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

1990 - 2004

Main authors SL Baggott, L Cardenas, M Downes, E Garnett, J Jackson, Y Li, N Passant, A Thomson

With contributions from DG Thistlethwaite, A Wagner, J Watterson

November 2006

This work forms part of the Climate, Energy Science and Analysis (CESA) Division Research Programme of the Department for Environment, Food and Rural Affairs

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Preface

This is the Greenhouse Gas Inventory Report for England, Scotland, Wales and Northern Ireland submitted in the year 2006 to the UK Department for Environment, Food & Rural Affairs, the Scottish Executive, the Welsh Assembly Government and the Department of Environment for Northern Ireland. It contains greenhouse gas emission inventories for the constituent countries of the UK for the period 1990 to 2004, and the descriptions of the methods used to produce the estimates. Tabular data in the Common Reporting Format (CRF) covering greenhouse gas emissions from England, Scotland, Wales, Northern Ireland and the UK for the period 1990 to 2004 are presented in Appendix 2 of this report.

These greenhouse gas inventories are based on the same datasets used by the UK Greenhouse Gas Inventory (GHGI) and the National Atmospheric Emissions Inventory (NAEI) for reporting atmospheric emissions under other international agreements and are consistent with the GHGI and the NAEI where they overlap. Datasets used for the development of this DA inventory are the same as those presented to the UNFCCC in April 2006.

This inventory is compiled on behalf of the UK Department for Environment, Food & Rural Affairs (Climate, Energy Science and Analysis (CESA) Division) and the Devolved Administrations, by the National Environmental Technology Centre (Netcen). We acknowledge the positive support and advice from DEFRA and the Devolved Administrations throughout the work, and we are grateful for the help of all those who have contributed to this report.

Units and Conversions

Emissions of greenhouse gases presented in this report are given in Gigagrammes (Gg), Million tonnes (Mt) and Teragrammes (Tg). GWP weighted emissions are also provided. To convert between the units of emissions, use the conversion factors given below.

Prefixes and multiplication factors

Multiplication factor	Abbreviation	Prefix	Symbol
1,000,000,000,000,000	10^{15}	peta	P
1,000,000,000,000	10^{12}	tera	T
1,000,000,000	10^{9}	Giga	G
1,000,000	10^{6}	mega	M
1,000	10^{3}	kilo	k
100	10^{2}	hecto	h
10	10^{1}	deca	da
0.1	10^{-1}	deci	d
0.01	10^{-2}	centi	c
0.001	10^{-3}	milli	m
0.000,001	10^{-6}	micro	μ

1 kilotonne (kt) = 10^3 tonnes = 1,000 tonnes
1 Million tonne (Mt) = 10^6 tonnes = 1,000,000 tonnes

1 Gigagramme (Gg) = 1 kt
1 Teragramme (Tg) = 1 Mt

Conversion of carbon emitted to carbon dioxide emitted

To convert emissions expressed in weight of carbon, to emissions in weight of carbon dioxide, multiply by 44/12.

Conversion of Gg of greenhouse gas emitted into Gg CO_2 equivalent

Gg (of GHG) * GWP = Gg CO_2 equivalent

The GWP is the Global Warming Potential of the greenhouse gas. The GWPs of the greenhouse gases are given in **Table 1.1** of **Chapter 1**.

Abbreviations for Greenhouse Gases and Chemical Compounds

Type of greenhouse gas	Formula or abbreviation	Name
Direct	CO_2	Carbon dioxide
Direct	CH_4	Methane
Direct	N_2O	Nitrous oxide
Direct	HFCs	Hydrofluorocarbons
Direct	PFCs	Perfluorocarbons
Direct	SF_6	Sulphur hexafluoride
Indirect	CO	Carbon monoxide
Indirect	NMVOC	Non-methane volatile organic compound
Indirect	NO_X	Nitrogen oxides (reported as nitrogen dioxide)
Indirect	SO_2	Sulphur dioxide

HFCs, PFCs and SF_6 are collectively known as the 'F-gases'.

Direct greenhouse gases have a direct effect on radiative forcing within the atmosphere. Reactive gases such as carbon monoxide (CO), volatile organic compounds (VOC), nitrogen oxides (NO & NO_2) and sulphur dioxide (SO_2), are termed **indirect** greenhouse gases. These pollutants are not significant direct greenhouse gases, but through atmospheric chemistry they impact upon the abundance of the direct greenhouse gases.

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 2004. 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 2004 UK Greenhouse Gas Inventory (Baggott *et al.*, 2006) Issue 1. 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 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.

Defra requested a review of the method used to estimate emissions of methane from solid waste disposal to landfill after the 2004 National Greenhouse Gas Inventory[1] was submitted to the FCCC on the 15th April 2006. This work was completed as part of a review to ensure that the UK's Base Year emissions were estimated as accurately as possible, since the Base Year emissions have determined the UK's Assigned Amount under the Kyoto Protocol. The UK has now revised the method it uses to estimate methane emissions from the solid waste disposal to landfill, and the method now uses the latest IPCC factors for the fraction of methane oxidised. Issue 2 of the UK Greenhouse Gas Inventory (Baggott *et al.*, 2006) was submitted in October 2006.

The revision was carried out after the preparation of the 2006 DA inventory and owing to time constraints it has not been possible to update the whole of this report, and all of the emissions presented. However, a comparison of the methane emissions from landfill using both the methodology used for the estimation of emissions for this report, and the new methodology is presented in table 1.11.1. in Appendix 1. Overall, the effect has been to increase UK methane

[1] 2006 UK National Inventory Report, containing estimates of emissions from 1990 to 2004 inclusive.

emissions by approximately 12%. The UK total GHG emissions presented in this report also remain consistent with the initial submission to the FCCC on the 15th April to maintain consistency with DA totals. Revised UK totals are presented on the CD accompanying this report. Revisions to the methodology for landfill methane will be incorporated in the 2007 DA inventory.

The study shows that the UK distribution of regional net greenhouse gas emissions in 2004, expressed in terms of global warming potentials (GWP), is[2]:

- England 78.1%
- Scotland 8.2%
- Wales 7.6%
- Northern Ireland 3.3%
- Unallocated 2.8%

Table ES1 (below) presents emissions of the six greenhouse gases in more detail for the base year and 2004. Tables ES2.1.1 to ES 2.5.3 present the time series of emissions for each constituent country, and for unallocated emissions.

UK trends in emissions of greenhouse gases over recent years[3] are as follows:

- **Carbon dioxide**: Overall UK emissions have fallen by 5.6% between 1990 and 2004, 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 50% between 1990 and 2004, due primarily to significant reductions in methane emissions from waste disposal and coal mining sources across all constituent countries.

- **Nitrous oxide**: Overall UK emissions have fallen by 40% between 1990 and 2004, 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 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 42.8% between 1995 and 2004, 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.

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

- **PFCs**: Overall UK emissions have fallen by 25.2% between 1995 and 2004, 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 9% between 1995 and 2004. This has been caused by a partial switch to the use of HFC 134a as a cover gas by one of the main magnesium producers.

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 and Scotland. In order to make emission estimates for fuel consumption, therefore, the available data has been supplemented with surrogate statistics including: population, GVA, employment statistics and production of industrial products. These activity statistics have been used to provide an estimated disaggregation of total UK emissions across the countries.

For other key emission sources (such as industrial processes, agriculture, land-use change and forestry, waste disposal) there are more reliable and complete country-level datasets available, although some of these are less detailed than data used for the UK Inventory.

As a result of these data availability issues, it should be noted that the emission estimates for the England, Scotland, Wales and Northern Ireland inventories are subject to greater uncertainty than the equivalent UK estimates. Chapter 7 of this report outlines significant changes to inventory methodology that have impacted upon the DA-level estimates for GHG emissions, including changes to LULUCF emission and removal estimates.

This inventory contains estimates of GHGs (CO_2, CH_4 and N_2O) from the road transport sector which have been calculated using two methods. One method is consistent with that used in the national GHG inventory and is based on vehicle kilometre travelled data for the constituent countries of the UK, *with the sum of the DA-level inventories constrained to meeting the total of the UK inventory for the road transport sector.* The UK total emissions are derived from fuel sales data of petrol and DERV from the DTI. However, the criticism of this method is that the presentation of results does not always provide a CO_2 emission trend for the DAs that is directly consistent with the vehicle kilometre trend data, as the fluctuations in UK fuel data (from DTI) have a more significant impact on the resultant emission trends. As an alternative, road transport CO_2 emissions from the constituent countries of the UK may be estimated *solely by vehicle kilometre data unconstrained to the UK total derived from fuel consumption data*. In 1990, the estimated CO_2 emissions from these two methods agreed closely. However, this agreement has deteriorated during the 1990s, and now the estimated CO_2 emissions using the vehicle kilometre approach are approximately 10% greater than those estimated using a fuel sales data based approach. The resulting

effect on UK road transport emissions of greenhouse gases is that whereas using the fuel sales data emissions are estimated to have increased by 12% since 1990, using the vehicle km data emissions these are estimated to have increased by 22%. The difference in the estimates from the two methods varies slightly according to constituent country. Further information about these two methods is given in Appendix 1 (see Section 1.4.3. onwards).

A number of sectors which were previously 'unallocated' have now been allocated to each of the four constituent countries. This allocation is currently experimental and will be refined in forthcoming DA inventories. These sectors are domestic aviation and shipping, and military aviation and shipping.

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 2005) covered the years up to and including 2003, whilst this report gives emission estimates for the years up to and including 2004.

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 DTI 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 2003") 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.

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 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.

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

Greenhouse Gas			England	Scotland	Wales	Northern Ireland	Unallocated	United Kingdom
CO2	1990 Emission	Mt C equiv	128.9	13.6	11.1	4.3	3.6	161.5
	1990 Percentage	%	79.8	8.4	6.9	2.7	2.2	100.0
	2004 Emission	Mt C equiv	120.2	11.7	11.4	4.4	4.7	152.5
	2004 Percentage	%	78.8	7.7	7.5	2.9	3.1	100.0
	Change 1990/2004	%	-6.7	-14.1	2.3	3.6	32.3	-5.6
CH4	1990 Emission	Mt C equiv	19.9	2.1	1.8	0.8	0.5	25.1
	1990 Percentage	%	79.3	8.2	7.2	3.3	2.0	100.0
	2004 Emission	Mt C equiv	9.1	1.3	1.1	0.8	0.3	12.5
	2004 Percentage	%	72.4	10.2	9.1	6.1	2.3	100.0
	Change 1990/2004	%	-54.4	-38.4	-37.2	-6.4	-42.0	-50.1
N2O	1990 Emission	Mt C equiv	15.1	1.7	1.0	0.8	0.0	18.6
	1990 Percentage	%	80.9	9.1	5.3	4.5	0.2	100.0
	2004 Emission	Mt C equiv	8.1	1.4	0.9	0.7	0.0	11.1
	2004 Percentage	%	72.9	12.3	8.0	6.5	0.4	100.0
	Change 1990/2004	%	-46.2	-19.9	-10.9	-14.0	30.7	-40.4
HFC	1995 Emission	Mt C equiv	4.2	0.0	0.0	0.0	0.0	4.2
	1995 Percentage	%	98.5	0.9	0.4	0.3	0.0	100.0
	2004 Emission	Mt C equiv	2.1	0.2	0.1	0.1	0.0	2.4
	2004 Percentage	%	84.9	8.1	4.2	2.8	0.0	100.0
	Change 1995/2004	%	-50.7	445.7	441.5	515.2	n/a	-42.8
PFC	1995 Emission	Mt C equiv	0.1	0.0	0.0	0.0	0.0	0.1
	1995 Percentage	%	49.9	18.6	31.3	0.2	0.0	100.0
	2004 Emission	Mt C equiv	0.1	0.0	0.0	0.0	0.0	0.1
	2004 Percentage	%	63.8	21.3	14.9	0.0	0.0	100.0
	Change 1995/2004	%	-4.4	-14.3	-64.3	-100.0	n/a	-25.2
SF6	1995 Emission	Mt C equiv	0.3	0.0	0.0	0.0	0.0	0.3
	1995 Percentage	%	90.7	2.5	6.7	0.2	0.0	100.0
	2004 Emission	Mt C equiv	0.3	0.0	0.0	0.0	0.0	0.3
	2004 Percentage	%	87.6	5.3	6.3	0.8	0.0	100.0
	Change 1995/2004	%	-12.1	92.2	-14.3	382.2	n/a	-9.0
Total	Base Year Emission	Mt C equiv	168.4	17.5	14.0	6.0	4.1	209.9
	Base Year Percentage	%	80.2	8.3	6.7	2.8	1.9	100.0
	2004 Emission	Mt C equiv	139.8	14.6	13.6	6.0	5.0	178.9
	2004 Percentage	%	78.1	8.2	7.6	3.3	2.8	100.0
	Change Base Year/2004	%	-17.0	-16.5	-3.3	0.7	23.3	-14.7

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 (MtCO2 equivalent)

England	**Mt CO_2 equivalent**									**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**baseyr - 2004**
CO_2	472.5	430.2	426.2	417.0	420.2	437.8	431.4	440.5	440.8	-6.7%
CH_4	72.9	62.3	53.3	47.8	45.0	40.3	38.8	34.5	33.2	-54.4%
N_2O	55.3	44.4	44.7	31.7	32.0	30.0	29.0	28.7	29.7	-46.2%
HFCs	11.4	15.3	16.5	10.0	8.1	8.6	8.7	8.9	7.5	-50.7%
PFCs	1.0	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	-4.4%
SF_6	0.9	1.1	1.1	1.3	1.6	1.3	1.4	1.2	1.0	-12.1%
Total (Net Emissions)	614.0	553.5	542.1	508.0	507.2	518.2	509.4	513.9	512.5	-17.0%
CO_2 net emissions from LUCF	5.7	5.1	4.2	4.0	3.9	3.8	3.6	3.6	3.2	
CH_4 emissions from LUCF	0.010	0.008	0.010	0.013	0.014	0.017	0.014	0.013	0.012	
N_2O emissions from LUCF	0.0010	0.0008	0.0011	0.0013	0.0014	0.0017	0.0014	0.0013	0.0012	

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

England	**Mt C equivalent**									**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**baseyr - 2004**
CO_2	128.9	117.3	116.2	113.7	114.6	119.4	117.7	120.1	120.2	-6.7%
CH_4	19.9	17.0	14.5	13.0	12.3	11.0	10.6	9.4	9.1	-54.4%
N_2O	15.1	12.1	12.2	8.7	8.7	8.2	7.9	7.8	8.1	-46.2%
HFCs	3.1	4.2	4.5	2.7	2.2	2.3	2.4	2.4	2.1	-50.7%
PFCs	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	-4.4%
SF_6	0.3	0.3	0.3	0.3	0.4	0.3	0.4	0.3	0.3	-12.1%
Total (Net Emissions)	167.4	150.9	147.9	138.5	138.3	141.3	138.9	140.2	139.8	-17.0%
CO_2 net emissions from LUCF	1.6	1.4	1.1	1.1	1.1	1.0	1.0	1.0	0.9	
CH_4 emissions from LUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
N_2O emissions from LUCF	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 CO2 Equivalent)

England	**Aggregated emission trends per source category (Mt CO_2 equivalent)**								
Source Category	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
1. Energy	484.4	438.1	432.1	422.2	424.4	442.6	437.0	443.2	443.3
2. Industrial Processes	52.0	44.5	45.6	26.1	25.2	23.7	21.8	22.3	22.0
3. Solvents and other product use[a]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Agriculture	34.0	32.0	31.7	31.5	30.4	28.0	28.4	27.8	27.9
5. Land-use Change and Forestry (net emissions)	5.7	5.1	4.2	4.0	3.9	3.9	3.6	3.6	3.2
6. Waste	36.3	32.1	26.8	22.5	21.6	18.3	16.9	15.3	14.3
7. Other	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.8	1.8
Total	**614.0**	**553.5**	**542.1**	**508.0**	**507.2**	**518.2**	**509.4**	**513.9**	**512.5**

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

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

Table ES2.2.1 GHG emissions for Scotland (MtCO2 equivalent)

Scotland	**Mt CO_2 equivalent**									**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**baseyr - 2004**
CO_2	50.0	48.3	49.9	48.1	49.8	49.2	45.3	45.6	43.0	-14.1%
CH_4	7.6	7.2	6.8	6.1	6.0	5.6	5.1	4.7	4.7	-38.4%
N_2O	6.2	5.6	5.5	5.4	5.3	5.2	5.2	5.2	5.0	-19.9%
HFCs	0.0	0.1	0.4	0.5	0.5	0.6	0.7	0.7	0.7	445.7%
PFCs	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-14.3%
SF_6	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	92.2%
Total (Net Emissions)	64.0	61.4	62.8	60.2	61.7	60.7	56.4	56.3	53.5	-16.5%
CO_2 net emissions from LUCF	-2.5	-3.7	-3.9	-3.9	-3.9	-4.0	-4.2	-4.3	-4.6	
CH_4 emissions from LUCF	0.003	0.003	0.003	0.004	0.004	0.005	0.004	0.004	0.004	
N_2O emissions from LUCF	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0004	0.0004	0.0004	

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

Scotland	**Mt C equivalent**									**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**baseyr - 2004**
CO_2	13.6	13.2	13.6	13.1	13.6	13.4	12.4	12.4	11.7	-14.1%
CH_4	2.1	2.0	1.9	1.7	1.6	1.5	1.4	1.3	1.3	-38.4%
N_2O	1.7	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.4	-19.9%
HFCs	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	445.7%
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-14.3%
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	92.2%
Total (Net Emissions)	17.4	16.8	17.1	16.4	16.8	16.6	15.4	15.4	14.6	-16.5%
CO_2 net emissions from LUCF	-0.7	-1.0	-1.1	-1.1	-1.1	-1.1	-1.1	-1.2	-1.3	
CH_4 emissions from LUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
N_2O emissions from LUCF	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 CO2 Equivalent)

Scotland	**Aggregated emission trends per source category (Mt CO_2 equivalent)**								
Source Category	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
1. Energy	53.8	53.7	55.3	53.2	55.0	54.5	50.4	50.5	48.3
2. Industrial Processes	1.5	0.8	1.1	1.1	1.1	1.2	1.3	1.3	1.3
3. Solvents and other product use[a]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Agriculture	8.6	8.3	8.2	8.0	7.7	7.5	7.5	7.4	7.3
5. Land-use Change and Forestry (net emissions)	-2.5	-3.7	-3.9	-3.9	-3.9	-4.0	-4.2	-4.2	-4.6
6. Waste	2.3	2.2	1.9	1.6	1.6	1.4	1.2	1.1	1.1
7. Other	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total	**64.0**	**61.4**	**62.8**	**60.2**	**61.7**	**60.7**	**56.4**	**56.3**	**53.5**

[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 ES2.3.1 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 (MtCO2 equivalent)

Wales	**Mt CO_2 equivalent**									**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**baseyr - 2004**
CO_2	40.8	39.0	41.7	42.1	44.0	41.9	35.6	38.1	41.8	2.3%
CH_4	6.6	5.6	5.2	5.0	4.9	4.5	4.4	4.2	4.2	-37.2%
N_2O	3.6	3.6	3.8	3.7	3.5	3.4	3.3	3.3	3.2	-10.9%
HFCs	0.0	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	441.5%
PFCs	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	-64.3%
SF_6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-14.3%
Total (Net Emissions)	51.5	48.5	51.2	51.2	52.9	50.3	43.7	46.1	49.7	-3.3%
CO_2 net emissions from LUCF	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	
CH_4 emissions from LUCF	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
N_2O emissions from LUCF	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	

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

Wales	**Mt C equivalent**									**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**baseyr - 2004**
CO_2	11.1	10.6	11.4	11.5	12.0	11.4	9.7	10.4	11.4	2.3%
CH_4	1.8	1.5	1.4	1.4	1.3	1.2	1.2	1.1	1.1	-37.2%
N_2O	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	-10.9%
HFCs	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	441.5%
PFCs	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-64.3%
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-14.3%
Total (Net Emissions)	14.0	13.2	14.0	14.0	14.4	13.7	11.9	12.6	13.6	-3.3%
CO_2 net emissions from LUCF	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	
CH_4 emissions from LUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
N_2O emissions from LUCF	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 CO2 Equivalent)

Wales	**Aggregated emission trends per source category (Mt CO_2 equivalent)**								
Source Category	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
1. Energy	41.4	38.6	41.0	41.2	43.3	41.7	35.9	37.9	41.6
2. Industrial Processes	2.1	2.1	2.3	2.4	2.5	1.9	1.5	1.9	2.0
3. Solvents and other product use[a]	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	5.5	5.5
5. Land-use Change and Forestry (net emissions)	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2
6. Waste	2.1	1.9	1.6	1.3	1.3	1.1	1.0	0.9	0.9
7. Other	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	**51.5**	**48.5**	**51.2**	**51.2**	**52.9**	**50.3**	**43.7**	**46.1**	**49.7**

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

Tables ES2.4.1 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 (MtCO2 equivalent)

Northern Ireland	**Mt CO_2 equivalent**									**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**baseyr - 2004**
CO_2	15.7	16.7	16.3	16.9	16.4	16.6	15.4	15.5	16.3	3.6%
CH_4	3.0	3.0	3.1	3.0	2.9	2.9	2.8	2.8	2.8	-6.4%
N_2O	3.1	3.3	3.4	3.5	3.2	3.3	2.8	2.7	2.7	-14.0%
HFCs	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	515.2%
PFCs	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	382.2%
Total (Net Emissions)	21.8	23.1	22.9	23.6	22.7	22.9	21.2	21.3	22.0	0.7%
CO_2 net emissions from LUCF	0.0	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	
CH_4 emissions from LUCF	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
N_2O emissions from LUCF	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	

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

Northern Ireland	**Mt C equivalent**									**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**baseyr - 2004**
CO_2	4.3	4.6	4.4	4.6	4.5	4.5	4.2	4.2	4.4	3.6%
CH_4	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	-6.4%
N_2O	0.8	0.9	0.9	0.9	0.9	0.9	0.8	0.7	0.7	-14.0%
HFCs	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	515.2%
PFCs	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	382.2%
Total (Net Emissions)	5.9	6.3	6.3	6.4	6.2	6.3	5.8	5.8	6.0	0.7%
CO_2 net emissions from LUCF	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	
CH_4 emissions from LUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
N_2O emissions from LUCF	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 CO2 Equivalent)

Northern Ireland	**Aggregated emission trends per source category (Mt CO_2 equivalent)**								
Source Category	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
1. Energy	15.7	16.9	16.4	17.2	16.8	17.1	15.8	16.0	16.7
2. Industrial Processes	0.7	0.8	1.0	1.1	0.9	0.9	0.4	0.4	0.5
3. Solvents and other product use[a]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Agriculture	4.8	4.9	5.2	5.1	4.8	4.9	4.9	4.8	4.7
5. Land-use Change and Forestry (net emissions)	0.0	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3
6. Waste	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3
7. Other	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	**21.8**	**23.1**	**22.9**	**23.6**	**22.7**	**22.9**	**21.2**	**21.3**	**22.0**

[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 ES2.5.1 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 (MtCO2 equivalent)

Unallocated	**Mt CO_2 equivalent**									**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**baseyr - 2004**
CO_2	13.0	15.4	16.0	16.7	15.9	16.0	17.2	16.7	17.2	32.3%
CH_4	1.8	1.7	1.5	1.3	1.1	1.1	1.0	1.0	1.0	-42.0%
N_2O	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	30.7%
HFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Total (Net Emissions)	14.9	17.3	17.6	18.1	17.2	17.3	18.4	17.9	18.4	23.3%
CO_2 net emissions from LUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CH_4 emissions from LUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
N_2O emissions from LUCF	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 C equivalent**									**% change**
	1990	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**baseyr - 2004**
CO_2	3.6	4.2	4.4	4.5	4.3	4.4	4.7	4.6	4.7	32.3%
CH_4	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.3	-42.0%
N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.7%
HFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
PFCs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
SF_6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Total (Net Emissions)	4.1	4.7	4.8	4.9	4.7	4.7	5.0	4.9	5.0	23.3%
CO_2 net emissions from LUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CH_4 emissions from LUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
N_2O emissions from LUCF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Table ES2.5.3 Unallocated emission trends per source category for unallocated emissions (Mt CO2 Equivalent)

Unallocated	**Aggregated emission trends per source category (Mt CO_2 equivalent)**								
Source Category	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
1. Energy	14.9	17.3	17.6	18.1	17.2	17.3	18.4	17.9	18.4
2. Industrial Processes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3. Solvents and other product use[a]	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
5. Land-use Change and Forestry (net emissions)	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
7. Other	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**

[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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Document Revision History

Version	Comment
Draft	Tables of emissions issued for comment to the DAs. Comments received and revisions made.
Issue 1	First issue to the DAs and Defra
Issue 1.1	Revised report, based on comments from the DAs, Defra, IGER and CEH
Issue 1.2	Minor revisions following further comments from the DAs

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 needed 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 Executive (SE), 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 2004 (Baggott *et al* 2005).

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 2004. 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 Issue 1 of the UK Greenhouse Gas Inventory (Baggott *et al*, 2006), submitted in April 2006. This report follows the convention used in Baggott *et al* (2006) of reporting carbon dioxide emissions and removals as net totals.

Certain emissions cannot be allocated to a country and are reported in a table for unallocated emissions. Unallocated emissions for these inventories are limited to

emissions from the offshore oil and gas industry. This is in contrast to reporting in earlier years, when domestic aviation and shipping and military emissions were also reported as unallocated.

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 2004. The reasons for any significant trends in emissions, issues regarding data availability and uncertainty estimates are provided for each inventory. Tables 9.1 to 9.6 present the summary data for these years as global warming potential (GWP) weighted emissions.

Appendix 1: This appendix describes in detail the methodology of the estimates and how the Devolved Administration inventories relate to the UK Greenhouse Gas Inventory.

Appendix 2: This appendix provides IPCC Sectoral Tables for 1990 and 2004 for England, Scotland, Wales and Northern Ireland. Summary tables (IPCC Sectoral Table 7A) are provided for 1995, 1998 to 2003 for England, Scotland, Wales and Northern Ireland. UK summary tables are also reported. Table 3 of the Sectoral Tables has been omitted because this reports Volatile Organic Compounds (VOCs) which are not relevant to this study. In IPCC Tables, emissions are reported in Gigagrammes (Gg).[4]

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.

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

Table 1.1 GWP of Greenhouse Gases on a 100-year Horizon (t CO_2 equiv/ t gas)

Greenhouse Gas	Global Warming Potential (t CO_2 equiv / 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 2003, whilst this report gives emission estimates for the years up to and including 2004.

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 DTI 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 2001") 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.

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.

2. Emissions in England

2.1 CARBON DIOXIDE

Figure 1 (see Chapter 9) shows the emissions of CO_2 for 1990 to 2004 broken down by major IPCC source category and Table 2.1 (below) highlights the most significant IPCC sectors in 2004. Total emissions of CO_2 in England accounted for 78.8% of the UK total in 2004 and have declined by 6.7% since 1990.

Table 2.1 Largest Sources and Sinks of CO_2 Emissions in 2004: England

IPCC Sector	% of total 2004 England CO_2 Emissions[5]	Change against 1990 baseline (%)
1A1a – Power Generation	31.2	- 20.3
1A1b – Petroleum Refining	2.8	+ 3.1
1A2a – Manufacturing Industry & Construction: Iron & Steel	2.7	- 8.7
1A2f – Manufacturing Industry & Construction: Other	12.9	- 9.5
1A3b – Road Transport	22.4	+ 7.8
1A4a – Commercial / Institutional	4.5	- 8.9
1A4b - Residential	16.5	+ 14.7
2A1 – Cement Production	1.0	- 15.7
5B2 – Land Converted to Cropland	1.3	- 3.5
5C2 – Land Converted to Grassland	(0.9) (SINK)	+ 19.5[6]
5E2 – Land Converted to Settlements	0.7	- 13.8

The largest source of CO_2 emissions in England is from Energy Industries and in 2004 this contributed 34.7% of the total CO_2 for the country, down from 39.5% 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 31.2% of the total English CO_2 emission, which is slightly higher than the UK proportion of 30.5%.

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)

[5] Percentages are quoted a s a proportion of the total net emissions. Emissions and removals are no longer reported separately.
[6] Category 5C2 is a net SINK, and therefore the +19.5 % figure refers to an increase in the store of carbon, rather than an increase in the emission.

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 18.1% since 1990. At the UK level, the reduction in CO_2 emissions from Energy industries over 1990-2004 is only 12.2%. 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 2.8% of CO_2 emissions in England in 2004, lower than the UK mean contribution of 3.1% of total CO_2 emissions from refineries in 2004. Refinery CO_2 emissions in England have increased by 3.1% 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 however increased by 33.7% from 1990 to 2004 as a result of an increase in gas consumption by the oil and gas industry, although the 1990 figures are highly uncertain.

Combustion emissions from Manufacturing Industry and Construction (IPCC Sector 1A2) account for 16% of the English total. The iron and steel industry in England accounts for 63.2% of the UK Iron and Steel combustion emissions. The 'Other industry' category (IPCC sector 1A2f) for England contributes 82.4% towards the UK 'Other industry' total.

Road Transport is the largest single source after power generation, contributing 17.7% to the English total CO_2 emission. The contribution of English Road Transport to UK Road Transport CO_2 emissions is 82.7%, which is slightly less than that which would be expected from England's population (83.7% of UK[7]). The emission has risen by 7.8% from 1990 to 2004 compared with an 9.1% rise for the UK. (See also the discussion regarding road transport emission estimation methodology in Appendix 1.)

Other combustion emissions arise from the domestic (residential), commercial and public sectors. 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 16.5% of the English total. As a proportion of UK domestic emissions they are estimated to represent 82.8%, which is slightly less than would be expected from England's population (83.7%).

Fugitive emissions from fuels arise mainly from flaring of coke oven gas and flaring at terminals and are not significant.

Industrial processes produce emissions from non-combustion sources such as the use of limestone in cement and glass making. The largest contribution is from Cement Production constituting 1.0% of the English total with smaller emissions

[7] Where population percentages are quoted throughout this report, they are taken from ONS data for 2004.

from glass, ammonia, aluminium, iron and steel production contributing a further 0.6% of the English total in 2004. 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 - combustion emissions from industry are covered by category 1A2. Carbon dioxide emissions from waste incineration are not significant. Since 1997 all waste incinerators were converted to generate electricity and hence their emissions are now reported within IPCC sector 1A1a: Power Generation.

Data are calculated and presented in this report for net emissions of carbon dioxide from Land Use Change and Forestry. England is a net source of carbon dioxide from LULUCF activities although the size of this source has diminished by 44% since 1990. The LULUCF data in this report have been extensively revised in comparison with last year's publication, including revisions to the reporting categories. This is explained further in Appendix 1.

2.2 METHANE

Figure 2 (see Chapter 9) shows the emissions of methane for 1990 to 2004 broken down by major IPCC source category and Table 2.2 (below) highlights the most significant IPCC sectors in 2004. Total emissions of methane in England accounted for 72.4% of the UK total in 2004 and have declined by 54.4% since 1990. The major sources of methane in England are waste disposal, coal mining, leakage from the gas distribution system and agriculture.

Table 2.2 Largest Sources of CH_4 Emissions in 2004: England

IPCC Sector	% of total 2004 England CH_4	Change against 1990 baseline (%)
1A4b – Domestic combustion	1.3	- 56.4
1B1a – Mining activities	14.1	- 71.7
1B2b – Transmission / Distribution (Gas leakage from distribution grid)	12.7	- 40.0
4A1 – Enteric Fermentation (Cattle)	20.5	- 16.5
4A3 - Enteric Fermentation (Sheep)	4.7	- 20.8
4B1 – Manure Management (Cattle)	3.3	- 18.6
6A1 – Managed Waste Disposal on Land	36.6	- 63.8
6B2 – Wastewater Handling	2.0	+ 13.2

The largest source of methane emissions in England is agriculture[8]. This contributes 31.1% to the overall CH_4 emissions in England, with cattle responsible for 77% of the agricultural emissions. Emissions from agriculture are largely dependent on the numbers of livestock and have fallen by 19% from 1990 to 2004 resulting from a decline in cattle and sheep numbers. England accounts for around 55% of UK agricultural methane emissions. Of the total emission from agriculture in England, 84% is due to enteric fermentation.

The next largest source of methane emissions in England is waste disposal. This contributes around 39% to England's emissions and is dominated by landfill methane[9] with a small contribution from wastewater treatment. The landfill emission is around 87% of the UK landfill emission, which is slightly higher than would be expected from England's population (83.7%). Estimates are based on data on disposal of municipal solid waste and sewage sludge in England, using UK data for waste composition and the percentage of MSW disposed to landfill. Also it has been assumed that the proportion of methane recovered in England reflects that recovered in the UK. Since 1990, landfill emissions in England have declined by 63.8% 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.

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 27% of the English total methane emission compared with the UK average of 23.8%. 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 14.1%, natural gas distribution 12.7% and oil and gas terminals 0.2% of the English total. Coal mining emissions have declined by 72% from 1990 to 2004 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 2004 is around 40%.

Fuel combustion activities account for 2.9% of England's emissions of methane, mostly from domestic coal combustion and road transport.

2.3 NITROUS OXIDE

Figure 3 (see Chapter 9) shows the emissions of nitrous oxide for 1990 to 2004 broken down by major IPCC source category and Table 2.3 (below) highlights the most significant IPCC sectors in 2004. Total emissions of nitrous oxide in England accounted for 72.9% of the UK total in 2004 and have declined by 46.2% since 1990. The major sources of nitrous oxide in England are

[8] Data pertaining to agriculture emissions are provided by the Institute of Grassland and Environmental Research.

[9] The landfill methane estimates referred to here relate to unrevised emission totals. See executive summary for explanation

combustion, agriculture and chemical processes. Emission estimates are typically subject to significant error, particularly those from agriculture, primarily due to uncertainties associated with certain emission factors.

Table 2.3 Key Categories: England N_2O Emissions in 2004

IPCC Sector	% of total 2004 England N_2O	Change against 1990 baseline (%)
1A1a – Power Generation	2.9	- 41.0
1A2f – Manufacturing Industry & Construction	3.6	- 12.6
1A3b – Road Transport	14.0	+ 390
2B2 – Nitric Acid Production	9.8	- 12.8
2B3 – Adipic Acid Production	3.7	- 95.6
4B12 – Solid Storage & Drylot	2.2	- 21.0
4D – Agricultural Soils	56.4	- 16.7
6B2 – Wastewater Handling	3.4	+ 17.6

Of the total English emission of 95.8 kt N_2O in 2004, 56.6 kt N_2O of this was from agriculture, representing 59% of the total. Most of these were emissions arising from the agricultural soils category as a result of processes in the soil arising from, in order of magnitude:

[Note: numbers in brackets show the percentage of the total agricultural soils N_2O emission (*Source*: IGER 2006, Personal Communication)]

- synthetic fertiliser application (28%)
- leaching of fertiliser nitrogen and applied animal manures to ground and surface water (27%)
- wastes from grazing animals (14%)
- ploughing in crop residues (14%)
- manure used as fertiliser (9%)
- atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NOx) (6%)
- cultivation of legumes (1.3%)
- cultivation of histosols (i.e. high organic content soils) (0.8%)
- biological fixation in improved grass (0.5%)

A relatively small proportion (2.5kt 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 17% in the period 1990-2004 and in 2004 represent around 66% of UK agricultural emissions.

Up until 1998, a 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 40% of England's N_2O emissions and 98% 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 2004, the sum of the English emissions from the nitric acid and adipic acid production is around 13.0 kt N_2O, equivalent to 9.9% of the total UK N_2O emission.

The remaining emissions of nitrous oxide in England result from road transport (14.0%) and other combustion sources (10%) - mainly combustion in power generation and industry. Note that emissions of nitrous oxide from road transport have risen by several hundred percent over the period as a result of the increasing use of catalytic converters on motor vehicles.

2.4 HYDROFLUOROCARBONS

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 72% 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 2004, HCFC and HFC production in England contributed only 3.8% of total English HFC emissions (as CO_2 equivalent) and 3.2% of total UK HFC emissions (as CO_2 equivalent).

In 2004, refrigeration contributed 57% of total English HFC emissions (as CO_2 equivalent) due to losses from refrigeration and air conditioning equipment during its manufacture and lifetime. Aerosols contributed 29% to the total English HFC GWP emission in 2004, the main sources being industrial aerosols and medical use of metered dose inhalers. The remaining emission sources (foams, fire-fighting and solvents) contributed 10.5% of total English HFC emissions.

In 1998, total emissions of HFCs in England had increased by 71% since 1990 due to the increasing use of HFCs in aerosols and refrigeration and the increased production of HCFCs and HFCs. HFC emission reductions across several sectors after 1998 mean that emissions of HFCs in England in 2004 are down to 66% of their 1990 levels.

2.5 PERFLUOROCARBONS

The largest sources of perfluorocarbons in England are Halocarbon production which contributes 47% of the PFC emissions and aluminium production, which accounts for 42% of total English PFC emissions (as CO_2 equivalent) in 2004. Aluminium plants are also located in Scotland and Wales and overall England contributes 62% to the total UK emissions from aluminium production.

The remaining emissions of PFC in England arise from the IPCC category 2F8 'Other'. This category accounts for 10.4% of the 2004 English total (as CO_2 equivalent). Emissions in this category consist mostly of emissions from the electronics industry.

2.6 SULPHUR HEXAFLUORIDE

The main sources of sulphur hexafluoride emissions are from use as electrical insulation, which accounts for 46% of SF_6 emissions in England in 2004 and as a cover gas in magnesium production which accounted for around 37% in 2004. Magnesium production is largely concentrated in England and accounts for 93% of the UK magnesium production emission. Sulphur hexafluoride is also emitted from other sources: electrical switchgear used in power transmission, electronics applications and leakage from the soles of certain brands of training shoes. The sum of these emissions accounts for around 18% of total English SF_6 emissions in 2004.

The sum of SF_6 emissions from England represents 88% of the UK total in 2004. Emissions of SF_6 in England have increased by 5.2% since 1990 due to increases in emissions from trainers, magnesium production and switchgear, but have decreased by 12% relative to the 1995 base year.

3. Emissions in Scotland

3.1 CARBON DIOXIDE

Figure 1 (see Chapter 9) shows the emissions of carbon dioxide for 1990 to 2004 broken down by major IPCC source category and Table 3.1 (below) highlights the most significant IPCC sectors in 2004. Total emissions of carbon dioxide in Scotland accounted for 7.7% of the UK total in 2004 and have declined by 14.1 % since 1990.

Table 3.1 Largest Sources and Sinks of CO_2 in 2004: Scotland

IPCC Sector	% of total 2004 Scotland CO_2 Emissions[10]	Change against 1990 baseline (%)
1A1a – Power Generation	35.9	+ 3.8
1A1b – Petroleum Refining	4.5	- 32.9
1A1c – Manufacture of Solid Fuels	4.4	+ 21.0
1A2f – Manufacturing Industry & Construction: Other	13.8	- 16.5
1A3b – Road Transport	22.8	+ 8.3
1A4b - Residential	16.4	+ 1.2
5A2 – Land converted to Forest Land	- 24.4 (SINK)	+ 38.8[11]
5B2 – Land converted to Cropland	15.2	+ 8.3
5C2 – Land Converted to Grassland	- 6.38 (SINK)	+ 18.7

The largest source of CO_2 emissions in Scotland is Energy Industries, which includes power generation, refineries, solid fuel transformation processes and the oil and gas industry. In 2004, power generation (IPCC category 1A1a) contributed around 36% of the total Scottish CO_2 emission, which is somewhat higher than the UK average of 30.5%. Scottish emissions from 1A1a have increased by 3.8% since 1990 in contrast with a fall of 16.3% in UK emissions.

These observations may be due to Scotland generating electricity that is subsequently exported and used elsewhere in the UK[12]. The mix of generation

[10] Percentages are quoted a s a proportion of the total net emissions. Emissions and removals are no longer reported separately.
[11] Category 5A2 is a net SINK, not a SOURCE of CO_2 emissions, and therefore the +38.8 % figure represents an increase in the store of carbon rather than an increase in an emission of CO_2.

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.

Petroleum refining constitutes a larger proportion of national emissions in Scotland at 4.5 % compared with 3.1% 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 4.4% of Scottish emissions, mostly from gas consumption at oil & gas terminals and gas separation plant. Only those emissions arising from on-shore installations in Scotland have been included.

CO_2 emissions from Manufacturing Industry and Construction (IPCC Sector 1A2) account for 13.9% of the Scottish total compared with 15.7% for the UK. Between 1990 and 2004, 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 23% of the Scottish total. Scotland's contribution to UK road transport emissions is 8.2%, which is slightly lower than would be expected from Scotland's population (8.5%). The emission has risen by 8.3% over the period (1990-2004) compared with a 9.1% rise for the UK. (See also the discussion regarding road transport emission estimation methodology in Appendix 1.)

Other combustion emissions arise from the domestic, commercial and public sectors. 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 16.4% of the Scottish total. As a proportion of UK domestic emissions they are 8.0% which is consistent with Scotland's population (8.5%).

Around 0.7% of emissions arise from oil and gas fugitives, mainly oil and gas flaring. Between 1990 to 2004, emissions from flaring have fallen by 69% due to greater focus on gas flaring reduction through environmental regulations.

Industrial processes produce emissions from non-combustion sources such as the use of limestone in cement and glass making. The largest contribution is from cement with smaller emissions from glass and aluminium production. Together these processes emitted around 0.9% of the Scottish total in 2004 and have decreased by 42% over 1990-2004. Since 1990 emissions from iron and steel processes have become negligible (due to the Ravenscraig plant closure).

[12] More information about the amount of electricity exported from Scotland to the other DAs has been supplied to Netcen in a personal communication from Joe Ewins (DTI). This information will be considered in future inventories to further explain the observed trends

Carbon dioxide emissions from waste incineration are not significant.

Data are calculated and presented in this report for net emissions of carbon dioxide from Land Use Change and Forestry. Overall, Scotland is a net sink for carbon dioxide from LULUCF and since 1990, the size of this sink has increased by 82% from 2.5 to 4.6 Mt CO_2. The LULUCF data in this report have been extensively revised in comparison with last year's publication, including revisions to the reporting categories. This is explained further in Appendix 1.

3.2 METHANE

Figure 2 (see Chapter 9) shows the emissions of methane for 1990 to 2004 broken down by major IPCC source category and Table 3.2 (below) highlights the most significant IPCC sectors in 2004. Total emissions of methane in Scotland accounted for 10.2% of the UK total in 2004 and have declined by 38% since 1990. The major sources of methane in Scotland are waste disposal, coal mining, leakage from the gas distribution system and agriculture.

Table 3.2 Largest Sources of CH_4 Emissions in 2004: Scotland

IPCC Sector	% of total 2004 Scotland CH_4	Change against 1990 baseline (%)
1A4b – Residential	1.0	- 82.8
1B1a – Mining activities	1.2	- 90.7
1B2b – Transmission / Distribution	7.3	- 41.0
4A1 – Enteric Fermentation (Cattle)	43.2	- 4.0
4A3 - Enteric Fermentation (Sheep)	17.6	-17.3
4B1 – Manure Management (Cattle)	5.4	- 5.5
6A1 – Managed Waste Disposal on Land	18.5	- 59.5
6B2 – Wastewater Handling	1.4	+ 7.7

The largest source of methane emissions in Scotland is agriculture. Around 68% of Scottish emissions arise from agriculture with cattle responsible for 71% and sheep 26% of Scottish agricultural emissions. Scottish agricultural emissions arise from enteric fermentation in livestock (90%) and the handling of their wastes (10%). Emissions are largely dependent on the numbers of livestock and have fallen by 8% over the period 1990-2004, due to a decline in cattle and sheep numbers. Scotland accounts for around 17% of UK agricultural methane emissions.

The next largest source of methane in Scotland in 2004 is waste disposal. This contributes around 20% to Scotland's emissions and is dominated by landfill

methane[13] with a small contribution from wastewater treatment. Scotland contributes 6.1% to the UK's landfill emission, which is slightly lower than its 8.5% share of the UK population total. Estimates were based on data on arisings of municipal solid waste and sewage sludge in Scotland but using UK data for their composition and the proportion of Municipal Solid Waste disposed of to landfill. It has been assumed that the degree of methane recovery from Scottish landfills reflects that of the UK. Landfill emissions have fallen by 60% since 1990 due an increase in the use of methane recovery systems, though this reduction assumes the UK trend. Emissions from wastewater treatment are estimated to be around 8.5% of UK wastewater treatment emissions. They have increased significantly since 1998 when sea dumping ended and other disposal routes were adopted.

The category Fugitive Emissions from Fuels (IPCC Sector 1B) reports emissions of methane from coal mining, the oil and gas industry and natural gas distribution. The combined emission is 9.5% of the Scottish total. This is a lower proportion compared with the UK as a whole, where fugitives are around 24% of the total 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 1.2%, oil and gas terminals 0.5% and natural gas distribution 7.3% of the Scottish total. Coal mining emissions have declined by 91% over the period due to the decline in the coal industry. Emissions from the oil & gas industry have fallen by 88% over the same period due to tighter regulation of environmental emissions. Gas leakage from the gas transmission system was reduced by 41% over 1990-2004 as the mains and services are renewed. The estimate of gas leakage from the gas transmission system is based on UK National Grid data.

Fuel combustion activities account for 1.9 % of Scottish methane emissions. These emissions stem primarily from power generation and domestic fuel combustion.

3.3 NITROUS OXIDE

Figure 3 (see Chapter 9) shows the emissions of nitrous oxide for 1990 to 2004 broken down by major IPCC source category and Table 3.3 (below) highlights the most significant IPCC sectors in 2004. Total emissions of nitrous oxide in Scotland accounted for 12.3% of the UK total in 2004 and have declined by 19.9% since 1990. The major sources of nitrous oxide in Scotland are combustion and agriculture. Emission estimates are typically subject to significant error, particularly those from agriculture, primarily due to uncertainties associated with certain emission factors.

[13] The landfill methane estimates referred to here relate to unrevised emission totals. See executive summary for explanation.

Table 3.3 Largest Sources of N_2O Emissions in 2004: Scotland

IPCC Sector	% of total 2004 Scotland N_2O	Change against 1990 baseline (%)
1A1a – Power Generation	2.0	- 8.5
1A2f – Manufacturing Industry & Construction	2.3	-26.7
1A3b – Road Transport	8.3	+ 378
4B12 – Solid Storage & Drylot	3.7	- 2.6
4D – Agricultural Soils	77.9	- 21.0
6B2 – Wastewater Handling	2.0	+ 11.9

Of the total Scottish emission of 16kt N_2O in 2004, around 13kt N_2O of this was from agriculture, representing 82% of the total. Most of these were emissions arising from the agricultural soils category as a result of processes in the soil arising from, in order of magnitude:

[Note: numbers in brackets show the percentage of the total agricultural soils N_2O emission (*Source*: IGER 2006, Personal Communication)]

- leaching of fertiliser nitrogen and applied animal manures to ground and surface water (28%)
- synthetic fertiliser application (26%)
- wastes from grazing animals (22%)
- manure used as fertiliser (9%)
- ploughing in crop residues (7%)
- atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NO_x) (7%)
- biological fixation in improved grass (0.8%)
- cultivation of histosols (i.e. high organic content soils) (0.2%)
- cultivation of legumes (<0.1%)

A relatively small proportion (0.65kt N_2O) is emitted from animal manure management. Scottish agricultural nitrous oxide emissions have fallen by 21% between 1990 and 2004, and in 2004 represent around 15% of UK agricultural emissions.

The remaining emissions of nitrous oxide result from fuel combustion (2.6 kt N_2O). Just over half (1.3 kt N_2O) of this is from road transport with the remainder arising from stationary combustion such as power generation and industrial sources. Note that emissions of nitrous oxide from road transport have risen by several hundred percent over the period as a result of the increasing use of catalytic converters on motor vehicles.

In 1990 around 1.3 kt of nitrous oxide were emitted from a nitric acid plant in Leith, however by 1995 this had been dismantled and moved to Dublin. This is a major component of the reduction in Scottish emissions.

3.4 HYDROFLUOROCARBONS

Scottish emissions of HFCs were 8.1% of the UK total (as CO_2 equivalent) in 2004. The main sources are aerosols and refrigeration.

In 2004, refrigeration contributed 58% 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% to the total Scottish HFC emission in 2004, the main sources being industrial aerosols and medical use of metered dose inhalers. The remaining emission sources (foams, fire-fighting and solvents) contributed 11% of total Scottish HFC emissions.

The total emission has increased from virtually zero in 1990 to 719.5 kt in 2004 due to the greater use of these substances to replace alternative banned species such as CFCs.

3.5 PERFLUOROCARBONS

The largest source of perfluorocarbons in Scotland is consumption by the electronics industry. In 2004, 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 21.3% of the UK total (as CO_2 equivalent) and have decreased by 33.8% over 1990-2004 as the decreases in emissions from the aluminium production have out-weighed the increase from the electronics industry.

3.6 SULPHUR HEXAFLUORIDE

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 2004 are 5.3% of the UK total and in Scotland the emissions of SF_6 have increased by 197% over 1990-2004.

4. Emissions in Wales

4.1 CARBON DIOXIDE

Figure 1 (see Chapter 9) shows the emissions of carbon dioxide for 1990 to 2004 broken down by major IPCC source category and Table 4.1 (below) highlights the most significant IPCC sectors in 2004. Total emissions of carbon dioxide in Wales accounted for 7.5% of the UK total in 2004 and have increased by 2.3% since 1990.

Table 4.1 Largest Sources and Sinks of CO_2 in 2004: Wales

IPCC Sector	% of total 2004 Wales CO_2 Emissions[14]	Change against 1990 baseline (%)
1A1a – Power Generation	31.1	+ 15.6
1A1b – Petroleum Refining	8.3	- 3.6
1A2a – Manufacturing Industry & Construction: Iron & Steel	16.6	- 11.0
1A2f – Manufacturing Industry & Construction: Other	9.1	+ 4.7
1A3b – Road Transport	14.3	+ 8.6
1A4a – Commercial / Institutional	2.4	- 17.3
1A4b - Residential	11.3	+ 16.1
5A2 – Land Converted to Forest Land	-3.8 (SINK)	+ 34.4[15]
5B2 – Land Converted to Cropland	2.5	+ 7.6

The largest source of CO_2 emissions in Wales is Energy Industries, which includes power generation, refineries and solid fuel transformation processes. Electricity generation contributed around 31.1% of the total Welsh carbon dioxide emissions in 2004, which is slightly higher than the UK proportion of 30.5%. Emissions from electricity generation in Wales have increased by 15.6% compared with a fall of 16.3% in UK emissions over 1990 to 2004.

There is now only one nuclear power station in Wales whilst there has been a growth of Combined Cycle Gas Turbines (CCGTs) to replace the generating

[14] Percentages are quoted a s a proportion of the total net emissions. Emissions and removals are no longer reported separately.
[15] Category 5A2 is a net SINK, and therefore the +34.4 % figure refers to an increase in the store of carbon, rather than an increase in the emission.

capacity from Trawsfynydd Nuclear Station which closed in 1991. The remaining fossil fuel generation is from two conventional coal stations.
There has been an increase in generation capacity in Wales from the opening of several CCGTs: 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 quantity of coal consumed at Aberthaw power station has declined over the period 1990 to 2004. Two power stations have closed: the oil-fired station at Pembroke, and the coal-fired station at Uskmouth. Uskmouth has subsequently re-opened as Fifoots after being upgraded and fitted with Flue Gas Desulphurisation.

Petroleum refining constitutes 8.3% of Welsh CO_2 emissions in 2004 compared with 3.1% for the UK. The other energy emissions are mostly combustion emissions from coke ovens and solid fuel plant and account for 0.7% of the 2004 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 25.7% of the Welsh total compared with 15.7% 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 36.4% of UK Iron and Steel combustion emissions in 2004. The Welsh 'other industry' category is 5.5% of the UK total.

Iron & Steel Sector in Wales: Recent Trends

Over recent years there have been significant fluctuations in the CO_2 emissions from the iron and steel sector in Wales, and these have had a big impact on the total CO_2 emissions trends. Both iron & steel production and coke use statistics dipped in 2002, primarily due to the explosion at Port Talbot blast furnace #5 in November 2001 (the furnace provides just under half of Port Talbot production and didn't come back on line until January 2003). Hence Wales CO_2 emissions dipped in 2002 as the production of pig iron at Port Talbot during 2002 was limited to the 2 Mtonnes capacity of #4 blast furnace, whereas during 2001 and 2003 there was additional production of approximately 1-1.5 Mtonnes from the old and new #5 furnaces respectively.

More generally, pig iron production in Wales increased throughout the 1990s, but then in 2001 the Llanwern blast furnaces were closed with the result that pig iron production fell from 5.2 Mtonnes in 2000 to 3.4 Mtonnes in 2001. The loss of #5 at Port Talbot then led to a further fall to 1.9 Mtonnes in 2002 before the new #5 came on stream in 2003 and production of pig iron increased again to 3.3 Mtonnes, leading to a significant growth in CO_2 emissions from this source over 2002-2003. Emissions from the iron and steel sector in 2004 have shown an increase of 6.1%, due to an increase in blast furnace gas use, based on statistics reported by ISSB.

Road transport is the largest single source after power generation and iron and steel, and comprises 14.3% of the total Welsh carbon dioxide emission in 2004. The contribution of Welsh Road Transport to UK Road Transport CO_2 emissions is

5.0%, which is consistent with Wales' population (4.9% of UK population). The emission has risen by 8.6% from 1990 to 2004 compared with a 9.1% rise for the UK. (See also the discussion regarding road transport emission estimation methodology in Appendix 1.)

Other combustion emissions arise from the domestic, commercial and public sectors. 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 11.3% of the Welsh total in 2004. As a proportion of UK domestic emissions they are estimated to represent 5.4%, which is consistent with the relative populations.

Industrial processes also produce emissions from non-combustion sources such as the use of limestone in cement and glass making. In Wales the largest contribution is from the Iron & Steel Industry from a range of sources: limestone use in blast furnaces, flaring of blast furnace gas and electric arc furnaces. Other industrial processes include cement, aluminium and glass production. Together these processes emitted 3.7% of the Welsh total in 2004. The Welsh industrial process emission is 13% of the UK due to the high proportion of iron & steel and aluminium production in Wales.

Data are calculated and presented in this report for net emissions of carbon dioxide from Land Use, Land Use Change and Forestry (LULUCF). Wales is a net sink of carbon dioxide from LULUCF activities and the size of this sink has increased from 0.24 to 0.25 Mt CO_2 since 1990. The LULUCF data in this report have been extensively revised in comparison with last year's publication, including revisions to the reporting categories. This is explained further in Appendix 1.

There are no municipal waste incinerators in Wales but a small emission from clinical incineration is reported.

4.2 METHANE

Figure 2 (see Chapter 9) shows the emissions of methane for 1990 to 2004 broken down by major IPCC source category and Table 4.2 (below) highlights the most significant IPCC sectors in 2004. Total emissions of methane in Wales accounted for 9.1% of the UK total in 2004 and have declined by 37.2% since 1990. The major sources of methane in Wales are waste disposal, coal mining, leakage from the gas distribution system and agriculture.

Table 4.2 Largest Sources of CH_4 Emissions in 2004: Wales

IPCC Sector	% of total 2004 Wales CH_4	Change against 1990 baseline (%)
1A2a – Manufacturing Industry & Construction: Iron & Steel	1.3	- 16.4
1A4b – Residential	1.1	-15.3
1B1a – Mining activities	4.5	- 83.8
1B2b – Transmission / Distribution	6.1	- 23.5
4A1 – Enteric Fermentation (Cattle)	36.0	- 1.6
4A3 - Enteric Fermentation (Sheep)	24.2	- 7.8
4B1 – Manure Management (Cattle)	5.6	- 2.9
6A1 – Managed Waste Disposal on Land	17.8	- 62.6

The largest source of methane emissions in Wales is agriculture. Around 67% of Wales' methane emissions arise from agriculture, with cattle responsible for 62% and sheep 37% of Welsh agricultural emissions. Welsh agricultural emissions arise from enteric fermentation in livestock (90%) and the management of their wastes (10%). Emissions are largely dependent on the numbers of livestock and have decreased by 4.1% over the period 1990-2004, due to a decline in cattle and sheep numbers. Wales accounts for around 15% of UK agricultural emissions.

The next largest source of methane is waste, which contributes 18.8% to Wales' emissions in 2004. Of this, 95% is landfill methane[16], with a small contribution from wastewater treatment (5%). The landfill emission is 5.3% of UK landfill emissions which is consistent with the respective populations. Estimates were based on data on arisings of municipal solid waste and sewage sludge in Wales but using UK data for their composition and the proportion of MSW disposed of to landfill. The degree of methane recovery on Welsh landfills was assumed to reflect that of the rest of the UK. On this basis, landfill emissions have fallen by 62.6% since 1990 because of increasing use of methane recovery systems reflecting the UK trend. Emissions from Welsh wastewater treatment are 4.9% of UK wastewater treatment emissions and are dependent on the data on sewage disposals and disposal routes used.

The category Fugitive Emissions from Fuels (IPCC Sector 1B) reports emissions of methane from coal mining, coke production and natural gas distribution. The combined emission is 10.7% of the 2004 Welsh total, compared to a UK average of 24%. This is due to the greater contribution of coal mining, oil and gas production and leakage from the gas transmissions system elsewhere in the UK.

[16] The landfill methane estimates referred to here relate to unrevised emission totals. See executive summary for explanation.

Of these fugitive emissions, coal mining contributes 4.5% and natural gas distribution 6.1% to the 2004 Welsh total methane emission. Coal mining emissions have declined by 83.8% over 1990-2004 due to the decline in the coal industry, whilst emissions from gas leakage from the gas transmission system have reduced by 23.5% as the mains and services have been renewed.

Fuel combustion activities account for 3.1% of total Welsh methane emissions. These emissions stem primarily from sintering processes in the iron and steel industry, power generation and domestic combustion.

4.3 NITROUS OXIDE

Figure 3 (see Chapter 9) shows the emissions of nitrous oxide for 1990 to 2004 broken down by major IPCC source category and Table 4.3 (below) highlights the most significant IPCC sectors in 2004. Total emissions of nitrous oxide in Wales accounted for 8.0% of the UK total in 2004 and have declined by 10.9% since 1990. The major sources of nitrous oxide in Wales are combustion and agriculture. Emission estimates are typically subject to significant error, particularly those from agriculture, primarily due to uncertainties associated with certain emission factors.

Table 4.3 Largest Sources of N_2O Emissions in 2004: Wales

IPCC Sector	% of total 2004 Wales N_2O	Change against 1990 baseline (%)
1A1a – Power Generation	1.7	- 39.3
1A3b – Road Transport	8.2	+ 405.4
1A4c – Agriculture, Forestry and Fisheries	1.7	-6.9
4B12 – Solid Storage & Drylot	3.6	- 4.0
4D – Agricultural Soils	78.0	- 17.3
6B2 – Wastewater Handling	1.8	+ 15.6

Of the total Welsh emission of 10.5kt N_2O in 2004, 8.6 kt N_2O (82%) of this was from agriculture. Most of these were emissions arising from the agricultural soils category as a result of processes in the soil arising from, in order of magnitude:

[Note: numbers in brackets show the percentage of the total agricultural N_2O emission (*Source*: IGER 2006, Personal Communication)]

- wastes from grazing animals (33%)
- leaching of fertiliser nitrogen and applied animal manures to ground and surface water (29%)
- synthetic fertiliser application (19%)
- manure used as fertiliser (9%)

- atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NOx) (8%)
- ploughing in crop residues (1%)
- biological fixation in improved grass (1%)
- cultivation of histosols (i.e. high organic content soils) (0.5%)
- cultivation of legumes (<0.1%)

A relatively small proportion (0.4 kt N_2O) is emitted from the treatment of agricultural wastes (manure management). Welsh agricultural nitrous oxide emissions have fallen by 17% between 1990 and 2004, and in 2004 represent around 10% of UK agricultural emissions.

The remaining 1.9 kt (18 % of the 2004 Welsh total) of nitrous oxide emissions results from fuel combustion activities, iron and steel, and waste water treatment. The main sources are power generation, road transport and manufacturing industry. Note that emissions of nitrous oxide from road transport have risen by several hundred percent over the period as a result of the increasing use of catalytic converters on motor vehicles.

4.4 HYDROFLUOROCARBONS

In 2004 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 52.9% to the total Welsh HFC emission (as CO_2 equivalent) due to losses from refrigeration and air conditioning equipment during its manufacture and lifetime. Aerosols contribute 34.5% 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 12.6% to the total Welsh HFC emission (as CO_2 equivalent) in 2004.

4.5 PERFLUOROCARBONS

The largest emission source of perfluorocarbons in Wales is the aluminium industry, which contributes 91% of the total Welsh PFC emission (as CO_2 equivalent) in 2004, and 31% of UK aluminium emissions. The electronics industry also makes an important contribution accounting for 8.9% of Wales' PFC emission (as CO_2 equivalent) and 5% of UK electronics emissions. The remaining sources are fire extinguishers and refrigeration. Overall, Welsh PFC emissions are 14.9% of the UK PFC total (as CO_2 equivalent). Emissions of PFC have decreased by 83.2% from 1990 to 2004 mainly as a result of improved control measures in the aluminium industry.

4.6 SULPHUR HEXAFLUORIDE

Welsh emissions of sulphur hexafluoride are estimated at 6.3 % of the UK total in 2004. The largest source of emissions is from IPCC category 2F8 and this accounts for 62% 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 SF6 in Wales is from industry use as a cover gas in magnesium

production. This accounts for around 38% of total Welsh emissions and comprises 7% of the UK magnesium production emission.

5. Emissions in Northern Ireland

5.1 CARBON DIOXIDE

Figure 1 (see Chapter 9) shows the emissions of carbon dioxide for 1990 to 2004 broken down by major IPCC source category and Table 5.1 (below) highlights the most significant IPCC sectors in 2004. Total emissions of carbon dioxide in Northern Ireland accounted for 2.9% of the UK total in 2004 and have increased by 3.6% since 1990.

Table 5.1 Largest Sources and Sinks of CO_2 in 2004 : Northern Ireland

IPCC Sector	% of total 2004 N. Ireland CO_2 Emissions[17]	Change against 1990 baseline (%)
1A1a – Power Generation	29.5	- 12.2
1A2f – Manufacturing Industry & Construction: Other	14.6	+ 56.7
1A3b – Road Transport	29.7	+ 49.8
1A4b - Residential	20.6	- 16.2
5B2 – Land Converted to Cropland	7.0	- 10.1
5C2 – Land Converted to Grassland	- 8.4 (SINK)	+ 9.0[18]
5E2 – Land Converted to Settlements	3.5	- 0.1

Road transport is the largest source of carbon dioxide emissions in Northern Ireland and comprises 29.7% of the 2004 total. The contribution of Northern Irish Road Transport to UK Road Transport CO_2 emissions is 4%, which is slightly higher than that which would be expected from Northern Ireland's population (2.9% of UK). The emission has risen by 49.8% from 1990 to 2004 compared with an 9.1% rise for the UK. (See also the discussion regarding road transport emission estimation methodology in Appendix 1.)

Energy Industries is the next largest source of carbon dioxide emissions in Northern Ireland, and in Northern Ireland this is entirely power generation as there are no refineries, collieries, solid fuel transformation plant or oil and gas processing sources. Electricity generation contributed 29.5% of the total emission, which is similar to the UK proportion of 30.5%. 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

[17] Percentages are quoted a s a proportion of the net emissions, emissions and removals are no longer reported separately

[18] Category 5C2 is a net SINK, and therefore the +9.0 % figure refers to an increase in the store of carbon, rather than an increase in the emission.

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. Emissions from electricity generation decreased by 12.2% over the 1990-2004, largely due to the conversion to natural gas.

Combustion emissions from Manufacturing Industry and Construction (IPCC Sector 1A2) account for 14.6% of the total Northern Ireland carbon dioxide emission compared with 15.7% 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 3.4% towards the UK Other Industry total, and has increased by approximately 56.7% over the period 1990-2004.

CO_2 Emissions in Northern Ireland: Recent Trends

Between 2003 and 2004, a sharp increase (40%) in CO_2 emissions from industrial combustion sources in Northern Ireland has been noted. The main reason for this is large fluctuations in the time series of burning oil use in the industrial sector (DTI, 2005). This time series is quite uncertain, owing to structural changes in the oil industry, which means that oil products are sold on to intermediate companies, before finally reaching the end user. This makes it much more difficult for the DTI to collect data about the destination of burning oil supplied to sectors (e.g. to industrial, domestic sectors etc.). The time series of this data is currently being reviewed, and may lead to a revision of historic data in future greenhouse gas inventories for Northern Ireland.

An increase of 9% has also been noted in the transport sector. This has been caused by a large increase in the vehicle km (vkm) data for HGVs, supplied by DRDNI. This time series has also recently been reviewed and revised by the DRDNI, and these revisions will be incorporated into the DA Inventories for 2005.

Other combustion emissions arise from the domestic, commercial and public sectors. 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 20.6% of the Northern Irish total. As a proportion of UK domestic emissions they are estimated to represent 3.8%, 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. 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. The high consumption of coal and oil result in a higher emission per unit energy use than in the rest of the UK.

Industrial process emissions (primarily from mineral processing sources) in Northern Ireland contribute 1.5% to the total 2004 CO_2 emission. Waste incineration is not a significant source of CO_2 in Northern Ireland.

Data are calculated and presented in this report for net emissions/removals of carbon dioxide from Land Use, Land Use Change and Forestry (LULUCF). Northern Ireland is a net sink of carbon dioxide from LULUCF activities and the size of this sink has increased from 0.04 Mt CO_2 to 0.3 Mt CO_2 between 1990 and 2004. The LULUCF data for 1990 to 2003 in this report have been extensively revised in comparison with last year's publication. Details of this are included in Appendix 1.

5.2 METHANE

Figure 2 (see Chapter 9) shows the emissions of methane for 1990 to 2004 broken down by major IPCC source category and Table 5.2 (below) highlights the most significant IPCC sectors in 2004. Total emissions of methane in Northern Ireland accounted for 6.1% of the UK total in 2004 and have declined by 6.4% since 1990. The main sources of methane in Northern Ireland are waste disposal and agriculture.

Table 5.2 Largest Sources of CH_4 Emissions in 2004: Northern Ireland

IPCC Sector	% of total 2004 N. Ireland CH_4	Change against 1990 baseline (%)
1A4b – Residential	2.5	- 52.8
4A1 – Enteric Fermentation (Cattle)	66.6	+ 9.0
4A3 - Enteric Fermentation (Sheep)	8.0	- 20.0
4B1 – Manure Management (Cattle)	9.8	+ 11.7
6A1 – Managed Waste Disposal on Land	8.4	- 50.3

The largest source of methane emissions in Northern Ireland is agriculture. Around 87% of Northern Ireland's emissions arise from agriculture with cattle responsible for 88% of agricultural emissions. Agricultural emissions arise from enteric fermentation in livestock (86%) and the management of their wastes (14%). Emissions are dependent on the numbers of livestock and have increased by 5% over the period (1990 to 2004) resulting from an increase in cattle. Northern Ireland accounts for around 13% of UK agricultural emissions.

Waste disposal contributes 9% to Northern Ireland's 2004 CH_4 emissions totally, from landfill methane[19] (8%) and wastewater treatment (1%). The landfill emission is 1.7% of UK landfill emissions compared to a share of the UK population of 2.9%. Estimates are based on data on arisings of municipal solid waste and sewage sludge in Northern Ireland using UK data for waste composition, percentage of MSW disposed to landfill, and proportion of methane recovery. On this basis, landfill emissions have fallen by 50% due to increasing use of methane recovery systems, reflecting the UK trend. Emissions from wastewater treatment are 2.8% of UK wastewater treatment emissions.

Combustion emissions are not a large source of methane, accounting for only 2.9% of the total Northern Irish methane emission, mostly from domestic combustion of coal and anthracite.

5.3 NITROUS OXIDE

Figure 3 (see Chapter 9) shows the emissions of nitrous oxide for 1990 to 2004 broken down by major IPCC source category and Table 5.3 (below) highlights the most significant IPCC sectors in 2004. Total emissions of nitrous oxide in Northern Ireland account for 6.5% of the UK total in 2004 and have declined by 14.0% since 1990. The major sources of nitrous oxide in Northern Ireland are agriculture and road transport. Emission estimates are typically subject to significant error, particularly those from agriculture, primarily due to uncertainties associated with certain emission factors.

Table 5.3 Largest Sources of N_2O Emissions in 2004: Northern Ireland

IPCC Sector	% of total 2004 N. Ireland N_2O	Change against 1990 baseline (%)
1A2f – Other Industry	1.7	+ 89.7
1A3b – Road Transport	7.2	+ 448.6
1A4c – Agriculture Forestry and Fisheries	1.8	- 10.2
4B12 – Solid Storage & Drylot	5.8	- 4.2
4D – Agricultural Soils	79.3	- 8.8

Of the total Northern Irish emission of 8.6kt N_2O in 2004, around 7.3 kt N_2O (86%) was from agriculture. Most of these were emissions from the agricultural soils category as a result of processes in the soil arising from, in order of magnitude:

[19] The landfill methane estimates referred to here relate to unrevised emission totals. See executive summary for explanation

[Note: numbers in brackets show the percentage of the total agricultural soils N_2O emission (*Source*: IGER 2006, Personal Communication)]

- leaching of fertiliser nitrogen and applied animal manures to ground and surface water (30%)
- wastes from grazing animals (24%)
- synthetic fertiliser application (21%)
- manure used as fertiliser (15%)
- atmospheric deposition of ammonia (NH_3) and oxides of nitrogen (NOx) (8%)
- ploughing in crop residues (1%)
- improved grass (1%)
- histosols (i.e. high organic content soils) (0.2%)
- cultivation of legumes (<0.1%)

A relatively small emission (0.5 kt N_2O) comes from the treatment of animal wastes (Manure Management). Northern Irish agricultural nitrous oxide emissions have fallen by 9% between 1990 and 2004, and in 2004 represent around 9% of UK agricultural emissions.

Fuel combustion contributes 13% (1.1 kt N_2O) to the overall N_2O total in Northern Ireland, with 0.6kt from road transport and the remainder from stationary combustion in other sectors. Note that emissions of nitrous oxide from road transport have risen by several hundred percent over the period as a result of the increasing use of catalytic converters on motor vehicles.

Wastewater treatment accounts for 1.3% of the total N_2O emissions in Northern Ireland in 2004, having increased by 20.0% over 1990-2004.

5.4 HYDROFLUOROCARBONS

Total Northern Irish emissions of HFCs in 2004 were 2.8% of the UK Total (as CO_2 equivalent). The largest source was refrigeration (including air conditioning) contributing 58.7% of the Northern Ireland HFC total due to losses from refrigeration and air conditioning equipment during its manufacture and lifetime. Aerosols contributed 30.2% to the total Northern Irish HFC emission in 2004, the main sources being industrial aerosols and medical use of metered dose inhalers. The remaining emission sources (foams, fire-fighting and solvents) contributed 11.0% of total Northern Irish HFC emissions. The total emission has increased from virtually zero in 1990 to 244kt CO_2 equivalent in 2004.

5.5 PERFLUOROCARBONS

There are no estimated emissions of PFCs in Northern Ireland in 2004. In 1990, emissions arose from electronics and sporting goods, but emissions from these sources fell to zero in 1995. Between 1995 and 2001, emissions were from refrigeration and fire fighting. Neither of these sources occur after 2001 in the UK.

5.6 SULPHUR HEXAFLUORIDE

Northern Ireland SF_6 emissions accounted for 0.8% of the UK total in 2004. 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.

6. Unallocated Emissions

A number of sectors which were previously reported as "unallocated" have been split out into the DAs for the 1990 to 2004 inventories. These are listed below, and details about the methodology used to break the UK total down to regional level are included in the relevant sections of Appendix 1:

- fishing
- coastal shipping
- domestic aviation
- naval vessels
- military aircraft

Emissions from offshore oil and gas installations remain unallocated since there was no clear method for attributing these emissions to the individual DAs. As a proportion of the 2004 UK totals they account for the following:

- Carbon dioxide 3.1% (up 32.3% since 1990)
- Methane 2.3% (down 42.0% since 1990)
- Nitrous oxide 0.4% (up 30.7% since 1990)

There are no unallocated emissions of halocarbons and sulphur hexafluoride.

The breakdown of key source categories for unallocated GHG emissions is as follows:

Table 6.1 Largest Sources of CO_2 Emissions in 2004: Unallocated

IPCC Sector	% of total 2004 Unallocated CO_2	Change against 1990 baseline (%)
1A1cii – Other Energy Industries	77.6	+ 52.5
1B2a – Oil Production	1.9	- 77.2
1B2ciii - Flaring	20.5	+ 25.4

The increases in 1A1cii are due to increased activity in the offshore oil & gas sector and stem primarily from gas separation plant and own gas combustion by offshore operators.

Table 6.2 Largest Sources of CH_4 Emissions in 2004: Unallocated

IPCC Sector	% of total 2004 Unallocated CH_4	Change against 1990 baseline (%)
1A1cii – Other Energy Industries	4.4	+ 47.5
1B2a – Oil Production	14.1	- 79.4
1B2ciii - Flaring	27.2	- 30.9
1B2ciii - Venting	54.3	- 11.7

The increases in 1A1cii are due to increased activity in the offshore oil & gas sector, from gas separation plant and other sources, whilst industry efforts to reduce the flaring and venting of petroleum gases have led to significant reductions in emissions from those sources.

Table 6.3 Largest Sources of N_2O Emissions in 2004: Unallocated

IPCC Sector	% of total 2004 Unallocated N_2O	Change against 1990 baseline (%)
1A1cii – Other Energy Industries	76.2	+ 39.5
1B2ciii - Flaring	23.1	+ 21.0

The increases in these sectors are due to increased activity in the offshore oil & gas sector, from gas separation plant and other sources.

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; the precise availability of data across all sub-sectors of the regional inventories is discussed in Appendix 1.

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** (for most of these, country data are available from producers, trade associations, the Environment Agency's Pollution Inventory, the Scottish Environmental Protection Agency's EPER inventory and the Northern Ireland Department of Environment's ISR inventory.)

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* (DTI, 2005), 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.

Northern Ireland produces a complete annual set of fuel statistics, though this only gives sectoral consumption for coal and total consumption for oil products.

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, owing to the problems of reporting potentially commercial data.

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.

UK National Grid provides gas sales statistics disaggregated by region and consumer size and Phoenix Gas provides data for natural gas consumption in NI disaggregated by type of consumer.

Fuel consumption within the iron & steel industry is well covered by *Iron and Steel Industry Statistics* (ISSB, 2004) although in the latest editions some of the

more detailed regional data are not reported; equivalent data are available on request. The ISSB data deal with primary iron and steel production but excludes most secondary processes.

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.

Carbon emissions data are available for refineries from UKPIA and the Environment Agency's Pollution Inventory.

Detailed data are available for the offshore industry from the UKOOA EEMS database which includes installation and process-specific data for 1995, and 1998 to 2004 of varying coverage; earlier years in the UKOOA 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.

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

- Domestic coal & oil
- Miscellaneous/Commercial 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:

- Emissions from commercial and other manufacturing industry are estimated using regional GVA figures as an indication of the economic activity in the DAs.
- The regional disaggregation of agricultural sector fuel combustion emissions and oil consumption in the commercial and public service sectors are based on employment statistics.
- Limited data on coal consumption have been collected for England and Wales in 1995, and 1998 to 2002 from coal producers.
- For England, Wales and Scotland, domestic oil use is estimated based on population, whilst for Northern Ireland, housing survey data have been used.

7.2 SIGNIFICANT CHANGES TO INVENTORY METHODOLOGY

A number of changes have been made to the estimates since the last study (Baggott *et al* 2005) due to revisions to:

- carbon, 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 UK method improvement: Integration of EU ETS data & other industrial fuel use data

For some key industry sectors, data provided directly by UK industry or from the UK database used within the EU-ETS system has been used to improve the time-series of industrial fuel use. Such modifications have been limited to a few industry sectors where specific problems have been identified with the DTI energy balance dataset during 2005, and in all cases the modifications have been conducted such that the total UK energy use reported via the GHG inventory is consistent with DTI UK energy statistics. For example, the UK cement industry use of coal, oil, gas, petcoke and substitute fuels such as tyres has been revised to coincide with estimates provided directly by the industry over 1998-2004. In addition, greater integration of datasets directly from Corus, the UK's main iron & steel producer, has lead to improvements of estimated fuel use at the four integrated steelworks in the UK. The NIC and the DTI continues and aims to ensure that future UK Energy Statistic publications are more consistent with the EU-ETS reports and other industry-derived energy use datasets.

7.2.2 UK methodology improvement: A revision of the time-series or methane emission estimates from waste disposal at landfills

Defra requested a review of the method used to estimate emissions of methane from solid waste disposal to landfill after the 2004 National Greenhouse Gas Inventory[20] was submitted to the FCCC on the 15th April 2006. This work was completed as part of a review to ensure that the UK's Base Year emissions were estimated as accurately as possible, since the Base Year emissions have determined the UK's Assigned Amount under the Kyoto Protocol. The UK has now revised the method it uses to estimate methane emissions from the solid waste disposal to landfill, and the method now uses the latest IPCC factors for the fraction of methane oxidised. Issue 2 of the UK Greenhouse Gas Inventory (Baggott *et al.*, 2006) was submitted in October 2006.

The revision was carried out after the preparation of the 2006 DA inventory and owing to time constraints it has not been possible to update the estimates presented here to reflect the revision. Overall, the effect has been to increase UK methane emissions by approximately 12%. The UK total GHG emissions presented in this report also remain consistent with the initial submission to the

[20] 2006 UK National Inventory Report, containing estimates of emissions from 1990 to 2004 inclusive.

FCCC on the 15th April to maintain consistency with DA totals. Revised UK totals are presented on the CD accompanying this report. Revisions to the methodology for landfill methane will be incorporated in the 2007 DA inventory.

7.2.3 UK Method Improvement: A review of the combustion of lubricating oils by vehicles and industrial machinery

Analysis by UK experts in transport emissions and oil combustion have lead to a revision to the assumptions regarding re-use or combustion of lubricating oils from vehicle and industrial machinery. A review of the estimation method and sector allocations within the 1990-2003 inventory has lead to reductions in the estimated emissions and a re-allocation to other IPCC sectors from combustion within the 1A3d (Road Transport) sector.

7.2.4 UK Method improvement: A review to investigate the emissions of nitrous oxide from adipic acid and nitric acid production plant in the UK

Through direct consultation with plant operators, an improved understanding of the plant design, abatement, emissions monitoring and reporting systems was developed. Minor revisions to activity data over recent years have been made, although total emissions reported via the Environment Agency Pollution Inventory and the UK GHG Inventory are unchanged. Some changes to Implied Emission Factors are evident, and a greater understanding of the variability of these factors has been gained.

7.2.5 UK Method Improvement: A review of the fate of benzoles and coal tars

Benzoles and coal tars are shown as an energy use in UK DTI energy statistics and up until the 2002 version of the GHGI, the carbon was included in the coke ovens carbon balance as an emission of carbon from the coke ovens. In reality, the benzoles and coal tars are recovered and sold. Therefore, when the carbon balance methodology was improved for the 2003 GHG (2005 NIR) inventory, it was treated as a non-emissive output from the coke ovens. However, we were not sure what the ultimate fate of the carbon was but were unable to research this in time for the 2003 GHG inventory (2005 NIR). It was therefore treated as an emission from the waste disposal sector - thus ensuring that total UK carbon emissions were not altered until we had sufficient new information to judge what the fate of the carbon was. The new analysis concludes that we can treat all of the carbon as stored and so the carbon emission included in the 2005 inventory has been removed from the 2006 GHG inventory.

7.2.6 UK Method Improvement: A comprehensive review of the emissions dataset from the offshore oil & gas industry

A review of these data across the full time-series was conducted during autumn 2005 by the UK trade association, UKOOA, in response to the development of the EU-ETS. Several significant changes to emission factors, and in some cases gap-filling of activity data lead to a significant revision of the full time-series of data back to 1990 within the UK GHG inventory. The 2005 revisions to UKOOA datasets from offshore oil & gas sources include:

- Changes to carbon emission factors for some combustion sources, to ensure that emissions reported via the UK GHG inventory are consistent with those reported via the EU Emissions Trading Scheme.
- The sector-specific splits for the 1990-1994 datasets have been re-allocated by benchmarking against the 1997 UKOOA dataset. Previously the 1990-1994 emission totals were split out based on 1995 data, but irreconcilable gaps in the 1995 and 1996 datasets have been identified that indicate that use of the 1997 dataset will provide a more accurate estimate for 1990-1994. The missing sources in 1995 and 1996 will lead to a slight under-report of GHG emissions in those years.
- Changes to some historic emission estimates of methane and nitrous oxide where the application of emission factors has been identified as inconsistent across the time-series.

7.2.7 UK source reallocation: Emissions of peat

Emissions of domestic peat combustion have been re-allocated. Emissions were always included in the UK GHG inventory but were not allocated to the correct sector (LULUCF sector, category 5E in the 2005 NIR). A Tier 2 methodology drawing on default emission factors was developed and the emissions accounted within IPCC sector 1A4b.

7.2.8 UK method improvements: LULUCF

Within the LULUCF emissions inventory, minor corrections and improvements have been made to the LULUCF model used by CEH, leading to revisions across the reporting time series. Revisions to land use activity data, soil density assumptions and emission / sink factors for some land uses have been made, and the sectoral disaggregation of some emissions / sinks have been altered. Further details of the recalculations are given in the LULUCF chapter in the UK National Inventory Report (2006).

7.2.9 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:

- Point sources: Emissions from large point sources have been estimates from data reported in the PI, EPER and ISR data. Previously the regional split has been based on fuel consumption estimates or plant capacities. This affects the inventory years 2000-2004.

- Disaggregation of unallocated emissions: Domestic aviation, shipping and military emissions have now been allocated to each of the DAs. The regional splits have been based on movements at major airports, port movements, and GVA data for military aircraft and naval emissions.

- Miscellaneous fuel use: Emissions from the "other manufacturing industry" and "commercial and institutional" categories have previously been disaggregated using the Science Policy Research Unit (SPRU) database of boilers and their capacities. However, this was taken from a survey conducted in 1995 and is therefore no longer considered to be an accurate representation of the distribution of emissions from these sources. A time series of regional GVA data has been used to replace to break down the UK total for these sources.

8. Uncertainty in the Inventories

A study (Eggleston *et al*, 1998) estimated the uncertainty in the UK Inventory. These estimates have been revised to account for changes in the 2004 national inventory (Baggott *et al*, 2006) and are given in Table 9.1. The total UK uncertainty is consistent with the totals reported in Issue 1 of the National Inventory Report, submitted to the UNFCCC in April 2006 (Baggott *et al*, 2006).

As a result of the activity data gaps in the Devolved Administration inventories, the estimates will be more uncertain than for the UK inventory. The uncertainties in the emission totals have been estimated using a Monte Carlo simulation. It is difficult to estimate the uncertainties in some of the activity data used in the DA-level inventories due to the data gaps, since it is unknown how closely the surrogate data reflect actual fuel consumption. Hence, in the simulation it has been necessary to make fairly speculative assumptions on the uncertainties in the country-specific activity data. The approach adopted is discussed in Appendix 1. The uncertainty estimates are reported in Table 9.1. The N_2O distribution is heavily skewed[21], so that 2.5% and 97.5% confidence limits are quoted.

Table 9.1 Estimated Uncertainties[1] in the DA Inventories in 2004

GHG	Units	England	Scotland	Wales	N Ireland	UK
CO_2	± %	1.7	11.0	2.4	7.4	2.2
Methane	± %	19.6	15.5	15.2	16.1	16.8
N_2O	Lower kt	22	3	2	1	29
	Upper kt	324	69	45	38	475
HFC	± %	25	21	21	21	21
PFC	± %	21	13	13	-	13
SF_6	± %	19	16	16	16	16
Total	**± %**	**12**	**27**	**18**	**35**	**14**

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 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.

[21] 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.

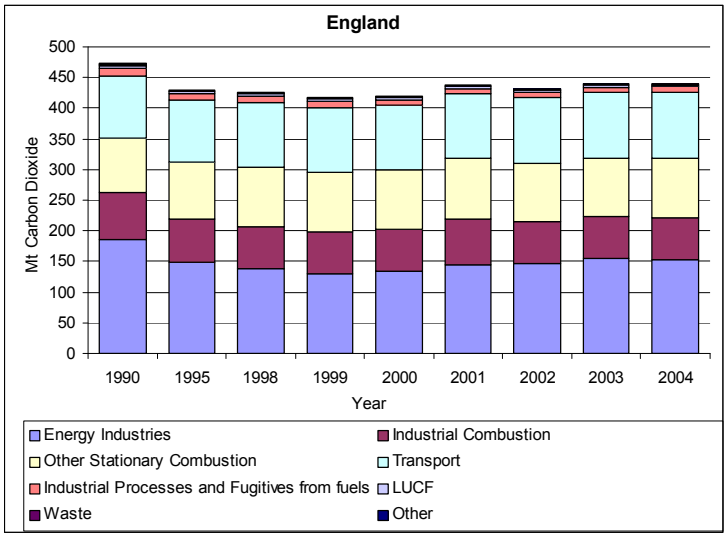
9. Summary Graphs

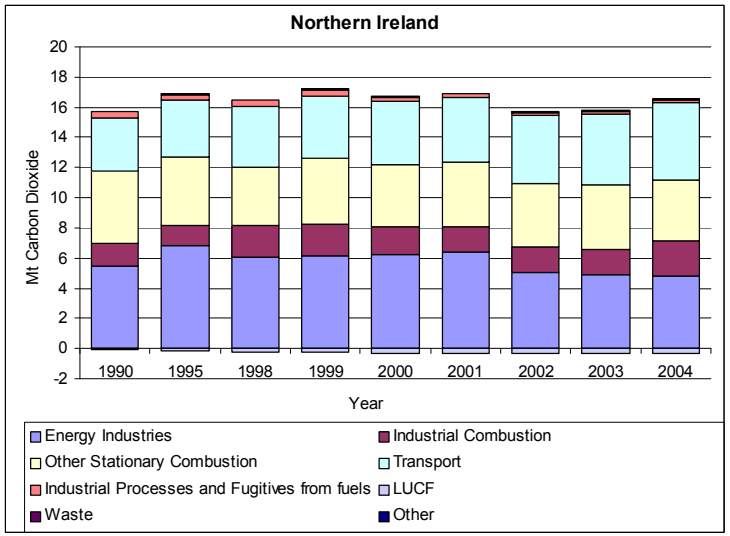
Graphs illustrating the greenhouse gas emissions for the years 1990, 1995, and 1998 to 2004 for the UK and the Devolved Administration are shown in figures 9.1 to 9.6. All of the plots show emissions as CO_2 equivalent, and net emissions/removals are reported in line with the changes to reporting for the Land Use Change and Forestry Sector.

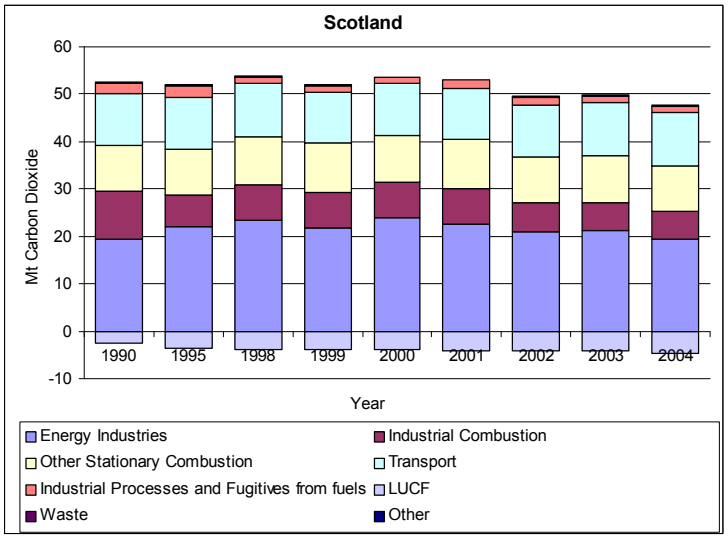
The summary data and time-series trends illustrated by these graphs are also presented in more detailed country-specific tables in Appendix 2, including a breakdown of total greenhouse gas emissions by the following IPCC Source Categories:

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

Figure 9.1 Emissions of CO_2







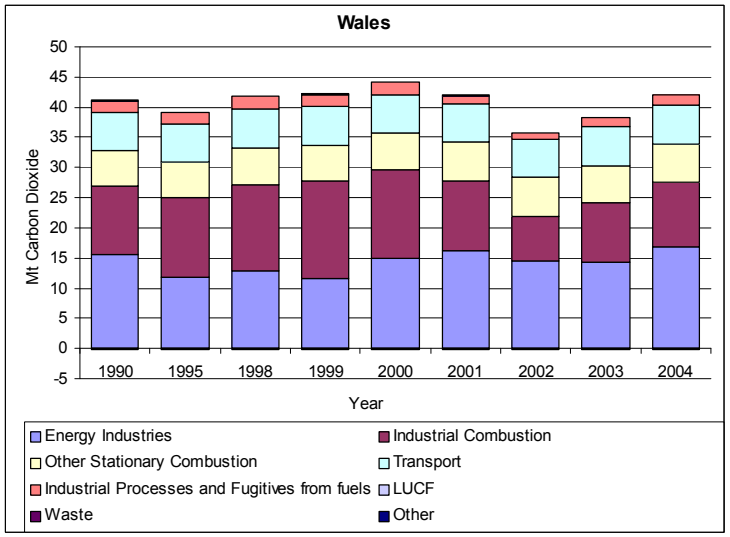
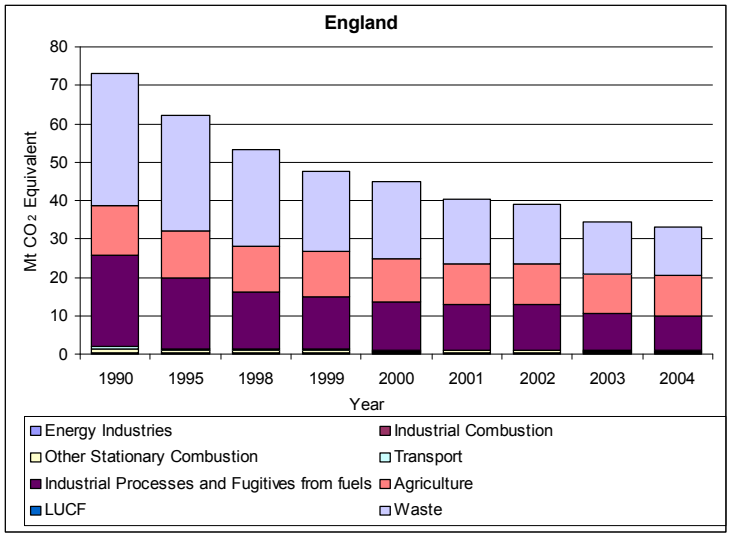
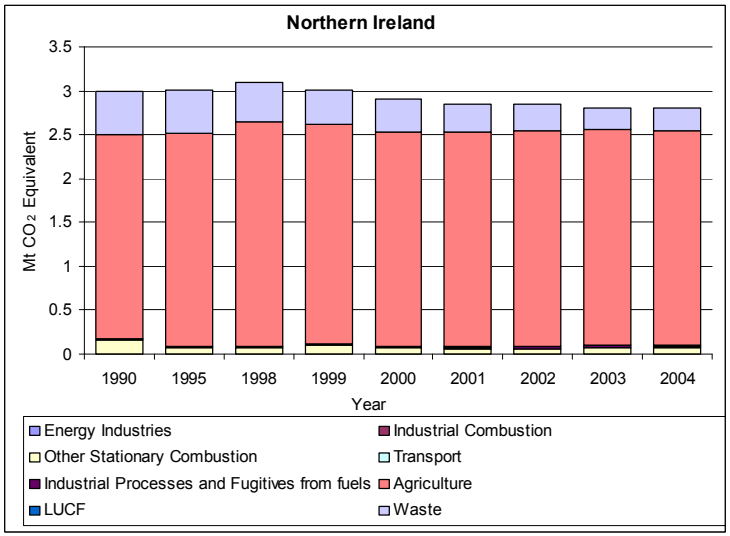
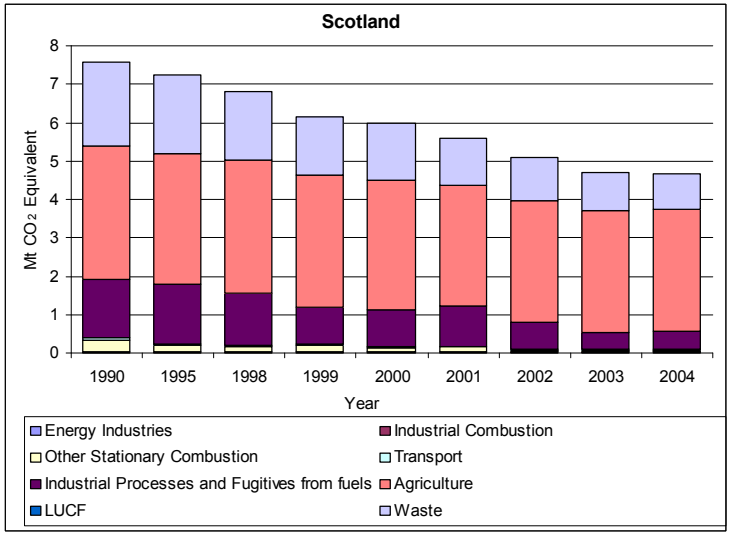


Figure 9.2 Emissions of Methane







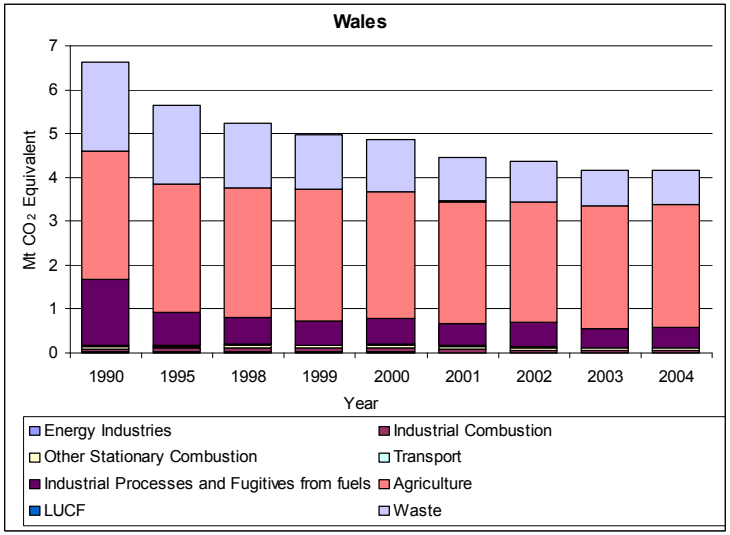
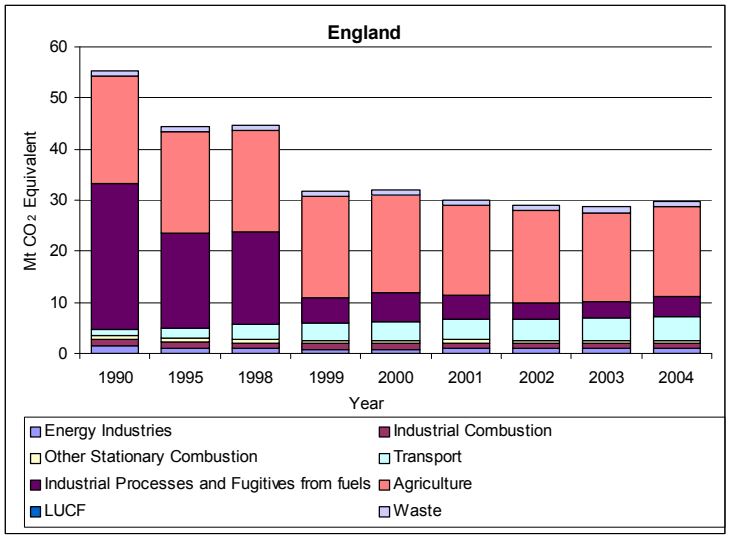
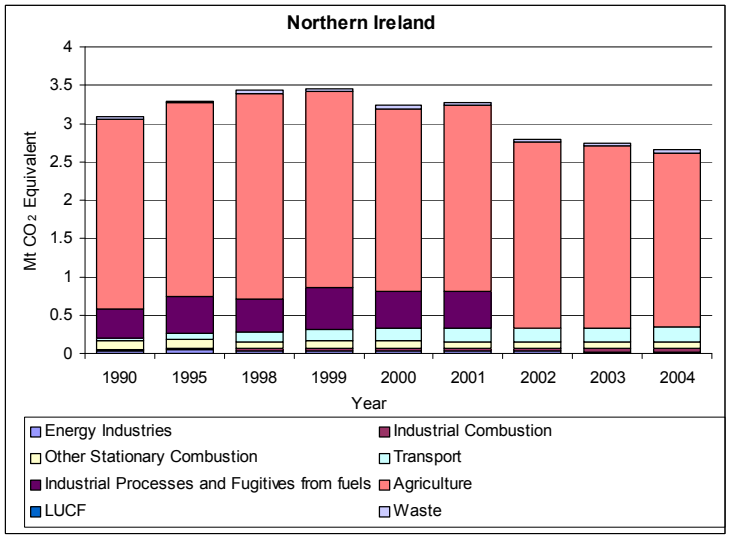
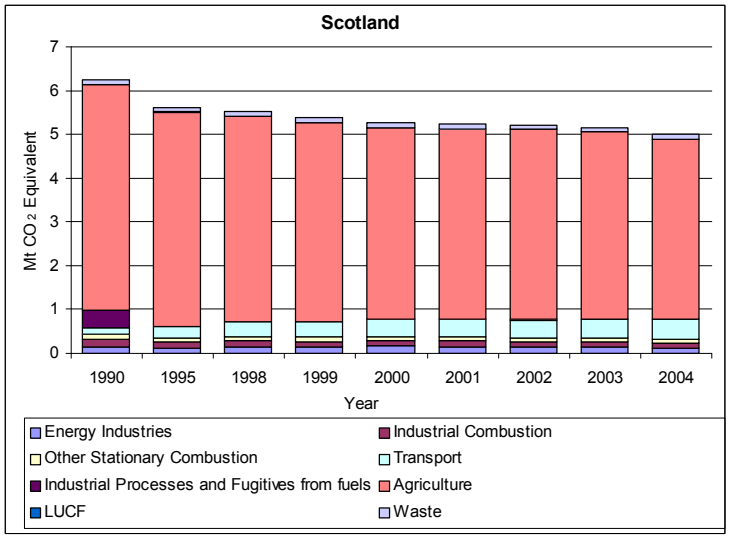


Figure 9.3 Emissions of Nitrous Oxide







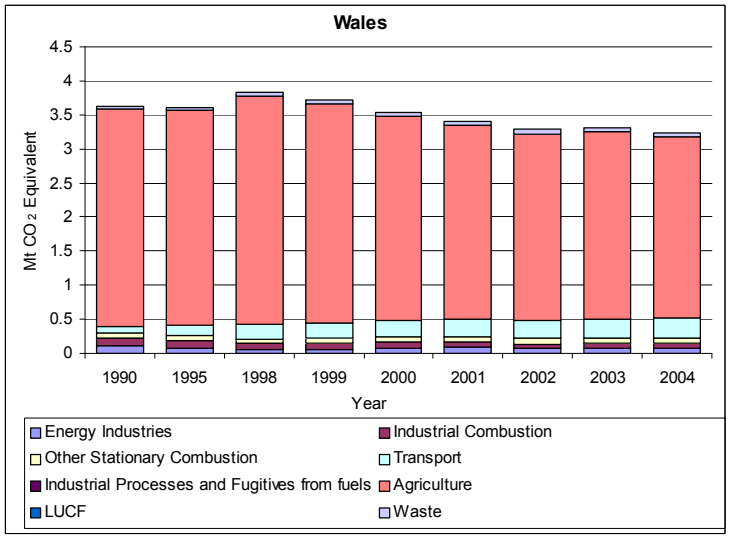
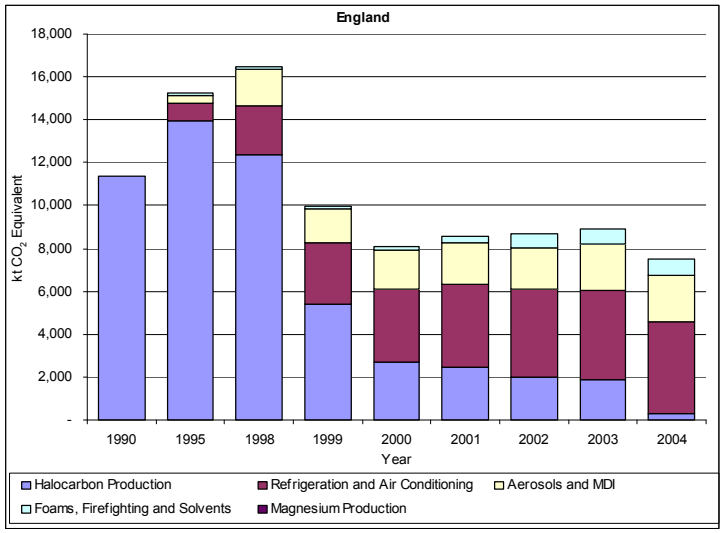
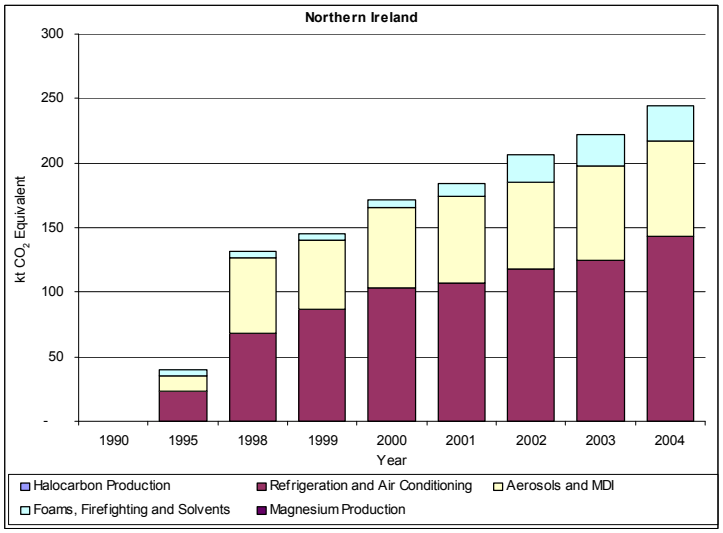
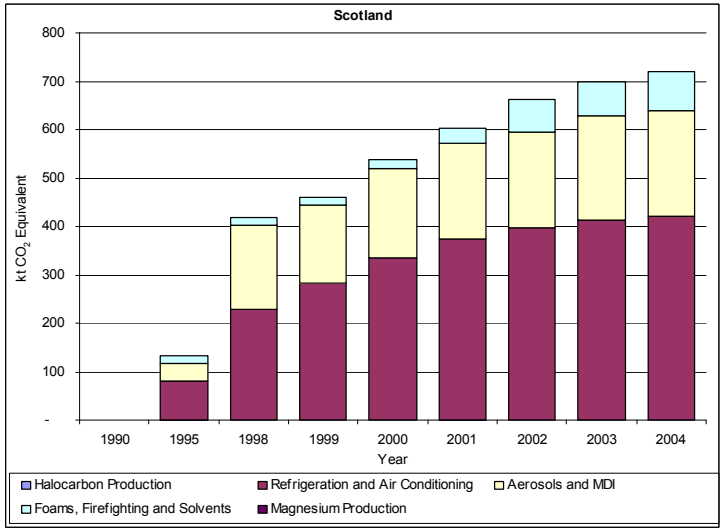


Figure 9.4 Emissions of HFCs







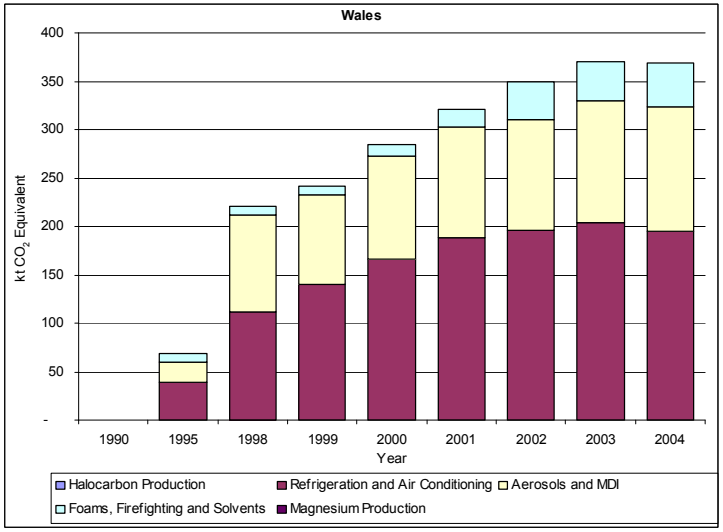
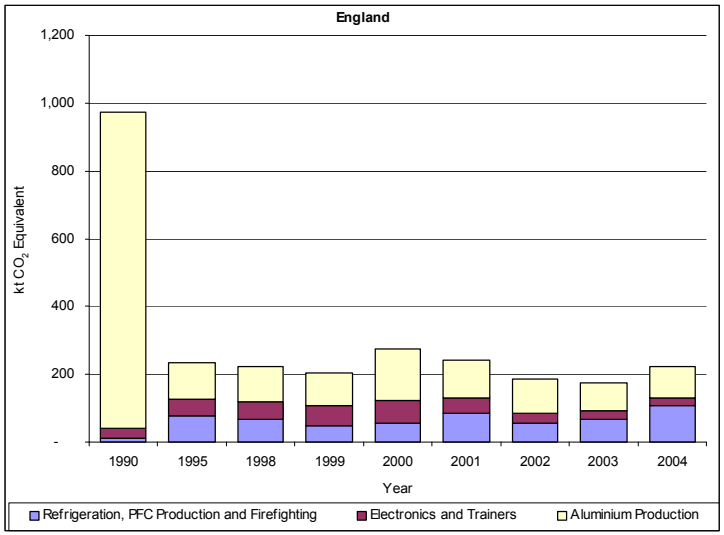
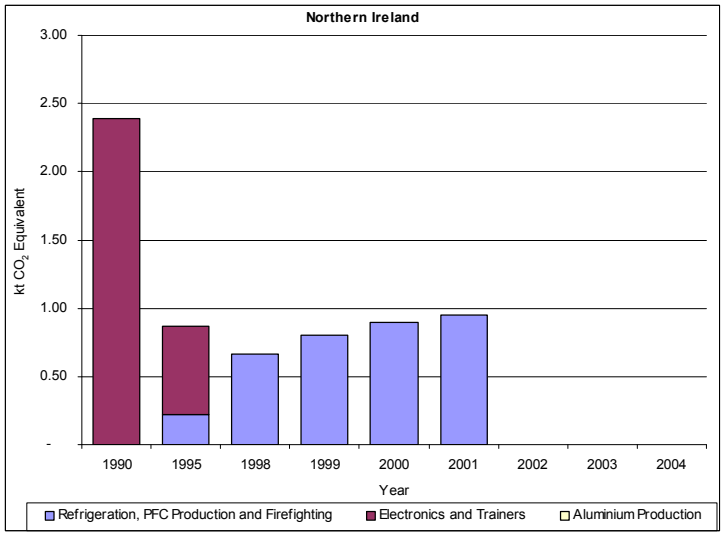
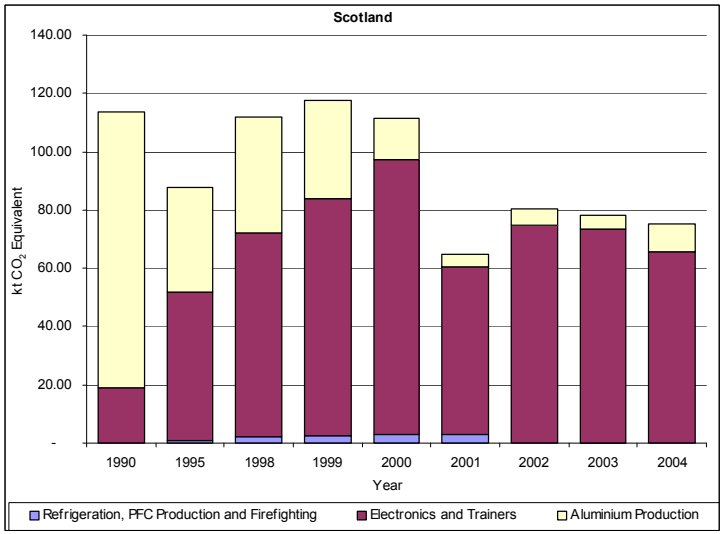


Figure 9.5 Emissions of PFCs







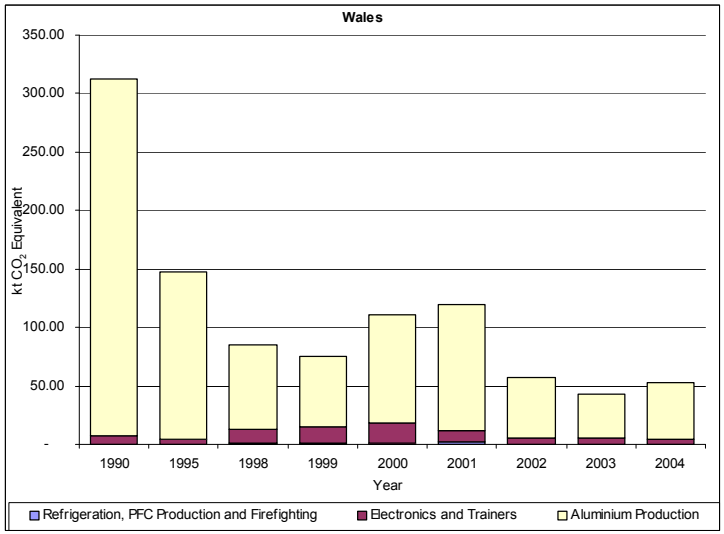
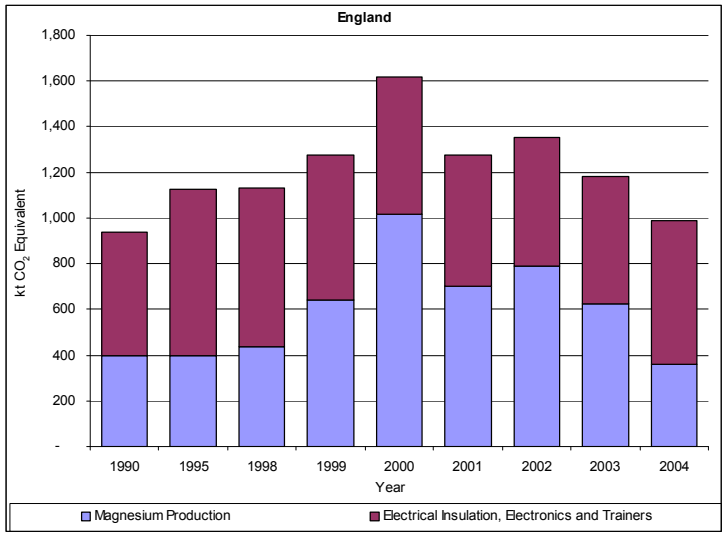
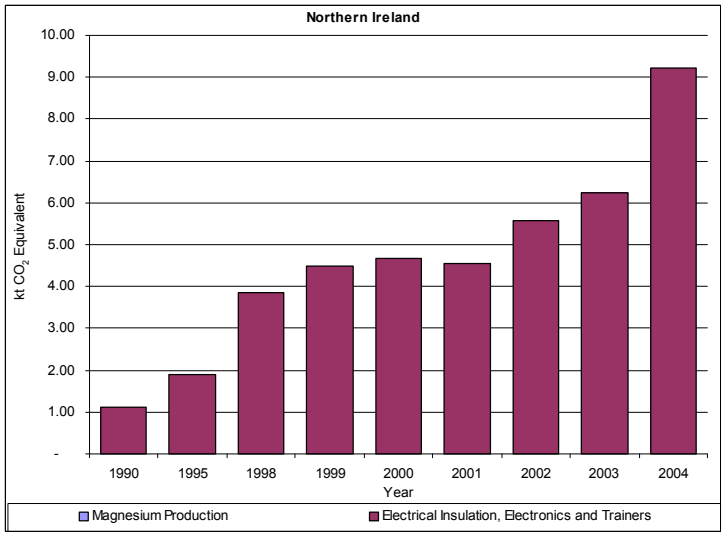
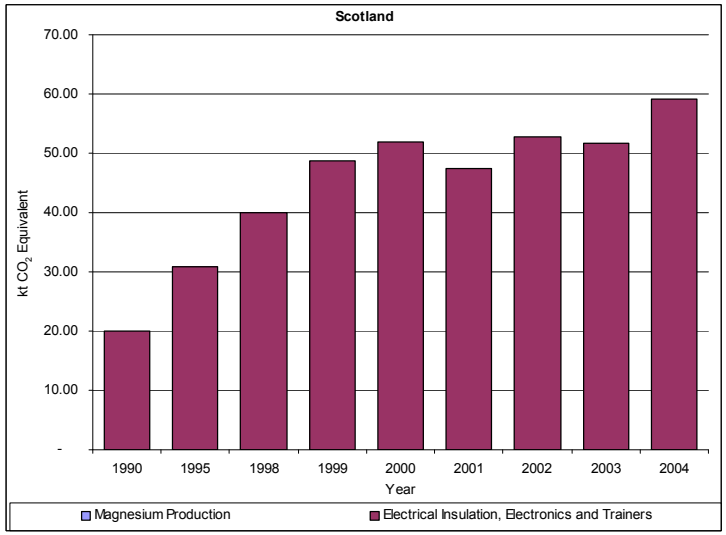
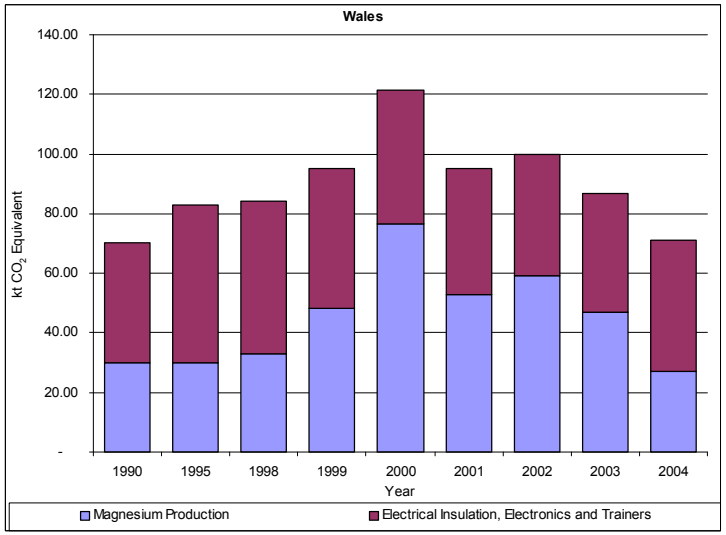


Figure 9.6 Emissions of SF_6









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Appendices

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