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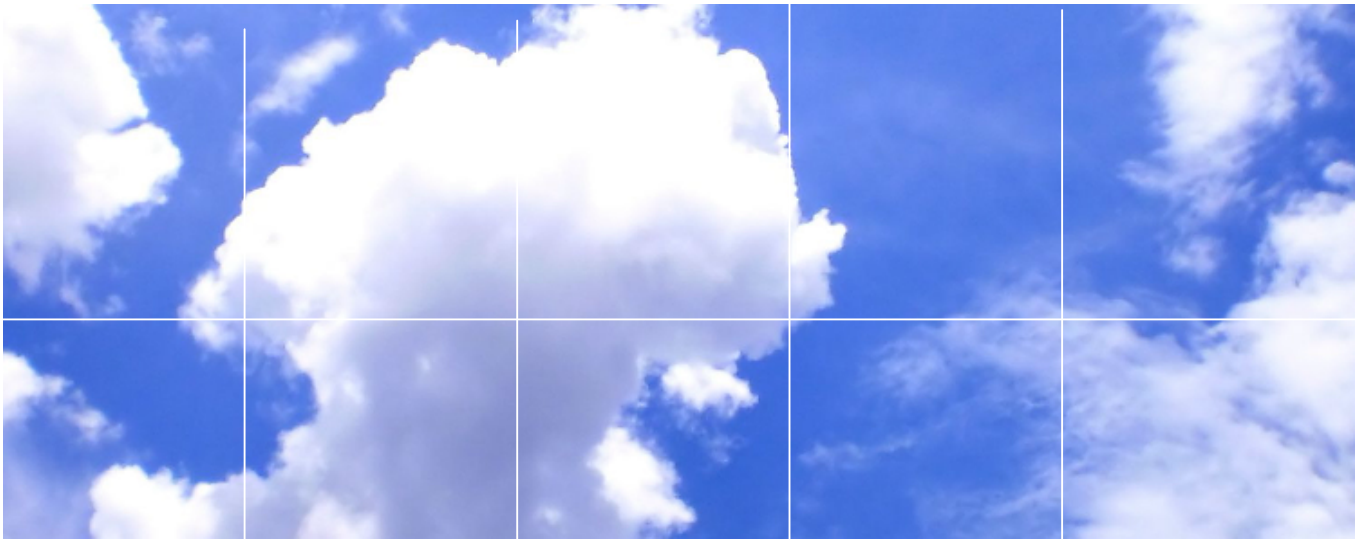

Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 - 2006

Report to the Department for Environment, Food and Rural Affairs, The Scottish Government, The Welsh Assembly Government and The Northern Ireland Department of Environment.

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AEA
The Gemini Building
Fermi Avenue
Didcot
Oxfordshire
OX11 0QS

Tel: 0870 190 6584
Fax: 0870 190 6607

AEA is a business name of AEA Technology plc

AEA is certificated to ISO9001 and ISO14001

Authors	Name	Joanna Jackson, Yvonne Li, Neil Passant, Jenny Thomas, Glen Thistlethwaite, Amanda Thomson & Laura Cardenas
Approved by	Name	John Watterson
	Signature	
	Date	

Executive Summary

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, 1998 to 2006. 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 2006 UK Greenhouse Gas Inventory (Choudrie et al., 2008). Emissions from offshore sources cannot be allocated to any country, so an unallocated category is used to report these. UK territorial coverage in this report includes the Crown Dependencies of Jersey, Guernsey and Isle of Man but 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. Emissions from the Crown Dependencies are all allocated to England.

All percentages quoted in this report are based on net emission estimates held at full precision and may therefore differ slightly from those that can be calculated from summary tables.

The study shows that the UK distribution of regional net greenhouse gas emissions in 2006, expressed in terms of global warming potentials (GWP), is[1]:

- England 77.1%
- Scotland 9.1%
- Wales 7.8%
- Northern Ireland 3.4%
- Unallocated 2.6%

Table ES1 (below) presents emissions of the six greenhouse gases in more detail for the base year and 2006. 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[2] are as follows:

- **Carbon dioxide**: Overall UK emissions have fallen by 6.4% between 1990 and 2006, mainly driven by the installation of combined cycle gas turbines (CCGT) in the power generation sector in England and reductions in CO_2 emissions from industry in England, Scotland and Wales.

- **Methane**: Overall UK emissions have fallen by 52.5% between 1990 and 2006, due primarily to significant reductions in methane emissions from waste disposal and coal mining sources.

- **Nitrous oxide**: Overall UK emissions have fallen by 40.0% between 1990 and 2006, driven predominantly by a large reduction in emissions following the installation of abatement measures at an adipic acid plant in England. This overall downward trend is offset to a small degree by a rise

[1] The percentages presented in these figures are rounded to one decimal place, but are calculated from emission estimates calculated at full precision.
2 Base years for UK Greenhouse Gas Emissions are: 1990 for carbon dioxide, methane and nitrous oxide, 1995 for the fluorinated gases.

across all constituent countries in nitrous oxide emissions from the transport sector over the period due to increased use of three-way catalytic converters.

- **HFCs**: Overall UK emissions have fallen by 40.7% between 1995 and 2006, mainly due to a big reduction in emissions following the installation of improved abatement equipment at a HCFC plant in England. However, there is 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 37.1% between 1995 and 2006, 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 29.1% between 1995 and 2006. This is mostly due to decreases in emissions from the magnesium industry.

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 by the Department for Business, Enterprise and Regulatory Reform (BERR), providing estimated fuel use data for the following sectors:

- Industry
- Agriculture
- Commercial services
- Public Administration
- Residential

The BERR 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, and to date provide estimates of fuel use to LA level for 2003, 2004 and 2005. Although the BERR data are known to be somewhat uncertain (due to the need to model solid and petroleum-based fuel use across many sectors, supplementing meter data for gas and electricity use), they are regarded as the best dataset available to inform the patterns of fuel use across the Devolved Administrations. Hence they have been 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 & 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 1990-2005 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:

- Industrial fuel use
- Waste Management
- Domestic Aviation
- Agricultural Mobile Machinery
- Road transport
- Agriculture: Nitrogen excretion rates
- Rail Transport
- Cement & Lime Process emissions
- Chemical Industry
- Closed coal mine emissions
- Secondary aluminium process emissions

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 October 2007) covered the years up to and including 2005, whilst this report gives emission estimates for the years up to and including 2006.

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 the BERR via 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, 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.

Notes on Table ES1 (Below)

#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.

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_1990-2006_v1_300608"

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

Greenhouse Gas		Units	England	Scotland	Wales	Northern Ireland	Unallocated	UK
CO_2	1990	kt CO_2e	468,897.9	50,687.7	43,236.3	16,578.4	13,023.5	592,423.8
	1990 Percentage	%	79.1%	8.6%	7.3%	2.8%	2.2%	100.0%
	2006	kt CO_2e	432,848.5	47,223.5	42,450.2	16,331.0	15,663.5	554,516.7
	2006 Percentage	%	78.1%	8.5%	7.7%	2.9%	2.8%	100.0%
	Percentage change from BY	%	-7.7%	-6.8%	-1.8%	-1.5%	20.3%	-6.4%
CH_4	1990	kt CO_2e	78,667.5	10,982.9	7,881.4	4,147.0	1,807.2	103,485.9
	1990 Percentage	%	76.0%	10.6%	7.6%	4.0%	1.7%	100.0%
	2006	kt CO_2e	33,969.9	6,232.3	4,857.4	3,291.0	785.2	49,135.7
	2006 Percentage	%	69.1%	12.7%	9.9%	6.7%	1.6%	100.0%
	Percentage change from BY	%	-56.8%	-43.3%	-38.4%	-20.6%	-56.6%	-52.5%
N_2O	1990	kt CO_2e	50,650.0	6,245.7	3,702.1	3,121.9	110.6	63,830.4
	1990 Percentage	%	79.4%	9.8%	5.8%	4.9%	0.2%	100.0%
	2006	kt CO_2e	27,385.2	4,727.9	3,268.5	2,592.6	319.1	38,293.3
	2006 Percentage	%	71.5%	12.3%	8.5%	6.8%	0.8%	100.0%
	Percentage change from BY	%	-45.9%	-24.3%	-11.7%	-17.0%	188.5%	-40.0%
HFCs	1995	kt CO_2e	15,259.0	131.9	67.5	39.3	0.0	15,497.7
	1995 Percentage	%	98.5%	0.9%	0.4%	0.3%	0.0%	100.0%
	2006	kt CO_2e	7,827.7	734.7	382.5	237.6	0.0	9,182.5
	2006 Percentage	%	85.2%	8.0%	4.2%	2.6%	0.0%	100.0%
	Percentage change from BY	%	-48.7%	457.1%	466.4%	505.0%	NA	-40.7%
PFCs	1995	kt CO_2e	235.0	87.6	147.3	0.9	0.0	470.8
	1995 Percentage	%	49.9%	18.6%	31.3%	0.2%	0.0%	100.0%
	2006	kt CO_2e	184.7	66.6	44.9	0.0	0.0	296.2
	2006 Percentage	%	62.4%	22.5%	15.2%	0.0%	0.0%	100.0%
	Percentage change from BY	%	-21.4%	-23.9%	-69.5%	-100.0%	NA	-37.1%
SF_6	1995	kt CO_2e	1,123.7	30.8	82.9	1.9	0.0	1,239.3
	1995 Percentage	%	90.7%	2.5%	6.7%	0.2%	0.0%	100.0%
	2006	kt CO_2e	757.8	57.7	54.0	8.6	0.0	878.1
	2006 Percentage	%	86.3%	6.6%	6.1%	1.0%	0.0%	100.0%
	Percentage change from BY	%	-32.6%	87.2%	-34.9%	352.6%	NA	-29.1%
Total	Base year	kt CO_2e	614,833.2	68,166.6	55,117.5	23,889.4	14,941.3	776,947.9
	Base year Percentage	%	79.1%	8.8%	7.1%	3.1%	1.9%	100.0%
	2006	kt CO_2e	502,973.7	59,042.7	51,057.5	22,460.8	16,767.8	652,302.5
	2006 Percentage	%	77.1%	9.1%	7.8%	3.4%	2.6%	100.0%
	Percentage change from BY	%	-18.2%	-13.4%	-7.4%	-6.0%	12.2%	-16.0%

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 ($MtCO_2$ equivalent)

England	Mt CO_2 Equivalent											% change
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	BY to 2006
CO_2	468.9	427.2	425.0	416.5	420.5	433.4	426.8	437.6	435.7	438.1	432.8	**-7.7%**
CH_4	78.7	67.6	57.7	53.7	50.0	45.4	43.3	38.3	36.5	34.7	34.0	**-56.8%**
N_2O	50.7	40.3	41.5	31.4	31.3	29.4	28.5	28.3	29.4	28.5	27.4	**-45.9%**
HFCs	11.4	15.3	16.5	10.0	8.1	8.6	8.7	9.0	7.6	7.9	7.8	**-31.2%**
PFCs	1.0	0.2	0.2	0.2	0.3	0.2	0.2	0.1	0.2	0.2	0.2	**-81.0%**
SF_6	0.9	1.1	1.1	1.3	1.6	1.3	1.4	1.2	1.0	0.9	0.8	**-19.3%**
Total (Net Emissions)	**611.5**	**551.7**	**542.0**	**513.0**	**511.9**	**518.3**	**508.8**	**514.5**	**510.3**	**510.3**	**503.0**	**-18.2%**
Net CO_2 Emissions from LULUCF	5.7	5.1	4.1	3.9	3.9	3.8	3.5	3.5	3.2	3.0	3.0	
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	
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	

Table ES2.1.2 GHG emissions for England (MtC equivalent)

England	Mt Carbon Equivalent											% change
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	BY to 2006
CO_2	127.9	116.5	115.9	113.6	114.7	118.2	116.4	119.3	118.8	119.5	118.0	**-7.7%**
CH_4	21.5	18.4	15.7	14.6	13.6	12.4	11.8	10.4	9.9	9.5	9.3	**-56.8%**
N_2O	13.8	11.0	11.3	8.6	8.5	8.0	7.8	7.7	8.0	7.8	7.5	**-45.9%**
HFCs	3.1	4.2	4.5	2.7	2.2	2.3	2.4	2.4	2.1	2.1	2.1	**-48.7%**
PFCs	0.3	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.1	**-21.4%**
SF_6	0.3	0.3	0.3	0.3	0.4	0.3	0.4	0.3	0.3	0.3	0.2	**-32.6%**
Total (Net Emissions)	**166.8**	**150.5**	**147.8**	**139.9**	**139.6**	**141.4**	**138.8**	**140.3**	**139.2**	**139.2**	**137.2**	**-18.2%**
Net CO_2 Emissions from LULUCF	1.5	1.4	1.1	1.1	1.1	1.0	1.0	1.0	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	
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	

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

England	Aggregate Emission Trends by Source Category										
IPCC Source Category	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1. Energy	479.9	434.2	430.2	421.0	424.2	437.4	431.7	439.9	437.7	439.2	433.5
2. Industrial Processes	49.2	42.4	44.5	27.9	26.4	25.2	23.3	23.8	23.3	22.8	22.3
3. Solvent and Other Product Use[a]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Agriculture	34.1	32.1	31.8	31.6	30.5	28.1	28.5	28.0	28.2	27.6	26.7
5. LULUCF	5.7	5.1	4.2	4.0	3.9	3.8	3.5	3.6	3.3	3.1	3.0
6. Waste	42.5	37.7	31.4	28.6	26.9	23.8	21.8	19.3	17.9	17.5	17.4
Total	**611.5**	**551.7**	**542.0**	**513.0**	**511.9**	**518.3**	**508.8**	**514.5**	**510.3**	**510.3**	**503.0**

[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 ($MtCO_2$ equivalent)

Scotland	Mt CO_2 Equivalent											% change
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	BY to 2006
CO_2	50.7	49.5	49.9	46.7	49.7	49.9	46.5	46.9	44.9	44.1	47.2	**-6.8%**
CH_4	11.0	10.1	9.1	8.3	8.0	7.2	6.7	6.1	6.1	6.1	6.2	**-43.3%**
N_2O	6.2	5.6	5.5	5.4	5.3	5.3	5.3	5.2	5.1	4.9	4.7	**-24.3%**
HFCs	0.0	0.1	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.7	0.7	**457.1%**
PFCs	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**-23.9%**
SF_6	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	**87.2%**
Total (Net Emissions)	**68.0**	**65.5**	**65.1**	**61.1**	**63.7**	**63.1**	**59.3**	**59.0**	**56.9**	**56.0**	**59.0**	**-13.4%**
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	
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	
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	

Table ES2.2.2 GHG emissions for Scotland (MtC equivalent)

Scotland	Mt Carbon Equivalent											% change
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	BY to 2006
CO_2	13.8	13.5	13.6	12.7	13.6	13.6	12.7	12.8	12.3	12.0	12.9	**-6.8%**
CH_4	3.0	2.8	2.5	2.3	2.2	2.0	1.8	1.7	1.7	1.7	1.7	**-43.3%**
N_2O	1.7	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.3	1.3	**-24.3%**
HFCs	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	**457.1%**
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**-23.9%**
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**87.2%**
Total (Net Emissions)	**18.6**	**17.9**	**17.7**	**16.7**	**17.4**	**17.2**	**16.2**	**16.1**	**15.5**	**15.3**	**16.1**	**-13.4%**
Net CO_2 Emissions from LULUCF	-0.7	-1.0	-1.0	-1.1	-1.1	-1.1	-1.1	-1.2	-1.3	-1.3	-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	
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	

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

Scotland	Aggregate Emission Trends by Source Category										
IPCC Source Category	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1. Energy	54.4	54.7	55.1	51.8	54.8	55.1	51.6	51.7	50.2	49.5	52.4
2. Industrial Processes	1.7	0.9	1.3	1.3	1.4	1.4	1.5	1.6	1.6	1.5	1.5
3. Solvent and Other Product Use[a]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Agriculture	8.7	8.4	8.2	8.0	7.8	7.5	7.5	7.5	7.3	7.2	7.0
5. LULUCF	-2.5	-3.6	-3.8	-3.9	-3.9	-4.0	-4.2	-4.2	-4.6	-4.6	-4.5
6. Waste	5.8	5.1	4.3	3.9	3.7	3.1	2.9	2.5	2.4	2.4	2.5
Total	**68.0**	**65.5**	**65.1**	**61.1**	**63.7**	**63.1**	**59.3**	**59.0**	**56.9**	**56.0**	**59.0**

[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 ($MtCO_2$ equivalent)

Wales	**Mt CO_2 Equivalent**											**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**BY to 2006**
CO_2	43.2	40.8	43.1	44.4	46.5	43.9	37.4	38.7	42.5	40.6	42.5	**-1.8%**
CH_4	7.9	6.8	6.2	6.0	5.7	5.2	5.0	4.8	4.8	4.8	4.9	**-38.4%**
N_2O	3.7	3.7	3.9	3.8	3.6	3.5	3.3	3.4	3.3	3.4	3.3	**-11.7%**
HFCs	0.0	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	**466.4%**
PFCs	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	**-69.5%**
SF_6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**-34.9%**
Total (Net Emissions)	**55.2**	**51.6**	**53.6**	**54.5**	**56.3**	**53.1**	**46.3**	**47.4**	**51.1**	**49.2**	**51.1**	**-7.4%**
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	
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	
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	

Table ES2.3.2 GHG emissions for Wales (MtC equivalent)

Wales	**Mt Carbon Equivalent**											**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**BY to 2006**
CO_2	11.8	11.1	11.8	12.1	12.7	12.0	10.2	10.6	11.6	11.1	11.6	**-1.8%**
CH_4	2.1	1.8	1.7	1.6	1.6	1.4	1.4	1.3	1.3	1.3	1.3	**-38.4%**
N_2O	1.0	1.0	1.1	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	**-11.7%**
HFCs	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**466.4%**
PFCs	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**-69.5%**
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**-34.9%**
Total (Net Emissions)	**15.1**	**14.1**	**14.6**	**14.9**	**15.4**	**14.5**	**12.6**	**12.9**	**13.9**	**13.4**	**13.9**	**-7.4%**
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	
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	
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	

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

Wales	Aggregate Emission Trends by Source Category										
IPCC Source Category	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1. Energy	44.2	40.9	42.8	44.0	46.1	44.0	37.9	38.7	42.3	40.5	42.3
2. Industrial Processes	2.2	2.2	2.4	2.4	2.6	2.0	1.6	2.0	2.2	2.2	2.3
3. Solvent and Other Product Use[a]	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	6.3	6.2	5.9	5.6	5.5	5.6	5.5	5.5	5.5
5. LULUCF	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2
6. Waste	2.9	2.6	2.2	2.0	1.9	1.6	1.5	1.3	1.3	1.3	1.3
Total	**55.2**	**51.6**	**53.6**	**54.5**	**56.3**	**53.1**	**46.3**	**47.4**	**51.1**	**49.2**	**51.1**

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

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 ($MtCO_2$ equivalent)

Northern Ireland	**Mt CO_2 Equivalent**											**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**BY to 2006**
CO_2	16.6	16.9	15.8	16.0	15.8	16.1	14.8	14.7	14.8	15.5	16.3	**-1.5%**
CH_4	4.1	4.0	3.9	3.7	3.5	3.4	3.3	3.3	3.2	3.2	3.3	**-20.6%**
N_2O	3.1	3.3	3.4	3.5	3.2	3.3	2.8	2.8	2.7	2.6	2.6	**-17.0%**
HFCs	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	**505.0%**
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**-100.0%**
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**352.6%**
Total (Net Emissions)	**23.9**	**24.3**	**23.3**	**23.3**	**22.8**	**23.0**	**21.1**	**21.0**	**20.9**	**21.6**	**22.5**	**-6.0%**
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	
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	
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	

Table ES2.4.2 GHG emissions for Northern Ireland (MtC equivalent)

Northern Ireland	**Mt Carbon Equivalent**											**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**BY to 2006**
CO_2	4.5	4.6	4.3	4.4	4.3	4.4	4.0	4.0	4.0	4.2	4.5	**-1.5%**
CH_4	1.1	1.1	1.1	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	**-20.6%**
N_2O	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.7	0.7	0.7	**-17.0%**
HFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	**505.0%**
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**-100.0%**
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**352.6%**
Total (Net Emissions)	**6.5**	**6.6**	**6.3**	**6.4**	**6.2**	**6.3**	**5.8**	**5.7**	**5.7**	**5.9**	**6.1**	**-6.0%**
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	
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	
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	

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

Northern Ireland	Aggregate Emission Trends by Source Category										
IPCC Source Category	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1. Energy	16.6	17.1	16.0	16.2	16.3	16.6	15.2	15.1	15.2	15.8	16.5
2. Industrial Processes	0.8	0.9	1.0	1.1	0.9	0.9	0.5	0.5	0.5	0.7	0.7
3. Solvent and Other Product Use[a]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Agriculture	4.8	5.0	5.3	5.1	4.9	4.9	4.9	4.9	4.8	4.6	4.7
5. LULUCF	0.0	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
6. Waste	1.6	1.5	1.2	1.1	1.1	0.9	0.8	0.8	0.7	0.8	0.8
Total	**23.9**	**24.3**	**23.3**	**23.3**	**22.8**	**23.0**	**21.1**	**21.0**	**20.9**	**21.6**	**22.5**

[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 ES2.5.1 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 ($MtCO_2$ equivalent)

Unallocated	Mt CO_2 Equivalent											% change
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	BY to 2006
CO_2	13.0	15.4	16.0	16.7	15.9	16.0	17.2	16.7	17.2	16.9	15.7	**20.3%**
CH_4	1.8	1.7	1.5	1.3	1.1	1.1	1.0	1.0	1.0	0.9	0.8	**-56.6%**
N_2O	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.3	0.3	**188.5%**
HFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**NA**
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**NA**
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**NA**
Total (Net Emissions)	**14.9**	**17.3**	**17.6**	**18.1**	**17.2**	**17.3**	**18.4**	**17.9**	**18.4**	**18.1**	**16.8**	**12.2%**
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	
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	
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	

Table ES2.5.2 Unallocated GHG emissions (MtC equivalent)

Unallocated	Mt Carbon Equivalent											% change
	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	BY to 2006
CO_2	3.6	4.2	4.4	4.5	4.3	4.4	4.7	4.6	4.7	4.6	4.3	**20.3%**
CH_4	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	**-56.6%**
N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	**188.5%**
HFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**NA**
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**NA**
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**NA**
Total (Net Emissions)	**4.1**	**4.7**	**4.8**	**4.9**	**4.7**	**4.7**	**5.0**	**4.9**	**5.0**	**4.9**	**4.6**	**12.2%**
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	
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	
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	

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

Unallocated	Aggregate Emission Trends by Source Category										
IPCC Source Category	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1. Energy	14.9	17.3	17.6	18.1	17.2	17.3	18.4	17.9	18.4	18.1	16.8
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
3. Solvent and Other Product Use[a]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5. LULUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6. Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**14.9**	**17.3**	**17.6**	**18.1**	**17.2**	**17.3**	**18.4**	**17.9**	**18.4**	**18.1**	**16.8**

[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

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Science policy enquiries should be directed to Yamide Dagnet, CEOSA Division, Department for Environment, Food and Rural Affairs, Area 3F, Ergon House, 17 Smith Square, London, SW1P 3JR, UK, Tel: +44 (0)20 7238 3372, Fax: +44 (0) 20 7082 8152, E-mail: yamide.dagnet@defra.gsi.gov.uk

Technical enquiries should be directed to Glen Thistlethwaite, AEA Group, Gemini Building, Fermi Avenue, Harwell, Didcot, Oxfordshire, OX11 0QR, UK, Tel: +44 (0) 870 190 6584, Fax: +44 (0) 870 190 6318, E-mail: glen.thistlethwaite@aeat.co.uk

Technical enquiries on land use, land use change and forestry should be addressed to Dr A Thomson, Centre for Ecology and Hydrology (Edinburgh), Bush Estate, Penicuik, EH26 OQB, UK, Tel: +44 (0) 131 445 8575, Fax +44 (0) 131 445 3943, E-mail: amath@ceh.ac.uk

Technical enquiries on agriculture should be addressed to Dr. L Cardenas at North Wyke Research (NWRes), Devon, EX20 2SB, UK, Tel: +44 (0) 1837 883528, Fax: + 44 (0) 1837 82139, E-mail: laura.cardenas@bbsrc.ac.uk

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Document Revision History	
Version	Comment
Draft for comment	Tables of emissions issued for comment to the DAs. Comments received. No revisions required. Queries regarding agriculture inventory passed on to North Wyke. Draft Report prepared and submitted to Defra and DAs for comment, 15th August 2008
Issue 1	Revisions made to address DA feedback, issued 2nd September 2008.

1 Introduction

1.1 Background to Inventory Development for the Devolved Administrations

The United Nations Framework Convention on Climate Change (FCCC) was ratified by the United Kingdom in December 1993 and came into force in March 1994. Parties to the Convention are committed to develop, publish and regularly update national emission inventories of greenhouse gases (GHG).

Following devolution, a national UK inventory continues to be necessary to ensure the UK fulfils its reporting requirements under the FCCC and to monitor the legally binding commitments under the Kyoto Protocol to reduce greenhouse gas emissions. However, some of the measures to deliver GHG emission reductions are devolved and information on the emissions from the four individual countries is needed to support action in each country.

Therefore, Defra agreed with the Scottish Government, the Welsh Assembly Government and in Northern Ireland, the Department of the Environment, to carry out a joint research project to provide first estimates of GHG emissions inventories for England, Scotland, Wales and Northern Ireland. The results of this study were published in *Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 and 1995: A Scoping Study, AG Salway et al (1999).* Subsequently these studies have been updated for 1998 to 2006.

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 2006. 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)

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 are consistent with the UK Greenhouse Gas Inventory (Choudrie *et al.*, 2008), submitted to the UNFCCC in April 2008. This report follows the convention used in Choudrie *et al.*, 2008 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 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 2006. The reasons for any significant trends in emissions, issues regarding data availability and uncertainty estimates are provided for each inventory. Tables 8.1 to 8.6 present the summary data for these years as global warming potential (GWP) weighted emissions.

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 2006 for England, Scotland, Wales and Northern Ireland. Summary tables (IPCC Sectoral Table 7A) are provided for 1995 and 2006 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).[3]

1.3 Global Warming Potential

Greenhouse gases all have different degrees of effectiveness in global warming. The Global Warming Potential (GWP) is an attempt to provide a simple measure of the relative radiative effects of the emissions of the various gases. 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 FCCC 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 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

1.4 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 report covered the years up to and including 2005, whilst this report gives emission estimates for the years up to and including 2006.

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 the BERR via 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 2005") 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, a more representative emission factor for one or more greenhouse gases may have been derived for a given

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

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.

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.

1.5 Future Developments of the GHG Inventories for England, Scotland, Wales and Northern Ireland

In recent years, each of the constituent countries of the UK has developed their own Climate Change policy aims, including GHG emission reduction targets. In addition, there is an increasing focus on the evaluation of the impact of both reserved (UK) and devolved (DA) policies upon GHG emission trends.

The data (and trends) reported within the DA GHG inventories are coming under greater scrutiny, and the sensitivity of the DA data to changes in activities within sectors from implemented action has been researched by recent climate change policy studies. Hence the DA GHG inventory continues to be developed, aiming to provide an effective and accurate reporting tool and reflecting the impact upon emissions from the implementation of both devolved and reserved measures.

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. Achieving these commitments has been identified as high profile and priority within each country.

- **Scotland**. The Economic Strategy for Scotland 2007 commits the Scottish Government to an 80% reduction in greenhouse gases by 2050, a target that is likely to become a statutory commitment in due course;
- **Wales**. 'One Wales' commits the Assembly Government to achieving 3% year-on-year reductions in greenhouse gases from 2011 onwards; and
- **Northern Ireland**. The Programme for Government 2008-11 commits the Northern Ireland Executive to a reduction of 25% in GHG emissions by 2025, based on 1990 levels.

Source sectors that may be focused upon for future data and method improvements include sectors where devolved action is likely to play more of a significant role (i.e. excluding sectors such as energy intensive industries that are managed primarily under UK regulatory and economic measures):

- Residential fuel use
- Commercial and public sector fuel use
- Landfill waste
- Agricultural livestock sources (i.e. from both waste management and enteric fermentation)

In addition, further work is required to develop "End User" GHG inventories for the constituent countries, whereby emissions from refineries and power stations are re-allocated to reflect secondary fuel (electricity, refined petroleum fuels) 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 will also provide a more representative picture of consumption patterns within the UK, rather than the production-based data presented in this report.

2 Emissions in England

2.1 Summary of Main Emission Sources

The main emission sources for England in 2006 are summarised in Table 2.1 below, expressed as a percentage of the total English GHG emissions in 2006 of 503.0 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 8%
- CH_4 emissions have reduced by 57%
- N_2O emissions have reduced by 46%
- HFC emissions have reduced by 49%
- PFC emissions have reduced by 21%
- SF_6 emissions have reduced by 33%
- Total GHG emissions (as CO_2-equivalents) have reduced by 18%

The largest emissions source is CO_2 from power stations, which accounted for 29% of total English greenhouse gas emissions in 2006. 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 2006 English GHG emissions.

Table 2.1 Emissions Summary for England, 2006 (kt CO_2e)

Summary of Main Emission Sources, England 2006 (kt CO_2e)				
Gas	Sector Name	IPCC code	Emission	Percentage of total GWP Weighted Emissions
CO_2	Power stations	1A1a	144962	29%
CO_2	Road Transport	1A3b	99316	20%
CO_2	Residential Combustion	1A4b	65565	13%
CO_2	Other Industrial Combustion	1A2f	52055	10%
CO_2	Commercial and Institutional Combustion	1A4a	18689	4%
N_2O	Agricultural Soils	4D	15906	3%
CH_4	Landfill	6A1	15269	3%
CO_2	Iron and Steel	1A2a	12031	2%
CO_2	Refineries	1A1b	10634	2%
CH_4	Enteric fermentation - Cattle	4A1	6488	1%

Note that in the IPCC sector discussion text below, the percentages quoted are derived from the inventory and emissions data stored at full precision in a spreadsheet. These data can be found on the NAEI web site and on the CD-ROM attached to the back page of the printed version of 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, as well as fugitive emissions from energy industries. In England, the energy sector contributes 86% to total GWP weighted emissions. 98% of energy sector emissions are CO_2.

Energy Industries (IPCC Sector 1A1) is the largest source of CO_2 in England and in 2006 this contributed 36.5% of the total CO_2 for the country, down from 36.8% of the England total of CO_2 emissions in 1990. This sector includes power generation, refineries, solid fuel transformation processes and the oil and gas industry. Power generation in England contributed 33.5% of the total English CO_2 emission in 2006, which is slightly higher than the UK proportion of 33.1%. Note also that

England is a net importer of electricity from both Wales and Scotland[4]. The inventories presented here are point source inventories, and hence the GHG emissions from the power generated in Wales and Scotland and exported to England are allocated to Wales and Scotland.

The mix of generation capacity is different in England from the rest of the UK: there is 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. Emissions from Energy Industries in England have decreased by 15.4% since 1990. At the UK level, the reduction in CO_2 emissions from Energy industries over 1990-2006 is only 8.9%. This difference can be explained, in part, by the installation of CCGTs in England and increased nuclear capacity and utilisation in England over the period. The CCGTs have higher efficiency than conventional thermal stations and produce lower emissions per GWh electricity generated.

Petroleum refining constitutes 2.5% of CO_2 emissions in England in 2006, lower than the UK mean contribution of 3.4% of total CO_2 emissions from refineries in 2006. Refinery CO_2 emissions in England have decreased by 9.7% since 1990. The other energy emissions are relatively small and are mostly gas consumption at oil and gas terminals, gas separation plant, coking and solid fuel production. Only emissions arising from on-shore installations in England have been included. Other energy emissions have decreased by 5.1% from 1990 to 2006, which is mostly driven by a sharp decline in own gas use at oil terminals from 2005 to 2006.

Combustion emissions from Manufacturing Industry and Construction (IPCC Sector 1A2) account for 14.8% of the English CO_2 total. The iron and steel industry in England accounts for 63.7% of the UK Iron and Steel combustion emissions. The 'Other industry' category (IPCC sector 1A2f) for England contributes 82.1% towards the UK 'Other industry' CO_2 total.

Road Transport is the largest single source of CO_2 after power generation, contributing 22.9% to the English total CO_2 emission. The contribution of English road transport to UK road transport CO_2 emissions is 82.6%, which is slightly less than that which would be expected from England's population (83.8% of UK[5]). The emission has risen by 8.4% from 1990 to 2006 compared with a 10.0% rise for the UK.

Other combustion emissions arise from the domestic (residential), commercial, public sectors and agriculture stationary combustion. 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. CO_2 emissions from domestic combustion sources are estimated to account for 15.1% of the English total. As a proportion of UK domestic emissions they are estimated to represent 82.2%, which is slightly less than would be expected from England's population (83.8%).

N_2O emissions from combustion sources account for 26% of the English total. These arise mainly from road transport, amounting to 15.7% of England's total N_2O emissions having increased by over 400% since 1990, due to the increase in the number of vehicles using three way catalysts. Fuel combustion emissions 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 is around 21.2% of the English total methane emission compared with the UK average of 18.4%. The higher English emission is due to the greater contribution of coal mining and leakage from the gas transmission system in England than elsewhere in the UK. Of these fugitive methane emissions, coal mining contributes 9.4%, natural gas distribution 11.5% and oil and gas terminals 0.1% of the English total. Coal mining emissions have declined by 80.2% from 1990 to 2006 due to the decline in the coal industry. Gas leakage from the gas transmission system is reducing as the mains and services are renewed. The reduction in leakage between 1990 and 2006 is around 44.5%.

[4] For details, see the BERR Energy Trends publication from December 2007, page 16.
[5] Where population percentages are quoted throughout this report, they are taken from ONS data for 2006.

2.3 Industrial Processes

Industrial processes produce emissions from non-combustion sources such as the use of limestone in cement and glass making. Over half of the emissions from this sector in England are CO_2 (51%), with HFCs contributing a further 34%, although total greenhouse gas emissions from this sector only contribute 4.4% 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, constituting 1.1% of English total CO_2 emissions, with smaller emissions from glass, ammonia, aluminium, iron and steel production contributing a further 1.0% of the English total in 2006. England emits all of the UK's emissions from lime production and ammonia production, 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 75% of HFC emissions (as CO_2 equivalent) in England and 71% of total UK HFC emissions (as CO_2 equivalent). Over recent years, HFC emissions from the manufacture of HCFCs and HFCs have been reduced through the installation of improved abatement systems on HCFC production plant. In 2006, HCFC and HFC production in England contributed only 3.9% of total English HFC emissions (as CO_2 equivalent) and 12.1%[6] of total UK HFC emissions (as CO_2 equivalent).

In 2006, the largest sources of HFC emissions are refrigeration, air conditioning, and aerosols and metered dose inhalers. These sources account for 84% of English HFC emissions in 2006, and for 30% 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, and 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.

N_2O emissions account for 11% of total GHG emissions from the industrial process sector in England, and 10% of the total English N_2O emission occurs here. Up until 1998, a more substantial proportion of England's nitrous oxide emissions were produced by chemical processes, namely adipic acid production and to a lesser extent nitric acid production. In 1998, these processes constituted around 36% of England's total N_2O emissions and 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 emissions from this source were significantly reduced. In 2006, the sum of the English emissions from the nitric acid and adipic acid production is around 7.6 kt N_2O, equivalent to 8.6% of the total English N_2O emission, 6.2% of the UK total.

3.4% of total GHG emissions from the industrial process sector in England are sulphur hexafluoride (SF_6). The main sources of SF_6 emissions are from use as electrical insulation, which accounts for 58% of SF_6 emissions in England in 2006 and as a cover gas in magnesium production which accounted for around 23%. Magnesium production is largely concentrated in England; English emissions account for 93% of the UK magnesium production emission. Sulphur hexafluoride is also emitted from other sources including electronics applications and leakage from the soles of certain brands of training shoes. The sum of these emissions accounts for around 19% of total English SF_6 emissions in 2006. Emissions of SF_6 have decreased by 33% since 1995.

PFC emissions only account for 1% of emissions in the industrial process sector in England, and for around 0.04% of total English GHG emissions. The largest sources in England in 2006 were by-product emissions from primary aluminium production (40%) and fugitive emissions from PFC manufacture (49%). English PFC emissions account for 62.4% of total UK PFC emissions, and have declined by 21.4% since 1995.

Emissions of methane from this sector are not significant.

[6] This is a significant increase from 2005 due to an error in the 2005 report where this figure wasn't presented as CO_2 equivalent.

2.4 Agriculture

GHG emissions from agriculture comprise entirely of methane and N_2O. English emissions represent 61% of the UK total in this sector and the agriculture sector accounts for 5.3% of the English GHG total.

Agriculture is the second largest source of methane emissions in England[7]. This contributes 29% to the overall CH_4 emissions in England in 2006, with cattle responsible for 77% of the agricultural methane emissions. Emissions from agriculture are largely dependent on the numbers of livestock and have fallen by 22% from 1990 to 2006 resulting from a decline in cattle and sheep numbers. Of the total emission from agriculture in England, 84% is due to enteric fermentation.

Of the total English emission of 88.3 kt N_2O in 2006, 53.6 kt N_2O of this was from agriculture, representing 61% of the total. Most of these (95%) 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 (28.0%)
- leaching of fertiliser nitrogen and applied animal manures to ground and surface water (26.9%)
- wastes from grazing animals (14.4%)
- ploughing in crop residues (13.3%)
- manure used as fertiliser (8.8%)
- atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NOx) (6.0%)
- cultivation of legumes (1.3%)
- cultivation of histosols (i.e. high organic content soils) (0.8%)
- biological fixation in improved grass (0.6%)

A relatively small proportion (2.5 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 21.5% in the period 1990-2006 and in 2006 represent around 2.9% of UK agricultural emissions.

2.5 Land Use, Land Use Change and Forestry

The LULUCF sector contains both sources and sinks of carbon dioxide, as well as small sources of methane and nitrous oxide. England is a net source of carbon dioxide from LULUCF activities although the size of this source has diminished by 47% between 1990 and 2006 from 5.7 to 3.0 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 Forestland and Grassland categories are increasing. The Cropland category is the largest overall.

Net emissions in 1990 are estimated here to be 5.73 Mt CO_2 compared to 5.71 Mt CO_2 in the 2005 DA inventory report. For 2005 a net source of 3.09 Mt CO_2 is estimated here compared to 3.08 Mt CO_2 in the 2005 inventory. Differences between the inventories are due to the inclusion of a new activity (biomass burning emissions due to forest wildfires), revision of the 2000-2004 data on conversion of Forestland to Settlement, which also affected the land use transition matrix, and some revisions of the data used for allocating liming to Grassland or Cropland. Activity data was updated with 2006 estimates. There were no changes in methods this year. Appendix 1 contains details of the methods and data sources used.

The inclusion of two new activities (forest wildfires and N fertilisation of newly planted forests) affected estimates of methane and nitrous oxide. Emissions of these gases due to LULUCF activities remain small: 0.017 Mt CO_2 equivalent of methane and 0.002 Mt CO_2 equivalent of nitrous oxide in 2006.

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

It should be noted that an estimate of LULUCF sources and sinks for the Crown Dependencies is included within the England inventory, under sector 5G; the size of the overall Crown Dependency sink has increased from -0.04 to -0.07 Mt CO_2 from 1990 to 2006.

2.6 Waste

The waste sector contributes 3.5% to total GHG emissions in England, and is the largest source sector for methane emissions, representing 47% of total methane emissions.

This is dominated by landfill methane with a small contribution from wastewater treatment. The landfill emission is around 78.5% of the UK landfill emission, which is slightly lower than would be expected from England's population (83.8%). Estimates are based on data on disposal of municipal solid waste and sewage sludge in England. This year new waste management data from the www.wastedataflow.org website have been used. This has provided a more detailed insight into the UK % share of waste disposals to landfill for England. Data for 2000-2006 are currently available (and hence the 2000 split assumed as the best estimate for the 1990-1999 years), and this method revision has led to lower methane emission estimates across the time series in England, compared to previous inventory data. Note, however, that 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. Since 1990, landfill emissions in England have declined by 61.7% due to the increasing use of methane recovery systems. This is the same trend as is observed for the UK as a whole. Emissions from wastewater treatment are around 2% of the English total methane emissions and comprise 83.8% of UK wastewater emissions.

3 Emissions in Scotland

3.1 Summary of Main Emission Sources

The main emission sources for Scotland in 2006 are summarised in Table 3.1 below, expressed as a percentage of the total Scottish GHG emissions in 2006 of 59.0 Mt CO_2-equivalent. 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 7%
- CH_4 emissions have reduced by 43%
- N_2O emissions have reduced by 24%
- HFC emissions have increased by 457%
- PFC emissions have reduced by 24%
- SF_6 emissions have increased by 87%
- Total GHG emissions (as CO_2-equivalents) have reduced by 13.4%

The largest emissions source in Scotland is CO_2 from power stations, which accounted for 32% of net Scottish emissions in 2006. The largest methane source is from landfill, and the largest source of N_2O emissions is agricultural soils. Together, these ten categories 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 amount to a removal of 12 $MtCO_2$ in 2006.

Table 3.1 Emissions Summary for Scotland, 2006 (kt CO_2e)

Summary of Main Emission Sources, Scotland 2006 (kt CO_2e)				
Gas	Sector Name	IPCC code	Emission	Percentage of total GWP Weighted Emissions
CO_2	Power stations	1A1a	19010	32%
CO_2	Road Transport	1A3b	10066	17%
CO_2	Residential Combustion	1A4b	7061	12%
CO_2	Land Converted to Cropland	5B2	6585	11%
CO_2	Other Industrial Combustion	1A2f	5639	10%
N_2O	Agricultural Soils	4D	3538	6%
CH_4	Landfill	6A1	2327	4%
CH_4	Enteric fermentation - Cattle	4A1	2125	4%
CO_2	Commercial and Institutional Combustion	1A4a	2055	3%
CO_2	Refineries	1A1b	2023	3%

Note that in the IPCC sector discussion text below, the percentages quoted are derived from the inventory and emissions data stored at full precision in a spreadsheet. These data can be found on the NAEI web site and on the CD-ROM attached to the back page of the printed version of 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 accounts for 89% of total greenhouse gas emissions in Scotland, and CO_2 emissions contribute 97% of the emissions in this sector. This sector includes all emissions from fuel combustion, and also fugitive emissions from fuels.

Energy Industries is 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 2006, power generation (IPCC category 1A1a) contributed around 40.3% of the total Scottish CO_2 emission, which is slightly

higher than the UK average of 33.1%. Scottish emissions from 1A1a have increased by 28% since 1990 in contrast with a fall of 9.9% in UK emissions.

These observations are partly due to Scotland generating electricity that is subsequently exported and used elsewhere in the UK. BERR data (BERR, 2007) shows that in 2006, Scotland exported over 20% of all electricity generated to England and Northern Ireland; the amount of electricity exported from Scotland in 2006 was 50% greater than in 2005. The mix of generation capacity in Scotland is different from the rest of the UK, with a higher proportion of nuclear and hydro-electricity plant, and hence a lower carbon dioxide emission may be expected. On the other hand, the fossil fuel generation in Scotland is from conventional coal and gas fired stations, whilst in England and Wales there has been increased commissioning and utilisation of combined cycle gas turbines (CCGT) over the period that have higher generation efficiencies than conventional thermal plant.

CO_2 emissions from petroleum refining constitute a larger proportion of national emissions in Scotland at 4.3% of the CO_2 total, compared with 2.8% for the UK due to the greater incidence of oil and gas landings in Scotland from offshore facilities compared to the UK average. The other energy emissions account for around 3.2% of Scottish emissions, mostly 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".

CO_2 emissions from Manufacturing Industry and Construction (IPCC Sector 1A2) account for 12.1% of the Scottish CO_2 total compared with 14.8% for the UK. Between 1990 and 2006, CO_2 emissions have declined over the period by 41%, mainly due to the closure of the Ravenscraig steel plant.

Road transport is the largest single source of CO_2 after power generation and comprises around 17% of the Scottish total. Scotland's contribution to UK road transport emissions is 8.4%, which is expected from Scotland's population (8.4%). The emission has risen by 11.4% over the period (1990-2006) compared with a 10.0% rise for the UK. Road transport is also the most significant source of N_2O emissions in the energy sector, accounting for 9.0% of total N_2O emissions in Scotland. Emissions of N_2O from this source have increased by several hundred per cent as a result of the increasing use of three way catalysts.

Other combustion emissions arise from the domestic, commercial, public sectors and agriculture stationary combustion[8]. 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. CO_2 emissions from domestic combustion sources are estimated to account for around 15.0% of the Scottish total. As a proportion of UK domestic emissions they are 8.9% which is slightly higher than would be expected from Scotland's population (8.4%). Domestic combustion is also the largest combustion related source of methane, contributing 0.8% 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 is 7.2% of the Scottish methane total. This is a lower proportion compared with the UK as a whole, where fugitives are around 18.4% of the total methane emissions. This is as a result of the greater contribution of coal mining and leakage from the gas transmission system elsewhere in the UK.

Of these emissions, those from coal mining contributed 1.8%, oil and gas terminals 0.1% and natural gas distribution 4.9% of the Scottish methane total. Coal mining emissions have declined by 81.8% over the period due to the decline in the coal industry. Emissions from the oil & gas industry have fallen by 91.3% over the same period due to tighter regulation of environmental emissions, but it has been noted in 2006 that some installations in Scotland have unexpectedly reported very small fugitive emissions of methane and VOCs, perhaps in error. Hence there may be a slight under-estimate of methane emissions from the oil & gas terminals in Scotland in 2006. Gas leakage from the gas transmission system was reduced by 46.2% over 1990-2006 as the mains and services are renewed. The estimate of gas leakage from the gas transmission system is based on UK National Grid data.

[8] Crop production data specific to Scotland for 2006 was missing leading to an underestimation of methane and nitrous oxide emissions from agriculture stationary combustion. This will be corrected in the 2007 inventory revision.

Only around 1.5% of CO_2 emissions arise from oil and gas fugitives, mainly from processes at oil and gas terminals (1.0%), as well as oil and gas flaring (0.6%). Between 1990 and 2006, oil and gas process emissions increased by 32.2%, while emissions from flaring have decreased by 70.3%.

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 26% of total Scottish emissions from the industrial process sector.

In 2006, refrigeration and air conditioning contributed 55.6% of total Scottish HFC emissions (as CO_2 equivalent) due to losses from refrigeration and air conditioning equipment during its manufacture and lifetime. Aerosols contributed 31.8% to the total Scottish HFC emission in 2006, the main sources being industrial aerosols and medical use of metered dose inhalers. The remaining emission sources (foams, fire-fighting and solvents) contributed 12.6% of total Scottish HFC emissions.

Total emissions of HFCs have increased significantly since the 1995 base year, in contrast to a large decrease in emissions for England (which has the largest effect on the UK total). This is because English emissions before 1998 were dominated by fugitive and by-product emissions from HFC and HCFC manufacture, which have now decreased significantly due to the installation of abatement equipment, offsetting the increases from other sources; there is no manufacture of fluorinated gases in Scotland.

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. Together these processes emitted around 1.4% of the Scottish total in 2006 and have decreased by 38% over 1990-2006.

In 1990, nitric acid manufacture and iron and steel were both important sources of greenhouse gases in the Scottish industrial process sector. However, emissions from these sources in 2006 are negligible since the closure of the Ravenscraig iron and steel plant, and the relocation of the only Scottish nitric acid plant to Dublin in 1995. In 1990 around 394kt CO_2e of nitrous oxide were emitted from a nitric acid plant in Leith, and 466kt CO_2 were emitted from iron and steel processes. These plant closures have made a significant contribution to the decrease in Scottish emissions since the 1990 base year.

Emissions of PFCs represent 4.3% of Scottish GHG emissions in the industrial process sector. The largest source of perfluorocarbons in Scotland is consumption by the electronics industry. In 2006, this contributed around 87% to the total Scottish PFC emission (as CO_2 equivalent). The other main source of PFCs in Scotland is aluminium production and this contributes 13% to the total emissions of PFCs from Scotland. Overall, Scottish PFC emissions account for 20% of the UK total (as CO_2 equivalent) and have decreased by 23.9% over 1995-2006 as the decreases in emissions from the aluminium production have out-weighed the increase from the electronics industry.

SF_6 emissions represent 3.7% of Scottish industrial process emissions. All emissions of SF_6 in Scotland occur in the IPCC category 2F8. This category includes emissions from the electronics industry, as well as leakage from electrical switchgear and from the soles of certain brands of training shoes. Overall emissions in 2006 are 6.6% of the UK total and in Scotland the emissions of SF_6 have increased by 87% over 1995-2006.

3.4 Agriculture

Emissions from the agriculture sector contribute 12% 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 from cattle is the largest single source of methane emissions in Scotland (101 kt CH_4), contributing 34% of Scottish methane emissions. Total emissions from cattle (including both waste management and enteric fermentation) are 73% of total methane emissions from agriculture in Scotland, with sheep responsible for a further 24%. Emissions are largely dependent on the numbers of livestock and have fallen by 6% over the period 1990-2006, due to a decline in cattle and sheep numbers. Scotland accounts for around 18% of UK agricultural methane emissions.[9]

Of the total Scottish emission of 15.23kt N_2O in 2006, around 12.1kt N_2O of this was from agriculture, representing 79% of the total. The agriculture sector also includes the largest source of N_2O emissions; emissions from agricultural soils (11.4 kt N_2O) contribute 94% of total N_2O emissions, and 57% of GHG emissions from the agriculture sector. Scottish emissions of N_2O have declined by 27.5% over the period 1990-2006. 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 (30.4%)
- synthetic fertiliser application (26.4%)
- wastes from grazing animals (24.8%)
- manure used as fertiliser (9.9%)
- ploughing in crop residues (0%)[10]
- atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NO_x) (7.4%)
- biological fixation in improved grass (0.9%)
- cultivation of histosols (i.e. high organic content soils) (0.2%)
- cultivation of legumes (0%)[2]

3.5 Land Use, Land Use Change and Forestry

Data are calculated and presented in this report for net emissions of carbon dioxide from Land Use Change and Forestry (LULUCF). LULUCF activities are also a very small source of methane and N_2O (from biomass burning), although these are not significant to total emissions of these gases.

The LULUCF sector contains both sources and sinks of carbon dioxide, as well as small sources of methane and nitrous oxide. Scotland is a net sink of carbon dioxide from LULUCF activities. The size of this sink has increased by 78%, from -2.5 to -4.5 Mt CO_2, between 1990 and 2006 although this trend has levelled off since 2004. Net emissions/removals in Scotland are dominated by the large Forestland sink (-9.8 Mt CO_2 in 2006) although the Cropland source is also significant (6.6 Mt CO_2 in 2006).

Net removals in 1990 are estimated here to be -2.53 Mt CO_2 compared to -2.54 Mt CO_2 in the 2005 DA inventory report. For 2005 a net sink of -4.60 Mt CO_2 is estimated here compared to -4.58 Mt CO_2 in the 2005 inventory. Differences between the inventories are due to the inclusion of a new activity (biomass burning emissions due to forest wildfires), revision of the 2000-2004 data on conversion of Forestland to Settlement, which also affected the land use transition matrix, and some revisions of the data used for allocating liming to Grassland or Cropland. Activity data was updated with 2006 estimates. There were no changes in methods this year. Appendix 1 contains details of the methods and data sources used.

The inclusion of two new activities (forest wildfires and N fertilisation of newly planted forests) affected estimates of methane and nitrous oxide. Emissions of these gases due to LULUCF activities remain small: 0.009 Mt CO_2 equivalent of methane and 0.001 Mt CO_2 equivalent of nitrous oxide in 2006

[9] Cattle replacement numbers were overestimated for Scotland for 2006, resulting in a slight overestimation of methane emissions (4.7%). This error will be corrected in the 2007 inventory revision.
[10] Crop production data specific to Scotland for 2006 was missing, leading to an underestimation of nitrous oxide emissions (7.2%). This will be corrected in the 2007 inventory revision.

3.6 Waste

Waste emissions in Scotland are dominated by methane emissions from landfills. This accounts for 92% of total greenhouse gas emissions from the waste sector. Scottish landfill emissions represent 12% 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 arisings of municipal solid waste and sewage sludge in Scotland. Information this year has been obtained from www.wastedataflow.org, providing summary data from LA waste management reporting, including a more 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. This method revision has led to much higher methane emission estimates across the time series in Scotland, compared to previous inventory data. Note, however, that 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. Landfill emissions in Scotland have fallen by 58% 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 6.8% 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 sea dumping ended and other disposal routes were adopted.

4 Emissions in Wales

4.1 Summary of Main Emission Sources

The main emission sources for Wales in 2006 are summarised in Table 4.1 below, expressed as a percentage of the total Welsh GHG emissions in 2006 of 51.1 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%
- CH_4 emissions have reduced by 38%
- N_2O emissions have reduced by 12%
- HFC emissions have increased by 466%
- PFC emissions have reduced by 70%
- SF_6 emissions have reduced by 35%
- Total GHG emissions (as CO_2-equivalents) have reduced by 7.4%

In Wales, 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, these ten categories account for 87% of the Welsh total net emissions in 2006.

Table 4.1 Emissions Summary for Wales, 2006 (kt CO_2e)

Summary of Main Emission Sources, Wales 2006 (kt CO_2e)				
Gas	Sector Name	IPCC code	Emission	Percentage of total GWP Weighted Emissions
CO_2	Power stations	1A1a	14007	27%
CO_2	Iron and Steel	1A2a	6802	13%
CO_2	Road Transport	1A3b	6118	12%
CO_2	Residential Combustion	1A4b	4349	9%
CO_2	Other Industrial Combustion	1A2f	4078	8%
CO_2	Refineries	1A1b	3027	6%
N_2O	Agricultural Soils	4D	2476.88	5%
CH_4	Enteric fermentation - Cattle	4A1	1558.73	3%
CH_4	Landfill	6A1	1143.92	2%
CO_2	Land Converted to Cropland	5B2	1050	2%

Note that in the IPCC sector discussion text below, the percentages quoted are derived from the inventory and emissions data stored at full precision in a spreadsheet. These data can be found on the NAEI web site and on the CD-ROM attached to the back page of the printed version of 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 96.6% of total GHGs in this sector. Emissions of methane and N_2O from fuel combustion are much smaller, amounting to only 3.3% of the sector. Fugitive emissions from fuels are an important source of methane, accounting for 14.6% of the Welsh methane total, although they only account for 1.7% of total energy sector emissions. The energy sector accounts for 82.8% of total Welsh GHG emissions.

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 around 33.0% of the total Welsh carbon dioxide emissions in 2006, which is slightly lower than the UK proportion of 33.1%. Emissions from electricity generation in Wales have increased by 24.4% compared with a fall of 9.9% in UK emissions over 1990 to 2006.

These observations are partly due to Wales generating electricity that is subsequently exported and used elsewhere in the UK. BERR data (BERR, 2007) indicates that in 2006, Wales exported 3888 GWh of electricity to England, just over 11% of all power generated in Wales; the amount of electricity exported from Wales in 2006 was slightly lower than that exported in 2005, which BERR have estimated as 4497 GWh.

There is now only one nuclear power station 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. One power station (oil-fired) at Pembroke has closed. 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.

Petroleum refining constitutes 7.1% of Welsh CO_2 emissions in 2006 compared with 2.8% for the UK. The other energy emissions are mostly combustion emissions from coke ovens and solid fuel plant and account for 0.9% of the 2006 Welsh carbon dioxide total emission. There are no significant emissions from oil and gas production.

Combustion emissions from Manufacturing Industries and Construction (IPCC Sector 1A2) account for 25.6% of the Welsh CO_2 total compared with 14.8% 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 36.0% of UK Iron and Steel combustion emissions of CO_2 in 2006. The sintering process in the iron and steel sector is also the most significant combustion source of methane in Wales, accounting for 1.2% of total Welsh methane emissions. Welsh CO_2 emissions from the 'other industry' category are 6.4% of the UK CO_2 total for this sector.

Road transport is the largest single source of CO_2 after power generation and iron and steel, and comprises 14.4% of the total Welsh carbon dioxide emission in 2006, which is 12% of all Welsh GHG emissions. The contribution of Welsh Road Transport to UK Road Transport CO_2 emissions is 5.1%, which is consistent with Wales' population (4.9% of UK population). The emission has risen by 11.1% from 1990 to 2006 compared with a 10% rise for the UK. (See also the discussion regarding road transport emission estimation methodology in Appendix 1). Road transport is also the most significant source of N_2O emissions in the energy sector, accounting for 8.4% of total Welsh N_2O emissions. These emissions have increased significantly since 1990 due to a higher prevalence of vehicles fitted with three way catalysts in the UK fleet.

Other combustion emissions arise from the domestic, commercial, public sectors and agriculture stationary combustion[11]. 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. CO_2 emissions from domestic combustion sources are estimated to account for 10.2% of the Welsh total in 2006. As a proportion of UK domestic emissions they are estimated to represent 5.5%, which is consistent with the relative populations.

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 a much smaller contribution from N_2O and CO_2. The largest methane source in this category is coal mining, which represents 9.7% of total Welsh methane emissions, and 2.2% of total UK emissions from this sector. Emissions from this source have decreased by 68.6% since 1990 due to the decline in the mining industry in Wales. The other major source is leakage from the gas distribution network, which amounts to 4.8% of the Welsh methane total. This emission has decreased by 27.5% since 1990, due to the renewal of the gas supply network.

[11] Crop production data specific to Wales in 2006 was missing, leading to an underestimation of methane and nitrous oxide emissions from agriculture stationary combustion. This will be corrected in the 2007 inventory revision.

4.3 Industrial Processes

The industrial process sector includes emissions from all non-fuel combustion sources in the industrial sector. In Wales, the largest emission in this 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. This accounts for 25% of Welsh total greenhouse gas emissions from this sector. 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 are not significant in this sector.

CO_2 emissions from cement and glass production amount to 2.1% of total CO_2 emissions in Wales; Welsh process emissions from the glass industry represents 25% of total UK emissions in this sector. Aluminium production in Wales is a significant source of both CO_2 and PFC emissions, which together account for 12% of total greenhouse gas emissions from the industrial process sector.

In 2006 the total HFC emission in Wales was 4.2% of the UK HFC total (as CO_2 equivalent). Refrigeration is the largest source and contributes 50.6% to the total Welsh HFC emission (as CO_2 equivalent) due to losses from refrigeration and air conditioning equipment during its manufacture and lifetime. The use of aerosols contribute 35.4% to the total Welsh HFC emission (as CO_2 equivalent), the main sources being industrial aerosols and medical use of metered dose inhalers. The remaining emission sources (foams, fire-fighting and solvents) contributed 14% to the total Welsh HFC emission (as CO_2 equivalent) in 2006. Emissions of HFCs in Wales have increased significantly since the 1995 base year, compared to a 48.7% decrease for England, and 40.7% for the UK. This is because there is no manufacture of these gases in Wales, and reductions in this sector have helped to offset the increases in HFC use in England.

Welsh emissions of sulphur hexafluoride are estimated at 6.1 % of the UK total in 2006. The largest source of emissions is from IPCC category 2F8 and this accounts for 76.2% of emissions. 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 industry use as a cover gas in magnesium production. This accounts for around 23.8% of total Welsh SF_6 emissions and comprises 7% of the UK magnesium production emission.

4.4 Agriculture

Agriculture accounts for 11% of total greenhouse gases in Wales, and is the most significant source sector for methane and N_2O, accounting for 58% and 80% 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 32% of total Welsh methane emissions and 55% of methane emissions from the agriculture sector, with enteric fermentation in sheep accounting for a further 34% 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 3.3% from 1990-2006 in line with a decrease in sheep and cattle numbers, although this is much less than the average UK decline in these emissions, which was 13.8% over the same period.

The other major source of emissions in the agriculture sector is agricultural soils (7.9 kt N_2O), which constitutes a significant emission of N_2O (% of the Welsh N_2O total, 95% of the agricultural total). Welsh emissions of N_2O have declined by 18.7% over the period 1990-2006.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 (34.0%)

- leaching of fertiliser nitrogen and applied animal manures to ground and surface water (28.9%)
- synthetic fertiliser application (18.1%)
- manure used as fertiliser 9.6(%)
- atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NOx) (9.6%)
- ploughing in crop residues (0%)[12]
- biological fixation in improved grass (1.1%)
- cultivation of histosols (i.e. high organic content soils) (0.5%)
- cultivation of legumes (0.4%)

4.5 Land Use, Land Use Change and Forestry

The LULUCF sector contains both sources and sinks of carbon dioxide, as well as small sources of methane and nitrous oxide. Wales is a net sink of carbon dioxide from LULUCF activities and the size of this sink has only slightly reduced between 1990 and 2006: from -0.24 to -0.20 Mt CO_2. The Forestland net sink (-1.5 Mt CO_2 in 2006) and the Cropland net source (1.0 Mt CO_2 in 2006) are the largest contributors to the LULUCF sector in Wales.

Net removals in 1990 are estimated here to be -0.238 Mt CO_2 compared to -0.244 Mt CO_2 in the 2005 DA inventory report. For 2005 a net sink of -0.231 Mt CO_2 is estimated here compared with -0.247 Mt CO_2 in the 2005 inventory. Differences between the inventories are due to the inclusion of a new activity (biomass burning emissions due to forest wildfires), revision of the 2000-2004 data on conversion of Forestland to Settlement, which also affected the land use transition matrix, and some revisions of the data used for allocating liming to Grassland or Cropland. Activity data was updated with 2006 estimates. There were no changes in methods this year. Appendix 1 contains details of the methods and data sources used.

The inclusion of two new activities (forest wildfires and N fertilisation of newly planted forests) affected estimates of methane and nitrous oxide. Emissions of these gases due to LULUCF activities remain small: 0.002 Mt CO_2 equivalent of methane and 0.0002 Mt CO_2 equivalent of nitrous oxide in 2006.

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 23.6% of total Welsh methane emissions, and have decreased by 58.9% since 1990, due to increasing use of methane recovery systems. Estimates were based on data on arisings of municipal solid waste and sewage sludge in Wales 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, enabling a more detailed DA split of waste disposed to landfill to be derived compared to previous inventory waste data. Data for 2000-2006 are currently available (and hence the 2000 split assumed as the best estimate for the 1990-1999 years), and this method revision has led to slightly higher methane emission estimates across the time series in Wales, compared to previous inventory data. Note, however, that 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 1.9% of total Welsh N_2O emissions, and these emissions account for 4.9% of UK wastewater treatment N_2O emissions and are dependent on the data on sewage disposals and disposal routes used.

[12] Crop production data specific to Wales for 2006 missing, leading to a minor underestimation of nitrous oxide emissions. To be corrected in the 2007 inventory revision.

5 Emissions in Northern Ireland

5.1 Summary of Main Emission Sources

The main emission sources for Northern Ireland in 2006 are summarised in Table 5.1 below, expressed as a percentage of the total Northern Irish GHG emissions in 2006 of 22.5 Mt CO_2-equivalent. 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 1.5%
- CH_4 emissions have reduced by 21%
- N_2O emissions have reduced by 17%
- HFC emissions have increased by 505%
- PFC emissions have reduced by 100%
- SF_6 emissions have increased by 353%
- Total GHG emissions (as CO_2-equivalents) have reduced by 6.0%

Emissions in Northern Ireland are dominated by CO_2 from power stations, road transport and residential combustion, which together account for 59% of the total net emissions. Agricultural sources, including N_2O from soils, CH_4 from enteric fermentation, and CO_2 from stationary combustion in this sector all appear in the list of the ten largest sources.

Table 5.1 Emissions Summary for Northern Ireland, 2006 (kt CO_2e)

Summary of Main Emission Sources, Northern Ireland 2006 (kt CO_2e)				
Gas	Sector Name	IPCC code	Emission	Percentage of total GWP Weighted Emissions
CO_2	Power stations	1A1a	5733	26%
CO_2	Road Transport	1A3b	4800	21%
CO_2	Residential Combustion	1A4b	2756	12%
N_2O	Agricultural Soils	4D	2035.15	9%
CH_4	Enteric fermentation – Cattle	4A1	1923.30	9%
CO_2	Other Industrial Combustion	1A2f	1625	7%
CO_2	Land Converted to Cropland	5B2	1133	5%
CH_4	Landfill	6A1	717.37	3%
CO_2	Land Converted to Settlements	5E2	569	3%
CO_2	Agriculture - Stationary Combustion	1A4c	438	2%

Note that in the IPCC sector discussion text below, the percentages quoted are derived from the inventory and emissions data stored at full precision in a spreadsheet. These data can be found on the NAEI web site and on the CD-ROM attached to the back page of the printed version of 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 74% of total greenhouse gas emissions. This is much lower than the UK average contribution from this sector, which in 2006 was 86%. This is because, unlike the other DAs, Northern Ireland does not have any refineries, iron and steel industry, oil and gas terminals, coal mining, and because leakage from the gas supply network is minimal due to the relatively young age of the network.

Power generation is still the largest source of CO_2 in Northern Ireland with road transport the second largest source. Greenhouse gas emissions from power generation (mostly CO_2) represent 35% of total emissions from the energy sector, and 26% of total emissions.

The mix of generation capacity is quite different 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 high emission from electricity generation. 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. 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.

CO_2 emissions from electricity generation increased by 4.9% between 1990 and 2006. The emissions have shown a 6.6% increase from 2005 to 2006, due to significant increases in emissions from Kilroot and Coolkeeragh, of 15 and 47%, respectively. Note however that these emission increases are partly due Northern Ireland generating electricity that is subsequently exported and sold into the Republic of Ireland electricity grid, as the ongoing development of the "All Island Grid" has opened up the Ireland electricity market. BERR data (BERR, 2007) shows that since 2005 Northern Ireland has become a net exporter of electricity, and in 2006, net exports from Northern Ireland amounted to 873 GWh of electricity, around 8.5% of all power generated in Northern Ireland. This is a significant increase on the previous year; in 2005 Northern Ireland only exported a net 386 GWh, or 4% of total electricity generated there.

Emissions from road transport represent 29.4% of the 2006 Northern Ireland CO_2 total, and this emission has risen by 49.5% since 1990, compared with a 10.0% increase for the UK over the same period (See also the discussion regarding road transport emission estimation methodology in Appendix 1.) Road transport is also becoming an increasingly significant source of N_2O emissions, with emissions rising by several hundred per cent since 1990, to represent 7.2% of total N_2O emissions, and the largest combustion related source of N_2O in Northern Ireland

Combustion emissions from Manufacturing Industry and Construction (IPCC Sector 1A2) account for 9.9% of the total Northern Ireland carbon dioxide emission compared with 14.8% 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 2.6% towards the UK Other Industry total, and has decreased by approximately 20.6% over the period 1990-2006, compared with a UK average 15.8% decrease for this sector.

Other combustion emissions arise from the domestic, commercial, public sectors and agriculture stationary combustion[13]. CO_2 emissions from domestic combustion sources are estimated to account for 16.9% of the Northern Irish CO_2 total. As a proportion of UK domestic emissions they are estimated to represent 3.5%, which is slightly higher than would be expected from Northern Ireland's population (2.9% of UK). 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 28.5% 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 3.1% to the over all emissions total, and more than half of these emissions (56%) are CO_2 from the cement industry. There are no sources of methane, N_2O or PFCs in this sector in Northern Ireland in 2006, and the remainder of the emissions in this sector are made up of smaller CO_2 emission sources, and emissions of HFCs and SF_6.

[13] Crop production data specific to Northern Ireland for 2006 was missing leading to an underestimation of methane and nitrous oxide emissions from agriculture stationary combustion. This will be corrected in the 2007 inventory revision.

Total Northern Irish emissions of HFCs in 2005 were 2.6% of the UK total (as CO_2 equivalent), and represent 34% of total greenhouse gas emissions in the Northern Ireland industrial process sector. The largest source was refrigeration (including air conditioning) contributing 53.3% of the Northern Ireland HFC total due to losses from refrigeration and air conditioning equipment during its manufacture and lifetime. Aerosols contributed 33.4% to the total Northern Irish HFC emission in 2006, the main sources being industrial aerosols and medical use of metered dose inhalers. The remaining emission sources (foams, fire-fighting and solvents) contributed 13.3% of total Northern Irish HFC emissions. The total emission has increased from virtually zero in 1990 to 238kt CO_2 equivalent in 2006.

Northern Ireland SF_6 emissions accounted for 1.0% of the UK total in 2006. The main sources of sulphur hexafluoride emissions are leakage from the electrical switching gear used in electricity transmission and the soles of certain brands of training shoes. The use of SF_6 in the electronics industry in Northern Ireland is negligible.

5.4 Agriculture

Emissions from agriculture represent 21% of total greenhouse gas emissions in Northern Ireland in 2006, which is a much higher proportion than the UK average (7%). This is because there are fewer industry and energy related emission sources in Northern Ireland than there are elsewhere in the UK, and hence agriculture emissions are comparatively more important.

Methane emissions from this sector arise from enteric fermentation in livestock (86%) and the management of animal wastes (14%). The largest single source of methane emissions in Northern Ireland is enteric fermentation from cattle. This source alone accounts for 58% of total methane emissions in Northern Ireland[14], and for 41% of total greenhouse gas emissions in the agriculture sector. These emissions are dependent on livestock numbers, and have increased by 6.7% since 1990, mainly influenced by an increase in cattle numbers. This is in contrast to the over all trend for the UK, which shows a decrease in emissions of methane from this source. Emissions from Northern Ireland represent 14% of total UK agricultural methane.

The largest source of N_2O emissions is also in the agriculture sector. Emissions from agricultural soils (6.5 kt N_2O) account for 79% of the total Northern Irish N_2O emission in 2006. Northern Irish agricultural nitrous oxide emissions have fallen by 13% between 1990 and 2006, and in 2006 represent around 9% 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 (29.9%)
- wastes from grazing animals (25.5%)
- synthetic fertiliser application (19.4%)
- manure used as fertiliser (16.0%)
- atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NOx) (8.0%)
- ploughing in crop residues (0%)[15]
- improved grass (1.0%)
- histosols (i.e. high organic content soils) (0.2%)
- cultivation of legumes (0%)[6]

5.5 Land Use, Land Use Change and Forestry

The LULUCF sector contains both sources and sinks of carbon dioxide, as well as small sources of methane and nitrous oxide. Northern Ireland is a net sink of carbon dioxide from LULUCF activities:

[14] Cattle replacement numbers were overestimated for Northern Ireland for 2006, resulting in a slight overestimation of methane emissions (3.5%). To be corrected in the 2007 inventory revision.
[15] Crop production data specific to Northern Ireland for 2006 missing, leading to a minor underestimation (0.9%) of nitrous oxide emissions. To be corrected in the 2007 inventory revision

the size of this sink has increased from -0.03 to -0.29 Mt CO_2 from 1990 to 2006. The Cropland net source (1.1 Mt CO_2 in 2006) and the Grassland net sink (-1.2 Mt CO_2 in 2006) are the largest contributors to the LULUCF sector in Northern Ireland. Net emissions from the Cropland category have diminished over time, while net removals from Grassland have increased.

Net removals in 1990 are estimated to be -0.030 Mt CO_2 here and -0.045 Mt CO_2 in the 2005 DA inventory report. For 2005 a net sink of -0.296 Mt CO_2 is estimated here compared to a net source of -0.308 Mt CO_2 in the 2005 inventory. Differences between the inventories are due to the inclusion of a new activity (biomass burning emissions due to forest wildfires), revision of the 2000-2004 data on conversion of Forestland to Settlement, which also affected the land use transition matrix, and some revisions of the data used for allocating liming to Grassland or Cropland. Activity data was updated with 2006 estimates. There were no changes in methods this year. Appendix 1 contains details of the methods and data sources used.

The inclusion of two new activities (forest wildfires and N fertilisation of newly planted forests) affected estimates of methane and nitrous oxide. Emissions of these gases due to LULUCF activities remain small: 0.001 Mt CO_2 equivalent of methane and 0.0001 Mt CO_2 equivalent of nitrous oxide in 2006.

5.6 Waste

Emissions from the waste sector represent 3.5% of total greenhouse gas emissions in Northern Ireland, and 3.6% 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 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. This method revision has led to much higher methane emission estimates across the time series in Northern Ireland, compared to previous inventory data. Note, however, that 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. Methane emissions are still based on UK recovery, on this basis, landfill emissions have fallen by 55% due to increasing use of methane recovery systems.

Emissions from wastewater treatment represent 2.9% of UK emissions from this source, which is higher than the relative populations. Wastewater treatment is a relatively important source of N_2O emissions, representing 1.4% of total N_2O emissions in Northern Ireland.

6 Unallocated Emissions

Emissions from offshore oil and gas installations are accounted as “unallocated” emissions. The total “unallocated” emissions in 2006 accounts for 2.6% of UK emissions, this is an increase from 1990 figure of 1.9%. As a proportion of the 2006 UK totals they account for the following:

- Carbon dioxide 2.8% (up 20% since 1990)
- Methane 1.6% (down 57% since 1990)
- Nitrous oxide 0.8% (up 189% since 1990)

There are no unallocated emissions of halocarbons and sulphur hexafluoride.

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7 Availability of Data & Changes to Inventory Methodologies

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. A complete set of such 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). In 2005, the EUETS 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 NI DoE) 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 Availability of Data by Sector

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

- **Agriculture** (Defra)
- **Land Use Change and Forestry** (Centre for Ecology and Hydrology)
- **Industrial Processes & Large Combustion Plant** (for most of these, country data are available from producers, trade associations, the Environment Agency's Pollution Inventory, the Scottish Environmental Protection Agency's SPRI and the Northern Ireland Department of Environment's ISR.)
- **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 (a UK average fleet is assumed).

7.1.1 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* (BERR, 2007), and this publication does include 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 & Wales combined. This regional data is of limited use, since it provides no sectoral 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 statistics disaggregated by region and consumer size and Phoenix Gas and Firmus Energy provide data for natural gas consumption in NI disaggregated by type of consumer. Therefore for each constituent country the overall gas consumption data is of good quality, but there may be some mis-allocations between source sectors. For example, many of the smaller consumers may be either domestic or small commercial operations.

Fuel consumption within the iron & steel industry is well documented by *Iron and Steel Industry Statistics* (ISSB, 2007). The ISSB data deal with 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 & Wales) and point source data obtained directly from SEPA and DoE NI. However, there has only been a consistent UK-wide set of emissions data from these sources since 2002, and hence estimates for earlier years are more uncertain and are based on operator-supplied information, BERR fuel use data (e.g. for power stations) and plant production data from trade associations (e.g. cement industry data from the BCA). Data are now also available through the EU Emissions Trading Scheme for power generation and other large combustion sources.

Emissions data for the refineries sector are provided annually by UKPIA, providing a detailed breakdown of plant-specific emission sources for each refinery in the UK. Once again, this detailed data has only been available for more recent years and historic emission estimates back to 1990 are based on industry estimates of plant production rather than on reported emissions or fuel use data, and hence are subject to greater uncertainty. The EUETS data for refineries has proven to be of little use in the improvement of the UK and DA inventories to date as different refinery operators use different approaches to fulfilling reporting requirements, providing an inconsistent picture of fuel use across this industry. This is especially true for 2006 data, as reported emissions to different mechanisms (PI/SPRI, EUETS, UK GHGI) by refinery operators differ by a very significant margin for some sites.

Detailed data are available for the oil & gas exploration & production industry (for both offshore and onshore installations) from the Oil & Gas UK EEMS database which includes installation and process-specific data for 1995, and 1998 to 2006 of varying coverage; earlier years in the Oil & Gas UK dataset are more sparsely populated and appear to be less consistent across the industry. All 1990 sector splits have been based on extrapolating back the 1995 sector splits. There are some data inconsistencies evident across the time-series of the EEMS data, and hence the trends in emissions from the oil & gas extraction sector are quite uncertain

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 coal & oil
- Miscellaneous/Commercial and public sector coal & oil
- Agriculture sector coal & oil
- All fuel use within the “Other Manufacturing Industry” sector (excluding cement and autogeneration)

Various surrogates are used to estimate these sources:

- The regional disaggregation of agricultural sector fuel combustion emissions and oil consumption in the commercial and public service sectors 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.

- BERR Regional Energy Statistics are used for solid and liquid fuels in the commercial, public, small industrial and domestic sectors.
- Domestic sector estimates are based on BERR Regional Energy Statistics and reported trends in fuel use from Northern Ireland Housing Condition Surveys, to ensure that the effects of the developing gas supply infrastructure in Northern Ireland is reflected in the inventory.

The regional energy statistics published by the Department for Business, Enterprise and Regulatory Reform (BERR), provide fuel use estimates by Local Authority for the following sectors:

- Industry
- Agriculture
- Commercial services
- Public Administration
- Residential

The BERR 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, and to date provide estimates of fuel use to LA level for 2003, 2004 and 2005. Although the BERR data are known to be somewhat uncertain (due to the need to model solid and petroleum-based fuel use across many sectors, supplementing meter data for gas and electricity use), they are regarded as the best dataset available to inform the patterns of fuel use across the Devolved Administrations. Hence they have been used to underpin the CO2 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 BERR regional energy data to inform DA-specific trends in energy use since 1990 by sector are limited due to a number of factors:

- The BERR regional energy data only cover recent years in the time-series (2003 to 2005). Hence, although the use of these data provides the best estimates of DA fuel use for recent years, 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 BERR have been used to back-calculate the DA-specific fuel use and GHG emissions in 1990. For other sectors, the UK trends 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 have grown. Hence the data are subject to ongoing review and improvement, and changes to the data and compilation methods have been made since the 1990-2005 DA GHG inventory publication. Detailed review of the regional energy data available from BERR during the 1990-2006 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 regional gas use data presented within the periodic BERR publication, Energy Trends, differ significantly from the UK gas use totals reported in DUKES, due to different reporting criteria. 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 BERR data. These issues have been raised with the BERR Energy Statistics team, and further work aims to clarify the source of the data disparities.

- Fuel use estimates stem from meter data for gas and electricity use, with gas and electricity suppliers approached to provide a breakdown of fuel use by end-user sub-sector. Typically the gas and electricity suppliers provide a split of annual fuel use for domestic and “industrial-commercial” customers. The detail of the estimated fuel use split is not consistent and detailed across all suppliers and estimates of domestic fuel use are typically based on the scale of annual fuel use. Hence it is very likely that small commercial fuel users will be reported within the “domestic” sector. The sector estimates (at UK, DA and LA level) are therefore somewhat uncertain, whilst overall fuel use and emission estimates are more accurate.

7.2 Significant Changes to Inventory Methodology

A number of changes have been made to the estimates since the last study (Jackson *et al* 2007) due to revisions to:

- Carbon dioxide, methane and nitrous oxide emission estimates in the UK inventory; and
- Disaggregation methodologies to derive DA inventories from the UK data.

The most significant changes are described below.

7.2.1 Changes to the UK Greenhouse Gas Inventory

The National 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 (Choudrie *et al* 2008), and a short summary of the most significant changes to this year's inventory is included below:

- **Revised fuel consumption factors for road transport.** A revised set of functions relating fuel consumption factors to speed for different vehicle classes has been used across the UK and DA GHG Inventories. For heavy-duty vehicles, average miles per gallon fuel efficiency statistics have also been used for the first time. This revision has changed the allocation of fuel consumption (petrol and diesel) and hence CO2 emissions between each vehicle class, although the total fuel consumption of petrol and diesel (hence CO2 emissions) for the sector each year is unchanged as it is normalised to the fuel use data reported in DUKES.

- **Railways.** Estimated emissions from Railways (1A3c) have increased across the time series due to improved rail freight emission factors being used, and using a new model to estimate emissions from passenger transport.

- **Closed Coal Mines (2005 only).** Emissions of methane from closed coal mines now include emissions from mines which closed in 2005. These had been omitted from the previous inventory.

- **Cement & Lime Processes.** Increases in 2A1 emissions across the time series have been made due to a change to the methodology for estimating decarbonisation emissions. The methodology now uses data generated by UK cement clinker producers for the purposes of reporting to the EU Emission Trading Scheme.

- **Chemical Industry.** Significant decreases in CO_2 emission estimates from energy recovery in the chemical industry (2B5) from waste fuels have been made due to use of a revised carbon emission factor in waste products. This has led to a revision across the time series.

- **Aluminium (2005 only).** An increase in 2005 process emissions has been made due to an update to the estimate of aluminium production (category 2C3).

- **Agriculture (4B): Nitrogen excretion rates.** In the 1990-2006 UK GHG inventory compilation, nitrogen excretion factors have been modified across all the UK using new data from research by ADAS (ADAS, 2007). This revision has increased nitrous oxide emission estimates from manure and solid storage sources across all of the UK and DA GHG inventories.

7.2.2 Revisions to Regional Disaggregation Methodologies

A number of methods have been revised regarding the split of UK data to produce GHG inventories for England, Scotland, Wales and Northern Ireland. We have an ongoing process of improvement in this regard and increasingly are working towards harmonisation of our approach with other inventory products such as mapping grids and local inventory models.

The key changes in the latest inventory compilation are:

- **Industrial Fuel Use.** The 1990-2005 DA GHGI for the first time used the BERR Regional Energy Statistics to inform the DA fuel use estimates for several sectors for recent years, including fuel use in the 1A2f "Other Industry" IPCC sector. During this 1990-2006 DA GHGI compilation, further work has been conducted to align estimates with fuel use data available through the EU-ETS for more energy-intensive industrial installations, and to interrogate the BERR regional energy statistics in greater detail to derive fuel use estimates for major point sources. This process has led to some revisions of industrial fuel use allocation between DAs, and has also raised some inconsistencies most notably (as mentioned above in Section 7.1.1) regarding gas use data. Issues of disclosure of commercially confidential data prevent BERR from providing an explicit gas use split including data for major gas users. Hence estimates for over 70 "missing" large industrial sites have been made by AEA. The list of "missing" sites has been provided by BERR. AEA have used the EUETS dataset to estimate the gas use and emissions from these sites, but the reported total gas use is markedly different when the EUETS and BERR Energy Trends data are compared. In the absence of a fully consistent dataset, it has been assumed that the split derived from the EUETS data is applicable.

- **Waste Management.** GHG emissions from waste management and disposal are dominated by methane emissions from waste disposed to landfill. In previous inventories, the estimates the share of UK methane emissions from landfills for each DA were based on MSW arisings data available from the Defra Waste team and research conducted by other consultants. However, information from www.wastedataflow.org has been identified that summarises LA waste management reporting, and this includes a more 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. For some regions (but not all) the landfill disposal data is further broken down to present waste disposed to landfills with and without methane capture and oxidation systems. These data enable 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. This revision has had a significant impact on the DA inventories.

- **Domestic Aviation**. In the 1990-2005 inventory, emissions from flights originating in the Crown Dependencies (CDs) were left unallocated. All other fuel combustion sources in the CDs are reported within the inventory for England (as fuel use in the CDs is accounted within England by BERR), and in this 1990-2006 report, we have brought the aviation source into line with others; emissions from flights from the CDs are now reported in the England inventory.

- **Agricultural Mobile Machinery.** Recent work by AEA (NAEI, 2008) has derived a more representative split of regional off-road fuel use (i.e. mainly gas oil use in tractors and other mobile machinery) through research using the regional distribution of different land uses and farm types (pasture, arable, forestry). These land use data have been combined with data on the intensity of mobile machinery use by farm type (tractor hours per hectare of arable land, tractor hours per head of livestock), to develop a new agricultural off-road mapping grid. These data have been used to estimate DA GHG emissions from agricultural mobile machinery in preference to the previous method (which used regional agricultural employment data). This revision has had a significant impact on the DA GHG inventories, decreasing emission estimates across the time series in England, but increasing emission estimates across the time series in Scotland, Wales and Northern Ireland.

More information about the methodologies used is presented for each sector in Annex 1.

8 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 (Choudrie *et al.*, 2008) to account for data and methodological changes. Using the uncertainty method developed for the UK inventory, estimates of the uncertainty in the DA GHG inventories can also be calculated. These are presented in Table 7.1 below.

As a result of the activity data gaps in the Devolved Administration 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 BERR 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 uncertainty estimates for the 1990-2006 DA GHG inventories are reported in Table 7.1. The N_2O distribution is heavily skewed[16], so that 2.5% and 97.5% confidence limits are quoted.

Table 8.1 Estimated Uncertainties in the DA GHG Inventories in 2006

Uncertainties						
GHG	Units	England	Scotland	Wales	N Ireland	UK
CO_2	± %	1%	10%	2%	6%	2%
Methane	± %	23%	23%	17%	18%	20%
N_2O	Lower kt	19.8	2.5	1.8	1.2	27.2
	Upper kt	303.8	63.8	44.3	37.1	449.5
HFC	± %	22.3%	19.1%	19.0%	19.1%	19.0%
PFC	± %	16.8%	10.0%	10.0%	*NA*	10.1%
SF_6	± %	23.5%	20.1%	20.2%	20.0%	20.2%
Total	**± %**	**11.9%**	**23.8%**	**18.2%**	**35.4%**	**13.9%**

Notes

1. Uncertainty is defined as ± 2×(standard deviation)/mean %, which closely approximates the 95% confidence interval
2. Emissions of PFC in Northern Ireland are zero.

The relatively high uncertainties in the Scottish CO_2 and GWP inventories reflect the large contribution made by Land Use, Land Use Change & Forestry (LULUCF) to the Scottish CO_2 inventory. The high uncertainty in the GWP inventory for Northern Ireland and Wales is a consequence of the relatively large contributions of methane and agricultural N_2O. The high uncertainty in the Northern Ireland CO_2 inventory reflects the relatively high contribution from the more uncertain, smaller combustion sources. The GWP inventory for England has lower uncertainty as a consequence of the relatively low contributions to the English inventories from high uncertainty sources such as LULUCF and agricultural N_2O.

[16] The upper and lower estimates do not lie at an equal distance from the mean and therefore these limits are given separately for N_2O as it is inappropriate to quote a single % figure.

9 Summary Graphs

Graphs illustrating the greenhouse gas emissions for the years 1990, 1995, and 1998 to 2006 for the Devolved Administrations are shown in figures 8.1 to 8.6. All of the plots show net emissions as CO_2 equivalent.

The summary data and time-series trends illustrated by these graphs are also presented in more detailed country-specific tables in Appendix 2, including a breakdown of total greenhouse gas emissions by the following IPCC Source Categories:

- Energy
- Industrial Processes
- Agriculture
- Land Use, Land Use Change & Forestry
- Waste

Figure 9.1 Graphs of Carbon Dioxide Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2006

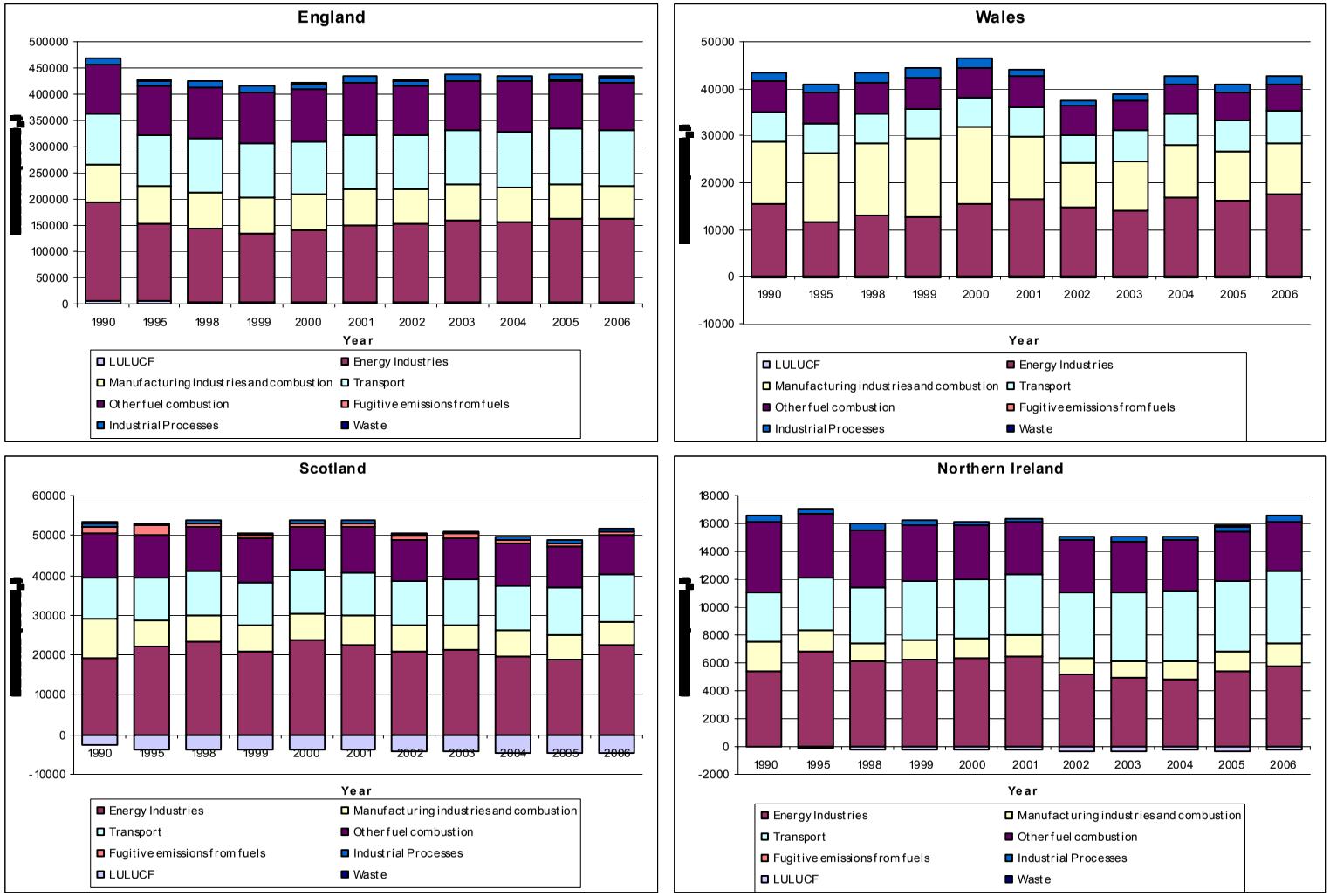


Figure 9.2 Graphs of Methane Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2006

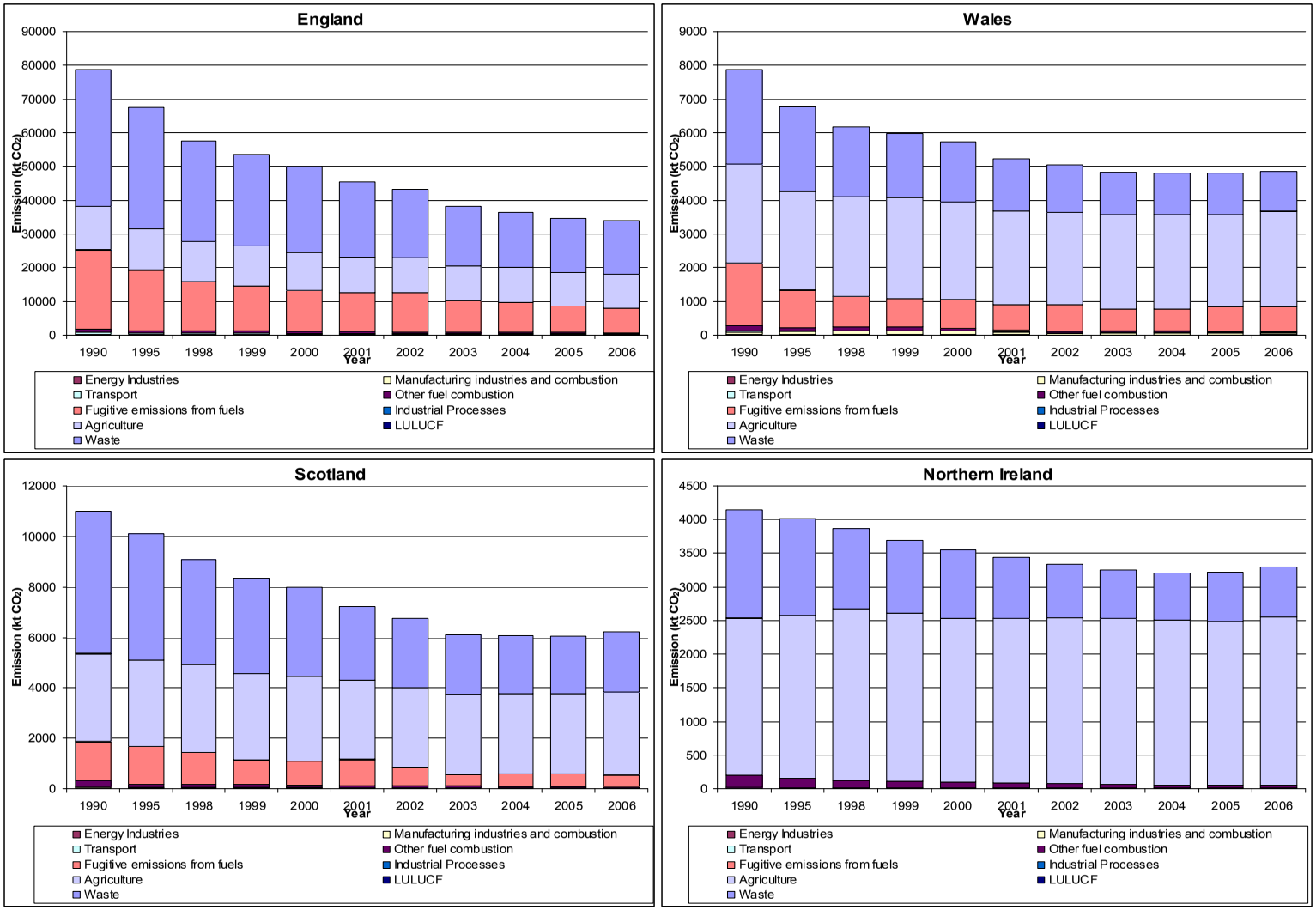


Figure 9.3 Graphs of Nitrous Oxide Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2006

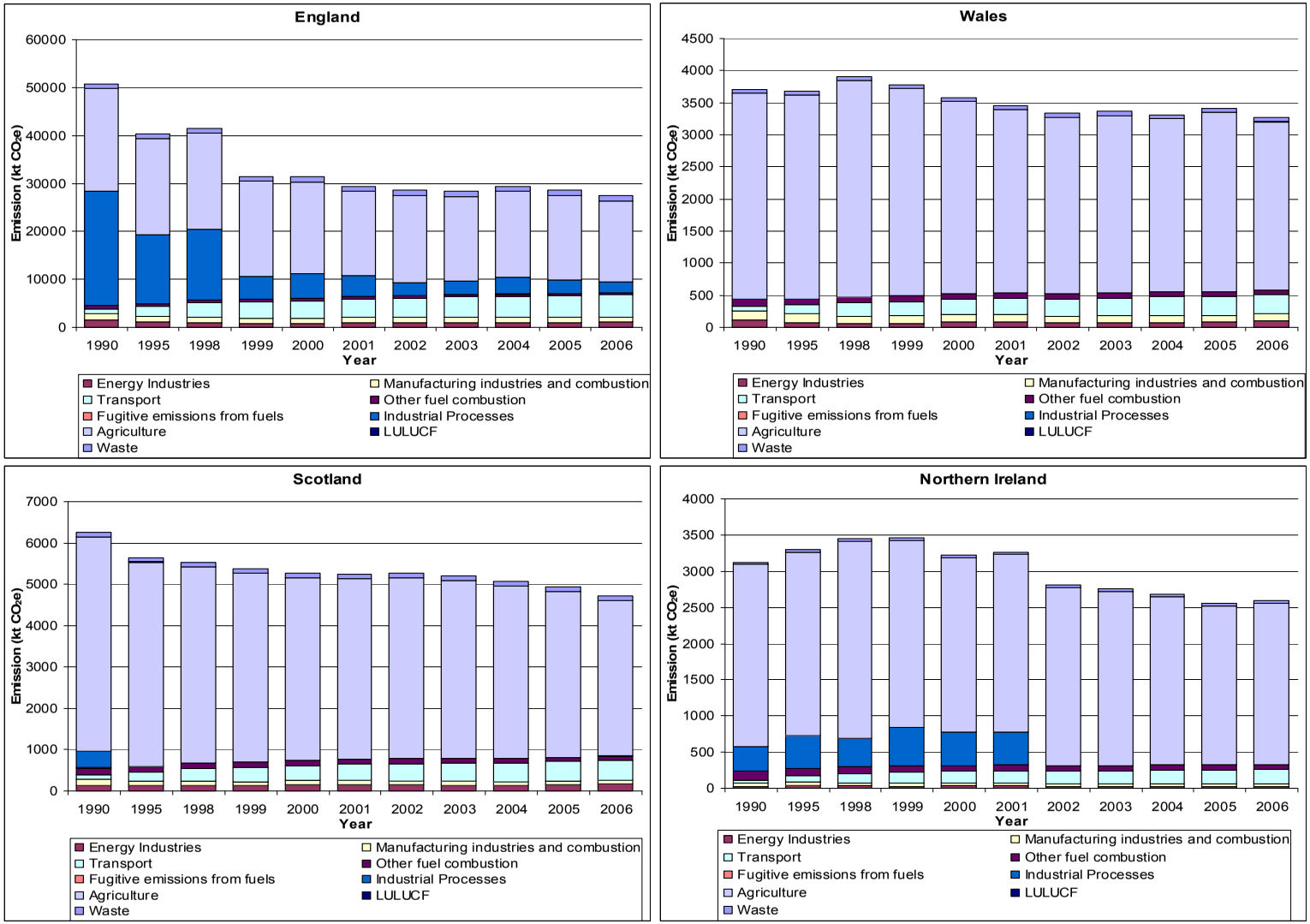


Figure 9.4 Graphs of HFC Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2006

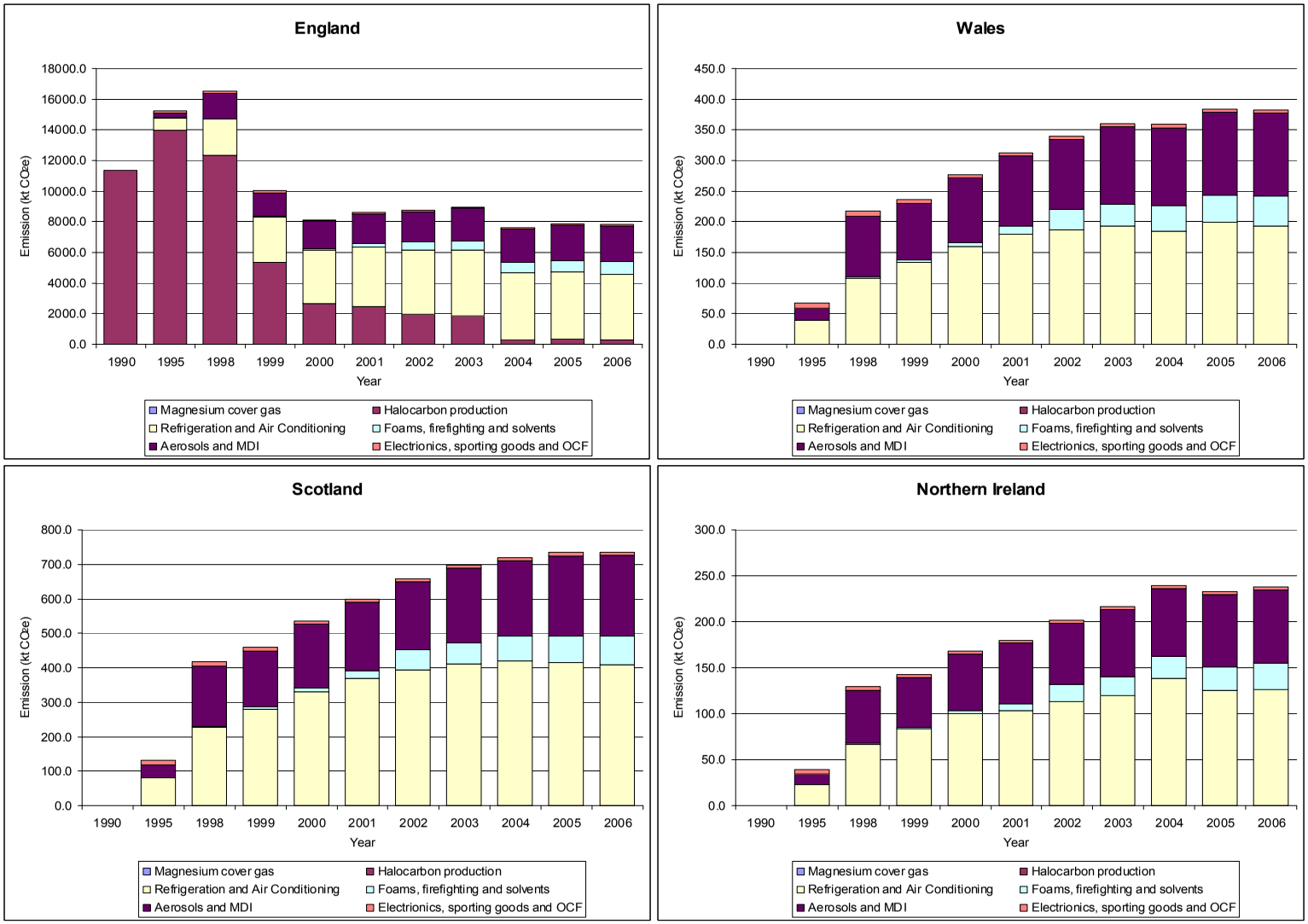


Figure 9.5 Graphs of PFC Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2006

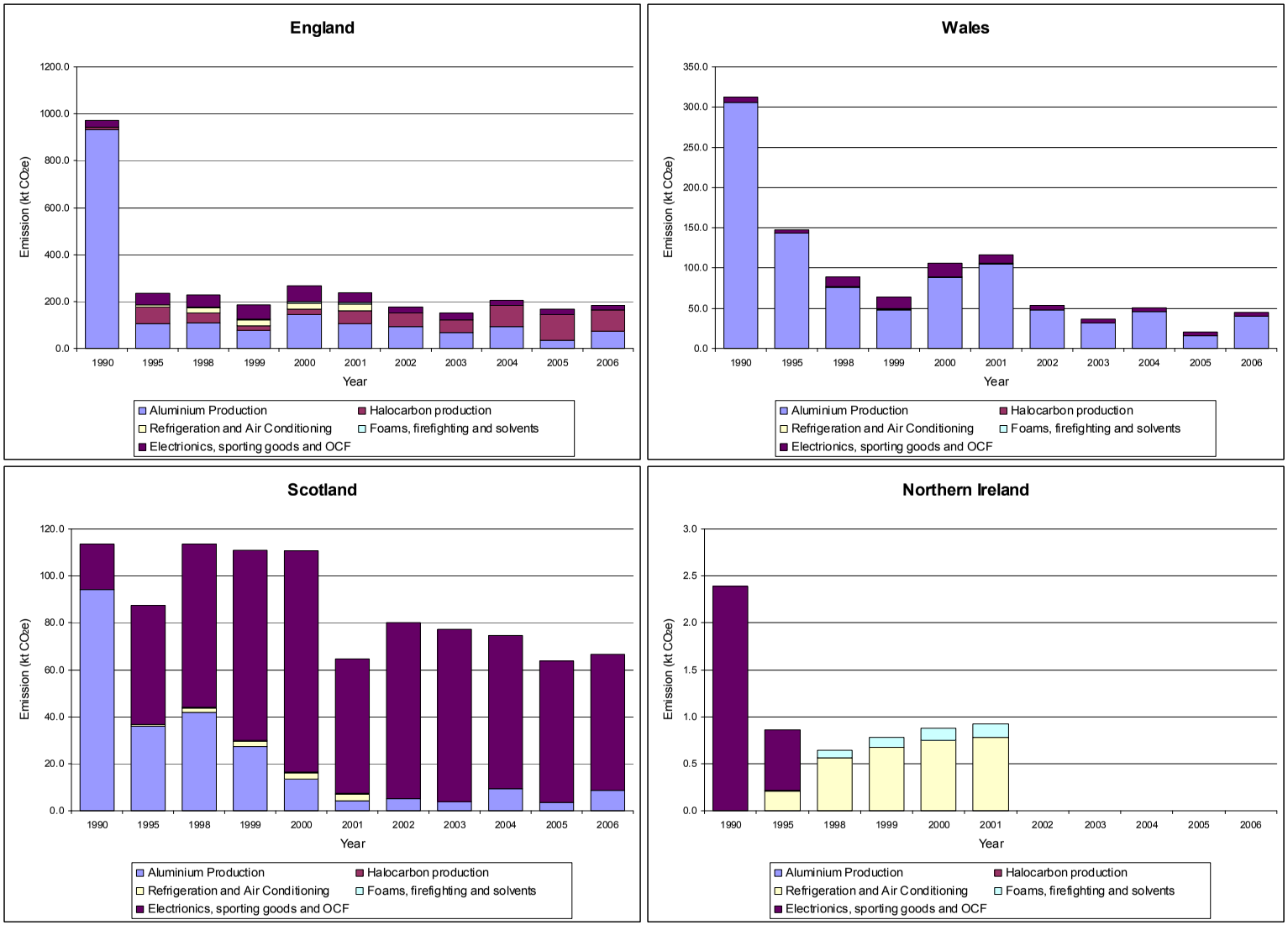
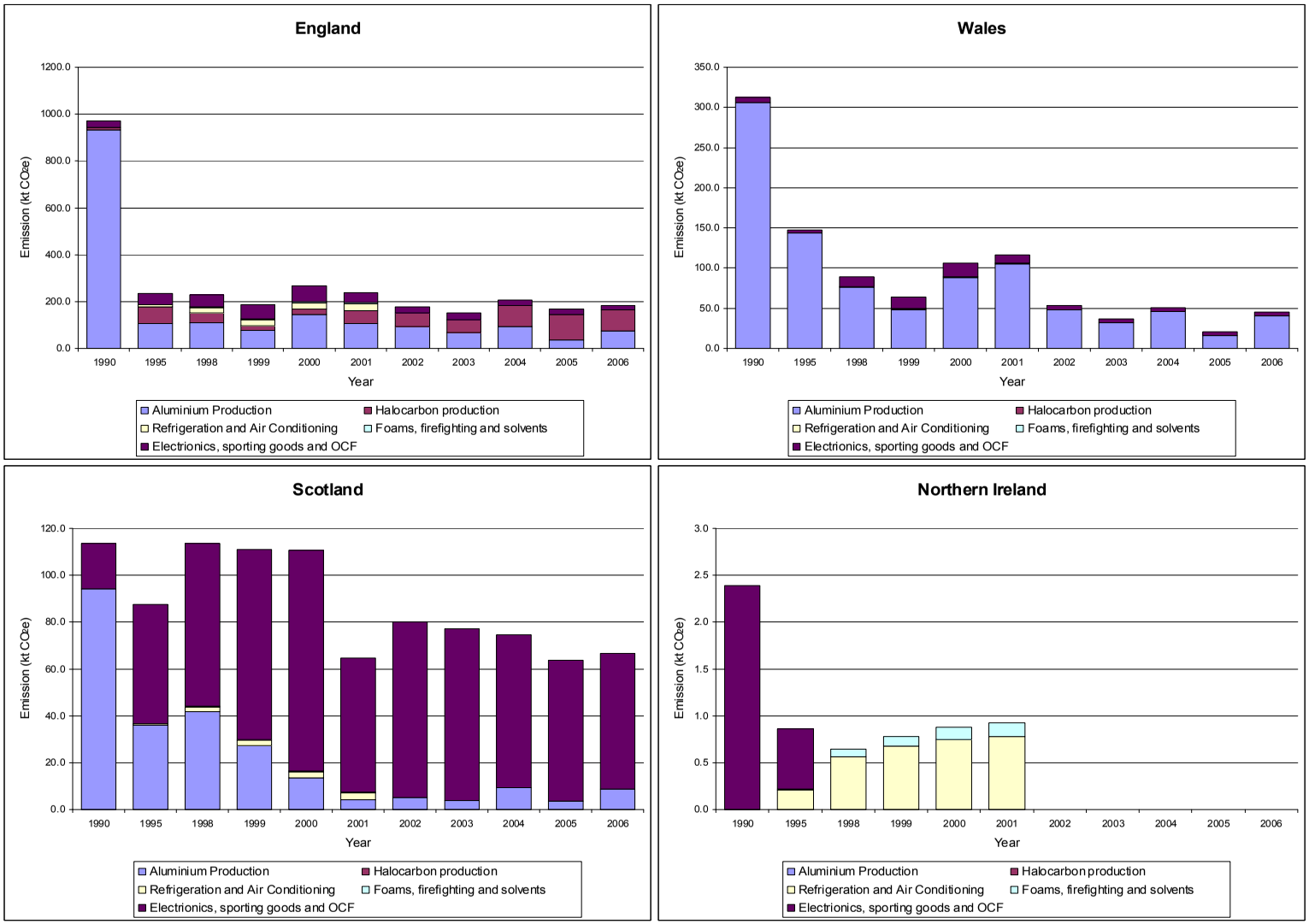


Figure 9.6 Graphs of SF_6 Emission Inventory Estimates for England, Scotland, Wales and Northern Ireland, 1990-2006



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AEA group
329 Harwell
Didcot
Oxfordshire
OX11 0QJ

Tel: 0870 190 6584
Fax: 0870 190 6607