment
Draft for comment	Report and tables of emissions issued for comment to the DAs and DECC.
Issue 1	Finalised version for publication.

1 Introduction

1.1 Background to Inventory Development for the Devolved Administrations

The United Nations Framework Convention on Climate Change (UNFCCC) was ratified by the United Kingdom in December 1993 and came into force on the 21st March 1994. The objective of the Convention is to stabilise greenhouse gas (GHG) emissions in the atmosphere and reduce the anthropogenic interference with the climate system. In order to achieve this, the international community requires accurate information on trends of emissions of GHGs, and the collective ability to alter these trends.

Annex I Parties to the Convention, that have ratified the Kyoto Protocol are required to submit to the secretariat net national GHG inventories, including all anthropogenic emissions of GHGs by sources and removals by sinks. The Parties are required to submit information on their national inventories on an annual basis and national communications periodically, according to dates established in the Conference of the Parties. The annual inventory reports must comply with the UNFCCC guidelines. The Kyoto Protocol supplements the UNFCCC by committing parties who have ratified the protocol to achieve individual targets established for the reduction of their respective GHG emissions. Under the protocol, the UK is legally bound to reduce emissions of the 'basket of 6' GHGs by 12.5% against baseline emissions over the first commitment period (2008-2012). However, the UK has also adopted a domestic target aimed at reducing emissions of carbon dioxide to 20% below 1990 levels by 2010.

In the United Kingdom, the National GHG Inventory and associated National Inventory Report is prepared to ensure that the UK fulfils its requirements under the UNFCCC and to monitor the legally binding commitments under the Kyoto Protocol to reduce GHG emissions. However, the powers to implement measures to deliver reductions in emissions of GHGs are devolved to the Scottish Government, Welsh Assembly Government and the Northern Ireland Executive. As a result, each of the Devolved Administrations (DAs) has developed national climate change legislation or strategies establishing targets for reductions in GHG emissions together with accompanying national climate change policy frameworks. The reductions in GHG emissions targeted in the UK as a whole, and in each of the respective DAs are discussed in Section 1.2.

The Department of Energy and Climate Change (DECC) and the DAs commission an annual work programme to compile GHG inventories for the DAs, in order to establish GHG emission baselines by source and to track progress towards reduction targets at DA level. This report summarises the findings of the joint research programme for the 1990-2009 GHG inventory cycle, which revises and updates the previous DA inventories that were published in September 2010.

This report presents separate GHG Inventories for England, Scotland, Wales and Northern Ireland for the years 1990, 1995, and 1998 to 2009. Emissions of the six direct GHGs are reported, namely:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF_6)

The UK GHG inventory is reported using Intergovernmental Panel on Climate Change (IPCC) sectoral tables (MacCarthy *et al.*, 2011), which are a subset of the IPCC Common Reporting Format (CRF). The latest UK GHG inventory was submitted to the UNFCCC in April 2011.

The GHG inventories for England, Scotland, Wales and Northern Ireland in this report are presented in a different format to the UK GHG inventory, but the sum of the DA inventories are fully consistent with

the UK GHG inventory. To provide information that is better aligned to the needs of DA policy teams, this report has been re-formatted to present the data according to National Communication format at the top level, with additional detail by IPCC sector code below that. The National Communication format presents the GHG emissions for the following policy areas:

- Energy Supply
- Business
- Industrial Process
- Transport
- Public sector
- Residential
- Agriculture
- Land Use, Land Use Change and Forestry (LULUCF)
- Waste

A table to show the mapping between IPCC sectors and National Communication sectors is provided in Appendix 6. Throughout the report, the description of emission source estimation methods, trends and method improvements uses the IPCC sector notation, as this level of detail is essential to present the source-specific information in a detailed and transparent manner.

Note that emissions of GHGs from offshore oil and gas exploration and production are reported within this report as “Unallocated” emissions.

1.2 The UK Climate Change Act and Country-Specific Climate Change Programmes

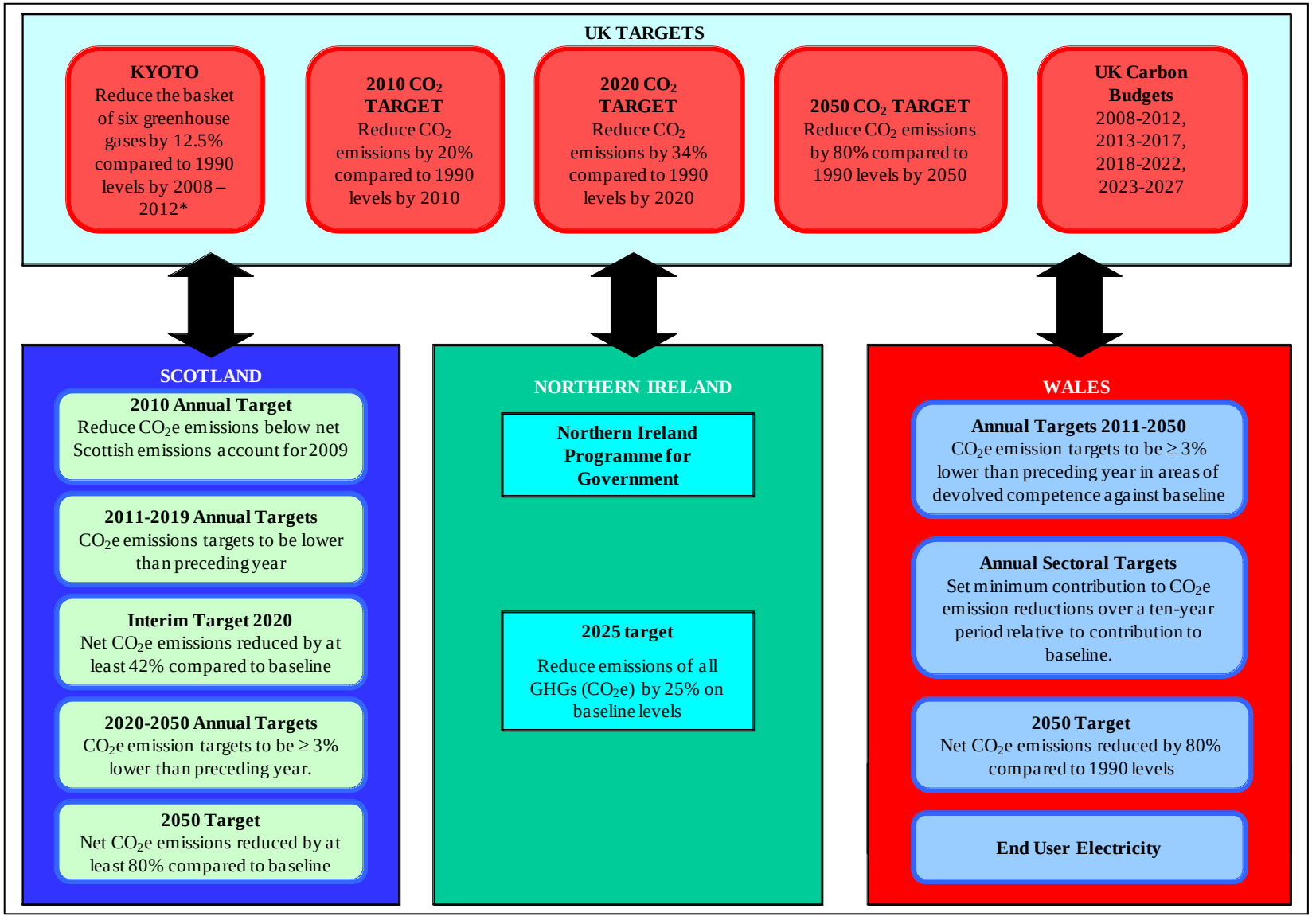
The UK Climate Change Act, which received Royal Assent on the 26th November 2008 established new legal requirements to monitor and report UK GHG emission reductions. The Act set a statutory target to reduce emissions of GHGs in the UK by 80 % against the baseline by 2050 with a minimum 34% reduction in carbon dioxide emissions to be achieved by 2020. The Act also introduced a Carbon Budgeting System whereby emission caps are set over 5 year periods, with three budgets established at a time to map out the emission trajectory to 2050. This Act represents the primary piece of climate change legislation relevant to England.

An overview of the main components of UK and DA climate change legislation and strategies is presented in Figure 1.1 below.

These national targets for DA GHG emission reductions are in addition to those established for the UK as a whole within international mechanisms and through domestic legislation. To ensure that domestic action in the UK progresses to address the challenging GHG reduction targets, there is an increasing focus on the evaluation of the impact of both reserved (UK) and devolved (DA) policies upon GHG emission sources.

The GHG inventories for England, Scotland, Wales and Northern Ireland help to support evidence-based development of climate change policy by the Scottish Government, Welsh Government and the Northern Ireland Executive, and are a mechanism by which tracking progress towards country-specific GHG emission reduction targets may be achieved. The implementation of new UK and country-specific legislation means that the requirements of the GHG inventories for the constituent countries is evolving, with a much greater focus on (i) sector-specific data accuracy, and (ii) sensitivity to policy impacts.

Figure 1.1 Greenhouse Gas Emission Reduction Targets: UK, Scotland, Wales and Northern Ireland



1.2.1 Scotland

The Climate Change (Scotland) Act 2009 establishes a long-term framework to address climate change and sets statutory targets to reduce Scotland's GHG emissions by at least 80% against the baseline by 2050, in line with the requirements of the UK Climate Change Act 2008, but extending beyond that to include emissions from international aviation and shipping.

An interim reduction target of at least 42% reduction to be achieved by 2020 has been confirmed by Scottish Ministers. This 42% target is higher than reductions outlined for the same period in the UK Act. The Scottish Act also specifies the requirement to set annual GHG emissions targets (net emissions with allowance for trading) in line with the attainment of the interim and 2050 targets, and the need to quantify emissions from all anthropogenic sources in Scotland, as well as a share of emissions from international aviation and shipping.

Under the Act, Scottish Ministers are required to set annual targets in the form of net emissions with allowance for trading for each calendar year from 2010 to 2050. In October 2010 the Scottish Parliament passed legislation setting the first batch of annual targets, for the years 2010 to 2022. The annual target for 2020 is equal to the interim target, whilst from 2020 onwards each annual target must be at least 3% lower than the previous year. In addition, from 2012, the Act places an obligation on the Scottish Government to prepare annual reports relating to emissions of GHG from Scotland. These annual reports must include a statement on the net emissions of the 'basket of 6' GHG from Scotland from 2010 forwards, together with information relating to the number of carbon units credited and debited within the traded sector and data relating to electricity generation and consumption.

1.2.2 Wales

In Wales, the 'One Wales Commitment'[6], established targets for reductions in GHG emissions by 3% per year from 2011 in areas of devolved competence, against a baseline of average emissions between 2006-10 and delivering the Welsh share of the statutory UK targets (80% of the 'basket of six' GHG by 2050) required by the Climate Change Act. In the One Wales commitment and the Climate Change Strategy for Wales published in October 2010, the Assembly also outlined the intention to set sector-specific targets for reductions in emissions from sectors that fall within the remit of devolved competence, including residential, public and transport sectors. The Strategy reiterates the Assembly Government's intention to achieve a 3% year on year reduction in GHG emissions from 2011. The Delivery Plan for Emission Reduction, published alongside the Strategy documents in October 2010, presents the detailed policy framework established to enable WG to achieve its GHG emission reduction commitments.

Under the Strategy, the Welsh Government will be required to prepare annual progress reports detailing emissions of GHG from the relevant sectors outlined in the One Wales Commitment. The Strategy identifies the disaggregated GHG Inventory as the principal tool that will be used to quantify progress against the defined targets.

1.2.3 Northern Ireland

The Northern Ireland Executive's Programme for Government 2008-2011 commits Northern Ireland to a 25% reduction in GHG levels by 2025 on 1990 levels. There are many sectors where reductions in emissions are targeted including the promotion of renewable energy, energy efficiency measures, increased forestry cover and measures to reduce emissions from the transport sector. The Northern Ireland Assembly and the Northern Ireland Executive have signed up to the Climate Change Act 2008 and specifically that Northern Ireland contributes to the UK carbon reduction targets set out in the Act and associated legislation. The Northern Ireland Executive agreed a "Northern Ireland Greenhouse Gas Emissions Reduction Action Plan" on 12 February 2011. A cross-departmental working group tracks progress and reports annually to the Northern Ireland Executive.

[6] The 'One Wales: A Progressive Agenda for the Government of Wales (2007)

1.3 DA GHG Inventories Improvement Programme

As a consequence of the development of DA-specific climate change legislation and strategies to reduce GHG emissions in each of the DAs, the emissions data and trends reported within the DA GHG inventories are coming under ever-greater scrutiny. The sensitivity of the DA data to changes in activities within sectors from implemented action has been researched by recent climate change policy studies.

Measures, policies and strategies continue to be developed to reduce GHG emissions; some policies and measures impact upon one sector, whilst others (e.g. promoting energy efficiency) may impact across many source sectors. Wales, Scotland, Northern Ireland and England each have devolved responsibility to address GHG emissions, and there are an increasing range of country-specific statutory and policy commitments.

To support the actions implemented within each country, the DA GHG inventories continue to be developed, aiming to provide an effective and accurate reporting tool and reflect the impact upon emissions from the implementation of both devolved and reserved measures.

The programme of improvement for the DA inventories includes periodic review of the available source data and estimation methods, in parallel with the programme of improvement to the UK GHG inventory. A considerable research effort has been invested in 2010 to improve GHG emission estimates at UK and DA level, and a prioritised list of future improvements has been developed in consultation with DECC and the DA Governments. Source sectors that may be focused upon for future data and method improvements at DA-level include:

- Residential fuel use
- Landfill waste
- Road transport
- Industrial combustion (to be reported in a more detailed sector-specific format), and
- Agricultural livestock sources (i.e. from both waste management and enteric fermentation)

1.3.1 End User Inventories for England, Scotland, Wales and Northern Ireland

In parallel to the improvement of the point source GHG inventories for England, Scotland, Wales and Northern Ireland, further research has been undertaken to develop End User GHG inventories for the constituent countries, whereby emissions from energy supply (electricity, refined petroleum fuels, gas and solid fuel production) are re-allocated to energy demand patterns across the UK. The development of End User GHG inventories enables better interrogation of the impacts of energy efficiency policies, as these impact upon both primary and secondary fuel use within the UK. The development of End User inventories provides a different picture of consumption patterns within the UK, compared to the production-based data. The DA end user inventories are presented in Appendix 5, with the data, methods and trends discussed in more detail in Chapter 10.

1.3.2 Traded and Non-Traded Emissions

In line with the requirements of the climate change legislation and strategies applicable in each DA, the segregation of emissions from the traded and non-traded sectors represents an important aspect for development and reporting in the UK and DA GHG inventories. The Scottish Government, Welsh Government and Northern Ireland Executive have limited powers over activities within the traded sector. However, the segregation of emissions between traded and non-traded sectors within the inventories is not only important for Wales where the net emissions account excludes emissions from the traded sectors, but also in Scotland where the Act requires quantification of the impact of both the traded and non-traded sectors.

The scope of the EUETS was expanded in 2008, which was the first year of Phase II of the scheme. The analysis of the DA traded and non-traded share within this report therefore focuses on the years 2008 and 2009 only. The analysis of the EUETS emissions data and fuel use data has been repeated and updated to assess the traded and non-traded emission estimates for each of the constituent

countries in 2008 and 2009, taking account of recalculations within the underlying DA GHG inventory datasets for each source sector since the 1990-2008 DA GHGI dataset was published in 2010.

An improvement programme research task focussed on the analysis of the EUETS (See Chapter 7), and the findings of the traded / non-traded emissions calculations are presented in Chapter 8 and Appendix 4.

1.4 Global Warming Potential

Depending upon their molecular weights, radiative properties and residence times in the atmosphere, each GHG has a different capacity to cause global warming. The Global Warming Potential (GWP) is an attempt to encapsulate these parameters and provide a simple measure of the relative radiative effects of the emissions of the relevant GHGs. The GWP is defined as the warming influence over a set time period of a gas relative to that of carbon dioxide. The index is defined as the cumulative radiative forcing between the present and some chosen time horizon caused by a unit mass of gas emitted now, expressed relative to that of carbon dioxide. It is necessary to define a time horizon because the gases have different lifetimes in the atmosphere.

Table 1.1 shows GWPs defined on a 100-year horizon (IPCC, 1996). The 1996 values were agreed internationally as the values that Parties are required to use for reporting GHG emissions to the UNFCCC and the Kyoto Protocol, although they were updated in 2001. For consistency with international reporting, the 1996 values are also used in this report. A range of GWP values is shown for HFCs and PFCs because these refer to a number of species, each with its own GWP. By weighting the emission of a gas with its GWP it is possible to undertake a comparison of the impacts of the emissions and reductions of different gases and estimate the total contribution to global warming of UK GHG emissions.

Table 1.1 Global Warming Potential of GHGs on a 100-year Horizon (t CO_2 equiv/ t gas)

Global Warming Potential on a 100-year Horizon	
Greenhouse Gas	Global Warming Potential (t CO_2 equivalent / t gas)
Carbon Dioxide	1
Methane	21
Nitrous Oxide	310
HFCs	140-11700
PFCs	6500-9200
SF_6	23900

1.5 Report Structure

This report is structured as follows:

Main body of the report: This part of the report presents and discusses the inventories for England, Scotland, Wales and Northern Ireland, providing GHG emissions data for the years 1990, 1995, and 1998 to 2009. The reasons for any significant trends in emissions, issues regarding data availability and uncertainty estimates are provided for each inventory. Figure 11.1 to Figure 11.6 present the summary data for these years as global warming potential (GWP) weighted emissions. Analysis of uncertainties in the reported trends in the inventories since the Base Year is presented within Chapter 9.

The appendices present more detailed data and the information about the methods used.

Appendix 1: This appendix describes in detail the methodology used to derive the DA GHG emission estimates for each source, and how the DA inventories relate to the UK GHG Inventory.

Appendix 2: This appendix provides GHG inventory emission tables for Base Year, 1990, 1995 and 2003 to 2009 for England, Scotland, Wales and Northern Ireland for the following National Communication sectors: Energy Supply (Table 1), Business (Table 2), Transport (Table 3), Public (Table 4), Residential (Table 5), Agriculture (Table 6), Industrial Process (Table 7), Land use, Land Use Change & Forestry (Table 8) and Waste Management (Table 9).

Appendix 3: This appendix outlines the calculation approach and GHG emission estimates from international aviation and international shipping sources that may be allocated to each of the constituent countries across the time-series. These data are not included within the main DA inventory data, but are presented as "memo items" to the DA inventories, in common with the international protocol adopted for the reporting of the UK GHG inventory to the UNFCCC.

Appendix 4: This appendix outlines the findings from an additional piece of research which compares the EUETS data against the DA GHG inventories, analysing where possible the traded share of emissions for each country in 2009.

Appendix 5: This appendix contains detailed tables of the DA End User inventories. The methods used for calculating these emissions are included in Chapter 10.

Appendix 6: This presents a mapping between source name, IPCC category and National Communication category.

Appendix 7: This presents the results of the industry sector task for the DA GHGI Improvement Programme 2010- 2011.

1.6 Revisions and Updates to the Greenhouse Gas Inventories

Each year, the GHG inventories for England, Scotland, Wales and Northern Ireland are extended and updated. The time series of the inventories are extended to include the latest inventory year, and the inventories are revised to reflect any new or amended activity or emission factor data.

Data revisions may lead to changes to emission estimates for any year in the time-series. Core energy statistics (all DECC references) are revised annually and hence historic data from DECC may be different from that used in the compilation of the previous inventory report. Similarly, where new research has derived a more representative emission factor for a given activity, then the GHG time-series estimates will be revised accordingly.

New data may become available due to the implementation of new regulations, or through the commissioning of bespoke research into activities and emissions for a given source. For example, new data on fuel use and fuel quality across several source sectors has become available for use in the UK and DA GHG inventories through the EUETS.

The nature of emission inventories is such that improvements to data collection or estimation techniques will inevitably lead to some revisions of historic data. Therefore, it is not appropriate to use data from previous reports and compare them with the figures in this report, without taking account of any changes to either the emission estimation methodology or the source data.

2 Emissions in England

2.1 Summary of GHG Emission Sources

The main GHG emission sources for England in 2009 are summarised in Table 2.1 below, expressed as a percentage of the total English GHG emissions in 2009 of 436 Mt carbon dioxide equivalent (CO_2e). Trends in English GHG emissions since the base years of 1990 (for carbon dioxide, methane and nitrous oxide) and 1995 (for fluorinated gases) are as follows:

- Carbon dioxide emissions have reduced by 19.8%
- Methane emissions have reduced by 65.2%
- Nitrous oxide emissions have reduced by 54.9%
- HFC emissions have reduced by 39.4%
- PFC emissions have reduced by 71.3%
- SF_6 emissions have reduced by 49.6%
- Total GHG emissions (as carbon dioxide -equivalents) have reduced by 29.5%

The total emissions from each National Communication sector are presented in executive summary table ES2.1.3. This table shows that energy supply is the biggest source of GHG emissions in England in 2009. The largest emissions source is carbon dioxide from power stations, which accounted for 28% of total English GHG emissions in 2009. The largest methane source is from waste landfill emissions, and the largest source of nitrous oxide emissions is agricultural soils. Together, the ten categories below account for almost 89% of the total 2009 English GHG emissions.

Table 2.1 GHG Emissions Summary for England in 2009

Summary of Main GHG Emission Sources England 2009, (kt CO_2e)				
Rank	Sector Name	IPCC code	Emission	Percentage of total GWP Weighted Emissions
1	Power stations	1A1a	122,563	28.1%
2	Road transport	1A3b	94,018	21.6%
3	Residential Combustion	1A4b	59,426	13.6%
4	Other Industrial Combustion	1A2f	44,683	10.2%
5	Agricultural Soils	4D	16,876	3.9%
6	Commercial and Institutional Combustion	1A4a	14,913	3.4%
7	Landfill	6A1	12,373	2.8%
8	Iron and Steel	1A2a	10,025	2.3%
9	Refineries	1A1b	9,549	2.2%
10	Enteric fermentation - Cattle	4A1	6,565	1.5%

Note that in the National Communication format sector discussion text below, the percentages quoted are derived from the inventory and emissions data stored at full precision. These data can be found on the NAEI web site and on the CD-ROM that accompanies this report. The percentages in the text of this chapter do not in all cases match directly with percentages in the above table (which are quoted as % of the total of all six GHG emissions).

2.2 Energy Supply

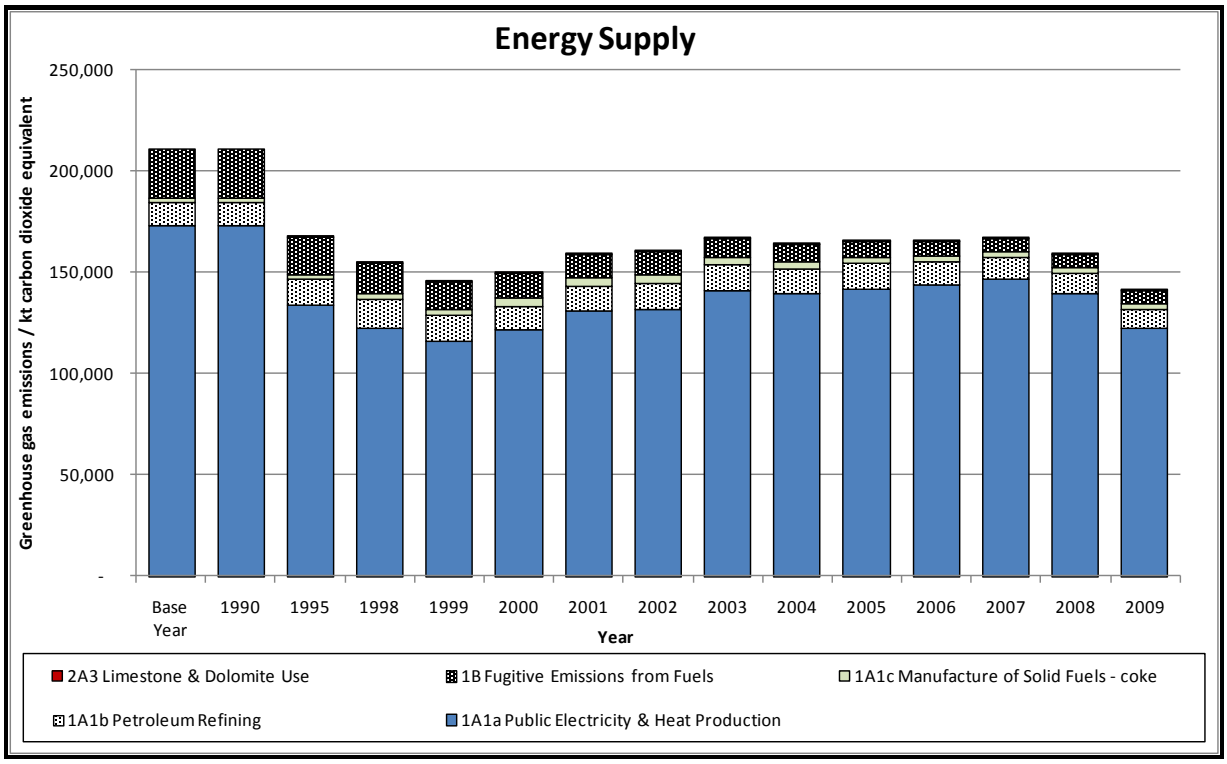
Energy supply includes emissions from power generation, refineries, coal mines, solid fuel transformation, oil and gas extraction and processing, other energy industries. In England, Energy Supply contributes 32% to total GHG emissions. 95% of energy sector emissions are carbon dioxide, accounting for 36.1% of carbon dioxide emissions from England in 2009. Energy Industries (IPCC Sector 1A1) represent the largest source of carbon dioxide in England, contributing 35.8% of the total carbon dioxide for the country in 2009 down 4.0% on their contribution to the England total of carbon dioxide emissions in 1990.

Power generation in England contributed 32.6% of the total English carbon dioxide emission in 2009, which is slightly higher than the UK proportion of 31.8%, however emissions from Energy Supply in England were just 80.6% of those in the UK as a whole, lower than the proportion the UK population resident in England (83.8%[7]). The mix of generation capacity in England (see Figure 2.1 below) differs from the other DAs due to a much higher proportion of combined cycle gas turbines (CCGT) stations; a lower proportion of conventional fossil fuel stations; a lower proportion of nuclear generation and no hydroelectricity. In addition, England is a net importer of electricity from both Wales and Scotland[8]. The "by source" inventories presented here allocate emissions to the constituent countries that those emissions occur in, and hence the GHG emissions from the power generated in Wales and Scotland and exported to England are allocated to Wales and Scotland respectively.

[*The England GHG "end user" emission estimates presented in Chapter 10 re-allocate the emissions from power stations where electricity is generated in Wales and Scotland and then imported to be consumed in England.*]

GHG emissions from power generation in England showed a gradual increase year-on-year from 1999-2007 but have decreased by 16% between 2007 and 2009, partly due to the recession and lower demand for electricity. Gas and coal represent the principal sources of power generation, with nuclear energy contributing around 16% of power generation in England in 2009.

Figure 2.1 GHG Emissions from Energy Supply in England, 1990 to 2009



[7] Where population percentages are quoted throughout this report, they are taken from ONS data for 2009.
[8] For details of regional electricity generation data, see the DECC Energy Trends publication from December 2010, article from page 16.

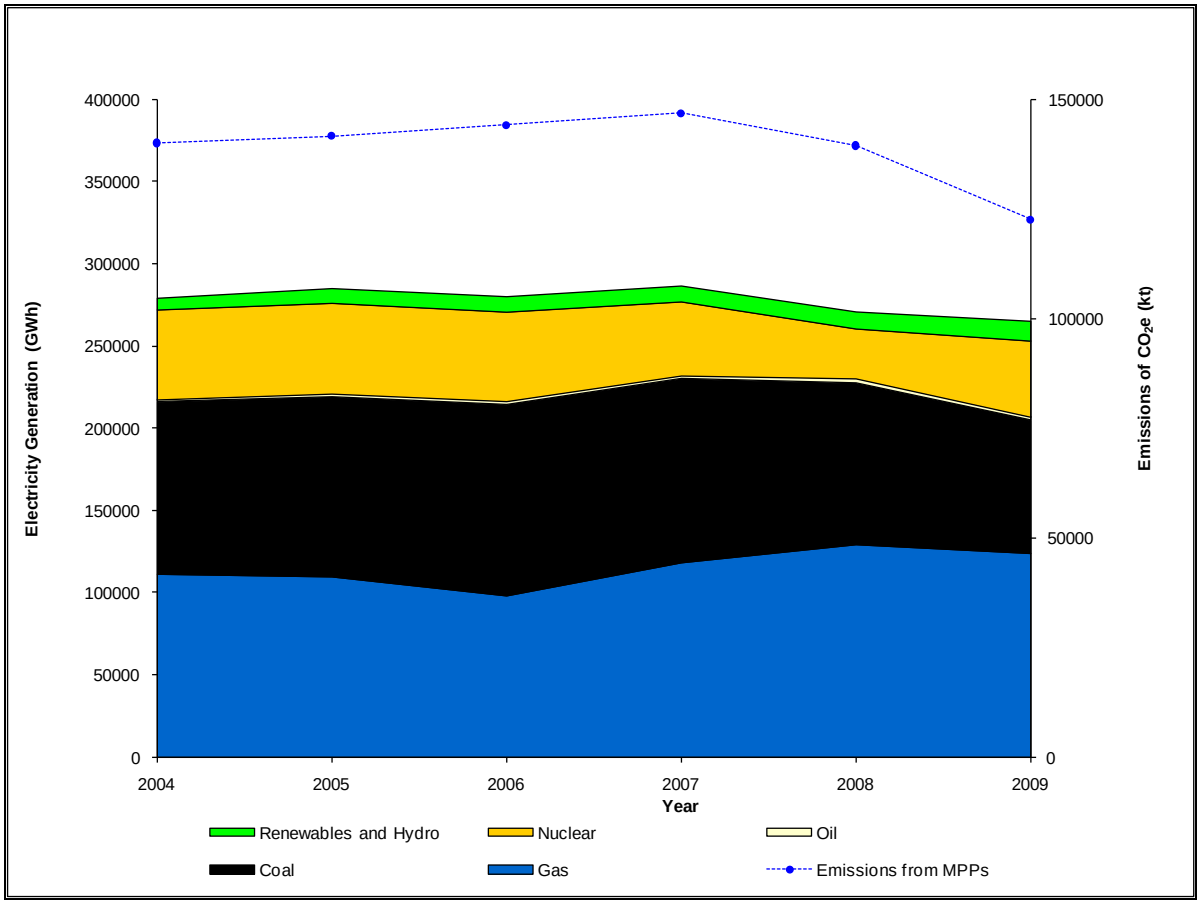
Table 2.2 and Figure 2.2 below present data for the Major Power Producers (MPPs) in England, excluding power generation by autogenerators.

Table 2.2 GHG Emissions Intensity of Electricity Generated by Major Power Producers in England, 2003 to 2009 (kt CO_2e/GWh)

Greenhouse Gas emission intensity of electricity generation by Major Power Producers in England (2003-2009)							
Emission year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Power generation emissions (kt CO_2e)	141,059	140,040	141,543	144,094	146,731	139,356	122,563
GWh Generated by Major Power Producers	283,877	273,699	278,871	273,715	280,314	264,480	257,888
kt CO_2e/ GWh	0.497	0.512	0.508	0.526	0.523	0.527	0.475

Overall, emissions of carbon dioxide from Energy Industries (Sector 1A1) in England have decreased by 27.9% since 1990, significantly more than across the whole of the UK where only a 23.2% reduction has occurred over the period 1990-2009. This difference can be explained, in part, by the installation of CCGTs in England, which have a higher efficiency than conventional thermal stations and produce lower emissions per GWh electricity generated. However, the general increase in nuclear capacity and utilisation in England over the period and the import of electricity from Wales and Scotland also contribute significantly to this difference.

Figure 2.2 Power Station GHG Emissions and Electricity Generation by Fuel by Major Power Producers in England, 2004 to 2009



Petroleum refining emissions have declined by 16.2% since 1990, and constitute 2.5% of carbon dioxide emissions in England in 2009, lower than the UK mean contribution of 3.1% of total carbon dioxide emissions from refineries in 2009. Other energy emissions are relatively small and are mostly from gas consumption at oil and gas terminals, gas separation plant, coking and solid fuel production. Other energy industry emissions in England have increased by 13% from 1990 to 2009. Note that only those emissions arising from on-shore installations in England have been included within the English GHG inventory; emissions from offshore oil & gas exploration and production facilities are reported as "Unallocated".

Nitrous oxide emissions from combustion sources in England account for 13.3% of the English nitrous oxide total, 3.6% of which is from Other Industrial Combustion and 3.0% from power stations. Fuel combustion emissions (IPCC sector 1A) only account for 13.3% of English nitrous oxide emissions, and just 2.5% of English methane emissions. The portion of these emissions which is classified under the National Communications (NC) Format Energy Supply sector accounts for just 3.5% and 0.4% of English nitrous oxide and methane emissions respectively; this is because some emissions classified IPCC 1A fall under other NCF categories (residential, business, public and agriculture).

The category Fugitive Emissions from Fuels (IPCC Sector 1B) reports emissions of GHGs from coal mining, coking, the oil and gas industry and natural gas distribution. The combined emission from this category constitutes around 19.3% of the English total methane emission in 2009 compared with the UK average of 18.7%. The higher emission from this category in England is due to the greater contribution of coal mining and leakage from the gas transmission system than in other parts of the UK. Coal mining contributes 6.2% of these fugitive methane emissions, whilst natural gas distribution 12.6% and oil and gas terminals 0.5% of the English total methane emissions. Coal mining emissions have declined by 88.8% from 1990 to 2009 due to the decline in the coal industry whilst methane emissions due to gas leakage from the gas transmission system has declined by an estimated 48.1% between 1990 and 2009 as the mains and services have been renewed.

2.3 Transport

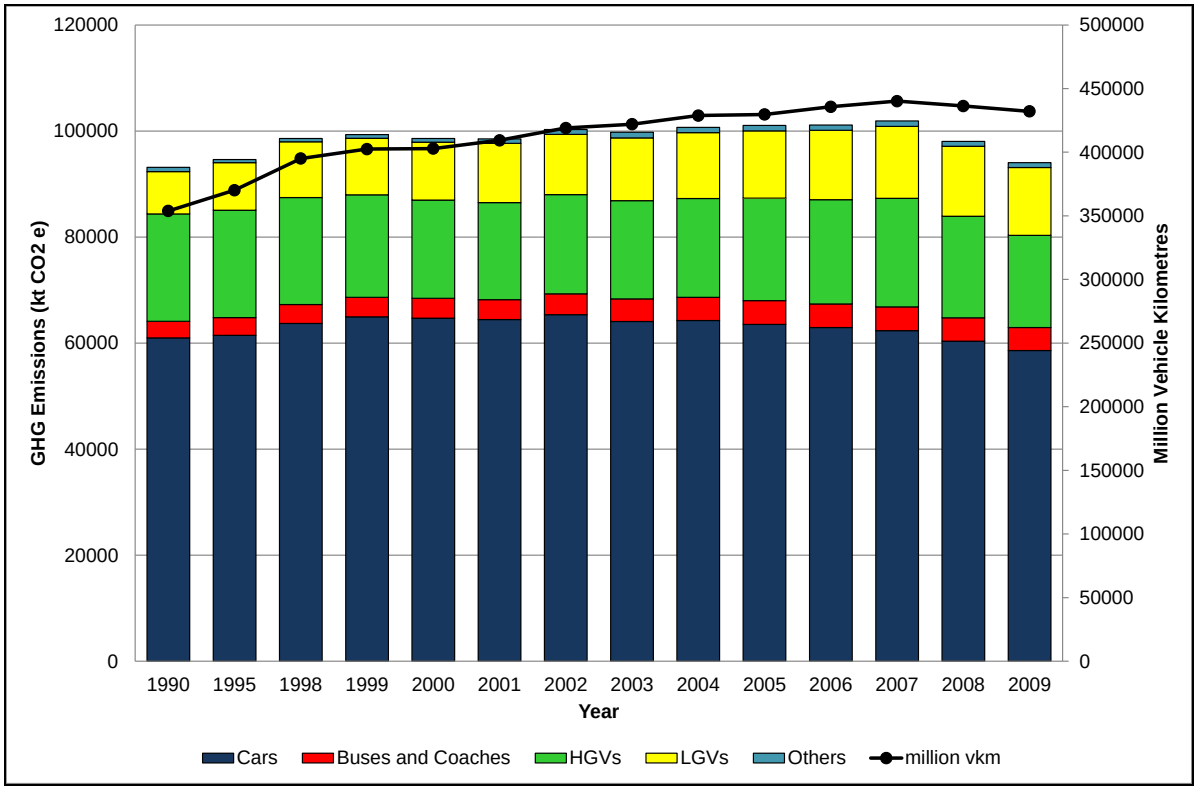
Transport includes emissions from aircraft, road, railways and shipping. In England, transport contributed 23% of the total English GHG emissions in 2009. 99% of emissions in the Transport sector are carbon dioxide, and the largest source of carbon dioxide in this sector arises from road transport, accounting for 93.8% of carbon dioxide emissions.

Road Transport represents the second largest single source of carbon dioxide in England contributing 25% to the English total carbon dioxide emission. The contribution of English road transport to UK road transport carbon dioxide emissions is 83.1%, which is slightly less than that which would be anticipated from England's population (83.8% of UK[9]). Emissions of carbon dioxide from the road transport sector in England have risen by 1.7% from 1990 to 2009 compared with a 2.7% rise for the UK as a whole, However from 2007 to 2009 emissions have fallen by 7.5% in England, and 7.3% in the UK as a whole. Emissions from this sector are dominated by emissions from cars that constitute approximately 62.4% of road transport emissions in 2009 (Figure 2.2). Heavy goods vehicles represent the second most significant source of carbon dioxide.

Aviation (domestic cruise and take off and landing) contributed 0.3% of total English carbon dioxide emissions in 2009. There was a gradual increase in emissions over the period of 1990-2005 but it has been declining since then; overall there was a 36% increase in emissions between 1990 and 2009. Rail and shipping (coastal, naval and fishing vessels) are both estimated to account for 0.4% of total English carbon dioxide in 2009. However, estimates from these sources are subject to high uncertainty given the limited DA-specific activity data. Electricity use from rail sector is included within the end user emission estimates within Chapter 10.

[9] Where population percentages are quoted throughout this report, they are taken from ONS data for 2009.

Figure 2.3 Total Road Traffic Vehicle km and GHG Emissions from Different Vehicle Types: England, 1990 to 2009



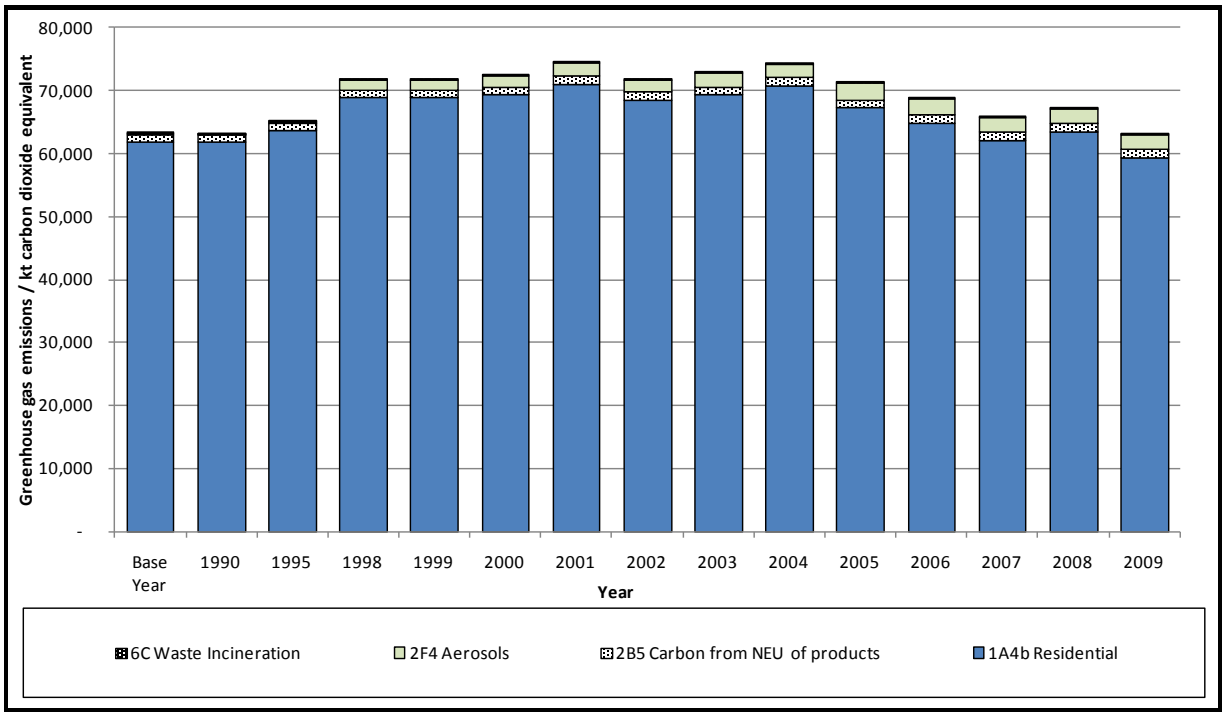
2.4 Residential

The residential sector includes emissions from domestic combustion, household products and accidental vehicle fires, and accounts for 14.5% of GHG emissions, and 16.2% of carbon dioxide emissions in England in 2009. Domestic combustion is the largest source of carbon dioxide in this sector, accounting for 97.3% of carbon dioxide, and 93.8% of all GHG emissions in the sector. IPCC sector 1A4b (Residential combustion) includes domestic combustion for cooking, water heating and space heating, as well as emissions from fuel use in house and garden machinery, and contributes 94.2% to the total GHG emissions in the residential sector, as shown below in Figure 2.4.

Carbon dioxide emissions from domestic combustion sources are estimated to account for 15.8% of the English total in 2009, and as a proportion of UK domestic emissions, are estimated to represent 80.5%, which is slightly lower than would be anticipated from England's 83.8% share of UK population.

Note that the emission estimates in the domestic sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels.

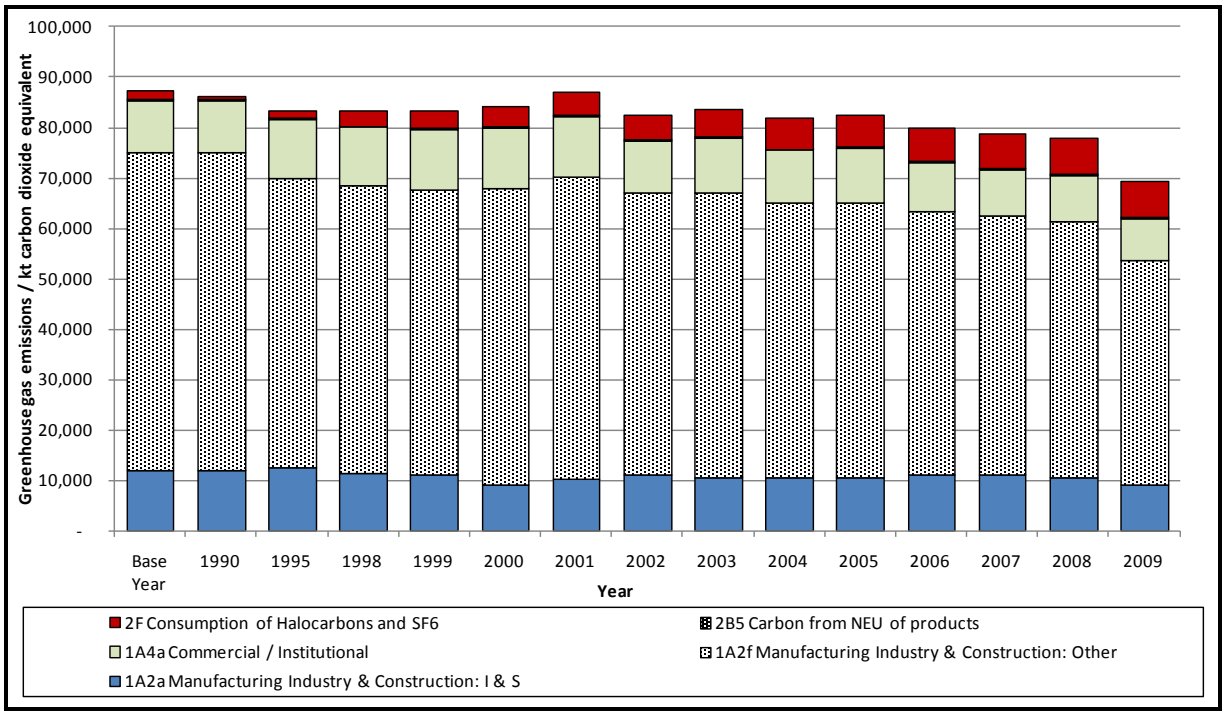
Figure 2.4 GHG Emissions from the Residential sector in England, 1990 to 2009



2.5 Business

The business sector includes emissions from manufacturing industry, construction, industrial combustion, refrigeration, air conditioning, foam and fire fighting, solvents and electronics. The sector accounts for 15.9% of GHG emissions and 16.3% of carbon dioxide emissions in England in 2009

Figure 2.5 GHG Emissions from the Business sector in England, 1990 to 2009



Combustion emissions from the manufacturing industry and construction sector (IPCC Sector 1A2) contribute the greatest amount of carbon dioxide emissions in the sector and account for 14.4% of the

English carbon dioxide total. The 'Other industry' category (IPCC sector 1A2f) for England contributes 82.7% towards the UK 'Other industry' carbon dioxide total.

Sulphur hexafluoride (SF_6) constitutes 0.7% of total GHG emissions from the business sector in England, with the main sources of SF_6 emissions coming from its application in electrical insulation, which accounted for 77.6% of sulphur hexafluoride emissions in England in 2009. Overall, the business sector accounts for 87.2% of sulphur hexafluoride emissions in England.

The main sources of hydrofluorocarbon (HFC) emissions come from refrigeration and air conditioning equipment, arising from losses during its manufacture and lifetime of equipment, which accounted for 68.1% of HFC emissions in England in 2009. Emissions from these sectors have risen by a factor of 8.3 in England since the 1995 base year.

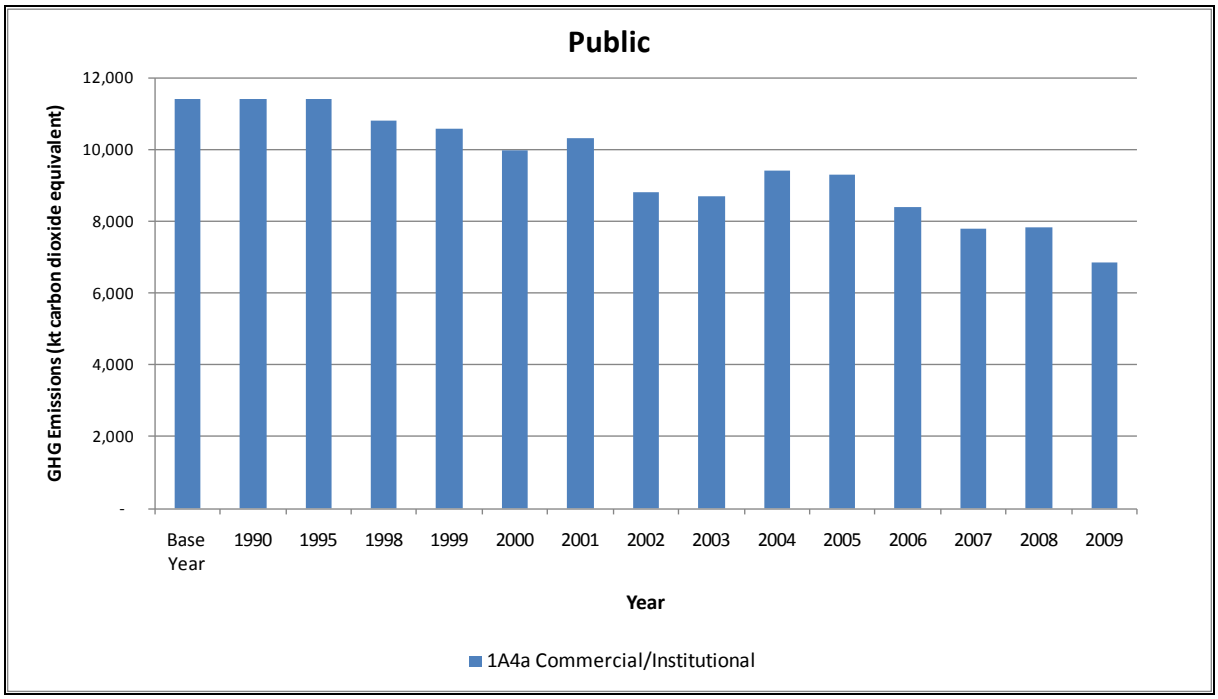
Perfluorocarbons (PFC) emissions only account for 0.03% of emissions in the business sector in England. The largest sources in England in 2009 were by-product emissions from primary aluminium production (51%), Electronics (28%) and fugitive emissions from PFC manufacture (18%). English PFC emissions account for 44.4% of total UK PFC emissions, and have declined by 71.3% since 1995.

The combustion emission estimates in the business sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels. Non-combustion emissions account for a total of 10.5% of the total business emissions in England. These data are also uncertain due to the lack of DA-specific data on F-gas sources and the use of proxies such as economic indices and population to estimate the DA share of UK emissions for these sources.

2.6 Public

Emissions from public sector combustion (IPCC Sector 1A4a) account for 1.6% of GHG emissions in England in 2009. In England 99.7% of emissions in this sector is carbon dioxide, which from 1990 to 2009 have fallen by 40%. This decrease is around double the average decrease across all sectors in England, and unlike many other sectors, there have only been two occasions since 1998 in which year-on-year emissions have risen in this sector.

Figure 2.6 GHG Emissions from the Public sector in England, 1990 to 2009



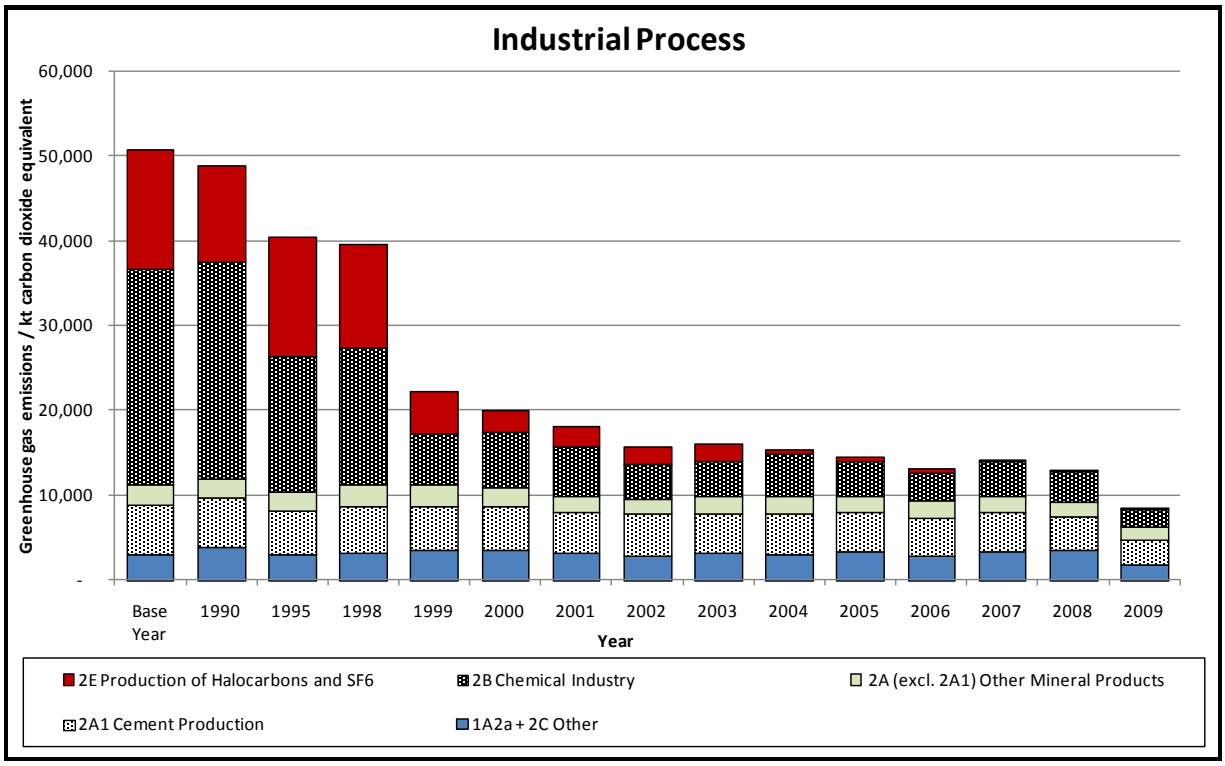
Note that the emission estimates in the public sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels.

2.7 Industrial Process

Industrial processes emit GHGs from non-combustion sources such as the use of limestone in cement and glass making, and contribute 1.85% of carbon dioxide, emissions in England. Carbon dioxide emissions account for 82% of GHG emissions from industrial processes in England in 2009, with HFCs contributing 1.38% although total GHG emissions from this sector only contribute 1.9% to the English total. Whilst the IPCC industrial sector includes all emissions of fluorinated gases, only 1.7% of emissions of fluorinated gases occur in this NC sector.

The iron and steel industry in England account for 8.0% of carbon dioxide emissions in this sector, and comprise 69.1% of the combustion emissions from UK iron and steel production. Cement production contributes 43% of carbon dioxide emission in this sector, which constitutes 0.8% of the total English carbon dioxide emissions. Smaller emissions from glass, ammonia, aluminium, iron and steel production contribute a further 0.5% of the English total in 2009. England emits all of the UK's GHG emissions from the production of lime and ammonia, but these emissions are not significant in terms of the English total, contributing just 0.6%.

Figure 2.7 GHG Emissions from Industrial Processes in England, 1990 to 2009



Historically the largest source of HFCs is fugitive emissions from the manufacture of HCFCs and HFCs. All such production is located in England and in 1998 this source contributed 75.6% of HFC emissions in England and 72.3% of total UK HFC emissions. Over recent years, HFC emissions from the manufacture of HCFCs and HFCs have declined as a result of the installation of improved abatement systems on HCFC production plant. In 2009, HCFC and HFC production in England contributed only 1.13% of total English HFC emissions and 0.96% of total UK HFC emissions.

Nitrous oxide emissions account for 14% of total GHG emissions from the industrial process sector in England, and 5% of the total English nitrous oxide emissions. Up until 1998, a more substantial proportion of England's nitrous oxide emissions were released from chemical processes, namely adipic acid production and to a lesser extent nitric acid production. In 1998, these processes constituted approximately 35% of England's total nitrous oxide emissions and around 99.7% of UK industrial process nitrous oxide emissions. In October 1998 a nitrous oxide abatement unit was

commissioned on the one adipic acid production plant in England and as a consequence, emissions from this source were significantly reduced. In 2009, the sum of the English emissions from the nitric acid and adipic acid production was around 1,178 kt carbon dioxide equivalent, equivalent to 4.9% of total English nitrous oxide emissions and 3.4% of the UK total.

Sulphur hexafluoride (SF_6) constitutes 0.9% of total GHG emissions from the industrial process sector in England, with the main sources of SF_6 emissions coming from its application as a cover gas in magnesium production, which accounted for all SF_6 emissions in this sector in 2009. Magnesium production is largely concentrated in England; and English emissions account for 93% of the UK magnesium production SF_6 emissions. Emissions of SF_6 in England have decreased by 49.6% since 1995.

Emissions of methane from this sector are not significant, accounting for just 1% of total GHG emissions in this sector.

2.8 Agriculture

GHG emissions from agriculture in England comprise mainly of nitrous oxide (59%) and methane (33%) with a small amount of carbon dioxide (8%) from Agricultural combustion and agrochemical use. English emissions represent 63% of the UK total in this sector and the agriculture sector accounts for 7.1% of the English GHG total.

Agriculture is the second largest source of methane emissions in England[10]. This contributes 34.7% to the overall methane emissions in England in 2009. Enteric fermentation contributed 82% to total agricultural methane (total was 480.1 kt methane). Cattle (dairy and beef, enteric and waste management) were responsible for 75% of the total agricultural methane (CH_4) emissions (enteric and waste management). Total emissions from sheep were 15% of the total methane (CH_4) from agriculture in England. Emissions from agriculture are largely dependent on the numbers of livestock and have fallen by 24.1% from 1990 to 2009 resulting from a decline in cattle and sheep numbers. Total CH_4 emissions decreased relative to 2008 by 1.3% (see Table 2.3).

Of the total English emission of 77.3 kt nitrous oxide in 2009, 58.6 kt was from agriculture, representing 75.8% of the total. Most of these (93%) were emissions arising from the agricultural soils category deriving from, in order of magnitude (see Table 2.4):

[Note: numbers in brackets give the category value as a percentage of the total agricultural soils nitrous oxide (N_2O) emission]

- synthetic fertiliser application (25.8%)
- leaching of fertiliser nitrogen and applied animal manures to ground and surface water (30.2%)
- wastes from grazing animals (13.2%)
- ploughing in crop residues (13.6%)
- manure used as fertiliser (8.3%)
- atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NOx) (5.8%)
- cultivation of legumes (1.7%)
- cultivation of histosols (i.e. high organic content soils) (0.8%)
- biological fixation in improved grass (0.6%)

A relatively small proportion (4.1 kt nitrous oxide) is emitted from the management of animal manure (emissions related to handling of manure before it is added to the soil). English agricultural nitrous oxide emissions have decreased by 21.7% in the period 1990-2009 and increased by 1.4% in 2009 relative to 2008.

[10] Agriculture sector emissions data are provided by Rothamsted Research, North Wyke.

Figure 2.8 GHG Emissions from Agriculture in England, 1990 to 2009

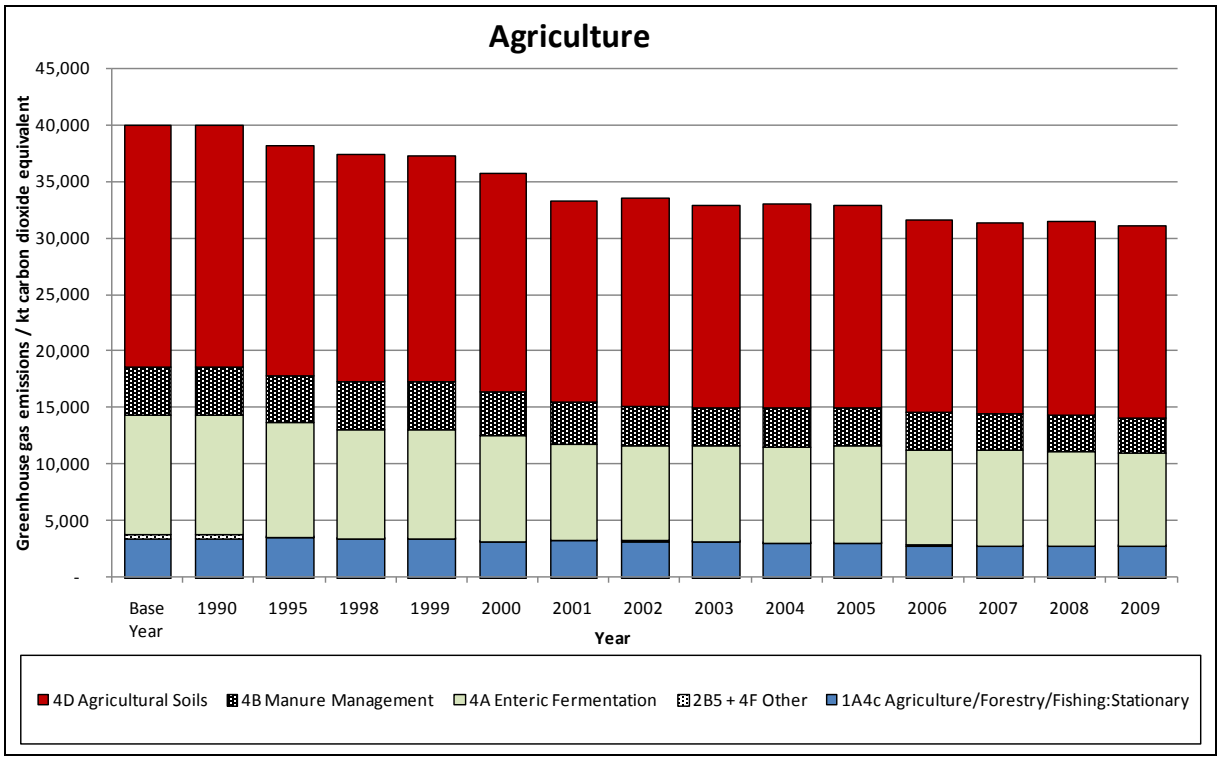


Table 2.3 Livestock Emissions of Methane in England by source in 2009 (kt CH_4)

Livestock Methane Emissions		
Category	Source	CH_4, kt
Total cattle	Wastes	49.38
	Enteric	312.6
Pigs	Wastes	27.3
	Enteric	5.81
Sheep	Wastes	1.61
	Enteric	68.0
Goats	Wastes	0.01
	Enteric	0.43
Horses	Wastes	0.40
	Enteric	5.12
Poultry	Wastes	9.18
	Enteric	0.00
Deer	Wastes	0.01
	Enteric	0.20

Table 2.4 Emissions of Nitrous Oxide from Agriculture in England by source in 2009 (kt N_2O)

Agriculture Nitrous Oxide Emissions	
Source	N_2O, kt
Improved Grass	0.32
Legumes	0.89
Crop residues	7.32
Fertilisers	13.9
Histosols	0.42
Animal waste management systems	4.15
Organic fertiliser applied to soil	4.46
Grazing	7.13
Leaching	16.27
Atmospheric deposition	3.13

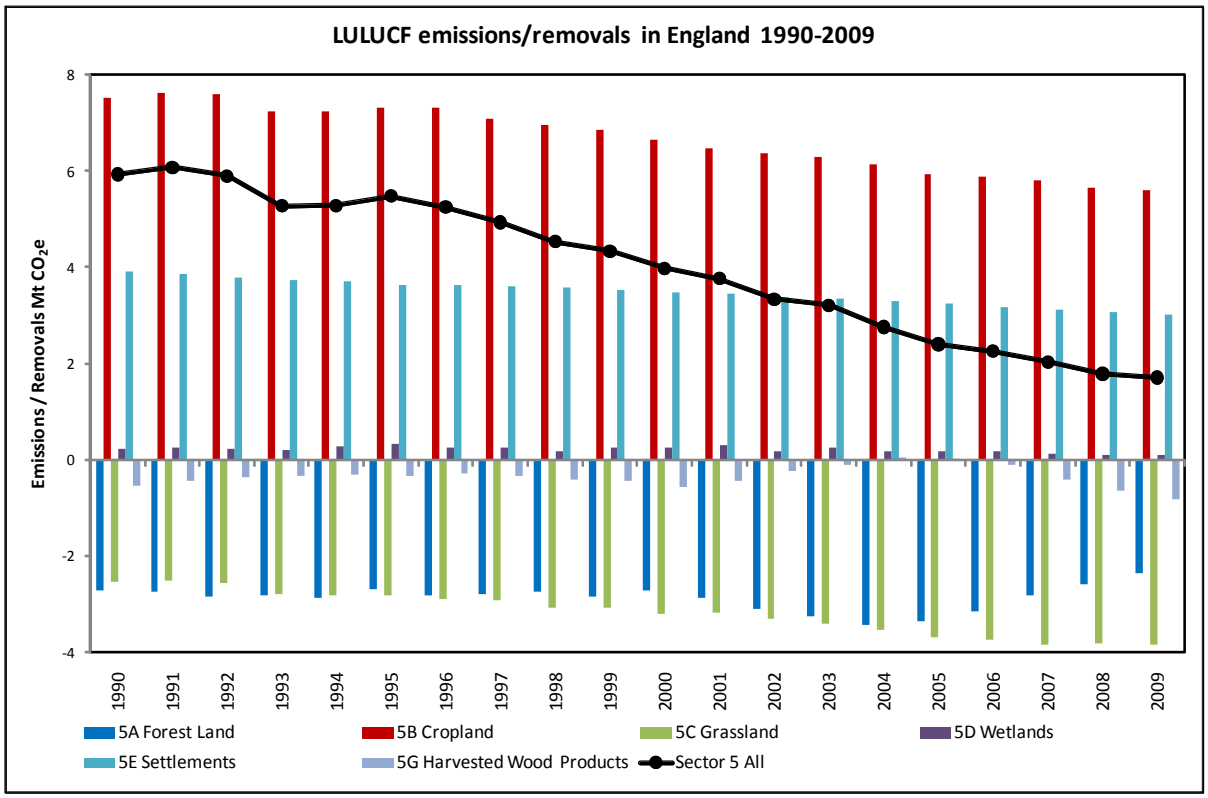
2.9 Land Use, Land Use Change and Forestry

The LULUCF sector includes carbon stock changes, emissions of GHG (CO_2, CH_4 and N_2O) by sources and removals of carbon dioxide by sinks from land use, land use change and forestry activities. Removals of carbon dioxide are conventionally presented as negative quantities. Total GHG emissions are described as carbon dioxide equivalents, using Global Warming Potentials (GWP) of 21 for methane and 310 for nitrous oxide (as used in the inventories submitted to the UNFCCC).

England is a net source of GHGs from LULUCF activities although the size of this source has diminished by 74.6% between 1990 and 2009 from 5.919 to 1.691 Mt carbon dioxide equivalent (CO_2e). Net emissions of GHGs from land use and land use change (Figure 2.9) in the Cropland and Settlement categories are diminishing over time, while net removals from the Grassland category are increasing. Net removals from the Forest Land category increased to 2004 but are now diminishing. The Wetlands and Harvested Wood Products categories make small contributions to the total.

Estimates of methane emissions from LULUCF activities are small, with 0.018 Mt CO_2e of methane in 2009. Estimated emissions of nitrous oxide are now larger than previously estimated due to the inclusion of nitrous oxide emissions from disturbance associated with land-use conversion to cropland for the first time. There were 0.250 Mt CO_2e of nitrous oxide emissions in 2009.

Figure 2.9 LULUCF Inventory Emissions and Removals by Category in England, 1990 to 2009



Net GHG emissions in 1990 were 5.737 Mt CO_2e in the 2008 inventory and 5.919 Mt CO_2e in the 2009 inventory. In 2008 they were 2.990 Mt CO_2e in the 2008 inventory vs. 1.691 Mt CO_2e in the 2009 inventory

Net emissions of carbon dioxide (CO_2) between 1990 and 1999 did not change significantly from the previous inventory (Figure 2.10). This conceals reduced emissions from the Land Use Change (LUC) to Cropland and LUC to Settlement categories and reduced removals from the LUC to Grassland category (due to the change in the LUC method from top-down to bottom-up) and increased emissions from Wetlands (reported for the first time). There were also reduced removals from Forest Land (due to adjustments accounting for deforestation losses). From 2000 onwards, there is a wider divergence between the inventories with the reduced emissions from Cropland making the most difference.

Carbon stock changes from post-1990 conversion of Forest Land to Cropland are included for the first time (in England) but only make a minor contribution (0.004 Mt CO_2 in 1990 and 0.002 Mt CO_2 in 2009). The inclusion of nitrous oxide (N_2O) emissions from disturbance associated with LUC to Cropland makes a bigger difference, as N_2O has a large GWP. Net emissions of N_2O from this activity were 0.99 Gg N_2O in 1990 (0.306 Mt CO_2e) and 0.80 Gg N_2O in 2009 (0.248 Mt CO_2e).

Figure 2.10 Differences between the 2008 and 2009 LULUCF Inventory in England

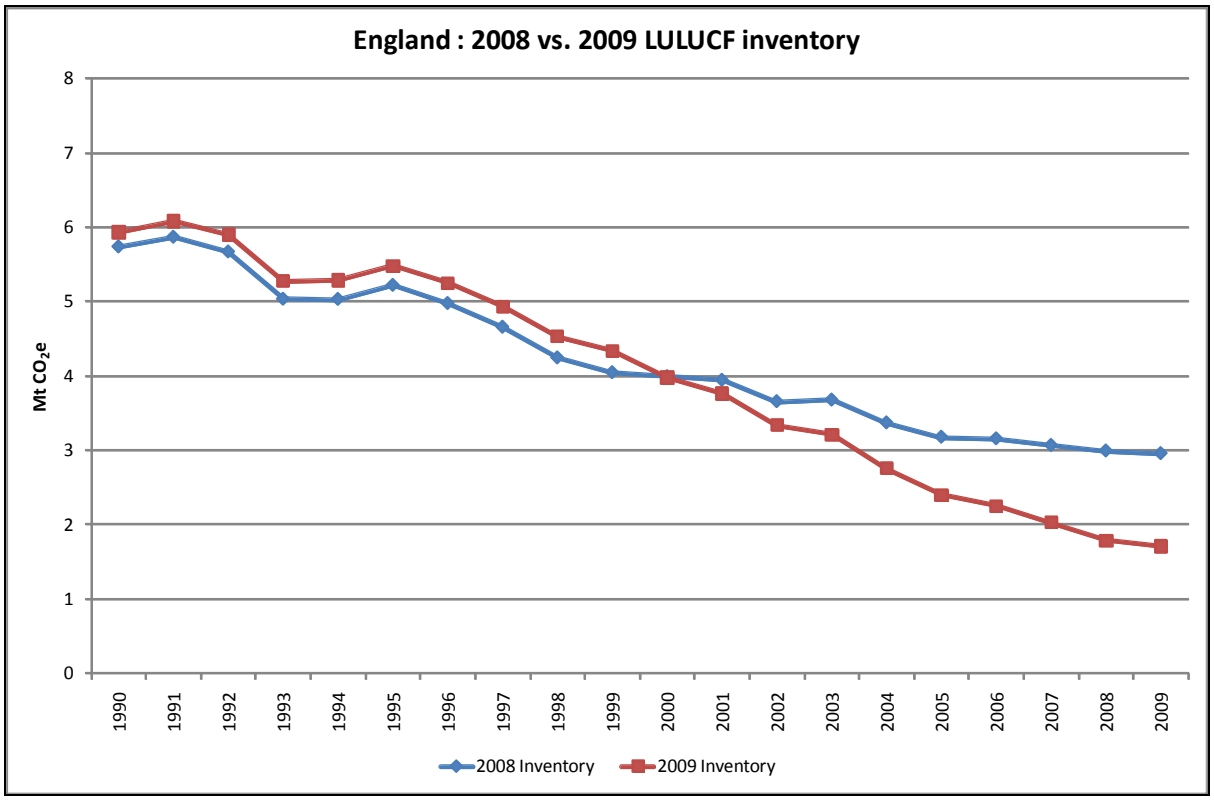


Table 2.5 Difference in 2008 LULUCF net Emissions between the 2008 and 2009 Inventories in England

Inventory Comparison (Mt carbon dioxide**)**						
	5A Forestland	5B Cropland	5C Grassland	5E Settlements	5G Other	Sector 5 All
Difference between 2008 and 2009 inventory	0.077	-0.791	0.096	-0.282	-0.048	1.205

The annual land use matrices for 1990-1991 and 2008-2009 for England are shown here (Table 2.6 and Table 2.7). The off-diagonal items (land use change data from the Countryside Survey, forest planting and deforestation datasets) in the matrix are used to estimate the land use change fluxes in the LULUCF inventory. The diagonal items (land remaining in the same use, in italics) are included for information and have an uncertainty attached as there is not a perfect match between the sum across the columns and the sum across the rows. The total area of England is reported as 13,043.5 kha. This is the Standard Area Measurement to mean high water reported by the Office of National Statistics (ONS 2009).

Table 2.6 Land Use Transition Matrix, ha, for England in 1990-1991

Land Use Transition Matrix (1990-1991)							
From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	*1041.9±0.5*	3.4	8.9	0	2.1	0.2	**1057.1**
Cropland	0.5	*4318±1.0*	62.9	0	0.6	0	**4381**
Grassland	8.7	55.3	*5084.6±1.6*	0	3.4	1.9	**5155.5**
Wetlands	0	0	0	*5.9*	0	0	**5.9**
Settlements	1.2	2.1	8.5	0	*1418.5±2.2*	0.2	**1428.3**
Other Land	0.2	0.1	0.7	0	0.2	*1013.4±1.1*	**1015.7**
Total (initial)	**1052.0**	**4380.0**	**5164.0**	**5.9**	**1427.0**	**1014.6**	***13,043.5***

Table 2.7 Land Use Transition Matrix, ha, for England in 2008-2009

Land Use Transition Matrix (2008-2009)							
From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	*1121±2.0*	2.0	5.8	0	1.1	0.1	1128.0
Cropland	0.1	*3889.1±8.7*	35.4	0	0.1	0	**3916.0**
Grassland	2.9	53.1	*5409.4±12.7*	0	4.8	1.9	**5484.7**
Wetlands	0	0	0	*4.6*	0	0	**4.6**
Settlements	0.6	4.6	5.3	0	*1462.4±0.7*	0.2	**1472.4**
Other Land	0.4	1.6	6.1	0	0.1	*1030.9±1.3*	**1037.8**
Total (initial)	**1127.0**	**3959.0**	**5449.3**	**4.6**	**1469.2**	**1034.3**	***13043.5***

The UK reports estimates of emissions and removals from activities in Article 3.3 (mandatory, Afforestation, Reforestation and Deforestation) and Article 3.4 (elective, Forest Management) of the Kyoto Protocol. The emissions and removals from Kyoto Protocol activities in England in 2009 are shown in 8. The methods and assumptions used in these reported emissions are described in Chapter 11 and Annex 3.7 of the National Inventory Report.

Table 2.8 GHG Emissions and Removals from KP-LULUCF Activities in England, 2009

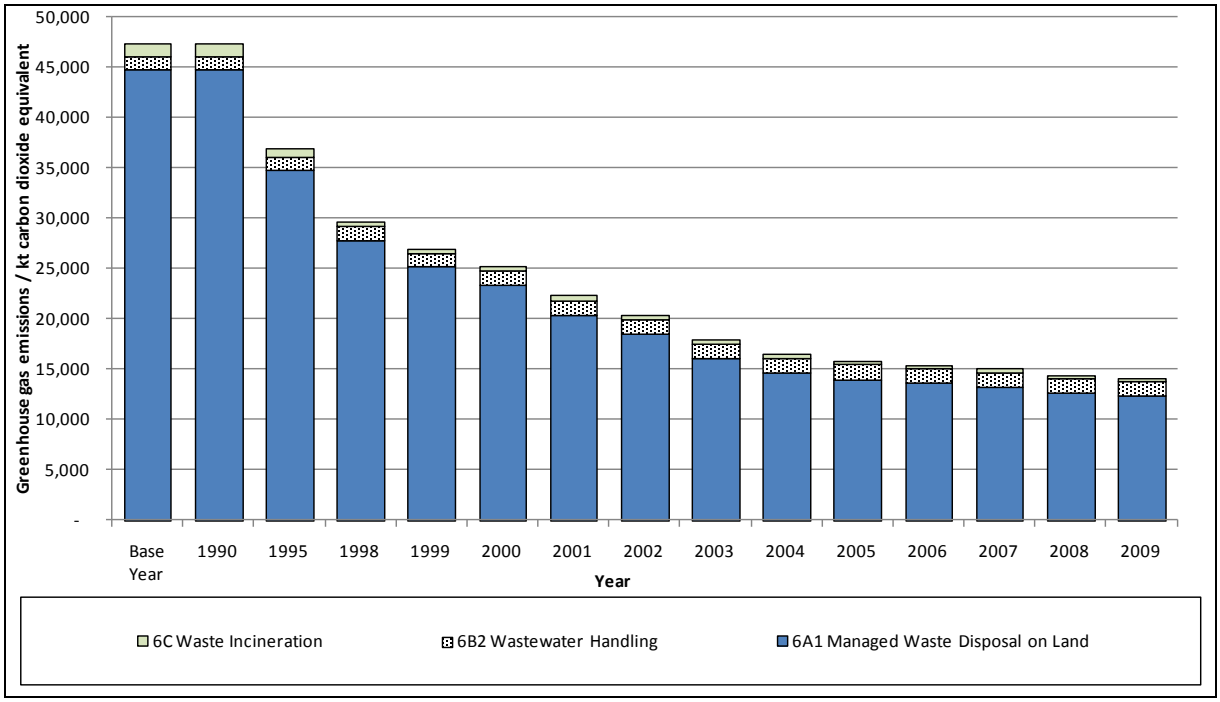
KP-LULUCF Activities		
Activity		England
3.3 Afforestation & Reforestation	Area, kha	84.89
	Net CO_2 emissions/removals, Gg CO_2	-0.898
	Emissions from biomass burning, Gg CO_2 eq.	NO
	N_2O emissions from N fertilization, Gg CO_2 eq.	0.0003
3.3 Deforestation	Area, kha	15.20
	Net CO_2 emissions/removals, Gg CO_2	0.321
	CO_2 emissions from biomass burning, Gg CO_2	0.150.
3.4 Forest Management	Area, kha	0.0002
	Net CO_2 emissions/removals, Gg CO_2	315.59
	CO_2 emissions from biomass burning, Gg CO_2	-1.485

The appendix describes methods and data sources used to calculate the LULUCF emissions and removals but for further details please refer to the latest National Inventory Report (MacCarthy *et al*. 2011).

2.10 Waste

The waste sector contributes 3.2% to total GHG emissions in England, and is the largest source sector for methane emissions, representing 43% of total methane emissions. Emissions from this sector are dominated by methane from landfill, with a small contribution from wastewater treatment. Emissions from landfill in England constitute approximately 78% of UK landfill emissions. Emissions of GHG from landfill in England have shown a significant decline (72.0%) between 1990 and 2009, as shown below in Figure 2.11, due largely to the progressive introduction of methane capture and oxidation systems within landfill management. This decline in emissions of GHG from landfills in England is slightly higher than the UK average of 71.7%.

Figure 2.11 GHG Emissions from Waste Management in England, 1990 to 2009



Estimates of emissions from landfill are based on data on the disposal of municipal solid waste and sewage sludge in England. However, there is not a direct link between MSW arising in a year and the methane emissions in that year. The model takes account of a time-series of MSW inputs, degradation and the methane release curve.

[Note that the UK landfill model was updated during the latest inventory cycle, and all methane estimates from 1990 onwards were revised. For further details see Chapter 7 and Appendix 1.]

The use of waste management data from the www.wastedataflow.org website in recent years has provided a more detailed insight into the UK % share of waste disposals to landfill for England with data for 2000-2009 are currently available (and hence the 2000 split assumed as the best estimate for the 1990-1999 years). The available data indicates that total municipal waste deposited to landfill annually in England between 2000 and 2009 has fluctuated decreased by 42%. Following the adoption of the Landfill (England and Wales) Regulations (2002), which necessitates significant reductions in biodegradable waste deposited to landfill and places greater requirement on the control and monitoring of emissions from landfill, a significant reduction of emissions of GHG from landfills is anticipated in future years.

Due to lack of detailed local data, the DA disaggregation method still retains the assumption that landfill methane recovery rates within each DA are the same as the UK average.

Emissions from wastewater treatment represent around 1% of the English total methane emissions and comprise 83.8% of UK wastewater methane emissions. Nitrous oxide emissions from waste water treatment represent 8.2% of emissions in the sector, and contribute 4.8% to the total emissions of nitrous oxide in England.

2.11 Emission Maps: England 2009

As part of the NAEI, the UK produces mapped emissions of carbon dioxide, methane and nitrous oxide. The maps are modelled estimates of emissions compiled at a 1 km^2 resolution and Figure 2.12 to Figure 2.14 show the emissions in England. The maps reveal the locations and intensities of the major sources of emissions and are used by AEA and other organisations for a variety of Government policy support work at the national scale, regional and local scale. Local area statistics are compiled from the maps and related data, for example, Local Authority level data on carbon dioxide emissions and fuel use have been produced for Defra and DECC since 2003 using data from the NAEI mapping work. As of March 2008, these datasets were reclassified as National Statistics (King et al and Bush et al, 2008). The distributions of methane and nitrous oxide emissions from agricultural sources are generated at a 5 km^2 resolution by the Centre for Ecology and Hydrology (CEH), and are then re-sampled at a resolution of 1 km^2 by the NAEI mapping team.

Emissions maps are produced for the latest year within the NAEI time series, and are available at:

http://www.naei.org.uk/mapping/mapping_2009.php

The most recent emission mapping methodology report can be found at:

http://www.naei.org.uk/reports.php

Figure 2.12 Emissions of Carbon Dioxide (t) in England in 2009

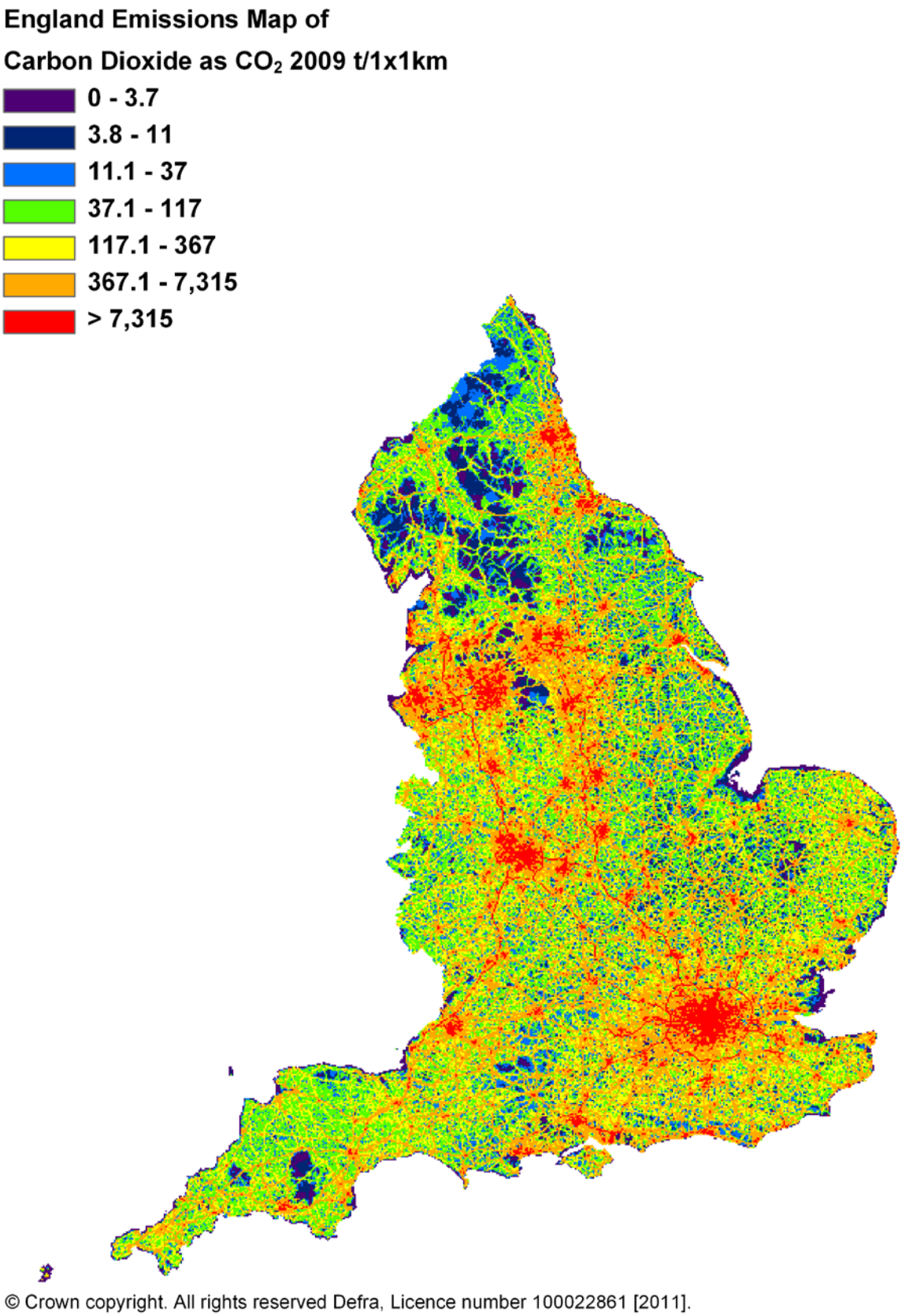


Figure 2.13 Emissions of Methane (t CO_2e) in England in 2009

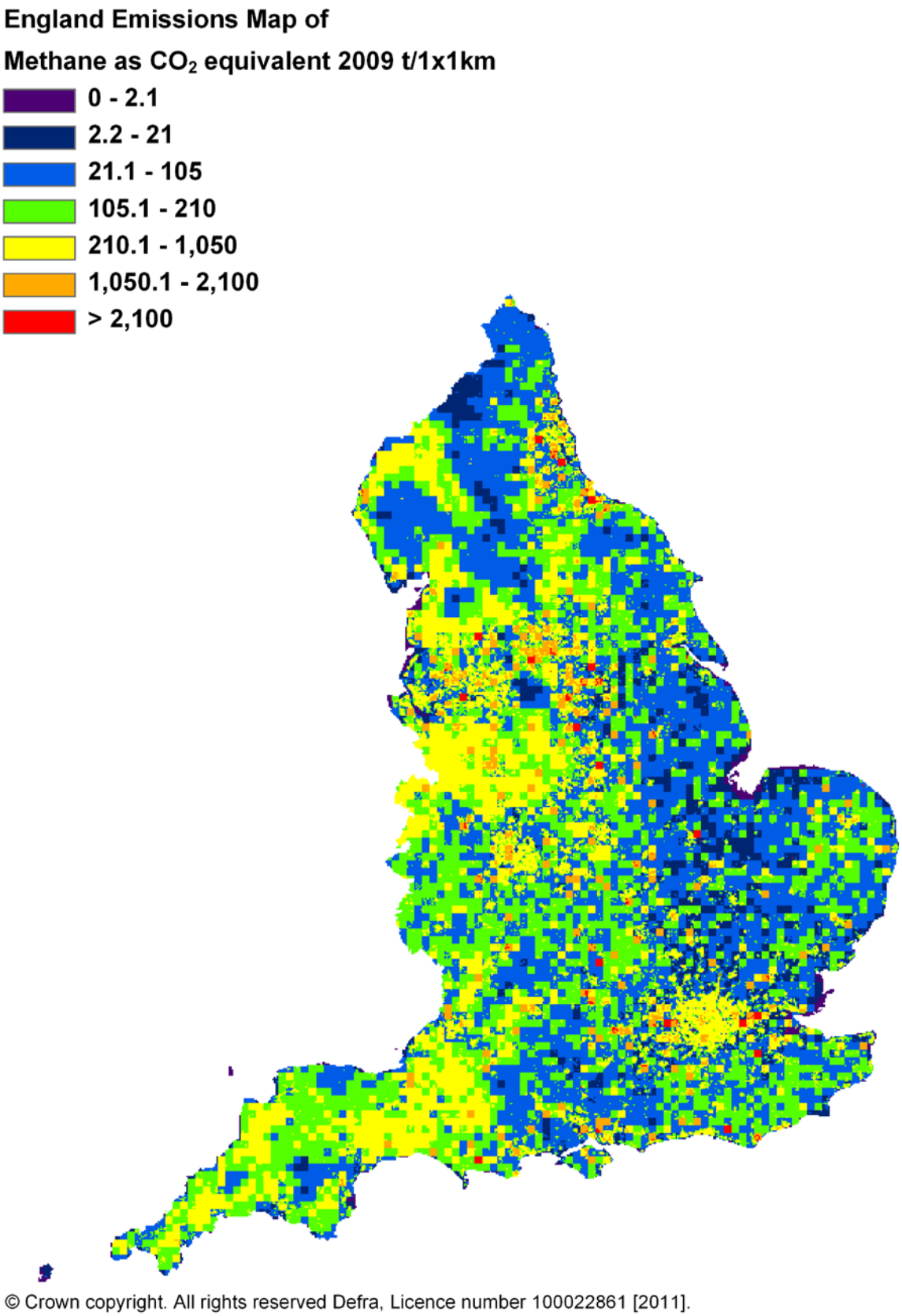
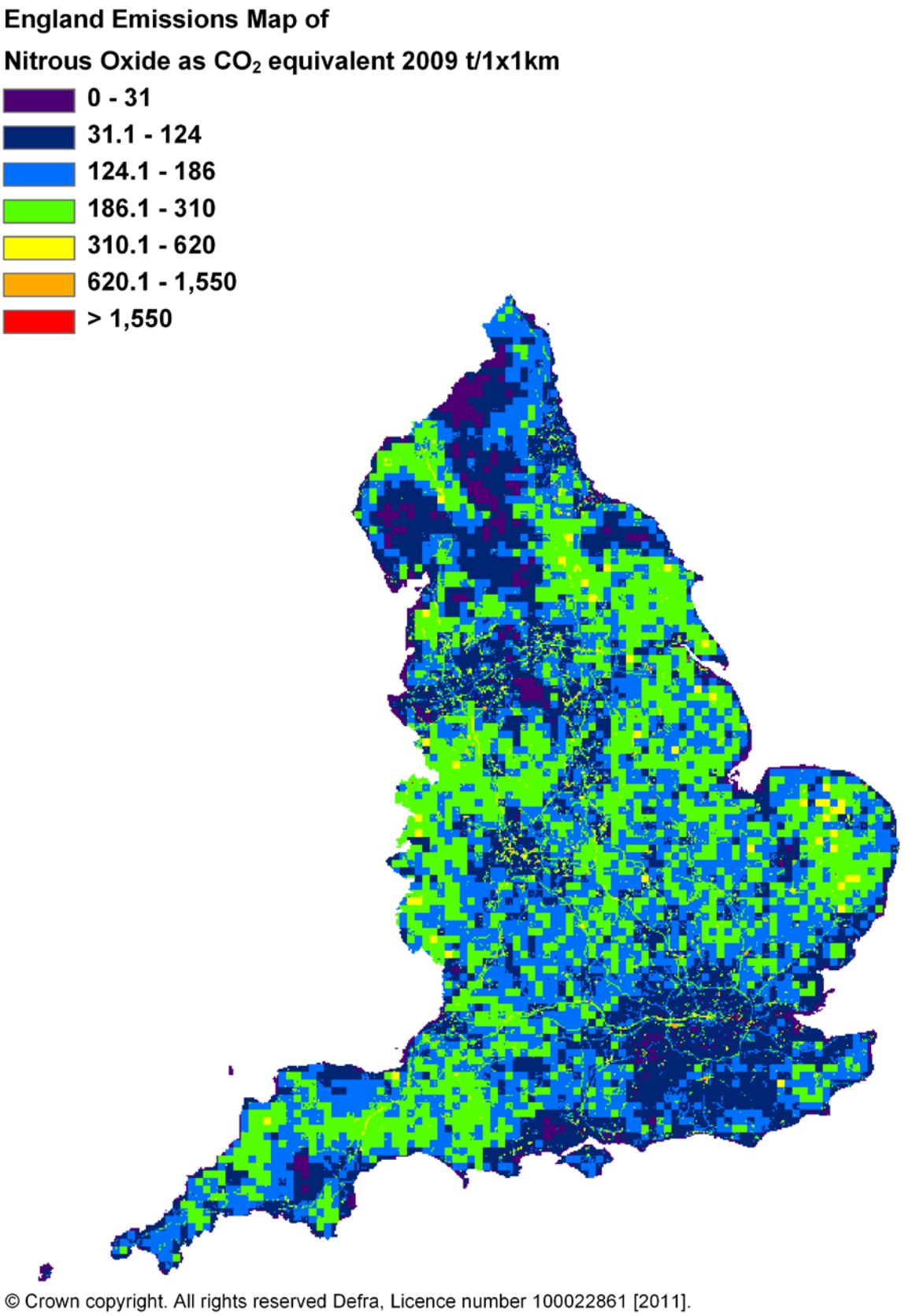


Figure 2.14 Emissions of Nitrous Oxide (t CO_2e) in England in 2009



3 Emissions in Scotland

3.1 Summary of GHG Emission Sources

The main GHG emission sources for Scotland in 2009 are summarised in Table 3.1 below, expressed as a percentage of the total Scottish GHG emissions in 2009 of 48.116 Mt carbon dioxide equivalents. The trends in Scottish GHG emissions since the base years of 1990 (for carbon dioxide, methane and nitrous oxide) and 1995 (for fluorinated gases) are as follows:

- Carbon dioxide emissions have reduced by 27.3%
- Methane emissions have reduced by 51.8%
- Nitrous oxide emissions have reduced by 29.5%
- HFC emissions have increased by 602.7%
- PFC emissions have reduced by 40.5%
- SF_6 emissions have increased by 56.5%
- Total GHG emissions (as CO_2 equivalents) have reduced by 30.5%

The total emissions from each National Communication sector are presented in executive summary table ES2.2.3. This table shows that energy supply is the biggest source of GHG emissions in Scotland in 2009.The largest emission source in Scotland is carbon dioxide from power stations (1A1a), which accounted for 28% of net Scottish GHG emissions in 2009. The largest methane source is from landfill (6A), and the largest source of nitrous oxide emissions is agricultural soils (4D). Together, the ten categories listed below account for more than 100% of the Scottish total net GHG emissions. This is because there are large sinks in the land use, land use change and forestry category, which amounted to a net removal of 5.7Mt carbon dioxide in 2009.

Table 3.1 GHG Emissions Summary for Scotland in 2009

Summary of Main GHG Emission Sources, Scotland 2009 (kt CO_2e)				
Rank	Sector Name	IPCC code	Emission	Percentage of total GWP Weighted Emissions
1	Power stations	1A1a	13,384	27.8%
2	Road transport	1A3b	9,515	19.8%
3	Residential Combustion	1A4b	6,977	14.5%
4	Land Converted to Cropland	5B2	5,582	11.6%
5	Other Industrial Combustion	1A2f	4,844	10.1%
6	Agricultural Soils	4D	3,798	7.9%
7	Refineries	1A1b	2,059	4.3%
9	Enteric fermentation - Cattle	4A1	1,918	4.0%
8	Landfill	6A1	1,917	4.0%
10	Other Energy Industries	1A1c	1,628	3.4%

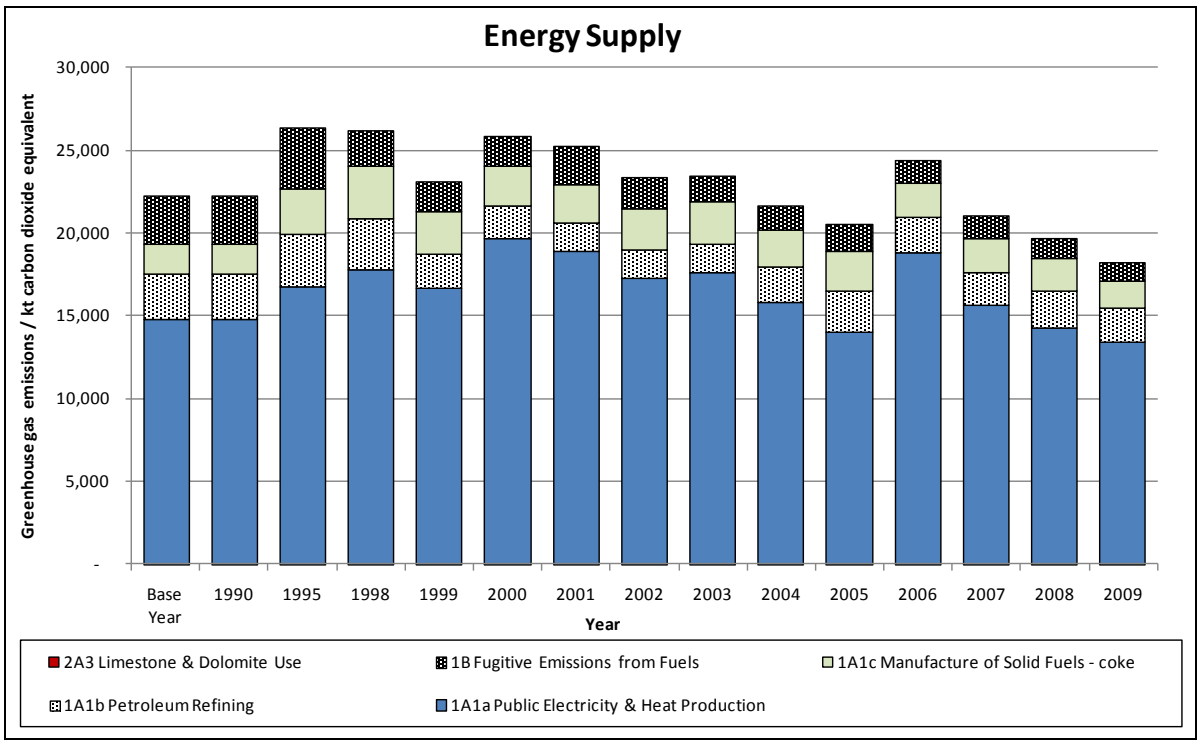
Note that in the National Communication format sector discussion text below, the percentages quoted are derived from the inventory and emissions data stored at full precision. These data can be found on the NAEI web site and on the CD-ROM that accompanies this report. The percentages in the text of this chapter do not in all cases match directly with percentages in the above table (which are quoted as % of the total of all six GHG emissions).

3.2 Energy Supply

The Energy Supply sector accounts for 37.8% of total GHG emissions in Scotland in 2009, and carbon dioxide emissions contribute 95.7% of the emissions in this sector. This sector includes emissions from: power generation, refineries, coal mines, solid fuel transformation, oil and gas extraction and processing, and other energy industries.

Power generation (IPCC category 1A1a) is the largest source of carbon dioxide emissions in Scotland, contributing 36.4% of the total Scottish carbon dioxide emission in 2009. This is slightly higher than the UK average of 31.8% due in part to Scotland's large carbon sink in the land use, land use change and forestry sector which reduces total net carbon dioxide emissions, and also due to the different mixture of fuels used to generate electricity in Scotland and the subsequent export of electricity from Scotland to England and Northern Ireland.

Figure 3.1 GHG Emissions from Energy Supply in Scotland, 1990 to 2009



Scottish emissions of GHGs from power generation (1A1a) have decreased by 9.5% since 1990, compared to a fall of 26.3% from power generation across the UK; this lesser reduction in Scotland also reflects the generation of electricity in Scotland that is exported for use elsewhere. Power generation and consumption data from DECC (DECC, 2010b) indicated that in 2009, approximately 24% of all electricity generated in Scotland was exported to England and Northern Ireland, an increase from 18% exported in 2008.

[*The Scotland GHG "end user" emission estimates presented in Chapter 10 re-allocate the emissions from power stations where electricity is generated in Scotland and then exported to be consumed in England and Northern Ireland.*]

The mix of generation capacity in Scotland (see Figure 3.2) is significantly different from the rest of the UK, with a high contribution in 2009 from nuclear power (33%) and renewable forms of energy (21%, largely hydro-electricity and onshore wind)[11]. As a consequence of this higher contribution from non-fossil fuel sources, lower carbon dioxide emissions may be anticipated. However, much of the remainder of power generation in Scotland comes from conventional coal-fired stations whilst in England and Wales there has been increased commissioning and utilisation of combined cycle gas turbines (CCGT) since the mid-1990s that have higher generation efficiencies than conventional

[11] See DECC Energy Trends December 2010, p17. http://www.decc.gov.uk/assets/decc/Statistics/publications/energytrends/1082-trendsdec10.pdf

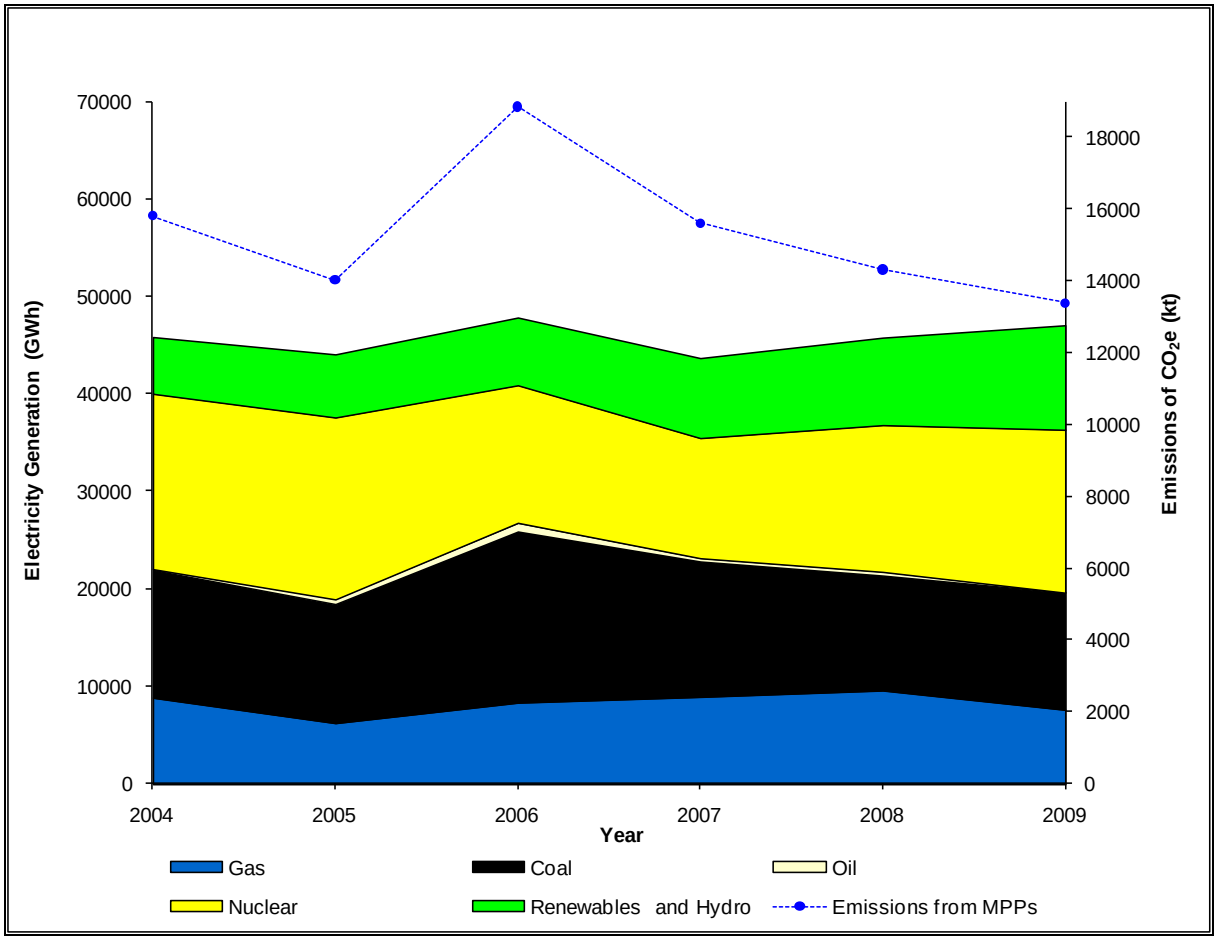
thermal plant. This difference is exemplified by the notable increase in GHG emissions from power generation in Scotland in 2006 in comparison with emissions over recent years. This increase in carbon dioxide from power generation coincided with a significant increase in power generation from coal in this year, from 12,092GWh in 2005 to 17,488GWh in 2006, compared to an average of 12,463 GWh in the three subsequent inventory years. This sharp increase in coal-fired power generation in 2006 influenced the overall Scotland GHG inventory significantly for that year, and table 3.2 shows that the GHG intensity of electricity generation in Scotland peaked in 2006 as a result.

Table 3.2 and Figure 3.2 below present data for the Major Power Producers (MPPs) in Scotland, excluding power generation by autogenerators.

Table 3.2 GHG Emissions Intensity of Electricity Generated by Major Power Producers in Scotland, 2003 to 2009 (kt CO_2e/GWh)

Greenhouse Gas emission intensity of electricity generation by Major Power Producers in Scotland (2003-2009)							
Emission year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Power generation emissions (kt CO_2e)	17,643	15,810	14,019	18,851	15,610	14,315	13,384
GWh Generated by Major Power Producers	43,728	44,453	41,848	45,528	42,542	45,028	45,314
kt CO_2e / GWh	0.403	0.356	0.335	0.414	0.367	0.318	0.295

Figure 3.2 Power Station GHG Emissions and Electricity Generation by Fuel by Major Power Producers in Scotland, 2004 to 2009



Carbon dioxide emissions from the petroleum refining (sector 1A1b) have declined by 26.4% since 1990. This source constitutes a high proportion of national emissions in Scotland at 5.6% of the carbon dioxide total, compared with an average of 3.1% across the UK; this reflects the significance of the Grangemouth refinery and the greater occurrence of oil and gas landings in Scotland from offshore facilities compared to the UK average. Other energy emissions account for around 10% of Scottish carbon dioxide emissions in 2009, and originate predominantly from gas consumption at oil and gas terminals and gas separation plant. Note that only those emissions arising from on-shore installations in Scotland are included within the Scottish GHG inventory; emissions from offshore oil & gas exploration and production facilities are reported as "Unallocated".

Carbon dioxide emissions from Manufacturing Industry and Construction (IPCC Sector 1A2) account for 13.1% of the Scottish carbon dioxide total compared with 14.3% for the UK. Between 1990 and 2009, carbon dioxide emissions from the sector have declined by 32.6%, mainly due to the closure of the Ravenscraig steel plant.

The category Fugitive Emissions from Fuels (IPCC Sector 1B) is a significant source of methane emissions, reporting emissions of methane from coal mining, the oil and gas industry and natural gas distribution. The combined emission from this Sector is 11.2% of the Scottish methane total. This is a lower proportion compared with the UK as a whole, where fugitive emissions constitute around 18.7% of the total methane emissions. This lower share reflects Scotland's lesser contribution to emissions from sources such as coal mining and leakage from the gas transmission system, but also that a high percentage of UK emissions in this sector are from offshore oil and gas installations. Of these emissions, those from coal mining (1B1a) contributed 5.4% oil and gas terminals 0.7% and natural gas distribution 5.2% of the Scottish methane total in 2009. Coal mining emissions have declined by 53% over the period due to the decline in the coal industry. Emissions from the oil and gas industry (1B2) have fallen by 64.4% over the same period due to tighter regulation of emissions. Gas leakage from the gas transmission system has reduced by 48.3% over 1990-2009 due to renewal of the mains and services infrastructure.

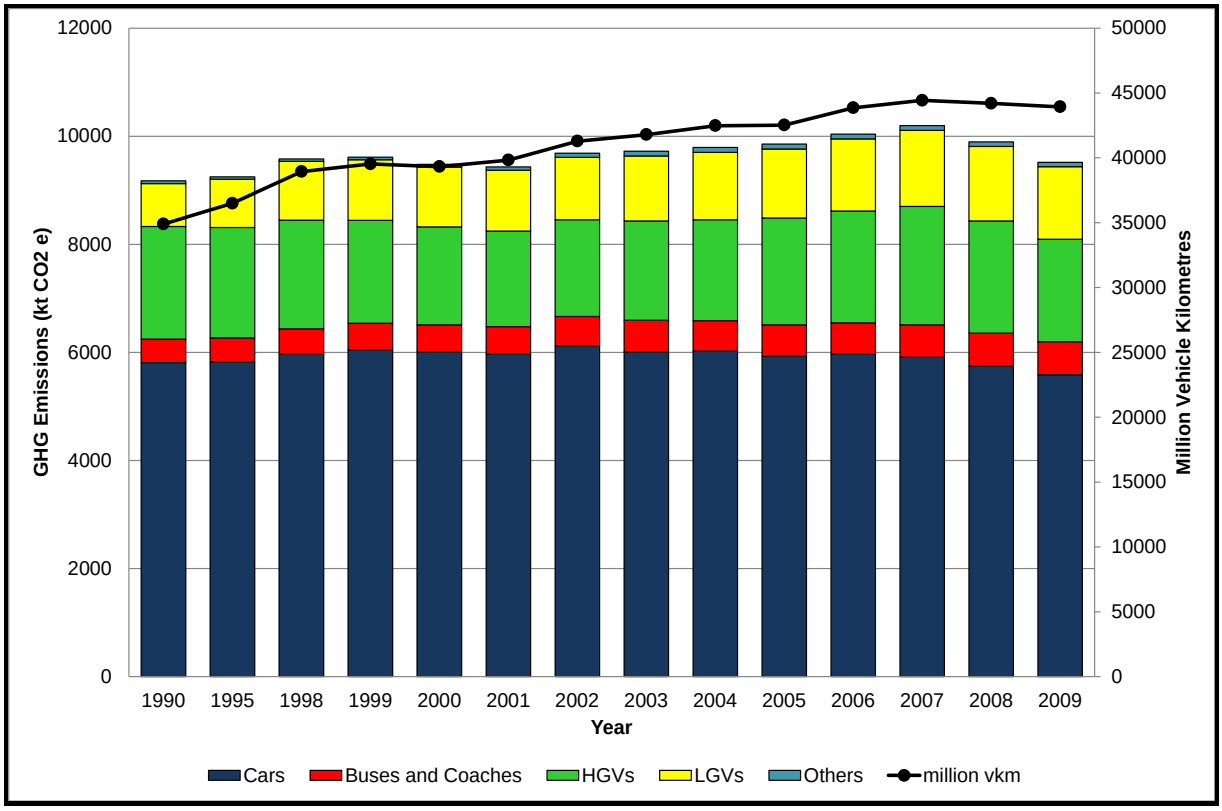
Only around 1.4% of carbon dioxide emissions arise from oil and gas fugitives (1B2), mainly from processes at oil and gas terminals (0.4%), as well as oil and gas flaring (0.9%). Between 1990 and 2009, oil and gas process emissions decreased by 53.8% whilst emissions from flaring have decreased by 62.5%.

3.3 Transport

Transport includes emissions from aircraft, road, railways and shipping. In Scotland, transport contributed 22.3% of the total Scottish GHG emissions (or 29.1% of total Scottish carbon dioxide emissions) in 2009. 99% of emissions in the transport sector are carbon dioxide and the largest source of carbon dioxide in this sector arises from road transport, accounting for 88.8% of carbon dioxide emissions.

Road transport represents the second largest single source of carbon dioxide in Scotland, contributing 25.8% to the total Scottish carbon dioxide emission. The contribution of Scottish road transport to UK road transport carbon dioxide emissions is 8.4% which is consistent with that anticipated from Scotland's population (8.4% of UK). Emissions from the road transport sector in Scotland have risen by 4.4% from 1990 to 2009, compared with a 2.7% rise for the UK as a whole. However since 2007, road transport emissions have fallen by 6.5% in Scotland and by 7.3% in the UK as a whole. Emissions from road transport are dominated by emissions from cars (approximately 58.8%) followed by emissions from heavy good vehicles (HGVs), light good vehicles (LGVs) and buses and coaches respectively (Figure 3.3).

Figure 3.3 Total Road Traffic Vehicle km and GHG Emissions from Different Vehicle Types: Scotland, 1990 to 2009



Aviation (domestic cruise and take off and landing) contributed 1.3% of total Scottish carbon dioxide emissions in 2009. There was a gradual increase in emissions over the period of 1990-2005 but it has been declining since then; overall there was a 58% increase in emissions between 1990 and 2009. Rail and shipping (coastal, naval and fishing vessels) are estimated to account for 0.5% and 0.9% of total Scottish carbon dioxide in 2009 respectively. There is a general increase in rail emissions whilst there is a general reduction in shipping emissions. However, estimates from these sources are subject to high uncertainty given the limited DA-specific activity data. Electricity use from rail sector is included within the end user emission estimates within Chapter 10.

3.4 Residential

The residential sector includes emissions from domestic combustion, household products and accidental vehicle fires, and accounts for 15.3% of GHG emissions, and 19.3% of carbon dioxide emissions in Scotland in 2009. Domestic combustion is the largest source of carbon dioxide in this sector, accounting for 97.7% of carbon dioxide, and 94.6% of all GHG emissions in the sector. IPCC sector 1A4b (Residential combustion) includes domestic combustion for cooking, water heating and space heating, as well as emissions from fuel use in house and garden machinery, and contributes 95.0% to the total GHG emissions in the residential sector, as shown below in Figure 3.4.

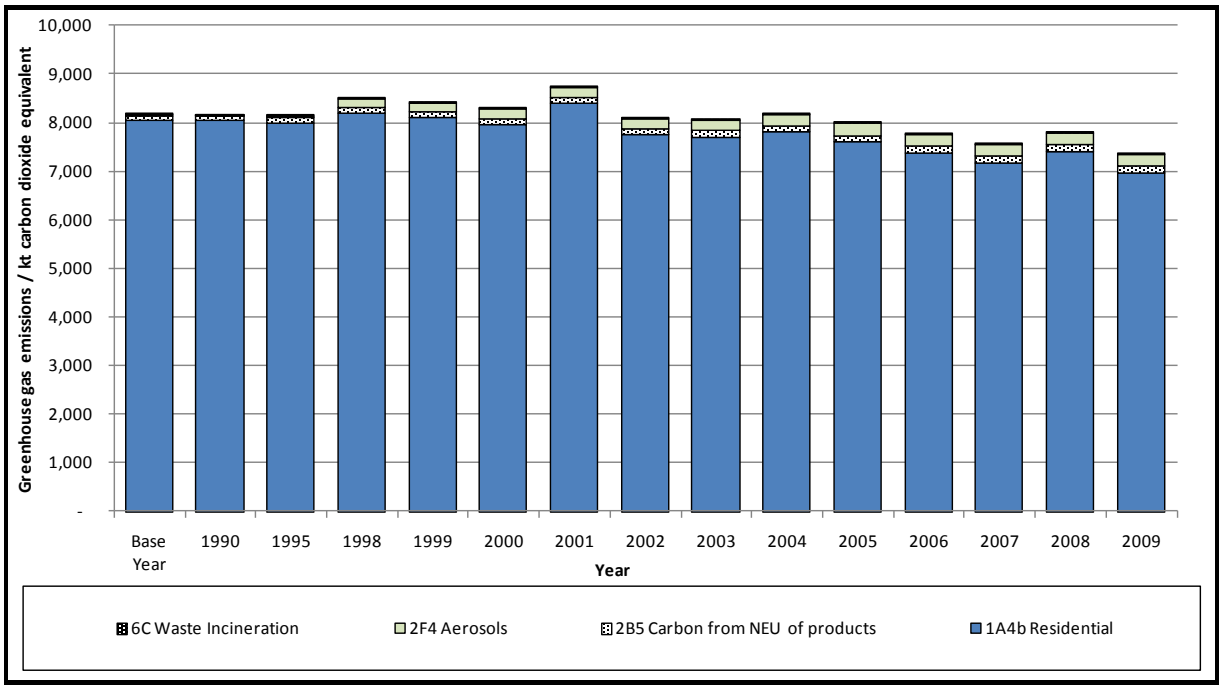
Carbon dioxide emissions from domestic combustion sources are estimated to account for 18.8% of the Scottish total in 2009, and as a proportion of UK domestic emissions, are estimated to represent 9.4% which is slightly higher than would be anticipated from Scotland's 8.4% share of UK population.

Domestic combustion is also the largest combustion related source of methane, contributing 1.1% to total Scottish methane emissions.

Note that combustion emission estimates from the residential sector are subject to uncertainty due to the absence of comprehensive, detailed fuel use data, particularly for solid and liquid fuels.

Emissions of HFC from the residential sector account for 26.1% of Scottish HFC emissions. Aerosols and metered dose inhalers are the only source of HFCs in the residential sector, and the most significant sources of HFC emissions in 2009.

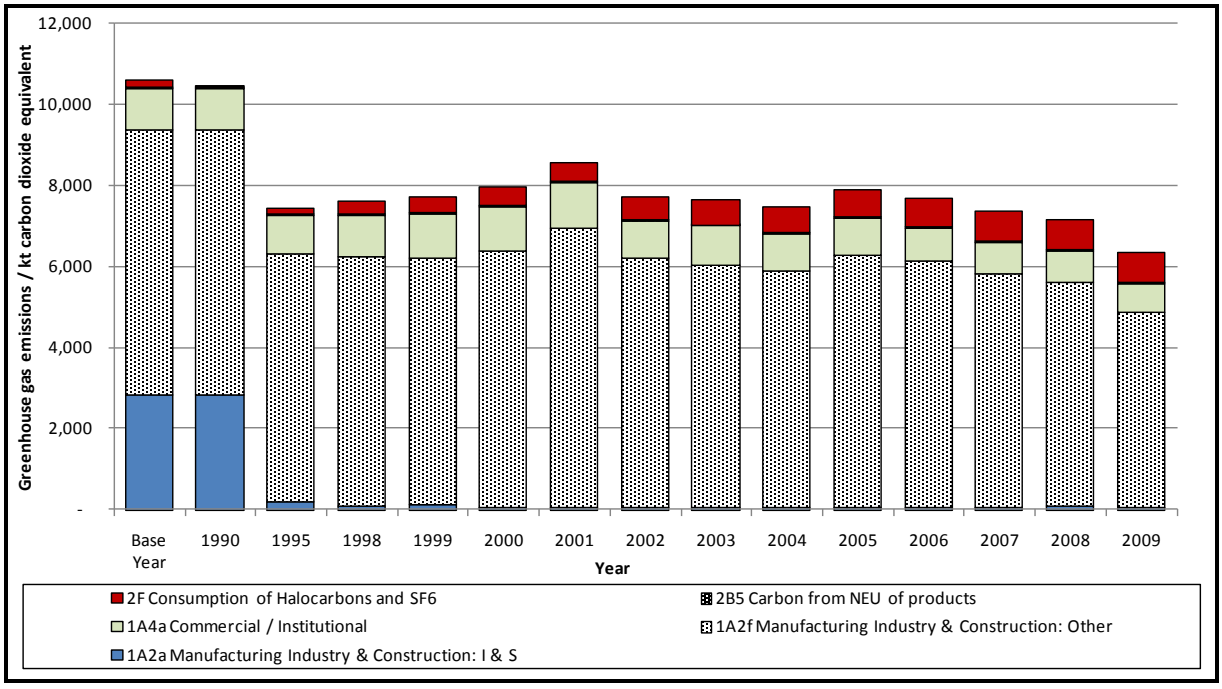
Figure 3.4 GHG Emissions from the Residential sector in Scotland, 1990 to 2009



3.5 Business

The business sector includes emissions from manufacturing industry, construction, industrial combustion, refrigeration, air conditioning, foam and fire fighting, solvents and electronics. The sector accounts for 13.2% of GHG emissions, and 15.1% of carbon dioxide emissions in Scotland in 2009.

Figure 3.5 GHG Emissions from the Business sector in Scotland, 1990 to 2009



Combustion emissions from the manufacturing industry and construction sector (IPCC Sector 1A2) contribute the greatest amount of carbon dioxide emissions in the sector and account for 13.1% of the Scottish carbon dioxide total, The 'Other industry' category (IPCC sector 1A2f) for Scotland contributes 9.0% towards the UK 'Other industry' carbon dioxide total.

Sulphur hexafluoride (SF_6) constitutes 0.8% of total GHG emissions from the business sector in Scotland, with the main sources of SF_6 emissions coming from its application in electrical insulation, which accounted for 68.2% of SF_6 emissions in Scotland in 2009. The business sector accounts for all SF_6 emissions in Scotland in 2009

The main source of hydrofluorocarbon (HFC) emissions come from refrigeration and air conditioning equipment, arising from losses during its manufacture and lifetime of equipment, which accounted for 68.5% of HFC emissions in Scotland in 2009. Emissions from these sectors have risen by a factor of 7.9 in Scotland since the 1995 base year.

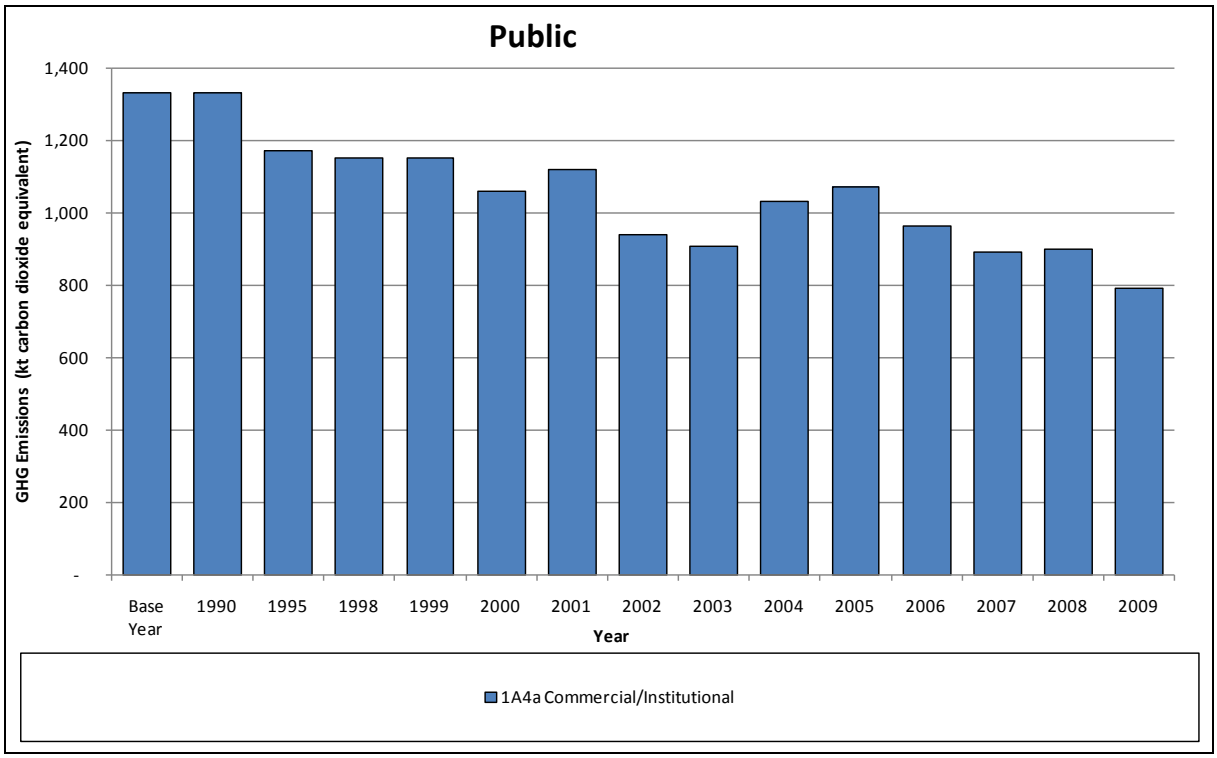
Perfluorocarbons (PFC) in the business sector account for 98.3% of emissions in Scotland. Total PFC emissions only account for around 0.1% of total Scottish GHG emissions in 2009.The largest sources in Scotland in 2009 were electronics (97.9%), by-product emissions from primary aluminium production (1.7%) and fugitive emissions from PFC manufacture (0.0%). Scottish PFC emissions account for 35.1% of total UK PFC emissions, and have declined by 40.5% since 1995.

Non-combustion emissions are estimated to account for a total of 12.4% of the total business emissions in Scotland in 2009. Note however that these data are uncertain due to a lack of DA-specific data on F-gas sources and the use of proxies such as economic indices and population to estimate the DA share of UK emissions for these sources.

3.6 Public

Emissions from public sector combustion (IPCC Sector 1A4a) account for 1.6% of GHG emissions in Scotland in 2009. In Scotland, 99.7% of emissions in this sector are carbon dioxide, and emissions are estimated to have declined by around 41% since 1990.

Figure 3.6 GHG Emissions from the Public sector in Scotland, 1990 to 2009

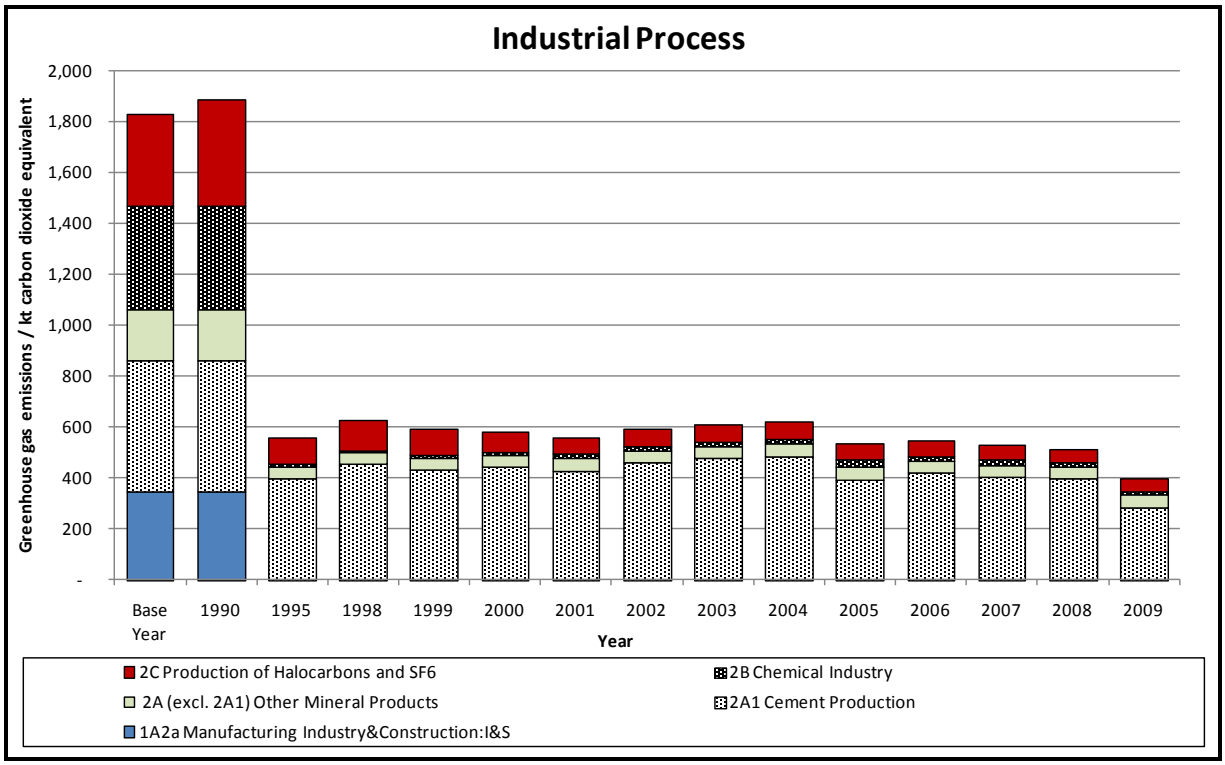


Note that the emission estimates in the public sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels.

3.7 Industrial Process

Industrial processes emit GHGs from non-combustion sources such as chemical processes, the production and use of fluorinated gases, and the use of limestone in cement and glass making, and contribute 0.83% to carbon dioxide emissions in Scotland.

Figure 3.7 GHG Emissions from Industrial Processes in Scotland, 1990 to 2009



The largest contribution of carbon dioxide emissions in this sector is from cement production, which accounts for 74% of emissions in this sector, and which constitutes 0.78% of the total Scottish carbon dioxide emissions. Emissions from glass, ammonia, aluminium, iron and steel production contribute a further 0.2% to the Scottish total in 2009.

In 1990, nitric acid manufacture and iron and steel were both important sources of GHGs in the Scottish industrial process sector. However, emissions from these sources in 2009 are negligible following the closure of the Ravenscraig iron and steel plant in 1992, and the relocation of the only Scottish nitric acid plant to Dublin in 1995. In 1990, around 394 kt carbon dioxide equivalent (CO_2e) of nitrous oxide were emitted from a nitric acid plant in Leith, and 244 kt carbon dioxide were emitted from iron and steel processes. These plant closures have made a significant contribution to the decreases in Scottish emissions for this sector since 1990.

The only source of PFCs in the Industrial Process sector in Scotland is aluminium production and this contributes 0.2% to the total emissions of PFCs from Scotland, having fallen by 99.1% from 1990 to 2009.

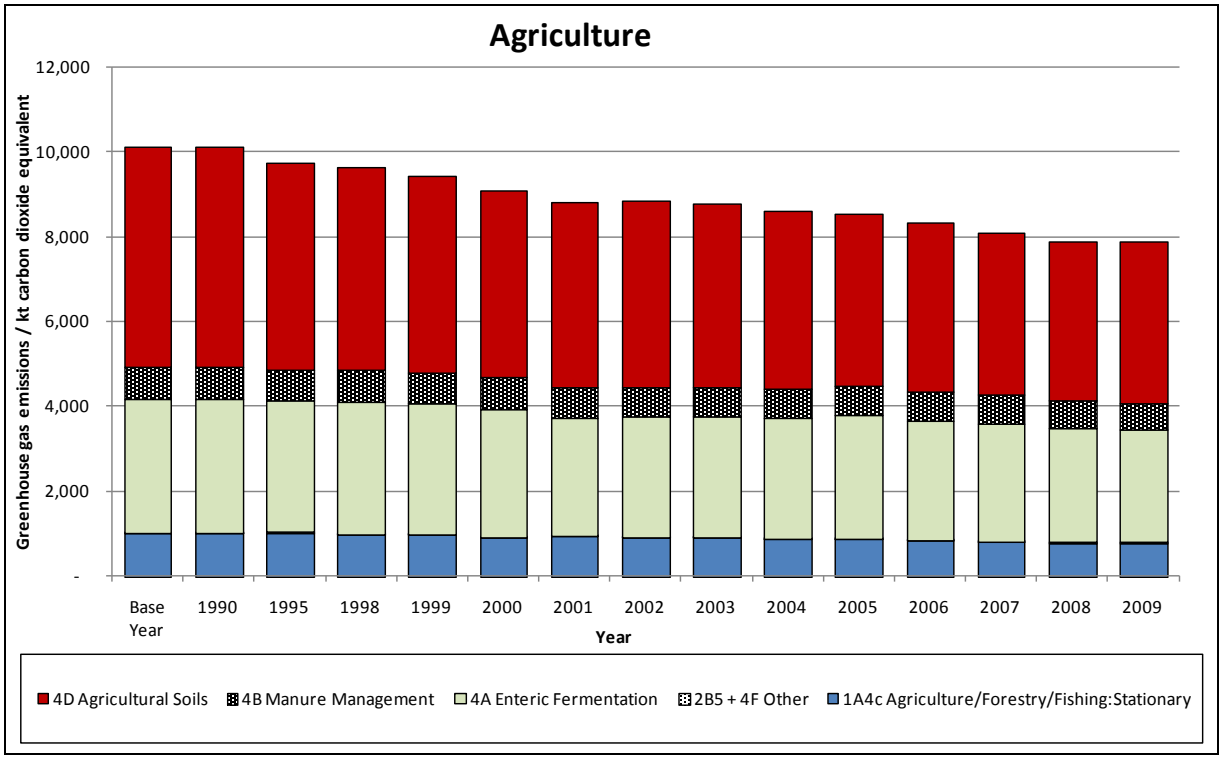
3.8 Agriculture

Emissions from the agriculture sector contribute 16% to total GHG emissions in Scotland. These emissions arise from livestock (enteric fermentation and waste management) and agricultural soils. In 1990, a small emission was also included from field burning, but this practice has now ceased in the UK and is therefore no longer a source.

Enteric fermentation from cattle is the largest single source of methane emissions in Scotland (125.6 kt CH_4), contributing 89% of Scottish agricultural methane emissions. Total emissions from cattle (including both waste management and enteric fermentation) are 73% of total methane emissions from agriculture in Scotland, with sheep responsible for a further 24%. Emissions are largely dependent on the numbers of livestock and have fallen by 16% over the period 1990-2009, due to a decline in cattle and sheep numbers. Scotland accounts for around 16.6% of UK agricultural methane emissions. Emissions decreased by 2.4% in 2009 compared to 2008.

Of the total Scottish emission of 15.9 kt nitrous oxide (N_2O) in 2009, around 13.5 kt N_2O of this was from agriculture. The agriculture sector also includes the largest single source of N_2O emissions; emissions from agricultural soils (12.3 kt N_2O) contributing 77% of total N_2O emissions, and 93% of N_2O emissions from the agriculture sector. Scottish emissions of N_2O have declined by 27.2% over the period 1990-2009 and decreased by 2.0% in 2009 relative to 2008. Emissions from the agricultural soils sector are broken down below:

Figure 3.8 GHG Emissions from Agriculture in Scotland, 1990 to 2009



[Note: numbers in brackets show the percentage of the total agricultural soils N_2O emission]

- synthetic fertiliser application (23.7%)
- leaching of fertiliser nitrogen and applied animal manures to ground and surface water (31.8%)
- wastes from grazing animals (20.1%)
- ploughing in crop residues (7.9%)
- manure used as fertiliser (8.8%)
- atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NO_x) (6.4%)
- cultivation of legumes (0.2%)
- cultivation of histosols (i.e. high organic content soils) (0.2%)
- biological fixation in improved grass (0.9%)

Table 3.3 Livestock Emissions of Methane in Scotland by source in 2009 (kt CH_4)

Livestock Methane Emissions		
Category	Source	CH_4, kt
Total cattle	Wastes	11.58
	Enteric	91.32
Pigs	Wastes	2.80
	Enteric	0.59
Sheep	Wastes	0.78
	Enteric	32.93
Goats	Wastes	0.00
	Enteric	0.03
Horses	Wastes	0.05
	Enteric	0.62
Poultry	Wastes	1.04
	Enteric	0.00
Deer	Wastes	0.00
	Enteric	0.06

Table 3.4 Emissions of Nitrous Oxide from Agriculture in Scotland by source in 2009 (kt N_2O)

Agriculture Nitrous Oxide Emissions	
Source	N_2O, kt
Improved Grass	0.11
Legumes	0.03
Crop residues	0.95
Fertilisers	2.87
Histosols	0.02
Animal waste management systems	0.92
Organic fertiliser applied to soil	1.07
Grazing	2.44
Leaching	3.86
Atmospheric deposition	0.77

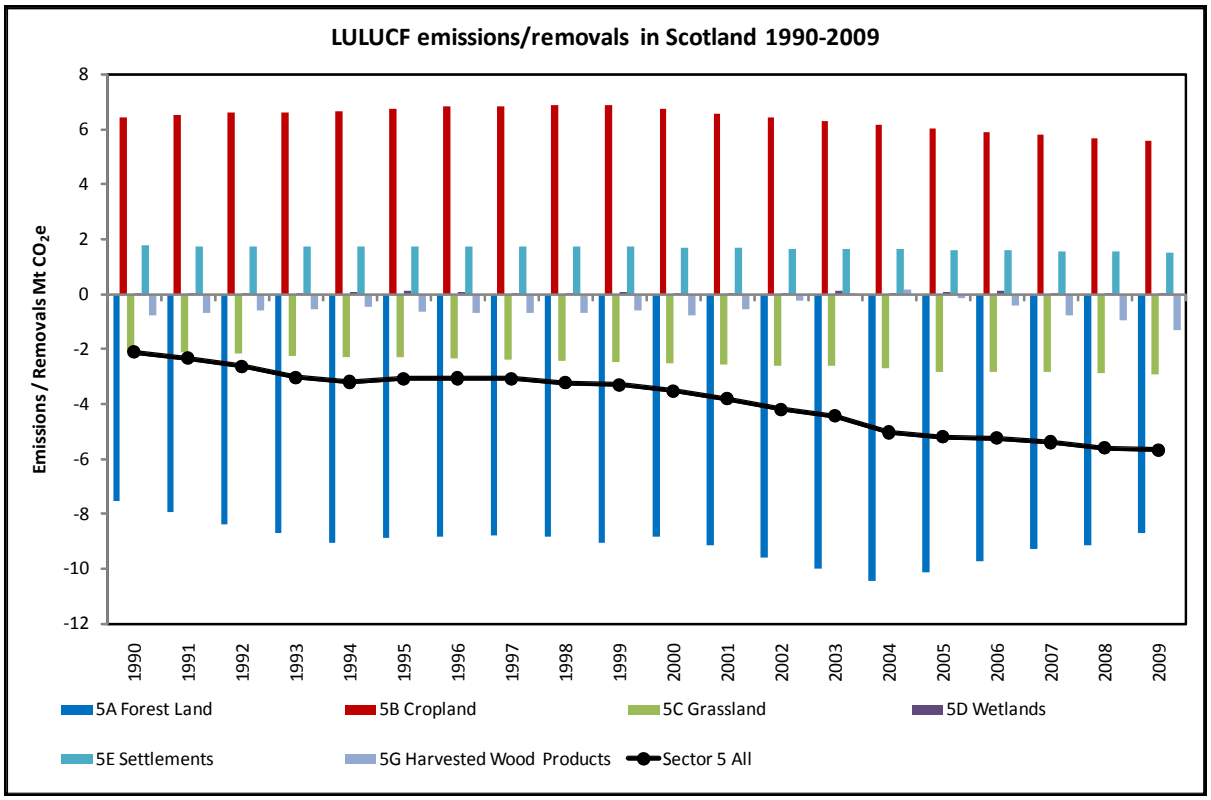
3.9 Land Use, Land Use Change and Forestry

The LULUCF sector includes carbon stock changes, emissions of GHGs (CO_2, CH_4 and N_2O) by sources and removals of CO_2 by sinks from land use, land use change and forestry activities. Removals of CO_2 are conventionally presented as negative quantities. Total greenhouse gas emissions are described as carbon dioxide equivalents (CO_2e), using Global Warming Potentials (GWP) of 21 for CH_4 and 310 for N_2O (as used in the inventories submitted to the UNFCCC).

Scotland is a net sink of carbon from LULUCF activities (Figure 3.9). The size of this sink has increased by 145%, from -2.437 to -5.932 Mt CO_2e, between 1990 and 2009. Net emissions/removals in Scotland are dominated by the large Forest Land sink (-8.662 Mt CO_2e in 2009) and Cropland source (5.615 Mt CO_2e in 2009).

Estimates of methane (CH_4) from LULUCF activities are small, with 0.009 Mt CO_2e of CH_4 in 2009. Estimated emissions of nitrous oxide (N_2O) are now larger than previously estimated due to the inclusion of N_2O emissions from disturbance associated with land-use conversion to Cropland for the first time. There were 0.302 Mt CO_2e of N_2O emissions in 2009.

Figure 3.9 LULUCF Inventory Emissions and Removals by category for Scotland, 1990 to 2009



Net LULUCF GHG emissions in 1990 were -2.518 Mt CO_2e in the 2008 inventory and -2.082 Mt CO_2e in the 2009 inventory. In 2008 they were -4.474 Mt CO_2e in the 2008 inventory vs. -5.570 Mt CO_2e in the 2009 inventory (Table 3.5).

Net emissions of CO_2 between 1990 and 2000 are slightly larger than in the previous inventory (Figure 3.10). There was a reduction in the size of the net sink due to slightly increased emissions from cropland, grassland and settlements (due to the change in the LUC method from top-down to bottom-up) and increased emissions from wetlands (reported for the first time). From 2001 onwards, there is a wider divergence between the inventories with the reduced emissions from cropland making the most difference.

The inclusion of N_2O emissions from disturbance associated with land-use conversion to cropland makes a noticeable addition. Net emissions of N_2O from this activity were 1.11 Gg (N_2O) in 1990 (0.344 Mt CO_2e) and 0.97 Gg N_2O in 2009 (0.301 Mt CO_2e).

Figure 3.10 Differences between the 2008 and 2009 LULUCF Inventory in Scotland

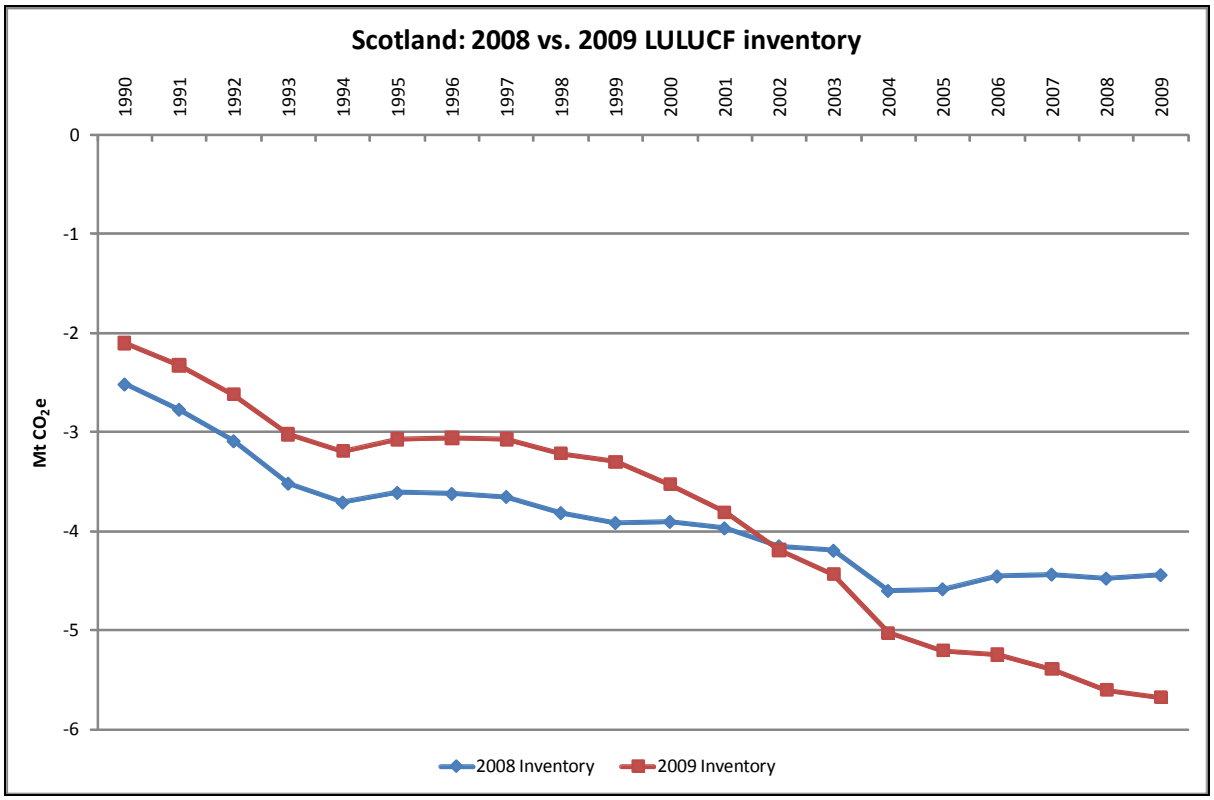


Table 3.5 Difference in 2008 LULUCF net Emissions between 2008 and 2009 Inventories in Scotland

	5A Forest Land	5B Cropland	5C Grassland	5D Wetlands	5E Settlements	5G Other	Sector 5 All
Difference between 2008 and 2009 inventory		Mt CO_2e					
	0.037	-0.946	-0.146	0.052	-0.112	-0.015	-1.130

The annual land use matrices for 1990-1991 and 2008-2009 for Scotland are shown here (Table 3.6 and Table 3.7). The off-diagonal items (land use change data from the Countryside Survey, forest planting and deforestation datasets) in the matrix are used to estimate the land use change fluxes in the LULUCF inventory. The diagonal items (land remaining in the same use, in italics) are included for information and have an uncertainty attached as there is not a perfect match between the sum across the columns and the sum across the rows. The total area of Scotland is reported as 7,880.7 kha. This is the Standard Area Measurement to mean high water reported by the Office of National Statistics (ONS 2009).

Table 3.6 Land Use Transition Matrix, kha, for Scotland in 1990-1991

From: / To:	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest Land	*1,198.1±2.7*	0.6	11.1	0	0.2	0.1	**1,212.8**
Cropland	0.1	*574.8±0.5*	21.4	0	0.3	0	**596.1**
Grassland	5.0	16.8	*5,662.9±1.5*	0	0.7	1.2	**5,685.1**
Wetlands	0	0	0	*1.6*	0	0.1	**1.7**
Settlements	0.3	0.1	2.2	0	*186.0±0.2*	0.0	**188.4**
Other Land	0.2	0.3	1.0	0	0.6	*195.0±0.6*	**196.5**
Total (initial)	**1,201.0**	**593.0**	**5,700.0**	**1.8**	**188.0**	**196.9**	***7,880.7***

Table 3.7 Land Use Transition Matrix, kha, for Scotland in 2008-2009

From: / To:	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest Land	*1,333.3±2.7*	0.3	4.0	0	0.6	0.1	**1341.0**
Cropland	0.0	*505.4±0.5*	9.5	0	0.0	0.0	**515.3**
Grassland	10.5	18.8	*5,723.7±0.1*	0	2.1	0.6	**5755.8**
Wetlands	0	0	0	*1.3*	0	0	**1.3**
Settlements	0.1	0.6	1.6	0	*194.7±1.3*	0.6	**197.8**
Other Land	0.7	0.1	1.2	0	0.1	*71.9±4.5*	**69.5**
Total (initial)	**1,342.0**	**524.7**	**5,739.9**	**1.3**	**195.2**	**77.7**	***7,880.7***

The UK reports estimates of emissions and removals from activities in Article 3.3 (mandatory, Afforestation, Reforestation and Deforestation) and Article 3.4 (elective, Forest Management) of the Kyoto Protocol. The emissions and removals from Kyoto Protocol activities in Scotland in 2009 are shown in 3.8. The methods and assumptions used in these reported emissions are described in Chapter 11 and Annex 3.7 of the National Inventory Report.

Table 3.8 GHG Emissions and Removals from KP-LULUCF Activities in Scotland in 2009

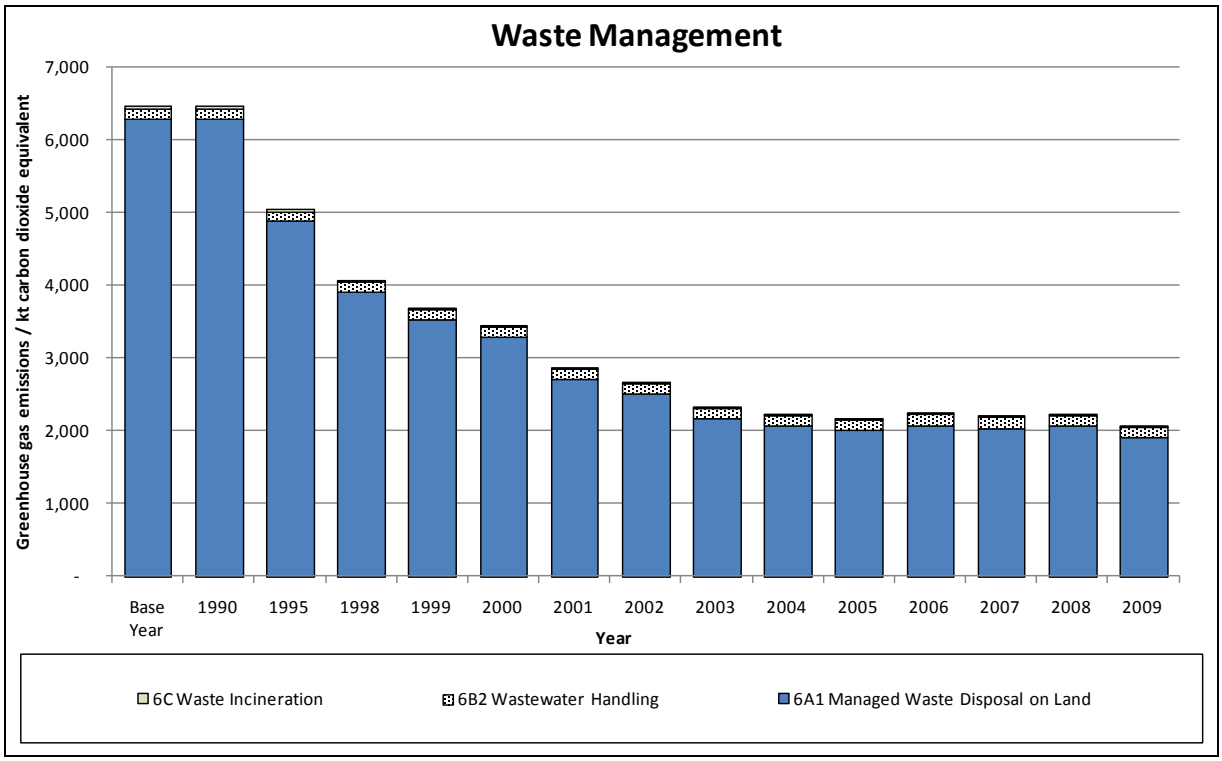
Activity		Scotland
3.3 Afforestation & Reforestation	Area, kha	180.15
	Net CO_2 emissions/removals, Mt CO_2	-1.677
	GHG emissions from biomass burning, Mt CO_2e	NO
	N_2O emissions from N fertilization, Mt CO_2e	0.0006
3.3 Deforestation	Area, kha	4.71
	Net CO_2 emissions/removals, Mt CO_2	0.099
	GHG emissions from biomass burning, Mt CO_2e	0.046
	N_2O emissions from LUC to cropland, Mt CO_2e	NO
3.4 Forest Management	Area, kha	841.32
	Net CO_2 emissions/removals, Mt CO_2	-6.988
	GHG emissions from biomass burning, Mt CO_2e	0.050

NO: Not Occurring

3.10 Waste

Waste emissions in Scotland are dominated by methane emissions from landfills. This accounts for 92.4% of total GHG emissions from the waste sector. In 2009, Scottish landfill emissions represent 12.1% of total UK landfill methane emissions, which is more than would be expected from the Scottish proportion of the population (8.4%).

Figure 3.11 GHG Emissions from Waste Management in Scotland, 1990 to 2009



The estimates are based on data on arisings of municipal solid waste (MSW) and sewage sludge in Scotland. However, there is not a direct link between MSW arising in a year and the methane emissions in that year. The model takes account of a time-series of MSW inputs, degradation and the methane release curve. This is notable in Scotland during the period 2007-2009, as there is a downward trend in MSW being disposed to landfill, but the methane emissions are estimated to be increasing.

[Note that the UK landfill model was updated during the latest inventory cycle, and all methane estimates from 1990 onwards were revised. For further details see Chapter 7 and Appendix 1.]

Data is obtained from www.wastedataflow.org, providing summary data from LA waste management reporting, including a detailed insight into the ultimate fate of MSW arisings. This data source includes regional data such as tonnages and percentages of MSW treatment and disposal options such as recycling, incineration and landfill. This data enables a more detailed DA split of waste disposed to landfill to be derived, and includes data back to 1999, which has been used to back-calculate the estimates to 1990 by DA. However, due to a lack of detailed local data, the DA disaggregation method still retains the assumption that landfill methane recovery rates within each of the DAs are the same as the UK average. Landfill emissions in Scotland are estimated to have fallen by 70% since 1990 due an increase in the use of methane recovery systems, though this reduction assumes the UK trend.

The remainder of the emissions from this sector mostly arise from wastewater treatment. Emissions of methane and nitrous oxide represent 6.1% of total GHG emissions in the waste sector. These emissions are estimated to be around 8.4% of UK wastewater treatment emissions. Emissions have

increased since 1998 when the disposal of sewage to the sea ended and other disposal routes were adopted.

3.11 Emission Maps: Scotland 2009

As part of the NAEI, the UK produces mapped emissions of carbon dioxide, methane and nitrous oxide. The maps are modelled estimates of emissions compiled at a 1 km^2 resolution and Figure 3.12 to 3.14 show the emissions in Scotland. The maps reveal the locations and intensities of the major sources of emissions and are used by AEA and other organisations for a variety of Government policy support work at the national scale, regional and local scale. Local area statistics are compiled from the maps and related data, for example, Local Authority level data on carbon dioxide end user emissions and fuel use have been produced for Defra and DECC since 2003 using data from the NAEI mapping work. As of March 2008, these datasets were reclassified as National Statistics (King et al and Bush et al, 2008). The distributions of methane and nitrous oxide emissions from agricultural sources are generated at a 5 km^2 resolution by the Centre for Ecology and Hydrology (CEH), and are then re-sampled at a resolution of 1 km^2 by the NAEI mapping team.

Emissions maps are produced for the latest year within the NAEI time series, and are available at:

http://www.naei.org.uk/mapping/mapping_2009.php

The most recent emission mapping methodology report can be found at:
http://www.naei.org.uk/reports.php

Figure 3.12 Emissions of Carbon Dioxide (t) in Scotland in 2009

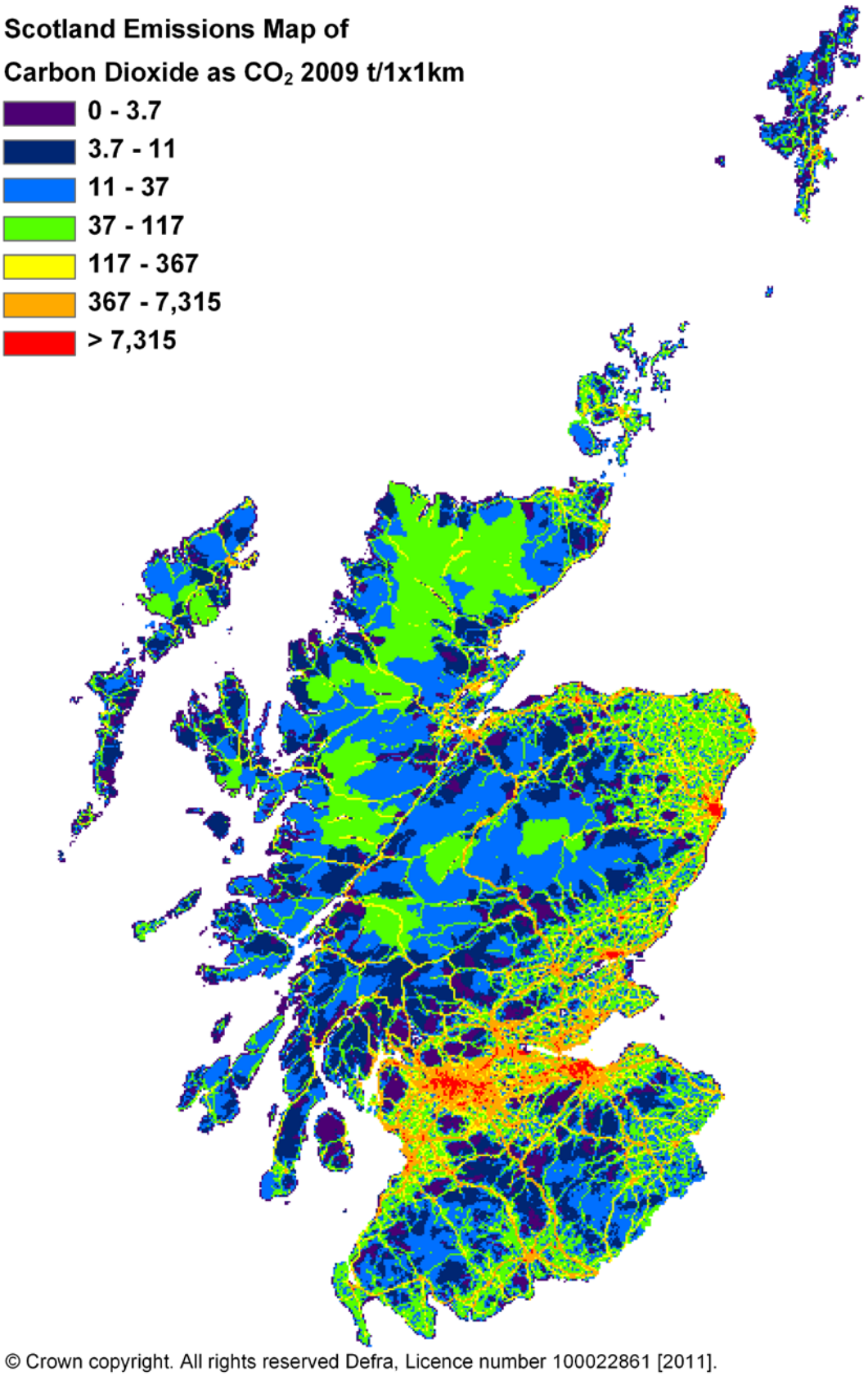


Figure 3.13 Emissions of Methane (t CO_2e) in Scotland in 2009

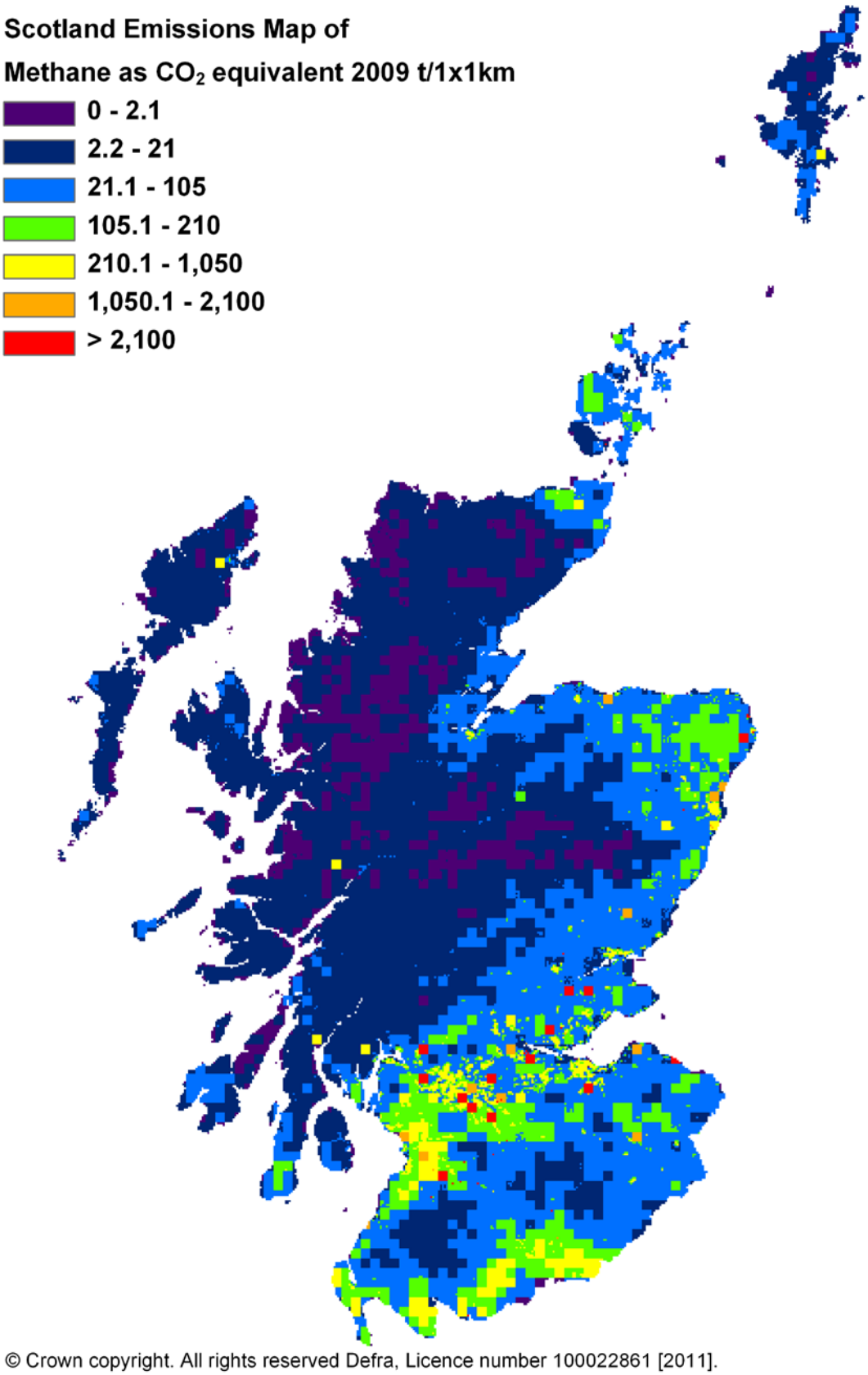
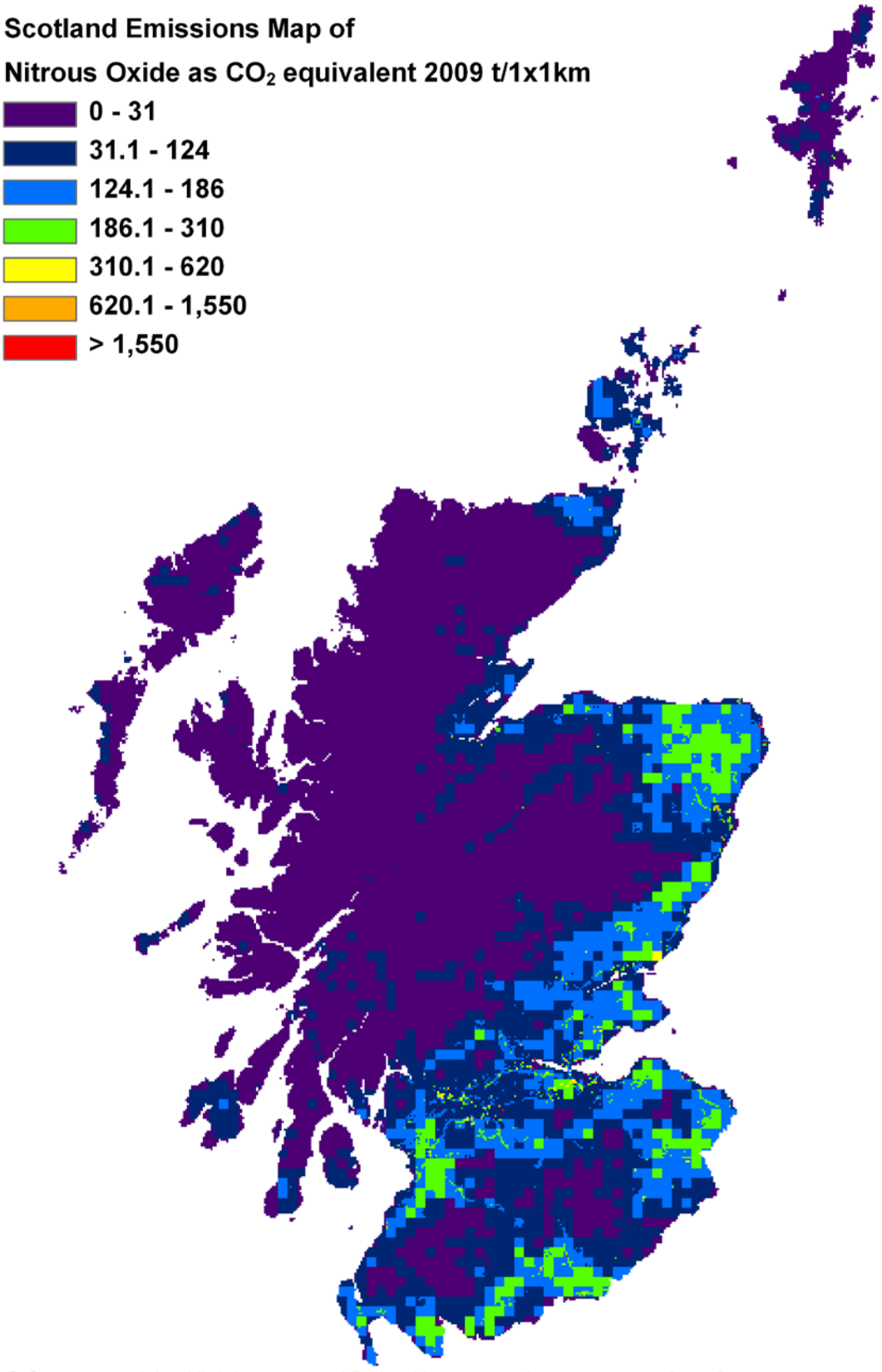


Figure 3.14 Emissions of Nitrous Oxide (t CO_2e) in Scotland in 2009



4 Emissions in Wales

4.1 Summary of GHG Emission Sources

The main GHG emission sources for Wales in 2009 are summarised in Table 4.1 below, expressed as a percentage of the total Welsh GHG emissions in 2009 of 42.6 Mt carbon dioxide equivalent (CO_2e). Trends in Welsh GHG emissions since the base years of 1990 (for carbon dioxide, methane and nitrous oxide) and 1995 (for fluorinated gases) are as follows:

- Carbon dioxide emissions have reduced by 19.3%
- Methane emissions have reduced by 45.7%
- Nitrous oxide emissions have reduced by 28.2%
- HFC emissions have increased by 580.8%
- PFC emissions have reduced by 79.5%
- SF_6 emissions have reduced by 50.4%
- Total GHG emissions (as CO_2e) have reduced by 23.3%

The total emissions from each National Communication sector are presented in executive summary table ES2.3.3. This table shows that energy supply is the biggest source of GHG emissions in Wales in 2009. After emissions from power stations and road transport, the largest emission source is carbon dioxide from combustion in the iron and steel sector, which is a very significant source for Wales. The largest methane source is from enteric fermentation in cattle (4A1) which represents 3.1% of GHG emissions in 2009, and the largest source of nitrous oxide emissions is agricultural soils (4D) representing 5.2%. Together, the ten categories listed in Table 4.1 accounted for 89% of the Welsh total net emissions in 2008.

Table 4.1 GHG Emissions Summary for Wales in 2009

Summary of Main GHG Emission Sources, Wales 2009 (kt CO_2e)				
Gas	Sector Name	IPCC code	Emission	Percentage of total GWP Weighted Emissions
1	Power stations	1A1a	11,266	26.4%
2	Road transport	1A3b	5,722	13.4%
3	Iron and Steel	1A2a	4,611	10.8%
4	Residential Combustion	1A4b	4,216	9.9%
5	Refineries	1A1b	3,337	7.8%
6	Other Industrial Combustion	1A2f	3,173	7.4%
7	Agricultural Soils	4D	2,201	5.2%
8	Enteric fermentation - Cattle	4A1	1,332	3.1%
9	Land Converted to Cropland	5B2	1,042	2.4%
10	Landfill	6A1	922	2.2%

Note – The way the emissions are quoted in this table differs slightly from the equivalent table published in the 2009 report, and total GHG emissions for each sector on a GWP basis are now quoted.

Note that in the NCF sector discussion text below, the percentages quoted are derived from the inventory and emissions data stored at full precision. These data can be found on the NAEI web site and on the CD-ROM that accompanies this report. The percentages in the text of this chapter do not in all cases match directly with percentages in the above table (which are quoted as % of the total of all six GHG emissions).

4.2 Energy Supply

Emissions from the Energy Supply sector are dominated by emissions of carbon dioxide from combustion sources, which represent 93.2% of total GHGs in this sector in 2009; emissions of methane and nitrous oxide from fuel combustion account for the remaining 6.8% of the total GHG emissions from the energy sector. Fugitive emissions from fuels are an important source of methane, accounting for 22.4% of the Welsh methane emissions in 2009; these emissions are primarily from leakage from the natural gas supply network and methane seepage from mining activities. Collectively, the Energy Supply sector accounts for 38% of total Welsh GHG emissions in 2009.

The largest source of carbon dioxide emissions in Wales is Energy Industries (IPCC sector 1A1), which includes power generation, refineries and solid fuel transformation processes. Power generation (1A1a) contributed an estimated 32.2% of the total Welsh carbon dioxide emissions in 2009, which is slightly higher than the UK proportion of 31.8%. GHG emissions from power generation in Wales have increased by 0.015% compared with a fall of 26.3% in UK emissions over 1990 to 2009 (Figure 4.1), but annual generation figures have varied considerably during this period, including a rise of 29.5% in power station emissions between 2007 and 2008 due to the re-opening of Aberthaw.

Electricity generation and consumption data (DECC, 20010b) indicate that in 2009 Wales exported 8,287 GWh of electricity to England, which is just over 26% of all power generated in Wales. The amount of electricity exported from Wales in 2009 has decreased from that exported in 2008 (11,682 GWh), which reflects the decrease in electricity demand in England in 2009.

[*The Wales GHG "end user" emission estimates presented in Chapter 10 re-allocate the emissions from power stations where electricity is generated in Wales and then exported to be consumed in England.*]

There is now only one nuclear power station in operation in Wales, contributing 19% to power generation in 2009, whilst there has been a growth of Combined Cycle Gas Turbines stations (CCGTs) partly to replace the generating capacity from Trawsfynydd Nuclear Station, which closed in 1991. The increase in generation capacity in Wales comes from the opening of a 500 MW CCGT at Deeside in 1994, a 1,420 MW CCGT at Connahs Quay in 1996, a 250 MW CCGT at Barry in 1998, and a 575 MW CCGT at Baglan Bay in 2002. The remaining fossil fuel generation is from two conventional coal stations; the coal-fired station at Uskmouth closed and subsequently re-opened as Fifoots after being upgraded and fitted with Flue Gas Desulphurisation. Aberthaw is the other conventional coal station. One power station (oil-fired) at Pembroke has closed.

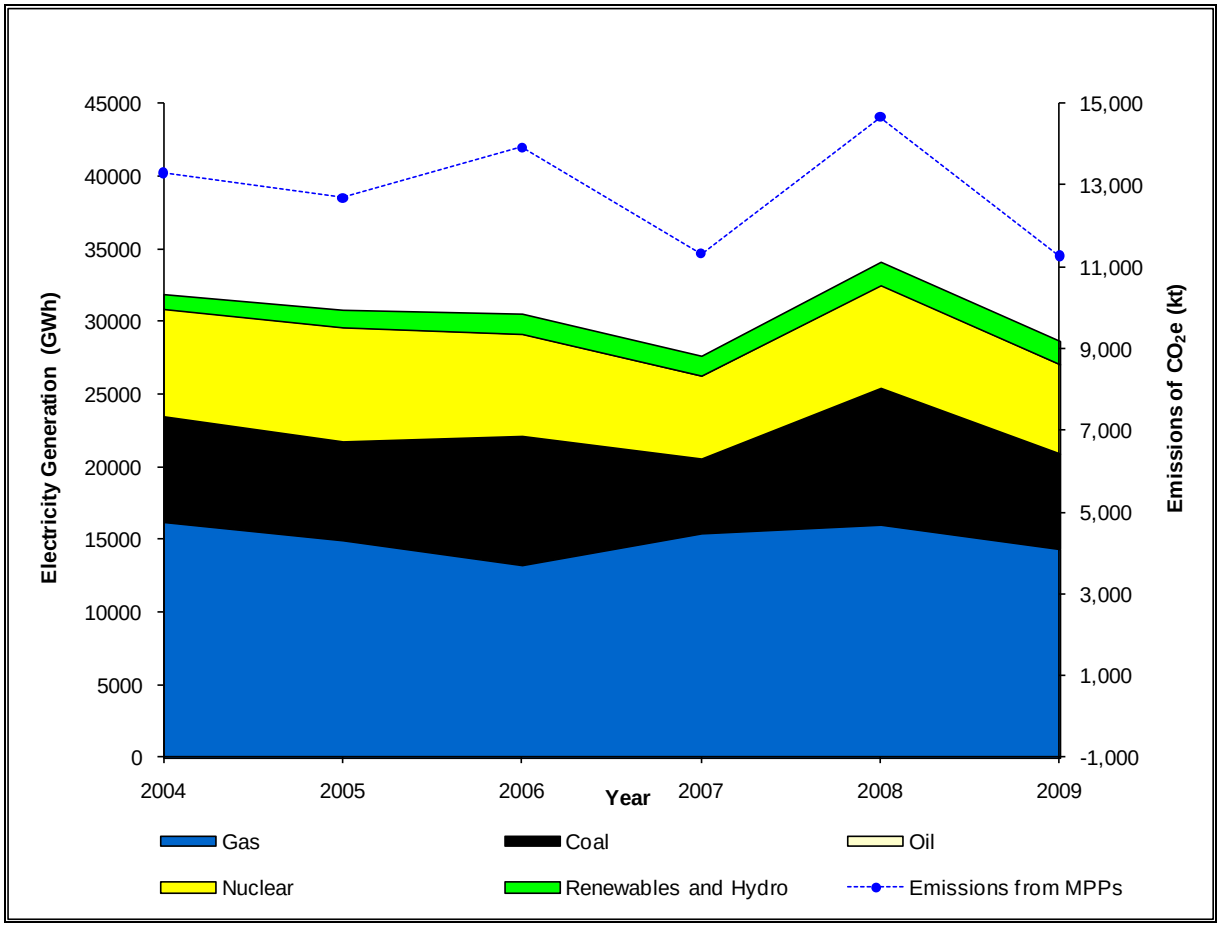
Figure 4.1 summarises data for the predominant sources of power-generation in Wales, and indicates that gas represents the principal source of power generation in Wales, with an estimated 14,376 GWh in 2009. Coal represented the second most significant source of power-generation (6,547GWh), followed by nuclear energy (6,122GWh). Energy generated from renewable sources was estimated to contribute 1,610GWh in 2009, a decrease of 17 GWh from 2008. The remaining portion of electricity is from the Other Generators category, which includes all generators that are not classified as Major Power Producers (except for those using renewables, which are included within the Renewables category), and hydro pumped storage.

Table 4.2 and Figure 4.1 below present data for the Major Power Producers (MPPs) in Wales, excluding power generation by autogenerators.

Table 4.2 Greenhouse Gas Emissions Intensity of Electricity Generated by Major Power Producers in Wales, 2003 to 2009 (kt CO_2e/GWh)

Greenhouse Gas emission intensity of electricity generation by Major Power Producers in Wales (2003-2009)							
Emission year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Power generation emissions (kt CO_2e)	10,795	13,295	12,683	13,923	11,322	14,663	11,266
GWh Generated by Major Power Producers	28,103	33,020	32,254	32,203	29,773	36,554	30,637
kt CO_2e / GWh	0.384	0.403	0.393	0.432	0.380	0.401	0.368

Figure 4.1 Power Station GHG Emissions and Electricity Generation by Fuel by Major Power Producers in Wales, 2004 to 2009



Petroleum refining (1A1b) constitutes 9.5% of Welsh carbon dioxide emissions in 2009 compared with 3.1% for the UK as a whole, which reflects the significance of the Pembroke and Milford Haven refineries. Other energy emissions (1A1c) are mostly combustion emissions from coke ovens and solid fuel plant and account for 1.3% of the 2009 Welsh carbon dioxide total emission.

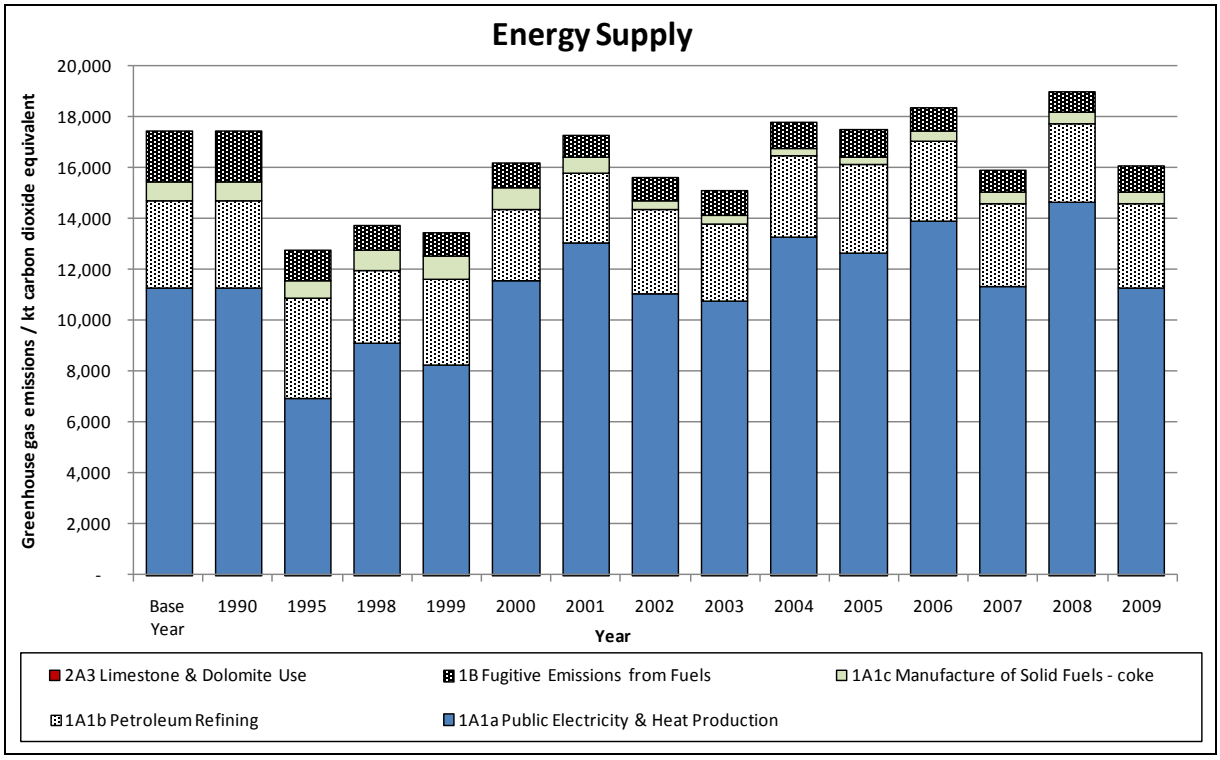
There are no significant emissions from oil and gas production. Note that only those emissions arising from on-shore installations in Wales have been included within the Welsh GHG inventory; emissions from offshore oil & gas exploration and production facilities are reported as “Unallocated”.

The category Fugitive Emissions from Fuels (IPCC Sector 1B) reports emissions from coal mining, coke production, oil and gas processes and natural gas distribution. The majority of these emissions are methane constituting 22.4% of the Welsh total methane emission in 2009, with much smaller contributions from nitrous oxide and carbon dioxide.

The largest methane source in this category is coal mining, which represents 16.9% of total Welsh methane emissions in 2009, and 26.4% of total UK emissions from this IPCC sector (1A1b). Emissions from this source have decreased by 50.4% since 1990 due to the decline in the mining industry in Wales.

The other major source of methane is leakage from the gas network, which amounts to 5.4% of the Welsh methane total. This emission has decreased by 28.7% since 1990, due to the renewal of the gas supply network.

Figure 4.2 GHG Emissions from Energy Supply in Wales, 1990 to 2009

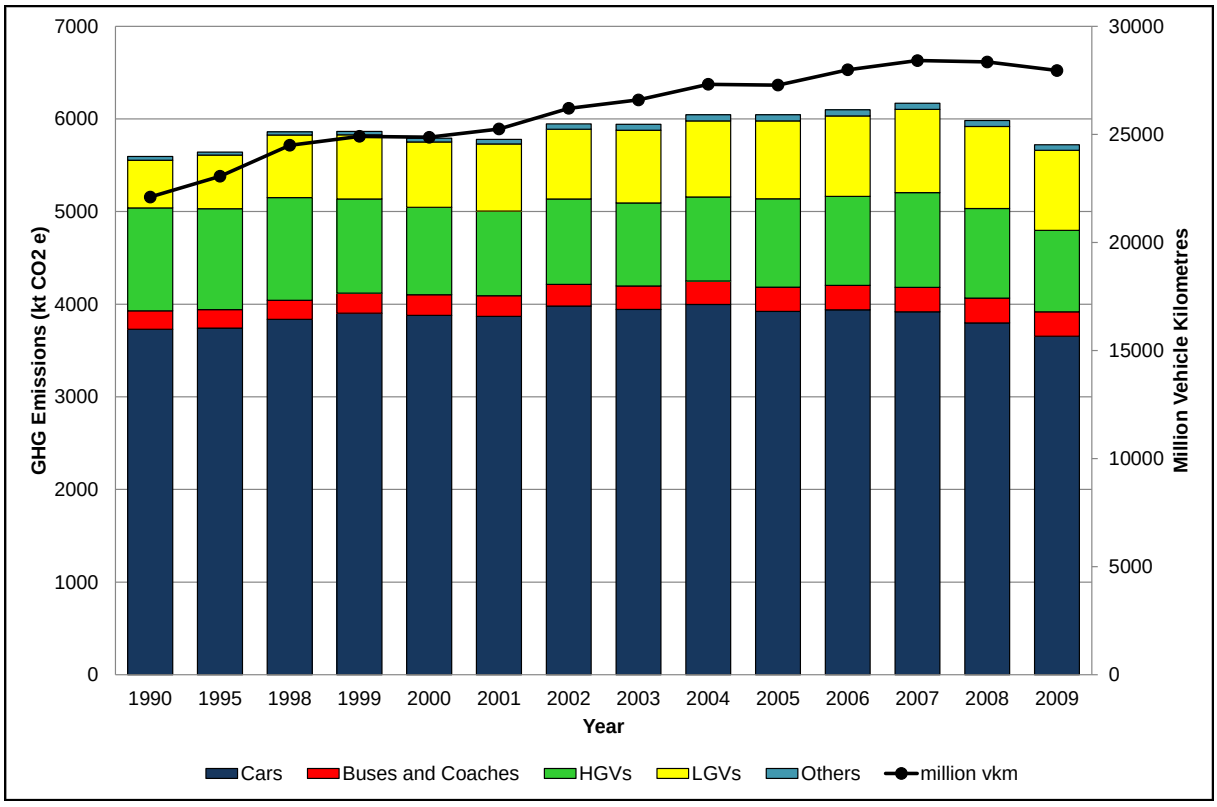


4.3 Transport

Transport includes emissions from aircraft, road, railways and shipping. In Wales, transport contributed 14.5% of the total Welsh GHG emissions (or 17.5% of total Welsh carbon dioxide emissions) in 2009. 99% of emissions in the Transport sector are carbon dioxide, and the largest source of carbon dioxide in this sector arises from road transport, accounting for 93.1% of carbon dioxide emissions.

Road Transport represents the second largest single source of carbon dioxide in Wales contributing 16.3% to the Welsh total carbon dioxide emission. The contribution of Welsh road transport to UK road transport carbon dioxide emissions is 5.1%, which is broadly consistent with that anticipated from Wales' population (4.9% of UK[12]). Emissions from the road transport sector in Wales have risen by 3.0% from 1990 to 2009 compared with a 2.7% rise for the UK as a whole; however from 2007 to 2009 emissions have fallen by 7.1% in Wales, and 7.3% in the UK as a whole. Emissions from the road transport sector are dominated by emissions from cars that constitute approximately 63.9% of emissions in 2009. Heavy goods vehicles represent the second most significant source of GHG emissions with 15.4% of the sector total.

Figure 4.3 Total Road Traffic Vehicle km and GHG Emissions from Different Vehicle Types: Wales, 1990 to 2009



Aviation (domestic cruise and take off and landing), rail and shipping (coastal, naval and fishing vessels) are estimated to account for 0.1%, 0.4% and 0.5% of the total Welsh carbon dioxide in 2009 respectively. There is an overall increase in avaiation and rail emissions between 1990 and 2009, whilst there is a general reduction in shipping emissions. However, estimates from these sources (rail and shipping) are subject to high uncertainty given the limited DA-specific activity data. Electricity use from rail sector is included within the end user emission estimates within Chapter 10.

[12] Where population percentages are quoted throughout this report, they are taken from ONS data for 2009.

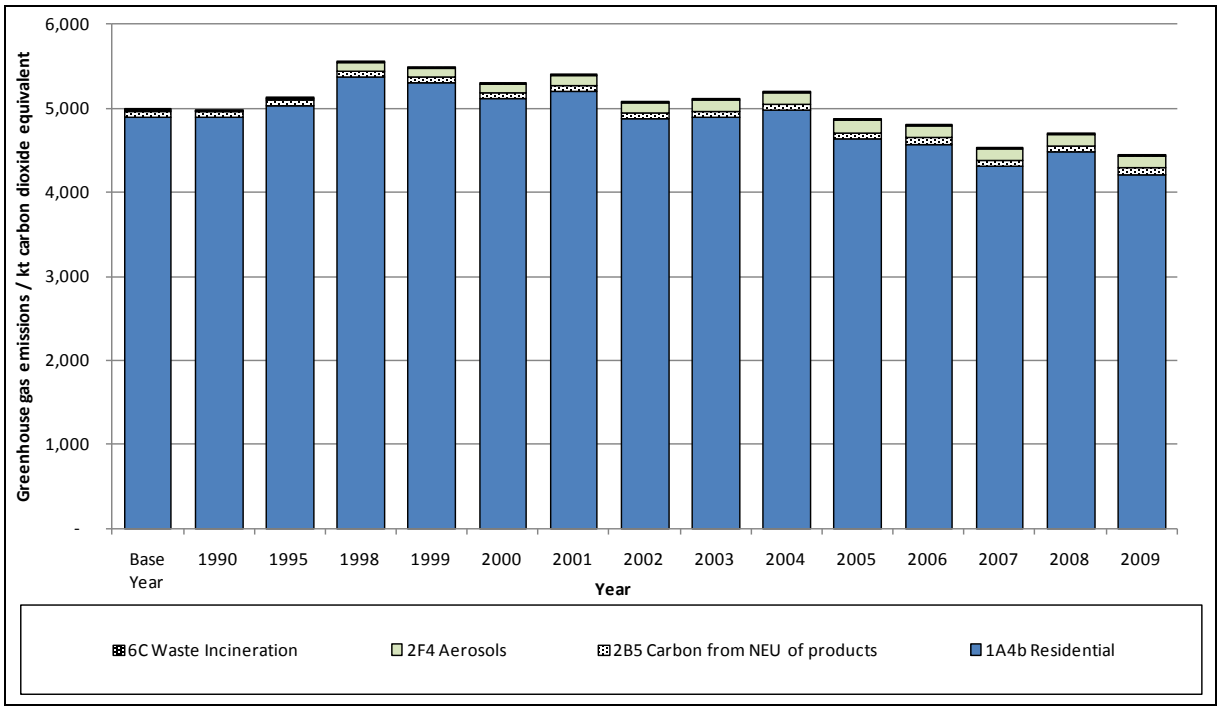
4.4 Residential

The residential sector includes emissions from domestic combustion, household products and accidental vehicle fires, and accounts for 10.4% of GHG emissions, and 12.1% of carbon dioxide emissions in Wales in 2009. As a proportion of UK domestic emissions they are estimated to represent 5.7%, which is slightly higher than the Wales share of UK population (4.9% in 2009), reflecting the higher incidence of solid fuel and oil-fired domestic heating from rural areas and in coal mining areas in Wales.

Domestic combustion is the largest source of carbon dioxide in this sector, accounting for 97.8% of carbon dioxide, and 94.8% of all GHG emissions in the sector. IPCC sector 1A4b (Residential combustion) includes domestic combustion for cooking, water heating and space heating, as well as emissions from fuel use in house and garden machinery, and contributes 95.2% to the total GHG emissions in the residential sector, as shown below in Figure 4.4.

Note that combustion emission estimates from the residential sector are subject to uncertainty due to the absence of comprehensive, detailed fuel use data, particularly for solid and liquid fuels.

Figure 4.4 GHG Emissions from the Residential sector in Wales, 1990 to 2009



4.5 Business

The business sector includes emissions from manufacturing industry, construction, industrial combustion, refrigeration, air conditioning, foam and fire fighting, solvents and electronics. The sector accounts for 19.0% of GHG emissions, and 21.9% of CO_2 emissions in Wales in 2009.

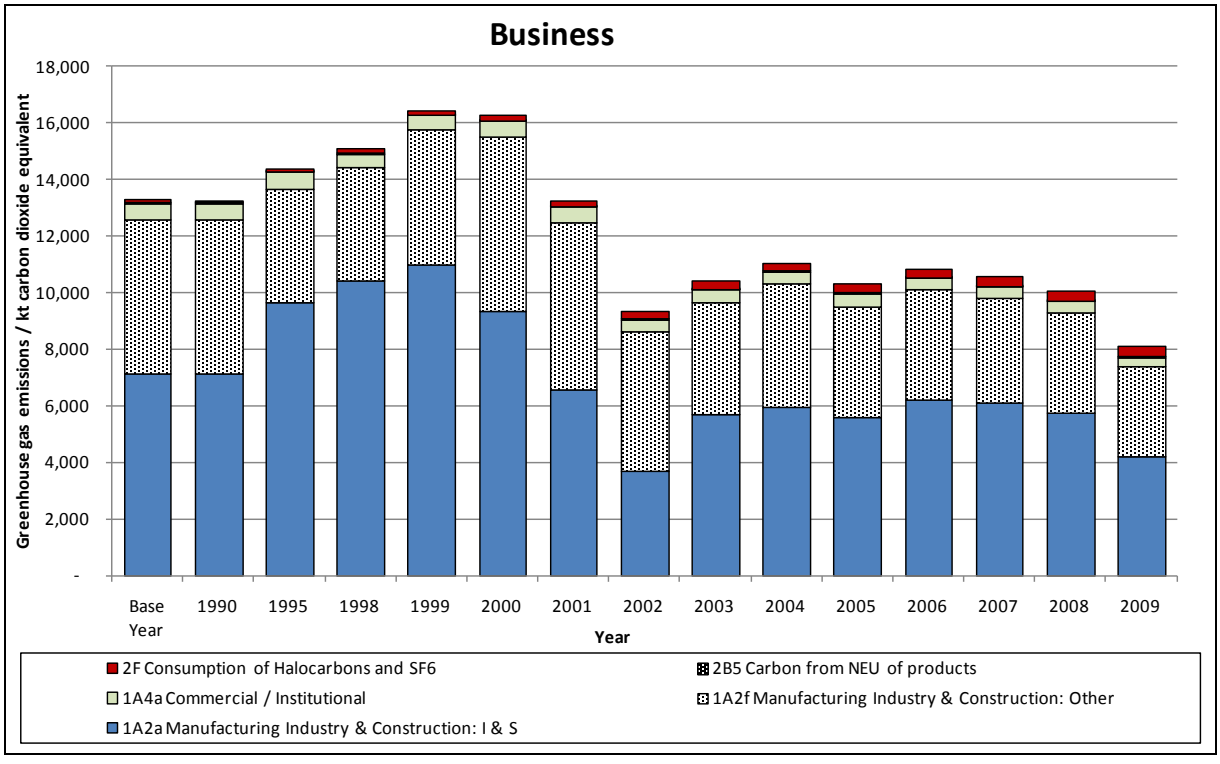
Combustion emissions from manufacturing industries and construction (IPCC sector 1A2) account for 22.0% of the Welsh carbon dioxide total compared with 14.3% for the UK. The high contribution from industry can be explained by the high concentration of iron and steel plant in Wales. This accounts for 31.6% of UK Iron and Steel combustion (1A2a) emissions of carbon dioxide in 2009. The 'Other industry' category (IPCC sector 1A2f) for Wales contributes 5.9% towards the UK 'Other industry' carbon dioxide total.

Sulphur hexafluoride (SF_6) constitutes 0.4% of total GHG emissions from the business sector in Wales, with the main sources of SF_6 emissions coming from its application in electrical insulation, which accounted for 77.8% of SF_6 emissions in Wales in 2009. Overall, the business sector accounts for 86.8% of SF_6 emissions in Wales.

The main source of hydrofluorocarbon (HFC) emissions come from refrigeration and air conditioning equipment, arising from losses during its manufacture and lifetime of equipment, which accounted for 63.2% of HFC emissions in Wales in 2009. Emissions from these sectors have risen by a factor of 7.6 in Wales since the 1995 base year.

Perfluorocarbons (PFC) emissions in the business sector account for 12.4% of PFC emissions in Wales in 2009. Total PFC emissions only account for around 0.009% of total Welsh GHG emissions in 2009. The largest sources in Wales in 2009 were by-product emissions from primary aluminium production (87.6%), electronics (12.0%), and commercial refrigeration (0.3%). Welsh PFC emissions account for 20.4% of total UK PFC emissions, and have declined by 79.5% since 1995.

Figure 4.5 GHG Emissions from the Business sector in Wales, 1990 to 2009

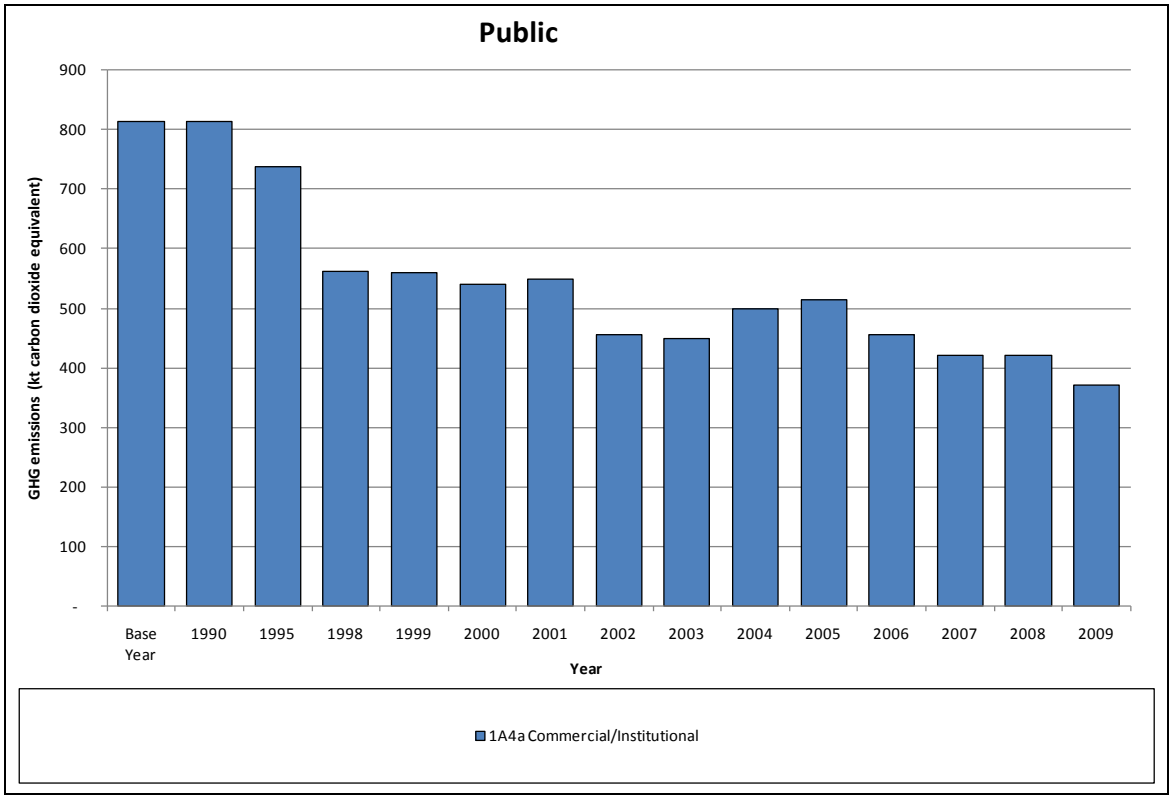


4.6 Public

Emissions from public sector combustion (IPCC Sector 1A4a) account for 1.6% of GHG emissions in Wales in 2009. In Wales 99.7% of emissions in this sector is carbon dioxide, which from 1990 to 2009 have fallen by around 54%.

Note that the emission estimates in the public sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels.

Figure 4.6 GHG Emissions from the Public sector in Wales, 1990 to 2009



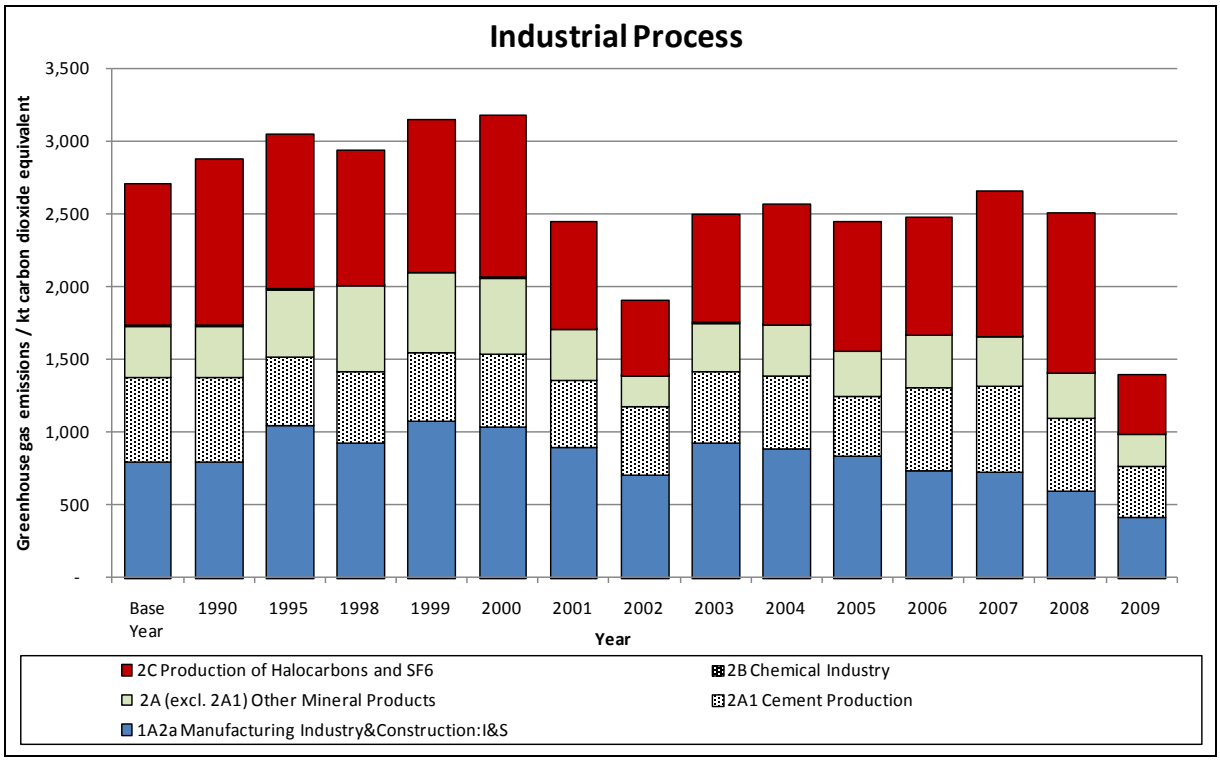
4.7 Industrial Process

The industrial process sector includes emissions from all non-fuel combustion sources in the industrial sector. In Wales, the largest emissions from the industrial process sector is carbon dioxide from processes in the iron and steel sector, which include limestone use in blast furnaces, flaring of blast furnace gas and electric arc furnaces. Emissions from iron and steel processes accounts for 18% of the Welsh total GHG emissions from the Industrial Process sector in 2009. Other significant sources include carbon dioxide emissions from cement, aluminium and glass production, as well as HFC emissions from refrigeration and aerosols. Emissions of methane and nitrous oxide from this sector are not significant.

Carbon dioxide process emissions from cement production accounts for 1.0% of the total carbon dioxide emissions in Wales. Aluminium production in Wales is a significant source of both carbon dioxide and PFC emissions, which together account for 10.9% of total GHG emissions from the industrial process sector in 2009.

Welsh emissions of sulphur hexafluoride are estimated at 7.0% of the UK total in 2009. The source of SF_6 in Wales is from its industry application as a cover gas in magnesium production. This application accounts for around 13.2% of total Welsh SF_6 emissions and comprises 7.0% of emissions of SF_6 from UK magnesium production.

Figure 4.7 GHG Emissions from Industrial Processes in Wales, 1990 to 2009



4.8 Agriculture

Agriculture accounts for 12.5% of total GHG in Wales, and is the most significant source sector for methane and nitrous oxide, accounting for 54% and 87% of total Welsh emissions of these two gases, respectively.

The largest single source of methane emissions in Wales is enteric fermentation from cattle, which accounts for 30% of total Welsh methane emissions in 2009. Within the Agriculture sector, cattle enteric fermentation accounts for 55% of methane emissions, with enteric fermentation in sheep accounting for a further 34% of all agriculture methane emissions. Total emissions arising from enteric fermentation amount to 90% of methane emissions from agriculture, with the remaining 10% of emissions coming from animal wastes. Emissions from agriculture are largely dependent on livestock numbers, and have declined by 18% from 1990-2009 in line with a decrease in sheep and cattle numbers. Total methane emissions decreased relative to 2008 by 2.4%.

The other major source of emissions in the agriculture sector is agricultural soils (7.6 kt N_2O), which constitutes a significant emission of N_2O (41% of the Welsh N_2O total, 93% of the agricultural total). Welsh emissions of N_2O have declined by 29% over the period 1990-2009 and decreased by 0.6% in 2009 relative to 2008.A further breakdown of these emissions is shown below:

[Note: numbers in brackets give the category value as a percentage of the total agricultural N_2O emission]

- synthetic fertiliser application (16.7%)
- leaching of fertiliser nitrogen and applied animal manures to ground and surface water (32.8%)
- wastes from grazing animals (30.2%)
- ploughing in crop residues (1.5%)
- manure used as fertiliser (9.7%)
- atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NOx) (7.3%)
- cultivation of legumes (0%)

- cultivation of histosols (i.e. high organic content soils) (0.5%)
- biological fixation in improved grass (1.2%)

Figure 4.8 GHG Emissions from Agriculture in Wales, 1990 to 2009

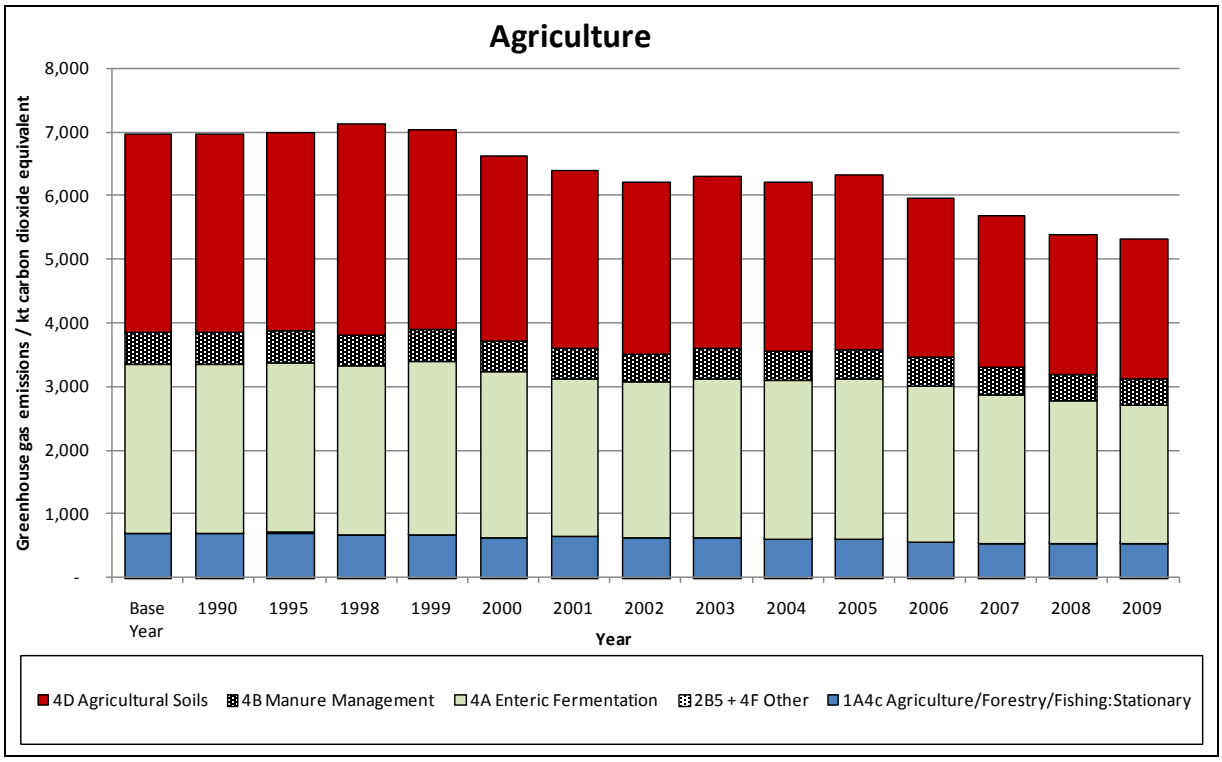


Table 4.3 Livestock Emissions of Methane in Wales by source in 2009 (kt)

Livestock Methane Emissions		
Category	Source	CH_4, kt
Total cattle	Wastes	9.68
	Enteric	63.4
Pigs	Wastes	0.16
	Enteric	0.03
Sheep	Wastes	0.93
	Enteric	39.2
Goats	Wastes	0.00
	Enteric	0.03
Horses	Wastes	0.06
	Enteric	0.82
Poultry	Wastes	0.56
	Enteric	0.00
Deer	Wastes	0.00
	Enteric	0.01

Table 4.4 Emissions of Nitrous Oxide from Agriculture in Wales by source in 2009 (kt)

Agriculture Nitrous Oxide Emissions	
Source	N_2O, kt
Improved Grass	0.09
Legumes	0.00
Crop residues	0.11
Fertilisers	1.17
Histosols	0.04
Animal waste management systems	0.52
Organic fertiliser applied to soil	0.68
Grazing	2.12
Leaching	2.30
Atmospheric deposition	0.51

4.9 Land Use, Land Use Change and Forestry

The LULUCF sector includes carbon stock changes, emissions of GHGs (CO_2, CH_4 and N_2O) by sources and removals of CO_2 by sinks from land use, land use change and forestry activities. Removals of CO_2 are conventionally presented as negative quantities. Total greenhouse gas emissions are described as CO_2e, using Global Warming Potentials (GWP) of 21 for $CH_4$and 310 for N_2O (as used in the inventories submitted to the UNFCCC).

Wales is generally a small net sink of CO_2 from LULUCF activities (Figure 4.9): it was a small net source between 1997 and 1999. The size of this sink has slightly increased between 1990 and 2009: from -0.041 to -0.258 Mt CO_2e. The Forest Land net sink (-1.193 Mt CO_2e in 2009) and the Cropland net source (1.038 Mt CO_2e in 2009) are the largest contributors to the LULUCF sector in Wales.

Estimates of methane (CH_4) emissions from LULUCF activities are small, with 0.002 Mt CO_2e of CH_4 in 2009. Estimated emissions of N_2O are now larger than previously estimated due to the inclusion of N_2O emissions from disturbance associated with land-use conversion to cropland for the first time. There were 0.055 Mt CO_2e of N_2Oemissions in 2009.

Net GHG emissions in 1990 were -0.237 Mt CO_2e in the 2008 inventory and -0.041 Mt CO_2e in the 2009 inventory. In 2008 they were -0.193 Mt CO_2e in the 2008 inventory vs. -0.253 Mt CO_2e in the 2009 inventory (Table 4.5).

Net emissions of carbon dioxide (CO_2) between 1990 and 1999 were higher in the 2009 inventory than in the 2008 inventory, and Wales was a small net source between 1997 and 2000. There were greater net emissions from LUC to cropland and LUC to settlements between 1990 and 1999 in the 2009 inventory, and greater net removals from LUC to grassland (due to changes from a top-down to a bottom-up approach in the LUC model). From 2000 onwards, net emissions decline at a faster rate in the 2009 inventory than in the 2008 inventory, with the reduced emissions from LUC to cropland making the most difference.

The inclusion of N_2O emissions from disturbance associated with land-use conversion to cropland makes a bigger difference, as N_2O has a high GWP. Net emissions of N_2O from this activity were 0.196 Gg N_2O in 1990 (0.061 Mt CO_2e) and 0.178 Gg N_2O in 2009 (0.055 Mt CO_2e).

Figure 4.9 LULUCF Inventory Emissions and Removals by Category for Wales, 1990 to 2009

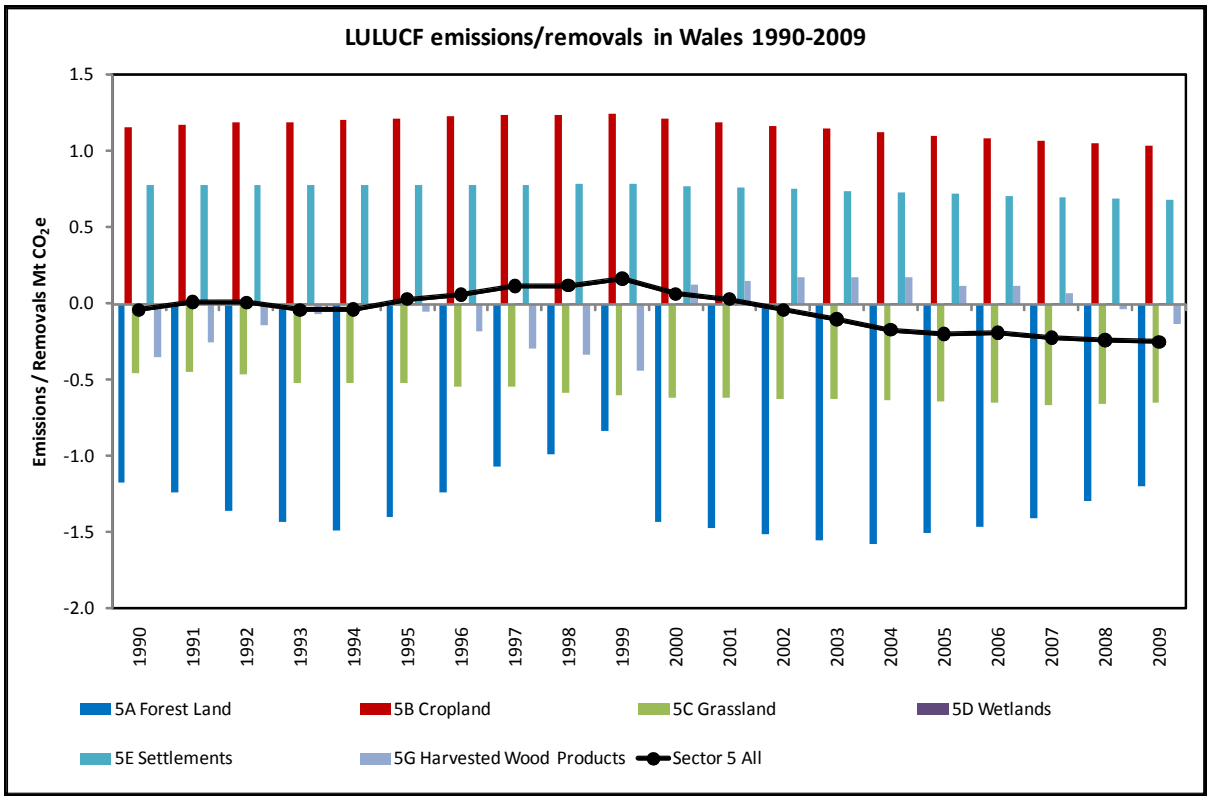


Figure 4.10 Differences between the 2008 and 2009 LULUCF Inventory in Wales

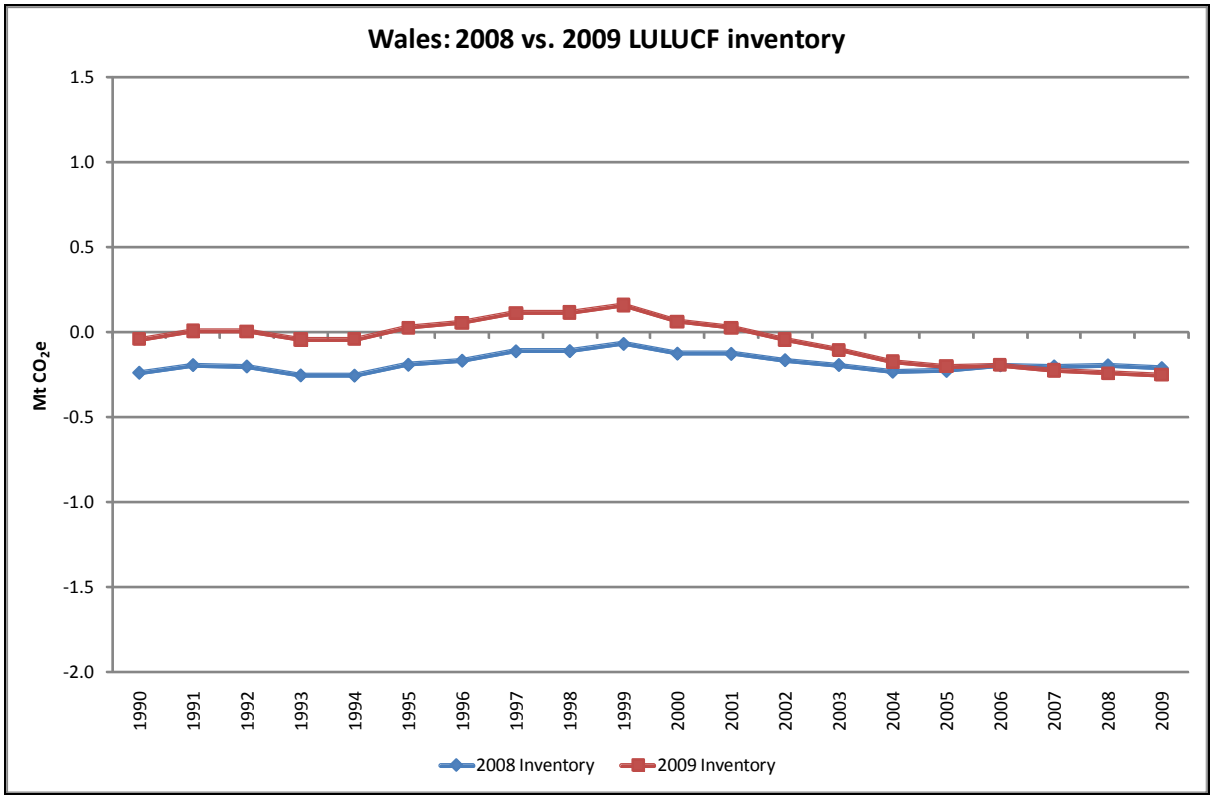


Table 4.5 Difference in 2008 LULUCF net Emission between 2008 and 2009 Inventories in Wales

	5A Forest Land	5B Cropland	5C Grassland	5D Wetlands	5E Settlements	5G Other	Sector 5 All
Difference between 2008 and 2009 inventory		Mt CO_2e					
	0.008	0.000	-0.053	0.000	-0.001	-0.002	-0.048

The annual land use matrices for 1990-1991 and 2008-2009 for Wales are shown here (Table 4.6 and Table 4.7). The off-diagonal items (land use change data from the Countryside Survey, forest planting and deforestation datasets) in the matrix are used to estimate the land use change fluxes in the LULUCF inventory. The diagonal items (land remaining in the same use, in italics) are included for information and have an uncertainty attached as there is not a perfect match between the sum across the columns and the sum across the rows. The total area of Wales is reported as 2,077.9 kha. This is the Standard Area Measurement to mean high water reported by the Office of National Statistics (ONS 2009).

Table 4.6 Land Use Transition Matrix, kha, for Wales in 1990-1991

From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	*282.0±0.3*	0.2	2.4	0	0.2	0.0	**284.5**
Cropland	0.0	*44.0±0.4*	8.0	0	0.1	0	**51.7**
Grassland	1.5	5.5	*1,451.6±1.8*	0	0.6	0.2	**1,461.1**
Wetlands	0	0	0	*0.5*	0	0	**0.5**
Settlements	0.1	0.2	1.8	0	*130.0±0.6*	0.0	**131.6**
Other Land	0.1	0.0	0.2	0	0.0	*148.7±0.5*	**148.5**
Total (initial)	**284.0**	**50.3**	**1,462.2**	**0.5**	**131.5**	**149.3**	***2,077.9***

Table 4.7 Land Use Transition Matrix, kha, for Wales in 2008-2009

From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	*283.2±1.0*	0.1	1.5	0	0.2	0.0	**284.0**
Cropland	0.0	*71.2±0.5*	4.0	0	0.0	0.0	**75.7**
Grassland	0.3	3.5	*1,435.1±1.5*	0	0.5	0.2	**1,441.1**
Wetlands	0	0	0	*0.5*	0	0	**0.5**
Settlements	0.1	0.0	1.2	0	*148.5±0.5*	0.0	**150.3**
Other Land	0.4	0	1.9	0	0.0	*125.5±1.5*	**126.3**
Total (initial)	**285.0**	**74.3**	**1,442.2**	**0.5**	**148.7**	**127.2**	***2,077.9***

The UK reports estimates of emissions and removals from activities in Article 3.3 (mandatory, Afforestation, Reforestation and Deforestation) and Article 3.4 (elective, Forest Management) of the Kyoto Protocol. The emissions and removals from Kyoto Protocol activities in Wales in 2009 are shown in Table 4.8. The methods and assumptions used in these reported emissions are described in Chapter 11 and Annex 3.7 of the National Inventory Report.

Table 4.8 GHG Emissions and Removals from KP-LULUCF Activities in Wales

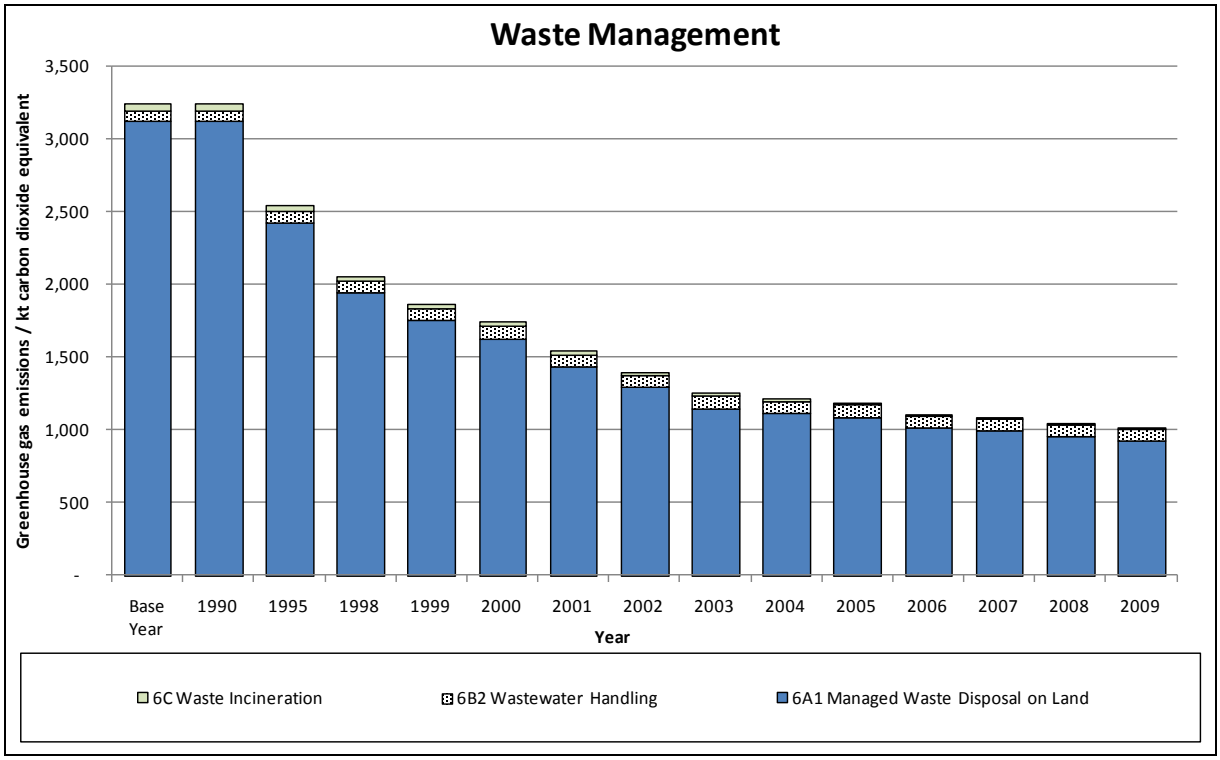
Activity		Wales
3.3 Afforestation & Reforestation	Area, kha	8.79
	Net CO_2 emissions/removals, Mt CO_2	-0.095
	GHG emissions from biomass burning, Mt CO_2e	NO
	N_2O emissions from N fertilization, Mt CO_2e	0.00003
3.3 Deforestation	Area, kha	1.03
	Net CO_2 emissions/removals, Mt CO_2	0.022
	GHG emissions from biomass burning, Mt CO_2e	0.010
	N_2O emissions from LUC to cropland, Mt CO_2e	NO
3.4 Forest Management	Area, kha	152.23
	Net CO_2 emissions/removals, Mt CO_2	-1.111
	GHG emissions from biomass burning, Mt CO_2e	0.014

4.10 Waste

The waste sector contributes 2.4% to total GHG emissions in Wales and is the largest source sector for methane emissions, representing 21% of total CH_4 emissions. GHG emissions in the waste sector are dominated by methane emissions from landfills, which represent 90.9% of total GHG emissions from this sector. The remaining emissions are accounted for by wastewater treatment, and a small emission from waste incineration.

Emissions of methane from landfills represent 20.6% of total Welsh methane emissions in 2009, and have decreased by 70.5% since 1990, due to increasing use of methane capture and oxidation systems. Estimates were based on data on arisings of municipal solid waste and sewage sludge in Wales using data from www.wastedataflow.org. However, there is not a direct link between MSW arising in a year and the methane emissions in that year, as the model takes account of a time-series of MSW inputs, degradation and the methane release curve.

Figure 4.11 GHG Emissions from Waste Management in Wales, 1990 to 2009



[Note that the UK landfill model was updated during the latest inventory cycle, and all methane estimates from 1990 onwards were revised. For further details see Chapter 7 and Appendix 1.]

This data source includes regional data such as tonnages and percentages of MSW treatment and disposal options such as recycling, incineration and landfill, enabling a detailed DA split of waste disposed to landfill to be derived. Data for 2000-2009 are currently available (and the 2000 split is assumed as the best estimate for the 1990-1999 years). Due to lack of detailed local data, the DA disaggregation method still retains the assumption that landfill methane recovery rates are the UK average within each DA.

Emissions from wastewater treatment represent around 0.4% of the Welsh total methane emissions and comprise 4.9% of UK wastewater methane emissions. Nitrous oxide emissions from waste water treatment represent 6.6% of emissions in the sector, and contribute 2.4% to the total emissions of nitrous oxide in Wales.

4.11 Emission Maps: Wales 2009

As part of the NAEI, the UK produces mapped emissions of carbon dioxide (CO_2), methane and nitrous oxide. The maps are modelled estimates of emissions compiled at a 1 km^2 resolution and Figure 4.12 to Figure 4.14 shown the emissions in Wales. The maps reveal the locations and intensities of the major sources of emissions and are used by AEA and other organisations for a variety of Government policy support work at the national scale, regional and local scale. Local area statistics are compiled from the maps and related data, for example, Local Authority level data on carbon dioxide emissions and fuel use have been produced for Defra and DECC since 2003 using data from the NAEI mapping work. As of March 2008, these datasets were reclassified as National Statistics (King et al and Bush et al, 2008). The distributions of methane and nitrous oxide emissions from agricultural sources are generated at a 5 km^2 resolution by the Centre for Ecology and Hydrology (CEH), and are then re-sampled at a resolution of 1 km^2 by the NAEI mapping team.

Emissions maps are produced for the latest year within the NAEI time series, and are available at:

http://www.naei.org.uk/mapping/mapping_2009.php

The most recent emission mapping methodology report can be found at:

http://www.naei.org.uk/reports.php

Figure 4.12 Emissions of Carbon Dioxide (t) in Wales in 2009

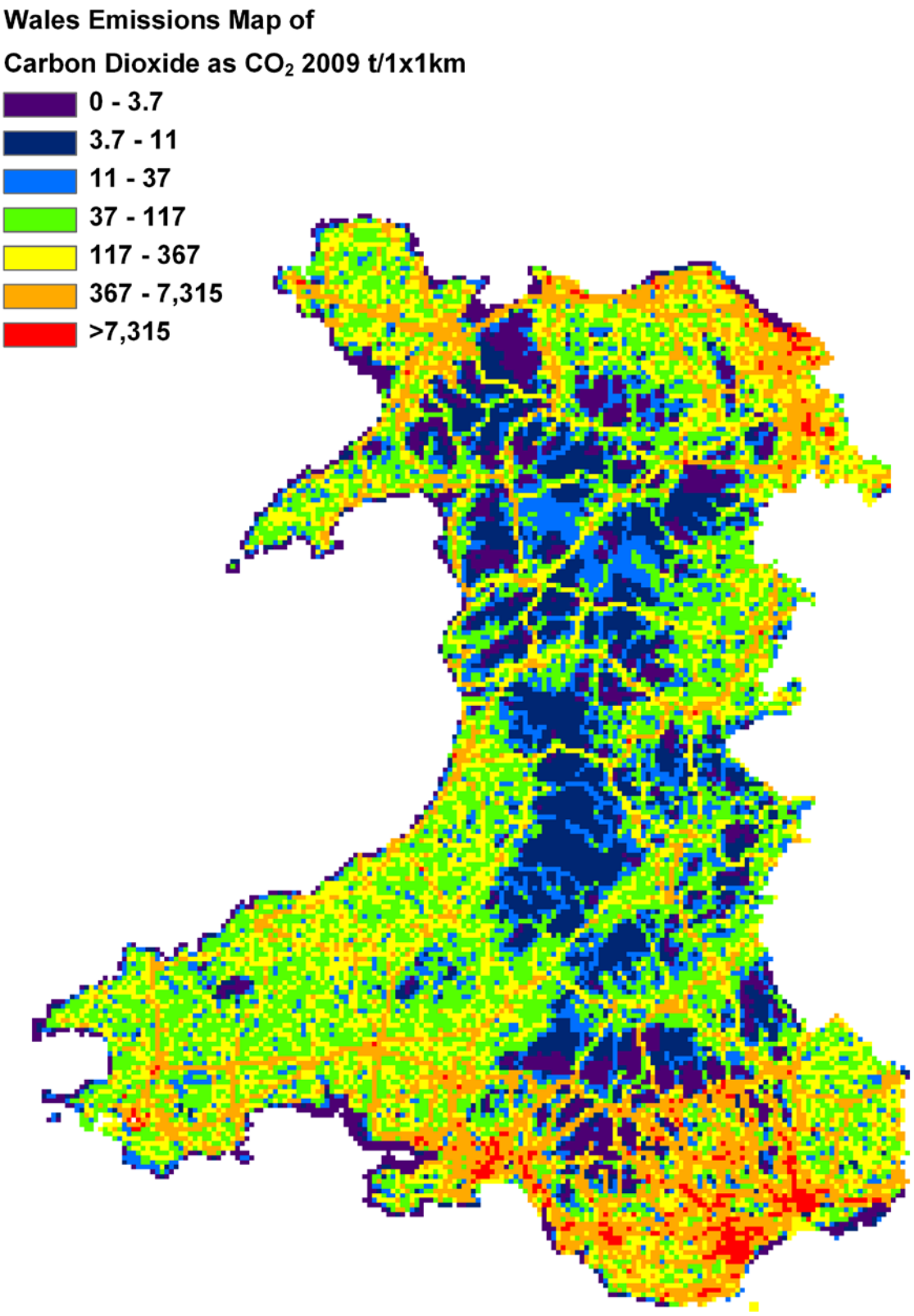


Figure 4.13 Emissions of Methane (t CO_2e) in Wales in 2009

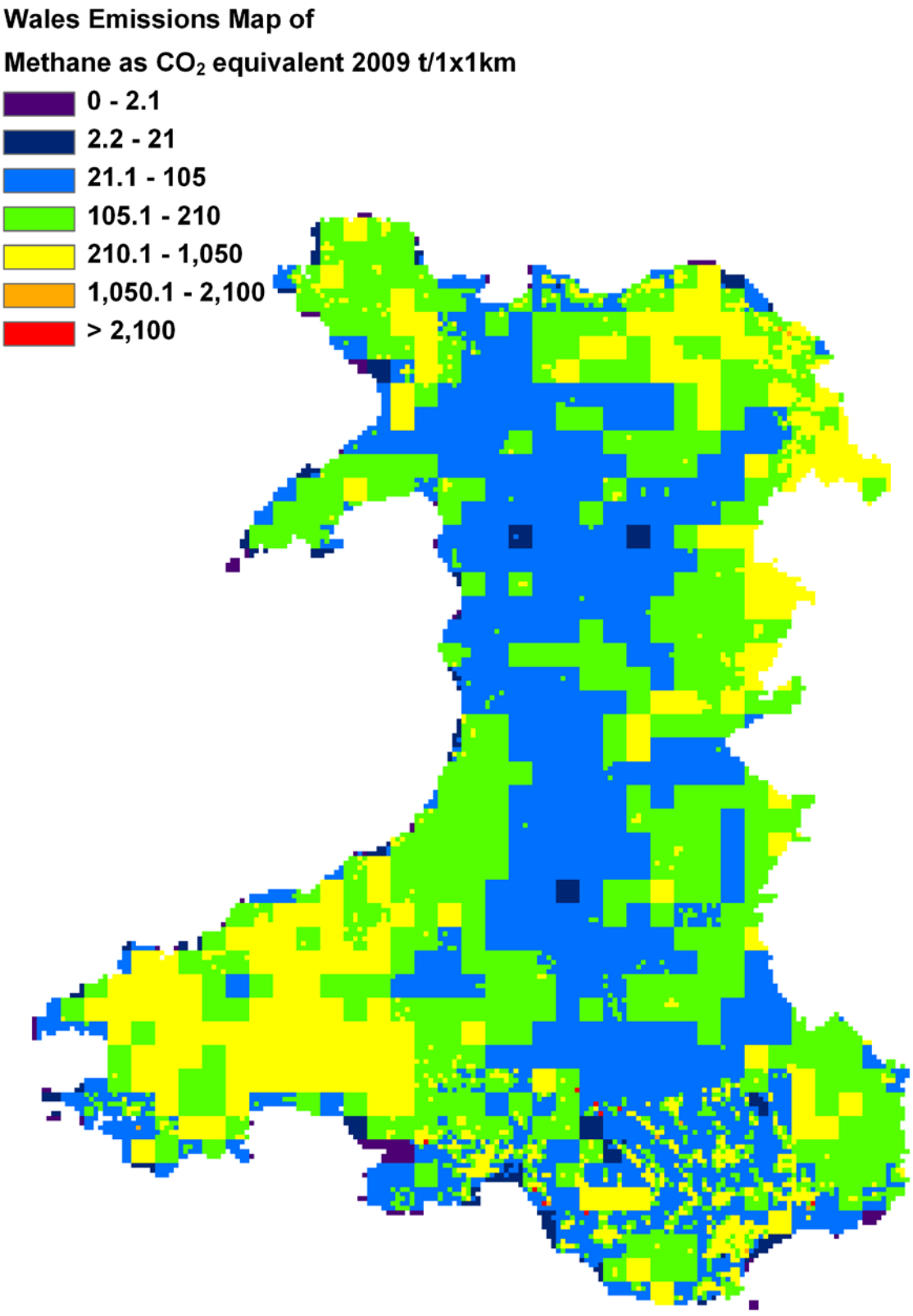
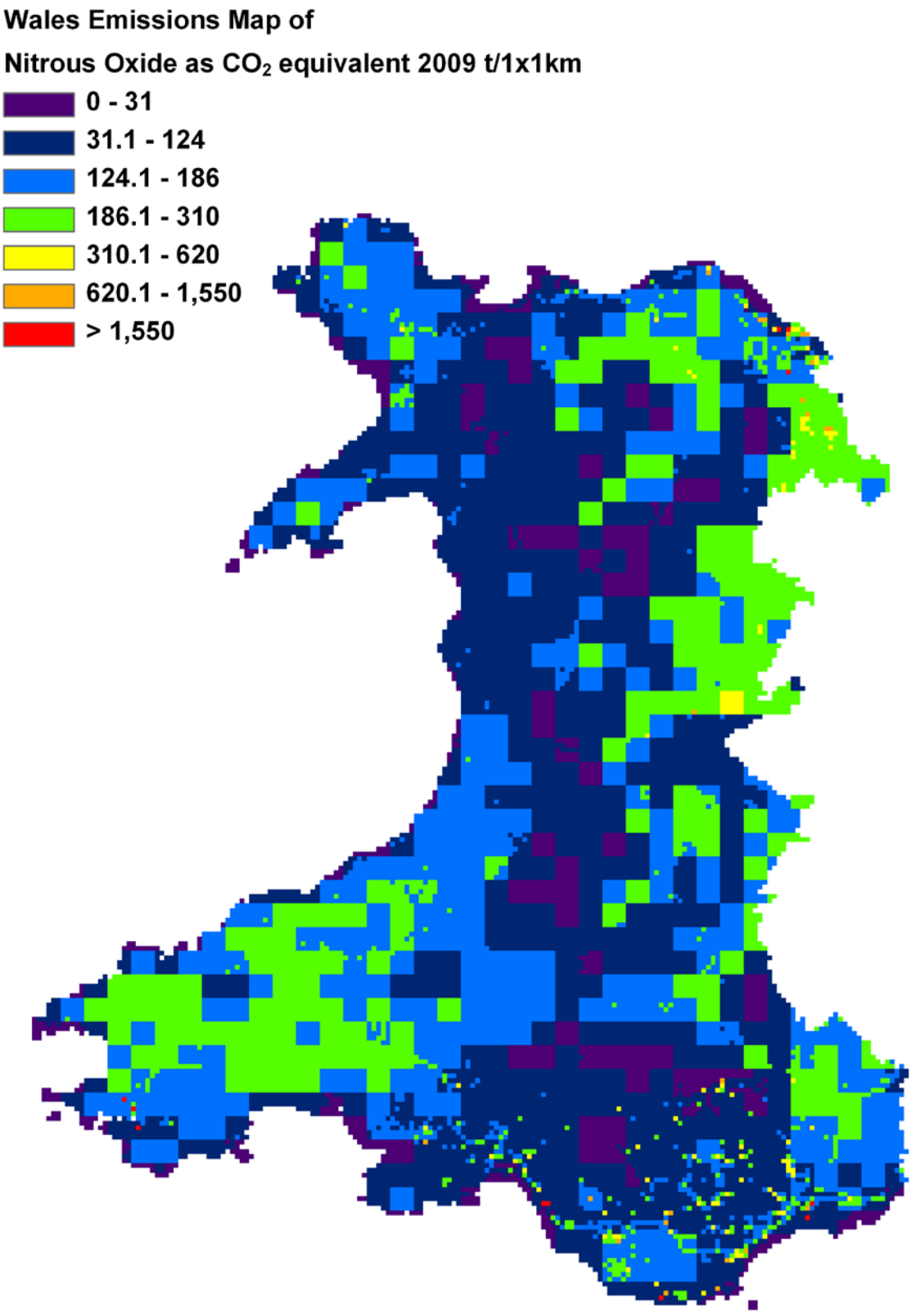


Figure 4.14 Emissions of Nitrous Oxide (t CO_2e) in Wales in 2009



5 Emissions in Northern Ireland

5.1 Summary of GHG Emission Sources

The main GHG emission sources for Northern Ireland in 2009 are summarised in Table 5.1 below, expressed as a percentage of the total Northern Irish GHG emissions in 2009 of 19.5 Mt carbon dioxide equivalent (CO_2e). The trends in Northern Irish GHG emissions since the base years of 1990 (for carbon dioxide, methane and nitrous oxide) and 1995 (for fluorinated gases) are as follows:

- Carbon dioxide emissions have reduced by 18.0%
- Methane emissions have reduced by 29.6%
- Nitrous oxide emissions have reduced by 27.1%
- HFC emissions have increased by 639%
- PFC emissions have reduced by 90.2%
- SF_6 emissions have increased by 201%
- Total GHG emissions (as CO_2 equivalents) have reduced by 20.3%

The total emissions from each National Communication sector are presented in executive summary table ES2.4.3. This table shows that agriculture is the biggest source of GHG emissions in Northern Ireland in 2009, due to high emissions of nitrous oxide from soils and methane from enteric fermentation in livestock. Energy sector emissions in Northern Ireland are also major contributors to the Northern Ireland GHG inventory, dominated by carbon dioxide from power stations, road transport and residential combustion. These three sources account for 55.6% of total net Northern Ireland GHG emissions in 2009.

Table 5.1 GHG Emissions Summary for Northern Ireland in 2009

Summary of Main GHG Emission Sources, Northern Ireland 2009 (kt CO_2e)				
Rank	Sector Name	IPCC code	Emission	Percentage of total GWP Weighted Emissions
1	Road transport	1A3b	3,899	20.0%
2	Power stations	1A1a	3,671	18.8%
3	Residential Combustion	1A4b	3,285	16.8%
4	Agricultural Soils	4D	2,031	10.4%
5	Enteric fermentation - Cattle	4A1	1,842	9.4%
6	Other Industrial Combustion	1A2f	1,335	6.8%
7	Land Converted to Cropland	5B2	1,097	5.6%
8	Land Converted to Settlements	5E2	810	4.1%
9	Landfill	6A1	657	3.4%
10	Agriculture, Forestry and Fishing	1A4c	477	2.4%

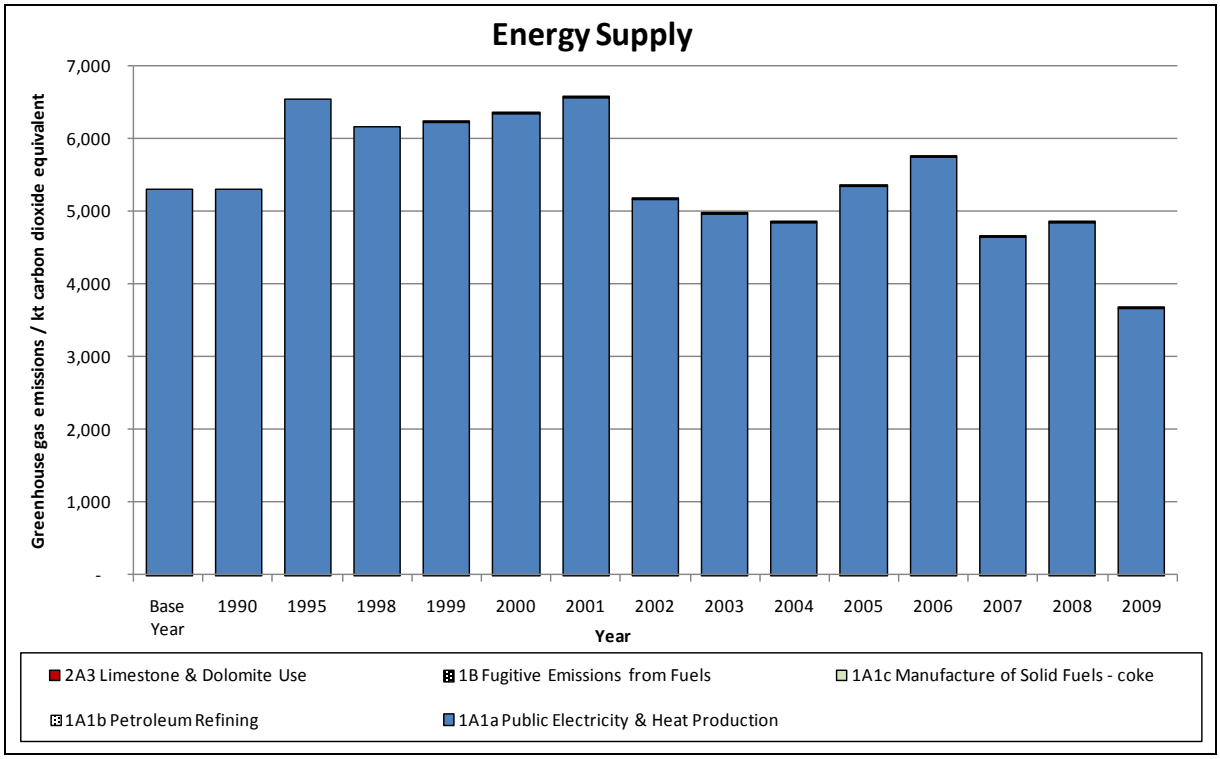
Note that in the NCF sector discussion text below, the percentages quoted are derived from the inventory and emissions data stored at full precision. These data can be found on the NAEI web site and on the CD-ROM that accompanies this report. The percentages in the text of this chapter do not in all cases match directly with percentages in the above table (which are quoted as % of the total of all six GHG emissions).

5.2 Energy Supply

In Northern Ireland, emissions from the Energy sector represent 19% of total GHG emissions in 2009. This is much lower than the UK average contribution from this sector, which in 2009 was 35%. This is because, unlike the other DAs, Northern Ireland does not have any refineries, iron and steel industry, oil and gas terminals or coal mining. In addition, leakage from the gas supply network in Northern Ireland is minimal due to the relatively young age of the network.

The impacts of the All Island Project, to develop a more integrated gas and electricity supply network and market across Northern Ireland and the Republic of Ireland, are unclear in the recent energy sector trends. On 1st November 2007 the Single Electricity Market (SEM) went live, commencing the trading of wholesale electricity in Ireland and Northern Ireland on an All-Island basis. The impacts of this development on power generation within Northern Ireland will be reviewed over the next few years. Generation and emissions from the power sector in Northern Ireland showed signs of a decreasing trend in 2007, 2008 and 2009 compared to 2006, but longer-term trends need to be observed to further understand the effects of the market changes.

Figure 5.1 GHG Emissions from Energy Supply in Northern Ireland, 1990 to 2009



Power generation is the largest source of carbon dioxide in Northern Ireland, accounting for 27% of emissions in 2009. Carbon dioxide emissions from power generation decreased by 24% compared with 2008 emissions, mainly due to a 33% decrease in coal-fired generation to 1,372 GWh, but have declined by 31% since 1990.

The mix of generation capacity is quite different in Northern Ireland from the rest of the UK and from 1990 to 1995 consisted entirely of coal and oil fired stations. In 1996, the largest power station in Northern Ireland, Ballylumford, was converted from oil to use natural gas. The lack of nuclear and renewable generation up to 1996, together with the lack of natural gas contributed to the proportionately higher emissions from electricity generation compared to the other DAs. Moreover, the non-availability of natural gas led to a proportionately higher consumption of electricity than in the rest of the UK, also increasing emissions in the early part of the time-series. The emission of carbon dioxide per unit energy produced is lower for natural gas than other fossil fuels. Natural gas has been supplied to some industrial, commercial and domestic users since 1999 and gas use continues to grow as the supply infrastructure is developed.

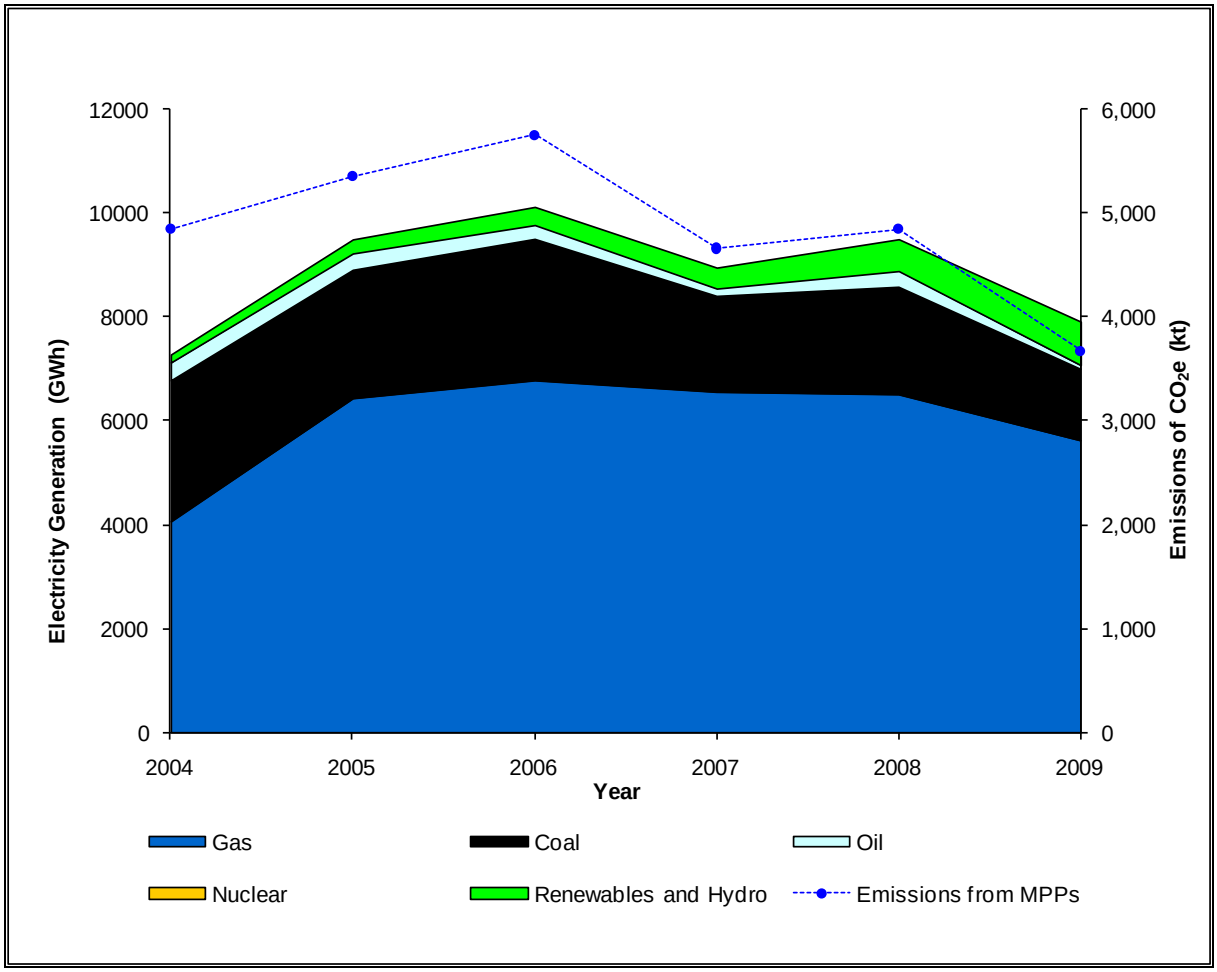
Table 5.2 and Figure 5.2 below present data for the Major Power Producers (MPPs) in Northern Ireland, excluding power generation by autogenerators.

Table 5.2 GHG Emissions Intensity of Electricity by Major Power Producers in Northern Ireland, 2003 to 2009 (kt CO_2e/GWh)

Greenhouse Gas emission intensity of electricity generation by Major Power Producers in Northern Ireland (2003-2009)							
Emission year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Power generation emissions (kt CO_2e)	4,964	4,846	5,356	5,749	4,661	4,844	3,671
GWh Generated by Major Power Producers	6,892	7,141	9,239	9,787	8,780	9,223	7,628
kt CO_2e / GWh	0.720	0.679	0.580	0.587	0.531	0.525	0.481

Northern Ireland generates electricity that can be subsequently exported and sold into the Republic of Ireland electricity grid, whilst the country also imports electricity from Scotland via the Moyle interconnector. In 2005 and 2006 Northern Ireland was a net exporter of electricity (DECC, 2010b); in 2006, net exports from Northern Ireland amounted to 873 GWh of electricity, around 8.5% of all power generated in Northern Ireland. However from 2007 to 2009 Northern Ireland was a net importer of electricity, importing 1,570 GWh of electricity in 2009, around 19.6% of all power generated in Northern Ireland. This was a significant increase from 2007 and 2008, when imports represented 4.4% and 3.4% of consumption respectively.

Figure 5.2 Power Station GHG Emissions and Electricity Generation by Fuel by Major Power Producers in Northern Ireland, 2004 to 2009



[*The Northern Ireland GHG "end user" emission estimates presented in Chapter 10 re-allocate the emissions from power stations where electricity is generated in Northern Ireland and then exported to be consumed in the Republic of Ireland, as well as accounting for electricity imports from Scotland.*]

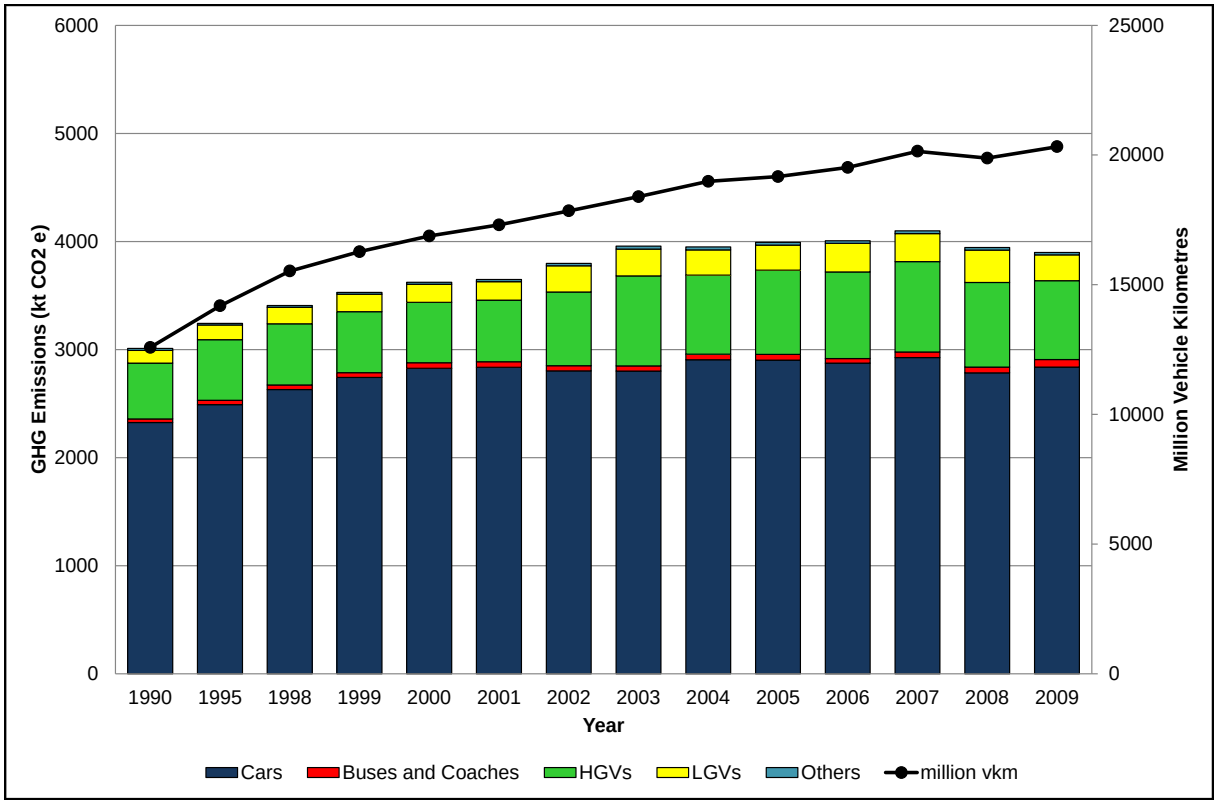
There are no emissions in the category Fugitive Emissions from Fuels, and there are therefore no significant sources of methane in the energy sector in Northern Ireland.

5.3 Transport

Transport includes emissions from aircraft, road, railways and shipping. In Northern Ireland, transport contributes 21.8% to total Northern Irish GHG emissions (or 31.1% of the total Northern Irish carbon dioxide emissions) in 2009. 99% of emissions in the Transport sector are carbon dioxide, and the largest source of carbon dioxide in this sector arises from road transport, accounting for 91.7% of carbon dioxide emissions in the Transport sector.

Road Transport represents the second largest single source of carbon dioxide in Northern Ireland contributing 28.5% to the Northern Irish total carbon dioxide emission. The contribution of Northern Irish road transport to UK road transport carbon dioxide emissions is 3.4% which is slightly more than that which would be anticipated from Northern Ireland' population (2.9% of UK). Carbon dioxide emissions from the road transport sector in Northern Ireland have risen by 30.3% from 1990 to 2009 compared with a 2.7% rise for the UK as a whole, however since 2007, road transport emissions have fallen by 4.8% in Northern Ireland and by 7.3% in the UK as a whole. Emissions from the road-transport sector are dominated by emissions from cars that constitute approximately 72.9% of carbon dioxide emissions in 2009, whilst heavy goods vehicles represent the second most significant source of carbon dioxide.

Figure 5.3 Total Road Traffic Vehicle km and GHG Emissions from Different Vehicle Types: Northern Ireland, 1990 to 2009



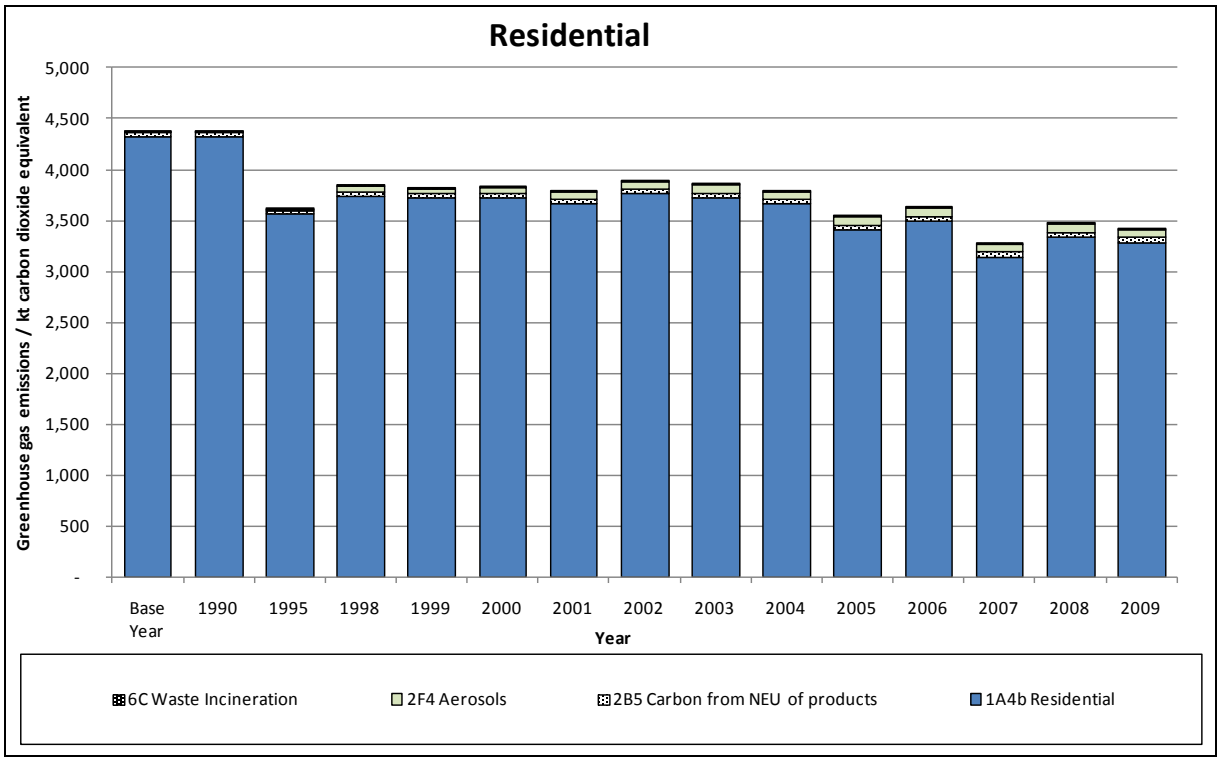
Aviation (domestic cruise and take off and landing) contributed 1.3% of total Northern Irish carbon dioxide emissions in 2009 and there was a 76% increase in emissions between 1990 and 2009. Rail and shipping (coastal, naval and fishing vessels) are estimated to account for 0.3% and 0,6% of total Northern Irish carbon dioxide in 2009 respectively. There is a general increase in rail emissions whilst

there is a general reduction in shipping emissions. However, estimates from these sources are subject to high uncertainty given the limited DA-specific activity data. Electricity use from rail sector is included within the end user emission estimates within Chapter 10.

5.4 Residential

The residential sector includes emissions from domestic combustion, household products and accidental vehicle fires, and accounts for 17.5% of GHG emissions, and 24.2% of carbon dioxide emissions in Northern Ireland in 2009. Domestic combustion is the largest source of carbon dioxide in this sector, accounting for 98.3% of carbon dioxide, and 96.0% of all GHG emissions in the sector. IPCC sector 1A4b (Residential combustion) includes domestic combustion for cooking, water heating and space heating, as well as emissions from fuel use in house and garden machinery, and contributes 96.3% to the total GHG emissions in the residential sector, as shown below in Figure 5.4.

Figure 5.4 GHG Emissions from the Residential sector in Northern Ireland, 1990 to 2009



Carbon dioxide emissions from domestic combustion sources are estimated to account for 23.8% of the Northern Irish total in 2009, and as a proportion of UK domestic emissions, are estimated to represent 4.4% which is higher than would be anticipated from Northern Ireland's 2.9% share of UK population. The reason for this is the very limited availability of natural gas resulting in the high consumption of coal, burning oil and gas oil in the domestic sector, although natural gas is becoming more widely available and residential carbon dioxide emissions have shown a decrease of 20.6% since 1990. Northern Ireland has a proportionately higher consumption of LPG (bottled gas) than the rest of the UK, but in absolute terms this is not a significant source of carbon dioxide emissions. Domestic combustion is also the largest combustion related source of methane, contributing 1.1% to total Northern Irish methane emissions.

Note that the emission estimates in the domestic sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels.

Emissions of HFC from the residential sector account for 28.4% of Northern Irish HFC emissions in 2009.

5.5 Business

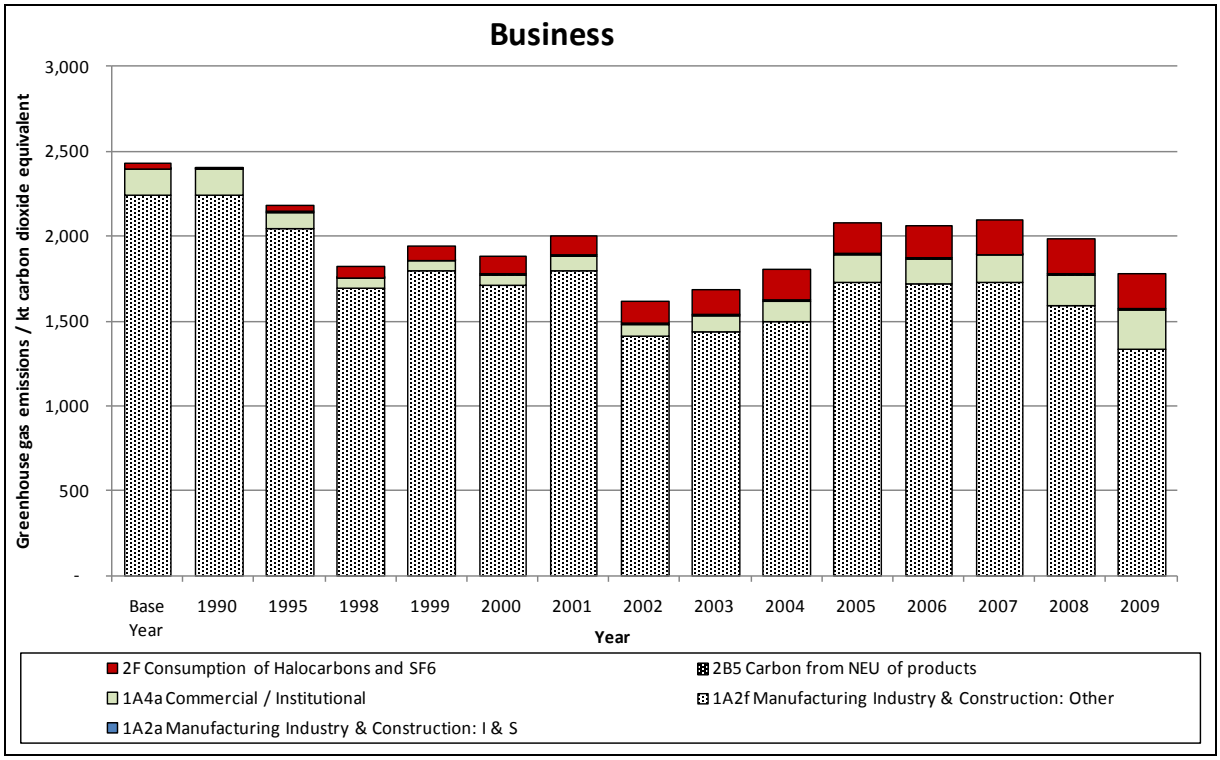
The business sector includes emissions from manufacturing industry, construction, industrial combustion, refrigeration, air conditioning, foam and fire fighting, solvents and electronics. The sector accounts for 9.1% of GHG emissions, and 11.3% of CO_2 emissions in Northern Ireland in 2009.

Combustion emissions from manufacturing industry and construction (IPCC Sector 1A2) account for 9.6% of the total Northern Ireland carbon dioxide emission in 2009 compared with 14.3% for the UK. There is no iron and steel production in Northern Ireland, so the category is entirely 'Other Industry'. The Other Industry category (IPCC sector 1A2f) for Northern Ireland contributes 2.5% towards the UK Other Industry total in 2009, and has decreased by an estimated 40.4% over the period 1990-2009, compared with a UK average 30.2% decrease for this sector. The higher reduction reflects the impacts of a gradual growth in access to the gas network over the last 10 years in Northern Ireland, enabling fuel-switching from more carbon-intensive oil- and coal-fired boilers to gas.

Sulphur hexafluoride (SF_6) constitutes 0.3% of total GHG emissions from the business sector in Northern Ireland, with the main sources of SF_6 emissions coming from its application in electrical insulation, which accounted for 69.4% of SF_6 emissions in Northern Ireland in 2009. The business sector accounts for 100.0% of SF_6 emissions in Northern Ireland.

The main sources of HFC emissions come from refrigeration and air conditioning equipment, arising from losses during manufacture and the lifetime of equipment, which accounted for 65.7% of HFC emissions in Northern Ireland in 2009. Emissions from these sectors have risen by a factor of 8.4 in Northern Ireland since the 1995 base year.

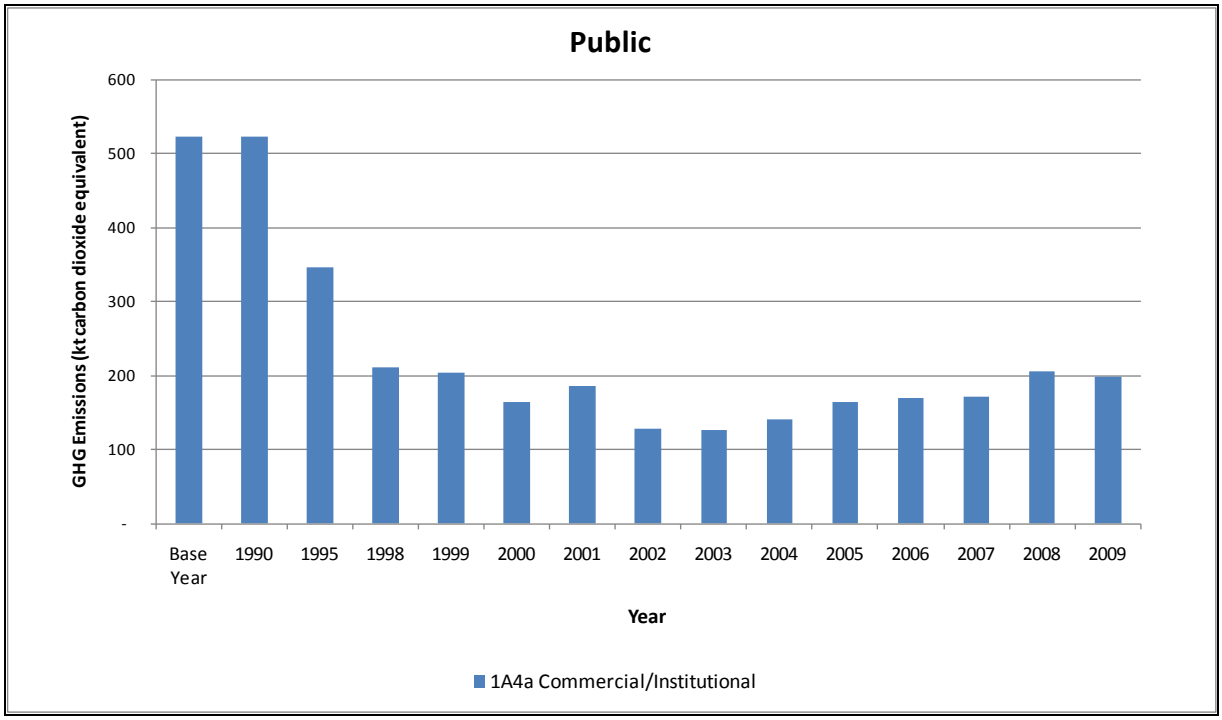
Figure 5.5 GHG Emissions from the Business sector in Northern Ireland, 1990 to 2009



5.6 Public

Emissions from public sector combustion (IPCC Sector 1A4a) account for 1 0% of GHG emissions in Northern Ireland in 2009. In Northern Ireland 99.5% of emissions in this sector are carbon dioxide, which from 1990 to 2009 have fallen by 62%.

Figure 5.6 GHG Emissions from the Public sector in Northern Ireland, 1990 to 2009

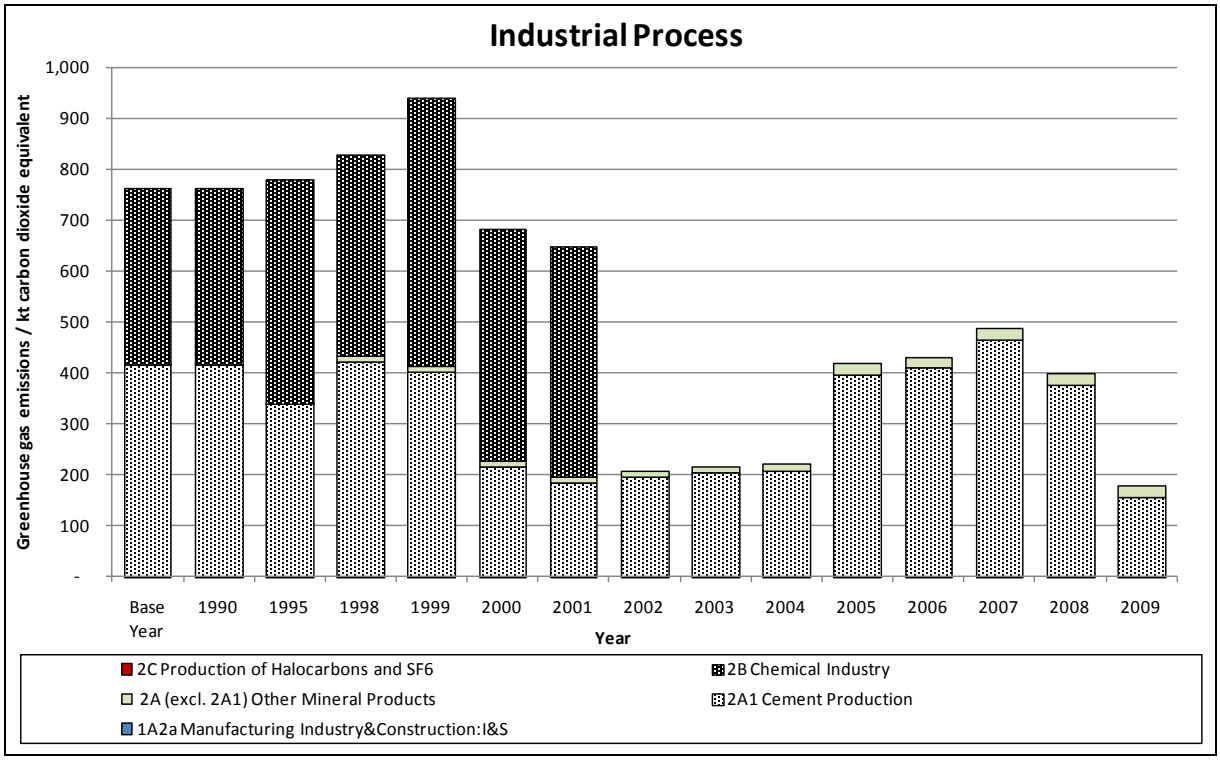


Note that the emission estimates in the public sector are associated with high uncertainty due to the absence of comprehensive, detailed DA-specific fuel use data, particularly for solid and liquid fuels. However, in Northern Ireland the Public Sector Energy Campaign has been reporting on public sector annual fuel use since the early 2000s, and hence the data quality for the later years is much improved. The data for this sector in the 1990s is more uncertain.

5.7 Industrial Process

Total GHG emissions from industrial processes in Northern Ireland contribute 0.9% to the overall emissions total, and are all carbon dioxide emissions in 2009. Approximately 88% of these emissions are process carbon dioxide emissions attributed to the cement industry. In 2009 the sector emissions are 77% lower than in 1990, partly due to the 2009 down-turn in cement production in Northern Ireland which has roughly halved since 2008, but also due to the closure of a nitric acid plant in 2001 and the consequent reduction in nitrous oxide emissions from the chemical industry sector.

Figure 5.7 GHG Emissions from Industrial Processes in Northern Ireland, 1990 to 2009



5.8 Agriculture

Emissions from agriculture represent 26.6% of total GHG emissions in Northern Ireland in 2009, which is a much higher proportion than the UK average (8.8%). Agriculture is the biggest source of GHG emissions in Northern Ireland. This is because there are fewer industry and energy related emission sources in Northern Ireland than there are elsewhere in the UK, and hence agriculture emissions are comparatively more important.

Methane emissions from this sector arise from enteric fermentation in livestock (85%) and the management of animal wastes (15%). The largest single source of methane emissions in Northern Ireland is enteric fermentation from cattle (IPCC sector 4A1). This source alone accounts for 59% of total methane emissions in Northern Ireland, and for 76% of total CH_4 emissions in the agriculture sector. These emissions are dependent on livestock numbers, and have increased by 6.4% since 1990, mainly influenced by an increase in cattle numbers. This is in contrast to the overall trend for the UK, which shows a decrease in emissions of methane from this source. Emissions from Northern Ireland represent 13.5% of total UK agricultural methane. Total CH_4 emissions from agriculture decreased relative to 2008 by 1.4%.

The largest source of N_2O emissions is also in the agriculture sector. Emissions from agricultural soils (6.6kt N_2O) account for 80% of the total Northern Irish N_2O emission in 2009. Northern Irish agricultural N_2O emissions have fallen by 18% between 1990 and 2009, and decreased by 0.3% in

2009 relative to 2008. In 2009 they represented around 8.5% of UK agricultural N_2O emissions. A further breakdown of the agricultural soils sector emission is shown below:

[Note: numbers in brackets give the category value as a percentage of the total agricultural soils N_2O]

- synthetic fertiliser application (16.0%)
- leaching of fertiliser nitrogen and applied animal manures to ground and surface water (33.8%)
- wastes from grazing animals (24.8%)
- ploughing in crop residues (1.2%)
- manure used as fertiliser (15.8%)
- atmospheric deposition of NH_3 and NOx (7.6%)
- cultivation of legumes (0%)
- histosols (i.e. high organic content soils) (0.2%)
- biological fixation in improved grass (1.0%)

Figure 5.8 GHG Emissions from Agriculture in Northern Ireland, 1990 to 2009

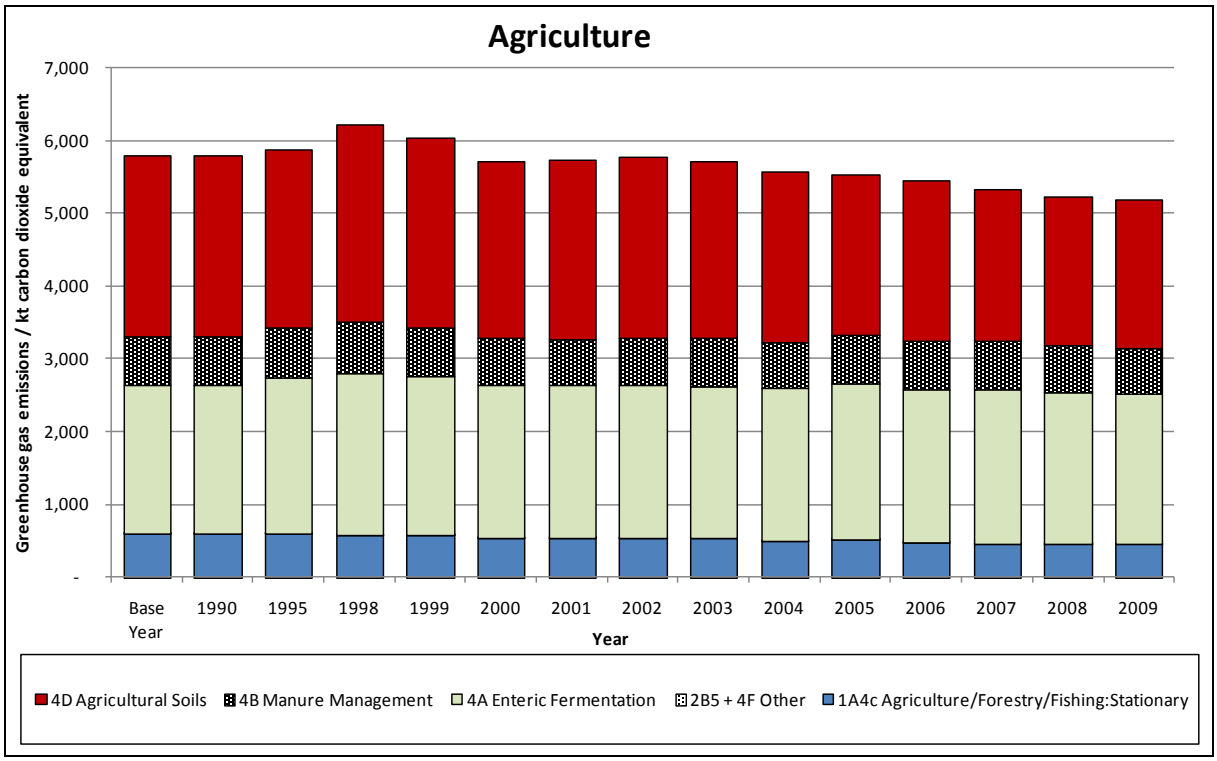


Table 5.3 Livestock Emissions of Methane in Northern Ireland by source in 2009 (kt CH_4)

Livestock Methane Emissions		
Category	Source	CH_4, kt
Total cattle	Wastes	13.19
	Enteric	87.73
Pigs	Wastes	3.06
	Enteric	0.65
Sheep	Wastes	0.21
	Enteric	8.84
Goats	Wastes	0.00
	Enteric	0.01
Horses	Wastes	0.02
	Enteric	0.22
Poultry	Wastes	1.29
	Enteric	0.00
Deer	Wastes	0.00
	Enteric	0.03

Table 5.4 Emissions of Nitrous Oxide from Agriculture in Northern Ireland by source in 2009 (kt N_2O)

Agriculture Nitrous Oxide Emissions	
Source	N_2O, kt
Improved Grass	0.06
Legumes	0.00
Crop residues	0.08
Fertilisers	1.02
Histosols	0.01
Animal waste management systems	0.86
Organic fertiliser applied to soil	1.02
Grazing	1.60
Leaching	2.19
Atmospheric deposition	0.49

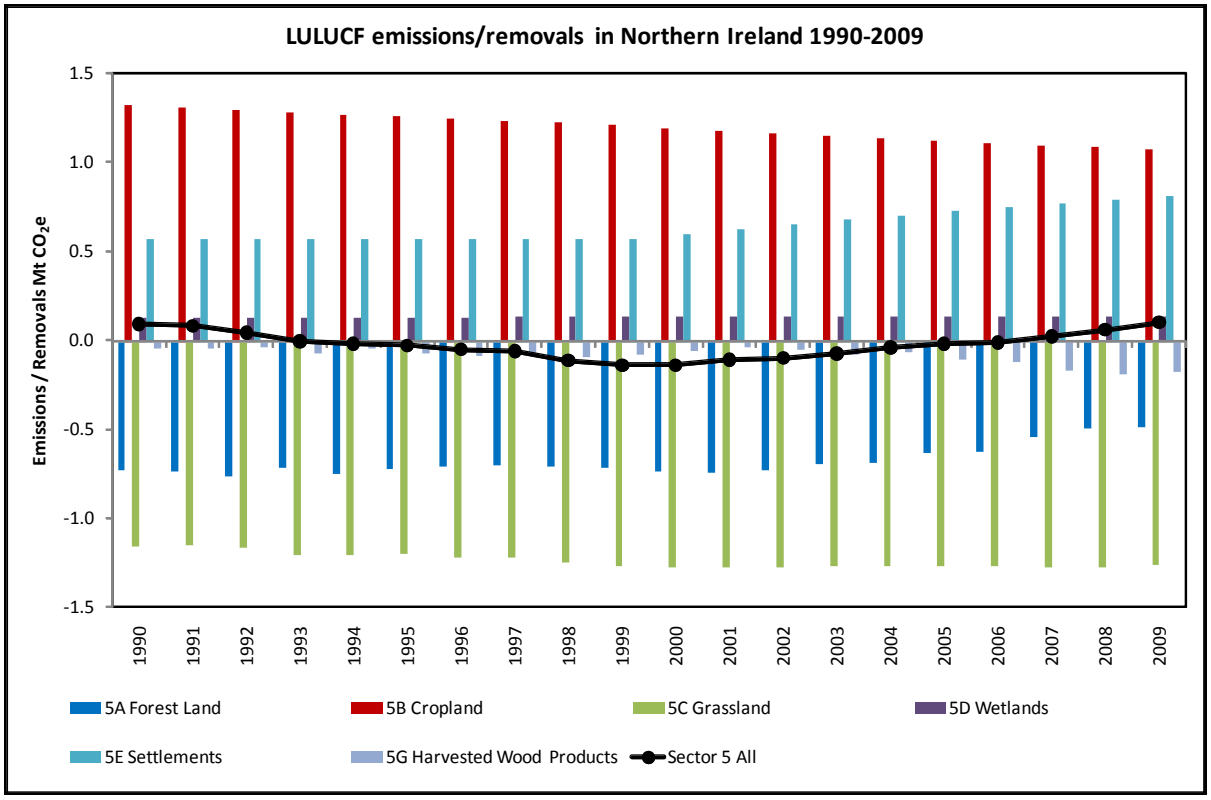
5.9 Land Use, Land Use Change and Forestry

The LULUCF sector includes carbon stock changes, emissions of GHGs (CO_2, CH_4 and N_2O) by sources and removals of CO_2 by sinks from land use, land use change and forestry activities. Removals of CO_2 are conventionally presented as negative quantities. Total greenhouse gas emissions are described as CO_2e, using Global Warming Potentials (GWP) of 21 for CH_4 and 310 for N_2O (as used in the inventories submitted to the UNFCCC).

Northern Ireland was a small net source of GHGs from LULUCF activities in 1990 of 0.080 Mt CO_2e, a small net sink between 1993 and 2006 (reaching -0.140 Mt CO_2e in 1999), and has now returned to being a small net source of 0.100 Mt CO_2e in 2009. The Cropland net source (1.02 Mt CO_2e in 2009) and the Grassland net sink (-1.261 Mt CO_2e in 2009) are the largest contributors to the LULUCF sector in Northern Ireland.

Estimates of CH_4 and N_2O emissions due to LULUCF activities remain small: 0.0003 Mt CO_2e of CH_4 and 0.030 Mt CO_2e of N_2O in 2009.

Figure 5.9 LULUCF Inventory Emissions and Removals by Category for Northern Ireland, 1990 to 2009

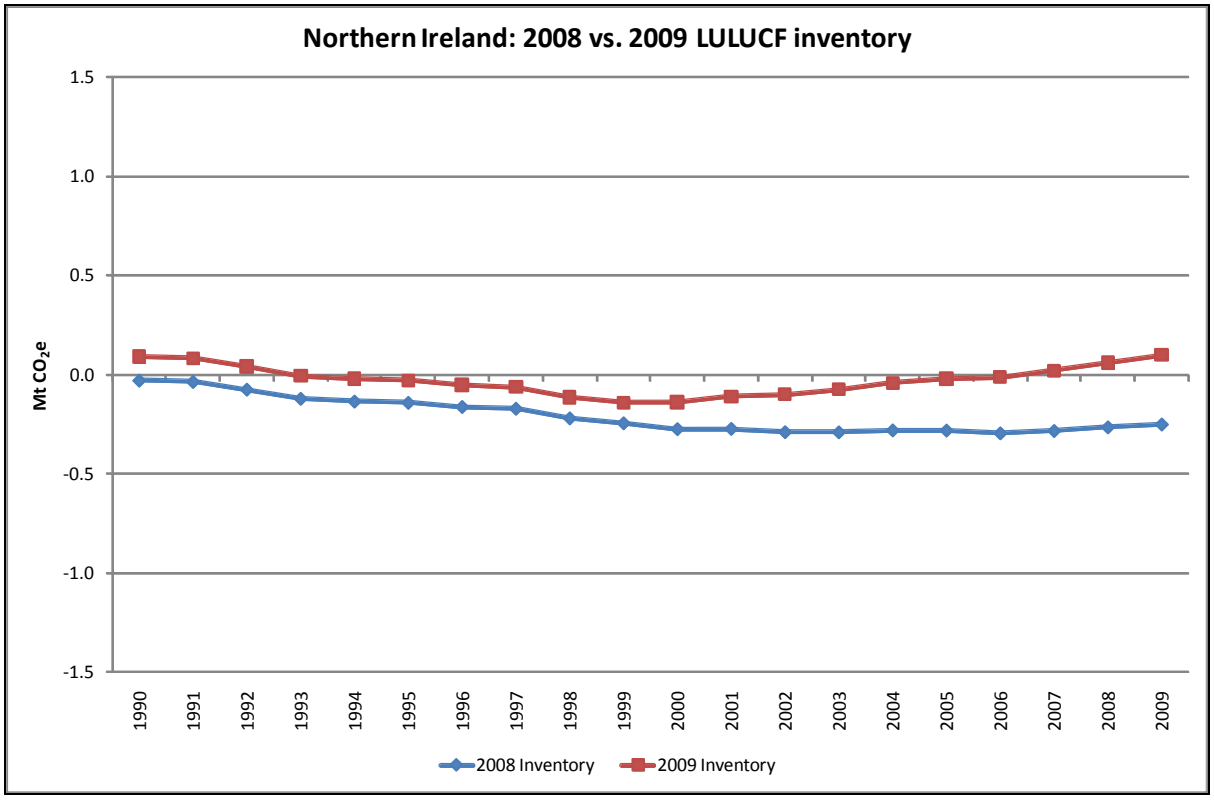


Net GHG emissions in 1990 were -0.028 Mt CO_2e in the 2008 inventory and 0.080 Mt CO_2e in the 2009 inventory. In 2008 they were -0.265 Mt CO_2e in the 2008 inventory vs. 0.062 Mt CO_2e in the 2009 inventory.

Net emissions of CO_2 between 1990 and 1999 were slightly higher in the 2009 inventory compared to the 2008 inventory. This is due to a reduced net sink in the LUC to grassland category (due to changes in the LUC model from a top-down to a bottom-up approach) and increased emissions from the wetlands category (reported for the first time). From 2000 onwards, there is wider divergence between the inventories, with net emissions increasing at a greater rate in the 2009 inventory. This is from a combination of wetlands emissions, reduced net emissions from LUC to cropland and increased net emissions from LUC to settlements and grassland. Some emissions from peat extraction were also moved from the grassland category to the wetlands category, applied to the whole time series.

The inclusion of N_2O emissions from disturbance associated with land-use conversion to cropland makes a bigger difference, as N_2O has a high GWP. Net emissions of N_2O from this activity were 0.23 Gg N_2O in 1990 (0.071 Mt CO_2e) and 0.09 Gg N_2O in 2009 (0.029 Mt CO_2e).

Figure 5.10 Difference in 2008 LULUCF net Emission between 2008 and 2009 Inventories in Northern Ireland



The annual land use matrices for 1990-1991 and 2008-2009 for Northern Ireland are shown here in table 5.6 and table 5.7.

Table 5.5 Difference in 2008 LULUCF net Emissions between the 2008 and 2009 Inventories in Northern Ireland

Inventory Comparison (Mt carbon dioxide**)**							
	5A Forestland	5B Cropland	5C Grassland	5D Wetland	5E Settlements	5G Other	Sector 5 All
Difference between 2008 and 2009 inventory	0.001	-0.016	-0.015	0.13	0.221	0.000	0.325

The off-diagonal items (land use change data from the Countryside Survey, forest planting and deforestation datasets) in the matrix are used to estimate the land use change fluxes in the LULUCF inventory. The diagonal items (land remaining in the same use, in italics) are included for information and have an uncertainty attached as there is not a perfect match between the sum across the columns and the sum across the rows. The total area of Northern Ireland is reported as 1,413.0 kha. This is the Standard Area Measurement to mean high water reported by the Office of National Statistics (ONS 2009).

Table 5.6 Land Use Transition Matrix, ha, for Northern Ireland in 1990-1991

From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	*73.5±0.2*	0	1.6	0	0	0	**74.9**
Cropland	0.0	*59.3±1.8*	3.7	0	0	0	**64.7**
Grassland	0.3	5.9	*1,070.6±0.1*	0	0	0	**1,076.7**
Wetlands	0	0	0	*4.5*	0	0	**4.5**
Settlements	0.1	0.0	1.0	0	*56.4±0.6*	0	**56.9**
Other Land	0.0	0	0.7	0	0	*135.6±1.0*	**135.3**
Total (initial)	**74.0**	**63.4**	**1,077.6**	**4.5**	**56.9**	**136.6**	***1,413.0***

Table 5.7 Land Use Transition Matrix, ha, for Northern Ireland in 2008-2009

From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	*86.2±0.4*	0	2.0	0	0.1	0.1	**88.0**
Cropland	0.0	*55.2±2.5*	3.2	0	0.0	0.0	**58.1**
Grassland	0.3	4.0	*1,042.2±1.9*	0	0.3	0.4	**1,049.1**
Wetlands	0	0	0	*1.0*	0	0	**1.0**
Settlements	0.1	0.1	2.1	0	*75.5±0.1*	0.1	**77.9**
Other Land	0.0	0.0	0.2	0	0.0	*139.8±1.2*	**138.8**
Total (initial)	**87.0**	**59.5**	**1,047.9**	**1.0**	**76.0**	**141.6**	***1,413.0***

The UK reports estimates of emissions and removals from activities in Article 3.3 (mandatory, Afforestation, Reforestation and Deforestation) and Article 3.4 (elective, Forest Management) of the Kyoto Protocol. The emissions and removals from Kyoto Protocol activities in Northern Ireland in 2009 are shown in table 5.8. The methods and assumptions used in these reported emissions are described in Chapter 11 and Annex 3.7 of the National Inventory Report.

Table 5.8 GHG Emissions and Removals from KP-LULUCF Activities in Northern Ireland

KP-LULUCF Activities		
Activity		N Ireland
3.3 Afforestation & Reforestation	Area, kha	14.81
	Net CO_2 emissions/removals, Gg CO_2	-0.154
	Emissions from biomass burning, Gg CO_2 eq.	NO
	N_2O emissions from N fertilization, Gg CO_2 eq.	0.00002
3.3 Deforestation	Area, kha	NO
	Net CO_2 emissions/removals, Gg CO_2	NO
	CO_2 emissions from biomass burning, Gg CO_2	NO
3.4 Forest Management	Area, kha	66.30
	Net CO_2 emissions/removals, Gg CO_2	-0.328
	N_2O emissions from LUC to cropland burning, Mt CO_2	NO

The appendix describes methods and data sources used to calculate the LULUCF emissions and removals but for further details please refer to the latest National Inventory Report (MacCarthy *et al*. 2011).

5.10 Waste

Emissions from the waste sector represent 3.6% of total GHG emissions in Northern Ireland, and 4.0% of total UK waste emissions.

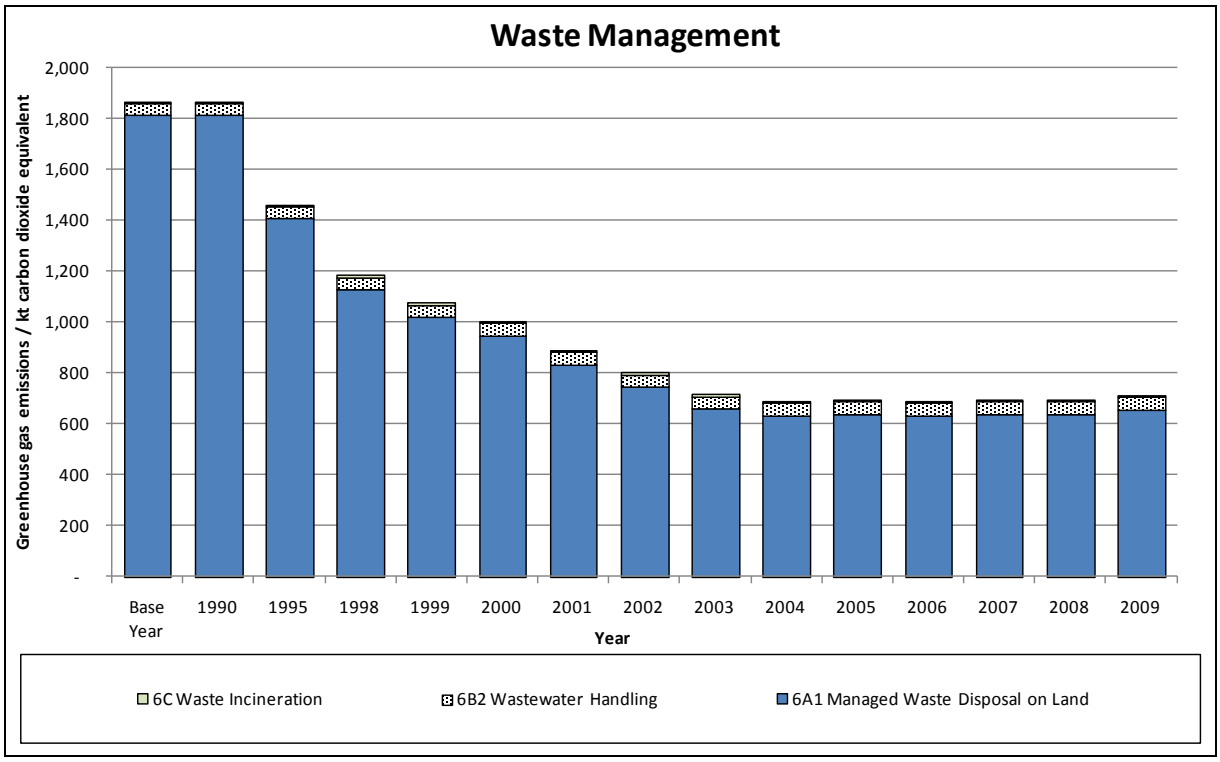
These emissions are dominated by methane emissions from landfills, which comprise 92.4% of total GHG emissions in the waste sector. Estimates are based on data on arisings of municipal solid waste and sewage sludge in Northern Ireland using data from www.wastedataflow.org. This data source includes regional data such as tonnages and percentages of MSW treatment and disposal options such as recycling, incineration and landfill. This enables a detailed DA split of waste disposed to landfill to be derived, and includes data back to 1999, which has been used to back-calculate the estimates to 1990 by DA. However, there is not a direct link between MSW arising in a year and the methane emissions in that year, as the model takes account of a time-series of MSW inputs, degradation and the methane release curve.

[Note that the UK landfill model was updated during the latest inventory cycle, and all methane estimates from 1990 onwards were revised. For further details see Chapter 7 and Appendix 1.]

Due to lack of detailed local data, the DA disaggregation method still retains the assumption that landfill methane recovery rates are the UK average within each DA. On this basis the landfill emissions in Northern Ireland have fallen by 64% since 1990 due to increasing use of methane recovery systems.

Emissions from wastewater treatment represent 2.9% of UK emissions from this source, which is similar to the relative populations. Wastewater treatment is a relatively important source of nitrous oxide emissions, representing 1.6% of total nitrous oxide emissions in Northern Ireland in 2009.

Figure 5.11 GHG Emissions from Waste Management in Northern Ireland, 1990 to 2009



5.11 Emission Maps: Northern Ireland 2009

As part of the NAEI, the UK produces mapped emissions of carbon dioxide (CO_2), methane and nitrous oxide. The maps are modelled estimates of emissions compiled at a 1 km^2 resolution and Figure 5.122 to 14 shown the emissions in Northern Ireland. The maps reveal the locations and intensities of the major sources of emissions and are used by AEA and other organisations for a variety of Government policy support work at the national scale, regional and local scale. Local area statistics are compiled from the maps and related data, for example, Local Authority level data on carbon dioxide emissions and fuel use have been produced for Defra and DECC since 2003 using data from the NAEI mapping work. As of March 2008, these datasets were reclassified as National Statistics (King et al and Bush et al, 2008). The distributions of methane and nitrous oxide emissions from agricultural sources are generated at a 5 km^2 resolution by the Centre for Ecology and Hydrology (CEH), and are then re-sampled at a resolution of 1 km^2 by the NAEI mapping team.

Emissions maps are produced for the latest year within the NAEI time series, and are available at:

http://www.naei.org.uk/mapping/mapping_2009.php

The most recent emission mapping methodology report can be found at:

http://www.naei.org.uk/reports.php

Figure 5.12 Emissions of Carbon Dioxide (t) in Northern Ireland in 2009

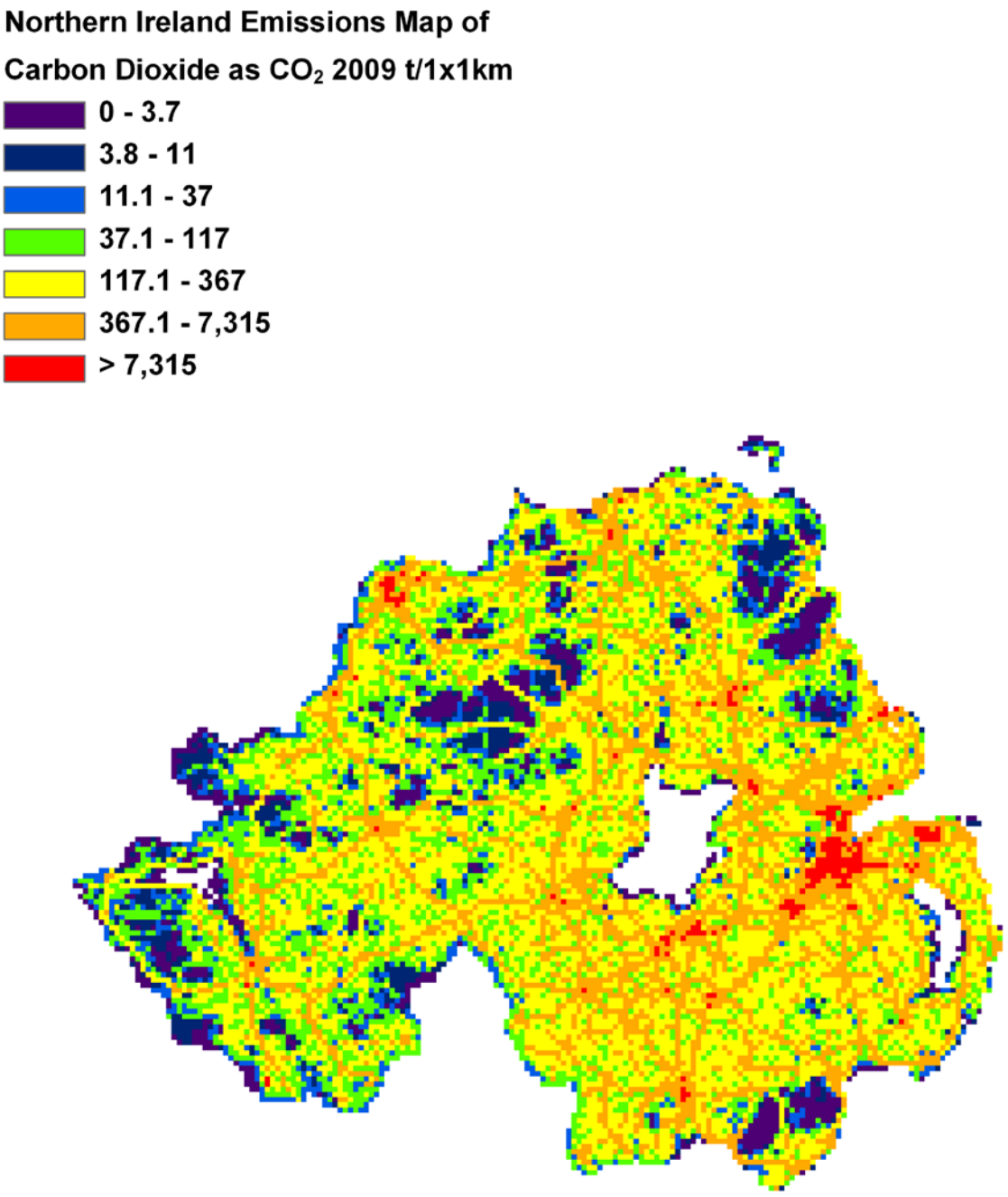


Figure 5.13 Emissions of Methane (t CO_2e) in Northern Ireland in 2009

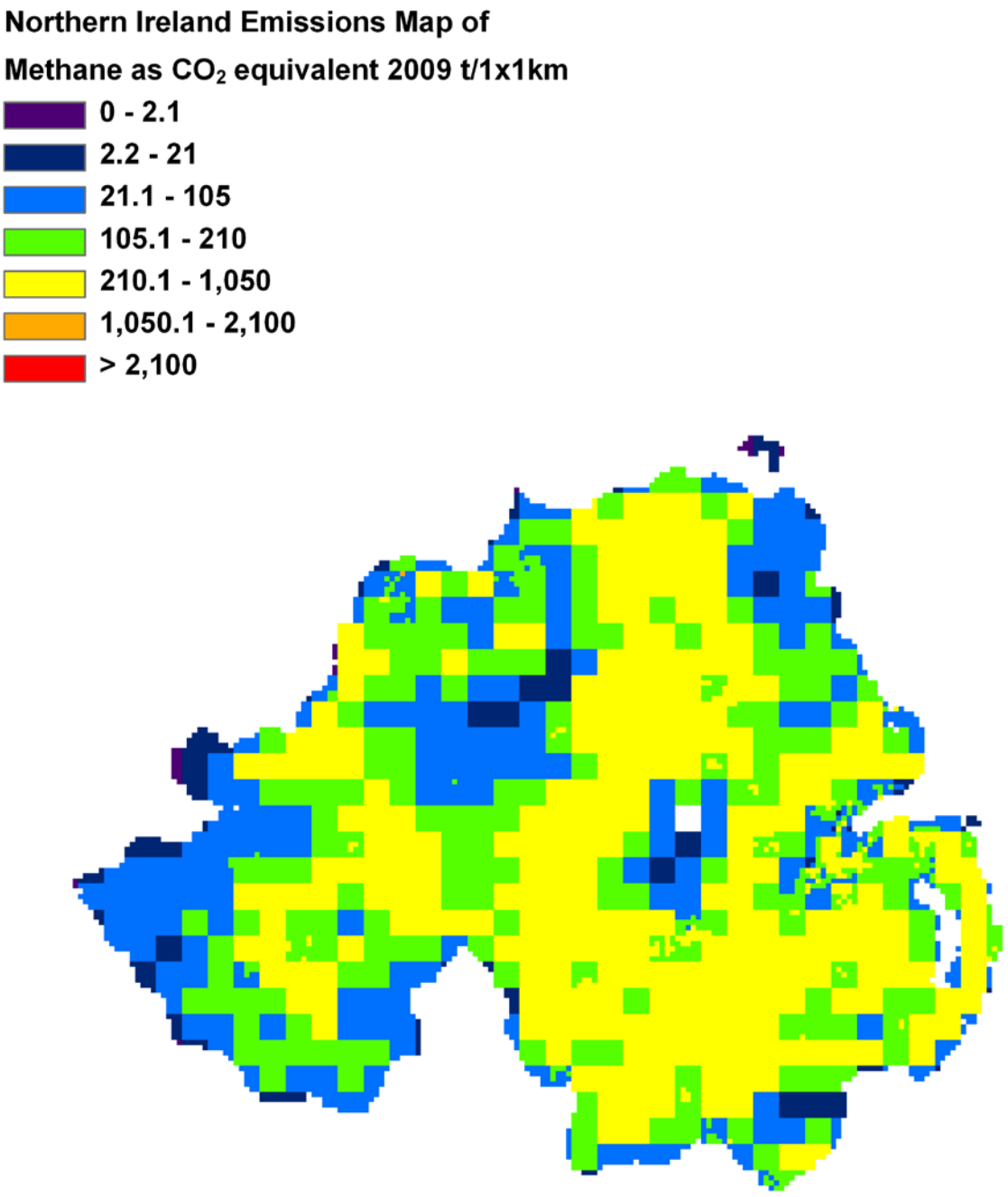
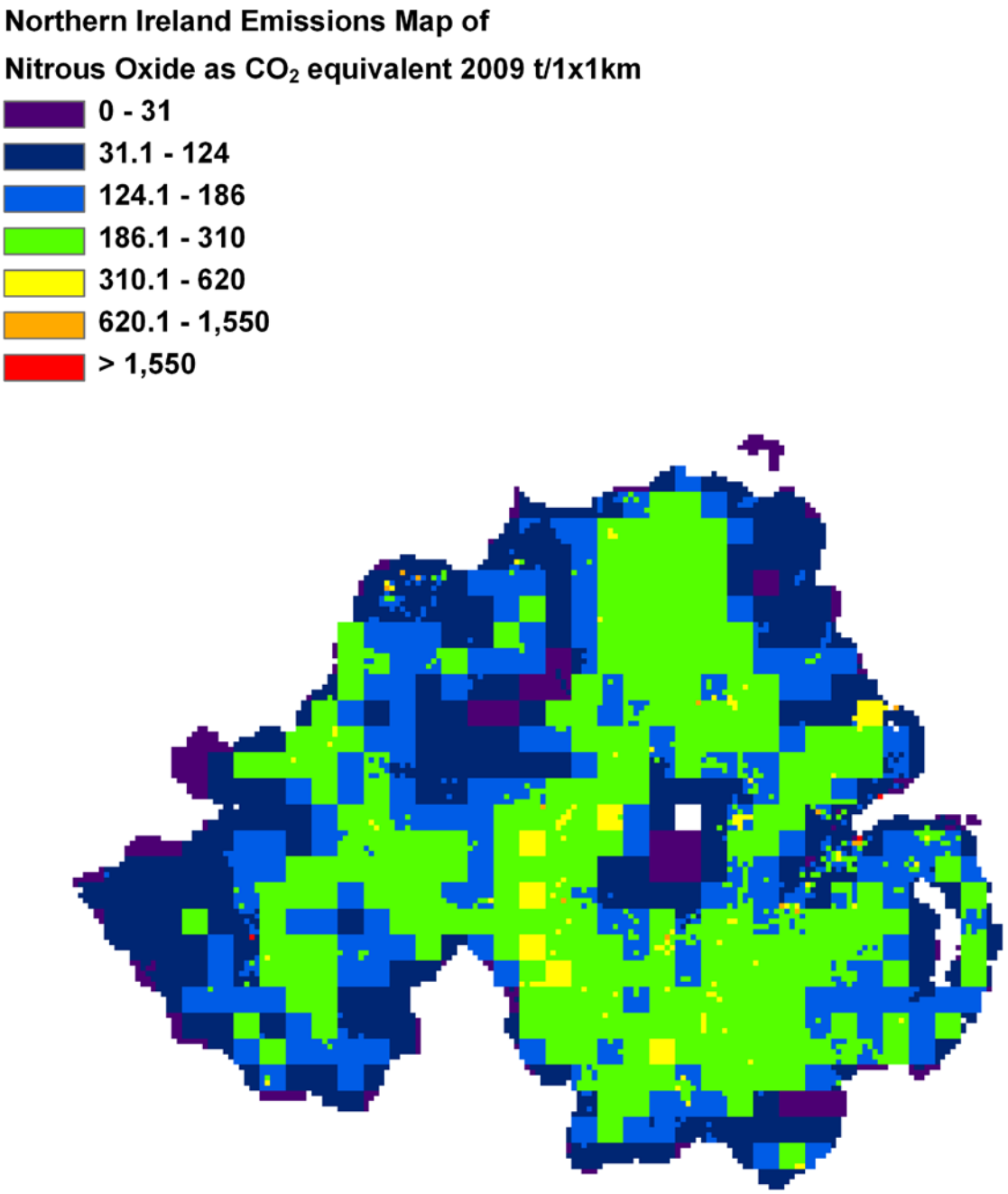


Figure 5.14 Emissions of Nitrous Oxide (t CO_2e) in Northern Ireland in 2009



6 Unallocated Emissions

Emissions from offshore oil and gas installations are accounted as “unallocated” emissions. The total “unallocated” emissions in 2009 account for 2.8% of UK emissions, this is an increase from the 1990 figure of 1.9%. As a proportion of the 2009 UK totals they account for the following:

- Carbon dioxide 3.0% (up 9.3% since 1990)
- Methane 2.2% (down 47% since 1990)
- Nitrous oxide 0.8% (up 26% since 1990)

There are no unallocated emissions of halocarbons and sulphur hexafluoride.
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7 Data Availability, Recalculations and the Inventory Improvement Programme

This chapter reports on progress under the DA GHG inventory improvement programme, provides an overview of the data availability for DA GHG inventory compilation, and summarises the main data revisions, changes to methods and inventory recalculations since the 1990-2008 inventory cycle.

7.1 Data Available for DA GHG Inventory Compilation

In order to estimate a complete GHG inventory for each constituent country of the UK, it would be necessary to have a complete set of activity data for each country to the same level of detail as that used for the UK Inventory. Such a set of data is not available; in particular there are no comprehensive fuel use statistics for the constituent countries of the UK.

As environmental regulation and related monitoring mechanisms have developed within the UK, the availability of emissions and fuel use data has also developed. Each year the availability of data that could be used to inform or improve emission inventories is changing, but for many sources there is very limited data available to improve DA-estimates back to the Kyoto Protocol Base Years of 1990 (for carbon dioxide, methane and nitrous oxide) and 1995 (for fluorinated gases). Since 2005, the EU Emissions Trading System (EUETS) has provided a new data source for fuel consumption on a site-by-site basis for many of the most energy intensive industrial installations in the UK, and these new data have been used in conjunction with existing point-source emissions data (from the EA, SEPA and NIEA) to improve the DA GHG estimates for recent years.

The availability of data and estimation methodologies employed to disaggregate the UK across the constituent countries to compile the DA inventories are discussed in Appendix 1 for each source sector.

7.1.1 Data Availability by Sector

Generally, sufficient country-specific activity data are available for the following sectors:

- **Agriculture.** Annual agricultural survey data on livestock numbers, fertiliser use and arable production are provided by Defra and the DA Governments;
- **Industrial Processes & Large Combustion Plant.** For high-emitting industrial sources, site-specific data are available from site operators and trade associations. Annual emission estimates (including GHGs) are reported for all IPPC/EPR regulated sites via the Environment Agency's Pollution Inventory, the Scottish Environmental Protection Agency's Scottish Pollutant Releases Inventory and the Northern Ireland Environment Agency's Inventory of Statutory Releases. Carbon dioxide emission estimates and fuel use data are also made available to the inventory agency from all sites that operate within the EU Emissions Trading System; and
- **Road Transport.** Detailed road count point data are available for major roads across the DAs; the Department for Transport (DfT) publishes such data for Great Britain, whilst the Department for Regional Development Northern Ireland (DRDNI) published road traffic statistics annually for Northern Ireland. Estimates are made based on assessments of vehicle kilometre data, broken down at detailed vehicle-type level. Vehicle fleet statistics are also available from the DVLA and DRDNI, and this enables the DA inventory analysis to take account of the local fleet composition within each DA.

7.1.2 Fuel Consumption

The availability of data across this wide-ranging sector of activity is very variable. Furthermore, the small-scale combustion sources such as residential, commercial, public sector and small scale

industrial combustion are economic sectors where devolved Government policy levers can take greatest effect. The improvement of DA energy data for these sectors is one of the highest priorities in the DA GHGI improvement programme, and was the subject of the DA sector workshop in May 2011.

The basis for all of the UK NAEI fuel consumption data are the *Digest of UK Energy Statistics* (DECC, 2010a), and this publication includes some regional data such as coal production, domestic gas consumption and consumption of liquid fuels. The liquid fuel data consist of totals of different types of liquid fuel for Northern Ireland, Scotland and England and Wales combined. This regional data is of limited use, since it provides no sector split for final consumption of oils and the data are based on sales information from refineries, and does not track secondary sales across the UK fuel market.

UK National Grid provides gas sales data for Great Britain disaggregated by region and consumer size, and these data are used to inform the sub-national energy statistics published by DECC[13]. These sub-national gas data estimates are based on meter information and are not fully consistent with the DUKES totals for the domestic and non-domestic sectors, but do provide the best available dataset to allocate the overall gas consumption for England, Scotland and Wales. The data provide no detail on gas allocations to specific sectors other than the domestic and non-domestic split, however.

In Northern Ireland, Phoenix Gas and Firmus Energy provide data for natural gas consumption. Similar to the GB data published by DECC, these data are disaggregated by type of consumer into domestic and non-domestic. Limited further detail is available on the sectors using the gas.

Fuel consumption within the iron and steel industry is documented by *Iron and Steel Industry Statistics Bureau* (ISSB, 2010). The ISSB data covers primary iron and steel production but excludes most secondary processes. DUKES data are therefore also used to refine estimates for this sector.

Emissions from power generation and the cement and lime industry are calculated from emissions data within the Pollution Inventory (England and Wales), Scottish Pollutant Releases Inventory (Scotland) and the Inventory of Statutory Releases (Northern Ireland). However, there has only been a consistent UK-wide set of emissions data from these sources in 2002 and from 2004 onwards. Emission estimates for earlier years are more uncertain and are based on operator-supplied information, DECC fuel use data (e.g. for power stations) and plant production data from trade associations (e.g. cement industry data from the BCA). Emissions data for 2005 onwards are now also available through the EUETS for power generation and other large combustion sources, with emissions data by fuel for each site made available to the inventory agency. For recent years, therefore, the EUETS data are used as the primary data source to inform installation-specific emission factors for fuel use in the power, refinery and cement sector, and the EUETS activity data are also used to inform fuel use estimates by DA for these high emitting sectors. In some cases this has led to deviations from published DUKES fuel use allocations within the UK and DA GHG inventories.

Emissions data for the refineries sector are provided annually by UKPIA, providing a detailed breakdown of plant-specific emission sources for each refinery in the UK. Once again, this detailed data has only been available for more recent years and historic emission estimates back to 1990 are based on industry estimates of plant production rather than on reported emissions or fuel use data, and hence are subject to greater uncertainty. The EUETS data for refineries has been used to improve the UK and DA inventories (see section 7).

Detailed data are available for the oil and gas exploration & production industry (for both offshore and onshore installations) from the DECC Oil & Gas Environmental Emissions Monitoring System (EEMS) database which includes installation and process-specific data for 1995, and 1998 to 2009 of varying coverage; earlier years in the oil & gas sector dataset are more sparsely populated and appear to be less consistent across the industry. All 1990 sector splits have been based on extrapolating back sector splits from later years. There are some data inconsistencies evident across the time-series of the EEMS data, and hence the trends in emissions from the oil and gas extraction sector are quite uncertain and are revised annually with the regulators at DECC in Aberdeen.

[13] http://www.decc.gov.uk/assets/decc/statistics/publications/energytrends/1082-trendsdec10.pdf

Northern Ireland produces an annual set of fuel statistics that include sector-specific consumption data for coal and total consumption for oil products. However, the limited scope and detail of these datasets limits their usefulness in inventory compilation. The Annual Coal Enquiry in Northern Ireland does not provide a breakdown of solid fuel use by type (i.e. steam coal, anthracite, coke data are not provided separately) and there is no detail regarding use of different oil grades by end-users. Cross-border solid and liquid fuel transfers with the Republic of Ireland are not included within the data, as the data are compiled from port import statistics (coal) and refinery fuel sales information (oils).

Up until 1994, the Welsh Office produced a fairly detailed set of fuel statistics based on DTI estimates. However this has been discontinued since the privatisation of the energy industries, due to concerns of commercial confidentiality.

Scotland does not publish fuel statistics. Limited data on coal production and gas consumption in 1990 has previously been provided and forms the basis of some extrapolated data estimations.

Hence the main sources where fuel use data have been estimated are:

- Domestic use of solid fuels and petroleum-based fuels;
- Miscellaneous/Commercial and public sector use of solid fuels and petroleum-based fuels;
- Agriculture sector use of solid fuels and petroleum-based fuels ; and
- All fuel use within the “Other Manufacturing Industry” sector (excluding cement and autogeneration).

Various surrogates are used to derive regional estimates of fuel use for these source sectors:

- The regional disaggregation of agricultural sector fuel combustion emissions and oil consumption are based on employment statistics, except for oil use by mobile agricultural machinery which are disaggregated using land use, farm type and average machinery use factors;
- DECC Sub-national Energy Statistics are used for solid and liquid fuels in the commercial, public, small industrial and domestic sectors; and
- Domestic sector estimates are based on DECC Sub-national Energy Statistics and reported trends in fuel use from Northern Ireland Housing Condition Surveys, the DEMScot model (in Scotland) and a BRE model for England and Wales.

Sub-national energy statistics are published annually by the Department for Energy and Climate Change (DECC) within the quarterly *Energy Trends*[14] publication. These sub-national statistics are limited in their detail when compared to UK-level energy statistics (as used in the UK GHG Inventory compilation), but do provide estimated fuel use data for England, Scotland, Wales and Northern Ireland for the following source sectors:

- Industry & Commercial;
- Agriculture; and
- Residential.

The DECC sub-national energy statistics have been developed in recent years to provide estimates of fuel use and carbon dioxide emissions data at Local Authority (LA) level across the UK. The latest available data include LA solid and liquid fuel use estimates for 2005 to 2008, with gas and electricity data also available up to 2009.

The DECC data at local and regional level are derived from analysis of gas and electricity meter point data, supplemented by additional research to estimate the distribution of solid fuels and petroleum-based fuels across the UK. Since the initial study and presentation of experimental data for 2003 and 2004, each annual revision to the local and regional data has included data improvements through targeted sector research. These DECC Sub-national Energy Statistics continue to evolve and improve, reducing data inaccuracies, but nevertheless are subject to greater uncertainty and less

[14] The latest available data are taken from the December 2010 Energy Trends: http://www.decc.gov.uk/en/content/cms/statistics/publications/trends/trends.aspx

detail than the UK energy statistics presented within DUKES (DUKES is used to underpin the UK GHG inventory). However, they are regarded as the best dataset available to inform the patterns of fuel use across the DAs and are therefore used to underpin the carbon dioxide emission estimates from fuel combustion sources within the inventories presented here, in conjunction with other data sources such as EUETS fuel use data for large industrial sites and other DA-specific energy data.

However, the usefulness of the DECC sub-national energy data to inform DA-specific trends in energy use since 1990 by sector are limited due to a number of factors:

- The DECC sub-national energy data only cover recent years in the time-series (2003 to 2009). These data provide the best estimate of DA fuel use for recent years, but their use do not guarantee any improvement to the accuracy of DA-specific emission trends since 1990. For some sectors (e.g. residential) where additional periodic publications give indications of relative trends in fuel use across the DAs, the recent data from DECC have been used to back-calculate the DA-specific fuel use and GHG emissions in 1990. For other sectors, the UK trends evident from DUKES data are all that is available to inform DA trends since 1990;

- The sub-national gas data are not fully consistent with the UK gas use estimates published within DUKES; the sub-national statistics are derived from meter point data, whilst the UK-wide consumption data in DUKES are based on overall gas sales data from energy suppliers. Notably the local authority gas use data presented within Energy Trends, differ from the UK gas use totals reported in DUKES, due to different reporting criteria. The local authority gas use data are weather-corrected and do not cover a calendar year, and both of these factors affect the comparability of the regional to national gas use data as well as the accuracy of the regional-level estimates. In many cases, analysis of major installation gas use from EUETS data does not compare closely with the reported gas use by major industrial sites that are outlined within the DECC data. Although progress has been made to resolve many such data inconsistencies, issues of data confidentiality have inhibited complete resolution of these matters, and work is ongoing within DECC to identify improvements; and

- The sub-national gas and electricity data are derived based on meter data provided by fuel suppliers; the provision of meter data for analysis is incomplete, with typically around 20-25% of meter readings being “estimated” due to lack of updated meter readings. The data comprise annual fuel consumption data allocated to broad end-user sub-sectors; gas use data are allocated to “domestic” and “industrial and commercial” users based on the annual consumption levels, whilst the electricity data are available at slightly greater resolution based on analysis of electricity tariff information. The detailed allocation of fuel use to end-user sector is therefore quite uncertain, and this has knock-on effects across the analysis conducted to estimate non-gas, non-electricity fuels. As a consequence, the sector-specific fuel use estimates (at UK, DA and LA level) are somewhat uncertain, whilst overall fuel use and emission estimates are more accurate.

7.2 Inventory Recalculations

A number of changes have been made to the estimates since the last study (Sneddon *et al* 2010) due to: (i) revisions to methodologies and source data within the UK GHG inventory, and (ii) through revisions to available data at local and sub-national level such as revised local energy data within the DECC sub-national Energy Statistics and from analysis of Phase II EUETS data.

The UK GHG inventory is updated each year to reflect changes in statistics for earlier years, or changes to emission factors or methodologies. These changes are explained in the National Inventory Report (MacCarthy *et al* 2011). The majority of changes impact on the latter part of the time series (from 2005 onwards). This is due to the availability of EUETS data for this period, and it is also the period covered by revisions to statistics in DUKES.

Appendix 1 of this report provides more information about the DA inventory compilation methodologies and source data.

Table 7.1 presents an overview of the impact of inventory recalculations at DA and UK level.

Table 7.1 Summary of the impact of recalculations by gas (2009 inventory estimate - 2008 inventory estimate, as kt CO_2e

Summary of recalculations by gas (kt CO_2e)					
DA	GHG	Base Year	2006	2007	2008
England	CO_2	-2,105	-2,545	-2,665	-4,053
	CH_4	4,824	-2,929	-3,126	-3,670
	N_2O	1,549	1,434	1,473	1,528
	HFCs	-16	-191	-364	-330
	PFCs	0	0	0	0
	SF_6	0	0	0	0
England Total		4,252	-4,230	-4,682	-6,526
Scotland	CO_2	-363	-1,312	-1,632	-2,061
	CH_4	740	-267	-303	-400
	N_2O	629	572	559	548
	HFCs	-2	-19	-36	-33
	PFCs	0	0	0	0
	SF_6	0	0	0	0
Scotland Total		1,004	-1,025	-1,412	-1,945
Wales	CO_2	23	-291	-276	-426
	CH_4	355	-12	18	-5
	N_2O	244	235	234	232
	HFCs	-1	-11	-20	-18
	PFCs	0	0	0	0
	SF_6	0	0	0	0
Wales Total		621	-80	-44	-216
Northern Ireland	CO_2	-793	-770	-1,035	-935
	CH_4	63	-145	-170	-191
	N_2O	218	180	176	178
	HFCs	0	-6	-12	-11
	PFCs	0	0	0	0
	SF_6	0	0	0	0
Northern Ireland Total		-512	-741	-1,041	-959
Unallocated	CO_2	-75	-359	-432	-432
	CH_4	0	0	-7	0
	N_2O	0	-8	-9	-4
	HFCs	0	0	0	0
	PFCs	0	0	0	0
	SF_6	0	0	0	0
Unallocated Total		-75	-366	-448	-436
UK	CO_2	-3313	-5277	-6041	-7908
	CH_4	5982	-3352	-3588	-4266
	N_2O	2640	2413	2434	2483
	HFCs	-19	-227	-432	-390
	PFCs	0	0	0	0
	SF_6	0	0	0	0
UK Total		5,289.8	- 6,442.6	- 7,626.7	- 10,082.1

Note: Base year emissions are not the UK's fixed base year emissions

The largest recalculations for non-carbon dioxide GHGs are due to revisions to data and methods for a small number of emission sources, summarised below:

Methane – Revisions to the UK model used to estimate landfill waste methane has led to large changes to methane estimates from all of the DAs. This is by far the most significant revision in the methane inventory, increasing emission estimates in the base year and decreasing emission estimates in recent years for all DAs. Smaller changes to DA methane emission estimates are evident for coal mining emission sources due to a new study on closed coal mine methane emissions in 2011. The UK GHGI method changes for methane emissions from waste water treatment, sewage treatment and disposal have led to reductions in DA emission estimates across the time series.

Nitrous oxide – There has been an increase in nitrous oxide emissions across the time series, affecting all DAs. This is almost exclusively due to changes in the estimates for nitrous oxide emissions from agricultural soils.

Time series of the application of sewage sludge to land was included in the 2009 inventory. Emissions from sewage sludge used as fertiliser are reported under agricultural soils by IPCC. The calculation involves estimating the amount of nitrogen contained per dry matter unit of sludge and applying IPCC emission factors. Data sources for the annual production of sewage sludge (as dry matter) were obtained from Brian Chambers (pers. comm. ADAS) for 1996; from Directive 86/278 for 2004-2006 on the basis of the data contained in the records referred to in Article 10; Sludge used in agriculture (Tonnes dry matter/year); from OFWAT, the Water Commissioner for Scotland and the Northern Ireland regulator, UREGNI for 2008-2009. The amounts for the missing years were derived by interpolation/extrapolation of the available data. The UK follows the IPCC (1997) methodology. This assumes that 20% of the total sludge N applied to soil volatilises as NO_x and NH_3 and therefore does not contribute to nitrous oxide (N_2O) emissions

This change has affected all DAs. Other recalculations affecting nitrous oxide include a small increase in estimates of nitrous oxide from waste water treatment and disposal, affecting all DAs and across the time series. Revisions to emissions factors for fuel use in the rail and shipping sector have also led to small reductions in nitrous oxide emissions across all DAs and across the time series.

HFCs – Revisions to the refrigeration model during the 1990-2009 inventory cycle has led to small decreases in emissions from all DAs across the time series, with larger reductions evident in recent years. Activity data revisions to foam blowing, aerosols and meter dose inhalers have led to small reductions in emissions in 2008 across all DAs.

PFCs – No recalculations have been made.

SF_6 – No recalculations have been made.

For carbon dioxide, the inventory recalculations arise from a combination of many data and method revisions across several source sectors. The following sectoral tables indicate where these changes have been made.

Table 7.2 details the impact of changes to methods and data at UK level, and the reasons for these changes. Note this table is presented in terms of carbon dioxide equivalent (CO_2e); the reasons for changes listed, however, consider the effects of individual GHGs on the change in carbon dioxide equivalent (CO_2e).

Tables 7.3 – 7.6 show the magnitude of the changes at DA level, and indicate where there have been changes to DA data and methods, in addition to the UK GHGI changes.

Table 7.2 Reasons for Changes: UK GHG Inventory Recalculations

Revisions summary (UK)		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
1A1a	The power stations database has been reviewed, leading to fuel use and type reallocations in some years. DUKES revisions affect emissions in later years.	-1,083	-376	-292	-797
1A1b	Activity data for pet coke revised to be in line with EUETS data. Emission factors for OPG based on EUETS data now used within the inventory.	-750	445	137	572
1A1c	Revised emission factors and activity data for OPG combustion at gas separation plant, and also for colliery methane (throughout the time series) using factors derived from EUETS.	-56	80	-169	-218
1A2a	Revised activity statistics for coal and fuel oil use.	0	-6	325	73
1A2f	New method for lime production has led to a reallocation of natural gas within the sector; lubricant use has been reallocated following research into the impact of the Waste Incineration Directive; EU ETS emission factors are now used for colliery methane (from 2005), and for OPG and petroleum coke from 2008 onwards. EFs for earlier years extrapolated/interpolated. Use of a more detailed, sector-specific set of activity drivers for estimating equipment populations within the off road machinery model.	1,057	1,250	1,203	2,846
1A3a	Reallocation of flights between domestic and international to account for flights between the UK and the Crown Dependencies now being considered international (for the purposes of "UK Only" reporting).	-80	-105	-109	-105
1A3b	A number of changes were made and are described in detail in the National Inventory Report for the UK submissions to UNFCCC. Briefly, these include: • Revisions to vkm data by vehicle and road type from 1993-2008 based on new data from DfT • Assumptions on the split between buses and coaches on urban and rural roads and the split between buses of different sizes. • A more detailed breakdown in the activity of 2-stroke and 4-stroke motorcycles • New figures from DfT on the average fuel efficiencies of HGVs and buses • Estimation of CH4 and N2O emissions from vehicles running on LPG These changes affect the full time series of emissions.	-14	-34	-68	-94
1A3c	Revised diesel fuel consumption data for passenger and particularly freight trains using new information from train operators (ATOC) and the Office of Rail Regulation. Emissions from the consumption of coal used to power steam trains (heritage trains) are included for the first time using new data in DUKES.	-279	-338	-279	-295

Revisions summary (UK) Table 7.2 continued		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
1A3d	A new methodology developed by Entec for estimating fuel consumption and emissions from national navigation and fishing based on detailed shipping movement data for different vessel types and operations, combined with DfT port statistics. Consistency with national marine fuel statistics was maintained by re-allocating the remaining fuel consumption to international shipping (difference between total marine fuel consumption in DUKES and estimates of domestic shipping consumption).	-2,381	-3,832	-3,296	-3,784
1A3e	Small revision to estimate for aircraft support vehicles based on revised passenger number estimates. Use of a more detailed, sector-specific set of activity drivers for estimating equipment populations within the off road machinery model	0	0	0	-21
1A4a	Main changes are revisions to activity statistics for natural gas use in the public and miscellaneous commercial sectors, and reallocations for gas oil based on new data for other sectors (off road, rail)	794	-278	-781	-1,843
1A4b	Main change is revised data for petroleum coke for domestic use across the time series, based on new research (both EF and AD). In later years, peat and natural gas activity data have been revised.	-752	138	-133	-829
1A4c	Main changes are inclusion of estimate for fishing vessels, revision to estimated emissions from agricultural machinery and a revision to the energy statistics for coal and straw.	18	-89	-79	-58
1A5b	Revised fuel consumption data supplied by the defence fuels group for military aviation and shipping	0	0	0	-184
1B1b	Revision to activity statistics for coke oven gas flaring and coal use in SSF production	0	0	60	104
1B2a	Offshore oil and gas emissions now reported separately, no material changes to the emissions data (except for revisions to EEMS data in later years).	-1,515	-757	-586	-513
1B2b	Change to method to calculate weighted average gas composition across the UK, inclusion of gas leakage at the point of use.	1,534	784	822	418
1B2c_Flaring	Offshore oil and gas emissions now reported separately, no material changes to the emissions data (except for revisions to EEMS data in later years).	0	1	-26	-59
1B2c_Venting	Offshore oil and gas emissions now reported separately, no material changes to the emissions data (except for revisions to EEMS data in later years).	0	0	-8	-7
2A2	Revision to lime production statistics	0	0	-140	-249

Revisions summary (UK) Table 7.2 continued		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
2A3	Method for glass production revised to use time series from British Glass, revised activity data used for soda ash use for glass production. Revised data for FGD from the British Geological Survey.	32	9	13	-60
2A4	Method for glass production revised to use time series from British Glass, revised activity data used for soda ash use for glass production.	0	-11	-11	-12
2B3	Small revision to operator reported data for adipic acid manufacture	0	2	0	0
2B5	Revised estimate for breakdown of household products based on revised household statistics	0	-11	4	16
2C1	Revision to emission factor for blast furnace gas	0	0	-1	-3
2C3	Small revision to reported emissions data from one of the aluminium plant operators.	0	0	0	0
2F1	Small revisions made to refrigeration estimates based on peer review of the UK inventory	-19	-45	-80	-117
2F2	Speciation of the F-gases for the foams sector has allowed foams with GWP values not in the IPCC Second Assessment Report to be removed from the inventory	0	-182	-162	-135
2F4	Updated aerosols data from BAMA incorporated	0	0	-190	-138
4A10	Small revision to livestock statistics for deer	0	0	0	6.577E-04
4B10	Small revision to livestock statistics for deer	0	0	0	1.638E-05
4D	New source added - sewage sludge applied to agricultural land. A correction has also been made to the method for nitrogen leaching and run-off.	1,685	1,655	1,690	1,716
5A1	Countryside survey update and a restructuring of forest categories using 20 year transition rather than pre and post 1990	-6,360	-11,159	-10,394	-10,020
5A2	Countryside survey update and a restructuring of forest categories using 20 year transition rather than pre and post 1990	6,359	11,296	10,523	10,143
5B1	Splitting grassland conversion between pasture and semi-natural, reallocations between cropland and grassland, update to methods and countryside survey data	5	9	10	9

Revisions summary (UK) Table 7.2 continued		**Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e**			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
5B2	Splitting grassland conversion between pasture and semi-natural, reallocations between cropland and grassland, update to methods and countryside survey data	650	-1,281	-1,528	-1,761
5C	Reallocations between cropland and grassland, update to methods and countryside survey data	-2	-12	15	61
5C1	Reallocations between cropland and grassland, update to methods and countryside survey data	-395	-426	-286	-335
5C2	Reallocations between cropland and grassland, update to methods and countryside survey data	266	-243	-234	-199
5E	Updates to method, countryside survey and felling licence data.	9	-4	-15	-21
5E2	Updates to method, countryside survey and felling licence data.	-35	-76	-119	-152
5G	Felling licence data update	-1	22	-5	-70
6A1	Use of revised waste model, incorporating new data for waste sent to landfill and other assumptions	6,377	-2,921	-3,340	-3,784
6B2	Revised estimate for methane based on new research. Uses emission factor and activity data direct from the water companies. Slight change to N2O estimates based on revised time series of protein consumption.	-204	-277	-290	-331
6C	Reallocation of certain sites from chemical waste incineration to other sectors, and revised activity data identified for clinical waste and sewage sludge incineration	6	-130	-124	-127

Table 7.3 Reasons for Changes: England GHG Inventory Recalculations

Revisions summary (England)		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
1A1a	No change to method. Changes are as a result of revisions at UK level.	-643	-270	-230	-587
1A1b	No change to method. Changes are as a result of revisions at UK level.	-484	302	91	382
1A1c	Method for upstream oil and gas revised to enable more detailed emissions data analysis, in line with changes to the UK GHGI. A small number of data revisions for oil and gas installations from comparison of emissions reported via EEMS, EUETS and IPPC/EPR. DA estimates from gas production revised to use data from EUETS from gas compressor sites and LNG terminals, over-writing assumptions and revising DA data back to 1990.	-148	33	13	18
1A2a	No change to method. Changes are as a result of revisions at UK level, or within ISSB regional energy statistics for recent years.	0	-5	227	-11
1A2f	Several revisions due to use of EUETS data and also from specific site enquiries through review of IPPC documents and consultation with regulators and operators, leading to revised assumptions on fuel use and emission sources for several sites. EUETS data for the glass industry for 2009 provided new data on DA fuel use in that sector, which has been used to revise assumptions back through the time-series.	886	1,208	1,198	2,593
1A3a	No change to DA method. Revisions to assumptions within UK method lead to small revisions to the DA data also.	-30	-29	-29	-26
1A3b	Revisions to the DA method to use more DA-specific fleet information (to over-write the use of GB-fleet information in the past inventories) on petrol/diesel car mix, car, engine size and age distribution for cars, LGVs and rigid HGVs. Since the fleet composition of England is very similar to the GB, England GHG emissions only revised slightly up across the time series (by 0.4 – 0.7%).	458	713	647	684
1A3c	No change in method. UK-wide reductions in recent years have had slightly different impacts across the DAs in total, due to different significance within each DA of the different rail types for which inventory estimates are made: intercity, regional and freight.	-156	-225	-187	-219
1A3d	No change in method. Revisions to UK GHGI time series split between domestic and international shipping affect all of the DA shipping estimates.	-1,493	-2,632	-2,262	-2,603
1A3e	No change in method. Changes are as a result of revisions at UK level.	0	-2	-2	-15
1A4a	UK data revisions to gas oil activity data have knock-on effect here, but also there have been method revisions to take account of the Northern Ireland Public Sector Energy Campaign data to revise the time series of fuel use in NI public sector. More work is needed to resolve data inconsistencies for gas oil in recent years.	611	-252	-698	-1,651

Revisions summary (England) Table 7.3 Continued		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
1A4b	UK revisions to activity data affect the DA trends, with peat data revised down across the time series, affecting the NI and S data. Use of revised mapping grids for several fuels has led to some notable changes in allocations of solid fuels (lower in NI than previously estimated), with smaller revisions to the GB split between E, S and W. A small correction to increase non-gas fuel use in Scotland in 1990, to reflect the growth in gas use evident between 1990 and 1995. To implement time series consistency checks in light of the new mapping grids and peat data, annual energy use per capita in the domestic sector by DA back to 1990 have been calculated, to identify where there may be systematic under- or over-reporting of fuel use in the residential sector. The DA estimates for non-metered fuels remain uncertain, and further work is proposed through the DA GHGI Improvement Programme.	-943	-43	107	-608
1A4c	No change in method. The main impact is the revision to gas oil allocation for agricultural machinery in recent years.	11	-48	-43	-19
1A5b	No change in method. UK revisions to gas oil and ATF use in military vehicles affects all DA inventories.	0	0	0	-158
1B1a	Revised DA allocations across the time series, taken from the 2011 research to estimate the methane emissions from coal mining activities.	-43	-299	-348	-371
1B1b	No change in method. Changes are as a result of revisions at UK level.	0	0	58	102
1B2a	Method for upstream oil and gas revised to enable more detailed emissions data analysis, in line with changes to the UK GHGI.	-79	-189	-110	-113
1B2b	The UK method improvement for gas compositional analysis affects the DA data also.	96	213	317	107
1B2c_Flaring	Revisions to EEMS data. Method change to enable oil and gas data to be reported separately, in line with UK GHGI method.	0	-3	-5	-4
1B2c_Venting	Revisions to EEMS data. Method change to enable oil and gas data to be reported separately, in line with UK GHGI method.	0	0	-7	-7
2A1	No revision to DA method. Small site-specific revisions based on EUETS data and improved understanding of process / combustion split of total emissions.	0	0	-5	0
2A2	UK revision to method only affects England.	0	0	-140	-249
2A3	Glass data revised due to much more comprehensive coverage of the sector within EUETS for the first time in 2009. This has led to time-series revisions of DA activity and emissions.	27	6	11	-31
2A4	Glass data revised due to much more comprehensive coverage of the sector within EUETS for the first time in 2009. This has led to time-series revisions of DA activity and emissions.	0	-11	-10	-8
2B3	No change in DA method.	0	2	0	0
2B5	No change in DA method.	0	-9	3	15
2C1	No change in DA method.	0	0	-1	-2
2C3	No change in DA method.	0	0	0	1
2F1	No change in method. Changes are as a result of revisions at UK level.	-16	-38	-69	-100
2F2	No change in method. Changes are as a result of revisions at UK level.	0	-152	-136	-114

Revisions summary (England) Table 7.3 Continued		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
2F4	No change in method. Changes are as a result of revisions at UK level.	0	0	-160	-116
4D	No change in method. Changes are as a result of revisions at UK level.	1,081	1,071	1,111	1,140
5A1	No change in method. Use of new surveys and data within UK method impacts across all DAs.	-2,047	-2,377	-2,004	-1,742
5A2	No change in method. Use of new surveys and data within UK method impacts across all DAs.	2,036	2,439	2,060	1,795
5B1	No change in method. Use of new surveys and data within UK method impacts across all DAs.	-1	7	8	8
5B2	No change in method. Use of new surveys and data within UK method impacts across all DAs. Recalculations across the time series lead to greater declines in emission trends since 1990 across all DAs.	41	-649	-728	-802
5C	No change in method. Use of new surveys and data within UK method impacts across all DAs.	-1	-9	11	43
5C1	No change in method. Use of new surveys and data within UK method impacts across all DAs.	-233	-177	-136	-161
5C2	No change in method. Use of new surveys and data within UK method impacts across all DAs.	254	-159	-160	-141
5E	No change in method. Use of new surveys and data within UK method impacts across all DAs.	7	-3	-11	-15
5E2	No change in method. Use of new surveys and data within UK method impacts across all DAs.	-104	-203	-239	-267
5G	No change in method. Use of new surveys and data within UK method impacts across all DAs.	-1	17	-3	-49

Revisions summary (England) Table 7.3 Continued		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
6A1	Revision of landfill model at UK level affects all DA estimates, but there has been no change in the DA allocation method. All DAs now show much greater reductions in methane emissions from landfills compared to the previous estimates.	5,098	-2,293	-2,613	-2,935
6B2	Waste water treatment method for the UK inventory is now based on more DA-specific data across the time series, with all emission estimates of methane lower in all DA inventories.	-170	-232	-243	-277
6C	No change in method.	5	-109	-106	-108

Table 7.4 Reasons for Changes: Scotland GHG Inventory Recalculations

Revisions summary (Scotland)		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
1A1a	No change to method. Changes are as a result of revisions at UK level.	-178	-48	-16	-69
1A1b	No change to method. Changes are as a result of revisions at UK level.	-119	57	17	79
1A1c	Method for upstream oil and gas revised to enable more detailed emissions data analysis, in line with changes to the UK GHGI. A small number of data revisions for oil and gas installations from comparison of emissions reported via EEMS, EUETS and IPPC/EPR. DA estimates from gas production revised to use data from EUETS from gas compressor sites and LNG terminals, over-writing assumptions and revising DA data back to 1990.	164	424	253	156
1A2a	No change to method. Changes are as a result of revisions at UK level, or within ISSB regional energy statistics for recent years.	0	0	0	1
1A2f	Several revisions due to use of EUETS data and also from specific site enquiries through review of IPPC documents and consultation with regulators and operators, leading to revised assumptions on fuel use and emission sources for several sites. EUETS data for the glass industry for 2009 provided new data on DA fuel use in that sector, which has been used to revise assumptions back through the time-series.	-17	-91	-127	53
1A3a	No change to DA method. Revisions to assumptions within UK method lead to small revisions to the DA data also.	-39	-58	-59	-57
1A3b	Revisions to the DA method to use more DA-specific fleet information (to over-write the use of GB-fleet information in the past inventories) on petrol/diesel car mix, car, engine size and age distribution for cars, LGVs and rigid HGVs. The small reduction in road transport GHG emissions (-0.3% to -1.3%) for Scotland is due to a combination of factors: newer fleet composition for Scotland based on DVLA data and that there are more small engine-sized (<1400cc) cars registered in Scotland than the GB average.	-119	-135	-109	-94
1A3c	No change in method. UK-wide reductions in recent years have had slightly different impacts across the DAs in total, due to different significance within each DA of the different rail types for which inventory estimates are made: intercity, regional and freight.	-56	-49	-39	-36
1A3d	No change in method. Revisions to UK GHGI time series split between domestic and international shipping affect all of the DA shipping estimates.	-551	-667	-578	-649
1A3e	No change in method. Changes are as a result of revisions at UK level.	0	2	0	-5
1A4a	UK data revisions to gas oil activity data have knock-on effect here, but also there have been method revisions to take account of the Northern Ireland Public Sector Energy Campaign data to revise the time series of fuel use in NI public sector. More work is needed to resolve data inconsistencies for gas oil in recent years.	87	-24	-64	-161

Revisions summary (Scotland) Table 7.4 Continued		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
1A4b	UK revisions to activity data affect the DA trends, with peat data revised down across the time series, affecting the NI and S data. Use of revised mapping grids for several fuels has led to some notable changes in allocations of solid fuels (lower in NI than previously estimated), with smaller revisions to the GB split between E, S and W. A small correction to increase non-gas fuel use in Scotland in 1990, to reflect the growth in gas use evident between 1990 and 1995. To implement time series consistency checks in light of the new mapping grids and peat data, annual energy use per capita in the domestic sector by DA back to 1990 have been calculated, to identify where there may be systematic under- or over-reporting of fuel use in the residential sector. The DA estimates for non-metered fuels remain uncertain, and further work is recommended to reduce uncertainty in this source.	392	370	323	229
1A4c	No change in method. The main impact is the revision to gas oil allocation for agricultural machinery in recent years.	4	-17	-15	-16
1A5b	No change in method. UK revisions to gas oil and ATF use in military vehicles affects all DAs.	0	0	0	-15
1B1a	Revised DA allocations across the time series, taken from the 2011 research to estimate the methane emissions from coal mining activities.	24	121	127	135
1B2a	Method for upstream oil and gas revised to enable more detailed emissions data analysis, in line with changes to the UK GHGI.	-310	-503	-390	-241
1B2b	The UK method improvement for gas compositional analysis affects the DA data also.	312	505	406	237
1B2c_Flaring	Revisions to EEMS data. Method change to enable oil and gas data to be reported separately, in line with UK GHGI method.	0	0	-2	-88
2A1	No revision to DA method. Small site-specific revisions based on EUETS data and improved understanding of process / combustion split of total emissions.	0	0	3	0
2A3	Glass data revised due to much more comprehensive coverage of the sector within EUETS for the first time in 2009. This has led to time-series revisions of DA activity and emissions.	5	0	1	-1
2A4	Glass data revised due to much more comprehensive coverage of the sector within EUETS for the first time in 2009. This has led to time-series revisions of DA activity and emissions.	0	-2	-1	-3
2B5	No change in DA method.	0	-1	0	-1
2C3	Small revision to data for Scottish plant in 2008.	0	0	0	-2
2F1	No change in method. Changes are as a result of revisions at UK level.	-2	-4	-6	-10
2F2	No change in method. Changes are as a result of revisions at UK level.	0	-15	-14	-11
2F4	No change in method. Changes are as a result of revisions at UK level.	0	0	-16	-12
4D	No change in method. Changes are as a result of revisions at UK level.	274	250	249	249
5A1	No change in method. Use of new surveys and data in UK method impacts across all DAs.	-3,109	-6,995	-6,727	-6,766
5A2	No change in method. Use of new surveys and data in UK method impacts across all DAs.	3,131	7,068	6,804	6,837
5B1	No change in method. Use of new surveys and data within UK method impacts across all DAs.	6	2	1	1

Revisions summary (Scotland) Table 7.4 Continued		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
5B2	No change in method. Use of new surveys and data within UK method impacts across all DAs. Recalculations across the time series lead to greater declines in emission trends since 1990 across all DAs.	350	- 671	-812	-944
5C	No change in method. Use of new surveys and data within UK method impacts across all DAs.	0	-2	4	15
5C1	No change in method. Use of new surveys and data within UK method impacts across all DAs.	-60	-146	-47	-71
5C2	No change in method. Use of new surveys and data within UK method impacts across all DAs.	46	-89	-93	-90
5E	No change in method. Use of new surveys and data within UK method impacts across all DAs.	2	-1	-3	-5
5E2	No change in method. Use of new surveys and data within UK method impacts across all DAs.	8	-72	-91	-107
5G	No change in method. Use of new surveys and data within UK method impacts across all DAs.	-1	3	-3	-17
6A1	Revision of landfill model at UK level affects all DA estimates, but there has been no change in the DA allocation method. All DAs now show much greater reductions in methane emissions from landfills compared to the previous estimates.	716	-350	-404	-481

Revisions summary (Scotland) Table 7.4 Continued		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
6B2	Waste water treatment method for the UK inventory is now based on more DA-specific data across the time series, with all emission estimates of methane lower in all DA inventories.	-18	-23	-24	-28
6C	No change in method.	0	-10	-10	-10

Table 7.5 Reasons for Changes: Wales GHG Inventory Recalculations

Revisions summary (Wales)		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
1A1a	No change to method. Changes are as a result of revisions at UK level.	-84	-39	-32	-100
1A1b	No change to method. Changes are as a result of revisions at UK level.	-148	86	28	112
1A1c	Method for upstream oil and gas revised to enable more detailed emissions data analysis, in line with changes to the UK GHGI. A small number of data revisions for oil and gas installations from comparison of emissions reported via EEMS, EUETS and IPPC/EPR. DA estimates from gas production revised to use data from EUETS from gas compressor sites and LNG terminals, over-writing assumptions and revising DA data back to 1990.	3	-8	-8	-6
1A2a	No change to method. Changes are as a result of revisions at UK level, or within ISSB regional energy statistics for recent years.	0	0	97	84
1A2f	Several revisions due to use of EUETS data and also from specific site enquiries through review of IPPC documents and consultation with regulators and operators, leading to revised assumptions on fuel use and emission sources for several sites. EUETS data for the glass industry for 2009 provided new data on DA fuel use in that sector, which has been used to revise assumptions back through the time-series.	88	22	6	93
1A3a	No change to DA method. Revisions to assumptions within UK method lead to small revisions to the DA data also.	0	-2	-2	-2
1A3b	Revisions to the DA method to use more DA-specific fleet information (to over-write the use of GB-fleet information in the past inventories) on petrol/diesel car mix, car, engine size and age distribution for cars, LGVs and rigid HGVs. The small reduction in road transport GHG emissions for Wales is due to a combination of factors: older fleet composition as indicated by regional licensing data/DVLA data, more small engine-sized (<1400cc) cars and slightly higher diesel car penetration in Wales than in the rest of GB.	-53	-29	-27	-28
1A3c	No change in method. UK-wide reductions in recent years have had slightly different impacts across the DAs in total, due to different significance within each DA of the different rail types for which inventory estimates are made: intercity, regional and freight.	-66	-65	-53	-42
1A3d	No change in method. Revisions to UK GHGI time series split between domestic and international shipping affect all of the DA shipping estimates.	-248	-372	-321	-375
1A4a	UK data revisions to gas oil activity data have knock-on effect here, but also there have been method revisions to take account of the Northern Ireland Public Sector Energy Campaign data to revise the time series of fuel use in NI public sector. More work is needed to resolve data inconsistencies for gas oil in recent years.	50	-16	-35	-84

Revisions summary (Wales) Table 7.5 Continued		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
1A4b	UK revisions to activity data affect the DA trends, with peat data revised down across the time series, affecting the NI and S data. Use of revised mapping grids for several fuels has led to some notable changes in allocations of solid fuels (lower in NI than previously estimated), with smaller revisions to the GB split between E, S and W. A small correction to increase non-gas fuel use in Scotland in 1990, to reflect the growth in gas use evident between 1990 and 1995. To implement time series consistency checks in light of the new mapping grids and peat data, annual energy use per capita in the domestic sector by DA back to 1990 have been calculated, to identify where there may be systematic under- or over-reporting of fuel use in the residential sector. The DA estimates for non-metered fuels remain uncertain, and further work is proposed through the DA GHGI Improvement Programme.	336	215	185	99
1A4c	No change in method. The main impact is the revision to gas oil allocation for agricultural machinery in recent years.	2	-12	-10	-12
1A5b	No change in method. UK revisions to gas oil and ATF use in military vehicles affects all DA inventories.	0	0	0	-7
1B1a	Revised DA allocations across the time series, taken from the 2011 research to estimate the methane emissions from coal mining activities.	19	177	220	236
1B1b	No change in method. Changes are as a result of revisions at UK level.	0	0	1	2
1B2a	Method for upstream oil and gas revised to enable more detailed emissions data analysis, in line with changes to the UK GHGI.	0	-1	-17	-16
1B2b	The UK method improvement for gas compositional analysis affects the DA data also.	1	2	31	15
2A3	Glass data revised due to much more comprehensive coverage of the sector within EUETS for the first time in 2009. This has led to time-series revisions of DA activity and emissions.	1	-2	-4	-32
2A4	Glass data revised due to much more comprehensive coverage of the sector within EUETS for the first time in 2009. This has led to time-series revisions of DA activity and emissions.	0	-2	-4	-4
2B5	No change in DA method.	0	-1	0	1
2C1	No change in DA method.	0	0	0	-1
2C3	No change in DA method.	0	0	0	1
2F1	No change in method. Changes are as a result of revisions at UK level.	-1	-2	-3	-4
2F2	No change in method. Changes are as a result of revisions at UK level.	0	-9	-8	-7
2F4	No change in method. Changes are as a result of revisions at UK level.	0	0	-9	-7
4D	No change in method. Changes are as a result of revisions at UK level.	180	178	175	170
5A1	No change in method. Use of new surveys and data within UK method impacts across all DAs.	-725	-1,350	-1,295	-1,192
5A2	No change in method. Use of new surveys and data within UK method impacts across all DAs.	724	1,345	1,289	1,187

Revisions summary (Wales) Table 7.5 Continued		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
5B2	No change in method. Use of new surveys and data within UK method impacts across all DAs. Recalculations across the time series lead to greater declines in emission trends since 1990 across all DAs.	189	42	21	1
5C	No change in method. Use of new surveys and data within UK method impacts across all DAs.	0	-1	0	2
5C1	No change in method. Use of new surveys and data within UK method impacts across all DAs.	0	-1	-1	-1
5C2	No change in method. Use of new surveys and data within UK method impacts across all DAs.	-57	-68	-62	-55
5E	No change in method. Use of new surveys and data within UK method impacts across all DAs.	0	-1	-1	-2
5E1	No change in method. Use of new surveys and data within UK method impacts across all DAs.	0	0	0	0
5E2	No change in method. Use of new surveys and data within UK method impacts across all DAs.	63	19	10	1
5G	No change in method. Use of new surveys and data within UK method impacts across all DAs.	1	4	1	-2
6A1	Revision of landfill model at UK level affects all DA estimates, but there has been no change in the DA allocation method. All DAs now show much greater reductions in methane emissions from landfills compared to the previous estimates.	356	-171	-196	-220
6B2	Waste water treatment method for the UK inventory is now based on more DA-specific data across the time series, with all emission estimates of methane lower in all DA inventories.	-10	-14	-14	-16
6C	No change in method.	1	-7	-6	-6

Table 7.6 Reasons for Changes: Northern Ireland GHG Inventory Recalculations

Revisions summary (Northern Ireland)		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
1A1a	No change to method. Changes are as a result of revisions at UK level.	-179	-19	-14	-41
1A2f	Several revisions due to use of EUETS data and also from specific site enquiries through review of IPPC documents and consultation with regulators and operators, leading to revised assumptions on fuel use and emission sources for several sites. EUETS data for the glass industry for 2009 provided new data on DA fuel use in that sector, which has been used to revise assumptions back through the time-series.	100	111	125	106
1A3a	No change to DA method. Revisions to assumptions within UK method lead to small revisions to the DA data also.	-11	-17	-19	-20
1A3b	The large changes in road transport emissions for Northern Ireland are due to revision to vehicle km activity for cars, LGVs and rigid HGVs. This followed on from clarification with Traffic Information and Control Centre at DRDNI on the vehicle classifications used in the traffic census report which is different to those used by DfT for the rest of the UK. The vehicle km data provided by DRDNI are categorised into five groups, with the first and second categories as 'Car and Vans' and 'Med Commercial'. In the past, 'Car and Vans' vehicle km data were further split into cars and LGVs based on the Northern Ireland's licensing statistics, while 'Med Commercial' has been associated with rigid HGVs. Through clarification with DRDNI, the van component of the 'Car and Vans' category is associated with car-sized vans, while 'Med Commercial' category is associated with medium goods van. This means that LGVs and rigid vkm have been misallocated (and overestimated) in the past. Therefore corrections have been made to the vehicle km allocation methodology and this led to a 10-15% reduction in emissions for Northern Ireland across the whole time series in the 2009 inventory.	-301	-583	-578	-658
1A3c	No change in method. UK-wide reductions in recent years have had slightly different impacts across the DAs in total, due to different significance within each DA of the different rail types for which inventory estimates are made: intercity, regional and freight.	-1	0	0	2
1A3d	No change in method. Revisions to UK GHGI time series split between domestic and international shipping affect all of the DA shipping estimates.	-88	-161	-135	-158
1A3e	No change in method. Changes are as a result of revisions at UK level.	0	0	1	0
1A4a	UK data revisions to gas oil activity data have knock-on effect here, but also there have been method revisions to take account of the Northern Ireland Public Sector Energy Campaign data to revise the time series of fuel use in NI public sector. More work is needed to resolve data inconsistencies for gas oil in recent years.	46	15	16	53

Revisions summary (Northern Ireland) Table 7.6 Continued		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
1A4b	UK revisions to activity data affect the DA trends, with peat data revised down across the time series, affecting the NI and S data. Use of revised mapping grids for several fuels has led to some notable changes in allocations of solid fuels (lower in NI than previously estimated), with smaller revisions to the GB split between E, S and W. A small correction to increase non-gas fuel use in Scotland in 1990, to reflect the growth in gas use evident between 1990 and 1995. To implement time series consistency checks in light of the new mapping grids and peat data, annual energy use per capita in the domestic sector by DA back to 1990 have been calculated, to identify where there may be systematic under- or over-reporting of fuel use in the residential sector. The DA estimates for non-metered fuels remain uncertain, and further work is proposed through the DA GHGI Improvement Programme.	-537	-403	-748	-549
1A4c	No change in method. The main impact is the revision to gas oil allocation for agricultural machinery in recent years.	1	-12	-10	-12
1A5b	No change in method. UK revisions to gas oil and ATF use in military vehicles affects all DA inventories.	0	0	0	-4
2A1	No revision to DA method. Small site-specific revisions based on EUETS data and improved understanding of process / combustion split of total emissions.	0	0	3	0
2A3	Glass data revised due to much more comprehensive coverage of the sector within EUETS for the first time in 2009. This has led to time-series revisions of DA activity and emissions.	0	5	5	5
2A4	Glass data revised due to much more comprehensive coverage of the sector within EUETS for the first time in 2009. This has led to time-series revisions of DA activity and emissions.	0	4	4	4
2B5	No change in DA method.	0	0	0	1
2F1	No change in method. Changes are as a result of revisions at UK level.	0	-1	-2	-3
2F2	No change in method. Changes are as a result of revisions at UK level.	0	-5	-5	-4
2F4	No change in method. Changes are as a result of revisions at UK level.	0	0	-5	-4
4D	No change in method. Changes are as a result of revisions at UK level.	150	155	155	157
5A1	No change in method. Use of new surveys and data within UK method impacts across all DAs.	-479	-437	-368	-320
5A2	No change in method. Use of new surveys and data within UK method impacts across all DAs.	468	444	369	324
5B2	No change in method. Use of new surveys and data within UK method impacts across all DAs. Recalculations across the time series lead to greater declines in emission trends since 1990 across all DAs.	70	-3	-10	-16
5C1	No change in method. Use of new surveys and data within UK method impacts across all DAs.	-102	-102	-102	-102
5C2	No change in method. Use of new surveys and data within UK method impacts across all DAs.	22	73	80	87

Revisions summary (Northern Ireland) Table 7.6 Continued		Magnitude of change (2009 estimate – 2008 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2006	2007	2008
5E2	No change in method. Use of new surveys and data within UK method impacts across all DAs.	-2	180	201	221
5G	No change in method. Use of new surveys and data within UK method impacts across all DAs.	0	-1	-1	-1
6A1	Revision of landfill model at UK level affects all DA estimates, but there has been no change in the DA allocation method. All DAs now show much greater reductions in methane emissions from landfills compared to the previous estimates.	207	-107	-126	-148
6B2	Waste water treatment method for the UK inventory is now based on more DA-specific data across the time series, with all emission estimates of methane lower in all DA inventories.	-6	-8	-8	-10
6C	No change in method.	0	-3	-3	-3

7.3 Inventory Improvement Programme

A programme of inventory improvements has been implemented by DECC, the Scottish Government, Welsh Government and the Northern Ireland Government, following the review of the DA GHG inventories in 2009. The improvement programme targets emission sources that are assessed to be the highest priorities due to either high uncertainty in current estimates and / or poor sensitivity of the inventory methodology to DA Government policy actions.

The improvement programme is integrated with the UK GHG inventory improvement process, and is managed via the National Inventory Steering Committee (NISC). This ensures that all UK and DA GHG inventory stakeholders are engaged in the identification, prioritisation and implementation of inventory improvements, and are kept informed of progress on the DA GHGI research tasks.

The second year of the DA GHG inventory improvement programme, implemented during 2010-11, included:

- **IPPC permit review. Industry sector research task**, to address data inconsistencies and uncertainties arising in specific industrial sectors from emissions reported under IPPC and EUETS, through review of IPPC documents to determine reporting scope, fuels used (including biofuels) and emission sources (e.g. combustion, flaring, process). See Appendix 7 for a summary of this task;
- **EUETS research task**, to review 2009 EUETS data across all sites in the UK, to determine DA-specific emissions, fuel quantity and fuel quality data by economic sector, to improve the detail and accuracy of the traded / non-traded emissions analysis for the DA GHGI, which is presented in Chapter 8 and Appendix 4;
- **EUETS Phase III and National Allocation Plan research,** to investigate the available data from National Allocation Plans to inform DA inventory fuel use assumptions prior to 2005, and to review the available information regarding the extension to scope of EUETS in Phase III (2012 onwards) to help inform future DA non-traded share estimates;
- **REPI and CRC Scoping Study**, to review the available data from two emerging data sources on energy data in the commercial and industrial sectors. The REPI dataset comprises energy data estimates from all IPPC/EPR regulated sites in England and Wales, whilst the CRC registration phase data comprises electricity data from participants from a wide scope of economic sectors preparing for the first year of CRC operation in 2011. Both datasets will potentially provide important new energy data for DA inventory work in future;
- **Upstream oil and gas data processing.** Through a revision to the data management of upstream oil and gas data in the UK and DA GHG inventory systems, greater reporting detail and transparency has been achieved and improvements to the UK and DA end user emission inventories have been achieved;
- **Road Transport method improvements.** Following on from the road transport inventory workshop held in 2010, an improvement programme for the road transport sector was undertaken during 2011 in two stages: Phase I was a scoping study which assessed the availability and use of regional data, and the likely impact on GHG emissions if adopting such information; Phase II was the actual implementation of the findings from Phase I. Through the use of DVLA and DRDNI vehicle fleet statistics, the 2009 DA GHG inventory method has been overhauled to be more representative of DA fleets.
- **Review of DA Climate Change Action Plans.** In order to review the key policy areas that the DAs are implementing measures to address climate change, the action plans put together in the last 12 months by the Welsh Government, Scottish Government and the DECC Low Carbon Transition plan have been reviewed, to (i) identify priority sectors for inventory method improvements in order to better represent the local policy actions that the DA strategies and action plans will implement, and (ii) to seek out new data that could be useful in future DA GHGI compilation work, due to new policy tracking measures implemented through these strategies and action plans;
- **Sub-national energy data and end users inventory workshop**, to bring together the energy statistics experts from DECC (sub-national statistics team) and across the DA Governments, to review the current GHG inventory compilation system for energy data and to work through

the inventory agency approach to end user emission inventory compilation. The workshop identified a series of possible new energy data research strands for DECC and the DAs to consider during 2011-12, to improve the accuracy of the source data and inventory method;

- **Review of other priority sectors and data mining exercise**, to consult / meet with DA contacts to identify new data sources for DA inventory compilation.

The findings of these research tasks are summarised below. For further information on the research studies that were commissioned, please see the reports on the NAEI website, at: http://naei.defra.gov.uk/reports.php?list=DA

Within the agriculture sector, ongoing improvement work is focussing on the development of more detailed inventory compilation methods to achieve IPCC Tier 2 level methodologies, using UK-specific emission factors for more source sectors. Field research and data analysis is ongoing, commissioned by Defra, and the development of new inventory estimates is being considered for future inventory compilation cycles, using DA-specific activity data from farm surveys.

The Land Use, Land Use Change and Forestry inventory has recently been overhauled by the Centre of Ecology and Hydrology to incorporate a range of improvements and to update the underlying activity data from a new Countryside Survey dataset. The full details of the new data, methods and reporting formats, including the impacts on the DA GHG inventory data for LULUCF across the time series were included within a report published in April 2011 which can be downloaded from:

http://uk-air.defra.gov.uk/reports/cat07/1104140943_LULUCF_DA_GHGI_report_2009_v4.pdf

7.3.1 IPPC Permit Review: Industry Sector Research Task

The study team reviewed site-specific emissions data and regulatory permit information, to resolve differences between GHG data reported across different emission reporting mechanisms such as IPPC, EUETS and EEMS. Priority sites within the iron and steel, chemical, paper and pulp and food and drink sectors were identified through quality checks on data consistency of carbon dioxide emissions under different reporting systems. Regulatory permits were obtained from regulators and public registers, and the scope of reporting for each site was investigated to resolve data discrepancies. The work has led to revisions in inventory data and emission allocations, correcting errors and revising assumptions within emission estimates by site and sector, thereby improving the DA GHG inventories and Local Authority carbon dioxide datasets. For further details, please see Appendix 7.

The research has enabled the AEA inventory team to resolve data discrepancies for a number of sites, and to conduct a wide-ranging quality check of several sectors where high uncertainties were evident in the GHGI datasets from different reporting mechanisms. For the majority of sites studied, the work has led to an improved understanding of site activities, design, and scope of reporting to different mechanisms. Gaps and inconsistencies in data have been resolved for a number of high emitting sites, reducing uncertainties in GHGI data at all spatial scales.

7.3.2 EUETS Research Task

The emissions data from sites operating within the EU Emissions Trading Scheme is one of the most important datasets used in DA GHG inventory compilation, as the data provides a detailed insight into fuel use and fuel quality across the highest emitting industrial and commercial sites across the UK. The scope of the EUETS dataset increased in 2008 to cover a wider range of sites as Phase II of the scheme began. As in previous years, a detailed review of the full scope of 2009 EUETS data was conducted during the compilation of the UK and DA inventories, in order to maximise the usefulness of the EU ETS data within (i) the compilation of UK energy statistics for specific sectors, (ii) the development of UK and DA fuel-specific emission factors within the UK and DA GHG inventories, and hence (iii) the estimation of DA-level traded and non-traded GHG emissions.

Analysis of the 2009 EU ETS dataset has provided information to further improve the understanding of the emissions and fuel quality for a wide range of sectors within each of the constituent countries of

the UK. The allocation of all EUETS sites to DUKES categories was agreed with DECC DUKES, and fuel characteristics reported under EUETS, such as calorific values and carbon contents, were used to allocate the EUETS fuels to DUKES fuel categories. UK-wide activity data analysis indicated that there are several source sectors where UK energy allocations within DUKES may be reviewed in light of the 2009 EU ETS dataset, and a series of emails and meetings with the DECC energy statistics team has led to several revisions to UK energy statistics as a result.

The research also reviewed where new fuel quality data (such as carbon dioxide emission factors) from the EUETS could be used within DA GHGI compilation. Previously the GHGI had used emission factors derived from Tier 3 analysis of fuels in the power station, autogeneration and refineries sectors only. Analysis of the 2009 EUETS data indicated that for the majority of other sectors and fuels there are data inconsistencies and variability in reporting, and hence the use of EU ETS fuel quality data within the UK GHGI estimates remains limited; only a handful of sectors exhibit fuel quality data that are consistent and repeatable as to be directly useful to displace the current UK fuel factor defaults.

The analysis of the 2009 dataset has, however, led to greater use of EUETS fuel quality data for a range of fuels and sectors, including for OPG fuel use in the refinery and other sectors and coal mine methane use in all sectors.

The 2009 EUETS dataset also contains a much greater coverage of sites and emission sources (combustion and process) from the glass industry, which has led to revisions back through the time-series to re-assess the DA share of fuel use and emissions from this sector. Previously the DA allocation of emissions from the glass sector was based on site information on production capacity, but access to fuel use data for 2009 has enabled these assumptions to be over-written with some fuel-specific DA allocations. These revisions have led to improvements to DA GHGI data and also to the DA air quality pollutant inventories.

EUETS activity data has also been used to over-write assumptions of the DA share of emissions from gas and LPG use in gas network compressor stations on the transmission network and at LNG terminals. The EUETS includes estimates of fuel use in this sector, and the sum of EUETS data for the larger gas compressor and LNG terminal sites accounts for all of the reported fuel use in this sector (indicating that there may be an under-report or mis-allocation within the UK energy statistics and UK GHGI). These new data have been used to replace previous proxy data to derive the DA share of UK emissions, improving data accuracy and transparency. This method revision has enabled, for example, a more representative trend of emissions to be present that reflects the increase in emissions within Wales in the last few years that have arisen from the commissioning and operation of new LNG reception terminals on the South Wales coast.

Based on the 2009 EUETS analysis, the inventory agency has worked with the DECC DUKES to revise recent fuel allocations for the refinery sector, and this has increased the emissions reported in recent years, to address an under-report in fuel allocation to the sector for fuel oil and petcoke. We are aware from the 2009 dataset that there remain some uncertainties regarding OPG allocations to the sector within DUKES. In addition to the revision of activity data, the EUETS analysis has also prompted a revision within the UK GHGI to lower the carbon dioxide emission factor for the fuel OPG. The OPG compositional analysis conducted by operators when reporting to Tier 3 of the EUETS indicates that previous estimates of the carbon content of the fuel were too high. This has led to a small revision to emission estimates from OPG combustion across the time series and at all sites, reducing emission estimates from this source in England, Scotland and Wales.

7.3.3 EUETS Phase III and National Allocation Plan Research

This research is ongoing. The inventory agency has sought access to data from the National Allocation Plan (NAP) for Phase I and for the extended scope of emissions expected as the EUETS scope increases in Phase III of the scheme (from 2012). The DECC EUETS team has provided the NAP data for Phase I, but only aggregated emissions data by site are available. Site-specific fuel use data are not available, and hence there is no progress to be made from this dataset as assumptions regarding fuel use patterns around the UK cannot be made based on emissions data alone. For the forward-looking element of the work, new data on entrants to the scheme in Phase III has been provided and analysed to provide an indication of the DA-specific extension to coverage of the traded

sector. Further work is ongoing to analyse information for operators already within the EUETS where scope extensions in Phase III are likely. The inventory agency is aware of new data being collected by the EUETS regulators in this regard, but it appears very unlikely that these data will become available for use, and hence a series of assumptions will be made to assess the extension to scope for these current EUETS operators. This analysis relies upon interpretation of the higher emissions reported in IPPC data sets for these sites, but there is significant uncertainty regarding the source of these emissions which could, for example, be from burning of biofuels, from conventional fuels, or be process-related. The results of the analysis will therefore be highly uncertain.

7.3.4 REPI and CRC Scoping Study

This study comprised a review of two new energy and emissions datasets that are generated through new regulatory mechanisms:

- **The Resource Efficiency Physical Index (REPI).** These data were collected for the first time in 2010-11 by the Environment Agency of England and Wales, from all site operators that are permitted under Environmental Permitting Regulations (EPR). The data include estimates of annual energy and water consumption, site production, and waste generation.

- **The Carbon Reduction Commitment Energy Efficiency Scheme (CRC).** This is a new UK-wide emissions trading scheme that will become operational during 2011-12; a dataset from scheme participants of registration data has been made available for review.

In both cases, the data are not publicly available but have been provided for this review in order to assess their usefulness for the purposes of reporting the UK GHG inventory.

The inventory agency reviewed the data, assessed the quality and completeness of the data, and compared aggregated data from the CRC and REPI against national energy statistics published within the Digest of UK Energy Statistics (DUKES), and emissions data published through the EU Emissions Trading System (EUETS) and the inventories of emissions from sites regulated under Environmental Permitting Regulations (EPR).

The study sought to identify where the new data may be useful (now or in the future) to improve the accuracy and sensitivity to policy actions of the UK and DA GHG inventories; the data may be useful to inform national and sub-national energy statistics that underpin UK and DA emission inventories as well as emission maps. Hence, the review focussed on the geographical- and sector- resolution of the data, and the study recommendations for future research were primarily aimed at improving the completeness and granularity of reporting via these mechanisms in future.

The review highlighted that both datasets are not directly useful for inventory emissions work at this time; further development and research will be needed to make use of these new datasets due to limitations in the scope, detail, completeness and quality of the data. The completeness and quality of reporting is insufficient to enable comprehensive analysis of either dataset.

The REPI data provides energy data that are sectorally- and geographically-referenced. The study team identified data outliers and estimated that the reported energy use was at least 70% consistent with other datasets such as that available from the EUETS. The REPI data do not provide complete coverage for industry sectors, but nevertheless provides a significant step forward in coverage of energy reporting within many sectors in England and Wales, as many companies under the EUETS reporting threshold do report their energy use data under REPI.

The CRC data was found to be very difficult to analyse and identify benefits to energy and emissions data reporting. Data are presented by participant organisation and are not geographically-referenced. Some public sector data can be geographically-referenced. Many CRC participants operate across more than one economic sector, and hence the sector-referencing of the CRC dataset is limited. The analysis identified many instances of mis-reporting by participants, often by up to three orders of magnitude. The CRC registration dataset was therefore regarded to be of very limited use for emissions inventory work; the study team opted to focus on the public sector to perform more detailed data analysis, in order to explore the sector data that appeared to be potentially most useful from the

CRC. This analysis indicated that the coverage of public sector bodies within CRC varies within the UK but that in some cases a high percentage of organisations evidently report under CRC and therefore the data may become useful to inform de-minimis energy allocations for the public sector at DA and UK level.

7.3.5 Upstream Oil and Gas Data Processing

Through consultation with the DECC team at the offshore inspectorate in Aberdeen, each installation that reports through the EEMS system was allocated to either the "upstream oil" or "upstream gas" sector. Within the UK GHGI data processing systems, revisions to data management and reporting were implemented during 2010 to enable the UK GHG inventory to report the data at a more detailed level. The outcomes of this work are detailed within the National Inventory Report (MacCarthy et al, 2011).

As a consequence of this development, the DA GHGI data management system has also been updated in this inventory cycle in order that the improvements to the UK GHGI could be integrated to the DA GHG inventories. This development also enables the DA end user inventory method to use the oil and gas data separately and deliver improvements to the re-allocation of energy supply sector emissions within the DA end user inventories. The revision to oil and gas data processing systems has not had any effect on the "by source" DA GHG inventory totals, but it has improved the detail of reporting. The improvements to the DA end user data through the method improvement are evident within the data presented in Chapter 10 and Appendix 5.

7.3.6 Road Transport

The road transport sector is a high emitting sector in all of the DA inventories and a key target sector for emission reductions to be achieved through national and regional policy actions. In April 2010, a road transport inventory workshop was held with officials from DECC, DfT, representatives of each of the DAs and members of the inventory team to discuss the current methodologies used in the DA inventories and how they could be improved. The workshop has promoted better communication with key statistics and policy leads within the DAs, as well as identifying specific tasks for consideration within the DA GHGI inventory programme. One of the priorities for improvement was outlined to be greater consideration of DA-specific input data. Subsequently, an improvement programme for the road transport sector was undertaken during 2011 in two stages: Phase I was a scoping study which assessed the availability and use of regional data, and the likely impact on GHG emissions if adopting such information; Phase II was the actual implementation of the findings from Phase I, which also represented the improvements made to the 2009 DA GHGI,

Four specific transport features that influence emissions from road transport were reviewed in Phase 1: vehicle fleet composition, speed, passenger car trip lengths and use of alternative fuels. Further details can be found in the scoping study report (Pang et al., 2011) and the main findings are summarised below:

- Interrogation of vehicle licensing data held by the Driver and Vehicle Licensing Agency for England, Scotland and Wales and Department for Regional Development Northern Ireland (DRDNI) has shown that there are some regional differences in the composition of the fleet (i.e. differences in petrol/diesel car mix, engine size and age distribution);

- Passenger car trip lengths (which are used to estimate cold start emissions of nitrous oxide from petrol cars) are shorter in Northern Ireland while there is no significant differences in trip lengths for England, Scotland and Wales compared with the GB average currently assumed in inventories;

- All DAs collect speed data based on traffic count data, surveys, moving car methods and traffic models; however, it was not possible within the timescales of this programme to obtain and analyse comparable vehicle speed data for each country to determine whether there were any statistically significant differences to average speeds assumed at GB level. Therefore further work would be needed to explore the use of DA-specific speed data;

- Regional data on the consumption of biofuels in the road transport fleet across the DAs have not been found. There are differences in the number of LPG vehicles licensed, but these are presently regarded as too insignificant to warrant any change in the method to allocate LPG emissions between countries.

Based on the above findings, DA-specific fleet data for cars, LGVs and rigid HGVs for Scotland, Wales and England and the use of Northern Ireland-specific trip length were incorporated in the 2009 DA road transport inventory. The scoping study report also recommends that further development of the models should be considered to improve the sensitivity of the road transport estimates to policy options.

7.3.7 Review of DA Climate Change Action Plans

The inventory agency reviewed a number of UK and DA Government climate change policy documents, to identify: (i) key policies and policy areas where impacts of policies upon activity data and emission factors are expected to be reflected in overall emission inventory data, and (ii) new policy-specific data mechanisms (e.g. to track policy implementation) that may become useful in the future development of inventory methodologies at the UK and/or DA level.

The review focused on the energy, industrial process and waste sectors of the GHG inventory, and looked in detail at recent top-level policy documents from UK and DA Governments, including:

- **UK**: Low Carbon Transition Plan, Low Carbon Transport, Delivering the Low Carbon Transition Plan;
- **Wales**: Climate Change Strategy for Wales: Delivery Plan for Emission Reduction, Renewable Energy Route-map for Wales;
- **Scotland**: Low Carbon Scotland: The Draft Report on Proposals and Policies, Zero Waste Plan, Scottish Building Standards (website), Public Bodies Climate Change Duties, Energy Assistance Package.

The review highlighted a range of possible options for future inventory improvement research, based on the available information on policy implementation and new data mechanisms expected to be implemented to track policies.

In many cases, the systems of DECC and DA policy monitoring and reporting are still under development, and hence there are many areas where the detail of what might be achieved through further research of these information sources is not clear. However, the emission sources identified as the highest priorities for further research to augment current data and inventory methods were:

- **Waste.** New DA reporting mechanisms could inform the development of DA-specific models using available policy data (e.g. Scottish Zero Waste Plan, WG policy on biodegradable waste targets);
- **Energy Supply and Industry.** The REPI dataset (England and Wales IPPC sites only) includes site-specific energy data (including electricity data) that could be used to improve the level of sector resolution for estimates from all regulated industrial sites in Wales;
- **All energy sectors**. The Low Carbon Transition Plan has a wide range of targets and performance indicators that could provide useful data for specific sectors;
- **Business, Energy Supply and Industry**. Climate Change Levy Information may provide site-specific energy use data for a wide range of sites in industrial and commercial sectors;
- **Business and Public**. Energy Performance Certificates and Display Energy Certificates for building energy use could be used directly to inform energy use estimates by fuel, by sector, by location, or to improve the energy mapping methodology currently used in the sub-national energy statistics analysis;
- **Public.** FReM (Treasury public sector energy reporting system) sustainability reporting for the public sector may become a useful new dataset to inform public energy and emissions data.

7.3.8 Sub-National Energy Data and End User Inventory Workshop

Emissions from energy use are a major contributor to carbon dioxide emissions across the DAs, and whilst the energy statistics for the most energy intensive regulated industries are well documented and understood, the data for small-scale energy combustion within the domestic, public, commercial and small-scale industry sectors are scarce and the GHG estimates are subject to high uncertainty. These small-scale combustion sectors are also the energy sources where DA policy levers are the primary mechanism to mitigate GHG emissions. In order to develop a more accurate evidence base for policy development in these sectors and also to ensure that mitigation actions are represented within the DA inventory trends, development of the sub-national energy data is required.

The workshop brought together the leading energy statisticians and energy and climate change policy analysts from DECC and the DAs, to work through the current data limitations, exchange ideas and formulate a coherent plan to take forward the development of DA energy data. The afternoon session of the workshop focussed on the inventory agency method for the DA end user inventory, in order to cover the requirements for improved DA electricity data, but also to exchange knowledge of data sources, options and priorities for future improvements.

The workshop covered:

- the key limitations of current energy datasets and the significance of the small-scale combustion sectors for DA targets, once “end user” emissions are considered;
- the energy modelling approaches currently used to disaggregate the UK data on non-metered fuels;
- updates from the DECC sub-national energy statistics team on their work programme to take forward IDBR and meter data matching, their programme timescales and reviews of analysis;
- a summary of key data requirements to meet target-tracking and policy evaluation and development requirements in Scotland, Wales and Northern Ireland. Key sectors of interest for all DAs were agreed as business, residential and public, especially in Wales where sector-specific targets are set;
- an overview of ongoing developments in energy efficiency and climate change policy areas, including options for improving geographical and sector resolution of energy data considering new datasets (e.g. REPI, CRC);
- comparisons in data availability between the DAs, such as the different data reporting detail for Northern Ireland compared to GB due to a more limited energy market in NI;
- a discussion of opportunities for development of data management and reporting systems to develop an agreed list of priorities, task owners and required timescales for improvements.

The workshop discussions regarding the DA end user model covered:

- DA-specific data limitations and the links to the “by source” inventory data;
- The growing focus on end user inventories to support the evidence base and tracking for energy efficiency policy programmes;
- The suite of recent improvements to the DA end user inventory method, and the need for more detailed electricity data in order to take the work forward to deliver more detailed sector-specific end user inventories.

The priorities for improvement of the DA method were outlined to be sensitivity to policy actions, greater consideration of DA-specific input data where available, and a clarification of the UK-wide assumptions and data that are included within the current method.

As a result of the workshop, communication across the DA energy policy areas has been initiated, with individuals identified to lead on collection and provision of any new information across the group. Work has continued since the workshop to exchange information and seek out new data sources from the Scottish Government Energy Efficiency Action Plan team and also through meetings to explore the usefulness of the National Energy Efficiency Database within the energy and emissions mapping work that underpins some sections of the sub-national energy statistics published by DECC.

7.3.9 Data Mining and other DA GHGI Improvements

In order to identify new data resources that may be useful for the improvement of GHG emissions estimates within the energy, industrial process and waste sectors of the DA inventories, the AEA inventory team have conducted web-searches and consultation with DA policy leads and analysts. The process included teleconferences, meetings, emails and internet searches to identify and review possible new data sources.

This process led to several inventory improvements within the latest inventory cycle, and has also identified new data that may help with ongoing research at UK GHG inventory level, or within future DA GHG inventory improvements.

Data and method improvements implemented within the 1990-2009 DA GHGI cycle include:

- **Landfill Waste Model**. The AEA team provided a suite of DA-specific waste sector datasets that have been incorporated into the landfill model revision funded by Defra during the 1990-2009 UK GHGI cycle. Consultation with waste sector experts during 2010 led to the collation of new information from recent waste survey and compositional studies including: MSW composition (Scotland WRAP study, Wales WRAP study), public sector waste arisings survey (Wales), Commercial & Industrial & Agricultural waste fate studies (Wales), Northern Ireland waste compositional study and Commercial & Industrial waste sector report.

- **Domestic sector**. The AEA energy and emissions mapping team have overhauled the domestic sector maps to include new census data and more detailed housing data for Northern Ireland. In addition, new data on peat use in the domestic sector has been provided by CEH, which greatly reduces the estimates for peat use in the domestic sector, especially in Northern Ireland. The maps and CEH peat data only provide snapshots of analysis for the latest year and where large revisions to previous data are evident, the DA inventory compilation needs to take account of the impacts on time-series consistency that such revisions will have. As a result, the domestic sector time series has been revised, through a review of data across all fuels (including electricity) in the sector to determine UK and DA energy consumption per capita and to identify any spurious trends in these data back to 1990. These revisions provide a realistic trend in emissions for the sector for each DA, but further work is recommended to develop the DA energy data for the sector further.

- **Northern Ireland Public Sector Energy Campaign data**. Consultation with DFPNI has provided new data from public sector energy reports from 2002 to 2009, covering all fuels (including electricity) used in public sector buildings in Northern Ireland. These data have been used to replace previous estimates of fuel use in that sector, for most (but not all) fuels. The PSEC data scope covers building energy use and is a close match to the DUKES category description, and therefore the data have been used directly to inform gas and solid fuel use within the public sector in Northern Ireland. The reported gas oil use in the PSEC report is significantly higher than that currently reported for the UK as a whole; in the UK GHGI programme, the limited data on gas oil has been identified as problematic and these data from PSEC should now also be taken into consideration to help inform future gas oil allocations to the public sector, In the current NI inventory, therefore, there is a small under-report in public sector emissions due to this discrepancy.

- **Waste water treatment and sewage sludge treatment and disposal data.** As part of a wider UK GHGI programme of work to develop an improved method for UK emissions from the waste water treatment sector, consultation with contacts in Scottish Water and Northern Ireland Water helped to secure new data that were used within the method overhaul, and have therefore led to improvements in the estimates within both the UK and DA inventories. More work is needed to obtain data from more water companies in England and Wales to further improve the estimates in future.

In addition to the revisions noted above, the DA data mining task has also highlighted other areas where new data could become useful for DA GHGI method improvements, including:

- **Shipping Data from the DfT Maritime Statistics team.** The DfT maritime statistics team hold data on port freight movements disaggregated by domestic and international shipping routes, and therefore it could be possible to derive separate shipping DA drivers for the domestic and international shipping components of the inventory. We have obtained as full a time series as the DfT database can provide, which enables separate DA shares of UK activity for domestic and international shipping to be derived.

- **Landfill Gas Utilisation Data.** One of the main challenges in improving the DA-specific estimates of methane emissions from landfills is to identify a dataset to inform the local activity to capture and oxidise the methane in flares or engines. This is a key step in identifying the DA opportunity for waste sector policy implementation to address those sites where additional landfill gas utilisation could be achieved. Through review of the DECC Energy Trends articles, it is noted that landfill gas engine electricity generation statistics are available disaggregated by DA within renewable energy data tables, for 2003 to 2009. Although this only covers one part of the waste sector data needed, these data could be very useful to improve the DA estimates for landfill waste emissions.

Other research that has not yet led to any new data sources but has helped improve the understanding of available data includes:

- **Consultation with experts within DETINI and DOENI to clarify the availability of energy data for Northern Ireland.** This has clarified the scope and detail of the Coal Inquiry and Inland Deliveries of oil, which are considered as a constraining quality check within the N Ireland GHG inventory, but not as a direct data source. DoENI have identified that energy data are reported by operators regulated under IPPC/EPR and there is work ongoing (within DOENI) to collate these data for review and subsequent use within the GHGI.

- **Display Energy Certificates**. The AEA team has investigated access to Display Energy Certificate data, which may be useful to improve the underlying assumptions that feed into the energy and emissions mapping work for specific source sectors such as the public sector. This work is ongoing. Specific data have been identified (e.g. NHS Trust Wales energy data), but more needs to be done to obtain more complete data.

- **Scottish Energy Efficiency Action Plan.** The AEA team has met with the Scottish Government EEAP team of statisticians to exchange information and seek out new data that may be generated through policy-specific tracking mechanisms. We understand that work is due to be commissioned to develop a new database of buildings information for the non-domestic sector which may become useful for improving assumption underpinning DA energy and emissions mapping in future.

8 Traded and Non-Traded DA GHG Emissions

8.1 Background

The data analysis and reporting of GHG emission inventories in the UK, both at the national and sub-national level, is increasingly coming under scrutiny for the purposes of energy and climate change policy development, evaluation and appraisal. Part of the challenge is to develop a better understanding of the emission sources that are predominantly impacted by UK-wide emissions trading policies, primarily the EU Emissions Trading Scheme (EUETS).

In order to support evidence-based policy development within the climate change strategies and programmes implemented by the DA Governments of Scotland, Wales and Northern Ireland, it is necessary to develop a more detailed understanding of the scope of the "non-traded" emissions sector (i.e. those emission sources that are not within the EUETS) and hence better understand the GHG emission sources where devolved policies can have the greatest impact.

The non-traded sector in the UK is primarily the smaller-scale emitting sites. These are usually sources where comprehensive accurate data on energy use and / or emissions are not available. Emissions from the traded sector are better known, since the mechanism for trading requires reporting of detailed emissions, activity and emission factor data. The current approach to deriving the non-traded emission estimates is therefore by difference from the total DA GHG inventory data and the EUETS emissions data:

Non-traded emissions	=	total emissions	–	traded emissions

The DA GHG inventory data are derived from the UK GHG inventory data, which in turn is linked directly (for high emitting, energy-intensive sites, such as those within the EUETS) to industry-specific fuel allocations within the Digest of UK Energy Statistics (DUKES).

Detailed analysis of the EUETS dataset has been conducted and the findings were published in May 2011[15], in order to maximise the usefulness of the EUETS data within (i) the compilation of UK energy statistics for specific sectors, (ii) the development of UK and DA fuel-specific emission factors within the UK and DA GHG inventories, and hence (iii) the estimation of DA-level traded and non-traded GHG emissions. The research focussed on analysis of the 2009 EUETS dataset, looking in detail at the available data for a wide range of source sectors. The EUETS dataset covers emissions from a scope of installations that are very similar in 2009 compared to 2008, as the scheme is in Phase II since 2008, and only a small number of additional sites reported in 2009, notably in the glass sector. Analysis of the Phase II EUETS dataset has facilitated a greater understanding of the emissions and fuel quality data from EUETS within each of the constituent countries of the UK, improving the accuracy of the DA and UK GHG inventories for several high-emitting source sectors.

The estimates derived for the traded and non-traded sectors of the DA GHG inventories presented here are for the years 2008 and 2009 only, as the earlier years of EUETS data covering 2005 to 2007 were during Phase 1 of the scheme when a more limited scope of installations was included. Comparison of data from Phase I and Phase II is therefore of little value.

[15] "2009 EUETS Data Analysis for the UK GHGI: Task 2 of the 2010 UK-DA GHG Inventory Improvement Programme" Passant and Thistlethwaite, May 2011 http://uk-air.defra.gov.uk/reports/cat07/1106161307_IP_Task_2_EUETS_Issue_1.pdf

8.2 Traded and Non-traded Inventory Estimates: Data Quality and Reporting Format Issues

The EUETS site data have been analysed to allocate fuels and sites to align with inventory criteria, in consultation with DECC DUKES energy statisticians and EUETS regulatory experts from the Environment Agency of England and Wales, the Scottish Environment Protection Agency and the Northern Ireland Environment Agency.

The research published in May 2011 comprised a detailed comparison of fuel use allocations by sector between the 2009 EUETS and the DECC national energy statistics within DUKES, as well as reviewing the latest fuel quality information by sector available from EUETS. The research showed that direct comparison of EUETS data and alignment with DUKES sectors and GHG inventory IPCC sector reporting format is problematic for a number of reasons:

- **Disparity between DUKES and EUETS sector fuel use totals**. There are several industrial sectors where large differences are evident in the 2009 fuel allocations within DUKES, compared to the data reported by operators under EUETS. The fuel use data from EUETS are generally considered to be of good quality, having been subject to a rigorous data checking and verification process. The EUETS does not always cover 100% of sites within a sector, however. There are a number of instances where the EUETS fuel use data are higher than the data reported within DUKES. As DUKES is the primary data source for UK fuel use within the UK GHGI, therefore, the DA GHG inventory emissions may be lower than the sum of the EUETS site emissions within a sector.

- **Differences in scope and definitions between IPCC sectors and EUETS reporting**. IPCC reporting requires that a distinction is made between fuel combustion emissions and process emissions, and all emissions from all sources need to be captured. The scope of EUETS reporting is not always comprehensive, i.e. emissions from some sources on site may be excluded from EUETS data. Furthermore, the reporting format of the EUETS does not explicitly separate the GHG emission sources between different activities on site. These scope and reporting limitations make it very difficult to either directly use in, or reconcile the reported data with the IPCC format emissions calculated and presented within the UK and DA GHG inventories.

As a result of these data format and data quality issues, the derivation of traded and non-traded emission estimates requires:

(i) IPCC sector aggregation or division, altering the detail of the IPCC sector reporting format, to match the level of detail available from EUETS reporting for specific industries. Examples include the division of 1A1c to enable data to then be aggregated with other IPCC sectors for iron and steel sector reporting (1A1c coke production, aggregated with 1A2a, 2A3 and 2C1), oil & gas sector reporting (1A1c gas use, aggregated with 1B2c flaring and venting), leaving 1A1c (gas production) and 1A1c (other energy industries) to be reported separately. In addition, cement combustion (1A2f_cement) must be reported aggregated with the decarbonisation sources (2A1) to enable comparison against EUETS.

(ii) Calculation of non-traded DA GHGI data such that the data inconsistencies between DUKES and EUETS fuel use are minimised, removing the inconsistencies by (in most cases) assuming that the EUETS data for a given sector are the more accurate estimates. A key example in the 2009 dataset is the 1A1b Refinery combustion emissions, where the EUETS emissions are higher than those estimated within the UK GHG inventory and the DA GHG inventories. The EUETS data are around 11% higher than the inventory estimates, but the sector is effectively “100% traded”. In the derivation of the non-traded emission estimates, the EUETS data are assumed to be more accurate; the refinery sector is assigned a zero non-traded emission.

The comparison between reported EUETS emissions and the DA GHG inventory data are presented below, by (amended) IPCC sector. [Note that the data presented in the tables have been rounded to 3 or 4 significant figures, and the data may not always appear to be fully consistent as a result.] Detailed

tables showing the full DA traded and non-traded emission estimates for 2008 and 2009 are provided in Appendix 4.

8.2.1 DA Traded and Non-Traded GHG Emission Estimates (2008-2009)

The traded and non-traded emission estimates for each of the DAs in 2008 and 2009 are summarised in the tables below. In each case, data are presented for:

- Traded carbon dioxide emissions (taken directly from EUETS);
- Total inventory and Non-traded estimates for all GHGs;
- Total inventory and Non-traded estimates for carbon dioxide; and
- Energy and Industry DA inventory and non-traded share for carbon dioxide.

Table 8.1 Overall DA Traded and Non-Traded Emission Estimates, 2008-2009

Traded and Non-Traded Emissions, 2009					
	Units	England	Scotland	Wales	N Ireland
EUETS CO_2 emissions	Mt CO_2	168.5	22.0	21.8	4.33
GHGI total net GHG emissions	Mt CO_2e	436.0	48.1	42.6	19.5
"Non-traded" total net GHG emissions	Mt CO_2e	268.7	26.3	21.3	15.2
Non-Traded sector	%	61.6	54.7	50.0	78.0
GHGI total net CO_2 emissions	Mt CO_2	373.0	36.5	34.8	13.6
"Non-traded" total net CO_2 emissions	Mt CO_2	205.7	14.7	13.5	9.27
Non-Traded sector	%	55.1	40.3	38.8	68.4
GHGI IPCC Energy & Industrial process CO_2 Emissions	Mt CO_2	371.3	42.5	35.1	13.5
"Non-traded" Energy & Industrial process CO_2 emissions	Mt CO_2	204.0	20.7	13.8	9.20
Non-Traded sector	%	54.9	48.7	39.3	68.2
Traded and Non-Traded Emissions, 2008					
	Units	England	Scotland	Wales	N Ireland
EUETS CO_2 emissions	Mt CO_2	193.5	23.8	26.6	5.87
GHGI total net GHG emissions	Mt CO_2e	478.0	51.8	49.3	21.2
"Non-traded" total net GHG emissions	Mt CO_2e	286.9	28.2	23.0	15.4
Non-Traded sector	%	60.0	54.5	46.6	72.4
GHGI total net CO_2 emissions	Mt CO_2	412.3	40.0	41.6	15.2
"Non-traded" total net CO_2 emissions	Mt CO_2	221.2	16.4	15.2	9.4
Non-Traded sector	%	53.7	41.1	36.6	61.5
GHGI IPCC Energy & Industrial process CO_2 Emissions	Mt CO_2	410.5	45.9	41.9	15.2
"Non-traded" Energy & Industrial process CO_2 emissions	Mt CO_2	219.5	23.3	15.5	9.3
Non-Traded sector	%	53.5	48.6	37.1	61.4

Total net carbon dioxide emissions in Scotland and Wales are lower than energy and industry carbon dioxide emissions in both years. This is because of the carbon sink in both regions due to LULUCF activities. As a result the non-traded emissions calculated from net total carbon dioxide is significantly lower for Scotland in particular. The figures calculated on the basis of energy and industry emissions only are perhaps a more reliable indicator of the scale of non-traded emissions across the four regions.

In the analysis of the above data, it must be noted that there are considerable uncertainties in the DA inventory estimates, and we have a relatively small dataset of traded and non-traded estimates. Therefore whilst it is perhaps useful to consider the relative opportunity for DA policy action in future mitigation efforts across different sectors by looking at the non-traded data in more detail, there is an underlying need for greater data gathering at DA level to improve the evidence base for policy development. The data analysis and discussion presented below needs to be considered with the data uncertainties in mind.

Considering the total GHG inventories and the non-traded share of GHG emissions, the UK non-traded share is 57.6% in 2008 and 59.3% in 2009. Between 2008 and 2009, the GHG emissions from non-traded sources declined by 21.8 Mt carbon dioxide (CO_2) or 6.1%, due in part to the impact of the recession. The non-traded estimates for England, Wales and Scotland all exhibit trends similar to the UK average, ranging from 6.3% reductions in England to 6.6% in Scotland and 7.3% in Wales. In Northern Ireland, the non-traded share of GHG emissions declined by only 1% between 2008-2009, but there is greater uncertainty in the non-traded emission estimates in Northern Ireland due to the much greater reliance on solid and liquid fuel use within the economy, the estimates of which are more uncertain than those for metered fuels (gas, electricity). Nevertheless, this notably lower reduction in the non-traded share in Northern Ireland may reflect the greater impact on emissions related to the energy-intensive industries evident in GB, where a lesser demand for fuels within a shrinking UK economy would be expected to have a knock-on effect to ancillary services to the energy sector (for example, a reduction in energy and heavy industry transport-related emissions, which are within the non-traded sector).

The DA data above illustrate the regional differences in the EUETS coverage and significance in the context of the overall DA inventories, which indicates the level of opportunity for DA policy actions in the non-traded sector. These estimates of non-traded emissions may affect the analysis to determine DA GHG emission reduction targets, where those targets are applied to the non-traded sector only, rather than to the complete DA GHG inventories.

The data for Wales show that the coverage of the EUETS is consistently higher than the UK average, which reflects the high share of heavy industries in Wales; Wales exports electricity to England and has a high percentage of UK refinery capacity (almost 22% of UK traded sector emissions in 2009) and iron and steel manufacture (35% of UK traded sector emissions). As a result, the non-traded sector in Wales (which is the focus for WG Climate Change Strategy policy actions and targets) is only 37.1% of the energy and industrial process carbon dioxide emissions in 2008, and 39.3% in 2009. In 2007 (the last year of Phase I of the EUETS) the non-traded share of Wales carbon dioxide emissions was estimated to be around 42% of the total inventory; the expansion of the coverage of sites and sources within EUETS in Phase II of the scheme (which runs from 2008 to 2012) has increased the traded share in Wales by a further 5% of total carbon dioxide emissions. The expansion of the EUETS scope in Wales may affect the WG Climate Change Strategy targets, where emission baselines of the non-traded sector emissions need to account for the full scope of EUETS emissions.

The non-traded sector estimates for Scotland indicate that the significance of Phase II EUETS is higher than the UK average, with only 48.7% of energy and industrial process carbon dioxide inventory emissions in the non-traded sector in 2009 (48.6% in 2008), compared to 52.0% in the UK in 2009 (50.1% in 2008). Review of sector-specific EUETS data from 2009 across the UK shows that Scotland has a disproportionately high share of EUETS emissions in specific industrial sectors; for example, in the chemicals sector, Scottish sites account for 32% of the UK sector traded emissions, whilst in the paper, pulp and packaging sector, Scottish sites account for 13% of the UK traded emissions. The Grangemouth refinery accounts for 14% of UK refinery sector emissions whilst oil and gas terminals in Scotland account for 9% of total UK sector traded emissions.

The Northern Ireland inventory has a much higher non-traded element compared to GB, with non-traded GHG emissions accounting for 68.2% of energy and industrial process carbon dioxide emissions in 2009 (61.4% in 2008). This reflects the lower level of heavy industry in Northern Ireland, where there are no refineries, oil & gas terminals or iron and steelworks for example. Analysis of the 2009 EUETS data shows that Northern Ireland has a 2.5% share of the power sector traded emissions, whilst the only sectors where Northern Ireland has a higher share are in the cement sector (4.8% of UK sector traded emissions), glass sector (5.9% of UK sector emissions) and the public sector (3.4% of UK sector traded emissions) in 2009.

England non-traded emissions are estimated to be around 54.9% of energy and industrial process carbon dioxide emissions in 2009 (53.5% in 2008), a few percent higher than the UK average. There are many industrial and commercial sectors where England has a high share of the UK traded emissions in 2009; for example, sites in England account for 65% of iron and steel EUETS emissions, 81% of power generation EUETS emissions, 83% of public sector traded emissions and 79% of cement sector traded emissions. England has a lower representative share of EUETS emissions in the refinery and oil & gas sectors, reflecting the high incidence of such sites in Wales and Scotland.

8.2.2 IPCC Sector Traded / Non-Traded Emissions Share, 2009

IPCC Sector 1A1a: Power Generation

This sector covers major power stations in the UK. Almost all power stations operate within the EUETS. Exceptions arise for some very small power stations generating electricity in remote areas, and MSW incinerators. In the latter case, most of the carbon is from biological sources and therefore excluded from the DA GHGIs.

Table 8.2 IPCC Sector 1A1a: Power Generation, 2009

Power Generation					
IPCC Sector		England	Scotland	Wales	N Ireland
1A1a	GHGI, Mt CO_2	121.8	13.3	11.2	3.66
	Traded, Mt CO_2	121.4	13.3	11.3	3.70
	Non-Traded share, %	0.3	0	0	0

The traded share is expected to be lower than, but close to 100%, and this is the case in England, whilst in Scotland the traded emissions are 100% consistent with the GHGI. In Wales and Northern Ireland the GHGI data are in fact fractionally lower than the EUETS data.

There remain some small data discrepancies between the sum of all power station site fuel use data reported in EUETS compared to those for the power sector within DUKES, but the data are very closely consistent. Note also that the GHGI calculations use DA-specific carbon dioxide emission factors derived from the EUETS rather than UK averages, to ensure that the carbon content of local fuels is represented in the DA GHGI.

IPCC Sector 1A1b: Petroleum Refineries

This sector covers petroleum refineries and there are very significant inconsistencies between the EUETS data and the GHGI totals; the traded emissions in England, Scotland and Wales (there are no refineries in Northern Ireland) are around 11% higher than the total emissions given in the DA inventories.

Table 8.3 IPCC Sector 1A1b: Petroleum Refineries, 2009

Petroleum Refineries					
IPCC Sector		England	Scotland	Wales	N Ireland
1A1b	GHGI, Mt CO_2	9.46	2.04	3.31	-
	Traded, Mt CO_2	10.6	2.26	3.62	-
	Non-Traded share, %	0	0	0	-

Following analysis of the 2007 EUETS data for refineries and consultation with the refinery trade association, UKPIA and the DECC DUKES team, the UK GHGI for 2008 and 2009 have been compiled using the EUETS data (in preference to DUKES data) for petroleum coke. This addressed one observed mis-report in petroleum coke activity data in DUKES, which it is understood related to problems in the PPRS reporting system (used to compile DUKES) for a couple of refinery sites. The analysis of the 2009 EUETS data indicates that there are inconsistencies in emissions from other fuels, including fuel oil and OPG, which are primarily due to activity data discrepancies between those reported in EUETS and those used in the GHGI.

This sector is effectively 100% traded, with all refinery sites operating within the EUETS. The differences in the EUETS-GHGI data have been taken into account in the calculation of the DA traded emissions estimates. It is assumed that the EUETS data are the more accurate estimates for this sector, and revision of the activity data and emission factors are planned for the next inventory cycle. The analysis of 2009 EUETS data has been shared with the DECC energy statistics team for consideration within DUKES 2011. The allocation of EUETS fuel data to specific DUKES category fuels is particularly problematic for the refinery sector, as such a wide range of fuels of variable hydrocarbon content and hence carbon dioxide emission factor, are burned to raise heat and steam on refinery sites. The allocation of "OPG" is therefore somewhat uncertain within the analysis of EUETS data.

IPCC Sector 1A1c (coke) / 1A2a / 2A3 (BOS, Sinter) / 2C1: Iron & Steel

Within the EUETS, the emissions from iron and steelworks are not reported separately such that the allocation of EUETS emissions across a range of IPCC sectors can be achieved. For this reason, the iron and steel sector emissions are compared against the DA GHGI data by aggregating the relevant parts of the IPCC format inventories:

- 1A1c: energy industry activities (coke production);
- 1A2a: fossil fuel combustion sources (combustion of coke, blast furnace gas, coke oven gas);
- 2A3: process emissions (BOS plant and sinter plant processes); and
- 2C1: process emissions (decarbonisation of limestone and dolomite).

The iron and steel sector is dominated by the integrated Corus steelworks, all of which are included within the EUETS, with a number of large-scale electric arc steelworks making a secondary contribution. There are also a number of smaller-scale iron and steel operators that are not included within the EUETS (e.g. secondary iron & steel processing plant such as rolling mills and foundries). Therefore the traded sector is expected to be a very high percentage, but the GHGI emissions are expected to be slightly higher than the EUETS data due to these smaller, non-ETS sites. This is reflected in the data below.

Table 8.4 IPCC Sector 1A1c (coke) / 1A2a / 2A3 (BOS, Sinter) / 2C1: Iron & Steel, 2009

Iron and Steelworks*					
IPCC Sector		England	Scotland	Wales	N Ireland
1A1c / 1A2a / 2A3 / 2C1	GHGI, Mt CO_2	11.1	0.04	5.08	-
	Traded, Mt CO_2	10.0	0	4.95	-
	Non-Traded share, %	10.2	100	2.5	-

*The comparison shown above between EUETS and the GHGI excludes emissions from iron and steel flaring, which are notably higher in the EUETS than within the GHGI. In DUKES for 2009, the energy data for this source was much lower than in previous years, and although the EUETS data also exhibit a reduction in energy use since 2008, the DUKES data looks to be too low. The emissions from Electric Arc furnaces are also higher in EUETS than the GHGI, but this is a relatively minor source of GHGs within the sector as a whole. The exclusion of iron and steel flaring in this sector example leads to a difference to the quoted data within the overall traded / non-traded tables presented in Appendix 4.

In both England and Wales, the combined sector emissions are dominated by iron and steel sources, with the large integrated steelworks and large electric arc steelworks all reporting within the EUETS. The traded share of emissions for this sector in 2009 is 90% in England and 97% in Wales, due mainly to the Corus integrated steelworks. Scotland has no integrated or large electric arc steelworks and so emissions from the iron and steel sector are very minor with no EUETS sites. Northern Ireland is not thought to have any iron and steel sector emissions

IPCC Sector 1A1c / 1B2c flaring and venting: Oil and Gas

This sector includes oil and gas terminal sites, and the scope of EUETS for these sites covers combustion processes and flaring activities. The traded sector is expected to cover a high percentage of the inventory total, but there are a number of smaller sites below the EUETS reporting threshold.

Table 8.5 IPCC Sector 1A1c / 1B2c flaring and venting: Oil and Gas, 2009

Oil and Gas					
IPCC Sector		England	Scotland	Wales	N Ireland
1A1c / 1B2c flaring & venting	GHGI, Mt CO_2	1.47	1.72	0.049	-
	Traded, Mt CO_2	1.15	1.67	0.043	-
	Non-Traded share, %	28	5	14	-

In Phase II of the EUETS, flaring and combustion sources from oil & gas extraction are included within the scope of the scheme. The Scotland data show a very high traded share, whilst in England the data from the GHGI is notably higher than the EUETS total, indicating that more process sources and smaller combustion plant outside of EUETS are evident. There is a moderate level of uncertainty in the data for this sector, however, due to data reporting inconsistencies that are evident by plant operators. Specific research has been conducted to address the most significant data reporting inconsistencies between different reporting mechanisms (i.e. through comparison of data from EUETS against those reported by operators to DECC under the EEMS system), but some problems do persist.

IPCC Sector 1A2f_cement and 2A1: Cement (combustion and process emissions)

The reporting of emissions from cement kilns in the EUETS provides an estimate of the emissions split by combustion and process sources such as decarbonisation of the limestone and other feedstock to the kilns. The comparison of EUETS against GHGI emissions is presented at an aggregated level as there are small discrepancies in the allocation of emissions between the combustion and process sources, within the GHGI and / or the EUETS. Overall the carbon dioxide emissions show very close consistency now that in Phase II all of the UK cement kilns are operating within the EUETS, and hence the industry's emissions are 100% traded.

Table 8.6 IPCC Sector 1A2f_cement & 2A1: Cement (combustion & process emissions), 2009

Cement					
IPCC Sector		England	Scotland	Wales	N Ireland
1A2f_cement / 2A1	GHGI, Mt CO_2	4.48	0.44	0.53	0.24
	Traded, Mt CO_2	4.45	0.43	0.53	0.24
	Non-Traded share, %	0	0	0	0

Sector 1A2f: Other Industry Combustion (excluding cement and lime)

This sector covers all of the non-cement and non-lime industrial combustion sources, including non ferrous metals, chemicals, paper and pulp, food and drink, engineering and so on. The UK GHG inventory currently reports all industrial combustion emissions (other than iron and steel) under the category 1A2f.

The sites reported in sector 1A2f include both larger combustion plant operating within the EUETS as well as numerous smaller plant which do not. Therefore it should be expected that the traded emissions total should be significantly lower than the DA GHGI sector totals. This is the case in all countries, except for Scotland where a small number of sites (mainly chemical and petrochemical production sites at Grangemouth and elsewhere on the east coast) dominate the sector with high emissions that are reported in the traded sector.

Table 8.7 illustrates the overall relationship between EUETS data and the country GHGI estimates:

Table 8.7 Inventory Sector 1A2f: Other Industry Combustion (excl. cement and lime), 2009

Other industry					
Inventory Sector		England	Scotland	Wales	N Ireland
1A2f (other)	GHGI, Mt CO_2	41.6	4.60	2.92	1.21
	Traded, Mt CO_2	16.4	3.76	0.73	0.33
	Non-Traded share, %	62	20	76	74

The emission estimates in this sector are amongst the most uncertain in the DA GHG inventories, as the fuel use data for small-scale industries are scarce and the inventory estimates are based on modelled energy distributions according to industry indicator data (employment, production, GVA etc) to supplement available emissions data from those sites that are regulated under EUETS and/or Integrated Pollution Prevention and Control.

The estimates of the non-traded share for 1A2f (inventory) are therefore somewhat uncertain, but there is a clear distinction in the level of non-traded emissions within the sector, in the different countries. Scotland has a much higher percentage of industrial emissions within the traded sector compared to the rest of the UK, whilst the Wales and Northern Ireland “other industry” sectors have a much higher percentage of overall emissions that are outside of the EUETS.

More detailed analysis of the 1A2f traded sites reveals some of the underlying reasons in these variations within the UK, which in part are due to the regional variation in the UK share of economic sectors that fall under EUETS regulation.

The sector 1A2f emissions can be broken down into more detailed industry sub-sectors, in line with the recommended IPCC reporting structure under 1A2:

- 1A2b: Non-ferrous metals
- 1A2c: Chemicals
- 1A2d: Paper & Pulp
- 1A2e: Food and drink

(Note that the UK and DA GHGI do not currently utilise this more detailed reporting format, although work is ongoing to develop this greater level of detail in the UK GHG inventory.)

Table 8.8 DA Traded Emissions in 1A2b to 1A2f IPCC Categories, 2009

DA Estimates for Other Industry				
IPCC Sector	**England Mt CO_2**	**Scotland Mt CO_2**	**Wales Mt CO_2**	**N Ireland Mt CO_2**
1A2b: Non-ferrous metals	2.56	0	0	0
1A2c: Chemicals	5.20	2.62	0.23	0.095
1A2d: Paper & Pulp	2.27	0.37	0.12	0.012
1A2e: Food and drink	2.40	0.24	0.11	0.083
1A2f: Other industries	3.93	0.53	0.27	0.13
TOTAL	**16.36**	**3.76**	**0.73**	**0.33**

The breakdown of the EUETS sites into the more detailed 1A2b, c, d, e and f IPCC categories shows that Scottish EUETS sites account for almost 18% of the total emissions within the inventory 1A2f sector, due mainly to the high emissions share in Scotland in the chemical sector (32% of the UK traded emissions), and a 13% share of UK traded paper and pulp sector emissions. Together these industries comprise 58% of the total UK EUETS emissions under the 1A2f inventory category in 2009.

All non-ferrous metal sites within the EUETS are in England. Wales sites in EUETS represent a 3 to 6% share across the 1A2c, d, e and f IPCC sectors, whilst Northern Ireland sites are primarily food and drink or "other" (e.g. engineering) sites, of which the country has a 3% share of the UK total of traded emissions in 2009.

This analysis shows that Scotland has a high proportion of the EUETS sites in 1A2f but it doesn't necessarily follow that Scotland should have significantly lower non-traded emissions than the other countries. It may be that the ETS sites employ a large proportion of the working population, and this is likely to be the case in some areas of Scotland, where ETS industries dominate the employer landscape, e.g. around Aberdeen with the oil & gas industry, and Grangemouth with it's chemicals complex. On the national scale, however, this 20% non-traded share figure appears to be unrealistically low, indicating an under-report of emissions within the Scottish inventory for these industrial sources. There remains a significant challenge to improve the detail of "bottom-up" industrial energy data across all parts of the UK, to reduce the uncertainties in the DA inventories.

IPCC Sector 1A4a: Public Sector and Commercial

This sector covers commercial and public sector combustion plant. These sectors are characterised by a wide range of plant size, with relatively few large plant and numerous smaller plant that do not operate within the EUETS. Only a small percentage of emissions (mainly from large installations such as hospitals, large commercial sites / boilers) are expected to be within the traded sector, and the figures support this.

Table 8.9 IPCC Sector 1A4a: Public Sector and Commercial Emissions, 2009

Public Sector and Commercial Emissions					
IPCC Sector		England	Scotland	Wales	N Ireland
1A4a public	GHGI, Mt CO_2	6.82	0.79	0.37	0.20
	Traded, Mt CO_2	1.11	0.16	0.02	0.045
	Non-Traded share, %	84	80	95	78
1A4a commercial	GHGI, Mt CO_2	8.04	0.69	0.35	0.23
	Traded, Mt CO_2	0.17	0	0	0
	Non-Traded share, %	98	100	100	100

The traded percentage varies quite significantly from country to country, being lowest in Wales and highest in Northern Ireland; this variability reflects the fact that this is a relatively small dataset with very few sites in these sectors included within EUETS, and hence a small number of traded sites have a significant impact on the percentage share. The sites that are within EUETS are mainly hospitals, MOD sites and institutions such as universities. Where such sites are not operating within EUETS, there is a strong likelihood that many of them will fall under the CRC Energy Efficiency Scheme which is now in its first year of operation.

IPCC Sector 2: Industrial Processes (excluding cement and iron & steel)

This sector includes industrial processes such as the manufacture of lime, glass and aluminium, and other non-combustion sources such as emissions of carbon dioxide from the use of Flue Gas Desulphurisation (FGD) in power stations.

Relatively few of these process sources are included under the scope of EUETS, although within Phase II the inclusion of all glass sector emissions has increased the traded share. This is reflected in the figures, with a high percentage of emissions remaining in the non-traded sector across GB, whilst in Northern Ireland the dominance of the (traded) glass sector in industrial process emissions leads to a much lower non-traded share. The slightly higher level of traded emissions coverage in England is due to the glass sector and power station FGD, whilst in Scotland, Wales and Northern Ireland the traded emissions are almost entirely from the glass sector.

Table 8.10 IPCC Sector 2: Industrial Process Emissions (excl. cement and iron & steel), 2009

Industrial Process Emissions					
IPCC Sector		England	Scotland	Wales	N Ireland
2	GHGI, Mt CO_2	2.33	0.13	0.15	0.029
	Traded, Mt CO_2	0.98	0.048	0.011	0.022
	Non-Traded share, %	58	63	94	26

9 Uncertainty in the Inventories

A study (Eggleston et al, 1998) estimated the uncertainty in the UK Inventory, and these estimates are revised annually in the compilation of the UK GHG inventory to account for data and methodological changes (Jackson et al., 2010). In addition to the updates made annually to the model, over the past few years, the model has been reviewed and improved, to better account for correlations and lognormal distributions. These changes are described in Choudrie et al., 2008.

The improvements made to the UK model have also been reflected in the DA uncertainties model.

As a result of the activity data gaps in the DA inventories, the estimates will be more uncertain than for the UK inventory. Expert judgement has been used to assess the degree of additional uncertainty due to the use of proxy activity data, informed by the comparison of the new datasets such as EUETS and the DECC regional energy statistics with historic data. The uncertainties in the emission totals have been estimated using a Monte Carlo simulation. In recent years the revisions to UK fuel use statistics (DUKES) have been significant for several fuels, notably coal, gas oil and fuel oil. Overall data quality and sector allocations are improving, but for some source sectors, significant uncertainties remain, even at UK level.

The method used to estimate uncertainties in the DA inventories in a single year and the trend is described in Appendix 1.

The uncertainty estimates for the 1990-2009 DA GHG inventories are reported in Table 9.1 below.

The table presents the central estimate from the Monte Carlo simulation for each GHG and for each DA, for the base year and the latest year and the estimated uncertainty on the total. In addition, the central estimate of the trend (expressed as the percentage change from the base year) is presented together with the 5 and 95 percentile estimates.

Table 9.1 Estimated Uncertainties in the DA GHG Inventories: Base Years, 2009 and Trend

	Base Year		Latest Year (2009)		Trend (Base Year to 2009)		
Gas (kt CO_2e)	Central Estimate	Uncertainty Introduced on total	Central Estimate	Uncertainty Introduced on total	Central Estimate	5 Percentile	95 Percentile
Scotland							
Carbon Dioxide CO_2	50,200	10%	36,480	12%	-27%	-38%	-16%
Methane CH_4	11,770	31%	5,680	21%	-51%	-66%	-32%
Nitrous Oxide N_2O	6,971	304%	4,941	269%	-30%	-49%	-19%
HFC	128	24%	899	26%	614%	385%	898%
PFC	87	17%	52	59%	-40%	-75%	-3%
SF_6	31	17%	48	19%	58%	20%	101%
Total	69,186	32%	48,099	29%	-30%	-39%	-21%
Wales							
Carbon Dioxide CO_2	43,153	3%	34,814	3%	-19%	-23%	-16%
Methane CH_4	8,227	23%	4,473	15%	-45%	-59%	-30%
Nitrous Oxide N_2O	3,870	328%	2,793	275%	-26%	-40%	-8%
HFC	66	23%	447	25%	591%	381%	848%
PFC	147	5%	30	19%	-80%	-84%	-76%
SF_6	83	17%	41	16%	-50%	-61%	-37%
Total	55,546	23%	42,599	18%	-23%	-27%	-19%
Northern Ireland							
Carbon Dioxide CO_2	16,533	8%	13,554	8%	-18%	-27%	-8%
Methane CH_4	4,439	25%	3,130	18%	-28%	-48%	-6%
Nitrous Oxide N_2O	3,447	308%	2,528	296%	-33%	-65%	-17%
HFC	38	21%	285	24%	648%	435%	915%
PFC	1	20%	0	18%	-90%	-93%	-87%
SF_6	2	20%	6	21%	204%	126%	302%
Total	24,460	44%	19,503	39%	-20%	-28%	-12%

(table continued below)

Table 9.1: Estimated Uncertainties in the DA GHG Inventories: Base Years, 2009 and Trend: *continued*

	Base Year		Latest Year (2009)		Trend (Base Year to 2009)		
Gas (kt CO_2e)	Central Estimate	Uncertainty Introduced on total	Central Estimate	Uncertainty Introduced on total	Central Estimate	5 Percentile	95 Percentile
England							
Carbon Dioxide CO_2	465,190	2%	372,932	1%	-20%	-22%	-18%
Methane CH_4	83,728	29%	29,222	24%	-64%	-76%	-50%
Nitrous Oxide N_2O	52,965	167%	23,992	247%	-61%	-82%	-34%
HFC	15,222	14%	9,210	26%	-39%	-56%	-21%
PFC	227	7%	65	19%	-71%	-77%	-65%
SF_6	1,126	17%	566	16%	-49%	-60%	-37%
Total	618,457	15%	435,987	14%	-29%	-33%	-26%
Unallocated							
Carbon Dioxide CO_2	13,098	14%	14,300	5%	10%	-5%	28%
Methane CH_4	1,856	25%	977	25%	-47%	-63%	-26%
Nitrous oxide N_2O	229	101%	289	106%	56%	-66%	354%
HFC	-	N/A	-	N/A	N/A	N/A	N/A
PFC	-	N/A	-	N/A	N/A	N/A	N/A
SF_6	-	N/A	-	N/A	N/A	N/A	N/A
Total	15,183	13%	15,566	5%	3%	-10%	18%
UK							
Carbon Dioxide CO_2	588,174	2%	472,081	2%	-20%	-22%	-17%
Methane CH_4	110,021	28%	43,482	21%	-60%	-72%	-45%
Nitrous Oxide N_2O	67,481	197%	34,542	254%	-56%	-78%	-31%
HFC	15,446	14%	10,861	26%	-29%	-49%	-8%
PFC	462	7%	147	31%	-68%	-78%	-58%
SF_6	1,239	17%	661	16%	-46%	-57%	-33%
Total	782,822	18%	561,774	16%	-28%	-32%	-25%

Notes

1. Uncertainty is defined as $\pm$ 2×(standard deviation)/mean %, which closely approximates the 95% confidence interval.
2. Base years are 1990 for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O); 1995 for HFCs, PFCs and SF_6.
3. The uncertainty model takes emission estimates by gas for each source, applies an uncertainty distribution for that source and calculates a statistical mean, presented above as the central estimate. The emissions data in this table are taken from the Monte Carlo model output. The central estimates by gas for 1990 and the latest inventory year are very similar but not identical to the emission estimates in the DA inventories.

10 End User GHG Inventories for the Devolved Administrations

10.1 Introduction

Emissions of GHGs reported under international conventions are typically on a "by source" basis. This means that the emissions are allocated to the source sector at the point of their release. For example, emissions from refining oils are allocated to the refineries, and emissions from the combustion of fuel in vehicles are allocated to the relevant transport sector.

This section of the report presents emissions on an "end user" basis. In this case, all emissions associated with energy supply (e.g. power generation, coal mining, oil and gas extraction, refineries) are allocated to the final users of the energy. In the above example, the emissions from the refineries would be reallocated to all oil users, including within the transport sector. Therefore, the main usefulness of end user emission inventories is to present a more representative picture of emissions due to consumption, rather than production. End user inventories are needed in order to reflect the full impact of energy efficiency policies as they show the emissions associated with sector consumption of all fuels, including emissions associated with electricity use.

During 2008, a scoping study was undertaken to assess the feasibility of generating end user emission inventories for the DAs. Initial estimates were published during 2009, and a DA end users inventory model was developed (Abbott *et al*., 2009). This model took into account the different fuel mix for energy generation in each of the DAs, and the transfer of electricity between the DAs. No data were available to reflect the transfer of other fuels between the DAs. Further consultation with data users has led to a revision to the DA end user inventory method. The new approach used to derive the data presented here applies a UK-wide emission factor for the power generation sector, rather than a DA-specific factor; this approach does not therefore take account of the local power generation fuel mix, but does provide a greater level of consistency with other datasets, including the UK end user inventory, and the local authority carbon dioxide statistics, which are also presented on an end user basis.

The scope of the emissions allocated within these DA end user inventories is bounded by the definition of the "UK" emissions, as applied in the main DA by source inventories. The sum of the DA end user emissions equals the sum of the DA by source emissions. GHG emissions associated with fuel imports (e.g. electricity imported from the EU and consumed in the UK) are NOT reported within these data. However, the emissions of GHGs associated with the refining of fuels that are subsequently exported ARE included in these DA inventories, as the emissions are produced at source within the UK energy supply industry. An example of this is for international aviation and shipping; whilst the GHG emissions from the direct use of petroleum fuels in those "memo item" sources are EXCLUDED from the end user inventories, the emissions associated with the SUPPLY of those fuels to those sectors (i.e. upstream oil extraction and refinery emissions within the UK) ARE included in the DA end user inventories, reported within the "exports" line.

10.2 End User Methodology

The method for calculating UK emissions on an end user basis is described in Annex 13 of the National Inventory Report (MacCarthy et al., 2011). The calculation uses an iterative approach, carried out in a database. As an overview, the approach 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 of the fuel they use (these sectors can include other fuel producers).

3. By this stage in the calculation, emissions from final users will have increased and those from fuel and electricity producers will have decreased. The sum of emissions from fuel producers and power stations in a particular year as a percentage of the total emissions is then calculated. If this percentage, for any year, exceeds a predetermined value (e.g. 1% or 0.01%) 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. This calculation results in a table of emissions for the UK on an end user basis. Emissions from the energy supply sector are decreased to a very small number, and emissions within the end user sectors are increased.

DA end user estimates are then calculated by disaggregating the UK level estimates, in the same way as the DA source inventories are produced. The estimates for direct fuel use in the end use sectors, and emissions from energy supply, are therefore consistent with the DA source inventories.

In order to allocate the energy supply emissions to all sources, additional estimates have been required for the disaggregation of electricity use, and for the exports[16] category. Table 10.1 summarises the assumptions used for electricity use and exports:

Table 10.1 Summary of Assumptions used for Electricity Use and Exports

Assumptions for Electricity and Exports		
Source Name	Activity Name	Description
Public sector	Electricity	Northern Ireland public sector electricity use for 2003 onwards is taken from the Public Sector Energy Campaign dataset (DFPNI 2011), whilst the DA share of GB activity is derived from analysis of the Inter-Departmental Business Register for 2003 onwards. The 1990 estimates for all DAs are based on economic indicators from previous studies using the REEIO model.
Miscellaneous industrial/commercial	Electricity	The DA share of UK activity is derived from analysis of the Inter-Departmental Business Register for 2003 onwards, whereas the 1990 estimates are based on economic indicators from previous studies using the REEIO model.
Domestic	Electricity	Country-specific domestic electricity use in GWh, is taken from analysis within DECC Energy Trends December 2010 (for 2006 to 2009), December 2009 for 2005, December 2008 for 2003 and 2004, and from REEIO analysis for 1990.
Iron and steel - combustion plant, and Blast Furnaces	Electricity	Country-specific electricity use data for 2003 onwards is derived from ISSB regional energy statistics, and 1990 electricity use is estimated from ISSB regional production statistics.
Railways	Electricity	Regional estimates of rail gas-oil consumption are used to estimate the DA share of UK rail sector electricity consumption.
Gas production	Electricity	Site-specific data on activity at oil & gas terminals, available from the DECC Oil & Gas EEMS reporting system are used to estimate the DA share of UK sector electricity consumption.
Refineries - combustion	Electricity	Carbon dioxide emissions from refineries are used to estimate the DA share of UK sector electricity consumption.
Collieries - combustion	Electricity	Regional coal production data are used to estimate the DA share of UK electricity use by collieries.
Exports	Electricity	DA data on electricity exports are published within the periodic DECC publication "Energy Trends".

[16] Exports refer to the emissions associated with the production of fuel or electricity which is then exported from the UK, or used as fuels for international aviation or shipping.

Assumptions for Electricity and Exports		
Source Name	Activity Name	Description
Other industrial combustion	Electricity	For 2003 onwards, the "other industry" estimate of DA electricity use is derived by difference using the DECC Energy Trends DA totals for electricity sales and the estimates for other sectors. The 1990 estimates are calculated by difference, using 1989 regional electricity sales data scaled to 1990 UK electricity totals.
Agriculture - stationary combustion	Electricity	Employment on Agricultural Holdings data is used to estimate the DA share of UK sector electricity use for all years.
Exports	Aviation turbine fuel Burning Oil DERV Fuel Oil Gas Oil Petrol	In each year, the DA share of carbon dioxide emissions from refineries is used as an indicator of DA oil exports.
Exports	Coke	Regional data on coal consumed in coke ovens from ISSB statistics, DUKES, and WDig Hist Stats are used to estimate the DA share of coke exports.
Exports	SSF	Regional data on SSF production, based on reported or estimated annual plant production by site are used to estimate the DA share of SSF exports.

10.3 Revisions to End User Inventory Source Data and Methodology

The DA end user method has been updated since the 1990-2008 DA GHG inventory report, with data and method improvements to further develop the DA end user estimates, to build upon new information and data. There have therefore been recalculations of the end user estimates as a result of these data and method updates. The key differences in the approach used for the DA end user calculation this year compared with last year are summarised below. This includes both changes to the methods used, and improvements to the data:

- **Method change**: Allocation of upstream oil and gas exploration and production emissions has been improved through consultation with DECC. Each installation in the sector has been allocated to either the "oil" or the "gas" sector, and the by source DA GHG inventories now report these emissions to a greater level of detail, in separate categories rather than aggregated as "oil and gas" emissions. This has enabled a method revision in the UK and DA end user compilation system. Previously all "oil and gas" sector emissions were allocated to end users of oil products, which led to an over-estimate within end user inventories for sources consuming oil products, and under-estimates for sources using gas. This method improvement provides a step change in allocating end user emissions more accurately between oil and gas users. The DA end users method has been modified to reflect the changes, which have also been made within the UK end users model.
- **Method change**: The allocation of emissions from autogenerators within the DA end user inventories has been improved in order to better reflect the DA patterns of electricity use by sites that autogenerate electricity. Many autogenerator sites only consume a small % of their total electricity generated and pass the remaining electricity back out to the public supply grid. In the previous DA end user model, the emissions from the fuel use to generate that electricity was ALL allocated to the autogenerator site, rather than being added to the emissions to be distributed for the electricity consumed from the public grid. The data management system

has been modified to ensure that for each DA the balance of autogenerator "own use" of electricity and autogenerator "export to grid" electricity is properly reflected in the inventories, with "own use" electricity emissions allocated to the site, and "exported to grid" electricity emissions tracked onwards to end users of electricity. This modification has been achieved using the data on fuel-specific autogeneration and the DA-specific transfers of autogenerated electricity to the public grid, as reported within the DA electricity generation and consumption articles published in the DECC December Energy Trends (DECC, 2010).

- **Public sector electricity use**: The allocation of public sector electricity use emissions has been amended to reflect the new dataset provided from the Northern Ireland Public Sector Energy Campaign (DFPNI, 2011), which includes data on electricity use within the public sector since 2003.

The overall approach of the DA end user inventories uses a UK-wide emission factor for electricity consumption, and this ensures consistency with the UK dataset, which is also the basis for the Local Authority end user carbon dioxide statistics. The approach reflects electricity distribution in the UK, since electricity is supplied via one grid. This removes the impacts of year on year fluctuations in local emission factors for electricity use which may disproportionately affect individual DAs. It does, however, mean that the reduced emissions from electricity generation by (for example) DA-specific efforts to increase renewable generation capacity, are shared out across the UK and not reflected locally. Hence it is important that the DAs pursue alternative data and mechanisms to track the impacts of any local efforts to reduce the carbon intensity of electricity generation.

10.4 Uncertainties and Limitations of the DA End User Emission Estimates

The "by source" DA emission inventories are one of the primary datasets used to calculate the DA end user emission estimates. The DA end user emission estimates therefore incorporate the uncertainties and limitations from the by source inventories, which stem from uncertainties in UK-level activities and emission factors as well as from limited DA-specific source data for certain activities, sources and years.

The additional data inputs used to calculate the DA end user inventories are outlined above in Section 10.2. Additional uncertainties in the DA end user estimates are introduced due to:

- **Limited availability of sector-specific electricity data at DA level**, especially for the year 1990 where very limited data are available at sector- or at DA-level. DECC publish DA-specific electricity use totals within Energy Trends, with data reported for 2003-2009. However, through consultation with the DECC sub-national statistics team, it has been identified that the Wales-England share of electricity consumption in recent years is based on an extrapolation of data from 2003 (Personal communication, DECC, 2011). Therefore the total electricity consumption data for England and Wales are associated with high uncertainty. The overall electricity consumption data for Scotland and Northern Ireland are associated with lower uncertainty. Within the Energy Trends tables, a statistical difference is reported for each DA for each year, from an analysis of the "generation-side" estimates against the "demand-side" estimates. This statistical difference is another useful indicator of the uncertainty in the total electricity use within each country. The DA end user inventory method calculates the "Other Industry" electricity allocation for each DA by difference from the reported Energy Trends total and the sum of all other source estimates, several of which are calculated using proxy data to determine a DA share of the UK sector electricity total reported in DUKES. This approach ensures that although there may be electricity emission allocation inaccuracies within the data presented here, the overall DA end user inventories are consistent with the Energy Trends data on DA electricity consumption.

- **Assumptions for exported fuels**. There are no data on DA-specific exports of fuels. Therefore it is currently assumed that for those fuels that are exported by the UK, the exports leave the UK proportionately according to where those fuels are produced in the UK. For example, the DA percentage share of refinery carbon dioxide emissions is used to disaggregate the emissions for exports of oils, i.e. assuming that refiners all export the same percentage of the oils that they produce.

Across all sectors, the sector-specific electricity estimates for each DA are uncertain, especially in the 1990 data where very limited sector-specific information is available. This must be taken into consideration when using the data to inspect the reported emission trends. The emission trends presented here for 1990 to 2009 are subject to high uncertainty, even at the DA-wide level. The estimates of overall DA electricity consumption in 1990 are derived from data on electricity sales by regional electricity supply boards that were last published for the year 1989, within DUKES 1991. Those 1989 regional data have been scaled to the overall 1990 UK electricity consumption statistics from DUKES.

In recent years there has been an increase in focus on sub-national energy use data and due to the level of detail that now is provided within the sub-national electricity generation and supply tables in Energy Trends, the 2003 to 2009 electricity use data (and hence DA end user estimates) are subject to lower uncertainty than those for 1990.

10.5 Results and Discussion

The DA end user emission estimates are presented below. The discussion concentrates on the differences in distribution across the DAs of the by source and by end user emissions, and the differences in the trends using the two approaches.

The outputs of the of the DA end users model are provided in detail in Appendix 5.

Note on the Format of Data Presentation
Since the DA analysis now uses the UK end user database, it is possible to replicate the format of the presentation of end user emissions used within the UK statistical release. This is based on National Communication format, supplemented with additional detail (at IPCC sector level). This allows direct comparison with the "by source" GHG *inventories presented at DA level.*

10.5.1 DA End User GHG Emissions Data

Table 10.2 shows that the UK distribution of DA net GHG emissions by end user in 2009, expressed in terms of total carbon dioxide equivalent emissions of the "basket of 6" GHGs.

Table 10.2 Share of DA GHG Emissions by End User and by Source, 2009

Share of DA GHG Emissions by End User and by Source			
	End User	**End User excluding exports**	**By source**
England	80.6%	78.7%	77.6%
Scotland	8.7%	8.4%	8.6%
Wales	6.9%	6.6%	7.6%
Northern Ireland	3.8%	3.7%	3.5%
Unallocated	0.0%	0.0%	2.8%

The estimated trends in the end user DA GHG inventories from the Kyoto Protocol Base Year (1990 for carbon dioxide, methane and nitrous oxide, and 1995 data for the fluorinated gases) to 2009 are

presented by gas in Table 10.3. Note that the trends from the base year are associated with high uncertainty.

Comparing the end user DA GHG inventories against the by source DA GHG inventories, provides an insight into the difference between energy consumption and energy production emission patterns within the UK. The data indicate that:

- England has a higher share of the end user emissions compared with the by source inventory, indicating that more fuel or electricity is consumed in England than is produced. The decrease in emissions from the Base Year to 2009 is smaller in the end user inventory, indicating that much of the reduction in emissions is from the energy supply sector, which is now reallocated across the DAs.
- Scotland has achieved greater reductions on an end user basis compared to the by source inventories, and in 2009 the share of the end user inventories was slightly lower than that reported within the by source inventories, which is due to the amount of electricity and refined fuels generated but not consumed in Scotland. The difference in the share might be expected to be higher, but the Scottish emissions are dominated by the business and residential sectors, both of which are heavily reliant on electricity and natural gas (more so than the other DAs in most cases). Both of these sectors have a higher share of the UK total within the end user dataset than the by source dataset, which reflects this fuel mix. For natural gas use, for example, emissions are reallocated from offshore sources (unallocated in the source inventory) to natural gas users.
- Wales has a smaller share of end user emissions compared to the by source estimates, and on the basis of end user emissions has achieved much higher emission reductions since the Base Year than the by source inventories indicate.
- Northern Ireland also has a greater share of end user emissions compared to the by source estimates. This is because emissions associated with the processing of fuels used in Northern Ireland (which takes place outside of Northern Ireland) are effectively imported into Northern Ireland in the model;

These results are consistent with several key underlying factors at DA level, including:

- DA electricity transfer data indicates that in most years, **England** is a net importer of electricity from both Wales and Scotland (as well as from France);
- In most years, **Scotland** is a net exporter of electricity to both England and Northern Ireland, and also hosts a significant share of upstream oil and gas sector infrastructure, such as major oil and gas terminals and the Grangemouth refinery.
- In most years, **Wales** is a net exporter of electricity to England, and has a high percentage share of both oil and solid fuel process industries (i.e. refineries and collieries);
- **Northern Ireland** has no fuel transformation industry other than electricity generation; there are no collieries, refineries or major upstream oil & gas infrastructure in Northern Ireland.

Table 10.3 Estimated Trends in the End User DA GHG Inventories from the Base Year to 2009, by Gas

DA Trends in End User Emissions				
Country	Gas	End User	End User excl. Exports	By source
England	**Carbon Dioxide CO_2**	-17.9%	-19.1%	-19.8%
	Methane CH_4	-63.7%	-64.0%	-65.2%
	Nitrous Oxide N_2O	-54.5%	-54.7%	-54.9%
	ALL GHGs	-27.7%	-28.7%	-29.5%
Scotland	**Carbon Dioxide CO_2**	-32.3%	-33.1%	-27.3%
	Methane CH_4	-55.6%	-55.7%	-51.8%
	Nitrous Oxide N_2O	-30.0%	-30.2%	-29.5%
	ALL GHGs	-35.0%	-35.7%	-30.5%
Wales	**Carbon Dioxide CO_2**	-27.2%	-29.3%	-19.3%
	Methane CH_4	-52.5%	-52.7%	-45.7%
	Nitrous Oxide N_2O	-28.4%	-28.8%	-28.2%
	ALL GHGs	-30.6%	-32.3%	-23.3%
N Ireland	**Carbon Dioxide CO_2**	-10.8%	-12.0%	-18.0%
	Methane CH_4	-34.8%	-34.9%	-29.6%
	Nitrous Oxide N_2O	-26.8%	-26.9%	-27.1%
	ALL GHGs	-16.8%	-17.6%	-20.3%

10.5.2 England End User GHG Inventories

The estimates of end user GHG emissions in England are summarised below:

Table 10.4 England End User GHG Inventories: 1990, 2003 to 2009 in Mt carbon dioxide equivalent (CO_2e)

England End User Emissions (Mt CO_2e)									
	Base Year	1990	2003	2004	2005	2006	2007	2008	2009
Agriculture	42.55	42.55	34.78	34.96	34.71	33.45	33.09	33.19	32.55
Business	194.05	192.95	170.57	168.57	166.35	168.18	165.16	161.31	138.48
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	6.44	6.44	11.73	11.63	12.01	11.00	11.58	10.73	11.06
Industrial Process	52.25	50.41	16.79	16.16	15.16	13.74	14.80	13.52	9.10
Land Use Change	5.92	5.92	3.21	2.75	2.40	2.22	2.00	1.76	1.69
Public	25.82	25.82	18.46	19.02	18.16	16.88	16.16	15.91	14.12
Residential	136.52	136.19	133.26	134.14	133.56	132.92	127.59	128.77	118.76
Transport	115.80	115.80	123.25	122.85	123.67	122.36	122.96	118.00	113.18
Waste Management	47.32	47.32	17.95	16.49	15.87	15.42	15.02	14.43	14.10
Total	**626.68**	**623.40**	**530.01**	**526.58**	**521.88**	**516.16**	**508.35**	**497.62**	**453.05**

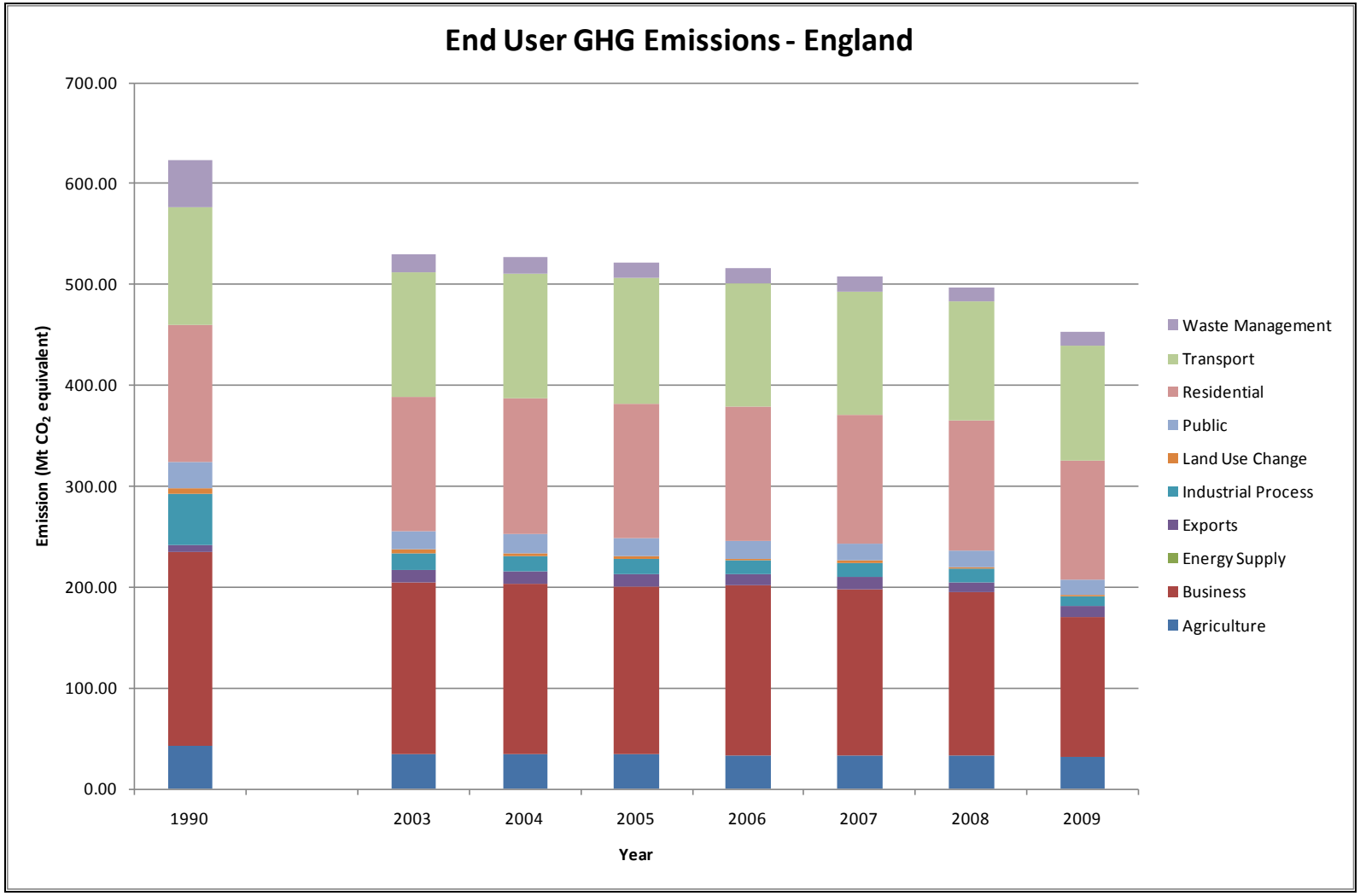
Table 10.5 Emission Trends by Sector in the England End User GHG Inventories

(Significant source sectors are indicated by the shaded rows.)

End User GHG Emission Trends in England			
	Base Year to 2009	2008 to 2009	Share of 2009 total
Agriculture	-23.5%	-1.9%	7.2%
Business	-28.6%	-14.1%	30.6%
Energy Supply	N/A	N/A	N/A
Exports	71.8%	3.1%	2.4%
Industrial Process	-82.6%	-32.7%	2.0%
Land Use Change	-71.4%	-3.7%	0.4%
Public	-45.3%	-11.2%	3.1%
Residential	-13.0%	-7.8%	26.2%
Transport	-2.3%	-4.1%	25.0%
Waste Management	-70.2%	-2.3%	3.1%
Total	-27.7%	-9.0%	100.0%
Total excluding exports	-28.7%	-9.2%	97.6%

Note that the base year to 2009 emission trends when the emission exports are discounted show that England end user emissions have reduced by **28.7%**. This compares to the reported reduction in the "by source" GHG inventory of **29.5%** over the same period.

Figure 10.1 England End User GHG Emissions by National Communication Category: 1990, 2003-2009 (Mt CO_2e)



10.5.3 Scotland End User GHG Inventories

The estimates of end user GHG emissions in Scotland are summarised below:

Table 10.6 Scotland End User GHG Inventories: 1990, 2003 to 2009 in Mt carbon dioxide equivalent (CO_2e)

Scotland End User Emissions (Mt CO_2e)									
	Base Year	1990	2003	2004	2005	2006	2007	2008	2009
Agriculture	10.56	10.56	9.18	9.02	8.90	8.72	8.45	8.22	8.18
Business	23.93	23.79	17.01	16.78	17.12	16.13	15.41	15.38	14.16
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	1.42	1.42	1.17	1.56	1.63	1.44	1.44	1.51	1.40
Industrial Process	2.13	2.19	0.61	0.62	0.54	0.55	0.53	0.51	0.40
Land Use Change	-2.08	-2.08	-4.42	-5.01	-5.20	-5.21	-5.35	-5.57	-5.66
Public	3.20	3.20	2.00	2.10	2.17	2.13	2.14	2.11	1.88
Residential	17.20	17.16	15.36	15.37	15.60	15.54	15.00	15.28	14.11
Transport	12.06	12.06	12.87	12.80	12.95	12.95	13.09	12.61	12.11
Waste Management	6.48	6.48	2.34	2.24	2.18	2.24	2.20	2.24	2.07
Total	74.89	74.78	56.12	55.47	55.90	54.49	52.92	52.29	48.65

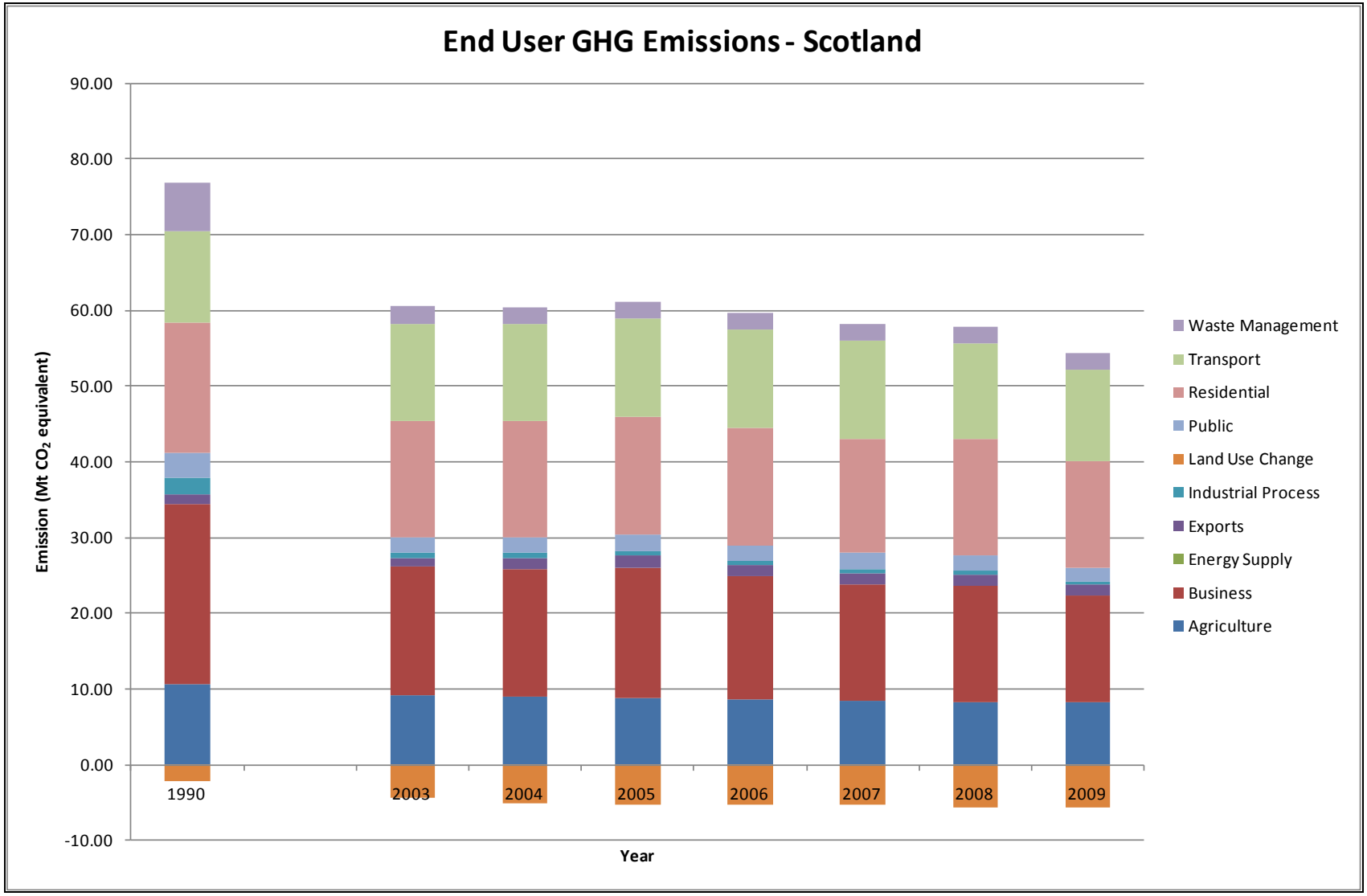
Table 10.7 Emission Trends by Sector in the Scotland End User GHG Inventories

(Significant source sectors are indicated by the shaded rows.)

End User GHG Emissions Trends in Scotland			
	Base Year to 2009	2008 to 2009	Share of 2009 total
Agriculture	-22.5%	-0.4%	16.8%
Business	-40.8%	-7.9%	29.1%
Energy Supply	N/A	N/A	N/A
Exports	-1.2%	-7.2%	2.9%
Industrial Process	-81.3%	-22.5%	0.8%
Land Use Change	171.8%	1.6%	-11.6%
Public	-41.4%	-10.9%	3.9%
Residential	-18.0%	-7.7%	29.0%
Transport	0.4%	-4.0%	24.9%
Waste Management	-68.0%	-7.2%	4.3%
Total	**-35.0%**	**-6.9%**	**100.0%**
Total excluding exports	-35.7%	-6.9%	97.1%

The base year to 2009 emission trend when the emission exports are discounted is a reduction of **35.7%**. This compares to the reported reduction in the “by source” GHG inventory of **30.5%** over the same period.

Figure 10.2 Scotland End User GHG Emissions by National Communication Category: 1990, 2003-2009 (Mt CO_2e)



10.5.4 Wales End User GHG Inventories

The estimates of end user GHG emissions in Wales are summarised below:

Table 10.8 Wales End User GHG Inventories: 1990, 2003 to 2009 in Mt carbon dioxide equivalent (CO_2e)

Wales End User Emissions (Mt CO_2e)									
	Base Year	1990	2003	2004	2005	2006	2007	2008	2009
Agriculture	7.37	7.37	6.63	6.52	6.63	6.28	5.99	5.68	5.59
Business	23.11	23.06	17.88	18.42	17.39	18.11	17.65	16.42	13.50
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	1.34	1.34	1.54	1.93	1.86	1.74	1.90	1.79	1.86
Industrial Process	3.38	3.54	2.84	2.83	2.65	2.77	2.91	2.77	1.76
Land Use Change	-0.04	-0.04	-0.14	-0.18	-0.19	-0.20	-0.24	-0.25	-0.26
Public	1.67	1.67	1.02	1.06	1.10	1.08	1.10	1.08	0.96
Residential	9.10	9.08	8.52	8.58	8.43	8.48	7.96	8.20	7.60
Transport	7.00	7.00	7.39	7.44	7.46	7.42	7.48	7.25	6.94
Waste Management	3.25	3.25	1.25	1.22	1.19	1.11	1.09	1.05	1.01
Total	56.19	56.27	46.93	47.82	46.51	46.78	45.83	43.97	38.97

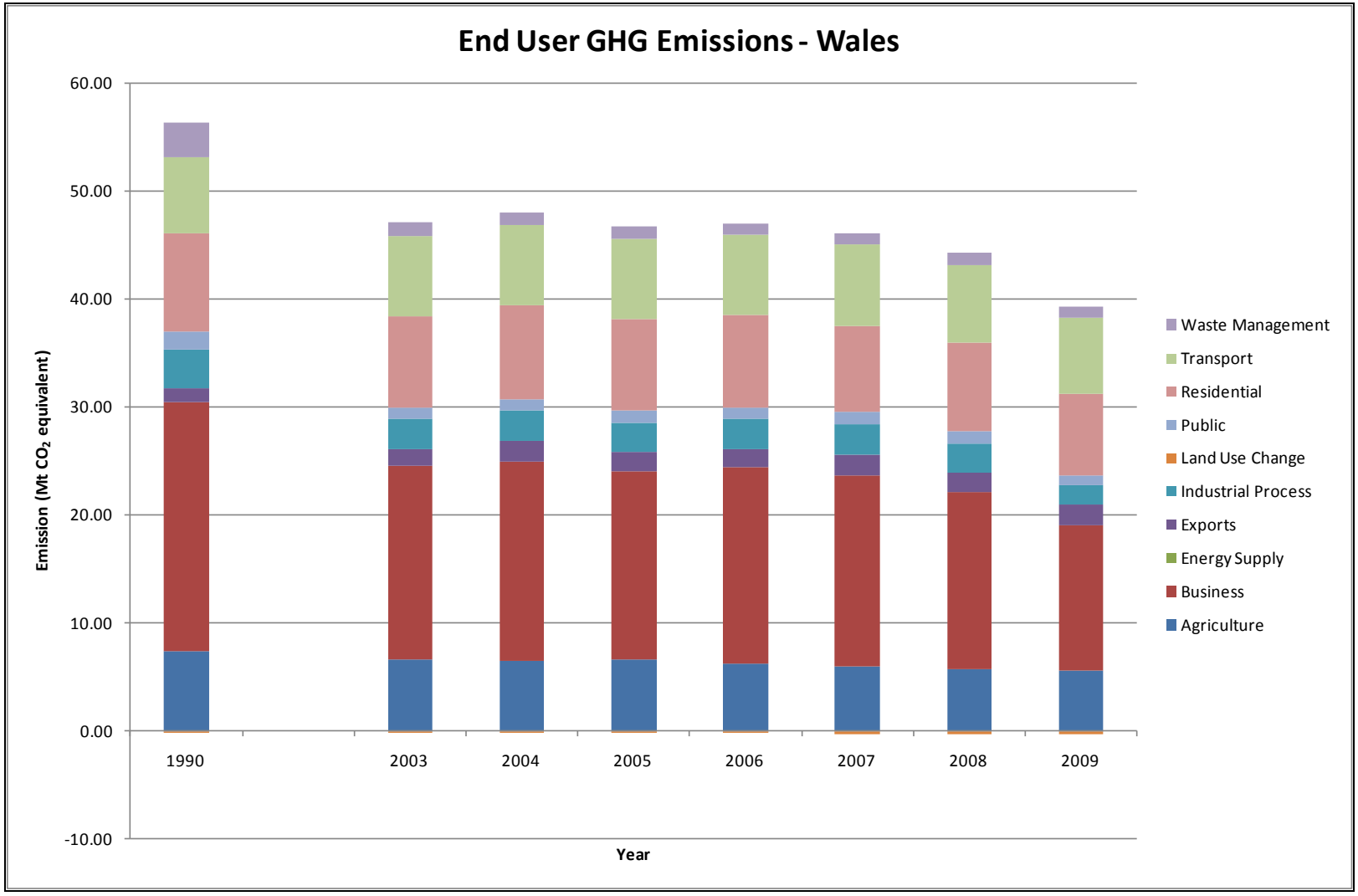
Table 10.9 Emission Trends by Sector in the Wales End User GHG Inventories

(Significant source sectors are indicated by the shaded rows.)

End User GHG Emission Trends in Wales			
	Base Year to 2009	2008 to 2009	Share of 2009 total
Agriculture	-24.2%	-1.6%	14.3%
Business	-41.6%	-17.8%	34.7%
Energy Supply	N/A	N/A	N/A
Exports	38.4%	4.1%	4.8%
Industrial Process	-48.0%	-36.5%	4.5%
Land Use Change	523.2%	2.0%	-0.7%
Public	-42.4%	-10.8%	2.5%
Residential	-16.5%	-7.3%	19.5%
Transport	-0.9%	-4.2%	17.8%
Waste Management	-68.8%	-3.0%	2.6%
Total	**-30.6%**	**-11.4%**	**100.0%**
Total excluding exports	-32.3%	-12.0%	95.2%

The base year to 2009 emission trend when the emission exports are discounted is a reduction of **32.3%** This compares to the reported reduction in the “by source” GHG inventory of **23.3%** over the same period.

Figure 10.3 Wales End User GHG Emissions by National Communication Category: 1990, 2003-2009 (Mt CO_2e)



10.5.5 Northern Ireland End User GHG Inventories

The estimates of end user GHG emissions in Northern Ireland are summarised below:

Table 10.10 Northern Ireland End User GHG Inventories: 1990, 2003 to 2009 in Mt carbon dioxide equivalent (CO_2e)

Northern Ireland End User Emissions (Mt CO_2e)									
	Base Year	1990	2003	2004	2005	2006	2007	2008	2009
Agriculture	6.17	6.17	6.01	5.86	5.80	5.72	5.60	5.49	5.42
Business	4.61	4.59	3.74	3.80	3.91	4.17	4.32	3.80	3.40
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.05	0.05	0.72	0.95	1.21	1.11	0.82	0.20	0.26
Industrial Process	0.76	0.76	0.22	0.22	0.42	0.43	0.49	0.40	0.18
Land Use Change	0.08	0.08	-0.06	-0.05	-0.03	-0.01	0.02	0.06	0.10
Public	1.19	1.19	0.62	0.67	0.69	0.72	0.72	0.77	0.72
Residential	6.82	6.81	5.98	5.87	5.74	5.94	5.49	5.78	5.53
Transport	3.80	3.80	4.96	4.90	4.99	4.94	5.06	4.87	4.78
Waste Management	1.87	1.87	0.72	0.69	0.69	0.69	0.69	0.69	0.71
Total	25.36	25.32	22.89	22.91	23.42	23.72	23.22	22.08	21.11

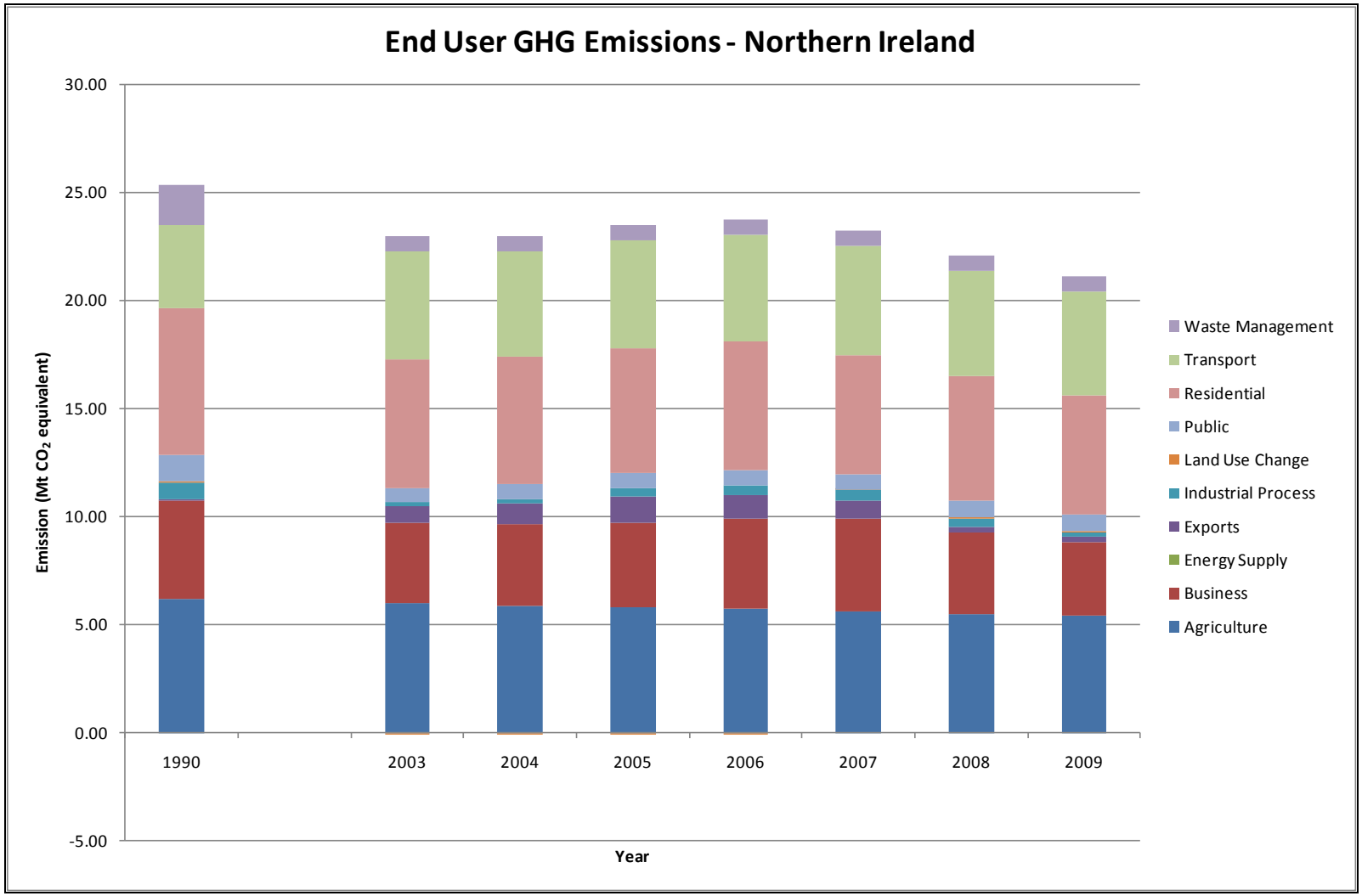
Table 10.11 Emission Trends by Sector in the Northern Ireland End User GHG Inventories

(Significant source sectors are indicated by the shaded rows.)

End User GHG Emission Trends in Northern Ireland			
	Base Year to 2009	2008 to 2009	Share of 2009 total
Agriculture	-12.3%	-1.4%	25.7%
Business	-26.2%	-10.5%	16.1%
Energy Supply	N/A	N/A	N/A
Exports	444.5%	27.1%	1.2%
Industrial Process	-76.5%	-55.2%	0.8%
Land Use Change	28.1%	65.8%	0.5%
Public	-39.4%	-6.1%	3.4%
Residential	-19.0%	-4.4%	26.2%
Transport	25.9%	-1.8%	22.7%
Waste Management	-61.9%	2.5%	3.4%
Total	**-16.8%**	**-4.4%**	**100.0%**
Total excluding exports	-17.6%	-4.7%	98.8%

Note that the base year to 2009 emission trends when the emission exports are discounted show that Northern Ireland end user emissions have reduced by **17.6%** This compares to the reported reduction in the "by source" GHG inventory of **20.3%** over the same period. The large increase in emissions in the Exports category is because the base year estimate only includes a small amount of end user uplift for international flights and shipping movements, whereas in 2009 Northern Ireland is an exporter of electricity to the Republic of Ireland.

Figure 10.4 Northern Ireland End User GHG Emissions by National Communication Category: 1990, 2003-2009 (Mt CO_2e)



10.5.6 Sector Analysis

The sector-specific data provide an insight into the impacts of the end user methodology, and an analysis of the outputs from the new DA end user approach is presented below.

Across all sectors, the sector-specific electricity estimates for each DA are uncertain, especially in the 1990 data where very limited sector-specific information is available. This must be taken into consideration when using the data to inspect the reported emission trends. It is likely that the trends reported in the 2003 to 2009 data are subject to lower uncertainty. Note that where variable percentage increases are evident between DAs, from the comparisons of by source emissions and the end user estimates, this is due to the DA-specific mix of fuels and electricity used within the sector.

Business

The business sector includes industrial and commercial energy use sources, in addition to a number of non-energy sources such as the use of fluorinated gases, which accounts for around 4% of the total business sector emission in 2009. The DA end user estimates for the business sector are summarised below:

Table 10.12 Business Sector DA End User Emissions: 1990, 2003-2009

Business Sector								
End User Emissions (Mt CO_2 e)	1990	2003	2004	2005	2006	2007	2008	2009
England	192.9	170.6	168.6	166.3	168.2	165.2	161.3	138.5
Scotland	23.8	17.0	16.8	17.1	16.1	15.4	15.4	14.2
Wales	23.1	17.9	18.4	17.4	18.1	17.6	16.4	13.5
Northern Ireland	4.6	3.7	3.8	3.9	4.2	4.3	3.8	3.4

DA % of End User Emissions	1990	2003	2004	2005	2006	2007	2008	2009
England	78.95%	81.54%	81.22%	81.24%	81.41%	81.55%	81.92%	81.68%
Scotland	9.74%	8.13%	8.08%	8.36%	7.81%	7.61%	7.81%	8.35%
Wales	9.44%	8.55%	8.87%	8.49%	8.77%	8.71%	8.34%	7.96%
Northern Ireland	1.88%	1.79%	1.83%	1.91%	2.02%	2.13%	1.93%	2.01%

End User/By Source	1990	2003	2004	2005	2006	2007	2008	2009
England	224%	204%	206%	202%	210%	210%	207%	200%
Scotland	227%	223%	224%	217%	210%	210%	214%	223%
Wales	174%	172%	167%	169%	167%	167%	163%	167%
Northern Ireland	191%	221%	211%	188%	202%	206%	192%	191%

The bottom table shows that the end user emission estimates are much higher than the by source emissions in the business sector across all of the DAs. The high percentage increase in the end users data compared to the by source data indicates the large contribution of the electricity component in the DA end user estimates. The use of electricity for heating, lighting and operating equipment has a marked effect on the emissions attributed to this sector, when compared to the emissions in the by source inventories which only include estimates from direct fuel use in the sector.

The ratio of end user emissions to by source emissions in Wales is lower than for the other DAs due to the high contribution of direct emissions from iron and steel production. The significance of the Business sector estimates within each DA end user inventory in 2009 is variable, ranging from 16.1% in Northern Ireland, 29.1% in Scotland 30.6% in England, up to 34.7% in Wales.

Residential Sector

The residential sector includes emissions from domestic fuel combustion and electricity use, in addition to smaller emissions from the breakdown of consumer products, accidental vehicle fires, and HFC emissions from the use of aerosols and metered dose inhalers. The non-fuel combustion sources are unchanged between the by source and end user approaches. The DA end user estimates for the residential sector are summarised below:

Table 10.13 Residential Sector DA End User Emissions: 1990, 2003-2009

Residential Sector								
End User Emissions (Mt CO_2 e)	1990	2003	2004	2005	2006	2007	2008	2009
England	136.2	133.3	134.1	133.6	132.9	127.6	128.8	118.8
Scotland	17.2	15.4	15.4	15.6	15.5	15.0	15.3	14.1
Wales	9.1	8.5	8.6	8.4	8.5	8.0	8.2	7.6
Northern Ireland	6.8	6.0	5.9	5.7	5.9	5.5	5.8	5.5

DA % of End User Emissions	1990	2003	2004	2005	2006	2007	2008	2009
England	80.47%	81.69%	81.81%	81.77%	81.60%	81.76%	81.48%	81.34%
Scotland	10.14%	9.41%	9.37%	9.55%	9.54%	9.62%	9.67%	9.66%
Wales	5.37%	5.22%	5.24%	5.16%	5.21%	5.10%	5.19%	5.21%
Northern Ireland	4.03%	3.67%	3.58%	3.52%	3.65%	3.52%	3.66%	3.79%

End User/By Source	1990	2003	2004	2005	2006	2007	2008	2009
England	216%	183%	181%	188%	194%	194%	192%	188%
Scotland	211%	190%	188%	195%	200%	199%	196%	192%
Wales	183%	167%	166%	174%	177%	176%	175%	172%
Northern Ireland	156%	156%	155%	162%	164%	168%	167%	162%

The percentage increase in the end users emissions data compared to the by source data indicates the additional contribution of the electricity component in the DA end user estimates, as well as the emissions associated with the extraction and processing of the other fuels used. In 1990, the ratio of end user to by source emissions in England and Scotland is markedly higher than the ratio for Wales and Northern Ireland. This mainly reflects the difference domestic energy consumption in the DA. For England and Scotland, this is 20 and 21%, respectively, compared with 16% for Wales and 14% for Northern Ireland.

Across all years, Northern Ireland shows the lowest percentage increase in emissions when compared to the by source emissions, which reflects the higher contribution to the energy mix from solid and liquid fuels compared with the other DAs. The end user increment for these fuels is much lower, since the direct emission forms a high percentage of the total (as opposed to electricity, where the end user increment forms 100% of the emission).

The domestic sector estimates of electricity use in 1990 for each DA are based on sales data from regional electricity companies for 1989, scaled to the 1990 UK domestic electricity use total. In addition, the Regional Energy Statistics published by DECC for recent years within the periodic publication Energy Trends, provides domestic sector estimates of electricity use for each DA. Therefore, these sector estimates are associated with lower uncertainty than many of the other sectors.

The reported trends in end user emissions since 1990 show that:

- England emissions have declined by 13%
- Scotland emissions have declined by 18%

- Wales emissions have declined by 16%
- Northern Ireland emissions have declined by 19%

In England, the majority of the reduction in emissions is due to decreased emissions from electricity consumption. This is despite an increase in electricity consumption since 1990, indicating that the main driver to emission reductions is the reduction in the carbon intensity of the fuel mix for electricity generation in the UK. The decrease is partially offset by increases in emissions from natural gas use and non-energy sources. Other smaller decreases are evident in emissions from coal, anthracite and SSF use.

The reasons for the decrease for Scotland are similar to England, with reductions in emissions from coal, coke and SSF playing a larger role; an increase in emissions from natural gas use a offsets the emissions reductions from coal use.

In Wales, coal, anthracite coke and gas oil use have decreased significantly, in addition to the decrease in emissions from electricity consumption. The decrease is partially offset by an increase in emissions from natural gas use since 1990.

For Northern Ireland, the trend in electricity emissions is far less important, since this forms a lower percentage of the overall fuel use mix. The majority of the decrease in emissions is from reduced solid fuel use, in favour of oils and natural gas.

Across all of the DAs, this sector is a very significant emission source within the national inventories; in England and Northern Ireland, the Residential sector is estimated to comprise 26% of the total end user emissions in 2009; in Scotland the Residential sector comprises 29% of the end-user total; whilst in Wales the figure is somewhat lower at 20%, partly due to the greater influence of iron and steel and industrial emissions in Wales.

Public Sector

This sector contains emissions from the combustion of fuel, and electricity use, within the public sector. The DA end user estimates for the public sector are summarised below:

Table 10.14 Public Sector DA End User Emissions: 1990, 2003-2009

Public Sector								
End User Emissions (Mt CO_2 e)	1990	2003	2004	2005	2006	2007	2008	2009
England	25.8	18.5	19.0	18.2	16.9	16.2	15.9	14.1
Scotland	3.2	2.0	2.1	2.2	2.1	2.1	2.1	1.9
Wales	1.7	1.0	1.1	1.1	1.1	1.1	1.1	1.0
Northern Ireland	1.2	0.6	0.7	0.7	0.7	0.7	0.8	0.7

DA % of End User Emissions	1990	2003	2004	2005	2006	2007	2008	2009
England	81.0%	83.6%	83.2%	82.1%	81.1%	80.3%	80.1%	79.9%
Scotland	10.0%	9.0%	9.2%	9.8%	10.2%	10.6%	10.6%	10.6%
Wales	5.2%	4.6%	4.6%	5.0%	5.2%	5.4%	5.4%	5.4%
Northern Ireland	3.7%	2.8%	2.9%	3.1%	3.5%	3.6%	3.9%	4.1%

End User/By Source	1990	2003	2004	2005	2006	2007	2008	2009
England	226%	212%	202%	195%	201%	207%	203%	206%
Scotland	241%	220%	204%	203%	220%	240%	234%	238%
Wales	205%	227%	213%	214%	237%	261%	255%	259%
Northern Ireland	228%	489%	474%	418%	426%	423%	373%	364%

The percentage increase in the end users data compared to the by source data for the public sector is much higher than in the residential sector. This is because this sector does not contain any sources which do not attract an end user increment (e.g. use of HFCs), or any significant fuel use that has no end user component, such as peat. The proportion of energy use in the form of electricity is also higher for the public sector than for the residential sector in most years.

The magnitude of the public sector estimates within each DA end user inventory in 2009 is quite low across the UK, ranging from 3.4% in Northern Ireland, 2.5% in Wales, 3.1% in England up to 3.9% in Scotland.

Across all of the DAs, the decline in total energy use within the sector is smaller than the decline in emissions, reflecting the change in the fuel mix to less carbon intensive fuels, both for direct consumption, and for electricity generation.

Transport

The transport category includes all emissions from road transport, rail (including stationary sources), national navigation and coastal shipping, domestic aviation, military aviation and coastal shipping. The DA end user estimates for the transport sector are summarised below:

Table 10.15 Transport DA End User Emissions: 1990, 2003-2009

Transport Sector								
End User Emissions (Mt CO_2 e)	1990	2003	2004	2005	2006	2007	2008	2009
England	115.80	123.25	122.85	123.67	122.36	122.96	118.00	113.18
Scotland	12.06	12.87	12.80	12.95	12.95	13.09	12.61	12.11
Wales	7.00	7.39	7.44	7.46	7.42	7.48	7.25	6.94
Northern Ireland	3.80	4.96	4.90	4.99	4.94	5.06	4.87	4.78

DA % of End User Emissions	1990	2003	2004	2005	2006	2007	2008	2009
England	83.5%	83.0%	83.0%	83.0%	82.9%	82.7%	82.7%	82.6%
Scotland	8.7%	8.7%	8.6%	8.7%	8.8%	8.8%	8.8%	8.8%
Wales	5.1%	5.0%	5.0%	5.0%	5.0%	5.0%	5.1%	5.1%
Northern Ireland	2.7%	3.3%	3.3%	3.3%	3.3%	3.4%	3.4%	3.5%

End User/By Source	1990	2003	2004	2005	2006	2007	2008	2009
England	114%	115%	114%	114%	113%	113%	112%	113%
Scotland	114%	115%	114%	114%	113%	113%	112%	113%
Wales	114%	115%	114%	114%	113%	113%	112%	113%
Northern Ireland	114%	115%	113%	114%	113%	113%	112%	112%

In many end user sectors, the fuel mix within each DA will vary and hence the impact of the end users approach will also vary quite markedly as the additional emissions associated with different fuel groups combine to derive the total end user estimate. This is reflected in the range of percentage increases from by source to end user estimates in the tables shown above for the business, domestic and public sectors, where both primary fuels and electricity are used throughout the UK.

In the transport sector, however, the majority of the fuels used are derived from petroleum processing (with the exception being combustion in the rail sector), and hence the effects of the end user method can be seen in isolation for the petroleum sector from the data above. In each year, the end user emissions for all DAs are around 12% to 15% higher than the by source estimates.

The emissions within this sector are dominated by road transport, for which the end user estimates are associated with lower uncertainty than for many sectors. This is due to the good quality of the DA-specific by source inventory estimates.

Across all DAs, the transport sector is a large emission source in the end user GHG inventories; in England, Scotland and Northern Ireland in 2009, the road transport sector comprised between 23-26% of the end user inventory total, whilst in Wales the road transport sector is estimated at 18% of the end use inventory total due to the greater influence of the iron and steel and industrial emissions in Wales compared to other DAs.

The reported trends in the transport sector since 1990 show that in Great Britain the end user emissions from this sector have not changed significantly, increasing between 0.4% and -2.3%, whilst the growth in transport end user emissions in Northern Ireland is marked, at around 26% since 1990.

Other Sectors

Emissions from the Land Use Change and Waste Management sectors are unchanged between the by source and end user approaches, since there are no emissions from energy use allocated to these sources.

The end user increment within the Industrial Process sector is limited to the use of fuels in ammonia production (feedstock use of natural gas), and iron and steel (where emissions are allocated to process use, rather than combustion).

For Agriculture, the increase in emissions using the End User approach is limited to the emissions from energy use within the sector, limiting the impact to a 4-7% increase in emissions. Emissions allocated to the Exports category accounted for around 2% of England emissions, 0.3% of Scotland, 0.1% of Northern Ireland emissions, and 0.4% of emissions from Wales. No emissions are allocated to this category within the by source inventories.

11 Summary Graphs

Graphs illustrating the net GHG emissions as carbon dioxide equivalent for 1990, 1995, and 1998 to 2009 for the DAs are shown in Figure 11.1 to Figure 11.6. The summary data and time-series trends are also presented in more detailed country-specific tables in Appendix 2, including a breakdown of total GHG emissions by National Communication sectors: Energy Supply, Transport, Business, Residential, Public, Industrial Process, Agriculture, Land Use, Land Use Change & Forestry, and Waste.

Figure 11.1 Graphs of Carbon Dioxide Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2009 (kt CO_2)

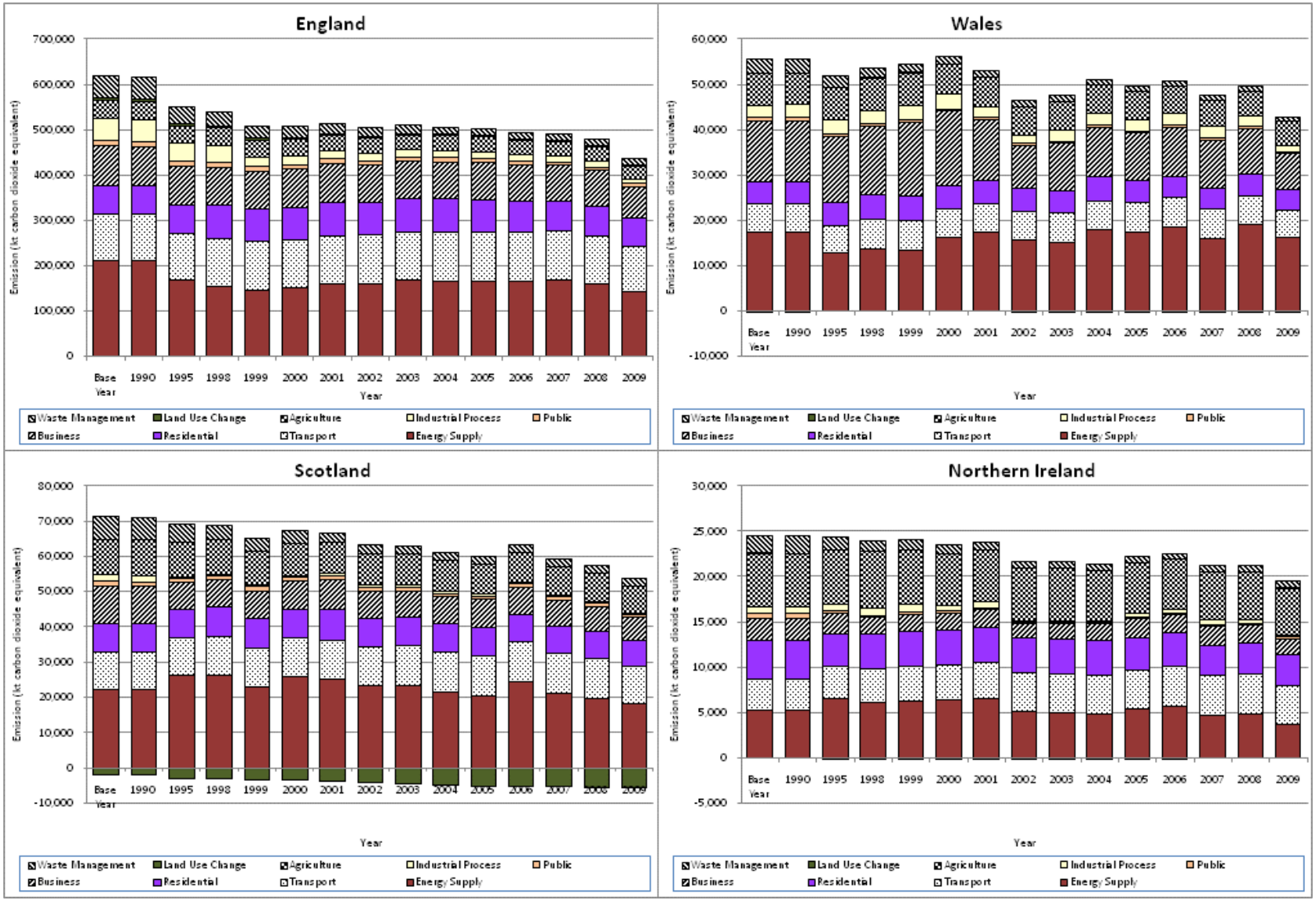


Figure 11.2 Graphs of Methane Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2009 (kt CO_2 e)

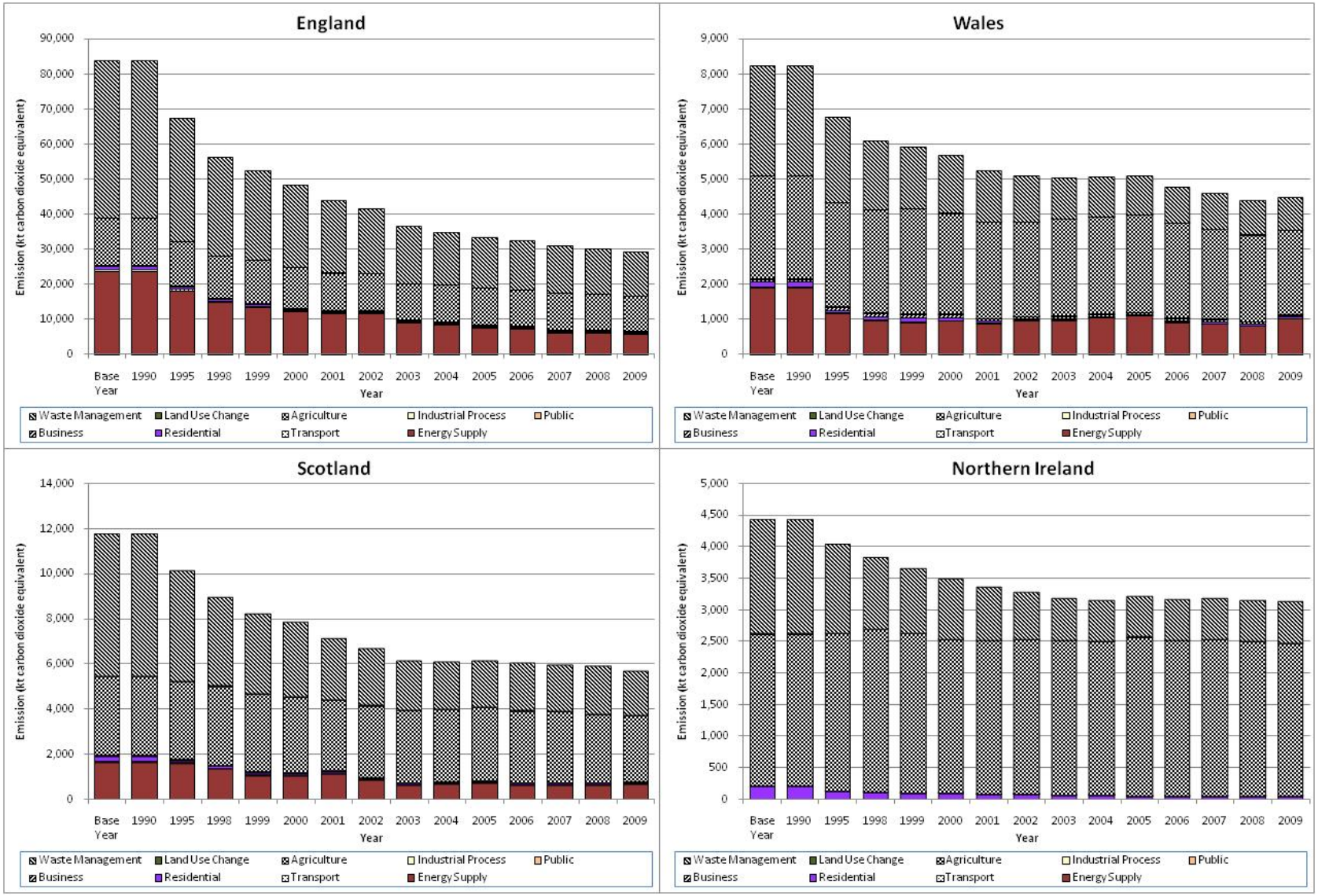


Figure 11.3 Graphs of Nitrous Oxide Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2009 (kt CO_2 e)

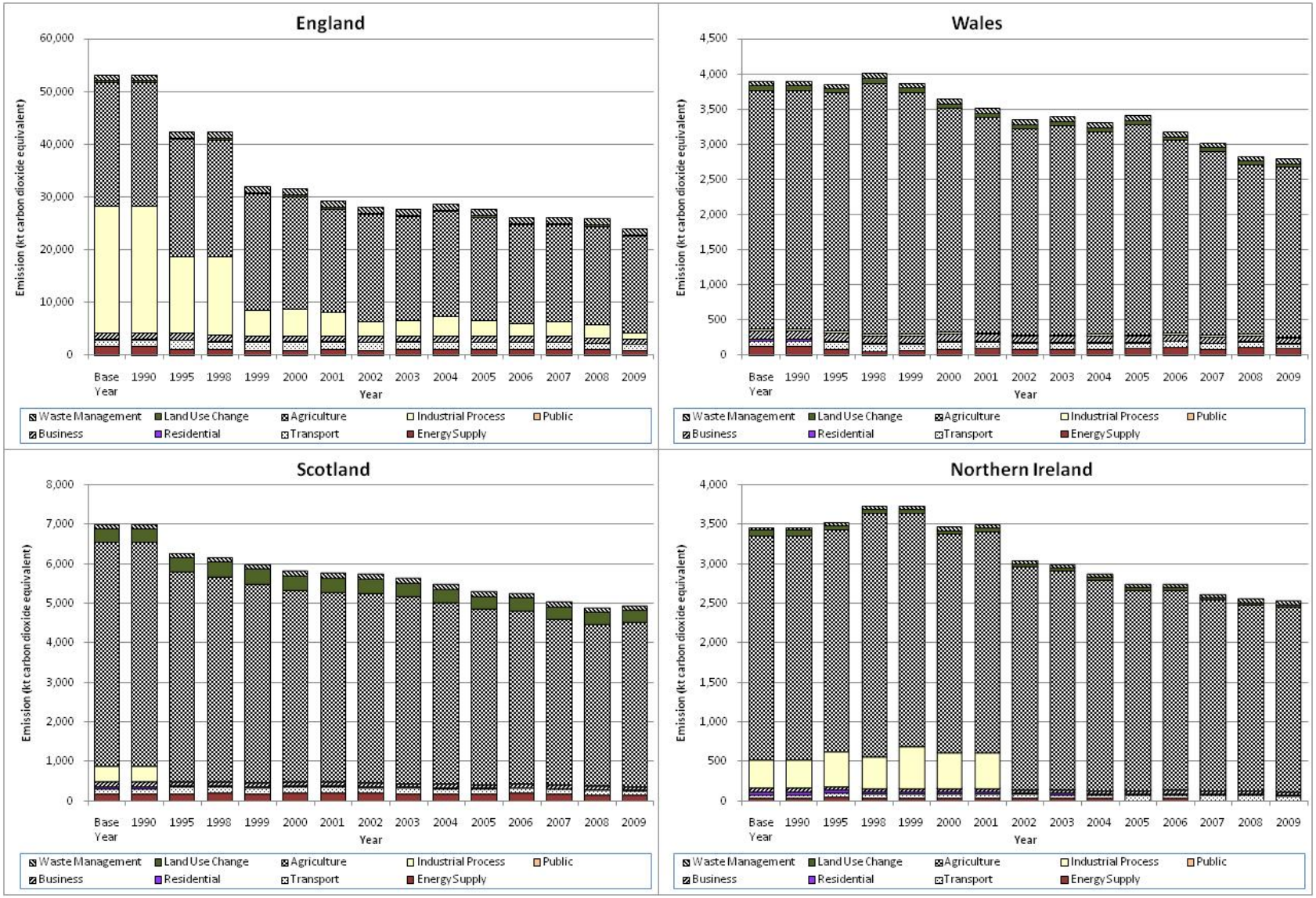


Figure 11.4 Graphs of HFC Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2009 (kt CO_2 e)

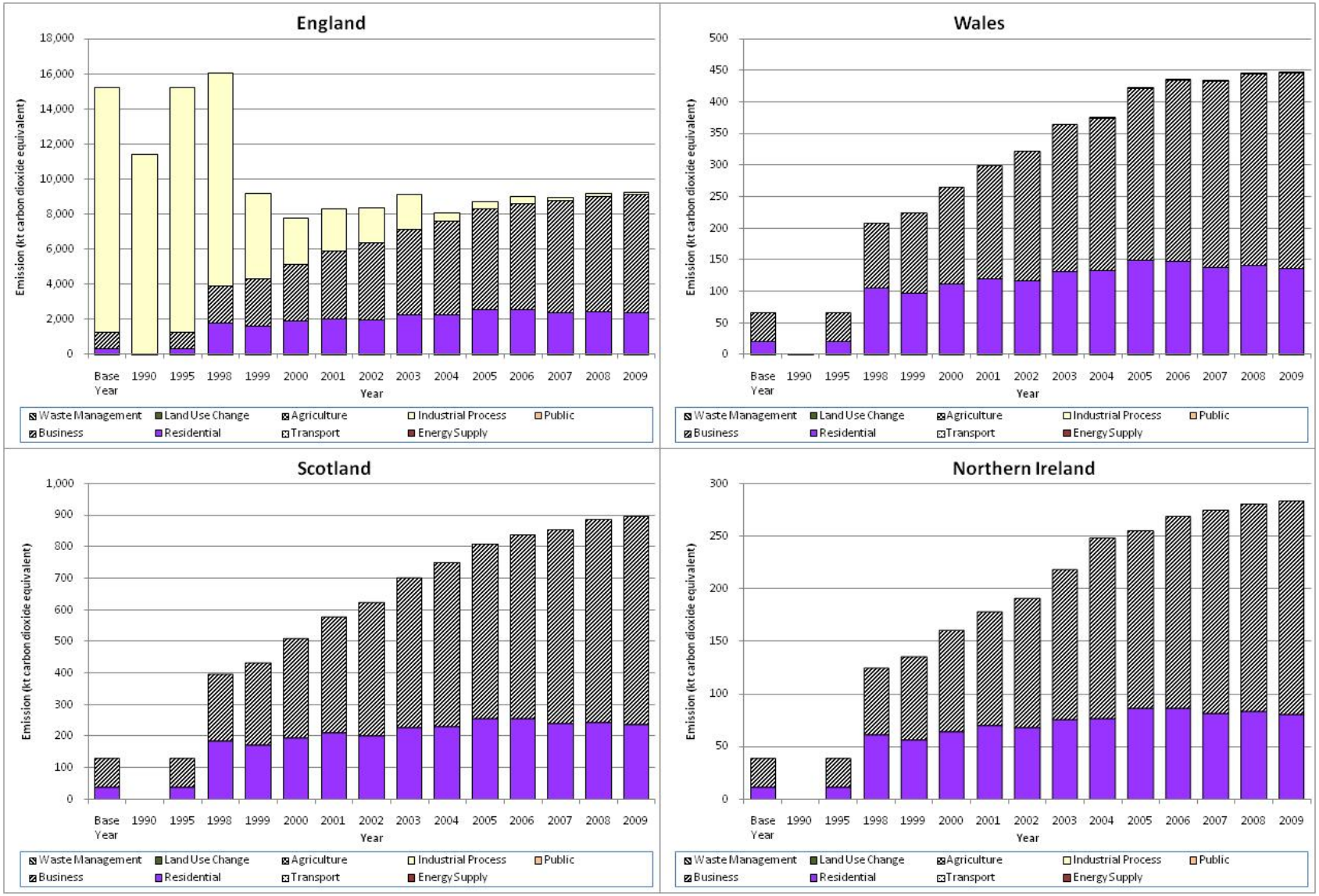


Figure 11.5 Graphs of PFC Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2009 (kt CO_2 e)

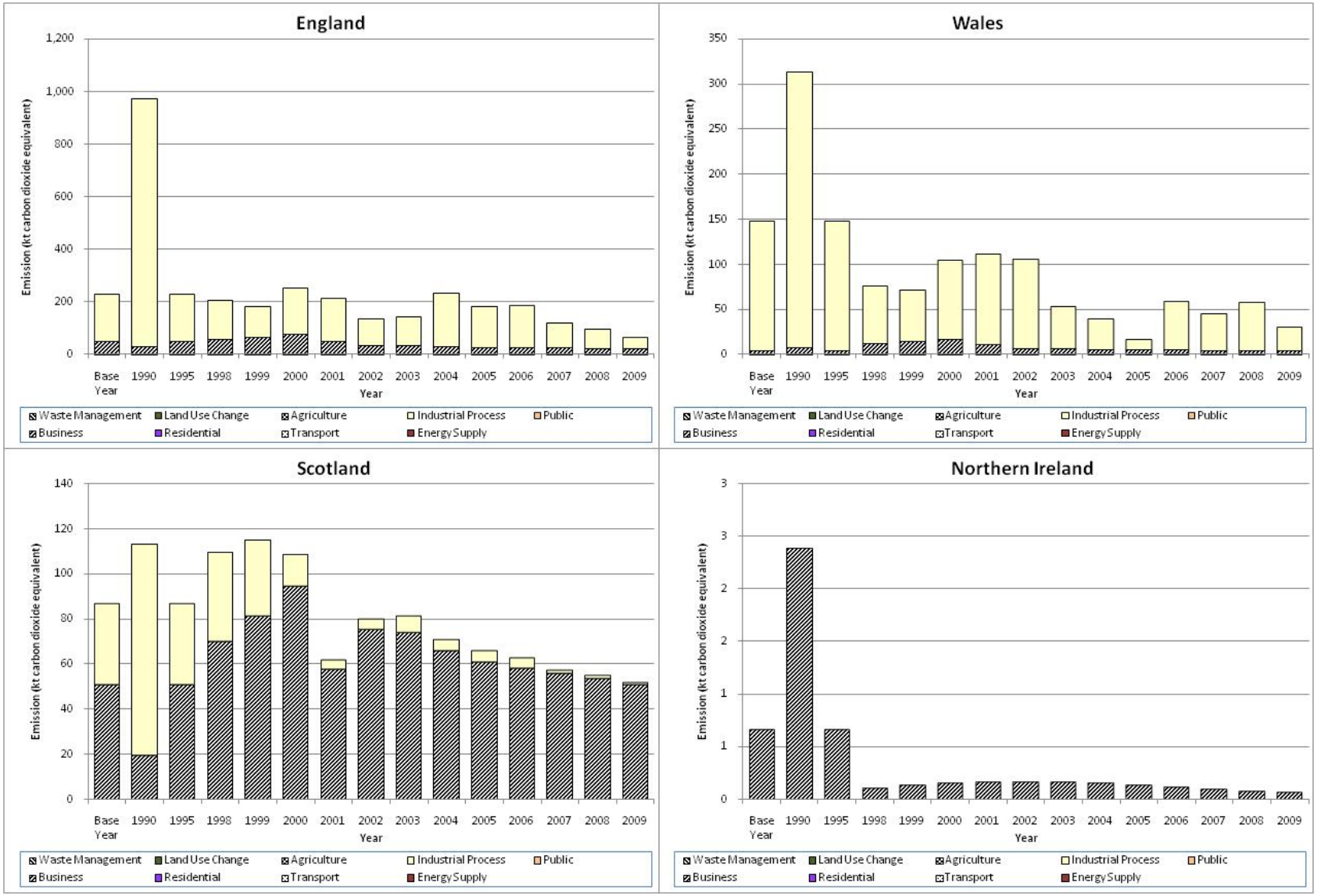
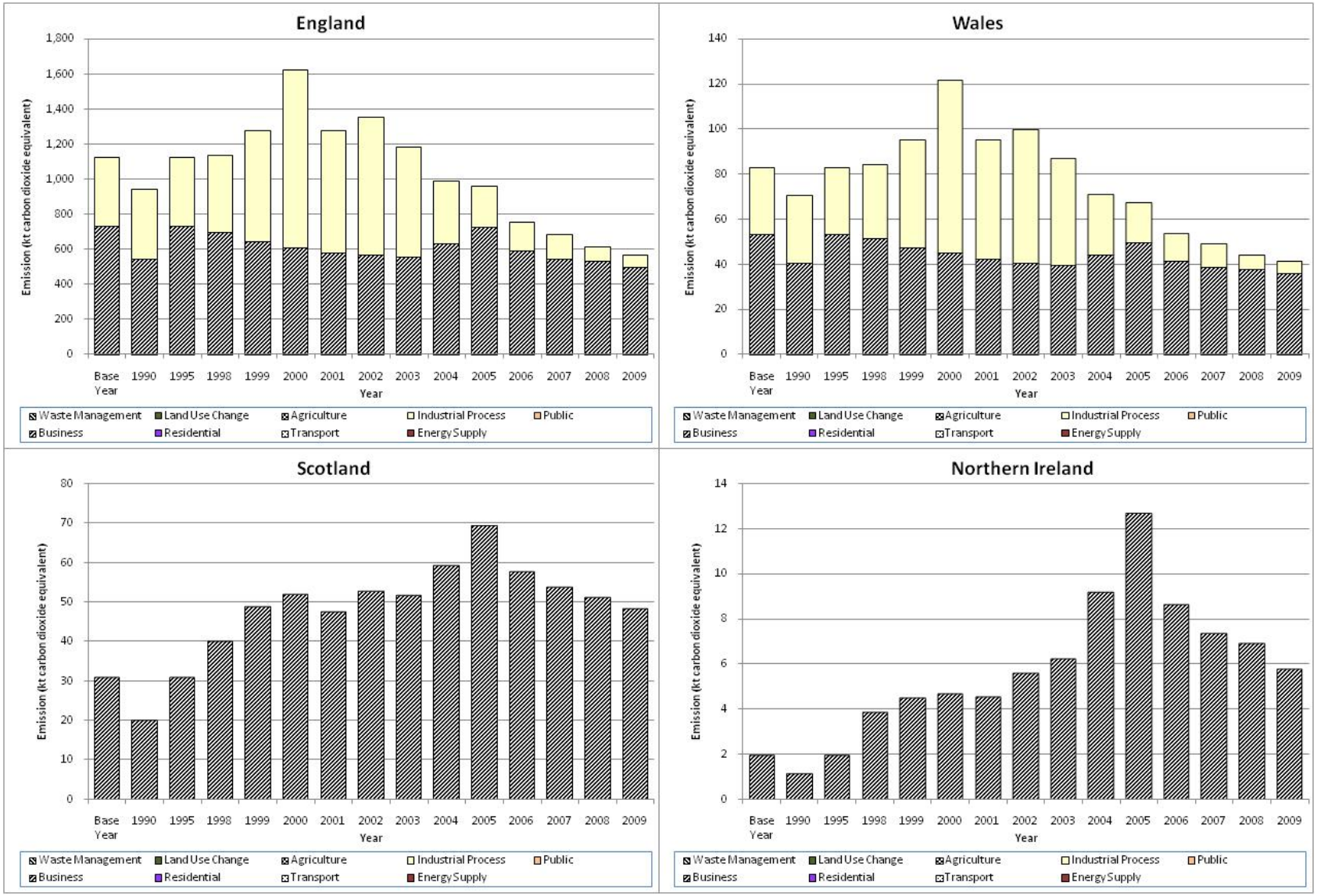


Figure 11.6 Graphs of SF_6 Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2009 (kt CO_2 e)



12 References

Abbott, J, Jackson, J, Thistlethwaite, G, Thomas, J (2009), End User GHG Inventories for England, Scotland, Wales and Northern Ireland: 1990, 2003 to 2007. AEAT/ENV/R/2882

ADAS (2008) Personal Communication, B Cottrill

Adger, N, Subak, S. (1995) *"Carbon fluxes resulting from Land Use Change: Land Use Data and Policy."* In: Carbon Sequestration in Vegetation and Soils (Ed. by MGR Cannell), DOE/ITE Contract EPG 1/1/3. Interim Report March 1995. Department of Environment, London.

AES Drax (2004), Power station fuel consumption, Personal Communication.

Agricultural Industries Confederation. (2006). "Fertiliser Statistics 2006 report." From www.agindustries.org.uk.

Alcan (2010), Personal Communication.

ATOC (2010), Fuel use by train operating companies, personal communication.

Boulter PG, TJ Barlow and IS McRae (2009). Emission Factors 2009: Report 3 - Exhaust Emission Factors for Road Vehicles in the UK. TRL Project Report PPR 356, June 2009. http://www.dft.gov.uk/pgr/roads/environment/emissions/report-3.pdf

Bell, D (2010), ISR and Power Station Fuel Consumption, Personal Communication, Northern Ireland Department of Environment.

BGS (1991, 1996, 2004, 2006-2010), *United Kingdom Minerals Yearbook*, British Geological Survey, Natural Environment Research Council.

BP (2004), Grangemouth Refinery, Personal Communication.

Bradley, I (1997) *"Carbon loss from drained lowland fens."* In: Carbon Sequestration in Vegetation and Soils (Ed. by MGR Cannell), DOE/ITE Contract EPG 1/1/3. Final Report March 1997. Department of Environment, London.

Bradley, R. I., Milne, R., Bell, J., et al. (2005). A soil carbon and land use database for the United Kingdom. *Soil Use and Management*, 21, 363-369.

British Cement Association (2010), Cement capacity by site, sector-wide fuel use and process emissions, Personal Communication.

British Glass (2001), Emissions from the UK Glass Industry. Report prepared for NETCEN.

British Glass (2010), Production Statistics for UK Glass Industry, Personal Communication.

Brown, KA, Smith, A, Burnley, SJ, Campbell, DJV, King, K, Milton, MJT (1999) *"Methane Emissions from UK Landfills"*, AEA Technology, AEAT-20624, Culham. Oxfordshire.

BSFP (2010). The British Survey of Fertiliser Practice: Fertiliser Use on Farm Crops for Crop Year 2009, Defra http://www.defra.gov.uk/statistics/files/defra-stats-foodfarm-environ-fertiliserpractice-2009.pdf

Cannell, MGR, Dewar, RC, Pyatt, DG, (1993) *"Conifer plantations on drained peatland in Britain: a net gain or loss of carbon?"* In: *Forestry 66*, 353-368.

Cannell, M. G. R. and Dewar, R. C. (1995). The Carbon Sink Provided by Plantation Forests and Their Products in Britain. *Forestry,* 68, 35-48

Cannell, MGR, Milne, R, Hargreaves, KJ, Brown, TAW, Cruickshank, MM, Bradley, RI, Spencer, T, Hope, D, Billett, MF, Adger, WN & Subak, S (1999) *"National inventories of terrestrial carbon sources and sinks: the UK experience."* In: *Climatic Change 42*, 505-530

Carey, P. D., S. Wallis, et al. (2008). Countryside Survey: UK Results from 2007, NERC/Centre for Ecology & Hydrology. http://www.countrysidesurvey.org.uk/reports2007.html

CAA (2010), UK airport statistics 2009 – annual. CAA , 2010. http://www.caa.co.uk/default.aspx?catid=80&pagetype=88&sglid=3&fld=2009Annual

Coal Authority (2010), Regional Coal Production: open cast and deep mined, Personal Communication.

Cooper, A. and McCann, T. (2002). Technical Report of the Northern Ireland Countryside Survey. University of Ulster.

Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment and in particular of the soil, when sewage sludge is used in agriculture. http://ec.europa.eu/environment/waste/sludge/index.htm

Cruickshank, MM, Tomlinson, RW (1997) *"Carbon loss from UK peatlands for fuel and horticulture."* In: *Carbon Sequestration in Vegetation and Soils* (Ed. by MGR Cannell), DOE, Contract EPG 1/1/3. Final Report March 1997. Department of Environment, London.

Cruickshank, M. M., R. W. Tomlinson, *et al*. (1998). "Carbon in the vegetation and soils of Northern Ireland." Biology and Environment-Proceedings of the Royal Irish Academy **98B**(1): 9-21.

Cruickshank, MM, and Tomlinson, RW, (2000) *"Change in soil carbon storage in Northern Ireland: estimated by the IPCC default and matrix methods."* In.: *Carbon Sequestration in Vegetation and Soils* (Ed. by R. Milne), DETR Contract EPG 1/1/39. Final Report April 2000. (Available at http://www.nbu.ac.uk/ukcarbon/)

DANI (1991, 1996, 1999, 2010), The Agricultural Census in Northern Ireland: Results for June 1990, 1995, 1998, 1999.

DARDNI (2000, 2001 et al), The Agricultural Census in Northern Ireland: Results for June 1999, 2000 et al.

DECC (2010a), "*Digest of UK Energy Statistics*" Department of Energy & Climate Change, HMSO.

DECC (2010b), *Energy Trends December 2010*, articles on DA electricity generation and consumption patterns and the regional energy statistics for 2003 to 2009.

DECC (2010c), Local gas use data by LDZ, personal communication.

DECC (2010d), Oil & Gas flaring and venting volume data by installation and gas landings information, personal communication.

DECC (2010e), Site-specific emission estimates from the Environmental Emissions Monitoring Systems (EEMS) for upstream oil and gas installations, including terminals and offshore sites, personal communication.

DECC (2010f), *Energy Trends March 2010,* articles on DA electricity generation and consumption patterns and the regional energy statistics for 2003 to 2008.

DECC (2010g), Energy Trends December 2010, http://www.decc.gov.uk/en/content/cms/statistics/publications/trends/trends.aspx

Department of Communities and Local Government (2007). Land use change in England to 2006. Additional tables LUCS-21A. UK Government, London

DEFRA (2003a), Sewage Sludge Disposal Tables produced for Digest of Environmental Statistics.

DEFRA (2001) June Agricultural Census for 2000. Department for Environment, Food and Rural Affairs.

DEFRA (2010a), Agricultural Census Statistics for UK, Annual Reference Tables, Labour Force. DEFRA Agricultural Statistics website.

DEFRA (2007b), 2006 EUETS emissions and fuel use data by site, personal communication.

DEFRA (2010c) Agriculture in the UK. http://www.defra.gov.uk/statistics/2010/03/18/auk-2009/

DETR (1997), Digest of Environmental Statistics, The Stationary Office.

Dewar, R. C. and Cannell, M. G. R. (1992). Carbon Sequestration in the Trees, Products and Soils of Forest Plantations - an Analysis Using UK Examples. *Tree Physiology*, 11, 49-71.

DfT (2010a) "Road Statistics 2009: Traffic, Speeds and Congestion" Transport Statistics Bulletin, 2010

DfT (2010b) Transport Statistics Great Britain, Table 2.2. Air Transport Movements

DfT (2008c), English Regional Traffic Growth and Speed Forecasts, Rev 1.1 April 2008, personal communication with Malcolm Jay, ITEA Division, DfT, April 2008

DfT (2010d), Maritime Statistics 2009. DfT Transport Statistics Report, September 2010. http://www2.dft.gov.uk/adobepdf/162469/221412/221658/223721/669555/maritimestatistics2009.pdf

DfT (2010e), personal communication with Mike Dark, Department for Transport, June 2010

DfT (2010f) Transport Statistics Great Britain: 2010 edition, The Stationery Office http://www2.dft.gov.uk/pgr/statistics/datatablespublications/tsgb/

DfT (2010g) personal communication with Iain Ritchie, Statistics Roads, DfT, August 2010

DLTR (2004), Aircraft Movement data, Personal communication.

DOE, (1993), UK Sewage Sludge Survey, CES Limited, HMSO

DRDNI (2010a), Northern Ireland Transport Statistics 2009-10, Central Statistics and Research Branch, Department for Regional Development. (Available at http://www.drdni.gov.uk/ni_transport_statistics_2009-10.pdf)

DRDNI (2010b), personal communication with David Compston, Traffic Information and Control Centre, September 2010

DRDNI (2010c), personal communication with Leah Ginn, Central Statistics and Research Branch, Department for Regional Development Northern Ireland, September 2010.

DTI (2001a), Development of UK Oil and Gas Resources, Department of Trade and Industry, The Stationary Office.

Dyson, K (ed.) (2009). *Inventory and projections of UK emissions by sources and removals by sinks due to land use, land use change and forestry*. Annual contract report to DECC, July 2009. At http://www.edinburgh.ceh.ac.uk/ukcarbon/reports.htm.

Edwards, P. N. and Christie, J. M. (1981). Yield models for forest management. Forestry Commission Booklet. 48. Forestry Commission, Edinburgh.

EEA (2007), EMEP/CORINAIR Emission Inventory Guidebook – 2007. Technical report No 16/2007. Group 7 – Road Transport, European Environment Agency August 2007. http://www.eea.europa.eu/publications/EMEPCORINAIR5/B710vs6.0.pdf

EFW (2001), Energy for Waste, Current and Projected Energy for Waste Capacity in UK as at December 2000.

Eggleston, HS, Salway, AG, Charles, D, Jones, BMR, Milne, R (1998), *"Treatment of Uncertainties for National Estimates of Greenhouse Gas Emissions"*, National Environmental Technology Centre, AEA Technology, Report AEAT - 2688.

Electricity Association (2004), Electricity transmission data, Personal Communication.

Entec (2010), UK Ship Emissions Inventory. Final Report to Defra, November 2010. http://uk-air.defra.gov.uk/reports/cat15/1012131459_21897_Final_Report_291110.pdf

Environment Agency (1999), UK Sewage Sludge Survey, Regional Presentation, WRc, R&D Project Record P2/065/1

Environment Agency (2010a), database of emissions to atmosphere from authorised processes in England & Wales, as reported to the Pollution Inventory (data for 1998-2009).

Environment Agency (2010b), database of EUETS operator data including fuel use, process details and emissions totals, personal communication.

European Environment Agency (2000), *"COPERT III: Computer Programme to Calculate Emissions from Road Transport - Methodology and Emission Factors (Version 2.1)"*, L. Ntziachristos and Z Samaras, European Topic Centre on Air Emissions, European Environment Agency, November 2000

Fernando, S. (2011). Update of Estimated Methane Emissions from UK Abandoned Coal Mines. At http://uk-air.defra.gov.uk/reports/cat07/1107080945_1775-ghg-improvement-project-wsp-report.pdf

Firmus Energy (2010), Northern Ireland gas sales for domestic and commercial & industrial customers for 2009, Personal Communication.

Haines-Young, R. H., Barr, C. J., Black, H. I. J., et al. (2000). *Accounting for nature: assessing habitats in the UK countryside.* DETR Countryside Survey 2000, London.

Hargreaves, KJ, Milne, R and Cannell, MGR, (2003). *"Carbon balance of afforested peatland in Scotland"* In: *Forestry* 76, 299 - 317

Haydock et al (2003) "*Emissions & Projections of HFCs, PFCs and SF_6 for the UK and Constituent Countries*", AEA Technology.

HECA NI (2005, 2010), Housing Condition Surveys 1996, 2001, 2004, 2009 personal communication.

Hobson, J, Palfrey, R, Sivil, D, Palfrey, E, Day, M, (1996) *"Control Measures to Limit CH_4 Emissions from Sewage and Sludge Treatment and Disposal",* WRc, Report No DOE 4118.

IPCC, (1997a), IPCC Revised 1996 Guidelines for National Greenhouse Gas Inventories, Volume 1, Greenhouse Gas Inventory Reporting Instructions, IPCC WGI Technical Support Unit, Hadley Centre, Meteorological Office, Bracknell, UK.

IPCC, (1997b), IPCC Revised 1996 Guidelines for National Greenhouse Gas Inventories, Volume 2, Greenhouse Gas Inventory Workbook, IPCC WGI Technical Support Unit, Hadley Centre, Meteorological Office, Bracknell, UK.

IPCC, (1997c), IPCC Revised 1996 Guidelines for National Greenhouse Gas Inventories, Volume 3, Greenhouse Gas Inventory Reference Manual, IPCC WGI Technical Support Unit, Hadley Centre, Meteorological Office, Bracknell, UK.

IPCC, (1996), Climate Change 1995. The Science of Climate Change. Contribution of Working Group 1 to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Ed. Houghton, JT, Cambridge University Press.
IPCC (2003). *Good Practice Guidance for Land Use, Land-Use Change and Forestry.* Institute for Global Environmental strategies (IGES) for the Intergovernmental Panel on Climate Change, Kanagawa, Japan.

ISSB, (2010) *Iron & Steel Industry Annual Statistics for the UK*, Consumption by Product by Region, personal communication.

Levy, P and Milne, R, (2003) Deforestation rates in the United Kingdom. In: *UK Emissions by Sources and Removals by Sinks due to Land Use, Land Use Change and Forestry Activities. Annual report (2003)* for DEFRA Contract EPG1/1/160 (Ed. by R. Milne). (Available at http://www.nbu.ac.uk/ukcarbon/)

Levy, P.E. and Milne, R. (2004) Estimation of deforestation rates in Great Britain. *Forestry,* 77, 9 –16.

LQM (2003) Methane emissions from landfill sites in the UK. Final report. January 2003. Report for the UK Department for Environment, Food and Rural Affairs. Authors: Gregory, R.G., Gillett, A.G., Bradley, D. LQM report 443/1. DEFRA contract EPG 1/1/145.

LRC (1999), Personal Communication from L Saddler, London Research Centre

MacCarthy J, Brown K, Webb N, Passant N, Thistlethwaite G, Murrells T, Watterson J, Cardenas L, Thomson A, Pang Y UK Greenhouse Gas Inventory, 1990 to 2009. Annual report for submission under the Framework Convention on Climate Change, AEA April 2011.

MAFF (1991, 1996,1999, 2000) June Agricultural Census for 1990, 1995, 1998 and 1999. Ministry of Agriculture, Fisheries and Food

MCG, (1999), UK Emissions of HFCs, PFCs and SF_6 Potential Emission Reduction Options. A study for the Department of the Environment carried out by March Consulting Group. Telegraphic House, Waterfront Quay, Salford Quays, Manchester

Milne, R and Brown, TA (1997) Carbon in the vegetation and soils of Great Britain. *Journal of Environmental Management*, 49, 413 - 433.

Milne, R, Brown, TAW and Murray, TD (1998). The effect of geographical variation in planting rate on the uptake of carbon by new forests of Great Britain. *Forestry*, 71, 298 – 309.

MLC (1986). Monitoring Landscape Change. Report prepared by Hunting Surveys & Consultants Ltd for Department of the Environment and the Countryside Commission.

NAEI (2010), NAEI UK Emission Mapping Methodology, September 2010

National Grid (2010), natural gas leakage from high pressure, low pressure distribution systems and from Above Ground Installations, personal communication.

NIEA (2010a), spreadsheet of emissions to atmosphere from authorised processes in Northern Ireland, as reported to the Inventory of Statutory Releases (data for 2005-2009).

NIEA (2010b), spreadsheet of EUETS operator data including fuel use, process details and emissions totals, personal communication.

NIO (1996, 2001, 2002, 2003, 2004, 2005, 2006), Northern Ireland Abstract of Statistics

Northern Gas Networks (2010) Natural Gas leakage from LDZ and AGIs, personal communication

Oil & Gas UK (2008), Environmental Database for annual Emissions and Discharges from Offshore Installations, from the EEMS reporting inventory.

Office for National Statistics (2000a), IDBR, Employment Database

Office for National Statistics. (2007). "UK Standard Area Measurements." Retrieved 26/01/2010, 2010, from http://www.ons.gov.uk/about-statistics/geography/products/geog-products-other/sam/index.html

Office for National Statistics (2010a), Datasets available pertaining to a wide range of industrial and population-related activities via the publications “Annual Abstract of Statistics” and “Regional Trends”, Office for National Statistics.

Office of National Statistics (2010b). *Mineral Extraction in Great Britain 2009. Business Monitor PA1007*. www.statistics.gov.uk.

Pang, Y., Walker, H., and Murrells, T (2011) Improving the Greenhouse Gas Inventories for Road Transport in Scotland, Wales and Northern Ireland. Report for DECC, Welsh Assembly Government, the Scottish Government and the Department of the Environment for Northern Ireland, AEAT/ENV/R/3167, April 2011.
http://uk-air.defra.gov.uk/reports/cat07/1106161316_IP_Task_23_DA_Road_Transport_Issue_1.pdf

Patel, NM (2000), Personal Communication, Strategic Consultancy, AEA Technology

Phoenix Natural Gas (2007), Gas consumption detailed by end-user sectors for 2005 and gas leakage data, Personal Communication

Phoenix Natural Gas (2010), Gas consumption and gas leakage data for 2009, Personal Communication

RCEP (1993), Royal Commission on Environmental Pollution, 17th Report, Incineration of Waste, HMSO, London

RWE Innogy (2006), Power station annual fuel consumption, Personal Communication.

Sage, PW, (2001), Methane from Abandoned Coal Mines in the UK, AEA Technology, Report AEAT/ENV/R/0500, Harwell

Scotia Gas Networks (2010) Natural Gas leakage from LDZ and AGIs, personal communication

Scottish Executive Rural Affairs Department (2000). Economic Report on Scottish Agriculture: 2000 edition.

Scottish Office (1991, 1996, 1999, 2000). Economic Report on Scottish Agriculture 1990, 1995, 1998, 1999.

Scottish Power plc (2006), annual Power Station Fuel Consumption, Personal Communication

Scottish and Southern Energy plc. (2006). Power Station Fuel Consumption, Personal Communication.

SEPA (2002), Scottish Waste Data Digest 2001

SEPA (2010a), Annual atmospheric emissions data for authorised processes in Scotland, from SEPA’s Pollution Release Inventory, Personal Communication.

SEPA (2010b), spreadsheet of EUETS operator data including fuel use, process details and emissions totals, personal communication.

Skiba, U. (2007). N fertilisation of UK forests. Personal communication

SMMT (2002), Regional car sales, Personal Communication.

SO (1996*),* Economic Report on Scottish Agriculture, 1996

SO, (1999), Scottish Energy Statistics. Paper supplied by G Winter, Scottish Office.

Soil Survey and Land Research Centre – personal communication

Sylvester-Bradley, R., Lunn, G., Foulkes, J., et al. (2002). Management strategies for high yields of cereals and oilseed rape. In HGCA R&D Conference - Agronomic Intelligence: The basis for profitable production, pp. 8.1-8.17. Home-Grown Cereals Authority.

Taylor, C. M. A. (1991). Forest fertilisation in Britain. Forestry Commission Bulletin 95.

Thomson, A.M., Hallsworth, S., Malcolm, H. (2011). Emissions and Removals of GHGs from Land Use Land Use Change and Forestry for England, Scotland, Wales and Northern Ireland: 1990-2009. At http://uk-air.defra.gov.uk/reports/cat07/1104140943_LULUCF_DA_GHGI_report_2009_v4.pdf

Thomson, A.M. (ed.) (2008). *Inventory and projections of UK emissions by sources and removals by sinks due to land use, land use change and forestry*. Annual contract report to Defra, July 2008. At http://www.edinburgh.ceh.ac.uk/ukcarbon/reports.htm.

Tomlinson (2010) Peat use within Scotland and Northern Ireland: summary of research findings from CEH, personal communication.

Transco (2004) Historic Gas Demands by Load Category, Personal Communication.

Translink (2010), Annual fuel consumption, Personal Communication.

UKOOA, (1999), Personal communication from P Russell, UKOOA (Environment Committee)

UKPIA (2010), Personal Communication, United Kingdom Petroleum Industry Association Ltd

UREGNI – Data supplied from utility regulator http://www.uregni.gov.uk/

Wales & West Utilities (2010) Natural Gas leakage from LDZ and AGIs, personal communication

White Young Green (2005), Methane Emissions from Abandoned Coal Mines, research report: Defra.

Williams, A, (1993), Methane Emissions, Watt Committee Report Number 28, The Watt Committee on Energy, London.

WO, (1998), Digest of Welsh Historical Statistics 1974-1996, The Welsh Office

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