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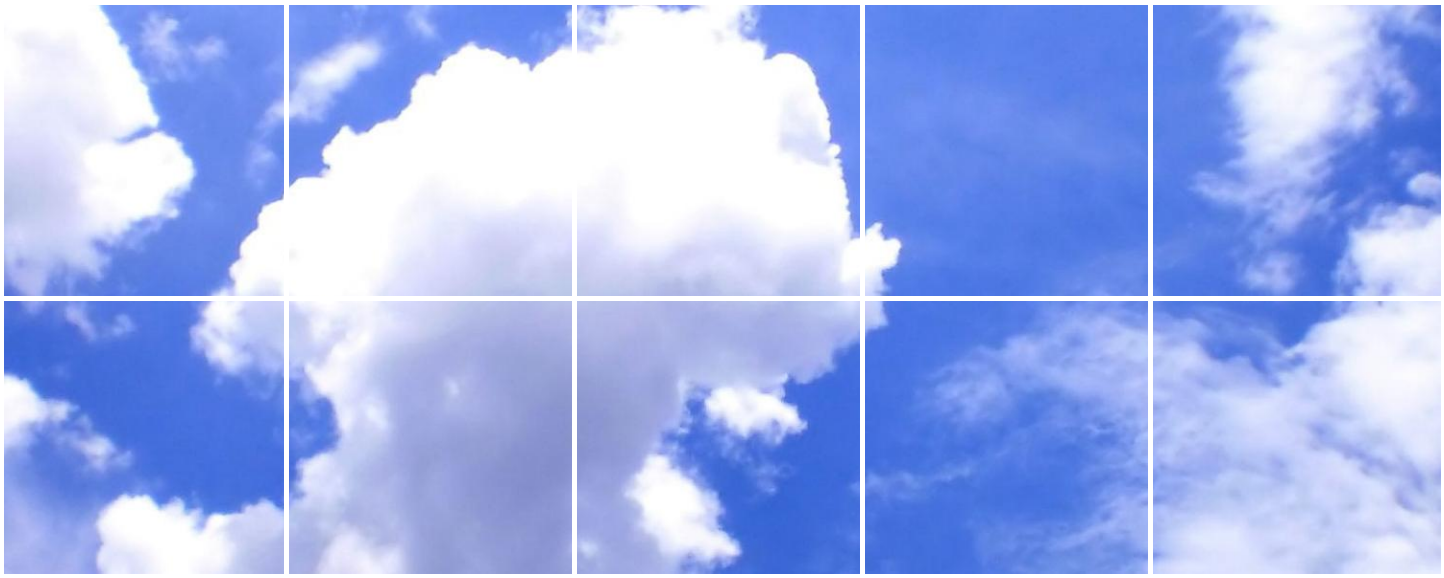

Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 - 2008

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

ISBN 978-0-9565155-1-3
AEAT/ENV/R/3067 Issue 1

September 2010

Title	Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 - 2008
Customers	Department of Energy and Climate Change, The Scottish Government, The Welsh Assembly Government, The Northern Ireland Department of Environment.
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Report Number	AEAT/ENV/R/3067 Issue 1
NAEI Reference	45322/2008/CD6851/GT
ISBN Number	978-0-9565155-1-3

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Executive Summary

Overview

This report presents estimates of greenhouse gas emission inventories for the constituent countries of the UK. Separate greenhouse gas emission inventories have been estimated for England, Scotland, Wales and Northern Ireland for the years 1990, 1995 and 1998 to 2008. The greenhouse gases 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 2008 UK Greenhouse Gas Inventory (MacCarthy et al., 2010). Emissions from offshore sources are not allocated to any country, and are reported separately within an "Unallocated" inventory category. These offshore emissions are primarily those from oil and gas exploration and production activities.

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 UK distribution of regional net[1] greenhouse gas emissions in 2008, 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 **77.4%** share of total net greenhouse gas emissions in 2008 and emissions have declined by **21.1%** since the Base Year.
- Scotland has an **8.6%** share of total net greenhouse gas emissions in 2008, and the trend since the Base Year is a decline of **21.3%**.
- Wales has a **7.9%** share of total net greenhouse gas emissions in 2008 and emissions have declined by **9.9%** since the Base Year.
- Northern Ireland has a **3.5%** share of total net greenhouse gas emissions in 2008, and the trend since the Base Year is a decline of **11.2%**.
- **2.6%** of the UK emissions total is unallocated in 2008. Unallocated emissions have declined by **5.7%** since the Base Year.

Table ES1 presents emissions of the six greenhouse gases in more detail for the base year and 2008. Tables ES2.1.1 to ES2.5.3 present the time series of emissions for each constituent country, and for unallocated emissions.

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

[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.

- **Carbon dioxide**: Overall UK emissions have fallen by 10.1% between 1990 and 2008, mainly driven by the installation of combined cycle gas turbines (CCGT) in the power generation sector in England and reductions in CO2 emissions from industry in England, Scotland and Wales.

- **Methane**: Overall UK emissions have fallen by 53.4% between 1990 and 2008, due primarily to significant reductions in methane emissions from waste disposal and coal mining.

- **Nitrous oxide**: Overall UK emissions have fallen by 47.9% between 1990 and 2008, 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 27.8% between 1995 and 2008, 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 54.8% between 1995 and 2008, 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 42.6% between 1995 and 2008. 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.

Regional energy statistics are published annually by the Department for Energy and Climate Change (DECC) within the quarterly *Energy Trends*[4] publication. These regional 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 regional energy statistics have been developed in recent years to provide estimates of fuel use and CO_2 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 2007, with gas and electricity data also available up to 2008.

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 Regional Energy Statistics continue to evolve and improve,

[4] The latest available data are taken from the December 2009 Energy Trends: http://www.decc.gov.uk/en/content/cms/statistics/publications/trends/trends.aspx

reducing data inaccuracies, but nevertheless are subject to greater uncertainty and less 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 Devolved Administrations and are therefore used to underpin the CO_2 emission estimates from fuel combustion sources within the inventories presented here, in conjunction with other data sources such as EU 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 Devolved Administrations, including estimates of arable production and livestock numbers;

Land Use, Land Use Change and Forestry 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 8 outlines the overall uncertainties of the DA GHG inventories.

Since the publication of the 1990-2007 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
- Domestic aviation
- Agriculture
- Land Use, Land Use Change & Forestry
- Waste management

Developing Country-Specific Climate Change Commitments and Related Inventory Improvements

The climate change policy agenda has been changing rapidly at Devolved Administration 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 associated Welsh Strategy (2008), and the Northern Ireland Programme for Government (2008), outline each of the Devolved Administrations' 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 Devolved Administrations 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 Devolved Administration, 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 (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 2008 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 2008 dataset show that:

- Across the **UK**, the non-traded share of overall carbon dioxide emissions is ***50.9%***;
- **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 ***54.1%*** of total CO_2 emissions in 2008, 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 2008 is only ***37.5%***;
- **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 2008 is ***44.8%***;
- **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 2008 is ***65%***;

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 ***78.6%*** share of UK GHG emissions in 2008, and the trend in emissions since the Base Year on an end user basis is ***-20.0%*** across all GHGs;
- **Scotland** has an ***8.4%*** share of UK GHG emissions in 2008, and the trend in emissions since the Base Year on an end user basis is ***-27.1%*** across all GHGs;
- **Wales** has a ***6.8%*** share of UK GHG emissions in 2008, and the trend in emissions since the Base Year on an end user basis is ***-20.9%*** across all GHGs;
- **Northern Ireland** has a ***3.7%*** share of UK GHG emissions in 2008, and the trend in emissions since the Base Year on an end user basis is ***-11.1%*** across all GHGs;

Revisions and Updates to the Greenhouse Gas Inventories

Each year, the greenhouse gas 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 2009) covered the years up to and including 2007, whilst this report gives emission estimates for the years up to and including 2008.

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 2004") 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 (2009), a more representative emission factor for one or more greenhouse gases 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 greenhouse gas 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 CO_2 data are based on the net emissions of CO_2, including net emissions/removals of CO_2 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_1990-2008_Issue 1.xls"

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

Table ES1								
Greenhouse Gas		Units	England	Scotland	Wales	Northern Ireland	Unallocated	UK
CO_2	1990	kt CO_2e	467274	50554	43134	17325	13162	591449
	1990 Percentage	%	79.0	8.5	7.3	2.9	2.2	100.0
	2008	kt CO_2e	416325	42057	41996	16171	14955	531503
	2008 Percentage	%	78.3	7.9	7.9	3.0	2.8	100.0
	Percentage change from BY	%	-10.9	-16.8	-2.6	-6.7	13.6	-10.1
CH_4	1990	kt CO_2e	78988	11043	7876	4382	1855	104143
	1990 Percentage	%	76	11	8	4	2	100
	2008	kt CO_2e	33690	6279	4373	3341	887	48570
	2008 Percentage	%	69.4	12.9	9.0	6.9	1.8	100.0
	Percentage change from BY	%	-57.3	-43.1	-44.5	-23.8	-52.2	-53.4
N_2O	1990	kt CO_2e	51564	6377	3646	3247	228	65061
	1990 Percentage	%	79.3	9.8	5.6	5.0	0.3	100.0
	2008	kt CO_2e	24295	4346	2593	2375	276	33885
	2008 Percentage	%	71.7	12.8	7.7	7.0	0.8	100.0
	Percentage change from BY	%	-52.9	-31.9	-28.9	-26.8	21.4	-47.9
HFCs	1995	kt CO_2e	15231	129	66	39	0	15466
	1995 Percentage	%	98.5	0.8	0.4	0.3	0.0	100.0
	2008	kt CO_2e	9489	919	463	292	0	11163
	2008 Percentage	%	85.0	8.2	4.2	2.6	0.0	100.0
	Percentage change from BY	%	-37.7	610.2	598.0	650.2	0.0	-27.8
PFCs	1995	kt CO_2e	227.5	86.8	146.9	0.7	0.0	461.9
	1995 Percentage	%	49.2	18.8	31.8	0.1	0.0	100.0
	2008	kt CO_2e	96	55	58	0.1	0	209
	2008 Percentage	%	46.2	26.2	27.6	0.0	0.0	100.0
	Percentage change from BY	%	-57.6	-37.0	-60.8	-89.3	0.0	-54.8
SF_6	1995	kt CO_2e	1123.7	30.8	82.9	1.9	0.0	1239.3
	1995 Percentage	%	90.7	2.5	6.7	0.2	0.0	100.0
	2008	kt CO_2e	609.1	51.2	43.8	6.9	0.0	711.1
	2008 Percentage	%	85.7	7.2	6.2	1.0	0.0	100.0
	Percentage change from BY	%	-45.8	66.3	-47.1	260.8	0.0	-42.6
Total	BY	kt CO_2e	614408	68222	54952	24995	15244	777820
	1990 Percentage	%	79.0	8.8	7.1	3.2	2.0	100.0
	2008	kt CO_2e	484505	53707	49526	22186	16118	626041
	2008 Percentage	%	77.4	8.6	7.9	3.5	2.6	100.0
	Percentage change from BY	%	-21.1	-21.3	-9.9	-11.2	5.7	-19.5

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

Table ES2.1.1: GHG emissions for England ($MtCO_2$ e)

England	Mt CO_2 Equivalent													
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Change BY to 2008
Carbon	467.3	426.3	423.8	415.2	419.5	432.8	426.0	437.1	435.1	434.1	427.9	426.8	416.3	-10.9%
CH_4	79.0	68.0	58.1	54.2	50.6	46.0	43.8	38.8	37.2	36.0	35.2	33.9	33.7	-57.3%
HFCs	11.4	15.2	16.0	9.2	7.7	8.2	8.6	9.2	8.2	8.9	9.2	9.3	9.5	-37.7%
N_2O	51.6	40.5	40.7	30.4	30.0	27.7	26.5	26.1	27.0	26.0	24.7	24.7	24.3	-52.9%
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	-57.6%
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	-45.8%
Total Net Emissions	**611.1**	**551.4**	**539.9**	**510.4**	**509.7**	**516.1**	**506.5**	**512.5**	**508.7**	**506.2**	**497.9**	**495.5**	**484.5**	**-21.1%**
Net CO_2 emissions from LULUCF	5.7	5.2	4.2	4	4	3.9	3.6	3.7	3.4	3.2	3.1	3	3	
Net CH_4 emissions from LULUCF	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	

Table ES2.1.2: GHG emissions for England (MtC e)

England	Mt C Equivalent													
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Change BY to 2008
Carbon	127.4	116.3	115.6	113.2	114.4	118.0	116.2	119.2	118.7	118.4	116.7	116.4	113.5	-10.9%
CH_4	21.5	18.5	15.8	14.8	13.8	12.5	12.0	10.6	10.1	9.8	9.6	9.3	9.2	-57.3%
HFCs	3.1	4.2	4.4	2.5	2.1	2.2	2.3	2.5	2.2	2.4	2.5	2.5	2.6	-37.7%
N2O	14.1	11.0	11.1	8.3	8.2	7.6	7.2	7.1	7.4	7.1	6.7	6.7	6.6	-52.9%
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	-57.6%
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	-45.8%
Total Net Emissions	**166.7**	**150.4**	**147.3**	**139.2**	**139.0**	**140.8**	**138.1**	**139.8**	**138.7**	**138.0**	**135.8**	**135.1**	**132.1**	**-21.1%**
Net CO_2 emissions from LULUCF	1.6	1.4	1.2	1.1	1.1	1.1	1.0	1.0	0.9	0.9	0.9	0.8	0.8	
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	
Net N_2O emissions from LULUCF	0	0	0	0	0	0	0	0	0	0	0	0	0	

Table ES2.1.3: Aggregated emission trends per source category for England (Mt CO_2 e)

England	Aggregate Emission Trends by Source Category												
IPCC Source Category	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1. Energy	478.3	432.9	427.4	417.7	421.0	434.3	428.1	436.3	433.9	432.1	425.9	422.6	412.5
2. Industrial Processes	49.3	42.4	44.0	27.1	26.0	24.8	23.2	24.1	24.1	24.0	23.1	24.4	23.8
3. Solvent and other Product Use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Agriculture	35.4	33.3	32.8	32.7	31.4	28.9	29.2	28.6	28.9	28.7	27.7	27.4	27.5
5. LULUCF	5.7	5.2	4.2	4.0	4.0	3.9	3.6	3.7	3.4	3.2	3.2	3.1	3.0
6. Waste	42.4	37.6	31.5	28.9	27.3	24.2	22.3	19.8	18.4	18.1	18.1	18.0	17.7
Grand Total	**611.1**	**551.4**	**539.9**	**510.4**	**509.7**	**516.1**	**506.5**	**512.5**	**508.7**	**506.2**	**497.9**	**495.5**	**484.5**

[a] Solvents and other product use emissions occur as NMVOC and so do not appear in this table, which covers direct greenhouse gases only.

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

Table ES2. 2.1: GHG emissions for Scotland (Mt CO_2 e)

Scotland	Mt CO_2 Equivalent													
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Change BY to 2008
CO_2	50.6	49.5	49.8	46.7	49.4	49.4	46.2	46.6	44.4	43.6	47.2	43.6	42.1	-16.8%
CH_4	11.0	10.2	9.2	8.5	8.1	7.3	6.9	6.2	6.2	6.3	6.3	6.3	6.3	-43.1%
HFCs	0.0	0.1	0.4	0.4	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	0.9	610.2%
N_2O	6.4	5.7	5.5	5.3	5.2	5.1	5.1	5.0	4.9	4.7	4.7	4.5	4.3	-31.9%
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	-37.0%
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	66.3%
Total Net Emissions	**68.1**	**65.7**	**65.1**	**61.1**	**63.4**	**62.6**	**59.0**	**58.7**	**56.4**	**55.6**	**59.2**	**55.3**	**53.7**	**21.3%**
Net CO_2 emissions from LULUCF	-2.5	-3.6	-3.8	-3.9	-3.9	-4.0	-4.2	-4.2	-4.6	-4.6	-4.5	-4.4	-4.5	
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	
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	

Table ES2. 2.2: GHG emissions for Scotland (Mt C e)

Scotland	Mt C Equivalent													
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Change BY to 2008
CO_2	13.8	13.5	13.6	12.7	13.5	13.5	12.6	12.7	12.1	11.9	12.9	11.9	11.5	-16.8%
CH_4	3.0	2.8	2.5	2.3	2.2	2.0	1.9	1.7	1.7	1.7	1.7	1.7	1.7	-43.1%
HFCs	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	610.2%
N_2O	1.7	1.6	1.5	1.5	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.2	1.2	-31.9%
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	-37.0%
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	66.3%
Total Net Emissions	**18.6**	**17.9**	**17.7**	**16.7**	**17.3**	**17.1**	**16.1**	**16.0**	**15.4**	**15.2**	**16.1**	**15.1**	**14.6**	**21.3%**
Net CO_2 emissions from LULUCF	-0.7	-1.0	-1.0	-1.1	-1.1	-1.1	-1.1	-1.1	-1.3	-1.3	-1.2	-1.2	-1.2	
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	
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	

Table ES2.2.3: Aggregated emission trends per source category for Scotland (Mt CO_2 e)

Scotland	Aggregate Emission Trends by Source Category												
IPCC Source Category	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1. Energy	54.3	54.7	54.9	51.6	54.3	54.4	51.0	51.1	49.3	48.6	52.1	48.4	46.9
2. Industrial Processes	1.7	0.9	1.3	1.3	1.4	1.4	1.5	1.6	1.7	1.6	1.7	1.7	1.7
3. Solvent and other Product Use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Agriculture	8.8	8.5	8.4	8.1	7.9	7.6	7.7	7.6	7.5	7.4	7.2	7.0	6.8
5. LULUCF	-2.5	-3.6	-3.8	-3.9	-3.9	-4.0	-4.1	-4.2	-4.6	-4.6	-4.5	-4.4	-4.5
6. Waste	5.8	5.1	4.3	4.0	3.7	3.1	2.9	2.6	2.5	2.5	2.6	2.6	2.8
Grand Total	**68.1**	**65.7**	**65.1**	**61.1**	**63.4**	**62.6**	**59.0**	**58.7**	**56.4**	**55.6**	**59.2**	**55.3**	**53.7**

[a] Solvents and other product use emissions occur as NMVOC and so do not appear in this table, which covers direct greenhouse gases only.

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

Table ES2.3.1: GHG emissions for Wales (Mt CO_2 e)

Wales	Mt CO_2 Equivalent													
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Change BY to 2008
CO_2	43.1	40.6	42.8	44.1	46.3	43.7	37.3	38.6	42.2	40.8	42.2	39.4	42.0	-2.6%
CH_4	7.9	6.8	6.2	6.0	5.7	5.2	5.1	4.8	4.8	4.9	4.8	4.6	4.4	-44.5%
HFCs	0.0	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	598.0%
N_2O	3.6	3.6	3.7	3.6	3.4	3.3	3.1	3.1	3.1	3.2	2.9	2.8	2.6	-28.9%
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	-60.8%
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	-47.1%
Total Net Emissions	**55.0**	**51.3**	**53.1**	**54.1**	**55.9**	**52.7**	**46.0**	**47.0**	**50.6**	**49.4**	**50.5**	**47.3**	**49.5**	**-9.9%**
Net CO_2 emissions from LULUCF	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	
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	
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	

Table ES2.3.2: GHG emissions for Wales (Mt C e)

Wales	Mt C Equivalent													
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Change BY to 2008
CO_2	11.8	11.1	11.7	12.0	12.6	11.9	10.2	10.5	11.5	11.1	11.5	10.8	11.5	-2.6%
CH_4	2.1	1.9	1.7	1.6	1.6	1.4	1.4	1.3	1.3	1.3	1.3	1.2	1.2	-44.5%
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	598.0%
N_2O	1.0	1.0	1.0	1.0	0.9	0.9	0.8	0.9	0.8	0.9	0.8	0.8	0.7	-28.9%
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	-60.8%
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	-47.1%
Total Net Emissions	**15.0**	**14.0**	**14.5**	**14.8**	**15.2**	**14.4**	**12.5**	**12.8**	**13.8**	**13.5**	**13.8**	**12.9**	**13.5**	**-9.9%**
Net CO_2 emissions from LULUCF	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	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	
Net N2O 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	

Table ES2.3.3: Aggregated emission trends per source category for Wales (Mt CO_2 e)

Wales	Aggregate Emission Trends by Source Category												
IPCC Source Category	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1. Energy	44.1	40.6	42.4	43.6	45.8	43.6	37.5	38.3	41.8	40.5	41.8	38.7	41.2
2. Industrial Processes	2.2	2.2	2.4	2.4	2.5	2.0	1.7	2.1	2.2	2.2	2.3	2.5	2.5
3. Solvent and other Product Use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Agriculture	6.1	6.1	6.2	6.2	5.8	5.6	5.4	5.5	5.4	5.5	5.2	5.0	4.7
5. LULUCF	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
6. Waste	2.9	2.6	2.2	2.0	1.9	1.7	1.5	1.4	1.4	1.4	1.3	1.3	1.3
Grand Total	**55.0**	**51.3**	**53.1**	**54.1**	**55.9**	**52.7**	**46.0**	**47.0**	**50.6**	**49.4**	**50.5**	**47.3**	**49.5**

[a] Solvents and other product use emissions occur as NMVOC and so do not appear in this table, which covers direct greenhouse gases only.

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

Table ES2.4.1: GHG emissions for Northern Ireland (Mt CO_2 e)

Northern Ireland	Mt CO_2 Equivalent													
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Change BY to 2008
CO_2	17.3	17.2	16.5	16.7	16.5	16.9	15.3	15.4	15.5	16.6	17.2	16.2	16.2	-6.7%
CH_4	4.4	4.1	4.0	3.8	3.6	3.5	3.4	3.3	3.3	3.3	3.3	3.4	3.3	-23.8%
HFCs	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	650.2%
N_2O	3.2	3.4	3.5	3.5	3.3	3.3	2.8	2.8	2.7	2.6	2.6	2.4	2.4	-26.8%
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	-89.3%
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	260.8%
Total Net Emissions	**25.0**	**24.7**	**24.1**	**24.1**	**23.6**	**23.9**	**21.8**	**21.7**	**21.7**	**22.8**	**23.3**	**22.3**	**22.2**	**-11.24%**
Net CO_2 emissions from LULUCF	0.0	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-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	
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	

Table ES2.4.2: GHG emissions for Northern Ireland (Mt C e)

Northern Ireland	Mt C Equivalent													
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Change BY to 2008
CO_2	4.7	4.7	4.5	4.5	4.5	4.6	4.2	4.2	4.2	4.5	4.7	4.4	4.4	-6.7%
CH_4	1.2	1.1	1.1	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	-23.8%
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	650.2%
N_2O	0.9	0.9	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.6	-26.8%
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	-89.3%
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	260.8%
Total Net Emissions	**6.8**	**6.7**	**6.6**	**6.6**	**6.4**	**6.5**	**5.9**	**5.9**	**5.9**	**6.2**	**6.4**	**6.1**	**6.1**	**-11.24%**
Net CO_2 emissions from LULUCF	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	
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	
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	

Table ES2.4.3: Aggregated emission trends per source category for Northern Ireland (Mt CO_2 e)

Northern Ireland	Aggregated Emission Trends by Source Sector												
IPCC Source Category	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1. Energy	17.5	17.3	16.6	16.8	16.9	17.3	15.7	15.7	15.8	16.7	17.2	16.2	16.2
2. Industrial Processes	0.8	0.9	1.0	1.1	0.9	0.9	0.5	0.5	0.5	0.7	0.8	0.8	0.7
3. Solvent and other Product Use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Agriculture	5.0	5.2	5.5	5.3	5.0	5.0	5.1	5.0	4.9	4.9	4.8	4.7	4.6
5. LULUCF	0.0	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
6. Waste	1.7	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.8	0.8	0.8	0.9
Grand Total	**25.0**	**24.7**	**24.1**	**24.1**	**23.6**	**23.9**	**21.8**	**21.7**	**21.7**	**22.8**	**23.3**	**22.3**	**22.2**

[a] Solvents and other product use emissions occur as NMVOC and so do not appear in this table, which covers direct greenhouse gases only

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

Table ES2.5.1: Unallocated GHG emissions (Mt CO_2 e)

Unallocated	Mt CO_2 Equivalent													
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Change BY to 2008
CO_2	13.2	18.0	18.9	18.7	17.8	18.5	18.8	17.9	17.9	17.5	15.7	16.2	15.0	13.6%
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	-52.2%
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	
N_2O	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	21.4%
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	
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	
Total Net Emissions	**15.2**	**20.1**	**20.9**	**20.5**	**19.5**	**20.1**	**20.4**	**19.4**	**19.4**	**18.7**	**16.8**	**17.5**	**16.1**	**5.73%**
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	
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	
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	

Table ES2.5.2: Unallocated GHG emissions (MtC e)

Unallocated	Mt C Equivalent													
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Change BY to 2008
CO_2	3.6	4.9	5.2	5.1	4.9	5.0	5.1	4.9	4.9	4.8	4.3	4.4	4.1	13.6%
CH4	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	-52.2%
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	
N2O	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	21.4%
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	
SF6_C_equiv	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	**4.2**	**5.5**	**5.7**	**5.6**	**5.3**	**5.5**	**5.6**	**5.3**	**5.3**	**5.1**	**4.6**	**4.8**	**4.4**	**5.73%**
Net CO2 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	
Net CH4 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	
Net N2O 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	

Table ES2.5.3 Emission trends per source category for unallocated emissions (Mt CO_2 e)

Unallocated	Aggregate Emission Trends by Source Category												
IPCC Source Category	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1. Energy	15.2	20.1	20.9	20.5	19.5	20.1	20.4	19.4	19.4	18.7	16.8	17.5	16.1
2. Industrial Processes	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. Solvent and other Product Use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5. LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6. Waste	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
Grand Total	**15.2**	**20.1**		**20.5**	**19.5**	**20.1**	**20.4**	**19.4**	**19.4**	**18.7**	**16.8**	**17.5**	**16.1**

[a] Solvents and other product use emissions occur as NMVOC and so do not appear in this table, which covers direct greenhouse gases only.

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). North Wyke Research (NWRes) provide the estimates of agricultural emissions under a separate contract to the Department for Environment, Food and Rural Affairs.

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Table of Contents

1 Introduction 1

1.1 Background to Inventory Development for the Devolved Administrations 1
1.2 The UK Climate Change Act and Country-Specific Climate Change Programmes 2
1.3 DA GHG Inventories Improvement Programme 5
1.4 Global Warming Potential 6
1.5 Report Structure 6
1.6 Revisions and Updates to the Greenhouse Gas Inventories 7

2 Emissions in England 8

2.1 Summary of GHG Emission Sources 8
2.2 Energy 8
2.3 Industrial Processes 12
2.4 Agriculture 13
2.5 Land Use, Land Use Change and Forestry 14
2.6 Waste 16
2.7 Emission Maps: England 2008 18

3 Emissions in Scotland 22

3.1 Summary of GHG Emission Sources 22
3.2 Energy 23
3.3 Industrial Processes 26
3.4 Agriculture 26
3.5 Land Use, Land Use Change and Forestry 28
3.6 Waste 30
3.7 Emission Maps: Scotland 2008 31

4 Emissions in Wales 35

4.1 Summary of GHG Emission Sources 35
4.2 Energy 35
4.3 Industrial Processes 38
4.4 Agriculture 39
4.5 Land Use, Land Use Change and Forestry 40
4.6 Waste 43
4.7 Emission Maps: Wales 2008 43

5 Emissions in Northern Ireland 47

5.1 Summary of GHG Emission Sources 47
5.2 Energy 47
5.3 Industrial Processes 50
5.4 Agriculture 51

5.5 Land Use, Land Use Change and Forestry 52
5.6 Waste 55
5.7 Emission Maps: Northern Ireland 2008 56
6 Unallocated Emissions 60
7 Data Availability, Recalculations and the Inventory Improvement Programme 61
7.1 Data Available for DA GHG Inventory Compilation 61
7.2 Inventory Recalculations 64
7.3 Inventory Improvement Programme 78
8 Traded and Non-Traded DA GHG Emissions 84
8.1 Background 84
8.2 Traded and Non-traded Inventory Estimates: Data Quality and Reporting Format Issues 84
9 Uncertainty in the Inventories 93
10 End User GHG Inventories for the Devolved Administrations 96
10.1 Introduction 96
10.2 End User Methodology 96
10.3 Revisions to End User Inventory Source Data and Methodology 98
10.4 Uncertainties and Limitations of the DA End User Emission Estimates 99
10.5 Results and Discussion 99
11 Summary Graphs 120
12 References 127
13 Acknowledgements 134

Appendices

Appendix 1 DA GHG Inventory Estimation Methodology
Appendix 2 Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland, 1990-2008, presented in Common Reporting Format
Appendix 3 International Aviation and Shipping Estimates for England, Scotland, Wales and Northern Ireland, 1990-2008
Appendix 4 Analysis of the Traded Share of Emissions in England, Scotland, Wales and Northern Ireland in 2008
Appendix 5 End User GHG Emission Estimates for England, Scotland, Wales and Northern Ireland: 1990, 2003 to 2008

Tables & Figures

Table ES1 Summary of Greenhouse Gas Emission Trends for UK and Constituent Countries (expressed as GWP-weighted equivalent mass of carbon)
Table ES2.1.1 England Emissions By Gas 1990-2008 (Mt CO_2 equivalent)
Table ES2.1.2 England Emissions By Gas 1990-2008 (Mt C equivalent)
Table ES2.1.3 England Aggregated Emission Trends By Source Category 1990-2008 (Mt CO_2 equivalent)
Table ES2.2.1 Scotland Emissions By Gas 1990-2008 (Mt CO_2 equivalent)
Table ES2.2.2 Scotland Emissions By Gas 1990-2008 (Mt C equivalent)
Table ES2.2.3 Scotland Aggregated Emission Trends By Source Category 1990-2008 (Mt CO_2 equivalent)
Table ES2.3.1 Wales Emissions By Gas 1990-2008 (Mt CO_2 equivalent)
Table ES2.3.2 Wales Emissions By Gas 1990-2008 (Mt C equivalent)
Table ES2.3.3 Wales Aggregated Emission Trends By Source Category 1990-2008 (Mt CO_2 equivalent)
Table ES2.4.1 Northern Ireland Emissions By Gas 1990-2008 (Mt CO_2 equivalent)
Table ES2.4.2 Northern Ireland Emissions By Gas 1990-2008 (Mt C equivalent)
Table ES2.4.3 Northern Ireland Aggregated Emission Trends By Source Category 1990-2008 (Mt CO_2 equivalent)
Table ES2.5.1 Unallocated Emissions By Gas 1990-2008 (Mt CO_2 equivalent)
Table ES2.5.2 Unallocated Emissions By Gas 1990-2008 (Mt C equivalent)
Table ES2.5.3 Unallocated Aggregated Emission Trends By Source Category 1990-2007 (Mt CO_2 equivalent)

Table 1.1 Global Warming Potential of Greenhouse Gases on a 100-year Horizon (t CO_2 equiv/ t gas)..... 6
Table 2.1 Emissions Summary for England, 2008 (kt CO_2e) 8
Table 2.2 Livestock Emissions of Methane in England by Source in 2008 (kt CH_4) 13
Table 2.3 Emissions of Nitrous Oxide from Agriculture in England by Source in 2008 (kt N_2O)..... 14
Table 2.4 Difference in 2007 LULUCF net Emissions between the 2007 and 2008 Inventories in England 15
Table 2.5 Land Use Transition Matrix, ha, for England in 1990-1991 15
Table 2.6 Land Use Transition Matrix, ha, for England in 2007-2008 15
Table 2.7 Greenhouse Gas Emissions and Removals from KP-LULUCF Activities in England, 2008 16
Table 3.1 Emissions Summary for Scotland, 2008 (kt CO_2e)..... 22
Table 3.2 Livestock Emissions of Methane in Scotland by source in 2008 (kt CH_4)..... 27
Table 3.3 Emissions of Nitrous Oxide from Agriculture in Scotland by Source in 2008 (kt N_2O).... 27
Table 3.4 Difference in 2007 LULUCF net Emission between the 2007 and 2008 Inventories in Scotland..... 29
Table 3.5 Land Use Transition Matrix, ha, for Scotland in 1990-1991 29
Table 3.6 Land Use Transition Matrix, ha, for Scotland in 2007-2008 29
Table 3.7 Greenhouse Gas Emissions and Removals from KP-LULUCF Activities in Scotland, 2008..... 30
Table 4.1 Emissions Summary for Wales, 2008 (kt CO_2e)..... 35
Table 4.2 Livestock Emissions of Methane in Wales by Source in 2008 (kt CH_4) 40
Table 4.3 Emissions of Nitrous Oxide from Agriculture in Wales by Source in 2008 (kt N_2O)..... 40
Table 4.4 Land Use Transition Matrix, ha, for Wales in 1990-1991 41
Table 4.5 Land Use Transition Matrix, ha, for Wales in 2007-2008 42
Table 4.6 Greenhouse Gas Emissions and Removals from KP-LULUCF Activities in Wales, 2008 42
Table 5.1 Emissions Summary for Northern Ireland, 2008 (kt CO_2e)..... 47
Table 5.2 Livestock Emissions of Methane in Northern Ireland by Source in 2008 (kt CH_4) 52
Table 5.3 Emissions of Nitrous Oxide from Agriculture in Northern Ireland by Source in 2008 (kt N_2O)..... 52
Table 5.4 Land Use Transition Matrix, ha, for Northern Ireland in 1990-1991 53
Table 5.5 Land Use Transition Matrix, ha, for Northern Ireland in 2007-2008 54
Table 5.6 Greenhouse Gas Emissions and Removals from KP-LULUCF Activities in Northern Ireland, 2008..... 54

Table 7.1 Summary of the impact of recalculations by gas (2008 inventory estimate - 2007 inventory estimate, as kt CO_2e) 65
Table 7.2 Reasons for changes at UK level 67
Table 7.3 Reasons for changes - England 69
Table 7.4 Reasons for changes – Scotland 72
Table 7.5 Reasons for changes – Wales 74
Table 7.6 Reasons for changes – Northern Ireland 76
Table 8.1 Overall DA Traded and Non-Traded Emission Estimates, 2008 86
Table 8.2 IPCC Sector 1A1a: Power Generation, 2008 87
Table 8.3 IPCC Sector 1A1b: Petroleum Refineries, 2008 88
Table 8.4 IPCC Sector 1A1c (coke) / 1A2a / 2A3 (BOS, Sinter) / 2C1: Iron & Steel, 2008 88
Table 8.5 IPCC Sector 1A1c / 1B2c flaring and venting: Oil and Gas, 2008 89
Table 8.6 IPCC Sector 1A2f_cement and 2A1: Cement (combustion and process emissions), 2008 89
Table 8.7 Inventory Sector 1A2f: Other Industry Combustion (excluding cement and lime), 2008. 90
Table 8.8 UK-wide estimates of “1A2f” into more detailed IPCC categories, 2008 90
Table 8.9 DA Traded Emissions in 1A2b to 1A2f IPCC Categories, 2008 90
Table 8.10 IPCC Sector 1A4a: Public Sector and Commercial Emissions, 2008 91
Table 8.11 IPCC Sector 2: Industrial Process Emissions (excluding cement and iron & steel), 2008 92
Table 9.1 Estimated Uncertainties in the DA GHG Inventories: Base Years, 2008 and Trend 94
Table 10.1 Summary of Assumptions used for Electricity Use and Exports 97
Table 10.2 Share of DA GHG Emissions by End User and by Source, 2008 100
Table 10.3 Estimated Trends in the End User DA GHG Inventories from the Base Year to 2008, by Gas 101
Table 10.4 England End User GHG Inventories: 1990, 2003 to 2008 (Mt CO2-e) 103
Table 10.5 Emission Trends by Sector in the England End User GHG Inventories 104
Table 10.6 Scotland End User GHG Inventories: 1990, 2003 to 2008 (Mt CO_2e) 106
Table 10.7 Emission Trends by Sector in the Scotland End User GHG Inventories 107
Table 10.8 Wales End User GHG Inventories: 1990, 2003 to 2008 (Mt CO_2e) 109
Table 10.9 Emission Trends by Sector in the Wales End User GHG Inventories 110
Table 10.10 Northern Ireland End User GHG Inventories: 1990, 2003 to 2008 (Mt CO_2e) 112
Table 10.11 Emission Trends by Sector in the Northern Ireland End User GHG Inventories 113
Table 10.12 Business Sector DA End User Emissions: 1990, 2003-2008 115
Table 10.13 Residential Sector DA End User Emissions: 1990, 2003-2008 116
Table 10.14 Public Sector DA End User Emissions: 1990, 2003-2008 117
Table 10.15 Transport DA End User Emissions: 1990, 2003-2008 118

Figure 1.1 Greenhouse Gas Emission Reduction Targets: UK, Scotland, Wales and Northern Ireland 3
Figure 2.1 Power Generation by Fuel and Cumulative GHG Emissions: England 10
Figure 2.2 Total Road Traffic Vehicle km and GHG emissions from Different Vehicle Types: England, 1990 - 2008 11
Figure 2.3 LULUCF Inventory Emissions and Removals by Category in England, 1990-2008 ... 14
Figure 2.4 Map of Emissions of Carbon Dioxide (t) in England in 2008 19
Figure 2.5 Map of Emissions of CH_4 (t CO_2 e) in England in 2008 20
Figure 2.6 Map of Emissions of N_2O (t CO_2 e) in England in 2008 21
Figure 3.1 Power Generation by Fuel and Cumulative GHG Emissions: Scotland 24
Figure 3.2 Total Road Traffic Vehicle km and GHG emissions from Different Vehicle Types: Scotland, 1990 - 2008 25
Figure 3.3 LULUCF Inventory Emissions and Removals by Category in Scotland, 1990 to 2008 28
Figure 3.4 Map of Emissions of CO_2 (t) in Scotland in 2008 32
Figure 3.5 Map of Emissions of CH_4 (t CO_2 e) in Scotland in 2008 33
Figure 3.6 Map of Emissions of N_2O (t CO_2 e) in Scotland in 2008 34
Figure 4.1 Power Generation by Fuel and Cumulative GHG Emissions: Wales 37
Figure 4.2 Total Road Traffic Vehicle km and GHG emissions from Different Vehicle Types: Wales, 1990 – 2008 38
Figure 4.3 LULUCF Inventory Emissions and Removals by Category in Wales, 1990 to 2008 ... 41
Figure 4.4 Map of Emissions of Carbon Dioxide (tonnes) in Wales in 2008 44
Figure 4.5 Map of Emissions of Methane (tonnes CO2 equivalent) in Wales in 2008 45
Figure 4.6 Map of Emissions of Nitrous Oxide (tonnes CO2 equivalent) in Wales in 2008 46

Figure 5.1 Power Generation by Fuel and Cumulative GHG Emissions: Northern Ireland 49
Figure 5.2 Total Road Traffic Vehicle km and GHG emissions from Different Vehicle Types: Northern Ireland, 1990 – 2008 50
Figure 5.3 LULUCF Inventory Emissions and Removals by Category in Northern Ireland, 1990 to 2008 53
Figure 5.4 Map of Emissions of Carbon Dioxide (tonnes) in Northern Ireland in 2008 57
Figure 5.5 Map of Emissions of Methane (tonnes CO_2 equivalent) in Northern Ireland in 2008 .. 58
Figure 5.6 Map of Emissions of Nitrous Oxide (tonnes CO_2 equivalent) in Northern Ireland in 2008 59
Figure 10.1 England End User GHG Emissions by National Communication Category: 1990, 2003-2008 (Mt CO_2-e) 105
Figure 10.2 Scotland End User GHG Emissions by National Communication Category: 1990, 2003-2008 (Mt CO_2-e) 108
Figure 10.3 Wales End User GHG Emissions by National Communication Category: 1990, 2003-2008 (Mt CO_2e) 111
Figure 10.4 Northern Ireland End User GHG Emissions by National Communication Category: 1990, 2003-2008 (Mt CO_2e) 114
Figure 11.1 Graphs of Carbon Dioxide Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2008 (kt CO_2) 121
Figure 11.2 Graphs of Methane Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2008 (kt CO_2 e) 122
Figure 11.3 Graphs of Nitrous Oxide Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2008 (kt CO_2 e) 123
Figure 11.4 Graphs of HFC Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2008 (kt CO_2 e) 124
Figure 11.5 Graphs of PFC Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2008 (kt CO_2 e) 125
Figure 11.6 Graphs of SF_6 Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2008 (kt CO_2 e) 126

Document Revision History	
Version	Comment
Draft for comment	Report and tables of emissions issued for comment to the DAs.
Issue 1	Incorporating comments from the DAs.

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 greenhouse gas 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 UNFCC 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 greenhouse gas emissions. Under the protocol, the UK is legally bound to reduce emissions of the 'basket of 6' greenhouse gases 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 Inventory and associated annual 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 greenhouse gas 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 has either developed or is in the process of developing national climate change legislation or strategies establishing targets for reductions in emissions of 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 devolved administrations are discussed in Section 1.5.

In 1999, Defra and the Devolved Administrations (DAs) recognised the future need to quantify GHG emissions from each of the four countries that comprise the UK, and agreed to undertake a joint research project to provide the first estimates of GHG emissions from England, Scotland, Wales and Northern Ireland. The resulting study: *'Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 and 1995: A Scoping Study'*[6] was published in 1999 and formed the framework for the development of the Devolved Administration (DA) Inventories from 1998 to the present.

This report updates and revises the earlier studies and presents separate GHG Inventories for England, Scotland, Wales and Northern Ireland for the years 1990, 1995, and 1998 to 2008. Emissions of the six direct greenhouse gases are reported, namely:

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

[6] Salway et al. (1999)

These inventories are reported using Intergovernmental Panel on Climate Change (IPCC) sectoral tables, which are a subset of the IPCC Common Reporting Format (CRF) and consistent with the UK greenhouse gas inventory (MacCarthy *et al.*, 2010). The latest inventory was submitted to the UNFCCC in April 2010. This report follows the convention used in MacCarthy *et al.*, 2010 of reporting carbon dioxide emissions and removals as net totals.

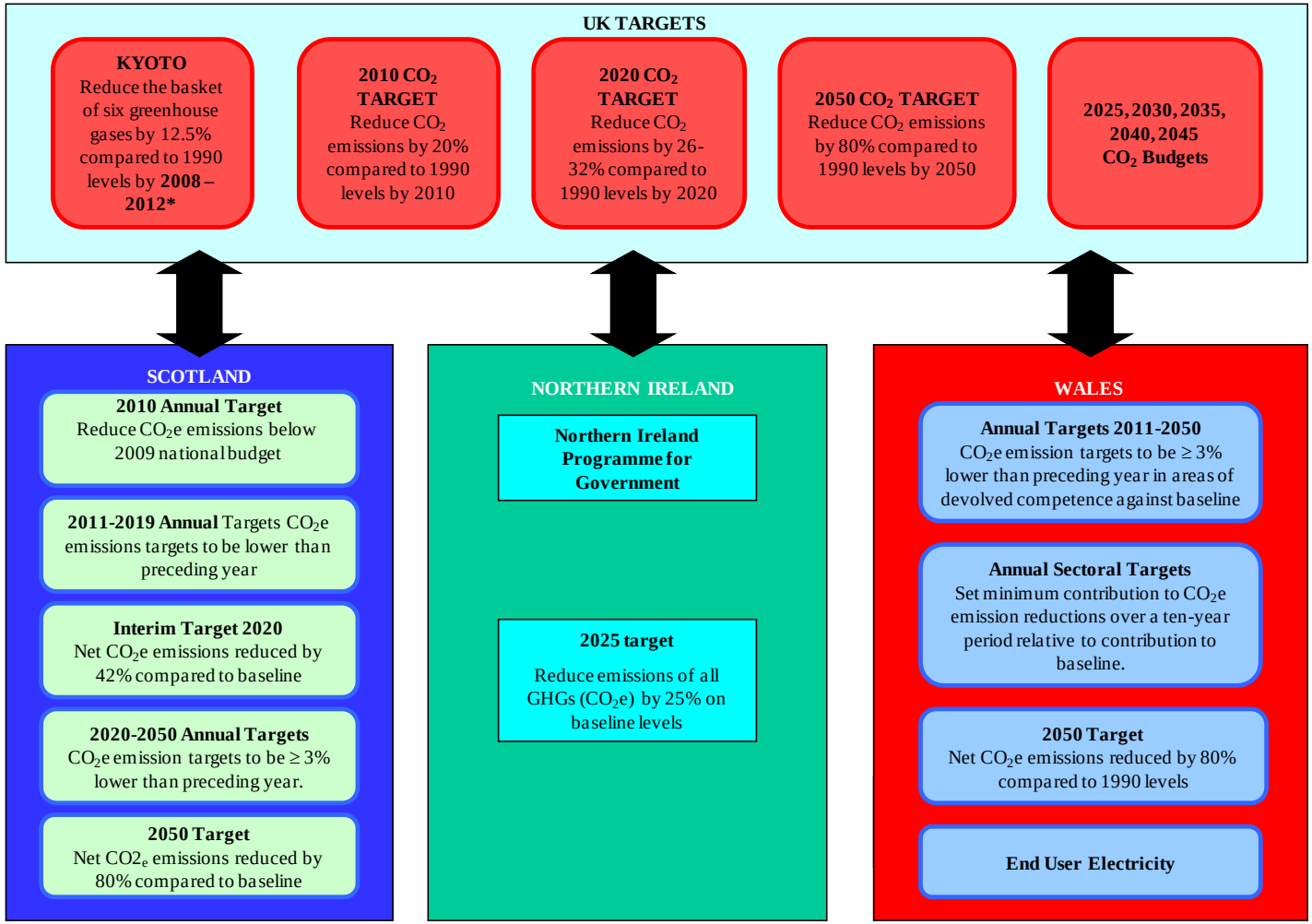
Where emissions cannot be allocated to a specific country, they are reported in a table for unallocated emissions; unallocated emissions presented in the DA inventories are limited to offshore emissions from the oil and gas exploration and production industry.

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

The Government's 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 greenhouse gases in the UK by 80 % against the baseline by 2050 with a minimum 26% reduction 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. The UK Climate Change 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.

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



These new national targets for 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 Assembly 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.

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 greenhouse gas 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 from the outset.

An interim reduction target of at least 42% reduction to be achieved by 2020 has now 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. The first batch of targets for the period 2010-2022 are still to be agreed by the Scottish Parliament. 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'[7], established targets for reductions in GHG emissions from Wales, targeting a 3% annual reduction in Carbon equivalent emissions in all areas of devolved competence by 2011 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 Wales Climate Change Strategy, 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. Further commitments were made to work with heavy industry and power generation sectors to promote reductions in emissions of GHGs from these sectors and to report CO_2e emissions from electricity consumption across Wales using a carbon intensiveness factor[8].

As outlined in the Climate Change Strategy High Level Policy Statement, released for consultation in January 2009, the Welsh Assembly 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.

[7] The 'One Wales: A Progressive Agenda for the Government of Wales (2007)
[8] Wales Climate Change Strategy

1.2.3 Northern Ireland

The Northern Ireland Executive's Programme for Government 2008-2011 commits Northern Ireland to a 25% reduction in greenhouse gas 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.

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 Devolved Administrations, 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 greenhouse gas 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 2009 to improve GHG emission estimates at UK and DA level. Source sectors that may be focused upon for future data and method improvements at DA-level include:

- Residential fuel use
- Oil and Gas Sectors
- Industry, 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 presented in this report.

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 in the UK and DA GHG inventories. The Scottish Government, Welsh Assembly 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.

Following expansion to the scope of the EUETS in 2008, which is the first year of Phase II of the scheme, the analysis of the EUETS emissions data and fuel use data has been repeated to assess the traded and non-traded emission estimates for each of the constituent countries in 2008. 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 greenhouse gas 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 greenhouse gases. 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 CO_2. 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 greenhouse gas emissions.

Table 1.1 Global Warming Potential of Greenhouse Gases 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 greenhouse gas emissions data for the years 1990, 1995, and 1998 to 2008. 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. New 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 Devolved Administration GHG emission estimates for each source, and how the Devolved Administration inventories relate to the UK Greenhouse Gas Inventory.

Appendix 2: This appendix provides IPCC sectoral tables for 1990 and 2008 for England, Scotland, Wales and Northern Ireland. Summary tables (IPCC Sectoral Table 7A) are provided for 1995 to 2008 for England, Scotland, Wales and Northern Ireland. UK summary tables are also reported. Table 3 of the sectoral tables are omitted because this table is only used to report Volatile Organic Compounds (VOCs), which are not relevant to this study. In IPCC tables, emissions are reported in Gigagrammes (Gg).[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 2008.

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**.

1.6 Revisions and Updates to the Greenhouse Gas Inventories

Each year, the greenhouse gas 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.

[9] One Gigagramme (Gg) equals one thousand tonnes, or one kilotonne (kt)

2 Emissions in England

2.1 Summary of GHG Emission Sources

The main GHG emission sources for England in 2008 are summarised in Table 2.1 below, expressed as a percentage of the total English GHG emissions in 2008 of 484.5 Mt CO_2-equivalent. Trends in English GHG emissions since the base years of 1990 (for CO_2, CH_4 and N_2O) and 1995 (for fluorinated gases) are as follows:

- CO_2 emissions have reduced by 10.9%
- CH_4 emissions have reduced by 57.3%
- N_2O emissions have reduced by 52.9%
- HFC emissions have reduced by 37.7%
- PFC emissions have reduced by 57.6%
- SF_6 emissions have reduced by 45.8%
- Total GHG emissions (as CO_2-equivalents) have reduced by 21.1%

The largest emissions source is CO_2 from power stations, which accounted for 29% of total English greenhouse gas emissions in 2008. The largest methane source is from waste landfill emissions, and the largest source of N_2O emissions is agricultural soils. Together, the ten categories below account for 88% of the total 2008 English GHG emissions.

Table 2.1 Emissions Summary for England, 2008 (kt CO_2e)

Summary of Main Emission Sources, England 2008 (kt CO_2e)				
Rank	Sector Name	IPCC code	Emission	Percentage of total GWP Weighted Emissions
1	Power stations	1A1a	139943	28.9
2	Road Transport	1A3b	97373	20.1
3	Residential Combustion	1A4b	64004	13.2
4	Other Industrial Combustion	1A2f	48037	9.9
5	Commercial and Institutional Combustion	1A4a	18720	3.9
6	Landfill	6A1	15629	3.2
7	Agricultural Soils	4D	15958	3.3
8	Iron and Steel	1A2a	11943	2.5
9	Refineries	1A1b	10251	2.1
10	Enteric fermentation - Cattle	4A1	6607	1.4

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 IPCC 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

The energy sector includes all emissions from fuel combustion sources (IPPC Sector 1A), as well as fugitive emissions from energy industries (IPPC Sector 1B). In England, the energy sector contributes 85% to total GHG emissions. 97% of energy sector emissions are CO_2, accounting for 96% of CO_2

emissions from England in 2008. Energy Industries (IPCC Sector 1A1) represent the largest source of CO_2 in England, contributing 36.5% of the total CO_2 for the country in 2008, down 3.5% on the England total of CO_2 emissions in 1990. The energy sector includes power generation, refineries, solid fuel transformation processes and the oil and gas industry.

Power generation in England contributed 33.4% of the total English CO_2 emission in 2008, which is slightly higher than the UK proportion of 32.5%. The mix of generation capacity in England (see Figure 2.1 below) differs from the other devolved administrations 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[10]. 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.

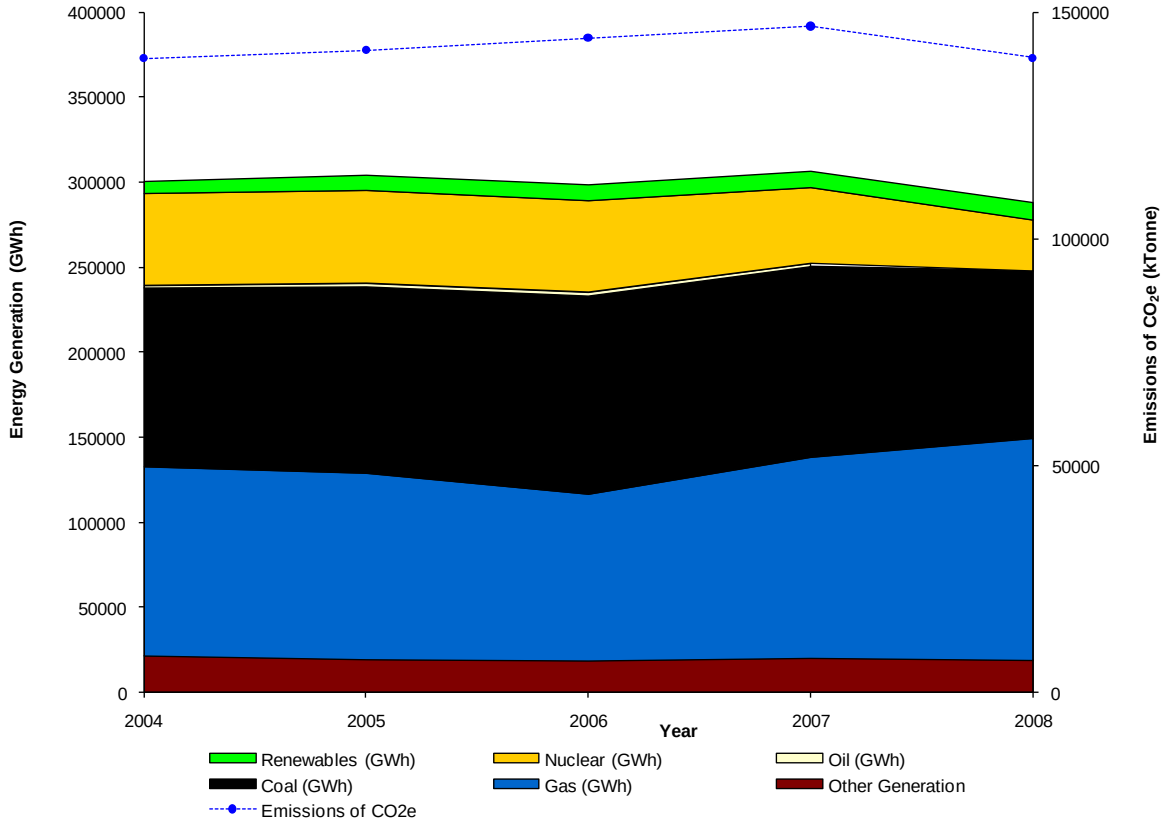
[*The England GHG "end user" emission estimates presented in Chapter 10 re-allocate the emissions from power stations where electricity is generated in Wales and Scotland and then imported to be consumed in England.*]

GHG emissions from power generation in England showed a gradual increase year-on-year from 1999-2007 but have decreased by 4.8% between 2007 and 2008. Gas and coal represent the principal sources of power generation, with nuclear energy contributing around 10% of power generation in England in 2008.

Overall, emissions of CO_2 from Energy Industries (Sector 1A1) in England have decreased by 18.6% since 1990, significantly more than across the whole of the UK where only a 13.3% reduction has occurred over the period 1990-2008. 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 increased 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.

[10] For details of regional electricity generation data, see the DECC Energy Trends publication from December 2009, article from page 16.

Figure 2.1 Power Generation by Fuel and Cumulative GHG Emissions: England

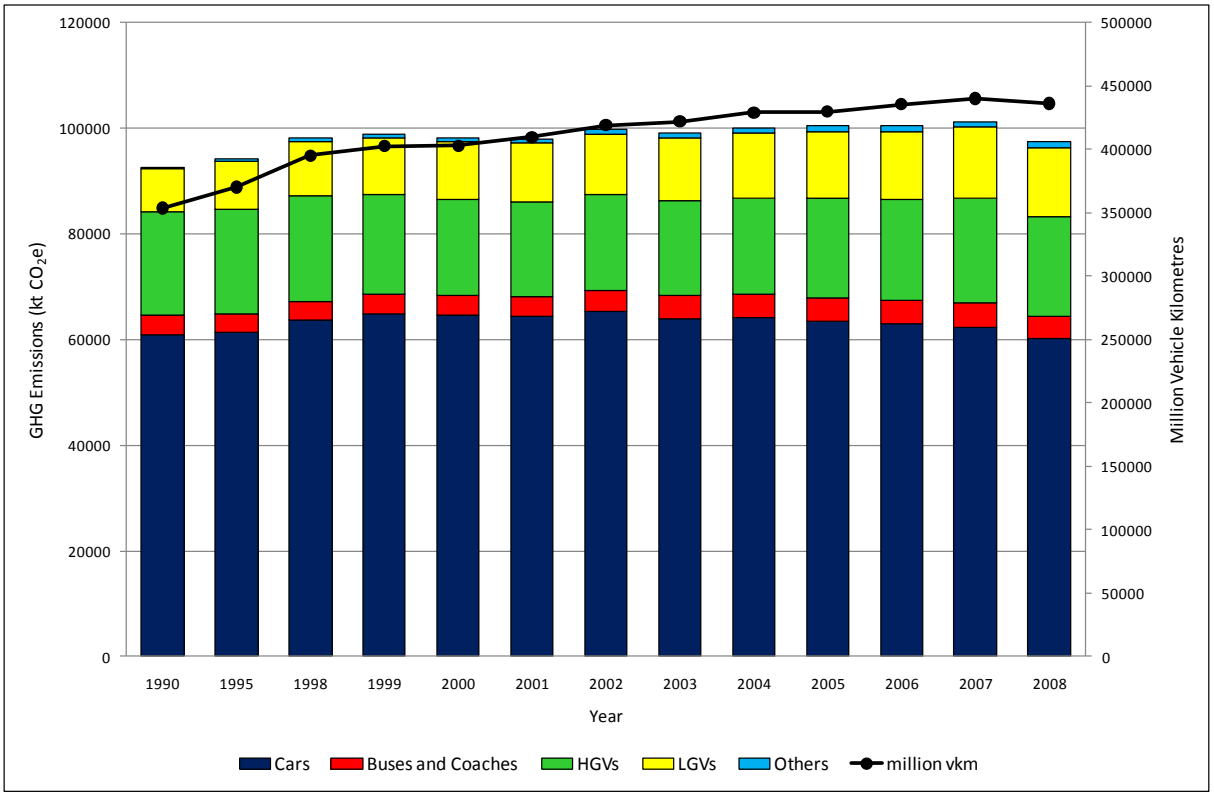


Petroleum refining emissions have declined by 13.7% since 1990, and constitute 2.4% of CO_2 emissions in England in 2008, lower than the UK mean contribution of 2.9% of total CO_2 emissions from refineries in 2008. Other energy emissions are relatively small and are mostly from gas consumption at oil and gas terminals, gas separation plant, coking and solid fuel production. Other energy industry emissions in England have increased by 8.9% from 1990 to 2008. 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".

Road Transport represents the second largest single source of CO_2 in England behind power generation, contributing 23.2% to the English total CO_2 emission. The contribution of English road transport to UK road transport CO_2 emissions is 82.5%, which is slightly less than that which would be anticipated from England's population (83.8% of UK[11]). Emissions from the road transport sector in England have risen by 5.7% from 1990 to 2008 compared with a 7.0% rise for the UK as a whole. Emissions from the sector are dominated by emissions from cars that constitute approximately 62% of emissions in 2008. Heavy goods vehicles represent the second most significant source of CO_2.

[11] Where population percentages are quoted throughout this report, they are taken from ONS data for 2008.

Figure 2.2 Total Road Traffic Vehicle km and GHG emissions from Different Vehicle Types: England, 1990 - 2008



Combustion emissions from the Manufacturing Industry and Construction sector (IPCC Sector 1A2) account for 14.1% of the English CO_2 total, with the iron and steel industry in England accounting for 65.3% of the combustion emissions from UK Iron and Steel production. The 'Other industry' category (IPCC sector 1A2f) for England contributes 82.1% towards the UK 'Other industry' CO_2 total.

Other combustion emissions arise from the domestic (residential), commercial, public sectors and agriculture stationary combustion (IPCC Sector 1A4). The emission estimations from these sectors are subject to quite significant uncertainty due to the absence of comprehensive, detailed fuel use data, particularly for solid and liquid fuels. Carbon dioxide emissions from domestic combustion sources are estimated to account for 15.3% of the English total in 2008, and as a proportion of UK domestic emissions, are estimated to represent 80.7%, which is slightly lower than would be anticipated from England's 83.8% share of UK population.

Nitrous oxide emissions from combustion sources in England account for 14.5% of the English N_2O total, comprising 3.6% from the road transport sector, 3.8% from other Industrial Combustion and 3.5% from power stations. Fuel combustion emissions (IPCC sector 1A) only account for 2.3% of English methane emissions, mostly from residential combustion.

The category Fugitive Emissions from Fuels (IPCC Sector 1B) reports emissions of methane from coal mining, coking, the oil and gas industry and natural gas distribution. The combined emission from this category constitutes around 18.7% of the English total methane emission in 2008 compared with the UK average of 16.6%. 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. Of these fugitive methane emissions, coal mining contributes 7.0%, natural gas distribution 11.3% and oil and gas terminals 0.3% of the English total. Coal mining emissions have declined by 85.5% from 1990 to 2008 due to the decline in the coal industry whilst gas leakage from the gas transmission system has declined by an estimated 45.8% between 1990 and 2008 as the mains and services have been renewed.

2.3 Industrial Processes

Industrial processes produce emissions from non-combustion sources such as the use of limestone in cement and glass making. Just under half of the emissions of CO_2e from industrial processes in England comprise of CO_2 (47%), with HFCs contributing a further 40%, although total greenhouse gas emissions from this sector only contribute 4.9% to the English total. All emissions of fluorinated gases occur in this sector.

The largest contribution of CO_2 emissions in this sector is from cement production, which constitutes 0.95% of the total English CO_2 emissions, with smaller emissions from glass, ammonia, aluminium, iron and steel production contributing a further 0.8% of the English total in 2008. England emits all of the UK's emissions from the production of lime and ammonia, but these emissions are not significant in terms of the English total. It should be noted that these emissions are non-combustion emissions; all fuel combustion emissions from industry are reported in category 1A2.

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 76% of HFC emissions (as CO_2 equivalent) in England and 72% of total UK HFC emissions (as CO_2 equivalent). 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 2008, HCFC and HFC production in England contributed only 1.3% of total English HFC emissions (as CO_2 equivalent) and 1.1% of total UK HFC emissions (as CO_2 equivalent). Refrigeration, air conditioning, and aerosols and metered dose inhalers constitute the most significant sources of HFC emissions in 2008, accounting for 92% of English HFC emissions and for 37% of total GHG emissions in the industrial process sector. Emissions from refrigeration arise from losses from refrigeration and air conditioning equipment during its manufacture and lifetime, whilst emissions from the aerosols sector occur mainly from industrial sources, and medical use as metered dose inhalers. Emissions from both of these sectors have risen significantly since the 1995 base year.

Nitrous oxide emissions account for 10% of total GHG emissions from the industrial process sector in England, and 10% of the total English N_2O 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 36% of England's total N_2O emissions and around 97% of UK industrial process N_2O emissions. In October 1998 an N_2O 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 2008, the sum of the English emissions from the nitric acid and adipic acid production is around 2,412kt CO_2 equivalent, equivalent to 9.9% of total English N_2O emissions and 7.1% of the UK total.

Sulphur hexafluoride (SF_6) constitutes 2.6% of total GHG emissions from the industrial process sector in England, with the main sources of SF_6 emissions coming from its application in electrical insulation, which accounted for 72% of SF_6 emissions in England in 2008 and as a cover gas in magnesium production, which accounted for around 13%. 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 45.8% since 1995.

PFC emissions only account for 0.4% of emissions in the industrial process sector in England, and for around 0.02% of total English GHG emissions. The largest sources in England in 2008 were by-product emissions from primary aluminium production (66%), Electronics (20%) and fugitive emissions from PFC manufacture (12%). English PFC emissions account for 46.2% of total UK PFC emissions, and have declined by 57.6% since 1995.

Emissions of methane from this sector are not significant.

2.4 Agriculture

GHG emissions from agriculture comprise entirely of methane and N_2O. English emissions represent 63% of the UK total in this sector and the agriculture sector accounts for 5.7% of the English GHG total.

Agriculture is the second largest source of methane emissions in England[12]. This contributes 30.3% to the overall CH_4 emissions in England in 2008. Enteric fermentation contributed 82% to total agricultural CH_4 (total was 486.2 kt CH_4) with cattle (dairy and beef) responsible for 75% of the total agricultural CH_4 emissions (enteric and waste management). Total emissions from sheep were 15% of the total CH_4 from agriculture in England. Methane emissions from agriculture are largely dependent on the numbers of livestock and have fallen by 23% from 1990 to 2008 resulting from a decline in cattle and sheep numbers. Total CH_4 emissions decreased relative to 2007 by 2%.

Of the total English emission of 78.37kt N_2O in 2008, 55.7 kt N_2O of this was from agriculture, representing 71% of the total. Of this 55.7 kt, most (92%) were emissions arising from the agricultural soils category deriving from, in order of magnitude:

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

- Synthetic fertiliser application (27.2%)
- Leaching of fertiliser nitrogen and applied animal manures to ground and surface water (26.3%)
- Wastes from grazing animals (14.0%)
- Ploughing in crop residues (15.2%)
- Manure used as fertiliser (8.8%)
- Atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NOx) (5.9%)
- Cultivation of legumes (1.1%)
- Cultivation of histosols (i.e. high organic content soils) (0.8%)
- Biological fixation in improved grass (0.6%)

A relatively small proportion (3.4 kt N_2O) 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 20.4% in the period 1990-2008 and increased by 2% in 2008 relative to 2007.

Table 2.2 Livestock Emissions of Methane in England by Source in 2008 (kt CH_4)

Livestock Methane Emissions		
Category	Source	CH_4, kt
Total cattle	Wastes	50.01
	Enteric	314.60
Pigs	Wastes	27.21
	Enteric	5.78
Sheep	Wastes	1.69
	Enteric	71.16
Goats	Wastes	0.01
	Enteric	0.41
Horses	Wastes	0.40
	Enteric	5.09
Poultry	Wastes	9.68
	Enteric	0.00
Deer	Wastes	0.00
	Enteric	0.19

[12] Data pertaining to agriculture emissions are provided by North Wyke Research

Table 2.3 Emissions of Nitrous Oxide from Agriculture in England by Source in 2008 (kt N_2O)

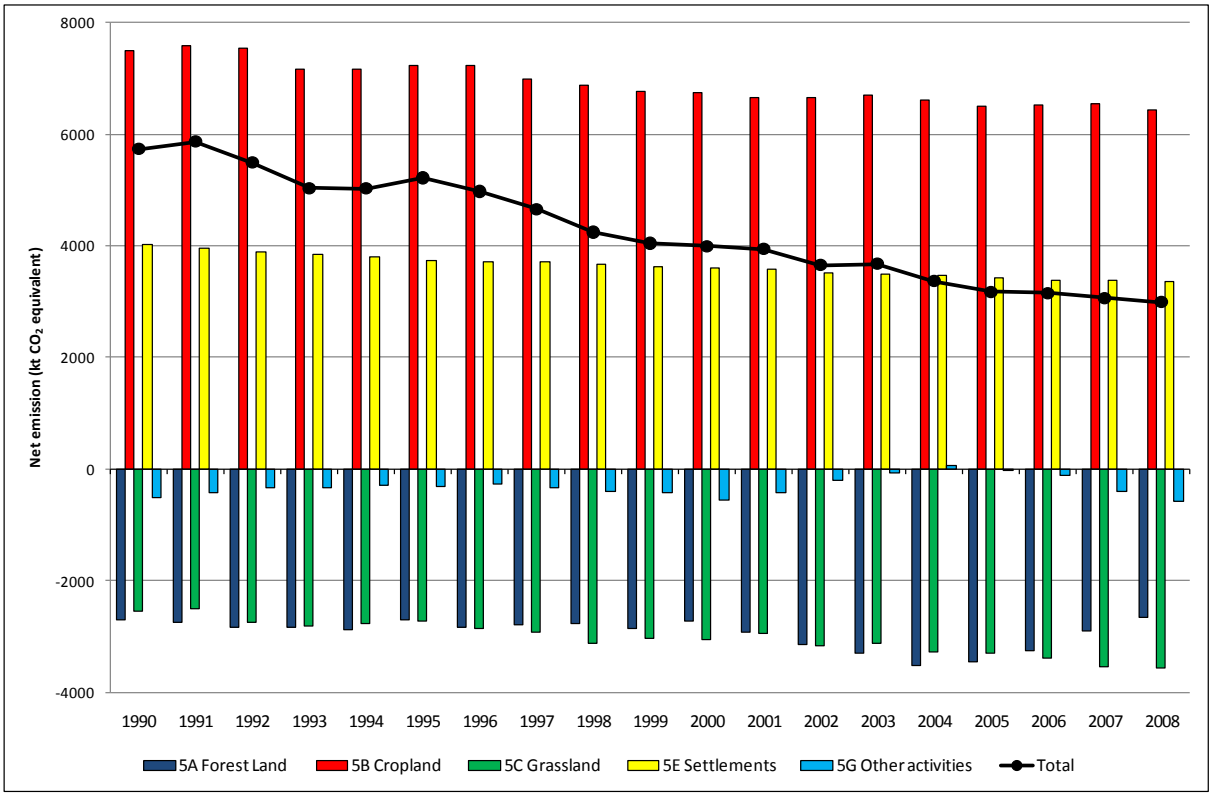
Agriculture N_2O emissions	
Source	N_2O, kt
Improved Grass	0.32
Legumes	0.56
Crop residues	7.83
Fertilisers	14.03
Histosols	0.42
Animal waste management systems	3.42
Organic fertiliser applied to soil	4.53
Grazing	7.23
Leaching	13.55
Atmospheric deposition	3.04

2.5 Land Use, Land Use Change and Forestry

The LULUCF sector includes carbon stock changes, emissions of greenhouse gases (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 carbon dioxide are conventionally presented as negative quantities.

England is a net source of carbon dioxide from LULUCF activities (Figure 2.3) although the size of this source has diminished by 48% between 1990 and 2008 from 5.72 to 2.97 Mt CO_2. Net emissions from land use and land use change 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 are now diminishing. The Cropland category is the largest overall source.

Figure 2.3 LULUCF Inventory Emissions and Removals by Category in England, 1990-2008



Estimates of methane and nitrous oxide emissions from LULUCF activities remain small, with 0.016 Mt CO_2 equivalent of methane and 0.002 Mt CO_2 equivalent of nitrous oxide in 2008 respectively

Net emissions from the LULUCF sector in 1990 have not changed from the 2007 DA inventory report. For 2007, a net source of 3.05 Mt CO_2 is estimated here compared to 3.12 Mt CO_2 in the 1990-2007 inventory (Table 2.4). The differences between the inventories are due to revisions in the deforestation activity data and the updating of 2007 activity data for liming and peat extraction.

Table 2.4 Difference in 2007 LULUCF net Emissions between the 2007 and 2008 Inventories in England

Inventory Comparison (Mt CO_2)						
	5A Forestland	5B Cropland	5C Grassland	5E Settlements	5G Other	Sector 5 All
Difference between 2007 and 2008 inventory	0.000	0.019	-0.091	-0.012	0.006	-0.079

The annual land use matrices for 1990-1991 and 2007-2008 for England are shown here (Table 2.5 and Table 2.6). 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. The total area of England is reported as 13,475,781 ha. This is 101% of the Standard Area Measurement reported by the Office of National Statistics (ONS 2007). This difference is due to the way that areas of sea are dealt with in the land use change calculations: it should be possible to resolve this issue when new data is incorporated in the coming year. There is not thought to be any bias in the estimation of land use areas.

Table 2.5 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	*845,857*	840	2,207	0	516	0	**849,420**
Cropland	0	*4,480,970*	62,879	0	626	0	**4,544,475**
Grassland	152	55,251	*5,615,323*	0	3,398	0	**5,674,124**
Wetlands	0	0	0	*0*	0	0	0
Settlements	463	2,129	8,461	0	*1,440,328*	0	**1,451,380**
Other Land	0	0	0	0	0	*956,382*	**956,382**
Total (initial)	**846,472**	**4,539,190**	**5,688,870**	**0**	**1,444,867**	**956,382**	***13,475,781***

Table 2.6 Land Use Transition Matrix, ha, for England in 2007-2008

Land Use Transition Matrix (2007-2008)							
From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	*912,122*	622	1,634	0	382	0	**914,759**
Cropland		*4,566,630*	62,879	0	626	0	**4,630,135**
Grassland	449	55,251	*5,357,405*	0	3,398	0	**5,416,502**

Land Use Transition Matrix (2007-2008)							
From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Wetlands	0	0	0	*0*	0	0	0
Settlements	319	2,129	8,461	0	*1,547,094*	0	**1,558,003**
Other Land	0	0	0	0	0	*956,382*	**956,382**
Total (initial)	**912,891**	**4,624,632**	**5,430,378**	**0**	**1,551,499**	**956,382**	***13,475,781***

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 are shown in Table 2.7. The methods and assumptions used in these reported emissions are described in Chapter 11 and Annex 3.7 of the National Inventory Report.

Table 2.7 Greenhouse Gas Emissions and Removals from KP-LULUCF Activities in England, 2008

KP-LULUCF Activities		
Activity		England
3.3 Afforestation & Reforestation	Area, kha	82.62
	Net CO_2 emissions/removals, Gg CO_2	-868.70
	Emissions from biomass burning, Gg CO_2 eq.	NO
	N_2O emissions from N fertilization, Gg CO_2 eq.	0.57
3.3 Deforestation	Area, kha	14.19
	Net CO_2 emissions/removals, Gg CO_2	324.77
	CO_2 emissions from biomass burning, Gg CO_2	116.81
3.4 Forest Management	Area, kha	317.03
	Net CO_2 emissions/removals, Gg CO_2	-1,787.25
	CO_2 emissions from biomass burning, Gg CO_2	70.93

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*. 2010). Planned improvements in the 2009 inventory are the restructuring of reporting in the different land use categories (this will improve consistency in the reporting of areas and should not affect overall emissions) and the incorporation of new activity data for forest management and deforestation. It is planned to assimilate information on land use change from the latest Countryside Survey (Carey *et al*. 2008) into the inventory but progress on this has been slow.

2.6 Waste

The waste sector contributes 3.7% to total GHG emissions in England, and is the largest source sector for methane emissions, representing 48% 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 77.6% of UK landfill emissions. Emissions of GHG from landfill in England have shown a significant decline (61%) between 1990 and 2008, 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 59.4%.

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 CH_4 release curve.

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 2000-2008 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 2008 has fluctuated decreased by 37%. 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 2% of the English total methane emissions and comprise 83.8% of UK wastewater CH4 emissions.

2.7 Emission Maps: England 2008

As part of the NAEI, the UK produces mapped emissions of CO_2, CH_4 and N_2O. The maps are modelled estimates of emissions compiled at a 1 km^2 resolution and Figure 2.4 to Figure 2.6 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 (formerly BERR) 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 CH_4 and N_2O 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 timeseries, and are available at:

http://www.naei.org.uk/mapping/mapping_2008.php

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

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

Figure 2.4 Map of Emissions of Carbon Dioxide (t) in England in 2008

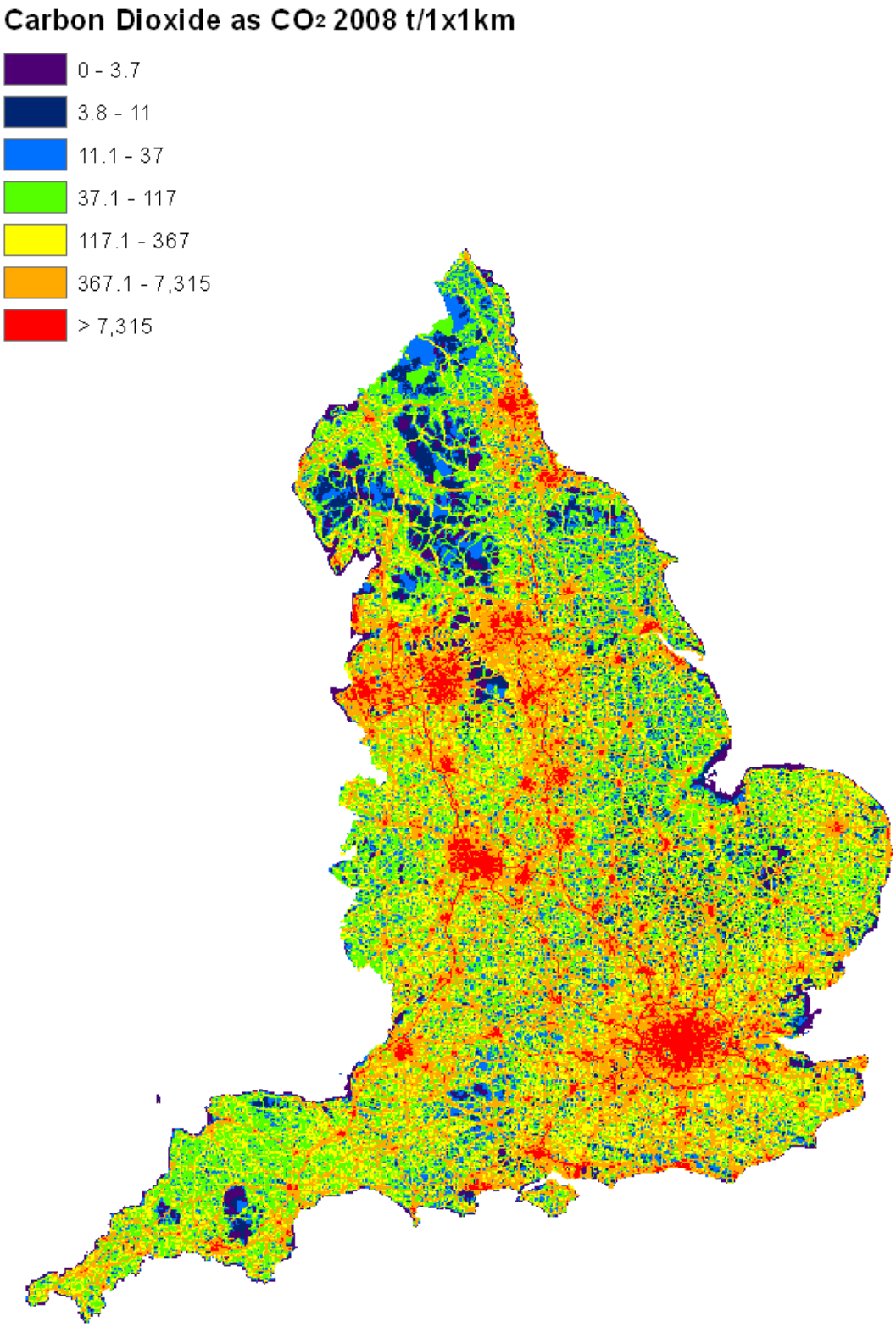


Figure 2.5 Map of Emissions of CH_4 (t CO_2 e) in England in 2008

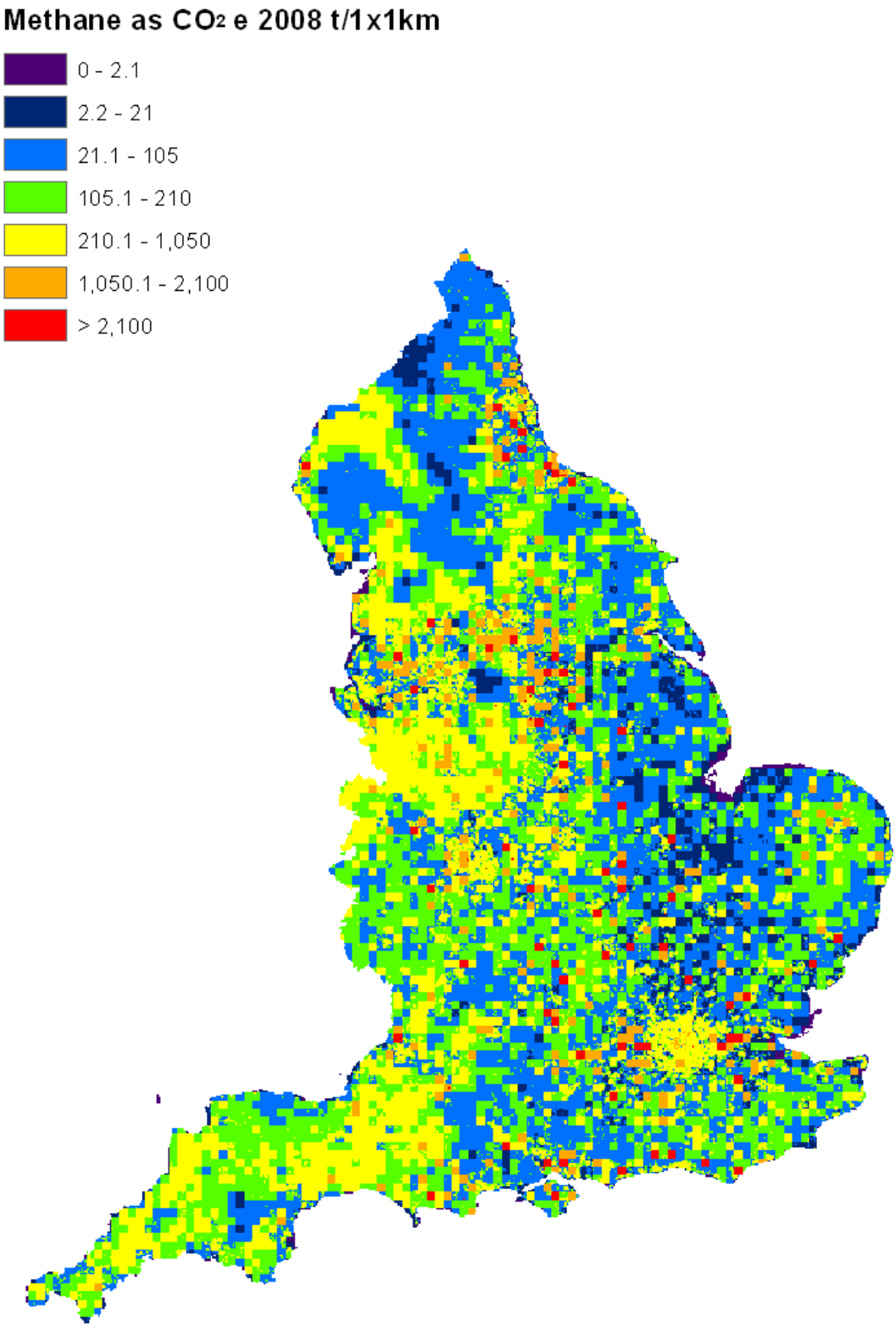
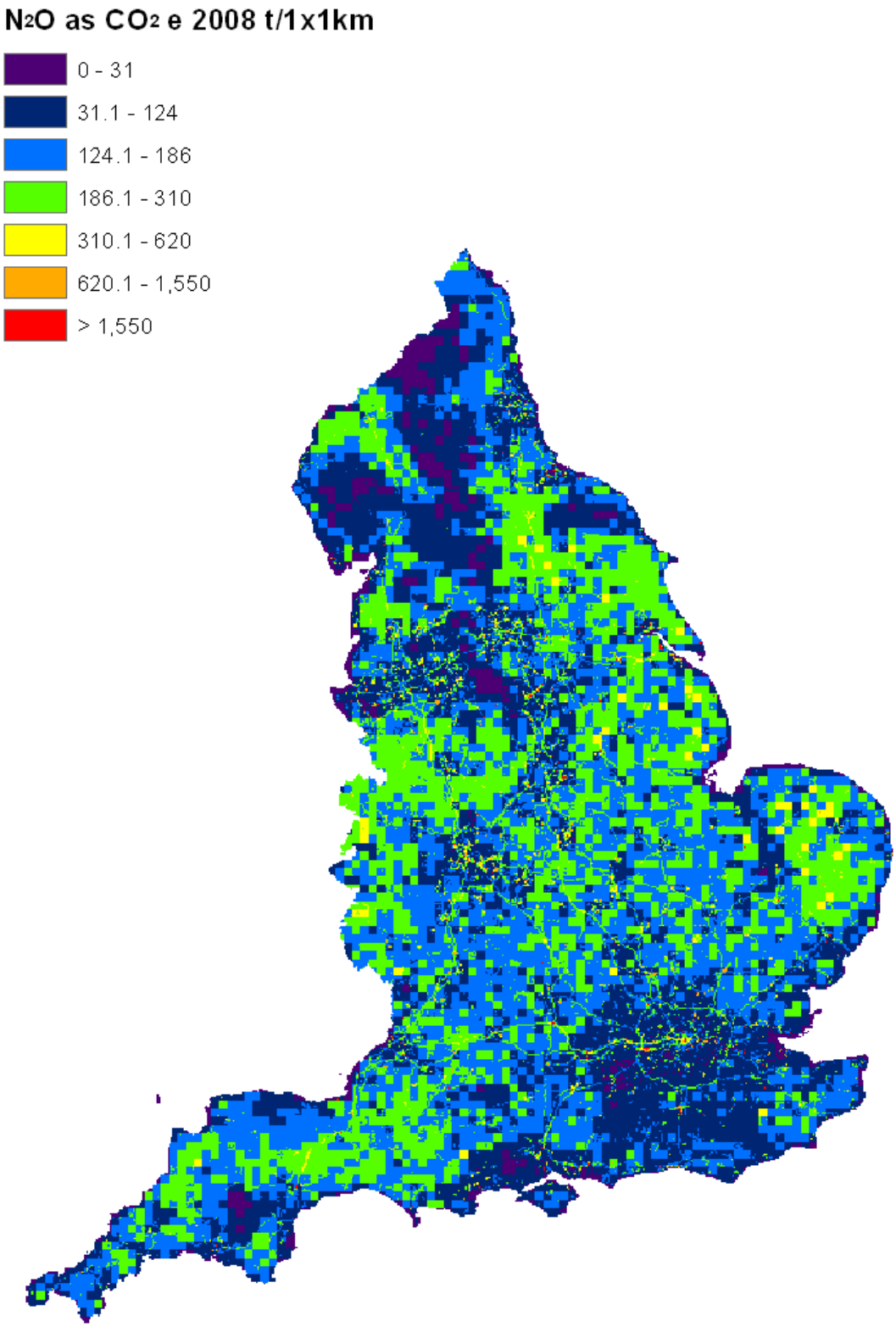


Figure 2.6 Map of Emissions of N_2O (t CO_2 e) in England in 2008



3 Emissions in Scotland

3.1 Summary of GHG Emission Sources

The main GHG emission sources for Scotland in 2008 are summarised in Table 3.1 below, expressed as a percentage of the total Scottish GHG emissions in 2008 of 53.7 Mt CO_2 e. The trends in Scottish GHG emissions since the base years of 1990 (for CO_2, CH_4 and N_2O) and 1995 (for fluorinated gases) are as follows:

- CO_2 emissions have reduced by 16.8%
- CH_4 emissions have reduced by 43.1%
- N_2O emissions have reduced by 31.9%
- HFC emissions have increased by 610.2%
- PFC emissions have reduced by 37.0%
- SF_6 emissions have increased by 66.3%
- Total GHG emissions (as CO_2-equivalents) have reduced by 21.3%

The largest emissions source in Scotland is CO_2 from power stations (1A1a), which accounted for 27% of net Scottish GHG emissions in 2008. The largest methane source is from landfill (6A), and the largest source of N_2O 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 removal of 13 $MtCO_2$ in 2008.

Table 3.1 Emissions Summary for Scotland, 2008 (kt CO_2e)

Summary of Main Emission Sources, Scotland 2008 (kt CO_2e)				
Rank	Sector Name	IPCC code	Emission	Percentage of total GWP Weighted Emissions
1	Power stations	1A1a	14384	26.8%
2	Road Transport	1A3b	9989	18.6%
3	Residential Combustion	1A4b	7184	13.4%
4	Land Converted to Cropland	5B2	6631	12.3%
5	Other Industrial Combustion	1A2f	5486	10.2%
6	Agricultural Soils	4D	3465	6.5%
7	Landfill	6A1	2559	4.8%
9	Refineries	1A1b	2111	3.9%
8	Enteric fermentation - Cattle	4A1	1960	3.6%
10	Commercial and institutional combustion	1A4a	1848	3.4%

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 IPCC 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

The energy sector (IPCC sector 1) accounts for 87.3% of total greenhouse gas emissions in Scotland, and CO_2 emissions contribute 97.8% of the emissions in this sector. This sector includes all emissions from fuel combustion, and also fugitive emissions from fuels.

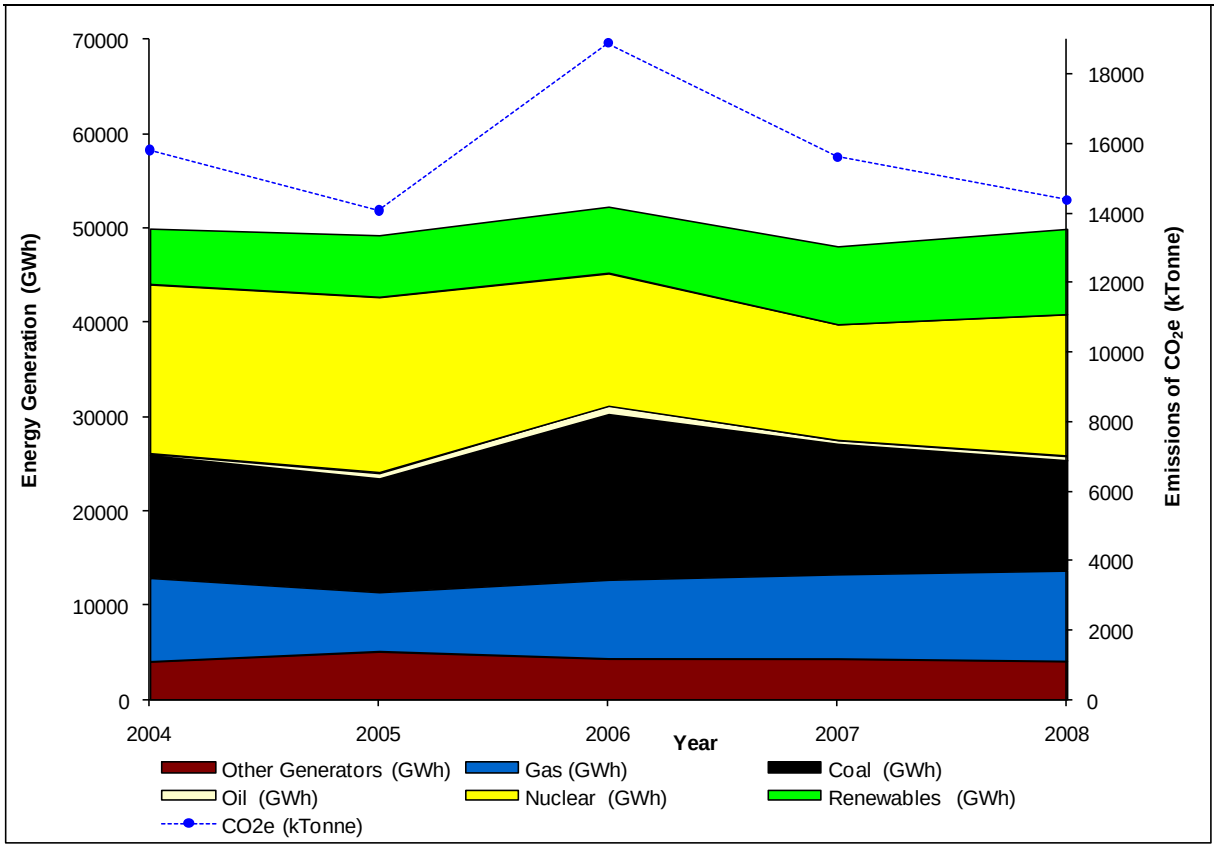
Energy industries constitute the largest source of CO_2 emissions in Scotland. This includes power generation, refineries, solid fuel transformation processes and the oil and gas industry. In 2008, power generation (IPCC category 1A1a) contributed around 34.0% of the total Scottish CO_2 emission, which is slightly higher than the UK average of 32.5% due to the Scotland's relatively large carbon sink in the land use, land use change and forestry sector which reduces total net CO2 emissions, the different mixture of fuels used to generate electricity in Scotland and to the export of electricity from Scotland to other parts of the UK.

2008 Scottish emissions of CO_2 from power generation have decreased by 3.8% since 1990 in contrast with a fall of 15.3% from power generation across the UK as a whole. These observations are partly due to Scotland generating electricity that is subsequently exported and used elsewhere in the UK. Power generation and consumption data from DECC (DECC, 2009b) indicated that in 2008, approximately 18% of all electricity generated in Scotland was exported to England and Northern Ireland, an increase from 15% exported in 2007.

[*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 3.1) is significantly different from the rest of the UK, with a higher contribution from nuclear power and renewable forms of energy (largely hydro-electricity). 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 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 thermal plant. This difference is exemplified by the notable increase in CO_2 emissions from power generation in Scotland in 2006 in comparison with emissions in 2005, 2007 and 2008. This increase in CO_2 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. This sharp increase in coal-fired power generation in 2006 influenced the overall Scotland GHG inventory significantly for that year, but emissions from coal-fired power generation were notably lower in 2007 and 2008.

Figure 3.1 Power Generation by Fuel and Cumulative GHG Emissions: Scotland



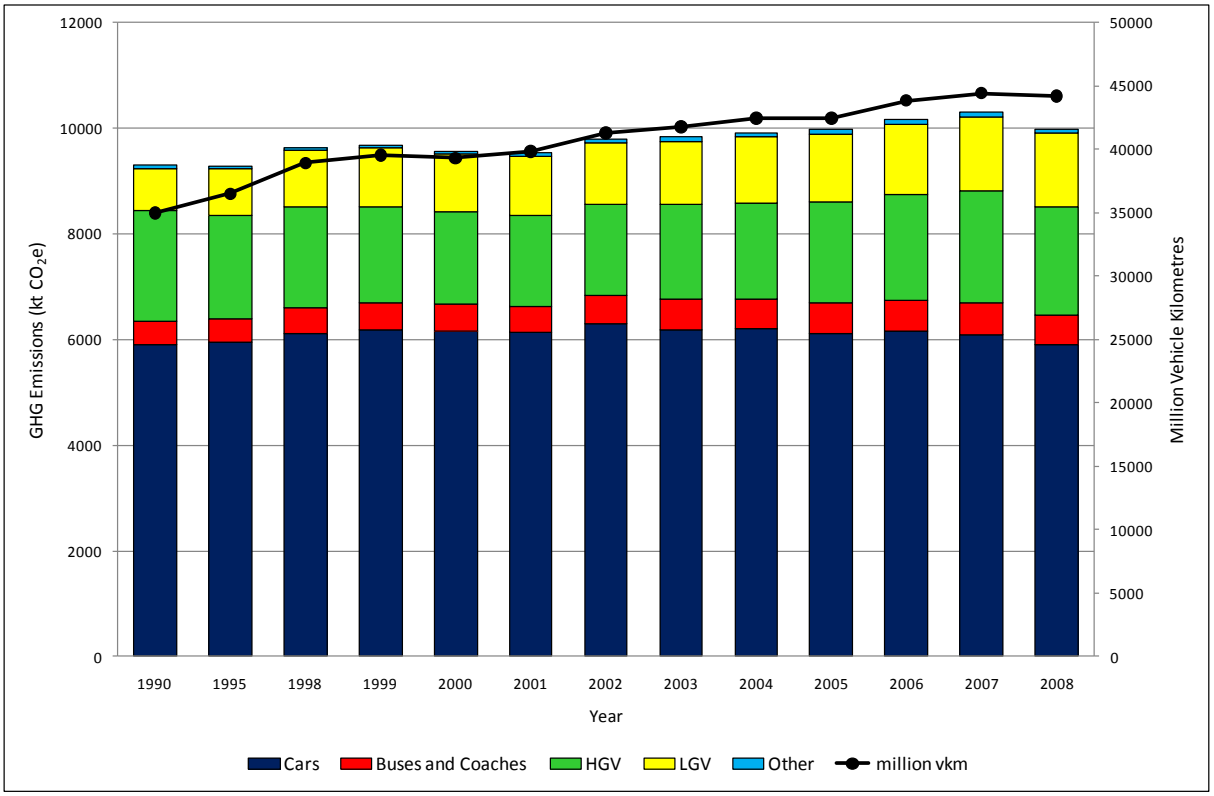
Carbon dioxide emissions from petroleum refining (sector 1A1b) constitute a high proportion of national emissions in Scotland at 5% of the CO_2 total, compared with 2.9% across the UK, which reflects the significance of the Grangemouth refinery and the greater occurrence of oil and gas landings in Scotland from offshore facilities compared to the UK average. Other energy emissions account for around 4.3% of Scottish CO_2 emissions in 2008, 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 have been 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 13.0% of the Scottish CO_2 total compared with 14.2% for the UK. Between 1990 and 2008, CO_2 emissions from the Sector have declined by 43%, mainly due to the closure of the Ravenscraig steel plant.

After power generation, road transport (1A3b) is the second largest single source of CO_2 in Scotland and comprises approximately 23.5% of the Scottish CO_2 total. Road transport also represents the second most significant source of N_2O emissions from the energy sector in Scotland, accounting for 2.0% of total nitrous oxide emissions in Scotland.

Scotland's contribution to UK road transport CO_2 emissions is 8.5%, which is broadly consistent with that anticipated from Scotland's population (8.4%) as a percentage of the UK total. CO_2 emissions from road transport in Scotland have shown a gradual increase over the period of 1990-2008, with emissions 8.1% higher in 2008 than in 1990, and slightly higher than the UK average during this period. This increase in GHG emissions over the period 1990-2008 parallels the notable increase in road traffic vehicle km recorded in Scotland. Emissions from road transport are dominated by emissions from cars (approximately 59%), followed by emissions from heavy goods vehicles (HGV), light goods vehicles (LGV) and buses/ coaches respectively.

Figure 3.2 Total Road Traffic Vehicle km and GHG emissions from Different Vehicle Types: Scotland, 1990 - 2008



Other combustion emissions arise from the residential, commercial, public and agriculture sectors. The emission estimates from these sectors are subject to uncertainty due to the absence of comprehensive, detailed fuel use data, particularly for solid and liquid fuels. Carbon dioxide emissions from residential combustion sources (1A4b) are estimated to account for 16.9% of the Scottish total. As a proportion of UK domestic emissions they are 9.0%, which is slightly higher than would be expected from Scotland's population (8.4% of the UK population in 2008). Domestic combustion is also the largest combustion related source of methane, contributing 1.2% to total Scottish methane emissions.

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 7.3% of the Scottish methane total. This is a lower proportion compared with the UK as a whole, where fugitive emissions constitute around 16.6% 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 contributed 1.6%, oil and gas terminals 0.3% and natural gas distribution 4.9% of the Scottish methane total. Coal mining emissions have declined by 83.8% over the period due to the decline in the coal industry. Emissions from the oil and gas industry have fallen by 86.7% over the same period due to tighter regulation of emissions. Gas leakage from the gas transmission system has reduced by 45.6% over 1990-2008 due to renewal of the mains and services infrastructure.

Only around 1.5% of CO_2 emissions arise from oil and gas fugitives, mainly from processes at oil and gas terminals (0.6%), as well as oil and gas flaring (1.0%). Between 1990 and 2008, oil and gas process emissions decreased by 31.7%, whilst emissions from flaring have decreased by 55.6%.

3.3 Industrial Processes

Industrial processes produce emissions 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. The largest emission in this sector is of HFCs from refrigeration and air conditioning, which contributes 35% of total Scottish emissions from the industrial process sector.

In 2008, refrigeration and air conditioning contributed 65% of total Scottish HFC emissions (as CO_2 equivalent) due to losses from refrigeration and air conditioning equipment during its manufacture and lifetime. Metered dose inhalers contributed 15% to the total Scottish HFC emission in 2008, with the remaining 20% of emissions comprising the Scottish HFC total attributed to foams, fire-fighting, aerosols and solvents. As a result of increases in emissions from refrigeration, air conditioning, domestic use of aerosols and metered dose inhalers, total emissions of HFCs in Scotland have increased by over 610% since the 1995 base year,

The largest CO_2 emission in this sector is from cement manufacture with smaller emissions from glass and aluminium production, and from stored carbon in products. Industrial processes emitted around 1.6% of the Scottish CO_2 total in 2008.

In 1990, nitric acid manufacture and iron and steel were both important sources of GHG in the Scottish industrial process sector. However, emissions from these sources in 2008 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 CO_2e of nitrous oxide were emitted from a nitric acid plant in Leith, and 244 kt CO_2 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 the 1990 base year.

Emissions of PFCs represent 3.2% of Scottish GHG emissions from the industrial process sector in 2008. The largest source of perfluorocarbons in Scotland is through their application in the electronics industry. In 2008, this contributed around 97% to the total Scottish PFC emission (as CO_2 equivalent). The other main source of PFCs in Scotland is aluminium production and this contributes 2.5% to the total emissions of PFCs from Scotland. Overall, Scottish PFC emissions account for 26% of the UK total (as CO_2 equivalent) and have decreased by 37.0% over the period 1995-2008 as the decreases in emissions from the aluminium production have out-weighed the increase from the electronics industry.

Emissions of SF_6 represent 3.0% of Scottish industrial process GHG emissions. All emissions of SF_6 in Scotland occur in the IPCC category 2F9. This category includes emissions from the electronics industry, as well as leakage from electrical switchgear and from the soles of certain brands of sport shoes. Overall, emissions of SF6 from Scotland in 2008 constitute 7.2% of the UK total and have increased by 66% over 1995-2008, due to increased emissions from all three major sources.

3.4 Agriculture

Emissions from the agriculture sector contribute 13% to total greenhouse gas 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 is the largest single source of methane emissions in Scotland (128.5 kt CH_4, 2,699 kt CO_2 e), contributing 43% of Scottish methane emissions. Total emissions from cattle (including both waste management and enteric fermentation) are 72% 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 14% over the period 1990-2008, due to a decline in cattle and sheep numbers. Scotland accounts for around 16.8% of UK agricultural methane emissions. Emissions decreased by 3% in 2008 compared to 2007.

Of the total Scottish emission of 14.02 kt N_2O in 2008, around 12.14kt N_2O of this was from agriculture, representing 87% of the total. The agriculture sector also includes the largest single source of N_2O emissions; emissions from agricultural soils (11.18 kt N_2O) contribute 80% of total N_2O emissions, and 92% of N_2O emissions from the agriculture sector. Scottish agricultural emissions of N_2O have declined by 29% over the period 1990-2008 and decreased by 2.6% in 2008 relative to 2007. Emissions from the agricultural soils sector are broken down below:

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

- Leaching of fertiliser nitrogen and applied animal manures to ground and surface water (28.0%)
- Synthetic fertiliser application (23.8%)
- Wastes from grazing animals (22.5%)
- Manure used as fertiliser (9.8%)
- Ploughing in crop residues (9.0%)
- Atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NO_x) (6.8%)
- Biological fixation in improved grass (0.9%)
- Cultivation of histosols (i.e. high organic content soils) (0.2%)
- Cultivation of legumes (0.17%)[2]

Table 3.2 Livestock Emissions of Methane in Scotland by source in 2008 (kt CH_4)

Livestock Methane Emissions		
Category	Source	CH_4, kt
Total cattle	Wastes	11.81
	Enteric	93.33
Pigs	Wastes	3.08
	Enteric	0.65
Sheep	Wastes	0.80
	Enteric	33.88
Goats	Wastes	0.00
	Enteric	0.02
Horses	Wastes	0.05
	Enteric	0.58
Poultry	Wastes	1.08
	Enteric	0.00
Deer	Wastes	0.00
	Enteric	0.05

Table 3.3 Emissions of Nitrous Oxide from Agriculture in Scotland by Source in 2008 (kt N_2O)

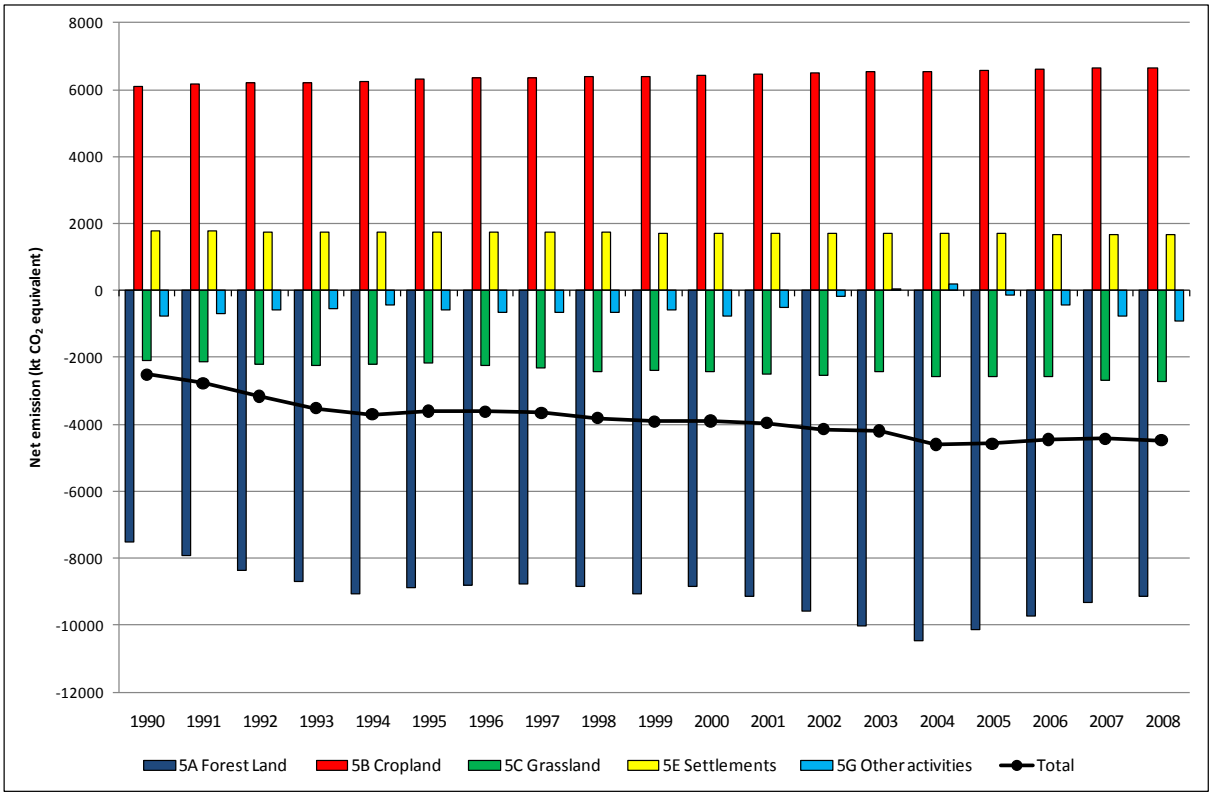
Agriculture N_2O emissions	
Source	N_2O, kt
Improved Grass	0.10
Legumes	0.02
Crop residues	1.00
Fertilisers	2.60
Histosols	0.02
Animal waste management systems	0.77
Organic fertiliser applied to soil	1.10
Grazing	2.50
Leaching	3.09
Atmospheric deposition	0.76

3.5 Land Use, Land Use Change and Forestry

The LULUCF sector includes carbon stock changes, emissions of greenhouse gases (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.

Scotland is a net sink of CO_2 from LULUCF activities (Figure 3.3). The size of this sink has increased by 78%, from -2.53 to -4.48 Mt CO_2, between 1990 and 2008, although this trend has levelled off since 2004. Net emissions/removals in Scotland are dominated by the large Forestland sink (-9.16 Mt CO_2 in 2008) although the Cropland source is also significant (6.64 Mt CO_2 in 2008).

Figure 3.3 LULUCF Inventory Emissions and Removals by Category in Scotland, 1990 to 2008



Estimates of methane and nitrous oxide emissions due to LULUCF activities remain small: 0.01 Mt CO_2 equivalent of methane and 0.001 Mt CO_2 equivalent of nitrous oxide in 2008.

Net emissions from the LULUCF sector in 1990 have not changed from the 2007 DA inventory report. For 2007, a net sink of -4.45 Mt CO_2 is estimated here, which represents no change from the 2007 DA inventory report estimate (Table 3.4). The minor differences between the inventories are due to revisions in the deforestation activity data and the updating of 2007 activity data for liming and peat extraction.

The annual land use matrices for 1990-1991 and 2007-2008 for Scotland are shown here (Table 3.5 and Table 3.6). 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. The total area of Scotland is reported as 8,771,771 ha. This is 109% of the Standard Area Measurement reported by the Office of National Statistics (ONS 2007). This difference is due to the way that areas of sea are dealt with in the land use change calculations, which has a greater impact in Scotland, due to its more convoluted coastline. It should be possible to resolve this issue when new data is incorporated in the coming year. There is not thought to be any bias in the estimation of land use areas.

Table 3.4 Difference in 2007 LULUCF net Emission between the 2007 and 2008 Inventories in Scotland

Inventory Comparison (Mt CO_2)						
	5A Forestland	5B Cropland	5C Grassland	5E Settlements	5G Other	Sector 5 All
Difference between 2007 and 2008 inventory	0.000	0.043	-0.034	-0.004	0.002	-0.007

Table 3.5 Land Use Transition Matrix, ha, for Scotland in 1990-1991

Land Use Transition Matrix (1990-1991)							
From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	1,056,019	745	14,329	0	199	0	**1,071,293**
Cropland	0	699,390	21,404	0	271	0	**721,065**
Grassland	48	16,839	6,023,044	0	676	0	**6,040,606**
Wetlands	0	0	0	0	0	0	0
Settlements	145	123	2,221	0	291,357	0	**293,846**
Other Land	0	0	0	0	0	644,961	**644,961**
Total (initial)	**1,056,212**	**717,097**	**6,060,998**	**0**	**292,503**	**644,961**	**8,771,771**

Table 3.6 Land Use Transition Matrix, ha, for Scotland in 2007-2008

Land Use Transition Matrix (2007-2008)							
From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	*1,227,287*	321	6,172	0	86	0	**1,233,866**
Cropland	0	*771,378*	21,404	0	271	0	**793,053**
Grassland	141	16,839	*5,764,827*	0	676	0	**5,782,482**
Wetlands	0	0	0	*0*	0	0	0
Settlements	100	123	2,221	0	*314,965*	0	**317,409**
Other Land	0	0	0	0	0	644,961	**644,961**
Total (initial)	**1,227,528**	**788,661**	**5,794,624**	**0**	**315,998**	**644,961**	**8,771,771**

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 are shown in Table 3.7. The methods and assumptions used in these reported emissions are described in Chapter 11 and Annex 3.7 of the National Inventory Report.

Table 3.7 Greenhouse Gas Emissions and Removals from KP-LULUCF Activities in Scotland, 2008

KP-LULUCF Activities		
Activity		Scotland
3.3 Afforestation & Reforestation	Area, kha	177.25
	Net CO_2 emissions/removals, Gg CO_2	-1,594.48
	Emissions from biomass burning, Gg CO_2 eq.	NO
	N_2O emissions from N fertilization, Gg CO_2 eq.	0.36
3.3 Deforestation	Area, kha	4.45
	Net CO_2 emissions/removals, Gg CO_2	101.75
	CO_2 emissions from biomass burning, Gg CO_2	36.60
3.4 Forest Management	Area, kha	840.60
	Net CO_2 emissions/removals, Gg CO_2	-7,518.12
	CO_2 emissions from biomass burning, Gg CO_2	76.62

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*. 2010). Planned improvements in the 2009 inventory are the restructuring of reporting in the different land use categories (this will improve consistency in the reporting of areas and should not affect overall emissions) and the incorporation of new activity data for forest management and deforestation. This will enable estimates of emissions from deforestation to be based on Scottish data, rather than extrapolated from data from England. It is planned to assimilate information on land use change from the latest Countryside Survey (Carey *et al*. 2008) into the inventory but progress on this has been slow.

3.6 Waste

Waste emissions in Scotland are dominated by methane emissions from landfills. This accounts for 92.9% of total greenhouse gas emissions from the waste sector. Scottish landfill emissions represent 12.7% of total UK landfill methane emissions, which is more than would be expected from the Scottish proportion of the population (8.4%).

The estimates are based on data on arising 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 CH_4 release curve. This is notable in Scotland during the period 2007-2008, as there is a downward trend in MSW being disposed to landfill, but the CH_4 emissions are estimated to be increasing.

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 54% 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 N_2O represent 6.3% of total greenhouse gas 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.

3.7 Emission Maps: Scotland 2008

As part of the NAEI, the UK produces mapped emissions of CO_2, CH_4 and N_2O. The maps are modelled estimates of emissions compiled at a 1 km^2 resolution and Figure 3.4 to Figure 3.6 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 emissions and fuel use have been produced for Defra and DECC (formerly BERR) 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 CH_4 and N_2O 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 timeseries, and are available at:

http://www.naei.org.uk/mapping/mapping_2008.php

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

Figure 3.4 Map of Emissions of CO_2 (t) in Scotland in 2008

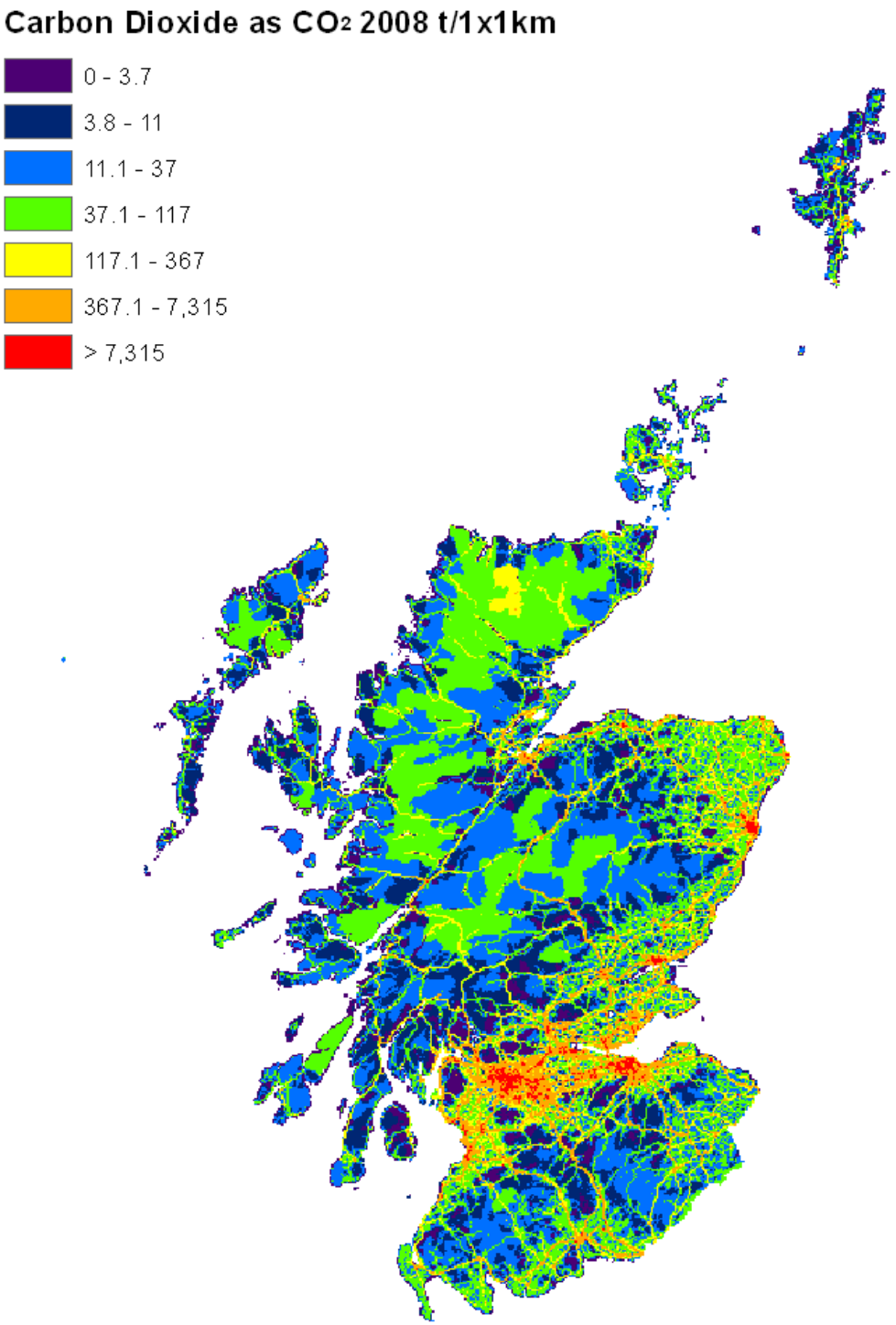


Figure 3.5 Map of Emissions of CH_4 (t CO_2 e) in Scotland in 2008

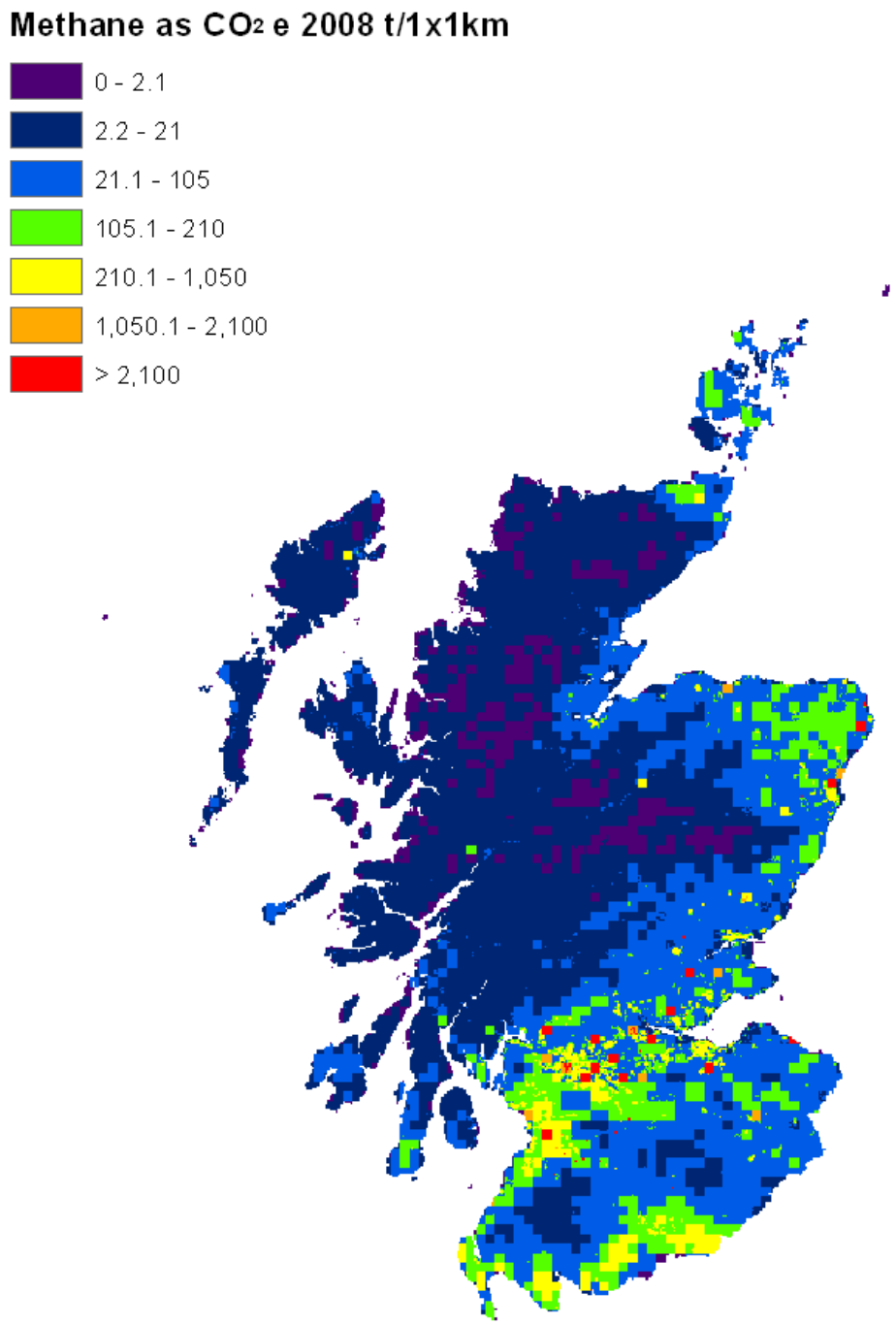
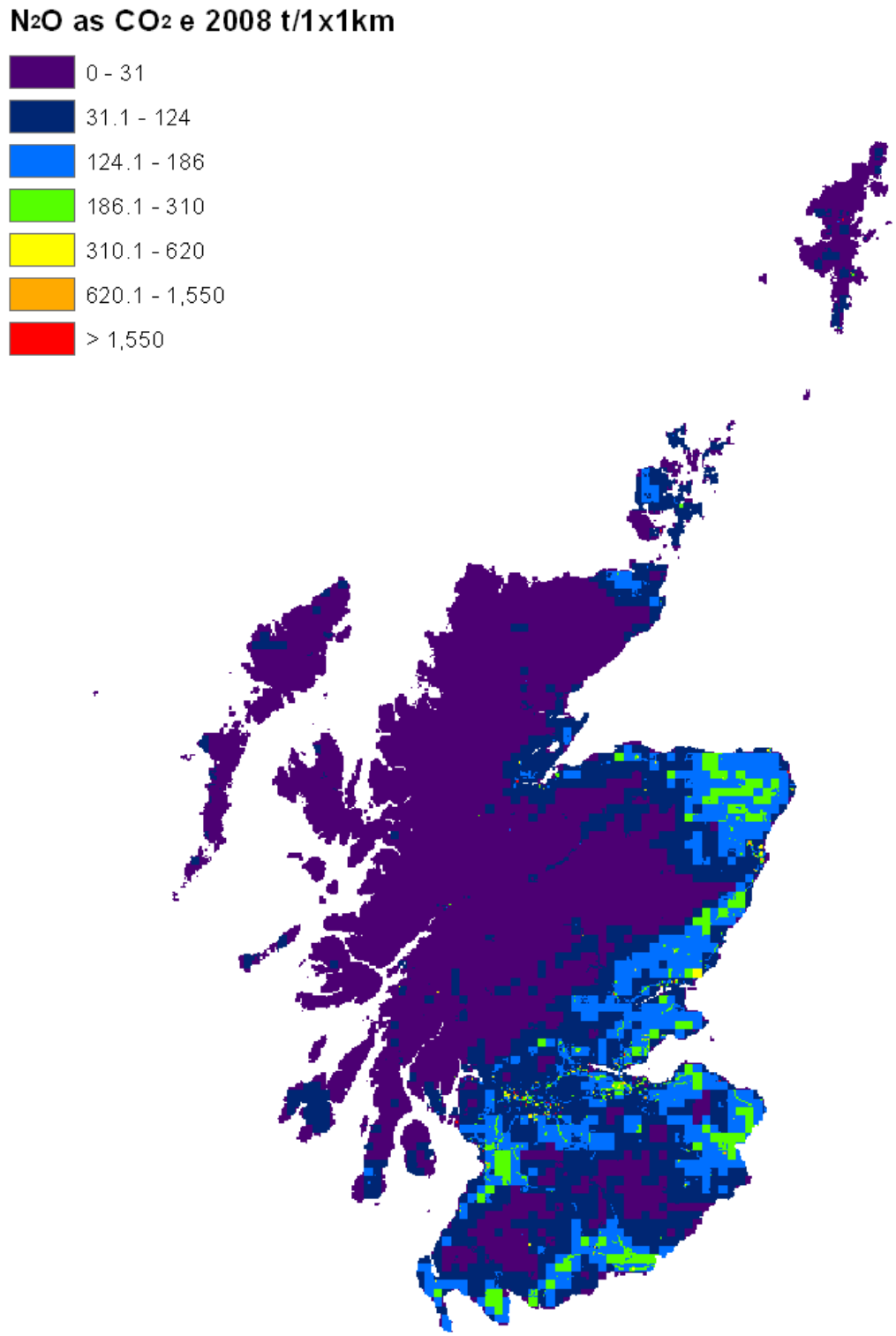


Figure 3.6 Map of Emissions of N_2O (t CO_2 e) in Scotland in 2008



4 Emissions in Wales

4.1 Summary of GHG Emission Sources

The main GHG emission sources for Wales in 2008 are summarised in Table 4.1 below, expressed as a percentage of the total Welsh GHG emissions in 2008 of 49.5 Mt CO_2-equivalent. Trends in Welsh GHG emissions since the base years of 1990 (for CO_2, CH_4 and N_2O) and 1995 (for fluorinated gases) are as follows:

- CO_2 emissions have reduced by 2.6%
- CH_4 emissions have reduced by 44.5%
- N_2O emissions have reduced by 28.9%
- HFC emissions have increased by 598.0%
- PFC emissions have reduced by 60.8%
- SF_6 emissions have reduced by 47.1%
- Total GHG emissions (as CO_2-equivalents) have reduced by 9.9%

In Wales, after emissions from power stations, the second largest emission source is CO_2 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, and the largest source of N_2O emissions is agricultural soils. Together, the ten categories listed in Table 4.1 accounted for 86% of the Welsh total net emissions in 2008.

Table 4.1 Emissions Summary for Wales, 2008 (kt CO_2e)

Summary of Main Emission Sources, Wales 2008 (kt CO_2e)				
Gas	Sector Name	IPCC code	Emission	Percentage of total GWP Weighted Emissions
1	Power stations	1A1a	14763	29.8
2	Iron and Steel	1A2a	6257	12.6
3	Road Transport	1A3b	6011	12.1
4	Residential Combustion	1A4b	4379	8.8
5	Other Industrial Combustion	1A2f	3470	7.0
6	Refineries	1A1b	2992	6.0
7	Agricultural Soils	4D	2019	4.1
8	Enteric fermentation - Cattle	4A1	1352	2.7
9	Landfill	6A1	1174	2.4
10	Land Converted to Cropland	5B2	1057	2.1

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 IPCC 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

Emissions from the energy sector are dominated by emissions of CO_2 from combustion sources, which represent 97.5% of total GHGs in this sector in 2008; emissions of CH_4 and N_2O from fuel combustion account for the remaining 2.5% of the total GHG emissions from the energy sector.

Fugitive emissions from fuels are an important source of methane, accounting for 12.5% of the Welsh methane emissions in 2008; these emissions are primarily from leakage from the natural gas supply network and methane seepage from mining activities. Collectively, the energy sector accounts for 83.3% of total Welsh GHG emissions in 2008.

The largest source of CO_2 emissions in Wales is Energy Industries (IPCC sector 1A1), which includes power generation, refineries and solid fuel transformation processes. Electricity generation contributed an estimated 35% of the total Welsh carbon dioxide emissions in 2008, which is slightly higher than the UK proportion of 32.5%. Emissions from electricity generation in Wales have increased by 30.5% compared with a fall of 15.3% in UK emissions over 1990 to 2008 (Figure 4.1), but annual generation figures have varied considerably during this period, including a rise of 30% in power station emissions between 2007 and 2008 due to the re-opening of Aberthaw.

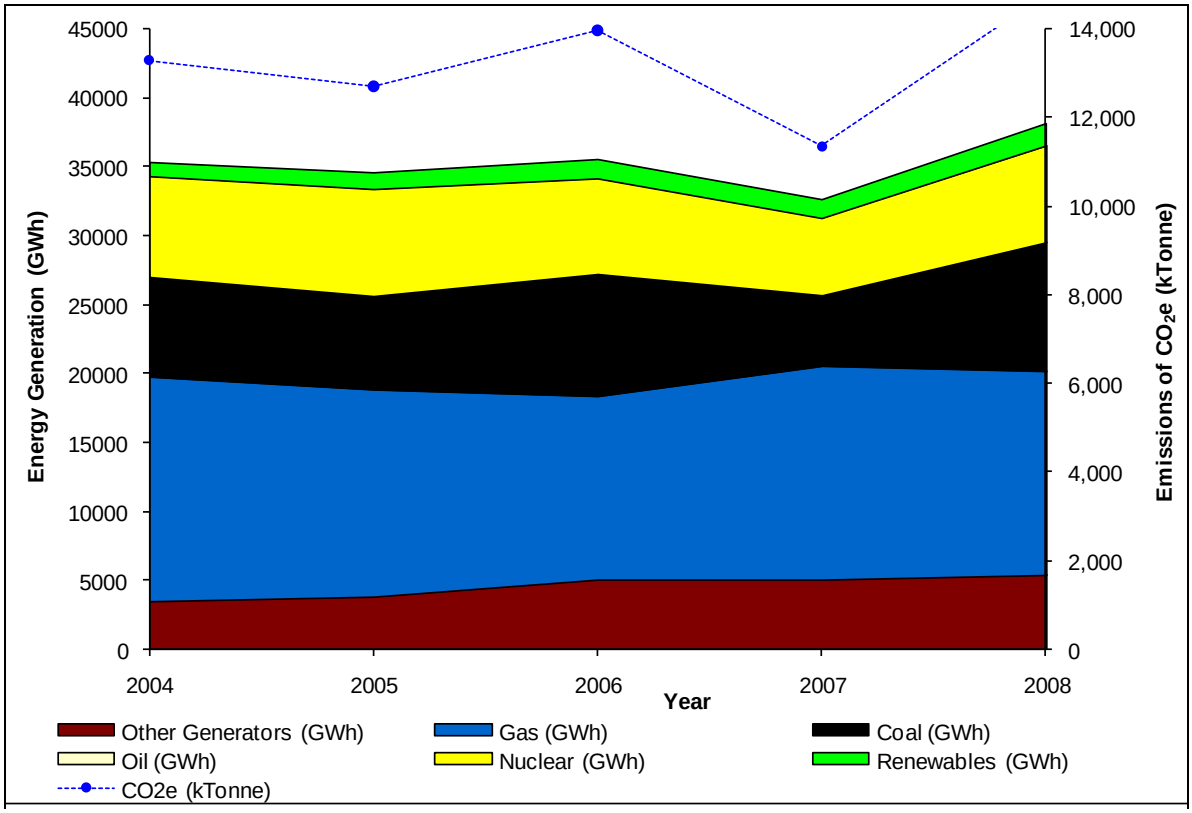
Electricity generation and consumption data (DECC, 2009b) indicates that in 2008 Wales exported 10,064 GWh of electricity to England, which is just over 26% of all power generated in Wales. The amount of electricity exported from Wales in 2008 has increased from that exported in 2007 (5,401 GWh). This is largely due to the reopening of Aberthaw; in 2007 there was a plant shut-down at Aberthaw to retro-fit 2 units with Flue Gas Desulphurisation abatement.

[*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 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. The impact of these temporal changes in power generation fuel mix is reflected in the noted increase in emissions of GHGs from Wales in 2008 compared with 2007.

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 14,746GWh in 2008. Coal represented the second most significant source of power-generation (9,364 GWh), followed by nuclear energy (7,080 GWh). Energy generated from renewable sources was estimated to contribute 1,627 GWh in 2008, an increase of 257 GWh from 2007. 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.

Figure 4.1 Power Generation by Fuel and Cumulative GHG Emissions: Wales

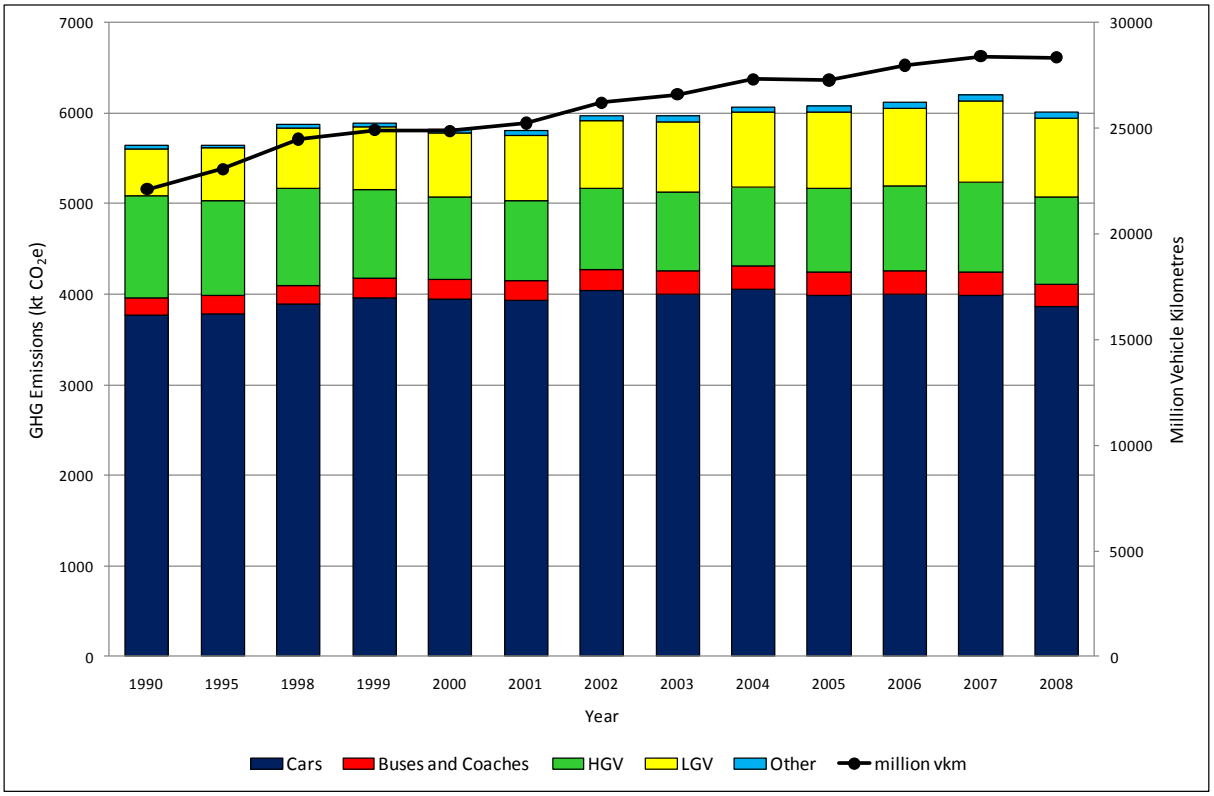


Petroleum refining constitutes 7.1% of Welsh CO_2 emissions in 2008 compared with 2.9% for the UK as a whole, which reflects the significance of the Pembroke and Milford Haven refineries. The other energy emissions are mostly combustion emissions from coke ovens and solid fuel plant and account for 1.0% of the 2008 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".

Combustion emissions from Manufacturing Industries and Construction (IPCC sector 1A2) account for 22.8% of the Welsh CO_2 total compared with 14.2% 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 34.3% of UK Iron and Steel combustion emissions of CO_2 in 2008. Welsh CO_2 emissions from the 'other industry' category (IPCC sector 1A2f) are estimated to be 5.9% of the UK CO_2 total for this sector in 2008.

Road transport represents the third largest single source of CO_2 in Wales after power generation and iron and steel, contributing 14.2% of the total Welsh carbon dioxide emission in 2008. The contribution of Welsh road transport to UK road transport CO_2 emissions is 5.1%, which is broadly consistent with Wales' population (4.9% of UK population in 2008). Emissions of CO_2 from road transport in Wales have risen by 7.1% from 1990 to 2008 compared with a 7.0% rise for the UK as a whole (Figure 4.2), with emissions from cars constituting approximately 64% of emissions, followed by emissions from HGVs, LDVs and buses / coaches.

Figure 4.2 Total Road Traffic Vehicle km and GHG emissions from Different Vehicle Types: Wales, 1990 – 2008



Other combustion emissions arise from the domestic, commercial, public and agriculture sectors. The emission estimates from these sectors are subject to quite significant uncertainty due to the absence of comprehensive, detailed fuel use data, particularly for solid and liquid fuels. Carbon dioxide emissions from domestic combustion sources are estimated to account for 10.3% of the Welsh total in 2008. As a proportion of UK domestic emissions they are estimated to represent 5.5%, which is slightly higher than the Wales share of UK population (4.9% in 2008), reflecting the higher incidence of solid fuel and oil-fired domestic heating from rural areas and in coal mining areas in Wales.

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, with much smaller contributions from N_2O and CO_2. The largest methane source in this category is coal mining, which represents 7.7% of total Welsh methane emissions in 2008, and 12.2% of total UK emissions from this sector. Emissions from this source have decreased by 77.5% 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 4.7% of the Welsh methane total. This emission has decreased by 38.8% since 1990, due to the renewal of the gas supply network.

4.3 Industrial Processes

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 CO_2 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 35% of the Welsh total greenhouse gas emissions from all industrial processes in 2008. Other significant sources include CO_2 emissions from cement, aluminium and glass production, as well as HFC emissions from refrigeration and aerosols. All emissions of HFCs, PFCs and SF_6 occur in this sector. Emissions of methane and N_2O from this sector are not significant.

Carbon dioxide process emissions from cement production accounts for 1.2% of the total CO_2 emissions in Wales. Aluminium production in Wales is a significant source of both CO_2 and PFC

emissions, which together account for 8.33% of total greenhouse gas emissions from the industrial process sector in 2008.

In 2008, the total HFC emission in Wales comprised 4.2% of the UK HFC total (as CO_2 equivalent). Refrigeration and air conditioning represents the largest source of HFC emissions, contributing 59.9% to the Welsh HFC emission total (as CO_2 equivalent) in 2008 and result primarily due to losses from refrigeration and air conditioning equipment during its manufacture and lifetime. The uses of aerosols contribute 31.7% to total Welsh HFC emissions (as CO_2 equivalent), the main sources being industrial aerosols and the medical use of metered dose inhalers. The remaining emission sources (foams, fire-fighting and solvents) contributed the remaining 8.4% to the total Welsh HFC emission (as CO_2 equivalent) in 2008. The trend in emissions of HFCs in Wales has shown a significant increase 598% since the 1995 base year, compared to a 37.7% decrease for England, and 27.8% for the UK as a whole.

Welsh emissions of sulphur hexafluoride are estimated at 6.2 % of the UK total in 2008. The largest source of emissions is from IPCC category 2F9, which accounts for 85.9% of SF6 emissions in Wales. This category includes leakage from the soles of certain brands of training shoes, emissions from the electrical switchgear used in electricity transmission, and emissions from the electronics sector. The other source of SF_6 in Wales is from its industry application as a cover gas in magnesium production. This application accounts for around 14.1% of total Welsh SF_6 emissions and comprises 7% of emissions of SF_6 from UK magnesium production.

4.4 Agriculture

Agriculture accounts for 9.4% of total greenhouse gases in Wales, and is the most significant source sector for methane and N_2O, accounting for 56% and 84% of total Welsh emissions of these two gases, respectively.

The largest single source of methane emissions in Wales is enteric fermentation from cattle. This accounts for 31% of total Welsh methane emissions and 55% of methane emissions from the agriculture sector, with enteric fermentation in sheep accounting for a further 35% of these 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 15% from 1990-2008 in line with a decrease in sheep and cattle numbers. Total CH_4 emissions decreased relative to 2007 by 4%.

The other major source of emissions in the agriculture sector is agricultural soils (7.1 kt N_2O), which constitutes a significant emission of N_2O (78% of the Welsh N_2O total, 92% of the agricultural total). Welsh emissions of N_2O have declined by 31% over the period 1990-2008 and decreased by 8% in 2008 relative to 2007. 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]

- Wastes from grazing animals (33.5%)
- Leaching of fertiliser nitrogen and applied animal manures to ground and surface water (28.3%)
- Synthetic fertiliser application (16.6%)
- Manure used as fertiliser (10.6%)
- Atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NOx) (7.8%)
- Ploughing in crop residues (1.4%)
- Biological fixation in improved grass (1.3%)
- Cultivation of histosols (i.e. high organic content soils) (0.6%)
- Cultivation of legumes (0%)

Table 4.2 Livestock Emissions of Methane in Wales by Source in 2008 (kt CH_4)

Livestock Methane Emissions		
Category	Source	CH_4, kt
Total cattle	Wastes	9.86
	Enteric	64.36
Pigs	Wastes	0.15
	Enteric	0.03
Sheep	Wastes	0.97
	Enteric	40.93
Goats	Wastes	0.00
	Enteric	0.04
Horses	Wastes	0.06
	Enteric	0.77
Poultry	Wastes	0.56
	Enteric	0.00
Deer	Wastes	0.00
	Enteric	0.01

Table 4.3 Emissions of Nitrous Oxide from Agriculture in Wales by Source in 2008 (kt N_2O)

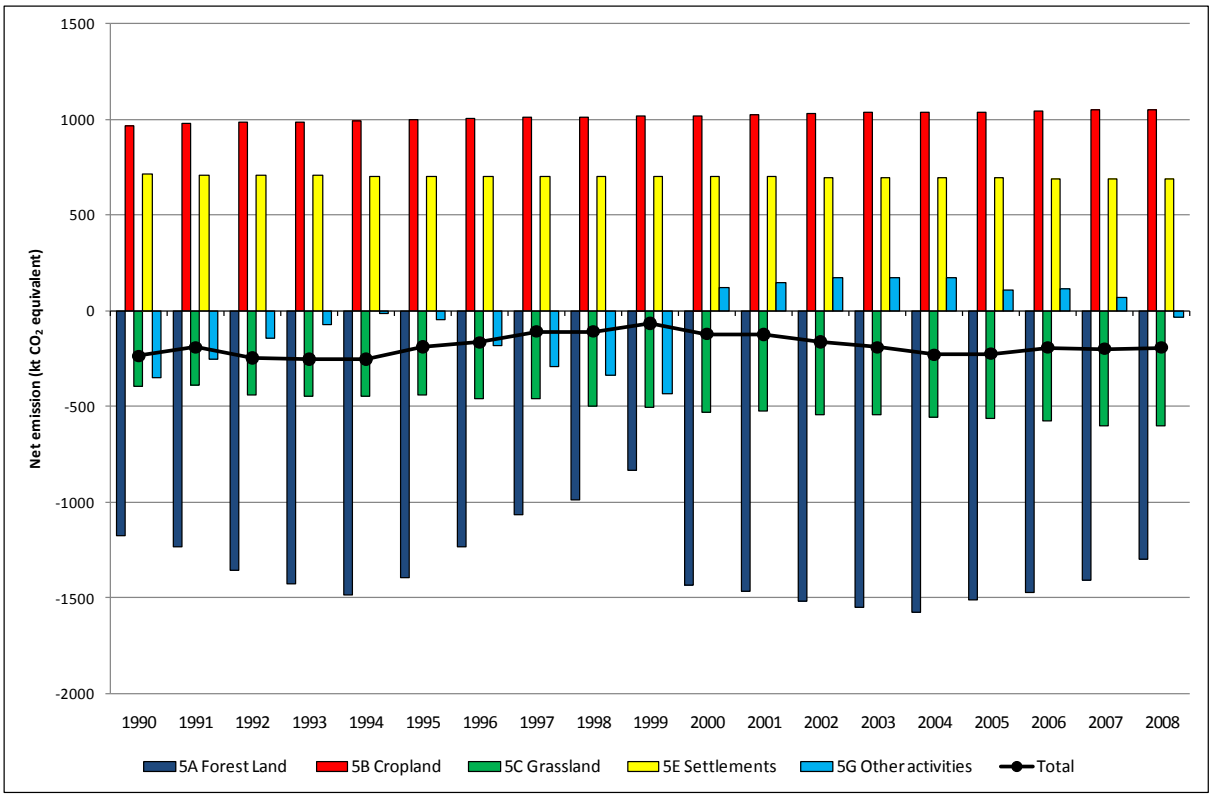
Agriculture N_2O emissions	
Source	N_2O, kt
Improved Grass	0.09
Legumes	0.00
Crop residues	0.09
Fertilisers	1.08
Histosols	0.04
Animal waste management systems	0.43
Organic fertiliser applied to soil	0.69
Grazing	2.18
Leaching	1.84
Atmospheric deposition	0.51

4.5 Land Use, Land Use Change and Forestry

The LULUCF sector includes carbon stock changes, emissions of greenhouse gases (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 carbon dioxide are conventionally presented as negative quantities.

Wales is a small net sink of carbon dioxide from LULUCF activities (Figure 4.3) and the size of this sink has only slightly reduced between 1990 and 2008: from -0.24 to -0.20 Mt CO_2. The Forestland net sink (-1.30 Mt CO_2 in 2008) and the Cropland net source (1.05 Mt CO_2 in 2008) are the largest contributors to the LULUCF sector in Wales.

Figure 4.3 LULUCF Inventory Emissions and Removals by Category in Wales, 1990 to 2008



Estimates of methane and nitrous oxide emissions due to LULUCF activities remain small: 0.002 Mt CO_2 equivalent of methane and 0.0003 Mt CO_2 equivalent of nitrous oxide in 2008.

Net emissions from the LULUCF sector in 1990 and 2007 have not changed overall from the 2007 DA inventory report. There are minor differences of <0.001 Mt CO_2 between categories due to revisions in the deforestation activity data and the updating of 2007 activity data for liming.

The annual land use matrices for 1990-1991 and 2007-2008 for Wales are shown here (Table 4.4 and Table 4.5). 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. The total area of Wales is reported as 2,185,442 ha. This is 103% of the Standard Area Measurement reported by the Office of National Statistics (ONS 2007). This difference is due to the way that areas of sea are dealt with in the land use change calculations: it should be possible to resolve this issue when new data is incorporated in the coming year. There is not thought to be any bias in the estimation of land use areas.

Table 4.4 Land Use Transition Matrix, ha, for Wales in 1990-1991

Land Use Transition Matrix (1990-1991)							
From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	265,409	45	558	0	44	0	**266,056**
Cropland	0	206,171	7,951	0	46	0	**214,168**
Grassland	12	5,486	1,459,446	0	589	0	**1,465,533**
Wetlands	0	0	0	0	0	0	0
Settlements	37	183	1,776	0	205,411	0	**207,407**

Land Use Transition Matrix (1990-1991)							
From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Other Land	0	0	0	0	0	32,279	**32,279**
Total (initial)	**265,458**	**211,884**	**1,469,731**	**0**	**206,091**	**32,279**	**2,185,442**

Table 4.5 Land Use Transition Matrix, ha, for Wales in 2007-2008

Land Use Transition Matrix (2007-2008)							
From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	272,825	30	367	0	29	0	**273,250**
Cropland		245,188	7,951	0	46	0	**253,185**
Grassland	36	5,486	1,390,766	0	589	0	**1,396,877**
Wetlands	0	0	0	0	0	0	0
Settlements	25	183	1,776	0	227,868	0	**229,852**
Other Land	0	0	0	0	0	32,279	**32,279**
Total (initial)	**272,886**	**250,886**	**1,400,860**	**0**	**228,532**	**32,279**	**2,185,442**

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 are shown in Table 4.6. The methods and assumptions used in these reported emissions are described in Chapter 11 and Annex 3.7 of the National Inventory Report.

Table 4.6 Greenhouse Gas Emissions and Removals from KP-LULUCF Activities in Wales, 2008

KP-LULUCF Activities		
Activity		Wales
3.3 Afforestation & Reforestation	Area, kha	8.67
	Net CO_2 emissions/removals, Gg CO_2	-89.84
	Emissions from biomass burning, Gg CO_2 eq.	NO
	N_2O emissions from N fertilization, Gg CO_2 eq.	0.03
3.3 Deforestation	Area, kha	1.12
	Net CO_2 emissions/removals, Gg CO_2	25.69
	CO_2 emissions from biomass burning, Gg CO_2	9.24
3.4 Forest Management	Area, kha	152.03
	Net CO_2 emissions/removals, Gg CO_2	-1220.89
	CO_2 emissions from biomass burning, Gg CO_2	20.73

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*. 2010). Planned improvements in the 2009 inventory are the restructuring of reporting in the different land use categories (this will improve consistency in the reporting of areas and will not affect overall emissions) and the incorporation of new activity data for forest management and deforestation. This will enable estimates of emissions from deforestation to be based on Welsh data, rather than extrapolated from data from England. It is planned to assimilate information on land use change from the latest Countryside Survey (Carey *et al*. 2008) into the inventory but progress on this has been slow.

4.6 Waste

Greenhouse gas emissions in the waste sector are dominated by methane emissions from landfills, which represent 91% of total 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 26.8% of total Welsh methane emissions, and have decreased by 57.6% 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 CH_4 release curve.

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 2000-2008 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 are 2.3% of total Welsh N_2O emissions, and these emissions account for 4.9% of UK wastewater treatment N_2O emissions.

4.7 Emission Maps: Wales 2008

As part of the NAEI, the UK produces mapped emissions of CO_2, CH_4 and N_2O. The maps are modelled estimates of emissions compiled at a 1 km^2 resolution and Figure 4.4 to Figure 4.6 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 (formerly BERR) 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 CH_4 and N_2O 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 timeseries, and are available at:

http://www.naei.org.uk/mapping/mapping_2008.php

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

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

Figure 4.4 Map of Emissions of Carbon Dioxide (tonnes) in Wales in 2008

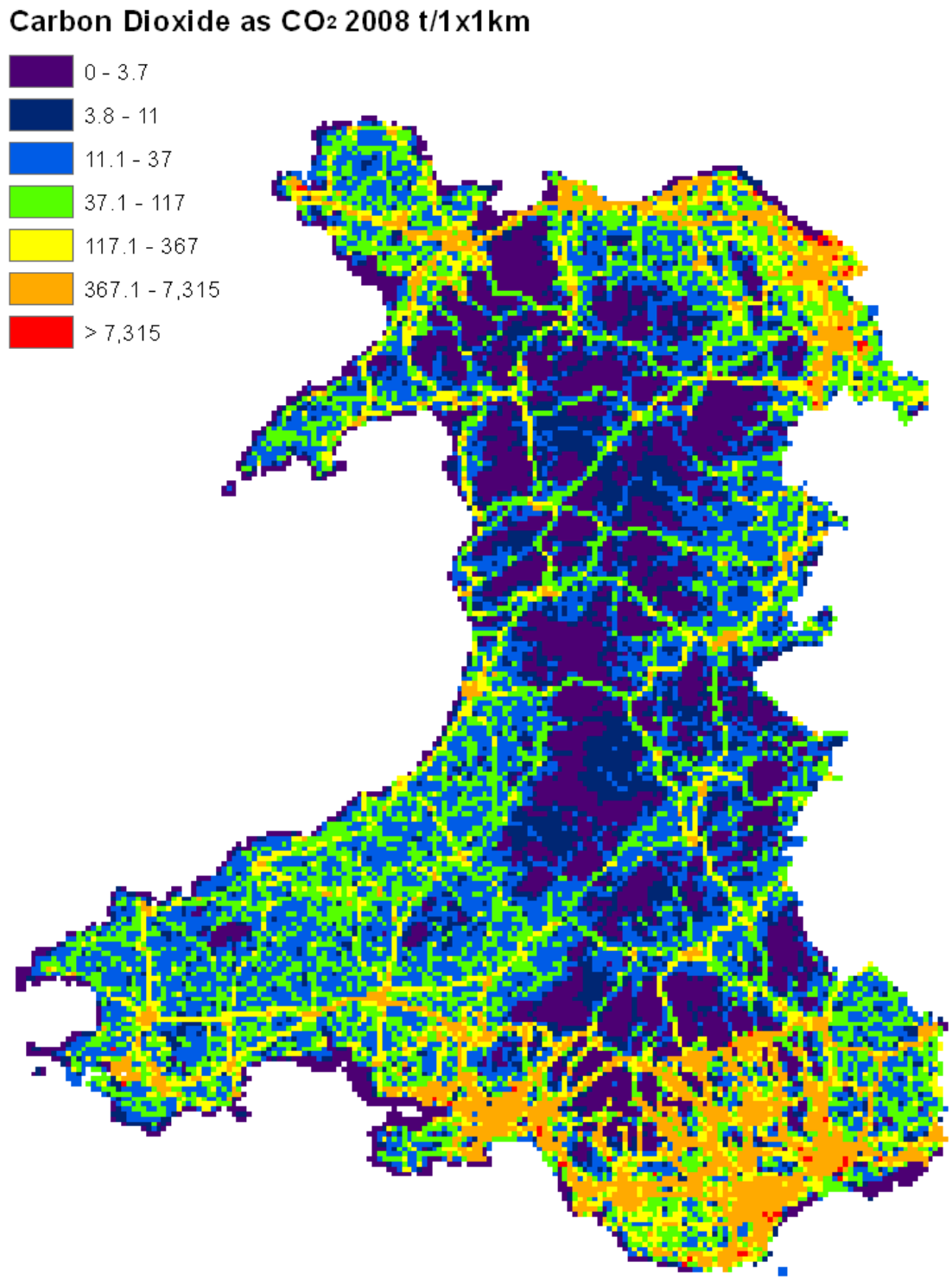


Figure 4.5 Map of Emissions of Methane (tonnes CO2 equivalent) in Wales in 2008

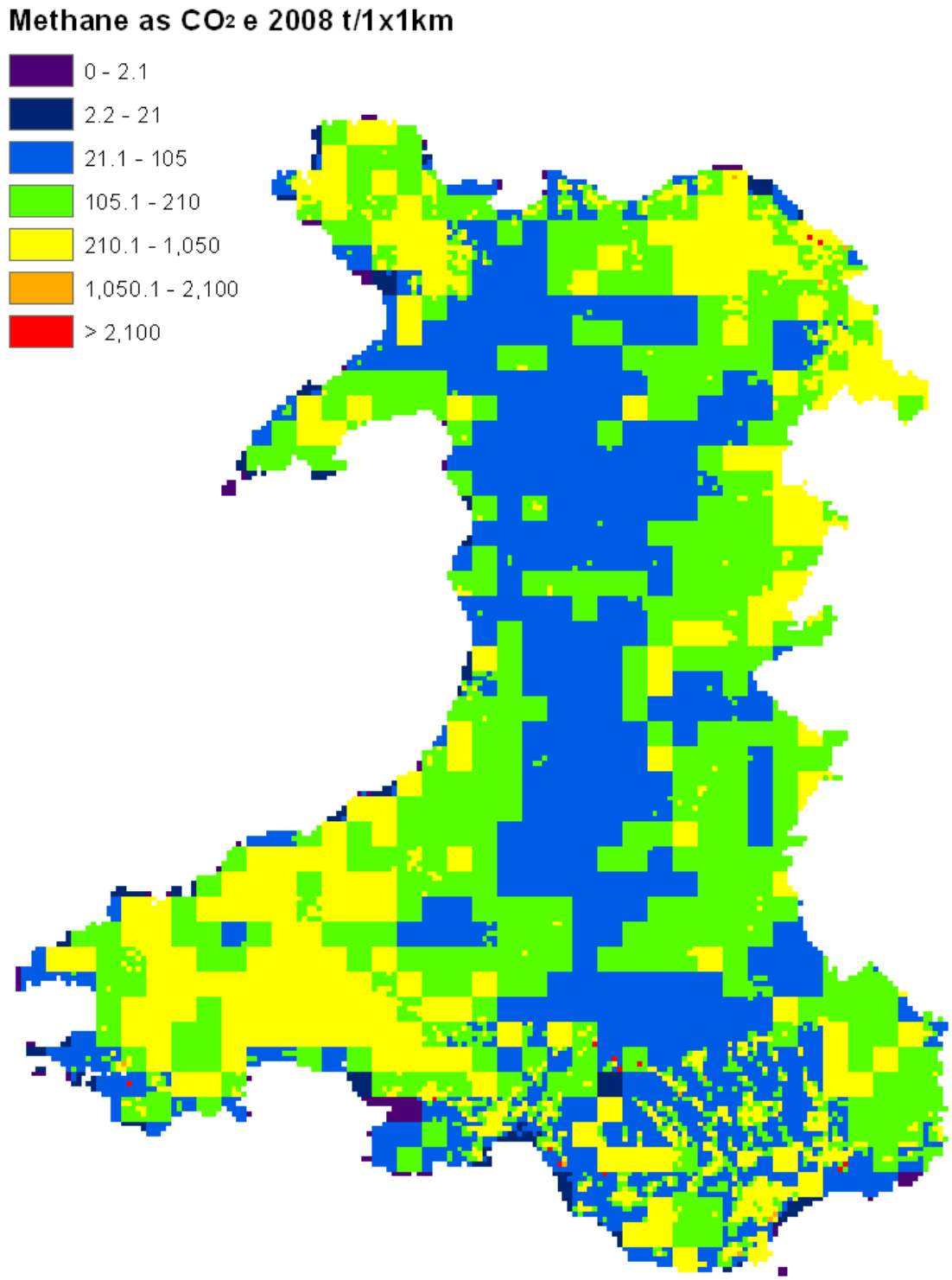
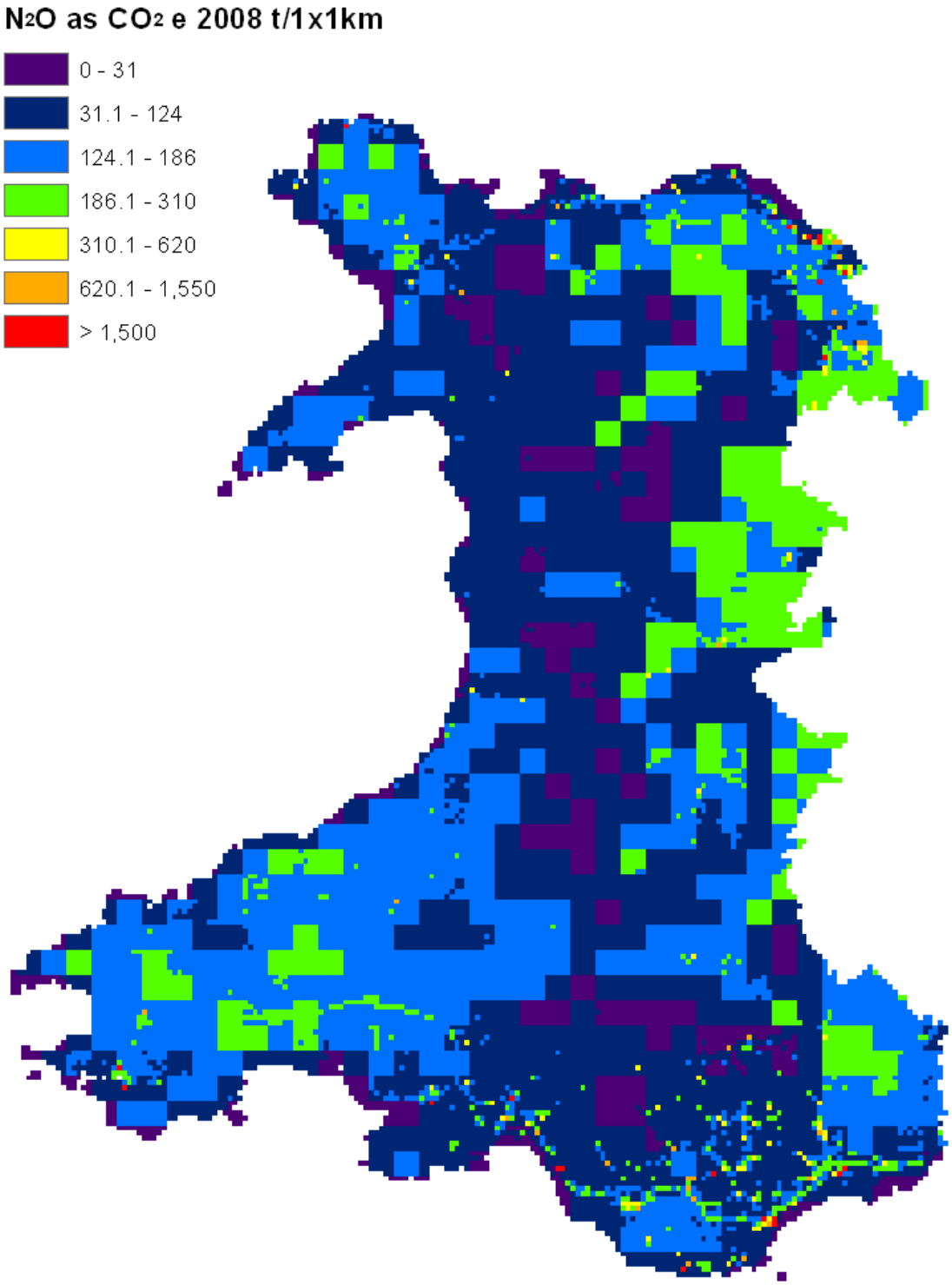


Figure 4.6 Map of Emissions of Nitrous Oxide (tonnes CO2 equivalent) in Wales in 2008



5 Emissions in Northern Ireland

5.1 Summary of GHG Emission Sources

The main GHG emission sources for Northern Ireland in 2008 are summarised in Table 5.1 below, expressed as a percentage of the total Northern Irish GHG emissions in 2008 of 22.2 Mt CO_2-equivalent. The trends in Northern Irish GHG emissions since the base years of 1990 (for CO_2, CH_4 and N_2O) and 1995 (for fluorinated gases) are as follows:

- CO_2 emissions have reduced by 6.7%
- CH_4 emissions have reduced by 23.8%
- N_2O emissions have reduced by 26.8%
- HFC emissions have increased by 650%
- PFC emissions have reduced by 89.3%
- SF_6 emissions have increased by 260.8%
- Total GHG emissions (as CO_2-equivalents) have reduced by 11.2%

Emissions in Northern Ireland are dominated by CO_2 from power stations, road transport and residential combustion, which together account for 59.6% of the total net greenhouse gas emissions. Agricultural sources, including N_2O from soils and CH_4 from enteric fermentation, in this sector all appear in the list of the ten largest sources.

Table 5.1 Emissions Summary for Northern Ireland, 2008 (kt CO_2e)

Summary of Main Emission Sources, Northern Ireland 2008 (kt CO_2e)				
Rank	Sector Name	IPCC code	Emission	Percentage of total GWP Weighted Emissions
1	Power Stations	1A1a	4885	22.0
2	Road Transport	1A3b	4601	20.7
3	Residential Combustion	1A4b	3885	17.5
4	Agricultural Soils	4D	1880	8.5
5	Enteric fermentation – Cattle	4A1	1869	8.4
6	Other Industrial Combustion	1A2f	1488	6.7
7	Land Converted to Cropland	5B2	1124	5.1
8	Landfill	6A1	788	3.6
9	Land Converted to Settlements	5E2	569	2.6
10	Cement - decarbonising	2A1	377	1.7

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 IPCC 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

In Northern Ireland, emissions from the Energy sector represent 73.2% of total greenhouse gas emissions. This is much lower than the UK average contribution from this sector, which in 2008 was 85.1%. 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 are slightly lower in 2007 and 2008 compared to 2006, but longer-term trends need to be observed to further understand the effects of the market changes.

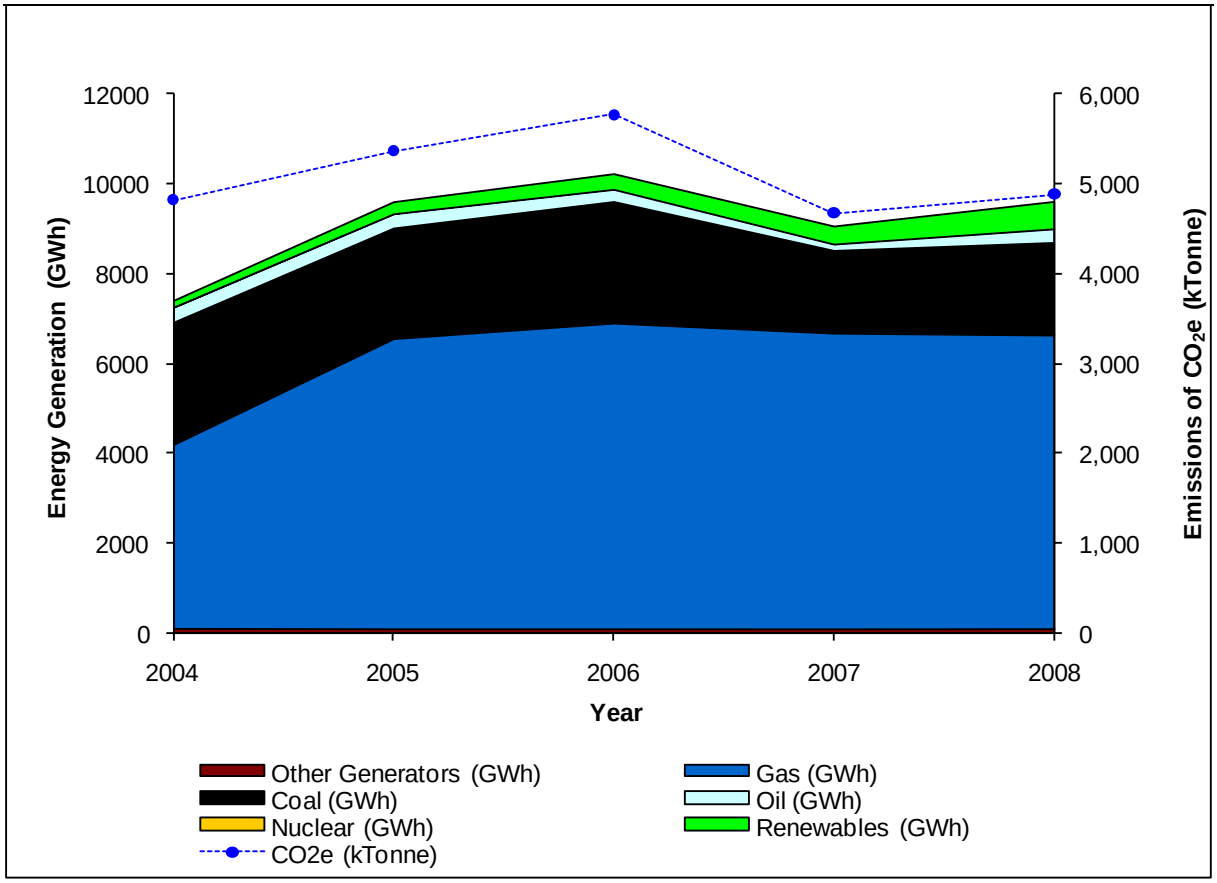
Power generation is the largest source of CO_2 in Northern Ireland, accounting for 30.1% of emissions in 2008. CO_2 emissions from power generation increased by 4.5% compared with 2007 emissions, mainly due to a 12% increase in coal-fired generation to 2,055 GWh, but have declined by 11% since 1990. GHG emissions from power generation also represent 30% of total emissions from the energy sector, and 22% of total GHG emissions in Northern Ireland in 2008.

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 CO_2 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.

Northern Ireland generates electricity that is 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, 2009b); in 2006, net exports from Northern Ireland amounted to 873 GWh of electricity, around 8.5% of all power generated in Northern Ireland. However in 2007 Northern Ireland was a net importer of electricity, importing 399 GWh of electricity, around 4% of all power generated in Northern Ireland. In 2008, Northern Ireland returned to being a net exporter of electricity, exporting 685 GWh of electricity, approximately 7% of all power generated in the country.

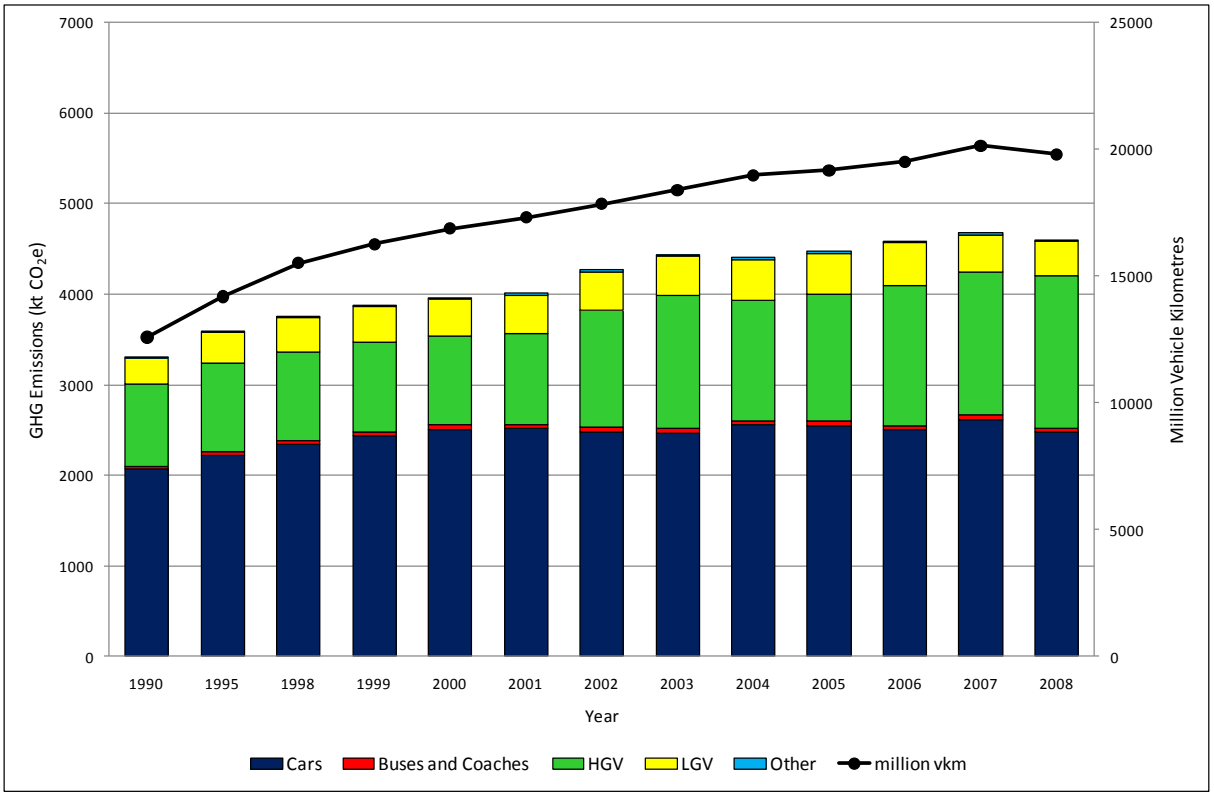
[*The Northern Ireland GHG "end user" emission estimates presented in Chapter 10 re-allocate the emissions from power stations where electricity is generated in Northern Ireland and then exported to be consumed in the Republic of Ireland, as well as accounting for electricity imports from Scotland*.]

Figure 5.1 Power Generation by Fuel and Cumulative GHG Emissions: Northern Ireland



Emissions from road transport represent 28.2% of the 2008 Northern Ireland CO_2 total, with emissions having risen by 39.5% since 1990 (Figure 5.2), compared with an 7.0% increase for the UK over the same period. Road transport also contributed 1.9% of total Northern Ireland N_2O emissions in 2008. The increases in road transport GHG emissions reflect a parallel increase in vehicle km travelled by road transport in Northern Ireland from 1990 to 2008 (see Figure 5.2). Cars represent the most significant source of CO_2 emissions from the road transport sector, contributing approximately 54% of CO_2 from the sector in 2008. HGVs contributed 36% of total Northern Ireland road transport CO_2 emissions in 2008, which is significantly higher than the UK average figure of 20%.

Figure 5.2 Total Road Traffic Vehicle km and GHG emissions from Different Vehicle Types: Northern Ireland, 1990 – 2008



Combustion emissions from Manufacturing Industry and Construction (IPCC Sector 1A2) account for 8.9% of the total Northern Ireland carbon dioxide emission in 2008 compared with 14.2% 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 2008, and has decreased by an estimated 30.7% over the period 1990-2008, compared with a UK average 23.4% 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.

Other combustion emissions arise from the domestic, commercial, public sectors and agriculture stationary combustion. Carbon dioxide emissions from domestic combustion sources are estimated to account for 23.4% of the Northern Ireland CO_2 total in 2008. As a proportion of UK domestic emissions they are estimated to represent 4.8%, which is much higher than would be expected from Northern Ireland's population (2.9% of UK population in 2008). 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 domestic CO_2 emissions have shown a decrease of 15.4% 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.

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 Industrial Processes

Total greenhouse gas emissions from industrial processes in Northern Ireland contribute 3.3% to the overall emissions total, and approximately 51% of these emissions are process CO_2 emissions attributed to the cement industry. There are no sources of methane or N_2O in this sector in Northern Ireland in 2008, and the remainder of the emissions in this sector are made up of smaller CO_2 emission sources, and emissions of HFCs, PFCs and SF_6.

Total emissions of HFCs from Northern Ireland in 2008 constituted 2.6% of the UK total (as CO_2 equivalent), and represent 39% of total greenhouse gas emissions in the Northern Ireland industrial process sector. Total HFC emissions in Northern Ireland have increased by over 650% since the 1995 base year, to approximately 292kt CO_2 equivalent in 2008, driven mainly by increased emissions from refrigeration and air conditioning units. The largest source of emissions in 2008 was refrigeration (including air conditioning), which contributed 62.5% of the Northern Ireland HFC total due to losses from refrigeration and air conditioning equipment during its manufacture and lifetime. Aerosols contributed 29.9% to the total Northern Irish HFC emission in 2008, the main sources being industrial aerosols and the medical application of metered dose inhalers. The remaining emission sources (foams, fire-fighting and solvents) contributed 7.5% of total Northern Irish HFC emissions.

Emissions of sulphur hexafluoride from Northern Ireland accounted for 1.0% of the UK total in 2008. The main sources of SF_6 emissions are leakage from the electronic insulation and the soles of certain brands of sports shoes. The use of SF_6 in the electronics industry in Northern Ireland is negligible.

5.4 Agriculture

Emissions from agriculture represent 20.8% of total greenhouse gas emissions in Northern Ireland in 2008, which is a much higher proportion than the UK average (7%). This is because there are fewer industrial 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. This source alone accounts for 56% 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 8% 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 agricultural CH_4 emissions decreased relative to 2007 by 1.4%.

The largest source of N_2O emissions is also in the agriculture sector. Emissions from agricultural soils (7.0 kt N_2O) account for 79.2% of the total Northern Irish N_2O emission in 2008. Northern Irish agricultural nitrous oxide emissions have fallen by 18.3% between 1990 and 2008, and decreased by 2.8% in 2008 relative to 2007. In 2008 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]

- Leaching of fertiliser nitrogen and applied animal manures to ground and surface water (29.2%)
- Wastes from grazing animals (27%)
- Synthetic fertiliser application (16.0%)
- Manure used as fertiliser (17%)
- Atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NOx) (8.2%)
- Ploughing in crop residues (1.3%)
- Improved grass (1.0%)
- Histosols (i.e. high organic content soils) (0.2%)
- Cultivation of legumes (0%)

Table 5.2 Livestock Emissions of Methane in Northern Ireland by Source in 2008 (kt CH_4)

Livestock Methane Emissions		
Category	Source	CH_4, kt
Total cattle	Wastes	13.35
	Enteric	89.00
Pigs	Wastes	2.84
	Enteric	0.60
Sheep	Wastes	0.22
	Enteric	9.24
Goats	Wastes	0.00
	Enteric	0.01
Horses	Wastes	0.02
	Enteric	0.21
Poultry	Wastes	1.32
	Enteric	0.00
Deer	Wastes	0.00
	Enteric	0.02

Table 5.3 Emissions of Nitrous Oxide from Agriculture in Northern Ireland by Source in 2008 (kt N_2O)

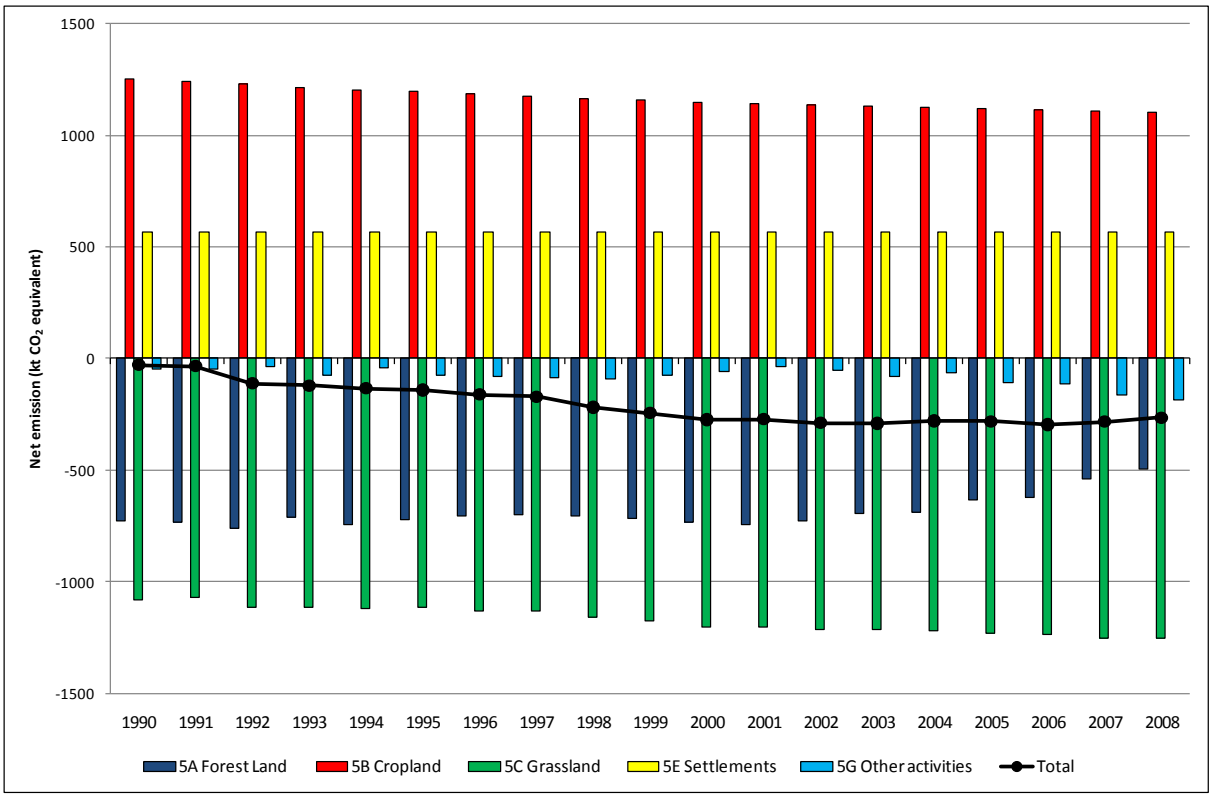
Agriculture N_2O emissions	
Source	N_2O, kt
Improved Grass	0.06
Legumes	0.00
Crop residues	0.08
Fertilisers	0.97
Histosols	0.01
Animal waste management systems	0.70
Organic fertiliser applied to soil	1.04
Grazing	1.64
Leaching	1.77
Atmospheric deposition	0.50

5.5 Land Use, Land Use Change and Forestry

The LULUCF sector includes carbon stock changes, emissions of greenhouse gases (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 carbon dioxide are conventionally presented as negative quantities.

Northern Ireland is a small net sink of carbon dioxide from LULUCF activities (Figure 5.3): the size of this sink has increased from -0.03 to -0.27 Mt CO_2 between 1990 and 2008. The Cropland net source (1.10 Mt CO_2 in 2008) and the Grassland net sink (-1.26 Mt CO_2 in 2008) are the largest contributors to the LULUCF sector in Northern Ireland.

Figure 5.3 LULUCF Inventory Emissions and Removals by Category in Northern Ireland, 1990 to 2008



Estimates of methane and nitrous oxide emissions due to LULUCF activities remain small: 0.0005 Mt CO_2 equivalent of methane and 0.0001 Mt CO_2 equivalent of nitrous oxide in 2008.

Net emissions from the LULUCF sector in 1990 and 2007 have not changed overall from the 2007 DA inventory report. There are minor differences of <0.001 Mt CO_2 between categories due to the updating of 2007 activity data for liming. A minor error in the area planted in Northern Ireland in 2007 (overestimated by 65 ha) was corrected, which led to a decrease in the carbon sink of -0.0002 Mt CO_2.

The annual land use matrices for 1990-1991 and 2007-2008 for Northern Ireland are shown here (Table 5.4 and Table 5.5). 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. The total area of Northern Ireland is reported as 1,325, 989 ha. This is 94% of the Standard Area Measurement reported by the Office of National Statistics (ONS 2007). It is thought that this difference is due to the way that areas of sea are dealt with in the land use change calculations, but areas of inland water might also be an issue: it should be possible to resolve this when new data is incorporated in the coming year. There is not thought to be any bias in the estimation of land use areas.

Table 5.4 Land Use Transition Matrix, ha, for Northern Ireland in 1990-1991

Land Use Transition Matrix (1990-1991)							
From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	69,343	3	1,623	0	0	0	**70,969**
Cropland	0	72,141	3,715	0	0	0	**75,855**
Grassland	0	5,872	1,064,992	0		0	**1,070,864**
Wetlands	0	0	0	0	0	0	0

Land Use Transition Matrix (1990-1991)							
From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Settlements	0	41	1,004	0	67,690	0	**68,734**
Other Land	0	0	0	0	0	39,567	**39,567**
Total (initial)	**69,343**	**78,056**	**1,071,333**	**0**	**67,690**	**39,567**	**1,325,989**

Table 5.5 Land Use Transition Matrix, ha, for Northern Ireland in 2007-2008

Land Use Transition Matrix (2007-2008)							
From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	83,888	1	548	0	0	0	**84,437**
Cropland		34,754	3,715	0	0	0	**38,469**
Grassland	0	5,872	1,071,157	0		0	**1,077,028**
Wetlands	0	0	0	0	0	0	0
Settlements	0	41	1,004	0	85,444	0	**86,488**
Other Land	0	0	0	0	0	39,567	**39,567**
Total (initial)	**83,888**	**40,667**	**1,076,423**	**0**	**85,444**	**39,567**	**1,325,989**

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 are shown in Table 5.6. The methods and assumptions used in these reported emissions are described in Chapter 11 and Annex 3.7 of the National Inventory Report.

Table 5.6 Greenhouse Gas Emissions and Removals from KP-LULUCF Activities in Northern Ireland, 2008

KP-LULUCF Activities		
Activity		Northern Ireland
3.3 Afforestation & Reforestation	Area, kha	14.58
	Net CO_2 emissions/removals, Gg CO_2	-142.98
	Emissions from biomass burning, Gg CO_2 eq.	NO
	N_2O emissions from N fertilization, Gg CO_2 eq.	0.01
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	66.00
	Net CO_2 emissions/removals, Gg CO_2	-346.37
	CO_2 emissions from biomass burning, Gg CO_2	5.97

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*. 2010). Planned improvements in the 2009 inventory are the restructuring of reporting in the different land use categories (this will improve consistency in the reporting of areas and will not affect overall emissions) and the incorporation of new activity data for peat extraction in Northern Ireland. It is planned to assimilate information on land use change from the latest Countryside Survey (Carey *et al*. 2008) into the inventory but progress on this has been slow.

5.6 Waste

Emissions from the waste sector represent 3.9% of total greenhouse gas emissions in Northern Ireland, and 3.8% of total UK waste emissions.

These emissions are dominated by methane emissions from landfills, which comprise 92% of total greenhouse gas 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 CH_4 release curve.

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 51% 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 N_2O emissions, representing 1.5% of total N_2O emissions in Northern Ireland in 2008.

5.7 Emission Maps: Northern Ireland 2008

As part of the NAEI, the UK produces mapped emissions of CO_2, CH_4 and N_2O. The maps are modelled estimates of emissions compiled at a 1 km^2 resolution and Figure 5.4 to Figure 5.6 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 (formerly BERR) 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 CH_4 and N_2O emissions from agricultural sources are generated at a 5 km^2 resolution by the Centre for Ecology and Hydrology (CEH), and are then resampled at a resolution of 1 km^2 by the NAEI mapping team.

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

http://www.naei.org.uk/mapping/mapping_2008.php

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

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

Figure 5.4 Map of Emissions of Carbon Dioxide (tonnes) in Northern Ireland in 2008

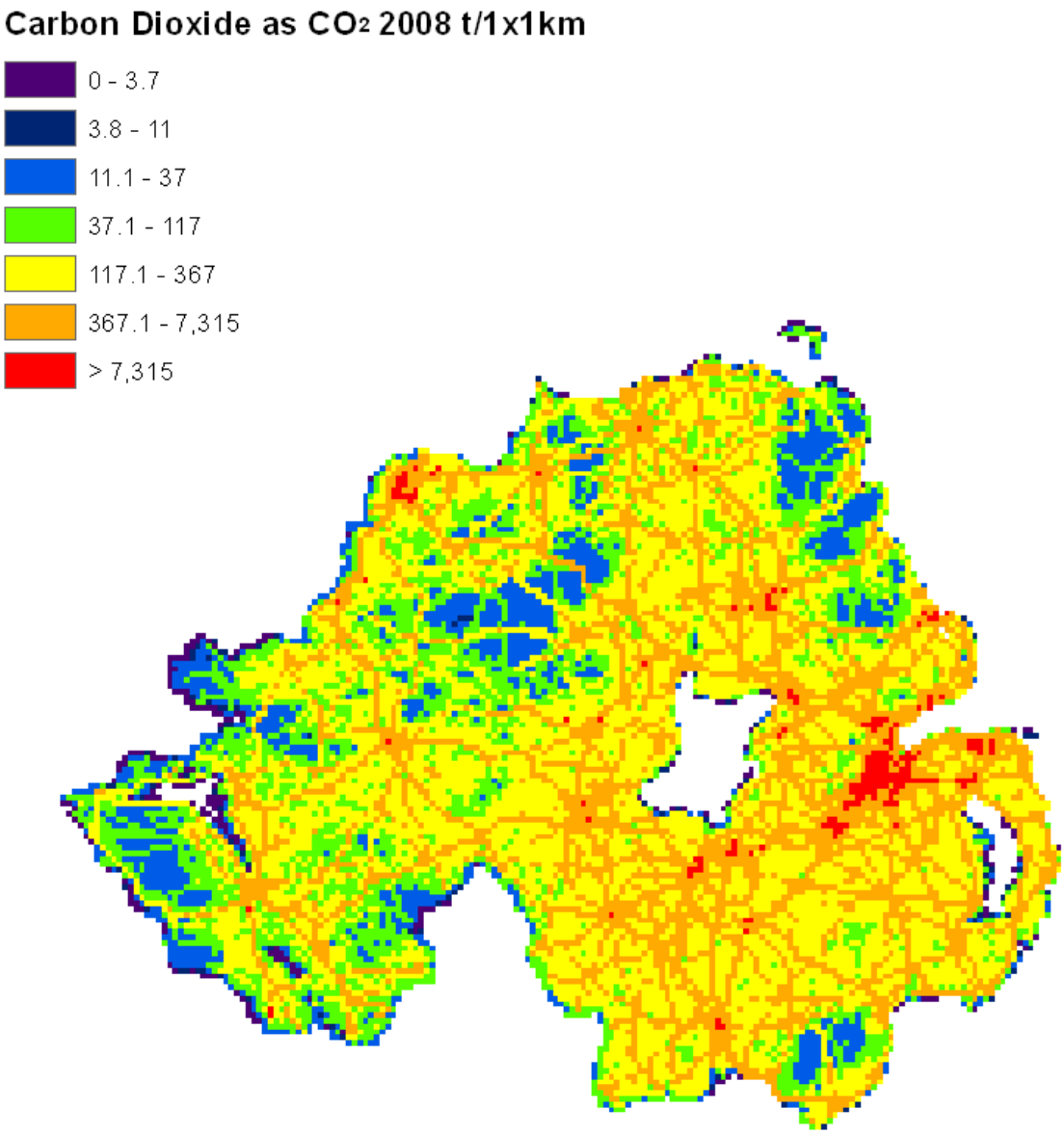


Figure 5.5 Map of Emissions of Methane (tonnes CO_2 equivalent) in Northern Ireland in 2008

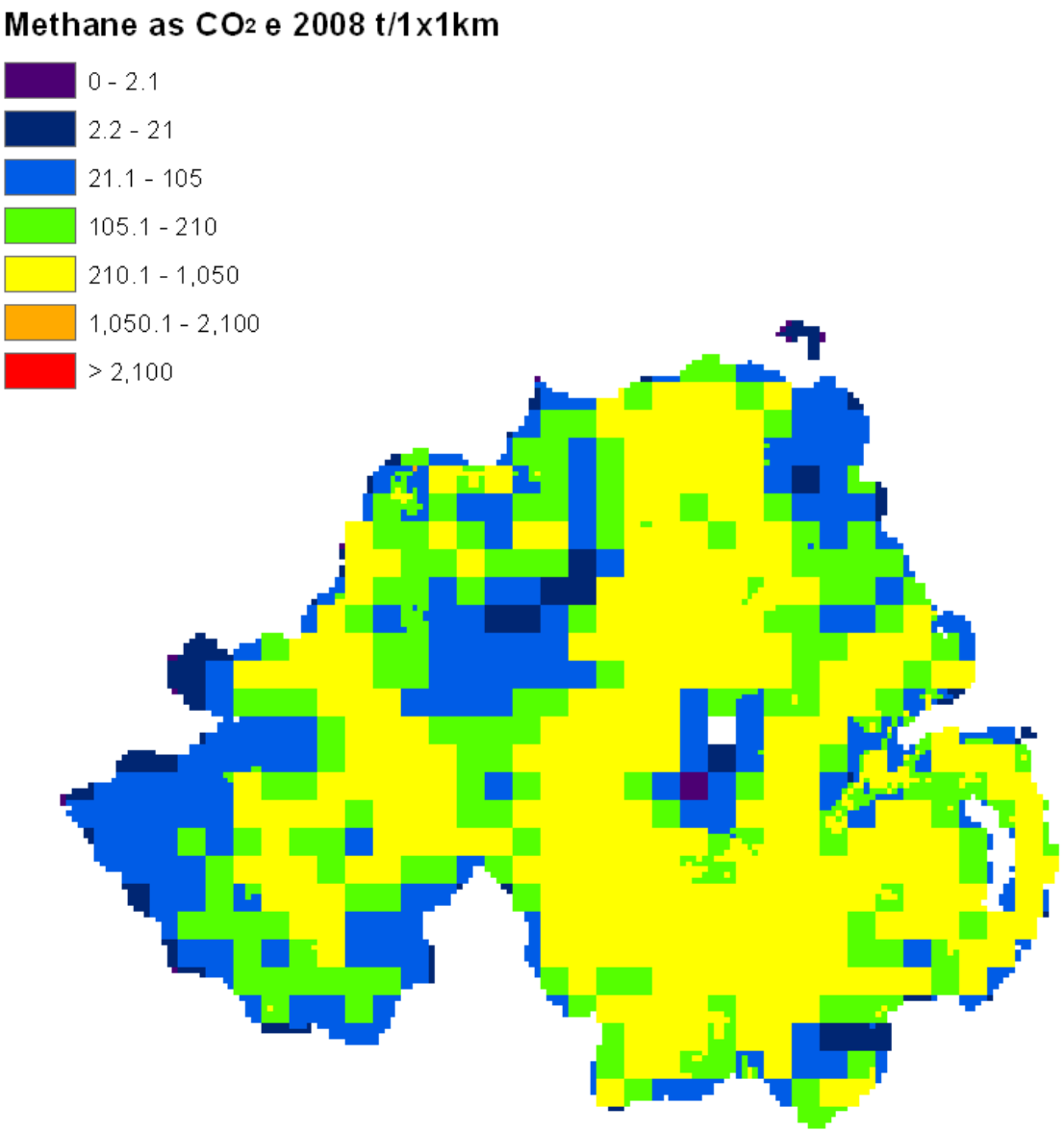
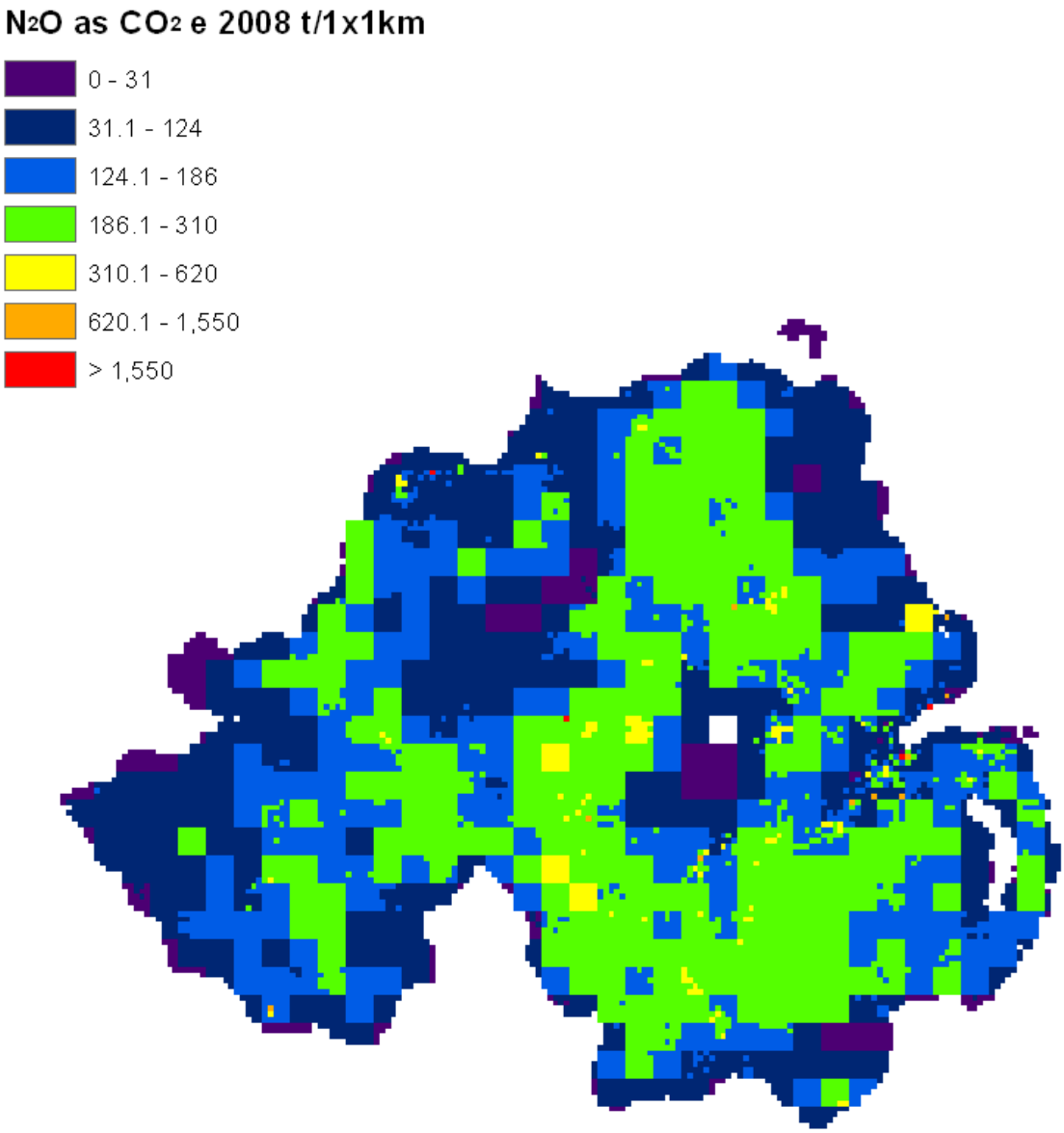


Figure 5.6 Map of Emissions of Nitrous Oxide (tonnes CO_2 equivalent) in Northern Ireland in 2008



6 Unallocated Emissions

Emissions from offshore oil and gas installations are accounted as “unallocated” emissions. The total “unallocated” emissions in 2008 account for 1.8% of UK emissions, this is a small decrease from the 1990 figure of 2.0%. As a proportion of the 2008 UK totals they account for the following:

- Carbon dioxide 2.8% (up 13.6% since 1990)
- Methane 1.8% (down 52% since 1990)
- Nitrous oxide 0.8% (up 21% 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 1990-2007 inventory cycle.

7.1 Data Available for DA GHG Inventory Compilation

In order to estimate a complete greenhouse gas 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 CO_2, CH_4 and N_2O) and 1995 (for fluorinated gases). Since 2005, the EU Emissions Trading Scheme (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 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** (Defra and the DA Governments);
- **Industrial Processes & Large Combustion Plant** (For high-emitting sites, site-specific data are available from producers, trade associations, the Environment Agency's Pollution Inventory, the Scottish Environmental Protection Agency's SPRI and the Northern Ireland Environment Agency's ISR, as well as from the EU Emissions Trading Scheme.); and
- **Road Transport** (DfT and DRDNI) Detailed road count point data are available for major roads across the DAs. Estimates are made based on assessments of vehicle kilometre data, broken down at detailed vehicle-type level. Some improvements may be possible if more detail regarding local fleet composition was to be made available.

7.1.2 Fuel Consumption

The availability of data across this wide-ranging sector of activity is very variable. The basis for all of the UK NAEI fuel consumption data are the *Digest of UK Energy Statistics* (DECC, 2009a), 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, whilst Phoenix Gas and Firmus Energy provide data for natural gas consumption in Northern

Ireland disaggregated by type of consumer into domestic and non-domestic. Therefore for each constituent country the overall gas consumption data is of good quality, but there is limited information to inform the allocation of gas use to a specific sector in each country.

Fuel consumption within the iron and steel industry is documented by *Iron and Steel Industry Statistics* (ISSB, 2009). 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 EU Emissions Trading Scheme (EU ETS) for power generation and other large combustion sources, although the scope of reporting to date is limited in some energy-intensive sectors due to EU-ETS opt-outs.

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 EU ETS data for refineries has been used to improve the UK and DA inventories (see section 7.3.1 Industry Sector Task).

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 2007 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.

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 usefulness of these statistics is somewhat unclear, as 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.

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 Regional 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 Regional 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.

Regional energy statistics are published annually by the Department for Energy and Climate Change (DECC) within the quarterly *Energy Trends*[13] publication. These regional 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 & Commercial;
- Agriculture; and
- Residential.

The DECC regional energy statistics have been developed in recent years to provide estimates of fuel use and CO_2 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 2007, with gas and electricity data also available up to 2008.

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 Regional 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 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 Devolved Administrations and are therefore used to underpin the CO_2 emission estimates from fuel combustion sources within the inventories presented here, in conjunction with other data sources such as EU ETS fuel use data for large industrial sites and other DA-specific energy data.

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

- The DECC regional energy data only cover recent years in the time-series (2003 to 2008). 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 likely DA trends since 1990;

- The availability and detail of local energy use data is evolving as demands for new local and regional energy use data are developing. Comparison of the regional energy data available from DECC during the 1990-2008 DA GHGI compilation has highlighted a number of inconsistencies between reported UK and local data, for which comprehensive solutions have not been found. Notably the local authority gas use data presented within the periodic DECC publication, 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

[13] The latest available data are taken from the December 2009 Energy Trends: http://www.decc.gov.uk/en/content/cms/statistics/publications/trends/trends.aspx

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. Analysis of major installation gas use from EU-ETS 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

- The starting point for the regional energy calculations is gas and electricity meter data provided by fuel suppliers. 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 (Jackson *et al* 2009) due to: (i) revisions to methodologies and source data within the UK GHG inventory, and (ii) through revisions to available data at local and regional level such as revised local energy data within the DECC Regional 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* 2010).

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 these changes at DA and UK level.

Table 7.1 Summary of the impact of recalculations by gas (2008 inventory estimate - 2007 inventory estimate, as kt CO_2 e)

Summary of recalculations by gas					
DA	GHG	Base Year	2005	2006	2007
England	CO_2	-118	77	-332	-122
	CH_4	29	363	179	273
	N_2O	359	295	195	298
	HFCs	-91	241	711	1,169
	PFCs	-7	4	4	3
	SF_6	0	0	0	0
England Total		172	980	756	1,620
Scotland	CO_2	68	237	352	519
	CH_4	32	19	-17	81
	N_2O	75	74	57	78
	HFCs	-10	25	69	113
	PFCs	-1	0	0	0
	SF_6	0	0	0	0
Scotland Total		165	356	462	791
Wales	CO_2	5	306	253	418
	CH_4	0	35	-15	-15
	N_2O	43	45	26	46
	HFCs	-5	15	36	56
	PFCs	0	0	0	2
	SF6_C_equiv	0	0	0	0
Wales Total		44	400	300	507
Northern Ireland	CO_2	-27	142	98	343
	CH_4	38	54	8	54
	N_2O	61	46	43	63
	HFCs	-2	9	22	35
	PFCs	0	0	0	0
	SF_6	0	0	0	0
Northern Ireland Total		70	252	172	495
Unallocated	CO_2	0	0	0	-154
	CH_4	0	0	0	8
	N_2O	0	0	0	2
	HFCs	0	0	0	0
	PFCs	0	0	0	0
	SF_6	0	0	0	0
Unallocated Total		0	0	0	-143
UK	CO_2	-72	762	372	1,004
	CH_4	99	470	154	401
	N_2O	539	461	320	486
	HFCs	-107	290	839	1,373
	PFCs	-9	5	4	5
	SF_6	0	0	0	0
UK Total		450	1,988	1,690	3,270

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

The major changes for non-CO_2 greenhouse gases are mostly down to a large change for one or two sources. As an overview, these changes are summarised below:

CH_4 – changes to methane emissions across the time series have arisen predominantly through changes to the dairy cattle weight assumptions used in the calculation of emission factors for enteric fermentation and emissions from animal wastes. In addition, a Tier 2 calculation has been used for beef cattle for the first time. These changes have been made as part of ongoing improvements to the agriculture inventory.

N_2O – there has been an increase in N_2O emissions across the time series, affecting all DAs. This is almost exclusively due to changes in the estimates for N_2O emissions from animal waste management systems. The calculation has been improved so that the nitrogen excretion rate is not corrected for N-volatilisation. This follows a recommendation from the UNFCCC expert review team. This change has affected all DAs.

HFCs – the refrigeration model was reviewed and extensively updated during the 1990-2008 inventory cycle. The estimates now make use of a new data source – refrigerant sales data. The use of these new data has led to an increase in emissions estimates for the latter part of the time series, and a modest decrease in the Base Year. This change has affected all DAs.

PFCs – a small emission of PFCs also arises from the refrigeration sector, and therefore emissions of this gas have been revised as part of the review of the model, affecting all DAs. A review of the time series of emissions from smaller PFC sources also indicated that emissions from fire extinguishers were assumed to stop occurring earlier in the time series and this assumption has now been revised. A revised estimate of PFC emissions from one of the aluminium plant operators has led to a more significant revision to PFC estimates for Wales in 2007.

SF_6 – no significant changes have been made.

For CO_2, there is not one single major change, rather a combination of a number of changes across numerous 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 CO_2e; the reasons for changes listed, however, consider the effects of individual GHGs on the change in CO_2e.

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

Table 7.2 Reasons for changes at UK level

Revisions summary		Magnitude of change (2008 estimate – 2007 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2005	2006	2007
1A1a	Revisions to energy statistics (DUKES) for natural gas and coal. Emission factors for natural gas have been revised for 2005, 2006 and 2007 based on revisions to the analysis of EU ETS data. These major revisions only affect 2005 onwards. Smaller changes across the time series include the impact of changing the emission factor for scrap tyres used for combustion in the cement industry in line with new data from the BCA.	1	250	736	436
1A1b	Revised method for petroleum coke use to ensure consistency with EU ETS data. This uses both activity data and emission factors from the EU ETS data, since we believe this is a more accurate data set. Revised activity statistics from DUKES for both natural gas (down, in 2006 and 2007) and OPG (down, 2007 only). Revised methane and nitrous oxide emission factors for coal, fuel oil and gas oil. These changes only affect 2005 onwards.	0	254	-119	643
1A1c	Revised carbon emission factor for offshore own gas use. Small revisions to emission factors for methane and nitrous oxide. This is based on data revisions from the EEMS reporting system. These changes only affect 2006 onwards.	0	0	-50	-113
1A2a	Revised activity statistics for fuel oil (revisions to the allocation of autogenerator fuels to this sector, DUKES), revised carbon emission factor for blast furnace gas.	0	109	113	105
1A2f	Method improvements for off road mobile machinery to incorporate more recent driver data for estimating the populations of equipment, and to better reflect the impact of progressive regulation for this sector. This affects the full time series, with the most significant changes from 2004 onwards. Activity data revisions have been made for autogenerators (DUKES, 2006 and 2007), and activity data revisions and reallocations between the UK and Crown Dependencies (CDs) for other industrial combustion have been made, based on further research into fuel use in the CDs (full time series).	12	-43	-724	-19
1A3a	Improvements to the aviation model (based on the outcomes of the Project for the Sustainable Development of Heathrow), to revise the take-off and landing cycle emission profiles of different aviation engines. This has led to changes to the allocation of emissions between domestic and international. In addition, a correction to aviation spirit consumption that was erroneously allocated to the Crown Dependencies has been re-allocated to the UK. This impacts the whole time series.	122	254	213	222
1A3b	Revised assumptions have been incorporated into the road transport model, including new methane emission factors, revised vehicle km statistics, catalytic failure rates, and the effects of accumulative mileage. Revised allocation of emissions between the UK and Crown Dependencies. This impacts the full time series of emissions.	-143	-156	-125	-189
1A3c	Revised activity data for freight rail from the Office of Rail Regulation's National Rail Trends Yearbook. This affects the whole time series.	-10	0	-12	-79

Table 7.2 Reasons for changes at UK level (continued)

Revisions summary		Magnitude of change (2008 estimate – 2007 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2005	2006	2007
1A3e	New activity drivers used for estimating equipment populations within the off road machinery model, and improvements to the incorporation of emission regulations by machinery classes.	-49	11	17	22
1A4a	Revisions to activity statistics for fuel oil, gas oil and natural gas. Estimates for gas oil are affected by reallocations between sectors following updates to fuel allocations for rail and off road. This affects the whole time series.	17	-46	-12	-89
1A4b	Revisions to activity statistics in DUKES (particularly natural gas in 2006 and 2007), changes to the off road machinery model (see 1A3e), changes to emissions from the Isle of Man (resulting in reallocations from the UK). These changes affect the full time series, although the largest change is as a result of the revisions to natural gas use in 2007.	-107	-94	85	499
1A4c	New activity drivers used for estimating equipment populations within the off road machinery model, and improvements to the incorporation of emission regulations by machinery classes. This affects the full time series, with the largest changes from 2005 onwards.	17	145	60	42
1A5b	Revised fuel use for both military aviation and naval shipping supplied by the Defence Fuels Group.	0	-53	76	-621
1B1b	No change	0	0	0	0
1B2a	Revised methane emissions from offshore oil and gas processes, based on EEMS data. Only affects 2007.	0	0	0	4
1B2b	New estimate for CO_2 from natural gas leakage based on a recommendation from the UNFCCC's Expert Review Team, inclusion of an estimate of both methane and CO_2 for Northern Ireland for the first time.	18	11	11	10
1B2c_Flaring	Revised data from the offshore operators within EEMS. Only affects 2007.	0	0	0	-19
1B2c_Venting	Revised data from the offshore operators within EEMS. Only affects 2007.	0	0	0	3
2A1	No change.	0	0	0	0
2A2	Replacement of provisional data for final data in 2007.	0	0	0	187
2A3	New activity data used for limestone and dolomite in glass manufacture. This change has been made since the time series of data used previously was considered to be both uncertain and incomplete. This affects the time series from 1999 onwards.	0	150	104	105
2A4	Revised glass production statistics in 2007.	0	0	0	-22
2B5	Minor revision to statistics for detergent use in 2007.	0	0	0	-3
2C1	Revised carbon emission factor for blast furnace gas.	0	1	1	1
2C3	Revised data from plant operators. This affects the UK total for PFCs in 2007, and the DA disaggregation for 2005-2007.	0	0	0	2
2F1	Emissions from refrigeration revised as part of an HFC forecasting project, taking into account new data for refrigerant sales. This is a major improvement to the HFC estimates for this sector.	-116	278	827	1360

Table 7.2 Reasons for changes at UK level (continued)

Revisions summary		Magnitude of change (2008 estimate – 2007 estimate), kt CO_2e			
IPCC Sector	UK Method and Data Revisions	Base Year	2005	2006	2007
2F2	Emissions from foams revised as part of the HFC forecasting project.	0	15	15	17
4A1, 4B1	Major revision to emission factors for cattle, based on new slaughter weight data for dairy cattle, and a Tier 2 calculation for other cattle. The use of a Tier 2 calculation for other cattle was recommended by the UNFCCC Expert Review Team. The change in cattle weights used for dairy cattle is a result of new data being identified, covering the full timeseries. These changes affect the full time series.	158	478	148	381
4B12, 4B13, 4B14	Revisions to nitrous oxide emissions to use nitrogen excretion rates not corrected for N volatilisation. This was identified by the UNFCCC Expert Review Team. These revisions affect the full time series.	538	431	417	431
4D	Change to emissions from farm animal waste, resulting from changes to the nitrogen excretion rates (see the note above).	-8	-19	-86	42
5A2	Correction of an error in the conifer afforestation rate. This only affects 2007.	0	0	0	0
5B1	Provisional data in 2007 replaced with finalised data for liming of cropland.	0	0	0	62
5C1	Provisional data in 2007 replaced with finalised data for liming of grassland.	0	0	0	-128
5C2, 5E, 5E2	Change to activity data for forest land converted to settlements. This affects the time series from 2005 to 2007.	0	-10	-13	-14
5G	Change to activity data for forest land converted to settlements which affects the amount of products from deforestation that enter the Harvested Wood Products pool. This affects the time series from 2005 to 2007.	0	6	8	8
6A1	Small change to resolve calculation rounding errors.	0	-10	4	0
6B2	Revision to time series of protein consumption.	0	24	-9	-20
6C	Revised estimate for chemical waste incineration, based on revised activity data supplied by the Environment Agency.	0	0	5	3

Table 7.3 Reasons for changes - England

Revisions summary		Magnitude of change (2008 estimate – 2007 estimate), kt CO_2e			
IPCC Sector	DA Specific Method and Data Revisions	Base Year	2005	2006	2007
1A1a	No change to method. Changes are as a result of revisions at UK level.	1	118	604	377
1A1b	No change to method. Changes are as a result of revisions at UK level.	0	180	-84	433
1A1c	Small revision to gas production data for one site in England across several years. Revision to 2007 ISSB regional data on coal use in coke ovens.	0	2	-29	25

Table 7.3 Reasons for changes – England (continued)

Revisions summary		Magnitude of change (2008 estimate – 2007 estimate), kt CO_2e			
IPCC Sector	DA Specific Method and Data Revisions	Base Year	2005	2006	2007
1A2a	No change to method. Changes are as a result of revisions at UK level.	0	100	115	107
1A2f	Revisions to the DA disaggregation are due to the use of EUETS Phase II data (which includes a wider scope of sites), and the industry improvement task, both of which have enabled revision of point source analysis for recent years of the timeseries. Allocation of cement emissions was corrected for 2005 onwards, to remove a double-count at one site in England.	-3	-342	-1163	-704
1A3a	No change to DA method, but the changes to the UK aviation model have impacted differently across the DA inventories, according to the aviation fleet and CAA flight data.	87	224	190	176
1A3b	The UK-wide revisions to fuel consumption-speed relationships used for individual vehicle types have led to changes in the contributions made by each vehicle class to emissions in each DA.	-229	-76	-105	-34
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.	-7	0	-9	-50
1A3e	No change to method. Changes are as a result of revisions at UK level.	-40	8	13	17
1A4a	Revision to gas use allocation in Northern Ireland from 2005 onwards, due to new information for recent years from fuel suppliers. Analysis of point source and area source data for recent years has led to a small re-allocation of gas use in both Scotland and Wales, decreasing the allocation to the commercial sector and increasing the allocation to the public sector across the time series. Changes to assumptions for the other DAs leads to changes in the allocation to England.	32	7	26	-70
1A4b	Correction to error in DA allocation of anthracite in 2006 and 2007 in the previous inventory calculations (now higher in England and Wales, lower in Scotland and N Ireland). Revision to recent trend in oil use in this sector in N Ireland due to HECA data showing a continuing growth in oil use in the sector, partly offset by a small increase in gas use and solid fuel use; this affects the 2007 estimate significantly, now showing a much smaller decline in oil use in the sector than reported previously. Recent revision to energy mapping grids in GB only have led to revisions in the allocation of solid fuel use in recent years (higher coal use in Scotland and Wales, lower in England), based on use of more recent census data and integration of the DEMScot model to the energy mapping analysis for the sector. The revision to GB energy modelling has also led to a slight re-allocation of oil use in the sector, with small increases in the GB share for Scotland and Wales.	-31	-288	-103	-20
1A4c	No change to method. Changes are as a result of revisions at UK level.	10	85	35	25
1A5b	No change to method. Changes are as a result of revisions at UK level.	0	-46	65	-533
1B1b	Small revision to ISSB stats, leading to higher emissions in England in 2007.	0	0	0	1
1B2a	Revisions to EEMS data leading to small increases in emissions in England in 2007.	0	0	0	3

Table 7.3 Reasons for changes – England (continued)

Revisions summary		Magnitude of change (2008 estimate – 2007 estimate), kt CO_2e			
IPCC Sector	DA Specific Method and Data Revisions	Base Year	2005	2006	2007
1B2b	No change in method. Correction to error in data calculations for leakage within GB, resolving a previous under-report in England and over-report in Wales and Scotland for 2005 onwards only.	16	78	76	54
1B2c_Flaring	Revisions to EEMS data, following Industry improvement task, leading to increase in England 2007 emissions, and reduced Scottish 2007 emissions.	0	0	0	16
1B2c_Venting	Minor revisions to EEMS data.	0	0	0	0
2A1	Correction to allocation of cement emissions for 2005 onwards, to remove a double-count at one site in England, due to availability of full detail of sector emissions through EUETS reporting.	0	-63	-69	-70
2A2	No change to DA method. The UK revision affects England only.	0	0	0	187
2A3	Access to EUETS data has enabled revisions to glass sector emissions for recent years at a site-specific level. Small revisions to ISSB stats also affect the Wales and England inventories.	0	121	92	88
2A4	Revisions in recent years to data for sites in England have led to some small emission revisions.	0	4	9	-13
2B5	Minor revisions to the DA split for chemical industry emissions, based on point source data.	0	1	2	-2
2C1	No change to method. Changes are as a result of revisions at UK level.	0	1	0	1
2C3	Small revisions to emissions from sites in England in 2005 and 2006.	0	39	53	0
2F1	No change in method. Slight variation between DAs in the overall impact of UK data revisions.	-98	231	701	1157
2F2	No change to DA method.	0	13	12	14
4A1, 4B1	No change to method. Changes are as a result of revisions at UK level.	94	300	96	219
4B12, 4B13, 4B14	No change to method. Changes are as a result of revisions at UK level.	363	274	267	272
4D	No change to method. Changes are as a result of revisions at UK level.	-6	-5	-53	27
5A2	No change in DA method.	0	0	0	0
5B1	No change in DA method.	0	0	0	19
5C1	No change in DA method.	0	0	0	-94
5C2, 5E, 5E2	Revisions to England data from 2005 onwards. Other DAs have very minor revisions.	0	-8	-9	-10
5G	Revisions to England data from 2005 onwards. Other DAs have very minor revisions.	0	5	6	6
6A1	Minor revisions across the time-series, based on data from Waste Data Flow.	-16	-4	21	10
6B2	No change in DA method.	0	20	-7	-17
6C	Revisions to England data in 2006 and 2007. (UK level changes only affect England).	0	0	5	3

Table 7.4 Reasons for changes – Scotland

Revisions summary		Magnitude of change (2008 estimate – 2007 estimate), kt CO_2e			
IPCC Sector	DA Specific Method and Data Revisions	Base Year	2005	2006	2007
1A1a	No change to method. Changes are as a result of revisions at UK level.	0	-191	-4	6
1A1b	No change to method. Changes are as a result of revisions at UK level.	0	34	-19	85
1A1c	Mainly the impact of changes at UK level. The DA disaggregation has been revised to account for a small revision to gas production data for one site in England across several years, and revision to 2007 ISSB regional data on coal use in coke ovens.	0	-2	-20	-21
1A2a	No change to method. Changes are as a result of revisions at UK level.	0	0	2	0
1A2f	Revisions are due to the use of EUETS Phase II data (which includes a wider scope of sites), and the industry improvement task, both of which have enabled revision of point source analysis for recent years of the time series. The 2008 EUETS data provides indications of more sites using gas in industrial sectors in Wales and Scotland than previously estimated.	8	196	220	353
1A3a	No change to DA method, but the changes to the UK aviation model have impacted differently across the DA inventories, according to the aviation fleet and CAA flight data.	24	16	19	33
1A3b	The UK-wide revisions to fuel consumption-speed relationships used for individual vehicle types have led to changes in the contributions made by each vehicle class to emissions in each DA.	51	67	141	56
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	-1	-17
1A3e	No change to method. Changes are as a result of revisions at UK level.	-7	2	3	4
1A4a	Analysis of point source and area source data for recent years has led to a small re-allocation of gas use in both Scotland and Wales, decreasing the allocation to the commercial sector and increasing the allocation to the public sector across the time series. Revision to gas use allocation in Northern Ireland from 2005 onwards, due to new information for recent years from fuel suppliers. Changes to assumptions for the other DAs leads to changes in the allocation to Scotland	-12	-6	-3	1
1A4b	Recent revision to energy mapping grids in GB only have led to revisions in the allocation of solid fuel use in recent years (higher coal use in Scotland), based on use of more recent census data and integration of the DEMScot model to the energy mapping analysis for the sector. The revision to GB energy modelling has also led to a slight re-allocation of oil use in the sector, with small increases in the GB share for Scotland. Correction to error in DA allocation of anthracite in 2006 and 2007 in the previous inventory calculations (now lower in Scotland).	-2	74	-6	42
1A4c	No change to method. Changes are as a result of revisions at UK level.	3	26	11	8
1A5b	No change to method. Changes are as a result of revisions at UK level.	0	-4	6	-50
1B1b	No change	0	0	0	0

Table 7.4 Reasons for changes – Scotland (continued)

Revisions summary		Magnitude of change (2008 estimate – 2007 estimate), kt CO_2e			
IPCC Sector	DA Specific Method and Data Revisions	Base Year	2005	2006	2007
1B2a	No change	0	0	0	0
1B2b	No change in DA method. Correction to error in data calculations for leakage within GB, resolving a previous under-report in England and over-report in Wales and Scotland for 2005 onwards only.	1	-38	-37	14
1B2c_Flaring	Revisions to EEMS data, following Industry improvement task, leading to increase in England 2007 emissions, and reduced Scottish 2007 emissions.	0	0	0	-1
1B2c_Venting	Minor revisions to EEMS data.	0	0	0	0
2A1	Correction to allocation of cement emissions for 2005 onwards, to remove a double-count at one site in England, due to availability of full detail of sector emissions through EUETS reporting.	0	20	21	19
2A2	No change	0	0	0	0
2A3	Access to EUETS data has enabled revisions to glass sector emissions for recent years at a site-specific level, increasing estimates for Scotland and N Ireland.	0	16	11	13
2A4	Revisions in recent years to data for sites in Scotland have led to some small emission revisions.	0	-1	-1	-1
2B5	Minor revisions to the DA split for chemical industry emissions, based on point source data.	0	0	-2	0
2C1	No change	0	0	0	0
2C3	Small revisions to reported emissions from sites in Scotland in 2005 and 2006.	0	-6	-16	0
2F1	No change in method. Slight variation between DAs in the overall impact of UK data revisions.	-11	24	68	112
2F2	No change to DA method.	0	1	1	1
4A1, 4B1	No change to method. Changes are as a result of revisions at UK level.	26	59	17	59
4B12, 4B13, 4B14	No change to method. Changes are as a result of revisions at UK level.	74	68	64	66
4D	No change to method. Changes are as a result of revisions at UK level.	0	0	-12	7
5A2	No change in DA method.	0	0	0	0
5B1	No change in DA method.	0	0	0	43
5C1	No change in DA method.	0	0	0	-35
5C2, 5E, 5E2	Revisions to England data from 2005 onwards. Other DAs have very minor revisions.	0	-2	-3	-3
5G	Revisions to England data from 2005 onwards. Other DAs have very minor revisions.	0	1	2	2
6A1	Minor revisions across the time-series, based on data from Waste Data Flow.	11	-2	-1	0
6B2	No change in DA method.	0	2	-1	-2
6C	No change	0	0	0	0

Table 7.5 Reasons for changes – Wales

Revisions summary		Magnitude of change (2008 estimate – 2007 estimate), kt CO_2e			
IPCC Sector	DA Specific Method and Data Revisions	Base Year	2005	2006	2007
1A1a	No change to method. Changes are as a result of revisions at UK level.	0	296	93	37
1A1b	No change to method. Changes are as a result of revisions at UK level.	0	40	-16	125
1A1c	Mainly the impact of changes at UK level. The DA disaggregation has been revised to account for a small revision to gas production data for one site in England across several years, and revision to 2007 ISSB regional data on coal use in coke ovens.	0	0	-1	-4
1A2a	No change to method. Changes are as a result of revisions at UK level.	0	8	-4	-2
1A2f	Revisions are due to the use of EUETS Phase II data (which includes a wider scope of sites), and the industry improvement task, both of which have enabled revision of point source analysis for recent years of the timeseries. The 2008 EUETS data provides indications of more sites using gas in industrial sectors in Wales and Scotland than previously estimated. Allocation of cement emissions was corrected for 2005 onwards, to remove a double-count at one site in England.	5	-45	89	178
1A3a	No change to DA method, but the changes to the UK aviation model have impacted differently across the DA inventories, according to the aviation fleet and CAA flight data.	4	8	7	6
1A3b	The UK-wide revisions to fuel consumption-speed relationships used for individual vehicle types have led to changes in the contributions made by each vehicle class to emissions in each DA.	2	17	-1	-32
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	-1	-11
1A3e	No change to method. Changes are as a result of revisions at UK level.	-1	0	0	0
1A4a	Analysis of point source and area source data for recent years has led to a small re-allocation of gas use in both Scotland and Wales, decreasing the allocation to the commercial sector and increasing the allocation to the public sector across the timeseries.	-4	-4	-5	-4
1A4b	Recent revision to energy mapping grids in GB only have led to revisions in the allocation of solid fuel use in recent years (higher coal use in Wales), based on use of more recent census data and integration of the DEMScot model to the energy mapping analysis for the sector. The revision to GB energy modelling has also led to a slight re-allocation of oil use in the sector, with small increases in the GB share for Wales. Correction to error in DA allocation of anthracite in 2006 and 2007 in the previous inventory calculations (now higher in Wales).	-4	-18	104	132
1A4c	No change to method. Changes are as a result of revisions at UK level.	2	17	7	5
1A5b	No change to method. Changes are as a result of revisions at UK level.	0	-2	3	-23
1B1b	Small revision to ISSB stats, leading to lower emissions in Wales in 2007.	0	0	0	-1
1B2a	No change	0	0	0	0

Table 7.5 Reasons for changes – Wales (continued)

Revisions summary		Magnitude of change (2008 estimate – 2007 estimate), kt CO_2e			
IPCC Sector	DA Specific Method and Data Revisions	Base Year	2005	2006	2007
1B2b	No change in DA method. Correction to error in data calculations for leakage within GB, resolving a previous under-report in England and over-report in Wales and Scotland for 2005 onwards only.	1	-29	-29	-58
1B2c_Flaring	No change.	0	0	0	0
1B2c_Venting	No change.	0	0	0	0
2A1	Correction to allocation of cement emissions for 2005 onwards, to remove a double-count at one site in England, due to availability of full detail of sector emissions through EUETS reporting.	0	22	28	28
2A2	No change	0	0	0	0
2A3	Small revisions to ISSB stats have affected the Wales inventory.	0	8	-2	0
2A4	Wales data revised for 2006 and 2007 due to new information on site closures.	0	-2	-9	-7
2B5	Minor revisions to the DA split for chemical industry emissions, based on point source data.	0	-1	0	0
2C1	No change	0	0	0	0
2C3	Small revisions to reported emissions from sites in Wales in 2005 and 2006.	0	-33	-37	2
2F1	No change in method. Slight variation between DAs in the overall impact of UK data revisions.	-5	14	36	55
2F2	No change to DA method.	0	1	1	1
4A1, 4B1	No change to method. Changes are as a result of revisions at UK level.	19	64	20	45
4B12, 4B13, 4B14	No change to method. Changes are as a result of revisions at UK level.	43	36	33	36
4D	No change to method. Changes are as a result of revisions at UK level.	-1	0	-8	4
5A2	No change in DA method.	0	0	0	0
5B1	No change in DA method.	0	0	0	0
5C1	No change in DA method.	0	0	0	0
5C2, 5E, 5E2	Revisions to England data from 2005 onwards. Other DAs have very minor revisions.	0	-1	-1	-1
5G	Revisions to England data from 2005 onwards. Other DAs have very minor revisions.	0	0	0	0
6A1	Minor revisions across the time-series, based on data from Waste Data Flow.	-15	1	-8	-5
6B2	No change in DA method.	0	1	0	-1
6C	No change	0	0	0	0

Table 7.6 Reasons for changes – Northern Ireland

Revisions summary		Magnitude of change (2008 estimate – 2007 estimate), kt CO_2e			
IPCC Sector	DA Specific Method and Data Revisions	Base Year	2005	2006	2007
1A1a	No change to method. Changes are as a result of revisions at UK level.	0	27	44	17
1A1b	No change	0	0	0	0
1A1c	No change	0	0	0	0
1A2a	No change	0	0	0	0
1A2f	Revisions are due to the use of EUETS Phase II data (which includes a wider scope of sites), and the industry improvement task, both of which have enabled revision of point source analysis for recent years of the timeseries. New data from fuel suppliers on the estimated split of gas use in Northern Ireland (between commercial, public and other industry) has led to increased estimates of gas use in industry in Northern Ireland for 2005 onwards. EUETS Phase II data has revised the allocation of fuel oil use in industry in Northern Ireland. Allocation of cement emissions was corrected for 2005 onwards, to remove a double-count at one site in England.	2	147	129	155
1A3a	No change to DA method, but the changes to the UK aviation model have impacted differently across the DA inventories, according to the aviation fleet and CAA flight data.	7	7	-2	8
1A3b	The UK-wide revisions to fuel consumption-speed relationships used for individual vehicle types have led to changes in the contributions made by each vehicle class to emissions in each DA. The impacts are greatest in N Ireland, due to the fleet mix and fuel use patterns by different vehicle types evident in N Ireland, which has led to slight reductions in N Ireland road transport emissions in recent years. Other DAs show smaller changes from the impact of the UK-wide revisions.	33	-164	-161	-179
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.	0	0	0	-2
1A3e	No change to method. Changes are as a result of revisions at UK level.	-1	0	0	1
1A4a	Revision to gas use allocation in Northern Ireland from 2005 onwards, due to new information for recent years from fuel suppliers.	1	-43	-31	-16
1A4b	Revision to recent trend in oil use in this sector in N Ireland due to HECA data showing a continuing growth in oil use in the sector, partly offset by a small increase in gas use and solid fuel use; this affects the 2007 estimate significantly, now showing a much smaller decline in oil use in the sector than reported previously. Correction to error in DA allocation of anthracite in 2006 and 2007 in the previous inventory calculations (now lower in N Ireland).	-70	137	90	345
1A4c	No change to method. Changes are as a result of revisions at UK level.	2	16	7	5
1A5b	No change to method. Changes are as a result of revisions at UK level.	0	-1	2	-15
1B1b	No change	0	0	0	0

Table 7.6 Reasons for changes – Northern Ireland (continued)

Revisions summary		Magnitude of change (2008 estimate – 2007 estimate), kt CO_2e			
IPCC Sector	DA Specific Method and Data Revisions	Base Year	2005	2006	2007
1B2a	No change	0	0	0	0
1B2b	Emission estimate for Northern Ireland included for the first time	0	0	0	0
1B2c_Flaring	No change.	0	0	0	0
1B2c_Venting	No change.	0	0	0	0
2A1	Correction to allocation of cement emissions for 2005 onwards, to remove a double-count at one site in England, due to availability of full detail of sector emissions through EUETS reporting.	0	20	20	23
2A2	No change	0	0	0	0
2A3	Access to EUETS data has enabled revisions to glass sector emissions for recent years at a site-specific level, increasing estimates for N Ireland.	0	4	3	3
2A4	No change	0	0	0	0
2B5	No change	0	0	0	0
2C1	No change	0	0	0	0
2C3	No change	0	0	0	0
2F1	No change in method. Slight variation between DAs in the overall impact of UK data revisions.	-2	9	22	35
2F2	No change to DA method.	0	0	0	0
4A1, 4B1	No change to method. Changes are as a result of revisions at UK level, and minor revisions to cattle numbers for Northern Ireland in 2005 and 2006.	19	54	15	58
4B12, 4B13, 4B14	No change to method. Changes are as a result of revisions at UK level.	59	54	54	56
4D	No change to method. Changes are as a result of revisions at UK level.	0	-14	-13	4
5A2	No change in DA method.	0	0	0	0
5B1	No change in DA method.	0	0	0	0
5C1	No change in DA method.	0	0	0	1
5C2, 5E, 5E2	Revisions to England data from 2005 onwards. Other DAs have very minor revisions.	0	0	0	0
5G	Revisions to England data from 2005 onwards. Other DAs have very minor revisions.	0	0	0	0
6A1	Minor revisions across the time-series, based on data from Waste Data Flow.	20	-5	-8	-4
6B2	No change in DA method.	0	1	0	-1
6C	No change	0	0	0	0

7.3 Inventory Improvement Programme

A programme of inventory improvements has been implemented by DECC, the Scottish Government, Welsh Assembly 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 first year of the DA GHG inventory improvement programme, implemented during 2009-10, included:

- **Industry sector research task**, to address data inconsistencies and uncertainties arising in specific industrial sectors (upstream oil & gas, refineries, petrochemicals) from emissions reported under IPPC and EUETS;
- **EUETS research task**, to review 2008 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;
- **Wales public sector scoping study**, to investigate the inventory method for public sector GHG emissions in Wales, and to identify and review potential new data sources that could be used to develop a more accurate, policy-sensitive inventory method;
- **Road transport inventory workshop**, to bring together the road transport sector experts from DfT and across the DA Governments, to review the current GHG inventory compilation system, and to identify opportunities for greater integration of local / regional research and data to improve the accuracy of the 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 three research studies that were commissioned, please see the reports on the NAEI website, at:

http://www.naei.org.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 is currently undergoing a review process in order to identify the research priorities to be taken forward and considered by DECC and the NISC stakeholders, including consideration of DA-specific data sources. Revised DA-level data is being prepared from updated land use matrices from the Countryside Survey team at CEH, and revisions of data for peat use within DAs are anticipated in the next inventory cycle.

7.3.1 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 oil & gas, refinery and petrochemical 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.

Emission scopes were clarified for three refinery sites in England, and detailed review of the range of permits and activities across the Grangemouth refinery complex in Scotland also enabled resolution of a range of data uncertainties. Oil and gas terminal data were researched, leading to corrections and data re-allocations between sources across six terminal sites, and errors in reporting under IPPC were identified and resolved with regulators for terminals in Scotland and England.

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.

The research has also enabled essential updates and improvements to IPPC permit information and Pollution Climate Mapping (PCM) stack information resources to improve the air emissions modelling outputs to DECC and Defra.

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, and hence a detailed review of the full scope of EUETS data was conducted, 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 2008 EU ETS dataset facilitated a greater understanding of the emissions and fuel quality data from EU ETS within each of the constituent countries of the UK. The allocation of all EU ETS 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 2008 EU ETS dataset. The findings of the study have been shared with the DECC DUKES team, and further consultation to clarify sector fuel use data from EUETS has been conducted.

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. Currently the NAEI uses emission factors derived from Tier 3 analysis of fuels in the power station, autogeneration and refineries sectors only. Analysis of the 2008 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 main findings of the study regarding the integration of EUETS data within DA and UK GHGI datasets are:

- **Disparity between DUKES and EU ETS sector fuel use totals.** The EU ETS dataset is used by DECC DUKES to help inform the allocation of fuel in the following year's national energy statistics. There are several industrial sectors where large differences are evident in the 2008 fuel allocations within DUKES, compared to the data reported by operators under EU ETS. These DUKES allocations may be revised in the next compilation of DUKES, to reduce these data inconsistencies, and the Inventory Agency has shared this analysis with the DECC DUKES team with such allocation revisions in mind.

- **Differences in scope and definitions between IPCC sectors and EU ETS 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 EU ETS reporting is not always comprehensive, i.e. emissions from some sources on site may be excluded from EU ETS data. Furthermore, the reporting format of the EU ETS 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.

- **Large differences between the reported emission factors within EU ETS and the inventory.** In order to justify changing from the emission factors currently used within the GHG inventory to factors reported in EU ETS, it is important to ensure that the new factors would be of a higher quality, and more representative of fuels used in the UK, than the current factors. It is not possible to fully assess this when: (i) the reported emission factors are highly variable between operators or across years, (ii) the data are based on only a limited number of operators using higher tier reporting, and/or (iii) the data covers only a small proportion of the fuel use within a given sector. A larger dataset of EU ETS emission factors is needed for the analysis of fuel quality to be used within the UK and DA GHGI.

7.3.3 Wales Public Sector Scoping Study

The public sector across the UK has a key role to play in delivering GHG emission reductions, both within its own estate and through policies, actions and purchasing decisions in the wider community. WAG expects to develop a specific emission reduction target for the public sector in Wales, in order to lead by example as part of the Climate Change Strategy currently being drafted.

The current GHG inventory estimates for the DA public sector are based on limited data, using a top-down method from DECC UK-level fuel use reporting across the sector, disaggregated across the constituent countries using a combination of (very few) point source emissions, and estimates of regional activity through employment survey data. The DA GHGI estimates for the sector are not sensitive to local policy actions, and are unlikely to accurately reflect year-to-year changes in emissions and activities. This study researched other data available on energy use and emissions within a range of public sector bodies and involved consultation across organisations such as Local Authorities, NHS Trusts, the Environment Agency of England and Wales, WAG, DCLG, academic and community organisations.

The review identified several potentially useful sources of data that could be directly useful within a wider system of comprehensive public sector data reporting in future inventory work, including the energy reporting system used in NHS Wales, and the CRC Energy Efficiency Scheme. Other fledgling data collection mechanisms within organisations such as Local Supply Boards have potential to be expanded and co-ordinated such that they provide amore consistent, comprehensive scope of energy and emissions reporting than is currently evident; there are many examples of good practice but no coherent, comprehensive dataset is evident to enable a step forward in inventory data and compilation method accuracy and sensitivity.

7.3.4 Road Transport Inventory Workshop

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. The inventory methodology is a complex system of data management that uses a wide number of parameters, source data and assumptions to derive vehicle-type-specific emission estimates for the vehicle fleet across the UK. The workshop brought together the AEA transport inventory experts as well as DfT, Scottish Government, Welsh Assembly Government and Northern Ireland Department of Environment transport analysts and DECC, in order to exchange data sources and ideas to improve the DA GHGI method.

The workshop presentations outlined the inventory calculation method, activity data, emission factors, vehicle fleet data and assumptions, as well as data reconciliation issues between vehicle kilometre-based GHG emission estimates and fuel sales-based estimates.

DA policy demands in the transport sector were outlined, including considerations specific to cross-border fuel sales ("fuel tank tourism") between Northern Ireland and the Republic of Ireland and the setting of targets for emission reductions within climate change action plans and strategies at DA level.

New data sources outlined from the DA teams and potentially useful to improve the DA inventory method include:

- MOT data, data on journey times from travel surveys and ongoing work to develop a transport model (Northern Ireland)
- National Transport Model, National Travel Survey and limited inter-zone trip data (Scotland)
- Noise mapping datasets (Wales)

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 transport policy areas has been initiated, with individuals identified to lead on collection and provision of any new data to the AEA team, including review of available transport projections data through the Inter-Departmental Analysts Group. The workshop has led to the identification of specific tasks for future consideration within the DA GHGI improvement programme, including a review of DVLA vehicle fleet statistics for the GB fleet, and a review of national transport model data and assumptions.

7.3.5 Data Mining for future DA GHGI Inventory Development

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, including:

- **Housing Condition Surveys and National Housing Models**: Consultation with DECC and DCLG identified the development of a UK Housing model, to build upon existing resources of information. The model is not available yet and hence the existing data for the domestic sector energy mapping estimates have been retained for England and Wales (BRE 2006 model). Updates to Northern Ireland domestic sector data from the most recent HECA Housing Condition Survey have been used, and a meeting at Scottish Government with the team that compiles the Scottish Housing Condition Survey and the DEMScot model led to the revision of assumptions for Scotland within the 1990-2008 GHG inventory compilation. Use of the most up to date HCS data were combined with new census data from across the UK in the development of the latest domestic sector inventory estimates. Further work is planned for the 1990-2009 cycle, to incorporate additional data for Northern Ireland.

- **Landfill Waste Data**: Defra have commissioned a study at UK level to review the GHG emission estimates from the model used for methane emissions from landfill waste disposal. The UK model is known to have limitations as regards the detail and scope of input data from all across the UK for different waste types, and hence consultation and research was focussed on identifying and accessing new data that could be useful to improve the current UK model. SEPA have provided new information resources from the waste data digest as well as landfill

location and design information. Consultation with waste sector experts have 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. The full details of these studies have not been reviewed at this stage, as the study at UK level has now begun through Defra.

- **ISSB statistics on Iron & Steel regional fuel use and production.** Contact with ISSB led to some modifications to their database queries to enable greater detail on regional production and energy use to be derived on an annual basis. This led to several revisions to data in the latest inventory cycle for years back to 2002.

- **Northern Ireland Gas Use Data.** Review of data availability from Northern Ireland gas suppliers led to revisions in the sector allocations of gas use within the latest cycle. The detailed gas use data are commercially confidential due to the limited market, but improved detail in estimates of gas use by sector was obtained. Follow-up consultation with the industry regulator yielded no further information.

- **Northern Ireland Public Sector energy use**. Consultation with DFPNI has provided new data from public sector energy reports that were used as a data quality check in the latest compilation cycle. Further information has been sought to obtain a more detailed breakdown of the fuel use data by source, as the scope of the DFPNI reporting includes sources that are accounted for elsewhere within the inventory, and hence the data cannot be used directly, due to the risk of double-counting emissions.

- **Northern Ireland Strategic Energy Framework.** A series of consultations with policy contacts in DETINI clarified the level of energy data and policy development work currently available from DETINI, and preliminary documents relating to the forthcoming Strategic Energy Framework have been obtained and reviewed. The documents do not contain any new data, but do indicate that further studies of relevance are expected to become available in future. Further work is needed, especially to explore the available data / forecasts for the impacts of the All Island Energy Grid development.

- **Northern Ireland Sustainable Development Implementation Plan.** A teleconference with OFMDFM discussed the range of planned policy actions to be included within the forthcoming Plan, to provide a preliminary insight into the priorities for Northern Ireland data development. No new data sources were identified, but follow-up enquiries are planned.

- **Wales Energy and Industry sectors.** Consultation with WAG policy leads in the energy and industry sector have raised the profile of the GHGI work, but it is apparent that the data sources used by the WAG policy team are primarily existing data that are already used within the GHGI compilation process, i.e. Environment Agency emissions data and DECC energy use data. There are a series of industry site-specific studies conducted by the Carbon Trust, but these are periodic, not annual, studies and tend to focus on opportunities for savings and changes to processes, rather than providing more detail on current emission sources. Consultation with the team that compiles the Wales Energy Database also clarified that the work is not conducted annually, and the most recent “comprehensive” revision was based on 2004 data. This is a research report that we will continue to review and identify where new data may become available for use in the GHGI.

- **Scottish Sewage Sludge Treatment and Disposal.** A series of emails and calls to Scottish Water have developed working relationships with key personnel that work on the GHG emission estimates for that sector in Scotland, and some new information has been provided to be considered within future revisions to the waste water sector emissions in Scotland. There is further work to do here, to obtain more detailed data to ensure that emission double-counts are not introduced to the inventory, and this work is expected to proceed during the next inventory cycle.

Some data identified as part of this data mining exercise were not directly useful to the DA inventory (see below). The ONS regional trends data will be kept under review.

- **ONS Regional Trends data.** There are a range of regional indicators published by ONS, and in some cases the research available provides some potentially useful underlying data, for example a recent ONS waste management survey in Wales which could be useful to supplement the recent compositional studies that have been conducted. Much of the ONS data is based on periodic surveys, and provides data that could be of use / consideration as "proxy" data or within energy modelling for specific sectors, but this is not "new data" on energy use or sector emissions that will provide a fundamental improvement to the current DA GHG inventory methods.

- **Northern Ireland Farm Survey Data, Farm Modernisation Programme.** Consultation with DARDNI identified a data source on annual fertiliser sales that was passed on to the North Wyke inventory team to supplement their existing methodology. The data available from the Farm Modernisation Programme has been reviewed and is not directly useful, as there is nothing to indicate the level of changes in energy use of farm machinery.

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 Devolved Administration 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, within specific research published in May 2010[14], 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 2008 EUETS dataset, looking in detail at the available data for a wide range of source sectors. The EUETS has a broader scope in 2008 with more sites reporting in Phase II of the scheme; 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.

The estimates derived for the traded and non-traded sectors of the DA GHG inventories presented here are for the year 2008 only, as this is the most up to date representation of the traded share of inventory emissions.

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

[14] See "The DA GHGI Improvement Programme 2009-2010: EUETS Task", May 2010, available at: http://www.naei.org.uk/reports.php?list=DA

Environment Agency of England and Wales, the Scottish Environment Protection Agency and the Northern Ireland Environment Agency.

The research project earlier in 2010 sought to conduct a detailed comparison of fuel use allocations by sector between the 2008 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 2008 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 2008 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 13% 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 are provided in Appendix 4.

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

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

Traded and Non-Traded Emissions					
	Units	England	Scotland	Wales	N Ireland
EUETS CO_2 emissions	Mt CO_2	193.5	23.8	26.6	5.9
GHGI total net GHG emissions	Mt CO_2e	484.5	53.7	49.5	22.2
"Non-traded" total net GHG emissions	Mt CO_2e	293.5	30.5	23.3	16.3
Non-Traded sector	%	60.6	56.8	47.0	73.5
GHGI total net CO_2 emissions	Mt CO_2	416.3	42.1	42.0	16.3
"Non-traded" total net CO_2 emissions	Mt CO_2	225.3	18.8	15.7	10.3
Non-Traded sector	%	54.1	44.8	37.5	63.7
GHGI IPCC Energy & Industrial process CO_2 Emissions	Mt CO_2	413.0	46.5	42.2	16.4
"Non-traded" Energy & Industrial process CO_2 emissions	Mt CO_2	221.9	23.3	15.9	10.6
Non-Traded sector	%	53.7	50.1	37.7	64.3

Analysis of the non-traded share of the total carbon dioxide inventory for the UK in 2008 indicates that overall the non-traded share is 50.9% of the total CO_2 emissions. 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 much 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 (19% of UK traded sector emissions in 2008) 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 WAG Climate Change Strategy policy actions and targets) is only 37.5% of the total carbon dioxide emissions in 2008. In 2007 (the last year of Phase I of the EUETS) the non-traded share of Wales CO_2 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 CO_2 emissions. The expansion of the EUETS scope in Wales may affect the WAG 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 44.8% of total CO_2 inventory emissions in the non-traded sector, compared to 50.9% in the UK. Review of sector-specific EUETS data from 2008 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 30% of the UK sector traded emissions, whilst in the paper, pulp and packaging sector, Scottish sites account for 18% of the UK traded emissions. The Grangemouth refinery accounts for almost 14% of UK refinery sector emissions whilst oil and gas terminals in Scotland account for nearly 11% of total UK sector traded emissions. The 2007 (EUETS Phase I) non-traded share in Scotland was around 48% of the total CO_2 inventory,

whereas in 2008 the expansion to Phase II EUETS has pushed the non-traded share of the CO_2 inventory down to 44.8%.

Northern Ireland has a very different traded and non-traded share of the GHG inventory in 2008 compared to Wales and Scotland, with a much higher non-traded share (63.7%) of the CO_2 inventory. 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 2008 EUETS data shows that Northern Ireland has a 2.8% share of the power sector traded emissions, whilst the only sectors where Northern Ireland has a higher share are in the cement sector (7% of UK sector traded emissions) and the public sector (3.3% of UK sector traded emissions) in 2008. The expansion of the EUETS in 2008 has not affected Northern Ireland quite as significantly as in Wales or Scotland, as the non-traded share of the CO_2 inventory in 2007 under Phase I EUETS was estimated at 65%, and only a small increase in traded emissions is evident in Phase II.

England non-traded emissions are estimated to be around 54.1% of total CO_2 emissions 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; for example, sites in England account for 65% of iron and steel EUETS emissions, 80% of power generation EUETS emissions, 84% of public sector traded emissions and 76% of cement sector traded emissions. England has a lower representative share of EUETS emissions in the refinery and oil & gas, reflecting the high incidence of such sites in Wales and Scotland. The expansion of EUETS in 2008 has decreased the England non-traded share of CO_2 emissions only slightly from around 55% in 2007 (Phase I) to 54.1% in 2008.

8.2.2 IPCC Sector Traded / Non-Traded Emissions Share, 2008

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, 2008

Power Generation					
IPCC Sector		England	Scotland	Wales	N Ireland
1A1a	GHGI, Mt CO_2	139.0	14.28	14.68	4.86
	Traded, Mt CO_2	137.6	14.20	14.60	4.83
	Non-Traded share, %	1.0	0.6	0.6	0.7

The traded share is expected to be lower than, but close to 100%, and this is the case across all countries. There remain some very small data discrepancies between the sum of all power station site fuel use data in EUETS compared to those for the power sector within DUKES, but the data are closely consistent. These small discrepancies between the DUKES statistics and the EUETS data could contribute to the non-traded emissions in this sector (since the non traded sector estimates are calculated by difference from the sector total, which is based on the DUKES data). Note also that the GHGI calculations use DA-specific CO_2 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 13% higher than the total emissions given in the DA inventories.

Table 8.3 IPCC Sector 1A1b: Petroleum Refineries, 2008

Petroleum Refineries					
IPCC Sector		England	Scotland	Wales	N Ireland
1A1b	GHGI, Mt CO_2	10.16	2.09	2.97	-
	Traded, Mt CO_2	11.56	2.37	3.33	-
	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 was 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 2008 EUETS data now indicates that there are inconsistencies in emissions from other fuels, including fuel oil and OPG, which are due to a combination of activity data discrepancies and emission factor 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.

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, but there are 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). 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, 2008

Iron and Steelworks					
IPCC Sector		England	Scotland	Wales	N Ireland
1A1c / 1A2a / 2A3 / 2C1	GHGI, Mt CO_2	15.06	0.07	7.75	-
	Traded, Mt CO_2	13.34	0	7.05	-
	Non-Traded share, %	11	100	9	-

In England and Wales, the combined sector emissions are dominated by iron and steel sources, with the large integrated steelworks all reporting within the EUETS. The traded share of emissions for this sector in both England and Wales is around 90%, due to the Corus integrated steelworks. In Scotland this is a very minor source and no EUETS sites are evident in the sector.

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, 2008

Oil and Gas					
IPCC Sector		England	Scotland	Wales	N Ireland
1A1c / 1B2c flaring & venting	GHGI, Mt CO_2	1.38	1.92	0.05	-
	Traded, Mt CO_2	1.17	1.97	0.05	-
	Non-Traded share, %	15	0	0	-

The data for Scotland indicate that there are data inconsistencies to be resolved between the EUETS and the GHGI data. The discrepancy is due to activity data inconsistencies for fuels such as OPG, and there are emission factor differences between the GHGI and EUETS also. The DA Improvement Programme Industry sector task in 2010 has researched the site reporting in this sector, and improvements to the sector allocations within the GHGI have been identified, to reduce reporting and allocation uncertainties. However, there is a small dataset of fuel quality from EUETS and the use of these data within the GHGI is currently limited. Analysis of the 2009 EUETS data may help to improve the fuel quality dataset available for consideration in inventory compilation, to further harmonise the EUETS and GHGI emissions data.

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. Further work is needed to resolve this fully, but overall the CO_2 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 and 2A1: Cement (combustion and process emissions), 2008

Cement					
IPCC Sector		England	Scotland	Wales	N Ireland
1A2f_ cement / 2A1	GHGI, Mt CO_2	6.27	0.63	0.79	0.60
	Traded, Mt CO_2	6.25	0.63	0.79	0.60
	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 non-iron and steel emissions under the category 1A2f, although there are other categories specified by the IPCC for reporting under 1A2:

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

The IPCC sector 1A2f is intended for industries that are not classified into the above categories. This chapter relates to the *inventory* category 1A2f (i.e. all industrial combustion other than iron and steel), in addition to the *IPCC* category 1A2f. Where these sectors are referred to, IPCC or inventory is specified.

The sites reported in inventory sector 1A2f include both larger combustion plant operating within the EUETS as well as numerous smaller plant, which do not. Plant covered by CCAs are also absent from the traded figure, but will be represented within the GHGI data. Therefore it should be expected that the traded emissions total should be significantly lower than the DA GHGI sector totals, and this is the case in all countries. Table 8.7 below illustrates the overall relationship between EUETS data and the country GHGI estimates:

Table 8.7 Inventory Sector 1A2f: Other Industry Combustion (excluding cement and lime), 2008

Other industry					
Inventory Sector		England	Scotland	Wales	N Ireland
1A2f (other)	GHGI, Mt CO_2	44.31	5.15	3.11	1.22
	Traded, Mt CO_2	18.37	3.87	0.78	0.37
	Non-Traded share, %	59	25	75	70

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.

Table 8.8 UK-wide estimates of "1A2f" into more detailed IPCC categories, 2008

UK Estimates for other industry					
IPCC Sector	GHGI Mt CO_2	Traded Mt CO_2	Non-traded Mt CO_2	Non-traded %	Sector share of Inventory sector 1A2f %
1A2b: Non-ferrous metals	3.65	2.82	0.83	23	12
1A2c: Chemicals	12.61	9.02	3.58	28	39
1A2d: Paper & Pulp	5.35	3.23	2.12	40	14
1A2e: Food and drink	7.69	2.92	4.77	62	12
1A2f: Other industries	24.34	5.40	18.94	78	23
TOTAL	**53.64**	**23.40**	**30.24**	**56**	**100**

Table 8.9 DA Traded Emissions in 1A2b to 1A2f IPCC Categories, 2008

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	2.82	0	0	0

	(100)	(0)	(0)	(0)
1A2c: Chemicals	5.97 (66)	2.67 (30)	0.28 (3)	0.11 (1)
1A2d: Paper & Pulp	2.51 (78)	0.57 (18)	0.13 (4)	0.01 (0)
1A2e: Food and drink	2.45 (84)	0.30 (10)	0.10 (3)	0.08 (3)
1A2f: Other industries	4.62 (86)	0.34 (6)	0.27 (5)	0.17 (3)
TOTAL	**18.37 (79)**	**3.87 (17)**	**0.78 (3)**	**0.37 (2)**

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 17% of the total emissions within the inventory 1A2f sector, due mainly to the high emissions share in Scotland in the chemicals and paper and pulp sectors, which together comprise 53% of the total UK EUETS emissions under the 1A2f inventory category. All non-ferrous metal sites within the EUETS are in England. Wales sites in EUETS represent a 3 to 5% 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.

This analysis of the traded emissions in the industrial sub-sectors provides some indication as to why the Scottish non-traded share is lower than elsewhere in the UK, but 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 8.10 IPCC Sector 1A4a: Public Sector and Commercial Emissions, 2008

Public Sector and Commercial Emissions					
IPCC Sector		England	Scotland	Wales	N Ireland
1A4a public	GHGI, Mt CO_2	8.59	0.98	0.47	0.15
	Traded, Mt CO_2	1.15	0.16	0.015	0.04
	Non-Traded share, %	87	84	97	71
1A4a commercial	GHGI, Mt CO_2	10.07	0.86	0.44	0.18
	Traded, Mt CO_2	0.19	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 currently under development and will commence operation during 2010-11.

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 CO_2 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 the UK. The slightly higher level of traded emissions coverage in England is due to the glass, FGD and brick manufacture sectors, whilst in Scotland, Wales and Northern Ireland the traded emissions are almost entirely from the glass sector.

Table 8.11 IPCC Sector 2: Industrial Process Emissions (excluding cement and iron & steel), 2008

Industrial Process Emissions					
IPCC Sector		England	Scotland	Wales	N Ireland
2	GHGI, Mt CO_2	3.97	0.26	0.26	0.065
	Traded, Mt CO_2	1.07	0.06	0.01	0.009
	Non-Traded share, %	73	77	96	86

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 1990-2008 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 2.5 and 97.5 percentile estimates.

Table 9.1 Estimated Uncertainties in the DA GHG Inventories: Base Years, 2008 and Trend

	Base Year		Latest Year (2008)		Trend (Base Year to 2008)		
Gas (kt CO_2e)	Central Estimate	Uncertainty Introduced on total	Central Estimate	Uncertainty Introduced on total	Central Estimate	2.5 Percentile	97.5 Percentile
Scotland							
CO_2	50554	10%	42057	12%	-17%	-28%	-4%
CH_4	11043	29%	6279	24%	-42%	-60%	-18%
N_2O	6377	295%	4346	290%	-34%	-55%	-19%
HFC	129	25%	919	25%	623%	400%	911%
PFC	87	17%	55	58%	-37%	-73%	2%
SF_6	31	17%	51	19%	68%	28%	113%
Total	68222	29%	53707	26%	-21%	-31%	-10%
Wales							
CO_2	43134	3%	41996	3%	-3%	-6%	1%
CH_4	7876	21%	4373	18%	-44%	-58%	-28%
N_2O	3646	308%	2593	282%	-26%	-41%	-2%
HFC	66	23%	463	23%	610%	404%	872%
PFC	147	5%	58	19%	-61%	-68%	-53%
SF_6	83	16%	44	16%	-47%	-58%	-34%
Total	54952	21%	49526	15%	-10%	-15%	-5%
Northern Ireland							
CO_2	17325	9%	16171	7%	-7%	-16%	4%
CH_4	4382	23%	3341	18%	-23%	-43%	1%
N_2O	3247	289%	2375	303%	-33%	-64%	-17%
HFC	39	22%	292	23%	659%	443%	926%
PFC	1	19%	0	17%	-89%	-92%	-86%
SF_6	2	20%	7	24%	265%	162%	391%
Total	24995	38%	22186	33%	-11%	-19%	-2%

(table continued below)

Table 9.1: Estimated Uncertainties in the DA GHG Inventories: Base Years, 2008 and Trend: *continued*

	Base Year		Latest Year (2008)		Trend (Base Year to 2008)		
Gas (kt CO_2e)	Central Estimate	Uncertainty Introduced on total	Central Estimate	Uncertainty Introduced on total	Central Estimate	2.5 Percentile	97.5 Percentile
England							
CO_2	467274	2%	416325	1%	-11%	-13%	-9%
CH_4	78988	27%	33690	26%	-57%	-70%	-39%
N_2O	51564	153%	24295	239%	-59%	-79%	-32%
HFC	15231	14%	9489	25%	-37%	-54%	-19%
PFC	227	7%	96	25%	-58%	-65%	-50%
SF_6	1124	17%	609	16%	-45%	-57%	-32%
Total	614408	13%	484505	14%	-21%	-25%	-18%
Unallocated							
CO_2	13162	15%	14955	5%	14%	-2%	33%
CH_4	1855	27%	887	25%	-51%	-67%	-31%
N_2O	228	101%	276	105%	50%	-67%	342%
HFC	0	N/A	0	N/A	N/A	N/A	N/A
PFC	0	N/A	0	N/A	N/A	N/A	N/A
SF_6	0	N/A	0	N/A	N/A	N/A	N/A
Total	15244	13%	16118	5%	6%	-7%	22%
UK							
CO_2	591449	2%	531503	2%	-10%	-13%	-8%
CH_4	104143	26%	48570	23%	-53%	-67%	-35%
N_2O	65061	182%	33885	252%	-54%	-75%	-31%
HFC	15466	14%	11163	25%	-28%	-47%	-6%
PFC	462	7%	209	25%	-55%	-66%	-43%
SF_6	1239	17%	711	16%	-42%	-54%	-28%
Total	777820	16%	626041	14%	-19%	-23%	-16%

Notes

1. Uncertainty is defined as $\pm$ 2×(standard deviation)/mean %, which closely approximates the 95% confidence interval.
2. Base years are 1990 for CO_2, CH_4 and N_2O; 1995 for HFCs, PFCs and SF_6.

10 End User GHG Inventories for the Devolved Administrations

10.1 Introduction

Emissions of greenhouse gases 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 is 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.

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 ends 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 CO_2 statistics, which are also presented on an end user basis.

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., 2010). 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. Note that this method is different to the direct solution provided by the Gaussian elimination method, which was used for previous estimates of end user emissions at DA level.

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[15] 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	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.
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 2008 (for 2004 to 2007), March 2010 Energy Trends & pers. Comm. Laura Williams (DECC) for 2008 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	CO_2 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".
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 CO_2 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.

[15] Exports refers 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
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 previous estimates of end user GHG emissions from the Devolved Administrations was the first time that the calculations had been made. There have been some revisions to both source data used to inform the estimates, through new research, and also some changes to the underlying calculation methodology to bring the DA end users inventory system closer to the UK end users inventory method. 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**: The DA analysis now disaggregates total UK electricity emissions across all electricity users. This, in effect, means that the model uses UK-wide electricity generation GHG per GWh factors, whereas last year DA specific values were used. Transfers of electricity between the DAs are now implicit within the model, whereas the previous version explicitly accounted for these.
- **Method change**: Exports of all fuels (not just electricity) are now allocated to the "Exports" category. This mainly affects Wales and Scotland, as they have a disproportionately high share of the oil refinery, gas production and colliery industries, so more of the Wales and Scotland emissions are reported in the Exports category. The Exports category only includes emissions associated with fuels exported from the UK (and not transfers between the DAs).
- **International Aviation and Shipping**: The source emissions data are excluded from the new DA GHGI end user dataset, but the end user uplift (i.e. the emissions associated with the production of fuels that are then used for international flights or shipping movements) is included within the Exports category for each DA. This is consistent with the approach for bunker fuels within the UK end users data set.
- **Data Improvement**: All electricity drivers have been reviewed. The electricity allocations for the Public and Commercial sectors have been revised based on Inter-Departmental Business Register (IDBR) data from 2004 and 2007, and this has affected the Other industry electricity allocation, which is calculated as a residual once all other electricity allocations have been made (i.e. by difference for the total DA electricity consumption from DECC Energy Trends data). The existing electricity driver for the domestic sector (DECC Energy Trends and DUKES) and the iron and steel industry (ISSB stats) have been retained.

The first three changes listed all relate to the change in the model structure to disaggregate the UK estimates, rather than generating DA specific inventories. These changes were made to ensure consistency with the UK dataset, which is also the basis for the Local Authority end user CO_2 statistics. The approach also better 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.

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. Since DECC now publish DA-specific electricity use totals within Energy Trends, the overall electricity consumption of electricity by DA in the 2003 to 2008 dataset is less uncertain. (Within the Energy Trends tables, a statistical difference is reported for each Devolved Administration for each year, from an analysis of the "generation-side" estimates against the "demand-side" estimates. This statistical difference is a useful indicator of the uncertainty in the total electricity use within each country.) The estimation 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 CO_2 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 2008 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 regional energy use data and due to the level of detail that now is provided within the regional electricity generation and supply tables in Energy Trends, the 2003 to 2008 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" greenhouse gas 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 2008, expressed in terms of total CO_2 equivalent emissions of the "basket of 6" GHGs.

Table 10.2 Share of DA GHG Emissions by End User and by Source, 2008

Share of DA GHG Emissions by End User and by Source			
	End User	**End User excluding exports**	**By source**
England	80.4%	78.6%	77.4%
Scotland	8.7%	8.4%	8.6%
Wales	7.1%	6.8%	7.9%
Northern Ireland	3.8%	3.7%	3.5%
Unallocated	0.0%	0.0%	2.6%

The estimated trends in the end user DA GHG inventories from the Kyoto Protocol Base Year (1990 for CO_2, CH_4 and N_2O, and 1995 data for the fluorinated gases) to 2008 are presented by gas in Table 10.3. Note that the trends from the base year are associated with high uncertainty.

Table 10.3 Estimated Trends in the End User DA GHG Inventories from the Base Year to 2008, by Gas

Trends in End User Emissions				
Country	Gas	End User	End User excl. Exports	By source
England	**CO_2**	-8.7%	-9.7%	-10.9%
	CH_4	-56.6%	-56.8%	-57.3%
	N_2O	-52.5%	-52.7%	-52.9%
	ALL GHGs	-19.2%	-20.0%	-21.1%
Scotland	**CO_2**	-22.5%	-23.5%	-16.8%
	CH_4	-46.8%	-46.9%	-43.1%
	N_2O	-32.4%	-32.6%	-31.9%
	ALL GHGs	-26.3%	-27.1%	-21.3%
Wales	**CO_2**	-14.2%	-15.9%	-2.6%
	CH_4	-46.4%	-46.4%	-44.5%
	N_2O	-29.3%	-29.8%	-28.9%
	ALL GHGs	-19.5%	-20.9%	-9.9%
N Ireland	**CO_2**	0.1%	-3.9%	-6.7%
	CH_4	-30.6%	-30.9%	-23.8%
	N_2O	-26.5%	-26.7%	-26.8%
	ALL GHGs	-8.4%	-11.1%	-11.2%

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 2008 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.
- 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;
- Both Scotland and Wales have a lesser share of end user emissions compared to the by source estimates, and on the basis of end user emission each have achieved much higher emission reductions since the Base Year than the by source inventories indicate.

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;

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 2008 (Mt CO2-e)

England End User Emissions								
	Base Year	1990	2003	2004	2005	2006	2007	2008
Agriculture	41.52	41.52	33.74	33.97	33.73	32.48	32.05	32.09
Business	193.36	192.23	170.23	167.91	168.03	169.74	166.47	162.27
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	7.41	7.41	13.46	13.52	13.74	11.79	12.75	11.21
Industrial Process	52.14	50.30	16.64	15.93	14.96	13.71	14.91	13.79
Land Use Change	5.74	5.74	3.67	3.37	3.18	3.15	3.06	2.99
Public	25.24	25.24	18.02	18.64	18.21	18.00	17.04	17.25
Residential	135.70	135.37	130.22	131.24	127.53	126.98	121.77	123.77
Transport	119.17	119.17	127.08	126.33	127.40	126.08	126.72	122.13
Waste Management	42.39	42.39	19.78	18.42	18.15	18.05	17.98	17.75
Total	**622.67**	**619.38**	**532.83**	**529.33**	**524.93**	**519.99**	**512.74**	**503.25**

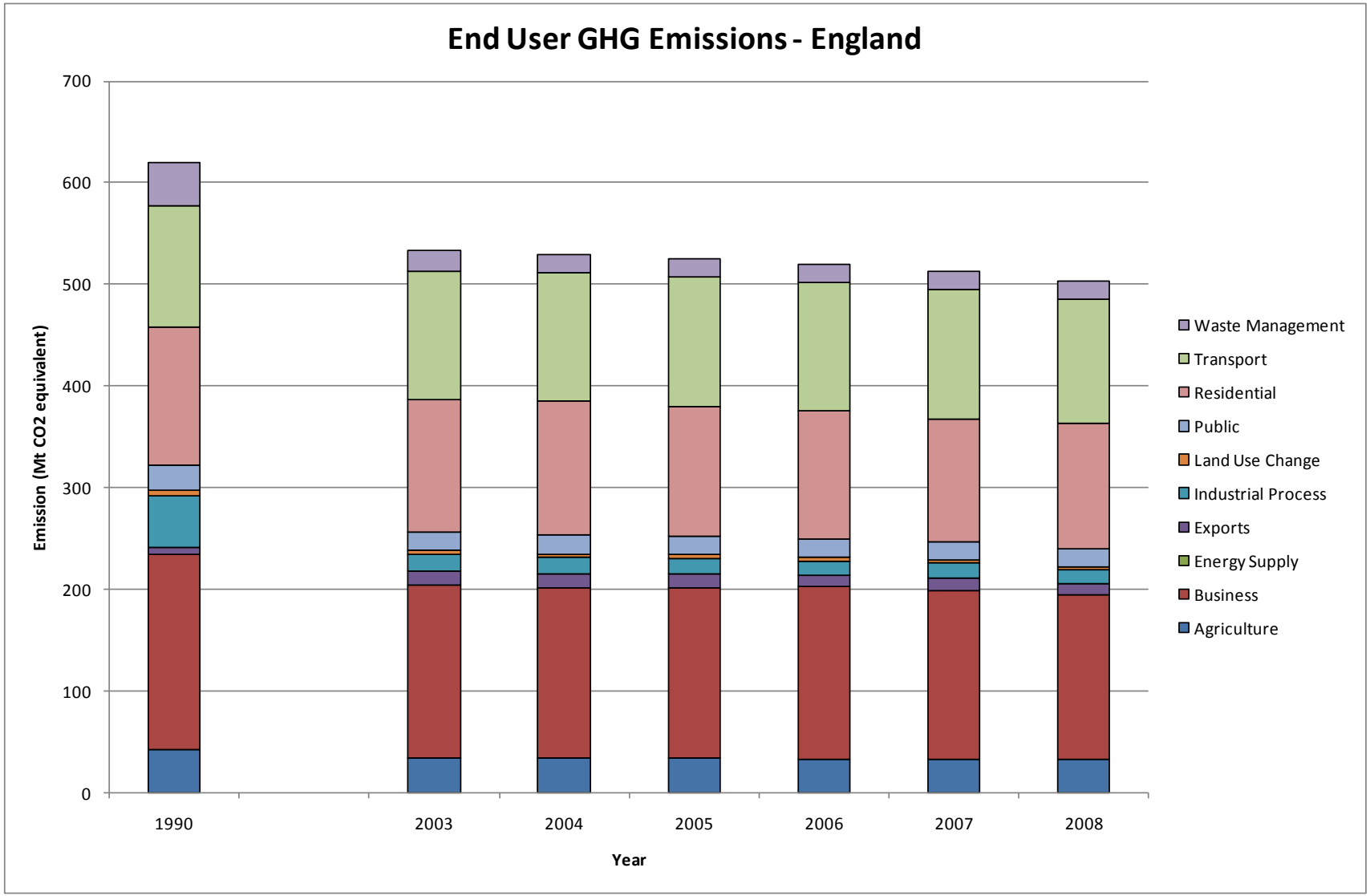
Table 10.5 Emission Trends by Sector in the England End User GHG Inventories

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

Emission Trends in England			
	Base Year to 2008	2007 to 2008	Share of 2008 total
Agriculture	-22.7%	0.1%	6.4%
Business	-16.1%	-2.5%	32.2%
Energy Supply	N/A	N/A	N/A
Exports	51.1%	-12.1%	2.2%
Industrial Process	-73.6%	-7.5%	2.7%
Land Use Change	-47.9%	-2.4%	0.6%
Public	-31.7%	1.2%	3.4%
Residential	-8.8%	1.6%	24.6%
Transport	2.5%	-3.6%	24.3%
Waste Management	-58.1%	-1.3%	3.5%
Total	**-19.2%**	**-1.9%**	**100.0%**
Total excluding exports	*-20.0%*	*-1.6%*	*97.8%*

Note that the base year to 2008 emission trends when the emission exports are discounted show that England end user emissions have reduced by **20.0%**. This compares to the reported reduction in the "by source" GHG inventory of **21.1%** over the same period.

Figure 10.1 England End User GHG Emissions by National Communication Category: 1990, 2003-2008 (Mt CO_2-e)



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 2008 (Mt CO_2e)

Scotland End User Emissions								
	Base Year	1990	2003	2004	2005	2006	2007	2008
Agriculture	10.30	10.30	8.94	8.80	8.69	8.50	8.23	8.00
Business	23.82	23.69	16.71	16.47	17.01	16.56	15.86	15.66
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	1.38	1.38	1.32	1.79	1.84	1.52	1.58	1.64
Industrial Process	2.13	2.19	0.61	0.62	0.54	0.55	0.53	0.52
Land Use Change	-2.52	-2.52	-4.19	-4.60	-4.58	-4.45	-4.43	-4.47
Public	3.12	3.12	1.95	2.06	2.17	2.26	2.26	2.28
Residential	16.67	16.63	14.64	14.62	14.47	14.43	13.97	14.34
Transport	13.18	13.18	13.88	13.76	13.98	14.13	14.17	13.75
Waste Management	5.78	5.78	2.58	2.50	2.49	2.62	2.64	2.75
Total	**73.87**	**73.76**	**56.43**	**56.02**	**56.60**	**56.12**	**54.80**	**54.47**

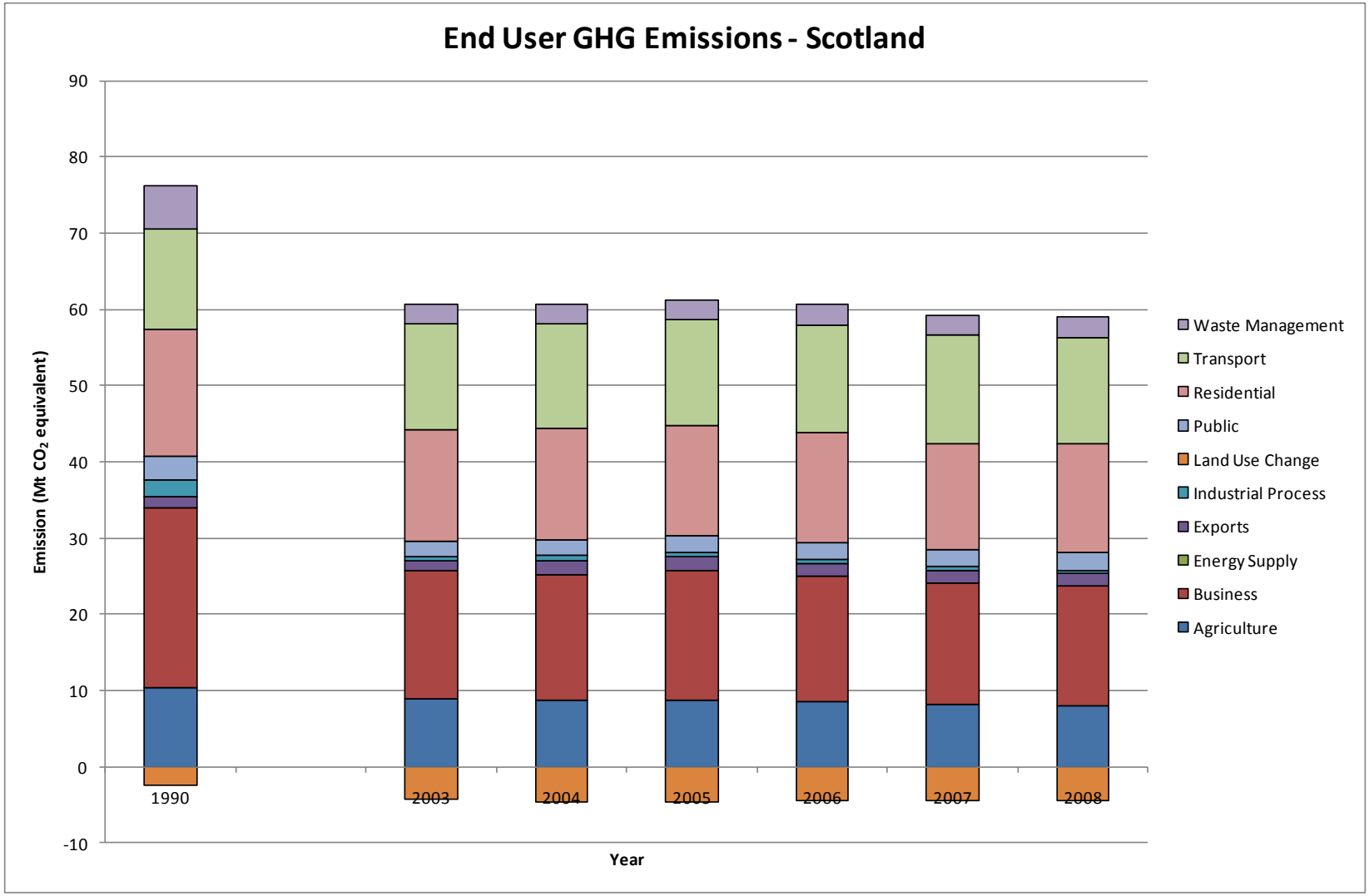
Table 10.7 Emission Trends by Sector in the Scotland End User GHG Inventories

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

Emissions Trends in Scotland			
	Base Year to 2008	2007 to 2008	Share of 2008 total
Agriculture	-22.4%	-2.8%	14.7%
Business	-34.2%	-1.2%	28.8%
Energy Supply	N/A	N/A	N/A
Exports	18.7%	3.9%	3.0%
Industrial Process	-75.5%	-1.5%	1.0%
Land Use Change	77.7%	0.9%	-8.2%
Public	-27.0%	1.1%	4.2%
Residential	-14.0%	2.6%	26.3%
Transport	4.4%	-3.0%	25.2%
Waste Management	-52.3%	4.3%	5.1%
Total	**-26.3%**	**-0.6%**	**100.0%**
Total excluding exports	*-27.1%*	*-0.7%*	*97.0%*

The base year to 2008 emission trend when the emission exports are discounted is a reduction of **27.1%**. This compares to the reported reduction in the “by source” GHG inventory of **21.3%** over the same period.

Figure 10.2 Scotland End User GHG Emissions by National Communication Category: 1990, 2003-2008 (Mt CO_2-e)



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 2008 (Mt CO_2e)

Wales End User Emissions								
	Base Year	1990	2003	2004	2005	2006	2007	2008
Agriculture	7.20	7.20	6.45	6.36	6.46	6.12	5.83	5.53
Business	22.86	22.80	17.62	18.23	17.45	17.90	17.34	16.45
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	1.51	1.51	1.79	2.26	2.15	1.88	2.13	1.98
Industrial Process	3.39	3.56	2.85	2.83	2.67	2.77	2.92	2.81
Land Use Change	-0.24	-0.24	-0.19	-0.23	-0.23	-0.19	-0.20	-0.19
Public	1.62	1.62	1.00	1.04	1.11	1.16	1.17	1.17
Residential	8.63	8.61	8.02	8.09	7.82	7.91	7.45	7.78
Transport	7.64	7.64	7.90	7.99	8.04	8.10	8.11	7.91
Waste Management	2.90	2.90	1.38	1.36	1.36	1.30	1.30	1.29
Total	**55.53**	**55.62**	**46.80**	**47.93**	**46.84**	**46.96**	**46.06**	**44.72**

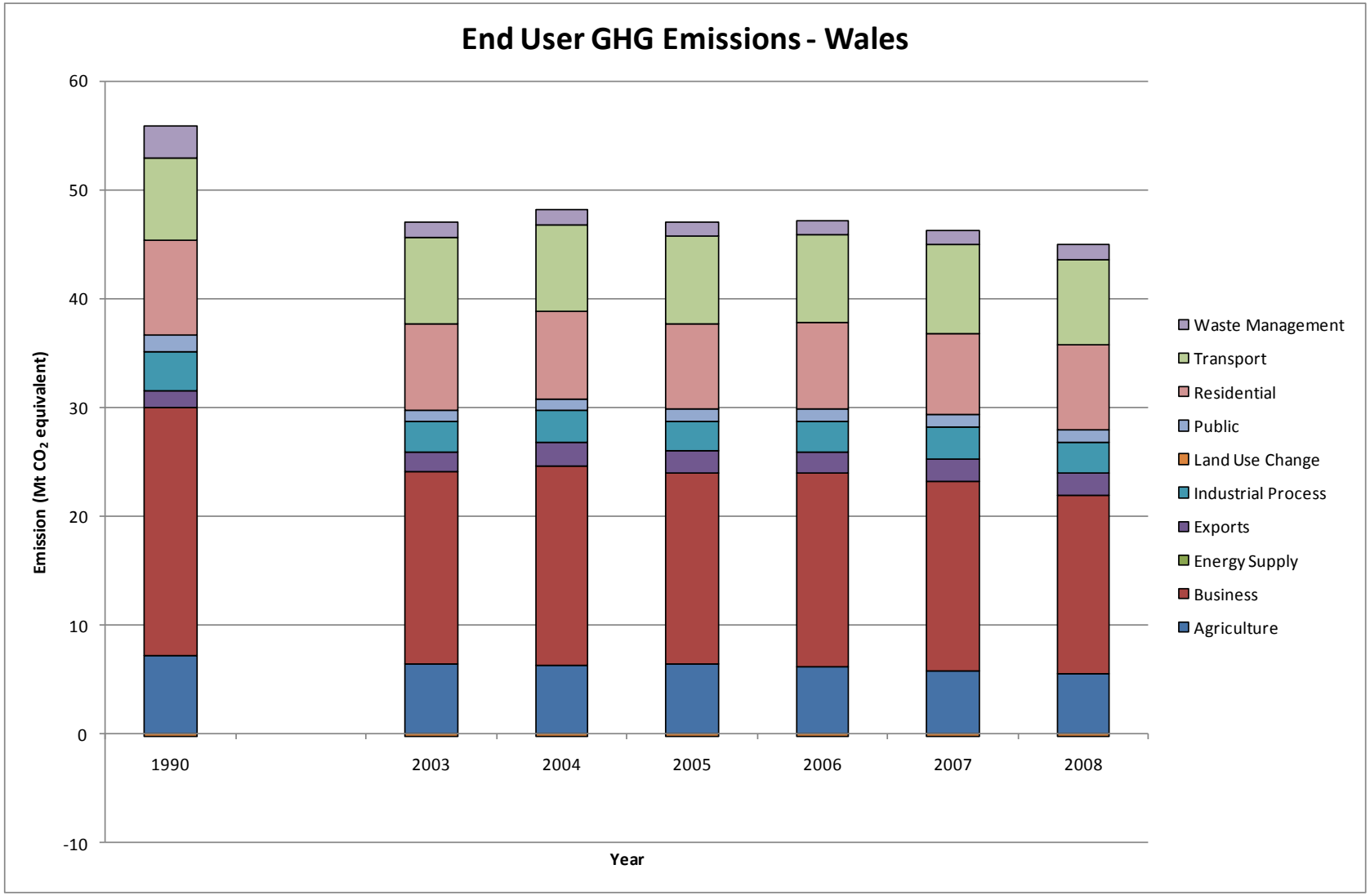
Table 10.9 Emission Trends by Sector in the Wales End User GHG Inventories

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

Emission Trends in Wales			
	Base Year to 2008	2007 to 2008	Share of 2008 total
Agriculture	-23.3%	-5.3%	12.4%
Business	-28.0%	-5.1%	36.8%
Energy Supply	N/A	N/A	N/A
Exports	31.2%	-6.8%	4.4%
Industrial Process	-17.3%	-4.0%	6.3%
Land Use Change	-18.6%	-3.1%	-0.4%
Public	-27.8%	0.5%	2.6%
Residential	-9.8%	4.5%	17.4%
Transport	3.4%	-2.5%	17.7%
Waste Management	-55.6%	-1.1%	2.9%
Total	**-19.5%**	**-2.9%**	**100.0%**
Total excluding exports	*-20.9%*	*-2.7%*	*95.6%*

The base year to 2008 emission trend when the emission exports are discounted is a reduction of **20.9%**. This compares to the reported reduction in the "by source" GHG inventory of **9.9%** over the same period.

Figure 10.3 Wales End User GHG Emissions by National Communication Category: 1990, 2003-2008 (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 2008 (Mt CO_2e)

Northern Ireland End User Emissions								
	Base Year	1990	2003	2004	2005	2006	2007	2008
Agriculture	6.04	6.04	5.85	5.72	5.67	5.59	5.46	5.35
Business	4.52	4.50	3.72	3.82	4.06	4.24	4.31	3.84
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.04	0.04	0.69	0.93	1.19	1.08	0.81	0.74
Industrial Process	0.76	0.76	0.22	0.22	0.41	0.42	0.48	0.39
Land Use Change	-0.03	-0.03	-0.29	-0.28	-0.28	-0.30	-0.28	-0.27
Public	1.16	1.16	0.50	0.51	0.56	0.60	0.63	0.60
Residential	7.27	7.26	6.03	6.13	6.05	6.23	6.16	6.21
Transport	4.32	4.32	5.73	5.64	5.77	5.85	5.96	5.87
Waste Management	1.67	1.67	0.79	0.77	0.79	0.81	0.83	0.85
Total	**25.76**	25.72	23.23	23.46	24.22	24.53	24.35	23.60

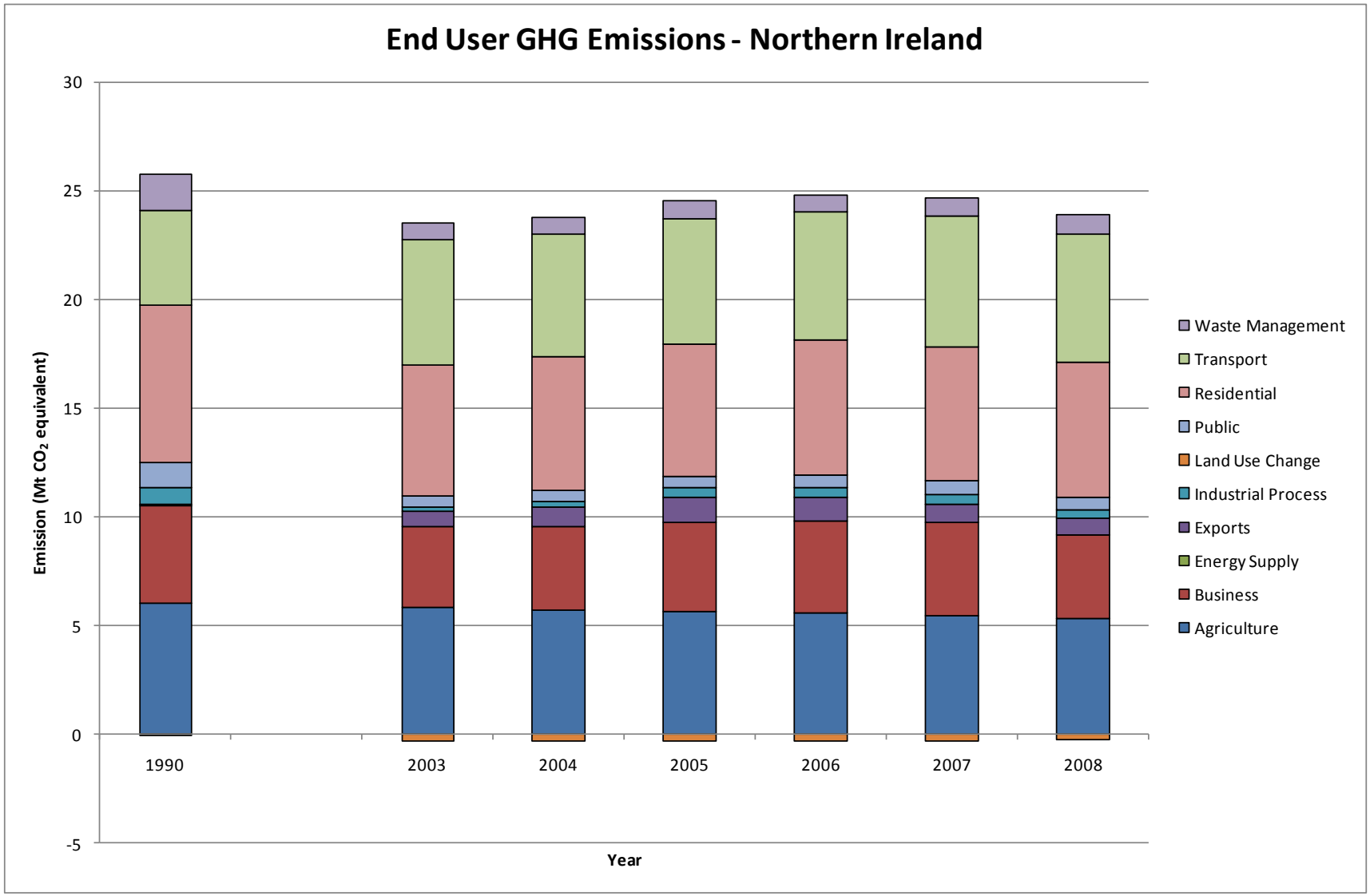
Table 10.11 Emission Trends by Sector in the Northern Ireland End User GHG Inventories

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

Emission Trends in Northern Ireland			
	Base Year to 2008	2007 to 2008	Share of 2008 total
Agriculture	-11.4%	-2.0%	22.7%
Business	-15.1%	-10.9%	16.3%
Energy Supply	N/A	N/A	N/A
Exports	1637.3%	-7.7%	3.2%
Industrial Process	-48.7%	-18.0%	1.7%
Land Use Change	844.6%	-6.5%	-1.1%
Public	-48.0%	-3.6%	2.6%
Residential	-14.6%	0.8%	26.3%
Transport	35.9%	-1.4%	24.9%
Waste Management	-48.7%	2.9%	3.6%
Total	**-8.4%**	**-3.1%**	**100.0%**
Total excluding exports	*-11.1%*	*-2.9%*	*96.8%*

Note that the base year to 2008 emission trends when the emission exports are discounted show that Northern Ireland end user emissions have reduced by **11.1%**. This compares to the reported reduction in the "by source" GHG inventory of **11.2%** 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 2008 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, 2003-2008 (Mt CO_2e)



10.5.6 Sector Analysis

The sector-specific data provide an insight into the impacts of the end user methodology, and a limited 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 2008 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 2008. The DA end user estimates for the business sector are summarised below:

Table 10.12 Business Sector DA End User Emissions: 1990, 2003-2008

Business Sector							
End User Emissions (Mt CO_2 e)	1990	2003	2004	2005	2006	2007	2008
England	192.23	170.23	167.91	168.03	169.74	166.47	162.27
Scotland	23.69	16.71	16.47	17.01	16.56	15.86	15.66
Wales	22.80	17.62	18.23	17.45	17.90	17.34	16.45
Northern Ireland	4.50	3.72	3.82	4.06	4.24	4.31	3.84

DA % of End User Emissions	1990	2003	2004	2005	2006	2007	2008
England	79.0%	81.7%	81.3%	81.4%	81.4%	81.6%	81.9%
Scotland	9.7%	8.0%	8.0%	8.2%	7.9%	7.8%	7.9%
Wales	9.4%	8.5%	8.8%	8.4%	8.6%	8.5%	8.3%
Northern Ireland	1.8%	1.8%	1.9%	2.0%	2.0%	2.1%	1.9%

End User/By Source	1990	2003	2004	2005	2006	2007	2008
England	226%	204%	206%	207%	215%	214%	213%
Scotland	227%	219%	220%	213%	213%	210%	217%
Wales	174%	170%	165%	169%	165%	165%	166%
Northern Ireland	196%	235%	224%	203%	217%	218%	204%

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 commercial sector estimates within each DA end user inventory in 2008 is variable, ranging from 16.3% in Northern Ireland, 28.8% in Scotland 7%, 32.2% in England, up to 36.8% 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, 2003-2008

Residential Sector							
End User Emissions (Mt CO_2 e)	1990	2003	2004	2005	2006	2007	2008
England	135.37	130.22	131.24	127.53	126.98	121.77	123.77
Scotland	16.63	14.64	14.62	14.47	14.43	13.97	14.34
Wales	8.61	8.02	8.09	7.82	7.91	7.45	7.78
Northern Ireland	7.26	6.03	6.13	6.05	6.23	6.16	6.21

DA % of End User Emissions	1990	2003	2004	2005	2006	2007	2008
England	80.6%	81.9%	82.0%	81.8%	81.6%	81.5%	81.4%
Scotland	9.9%	9.2%	9.1%	9.3%	9.3%	9.4%	9.4%
Wales	5.1%	5.0%	5.1%	5.0%	5.1%	5.0%	5.1%
Northern Ireland	4.3%	3.8%	3.8%	3.9%	4.0%	4.1%	4.1%

End User/By Source	1990	2003	2004	2005	2006	2007	2008
England	212%	178%	176%	178%	185%	185%	182%
Scotland	214%	189%	187%	189%	195%	193%	189%
Wales	186%	167%	165%	169%	173%	171%	169%
Northern Ireland	148%	154%	152%	154%	154%	153%	155%

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 in the electricity proportion of the total domestic energy consumption in the DA. For England and Scotland, this is 20 and 22%, respectively, compared with 17% for Wales and 13% 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). In addition to this, a high proportion of domestic energy consumption is from peat, accounting for 6-7% of energy use across the time series. There is currently no end user component applied to emissions from peat consumption, the data for which are associated with high uncertainty.

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 9%
- Scotland emissions have declined by 14%
- Wales emissions have declined by 10%
- Northern Ireland emissions have declined by 14%

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 more than offsets the emissions reductions from electricity use.

In Wales, coal, anthracite and coke use have decreased significantly, in addition to the decrease in emissions from electricity consumption. Similar to Scotland, the increase in emissions from natural gas use is greater than the reduction from electricity 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, Scotland Northern Ireland, the domestic sector is estimated to comprise 25-26% of the total end user emissions in 2008, whilst in Wales the figure is somewhat lower at 17%, 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, 2003-2008

Public Sector							
End User Emissions (Mt CO_2e)	1990	2003	2004	2005	2006	2007	2008
England	25.24	18.02	18.64	18.21	18.00	17.04	17.25
Scotland	3.12	1.95	2.06	2.17	2.26	2.26	2.28
Wales	1.62	1.00	1.04	1.11	1.16	1.17	1.17
Northern Ireland	1.16	0.50	0.51	0.56	0.60	0.63	0.60

DA % of End User Emissions	1990	2003	2004	2005	2006	2007	2008
England	81.0%	83.9%	83.8%	82.6%	81.7%	80.8%	81.0%
Scotland	10.0%	9.1%	9.3%	9.8%	10.3%	10.7%	10.7%
Wales	5.2%	4.6%	4.7%	5.0%	5.3%	5.5%	5.5%
Northern Ireland	3.7%	2.3%	2.3%	2.5%	2.7%	3.0%	2.8%

End User/By Source	1990	2003	2004	2005	2006	2007	2008
England	229%	207%	198%	197%	204%	210%	200%
Scotland	245%	215%	200%	206%	226%	246%	231%
Wales	208%	223%	209%	217%	241%	266%	250%
Northern Ireland	237%	398%	364%	341%	379%	397%	396%

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 2008 is quite low across the UK, ranging from 2.6% in Northern Ireland, 2.6% in Wales, 3.4% in England up to 4.2% in Scotland.

The 1990 electricity estimates in particular are uncertain, and the trends are therefore subject to high uncertainty, but there is a notably much higher reported reduction in emissions in the Northern Ireland public sector, where emissions are estimated to have declined by about 48% since 1990. This reduction is due to the change in the fuel mix in the sector; in 1990, 70% of energy used in the public sector came from solid and liquid fuels, whereas in 2008, natural gas and electricity make up 98% of the energy used.

Across all of the DAs, the decline in total energy use within the sector is much 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, 2003-2008

Transport Sector							
End User Emissions (Mt CO_2 e)	1990	2003	2004	2005	2006	2007	2008
England	119.17	127.08	126.33	127.40	126.08	126.72	122.13
Scotland	13.18	13.88	13.76	13.98	14.13	14.17	13.75
Wales	7.64	7.90	7.99	8.04	8.10	8.11	7.91
Northern Ireland	4.32	5.73	5.64	5.77	5.85	5.96	5.87

DA % of End User Emissions	1990	2003	2004	2005	2006	2007	2008
England	82.6%	82.2%	82.2%	82.1%	81.8%	81.8%	81.6%
Scotland	9.1%	9.0%	9.0%	9.0%	9.2%	9.1%	9.2%
Wales	5.3%	5.1%	5.2%	5.2%	5.3%	5.2%	5.3%
Northern Ireland	3.0%	3.7%	3.7%	3.7%	3.8%	3.8%	3.9%

End User/By Source	1990	2003	2004	2005	2006	2007	2008
England	116%	118%	116%	116%	114%	114%	114%
Scotland	116%	118%	116%	117%	114%	114%	114%
Wales	117%	119%	117%	117%	115%	115%	115%
Northern Ireland	116%	117%	116%	116%	114%	114%	113%

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 stationary combustion sources 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 113 to 117% higher than the by source estimates. Note that the ratio of end user to source estimates for transport emissions are significantly lower than the estimates from the previous version of the model. This is primarily a result of the new method for allocating emissions to the Exports category.

This increment is a slight over-estimate, as the majority of the upstream oil and gas processing emissions from offshore sources are allocated to petroleum processing within the end users method due to lack of detailed data (whilst gas consumption carries forward a slight under-estimate in the end users methodology). A planned improvement for both the UK and DA inventories is to separate out the upstream oil and gas processing emissions into oil or gas, and this will lead to improvements in the transparency of reporting by source, and the allocation of emissions by end user.

The emissions within this sector are dominated by road transport, for which, despite the methodological limitation outlined above, 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 2008, the road transport sector comprised around 24-25% 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 increased by between 2 and 4%, whilst the growth in transport end user emissions in Northern Ireland is marked, at around 36% 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 5-7% increase in emissions. Emissions allocated to the Exports category accounted for around 2% of England emissions, 3% of Scotland and Northern Ireland emissions, and 4% of emissions from Wales. No emissions are allocated to this category within the by source inventories.

10.5.7 Planned improvements

As part of the UK GHGI Improvement Programme, work is planned to disaggregate the upstream oil and gas production emissions and allocate them to either oil or gas. Currently, this distinction is not made, and the combined oil and gas emissions are all allocated to oil users. This leads to an overestimate of emissions from oil users and an underestimate for gas users. It is anticipated that this change will lead to decreases in emissions in the transport category, and increases in sectors where gas use is the major fuel, e.g. the residential sector. It may also impact the implied carbon intensity of the electricity generation sector. The full impact of the change will be assessed in the 1990 to 2009 end user emissions inventory.

11 Summary Graphs

Graphs illustrating the net greenhouse gas emissions as CO_2 equivalent for 1990, 1995, and 1998 to 2008 for the Devolved Administrations 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 greenhouse gas emissions by IPCC Source Categories: Energy, Industrial Processes, 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, 1990-2008 (kt CO_2)

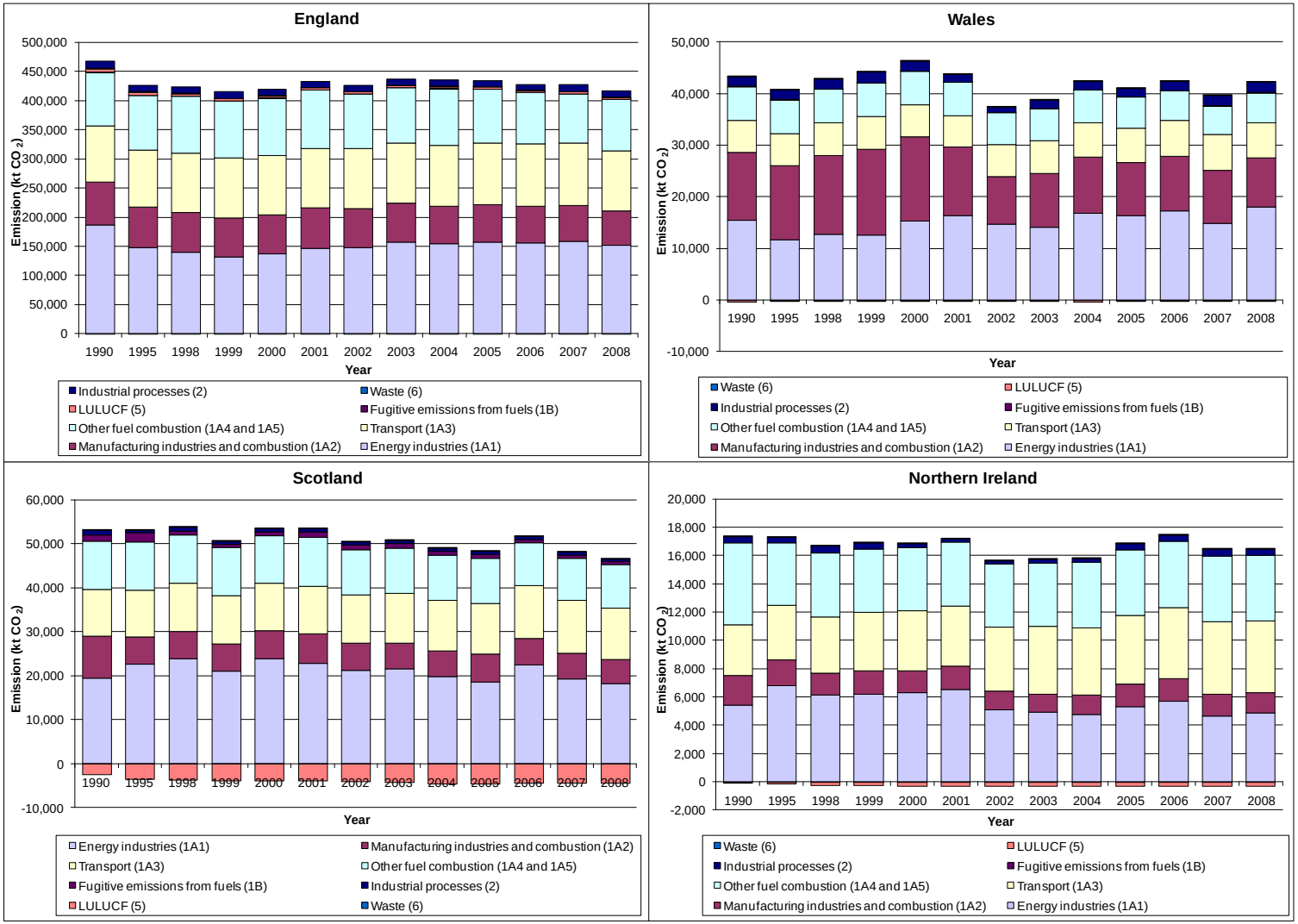


Figure 11.2 Graphs of Methane Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2008 (kt CO_2 e)

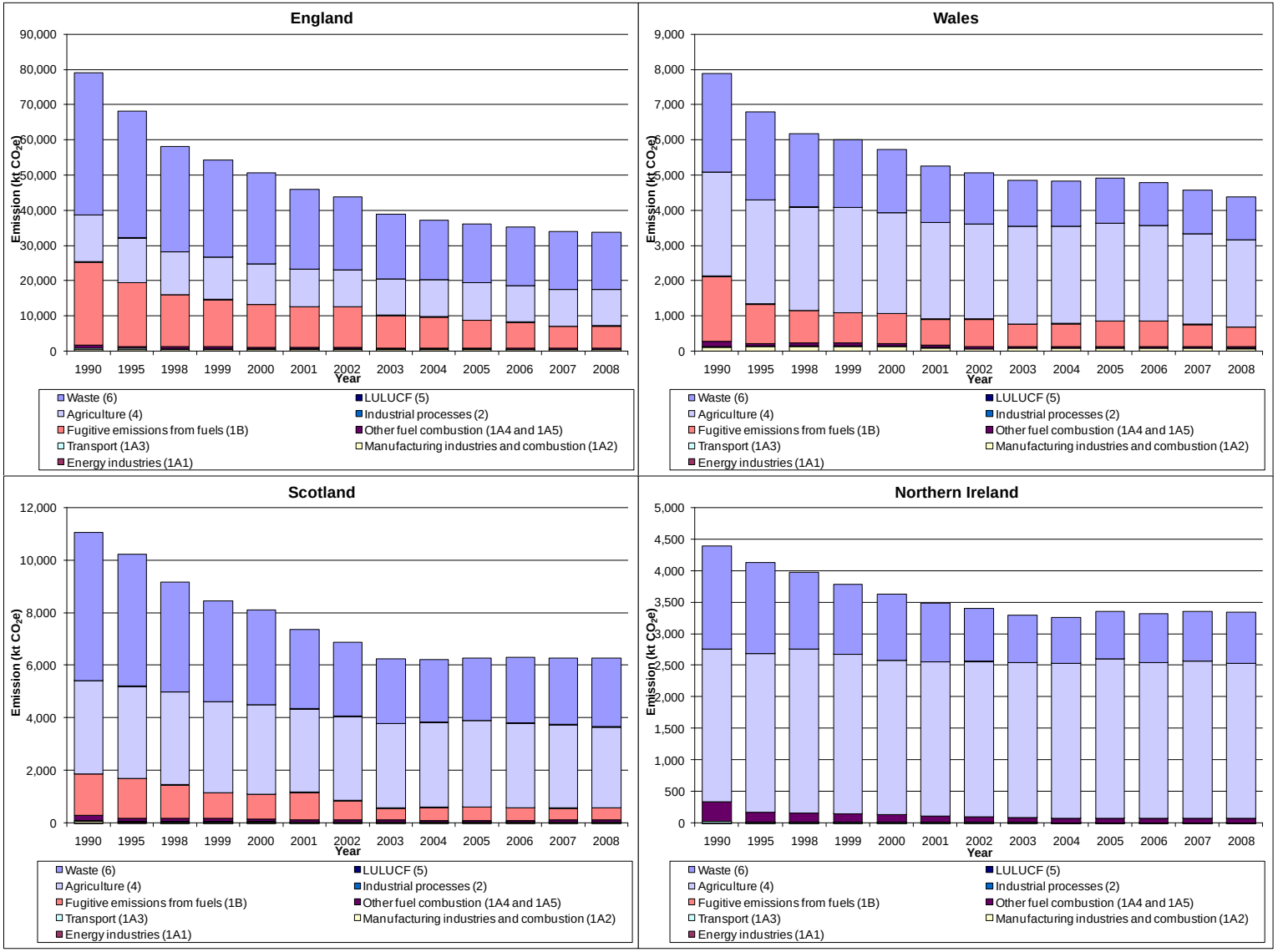


Figure 11.3 Graphs of Nitrous Oxide Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2008 (kt CO_2 e)

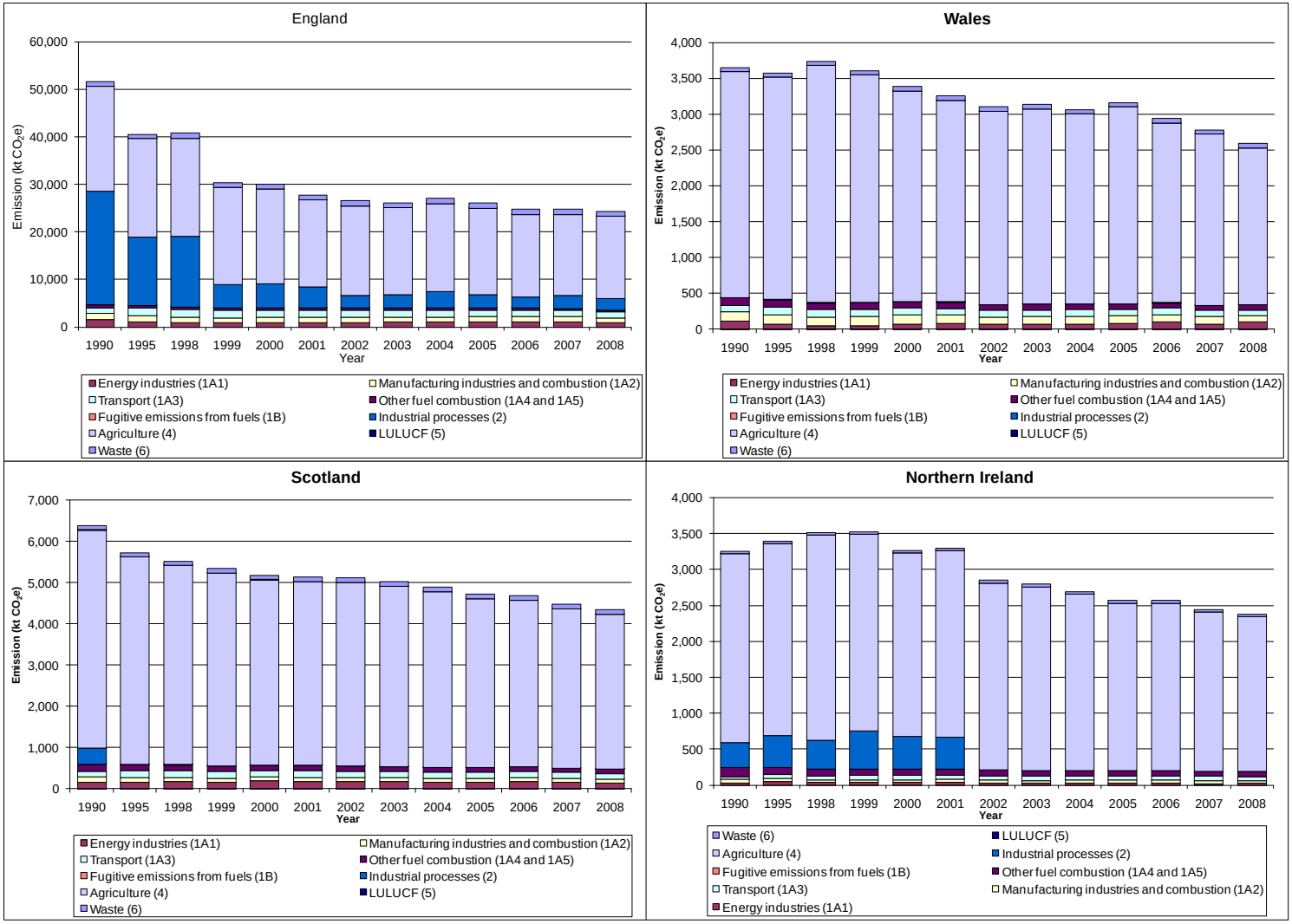


Figure 11.4 Graphs of HFC Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2008 (kt CO_2 e)

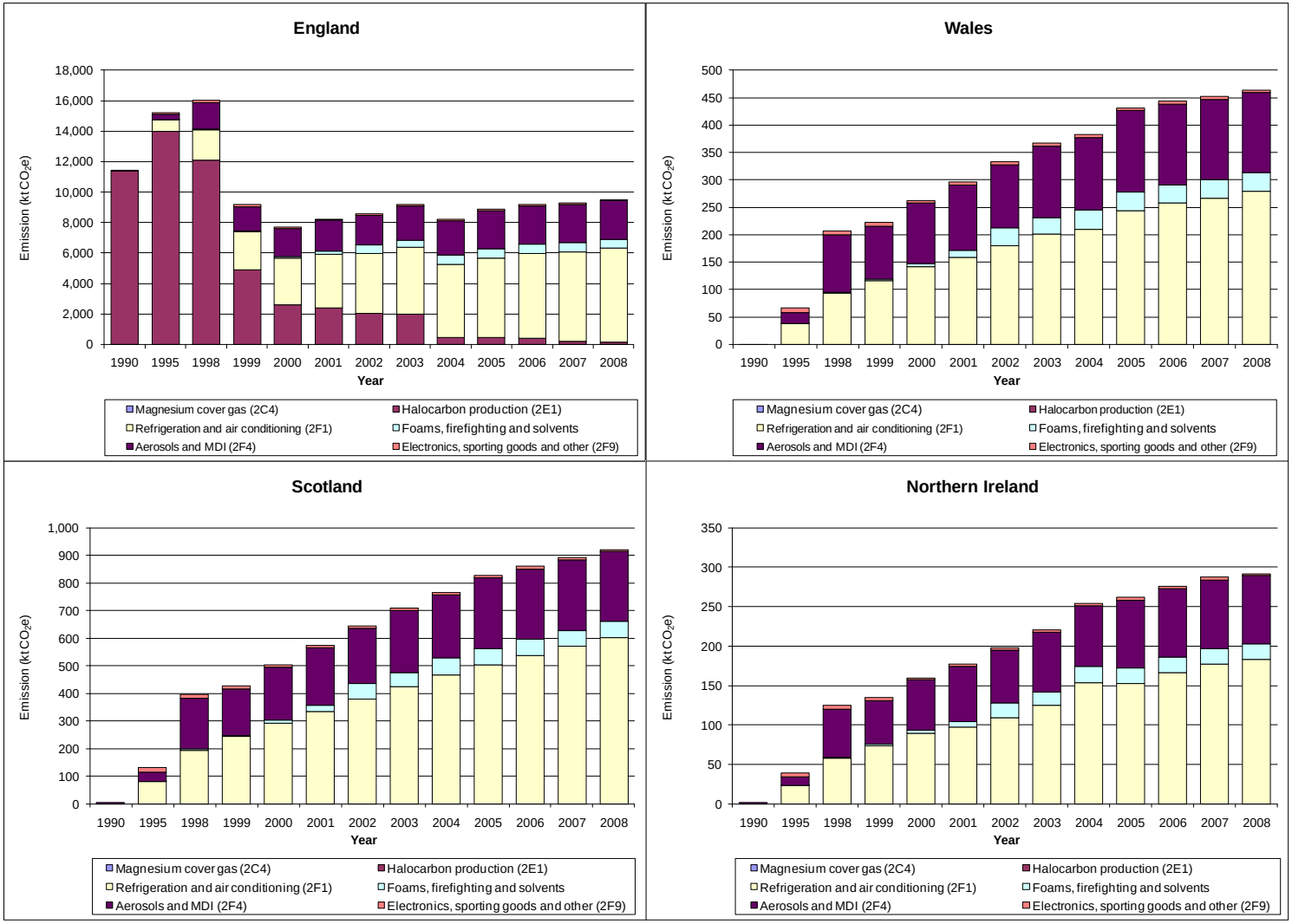


Figure 11.5 Graphs of PFC Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2008 (kt CO_2 e)

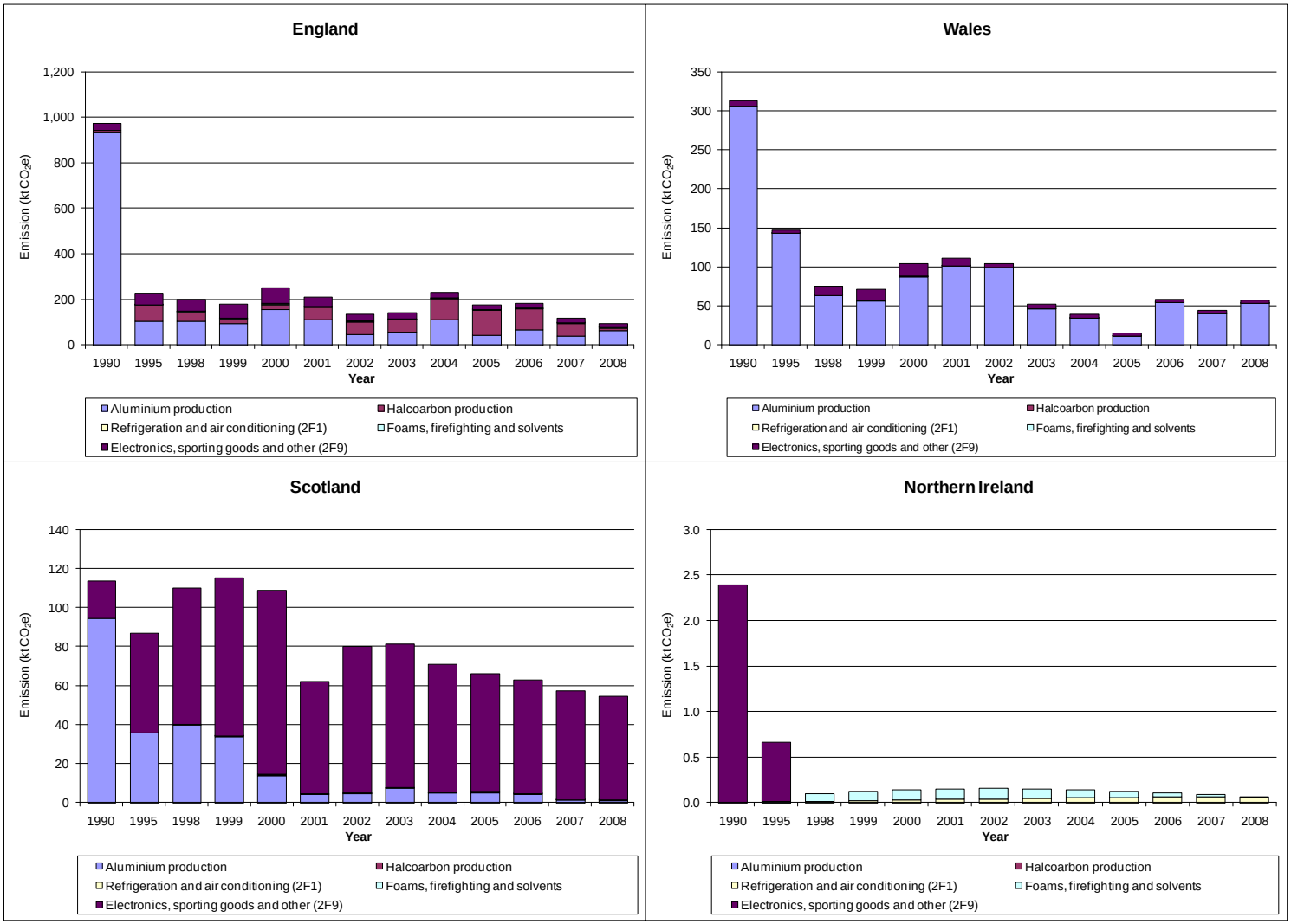
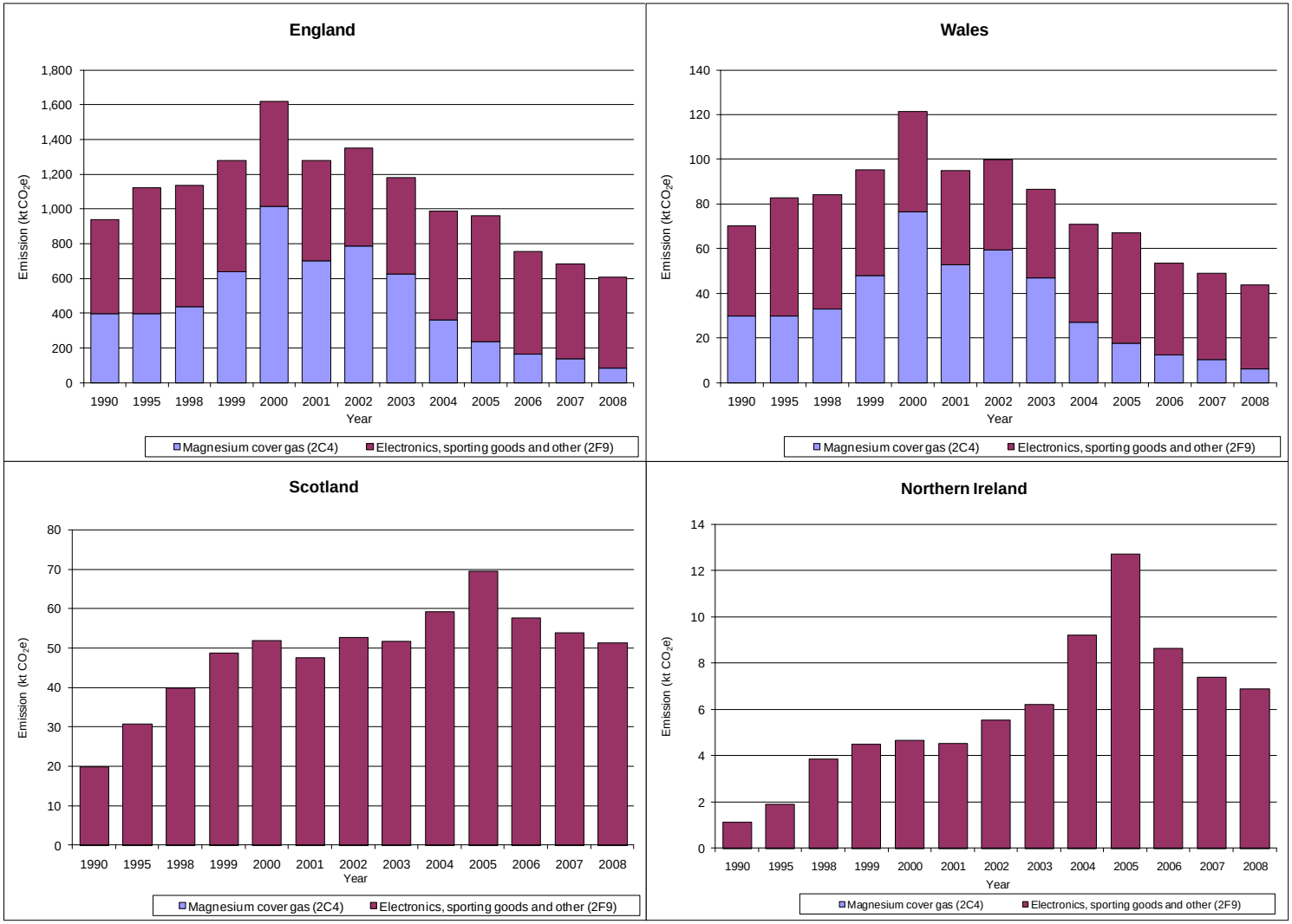


Figure 11.6 Graphs of SF_6 Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2008 (kt CO_2 e)



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13 Acknowledgements

The AEA Inventory team are very grateful to the following individuals and organisations for the contributions and support to the ongoing development of the DA GHG inventory work programme:-

- John Mackintosh and Helen Champion of DECC, Climate & Energy: Science and Analysis (CESA) Division.
- Liam Kelly and John Landrock of the Scottish Government.
- Brendan Forde and Michael Bennett of the Northern Ireland Department of Environment.
- Ross Hunter, Matt Sayer and Havard Prosser of the Welsh Assembly Government.
- Annie Sorbie of DfT
- Yvette Hood, Katherine Bass and Caroline Whalley of Defra.
- Amanda Thomson, Stephen Hallsworth and Deena Mobbs of the Centre for Ecology & Hydrology (CEH).
- Laura Cardenas, Sarah Gilhespy and Tom Misselbrook of North Wyke Research
- Julian Prime, Clive Evans, Roger Lampert, Laura Williams and Warren Evans of the DECC Energy Statistics team.

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