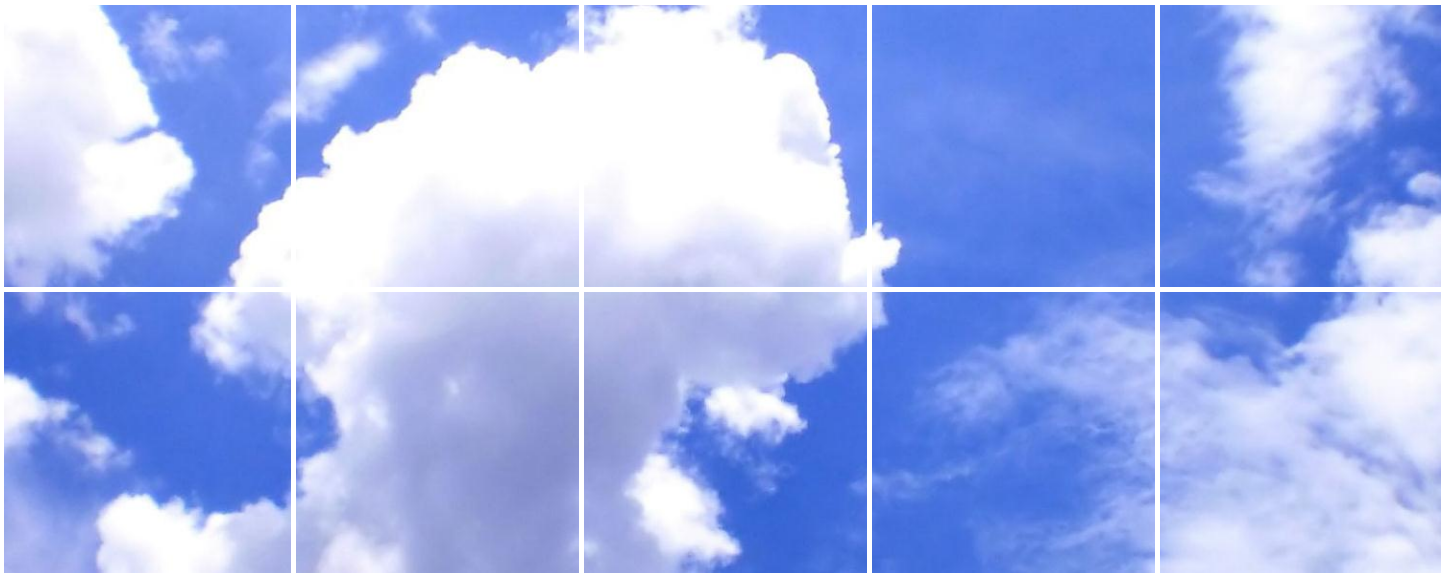
National Atmospheric Emissions Inventory



Appendices

Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 – 2012

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

June 2014

Aether RICARDO-AEA

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Appendix 1: Uncertainties in the UK and Devolved Administrations' GHG Inventory Estimates

A1.1 Introduction

The uncertainties in the UK Inventory are estimated using a Monte Carlo simulation. Eggleston *et al.* (1998) and Salway *et al.* (2001) describe this in detail. The method involves estimating the uncertainties in the activity data and the emission factors for all the emission source categories and then using a Monte Carlo simulation package to calculate the uncertainty in the emission totals.

In order to apply a similar approach to the Devolved Administrations' (DA) greenhouse gas (GHG) inventories, it is necessary to estimate uncertainties for the DA activity data (i.e. fuel consumption, production data). The same emission factors are used in the DA inventories as in the UK Inventory, so their uncertainties are known.

In the UK Inventory uncertainties in the activity data for fuel use are estimated on the basis of the statistical differences between fuel supply and demand data reported in the energy statistics. However, such data is not available for the DA-specific activity data used. Moreover, for some sources, no direct activity data is available at all, and it has been necessary to distribute the UK data using surrogate data (e.g. employment statistics). In such cases, it is impossible to say whether the surrogate statistics are an accurate indicator of fuel consumption.

A1.2 Uncertainty Estimation Methodology

The uncertainties in the DA GHG inventories are also estimated using a Monte Carlo simulation. In order to simplify the calculations, the source categories are broader than those used in the UK GHG Inventory simulation. In the DA inventory simulation, the combustion categories are effectively the total consumption of a particular fuel. This contrasts with the UK simulation where there is a further disaggregation into source categories (e.g. power stations, refineries). The rationale for this is that it is more practicable to estimate the uncertainty in the total consumption of a fuel in a region than to attempt to estimate uncertainties in diverse sectors where in some cases surrogates have been used.

For each of the broad source categories, an estimate of the activity uncertainty has been made for Scotland, Wales, Northern Ireland, and Unallocated emissions. The approach adopted was to estimate a factor to scale the UK uncertainty with, based on knowledge of the relative uncertainties of the DA estimates to each other, and to the UK total. Since the level of aggregation differs from the UK inventory, it is not possible to replicate the results from the UK model using the DA model, however efforts have been made to ensure that parameters are consistently applied across both models, where possible.

The factors used to weight the uncertainties for each of the DAs have been reviewed as part of the model update. The DA inventories have evolved since the uncertainty model was set up, and so some of the assumptions that were previously used are now no longer relevant. For example, different methods used to be used for fuel sales data in Northern Ireland and therefore the Northern Ireland estimate was assumed to be less uncertain than the other DAs. Now that the Department of Energy and Climate Change (DECC) sub-national energy statistics are used across all four DAs, this difference in uncertainty is no longer assumed.

It is important to note that the uncertainties in the inventories for the UK, England, Scotland, Wales, Northern Ireland, Unallocated are inter-dependent, because:-

UK Emissions = [England + Scotland + Wales + Northern Ireland + Unallocated]

Therefore uncertainties from the UK, Scotland, Wales, Northern Ireland, and Unallocated emissions are estimated using the model, and uncertainty in the English emissions are calculated.

In many of the non-combustion sources (e.g. industrial processes, coal mines) the overall uncertainty is dominated by the emission factor and the uncertainty in the activity data is not a determining factor. Therefore, there is unlikely to be any significant variation in uncertainties between DAs. In these cases, a low uncertainty for the activity data (say 1%) may be assumed for each DA, whilst the UK uncertainty for the emission factor is applied.

For sources where the UK total is made up as a sum of the DA totals, such as agriculture or Land Use, Land Use Change and Forestry (LULUCF), no additional uncertainty is introduced in the process of deriving the UK split, and therefore the UK uncertainty parameters are applied directly to the DA estimates.

In the case of halocarbons and sulphur hexafluoride (SF_6) emissions it is not considered feasible to attempt to assume varying uncertainties across the DAs. The fluorinated greenhouse gases (F-gas) uncertainties have been considered at a sector level. This means that the uncertainty for each sector emission at UK level has been applied to the DA estimates, so that the overall uncertainty for each of the F-gases reflects the mix of sources that are the most significant for each of the DAs, and their relative uncertainties.

A1.3 Trend Uncertainty Analysis

The DA uncertainty model has been extended to provide estimates of the uncertainty in the emissions trend. The model uses, where possible, the same principles as the UK uncertainty model, however, these estimates are currently indicative since it will take further improvement work to refine the estimates fully.

In order to estimate the uncertainty on the trend, it was necessary to make an estimate of the uncertainty in the base year (1990 for carbon dioxide, methane and nitrous oxide, and 1995 for the F-gases). This estimate is made for the UK Inventory, as part of the analysis presented in the National Inventory Report (Webb *et al*., 2014). Therefore, it was possible to make the DA uncertainty estimates using the method described above in conjunction with the UK estimates for the base year. The DA weighting factors were reviewed as part of this process, because changes to the source data and methods used across the time series mean that it is not always appropriate to apply the same weighting factor in the latest year as in the base year.

In addition to the estimation of the uncertainty in each year, it was also necessary to consider correlations between sources across years. The UK uncertainty model considers correlations in the estimates of:

- N_2O from agriculture;
- CH_4 from landfills;
- CH_4 from leakage from the gas distribution network; and
- N_2O from waste water treatment.

These correlations have been replicated in the DA model. The uncertainty in the trend is particularly sensitive to the correlation in emissions from agricultural soils.

A1.4 Uncertainty Analysis Results

As a result of the activity data gaps in the DA inventories, the estimates will be more uncertain than for the UK inventory. The difference in emissions coverage will also mean the uncertainties calculated for the UK in the DA inventory will be different than that for the UK in the UK inventory. Expert judgement has been used to assess the degree of additional uncertainty due to the use of proxy activity data, informed by the comparison of the new datasets such as the European Union Emissions Trading Scheme (EU ETS) and the DECC regional energy statistics with historic data. Overall data quality and sector allocations are improving, but for some source sectors, significant uncertainties remain, even at UK level.

For the 1990 – 2012 inventory, new analysis has been included for agricultural soils, provided by Rothamsted Research. The new analysis shows a much lower uncertainty than previously included for this source. This has been incorporated into the DA model.

The uncertainty estimates for the 1990-2012 DA GHG inventories are reported in Table A1.1. below. The table presents the central estimate from the Monte Carlo simulation for each GHG and for each DA, for the base year and the latest year and the estimated uncertainty on the total. In addition, the central estimate of the trend (expressed as the percentage change from the base year) is presented together with the 2.5 and 97.5 percentile estimates.

Table A1.1 Estimated Uncertainties in the DA GHG Inventories: Base Years, 2012 and Trend

	Base Year		Latest Year (2012)		Trend (Base Year to 2012)		
Gas (kt CO_2e)	Central Estimate	Uncertainty Introduced on total	Central Estimate	Uncertainty Introduced on total	Central Estimate	2.5 Percentile	97.5 Percentile
Scotland							
Carbon Dioxide CO_2	53,098	16%	37,469	15%	-29%	-41%	-15%
Methane CH_4	12,823	29%	6,799	23%	-46%	-61%	-29%
Nitrous Oxide N_2O	6,930	77%	5,052	82%	-27%	-33%	-22%
HFC	112	8%	1,134	6%	910%	827%	999%
PFC	87	17%	51	57%	-41%	-69%	-11%
SF_6	30	17%	35	22%	17%	-9%	45%
Total	73,080	15%	50,541	14%	-31%	-40%	-20%
Wales							
Carbon Dioxide CO_2	43,584	3%	37,583	4%	-14%	-17%	-10%
Methane CH_4	7,786	18%	4,503	17%	-42%	-53%	-30%
Nitrous Oxide N_2O	4,143	85%	3,136	85%	-24%	-29%	-19%
HFC	60	8%	565	6%	847%	769%	931%
PFC	147	5%	4	54%	-97%	-99%	-96%
SF_6	80	17%	34	14%	-57%	-64%	-49%
Total	55,800	7%	45,825	7%	-18%	-21%	-14%

Gas (kt CO_2e)	Base Year		Latest Year (2012)		Trend (Base Year to 2012)		
	Central Estimate	Uncertainty Introduced on total	Central Estimate	Uncertainty Introduced on total	Central Estimate	2.5 Percentile	97.5 Percentile
Northern Ireland							
Carbon Dioxide CO_2	16,703	9%	13,923	10%	-16%	-26%	-7%
Methane CH_4	4,354	18%	3,634	16%	-16%	-32%	2%
Nitrous Oxide N_2O	3,864	80%	3,055	90%	-22%	-29%	-16%
HFC	38	8%	365	6%	850%	772%	932%
PFC	1	20%	0	50%	-59%	-76%	-41%
SF_6	2	20%	3	16%	81%	45%	122%
Total	24,962	14%	20,981	15%	-16%	-23%	-9%
England							
Carbon Dioxide CO_2	463,397	3%	370,516	2%	-20%	-22%	-18%
Methane CH_4	77,390	24%	34,456	24%	-55%	-66%	-42%
Nitrous Oxide N_2O	54,324	52%	24,389	81%	-55%	-69%	-42%
HFC	15,111	9%	11,822	6%	-22%	-28%	-14%
PFC	227	7%	153	12%	-33%	-41%	-25%
SF_6	1,089	17%	470	14%	-57%	-64%	-48%
Total	611,539	6%	441,805	5%	-28%	-31%	-25%
Unallocated							
Carbon Dioxide CO_2	12,919	13%	13,038	8%	1%	-11%	15%
Methane CH_4	1,621	84%	1,097	31%	4%	-64%	96%
Nitrous oxide N_2O	259	104%	279	102%	35%	-63%	224%
HFC	-	N/A	-	N/A	N/A	N/A	N/A
PFC	-	N/A	-	N/A	N/A	N/A	N/A
SF_6	-	N/A	-	N/A	N/A	N/A	N/A
Total	14,799	15%	14,414	8%	-2%	-15%	12%
UK							
Carbon Dioxide CO_2	589,701	3%	472,529	2%	-20%	-22%	-18%
Methane CH_4	103,974	23%	50,489	21%	-51%	-62%	-38%
Nitrous Oxide N_2O	69,520	56%	35,911	82%	-49%	-62%	-37%
HFC	15,311	9%	13,871	6%	-9%	-17%	0%
PFC	461	7%	208	22%	-55%	-63%	-47%
SF_6	1,201	17%	542	14%	-55%	-62%	-46%
Total	780,168	6%	573,552	6%	-26%	-30%	-24%

Notes

1. Uncertainty is defined as $\pm$ 2×(standard deviation)/mean %, which closely approximates the 95% confidence interval.
2. Base years are 1990 for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O); 1995 for HFCs, PFCs and SF_6.
3. The uncertainty model takes emission estimates by gas for each source, applies an uncertainty distribution for that source and calculates a statistical mean, presented above as the central estimate. The emissions data in this table are taken from the Monte Carlo model output. The central estimates by gas for 1990 and the latest inventory year are very similar but not identical to the emission estimates in the DA inventories.
4.

A1.5 Sensitivity Analysis

The differing uncertainties between the DAs can largely be explained by the relative contribution of emission sources in each of the DAs. For example, where more uncertain sources are dominant, the resultant overall uncertainty calculated from the model will be more uncertain (and vice versa). Although the model is not yet able to produce a sectorally disaggregated output, a sensitivity analysis has been carried out by excluding certain high uncertainty sources (agricultural N_2O, LULUCF) to test the impact. A more detailed analysis has also been carried out on carbon in 2012.

Table A1.2 below shows the impact of removing LULUCF and Agricultural N_2O from the model, compared with the estimates including these emissions categories.

Table A 1.1 Sensitivity analysis, testing the impact of LULUCF and Agricultural N_2O

2012	United Kingdom	England	Scotland	Wales	Northern Ireland	Unallocated
Uncertainty on total emissions	6%	5%	14%	7%	15%	8%
Total excluding LULUCF	5%	5%	11%	7%	14%	8%
Total excluding Agriculture N_2O	3%	3%	13%	4%	9%	8%
1990	United Kingdom	England	Scotland	Wales	Northern Ireland	Unallocated
Uncertainty on total emissions	6%	6%	15%	7%	14%	15%
Total excluding LULUCF	6%	6%	14%	7%	14%	15%
Total excluding Agriculture N_2O	4%	5%	14%	4%	8%	15%

The analysis shows that removing N_2O from agriculture has an impact on all of the DAs, but this is most notable for Northern Ireland. This is because this emission source accounts for 13% of total emissions, compared with 5% for the UK as a whole in both the base year and the latest inventory year. Removing this source from the model implies that the remainder of the inventory for Northern Ireland is less uncertain than indicated by the overall analysis shown above. Unallocated emissions are not affected, since no LULUCF or agriculture emissions are unallocated within the inventory.

Scotland is affected the most by the removal of LULUCF emissions and removals, since this sector has a greater impact on Scotland's inventory than the other DAs. However, the impact of the removal of N_2O from agriculture is low, despite this source contributing a significant proportion to emissions from Scotland (8% in both 1990 and the base year).

It can be noted that Scottish CO_2 emissions are more uncertain than other DAs; the high uncertainty in CO_2 emissions has a greater impact on the total uncertainty than the uncertainty in N_2O emissions since CO_2 accounts for a much greater proportion of total emissions. A detailed analysis has been carried out to test what is causing the high uncertainty in Scottish CO_2 emissions, by removing one uncertainty category at a time from the analysis. This exercise found that whilst there was no single source category dominating the uncertainties, by removing emissions from OPG use and LULUCF from the model, the total uncertainty for CO_2 was lower. The analysis was then re-run to test the impact of removing both of these categories, and the impact of this was to reduce the uncertainties from 15% to 7% in 2012. Uncertainties from OPG use are high because the inventory is not constrained to the DUKES total and therefore there is no final check to ensure all use of this fuel is included.

Appendix 2: Devolved Administrations' GHG Inventory Compilation Methods and Data Sources

This appendix describes the methodology used to derive the by source Devolved Administrations' (DA) greenhouse gas (GHG) emission estimates for each source.

A2.1 Introduction

The UK Greenhouse Gas Inventory compiles national estimates of greenhouse gas emissions for submission to the UN Framework Convention on Climate Change under the requirements of the Kyoto Protocol. The most recent version of the inventory, published in April 2014, presents UK greenhouse gas emission estimates for the period 1990 to 2012 (Webb *et al*, 2014).

This report presents separate inventories of greenhouse gas emissions for England, Scotland, Wales and Northern Ireland for the years 1990, 1995 and 1998 to 2012 that are consistent with the 1990 to 2012 UK Greenhouse Gas Inventory.

The six direct greenhouse gases are considered:

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

By Source inventories allocate GHG emissions in the country that they are emitted, regardless of the end use of any fuel output or product that creates the demand for the emitting activity. The by source estimates for each DA include emissions from fuel combustion (Energy), industrial processes, agricultural practices (Agriculture), Land Use, Land Use Change and Forestry (LULUCF) and waste disposal (Waste). National totals for DAs exclude emissions from international aviation and shipping (which are presented as memo items) and of carbon dioxide from the burning of biofuels (which are considered to be renewable fuels from recently sequestered carbon). In addition, emissions of GHGs from offshore oil and gas exploration and production are classified within this report as "Unallocated" emissions and not attributed to any of the DAs.

A2.2 Reporting Format

The DA GHG inventories are presented in National Communication reporting format, in order that emissions align with policy analysis requirements of the DA Governments. Within the discussion of inventory compilation methodology, source data and trends, the IPCC sector nomenclature is used, as this enables information to be presented at a much greater level of detail, aligned with specific emission sources. The mapping between National Communication and IPCC sector format reporting is summarised in the table in Appendix 5.

The UK Inventory also reports emissions from international marine and aviation bunkers separately, as memo items to the main UK inventory dataset, in line with the reporting requirements of the United Nations Framework Convention on Climate Change (UNFCCC). DA emission estimates for these international transport sources are not included within the DA totals in this report, but are available within the supporting spreadsheet tables; the estimation methodology is described in the Transport section of this Appendix.

A2.3 General Approach

The UK Inventory is based on UK statistics for activities producing greenhouse gas emissions. These include fuel consumption, industrial production, agriculture, land use change and forestry and waste. In principle, it would be ideal to obtain a complete set of equivalent statistics for each constituent country to compile each inventory.

Such a set of statistics is not available for all sources and for all constituent countries and hence it is necessary to disaggregate UK emissions into the four constituent countries by an estimation procedure.

For most sources in the UK Inventory, the emission of a pollutant from a source is calculated from the general equation:

$$E = Ae \qquad \text{[Equation 1]}$$

where

E = Emission of pollutant (tonnes)
A = Activity (unit activity)
e = Emission Factor (tonnes pollutant/unit activity)

The activity unit may be fuel combustion (tonnes), or production of product (tonnes) or numbers of animals. A modified equation is used in the compilation of the Devolved Administration GHG inventories:

$$E_i = \frac{d_i Ae}{\sum_{j=1}^{5} d_j}$$

[Equation 2]

where

E_i = Emission (in tonnes) from either England (1),Scotland (2), Wales (3), Northern Ireland (4) or "Unallocated" (5)

d_i = A driver representing the contribution of the region to UK emissions

i = 1, 2, 3, 4, 5

The driver, d_i can be any one of:

1. The value of the activity data for the region. [For example, consumption of specific fuels or industrial production figures for the region.];
2. The fraction of the UK activity in the region;
3. The value of a surrogate activity data statistic in the region. Where the required activity is unavailable on a regional basis, a surrogate value may be used. [For example, employment statistics or manufacturing output of a specific product, used as a surrogate for consumption data of a given fuel.]; and
4. In cases where the emissions are derived from a complex model, the driver will be the actual emission for the region calculated from the model.

The modified equation [2] ensures that the sum of the emissions from England, Scotland, Wales and Northern Ireland, plus any "unallocated" (i.e. offshore) emissions, equals the total UK emission reported within the national inventory.

Where the driver is fuel consumption, then the sum of the drivers should add up to the UK consumption. However, in practice this may not be the case if the data are taken from different sources or may be based on the financial rather than the calendar year. The estimation procedure removes such discrepancies.

Thus the compilation of the greenhouse gas inventories for the constituent countries of the UK reduces to the estimation of a set of drivers, each appropriate to emissions from a specific source. In compiling the 1990-2012 inventories, over 230 drivers have been calculated.

Subsequent sections discuss the estimation of the drivers for each source category. Most of the detailed discussion is concentrated on the more complex categories, whilst simpler sources are summarised in Tables A2.1 to A2.10. The IPCC classification is used throughout (IPCC, 1997), and the following section provides a description of the abbreviations used throughout the Appendix 2 discussion.

A2.3.1 Summary of Abbreviations

AEAT	AEA Technology plc (now Ricardo-AEA)
BCA	British Cement Association
BERR	Department for Business Enterprise & Regulatory Reform
BGlass	British Glass
CA	Coal Authority
CAA	Civil Aviation Authority
DAs	Devolved Administrations
DARD	Department of Agriculture and Rural Development (Northern Ireland)
DTI	Department of Trade and Industry (now DECC)
DfT	Department for Transport
DECC	Department for Energy and Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
DETI	Department of Enterprise, Trade and Investment (Northern Ireland)
DETR	Department of Environment, Transport & the Regions
DFPNI	Department of Finance and Personnel, Northern Ireland
DLTR	Department for Local Government, Transport and the Regions
E	England
EA	The Environment Agency of England & Wales
EAF	Electric Arc Furnace
EM	Enviros March
EPER	European Pollutant Emissions Register
EUETS	EU Emission Trading Scheme
IPCC	Intergovernmental Panel on Climate Change
ISR	Inventory of Statutory Releases (NI DoE)
ISSB	Iron and Steel Statistics Bureau
LPG	Liquefied petroleum gas
LRC	London Research Centre
MAFF	Ministry of Agriculture, Fisheries and Food (now DEFRA)
MPA	Mineral Products Association
MSW	Municipal Solid Waste
NA	Not Available
NAEI	National Atmospheric Emissions Inventory
NI DoE	Northern Ireland Department of Environment
NIEA	Northern Ireland Environment Agency
NIO	Northern Ireland Office
NO	Not occurring
OFMDFM	Office of the First Minister and the Deputy First Minister (Northern Ireland)
ONS	Office for National Statistics
OPG	Other petroleum gas
PI	Pollution Inventory of the Environment Agency of England & Wales
S	Scotland
SEPA	The Scottish Environment Protection Agency
SPRI	Scottish Pollution Release Inventory
SSF	Solid smokeless fuel
UKOOA	UK Offshore Operators Association, now called “Oil & Gas UK”
UKPIA	United Kingdom Petroleum Industry Association
WO	Welsh Office
WS	Welsh Statistics

A2.4 Energy Industries

The drivers used for the energy industries are summarised in Table A2.2. This shows the base sources used in the National Atmospheric Emissions Inventory (NAEI) database, which correspond to the IPCC sources. The activity data used in the UK Inventory are shown together with the drivers used in the inventories for the constituent countries for 1990, 1995 and 1998 to 2012. The derivation of drivers sometimes differs between years depending on data availability.

A2.4.1 Electricity Production

Emissions are based on fuel consumption data provided by the major power generators in Great Britain and the Northern Ireland Office for 1990 to 1999: Scottish Power (2004), Scottish and Southern Energy (2004), Innogy (2004), PowerTech (2004), AES Drax (2004). From 2000 onwards, emissions data from the Pollution Inventory (Environment Agency, 2013a) the Scottish Pollution Release Inventory (SEPA, 2013a) and the Inventory of Statutory Releases (Northern Ireland Environment Agency, 2013a) has been used to estimate DA emissions. For emissions in 2005 onwards, fuel use and emissions data reported within the EUETS (Environment Agency, 2013b; SEPA, 2013b; Northern Ireland Environment Agency, 2013b) have been used to revise and update the annual fuel emission factors that are applied within the UK GHGI, and the DA GHGI. The emissions data reported via the EUETS are used to estimate DA share of UK emissions, whilst maintaining the emission totals consistent with the UK GHGI data. Country-specific electricity generation data (DECC, 2013b) are then used as a comparator against reported emissions, as a quality check for the power station emissions data.

Emissions from plant generating electricity from municipal solid waste combustion are less certain for pre-1999, but all the plant are known to be in England for 1990-98 and so the emissions will correspond to the UK emissions. Since 1999, two plants have been commissioned in Scotland, at Lerwick and Dundee and emissions estimations are based on emissions data reported to SEPA.

A small number of plants generate heat rather than electricity. Some of these generating plants burn poultry litter, or meat and bone meal, and these are all located in England. The distribution of landfill gas and sewage gas generation is assumed to correspond to the distribution of landfill sites and sewage treatment plant.

Table A2.2a: Energy Industries (Base Year – 1990)

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
Electricity Production	Power Stations	Coal, oil, natural gas	Consumption data from Power Generators
		Unrefined natural gas	NO
		Sewage gas	Sewage methane recovered
		Landfill gas	As landfill methane
		Orimulsion, MSW, poultry litter and tyres	All plant in England
Petroleum Refining	Refineries	All fuels	UKPIA CO_2 emission estimates for pre-1997
Manufacture of Solid Fuels	Coke Production	Colliery Methane	All such plant assumed to be in England
		Coke Oven gas, natural gas	Coal feed to coke ovens, ISSB, WS, DTI
		Coke	Coke breeze consumption, ISSB
		Blast Furnace gas	Coke consumed in blast furnaces, ISSB
	SSF Production	All fuels	Coal feed to SSF plant, DTI, WS
Other Energy Industries	Collieries	All other fuels	Deep mined coal production, data from British Coal Authority
		Coke oven gas	All such plant assumed to be in England
	Gas Production	Colliery methane	Deep mined coal production, data from British Coal Authority
		LPG and Natural gas	DA share of aggregate data from EUETS installations for natural gas use from 2005
	Upstream oil and gas / Gas Separation Plant	Unrefined natural gas, LPG, OPG	Estimates for terminals extrapolated from operator estimates within EEMS data in 1998
	Nuclear	Natural gas	All plant in England

Table A2.2b: Energy Industries (1995; 1998 to 2012)

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
Electricity Production	Power Stations	Coal, oil, natural gas	Emissions data and fuel consumption data from Power Generators; PI, EPER & ISR data from 2000 onwards; EUETS data from 2005 onwards.
		Unrefined natural gas	Some power facilities have used this fuel since 1995. Data provided by plant operators.
		Sewage gas	Sewage methane recovered
		Landfill gas	As landfill methane
		Orimulsion, MSW, poultry litter	From 1999, some MSW plant now also in Scotland.
Petroleum Refining	Refineries	All fuels	UKPIA CO_2 emission estimates for pre-1997. Pollution Inventory CO_2 emission estimates for 1998. UKPIA data for 1999 onwards. EUETS data from 2008 onwards. Deviations from DUKES fuel use allocations have been made for petroleum coke and Other Petroleum Gases (OPG), using EUETS activity data instead.
Manufacture of Solid Fuels	Coke Production	Colliery Methane	All such plant assumed to be in England.
		Coke oven gas	Coal feed to coke ovens, ISSB, WS, DTI and (since 1999) PI data. 2005 onwards: EUETS, CCA and PI data analysis
		Natural gas	Coal feed to coke ovens, ISSB, WS, DTI and (since 1999) PI data
		Coke	Coke breeze consumption, ISSB.
		Blast Furnace gas	Coke Consumed in Blast Furnaces, ISSB. 2005 onwards: EUETS, CCA and PI data analysis
	SSF Production	All fuels	Coal feed to SSF plant, DECC, WS.
Other Energy Industries	Collieries	All other fuels	Deep mined coal production, data from British Coal Authority.
		Coke oven gas	(1995 – current) No such plant operating.
	Gas Production	Colliery methane	Deep mined coal production, data from British Coal Authority.
		LPG and Natural gas	EUETS installation data for natural gas use from 2005 onwards. All other years estimated based on the aggregate DA share from the 2005 EUETS data.
	Upstream oil and gas	Unrefined natural gas, LPG, OPG	(1995 – current) Oil & Gas UK EEMS CO_2 estimates for terminals, DECC activity data. EUETS data for terminals.
	Nuclear	Natural gas	(1995 – current) Data not available.

A2.4.2 Petroleum Refining

UKPIA have provided a site-by-site breakdown of UK refining emissions for 1997 and 1999 – 2012 (UKPIA, 2013), presenting the emissions of a range of pollutants from combustion, process and fugitive sources. In addition, UKPIA have advised that refinery throughput did not vary significantly between 1990 and 1997. The EUETS data also provides (from 2008 onwards) a comprehensive scope of refinery emissions broken down by process and fuel, and these data are used to derive emission factors for fuel oil, natural gas and other petroleum gases (OPG) use in refineries within the UK and DA GHG inventories.

In the 1990-2012 GHG inventory, the activity data reported in the EUETS (EA, 2013b) for petroleum coke and other petroleum gases (OPG) use in refineries has been used in preference to activity data reported in DUKES. Emissions for 1998 are based on carbon dioxide emissions reported in the Pollution Inventory (EA: 1999a).

A2.4.3 Manufacture of Solid Fuels

This category comprises the production of coke and solid smokeless fuel (SSF). Country-specific data on coke ovens in the iron and steel industry are reported in detail by ISSB (2013), and emissions data for integrated steel works are reported via the PI and EUETS (Environment Agency, 2013b). Two coke ovens in England and Wales are not attached to an integrated iron and steel facility, and the consumption of coal by these ovens is estimated from WO (1998) and UK data (DECC: 1991, 2000-2013). The Welsh statistics are only available to 1993, so these data are used as an estimate of the Welsh non-iron and steel coking coal consumption in 1995. For 1998 to 2012, the non-iron and steel coking coal consumption data is apportioned between England and Wales using carbon dioxide emissions for the particular sites reported in the Pollution Inventory (EA: 2013a) and EUETS (EA: 2013b).

The generic driver for coke oven fuel consumption is the regional consumption of coking coal (ISSB, 2013). This driver is also used for natural gas consumption through the time series and coke oven gas consumption until 2004, and from 2005 data on coke oven gas emissions from the EUETS are used (EA, 2013b). Some coke ovens use blast furnace gas as fuel and the availability depends on blast furnace gas capacity (see Industrial Processes); emissions from blast furnace gas use are apportioned across DAs using regional data on coke consumption in blast furnaces (ISSB, 2013) until 2004 and from 2005 data on BFG emissions from the EUETS (EA, 2013b).Small amounts of colliery methane are consumed in the manufacture of solid fuels and this was judged to occur entirely in England where coking occurs in close proximity to deep mining. Small amounts of coke breeze are also used, and this has been disaggregated using data on other coke consumption from ISSB.

The estimation of emissions from SSF production is rather uncertain, as limited fuel use data are available from processes across the UK. Moreover, many of these are the new briquetting processes rather than coking processes and produce negligible emissions. For SSF plant operating in England and Wales, it is possible to estimate regional consumption using UK data (DECC, 2013a) and Welsh data (WO, 1998). Welsh data for 1995 has been estimated, whilst all SSF coking plant still operating since 1998 are known to be in England. Thus the driver used is coal consumed by SSF plant.

A2.4.4 Other Energy Industries

This category consists of a number of small emissions from collieries, the gas industry, the nuclear fuel industry and emissions from the upstream oil and gas exploration and production sector which comprises offshore rigs and vessels as well as onshore terminals. In the DA inventories, emissions from oil and gas terminals and offshore rigs and vessels are based on data provided by DECC (2013e). Installation-specific data are only available for post-1995, and until 1998 these data are incomplete and inconsistent across the time series, so are disregarded. Emissions for 1990 are extrapolated based on 1998 operator-reported data; previous use of data from the mid-1990s has now been dis-regarded, due to new research in the UK GHGI to address outlier implied emission factors for combustion and flaring of gaseous fuels. Emissions from gas separation plant are from combustion of process off-gases (mainly ethane) in terminals, which are reported by facility operators within emission estimates under EEMS (DECC 2013e); the emission factor for these emissions has been revised to reflect that the “OPG” in these terminals is predominantly ethane rather than the mixture of gases derived from refineries that is also known as “OPG”. Data on LPG and OPG use at oil and gas terminals is reported within EUETS (SEPA 2013b and EA 2013b) and these data are used to directly inform the DA GHGI estimates from 2005 onwards, with the DA split for earlier years is extrapolated back from EUETS data.

Emissions from gas combustion at installations linked to the gas supply network comprise activities at compressor stations, LNG terminals and other above ground installations. The UK GHGI estimates were previously based on the sector natural gas allocation in DUKES. However, a large number of the larger sites (compressor sites, LNG terminals) report their fuel use and emissions to the EUETS. Since 2008, the reported fuel use and emissions from these large sites in EUETS exceeds that reported within DUKES and the UK GHGI, indicating that there is a small gas mis-allocation within DUKES. Therefore in the 1990-2012 UK GHGI, the gas use data from EUETS have been used to

estimate the UK sector emissions, and the DA split has been derived directly from the data in EUETS (EA 2013b, SEPA 2013b); to retain the overall natural gas use energy balance for the UK, an equal and opposite reduction in gas use in "unclassified industry" (which is reported within IPCC 1A2f) was applied. The EUETS data are used for each year from 2005 onwards. For 1990-2004, the DA share of the gas use is estimated based on the 2005 EUETS totals. These estimates are uncertain: the UK data are an under-report; the EUETS data only cover the larger sites on the network and may not be representative of the overall DA split of activity; the 1990-2004 data are extrapolated from more recent data, assuming that the DA trends follow the UK-wide trend.

Other sources are minor and are covered in Table A2.2.

A2.5 Manufacturing Industries and Construction

The drivers used to estimate DA-specific fuel consumption from these sectors are summarised in Table A2.3.

A2.5.1 Iron and Steel

The ISSB (2013) provides annual report of detailed regional consumption of fuel by the steel industry and these data are used to inform regional iron and steel sector consumption of fuels such as natural gas which is used across many of the smaller production sites in the UK. Access to the detailed data for the steel sector from the Climate Change Agreement reporting system (Personal Communication: Hodges, 2013), has provided clarifications on fuel use and site allocations within the Ricardo-AEA point source dataset, to complement the EUETS dataset (EA, 2013b) which provides details for the highest-emitting sources in the iron and steel sector including the integrated steelworks. In addition, consultation with Tata Steel (Personal Communication: Mick Briggs and Bob Lewis, 2013) and the ISSB (Personal Communication: Donna Leach and Sophie Fatoba, 2013) during 2013 has led to a series of revisions to the activity data, fuel compositional data used in the mass balance method used in the UK GHGI, and the resolution of emissions data across different units within each of the UK integrated steelworks. This research was part of a UK inventory improvement programme research task commissioned by DECC[1] (Ricardo-AEA, 2014).

Energy use and emissions data for the integrated steelworks has been used to derive the DA estimates from 2005 onwards for the combustion of coke, blast furnace gas and coke oven gas in blast furnaces, sinter plant, iron and steel combustion plant and in iron and steel flaring sources. Prior to 2005, the ISSB regional energy statistics are used for those sources and fuels.

The consumption of coke by sinter plant is estimated as the non-blast furnace coke consumption (as this is the main other use of coke). The consumption of coke oven gas is distributed as proportional to ISSB regional figures for coal feed to coke ovens, whilst the consumption of blast furnace gas is distributed as proportional to ISSB regional figures for coke feed to blast furnaces. The production of these gases is estimated to be proportional to the fuel used as feedstock.

The ISSB reports the general consumption of coal, fuel oil, gas oil, LPG and natural gas by the primary iron and steel industry. This is a narrower definition than that used by DECC, which includes foundries and finishing plant, and therefore the DECC data used in the UK GHGI is higher than the ISSB data. Nevertheless, the regional ISSB data is used as a surrogate, since the distribution of the wider steel industry is directly linked to that of the primary industry, and the emissions from the secondary plant are considerably lower than the primary plant.

A2.5.2 Other Industry

DECC sub-national energy use data (DECC, 2013b), are based on local electricity and gas consumption patterns, as part of a project to develop Local Authority carbon dioxide emissions data. These statistics use local electricity and gas use data from the National Grid and the gas supply network operators (formerly Transco). Solid and liquid fuel use is calculated using point source consumption data (for major industrial sites), and a complex modelling process to distribute remaining UK fuel allocations that uses employment and population data, and takes account of smoke control zones and the patterns of gas and electricity consumption.

[1] GHG Inventory Research: Use of EUETS Data - Iron and Steel Sector: Review of UK data on emissions of GHGs from the Iron and Steel sector to utilise EUETS data in the national inventory

Table A2.3a: Manufacturing Industry and Construction (Base Year – 1990)

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
Iron & Steel	Sinter Plant	Coke-breeze	Other coke consumption, ISSB
	Iron & Steel	Blast furnace gas	Coke consumed in blast furnaces, ISSB, WO
		Coke oven gas	Coal feed to coke ovens, ISSB, WS
		Coke	Coke consumed in blast furnaces, ISSB, WO
		Other fuels	Regional fuel use data (ISSB): fuel oil, gas oil, LPG, coal, natural gas.
Other Industrial combustion	Non-ferrous metals	All fuels	Emissions analysis for 2012: Pollution Inventory (EA, SEPA, NIEA 2013a), EUETS (EA, SEPA, NIEA 2013b) IDBR and employment data (ONS, 2012). Overall analysis of the 1A2b,c,d,e and f sectors used to constrain the DA totals to previous 1A2 DA estimates, using 1A2f Other Industry as residual.
	Food and drink	All fuels	
	Paper and Pulp	All fuels	
	Chemicals	All fuels (except OPG)	
	Chemicals	OPG	Petrochemical plant capacity, emissions per unit capacity on site-specific data from PI/SPRI data, applying UK average to Welsh estimates.
	Other Industry	All oils	Sub-national oil consumption, DECC
		LPG	Sub-national energy statistics, DECC
		Lubricants	Sub-national energy data, DECC, less estimate of road transport use.
		Natural gas	Natural gas consumed, data from Transco
		Colliery Methane	Deep mined coal production, British Coal Authority
		Coal, coke	Sub-national energy statistics, DECC
		Coke oven gas	Coal feed to coke ovens, ISSB, WO, WS
		SSF	Sub-national energy statistics, DECC
		Wood	GDP data.
	Cement	Coal, oil, gas, petrocoke, tyres, waste oil	Regional cement capacity, BCA
	Ammonia (combustion)	Natural Gas	All such plant are located in England
	Autogenerators	Coal	All such plant are located in England
		Natural gas	(Data sources exactly as per “Other Industry” above)
	Other-Industry: Off-road	Gas oil, petrol	Industrial employment data (ONS)

Table A2.3b: Manufacturing Industry and Construction (1995; 1998 to 2012)

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
Iron & Steel	Sinter Plant	Coke-breeze	To 2004: Other coke consumption, ISSB. 2005 onwards: EUETS data supplemented by information from Tata Steel (2013)
	Iron & Steel	Blast furnace gas	To 2004: Coke use in blast furnaces, ISSB, WO. 2005 onwards: EUETS data supplemented by information from Tata Steel (2013)
		Coke oven gas	To 2004: Coal feed to coke ovens, ISSB, WS. 2005 onwards: EUETS data supplemented by information from Tata Steel (2013)
		Coke	To 2004: Coke use in blast furnaces, ISSB, WO. 2005 onwards: EUETS data supplemented by information from Tata Steel (2013)
		Other fuels	Regional fuel use data (ISSB): fuel oil, gas oil, LPG, coal, natural gas supplemented by information from Tata Steel (2013)
Other Industrial combustion	Non-ferrous metals	All fuels	Emissions analysis for 2012: Pollution Inventory (EA, SEPA, NIEA 2013a), EUETS (EA, SEPA, NIEA 2013b) IDBR and employment data (ONS, 2012). Overall analysis of the 1A2b,c,d,e and f sectors used to constrain the DA totals to previous 1A2 DA estimates, using 1A2f Other Industry as residual.
	Food and drink	All fuels	
	Paper and Pulp	All fuels	
	Chemicals	All fuels (except OPG)	
	Chemicals	OPG	Petrochemical plant emissions from PI/SPRI and EUETS. DECC data on Natural Gas Liquid deliveries used to interpolate where no emissions data.
	Other Industry	All oils	Sub-national oil consumption, DECC
		LPG	Sub-national energy statistics, DECC
		Lubricants	Sub-national energy data, DECC, less estimate of road transport use.
		Natural gas	Natural gas consumed, data from Transco (now UK National Grid) & (since 1995) from Phoenix Gas (NI). Sub-national energy statistics (DECC) and Ricardo-AEA point source data, analysed to minimise double-counting.
		Colliery Methane	Deep mined coal production, British Coal Authority
		Coal, coke	Sub-national energy statistics, DECC; Coal consumption, WO, NIO
		Coke oven gas	Coal feed to coke ovens, ISSB, WO, WS
		SSF	Sub-national energy statistics, DECC
		Wood	GDP data.
	Cement	All fuels	Regional cement capacity, BCA; For 2002 onwards, based on emissions reported to the EUETS, PI, SPRI and ISR (EA, NIEA and SEPA).
	Ammonia (combustion)	Natural Gas	All such plant are located in England
	Autogenerators	Coal	DECC sub-national energy statistics data on coal use by other power producers, Energy Trends December 2013.
		Natural gas	(Data sources exactly as per “Other Industry” above)
	Other-Industry: Off-road	Gas oil, petrol	Industrial employment data. (ONS)

The DECC sub-national energy statistics are revised and improved each year through targeted sector research aimed at reducing uncertainties in the modelling approach, and are now National Statistics. Previously the regional fuel use in these sectors has been developed using a complex balance approach based on limited source data. The lack of consistent and comprehensive fuel use or fuel sales data from across the DAs (especially for solid and liquid fuels) leads to significant potential errors in the distribution of UK fuel use across the regions. Expert judgement and proxy data are used to address data gaps and inconsistencies in DA energy use data over the time series; the DA emission estimates for earlier years in the inventory time series and the reported inventory trends are associated with higher uncertainty than the data and trends reported in the UK GHG inventory, due to the lack of detailed DA energy balance data.

The DECC sub-national energy statistics are used to derive estimates for industry sector combustion of fuels such as fuel oil, gas oil and coal. These data are based predominantly on analysis of available point source data, supplemented by production and employment surveys, and in several sectors new data on building Display Energy Certificates and Energy Performance Certificates have been used to provide a better indicator of DA energy use than the production or employment indices. Several industry sectors are now 100% covered under EUETS, such as the cement sector, and hence uncertainties in the DA GHGI estimates are much lower than previously for such sources. To supplement EUETS data, additional information from other pollution inventories (PI, SPRI, ISR) are used to improve the accuracy of the allocation of industrial combustion sources.

To reduce the risk of double-counting emissions, the mapping of area sources has been revised to remove the proxy data (i.e. employment or production indices) associated with those major point sources that can be accurately allocated. The revision of mapping grids for the area sources is conducted periodically as part of the NAEI work programme, with the industry data typically revised every 3-4 years. In 2011, new analysis was conducted to revise the grids for the emissions in year 2010, and these data are retained in the latest DA GHG inventory. This revision to the DA estimates for industry sectors enables a more accurate representation of the emissions in recent years following the recession, compared to the data presented in the 1990-2009 DA GHGI report which was based on area source analysis for the year 2006. Furthermore in the 2010 mapping update, the industry sector was analysed at a greater level of detail to enable DA-specific estimates to be derived for the non-ferrous metal (1A2b), chemicals (1A2c), paper and pulp (1A2d) and food, drink and tobacco (1A2e) sectors.

Note that the sub-national energy statistics have only been produced by DECC since 2003, and complete data (i.e. all fuels) are only available up to 2011, with gas and electricity data available up to 2012 within the DECC publication *Energy Trends December 2013* (DECC 2013b). The sub-national data are used to extrapolate estimates back across the time-series (assuming UK trends across all DAs) in many instances where more detailed data for the earlier years is absent. Hence the emission estimates & trends from solid and liquid fuels within the industrial combustion categories remain amongst the more uncertain estimates within the DA inventories, due to uncertainties from the modelling approach to derive the source activity data and the back-casting of emission estimates for the earlier years.

Liquid Petroleum Gas (LPG) has a number of uses, primarily in sectors such as domestic use and the growing sector of LPG use in road transport applications. Industrial use of LPG has been disaggregated based on DECC sub-national energy statistics (DECC, 2013b) for recent years, maintaining the mass balance approach for the earlier years where complete data are available.

The driver for emissions from lubricant use is based on regional lubricant sales (DECC, 2013a) with England and Wales being disaggregated based on regional manufacturing employment statistics (ONS, 2013a).

DECC (2013c) provides data on natural gas sales to consumers categorised by consumer size and region in Great Britain, excluding consumption by large industrial users and power generators. Consumption data for gas use in Northern Ireland is supplied by Airtricity (formerly Phoenix Gas) (2013) for 1999 onwards, Firmus Energy (2013) Energia (2013) and Vayu Ltd. (2013). These data sources are used to assess the overall gas use data for each country. Note however, that the DECC data are incomplete due to issues of commercial confidentiality for several large gas using sites, and a series of assumptions are made to estimate the gas use at these "missing" sites. Furthermore, the local authority gas use estimates do not cover a calendar year and are weather-corrected and are therefore not directly consistent with the annual fuel use data by sector that are reported in DUKES, which are used to underpin the UK and DA GHG inventory emission estimates from gas combustion. The overall gas use data for each country are uncertain as a result of these scope and reporting limitations.

The gas use within each economic sub-sector at country-level is then analysed based on the available data from the DECC sub-national energy statistics, supplemented by estimates of major point source gas use derived from analysis of the EUETS and pollution inventory emissions data. Similar to the approach adopted for gas oil, fuel oil and coal, the analysis of point source data enables greater direct allocation of gas use to industry or commercial sectors, reducing allocation uncertainties. Note that the driver determined for "other industry" is also used for "autogenerators". In Northern Ireland, supplementary information from gas suppliers provides a slightly more detailed breakdown of gas use by end-user sector, and this has been used to revise the allocations between industrial and commercial sectors across recent years.

Drivers for fuel consumption in cement kilns are based on annual regional clinker capacity data for 1990, 1995, 1998-2001 supplied by the British Cement Association (BCA: 2004). These are applied to all fuels, with a correction factor applied to Northern Ireland to account for the absence of natural gas. Where the UK estimate of fuel consumed in cement kilns has been revised for a given year, the regional

consumptions have also been revised. From 2002 onwards the emissions data reported to the PI, SPRI and ISR are used to disaggregate UK emissions (EA: 2009a, SEPA: 2009a, NIDoE: 2009a), until 2008 where the EUETS Phase II reporting scope covers all UK cement kiln sites. For 2008 onwards therefore, the EUETS data (EA: 2013b, SEPA: 2013b, NIEA: 2013b) are used to derive the DA estimates, in order that local fuel use patterns and emission factors are fully reflected within the DA inventory data, and to maintain consistency between the EUETS and DA GHGI.

"Autogeneration" refers to electricity generation by industry for its own use. In the case of coal, until 2012 the use of coal in autogeneration was dominated by a handful of plant based in England such as the Alcan power station at Lynemouth. Following the closure of the Alcan production site, the use of coal in autogeneration is a much lesser source in the UK; the estimated distribution of emissions from coal-fired autogeneration are taken from the DECC sub national energy stats for coal use by other generators (DECC, 2013b). Gas autogeneration is distributed according to the other natural gas "other industry" driver.

A2.6 Transport

The drivers used for transport are summarised in Table A2.4.

A2.6.1 Aviation

The disaggregation of the domestic aviation emissions uses a database of aircraft movement data from the Civil Aviation Authority, also used in the compilation of the UK GHG inventory.

The CAA database includes details of individual flights (airport origin, destination, fuel type, plane type, engine type), covering both domestic and international flights. Only domestic UK flights are included in the core DA GHG inventory data, as the DA inventory is aligned with the territorial coverage of the UK statistical release, which excludes international aviation and flights to Crown Dependencies, Overseas Territories and Gibraltar; however, for the purposes of reporting data to match the scope of Scottish Government GHG mitigation targets, estimates of the DA share of these international flights are also made using the same method, i.e. allocating emissions from flights to the DA of flight origin, using the CAA database. For England, Wales and Northern Ireland, these data are retained merely as memo items, accounted separately from the by source inventory totals.

Estimates of emissions from take-off and landing cycles and aircraft cruise have been calculated. The protocol adopted for disaggregating emissions across DAs is to assign all emissions from a flight to the DA of flight origin. In the 1990-2011 DA inventories, the method for disaggregating the flights to Crown Dependencies, Overseas Territories and Gibraltar was improved to take proper account of available information on flights to these destinations rather than merging the analysis with the UK-international flight data. This has an almost negligible impact on all of the DA aviation estimates, but removes inconsistencies where it is known that there are no direct flight routes between, for example, Scotland and Gibraltar.

Details of the aviation methodology can be found in the NIR. The driver for emissions from aircraft support vehicles is calculated based on aircraft movement data from the UK's major airports (CAA, 2013). Emission estimates for both domestic and international aviation are constrained at UK level by the fuel use data reported within the annual publication of DUKES. Annual aviation fuel sales in the UK therefore define the overall aviation emissions, in accordance with UNFCCC, UNECE and IPCC inventory guidance.

The DA emission estimates for domestic and international aviation are associated with low uncertainty; the emission estimates are based on a database of UK flight movements and detailed calculations of emissions from different phases of flights (take off, cruise, landing cycles).

A2.6.2 Navigation

Emissions from navigation (coastal shipping and fishing) are based on emission estimates within the UK GHGI that do not use the shipping fuel use data reported within DUKES (DECC 2013a), but instead uses data from a research study by AMEC (formerly Entec) under contract to Defra. The study calculated fuel consumption and emissions from shipping activities around UK waters using a bottom-up procedure based on detailed shipping movement data for different vessel types, fuels and journeys (Entec, 2010). The total fuel delivery statistics given in DUKES (marine bunker plus national navigation) are believed to be an accurate representation of the amount of fuel made available for marine consumption, but there is more uncertainty in the ultimate distribution and use of the fuels for domestic and international shipping consumption and hence the AMEC study data are used.

The overall approach can be summarised as follows:

- Fuel consumption and emissions for domestic journeys are taken from the AMEC study based on detailed movement data for 2007 in which AMEC provided an uplift to their bottom-up estimates to take account of missing vessel movements ;
- Fuel consumption and emissions for fishing vessels are taken from the AMEC study and reported separately under 1A4ciii;
- Estimates for domestic coastal shipping fuel consumption and emissions back-cast to 1990 and forecast to 2012 are used, which are derived from applying trends in port movement data as proxies for changes in activities of different types of vessels;
- Fuel consumption and emissions are calculated separately for naval shipping from data provided by the MoD;
- Fuel consumption and emissions are calculated separately for inland waterways from estimates of vessel population and activities;
- Fuel consumption and emissions are calculated separately for fishing which takes place in non-UK waters by UK vessels;
- Fuel consumption and emissions are calculated separately for shipping movements between the UK and Overseas Territories;
- A reconciliation with fuels data in DUKES is made whereby the difference between the sum of the currently reported fuel deliveries for marine bunkers and national navigation in DUKES and the sum of the fuel consumption estimate for domestic coastal shipping taken from AMEC, and the fuel consumption estimates for naval shipping, the UK's inland waterways, fishing outside UK waters and shipping movements between the Overseas Territories, is assigned to international shipping.

From the UK inventory for domestic navigation, the disaggregation of emissions between each constituent country is based on port movement data (DfT, 2013). The same approach is taken for the allocation of the international shipping emissions to each DA. As with the international aviation data, the Scottish Government GHG reduction targets take account of the Scottish share of international shipping, whereas for England, Wales and Northern Ireland the international shipping data are merely a memo item that are accounted for separate to the main DA by source dataset.

The DA emission estimates derived for domestic and international shipping are regarded as indicative, as there is limited data availability for regional marine shipping fuel use.

No detailed dataset of domestic and international shipping movements is currently available, and hence emissions are assigned based on the assumption that the total mass of port traffic per DA is a representative proxy to estimate shipping fuel sales and use in the ports and waters around the DAs. Note that the sum of the DA shipping emission allocations are constrained by the UK fuel use data for the sector; this method of estimation is therefore consistent with the principles of international inventory guidance, whereby emissions are allocated to the country at the point of fuel sale.

[Note that in the reporting of the UK GHGI, the emission estimates for international aviation and shipping are reported as "memo items" to the UK submission to the UNFCCC, and hence the approach taken for England, Wales and Northern Ireland is fully consistent with the UK reporting commitments.]

A2.6.3 Road Transport

Carbon dioxide, methane and nitrous oxide are emitted from the exhaust of all road vehicles with internal combustion engines. Carbon dioxide is the principal product of combustion and emissions are directly related to the fuel efficiency of the vehicle.

Methane is emitted as a result of the incomplete combustion of the fuel. Nitrous oxide is a by-product of the combustion process and emitted from partial oxidation of nitrogen present in the air.

All these pollutants are emitted by different amounts from vehicles of similar size running on petrol and diesel fuel. For example, diesel cars tend to be more fuel-efficient than petrol cars of a similar size, so their carbon emissions are lower. None of these pollutants are subject to regulatory type-approval emission limits as are those which have an impact on air quality. However, emissions of GHGs are affected by technologies introduced to reduce emissions of the regulated air quality pollutants. Methane emissions are lower from petrol vehicles fitted with a three-way catalyst, although the reduction in emissions of this pollutant by the catalyst is not as efficient as it is for other hydrocarbons. Measurements also suggest that a three-way catalyst, which is efficient at reducing NO_x emissions, can actually increase emissions of nitrous oxide, formed as a by-product of the catalyst NO_x reduction process, but evidence suggests that this is mainly a problem only for early generation catalyst cars.

Disaggregation of UK emissions across the DAs is based on local data from road traffic surveys run by the UK Department for Transport and the Department for Regional Development in Northern Ireland. Vehicle kilometre figures for different vehicle types and road types are combined with fuel consumption or emission factors. The vehicle kilometre data are also subject to uncertainty, but have shown a consistent growth in traffic across all the regions up to 2007. Traffic levels have gone down slightly in general between 2007 and 2012.

It is worth noting that the IPCC Reference Manual states that "the CORINAIR (programme), with a view to the input requirements of atmospheric dispersion models, applies the principle of territoriality (emission allocation according to fuel consumption) whereas the IPCC is bound to the principle of political responsibility (allocation according to fuel sale). For the IPCC, countries with a big disparity between emissions from fuel sales and fuel consumption have the option of estimating true consumption and reporting the emissions from consumption and trade separately." (IPCC, 1996).

UK emissions of carbon dioxide from road transport are reported to IPCC on the basis of fuel sales. However, basing road transport emissions on fuel sales in each constituent country of the UK does not provide a representative picture of trends in road transport emissions at regional level, due to issues of cross-border fuel sales (especially between Northern Ireland – Republic of Ireland) and sales data accounting issues within the UK (e.g. "supermarket sales" in Scotland allocated to original point of sale in northern England). Estimates based on fuel consumption calculated from traffic data in each DA are therefore regarded as a more representative approach, and are consistent with the CORINAIR (now EMEP/EEA) guidance.

Table A2.4a: Transport (Base Year – 1990)

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
Civil Aviation	Domestic cruise; Domestic Take-off & Landing	Aviation Gasoline, Jet Gasoline	CAA database of flight information (CAA, 2013) Fuel consumption: Digest of UK Energy Statistics (1990)
Road Transport	Road Transport	Petrol, Diesel oil	Road fuel sales, DECC; vehicle km, DfT Traffic data: National Traffic Census, DfT Dept of Regional Development (NI: 1990) Fuel consumption: Digest of UK Energy Statistics (1990)
Railways	Railways	Gas oil	The DfT Rail Emissions Model, calibrated against total train kilometres figures for 2009/10 taken from ORR's National Rail Trends Yearbook. DA estimates from 2010 back-cast to 1990, assuming DAs follow UK trend. Fuel consumption: Digest of UK Energy Statistics (1990-2013).
Navigation	Coastal shipping	Gas oil, Fuel oil	Back calculated from 2007 estimates by Entec based on detailed shipping movements. Backcasting done from 2007 using trends in port movement data, DfT Maritime Statistics Fuel consumption: Digest of UK Energy Statistics (1990)
Other	Aircraft Support	Gas oil	Regional aircraft movements, DfT Fuel consumption: Digest of UK Energy Statistics (1990)

Table A2.4b: Transport (1995; 1998 to 2011)

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
Civil Aviation	Domestic cruise; Domestic Take-off & Landing	Aviation Gasoline, Jet Gasoline	CAA database of flight information (CAA, 2013) Fuel consumption: Digest of UK Energy Statistics (DECC, 2013)
Road Transport	Road Transport	Petrol, Diesel oil, LPG	Vehicle km, DfT, NI DRD Emission factors: Boulter et al. (2009) COPERT 4 (EEA, 2010) Fuel efficiency: Road Freight Statistics, (DfT, 2013) Composition of fleet: Vehicle Licensing Statistics Report, DfT (GB) Dept of Regional Development (NI). Traffic data: National Traffic Census, DfT (England, Scotland, Wales: 1990-2012) Dept of Regional Development (NI: 1990-1999), Traffic Census Report (NI: 2000), Vehicle Kilometres of Travel Survey of Northern Ireland Annual Report (NI: 2001), Traffic and Travel Information, DRDNI (NI: 2002- 2012) Fuel consumption: Digest of UK Energy Statistics (DECC, 2013), Welsh Office fuels data (WO, 1998)
Railways	Railways	Gas oil	The DfT Rail Emissions Model, calibrated against total train kilometres figures for 2009/10 taken from ORR's National Rail Trends Yearbook. Fuel consumption: Digest of UK Energy Statistics (DECC, 2013)
Navigation	Coastal shipping	Gas oil, Fuel oil	Back calculated from 2007 estimates by Entec based on detailed shipping movements. Backcasting and forewardcasting done from 2007 using trends in port movement data, DfT Maritime Statistics Fuel consumption: Digest of UK Energy Statistics (DECC, 2013)
Other	Aircraft Support	Gas oil	Regional aircraft movements, DfT Fuel consumption: Digest of UK Energy Statistics (DECC, 2013)

Total emissions from road transport in each region are calculated from the following information:

- Emission factors for different types of vehicles. In the case of carbon emissions, fuel consumption factors can be used because the mass of carbon emitted is proportional to the mass of fuel consumed. Emission factors (g/km) and fuel consumption factors depend on the vehicle type and fuel type (petrol or diesel) and are influenced by the drive cycle or average speeds on the different types of roads;
- Traffic activity, including distance and average speed travelled by each type of vehicle on each type of road;
- Fleet composition in terms of the age of the fleet and the petrol/diesel mix. The age of the fleet determines the proportion of vehicles manufactured in conformity with different exhaust emission regulations (which have been successively tightened over the past 30 years); and
- One of the defining factors for the inventories is the proportion of petrol cars fitted with a three-way catalyst since this became mandatory for all new cars first registered in the UK from around August 1992, in accordance with EC Directive 91/441/EEC. The proportion of cars and vans running on diesel fuel is also an important factor. The sensitivity to the age of the fleet will be much less for the 1990 inventory because there were very few cars then fitted with catalysts and the difference in emissions from cars made to the earlier emission standards was much smaller.

There are a number of improvements made to the 2012 UK road transport inventory and thus affecting the DA inventories. The details of UK inventory improvements are presented within the UK National Inventory Report (Webb *et al*, 2014).

Emission factors

All the emission factors were consistent with those used in the latest UK Greenhouse Gas Emissions Inventory (Webb *et al*., 2014). Emission factors for methane are unchanged and they are developed by TRL on behalf of DfT (Boulter et al., 2009), expressed as speed-related functions for cars and LGVs and single average factors for HGVs, buses and motorcycles for urban, rural and motorways.

Nitrous oxide emission factors remain the same as those used in the last DA GHG inventory (except corrections have been made for coaches, London buses and HGVs 3.5-7.5t and 7.5-12t weight classes). They are based on factors obtained from the Emissions Inventory Guidebook (EEA, 2012). For petrol cars and LGVs, emission factors are provided for different Euro standards and driving conditions (urban, rural, highway) with adjustment factors that take into account the vehicle's accumulated mileage and the fuel sulphur content; both of these tend to increase emission factors. For diesel cars and LGVs, bulk emission factors are provided for different Euro standards and road types, with no fuel and mileage effects. The factors for HGVs and buses are provided for different Euro standards, weight classes and driving conditions. The factors for motorcycles make no distinction between different Euro standards and road types.

The uncertainties in the CH_4 and N_2O factors can be expected to be quite large. However, the relative differences between emission factors used for different technologies, Euro standards and fuels are likely to reflect realistic trends.

Fuel consumption factors are also unchanged and are based on the fuel consumption-speed relationships for detailed categories of vehicles compiled by TRL on behalf of DfT. They are used in conjunction with fleet-average fuel efficiency and vehicle CO_2 factors from other sources. These include fuel efficiency factors for HGVs and buses from sources in DfT. Further details on fuel consumption factors for other vehicle types can be found in the UK GHGI report (Webb *et al*., 2014).

Tables A2.4.1 to A2.4.3 show the fuel consumption and emission factors used for the inventory broken down by vehicle type, road type and emission standard which the vehicle was compliant with when manufactured and first registered. Tables A2.4.4 and A2.4.5 present the fleet-averaged fuel consumption factors for rigid and articulated HGVs, buses and coaches respectively from 1990-2012 for urban, rural and motorway conditions. For the other vehicle types and pollutants, CH_4 and N_2O, where the original source of the factors provided them as speed-emission factor equations, emission factors are calculated at average speeds typical of the road types shown in the tables A2.4.1 to A2.4.3. The average speeds used were same as those used in the last DA inventory as described below.

The emission factors shown in Tables A2.4.1-A2.4.3 refer to hot exhaust emissions that is the emissions occurring from the vehicle when the engine and catalyst are at their normal operating temperatures. The excess emissions occurring when the vehicle is started with the engine and catalyst cold was taken into account for calculating N_2O emissions from petrol cars and vans using the methodology given in COPERT 4 (EEA, 2010). Details of the cold start method are given in the latest UK Greenhouse Gas Emissions Inventory (Webb et al., 2014), but essentially it uses mg/km "cold start" emission factors for each Euro standard in combination with the distances travelled with the vehicle not fully warmed up. DA-specific data on trip lengths were gathered in the previous DA improvement programme and no significant difference in passenger car trip lengths were found for Scotland and Wales compared with the GB average, but trip lengths are shorter in Northern Ireland and this information has been incorporated in the DA inventory. Data for estimating cold start effects on methane emissions are not available, but the effects are considered to be probably smaller and within the range of uncertainty in the hot exhaust methane emission factors.

Age and composition of the fleet

Automatic Number Plate Recognition (ANPR) data provided by DfT (2013b, pers comm) are used to define the UK's vehicle fleet composition on the road. The ANPR data has been collected annually (since 2007) over 256 sites in the UK on different road types (urban and rural major/minor roads, and motorways) and regions. Measurements are made at each site on one weekday and one half weekend day in June, capturing approximately 1.4-1.7 million observations from all the sites each year. The data cover various vehicle and road characteristics such as fuel type, age of vehicle (which can be associated with its Euro standard), engine sizes, vehicle weight and road types.

The ANPR data is used to define fleet composition in two aspects:

- ***Petrol and diesel mix in the car fleet on different road types (urban, rural and motorway).*** The ANPR data confirmed that there is a preferential use of diesel cars on motorways, as was previously assumed in the inventory, but that preferential usage of diesel cars also extended to urban roads as well, although not to the extent as seen on motorways. The net result was an increase in diesel car km on urban roads, but less on motorways than had been previously assumed. For Northern Ireland, the ANPR data for 2010 and 2011 show that there was no major difference in the proportion of diesel cars observed on different road types and that the proportion was similar to that implied by the licensing data; as a result, it is assumed that there is no preferential use of diesel cars, and the petrol/diesel mix in car km should follow the proportion as indicated by the licensing statistics provided by DRDNI (2013a).

- ***Variations in age and Euro standard mix on different road types.*** The ANPR data tended to show that the diesel car, LGV and HGV fleet observed on the road was rather newer than inferred from the licensing records and mileage surveys.

The results from above are then further combined with regional licensing statistics provided by DfT from their Driver and Vehicle Licensing Agency database (hereafter referred to as DVLA data) to define regional variation (DfT, 2010a). The DVLA data were introduced in the 2009 DA inventories and show that there are some regional differences in the composition of fleet, including:

- The proportion of diesel cars in the fleet is similar in England and Scotland, but is consistently slightly higher in Wales.
- Scotland and Wales have a slightly higher proportion of smaller engine-size petrol cars compared with England and the GB average;
- Scotland has a newer petrol car fleet than England and Wales, while Wales appears to have an older diesel car fleet than England and Scotland.
- The van fleet in Scotland is newer then the GB average, while in Wales the van fleet is older

It should be noted that the application of the ANPR and DVLA data is dependent on the vehicle, pollutant and region combination. For instance, when calculating fuel consumption and CO_2 emissions, data on the average mpg fuel efficiency of different sizes of lorries from the Road Freight Statistics and the BSOG data for buses take precedence over the ANPR data, and they are continued to be used to define the fuel consumption/ CO_2 emissions for HGVs and buses respectively, without any adjustment to account for variations in the age of the HGV or bus fleets. Further details on the methodology of defining fleet composition are given in Webb et al., 2014.

Traffic data

The preferred indicators for road transport activity in emission inventories are traffic data in terms of vehicle kilometres travelled per year disaggregated by vehicle and road type. For the NAEI, vehicle kilometre data for the road network in Great Britain are provided by DfT for each vehicle type on roads classified as trunk, principal and minor roads in built-up areas (urban) and non-built-up areas (rural) and motorways (DfT, 2013c). These estimates are based on traffic counts from the rotating census and core census surveys.

A consistent time series of vehicle km data for 1993 to 2012 by road type and vehicle type for England, Wales and Scotland was provided by DfT (DfT, 2013c). Vehicle km data for 1993 was scaled to derive the 1990 values for England, Wales and Scotland, based on the GB trend between 1990 and 1993. As mentioned previously, the minor traffic estimates have been revised between 2000 and 2010 for England and Wales as a result of a planned benchmarking exercise. The revision does not affect minor road estimates for Scotland.

Vehicle kilometre data for Northern Ireland by vehicle type and road class were provided by the Department for Regional Development (DRD), Northern Ireland, Road Services (DRDNI, 2011a). These provided a consistent time-series of vehicle km data for all years up to 2010. Data for 2012- were derived using change factors provided by DRDNI (2013a). Motorcycle vehicle km data were not available from the DRDNI and so they were derived based on the ratio of motorcycles registered in Northern Ireland relative to the GB each year. The ratios were then applied to the motorcycle vehicle km activity data for the GB. There was a downward revision to the motorcycle vehicle km data for Northern Ireland across the time series as updated GB licensing statistics have been used in the 2011 and 2012 inventories.

Estimation of Emissions of Methane and Nitrous Oxide

Emissions of methane and nitrous oxide from road transport in the regions are calculated by combining the vehicle emission factors, fleet composition data and vehicle kilometre data for the different vehicle, fuel and road types. The emissions from petrol and diesel vehicles in each DA are normalised so that the totals across all DAs equal the UK emissions calculated for the pollutant and fuel type.

Estimation of Road Transport Carbon Dioxide Emissions

Road transport has been a very significant and growing source of carbon dioxide across all of the constituent countries of the UK.

For the purposes of the UK's reporting to the UNFCCC on greenhouse gas emissions under the Kyoto Protocol, the UK is required to use estimation and reporting methodologies that comply with IPCC guidance. The recommended methodology for estimation of carbon dioxide emissions from road transport sources applies the principle of political responsibility for emissions, whereby fuel sales data are used as the basis for the estimates. In this way, across a group of countries such as the Member States of the EU, there is no risk of double-counting road transport carbon dioxide emissions due to the use of different estimation methodologies[2].

Therefore, for the purposes of reporting to the UNFCCC and the determination of progress towards Kyoto Protocol emission reduction targets, the UK uses fuel sales data as the basis for carbon dioxide emission estimates from road transport in the National Inventory Report. However, for the purposes of compiling the Devolved Administration GHG inventories, the use of regional fuel sales data is problematic due to a couple of key issues:

- **Cross-border fuel sales** - This factor is especially evident in Northern Ireland, where the price differential between fuel in the UK and the Republic of Ireland may have encouraged purchase of fuel from outside of the UK (BERR: Personal Communication, 2004);
- **Supermarket fuel sales** - Where a supermarket chain purchases its fuel from storage facilities in England and then sells the fuel in other parts of the UK, the emissions from that fuel sold will be incorrectly attributed to England. Although this is known to be a potential source of inconsistency in the reporting of regional fuel sales from supermarkets, it is also likely to be evident across other economic sectors too (BERR: Personal Communication, 2004).

Adopting the IPCC estimation method of using fuel sales data in each DA produces carbon dioxide emission trends from road transport in Northern Ireland and Scotland that buck the UK trend of increasing emissions with time, contrary to vehicle kilometre data that are collected across the UK.

Table A2.4.1: Fuel Consumption Factors for Road Transport (in g fuel/km)

g fuel /km		Urban	Rural	Motorway
Petrol cars	Pre-Euro 1	66.4	62.8	69.1
	Euro 1	61.4	57.9	64.1
	Euro 2	58.8	55.3	61.5
	Euro 3	55.0	51.4	57.6
	Euro 4	50.8	47.2	53.4
	Euro 5	44.7	41.2	47.4
Diesel cars	Pre-Euro 1	60.3	55.0	61.2
	Euro 1	58.5	53.2	59.4
	Euro 2	54.9	49.6	55.8
	Euro 3	50.2	44.9	51.1
	Euro 4	47.7	42.4	48.7
	Euro 5	42.0	36.7	42.9
Petrol LGVs	Pre-Euro 1	68.7	64.1	70.0
	Euro 1	63.6	59.0	64.8
	Euro 2	60.9	56.3	62.1
	Euro 3	57.1	52.5	58.3
	Euro 4	52.3	47.7	53.6
Diesel LGV	Pre-Euro 1	61.9	68.4	91.9
	Euro 1	76.7	84.4	110.1
	Euro 2	71.5	77.5	106.0
	Euro 3	63.2	69.8	104.0

[2] Note that the UK methodology for estimating emissions of methane and nitrous oxide from road transport sources is based on vehicle kilometre data, in accordance with IPCC guidance.

g fuel /km		Urban	Rural	Motorway
	Euro 4	63.2	69.8	104.0
Mopeds, <50cc, 2st	Pre-Euro 1	25.5		
	Euro 1	15.3		
	Euro 2	12.3		
	Euro 3	10.7		
Motorcycles, >50cc, 2st	Pre-Euro 1	27.5	30.2	
	Euro 1	25.3	27.8	
	Euro 2	25.3	27.8	
	Euro 3	25.3	27.8	
Motorcycles, >50cc, 4st	Pre-Euro 1	35.3	35.1	53.9
	Euro 1	33.5	33.2	46.9
	Euro 2	31.6	31.9	49.3
	Euro 3	31.6	31.9	49.3

Table A2.4.2: Methane Emission Factors for Road Transport (in mg/km)

mg CH_4/km		Urban	Rural	Motorway
Petrol cars	Pre-Euro 1	73.0	21.8	57.7
	Euro 1	15.0	5.2	20.9
	Euro 2	15.8	9.6	9.7
	Euro 3	5.0	4.1	7.2
	Euro 4	1.3	1.0	1.8
	Euro 5	1.3	1.0	1.8
Diesel cars	Pre-Euro 1	12.3	10.2	10.0
	Euro 1	6.1	6.3	6.2
	Euro 2	2.9	1.7	1.2
	Euro 3	1.4	1.1	1.1
	Euro 4	1.0	0.8	0.7
	Euro 5	1.0	0.8	0.7
Petrol LGVs	Pre-Euro 1	73.0	21.8	57.7
	Euro 1	15.0	5.2	20.9
	Euro 2	15.8	9.6	9.7
	Euro 3	5.0	4.1	7.2
	Euro 4	1.3	1.0	1.8
	Euro 5	1.3	1.0	1.8
Diesel LGV	Pre-Euro 1	11.8	4.0	22.0
	Euro 1	6.7	1.7	5.8
	Euro 2	2.9	1.7	1.2
	Euro 3	2.2	0.6	1.0
	Euro 4	1.5	0.4	0.7
	Euro 5	1.5	0.4	0.7
Rigid HGVs	Pre-Euro I	185.5	50.2	43.6
	Euro I	85.0	23.0	20.0
	Euro II	54.4	20.0	18.6
	Euro III	47.6	21.4	18.2
	Euro IV	2.6	1.6	1.2
	Euro V	2.3	1.4	1.1
Artic HGVs	Pre-Euro I	381.8	174.5	152.7
	Euro I	175.0	80.0	70.0

mg CH_4/km		Urban	Rural	Motorway
	Euro II	112.0	69.6	65.1
	Euro III	98.0	74.4	63.7
	Euro IV	5.3	5.6	4.2
	Euro V	4.7	5.0	3.8
Buses & coaches	Pre-Euro I	381.8	174.5	152.7
	Euro I	175.0	80.0	70.0
	Euro II	113.8	52.0	45.5
	Euro III	103.3	47.2	41.3
	Euro IV	5.3	5.6	4.2
	Euro V	4.7	5.0	3.8
Mopeds, <50cc, 2st	Pre-Euro 1	219.0		
	Euro 1	43.8		
	Euro 2	24.1		
	Euro 3	19.7		
Motorcycles, >50cc, 2st	Pre-Euro 1	150.0	150.0	
	Euro 1	99.0	106.5	
	Euro 2	30.0	31.5	
	Euro 3	12.0	13.5	
Motorcycles, >50cc, 4st	Pre-Euro 1	200.0	200.0	200.0
	Euro 1	127.9	138.6	148.7
	Euro 2	126.7	93.1	107.1
	Euro 3	76.2	32.6	31.8

Table A2.4.3: N_2O Emission Factors for Road Transport (in mg/km)

N_2O(mg/km)	Standard	Urban	Rural	Motorway
Petrol cars	Pre-Euro 1	10.0	6.5	6.5
	Euro 1	21.3	13.8	6.9
	Euro 2	10.7	3.4	1.8
	Euro 3	1.4	0.6	0.5
	Euro 4	1.8	0.6	0.5
	Euro 5	1.8	0.6	0.5
Diesel cars	Pre-Euro 1	0.0	0.0	0.0
	Euro 1	2.0	4.0	4.0
	Euro 2	4.0	6.0	6.0
	Euro 3	9.0	4.0	4.0
	Euro 4	9.0	4.0	4.0
	Euro 5	9.0	4.0	4.0
Petrol LGVs	Pre-Euro 1	10.0	6.5	6.5
	Euro 1	22.0	13.8	6.9
	Euro 2	16.3	9.3	5.8
	Euro 3	10.5	4.6	4.6
	Euro 4	0.8	1.3	1.3
	Euro 5	0.8	1.3	1.3
Diesel LGV	Pre-Euro 1	0.0	0.0	0.0
	Euro 1	2.0	4.0	4.0
	Euro 2	4.0	6.0	6.0
	Euro 3	9.0	4.0	4.0
	Euro 4	9.0	4.0	4.0
	Euro 5	9.0	4.0	4.0

N_2O(mg/km)	Standard	Urban	Rural	Motorway
Rigid HGVs	Pre-Euro I	30.0	30.0	30.0
	Euro I	10.4	8.6	6.1
	Euro II	10.0	8.6	5.7
	Euro III	4.9	4.9	3.7
	Euro IV	10.6	12.9	10.6
	Euro V	27.6	37.1	31.3
Artic HGVs	Pre-Euro I	30.0	30.0	30.0
	Euro I	17.6	14.7	10.8
	Euro II	17.6	14.7	9.8
	Euro III	8.8	8.8	6.8
	Euro IV	18.6	22.9	18.8
	Euro V	47.9	65.1	54.5
Buses	Pre-Euro I	30.0	30.0	30.0
	Euro I	11.7	11.2	7.0
	Euro II	11.7	11.2	6.0
	Euro III	5.7	5.7	4.0
	Euro IV	12.4	13.1	11.4
	Euro V	32.2	35.2	33.6
Mopeds, <50cc, 2st	Pre-Euro 1	1.0		
	Euro 1	1.0		
	Euro 2	1.0		
	Euro 3	1.0		
Motorcycles, >50cc, 2st	Pre-Euro 1	2.0	2.0	
	Euro 1	2.0	2.0	
	Euro 2	2.0	2.0	
	Euro 3	2.0	2.0	
Motorcycles, >50cc, 4st	Pre-Euro 1	2.0	2.0	2.0
	Euro 1	2.0	2.0	2.0
	Euro 2	2.0	2.0	2.0
	Euro 3	2.0	2.0	2.0

Table A2.4.4: Fuel Consumption Factors for HGVs (in g fuel/km)

g fuel/km	Rigid HGVs			Artic HGVs		
	urban	rural	m-way	urban	rural	m-way
1990	272.4	217.7	231.5	438.8	337.1	343.6
1995	263.3	212.2	225.9	395.5	304.6	310.5
2000	247.8	204.8	219.2	370.2	287.7	293.2
2005	250.7	205.0	217.4	360.9	279.7	285.2
2006	261.9	213.1	225.5	363.4	281.4	286.9
2007	270.1	218.5	230.7	365.9	283.1	288.7
2008	279.6	226.0	238.5	379.8	293.5	299.3
2009	281.8	228.0	240.8	381.1	294.3	300.1
2010	285.3	229.9	242.5	384.9	296.9	302.7
2011	284.7	229.2	241.6	384.4	296.0	301.8
2012	284.6	228.9	241.3	384.6	295.9	301.8

Table A2.4.5: Average fuel consumption factors for buses and coaches (in g fuel/km) in the fleet based on DfT's BSOG data

g fuel/km	Urban	Rural	Motorway
1990	268.9	167.8	190.9
1995	260.8	163.3	187.0
2000	277.0	176.7	206.4
2005	322.7	207.1	244.3
2008	338.2	216.2	255.4
2009	340.8	217.5	257.2
2010	337.5	215.1	254.5
2011	336.8	214.4	253.8
2012	326.3	207.4	245.7

In order to provide a more representative assessment of transport emission trends of carbon dioxide within the constituent countries of the UK, the approach is either directly using regional vehicle km data to estimate road transport carbon dioxide emissions in each DA or using regional vehicle km data as a means to proportion the total UK road transport carbon dioxide emissions between each DA region.

They are described in the following sections:

Disaggregation of UK Carbon Dioxide Emissions by DA: Constrained Method:

In this method the sum of the DA inventories for carbon dioxide are constrained to meeting the total of the UK inventory for road transport which for carbon dioxide is derived from UK fuel sales data for petrol and DERV from DECC. The vehicle km data for each region are used to provide an estimated allocation of the total UK road transport emissions across the constituent countries. In constraining to sum to the national totals, this approach is consistent with that adopted across every other source sector in the DA GHG inventories.

However, the criticism of this method is that the presentation of results does not always provide a carbon dioxide emission trend for the DAs that is directly consistent with the vehicle kilometre trend data, as the fluctuations in UK fuel data (from DECC) have a more significant impact on the resultant emission trends.

Direct Calculation of DA Emissions: Unconstrained Method:

In this method, carbon dioxide emissions from constituent countries are derived directly from the regional vehicle km data and are not constrained to the UK totals based on national fuel consumption data. This method removes any year to year fluctuations caused by the normalisation process and enables the emission trends to mirror the smooth trends in vehicle km.

The difference in results between the constrained and unconstrained methods at DA level largely reflects the difference in the results at UK level between bottom-up calculated fuel consumption using vehicle km data and fuel consumption factors and the fuel sales data in DUKES. The reason for a disparity has previously been attributed to cross-border fuel sales ("fuel tourism") although model uncertainty was always emphasised as an additional, and probably a major explanation for the differences.

Any change in the methodologies or the factors used to calculate fuel consumption will affect the magnitude of the difference between calculated fuel consumption at national level and sales figures from DUKES and so, in turn, it will affect the disparity between the DA carbon dioxide emissions from the constrained and unconstrained approaches. In 2012, the bottom-up method underestimates petrol and diesel consumption by 6.6% and 2.9% respectively. This is considered well within the uncertainty of the factors used to derive the bottom-up estimates.

The trend in road transport carbon dioxide emissions for each DA and the UK calculated by the constrained and unconstrained methods across the time series is shown in Table A2.4.6 and Figure A2.4.1. Note that in the table, figures labelled "vkm" refer to the unconstrained method; figures labelled "Fuel sales" refer to the constrained method.

Further details on the fuel consumption vs. fuel sales reconciliation issue and normalisation procedure applied at UK level are given in Webb et al., 2014.

Note that emissions of methane and nitrous oxide both at UK level and for the DAs are calculated directly from vehicle km data and emission factors, and then are also normalised to match the fuel sales data involved.This is a method change compared to previous inventories, where non-CO_2 emissions were reported unconstrained to DUKES fuel use totals; a UNFCCC review recommendation to amend the UK inventory method to bring the CO2 and non-CO2 methods onto a consistent basis has been implemented in the 1990-2012 inventory cycle.

Table A2.4.6: Comparison between methods of Carbon Dioxide emissions for each DA (kt CO_2)[3] by vehicle type where vkm refers to the unconstrained method and fuel sales refers to the constrained method.

England		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO_2 (vkm)	Cars	59,415	60,235	61,984	62,634	61,872	61,838	62,232	61,241	61,123	60,179	59,687	58,488	56,723	55,372	52,686	51,622	50,273
	LGVs	7,902	8,958	10,390	10,525	10,699	10,991	11,118	11,568	12,075	12,309	12,675	13,106	12,705	12,346	12,390	12,589	12,692
	HGVs	19,305	18,784	19,378	19,888	19,968	20,446	20,301	20,807	20,688	20,092	20,459	20,744	20,557	18,801	19,083	18,668	18,418
	Buses	2,718	2,911	3,073	3,211	3,244	3,251	3,384	3,686	3,715	3,798	3,908	4,023	3,760	3,730	3,715	3,444	3,169
	Motorcycles	534	366	430	474	470	491	512	565	518	540	515	547	498	504	446	444	427
	TOTAL	89,875	91,253	95,255	96,733	96,253	97,017	97,548	97,867	98,119	96,917	97,245	96,908	94,243	90,753	88,320	86,768	84,978
CO_2 (fuel sales)	Cars	59,414	59,071	61,384	62,607	62,403	62,155	63,128	61,926	62,146	61,799	60,847	60,848	58,973	56,673	54,127	53,175	52,418
	LGVs	7,902	8,874	10,355	10,524	10,721	11,003	11,146	11,587	12,101	12,345	12,702	13,158	12,752	12,372	12,417	12,618	12,731
	HGVs	19,990	20,430	20,553	19,705	18,949	18,774	19,239	19,092	19,275	19,828	20,128	21,698	18,647	17,985	19,471	19,363	20,039
	Buses	2,718	2,911	3,073	3,211	3,244	3,251	3,384	3,686	3,715	3,798	3,908	4,023	3,760	3,730	3,715	3,444	3,169
	Motorcycles	534	358	425	474	475	494	521	572	529	559	529	578	527	521	465	466	457
	TOTAL	90,560	91,643	95,790	96,521	95,793	95,678	97,419	96,863	97,766	98,330	98,115	100,305	94,660	91,280	90,195	89,066	88,815

Scotland		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO2 (vkm)	Cars	5,670	5,714	5,820	5,849	5,776	5,774	5,890	5,821	5,827	5,732	5,795	5,686	5,533	5,402	5,127	5,003	4,918
	LGVs	786	891	1,080	1,103	1,089	1,108	1,137	1,184	1,225	1,256	1,311	1,378	1,352	1,318	1,331	1,343	1,361
	HGVs	1,985	1,894	1,919	1,951	1,945	1,970	1,937	2,064	2,071	2,057	2,160	2,228	2,240	2,078	2,091	2,038	2,050
	Buses	374	385	407	428	436	441	476	514	490	504	518	557	540	542	551	515	484
	Motorcycles	29	22	25	28	28	29	33	37	35	35	34	36	35	35	31	32	31
	TOTAL	8,844	8,905	9,251	9,359	9,274	9,322	9,472	9,621	9,649	9,583	9,817	9,885	9,700	9,376	9,131	8,932	8,843
CO2 (fuel sales)	Cars	5,670	5,606	5,766	5,847	5,824	5,803	5,973	5,884	5,923	5,883	5,905	5,910	5,746	5,524	5,262	5,149	5,121
	LGVs	786	883	1,076	1,103	1,091	1,109	1,140	1,186	1,228	1,259	1,314	1,383	1,357	1,321	1,334	1,346	1,365
	HGVs	2,056	2,060	2,036	1,933	1,846	1,809	1,835	1,894	1,930	2,030	2,125	2,330	2,032	1,988	2,134	2,114	2,230
	Buses	374	385	407	428	436	441	476	514	490	504	518	557	540	542	551	515	484
	Motorcycles	29	21	24	28	28	30	33	37	36	36	34	38	37	36	33	33	33
	TOTAL	8,915	8,955	9,308	9,338	9,225	9,192	9,457	9,517	9,607	9,713	9,896	10,219	9,712	9,412	9,313	9,157	9,232

[3] The totals in this table include emissions from Diesel and Petrol use, but do not include the small emissions from LPG and lubricants. These figures are therefore not directly comparable with the road transport emissions presented in Appendix 2, which include emissions from all fuel use.

Table A2.4.6 (continued): Comparison between methods of Carbon Dioxide emissions for each DA (kt CO_2)[4] by vehicle type where vkm refers to the unconstrained method and fuel sales refers to the constrained method.

Wales		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO2 (vkm)	Cars	3,638	3,675	3,742	3,774	3,722	3,725	3,802	3,781	3,819	3,735	3,755	3,698	3,588	3,473	3,293	3,216	3,128
	LGVs	510	578	668	684	694	711	735	767	800	817	841	866	853	833	843	851	854
	HGVs	1,057	1,001	1,044	1,024	995	1,002	986	995	998	985	996	1,033	1,030	933	927	892	882
	Buses	172	172	178	189	193	193	202	220	216	222	233	240	230	229	227	206	191
	Motorcycles	25	18	21	23	24	24	26	28	26	28	26	28	27	27	23	24	23
	TOTAL	5,402	5,444	5,653	5,694	5,627	5,654	5,752	5,790	5,859	5,785	5,852	5,865	5,728	5,494	5,313	5,190	5,078
CO2 (fuel sales)	Cars	3,638	3,605	3,707	3,773	3,752	3,743	3,854	3,821	3,879	3,829	3,824	3,838	3,721	3,549	3,378	3,307	3,253
	LGVs	510	573	666	684	696	712	737	768	802	819	843	869	856	835	845	853	856
	HGVs	1,095	1,088	1,107	1,015	944	920	934	913	930	972	980	1,081	934	892	946	925	959
	Buses	172	172	178	189	193	193	202	220	216	222	233	240	230	229	227	206	191
	Motorcycles	25	17	20	23	24	25	26	28	27	29	27	30	28	28	24	25	25
	TOTAL	5,439	5,456	5,679	5,683	5,609	5,591	5,754	5,750	5,853	5,870	5,907	6,058	5,770	5,533	5,419	5,316	5,284

Northern Ireland		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO2 (vkm)	Cars	2,275	2,458	2,589	2,684	2,758	2,778	2,733	2,735	2,823	2,805	2,786	2,822	2,701	2,769	2,664	2,601	2,548
	LGVs	116	136	152	159	165	169	240	246	230	227	261	254	294	235	217	221	219
	HGVs	490	519	541	578	600	635	737	933	811	811	836	851	844	738	747	702	694
	Buses	30	34	36	39	43	45	42	43	45	46	39	48	47	55	50	59	55
	Motorcycles	7	6	8	9	9	10	11	15	13	14	14	16	14	14	12	12	11
	TOTAL	**2,918**	**3,152**	**3,326**	**3,470**	**3,576**	**3,637**	**3,763**	**3,971**	**3,922**	**3,903**	**3,936**	**3,990**	**3,900**	**3,811**	**3,690**	**3,595**	**3,528**
CO2 (fuel sales)	Cars	2,275	2,413	2,566	2,683	2,779	2,790	2,766	2,760	2,862	2,867	2,830	2,915	2,790	2,822	2,724	2,666	2,640
	LGVs	116	135	152	159	165	170	241	246	230	227	261	254	295	235	217	222	220
	HGVs	508	564	573	572	570	583	698	856	755	800	823	890	766	706	763	728	756
	Buses	30	34	36	39	43	45	42	43	45	46	39	48	47	55	50	59	55
	Motorcycles	7	6	8	9	9	10	11	15	14	15	15	16	14	14	13	12	11
	TOTAL	**2,936**	**3,152**	**3,336**	**3,463**	**3,566**	**3,597**	**3,758**	**3,920**	**3,906**	**3,954**	**3,967**	**4,123**	**3,912**	**3,833**	**3,766**	**3,687**	**3,682**

[4] The totals in this table include emissions from Diesel and Petrol use, but do not include the small emissions from LPG and lubricants. These figures are therefore not directly comparable with the road transport emissions presented in Appendix 2, which include emissions from all fuel use.

Disaggregation of Emissions from LPG fuel Use

All emissions from LPG-fuelled vehicles are disaggregated based on the supply infrastructure that has developed in recent years to provide for this relatively new market. Information on LPG fuel supply stations was obtained from the Energy Saving Trust website, and the number of stations per DA has been used as an activity parameter to distribute UK-based emission figures for LPG consumption across each DA. It is hoped that in future years, actual LPG sales data by DA may become available to provide a more accurate methodology, though it should be noted that consumption of LPG as a transport fuel is still very small in comparison with consumption of petrol and diesel and has been declining from levels reached in 2008.

Emissions of methane and nitrous oxide from LPG consumption are calculated based on an estimate of the number of vehicles and distances travelled using this fuel.

Carbon emissions of LPG and lubricants burnt in engines are very small relative to emissions from the combustion of petrol and DERV.

A2.6.4 Railways

In accordance with the UK inventory, diesel rail emissions are compiled for three journey types: freight, intercity and regional for the DA regions. The allocation to different areas is based on information available from DfT's Rail Emissions Model (REM). This information was provided to the inventory team by direct communication with DfT (2012).

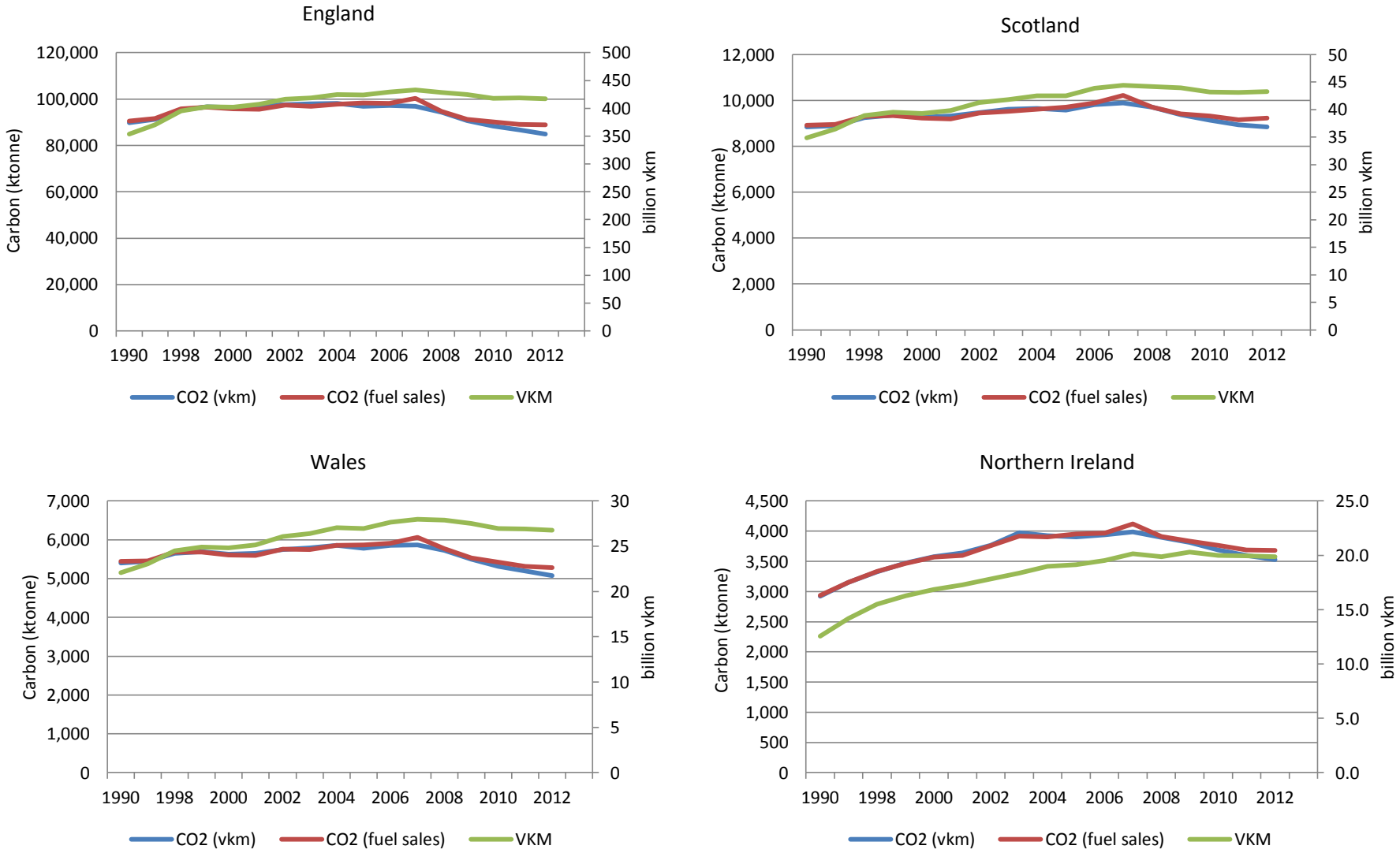
The REM covers all passenger train movements on the Great Britain rail network and provides engine kilometres by train class and by strategic route and is based on detailed information from published passenger rail timetables and Network Rail. The passenger rail movements cover 25 different train operating companies and have been calibrated against total train kilometres figures for 2009/10 taken from ORR's National Rail Trends Yearbook (ORR, 2010). The fuel consumption and emission factors were supplied to the REM by WS Atkins Rail.

REM combines the passenger train activity data with the emission factor information to provide emission estimates for each strategic route in Great Britain, which have then been allocated by the inventory team to England, Scotland and Wales. As outlined above, the most recent year in REM is currently 2009/10 and it has been assumed that the same split between the regions applies to other years. The passenger rail sector is fairly static and there are no large changes in emissions year to year and therefore in the absence of other data, this is a reasonable assumption. With the current rail electrification programme, this will not however be appropriate going forward.

Activity data for Northern Ireland is provided directly by Translink (Stewart, 2012) and the emissions arising are calculated separately and therefore this data is directly available from the UK inventory. Since 2002, the data provided covers passenger trains only as there has been no freight activity in Northern Ireland since this date.

Limited freight data is currently available from REM. Therefore data from a previous version of REM has been used to calculate the split in emissions by DA using the same approach as undertaken for passenger trains and then these figures have been applied to the 2012 UK inventory data.

Figure A2.4.1: Road transport CO_2 emission trends calculated by constrained and unconstrained methodologies and vehicle kilometres trends, 1990-2012.



A2.7 Other Sectors

A2.7.1 Commercial & Institutional

Emissions estimates for the source categories "public administration" and "miscellaneous and commercial" have previously been based on regional proxy activity data including GVA (as a broad indicator of economic activity across the DAs) or regional employment statistics. Similar to the source categories for small-scale industry and the domestic sector, there is very little detailed solid or liquid fuel use data for these sectors and hence the estimates are subject to greater uncertainty than well-documented sectors (i.e. energy-intensive industries).

The DECC sub-national energy statistics (DECC, 2013b), provide estimates of fuel use by Local Authority for each of these sectors, split by solid fuel types and "oil". These data are estimates that are based on (i) local electricity and gas meter data, and (ii) modelled estimates of the distribution of solid and liquid fuels using proxy data, concessionary coal data and information on smoke control zones. The estimation methodology has been developed for the latest inventory cycle and now follows a similar method to that described for other industrial combustion (see section A2.3.2). For gas oil, coal and gas, the available point source emissions data and fuel use data from EUETS and the pollution inventories have been analysed to allocate emissions to the DAs. The remaining emissions are allocated to the DAs using the energy modelling approach consistent with the DECC sub-national energy statistics.

National gas sales data for the commercial sector were previously reported by DTI (1992), but for later years (1995 to date) UK National Grid has provided data for regional gas use in the 73-732 MWh range. The UK National Grid source provides the closest data available for commercial and institutional consumers, but the total is lower than UK data reported by DECC (2013a). These data are used to distribute miscellaneous and public service gas use in GB.

Natural gas use data for Northern Ireland are supplied by Airtricity (formerly Phoenix Gas) for 1999 onwards (Airtricity, 2013), Firmus Energy providing sales data for 2005 onwards (Firmus Energy, 2013), Energia (2013) and Vayu Ltd providing sales data for 2010 onwards (Vayu, 2013). The commercial consumption is used as an estimate for Northern Ireland miscellaneous and public service gas consumption. A more detailed split of gas use across the domestic, commercial and industrial sectors in Northern Ireland in recent years has been provided by Airtricity, and expert judgement has been used to estimate the overall allocation of gas use to these sectors from the total gas sales data for Northern Ireland.

Consultation with DFPNI has led to the provision of detailed energy data from public sector energy reports from 2002 to 2009 and 2011, covering all fuels (including electricity) used in public sector buildings in Northern Ireland. The Public Sector Energy Campaign (PSEC) data have been used to replace previous estimates of fuel use in that sector, for most (but not all) fuels. The data scope covers building energy use and is a close match to the DUKES category description, and therefore the data have been used directly to inform gas and solid fuel use within the public sector in Northern Ireland. The reported gas oil use in the PSEC report is significantly higher than that currently reported for the UK as a whole; in the UK GHGI programme, the limited data on gas oil has been identified as problematic and these data from PSEC should now also be taken into consideration to help inform future gas oil allocations to the public sector. In the current NI inventory, therefore, there is a small under-report in public sector emissions due to this discrepancy. However, for other fuels the use of the PSEC data provides a more accurate estimate of sector emissions and trends.

Stationary combustion by the railway sector is classified as a commercial source. Consumption of burning oil, fuel oil, and coke is relatively insignificant, and has therefore been allocated according to the diesel oil driver used for locomotives. Natural gas consumption for electricity generation refers to the London Underground (Lotts Road power station – closed in 2001).

DECC (2013a) reports a small amount of solid waste (municipal, industrial & hospital) consumption for energy production in the commercial and miscellaneous sectors. Little is known about the distribution of these installations, but the emissions have been distributed using the split derived for MSW incinerators.

Table A2.5a: Other Sectors (Base Year – 1990)

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
Commercial & Institutional	Miscellaneous, Public service	Coal	DECC Sub-national energy statistics
		SSF	DECC Sub-national energy statistics
		Natural gas	Commercial Sales, DECC.
		Landfill gas	Landfill methane emissions
		Sewage gas	Sewage methane recovered
		fuel oil, gas oil	DECC Sub-national energy statistics
		MSW	As MSW incinerators
		Burning oil	DECC Sub-national energy statistics
	Railways	Oils and coal	Sub-national oil consumption, DECC

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
	(Stationary)	Natural gas	Assumed as all England
Residential	Domestic	Wood[5]	Domestic wood mapping grid
		Peat	Domestic peat consumption data, CEH
		SSF, coke, LPG	Sub-national energy statistics, NI HECA, DECC & Housing Condition Survey data, census data
		Natural gas	Domestic Gas data, DECC
		Burning oil, gas oil,	Sub-national energy statistics (oil), DECC & Housing Condition Survey data, NI HECA, census data
		Coal, anthracite	Sub-national energy statistics (coal, anthracite), DECC & Housing Condition Survey data, NI HECA, census data
		Fuel oil	Regional population, ONS
	House & Garden	DERV, petrol	Regional dwellings, ONS
Agriculture, Forestry & Fishing	Agriculture – stationary combustion	coal, coke, natural gas	Agricultural employment, MAFF
		burning oil, gas oil, fuel oil	DECC Sub-national energy statistics
		Straw[5]	Wheat production, MAFF
	Agricultural mobile machinery	Gas oil, petrol	Agricultural off-road mapping grid

Table A2.5b: Other Sectors (1995; 1998 to 2012)

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
Commercial & Institutional	Miscellaneous, Public service	Coal	DECC Sub-national energy statistics, point source data and energy modelling data, including EUETS data and PI/SPRI/ISR data, PSEC data.
		SSF	DECC Sub-national energy statistics
		Natural gas	Natural gas consumed (DECC 2013), Airtricity, Firmus, Vayu, PSEC data. GB estimates from point source data (including EUETS) and energy modelling data (including Display Energy Certificate data, employment and IDBR data)
		Landfill gas	Landfill methane emissions
		Sewage gas	Sewage methane recovered
		Fuel oil, gas oil	DECC Sub-national energy statistics, analysis of point source data and energy modelling data, including EUETS, PI/SPRI/ISR data, PSEC data
		MSW	As MSW incinerators
		Burning oil	DECC Sub-national energy statistics, PSEC data (DFPNI, 2014)
	Railways (Stationary)	Oil and coal	Regional gas oil consumption, Network Rail (GB) and Translink (NI)
		Natural gas	Assumed as all England
Residential	Domestic	Wood[6]	Domestic wood mapping grid
		Peat	Domestic peat consumption data, CEH
		SSF, coke, LPG	Sub-national energy statistics (SSF), DECC, 2009 mapping grid, using Housing Condition Survey data, NI HECA, DEMScot model, census data
		Natural gas	Domestic Gas sub-national split for GB from DECC, Transco & UK gas network operators, Data from Phoenix Gas, Vayu Ltd. and Firmus Energy (NI)
		Burning oil, gas oil,	Sub-national energy statistics (oil) from DECC, 2009 mapping grid using Housing Condition Survey data, NI HECA, DEMScot model, census.
		Coal, anthracite	Sub-national energy statistics (coal, anthracite), DECC, 2009 mapping grid using Housing Condition Survey data, NI HECA, DEMScot model, census.
		Fuel oil	Regional population, ONS
	House & Garden	DERV, petrol	Regional dwellings, ONS
Agriculture, Forestry & Fishing	Agriculture – stationary	coal, coke, natural gas	Agricultural employment, MAFF/Defra

[5] Used to calculate non-CO_2 emissions

[6] Used to calculate non-CO_2 emissions

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
	combustion	burning oil, gas oil, fuel oil	DECC Sub-national energy statistics
		Straw[6]	Wheat production, MAFF/Defra
	Agricultural mobile machinery	Gas oil, petrol	Agricultural off-road mapping grid

A2.7.2 Residential

Energy and emissions mapping analysis for the combustion of solid and liquid fuels in the residential sector was completed in 2011 and integrated into the 1990-2009 DA GHG inventory estimates; the DA share of UK fuel use totals for solid and liquid fuels are unchanged in the latest DA GHG inventory estimates. Annual gas use data estimates for the residential sector are provided by the gas suppliers in Northern Ireland (Airtricity: 2013; Firmus Energy: 2013; Vayu Ltd.: 2013; Energia: 2013) and these data have been used to estimate the residential emissions in 2012. The gas use estimates for Scotland, Wales and England are derived from the DECC sub-national energy statistics (DECC, 2013a) which presents a breakdown of gas use by Local Authority for the domestic and non-domestic sectors. Whilst the DECC sub-national energy statistics data are not directly consistent with the published UK gas use statistics for the sector, the DA share from these GB data are used to inform the gas use and emissions in Scotland, Wales and England corrected to the DUKES annual domestic gas data minus the Northern Ireland gas supplier estimates. Domestic natural gas consumption data is estimated for GB using the split presented in the DECC sub-national energy statistics for 2005 onwards (DECC, 2013a) whilst data for earlier years draws upon regional data obtained from Transco and other GB gas supply network operators.

The domestic sector DA method for the non-gas fuels does introduce uncertainty to the overall sector estimates, especially for Northern Ireland where the gas grid is limited and hence a higher proportion of the sector relies upon solid and liquid fuels. The maps and peat data only provide snapshots of analysis for the latest year and where large revisions to previous mapping grid data are evident, the DA inventory compilation must consider the impacts on time-series consistency for the sector as a whole. In order to enable a sector-wide quality check on the time-series data for the sector, estimates of the energy allocations in the sector across all fuels were derived (including estimated electricity use in each DA in the domestic sector).

Using the time series of population data, the energy use estimates per capita were calculated, in order to review the relative energy intensity per head across the time series for each DA. This is a quality check of limited usefulness given the variability in housing stock, fuel availability (e.g. on gas grid or not) climatic considerations and inter-annual variations of factors such as fuel price and average temperature which will all affect the local energy use in the sector. Further research is recommended to further develop the domestic sector dataset for each of the DAs, as this is a sector where DA policy levers can have a large impact and currently the evidence base for the energy use in the sector is uncertain.

The domestic sector emission estimates have been extrapolated back from recent mapping grid estimates, drawing on data on primary fuels used in the sector from Housing Condition Surveys in 1996, 2001 and 2006 (HECA NI, 2008), which provide a summary of fuel-switching trends away from solid fuels due to the development of the gas network and use of burning oil in Northern Ireland since the late 1990s. This approach is used for coal, anthracite, gas oil and burning oil. The Scottish Housing Condition Survey, census data and DEMScot model were considered within the domestic sector energy mapping work for 2009, which also considered more recent (2009) housing post-code level data for Great Britain, retaining some assumptions on the DA share of housing types from the 2001 census. (Personal Communication: Tsagatakis, 2010)

The consumption of fuel oil by the domestic sector is a very small amount, and is distributed simply according to population (ONS, 2013a). Domestic use of wood is estimated across the time-series using the latest mapping grid information on wood use (NAEI mapping, 2011). Domestic peat use estimates by DA are provided by the Centre for Ecology & Hydrology (Personal Communication: CEH, 2013).

A2.7.3 Agriculture, Forestry & Fisheries

Emissions from solid fuel use in the agriculture sector are not very significant, whilst regional gas use data in this sector are not available for Great Britain; in Northern Ireland the gas suppliers do provide an estimate of gas use in the agriculture sector and these data are used directly to inform Northern Ireland emission estimates for gas use, whilst in GB the emissions from agricultural sources are allocated on the basis of regional employment figures from DEFRA (2013a).

Work by AEAT (NAEI, 2008) to derive a more detailed split of regional off-road fuel use (i.e. mainly gas oil use in tractors and other mobile machinery) has utilised research to determine the regional distribution of different land uses and farm types (pasture, arable, forestry). These data have been combined with data on the intensity of mobile machinery use by farm type (tractor hours per hectare of arable land, tractor hours per head of livestock), to derive an agricultural off-road mapping grid to estimate geographical distribution of fuel use in the sector. These data have been used to estimate DA GHG emissions from agricultural mobile machinery.

A2.7.4 Military

Emissions from military aircraft and naval vessels are allocated across the DAs based on regional GVA data (ONS, 2013a). Army vehicle emissions are included within road transport data and other army emissions are included within public service categories but are not clearly defined.

A2.8 Fugitive Emissions from Fuels

A2.8.1 Coal Mining

Methane emissions arise from coal mining activities. Emissions from operating mines are estimated based on the amounts of deep mined and open cast coal produced. DA inventory estimates are based on regional coal production derived from a number of sources: Coal Authority (2013), BGS (2013), WO (1998), SO (1999), BERR (1996). A small emission occurs from coal storage and transport, which is based on deep mined coal production. Data suggests that only small amounts of coal are transported outside of the region of production and no attempt has been made to allow for this. Hence coal storage and transport emissions are distributed according to deep-mined production (Coal Authority, 2013).

DA estimates of methane emissions from abandoned coal mines are based on research undertaken by WSP (2011) on behalf of DECC, which uses a site-specific approach to estimating the methane content of seams, and rates of water ingress and methane emissions.

A2.8.2 Solid Fuel Transformation

For coke ovens, three fugitive emissions are estimated:

1. A 'residual' emission of CO_2 which reflects the difference between the carbon input to the coke oven and the carbon content of the coke and coke-oven gas produced;
2. Emissions from the flaring of coke-oven gas;
3. Emissions of methane from the process.

These are disaggregated based on the regional consumption of coking coal and site-specific fuel use data from EUETS (for 2005 onwards), as discussed in Section A2.2.3. For solid smokeless fuel (SSF) plant, the only fugitive emissions estimated are the 'residual' CO_2 emission and some process methane. The driver used is that for regional consumption of coal by SSF plant (see Section A2.2.3). It is known that some petroleum coke is used in SSF production but the amount is uncertain. The same driver is applied to the petroleum coke consumption.

A2.8.3 Oil and Natural Gas

All emissions from the oil & gas exploration and production industry that occur offshore are reported within the DA GHGI data as unallocated. Emissions from onshore oil and gas terminals in England, Wales and Scotland and from a small number of on-shore oil and gas fields, are based on operator reported data.

The estimates of terminal flaring and venting emissions are based on DECC (2013e) EEMS data for 1995, 1998-2012. Data is unavailable for 1990, so these are extrapolated based on flaring volumes reported in 1998 as the earliest year of EEMS where data are complete and consistent.

The 2000-2012 UK GHG inventories include a correction to account for flaring on onshore oil and gas fields excluded by the DECC EEMS inventory. Onshore flaring volumes are obtained from DECC sources (DECC, 2013d). Their significance in the UK national GHG inventory is minimal, but the data is more significant for the DA GHG inventories. Wytch Farm, which lies a few miles off the south coast of England, is classified as on-shore for this purpose.

The DECC EEMS inventory data provides data for fugitive emissions of carbon dioxide and methane from terminals for 1998-2012. Methane emissions arise from venting, oil storage and tanker loading and unloading, whilst carbon dioxide emissions arise from venting and processes. The DA estimates from operator reporting in 1998 are used to back-cast the DA share of UK emission totals for fugitive sources including: oil terminal storage, onshore oil loading, process emissions. Estimates provided by the trade association in 1999 (UKOOA, 1999) are used to derive the DA share of UK emissions from venting sources in 1995, with the 1995 DA share used to back-cast to 1990. Flaring volumes at oil and gas terminals and onshore production fields are available from DECC back to 1990.

UK inventory estimates of emissions of methane due to leakage from the gas transmission system are based on UK National Grid data of leakage from the high-pressure network, Above Ground Installations and the low-pressure networks. Estimates are provided by National Grid (2013) and the other gas network operators: Northern Gas Networks (2013), Scotia Gas Networks (2013), Airtricity (2013) and Wales & West Utilities (2013). Estimates are provided by Local Distribution Zones, enabling direct allocation to each of the constituent countries.

Table A2.7a: Fugitive Emissions from Fuels (Base Year – 1990)

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
Coal Mining	Deep mined coal Coal storage & transport	Deep mine coal production	Regional deep mine production, British Coal Authority.
	Open cast coal	Open cast mine coal production.	Regional open cast mine production, British Coal Authority
	Closed coal mines	NA	CH_4 from closed coal mines from WSP 2011
Solid Fuel transformation	Coke production	Coke production	Coal feed to coke ovens, ISSB, WS, DECC
	Flaring	Coke oven gas	Coal feed to coke ovens, ISSB, WS, DECC
	SSF production	Coal, Petrocoke	Coal feed to SSF plant, DECC, WS
Oil and gas production	Offshore Oil & Gas	NA	Fugitive emissions from Terminals (extrapolated from 1995)
	Oil Terminal Storage	NA	1998 operator reported emissions, EEMS
	Onshore Loading	Oil loaded	1998 operator reported emissions, EEMS
Venting & Flaring	Offshore Flaring	Volume gas flared	Flaring at terminals and onshore fields, UKOOA, DECC
	Offshore Venting	NA	Fugitive emissions from Terminals (extrapolated from 1995)
Natural Gas	Gas Leakage	Natural gas leakage	National Grid (Transco), Northern Gas Networks, Scotia Gas Networks, Wales & West Utilities
	Gas leakage	Leakage at point of use	Aggregate activity data by DA for residential, public and commercial gas

Table A2.7b Fugitive Emissions from Fuels (1995; 1998 to 2012)

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
Coal Mining	Deep mined coal Coal storage & transport	Deep mine coal production	Regional deep mine production, British Coal Authority.
	Open cast coal	Open cast mine coal production.	Regional open cast mine production, British Coal Authority
	Closed coal mines	NA	CH_4 from closed coal mines from WSP 2011
Solid Fuel transformation	Coke production	Coke production	Coal feed to coke ovens, ISSB, WS, DECC and (1999-2004) PI. 2005 onwards: EUETS (EA, SEPA, NIEA 2013b)
	Flaring	Coke oven gas	Coal feed to coke ovens, ISSB, WS, DECC and (1999-2004) PI. 2005 onwards: EUETS (EA, SEPA, NIEA 2013b)
	SSF production	Coal, Petrocoke	Coal feed to SSF plant, DECC, WS
Oil and gas production	Offshore Oil & Gas	NA	Oil & Gas UK GHG emissions from Terminals, DECC EEMS
	Oil Terminal Storage	NA	Data from storage emissions, DECC EEMS
	Onshore Loading	Oil loaded	Data from loading emissions, DECC EEMS
Venting & Flaring	Flaring	Volume gas flared	Flaring at terminals and onshore fields, Oil & Gas UK, DECC
	Venting	NA	Data from venting emissions, DECC EEMS
Natural Gas	Gas Leakage	Natural gas leakage	National Grid (Transco), Northern Gas Networks, Scotia Gas Networks, Wales & West Utilities, Phoenix Gas
	Gas leakage	Leakage at point of use	Aggregate activity data by DA for residential, public and commercial gas

A2.9 Industrial Processes

These sources report process and fugitive emissions from industrial processes as opposed to the emissions from fuel combustion used to provide energy to these processes. (Table A2.2 covers combustion emissions.) The drivers used for process and fugitive industrial releases are summarised in Table A2.8.

A2.9.1 Minerals Industries

Large emissions of carbon dioxide arise from the degradation of limestone used in cement and lime kilns. Cement emissions are estimated from the production of cement clinker, with regional emission estimations based on plant capacity data supplied by the British Cement Association[7] (2004) for 1990 to 2001. From 2002 to 2007, the regional split is based on reported emissions from the PI, SPRI and ISR, whereas in 2008 to 2012 all cement sites now report under EUETS and hence the emissions from combustion and process sources by site are derived from EUETS data. Through discussions with environmental regulators it has been determined that lime calcination only occurs in England.

Limestone and dolomite are also used in iron and steel production. Information from operators indicates that it would be impossible to identify all the different uses of limestone and dolomite in iron and steel making. The major use is in blast furnaces, and so emissions have been disaggregated based upon regional iron production figures (ISSB, 2013).

Limestone, dolomite and soda ash are also used in glass production. Emissions were previously disaggregated using plant capacity and carbon dioxide emissions data from British Glass for 1990, 1995, 1998 and subsequently extrapolated for 1999 and 2000. However, the improvement of data supplied via the Pollution Inventory (Environment Agency, 2013) has enabled more accurate disaggregation for the years 2000 and 2001. Historic data has therefore been revised where appropriate and the Pollution Inventory data now provides a more accurate methodology for regional disaggregation of UK data from 2002 onwards.

The 2009 to 2012 EUETS datasets contain a much greater coverage of sites and emission sources (combustion and process) from the glass industry, which are now used to inform time series estimates of DA activity and emissions. Previously the DA allocation of emissions from the glass sector was based on site information on production capacity, but access to fuel use data for 2009 to 2012 has enabled these assumptions to be over-written with fuel-specific DA allocations.

The inventory also reports carbon dioxide and methane emissions from Fletton brick production, as introduced in 2000. These bricks are made from Fletton clay which contains a significant amount of naturally occurring carbonaceous material and all such production occurs in England.

A2.9.2 Chemical Production

The UK Inventory reports emissions of carbon dioxide from ammonia production; nitrous oxide from adipic acid production and nitrous oxide from nitric acid production. Following the closure of a (nitric acid) fertiliser plant in Belfast in late 2001, all of the nitric acid, ammonia and adipic acid plants are within England. Prior to that, plant capacities for nitric acid production facilities were used to estimate the split in UK chemical production GHG sources. The adipic acid plant in England ceased production in 2009.

Table A2.8a: Industrial Processes (Base Year – 1990)

IPCC Category	NAEI Sources	Activity Data	Data used for deriving DA estimates from UK totals / Comments
Cement Production	Cement (decarbonising)	Clinker production	Regional cement production capacity, BCA
Lime Production	Lime (decarbonising)	Limestone consumption	All such plant located in England
Limestone and Dolomite Use	Glass production	Limestone and dolomite consumption	Regional glass production, British Glass
	Blast Furnaces	Limestone and dolomite consumption	Iron production, ISSB
Soda Ash Production and Use	Glass production	Soda Ash Consumption	Regional glass production, British Glass
Mineral Products: Other	Fletton Brick Production	Fletton Brick Production	All such plant located in England

[7] Production capacity data are used for cement emissions as the actual annual production data from cement plant are commercially confidential.

IPCC Category	NAEI Sources	Activity Data	Data used for deriving DA estimates from UK totals / Comments
Ammonia Production	Ammonia feedstock	Natural gas feedstock	All such plant located in England
Nitric Acid Production	Nitric Acid Production	Plant capacity	Regional plant capacity
Adipic Acid Production	Adipic Acid Production	Adipic acid made	All such plant located in England
Chemical Industry: Other	Methanol Production	Production of Methanol	All such plant located in England
Chemical Industry: Other	Ethylene Production	Production of Ethylene	Plant capacities
Chemical Industry: Other	Chemical Industry	NA	Extrapolated from PI data
Iron and Steel	Electric Arc Furnace	EAF steel production	Regional EAF production, ISSB
	Flaring	Blast furnace gas	Coke consumed in blast furnaces, ISSB, WO
Aluminium Production	Aluminium production	Primary aluminium produced	Regional aluminium plant capacity, ALCAN
SF_6 Used in Aluminium and Magnesium Foundries	SF_6 Cover gas	NA	Regional consumption & sales data, EM industry report 1999
Halocarbon & SF6 By-Product Emissions	Halocarbon Production	NA	All such plant are located in England.
Refrigeration and Air Conditioning	Refrigeration	NA	Regional population, ONS
	Supermarket Refrigeration	NA	Regional GDP, ONS
	Mobile Air conditioning	NA	Vehicle Registration data, AEAT industry report 2003
Foam Blowing	Foams	NA	Regional population, ONS
Fire Extinguishers	Fire fighting	NA	Regional population, ONS
Aerosols	Metered Dose Inhalers	NA	Regional population, ONS
	Aerosols (halocarbons)	NA	Regional population, ONS
Other	Electronics	NA	Regional electronics plant consumption, EM industry report 1999
	Training shoes	NA	Regional population, ONS
	Electrical Insulation	NA	Regional electrical capacity, AEAT industry report 2003

Table A2.8b: Industrial Processes (1995; 1998 to 2012)

IPCC Category	NAEI Sources	Activity Data	Data used for deriving DA estimates from UK totals / Comments
Cement Production	Cement (decarbonising)	Clinker production	Point source data from EUETS (2008 onwards), and the PI/SPRI/ISR (EA, SEPA & NIEA).
Lime Production	Lime (decarbonising)	Limestone consumption	All such plant located in England.
Limestone and Dolomite Use	Glass production	Limestone and dolomite	Regional glass production, BGlass. EUETS (2009 onwards)
	Blast Furnaces	Limestone and dolomite	Iron production, ISSB
Soda Ash Production and Use	Glass production	Soda Ash Consumption	Regional glass production, BGlass. EUETS (2009 onwards)
Mineral Products: Other	Fletton Brick Production	Fletton Brick Production	All such plant located in England
Ammonia Production	Ammonia feedstock	Natural gas feedstock	All such plant located in England
Nitric Acid Production	Nitric Acid Production	Plant capacity	Regional plant capacity, PI/SPRI/ISR. Since 2002, all plant located in England.
Adipic Acid Production	Adipic Acid Production	Adipic acid made	All such plant located in England
Chemical Industry: Other	Methanol Production	Production of Methanol	All such plant located in England
Chemical Industry: Other	Ethylene Production	Production of Ethylene	Plant Capacities, PI/SPRI/ISR
Chemical Industry: Other	Chemical Industry	NA	PI/SPRI/ISR data, or extrapolated from PI data
Iron and Steel	Electric Arc Furnace	EAF steel production	Regional EAF production, ISSB
	Flaring	Blast furnace gas	Coke Consumed in blast furnaces, ISSB, WO
Aluminium Production	Aluminium production	Primary aluminium produced	UK plant production & emissions data, Alcan, Rio-Tinto, EA, SEPA

SF_6 Used in Aluminium and Magnesium Foundries	SF_6 Cover gas	NA	Regional consumption & sales data from industry reports compiled by EM & AEAT
Halocarbon & SF6 By-Product Emissions	Halocarbon Production	NA	All such plant are located in England.
Refrigeration and Air Conditioning	Refrigeration	NA	Regional population, ONS
	Supermarket Refrigeration	NA	Regional GDP, ONS
	Mobile Air conditioning	NA	Vehicle Registration data, AEAT industry report 2003
Foam Blowing	Foams	NA	Regional population, ONS
Fire Extinguishers	Fire fighting	NA	Regional population, ONS
Aerosols	Metered Dose Inhalers	NA	Regional population, ONS
	Aerosols (halocarbons)	NA	Regional population, ONS
Other	Electronics	NA	Regional electronics plant consumption, EM industry report 1999 & AEAT industry report 2003
	Training shoes	NA	Regional population, ONS
	Electrical Insulation	NA	Regional electrical capacity, AEAT industry report 2003

The UK inventory reports emissions of methane from methanol production, ethylene production and the other chemical industry. The methanol plant is located in England, whilst ethylene production occurs in England, Scotland and Wales. These emissions are distributed based on data reported in the PI (Environment Agency, 2013a), SPRI (SEPA, 2013a) and plant capacity. Emissions are extrapolated to 1990 and 1995 based on plant capacities.

The emissions from the "other chemical industry" sector are disaggregated to England and Wales based on the site data in the Pollution Inventory. Data on emissions from other chemical processes are not available for Scotland.

A2.9.3 Metal Production

In the iron and steel industry, emissions of carbon dioxide arise from electric arc furnaces through the consumption of the graphite anodes. Regional data on steel production from electric arc furnaces is used to determine the regional drivers for this activity (ISSB, 2013).

The flaring of waste blast furnace gas is disaggregated according to the distribution of blast furnaces, using the driver derived for coal consumption by blast furnaces (ISSB, 2013) up to 2004, and then using plant-specific data from the EUETS for 2005 onwards (EA, SEPA, NIEA 2013b) verified using data from operators (Tata, 2013).

Emissions of carbon dioxide from iron and steel making are estimated from a mass balance on the coke consumed in blast furnaces; the blast furnace gas produced; the pig iron produced; the pig iron used in steel making and the crude steel produced. The emissions are distributed using appropriate drivers for each source and sink taken from ISSB (2013) and on site-specific information for the integrated steelworks taken from the EUETS for 2005 onwards.

The electrolytic process used to produce aluminium results in a carbon dioxide emission as the petroleum coke anode is consumed. Emission estimations are based on plant capacity data provided by Alcan (2004), for years up to 2002. The DA emissions data for 2003 onwards are based on PI and SPRI data (EA, 2013a; SEPA, 2013a). There have been some significant changes in the aluminium industry in recent years, with the closure of the Kinlochleven plant in 2000, and the recent closures of the Anglesey Aluminium and then the Lynemouth plant.

The anode baking process within aluminium production also results in emissions of PFCs, and estimates are provided by plant operators (Rio Tinto Alcan, 2013).

A2.9.4 Use of Halocarbons and Sulphur Hexafluoride

The UK emissions of halocarbons and sulphur hexafluoride (SF_6) were based on estimates from a model prepared initially by Enviros March (1999). This model was updated by AEAT (Haydock et al, 2003), with further updates at UK level for the refrigeration and air conditioning sectors during 2008-9 (Personal Communication: MacCarthy, 2010) and again during 2011 (Brown et al, 2012). For some sources, the emission is equal to the consumption of fluid (e.g. aerosols). For other sources the emissions occur during product manufacture, leakage

during product lifetime, and at product disposal (e.g. refrigerators). In these cases emissions are estimated from a time dependent model of the bank of fluid held in products, accounting for unit production and disposal.

Data for HFC emissions from metered dose inhalers in the UK are now taken from NHS prescription records which are available for each DA.

Supermarket refrigeration is regarded as sufficiently different from other refrigeration to warrant a separate study. Emissions are based on a market review of the number and size of supermarkets in the regions, combined with discussions with gas manufacturers on the sales into this sector. Discussions with supermarket owners also suggest that regional use could be approximately equated to sales volume, which in turn could be approximated by regional GVA estimates, which have been obtained from ONS (2013a). The DA GVA data are therefore used to estimate the share of refrigeration emissions within the UK.

Air conditioning systems in cars began to use HFC134a from around 1993. Data is supplied by SMMT on regional sales of new cars. Initially, installation of air conditioning was skewed towards company cars, which are broadly distributed according to population.

PFCs and SF_6 are used to cushion the soles of some training shoes. Data have previously been gathered from discussions with manufacturers. Sales figures for the devolved regions of the UK were not available, and therefore the regional split is made according to population.

Sulphur hexafluoride is used in electrical switchgear within the electricity transmission system. UK estimates are based on discussions with industry sources and summarised within the EM & AEAT model. Regional estimates are determined through consultation with power supply companies (NIE, Scottish Power & Scottish Electric, National Grid) and the Electricity Association.

For aerosols, the split by region is made on the basis of population, although use of these gases often have industrial applications. Making the split using population has the advantage of making the data directly comparable with the figures for the baseline years of 1990 and 1995.

Other sources such as fire extinguishers are very small and are likely to be distributed with the general population.

Emissions of SF_6 cover gas from magnesium production is based on regional sales and consumption data. This stable market is assessed within the AEAT model (2003), with all production located in England & Wales.

Emissions data for regional emissions from semiconductor wafer manufacture are estimated from manufacturing data and consultation with relevant trade associations, and incorporated within the AEAT model (2003).

A2.10 Agriculture

Rothamsted Research provides all data and information pertaining to agricultural sources within the Devolved Administration emission inventories.

The UK inventory is disaggregated into the Devolved Administrations of England, Scotland, Wales and Northern Ireland, with all default factors and emission factors carried over from the national inventory. The compilation of the emissions is carried out at DA level and added up to national level.

A2.10.1 Agricultural Soils

Annual consumption of synthetic fertilizer is estimated based on crop areas from the Devolved Administrations[8] and the British Survey of Fertiliser Practice (plus country-specific data for Northern Ireland provided by Paul Caskie, DARDNI). Crop production data were provided by Tom Johnson, DEFRA (England & Wales), Helen McAfee, The Scottish Government and Conor McCormack, DARDNI. The Scottish crop production time series for 2008 to 2012 was revised due to improved data sources. Some crop production values were also updated for E&W (from 2006).

The area of cultivated histosols has been kept consistent with the value reported under LULUCF. The UK total updated from 392 km^2 to 1500 km^2 is reported under England only (UK GHG Inventory, 1990 to 2012 Report, Section A 3.5.7; total area of peat 150,000 ha).

Data sources for the annual production of sewage sludge (as dry matter) are described in Waste sector (NIR Section 8.3).

A2.10.2 Livestock Enteric Fermentation and Manure Management

The dairy cattle emission factors (for dairy cows only) are estimated following the IPCC Tier 2 procedure (IPCC, 2000), using country-specific data for dairy cow live weight, milk yield, milk fat content, feed digestibility and activity (proportion of the year spent grazing) and vary from year to year. Livestock population data are reported annually as statistical outputs of the four Devolved Administrations of the UK (i.e. England, Wales, Scotland and Northern Ireland), based on the annual June Agricultural Survey for each country. The sources are for England: https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june, Scotland: http://www.scotland.gov.uk/Publications/2012/09/1148/downloads ; Wales: http://wales.gov.uk/statistics-and-research/survey-agricultural-horticulture/?lang=en and John Bleasdale, Welsh Government; and Northern Ireland from: http://www.dardni.gov.uk/june-agricultural-census-final-results and Paul Caskie, DARDNI. Milk production and fat in milk are obtained from Agriculture in the UK (Defra, 2013), with common values used across the DAs. Dairy cows live weights are derived from slaughter weight data, provided by Defra (http://www.defra.gov.uk/statistics/foodfarm/food/slaughter/). The proportional annual breakdown of the amounts of different forages consumed by dairy cows (40% as fresh grass, 50% as grass silage, 10% as maize silage) is based on expert opinion (Bruce Cottrill, ADAS) taking into account the proportion of time spent at grazing by dairy cows and the amount of maize grown in the UK. A country-specific value for the digestibility of feed (DE), expressed as a percentage of the gross energy, for dairy cows is used. As recommended by the Review Team, the value was adjusted from the 75% and is based on typical diets for cows over the lactating and non-lactating period, combining forage and concentrates, with energy values for the various feeds according to MAFF (1990). N excretion factors are kept in agreement with the UK NH_3 inventory (Cottrill and Smith, ADAS, 2006), with common values used across the DAs.

A Tier 2 methodology is used for the calculation of the enteric emissions from beef cows, but a time series of cattle weights is not available, and so a constant weight of 500 kg has been assumed (expert opinion, Defra). The digestibility value for beef cows used by the UK is 65% for annual average feed composition based on expert opinion (Bruce Cottrill, ADAS). A Tier 2 methodology is used for the calculation of the emissions from other cattle but live weight is not changed from year to year.

The UK uses IPCC Tier 1 default emission factor for enteric fermentation for all mature sheep (> 1 year old). The UK uses a country-specific emission factor for enteric fermentation for lambs at 40% of that of an adult sheep (Sneath et al. 1997) together with a reduction factor reflecting the reduced lifespan of lambs. The average lifespan of lambs is estimated by Wheeler et al. (2012) as 8.1 months. The UK emission factors for deer are country-specific and are based on Sneath et al. (1997). The UK has revised the time series data for horses 1990-2012 to include both agricultural and non-agricultural horses. The allocation of excreta to management systems has also been revised by reducing the allocation of manure to daily spread, affecting cattle, pigs & poultry. The difference was attributed to Deep litter as a

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

response to the review, the allocation of manure to solid storage and dry lot was changed to deep litter. The methane conversion factor (MCF) was updated from 1% to 39% for deep litter (previously solid storage and dry lot).

The CH_4 emission factors for manure management are calculated following IPCC Tier 2 methodology using default IPCC data for volatile solids (VS) and methane producing potential (Bo) parameters for each livestock type (except for dairy and beef cows, where a Tier 2 calculation is used to determine VS, and deer where no IPCC data are available), country-specific data for the proportion of manure from each livestock type managed according to the different animal waste management systems (AWMS) and IPCC default methane conversion factors for the different AWMS (IPCC 2000).

Calculation of N_2O emissions from manure management follows IPCC (1997) (equation 2, p 4.98) for each livestock category and subcategory, using country-specific data for nitrogen excretion by the different livestock types and for the proportion of manure managed according to the different AWMS, and default IPCC emission factors for the different AWMS (IPCC, 2000). Country-specific values for nitrogen excretion per head for the different livestock types were derived from the report of Defra project WT0715NVZ (Defra, 2006) with interpretation by Cottrill and Smith (ADAS)

A2.10.3 Reasons for changes

There were a number of changes in the inventory for this submission:

- Change in the digestibility value produced an increase in emissions across all DAs;
- Inclusion of non-agricultural horses also produced an increase in emissions;
- Changes in the distribution of the AWMS and the corresponding MCFs produced an increase in emissions in all DAs;
- Changes in crop production data in Scotland changed emissions between 2008 to 2011 whilst changes for England and Wales changed emissions from 2006 onwards;
- Revised data for sewage sludge produced a change in emissions.

A2.10.4 Planned improvements to the inventory

There are a number of planned improvements for the Agriculture inventory. UK emission factors are currently under review for:

- EF1, emission factor for direct soil emission – from a literature review and a field measurement programme;
- EF3, emission factor from manure management systems – from a literature review and a field measurement programme;
- EF5, nitrogen leaching/runoff factor – from a field measurement programme.

The UK aims to improve the spatial disaggregation of the inventory by calculating emissions using parameters specific at DA level.

The UK is improving the link between the NH_3 and GHG inventories, and incorporating NOx in a study (desk/experimental) which will review the current value of 20% of N lost as NH_3 and NOx.

A large programme of improvements to the UK inventory is underway, as a platform of projects to provide country specific data has been funded by Defra. Improvements include analysis of available data from the literature, and specific experimental work to improve the estimates of emissions of N_2O and CH_4.

A2.11 Land Use, Land Use Change & Forestry (LULUCF)

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

The description of the DA GHG inventory methodology and emission estimates are included in a report published in April 2014 (CEH, 2014). Net emissions and removals in greenhouse gases are summarised for each country and the reasons for differences from the previous inventory are provided.

Detailed information on the data and methods used in the LULUCF inventory is available in the 1990-2012 UK Greenhouse Gas Inventory Report, available on the National Atmospheric Emissions Inventory website http://naei.defra.gov.uk/. Chapter 7 and Annex 3.7 contain information on the LULUCF sector, and Chapter 11 contains additional information on the reporting of LULUCF activities for the Kyoto Protocol. Additional information on LULUCF and KP-LULUCF inventory reporting has been made available at http://ecosystemghg.ceh.ac.uk/.

The current LULUCF inventory methods use a combination of top-down and bottom-up approaches, based on activity data for each of the Devolved Administrations and the UK as a whole. As a result of this approach, estimates of emissions and removals from LULUCF activities are automatically produced at the DA and UK scale.

A2.12 Waste

A2.12.1 Solid Waste Disposal on Land

In the UK Inventory, emissions are estimated based on a model of methane production in landfill sites. The generation of methane is assumed to follow a first order model with different decay rates for different types of waste. The model requires data on waste disposals and waste composition from 1945 onwards.

The UK GHGI waste model was revised and updated during the 1990-2010 inventory cycle to correct a number of errors in the model from the previous inventory cycle, and incorporating a range of DA-specific data on waste composition, MSW arisings. These revisions have been retained. In the 1990-2012 inventory cycle, further revisions have been made to accommodate new data analysis on methane utilised in landfill gas engines and flares, drawing upon evidence from research by Defra and the Environment Agency. The revisions to the assumptions in the UK landfill model regarding methane utilisation are outlined in detail within the UK GHG National Inventory Report (Webb *et al*, 2014) and have led to higher estimates of methane emissions from landfills in all DAs in recent years (with much lower revisions for the early part of the time series).

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

The current model retains much of the design and functionality of the previous GHGI waste model; due to a lack of detailed local data, it is assumed that the level of methane recovery is the same in each region.

Data from the www.WasteDataFlow.org website are used to estimate DA landfill activity. The Waste Data Flow website is used by Local Authorities to track progress towards waste sector objectives. Reports from the Waste Data Flow organisation have been reviewed, and these provide a more detailed split of waste disposal options undertaken in the DAs, with ultimate fate of municipal waste recorded against numerous options, primarily: recycling, landfill and incineration.

The detailed methodology for determining DA emission estimates from landfills was revised by Defra in the 1990-2010 inventory cycle to derive estimates of landfill methane emissions by country. The method makes use of disaggregated waste arising and compositional analysis data to reflect better the individual country emissions, rather than taking UK aggregate emission estimates and scaling.

Following the update to MELMod (released in the 2011 inventory submission), we now have a much more disaggregated understanding of the waste quantity assumptions fed into different MELMod categories. The underlying data, as well as references, that fed into the 2011 revision is discussed in depth in a separate report.[9] Estimates of country-specific landfill tonnages are derived by:

- Using the data on Local Authority Collected Waste (**LACW**, previously known as MSW). There is not annual data on the quantity and composition of landfilling. For each country, however, there are periodic surveys of waste composition, as well as quarterly/annual data on quantity of waste landfilled, and the quantity/composition of recycling.

  These sources are combined to produce a best estimate of the quantity of different types of waste landfilled. The data are uncertain due to the limited nature and frequency of compositional surveys; however, the data on landfilling and recycling of materials is considered to be associated with low uncertainty.

  Country-specific data were revised back to 1995 within the UK model update in the 1990-2010 inventory. Data for 2011 and 2012 are derived based on a projection from 2010.

- Data are less frequent and complete for commercial and industrial (C&I) waste; DA-specific data have been used where available, whilst UK average data have been used to fill data gaps in other DAs.

  The quantity of different types of landfilling was computed from compositional data, landfill site returns, landfill tax data and data on the composition and destination of construction and demolition (which is required to determine what element of construction and demolition waste is methane-producing).

  The overall input to MELMod was not done on a country-by-country basis due to the data limitations.

[9] http://randd.defra.gov.uk/Document.aspx?Document=9887_WR1124Finalreportincludingappendices.pdf

The DA estimates are based on available data that were used within the UK MELMod model used in the 1990-2012 UK GHGI (Webb et al, 2014). The following section explains the method.

Local Authority Collected Waste (LACW)

- LACW estimates of landfilling by waste type are available for each country from 1995 to 2020.
- The time series of data were extrapolated back from 1995 and forward to 2012;
- The data time series was extrapolated back from 1995 for each country by applying the UK figures in Melmod pre-1995 to each country's share of overall LACW landfilling in 1995.
- The data time series was projected forward to 2012 by flatlining.

Commercial and Industrial Waste (C&I[10])

- DA-specific C&I waste data is very limited or not available at all; the method uses the available estimates of overall UK compositions of C&I (and C&D) waste landfilled in different years, based on waste surveys, and combines the UK-wide data with DA-specific estimates of total landfilling of commercial, and industrial, waste for given years (interpolated from the available survey evidence).
- Using the estimates over country-specific landfilling of both commercial and industrial waste, and applying the estimated UK C&I landfill composition allows a calculation of country specific estimates of the quantity and type of waste landfilled.
- Due to data limitations, the Eunomia revision only went as far back as 1997. A similar backwards extrapolation to that for LACW was performed, according to each country's relative share of combined commercial and industrial landfilling in 1997.
- As the C&I estimates are not country-specific in the revision, forward projections to 2012 are estimated on a country basis by taking the most recent year's data (at the time of the revision) – 2008/09 – for each country's share of commercial, and industrial, landfilling, and multiplying by the assumed overall UK composition for that year.
- The estimation of country-specific C&D landfilling (which feeds into the 'C&I' section of MELMod) followed the same process as set out above for C&I.

The method applies the current UK assumptions on methane capture and oxidation to the country-specific emission estimates.

A2.12.2 Waste Water Handling

Nitrous oxide emissions from waste-water handling are based on population statistics for the UK (ONS, 2013a) whilst methane emission estimates are based on operator reported data on treatment activities from water companies in England and Wales and from Scottish Water (Personal Communication: Jacques-Turner, 2013) and Northern Ireland Water Service directly (Personal communication: Pollock, 2013). Methane emission factors for water treatment and sewage sludge treatment and disposal options are derived from operator information provided for the UK GHGI compilation process (Scottish Water 2013, Northern Ireland Water 2013, Thames Water 2013, Yorkshire Water 2013, Anglian Water 2013, South West Water 2013). There has been some improvement to the UK GHGI methodology for this source during the 1990-2012 cycle, with almost 100% coverage of major UK water companies now reporting emission estimates to the NAEI/GHGI work programme.

Estimates of emissions from industrial waste water treatment are included in the UK GHG inventory in the 1990-2012 cycle and are distributed across the DAs based on the dataset from water companies outlined above.

A2.12.3 Waste Incineration

The UK Inventory reports emissions from the incineration of sewage sludge, municipal solid waste and some chemical waste. DA estimates are based on DEFRA (2013a) which reports data for the amount waste incinerated for Scotland, Northern Ireland and England & Wales.

[10] Also includes C&D waste in MELMod.

Emission drivers from MSW Incinerators for 1990-1995 are based on capacity data for individual incinerators taken from RCEP (1993). It is assumed there were no significant changes between 1990 and 1995. Estimates for recent years are based on plant capacity data (Patel, 2000). All of the larger MSW incinerator plant have been re-fitted during the late 1990s to generate electricity and are therefore reported as power stations in the regional inventories. A handful of smaller waste incinerators (municipal, industrial and clinical) are used for district heating and are reported as commercial or miscellaneous. The disaggregation of these smaller heat-generating plant is based on the same driver as for larger MSW incinerators, as there is no specific source of information that provides a more satisfactory estimation of the regional split. The total consumption of these incinerators is reported within the Digest of UK Energy Statistics (DECC, 2013a).

Emissions from clinical waste incineration are allocated to the regions based on a set of plant capacity data for 1998. Emissions data from chemical waste incineration are available for England and Wales only, based on data taken from the Pollution Inventory (Environment Agency, 2013a), and these data are used for the DA estimates also. Some chemical waste incineration takes place in Scotland but no emissions data are available, and hence the emissions contributed from this source are currently omitted from the Scottish inventory data. No chemical incinerators have been identified in Northern Ireland.

Appendix 3: Methods Used for Calculating End User Emissions

A3.1 Introduction

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

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

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

A3.2 End User Methodology

The method for calculating UK emissions on an end user basis is described in Annex 13 of the National Inventory Report (Webb et al., 2014). The calculation uses an iterative approach, carried out in a database. As an overview, the approach is summarised in the three steps below:

1. Emissions are calculated for each sector for each fuel.

2. Emissions from fuel and electricity producers are then distributed to those sectors that use the fuel according to the energy content of the fuel they use (these sectors can include other fuel producers).

3. By this stage in the calculation, emissions from final users will have increased and those from fuel and electricity producers will have decreased. The sum of emissions from fuel producers and power stations in a particular year as a percentage of the total emissions is then calculated. If this percentage, for any year, exceeds a predetermined value (e.g. 1% or 0.01%) the process continues at Step 2. If this percentage matches or is less than the predetermined value, the calculation is finished.

Convergence of this iterative approach is likely, as the fuel flows to the final users are much greater than fuel flows amongst the fuel producers. This calculation results in a table of emissions for the UK on an end user basis. Emissions from the energy supply sector are decreased to a very small number, and emissions within the end user sectors are increased.

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

In order to allocate the energy supply emissions to all sources, additional estimates have been required for the disaggregation of electricity use, and for the exports[11] category. Table A3.1 summarises the data used to derive DA estimates for sector-specific electricity use and exports.

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

Table A3.1 Summary of DA Data used to Derive Sector Estimates for Electricity Use and Exports

Assumptions for Electricity and Exports		
Source Name	Activity Name	Description
Public sector	Electricity	Northern Ireland public sector electricity use for 2003 onwards is taken from the Public Sector Energy Campaign dataset (DFPNI 2013), whilst the DA share of GB activity is derived from analysis of the Inter-Departmental Business Register for 2003 onwards. The 1990 estimates for all DAs are based on economic indicators from previous studies using the REEIO model.
Miscellaneous industrial / commercial	Electricity	The DA share of UK activity is derived from analysis of the Inter-Departmental Business Register for 2003 onwards, whereas the 1990 estimates are based on economic indicators from previous studies using the REEIO model.
Domestic	Electricity	Country-specific domestic electricity use in GWh, is taken from analysis within DECC Energy Trends March 2014 (for 2005 to 2012), December 2008 for 2003 and 2004, and from REEIO analysis for 1990. Scotland 1990 data are estimated by back-casting reported trends in domestic electricity use from the Scottish Housing Condition Survey. England, Wales and Northern Ireland data retain the % share from the REEIO analysis. No Northern Ireland data were available in the March 2014 Energy Trends, however, so the Northern Ireland domestic electricity in 2012 was estimated assuming that the domestic sector share of total NI electricity consumption was the same as in 2011.
Iron and steel - combustion plant, and Blast Furnaces	Electricity	Country-specific electricity use data for 2003 onwards is derived from ISSB regional energy statistics (ISSB, 2014), and 1990 electricity use is estimated from ISSB regional production statistics.
Railways	Electricity	The DfT Rail Emission Model indicates that there are no electrified lines in Wales or Northern Ireland, and has been used to estimate the UK share of total rail electricity use in England and Scotland.
Gas production	Electricity	Overall annual gas throughput via each of the Low Pressure Distribution Zones has been used as an indicator of regional electricity use in this sector. The LDZ throughput data are available from the gas network operators (National Grid, 2013; Northern .
Refineries - combustion	Electricity	Carbon dioxide emissions from refineries are used to estimate the DA share of UK sector electricity consumption.
Collieries - combustion	Electricity	Regional coal production data are used to estimate the DA share of UK electricity use by collieries.
Exports	Electricity	DA data on electricity exports are published within the periodic DECC publication “Energy Trends”. However, we note that the data published are the “net” import-export balance and the actual data on electricity exports from England and Northern Ireland have been obtained through personal communication with the DECC energy statistics team in 2014. (Personal communication: Gavin, 2014)
Other industrial combustion	Electricity	For 2003 onwards, the “other industry” estimate of DA electricity use is derived by difference using the DECC Energy Trends DA totals for electricity sales and the estimates for other sectors. The 1990 estimates are calculated by difference, using 1989 regional electricity sales data scaled to 1990 UK electricity totals.
Non-ferrous metals (combustion)	Electricity	Electricity use estimates by DA are based on analysis of the DA share of the economic sector from the Inter-Departmental Business Register for 2010, with the 2010 DA split applied across all years.
Chemicals (combustion)	Electricity	Electricity use estimates by DA are based on analysis of the DA share of the economic sector from the Inter-Departmental Business Register for 2010, with the 2010 DA split applied across all years.
Pulp, paper and print (combustion)	Electricity	Electricity use estimates by DA are based on analysis of the DA share of the economic sector from the Inter-Departmental Business Register for 2010, with the 2010 DA split applied across all years.
Food, drink and tobacco	Electricity	Electricity use estimates by DA are based on analysis of the DA share of the economic sector from the Inter-Departmental Business Register for 2010, with the 2010 DA split applied across all years.
Agriculture - stationary combustion	Electricity	For Northern Ireland, estimated electricity use is based on DETI (2010)[12] which provides electricity use estimates for the sector in 2005; the estimates for other years in Northern Ireland have been scaled on the UK sector electricity trends. For GB, employment on Agricultural Holdings data is used to estimate the DA share of GB sector electricity use for all years.
Exports	ATF, Burning Oil, DERV, Fuel Oil, Gas Oil, Petrol	In each year, the DA share of carbon dioxide emissions from refineries is used as an indicator of DA oil exports.
Exports	Coke	Regional data on coal consumed in coke ovens from ISSB statistics, DUKES, and WDig Hist Stats are used to estimate the DA share of coke exports.
Exports	SSF	Regional data on SSF production, based on reported or estimated annual plant production by site are used to estimate the DA share of SSF exports.

[12] http://www.detini.gov.uk/business_opportunities_and_challenges_arising_from_carbon_emissions_targets_interim_report.pdf

A3.3 Revisions to End User Inventory Data and Methodology

The DA end user method has been updated since the 1990-2011 DA GHG inventory report, with data and method improvements to further develop the DA end user estimates, to build upon new information and data. There have therefore been recalculations of the end user estimates as a result of these data updates. The key differences in the approach used for the DA end user calculation this year compared with last year are summarised below:

- Revisions to the total DA electricity sales data for 2011 are evident within DECC Energy Trends March 2014; the 2011 total electricity use allocations for Scotland and Northern Ireland have been increased by 6% compared to previous estimates, whilst the England electricity total demand has reduced by around 1%. These revisions will lead to higher 2011 end user estimates for Scotland and Northern Ireland than in previous inventory estimates, and lower estimates for England;
- Electricity estimates for the public sector in 2011 were revised based on new data from the Northern Ireland Public Sector Energy Campaign.

A3.3.1 End User Analysis by National Communication Sector

Analysis of the outputs from the updated DA end user model is presented below, with details provided for the National Communication sectors where the end user approach has the greatest impact compared to the by source inventories. More detail is provided within each of the DA chapters of this report.

Note that the application of UK-wide factors to derive end user emission estimates for electricity consumption in the UK has a notable impact on the re-distribution of power sector emissions from the by source inventory dataset, and affects the comparisons with overall DA source emissions. For example, the power sector emissions in Scotland in the by source inventory are lower per unit GWh generated than the rest of the UK, but a UK-wide factor is applied to all UK electricity consumption. This leads to an oddity in the comparison of by source and end user emissions, as Scotland in 2012 is a net exporter of electricity, but a net importer of electricity-related emissions in the end user model.

Business

The business sector includes industrial and commercial energy use sources, in addition to a number of non-energy sources such as the use of fluorinated gases. Across the UK in 2012 the end user estimates for the business sector are 206% that reported in the by source inventories, i.e. more than double the emissions are allocated to the business sector once the upstream energy processing emissions are allocated on to the users of refined fuels and electricity. This doubling of emissions on an end user basis increases the significance of the sector in the overall inventory; in 2012 in the by source inventory the business sector represents 15% of national GHG emissions, but on an end user basis this increases to 31%, highlighting the importance of the sector for energy efficiency policy implementation.

The high percentage increase in the end users data compared to the by source data indicates the large contribution of the electricity component in the DA end user estimates. The use of electricity for heating, lighting and operating equipment has a marked effect on the emissions attributed to this sector, when compared to the emissions in the by source inventories which only include estimates from direct fuel use in the sector.

Residential Sector

The residential sector includes emissions from domestic fuel combustion and electricity use, in addition to smaller emissions from the breakdown of consumer products, accidental vehicle fires, and HFC emissions from the use of aerosols and metered dose inhalers. The non-fuel combustion sources are unchanged between the by source and end user approaches.

In 2012 the UK end user estimates for the residential sector are 188% that reported in the by source inventories, due to the additional emissions allocated from the upstream energy process sectors to deliver the refined fuels and electricity that are consumed in the sector. The percentage increase in the end users emissions data compared to the by source data is predominantly due to the additional contribution of the electricity component in the DA end user estimates, although emissions associated with the extraction and processing of solid and petroleum fuels will also contribute.

Similar to the business sector above, much higher emissions on an end user basis increases the significance of the residential sector in the overall inventory; in 2012 in the by source inventory the residential sector represents 13% of national GHG emissions, but on an end user basis this increases to 25%, highlighting the importance of the residential sector for energy efficiency policy implementation.

The domestic sector estimates of electricity use in 1990 for each DA are based on sales data from regional electricity companies for 1989, scaled to the 1990 UK domestic electricity use total, with the Scottish estimates derived (as noted above) from Scottish Housing Condition Survey data. In addition, the sub-national energy statistics published by DECC for recent years within the periodic publication Energy

Trends, provides domestic sector estimates of electricity use for each DA. Therefore, these sector estimates are associated with lower uncertainty than many of the other sectors.

Public Sector

This sector contains emissions from the combustion of fuel, and electricity use, within the public sector. The percentage increase in the end users data compared to the by source data for the public sector is 196%, similar to that reported for the business sector and for the same reasons, i.e. the high use of electricity as a fuel in the sector to provide heating, lighting cooking etc. Despite the large increase, the sector as a whole remains a modest overall contributor to the national inventory totals: even on an end user basis, in 2012 the UK public sector only represents 3.5% of the national GHG emissions total.

Transport

The transport category includes all emissions from road transport, rail (including stationary sources), national navigation and coastal shipping, domestic aviation, military aviation and coastal shipping.

In many end user sectors, the fuel mix within each DA will vary and hence the impact of the end users approach will also vary quite markedly as the additional emissions associated with different fuel groups combine to derive the total end user estimate. In the transport sector, however, the majority of the fuels used are derived from petroleum processing (with the exception being combustion in the rail sector), and hence the effects of the end user method can be seen in isolation for the petroleum sector. The end user estimates in recent years are a steady 13-16% higher than the by source estimates, reflecting the additional emissions from upstream oil extraction and the oil refining sector.

Other Sectors

Emissions from the Land Use, Land Use Change and Forestry (LULUCF) and Waste Management sectors are unchanged between the by source and end user approaches, since there are no emissions from energy use allocated to these sources.

The end user increment within the Industrial Process sector is limited to the use of fuels in ammonia production (feedstock use of natural gas), and iron and steel (where emissions are allocated to process use, rather than combustion).

For Agriculture, the increase in emissions using the end user approach is limited to the emissions from energy use within the sector.

A3.3.2 Summary of End User Data for Wales "Electricity Only" Emissions

The allocation of emissions from electricity use in the end user DA inventories is of specific interest for the reporting of progress against GHG reduction targets for the Welsh Government; the Climate Change Strategy for Wales (2010) has established emission reduction targets that address the scope of devolved powers for the Welsh Government, and this requires analysis of the impact of the operation of the UK electricity supply grid. Therefore we present here a summary of the end user emissions that are allocated from the use of electricity in Wales during 2006 to 2012, as the Welsh Government targets use a baseline from 2006 onwards. Note that these data exclude the by source emission estimates and also the component of the end user dataset that relates to the use of solid fuels, natural gas and petroleum fuels.

Table A3.2 Wales End User Electricity Only Emissions, 2006-2012, $MtCO_2e$

NC Category	2006	2007	2008	2009	2010	2011	2012
Agriculture	0.3	0.3	0.3	0.27	0.28	0.26	0.27
Business	6.57	6.35	6.17	5.18	5.34	5.09	5.41
Energy Supply	0	0	0	0	0	0	0
Exports	0	0	0	0	0	0	0
Industrial Process	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Public	0.49	0.51	0.5	0.45	0.44	0.41	0.45
Residential	3.36	3.14	3.06	2.82	2.85	2.58	2.87
Transport	0	0	0	0	0	0	0
Wales Total	10.73	10.31	10.03	8.72	8.92	8.34	9.02

As outlined in the methodology text above, the main revisions to the Wales end user data stem from revisions to the electricity sales data published by DECC within Energy Trends and therefore the Wales share of end user emissions (overall and by sector); total electricity sales

data were revised upwards for both Scotland and Northern Ireland in 2011, and this has had the knock-on effect of slightly reducing the electricity emissions allocation to Wales in 2011.

Appendix 4: Emissions Analysis and Methods used for Devolved Administrations' Traded and Non-Traded Emissions

A4.1 Background

The data analysis and reporting of greenhouse gas (GHG) emission inventories in the UK, both at the national and sub-national level, is increasingly coming under scrutiny for the purposes of energy and climate change policy development, evaluation and appraisal. In recent years the GHG inventory improvement programme has focussed on developing close consistency with emissions data from new data reporting systems from UK-wide policy mechanisms such as the European Union Emissions Trading System (EU ETS).

For the UK to achieve progress in emission reductions across the economy, a detailed understanding of the scope, level and trend of non-traded GHG emissions (i.e. those emission sources that are not within the EUETS) is needed to support evidence-based policy development within the climate change strategies and programmes implemented by the Department of Energy and Climate Change (DECC) and the governments of Scotland, Wales and Northern Ireland; good quality GHG emissions data by source will enable the DAs to design and implement devolved policy mechanisms that are effective and cost-effective in achieving GHG reduction targets, to complement the actions through reserved UK-level policies and measures.

The analysis of the emissions and trends in the non-traded sector are of particular relevance for the Welsh Government, as the GHG reductions targets in Wales exclude the emissions from sites in EU ETS.

A4.1.1 UK Context: The Greenhouse Gas Effort Sharing Decision

In December 2008, the Greenhouse Gas (GHG) Effort Sharing Decision (ESD) was agreed as part of the EU 2020 Climate and Energy package of measures; the ESD sets EU Member State GHG reduction targets for the economic sectors that are not covered by the EU Emissions Trading System.

The UK target under the ESD equates to a reduction in emissions in the non-ETS sections of the UK economy of 16% below 2005 levels, by 2020. Furthermore the ESD includes a binding annual emissions reduction trajectory from 2013 to 2020 to keep the EU on track to meet its emissions reduction targets over that period, monitoring and evaluation provisions and flexibility mechanisms to enable Member States to cost-effectively meet their targets.

Each Member State has autonomy over which policy measures to use to meet their national targets, and in the UK the national mechanisms will be governed by the Climate Change Act, the Energy Act, the Renewable Energy Strategy and the Low Carbon Transition Plan.

At the national level, the UK GHG inventory has been subject to a detailed review by the European Commission, to assess data quality of the traded and non-traded components of the UK inventory. This review has focussed on the veracity of the current baseline inventory totals for 2005 and 2008-2010 and the level of consistency between data reported through the EU ETS and the GHG inventory.

A4.1.2 Non-Traded Emissions in the UK

Non-traded GHG emission sources in the UK comprise:

- small-scale fuel combustion sources in industry, the commercial sector, public sector and residential sector;
- transport emissions;
- agricultural emissions;
- Land Use Change and Forestry emissions / sinks;
- Waste sector emissions.

The small-scale fuel combustion sources are usually sources where comprehensive accurate data on energy use and / or emissions are not available at DA level. DA emissions in the traded sector are much more certain, since the mechanism for trading requires site-specific reporting of detailed emissions, activity and emission factor data. The current approach to deriving the non-traded fuel combustion emission estimates is therefore by difference from the total DA GHG inventory for energy emissions and the EUETS emissions data:

Non-traded emissions	=	total emissions	–	traded emissions

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

Through research with DECC energy statisticians, the UK GHG inventory team has integrated EU ETS activity and emission factor data into national energy statistics and GHG inventory estimates in order that close consistency has been achieved in the UK between the EU ETS and GHG inventory; inconsistencies between the inventory and EU ETS remain for a number of sources, but overall the data quality for the non-traded sector in the UK has improved greatly in recent years.

The estimates derived for the traded and non-traded sectors of the DA GHG inventories presented in this report are for the years 2008 to 2012 only, as the earlier years of EU ETS data covering 2005 to 2007 were during Phase 1 of the scheme when a more limited scope of installations was included. Comparison of data from Phase I and Phase II is therefore of little value.

A4.2 Data Quality and Reporting Format Issues

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

Sector activity data (fuel use, mineral use) from the 2012 EU ETS are analysed against the data reported in the national energy statistics within DUKES, and EU ETS fuel quality information by sector are used within the derivation of UK GHGI estimates for several high-emitting sectors. Direct comparison of EU ETS data and alignment with DUKES sectors and GHG inventory IPCC sector reporting format is problematic for a number of reasons:

- **Disparity between EU ETS and national activity statistics**. For most economic sectors, the EU ETS does not cover 100% of sites and fuel use in the UK, and therefore the sum of EU ETS activity data for most sectors is expected to be lower than the national statistics published by DECC DUKES (for energy use) and the British Geological Survey (for mineral use such as limestone, dolomite, clays). There were several industrial sectors where large differences were evident in the 2012 fuel allocations within DUKES, compared to the data reported by operators under EU ETS. The activity data from EU ETS are generally considered to be of good quality, having been subject to a rigorous data checking and verification process. The EUETS does not always cover 100% of sites within a sector, however. *There were a number of instances where the EU ETS fuel use data were higher than the data reported within DUKES; source-activity combinations where EUETS data were therefore used within the UK and DA GHG inventory compilation, deviating from the national statistics included refinery and industrial use of other petroleum gases (OPG), upstream oil and gas use of liquefied petroleum gas (LPG) and OPG and gas supply network use of natural gas.*
- **Differences in scope and definitions between IPCC sectors and EU ETS reporting**. IPCC reporting requires that a distinction is made between fuel combustion emissions and process emissions, and all emissions from all sources need to be captured. The scope of EUETS reporting is not always comprehensive, i.e. emissions from some sources on site may be excluded from EU ETS data. Furthermore, the reporting format of the EU ETS does not explicitly separate the GHG emission sources between different activities on site. These scope and reporting limitations make it very difficult to either directly use in, or reconcile the reported data with the IPCC format emissions calculated and presented within the UK and DA GHG inventories.

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

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

(ii) Calculation of non-traded DA GHGI data such that the data inconsistencies between DUKES and EU ETS fuel use are minimised, removing the inconsistencies by (in most cases) assuming that the EU ETS data for a given sector are the more accurate estimates.

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

Detailed tables showing the full DA traded and non-traded emission estimates for 2008-12, including detail of the additional end user emissions from use of electricity and non-electricity fuels, are provided in the supporting MS Excel spreadsheet.

A4.2.1 Devolved Administrations' Traded and Non-Traded GHG Emission Estimates (2008-2012)

The traded and non-traded emission estimates for each of the DAs in 2008 to 2012 are summarised in the tables below. In each case, data are presented for:

- Annual total traded GHG emissions;
- Annual total non-traded GHG emissions;
- Annual total GHG inventory emissions;
- Non-traded sector percentage share of the total GHG inventory.

Table A4.1 Devolved Administrations' Traded and Non-Traded Emission Estimates, 2008-2012

Country	Emissions scope (all units: kt CO_2e)	2008	2009	2010	2011	2012
ENGLAND	Traded Emissions	193,390	168,549	169,373	160,303	169,199
	Non-Traded Emissions	296,140	279,341	287,579	265,439	272,579
	Total inventory emissions	489,530	447,890	456,952	425,741	441,778
	Traded Share	*39.5%*	*37.6%*	*37.1%*	*37.7%*	*38.3%*
SCOTLAND	Traded Emissions	23,765	21,962	24,041	20,056	20,349
	Non-Traded Emissions	33,368	31,471	31,781	29,843	30,181
	Total inventory emissions	57,133	53,433	55,822	49,898	50,531
	Traded Share	*41.6%*	*41.1%*	*43.1%*	*40.2%*	*40.3%*
WALES	Traded Emissions	26,611	21,846	24,069	22,593	24,705
	Non-Traded Emissions	23,309	21,631	22,588	21,040	21,121
	Total inventory emissions	49,921	43,477	46,657	43,633	45,826
	Traded Share	*53.3%*	*50.2%*	*51.6%*	*51.8%*	*53.9%*
N IRELAND	Traded Emissions	5,864	4,332	4,627	4,383	4,505
	Non-Traded Emissions	16,555	16,429	17,076	16,141	16,469
	Total inventory emissions	22,418	20,760	21,703	20,524	20,974
	Traded Share	*26.2%*	*20.9%*	*21.3%*	*21.4%*	*21.5%*
UNALLOCATED	Traded Emissions	15,231	15,064	15,124	13,356	12,326
	Non-Traded Emissions	1,675	1,919	1,762	1,791	2,087
	Total inventory emissions	16,906	16,983	16,886	15,147	14,413
	Traded Share	*90.1%*	*88.7%*	*89.6%*	*88.2%*	*85.5%*
UNITED KINGDOM	Traded Emissions	264,861	231,753	237,234	220,690	231,084
	Non-Traded Emissions	371,047	350,791	360,786	334,254	342,438
	Total inventory emissions	635,908	582,543	598,020	554,943	573,522
	Traded Share	*41.7%*	*39.8%*	*39.7%*	*39.8%*	*40.3%*

A4.2.2 Analysis of Emissions 2008-2012

- The DA traded and non-traded emission estimates illustrate the regional differences in the EUETS coverage and significance in the context of the overall DA inventories, which indicates the level of opportunity for DA policy actions in the non-traded sector.
- Note that the traded share percentages in the table above are influenced by the impact of Land Use, Land Use Change and Forestry (LULUCF) sources and sinks on the overall DA inventories; in both Wales and (especially) Scotland there is a net carbon sink in the LULUCF sector which reduces the net GHG inventory emissions total in the table above. Hence the higher traded share percentage for Wales and Scotland is somewhat misleading in the context of GHG emissions in energy and industrial process sources.
- Note that there are considerable uncertainties in the DA inventory estimates due to the limited energy consumption data by DA. Therefore whilst it may be useful to consider the relative opportunity for DA policy action in future mitigation efforts across different sectors by looking at the non-traded data in more detail, there is an underlying need for greater (energy) data gathering at DA level to improve the evidence base for policy development.
- **The UK** traded share was 42% in 2008, down to 40% in 2009 to 2012. The inventory data indicates that as the recession affected the economy in 2008-9, the traded emissions declined at a greater rate (13% in one year) than the non-traded emissions (down 5% 2008-9). As the economy then picked up in 2009-10 combined cold winters at the start and end of 2010, the non-traded emissions grew at a greater rate (up 3%) than the traded sector emissions (up 2%). Between 2010 and 2011, both the traded and non-traded sectors have reduced by 7% and then increased between 2011 and 2012, with traded emissions increasing by almost 5% and non-traded by 2%.
- In **Northern Ireland**, the non-traded share of GHG emissions declined by only 1% between 2008-2009, and then grew by only 4% in 2009-10; note that there is greater uncertainty in the non-traded emission estimates in Northern Ireland due to the much greater reliance on solid and liquid fuel use within the economy, the estimates of which are more uncertain than those for metered fuels (gas, electricity). Nevertheless, this notably lower reduction in the non-traded share in Northern Ireland in 2008-9 and lesser growth in 2009-10 may reflect the greater impact on emissions related to the energy-intensive industries evident in GB, where a lesser demand for fuels within a shrinking UK economy would be expected to have a knock-on effect to ancillary services to the energy sector (for example, a reduction in energy and heavy industry transport-related emissions, which are within the non-traded sector). Trends in the non-traded sector since 2010 are similar to the UK with a 5% reduction to 2011 and then a 2% growth to 2012.
- The data for **Wales** show that the coverage of the EU ETS is consistently higher than the UK average, which reflects the high share of heavy industries in Wales; Wales exports electricity to England and has a high percentage of UK refinery capacity and iron and steel manufacture. As a result, the non-traded sector in Wales (which is the focus for WG Climate Change Strategy policy actions and targets) is around 50% of total GHG emissions, compared to the UK average of around 40% of emissions in the non-traded sector.
- In 2007 (the last year of Phase I of the EU ETS) the non-traded share of **Wales** carbon dioxide emissions was estimated to be around 48% of the total inventory; the expansion of the coverage of sites and sources within EU ETS in Phase II of the scheme (which runs from 2008 to 2012) has increased the traded share in Wales to around 53% of total carbon dioxide emissions. The expansion of the EU ETS scope in Wales may affect the WG Climate Change Strategy targets, where emission baselines of the non-traded sector emissions need to account for the full scope of EUETS emissions.
- The traded share estimates for **Scotland** are slightly higher than the UK average across all years since 2009. Review of sector-specific EU ETS data across the UK shows that Scotland has a disproportionately high share of EU ETS emissions in industrial combustion sectors. The Grangemouth refinery accounts for 14% of UK refinery sector emissions in 2012 whilst gas terminals in Scotland account for 53% of total UK onshore sector traded emissions.
- The **Northern Ireland** inventory has a much higher non-traded element compared to GB, with only 21% of inventory emissions within the EU ETS in 2012, compared to the 40% UK average; this reflects the lower level of heavy industry in Northern Ireland, where there are no refineries, oil & gas terminals or iron and steel works for example. Analysis of the 2012 EU ETS data shows that Northern Ireland has a 2.4% share of the power sector traded emissions, whilst the only sectors where Northern Ireland has a higher share are in the cement sector (3.9% of UK sector traded emissions), glass sector (2.6% of UK sector emissions) and the public sector (2.5% of UK sector traded emissions) in 2012.
- **England** traded share of emissions is around 38% of the inventory total in recent years, which is a few percentage lower than the UK average of around 40%. There are many industrial and commercial sectors where England has a high share of the UK traded emissions in 2012; for example, sites in England account for 80% of power generation EUETS emissions, 84% of public sector traded emissions and 76% of cement sector traded emissions. England has a lower representative share of EUETS emissions in

the iron and steel sector (64%), refinery (68%) and (onshore) oil & gas sectors (45%), reflecting the high incidence of such sites in Wales and Scotland.

Appendix 5: Mapping between Source Name, IPCC Category and National Communication

The table below presents a mapping between source name, IPCC category and National Communication category used to categorise emissions/removals for England, Wales, Scotland, Northern Ireland and un-allocated (emissions from the off-shore industry and its terminals producing oil and gas).

Table A5.1: Mapping between Source Name, IPCC Category and National Communication

NC Format	Categories used in Report Graphs	IPCC Sectors	Source Name
Energy Supply	Electricity Production	1A1a Public Electricity&Heat Production	Miscellaneous industrial/commercial combustion
			Power stations
			Public sector combustion
		2A3 Limestone & Dolomite Use	Power stations - FGD
	Gas Production	1B2b Distribution	Gas leakage
		1B2b Gas Exploration	Upstream Gas Production - Offshore Well Testing
		1B2b Gas Production	Upstream Gas Production - Gas terminal storage
			Upstream Gas Production - process emissions
		1B2b Transmission	Gas leakage
	Liquid Fuel Production	1A1b Petroleum Refining	Refineries - combustion
		1B2a Oil Exploration	Upstream Oil Production - Offshore Well Testing
		1B2a Oil Other	Upstream Oil Production - Onshore Oil Loading
		1B2a Oil Production	Upstream Oil Production - process emissions
		1B2a Oil Transport	Upstream Oil Production - Offshore Oil Loading
		1B2a Refining/Storage	Petroleum processes
			Upstream Oil Production - Oil terminal storage
	Offshore Industry	1B2c Flaring Gas	Upstream Gas Production - flaring
		1B2ci Venting Gas	Upstream Gas Production - venting
		1B2ci Venting Oil	Upstream Oil Production - venting
		1B2cii Flaring Oil	Upstream Oil Production - flaring
	Solid Fuel Production	1A1ci Manufacture of Solid Fuels-coke	Coke production
			Solid smokeless fuel production
		1A1cii Other Energy Industries	Collieries - combustion
			Gas production
			Nuclear fuel production
			Town gas manufacture
			Upstream Gas Production - fuel combustion
			Upstream oil and gas production - combustion at gas separation plant
			Upstream Oil Production - fuel combustion
		1B1a Post-Mining Activities	Coal storage and transport
		1B1a Surface Mines	Open-cast coal
		1B1a Underground Mines	Deep-mined coal
		1B1b Solid Fuel Transformation	Charcoal production
			Coke production
			Iron and steel - flaring
			Solid smokeless fuel production
		1B1c Closed Coal Mines	Closed Coal Mines
Transport	Aircraft & Airports	1A3aii Civil Aviation Domestic	Aircraft - domestic cruise
			Aircraft - domestic take-off and landing
		1A3e Other Transportation	Aircraft - support vehicles
	Other Transport	1A3c Railways	Rail - coal
			Railways - freight
			Railways - intercity
			Railways - regional
		1A3dii National Navigation	Inland goods-carrying vessels
			Marine engines
			Motorboats / workboats (e.g. canal boats, dredgers, service boats, tourist boats, river boats)

NC Format	Categories used in Report Graphs	IPCC Sectors	Source Name
			Personal watercraft e.g. jet ski
			Sailing boats with auxiliary engines
			Shipping - coastal
		1A4a Commercial/Institutional	Railways - stationary combustion
		1A4ciii Fishing	Fishing vessels
		1A5b Other:Mobile	Aircraft - military
			Shipping - naval
	Road Transport	1A3b Road Transportation	Road transport - all vehicles LPG use
			Road transport - buses and coaches - motorway driving
			Road transport - buses and coaches - rural driving
			Road transport - buses and coaches - urban driving
			Road transport - cars - cold start
			Road transport - cars - motorway driving
			Road transport - cars - rural driving
			Road transport - cars - urban driving
			Road transport - HGV articulated - motorway driving
			Road transport - HGV articulated - rural driving
			Road transport - HGV articulated - urban driving
			Road transport - HGV rigid - motorway driving
			Road transport - HGV rigid - rural driving
			Road transport - HGV rigid - urban driving
			Road transport - LGVs - cold start
			Road transport - LGVs - motorway driving
			Road transport - LGVs - rural driving
			Road transport - LGVs - urban driving
			Road transport - mopeds (<50cc 2st) - urban driving
			Road transport - motorcycle (>50cc 2st) - rural driving
			Road transport - motorcycle (>50cc 2st) - urban driving
			Road transport - motorcycle (>50cc 4st) - motorway driving
			Road transport - motorcycle (>50cc 4st) - rural driving
			Road transport - motorcycle (>50cc 4st) - urban driving
			Road vehicle engines
Residential	Aerosols and metered dose inhalers and other household products	2B5 Chemical Industry Other	Non-aerosol products - household products
		2F4 Aerosols	Aerosols - halocarbons
			Metered dose inhalers
	Other	6C Waste Incineration	Accidental fires - vehicles
	Residential combustion	1A4bi Residential	Domestic combustion
		1A4bii Residential:Off-road	House and garden machinery
Business	Industrial Combustion of fuels	1A2b Non-Ferrous Metals	Non-Ferrous Metal (combustion)
		1A2c Chemicals	Ammonia production - combustion
			Chemicals (combustion)
		1A2d Pulp Paper Print	Pulp, Paper and Print (combustion)
		1A2e Food drink tobacco	Food & drink, tobacco (combustion)
		1A2f Manufacturing Industry&Construction:Other	Autogeneration - exported to grid
			Autogenerators
			Cement production - combustion
			Lime production - non decarbonising
			Other industrial combustion
		1A2fii Manufacturing Industry&Construction:Off-road	Industrial engines
			Industrial off-road mobile machinery
		1A4a Commercial/Institutional	Miscellaneous industrial/commercial combustion
		2B5 Carbon from NEU of products	Other industrial combustion
	Iron and steel - combustion and electricity	1A2a Manufacturing Industry&Construction:I&S	Blast furnaces

NC Format	Categories used in Report Graphs	IPCC Sectors	Source Name
			Iron and steel - combustion plant
	Refrigeration and air conditioning	2F1 Refrigeration and Air Conditioning Equipment	Commercial Refrigeration
			Domestic Refrigeration
			Industrial Refrigeration
			Mobile Air Conditioning
			Refrigerated Transport
			Stationary Air Conditioning
	Use of fluorinated Gases	2F2 Foam Blowing	Foams
		2F3 Fire Extinguishers	Firefighting
		2F5 Solvents	Other PFC use
			Precision cleaning - HFC
		2F9 Other (one component foams)	One Component Foams
		2F9 Other (semiconductors electrical sporting goods)	Electrical insulation
			Electronics - PFC
			Electronics - SF6
			Sporting goods
Public	Public	1A4a Commercial/Institutional	Public sector combustion
Industrial Process	Cement production	2A1 Cement Production	Cement - decarbonising
	Chemical Production	2B1 Ammonia Production	Ammonia production - feedstock use of gas
		2B2 Nitric Acid Production	Nitric acid production
		2B3 Adipic Acid Production	Adipic acid production
		2C3 Aluminium Production	Primary aluminium production - general
			Primary aluminium production - PFC emissions
	Iron & Steel	1A2a Manufacturing Industry&Construction:I&S	Sinter production
		2C1 Iron&Steel	Electric arc furnaces
			Iron and steel - flaring
			Ladle arc furnaces
	Other Processes	2A2 Lime Production	Lime production - decarbonising
		2A3 Limestone & Dolomite Use	Basic oxygen furnaces
			Sinter production
		2A7 (Fletton Bricks)	Brick manufacture - Fletton
		2A7 Glass Production	Glass - general
		2B5 Chemical Industry Other	Chemical industry - ethylene
			Chemical industry - general
			Chemical industry - methanol
		2C4 Cover gas used in Al and Mg foundries	Magnesium cover gas
		2E1 Production of Halocarbons and Sulphur Hexafluoride	Halocarbons production - by-product
		2E2 Production of Halocarbons and Sulphur Hexafluoride	Halocarbons production - fugitive
		3 Solvent and Other Product Use	Solvent use
Agriculture	Crop Growing and Fertilizer Application	2B5 Chemical Industry Other	Agriculture - agrochemicals use
		4B13 Solid Storage and Drylot	Agriculture livestock - manure solid storage and dry lot
		4B14 Other	Agriculture livestock - manure other
		4D Agricultural Soils	Agricultural soils
	Field burning of agricultural wastes	4F1 Field Burning of Agricultural Residues	Field burning
		4F5 Field Burning of Agricultural Residues	Field burning
	Livestock	4A10 Enteric Fermentation Deer	Agriculture livestock - deer enteric
		4A1a Enteric Fermentation Dairy	Agriculture livestock - dairy cattle enteric
		4A1b Enteric Fermentation Non-Dairy	Agriculture livestock - other cattle enteric
		4A3 Enteric Fermentation Sheep	Agriculture livestock - sheep enteric
		4A4 Enteric Fermentation Goats	Agriculture livestock - goats enteric
		4A6 Enteric Fermentation Horses	Agriculture livestock - horses enteric
		4A8 Enteric Fermentation Swine	Agriculture livestock - pigs enteric
		4B10 Manure Management Deer	Agriculture livestock - deer wastes
		4B12 Liquid Systems	Agriculture livestock - manure liquid systems

NC Format	Categories used in Report Graphs	IPCC Sectors	Source Name
		4B1a Manure Management Dairy	Agriculture livestock - dairy cattle wastes
		4B1b Manure Management Non-Dairy	Agriculture livestock - other cattle wastes
		4B3 Manure Management Sheep	Agriculture livestock - sheep goats and deer wastes
		4B4 Manure Management Goats	Agriculture livestock - goats wastes
		4B6 Manure Management Horses	Agriculture livestock - horses wastes
		4B8 Manure Management Swine	Agriculture livestock - pigs wastes
		4B9 Manure Management Poultry	Agriculture livestock - broilers wastes
			Agriculture livestock - laying hens wastes
			Agriculture livestock - other poultry wastes
	Stationary and mobile combustion	1A4ci Agriculture/Forestry/Fishing:Stationary	Agriculture - stationary combustion
			Miscellaneous industrial/commercial combustion
		1A4cii Agriculture/Forestry/Fishing:Off-road	Agricultural engines
			Agriculture - mobile machinery
LULUCF	Creation and Maintenance of Settlements	5E1 Settlements remaining settlements	Settlements remaining Settlements
		5E2 Land converted to settlements	Land converted to Settlements
	Crop Growing and Fertilizer Application	5A Forest Land (Drainage of soils)	Forest Land - Drainage of Organic Soils
	Land Converted to Forest, Grass, Crop and/or Wetlands	5A2 Land Converted to Forest Land	Land converted to Forest Land
		5B2 Land Converted to Cropland	Land converted to Cropland
		5B2 N2O emissions from disturbance associated with land-use conversion to cropland	N2O emissions from disturbance associated with land-use conversion to cropland
		5C2 Land converted to grassland	Land converted to Grassland
		5D2 Land converted to wetlands	Land converted to Wetland
		5D2 Non-CO2 emissions from drainage of soils and wetlands	Non-CO2 emissions from drainage of soils and wetlands
	Land Maintained as Crops, Grass and Forest	5A1 Forest Land Remaining Forest Land	Forest Land remaining Forest Land
		5A2 Forest Land (N fertilisation)	Direct N2O emission from N fertilisation of forest land
		5B Liming	Cropland - Liming
		5B1 Cropland Remaining Cropland	Cropland remaining Cropland
		5C Liming	Grassland - Liming
		5C1 Grassland Remaining Grassland	Grassland remaining Grassland
		5D1 Wetlands remaining wetlands	Wetlands remaining Wetland
	Wood Products & Harvesting	5A Forest Land (Biomass Burning - wildfires)	Forest Land - Biomass Burning\Wildfires
		5B Cropland (Biomass Burning - controlled)	Cropland - Biomass Burning\Controlled Burning
		5B Cropland (Biomass Burning - wildfires)	Cropland - Biomass Burning\Wildfires
		5C Grassland (Biomass burning - controlled)	Grassland - Biomass Burning\Controlled Burning
		5C Grassland (Biomass Burning - wildfires)	Grassland - Biomass Burning\Wildfires
		5E Settlements (Biomass burning - controlled)	Settlements - Biomass Burning\Controlled Burning
		5G Other (Harvested wood)	Harvested Wood Products
Waste Management	Landfill	6A1 Managed Waste Disposal on Land	Landfill
	Waste Incineration	6C Waste Incineration	Incineration
			Incineration - chemical waste
			Incineration - clinical waste
			Incineration - sewage sludge
	Waste-water handling	6B1 Industrial Wastewater Handling	Industrial Waste Water Treatment
		6B2 Wastewater Handling	Sewage sludge decomposition
International Aviation and Shipping	Aircraft & Airports	International Aviation	Aircraft - international cruise
			Aircraft - international take-off and landing
	International fuel/energy use	International Aviation	Aircraft - international cruise
			Aircraft - international take-off and landing
		International Shipping	Shipping - international

Appendix 6: Recalculations between last year's (2013) and this year's (2014) Devolved Administrations' Greenhouse Gas estimates

This provides details of recalculations between 1990-2011 Devolved Administrations' (DA) greenhouse gas (GHG) Inventory estimates (Salisbury *et al*., 2013) and the latest 1990-2012 DA GHG Inventory estimates.

A6.1 Introduction

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

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

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

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

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

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

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

The programme of improvement for the DA inventories includes periodic review of the available source data and estimation methods, in parallel with the programme of improvement to the UK GHG inventory. A considerable research effort has been invested in 2013-14 to improve GHG emission estimates at UK and DA level, and a prioritised list of future improvements has been developed in consultation with DECC and the DA Governments.

A6.2 Revisions and Updates to the Greenhouse Gas Inventories

The overall impact of the recalculations from the previous inventory (1990-2011) to the current inventory (1990-2012) on the 2011 estimates are summarised in the table below.

Table A6.1 Summary of the impact of recalculations for 2011 emission estimates

IPCC Sector	England		Scotland		Wales		Northern Ireland	
	Sector Significance in 2012 (%)	Change in 2011 (ktCO2e)	Sector Significance in 2012 (%)	Change in 2011 (ktCO2e)	Sector Significance in 2012 (%)	Change in 2011 (ktCO2e)	Sector Significance in 2012 (%)	Change in 2011 (ktCO2e)
Change (ktCO2e)		43,239		3,693		1,153		1,310
Change (%)		9.3%		7.0%		2.6%		6.2%
Agriculture	7%	3,978.15	16%	816.85	13%	485.38	29%	758.40
Business	14%	-2,400.66	15%	-755.21	17%	-230.16	11%	124.50
Energy Supply	31%	-15.20	32%	-34.16	41%	-6.53	18%	6.87

IPCC Sector	England		Scotland		Wales		Northern Ireland	
	Sector Significance in 2012 (%)	Change in 2011 (ktCO2e)	Sector Significance in 2012 (%)	Change in 2011 (ktCO2e)	Sector Significance in 2012 (%)	Change in 2011 (ktCO2e)	Sector Significance in 2012 (%)	Change in 2011 (ktCO2e)
Exports	8%	38,875.08	4%	2,589.20	2%	1,364.29	3%	612.91
Industrial Process	2%	74.20	1%	0.14	3%	-37.50	1%	0.00
Land Use Change	0%	-2,980.90	-11%	-221.29	-1%	-772.73	1%	-304.98
Public	2%	1,935.30	3%	563.47	1%	90.99	1%	12.20
Residential	13%	-542.01	14%	-32.34	9%	-19.47	15%	-1.68
Transport	20%	67.19	20%	17.99	12%	-1.10	19%	-43.43
Waste	4%	4,247.97	5%	748.46	2%	279.98	3%	145.09

A6.2.1 Improvements to DA Inventory Data

In the derivation of the 1990-2012 DA GHGI datasets, the inventory methods and data sources for several GHG emission source sectors have been revised and improved.

The main impacts of recalculations for each Devolved Administration are presented in the chapters of the main report. Full details of the magnitude and reasons for changes are presented in table A7.2 below.

Table A6.2 – Reasons for change by IPCC Source Category

IPCC Sector	Reasons for change	England		Scotland		Wales		Northern Ireland	
		Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)
Total Change			4364.04 (1.03%)		1103.91 (2.21%)		-211.14 (-0.48%)		696.98 (3.4%)
1A1a: Public Electricity & Heat Production		29%	-55.35	25%	-12.14	32%	22.06	18%	6.87
1A1b: Petroleum Refining		2%	-49.44	4%	-9.61	6%	-15.17	0%	0.00
1A1c: Manufacture of Solid Fuels and other energy industries		0%	28.71	3%	16.40	2%	-9.01	0%	0.00
1A2a: Manufacturing Industry & Construction: Iron and Steel	Emission estimates for combustion of coke, coke oven gas and blast furnace gas have been revised due to the improvements made to the carbon balance model. This impacts the entire time series.	2%	-331.80	0%	-1.61	10%	-282.21	0%	0.00
1A2b: Non-Ferrous Metals	Revisions to DUKES mainly for natural gas and coal leading to a decrease in emissions	0%	-57.09	0%	-4.17	0%	-11.26	0%	-0.98
1A2c: Chemicals	A large proportion of the OPG burnt in the 1A2 sector has been re-allocated from 1A2f to 1A2c to improve the accuracy of reporting, as this use of other petroleum gases is known to occur within chemical and petrochemical production facilities. Activity data for chemical industry use of fuel oil, gas oil, natural gas and coal have been revised for the years 2008-2011 in the UK energy statistics.	2%	1,779.57	3%	574.17	1%	115.78	1%	35.20
1A2d: Pulp Paper Print		1%	-354.05	1%	-25.93	0%	-19.04	0%	-11.12
1A2e: Food drink tobacco		1%	101.97	1%	18.08	0%	-6.41	1%	75.23
1A2f: Manufacturing Industry & Construction: other	Significant reallocation of emissions from OPG to 1A2c to improve the accuracy of the inventory as a follow-on from the improvements implemented in the previous submission. Activity data for the sector's use of fuel oil, gas oil, natural gas and coal have all been revised for the years 2008-2011 in the UK energy statistics. A re-allocation of natural gas use to unclassified industry increased emissions in 1990-2001. The re-allocation was made to maintain overall consistency between natural gas use activity data in the GHG inventory and DUKES.	6%	-3,279.31	6%	-1,591.36	5%	-151.85	8%	36.28
1A3a: Civil Aviation Domestic	UK inventory method change led to some re-allocations of flights between domestic and international, where long-haul flights have intermediate stops in the UK. Therefore a variable impact across the DAs for both domestic and international flights.	0%	-8.51	1%	22.50	0%	0.34	1%	11.32
1A3b: Road Transportation		20%	65.63	18%	6.32	12%	3.17	18%	-51.37
1A3c: Railways		0%	0.09	0%	0.01	0%	0.01	0%	0.01

IPCC Sector	Reasons for change	England		Scotland		Wales		Northern Ireland	
		Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)
1A3d: National Navigation		0%	-6.57	1%	-1.17	0%	-0.93	0%	-0.34
1A3e: Other Transportation		0%	1.41	0%	-1.12	0%	-0.05	0%	-0.24
1A4a: Commercial/Institutional	Significant increase in gas consumption for recent years (recalculation due to DUKES), which is most prominent in Scotland.	4%	1,937.55	5%	877.85	2%	213.42	2%	12.09
1A4b: Residential		13%	107.14	14%	28.51	9%	10.47	15%	20.32
1A4c: Agriculture/Forestry/Fishing	Revisions to DUKES and an update of the mapping grids	1%	-7.51	2%	-2.04	1%	-2.07	2%	0.21
1A5b: Other: Mobile		0%	15.19	0%	-8.55	0%	-3.63	0%	-2.80
1B1a: Post-Mining Activities		0%	0.00	0%	0.00	0%	0.00	0%	0.00
1B1b: Solid Fuel Transformation		0%	-19.41	0%	-0.01	0%	-4.73	0%	0.00
1B1c: Closed Coal Mines		0%	0.00	0%	0.00	0%	0.00	0%	0.00
1B2a: Oil Exploration	Annual quality checking of the EEMS, EUETS and IPPC reported emissions data by installations did identify some errors in the assumptions used for the 2013 submission, and corrections have been made to increase methane emissions within the 2014 submission as a result.	0%	122.06	0%	0.04	0%	0.00	0%	0.00
1B2b: Distribution		1%	-38.00	1%	-13.26	1%	0.32	0%	0.01
1B2ci: Venting Gas		0%	-0.02	0%	0.00	0%	0.00	0%	0.00
1B2cii: Flaring Gas		0%	-3.75	1%	-15.57	0%	0.00	0%	0.00
2A1: Cement Production		1%	0.00	1%	0.00	1%	0.00	1%	0.00
2A2: Lime Production		0%	20.61	0%	0.00	0%	0.00	0%	0.00
2A3: Limestone & Dolomite Use	EUETS carbon emission factor data have been used for limestone and dolomite used in sintering and basic oxygen furnaces in steelworks. The data are available for the years 2007-2012 and the value for 2007 has been extrapolated back across the time series.	0%	19.90	0%	0.00	1%	18.14	0%	0.00
2A7: Other mineral products		0%	0.00	0%	0.00	0%	0.00	0%	0.00
2B1: Ammonia Production		0%	0.00	0%	0.00	0%	0.00	0%	0.00
2B2: Nitric Acid Production		0%	0.00	0%	0.00	0%	0.00	0%	0.00
2B3: Adipic Acid Production		0%	0.00	0%	0.00	0%	0.00	0%	0.00
2B5: Carbon from NEU of products	The CO2 estimate from burning of waste chemicals in 2B5, has been reviewed for the 2014 submission, both to ensure there is no double-counting of emissions already reported in 1A2c, but also to update the estimates to use operator data from Climate Change Agreements and other regulatory data sources.	0%	-187.60	0%	-17.33	0%	-8.27	0%	-4.94

IPCC Sector	Reasons for change	England		Scotland		Wales		Northern Ireland	
		Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)
2C1: Iron and Steel		0%	-11.81	0%	0.00	1%	-34.99	0%	0.00
2C3: Aluminium Production		0%	0.00	0%	0.00	0%	0.00	0%	0.00
2C4: Cover gas used in Al and Mg foundries	A review of the data sources and methodology used to estimate emissions from F-gases used as cover gases in magnesium foundries has been carried out in 2013. The assumptions about the fraction of SF6 and HFCs that are emitted from the consumption of these F-gases has been reviewed and in some cases amended.	0%	70.98	0%	0.00	0%	5.34	0%	0.00
2E1: Production of Halocarbons and Sulphur Hexafluoride		0%	0.00	0%	0.00	0%	0.00	0%	0.00
2E2: Production of Halocarbons and Sulphur Hexafluoride		0%	0.00	0%	0.00	0%	0.00	0%	0.00
2F1: Refrigeration and Air Conditioning Equipment		2%	21.87	2%	-11.95	1%	-5.75	1%	-4.17
2F2: Foam Blowing		0%	-0.22	0%	0.20	0%	-0.01	0%	0.03
2F3: Fire Extinguishers		0%	-0.14	0%	0.13	0%	-0.01	0%	0.02
2F4: Aerosols	A review of the data sources and methodology used to estimate emissions from metered dose inhalers (MDIs) has been carried out in 2013. The number of MDIs used each year in the UK has been derived from UK National Health Service (NHS) prescription data. HFC emissions have been calculated with revised estimates of the species and volumes of HFCs used as MDI propellants.	0%	-653.73	0%	-62.42	0%	-30.20	0%	-22.34
2F5: Solvents		0%	-0.07	0%	0.07	0%	0.00	0%	0.01
2F9: Other (one component foams)	There has been a revision to the emissions from SF6 in electrical insulation across the recent years of the time series, affecting all DAs.	0%	-116.58	0%	-8.28	0%	-9.33	0%	-0.65
3: Solvent and Other Product Use		0%	0.00	0%	0.00	0%	0.00	0%	0.00
4A1: Enteric Fermentation Cattle	Feed digestibility has decreased by 0.99% since last submission for all years, which increases the emission factor for this category. There was also a recalculation in the average milk yield for 2010, which couteracted this increase.	1%	20.84	4%	3.36	3%	4.07	9%	5.21
4A10: Enteric Fermentation Deer		0%	0.00	0%	0.00	0%	0.00	0%	0.00
4A3: Enteric Fermentation Sheep		0%	0.00	1%	0.00	2%	0.00	1%	0.00
4A4: Enteric Fermentation Goats		0%	0.00	0%	0.00	0%	0.00	0%	0.00
4A6: Enteric Fermentation Horses	Horse numbers were revised to include those not kept on agricultural holdings. These figures were not included in previous inventories.	0%	224.31	0%	15.94	0%	19.49	0%	8.91

IPCC Sector	Reasons for change	England		Scotland		Wales		Northern Ireland	
		Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)
4A8: Enteric Fermentation Swine		0%	0.00	0%	0.00	0%	0.00	0%	0.00
4B1: Manure Management Cattle	In response to reviewer questions, the UK revised its allocation of manure into the various management systems. In particular the amounts going to daily spread were reduced significantly and the amounts previously allocated to solid storage were reallocated to deep litter leading to an increase from 1% to 39% in the methane conversion factor.	1%	1,374.45	1%	460.90	1%	284.21	3%	431.14
4B10: Manure Management Deer		0%	0.00	0%	0.00	0%	0.00	0%	0.00
4B12: Liquid Systems	In response to reviewer questions, the UK revised its allocation of manure into the various management systems. In particular the amounts going to daily spread were reduced significantly and the amounts previously allocated to solid storage were reallocated to deep litter leading to an increase from 1% to 39% in the methane conversion factor. The use of liquid manure management systems has also increased by around 25%. Horse numbers were revised to include those not kept on agricultural holdings.	0%	5.49	0%	1.31	0%	0.63	0%	2.04
4B13: Solid Storage and Drylot		0%	397.87	1%	129.87	0%	74.07	1%	110.17
4B14: Other		0%	236.69	0%	15.78	0%	16.43	0%	42.22
4B3: Manure Management Sheep		0%	55.46	0%	27.20	0%	34.04	0%	7.44
4B4: Manure Management Goats		0%	0.61	0%	0.03	0%	0.06	0%	0.02
4B6: Manure Management Horses		0%	17.30	0%	1.23	0%	1.50	0%	0.69
4B8: Manure Management Swine		0%	1,023.00	0%	110.37	0%	7.23	1%	119.60
4B9: Manure Management Poultry		0%	101.37	0%	9.23	0%	9.08	0%	22.06
4D: Agricultural Soils		4%	528.02	8%	43.77	5%	36.66	12%	8.72
4F1: Field Burning of Agricultural Residues		0%	0.00	0%	0.00	0%	0.00	0%	0.00
4F5: Field Burning of Agricultural Residues		0%	0.00	0%	0.00	0%	0.00	0%	0.00
5A: Forest Land (Biomass Burning)	More accurate activity data for wildfires is now used in the inventory, which has led to some recalculations across the time series.	0%	-39.46	0%	-40.59	0%	-86.31	2%	-7.80
5A1: Forest Land Remaining Forest Land	The inventory now uses the CARBINE model to estimate emissions from LULUCF. This change in methodology has led to significant recalculations across the time series. CARBINE can represent a comprehensive range of forest tree species relevant to the UK, representing UK growth conditions and management practices, and combining area / age class information for carbon stocks. Compared to previous estimates, this more detailed methodology based on application of CARBINE provides greater representation of Forest Land and the range of forest management practices observed in the UK.	-1%	-3,442.12	-17%	-2,606.84	-3%	-1,484.02	-4%	-425.99
5A2: Land converted to forest land, forest land (N fertilisation)		0%	-80.07	-2%	646.89	0%	66.26	-1%	35.23
5B: Cropland (Biomass Burning)		0%	-0.27	0%	0.00	0%	0.00	0%	0.00
5B1: Cropland remaining cropland, liming		1%	74.85	5%	26.42	1%	2.92	2%	2.86

IPCC Sector	Reasons for change	England		Scotland		Wales		Northern Ireland	
		Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)
5B2: Land Converted to Cropland, N2O emissions from disturbance associated with land-use conversion to cropland		0%	-0.41	5%	82.35	1%	0.00	2%	0.00
5C: Grassland (Biomass burning)	More accurate activity data for wildfires is now used in the inventory, which has led to some recalculations across the time series.	0%	27.40	0%	174.09	0%	16.82	0%	-0.43
5C1: Grassland remaining grassland, Liming	Changes due to addition of estimate for by-products of sugar production and adjustment to extraction data.	0%	53.77	-4%	20.24	-1%	20.71	-3%	24.60
5C2: Land converted to grassland	Changes in methodology for Forest Land, in particular inclusion of pre-1920s forest and more detailed consideration of forest management has affected change in land areas converted from Grassland.	0%	40.50	-1%	263.56	-1%	24.18	-2%	-1.28
5D1: Wetlands remaining wetlands		0%	-6.35	0%	-37.14	0%	0.00	1%	0.00
5D2: Land converted to wetlands, Non-CO2 emissions from drainage of soils and wetlands		0%	0.00	0%	0.00	0%	0.00	0%	0.00
5E: Settlements (Biomass burning)		0%	-2.61	0%	-4.12	0%	-3.96	0%	-0.90
5E1: Settlements remaining settlements		0%	0.00	1%	0.00	1%	0.00	1%	0.00
5E2: Land converted to settlements		0%	-3.95	2%	-6.23	1%	-5.99	3%	-1.36
5G: Other (Harvested wood)	Main methodological revisions are the use of the CARBINE carbon accounting model for carbon stock change modelling and the inclusion of emissions from all forests older than 20 years in the Forest remaining Forest Land category – instead of just from post-1921 forests as was reported in previous submissions. The deforestation areas have also been updated.	0%	397.81	-1%	1,260.09	0%	676.65	0%	70.11
6A1: Managed Waste Disposal on Land	Following recommendation from the UNFCCC Centralized Review 2013, flaring data within the inventory is now based on the quantities of gas recorded as being collected and burnt in landfill gas engines and flares. Since 2009, operators of landfills permitted under the Integrated Pollution Prevention and Control (IPPC) Directive have been required to report the annual quantity of methane flared at the regulated sites under the terms of their operating permits. Because it has been obtained under the terms of IPPC operating permits, this data has documentation and quality control built in via the permitting procedures and operator obligations at an individual site level. The use of this dataset is therefore considered by the UK to be a robust and appropriate basis on which to evaluate the quantities of methane flared by operators.	3%	4,210.65	5%	746.30	2%	293.63	2%	144.34

IPCC Sector	Reasons for change	England		Scotland		Wales		Northern Ireland	
		Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)	Significance (2012)	2011 - 2011 (kt CO2e)
6B1: Industrial Wastewater Handling	Updated Index of Production data available to inform estimates in 2011 (and 2012).	0%	79.49	0%	6.39	0%	-7.93	0%	2.19
6B2: Wastewater Handling	A small double-count was removed from the 6B2 estimates of nitrous oxide. Within emission estimates reported in 6C there are nitrous oxide emissions from waste incineration of sewage sludge. Therefore this amount of nitrous oxide was double-counted within the 2013 submission, as the outputs from the IPCC Tier 1 method used to estimate nitrous oxide emissions in 6B2 were not amended for this component of the nitrogen in sewage sludge that were disposed to incineration. Therefore, the 6B2 estimates have been amended in the 2014 submission to remove this double-count, reducing the 6B2 estimates.	0%	-42.55	0%	-4.39	0%	-5.92	0%	-1.47
6C: Waste Incineration		0%	0.22	0%	0.14	0%	0.20	0%	0.03
		100%		*100%*		*100%*		*100%*	

The rows below relate to International Aviation and Shipping. The significance is calculated using total CO2e emissions **including** international aviation and shipping. The calculations above do not include these sectors in the total CO2e emissions.

International aviation	UK inventory method change led to some re-allocations of flights between domestic and international, where long-haul flights have intermediate stops in the UK. Therefore a variable impact across the DAs for both domestic and international flights.	6%	-49.41	2%	22.02	0%	0.67	1%	-2.94
International shipping		1%	347.36	2%	76.11	2%	64.41	2%	22.86

Appendix 7: Supporting Data Tables

The following tables provide additional data that are used to create graphs within the main report. These data are not included in the inventory data distributed alongside this report.

- Methane emissions from livestock by type (2012)
- Carbon dioxide emissions data for the two methodological approaches presented for Road Transport (1990-2012)
- Energy generation data for each Devolved Administration by fuel type (2005-2012)

Table A7.1 – Methane emissions from livestock by type (2012)

	England	Scotland	Wales	Northern Ireland
Cattle	8,775	2,555	1,803	2,575
Deer	3.97	1.16	0.19	0.58
Goats	9.66	0.44	0.80	0.36
Horses	330	32.2	40.2	14.5
Pigs	1,579	157	12	183
Poultry	288	36.0	20.1	46.9
Sheep	1,624	767	987	221

Table A7.3 – Energy generation data for each Devolved Administration by fuel type (2004-2012)

	2004	2005	2006	2007	2008	2009	2010	2011	2012
England	301,143	304,830	299,160	306,950	291,039	285,574	292,023	280,846	280,745
Coal	104,880	109,372	116,263	111,318	97,310	79,473	81,542	86,485	115,130
Gas	111,398	109,795	98,220	118,370	129,165	125,415	135,063	111,346	73,773
Nuclear	54,598	55,095	54,300	45,001	30,327	46,295	41,315	46,725	49,214
Oil	1,387	2,035	2,158	2,469	3,793	3,484	1,992	862	931
Renewables and Hydro	7,112	8,968	9,400	9,610	10,539	12,046	13,902	17,718	23,048
Other	21,768	19,565	18,819	20,182	19,905	18,861	18,209	17,710	18,649
Northern Ireland	7,413	9,620	10,246	9,074	9,624	8,016	7,612	7,930	7,392
Coal	2,711	2,455	2,701	1,833	2,040	1,371	1,817	1,414	2,367
Gas	4,083	6,453	6,799	6,576	6,537	5,642	4,840	5,301	3,609
Nuclear	0	0	0	0	0	0	0	0	0
Oil	347	331	286	154	334	78	73	52	44
Renewables and Hydro	153	271	350	404	609	828	762	996	1,177
Other	119	110	110	107	104	97	120	167	195
Scotland	49,937	49,237	52,250	48,069	50,121	51,173	49,965	51,237	49,498
Coal	13,002	12,092	17,488	13,802	11,591	11,896	14,653	10,728	11,867
Gas	8,851	6,250	8,346	8,938	9,822	7,430	6,618	6,227	3,680
Nuclear	18,013	18,681	14,141	12,344	15,079	16,681	15,293	16,892	17,050
Oil	149	556	914	379	431	278	206	160	155
Renewables and Hydro	5,832	6,486	6,963	8,216	9,141	10,759	9,564	13,747	14,756
Other	4,090	5,172	4,398	4,390	4,057	4,129	3,631	3,483	1,990
Wales	35,422	34,672	35,636	32,687	38,205	31,989	32,160	27,441	26,201
Coal	7,234	6,772	8,859	5,121	9,364	6,547	5,929	6,170	10,799
Gas	16,245	14,984	13,272	15,461	16,059	14,111	15,227	9,880	5,167
Nuclear	7,388	7,842	7,010	5,684	7,080	6,122	5,532	5,364	4,141
Oil	0	0	0	0	0	0	0	0	0
Renewables and Hydro	1,029	1,215	1,404	1,369	1,627	1,610	1,610	2,184	2,277
Other	3,526	3,859	5,091	5,052	4,075	3,599	3,862	3,843	3,817

Table A7.2 – Carbon dioxide emissions data for the two methodological approaches presented for Road Transport (1990-2012)

England		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO2 (vkm)	Cars	59,415	60,235	61,984	62,634	61,872	61,838	62,232	61,241	61,123	60,179	59,687	58,488	56,723	55,372	52,686	51,622	50,273
	LGVs	7,902	8,958	10,390	10,525	10,699	10,991	11,118	11,568	12,075	12,309	12,675	13,106	12,705	12,346	12,390	12,589	12,692
	HGVs	19,305	18,784	19,378	19,888	19,968	20,446	20,301	20,807	20,688	20,092	20,459	20,744	20,557	18,801	19,083	18,668	18,418
	Buses	2,718	2,911	3,073	3,211	3,244	3,251	3,384	3,686	3,715	3,798	3,908	4,023	3,760	3,730	3,715	3,444	3,169
	Motorcycles	534	366	430	474	470	491	512	565	518	540	515	547	498	504	446	444	427
	TOTAL	89,875	91,253	95,255	96,733	96,253	97,017	97,548	97,867	98,119	96,917	97,245	96,908	94,243	90,753	88,320	86,768	84,978
CO2 (fuel sales)	Cars	59,414	59,071	61,384	62,607	62,403	62,155	63,128	61,926	62,146	61,799	60,847	60,848	58,973	56,673	54,127	53,175	52,418
	LGVs	7,902	8,874	10,355	10,524	10,721	11,003	11,146	11,587	12,101	12,345	12,702	13,158	12,752	12,372	12,417	12,618	12,731
	HGVs	19,990	20,430	20,553	19,705	18,949	18,774	19,239	19,092	19,275	19,828	20,128	21,698	18,647	17,985	19,471	19,363	20,039
	Buses	2,718	2,911	3,073	3,211	3,244	3,251	3,384	3,686	3,715	3,798	3,908	4,023	3,760	3,730	3,715	3,444	3,169
	Motorcycles	534	358	425	474	475	494	521	572	529	559	529	578	527	521	465	466	457
	TOTAL	90,560	91,643	95,790	96,521	95,793	95,678	97,419	96,863	97,766	98,330	98,115	100,305	94,660	91,280	90,195	89,066	88,815
Scotland		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO2 (vkm)	Cars	5,670	5,714	5,820	5,849	5,776	5,774	5,890	5,821	5,827	5,732	5,795	5,686	5,533	5,402	5,127	5,003	4,918
	LGVs	786	891	1,080	1,103	1,089	1,108	1,137	1,184	1,225	1,256	1,311	1,378	1,352	1,318	1,331	1,343	1,361
	HGVs	1,985	1,894	1,919	1,951	1,945	1,970	1,937	2,064	2,071	2,057	2,160	2,228	2,240	2,078	2,091	2,038	2,050
	Buses	374	385	407	428	436	441	476	514	490	504	518	557	540	542	551	515	484
	Motorcycles	29	22	25	28	28	29	33	37	35	35	34	36	35	35	31	32	31
	TOTAL	8,844	8,905	9,251	9,359	9,274	9,322	9,472	9,621	9,649	9,583	9,817	9,885	9,700	9,376	9,131	8,932	8,843
CO2 (fuel sales)	Cars	5,670	5,606	5,766	5,847	5,824	5,803	5,973	5,884	5,923	5,883	5,905	5,910	5,746	5,524	5,262	5,149	5,121
	LGVs	786	883	1,076	1,103	1,091	1,109	1,140	1,186	1,228	1,259	1,314	1,383	1,357	1,321	1,334	1,346	1,365
	HGVs	2,056	2,060	2,036	1,933	1,846	1,809	1,835	1,894	1,930	2,030	2,125	2,330	2,032	1,988	2,134	2,114	2,230
	Buses	374	385	407	428	436	441	476	514	490	504	518	557	540	542	551	515	484
	Motorcycles	29	21	24	28	28	30	33	37	36	36	34	38	37	36	33	33	33
	TOTAL	8,915	8,955	9,308	9,338	9,225	9,192	9,457	9,517	9,607	9,713	9,896	10,219	9,712	9,412	9,313	9,157	9,232

Table A7.2 (continued) – Carbon dioxide emissions data for the two methodological approaches presented for Road Transport (1990-2012)

Wales		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO2 (vkm)	Cars	3,638	3,675	3,742	3,774	3,722	3,725	3,802	3,781	3,819	3,735	3,755	3,698	3,588	3,473	3,293	3,216	3,128
	LGVs	510	578	668	684	694	711	735	767	800	817	841	866	853	833	843	851	854
	HGVs	1,057	1,001	1,044	1,024	995	1,002	986	995	998	985	996	1,033	1,030	933	927	892	882
	Buses	172	172	178	189	193	193	202	220	216	222	233	240	230	229	227	206	191
	Motorcycles	25	18	21	23	24	24	26	28	26	28	26	28	27	27	23	24	23
	TOTAL	5,402	5,444	5,653	5,694	5,627	5,654	5,752	5,790	5,859	5,785	5,852	5,865	5,728	5,494	5,313	5,190	5,078
CO2 (fuel sales)	Cars	3,638	3,605	3,707	3,773	3,752	3,743	3,854	3,821	3,879	3,829	3,824	3,838	3,721	3,549	3,378	3,307	3,253
	LGVs	510	573	666	684	696	712	737	768	802	819	843	869	856	835	845	853	856
	HGVs	1,095	1,088	1,107	1,015	944	920	934	913	930	972	980	1,081	934	892	946	925	959
	Buses	172	172	178	189	193	193	202	220	216	222	233	240	230	229	227	206	191
	Motorcycles	25	17	20	23	24	25	26	28	27	29	27	30	28	28	24	25	25
	TOTAL	5,439	5,456	5,679	5,683	5,609	5,591	5,754	5,750	5,853	5,870	5,907	6,058	5,770	5,533	5,419	5,316	5,284
Northern Ireland		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO2 (vkm)	Cars	2,275	2,458	2,589	2,684	2,758	2,778	2,733	2,735	2,823	2,805	2,786	2,822	2,701	2,769	2,664	2,601	2,548
	LGVs	116	136	152	159	165	169	240	246	230	227	261	254	294	235	217	221	219
	HGVs	490	519	541	578	600	635	737	933	811	811	836	851	844	738	747	702	694
	Buses	30	34	36	39	43	45	42	43	45	46	39	48	47	55	50	59	55
	Motorcycles	7	6	8	9	9	10	11	15	13	14	14	16	14	14	12	12	11
	TOTAL	2,918	3,152	3,326	3,470	3,576	3,637	3,763	3,971	3,922	3,903	3,936	3,990	3,900	3,811	3,690	3,595	3,528
CO2 (fuel sales)	Cars	2,275	2,413	2,566	2,683	2,779	2,790	2,766	2,760	2,862	2,867	2,830	2,915	2,790	2,822	2,724	2,666	2,640
	LGVs	116	135	152	159	165	170	241	246	230	227	261	254	295	235	217	222	220
	HGVs	508	564	573	572	570	583	698	856	755	800	823	890	766	706	763	728	756
	Buses	30	34	36	39	43	45	42	43	45	46	39	48	47	55	50	59	55
	Motorcycles	7	6	8	9	9	10	11	15	14	15	15	16	14	14	13	12	11
	TOTAL	2,936	3,152	3,336	3,463	3,566	3,597	3,758	3,920	3,906	3,954	3,967	4,123	3,912	3,833	3,766	3,687	3,682

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