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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. The UK National Inventory Report (NIR) (Brown, et al., 2016) describes this approach 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 Devolved Administrations (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 it is assumed that the emission factor uncertainties are the same as for the UK.

In the UK Inventory uncertainties in the activity data are estimated on the basis of expert judgement. Making similar expert judgments for each DA would be a time-consuming activity and would be prone to inconsistencies with the UK uncertainties. 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. The uncertainties for activity in the individual DAs when expressed as a percentage should be higher than that of the total UK uncertainty. This is due to a statistical principle where, if the elements of a group have any independence from one another and are positive, the uncertainty of the sum of a group is less than the sum of the uncertainties of each element in the group.

A1.2 Uncertainty Estimation Methodology

The uncertainties in the DA GHG inventories are also estimated using a Monte Carlo simulation. For simplicity and consistency, the source categories used are the same as those used in the UK GHG Inventory simulation. For each of these source categories, activity uncertainties are derived for England, Scotland, Wales, Northern Ireland, and Unallocated based on the uncertainty for the UK total and the relative contributions to emissions from each of the DAs for this source category using the following equation:

$$U_{A_i} = U_A w_i \frac{\sum_i |E_i|}{\sqrt{\sum_i w_i{}^2 E_i{}^2}}$$

Where U_A is the uncertainty in the UK activity,

i is the DA,

U_{A_i} is the uncertainty in activity for DA i,

w_i is a weighting factor for DA i representing the relative uncertainty in the activity,

E_i is the emission for each of the DA i.

When independence is assumed between the DAs' activity estimates then this equation ensures that the sum of the DAs uncertainty is consistent with the UK uncertainty. For the simplest case of w_i = 1 for all i this equation gives the DAs the same % uncertainty each, but opting to use a weighting function attributes higher % uncertainties for small contributors and lower uncertainties to large contributors using the following equation:

$$w_i = \frac{1}{\sqrt[4]{E_i}}$$

For some key sources the calculated uncertainty was overwritten with expert judgement.

A1.3 Trend Uncertainty Analysis

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. 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.

In addition to the estimation of the uncertainty in each year, it was also necessary to consider correlations between sources across years. Similar to the UK assessment of uncertainties emission factors are assumed to be correlated between years and activity data is uncorrelated between years.

A1.4 Uncertainty Analysis Results

As UK emissions are the sum of the DAs' emissions, the estimates for the individual DAs will be more uncertain than for the UK total. The DA uncertainties are estimated independently of the UK inventory uncertainties and there are subtle differences in the calculations and assumptions made between these models, additionally any two runs of a Monte Carlo analysis will always give slightly different results (the difference reducing with more iterations). This means that the uncertainties calculated for the UK in the DA inventory will be slightly different than that for the UK in the UK inventory. Overall data quality and sector allocations are improving, but for some source sectors, significant uncertainties remain, even at UK level.

The uncertainty estimates for the 1990-2014 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[1] in the DA GHG Inventories: Base Years, 2014 and Trend

	Base Year[2]		Latest Year (2014)		Trend (Base Year to 2014)		
Gas (kt CO_2e)	Central Estimate[3]	Uncertainty Introduced on total	Central Estimate	Uncertainty Introduced on total	Central Estimate[3]	2.5 Percentile	97.5 Percentile
England							
Carbon Dioxide CO2	468,171	2%	324,949	2%	-31%	-32%	-29%
Methane CH4	101,679	24%	35,132	16%	-65%	-87%	-46%
Nitrous Oxide N2O	40,478	52%	14,949	41%	-63%	-129%	-25%
HFC	18,855	9%	13,899	12%	-26%	-39%	-13%
PFC	308	20%	129	26%	-58%	-82%	-36%
SF6	1,140	4%	404	6%	-65%	-69%	-60%
NF3	0	76%	0	91%	-68%	-166%	-1%
Total	630,632	5%	389,462	3%	-38%	-44%	-34%
Scotland							
Carbon Dioxide CO2	52,596	9%	32,150	12%	-39%	-44%	-35%
Methane CH4	17,729	32%	7,517	19%	-58%	-90%	-32%
Nitrous Oxide N2O	4,148	30%	3,262	37%	-21%	-62%	18%
HFC	127	21%	1,327	29%	945%	646%	1254%
PFC	116	46%	142	40%	23%	-43%	92%
SF6	36	25%	31	25%	-14%	-47%	20%
NF3	0	59%	0	55%	-44%	-118%	15%
Total	74,751	10%	44,429	10%	-41%	-49%	-33%
Wales							
Carbon Dioxide CO2	43,778	5%	38,559	3%	-12%	-17%	-8%
Methane CH4	10,191	27%	5,396	16%	-47%	-79%	-26%
Nitrous Oxide N2O	2,203	31%	1,760	45%	-20%	-64%	22%
HFC	65	29%	656	40%	905%	582%	1375%
PFC	172	28%	7	205%	-96%	-124%	-67%
SF6	83	14%	28	20%	-66%	-82%	-50%
NF3	0	262%	0	206%	-20%	-377%	230%
Total	56,493	6%	46,406	3%	-18%	-25%	-12%
Northern Ireland							
Carbon Dioxide CO2	16,561	9%	13,828	8%	-17%	-25%	-9%
Methane CH4	5,630	31%	4,346	17%	-23%	-61%	3%
Nitrous Oxide N2O	2,363	34%	1,737	39%	-26%	-71%	14%
HFC	38	38%	411	52%	972%	539%	1650%
PFC	1	555%	-	0%	-100%	-610%	-3%
SF6	5	73%	5	66%	2%	-100%	102%
N/ANF3	-	0%	-	0%	N/A	N/A	N/A
Total	24,598	10%	20,327	7%	-17%	-29%	-8%
Unallocated							
Carbon Dioxide CO2	11,894	5%	12,701	3%	7%	0%	12%
Methane CH4	1,928	15%	1,090	17%	-43%	-51%	-36%
Nitrous oxide N2O	249	89%	235	89%	-5%	-13%	-2%
HFC	-	0%	-	0%	N/A	N/A	N/A
PFC	-	0%	-	0%	N/A	N/A	N/A

Gas (kt CO_2e)	Base Year[2]		Latest Year (2014)		Trend (Base Year to 2014)		
	Central Estimate[3]	Uncertainty Introduced on total	Central Estimate	Uncertainty Introduced on total	Central Estimate[3]	2.5 Percentile	97.5 Percentile
SF6	-	0%	-	0%	N/A	N/A	N/A
NF3	-	0%	-	0%	N/A	N/A	N/A
Total	14,070	5%	14,026	3%	0%	-6%	5%
UK							
Carbon Dioxide CO2	593,000	2%	422,187	2%	-29%	-30%	-27%
Methane CH4	137,157	23%	53,481	13%	-61%	-81%	-43%
Nitrous Oxide N2O	49,441	44%	21,944	29%	-56%	-110%	-24%
HFC	19,085	9%	16,292	11%	-15%	-28%	-1%
PFC	597	16%	278	24%	-53%	-74%	-34%
SF6	1,264	4%	468	5%	-63%	-67%	-59%
NF3	1	46%	0	46%	-52%	-107%	-6%
Total	800,545	5%	514,651	3%	-36%	-40%	-32%

Notes:

1) Uncertainty is defined as $\pm$ 1.96$\times$(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 NF3, 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 the base year and the latest inventory year are very similar but not identical to the emission estimates in the DA inventories.

4) Where the central estimate says '0' this does not mean that there are no emissions, but that emissions are rounded to 0. '-' is used to represent no emissions.

A1.5 Uncertainty Model Improvements

This year the approach to uncertainties that was adopted was developed for a project for Scottish Government. A report, 'Development of the Uncertainty Analysis of the Scottish GHG Inventory' (Brown & Abbott, 2015) was prepared that explains the reasons for the different approach, comparisons to the previous approach and scenarios that explored sensitivities and functionalities.

The most significant difference between the approaches is that the previous approach generally applied an additional 'disaggregation' uncertainty to the UK uncertainty to sources which were disaggregated using a proxy data source (e.g. population), which was determined with expert judgement. The UK total uncertainty was calculated independently, and consistency between the UK and DAs was maintained by deriving the England uncertainty distribution as the UK minus the other DAs. The approach used this year determines how much additional uncertainty is required to maintain consistency with the total UK uncertainty and applies more to small contributors to total emissions than to larger contributors. This approach treats all DAs in the same way and reduces the requirement for expert judgement (but where it is thought appropriate expert judgement can still be used.

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 2016, presents UK greenhouse gas emission estimates for the period 1990 to 2014 (Brown, et al., 2016).

This report presents separate inventories of greenhouse gas emissions for England, Scotland, Wales and Northern Ireland for the years 1990, 1995 and 1998 to 2014 that are consistent with the 1990 to 2014 UK Greenhouse Gas Inventory.

The seven direct greenhouse gases are considered:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons (PFCs);
- Sulphur hexafluoride (SF_6); and
- Nitrogen trifluoride (NF_3)

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 are 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:

$$E_i = \frac{d_i Ae}{\sum_{j=1}^{5} d_j} \qquad \text{[Equation 2]}$$

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 1990-2014 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 Table A2. 1 to A2. 14. The IPCC classification is used throughout (IPCC, 2006), and the following section provides a description of the abbreviations used throughout the Appendix 2 discussion.

A2.3.1 Summary of Abbreviations

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
EU ETS	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 2014. 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), (BCA, 2004) PowerTech (2004), AES Drax (2004). From 2000 onwards, emissions data from the Pollution Inventory (EA, 2015a), the Scottish Pollution Release Inventory (SEPA, 2015a) and the Northern Ireland Pollution Inventory (NIEA, 2015a) has been used to estimate DA emissions. For emissions in 2005 onwards, fuel use and emissions data reported within the EU ETS (EA, 2015b; SEPA, 2015b; NIEA, 2015b) 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 EU ETS 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, 2015b) 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. 1: 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 EU ETS 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. 2: Energy Industries (1995; 1998 to 2014)

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 & NIPI data from 2000 onwards; EU ETS 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. EU ETS data from 2008 onwards. Deviations from DUKES fuel use allocations have been made for petroleum coke and Other Petroleum Gases (OPG), using EU ETS 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: EU ETS, 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: EU ETS, 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	EU ETS installation data for natural gas use from 2005 onwards. All other years estimated based on the aggregate DA share from the 2005 EU ETS data.
	Upstream oil and gas	Unrefined natural gas, LPG, OPG	(1995 – current) Oil & Gas UK EEMS CO_2 estimates for terminals, DECC activity data. EU ETS 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 – 2014 (UKPIA, 2015), 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 EU ETS 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 1990-2014 GHG inventory, the activity data reported in the EU ETS (EA, 2015a) 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, 2000).

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 (2015), and emissions data for integrated steel works are reported via the PI and EU ETS (EA, 2015b). Three 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, 2015a). 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 2014, 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, 2015a) and EU ETS (EA, 2015b).

The generic driver for coke oven fuel consumption is the regional consumption of coking coal (ISSB, 2015). 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 EU ETS are used (EA, 2015b). 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, 2015) until 2004 and from 2005 data on BFG emissions from the EU ETS (EA, 2015b).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, 2015a) 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 (2015e). 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 disregarded, 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, 2015e); the emission factor for these emissions reflects 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 EU ETS (SEPA, 2015b & EA, 2015b) 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 EU ETS 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 EU ETS. Since 2008, the reported fuel use and emissions from these large sites in EU ETS exceeds that reported within DUKES and the UK GHGI, indicating that

there is a small gas misallocation within DUKES. Therefore in the 1990-2014 UK GHGI, the gas use data from EU ETS have been used to estimate the UK sector emissions, and the DA split has been derived directly from the data in EU ETS (EA, 2015b; SEPA, 2015b); 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 1A2g) was applied.

The EU ETS 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 EU ETS totals. These estimates are uncertain: the UK data are an under-report; the EU ETS 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. 4.

A2.5.1 Iron and Steel

The ISSB (2015) 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 point source dataset, to complement the EU ETS dataset (EA, 2015b) 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, 2015b), 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 EU ETS Data - Iron and Steel Sector: Review of UK data on emissions of GHGs from the Iron and Steel sector to utilise EU ETS data in the national inventory

Table A2. 3: 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 2013: Pollution Inventory (EA, SEPA, NIEA 2014a), EU ETS (EA, SEPA, NIEA 2014b) IDBR and employment data (ONS, 2013). Overall analysis of the 1A2b, c, d, e, f and g sectors used to constrain the DA totals to previous 1A2 DA estimates, using 1A2g Other Industry as residual.
	Food and drink	All fuels	
	Paper and Pulp	All fuels	
	Chemicals (Energy)	All fuels (except OPG)	
	Chemicals (IPPU)	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. (Reported as industrial process.)
		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. 4: Manufacturing Industry and Construction (1995; 1998 to 2014)

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: EU ETS data supplemented by information from Tata Steel (2015)
	Iron & Steel	Blast furnace gas	To 2004: Coke use in blast furnaces, ISSB, WO. 2005 onwards: EU ETS data supplemented by information from Tata Steel (2015)
		Coke oven gas	To 2004: Coal feed to coke ovens, ISSB, WS. 2005 onwards: EU ETS data supplemented by information from Tata Steel (2015)
		Coke	To 2004: Coke use in blast furnaces, ISSB, WO. 2005 onwards: EU ETS data supplemented by information from Tata Steel (2015)
		Other fuels	Regional fuel use data (ISSB): fuel oil, gas oil, LPG, coal, natural gas supplemented by information from Tata Steel (2015)
Other Industrial combustion	Non-ferrous metals	All fuels	Emissions analysis for 2015: Pollution Inventory (EA, 2015a; SEPA, 2015a; NIEA, 2015a), EU ETS EA, 2015b; SEPA, 2015b; NIEA, 2015b) IDBR and employment data (ONS, 2013). Overall analysis of the 1A2b,c,d,e, f and g sectors used to constrain the DA totals to previous 1A2 DA estimates, using 1A2g Other Industry as residual. Coke use in NFM is now entirely allocated to the IPPU sector (Zinc production) and this is located only in England.
	Food and drink	All fuels	
	Paper and Pulp	All fuels	
	Chemicals (Energy)	All fuels (except OPG)	
	Chemicals (IPPU)	OPG	Petrochemical plant emissions from PI/SPRI and EU ETS. 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. (Reported as industrial process.)
		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 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 EU ETS, PI, SPRI and NIPI (reported to 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 2015.
		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 EU ETS, such as the cement sector, and hence uncertainties in the DA GHGI estimates are much lower than previously for such sources. To supplement EU ETS data, additional information from other pollution inventories (PI, SPRI, NIPI) 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 2013, with gas and electricity data available up to 2014 within the DECC publication *Energy Trends December 2015* (DECC, 2015b). 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, 2015b) 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, 2015a) with England and Wales being disaggregated based on regional manufacturing employment statistics (ONS, 2015). Under the 2006 IPCC Guidelines, the emissions from lubricant use are now reported within the Industrial Processes and Product Use (IPPU) sector 2D, rather than within the Energy sector 1A2, as previously reported under the 1996 IPCC Guidelines.

DECC (2015c) 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) (2015) for 1999 onwards, Firmus Energy (2015) and Vayu Ltd. (2015). 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 EU ETS 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 NIPI are used to disaggregate UK emissions (EA, 2009; SEPA, 2009; NIDoE, 2009), until 2008 where the EU ETS Phase II reporting scope covers all UK cement kiln sites. For 2008 onwards therefore, the EU ETS data (EA, 2015b; SEPA, 2015b; NIEA, 2015b) are used to derive the DA estimates, in order that local fuel use patterns and emission factors are fully reflected within the DA GHG inventory data, and to maintain consistency between the EU ETS and DA GHG inventory.

"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, 2015b). Gas autogeneration is distributed according to the other natural gas "other industry" driver.

As the UK and DA GHG inventories are now reported under the 2006 IPCC Guidelines, there are a small number of reporting re-allocations evident in the industrial sector. Coke use in the non-ferrous metals sector was formerly reported as an energy emission within 1A2b, but now is regarded as a process emission (i.e. coke being used as a reductant rather than fuel source) and hence under the 2006 IPCC Guidelines the GHG emissions are now reported within the IPPU sector (2B). All such emissions are allocated to England, as they are associated with the Britannia Zinc smelter that operated in England until 2000.

A2.6 Transport

The drivers used for transport are summarised in

Table A2. 6.

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. For the 1990-2011 DA inventory, 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.

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). Details of the aviation methodology can be found in the National Inventory Report (Brown, et al., 2016). The driver for emissions from aircraft support vehicles is calculated based on aircraft movement data from the UK's major airports (CAA, 2015). 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 (DECC, 2015a). Annual aviation fuel sales in the UK therefore define the overall aviation emissions, in accordance with UNFCCC, UNECE and IPCC inventory guidance.

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, 2015a), but instead uses data from a research study by AMEC Foster-Wheeler (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 Foster-Wheeler study data are used.

The overall approach can be summarised as follows:

- Fuel consumption and emissions for domestic journeys are taken from the AMEC Foster-Wheeler study based on detailed movement data for 2007 in which AMEC Foster-Wheeler 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 Foster-Wheeler study and reported separately under 1A4ciii;
- Estimates for domestic coastal shipping fuel consumption and emissions back-cast to 1990 and forecast to 2014 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 (MoD, 2015);
- 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 Foster-Wheeler, 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, 2015a). 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. In general, traffic levels have gone down slightly between 2007 and 2012, and increased from 2012 to 2014.

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. 5: 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, 2015) 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); this data is scaled based on the 2008 data from the Annual Road Traffic Estimates (2008-2013) (DRDNI, 2014) 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).
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. 6: Transport (1995; 1998 to 2014)

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, 2015) Fuel consumption: Digest of UK Energy Statistics (DECC, 2015a)
Road Transport	Road Transport	Petrol, Diesel oil, LPG	Vehicle km, DfT, NI DRD Emission factors: COPERT 4 v 11 (EEA, 2013) Fuel efficiency: COPERT 4 v11 (EEA, 2013) Composition of fleet: Vehicle Licensing Statistics Report, DfT (GB) Dept of Regional Development (NI). Traffic data: National Traffic Census, DfT (England, Scotland, Wales: 1990-2014) Annual Road Traffic Estimates for NI (2008-2013). 2014 data is estimated by scaling the 2013 NI data based on the 2013 to 2014 trend from the DfT National Traffic Census. Data for 1990-2007 is scaled based on the 2008 data from the Annual Road Traffic Estimates (2008-2013), using the following datasets: 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- 2007). Fuel consumption: Digest of UK Energy Statistics (DECC, 2015a) 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, 2015a)
Navigation	Coastal shipping	Gas oil, Fuel oil	Back calculated from 2007 estimates by AMEC Foster-Wheeler (formerly 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, 2015a)
Other	Aircraft Support	Gas oil	Regional aircraft movements, DfT Fuel consumption: Digest of UK Energy Statistics (DECC, 2015a)

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.

In the derivation of the 1990-2014 UK and DA GHG inventory estimates, no new data were provided by the Northern Ireland DRD regarding road vehicle movements by vehicle type. Therefore the activity for road vehicles in Northern Ireland for the year 2014 were estimated by Ricardo Energy and Environment based on the reported 2013-2014 GB road traffic trends, using DfT data, and applying the trend to historical Northern Ireland data for 2013.

Emission factors

All the emission factors were consistent with those used in the latest UK Greenhouse Gas Emissions Inventory (*yet to be published*). Emission factors for methane are now based on COPERT 4 v11 emission factors (EEA, 2013). Previously they were based on factors developed by TRL on behalf of DfT, 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 are based on the emission factors in COPERT 4 v11 (EEA, 2013). They are based on factors obtained from the Emissions Inventory Guidebook (EEA, 2013). 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 now based on fuel consumption factors based on COPERT 4 v11 (EEA, 2013), having previously been based on the fuel consumption-speed relationships for detailed categories of vehicles compiled by TRL (on behalf of DfT). The COPERT 4 factors included a method for passenger cars which applies a year-dependent 'real-world' correction to the average type-approval CO_2 factor weighted by new car sales in the UK from 2005-2014. The new car average type-approval CO_2 factors for cars in different engine size bands were provided by the Society of Motor Manufacturers and Traders (SMMT, 2015). The real-world uplift uses empirically-derived equations in the Guidebook that take account of average engine capacity and vehicle mass. Previous versions of the inventory calibrated speed-fuel consumption curves for HGVs and buses with independent data from DfT on the fuel efficiencies of these vehicles in the UK obtained from surveys of haulage companies and bus operators' fuel returns. However, DfT have recently found the data to be less complete than was previously considered and therefore less suitable for use in the inventory.

Table A2. 7 shows the UK fleet-averaged fuel consumption factors used for the inventory broken down by year of emission, and vehicle typ. Table A2. 8 shows the implied methane and nitrous oxide emission factors used for the inventory broken down by year of emission, and vehicle type. The age-mileage functions provided by TRL are used to work out the accumulated mileage effects in the calculation of N_2O emission factors. These factors are weightings according to the distances travelled by the mix of Euro classes in the fleet each year as well as the proportions of kilometres travelled at different speeds and therefore with different emission factors. These factors also include the contribution from cold start emissions.

Age and composition of the fleet

Automatic Number Plate Recognition (ANPR) data provided by DfT (2015b) are used to define the UK's vehicle fleet composition on the road. The ANPR data has been collected between 2007 and 2011, 2013 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 well as on urban roads, although not to the extent. For Northern Ireland, the ANPR data for 2010-2011, and 2013 shows 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. It is assumed that there is no preferential use of diesel cars, and that the petrol/diesel mix in car km follows the proportion as indicated by the licensing statistics provided by DRDNI (2014).

- ***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.

Previously, the results from above were combined with regional licensing statistics provided by DfT from their Driver and Vehicle Licensing Agency database to define regional variation. The application of the DVLA data were based on a one-off analysis carried out in 2010, combined with the fuel consumption factors based on the TRL/DfT source. Given the change of the fuel consumption factors (now based on COPERT 4 methodology), the previous application of the DVLA data will no longer be valid and hence was not applied to the latest UK and DA inventories.

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, 2015b; DfT, 2015c). 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 2014 by road type and vehicle type for England, Wales and Scotland was provided by DfT (DfT, 2015b). 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.

Vehicle kilometre data for Northern Ireland by vehicle type and road class are provided by DRDNI (2014). 2014 data was not available from this source so this is estimated by scaling the 2013 NI data based on the 2013 to 2014 trend from the DfT National Traffic Census. Data for 1990-2007 is scaled based on the 2008 data from the DRDNI (2014)using the following datasets: 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- 2007). 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 GB each year. The ratios were then applied to the motorcycle vehicle km activity data for GB.

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

[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.

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. 7: UK Fleet-averaged fuel consumption factors for road vehicles (in g fuel/km)

Source	1990	1995	2000	2005	2010	2013	2014
Petrol cars	56.3	55.8	54.8	54.9	54.0	52.3	51.6
Diesel cars	55.7	54.0	54.2	54.1	54.4	52.4	51.5
LGVs	77.9	78.7	77.6	74.8	74.6	73.5	72.7
HGVs	210	205	194	207	211	215	215
Buses and coaches	292	293	268	267	261	257	256
Mopeds and motorcycles	36.2	37.0	38.0	36.9	35.9	35.0	34.9

Table A2. 8: Methane and Nitrous Oxide Implied Emission Factors for Road Transport (in mg/km)

Pollutant	Source	1990	1995	2000	2005	2010	2013	2014
CH_4	Petrol cars	108.4	84.4	53.2	31.9	17.8	14.3	13.5
	DERV cars	16.8	12.1	7.6	2.7	1.0	0.6	0.5
	LGVs	76.7	51.9	24.8	7.4	2.8	1.8	1.6
	HGVs	73.3	72.1	64.2	63.1	36.6	19.7	15.7
	Buses and coaches	127.2	135.1	108.5	90.3	50.7	30.5	25.9
	Mopeds and motorcycles	201.3	201.0	187.2	152.5	109.8	93.3	87.9
N_2O	Petrol cars	8.0	13.6	11.0	7.2	2.8	1.9	1.7
	DERV cars	-	1.9	3.7	5.8	6.3	6.4	6.4
	LGVs	5.2	4.1	4.9	5.9	6.2	6.2	6.2
	HGVs	30.0	23.9	13.4	8.1	17.2	31.3	34.4
	Buses and coaches	30.0	25.3	15.4	8.8	13.7	20.7	23.2
	Mopeds and motorcycles	1.9	1.9	1.9	1.9	1.9	2.0	2.0

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 2014, the bottom-up method underestimates petrol and diesel consumption by 7.7% and 4.8% respectively.

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 Appendix 7. 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 Brown et al. (2016).

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.

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 2014 UK inventory data.

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, 2015b), 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 follows a similar method to that described for other industrial combustion. For gas oil, coal and gas, the available point source emissions data and fuel use data from EU ETS 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, 2001), 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 (2015a). 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, 2015), Firmus Energy providing sales data for 2005 onwards (Firmus Energy, 2015) and Vayu Ltd providing sales data for 2010 onwards (Vayu, 2015). 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 2014, 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 (2015a) 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. 9: Other Sectors (Base Year – 1990)

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
		Coal	DECC Sub-national energy statistics

IPCC Category	NAEI Sources	Activity: Fuel Consumption	Data used for deriving DA estimates from UK totals / Comments
Commercial & Institutional	Miscellaneous, Public service	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 (Stationary)	Oils and coal	Sub-national oil consumption, DECC
		Natural gas	Assumed as all England
Residential	Domestic	Wood[3]	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[3]	Wheat production, MAFF
	Agricultural mobile machinery	Gas oil, petrol	Agricultural off-road mapping grid

[3] Used to calculate non-CO_2 emissions

Table A2. 10: Other Sectors (1995; 1998 to 2014)

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 EU ETS data and PI/SPRI/NIPI data, PSEC data.
		SSF	DECC Sub-national energy statistics
		Natural gas	Natural gas consumed (DECC, 2015a), Airtricity, Firmus, Vayu, PSEC data. GB estimates from point source data (including EU ETS) 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 EU ETS, PI/SPRI/NIPI data, PSEC data
		MSW	As MSW incinerators
		Burning oil	DECC Sub-national energy statistics, PSEC data (DFPNI, 2015)
	Railways (Stationary)	Oil and coal	Regional gas oil consumption, Network Rail (GB) and Translink (NI)
		Natural gas	Assumed as all England
Residential	Domestic	Wood[4]	Domestic wood mapping grid
		Peat	Domestic peat consumption data, CEH
		SSF, coke, LPG	Sub-national energy statistics (SSF), DECC, 2011 mapping grid, scaled 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 Airtricity, Vayu Ltd. and Firmus Energy (NI)
		Burning oil, gas oil,	Sub-national energy statistics (oil) from DECC, 2011 mapping grid scaled using Housing Condition Survey data, NI HECA, DEMScot model, census.
		Coal, anthracite	Sub-national energy statistics (coal, anthracite), DECC, 2011 mapping grid scaled 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 combustion	coal, coke, natural gas	Agricultural employment, MAFF/Defra
		burning oil, gas oil, fuel oil	DECC Sub-national energy statistics
		Straw[4]	Wheat production, MAFF/Defra
	Agricultural mobile machinery	Gas oil, petrol	Agricultural off-road mapping grid

[4] Used to calculate non-CO_2 emissions

A2.7.2 Residential

Annual gas use data estimates for the residential sector are provided by the gas suppliers in Northern Ireland (Airtricity, 2015; Firmus Energy, 2015; Vayu Ltd, 2015) and these data have been used to estimate the residential emissions in 2014. The gas use estimates for Scotland, Wales and England are derived from the DECC sub-national energy statistics (DECC, 2015b) 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, 2015b) 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 for non-gas fuels were revised in the 1990-2013 DA GHGI dataset to reflect the improvements made in energy and emissions modelling from the full integration of the 2011 census data from all UK households, which has now become available for all countries. The census data has provided much more detail regarding the primary and secondary fuel use by household, and together with records of houses built in each DA, on- and off-gas-grid, the estimates of fuel-specific energy use have been extrapolated back and forth to cover the 2005-2014 dataset required for Local Authority level emissions reporting. This approach is used for coal, anthracite, gas oil and burning oil. The estimates from 2005 have been extrapolated back across the time series to reflect the overall estimated energy demand for each DA, constrained by the UK fuel use totals in DUKES.

The consumption of fuel oil by the domestic sector is a very small amount, and is distributed simply according to population (ONS, 2015). Domestic use of wood is estimated across the time-series using the latest mapping grid information on wood use (NAEI, 2011). Domestic peat use estimates by DA are provided by the Centre for Ecology & Hydrology and were updated significantly in the 1990-2014 inventory (Personal Communication: CEH, 2015).

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 (2015a).

Work by Ricardo Energy & Environment 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), annually reviewed and updated in the NAEI cycle and reported in the NIR and IIR, to derive an agricultural off-road mapping grid to estimate geographical distribution of fuel use in the sector (Murrells, et al., 2011) (Netcen, 2004) (Tsagatakis, et al., 2013). 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, 2015). 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 (2015), BGS (2015), WO (1998), SO (1999), BERR (1996, Personal Communications). 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, 2015).

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:

- 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;
- Emissions from the flaring of coke-oven gas;
- Emissions of methane from the process.

These are disaggregated based on the regional consumption of coking coal and site-specific fuel use data from EU ETS (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 (2015d) EEMS data for 1995, 1998-2014. 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 2000-2014 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, 2015d). 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 1998-2014. 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 (2015) and the other gas network operators: Northern Gas Networks (2015), Scotia Gas Networks (2015), Airtricity (2015)and Wales & West Utilities (2015). Estimates are provided by Local Distribution Zones, enabling direct allocation to each of the constituent countries.

Table A2. 11: 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. 12: Fugitive Emissions from Fuels (1995; 1998 to 2014)

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: EU ETS (EA, SEPA, NIEA 2015b)
	Flaring	Coke oven gas	Coal feed to coke ovens, ISSB, WS, DECC and (1999-2004) PI. 2005 onwards: EU ETS (EA, SEPA, NIEA 2015b)
	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, Airtricity
	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 A2.11.

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[5] (2004) for 1990 to 2001. From 2002 to 2007, the regional split is based on reported emissions from the PI, SPRI and NIPI, whereas in 2008 to 2014 all cement sites now report under EU ETS and hence the emissions from combustion and process sources by site are derived from EU ETS data (EA, 2015b; SEPA, 2015b; NIEA, 2015b). 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, 2015).

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 (EA, 2015a) has enabled more accurate disaggregation for the years 2000 and 2001. Historical 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 2014 EU ETS 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 2014 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. 13: 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
Ammonia Production	Ammonia feedstock	Natural gas feedstock and fuel	All such plant located in England

[5] 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
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
Petrochemical and carbon black production	Ethylene Production	Production of Ethylene	Plant capacities, extrapolated back from PI /SPRI or EU ETS data
	Carbon black production	Production of carbon black	
	Ethylene dichloride production	Ethylene dichloride production	
	Acrylonitrile production	Acrylonitrile production	
	Ethylene oxide production	Ethylene oxide production	
	Chemical industry other	NA	
Titanium dioxide production	Titanium dioxide production	Coke oven coke / petcoke use	All such plant located in England
Iron and Steel	Electric Arc Furnace	EAF steel production	Regional EAF production, ISSB
	Flaring	Blast furnace gas	Coke consumed in blast furnaces, ISSB, WO
Zinc production	Zinc production	Coke oven coke use	All plant in England
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 & SF_6 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
	Military applications	NA	Regional population, ONS
	Particle accelerators,	NA	Regional population, ONS
	Electrical Insulation	NA	Regional electrical capacity, AEAT industry report 2003
	N_2O from product uses	NA	Regional population, ONS

Table A2. 14: Industrial Processes (1995; 1998 to 2014)

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 EU ETS (2008 onwards), and the PI/SPRI/NIPI (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. EU ETS (2009 onwards)
	Blast Furnaces	Limestone and dolomite	Iron production, ISSB
Soda Ash Production and Use	Glass production	Soda Ash Consumption	Regional glass production, BGlass. EU ETS (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/NIPI. 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
Petrochemical and carbon black production	Ethylene Production	Production of Ethylene	Plant Capacities, PI/SPRI/NIPI and EU ETS data. (All carbon black plant closed in 2009)
	Carbon black production	Production of carbon black	
	Ethylene dichloride production	Ethylene dichloride production	
	Acrylonitrile production	Acrylonitrile production	
	Ethylene oxide production	Ethylene oxide production	
	Chemical industry other	NA	
Titanium dioxide production	Titanium dioxide production	Coke oven coke / petcoke use	All such plant located in England
Iron and Steel	Electric Arc Furnace	EAF steel production	Regional EAF production, ISSB
	Flaring	Blast furnace gas	Coke Consumed in blast furnaces, ISSB, WO
Zinc production	Zinc production	Coke oven coke use	All plant in England
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 & SF_6 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
	Military applications	NA	Regional population, ONS
	Particle accelerators,	NA	Regional population, ONS
	Electrical Insulation	NA	Regional electrical capacity, AEAT industry report 2003
	N_2O production and bottling plant	NA	All such plant are located in England (only operating since 2005).
	N_2O from product uses	NA	Regional population, ONS

The UK inventory reports emissions of GHGs from methanol production, ethylene production and the other chemical industry. Several specific sectors of the chemical and petrochemical industry were split out for the first time in the 1990-2013 inventories due to the use of the 2006 IPCC Guidelines; sources such as titanium dioxide and emissions from manufacture of ethylene oxide, ethylene dichloride, and

acrylonitrile are all now reported individually. The methanol plant is located in England, whilst ethylene production occurs in England, Scotland and Wales. The chemical and petrochemical sector emissions are distributed based on data reported in the PI (EA, 2015a), SPRI (SEPA, 2015a) and plant capacity. Emissions are extrapolated to 1990 and 1995 based on plant capacities. In many sectors, there are only plants evident in England.

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. Emissions of nitrous oxide from production and bottling plant from one site operational in England since 2005 are based on emissions reported in the Pollution Inventory (EA, 2015a).

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, 2015).

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, 2015) up to 2004, and then using plant-specific data from the EU ETS for 2005 onwards (EA, 2015b; SEPA, 2015b; NIEA, 2015b) verified using data from operators (Tata Steel, 2015).

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 (2015) and on site-specific information for the integrated steelworks taken from the EU ETS 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 (2015), for years up to 2002. The DA emissions data for 2003 onwards are based on PI and SPRI data (EA, 2015a; SEPA, 2015a). 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.

Emissions from zinc production were reported for the first time in the 1990-2013 DA GHG inventories, although the emissions are purely a re-allocation due to revised methods in the 2006 IPCC Guidelines, which re-classifies use of coke oven coke use in zinc production to the IPPU sector rather than as a fuel use in 1A2. All such manufacturing plant are known to have operated in England, and all were closed in the late 1990s / early 2000s.

The anode baking process within aluminium production also results in emissions of PFCs, and estimates are provided by plant operators (Rio Tinto Alcan, 2015).

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 SKM Enviros (1999). This model was updated by Ricardo (Haydock et al., 2003), with further updates at UK level for the refrigeration and air conditioning sectors during 2008-9 (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 (Personal communication, Gluckman, 2014).

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 (2015). 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 & Ricardo 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 has 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 Ricardo model (AEA, 2004), 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 Ricardo model (AEA, 2004). Within the 1990-2013 GHG inventories, for the first time this source included emissions of NF_3, which are estimated in the UK GHG inventory using a Tier 2 method from the 2006 IPCC Guidelines. Other new minor sources include F-gases from military applications (AWACS), particle accelerators and N_2O from product use, all of which are disaggregated based on GVA.

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

Direct emissions of N_2O from agricultural soils are estimated using the IPCC methodology (IPCC, 2006) and incorporating new country specific emission factors (EFs) for some of the N_2O sources as well as UK-specific parameters. The new EFs were derived from the Defra funded project AC0116, with the same values applied to all the DAs.

The IPCC method involves estimating contributions from: the use of inorganic nitrogen fertilizers, application of livestock manures to land, application of sewage sludge to land, urine and dung deposited by grazing animals in the field, crop residues returned to soils, net mineralisation of soil organic matter, cultivation of histosols (organic soils). In addition to these, the following indirect emission sources are estimated: emission of N_2O from atmospheric deposition of agricultural NO_x and NH_3 and emissions of N_2O from leaching and run-off of agricultural nitrate.

Annual consumption of synthetic fertiliser is estimated based on crop areas from the DAs[6] and application rates from the British Survey of Fertiliser Practice (BSFP) plus country-specific data for Northern Ireland provided by Paul Caskie, (DARDNI). Production data for crops, used in the calculation of N_2O emissions from the ploughing in of crop residues, are taken from various sources.[7] Emissions from inorganic N application are estimated using a new country specific EF for the 1990-2014 inventory, derived from Defra projects AC0114/AC0116.

[6] **England**: https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june and Sarah Thompson (DEFRA).
Scotland: http://www.gov.scot/Topics/Statistics/Browse/Agriculture-Fisheries/PubAbstract/Abstract2014; http://www.gov.scot/Publications/2014/10/6277/downloads and Graeme Kerr (The Scottish Government).
Wales: http://gov.wales/statistics-and-research/survey-agricultural-horticulture/?lang=en and John Bleasdale (Welsh Government).
Northern Ireland: http://www.dardni.gov.uk/index/statistics/crops-livestock-and-labour-numbers/statistics-farm-animal-populations.htm, Conor McCormack and Paul Caskie (DARDNI).

[7] Data includes England, Wales, Scotland and Northern Ireland; Cereal and oilseed production for England, Wales, Scotland, Northern Ireland: https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june; Rye, mixed corn and triticale production for England, Wales, Northern Ireland: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/364157/structure-jun2013prov-UK-16oct14.pdf; Linseed, sugar beet, peas and beans (dry) production for England, Wales, Northern Ireland: https://www.gov.uk/government/statistical-data-sets/agriculture-in-the-united-kingdom - chapter 7 crops; Vegetable production for England, Wales, Northern Ireland: BHS vegetable survey, https://www.gov.uk/government/statistics/horticulture-statistics-2014; Potato and maize production for England and Wales: Jim Holding (DEFRA): All other production data for Wales: John Bleasdale (Welsh Government); All other production data for Scotland: Nicola

Following the IPCC guidance, emissions from animal manures and slurries used as organic fertilizers are reported under agricultural soils using IPCC Tier 2 methodology and country-specific data for the amount of manure nitrogen applied to the land. New country specific EFs for the 1990-2014 inventory, derived from Defra projects AC0114/AC0116, are applied to different manure types.

The UK follows the IPCC 2006 Guidelines by using a nitrogen flow modelling approach which estimates that a significant proportion of the total N excreted by animals in managed systems (liquid, deep bedding and poultry manure without bedding or poultry manure with bedding), with the exception of daily spread, is lost prior to application to soils.

For sewage sludge applied to land the calculation involves estimating the amount of nitrogen contained per dry matter unit of sludge that is applied to land and applying IPCC default EFs.

Emissions from urine and dung deposited by grazing animals are reported under agricultural soils according to IPCC 2006 Guidelines. Emissions are calculated using new country-specific EFs for cattle grazing returns for the 1990-2014 inventory derived from Defra projects AC0114/AC0116. No experimental data were available for sheep grazing returns, so a conservative approach was taken by which the EF for cattle grazing returns has also been applied to sheep; IPCC 2006 Guidelines default EFs area 50% lower for sheep than for cattle grazing returns.

Emissions from the ploughing in of crop residues are calculated using the IPCC methodology and IPCC default EFs. Emissions from mineralisation refer to soil organic matter on land converted to cropland more than 20 years ago. The areas of cultivated histosols for each DA were derived from a review undertaken as part of Defra project AC0114.

Indirect emissions of N_2O from the atmospheric deposition of NH_3 and NO_x are estimated according to the 2006 IPCC guidelines using country specific values for the fraction of N that is volatilised and IPCC default EFs for the indirect N_2O emission. Indirect emissions of N_2O from leaching and runoff are estimated using country specific values for the fraction of N leached for inorganic fertilizer applications to grassland and excretal returns from grazing livestock; for fertilizer to arable land, crop residues, sewage sludge and manure application to land the default IPCC 2006 Guidelines values for $Frac_{LEACH}$ are used. The method used corrects for the N content of manures used as fuel (poultry bedding incineration).

Also reported are CO_2 emissions from liming (data compiled by CEH) and from urea fertilizer application.

A2.10.2 Livestock Enteric Fermentation and Manure Management

The enteric CH_4 emissions for dairy cattle (for dairy cows only) are estimated following the IPCC 2006 Tier 2 procedure, 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 Devolved Administrations, based on the annual June Agricultural Survey for each country[38]. Milk production and fat in milk are obtained from Agriculture in the UK (Defra, 2015b), with common values used across the DAs.

Dairy cow live weights were provided by Eileen Wall/Tracey Pritchard (SRUC). Mature weights for the different dairy size categories were obtained from an analysis of abattoir data (net carcase weight) from four abattoir companies across Great Britain for the years 2008-2013 combined with British Cattle Movement Society (BCMS) data (analysis conducted by Tracy Pritchard, SRUC). Combining the datasets using eartag identification enabled carcase weight to be linked with breed, gender, age, whether the animal had produced calves and location. Weighted means were obtained for all dairy females that had been slaughtered post-first calf, taking into account the average carcase weight and number of animals in different age groups. A killing out percentage of 47% was applied to all breeds (Juniper et al., 2006), although statistics are lacking on killing out percentage for different dairy breeds. The 1990-2007 time series and data for 2014 were estimated by applying the ratio of the existing UK slaughter data to the estimated dairy liveweights for 2008-2013.

A country-specific value for the digestibility of feed (DE) of 74.5%, is used, expressed as a percentage of the gross energy, for dairy cows. This value is on the high end of the range recommended by the IPCC (2006) for Western Europe of 55-75% for pasture fed animals, and is

Kerr (The Scottish Government); All other production data for Northern Ireland: http://www.dardni.gov.uk/index/statistics/crops-livestock-and-labour-numbers/crop-areas-and-production-1981-onwards.htm and Conor McCormack (DARDNI).

[8] Data derived as sum of totals for each Devolved Administration (i.e. England, Wales, Scotland and Northern Ireland), obtained from Devolved Administration statistical publications. June survey results: England: https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june and Sarah Thompson (DEFRA); Scotland: http://www.gov.scot/Topics/Statistics/Browse/Agriculture-Fisheries/PubAbstract/Abstract2014; http://www.gov.scot/Publications/2014/10/6277/downloads and Graeme Kerr (The Scottish Government); Wales: http://gov.wales/statistics-and-research/survey-agricultural-horticulture/?lang=en and John Bleasdale (Welsh Government); Northern Ireland: http://www.dardni.gov.uk/index/statistics/crops-livestock-and-labour-numbers/statistics-farm-animal-populations.htm and Conor McCormack (DARDNI).

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). The UK uses an energy balance approach to estimate the metabolisable energy (ME) requirement for a dairy cow for a year including the lactating and non-lactating period. This accounts for the ME required for maintenance for the entire year, the ME required for milk production during the lactating period and the ME required for pregnancy.

The UK has survey data on average concentrate feed use by dairy cows and use these data to derive the amount of energy supplied by concentrates over the entire year. The value of typical concentrate use (not the required or recommended use) for a 7,000 litre yielding cow of 0.29 kg concentrates per litre of milk (Nix, 2009) is derived from such survey data. This does not represent the amount of concentrate feed required to meet the whole energy demand for milk production, but is the typical concentrate use on UK dairy farms for that level of milk yield. The digestibility (DE as % of GE) value for concentrate feed (c. 82%) is derived from the typical mix of protein and energy feed ingredients. Using this value, the annual ME requirement that has to be met from forage can then be derived. The relative proportions of concentrate to forage DM intake per year estimated in this way are 29% concentrate and 61% forage.

The UK do not have detailed survey data on amounts of different forages consumed by dairy cows, so the proportional annual breakdown (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. The UK benefits from a relatively warm and wet maritime climate that is particularly suited to grassland production, as such grazing periods in the UK may be longer than those in other European countries.

The UK is currently undertaking research to improve activity data on typical forage diets for a range of livestock production systems. The digestibility values for the different forage components are taken from MAFF 1990 (UK Tables of Nutritive Value and Chemical Composition of Feedingstuffs, 1990, Rowett Research Services Ltd). For grazed grass, the value used is not an average of all DE estimates for grass in this database, but is the value specifically given by MAFF 1990 for 'Fresh grass (grazed) – all species', which is taken to be representative of the annual average DE for grazed grass (compiled from a total of 244 samples taken throughout the grazing period, and includes grasses with ME values ranging from 7.2 to 14.1, across a range of species including hybrid rye grasses, perennial rye grasses and Tall Fescue). While some farms may specifically feed in-calf heifers and dry cows a poorer quality of forage, this is not considered typical for most dairy farms, where the animals will be receiving forage of the same quality. 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). 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. Mature weights for the different beef size categories were obtained from an analysis of abattoir data (net carcase weight) from four abattoir companies across Great Britain for the years 2008-2013 combined with British Cattle Movement Society (BCMS) data (analysis conducted by Tracy Pritchard, SRUC). Combining the datasets using eartag identification enabled carcase weight to be linked with breed, gender, age, whether the animal had produced calves and location. Weighted means were obtained for all beef females that had been slaughtered post-first calf, taking into account the average carcase weight and number of animals in different age groups. A killing out percentage of 50% was applied to all breeds (Minchin et al., 2009), although statistics are lacking on killing out percentage for different beef breeds. The 1990-2007 time series and data for 2014 were estimated by applying the ratio of the existing UK slaughter data to the estimated beef live weights for 2008-2013. The digestibility value for beef cows used by the UK is 65% for annual average feed composition. This value is based on expert opinion (Bruce Cottrill, ADAS), reflecting the poorer quality diet that beef cows will generally receive in comparison with dairy cows.

A Tier 1 methodology is used for the calculation of the emissions from other cattle with default EFs (2006 IPCC Guidelines). The following six groups are included: dairy heifers, beef heifers, dairy replacements > 1 year, beef all other > 1 year, dairy calves < 1 year, beef calves < 1 year.

The UK uses IPCC Tier 1 default EFs for enteric fermentation for all mature sheep (> 1 year old). The UK uses a country-specific EF 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 estimated by Wheeler et al. (2012) as 8.1 months. The animals under category 'other sheep' are largely barren ewes that will be slaughtered at some time during the year. These are therefore assumed to be alive for 6 months of the year, which is reflected in the emission calculation rather than the emission factor. These emission factors are assumed constant over the entire time series. The UK EFs for pigs, goats, horses and deer are default IPCC (2006 IPCC Guidelines).

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 (B_o) parameters for each livestock type (except for dairy and beef cows, where a Tier 2 calculation is used to determine VS, and deer where a Tier 1 methodology and EF is used); 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 (2006) methodology 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, 2006). 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).

Indirect N_2O emissions from manure management comprise country-specific values for N loss due to volatilisation of NH_3 and NO_x, disaggregated by AWMS. Emissions of N_2O from the leaching/runoff associated with the storage of deep bedding as field heaps have been estimated using IPCC methodology (IPCC 2006 guidelines) with a country specific $Frac_{LEACH}$ value of 0.03 (Nicholson, et al., 2011).

Emissions from the combustion of poultry bedding for electricity generation are reported under power stations. Emissions occurring during storage of poultry bedding that will later be used for energy generation are included in the agricultural inventory (tonnage of poultry bedding incinerated obtained directly from EPR, Teresa Wachter Fuel Operations Manager, Energy Power Resources Limited, a total of 462,000 tonnes for 2014).

A2.10.3 Reasons for changes

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

- The default IPCC values for the parameters $Frac_{GasMS}$, $Frac_{GasF}$, $Frac_{GasM}$ and $Frac_{LossMS}$ have been replaced by country-specific values;
- The default IPCC emission factor EF_1 has been replaced by country-specific values for direct N_2O emissions from inorganic fertilizer applications and manure application to soils;
- The default IPCC emission factor EF_3 has been replaced by country-specific values for direct N_2O emissions from urine and dung deposited by grazing animals;
- The default IPCC values for the parameter $Frac_{Leach}$ has been replaced by country-specific values according to N source and land use.

Further details can be found in Appendix 6.

A2.10.4 Planned improvements to the inventory

The UK GHG agricultural inventory is undergoing large improvements in order to better quantify the emissions and reduce uncertainty. A consortia of a wide range of scientific expertise has been put together to fulfil the requirements for improving the UK GHG agricultural inventory. As part of this planned programme of improvement, a number of revisions were made to the inventory model for this reporting year.

Beyond improvements already implemented, the agriculture improvement plan comprises:

1. Restructuring the inventory to improve spatial and temporal disaggregation and incorporation of Tier 2 methodology in those areas where both measurement and activity data are available. This work will also to allow the inventory to reflect the effect of mitigation strategies[1].
2. Data mining to collate and review existing experimental agricultural data to deliver a set of country specific (Tier 2) emission factors and supporting farm practice data to enable an improved mapping of N_2O and CH_4 emissions for the United Kingdom with an assessment of uncertainty (Defra project AC0114).
3. Tier 2 methodology for enteric CH_4 estimates for all cattle and sheep categories (Defra projects AC0114/AC0115).
4. Further analysis of UK-specific measurement data on direct N_2O emissions, to develop country-specific emission factors responsive to agro-climatic gradients (EF_1, EF_3).
6. Development of country-specific EFs for N_2O from animal manure management systems from existing data[1].
7. Assessment of the effect of mitigation strategies, specifically the use of nitrification inhibitors and optimising fertiliser timing on N_2O emission from soils (DEFRA projects AC0116 and AC0213)

[1] (DEFRA Agricultural GHG R&D Platfom – www.ghgplatform.org.uk)

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.

A2.11 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 (LULUCF) activities. Removals of CO_2 are conventionally presented as negative quantities.

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 produced at the DA and UK scale. The description of the DA GHG inventory methodology and emission estimates are included in Appendix 8. Detailed information on the data and methods used in the LULUCF inventory can be found in Appendix 8.

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 1990-2013 inventory cycle. The methodology for calculating methane production in landfill sites was updated. Waste composition and commercial and industrial waste data were updated, along with updated assumptions about the combustion of methane in landfill gas engines and the approach to flaring at un-reporting sites, drawing upon evidence from research by Defra and the Environment Agency. The revisions to the assumptions in the UK landfill model regarding methane utilisation were provided in detail within the UK GHG National Inventory Report published in 2015.

The Ricardo 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 (Hogg, et al., 2011). Estimates of country-specific landfill tonnages are derived by:

- Using the data on Local Authority Collected Waste (**LACW**, previously known as MSW). There is no 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 onwards 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.

The DA estimates are based on available data that were used within the UK MELMod model used in the 1990-2014 UK GHGI. 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 onwards.
- The time series of data were extrapolated back from 1995 and forward where necessary to 2014;
- 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.

Commercial and Industrial Waste (C&I[9])

- 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 country-specific estimate of landfilling of 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 2014 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.

Methane capture and combustion in landfill gas flares and engines was calculated on a national basis from data on electricity generation from landfill gas (obtained from DUKES) and from site-specific data provided by the regulatory authorities. It was assumed that the proportion of gas collected for each DA was the same as the proportion calculated as being collected on a national basis.

A2.12.2 Biological Treatment of Solid Waste

Emissions of methane and nitrous oxide from composting of MSW, anaerobic digestion (AD) and Mechanical Biological Treatment (MBT) of MSW were introduced into the UK GHG inventory for 2013 using a Tier 1 methodology as specified in the 2006 IPCC Guidelines. The DA estimates have been derived from the UK GHGI totals, based on the % share of UK population in each DA. This was identified as an appropriate approach in view of the scale of emissions from this sector.

[9] Also includes construction and demolition waste in MELMod.

Activity data for this sector was derived from annual organics recycling reports, published between 1998 and 2012 by:

- The Waste and Resources Action Programme (WRAP - 2012, 2010 & 2009)
- The Association for Organics Recycling (2008, 2007 & 2006)
- The Composting Association (2005, 2004, 2003, 2001, 1999 & 1998)

Where necessary (e.g. for intervening years between published reports), activity data were interpolated between published values.

Emission factors for composting and anaerobic digestion are taken from IPCC (2006) default emission factors. The emission factor for mechanical biological treatment is assumed to be the same as for anaerobic digestion.

A2.12.3 Waste Water Handling

Nitrous oxide emissions from waste-water handling are based on population statistics for the UK (ONS, 2015) whilst methane emission estimates are based on operator reported data on treatment activities from water companies in England and Wales and from Scottish Water and Northern Ireland Water Service , all via an UKWIR data reporting mechanism. 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 (UKWIR, 2015).

There was significant improvement to the UK GHGI methodology for this source during the 1990-2013 cycle, with almost 100% coverage of major UK water companies now reporting emission estimates to the NAEI/GHGI work programme. For the first time in the 1990-2013 DA inventory dataset, methane emissions from private waste-water treatment facilities (e.g. septic tanks) were also included, based on bottom-up data from each country on the number of installations or permits for septic tanks that are recorded by the water companies. The UK estimates are based on a default IPCC methodology using UK-specific per capita Biochemical Oxygen Demand (BOD) and estimated population using private waste water management systems.

Estimates of emissions from industrial waste water treatment are distributed across the DAs based on the dataset from water companies outlined above.

A2.12.4 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 (2015a) which reports data for the amount waste incinerated for Scotland, Northern Ireland and England & Wales.

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. 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 plants 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, 2015a).

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 (EA, 2015a), 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 9 of the National Inventory Report (Brown et al., 2015). 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[10] category. Table A3. 1 summarises the data used to derive DA estimates for sector-specific electricity use and exports.

[10] 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 Northern Ireland Public Sector Energy Campaign (DFPNI, 2015), whilst the DA share of GB activity is derived from analysis of the Inter-Departmental Business Register for 2003 onwards. The 1990 estimates for all DAs are based on economic indicators from previous studies using the REEIO model.
Miscellaneous industrial / commercial	Electricity	The DA share of UK activity is derived from analysis of the Inter-Departmental Business Register for 2003 onwards, whereas the 1990 estimates are based on economic indicators from previous studies using the REEIO model.
Domestic	Electricity	Country-specific domestic electricity use in GWh, is taken from analysis within DECC Energy Trends December 2015 (for 2004-2008), DECC sub-national energy statistics March 2015 for 2008 onwards, DUKES 1991 data (for 1989) for 1990, and REEIO GVA data for 2000.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 December 2015 Energy Trends, however, so the Northern Ireland domestic electricity in 2014 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, 2015), 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, 2015; Northern Gas Networks, 2015; Wales and West Utilities, 2015; Scotia Gas, 2015).
Refineries - combustion	Electricity	Carbon dioxide emissions from refineries are used to estimate the DA share of UK sector electricity consumption (UKPIA, 2015).
Collieries - combustion	Electricity	Regional coal production data are used to estimate the DA share of UK electricity use by collieries. (UK Coal Authority, 2015)
Exports	Electricity	DA data on electricity exports are published within the periodic DECC publication “Energy Trends”, Table ET5.6.
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) 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.

A3.3 Revisions to End User Inventory Data and Methodology

The DA end user method was updated for the 1990-2013 DA GHG inventory report, with data and method improvements to further develop the DA end user estimates, to build upon new information and data. Since this update there have not been any changes to the End User inventory methods.

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.

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 2014 the end user estimates for the business sector are 183% that reported in the by source inventories, i.e. almost 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 2014 in the by source inventory the business sector represents 17% 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 2014 the UK end user estimates for the residential sector are 183% 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 2014 in the by source inventory the residential sector represents 12% of national GHG emissions, but on an end user basis this increases to 23%, 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 191%, 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 2014 the UK public sector only represents 3% 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 but gradually declining 14-12% 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) and results in a 5% increase on an end user basis. For Agriculture, the increase in emissions using the end user approach is limited to the emissions from energy use within the sector and results in a 4.2% increase on an end user basis.

A3.3.1 Summary of End User Data for Wales "Electricity Only" Emissions

The allocation of emissions from electricity use in the end user 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 2014, as the Welsh Government targets use a baseline from 2006 onwards. Note that these data exclude the by source emission estimates and 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 -2014, $MtCO_2e$

NC Category	2006	2007	2008	2009	2010	2011	2012	2013	2014
Agriculture	0.30	0.30	0.30	0.27	0.28	0.26	0.27	0.24	0.22
Business	6.57	6.35	6.17	5.18	5.36	5.08	5.39	5.10	4.46
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0	0	0	0	0	0	0.07	1.11	1.14
Industrial Process	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.005
Public	0.49	0.51	0.50	0.45	0.44	0.41	0.45	0.40	0.33
Residential	3.36	3.14	3.05	2.82	2.86	2.58	2.86	2.62	2.23
Transport	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.002
Wales Total	10.73	10.30	10.03	8.72	8.95	8.33	9.05	9.46	8.38

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 coming under increasing 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 EU ETS) 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 the industrial, agricultural, commercial, public and residential sectors;
- transport emissions[11];
- Agricultural process 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

[11] Note that aircraft emissions are traded, but the entire transport sector is excluded from the traded/non-traded analysis

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 EU ETS 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 2014 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/III is therefore of little value. Phase III of the EU ETS started in 2013, with a slightly increased scope of reporting compared with Phase II (2008-12). As a result, EU ETS data for 2013 onwards included emissions from some additional industrial combustion installations (e.g. roadstone coating plant) and certain industrial process sources were also included for the first time.

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, Natural Resources Wales, the Scottish Environment Protection Agency and the Northern Ireland Environment Agency.

Sector activity data (fuel use, mineral use) from the 2014 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. However, 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**. 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. Comparisons with UK energy statistics are therefore potentially very useful in revealing any areas of under- or over-estimation in the national statistics. However, 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). This is indeed what is generally found, and so we can conclude that there is no evidence of any problems in DUKES for these sectors. The comparison between EU ETS and DUKES is more informative in the case of sectors where we expect all, or nearly all sites to be covered by EU ETS e.g. for power stations, refineries etc. Here the EU ETS data should be the same or similar to that given in the UK energy statistics. In fact, there are a number of instances where the EU ETS fuel use data are higher than the data reported within DUKES, and so EU ETS data are therefore used within the UK and DA GHG inventory compilation, deviating from the national statistics. Examples include refinery and industrial use of other petroleum gases (OPG), upstream oil and gas use of liquefied petroleum gas (LPG) and OPG.
- **Differences in scope and definitions between IPCC sectors and EU ETS reporting**. IPCC reporting requires that a distinction is made between fuel combustion emissions and process emissions, and all emissions from all sources need to be captured. The scope of EU ETS reporting is not always comprehensive, i.e. emissions from some sources on site may be excluded from EU ETS data. Furthermore, the reporting format of the EU ETS does not explicitly separate the GHG emission sources between different activities on site. These scope and reporting limitations make it very difficult to either directly use in, or reconcile the reported data with the IPCC format emissions calculated and presented within the UK and DA GHG inventories.

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 2008-2014, 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 (2008-2014)

The traded and non-traded emission estimates for each of the DAs for 2008 to 2014 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, 2008-2014

Country	Emissions scope (all units: kt CO_2e)	2008	2009	2010	2011	2012	2013	2014
ENGLAND	Traded Emissions	193,390	168,549	169,373	160,313	169,199	160,906	140,102
	Non-Traded Emissions	303,891	282,965	290,579	264,084	269,734	261,865	249,141
	Total inventory emissions	497,280	451,514	459,952	424,397	438,933	422,771	389,242
	Traded Share	*38.9%*	*37.3%*	*36.8%*	*37.8%*	*38.5%*	*38.1%*	*36.0%*
SCOTLAND	Traded Emissions	23,765	21,962	24,041	20,056	20,349	19,441	17,002
	Non-Traded Emissions	35,040	32,402	32,451	29,593	29,972	29,344	27,425
	Total inventory emissions	58,805	54,364	56,492	49,648	50,322	48,785	44,426
	Traded Share	*40.4%*	*40.4%*	*42.6%*	*40.4%*	*40.4%*	*39.9%*	*38.3%*
WALES	Traded Emissions	26,611	21,846	24,069	22,616	24,705	29,644	26,191
	Non-Traded Emissions	24,068	22,080	22,725	21,009	21,150	20,776	20,211
	Total inventory emissions	50,679	43,926	46,794	43,625	45,855	50,420	46,402
	Traded Share	*52.5%*	*49.7%*	*51.4%*	*51.8%*	*53.9%*	*58.8%*	*56.4%*
N IRELAND	Traded Emissions	5,864	4,332	4,627	4,383	4,505	4,708	4,480
	Non-Traded Emissions	16,546	16,499	17,127	16,046	16,200	16,243	15,846
	Total inventory emissions	22,409	20,831	21,754	20,429	20,705	20,951	20,327
	Traded Share	*26.2%*	*20.8%*	*21.3%*	*21.5%*	*21.8%*	*22.5%*	*22.0%*
UNALLOCATED	Traded Emissions	15,231	15,064	15,124	13,356	12,341	12,400	11,003
	Non-Traded Emissions	1,850	2,102	1,942	1,971	2,326	1,932	3,024
	Total inventory emissions	17,081	17,166	17,067	15,327	14,667	14,332	14,026
	Traded Share	*89.2%*	*87.8%*	*88.6%*	*87.1%*	*84.1%*	*86.5%*	*78.4%*
UNITED KINGDOM	Traded Emissions	264,861	231,753	237,234	220,723	231,099	227,098	198,777
	Non-Traded Emissions	381,394	356,049	364,825	332,704	339,383	330,161	315,646

Country	Emissions scope (all units: kt CO_2e)	2008	2009	2010	2011	2012	2013	2014
	Total inventory emissions	646,255	587,801	602,059	553,427	570,482	557,260	514,424
	Traded Share	*41.0%*	*39.4%*	*39.4%*	*39.9%*	*40.5%*	*40.8%*	*38.6%*

A4.2.2 Analysis of Emissions 2008-2014

- The DA traded and non-traded emission estimates illustrate the regional differences in the EU ETS 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 41% in 2008, down to 39-40% in 2009 to 2011. The inventory data indicates that as the recession affected the economy in 2008-9, the traded emissions declined at a greater rate (down 13% 2008-9) than the non-traded emissions (down 7% 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 slightly greater rate (up 2.5%) than the traded sector emissions (up 2.4%). Between 2010 and 2011, both the traded and non-traded sectors have reduced by around 7-9% and then increased between 2011 and 2012, with traded emissions increasing by almost 5% and non-traded by 2%. In 2013, traded emissions fell slightly, by 2%, with a greater fall in non-traded emissions, down 3%. However, in 2014 a notable drop in traded emissions of 12% is almost entirely due to a sharp decline in the quantity of coal used in the generation of electricity, with the closure of two coal fired power stations. Non-traded emissions also fell by around 4% in 2014, due in part to lower reported fuel use across the economy.
- The **Northern Ireland** inventory has a much higher non-traded element compared to GB, with only 22% of inventory emissions within the EU ETS in 2014, compared to the 39% 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 2014 EU ETS data shows that Northern Ireland has a 2.5% share of the power sector traded emissions, whilst the only sectors where Northern Ireland has a higher share are in the cement sector (3.9% of UK sector traded emissions), glass sector (4.5% of UK sector emissions), food and drink sector (4.4% of UK sector emissions) and the other industrial combustion sector (3.3% of UK sector traded emissions) in 2014.
- In **Northern Ireland**, the non-traded share of GHG emissions declined by less than 1% between 2008-2009, and then grew by around 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). In recent years, trends in the non-traded sector are broadly similar to the UK but typically showing smaller decreases or increases; in 2014 the Northern Ireland non-traded share declined around 1% compared to 4.4%% across the UK.
- 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 44% of total GHG emissions, compared to the UK average of around 61% 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

(from 2008 to 2012) increased the traded share in Wales to around 53% of total carbon dioxide emissions. Now that the EU ETS has entered Phase III from 2013 onwards, the traded share in Wales has increased again, to 56% of the Wales GHGI total in 2014, a decline from 59% in 2013. 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 EU ETS emissions.

- The traded share estimates for **Scotland** are close to the UK average across all years since 2008, at around 38-40% of the GHGI total. 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 13% of UK refinery sector emissions in 2014 whilst oil and gas terminals in Scotland account for 52% of total UK onshore oil & gas exploration and production sector traded emissions.
- **England** traded share of emissions is around 36-38% of the inventory total in recent years, which is a few percentage points lower than the UK average of around 38-40%. There are many industrial and commercial sectors where England has a high share of the UK traded emissions in 2014; for example, sites in England account for 78% of power generation EU ETS emissions, 85% of public sector traded emissions, 83% of food and drink sector traded emissions and 74% of cement sector traded emissions. England has a lower representative share of EU ETS emissions in the iron and steel sector (57%), refinery (69%) and (onshore) oil & gas sectors (46%), reflecting the high incidence of such sites in Wales and Scotland. There has been a 6% increase in the percentage share of refinery emissions from 2013-14 however, in part due to closure of a Welsh refinery in late 2014 causing and decrease in the Welsh share and subsequent increase in England.

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

Sector	Graph Categories	IPCC sectors	Source Name
Energy Supply	Electricity production	1A1ai Public Electricity & Heat Production	Miscellaneous industrial/commercial combustion
			Power stations
			Public sector combustion
		2A4d Other process uses of carbonates: other	Power stations - FGD
	Gas production	1B2b1 Gas exploration	Upstream Gas Production - Offshore Well Testing
		1B2b3 Gas processing	Upstream Gas Production - process emissions
		1B2b4 Gas transmission and storage	Gas leakage
			Upstream Gas Production - Gas terminal storage
		1B2b5 Gas distribution	Gas leakage
	Liquid fuel production	1A1b Petroleum Refining	Refineries - combustion
		1B2a1 Oil exploration	Upstream Oil Production - Offshore Well Testing
		1B2a2 Oil Production	Petroleum processes
			Upstream Oil Production - process emissions
		1B2a3 Oil transport	Upstream Oil Production - Offshore Oil Loading
			Upstream Oil Production - Onshore Oil Loading
		1B2a4 Oil refining/storage	Upstream Oil Production - Oil terminal storage
	Offshore industry	1B2c Flaring Gas	Upstream Gas Production - flaring
		1B2c Flaring Oil	Upstream Oil Production - flaring
		1B2c Venting Gas	Upstream Gas Production - venting
		1B2c Venting Oil	Upstream Oil Production - venting
	Fuel production	1A1ci Manufacture of solid fuels	Coke production
			Solid smokeless fuel production
		1A1cii Oil and gas extraction	Upstream Gas Production - fuel combustion
			Upstream oil and gas production - combustion at gas separation plant
			Upstream Oil Production - fuel combustion
		1A1ciii Other energy industries	Collieries - combustion
			Gas production
			Nuclear fuel production
			Town gas manufacture
		1B1ai Underground mines: Abandoned	Closed Coal Mines
		1B1ai Underground mines: Mining activities	Deep-mined coal
		1B1ai Underground mines: Post-mining activities	Coal storage and transport
		1B1aii Surface mines: Mining activities	Open-cast coal
		1B1b Solid Fuel Transformation	Charcoal production
			Coke production
			Iron and steel - flaring
			Solid smokeless fuel production
Transport	Aircraft and airports	1A3a Domestic aviation	Aircraft - domestic cruise
			Aircraft - domestic take-off and landing
		1A3eii Other Transportation	Aircraft - support vehicles
	Other transport	1A3c Railways	Rail - coal
			Railways - freight
			Railways - intercity
			Railways - regional
		1A3d Domestic navigation	Inland goods-carrying vessels
			Motorboats / workboats (e.g. canal boats, dredgers, service boats, tourist boats, river boats)
			Personal watercraft e.g. jet ski
			Sailing boats with auxiliary engines
			Shipping - coastal
		1A4ai Commercial/Institutional	Railways - stationary combustion

Sector	Graph Categories	IPCC sectors	Source Name
		1A4ciii Fishing	Fishing vessels
		1A5b Other: Mobile	Aircraft - military
			Shipping - naval
		2D1 Lubricant Use	Marine engines
	Road transport	1A3bi Cars	Road transport - cars - cold start
			Road transport - cars - motorway driving
			Road transport - cars - rural driving
			Road transport - cars - urban driving
		1A3bii Light duty trucks	Road transport - LGVs - cold start
			Road transport - LGVs - motorway driving
			Road transport - LGVs - rural driving
			Road transport - LGVs - urban driving
		1A3biii Heavy duty trucks and buses	Road transport - buses and coaches - motorway driving
			Road transport - buses and coaches - rural driving
			Road transport - buses and coaches - 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
		1A3biv Motorcycles	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
		1A3bv Other road transport	Road transport - all vehicles LPG use
		2D1 Lubricant Use	Road vehicle engines
		2D3 Non-energy products from fuels and solvent use: Other	Road transport - urea
Residential	Aerosols and metered dose inhalers and other household products	2D2 Non-energy products from fuels and solvent use: Paraffin wax use	Non-aerosol products - household products
		2F4a Metered dose inhalers	Metered dose inhalers
		2F4b Aerosols: Other	Aerosols - halocarbons
	Other residential	5B1a composting municipal solid waste	Composting (household)
		5C2.2b Non-biogenic: Other	Accidental fires - dwellings
		5C2.2b Non-biogenic: Other Accidental fires (vehicles)	Accidental fires - vehicles
	Residential combustion	1A4bi Residential stationary	Domestic combustion
		1A4bii Residential: Off-road	House and garden machinery
Business	Industrial combustion of fuels	1A2b Non-Ferrous Metals	Autogeneration - exported to grid
			Autogenerators
			Non-Ferrous Metal (combustion)
		1A2c Chemicals	Chemicals (combustion)
		1A2d Pulp Paper Print	Pulp, Paper and Print (combustion)
		1A2e food processing beverages and tobacco	Food & drink, tobacco (combustion)
		1A2f Non-metallic minerals	Cement production - combustion
			Lime production - non decarbonising
			Other industrial combustion
		1A2gvii Off-road vehicles and other machinery	Industrial off-road mobile machinery
		1A2gviii Other manufacturing industries and construction	Autogeneration - exported to grid
			Autogenerators
			Other industrial combustion
		1A4ai Commercial/Institutional	Miscellaneous industrial/commercial combustion
		2B1 Chemical Industry: Ammonia production	Ammonia production - combustion
		2B8g Petrochemical and carbon black production: Other	Chemicals (combustion)
		2D1 Lubricant Use	Industrial engines
			Other industrial combustion
	Iron and steel - combustion	1A2a Iron and steel	Blast furnaces
			Iron and steel - combustion plant
	Other business	2D4 Other NEU	Non Energy Use: petroleum coke

Sector	Graph Categories	IPCC sectors	Source Name
		2G2 Particle accelerators	Particle accelerators
		2G3a Medical applications	N2O use as an anaesthetic
		5C2.2b Non-biogenic: Other	Accidental fires - other buildings
	Refrigeration and air conditioning	2E1 Integrated circuit or semiconductor	Electronics - HFC
			Electronics - NF3
		2F1a Commercial refrigeration	Commercial Refrigeration
		2F1b Domestic refrigeration	Domestic Refrigeration
		2F1c Industrial refrigeration	Industrial Refrigeration
		2F1d Transport refrigeration	Refrigerated Transport
		2F1e Mobile air conditioning	Mobile Air Conditioning
	Use of fluorinated gases	2F1f Stationary air conditioning	Stationary Air Conditioning
		2F2a Closed foam blowing agents	Foams
			Foams HFCs for the 2006 GLs
		2F2b Open foam blowing agents	One Component Foams
		2F3 Fire Protection	Firefighting
		2F5 Solvents	Precision cleaning - HFC
		2F6b Other Applications: Contained-Refrigerant containers	Refrigerant containers
		2G1 Electrical equipment	Electrical insulation
		2G2 Military applications	AWACS
		2G2e Electronics and shoes	Electronics - PFC
			Electronics - SF6
			Sporting goods
		2G2e Tracer gas	SF6 used as a tracer gas
Public	Public	1A4ai Commercial/Institutional	Public sector combustion
Industrial Process	Cement production	2A1 Cement Production	Cement - decarbonising
	Chemical industry	2B1 Ammonia Production	Ammonia production - feedstock use of gas
		2B10 Chemical Industry: Other	Chemical industry - general
		2B2 Nitric Acid Production	Nitric acid production
		2B3 Adipic Acid Production	Adipic acid production
		2B6 Titanium dioxide production	Chemical industry - titanium dioxide
		2B7 Soda Ash Production	Chemical industry - soda ash
		2B8a Methanol production	Chemical industry - methanol
		2B8b Ethylene Production	Chemical industry - ethylene
		2B8c Ethylene Dichloride and Vinyl Chloride Monomer	Chemical Industry - ethylene dichloride
		2B8d Ethylene Oxide	Chemical industry - ethylene oxide
		2B8e Acrylonitrile	Chemical industry - acrylonitrile
		2B8f Carbon black production	Chemical industry - carbon black
		2B9a1 Fluorchemical production: By-product emissions	Halocarbons production - by-product
		2B9b3 Fluorchemical production: Fugitive emissions	Halocarbons production - fugitive
		2C3 Aluminium Production	Primary aluminium production - PFC emissions
		2G4 Other product manufacture and use	Chemical Industry – other process sources
	Iron and steel	2C1a Steel	Basic oxygen furnaces
			Electric arc furnaces
			Ladle arc furnaces
		2C1b Pig iron	Iron and steel - flaring
		2C1d Sinter	Sinter production
	Other processes	2A2 Lime Production	Lime production - decarbonising
		2A3 Glass production	Glass - general
		2A4a Other process uses of carbonates: ceramics	Brick manufacture - all types
			Brick manufacture - Fletton
		2C3 Aluminium Production	Primary aluminium production - general
		2C4 Magnesium production	Magnesium cover gas
		2C6 Zinc Production	Non-ferrous metal processes
		2G3b N2O from product uses: Other	Other food - cream consumption
Agriculture	Field burning of agricultural wastes	3F Field burning	Field burning
	Livestock	3A1 Enteric Fermentation dairy cattle	Agriculture livestock - dairy cattle enteric
		3A1 Enteric Fermentation non-dairy cattle	Agriculture livestock - other cattle enteric
		3A2 Enteric Fermentation sheep	Agriculture livestock - sheep enteric
		3A3 Enteric Fermentation swine	Agriculture livestock - pigs enteric
		3A4 Enteric Fermentation other: deer	Agriculture livestock - deer enteric
		3A4 Enteric Fermentation other: goats	Agriculture livestock - goats enteric

Sector	Graph Categories	IPCC sectors	Source Name
		3A4 Enteric Fermentation other: horses	Agriculture livestock - horses enteric
		3B1 Manure Management dairy cattle	Agriculture livestock - dairy cattle wastes
		3B1 Manure Management non-dairy cattle	Agriculture livestock - other cattle wastes
		3B2 Manure Management sheep	Agriculture livestock - sheep wastes
		3B3 Manure Management swine	Agriculture livestock - pigs wastes
		3B4 Manure Management other: deer	Agriculture livestock - deer wastes
		3B4 Manure Management other: goats	Agriculture livestock - goats wastes
		3B4 Manure Management other: horses	Agriculture livestock - horses wastes
		3B4 Manure Management other: poultry	Agriculture livestock - all poultry wastes
			Agriculture livestock - broilers wastes
			Agriculture livestock - laying hens wastes
			Agriculture livestock - other poultry wastes
		3B4 Other	Agriculture livestock - manure leaching (indirect)
			Agriculture livestock - manure liquid systems (indirect)
			Agriculture livestock - manure other (indirect)
			Agriculture livestock - manure solid storage and dry lot (indirect)
	Stationary and mobile combustion	1A4ci Agriculture/Forestry/Fishing: Stationary	Agriculture - stationary combustion
		1A4cii Agriculture/Forestry/Fishing: Off-road	Agriculture - mobile machinery
		2D1 Lubricant Use	Agricultural engines
	Fertilizer and urea application	3D Agricultural Soils	Agricultural soils
		3D1 Agricultural soils-Mineralization/Immobilization	Agricultural soils - Mineralization/Immobilization Associated with change in Soil Organic Matter
		3G1 Liming - limestone	Liming
		3G2 Liming - dolomite	Liming
		3H Urea application	Agriculture - application of urea
Land Use Change	Creation and maintenance of forests	4A2 Land converted to Forest Land	Direct N2O emission from N fertilisation of forest land
		4A Forest Land	Forest Land - Drainage and rewetting and other management of organic and mineral soils
		4A1 Forest Land remaining Forest Land	Forest Land remaining Forest Land - Biomass Burning - Wildfires
			Forest Land remaining Forest Land - Carbon stock change
		4A2 5 Other land converted to Forest Land	Other land converted to Forest Land - Carbon stock change
		4A2 4 Settlements converted to Forest Land	Settlements converted to Forest Land - Carbon stock change
		4A2 2 Grassland converted to Forest Land	Grassland converted to Forest Land - Carbon stock change
		4A2 1 Cropland converted to Forest Land	Cropland converted to Forest Land - Carbon stock change
	Creation and maintenance of settlements	4E1 Settlements remaining Settlements	Settlements remaining Settlements - Direct N2O emissions from N Mineralization/Immobilization
			Settlements remaining Settlements - Carbon stock change
		4E2 3 Grassland converted to Settlements	Grassland converted to Settlements - Carbon stock change
			Grassland converted to Settlements - Direct N2O emissions from N Mineralization/Immobilization
		4E2 2 Cropland converted to Settlements	Cropland converted to Settlements - Carbon stock change
			Cropland converted to Settlements - Direct N2O emissions from N Mineralization/Immobilization
		4E2 1 Forest Land converted to Settlements	Forest Land converted to Settlements - Carbon stock change
			Forest Land converted to Settlements - Biomass Burning - Controlled Burning
			Forest Land converted to Settlements - Direct N2O emissions from N Mineralization/Immobilization
	Land converted to grass, crop and/or wetlands	4D2 Land converted to wetlands	Land converted for Peat Extraction - Carbon stock change
			Grassland converted to flooded land - Carbon stock change
		4B2 2 Grassland converted to Cropland	Grassland converted to Cropland - Carbon stock change
			Grassland converted to Cropland - Direct N2O emissions from N Mineralization/Immobilization
		4B2 1 Forest Land converted to Cropland	Forest Land converted to Cropland - Direct N2O emissions from N Mineralization/Immobilization
			Forest Land converted to Cropland - Biomass Burning - Controlled Burning

Sector	Graph Categories	IPCC sectors	Source Name
			Forest Land converted to Cropland - Carbon stock change
		4C2 4 Settlements converted to Grassland	Settlements converted to Grassland - Carbon stock change
		4C2 3 Wetlands converted to Grassland	Wetlands converted to Grassland - Carbon stock change
		4C2 2 Cropland converted to Grassland	Cropland converted to Grassland - Carbon stock change
		4C2 1 Forest Land converted to Grassland	Forest Land converted to Grassland - Direct N2O emissions from N Mineralization/Immobilization
			Forest Land converted to Grassland - Biomass Burning - Controlled Burning
			Forest Land converted to Grassland - Carbon stock change
	Wood products	4G Harvested Wood Products	HWP Produced and Exported - Carbon stock change
			HWP Produced and Consumed Domestically - Carbon stock change
		4B1 Cropland remaining Cropland	Cropland remaining Cropland - Biomass Burning - Wildfires
			Cropland remaining Cropland - Carbon stock change
	Land maintained as crops, grass or wetlands	4C1 Grassland remaining Grassland	Grassland remaining Grassland - Direct N2O emissions from N Mineralization/Immobilization
			Grassland remaining Grassland - Biomass Burning - Wildfires
			Grassland remaining Grassland - Carbon stock change
		4D1 Wetlands remaining wetlands	Peat Extraction Remaining Peat Extraction - Carbon stock change
		4B Cropland	Cropland - Drainage and rewetting and other management of organic and mineral soils
		4B2 4 Settlements converted to Cropland	Settlements converted to Cropland - Carbon stock change
		4C Grassland	Grassland - Drainage and rewetting and other management of organic and mineral soils
		4D Wetlands	Wetlands - Drainage and rewetting and other management of organic and mineral soils
Waste Management	Biological treatment	5B1a composting municipal solid waste	Total composting (non-household)
		5B2a Anaerobic digestion municipal solid waste	Mechanical Biological Treatment
			Anaerobic Digestion (other)
	Landfill	5A1a Managed Waste Disposal sites anaerobic	Landfill
	Waste incineration	5C1.1b Biogenic: Sewage sludge	Incineration - sewage sludge
		5C1.2a Non-biogenic: municipal solid waste	Incineration
		5C1.2b Non-biogenic: Clinical waste	Incineration - clinical waste
		5C1.2b Non-biogenic: Other Chemical waste	Incineration - chemical waste
	Waste-water handling	5D1 Domestic wastewater treatment	Sewage sludge decomposition
			Sewage sludge decomposition in private systems
		5D2 Industrial wastewater treatment	Industrial Waste Water Treatment
Exports	International aviation	Aviation Bunkers	Aircraft - international cruise
			Aircraft - international take-off and landing
			Aircraft between UK and CDs - Cruise
			Aircraft between UK and CDs - TOL
			Aircraft between UK and Gibraltar - Cruise
			Aircraft between UK and Gibraltar - TOL
			Aircraft between UK and other OTs (excl Gib.) - Cruise
			Aircraft between UK and other OTs (excl Gib.) - TOL
			Aircraft engines
	International shipping	Marine Bunkers	Shipping - international IPCC definition
			Shipping between UK and Gibraltar
			Shipping between UK and OTs (excl. Gib)

Appendix 6: Recalculations between the previous and this current Devolved Administrations' GHG Inventory

This provides details of recalculations between 1990-2013 Devolved Administrations' (DA) greenhouse gas (GHG) Inventory estimates (Salisbury et al., 2015) and the latest 1990-2014 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 historical 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 historical 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.

A6.2 Revisions and Updates to the Greenhouse Gas Inventories

In the derivation of the 1990-2014 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 the table below.

Table A6. 1: Reasons for recalculations between last year's (2015) and this year's (2016) GHG estimates for 2013 and 1990, by Sector

		England		Scotland		Wales		Northern Ireland	
IPCC Sector	Reasons for change	Change in emissions for 1990 (ktCO2e)	Change in emissions for 2013 (ktCO2e)	Change in emissions for 1990 (ktCO2e)	Change in emissions for 2013 (ktCO2e)	Change in emissions for 1990 (ktCO2e)	Change in emissions for 2013 (ktCO2e)	Change in emissions for 1990 (ktCO2e)	Change in emissions for 2013 (ktCO2e)
Total		-3,101 **-0.48%**	-5,261 **-1.13%**	-3,506 **-4.35%**	-1,839 **-3.47%**	-1,131 **-1.93%**	-278 **-0.54%**	-2,059 **-7.62%**	-1,401 **-6.12%**
Agriculture	The most significant change in the agriculture sector is the implementation of UK-specific N2O emission factors for agricultural soils. Previously, the emission estimates were based on a standard non-UK specific value.	-4,360	-3,360	-1,160	-819	-783	-643	-729	-677
Business	Recalculations are due to changes in DUKES: an increase in gas oil use in off-road machinery and a reduction in natural gas use in the commercial/industrial sector.	179	279	16	86	4	-140	7	15
Energy Supply	Very small recalculations in this sector are mainly due to an increase in the natural gas use in power stations. In Scotland in 2013, revised estimates of natural gas use in upstream oil and gas, and revisions to coal and MSW use in power stations has led to an overall decrease.	450	35	45	-33	58	93	50	27
Industrial Process	Very minor changes except in England where a new source of N2O from chemical production was added to the UK and DA GHG inventory in this submission. Emissions from sinter production in Wales in 2013 have been revised downwards slightly. Estimates for all DAs now include new (small) estimates of N2O emissions from use as a propellant in products such as squirty cream.	21	227	-2	4	-9	-27	1	1
Land Use Change	The most significant change is in the method for aggregating the output from the CARBINE model for Forest remaining Forest, allowing for the 20 year transition period, which was corrected to ensure that carbon stock changes were attributed to the correct reporting years. There was also a correction of the emissions factor for drainage of grassland on organic soil, which significantly reduces the emissions from this source	504	-1,585	-2,429	-974	-398	278	-1,398	-1,095
Public	Minor changes to estimates due to changes in fuel consumption. The most prominent is the reduction in emissions from the consumption of coal in Northern Ireland, due to provision of new PSEC data for 2013 and 2014.	-15	-38	-1	8	-1	-8	-1	-24

Appendix 6: Recalculations between the previous and this current Devolved Administrations' GHG Inventory

		England		Scotland		Wales		Northern Ireland	
IPCC Sector	Reasons for change	Change in emissions for 1990 (ktCO2e)	Change in emissions for 2013 (ktCO2e)	Change in emissions for 1990 (ktCO2e)	Change in emissions for 2013 (ktCO2e)	Change in emissions for 1990 (ktCO2e)	Change in emissions for 2013 (ktCO2e)	Change in emissions for 1990 (ktCO2e)	Change in emissions for 2013 (ktCO2e)
Residential	Recalculations are due to an increase in DUKES in the amount of biomass and burning oil combusted in this sector, which is partially offset by a reduction in natural gas consumption. The impact of these changes across the DAs differs according to the relative significance of each fuel in the sector at the DA-level.	-136	-58	-38	35	-19	51	57	135
Transport	Recalculations are due to change from using Department for Transport factors derived by TRL for fuel consumption and methane, to using the continuously updated COPERT 4 factors recommended in international guidelines. In addition, updated activity data have been used for the 2013 estimates in Northern Ireland.	543	-76	99	60	37	126	-31	227
Waste Management	Recalculations are mainly due to updates to the emission factor for domestic waste water treatment to align with international guidelines.	-301	-1,095	-27	-139	-15	-69	-12	-39
Exports	These small recalculations are mainly due to changes in DUKES.	13	412	-8	-66	-4	63	-2	27

Appendix 7: Supporting Data Tables and Graphs

The following tables and graphs provide additional information to supplement the main report. This information is not available in the inventory data distributed alongside this report.

- Methane emissions from livestock by type (2014)
- Energy generation data for each Devolved Administration by fuel type (2006-2014)
- Generation of electricity from renewable sources for each Devolved Administration by source type (2014)
- Carbon dioxide emissions data for the two methodological approaches presented for Road Transport (1990-2014)

Table A7. 1: Methane emissions from livestock by type ($ktCO_2e$, 2014)

	England	Scotland	Wales	Northern Ireland
Cattle	11,921	3,734	2,462	3,405
Deer	10.8	3.54	0.51	1.31
Goats	10.8	0.60	1.42	0.43
Horses	382	37	47	17.1
Pigs	664	52.9	4.81	86.1
Poultry	62.4	7.52	4.16	9.63
Sheep	1,979	885	1,293	251

Table A7. 2: Energy generation data from Major Power Producers for each Devolved Administration by fuel type (GWh, 2006-2014)

	2006	2007	2008	2009	2010	2011	2012	2013	2014
England	273,714	279,551	264,268	259,093	266,462	255,220	253,275	247,696	232,902
Coal	116,263	111,318	97,310	79,473	81,542	86,485	115,105	105,319	80,369
Gas	98,220	118,370	129,165	125,415	135,063	111,346	74,204	72,505	80,126
Nuclear	54,300	45,001	30,327	46,295	41,315	46,725	49,214	47,783	45,161
Oil	2,158	2,469	3,793	3,484	1,992	862	933	563	326
Renewables and Hydro	2,773	2,393	3,673	4,426	6,550	9,802	13,819	21,526	26,920
Northern Ireland	9,786	8,563	9,234	7,629	7,128	7,320	6,573	6,705	6,521
Coal	2,701	1,833	2,040	1,371	1,817	1,414	2,367	2,606	2,159
Gas	6,799	6,576	6,537	5,642	4,840	5,301	3,609	3,457	3,679
Nuclear	0	0	0	0	0	0	0	0	0
Oil	286	154	334	78	73	52	44	20	23
Renewables and Hydro	0	0	323	538	398	553	553	622	660
Scotland	44,343	41,338	44,055	44,198	43,401	44,275	44,214	46,158	42,382
Coal	17,488	13,802	11,591	11,896	14,653	10,728	11,867	10,802	10,152
Gas	8,346	8,938	9,822	7,430	6,618	6,227	3,680	3,497	880
Nuclear	14,141	12,344	15,079	16,681	15,293	16,892	17,050	18,498	16,633
Oil	914	379	431	278	206	160	155	161	181
Renewables and Hydro	3,454	5,875	7,132	7,913	6,631	10,268	11,462	13,200	14,536
Wales	29,576	27,111	33,563	27,762	27,646	22,741	21,242	20,740	15,607
Coal	8,859	5,121	9,364	6,547	5,929	6,170	10,824	11,478	7,478
Gas	13,272	15,461	16,059	14,111	15,227	9,880	4,737	3,432	4,187
Nuclear	7,010	5,684	7,080	6,122	5,532	5,364	4,141	4,326	1,953
Oil	0	0	0	0	0	0	0	0	0
Renewables and Hydro	435	845	1,060	982	958	1,327	1,540	1,504	1,989

Table A7. 3: Generation of electricity from renewable sources, GWh, 2014 (DECC, 2015g)

	Hydro	Wind	Wave and tidal	Landfill gas	Sewage gas	Other bioenergy	Solar PV	Total
England	98.8	16,429.1	0.1	4,256.7	773.4	15,080.3	3,447.1	40,085.4
Scotland	5,435.8	11,664.1	2.1	533.5	28.2	1,166.5	131.7	18,961.9
Wales	275.7	2,331.6	-	193.5	43.6	330.5	234.3	3,409.3
Northern Ireland	28.2	1,454.3	0.0	61.3	0.7	104.4	45.7	1,694.6

Note that the data above comprise generation of electricity from renewable sources from Major Power Producers (as summarised in Table A7. 2 above) and also from other generators. The data are consistent with data presented in Table 2 on page 58 of the December 2015 Energy Trends publication from DECC (DECC, 2015b), and include the generation of electricity from: thermal renewables, hydro natural flow, and non-thermal renewables. The data exclude generation of electricity from hydro pumped storage or use of wastes.

Table A7. 4: Carbon dioxide emissions data for the two methodological approaches presented for Road Transport (1990-2014)

England		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2 (vkm)	Cars	51,345	53,009	55,405	56,352	56,011	56,878	58,088	57,904	58,468	58,072	58,710	58,673	57,480	56,677	54,356	54,114	53,390	52,306	52,321
	LGVs	8,421	9,527	10,734	10,860	10,999	11,135	11,236	11,716	12,284	12,537	12,945	13,443	12,997	12,638	12,696	12,886	12,948	13,141	13,642
	HGVs	14,289	14,281	14,979	15,115	15,128	15,246	15,582	15,785	16,414	16,420	16,542	16,694	15,901	14,325	14,522	14,290	14,220	14,347	14,576
	Buses	3,573	3,818	3,870	3,839	3,646	3,581	3,568	3,715	3,638	3,598	3,680	3,725	3,360	3,290	3,291	3,038	2,870	2,919	2,893
	Motorcycles	576	392	449	494	489	510	530	582	531	552	524	555	503	506	445	442	423	397	407
	TOTAL	78,203	81,027	85,438	86,660	86,273	87,350	89,004	89,701	91,336	91,179	92,402	93,089	90,242	87,436	85,309	84,771	83,852	83,110	83,839
CO_2 (fuel sales)	Cars	58,914	59,216	61,692	62,853	62,625	62,548	63,808	62,734	63,008	63,055	62,542	62,694	61,002	59,084	57,250	56,717	56,480	55,436	55,873
	LGVs	9,777	10,883	12,094	12,034	12,053	12,078	12,170	12,529	12,935	13,290	13,600	14,091	13,305	13,098	13,405	13,510	13,652	13,814	14,355
	HGVs	16,982	16,618	16,982	16,704	16,463	16,472	16,820	16,836	17,216	17,348	17,342	17,454	16,203	14,836	15,337	14,982	14,989	15,070	15,319
	Buses	4,246	4,443	4,387	4,242	3,968	3,869	3,852	3,963	3,815	3,801	3,858	3,894	3,424	3,407	3,476	3,185	3,026	3,067	3,040
	Motorcycles	659	436	499	552	550	563	585	633	578	605	562	599	545	530	468	463	448	424	441
	TOTAL	90,579	91,595	95,654	96,386	95,660	95,529	97,234	96,695	97,552	98,098	97,904	98,732	94,478	90,954	89,936	88,858	88,595	87,811	89,028
Scotland		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2 (vkm)	Cars	4,908	5,066	5,279	5,345	5,314	5,401	5,601	5,617	5,693	5,652	5,822	5,827	5,729	5,667	5,422	5,375	5,352	5,260	5,256
	LGVs	812	924	1,092	1,113	1,096	1,100	1,127	1,177	1,225	1,260	1,321	1,394	1,366	1,333	1,347	1,360	1,374	1,397	1,453
	HGVs	1,480	1,451	1,496	1,495	1,482	1,474	1,491	1,569	1,644	1,684	1,745	1,791	1,733	1,581	1,591	1,557	1,577	1,588	1,569
	Buses	495	508	516	514	492	489	504	521	483	479	490	518	485	480	491	456	440	453	452
	Motorcycles	32	24	26	29	30	31	34	38	36	36	34	37	35	35	31	31	30	30	30
	TOTAL	7,728	7,973	8,408	8,495	8,413	8,494	8,757	8,921	9,080	9,111	9,412	9,567	9,348	9,097	8,881	8,780	8,773	8,727	8,760
CO_2 (fuel sales)	Cars	5,633	5,665	5,881	5,960	5,937	5,937	6,150	6,084	6,132	6,134	6,200	6,224	6,074	5,907	5,711	5,634	5,661	5,573	5,611
	LGVs	943	1,056	1,230	1,233	1,201	1,193	1,220	1,258	1,289	1,336	1,387	1,462	1,399	1,381	1,422	1,425	1,449	1,469	1,529
	HGVs	1,759	1,689	1,696	1,652	1,612	1,593	1,610	1,673	1,724	1,779	1,829	1,872	1,765	1,638	1,680	1,632	1,662	1,668	1,649
	Buses	588	591	585	568	535	528	544	555	507	507	514	542	494	497	518	479	464	476	475
	Motorcycles	37	26	29	32	33	34	38	42	39	39	37	39	38	37	33	33	32	31	33
	TOTAL	8,961	9,027	9,420	9,446	9,319	9,284	9,562	9,612	9,692	9,794	9,967	10,139	9,770	9,460	9,364	9,203	9,268	9,217	9,297

Table A7. 4 (continued): Carbon dioxide emissions data for the two methodological approaches presented for Road Transport (1990-2014)

Wales		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2 (vkm)	Cars	3,128	3,223	3,354	3,413	3,390	3,448	3,573	3,600	3,684	3,640	3,734	3,755	3,689	3,610	3,453	3,428	3,379	3,334	3,365
	LGVs	523	599	676	691	699	705	724	755	790	808	834	863	850	832	843	852	853	869	902
	HGVs	792	765	810	779	754	745	756	752	789	804	802	829	795	707	703	681	678	682	680
	Buses	227	227	226	227	219	214	215	223	213	211	222	225	207	204	203	184	175	181	180
	Motorcycles	27	19	22	24	25	26	27	29	27	28	27	28	27	27	23	24	23	22	23
	TOTAL	4,698	4,834	5,089	5,134	5,086	5,138	5,295	5,359	5,503	5,492	5,620	5,700	5,568	5,381	5,225	5,169	5,109	5,088	5,150
CO_2 (fuel sales)	Cars	3,590	3,604	3,738	3,805	3,785	3,788	3,921	3,897	3,963	3,946	3,974	4,007	3,904	3,762	3,637	3,593	3,574	3,531	3,591
	LGVs	608	684	762	765	765	764	784	807	832	857	877	905	870	862	890	893	899	914	949
	HGVs	941	891	918	861	821	805	816	802	828	850	841	867	810	733	742	714	715	717	715
	Buses	270	264	257	251	238	231	232	238	223	223	233	235	211	211	215	193	185	190	189
	Motorcycles	31	22	24	27	28	28	30	31	29	31	29	31	29	28	25	25	25	23	25
	TOTAL	5,440	5,465	5,699	5,709	5,636	5,617	5,783	5,775	5,876	5,906	5,953	6,044	5,825	5,596	5,509	5,418	5,397	5,375	5,468
Northern Ireland		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2 (vkm)	Cars	1,890	2,115	2,295	2,399	2,487	2,557	2,560	2,605	2,731	2,751	2,793	2,887	2,782	2,846	2,769	2,721	2,674	2,696	2,707
	LGVs	143	159	169	175	180	182	249	254	241	242	276	270	311	318	277	265	271	262	273
	HGVs	391	423	449	469	486	505	609	760	693	715	715	717	687	682	644	604	601	592	596
	Buses	63	72	75	77	79	81	70	67	68	68	58	70	67	66	70	73	84	86	86
	Motorcycles	7	7	9	10	10	10	11	15	14	15	14	16	14	14	12	11	10	9	9
	TOTAL	2,494	2,776	2,995	3,129	3,242	3,334	3,500	3,702	3,746	3,791	3,857	3,960	3,860	3,925	3,773	3,674	3,641	3,645	3,671
CO_2 (fuel sales)	Cars	2,169	2,368	2,560	2,673	2,770	2,805	2,804	2,815	2,928	2,971	2,966	3,073	2,933	2,963	2,918	2,852	2,827	2,855	2,885
	LGVs	170	185	191	193	197	197	270	272	253	256	290	283	317	329	293	278	286	275	287
	HGVs	464	492	509	518	529	545	658	811	727	756	750	749	700	706	680	633	633	622	627
	Buses	75	84	85	85	87	87	75	72	71	72	61	73	68	68	74	76	89	90	90
	Motorcycles	8	7	10	11	11	11	12	17	15	16	16	17	15	15	13	12	11	10	10
	TOTAL	2,886	3,136	3,354	3,479	3,593	3,645	3,819	3,985	3,994	4,071	4,082	4,195	4,033	4,081	3,978	3,852	3,847	3,852	3,899

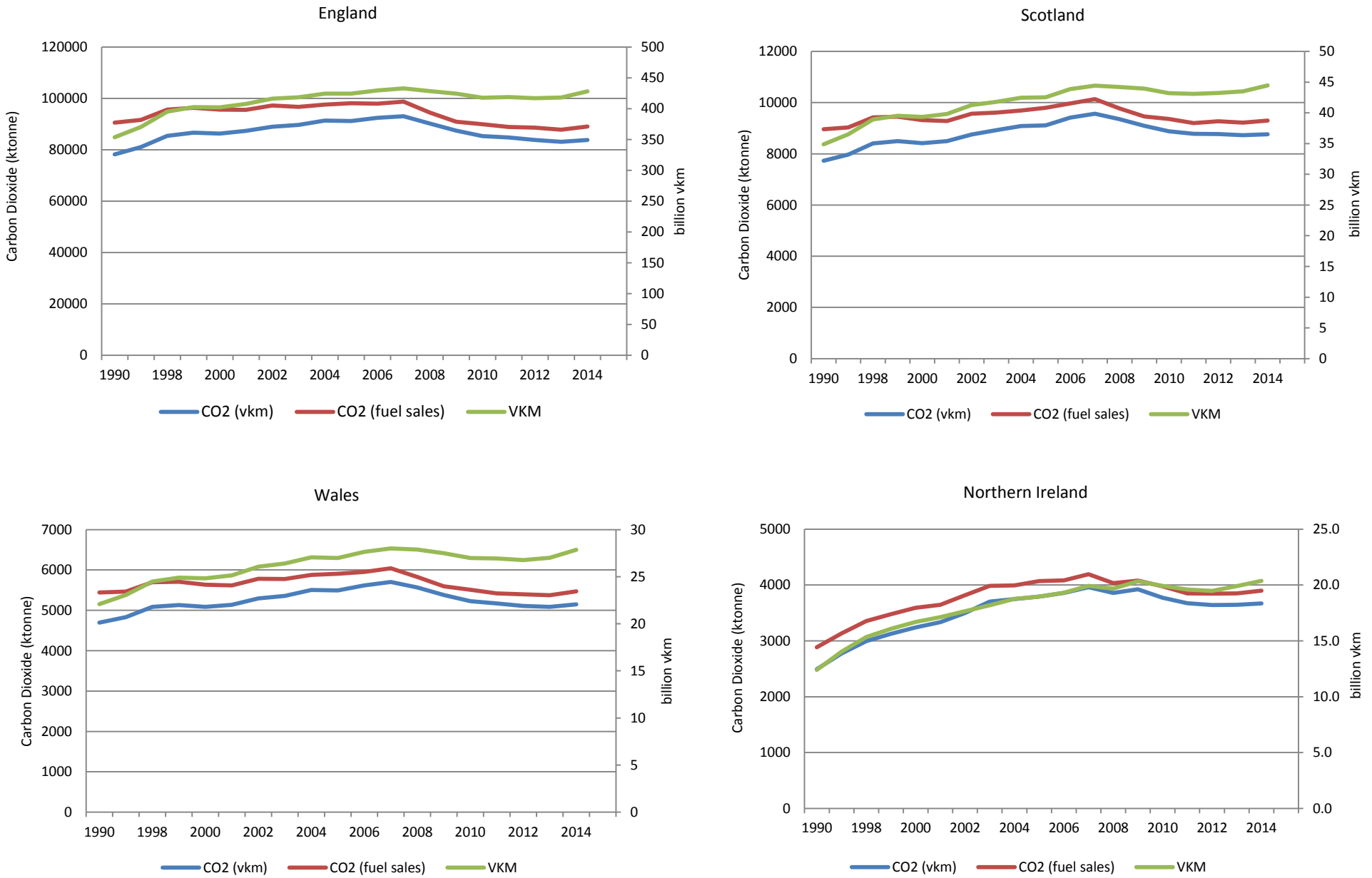

Figure A7. 1: Road transport CO_2 emission trends calculated by constrained and unconstrained methodologies and vehicle kilometres trends, 1990-201

Appendix 8: Emissions and Removals of Greenhouse Gases from Land Use, Land Use Change and Forestry (LULUCF) for England, Scotland, Wales and Northern Ireland: 1990-2014

A8.1 Introduction

A8.1.1 National Reporting

The Centre for Ecology and Hydrology (CEH), under contract to the Department of Energy and Climate Change (DECC) and previously under contract to the Department for Environment Food and Rural Affairs (Defra), produces yearly estimates of greenhouse gas emissions arising as a result of land-use, land use change and forestry activities.

Under international conventions, reporting is required for the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol (KP) at the UK, Overseas Territories and Crown Dependencies level, and at the UK level for the European Union Monitoring Mechanism (EUMM). KP reporting consists of five year commitment periods commencing in 2008. The second commitment period started in 2013 and there have been changes to the reporting framework and the activities that the UK has chosen to elect. Reporting on afforestation, reforestation, deforestation and forest management is mandatory (carbon credits from forest management are now constrained by a Forest Management Reference Level approach rather than a cap). The UK has also elected Cropland Management, Grazing Land Management and Wetland Drainage and Rewetting. The UK has reported Cropland Management and Grazing Land Management for the first time in the 1990-2014 KP inventory and a work programme to develop methods and datasets for reporting Wetland Drainage and Rewetting is underway. UK-level estimates are reported in the national statistical release in February. KP data for the individual UK administrations is included in section 7.

LULUCF emissions estimates are reported as part of the UK Greenhouse Gas Inventory Report (Brown et al., 2016). Chapter 6 and Annex 3.6 of the National Inventory Report contain information on the LULUCF sector, and Chapter 11 contains additional information on the reporting of LULUCF activities for the Kyoto Protocol.

The current LULUCF inventory methods use a combination of top-down and bottom-up[12] approaches, based on activity data for each of the UK Devolved Administrations and England and the UK as a whole. As a result of this approach, separate estimates of emissions and removals from LULUCF activities are produced for England, Scotland, Wales and Northern Ireland, and these are summed to give emissions and removals at the UK scale.

A8.1.2 UK Administration Reporting

This report details net emissions and removals for each UK administration for the 1990-2014 inventory and provides an explanation of changes since the previous edition of this report (1990-2013)[13]. In the main text, the trends in CO_2 emissions/removals are presented and discussed for each UK administration and each category within the LULUCF sector, along with total emissions of methane and nitrous oxide.

Summary tables for 1990, 1995, 2000, 2005, 2010, 2013 and 2014 are given for each country in section 6, and for LULUCF emissions/removals under the Kyoto Protocol in section 7. A full set of GHG emissions/removals and associated areas and annual land use change matrices for each country are published with this report. The data sources used in the compilation of the inventory are described in section 8.

[12] A top-down approach takes UK level activity data and spatially disaggregates it to report at the Devolved Administration level whereas a bottom-up approach takes individual spatially-disaggregated activity data and combines it to give a UK national total.

[13] http://naei.defra.gov.uk/reports/reports?report_id=810

A8.1.3 The LULUCF sector

The Land Use, Land Use Change and Forestry (LULUCF) sector includes carbon stock changes and emissions of greenhouse gases (carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)) from land use, land use change and forestry activities. Increases in carbon stocks (representing a removal of CO_2 from the atmosphere) are conventionally presented as negative quantities. Total greenhouse gas emissions are described as carbon dioxide equivalents (CO_2e), using Global Warming Potentials (GWP) of 25 for CH_4 and 298 for N_2O (IPCC 2006 Guidelines). CO_2 comprises the majority of emissions (96%) and all of the removals (100%) for LULUCF in the UK.

The LULUCF sector comprises six categories: Forest Land, Cropland, Grassland, Wetland, Settlements, Other Land and Harvested Wood Products.

Emissions and removals from land use arise from management activities on that land category. Emissions from land use change occur following a change from one land use category to another. This will have an immediate impact on the biomass carbon stocks and a more gradual impact on soils carbon stocks (over decades or even centuries), resulting in CO_2 being emitted or removed, depending on whether carbon stocks increase or decrease. These emissions are reported under *Land converted to X* for each category. After twenty years, the area of land moves from *Land converted to X* into *Land remaining X* for each category. For example, the *Grassland remaining Grassland* area in 1990 contains areas that underwent conversion prior to 1970, as well as long-established grassland. The area of *Land converted to Grassland* in 1990 contains the areas that were converted between 1971 and 1990. However, despite the transition between reporting categories, emissions and removals as a result of historical land use change continue to occur (and are reported) after the twenty year transition period.

The Forest land category includes carbon stock gains and losses and GHG emissions from forest management. Emissions from this category are relatively small and arise from fertilisation or drainage of afforested land (N_2O) and from wildfires (CH_4 and N_2O). Carbon stock gains and losses in forests and harvested wood products are modelled using the Forest Research CARBINE forest carbon accounting model. The model is able to represent all of the introduced and native plantation and naturally-occurring species relevant to the UK, the different growth rates of forests and four broad classes of forest management (clear-fell with thinnings, clear-fell without thinnings, thinned but not clear-felled and no timber production).

The Cropland category includes soil and biomass carbon stock changes and N_2O emissions associated with N mineralisation from land conversion to Cropland, soil and biomass carbon stock changes due to cropland management, CO_2 emissions from cropland on drained organic soils and GHG emissions from wildfires on cropland (rare). Cropland soils tend to have lower carbon stocks than soils under other land uses, so land use change to cropland results in a loss of carbon. Biomass carbon stock changes from cropland management are included in the 1990-2014 inventory for the first time.

The Grassland category includes soil and biomass carbon stock changes and N_2O emissions associated with N mineralisation from land conversion to Grassland, biomass carbon stock changes due to grassland management, CO_2 emissions from improved grassland on drained organic soils and GHG emissions from biomass burning (wildfires and controlled burning following deforestation to grassland). Land conversion to grassland will either result in a loss or gain of carbon stocks, depending on the original land category, but the balance is a net removal of CO_2 from the atmosphere. Biomass carbon stock changes from grassland management are included in the 1990-2014 inventory for the first time. Land use change between the Cropland and Grassland categories is a large source on emissions/removals in the inventory, reflecting the use of rotational land management: work is being undertaken to refine the modelling of land use change using additional data sources.

The Wetland category estimates emissions from managed peatlands (GHGs emitted from current and abandoned sites of commercial peat extraction) and emissions arising from water reservoir establishment since 1990. Emissions from peat extraction sites are on-site emissions arising from site disturbance and off-site emissions from horticultural peat. Off-site emissions from fuel peat are estimated in the Energy Sector under Residential emissions in 1A4b of the NIR. Approximately 90% of the volume of peat sold in the UK is for horticultural use, most of which is sold via retail for domestic use, and to the horticultural industry for use as growing media for commercial plant propagation. A work programme is underway to implement new IPCC guidance on wetland emissions and removals which will improve reporting of emissions from wetlands and organic soils under other categories.

The Settlements category includes soil and biomass carbon stock changes and N_2O emissions associated with N mineralisation from land conversion to Settlements and GHG emissions from controlled burning following deforestation to settlements.

Carbon stock changes in the Harvested Wood Products category are reported by product type (sawn timber, particleboard and paper) and by whether they are domestically consumed or exported (emissions from imports are not reported). Harvested wood products are produced from standard forest management and as a result of deforestation of Forest land to other land categories. Harvested Wood Products represent a temporary removal of CO_2 from the environment, until they reach the end of their lifecycle and decay releasing CO_2. Harvested Wood Products trends reflect the demand for, and lifetime of, timber products and forest management regimes.

A8.1.4 Changes to LULUCF Sector since the 1990-2013 inventory

With every annual update of the greenhouse gas inventory, emissions and removals will vary for each year from 1990 onwards due to the incorporation of new datasets and methodologies used to underpin the inventory. An overview of the improvements and data revisions since the 1990-2013 inventory is provided in Table A8. 1.

The largest changes were in the Forest, Grassland and Harvested Wood Product categories, due to the revision of carbon stock changes and harvested wood products arising from Forest remaining Forest areas, the addition of reporting biomass carbon stock changes from grassland management and the revision of the emissions factor for drainage of grassland on organic soils. The land use change soils model was also re-run with corrected deforestation areas, the methodology for calculating emissions from controlled burning was updated and additional activity data and revised methods were used to estimate areas of peatland extraction.

A detailed description of the changes in method and datasets can be found in Annex 3.6 of the 1990-2014 National Greenhouse Gas Inventory Report. In addition to methodology changes, other changes arise from updated activity data since the previous reporting year. All changes to LULUCF categories are summarised in Table A8. 1.

Table A8. 1: Improvements in the source data and/or methodology

IPCC Sector	Method and data revisions
4A Forest Land	The method for aggregating the output from the CARBINE model for Forest remaining Forest was corrected so that carbon stock changes are reported for the correct years.
4B Cropland	Biomass carbon stock changes due to cropland management are included for the first time. The land use change soils model was corrected to use deforestation reduction factors for reducing the estimates of deforestation derived from the Countryside Survey pre 2000 and expert judgement deforestation areas post 2000. The methodology and emissions factors for calculating emissions from controlled burning following deforestation were updated to follow the IPCC 2006 guidance.
4C Grassland	Biomass carbon stock changes due to grassland management are included for the first time. The emission factor used for grassland drainage was corrected. The land use change soils model was corrected to use deforestation reduction factors for reducing the estimates of deforestation derived from the Countryside Survey pre 2000 and expert judgement deforestation areas post 2000. The methodology and emissions factors for calculating emissions from controlled burning following deforestation were updated to follow the IPCC 2006 guidance.
4D Wetlands	The methodology for estimating areas of peat extraction has been updated following new datasets becoming available and the methodology used for tracking areas converted to and from peat extraction was corrected to rectify a previous inconsistency.
4E Settlements	The land use change soils model was corrected to use deforestation reduction factors for reducing the estimates of deforestation derived from the Countryside Survey pre 2000 and expert judgement deforestation areas post 2000. The methodology and emissions factors for calculating emissions from controlled burning following deforestation were updated to follow the IPCC 2006 guidance.
4G Harvested Wood Products	The method for aggregating the output from the CARBINE model for Harvested Wood Products arising from Forest remaining Forest was revised so that they are reported for the correct years.

A8.2 LULUCF Emissions and Removals in England

A8.2.1 England LULUCF Trends

The 1990-2014 Inventory shows England is a net sink of greenhouse gases from LULUCF activities since 2004 (Figure A8. 2:
Emissions **and removals of all gases by category for the LULUCF sector in England 1990-2014**

In 1990 the England LULUCF sector was a net source at 2.8 Mt CO_2e remaining fairly constant until 1995, followed by a steady decline to -2.9 Mt CO_2e in 2014 (see section 6 for emissions / removals by LULUCF category and gas).

The main influences on the trend for the LULUCF sector in England are emissions from Cropland and Settlement, balanced by removals from Forest land and Grassland. Emissions from Wetland (see section 2.2) are low for England relative to other emissions due to the relatively small areas of peat extraction, as are removals from Harvested Wood Products (Figure A8. 2).

The largest emissions source in England is the Cropland category, but this has steadily declined since its peak of 6.7 Mt CO_2e in 1995 to 5.1 Mt CO_2e in 2014. Emissions from Cropland include those from land use change and cropland management activities affecting biomass and soil carbon, biomass burning and drainage on organic soils. The Settlement category is a net source showing a declining trend from 4.1 Mt CO_2e in 1990 to 3.0 Mt CO_2e in 2014.

The Forest land and Grassland categories are net sinks throughout the whole time series from 1990 to 2014. Net removals from Forest land were smallest in 1994 at -4.5 Mt CO_2e , increasing to -6.3 Mt CO_2e in 2010 and remaining fairly constant for the rest of the time series.Net removals from Grassland have increased from -3.0 Mt CO_2e in 1990 to -4.7 Mt CO_2e in 2014.

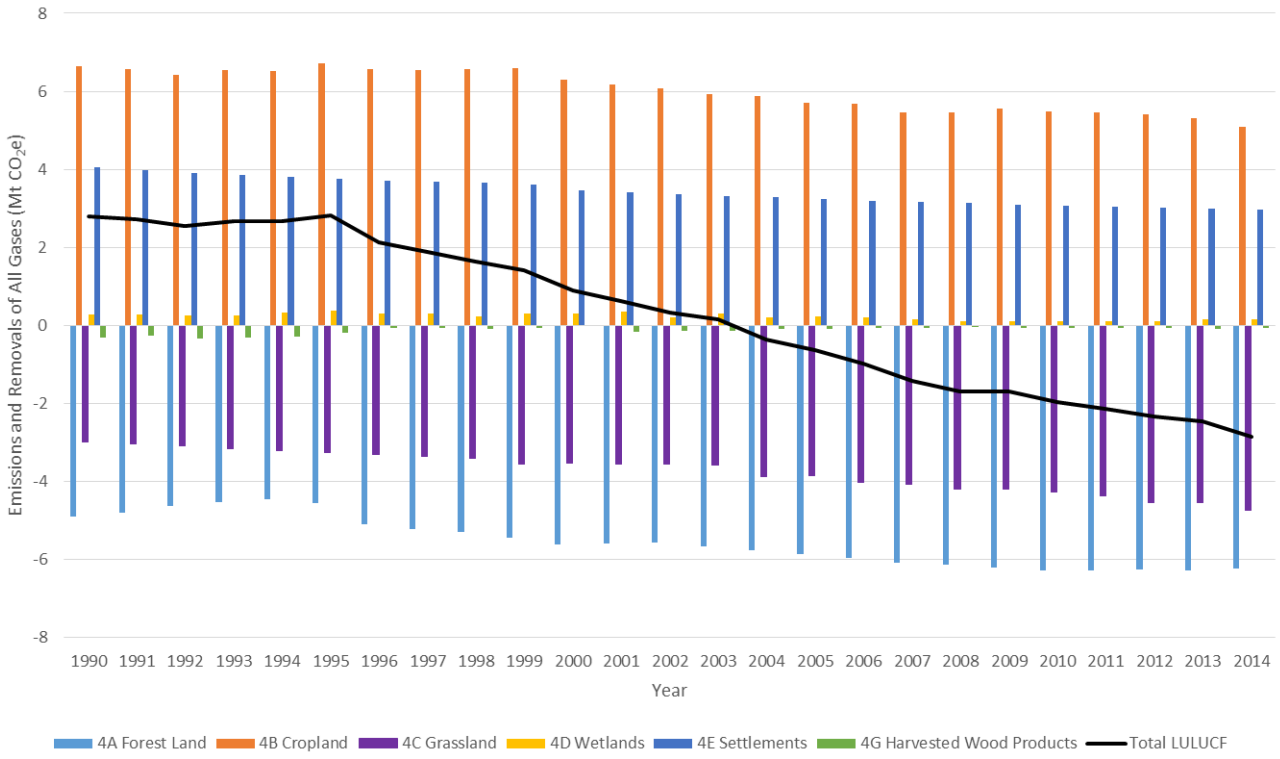

Figure A8. 2: Emissions and removals of all gases by category for the LULUCF sector in England 1990-2014

A8.2.2 England LULUCF Category Trends

The Forest land category for England is a net sink for 1990-2014. Much of the sink arises from ancient broadleaf forests which have undergone minimal or no management or harvesting. There is an increasing trend in net emissions from 1990-1994. This arises from harvesting of conifers planted in the 1920-1930s coinciding with a reduction in conifer planting during the 1990s. Note that emissions

from wildfires show inter-annual variability (Figure A8. 2A). GHG emissions in the category (from wildfires, nitrogen fertilisation and N_2O emissions from drainage) are very small compared to the carbon sink in forest soils and biomass.

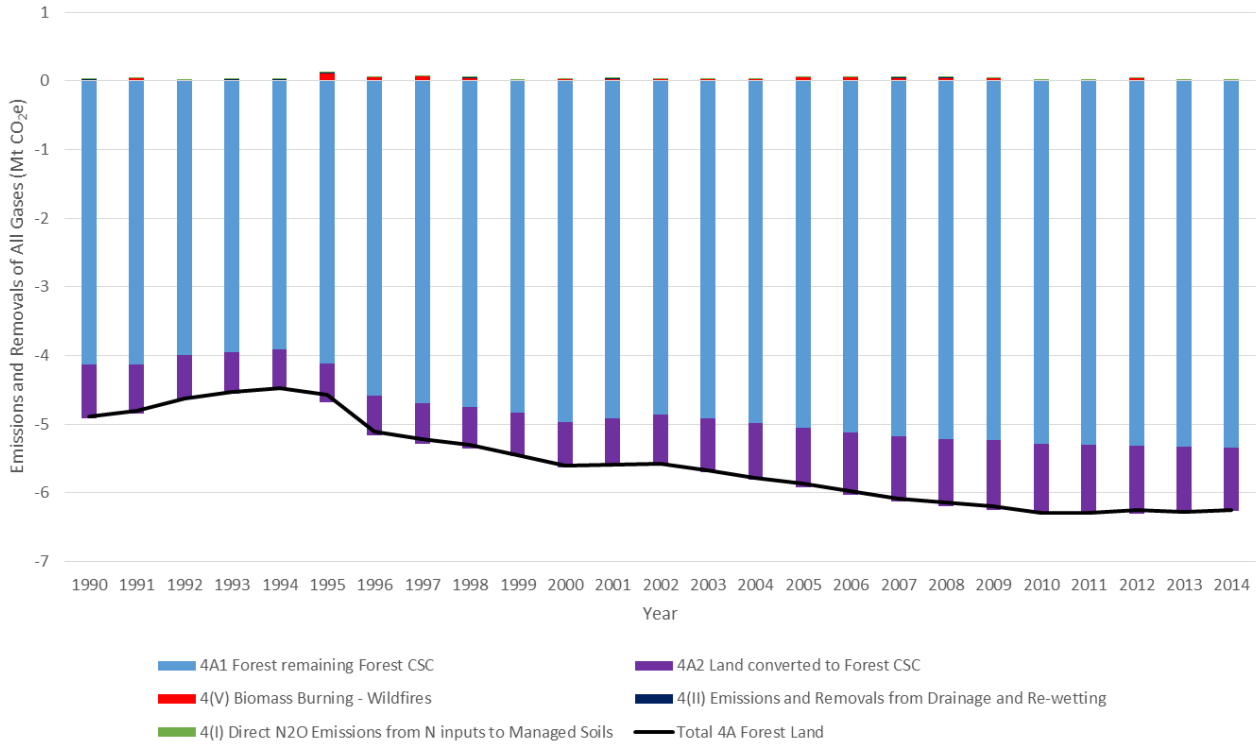

Figure A8. 2A: Emissions and removals of all gases by category for the 4A Forestry category in England 1990-2014

The Cropland category (see section A8.2.3) for England is a net, albeit shrinking, source between 1990 and 2014. Emissions arising from Land converted to Cropland (carbon stock changes and N_2O emissions from N mineralisation) are the largest contributor (Figure A8. 2B), but reducing over time. These emissions are the result of recent conversion from grassland and other land uses, although the rate of land use change to Cropland has decreased over time. Carbon emissions from drained cropland organic soils are a constant and significant source. Emissions from Cropland remaining Cropland are increasing over time, as continuing carbon stock losses from historical land use change move across from Land converted to Cropland sub-category after 20 years. The Cropland remaining Cropland category also includes carbon stock changes in biomass and soil carbon arising from cropland management (e.g. inputs of fertiliser, manure and crop residues, and change between cropland types). Other GHG emissions from biomass burning are insignificant.

The Grassland category (see section A8.2.3) for England is a net, increasing sink for 1990-2014. The main removals are due to land use change, appearing in the Land converted to Grassland (recent) and Grassland remaining Grassland (historical) sub-categories, primarily from conversion of Cropland to Grassland (Figure A8. 2C). Grassland remaining Grassland also now includes carbon sock change in biomass from grassland management (e.g. change between shrubby and non-shrubby grassland types,). Carbon emissions from drained organic soils under improved grassland are a constant source. GHG emissions from controlled burning following deforestation to Grassland have increased since 2000, with restoration of forest to open habitats and construction for renewable energy generation. There are a small amount of wildfire emissions reported in the time series (mainly heathland fires), with considerable inter-annual variability.

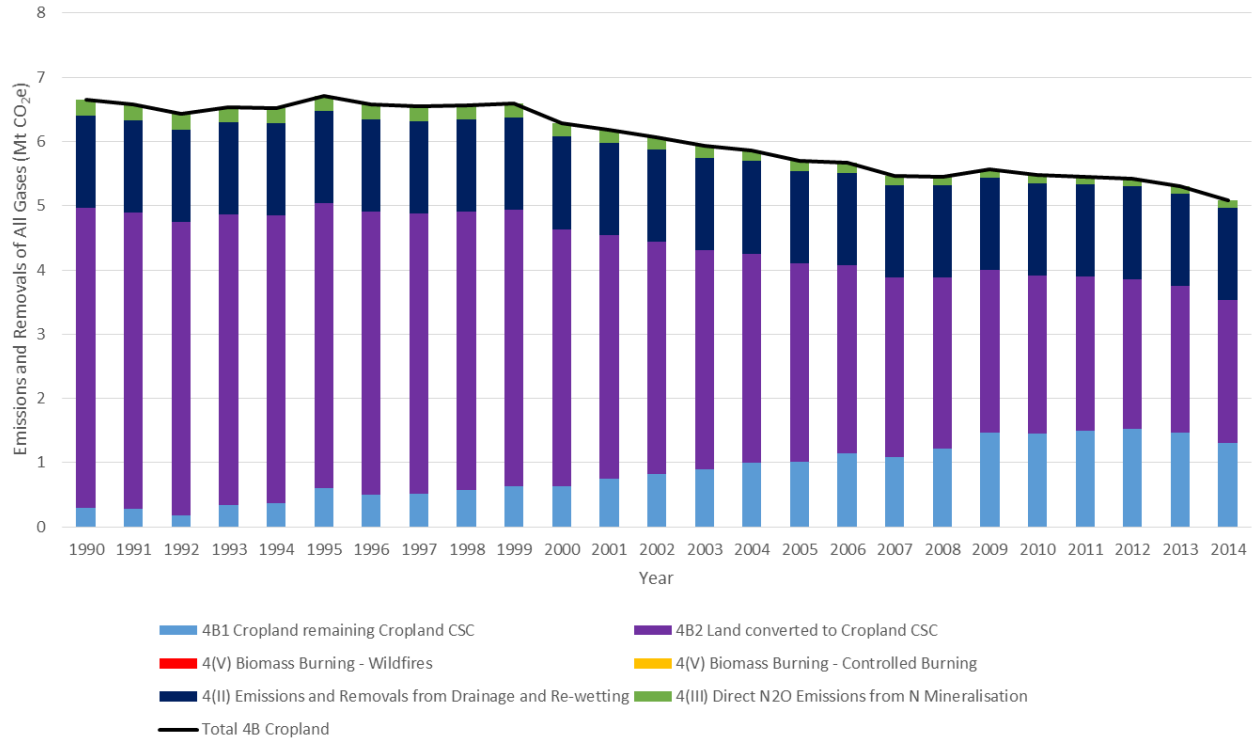

Figure A8. 2B: Emissions and removals of all gases by category for the 4B Cropland category in England 1990-2014

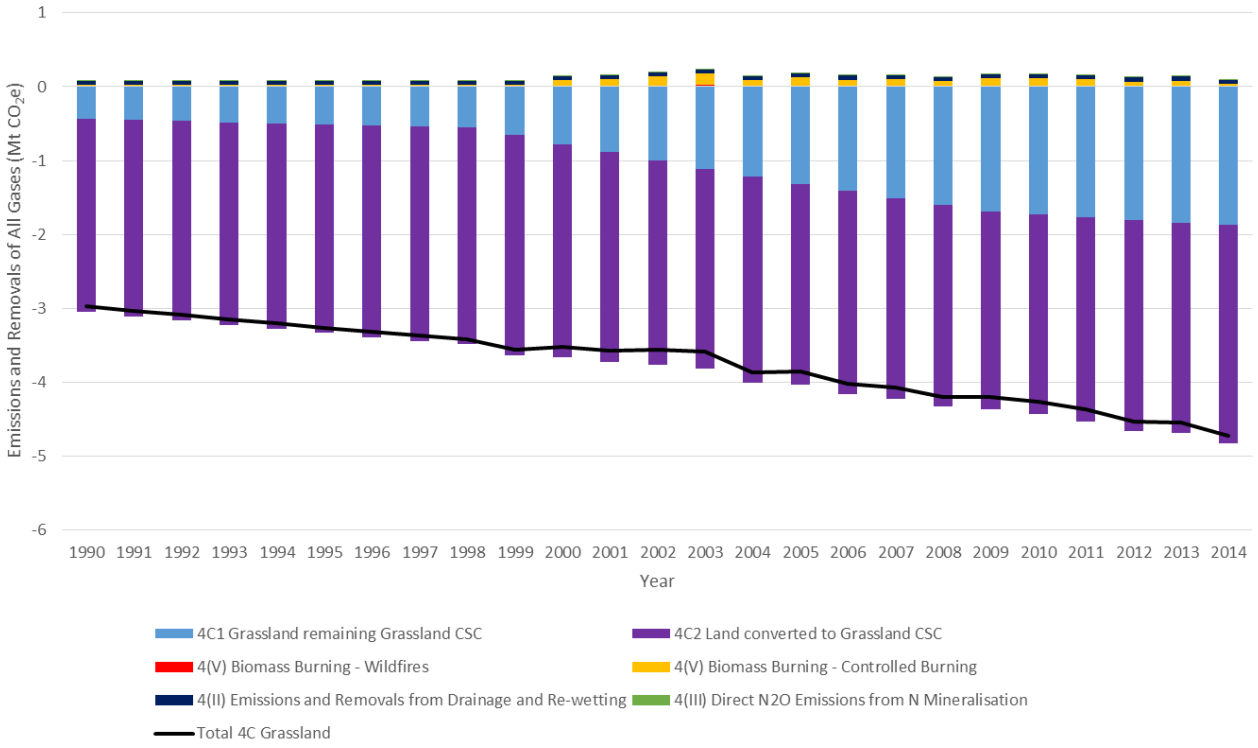

Figure A8. 2C: Emissions and removals of all gases by category for the 4C Grassland category in England 1990-2014

The Wetland category (see section A8.2.3) is a minor and predominantly decreasing source in England (Figure A8. 2D). It has the largest areas of commercial peat extraction in the UK but this area is decreasing due to reducing demand for horticultural peat, from 6.0 kha in 1990 to 4.5 kha in 2014. There are also insignificant contributions to emissions from land converted to peat extraction and to flooded land (reservoirs).

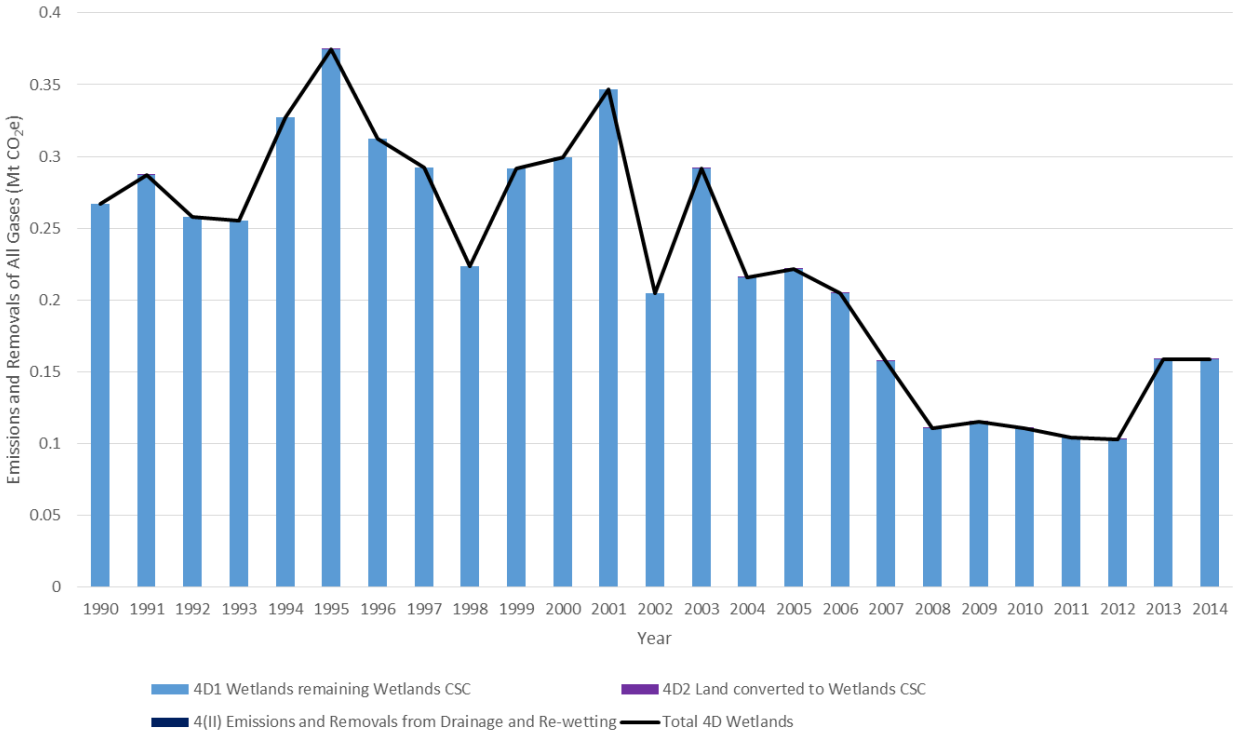

Figure A8. 2D: Emissions and removals of all gases by category for the 4D Wetland category in England 1990-2014

The Settlements category (see section A8.2.3) is the second largest emissions source in England after Cropland. Most emissions are from soil carbon stock losses following land use change on Land converted to Settlements (recent LUC) and Settlement remaining Settlement (historic LUC) (Figure A8. 2E). There are also related N_2O emissions from N mineralisation following land use change. There is a small and declining amount of GHG emissions resulting from controlled biomass burning during deforestation to Settlement.

The Harvested Wood Products category (see section A8.2.3) is a decreasing net sink for England over 1990-2014 (Figure A8. 2F). It is variable over time (the model is driven by both forest management and timber production statistics) and the majority of the products are consumed domestically in the UK.

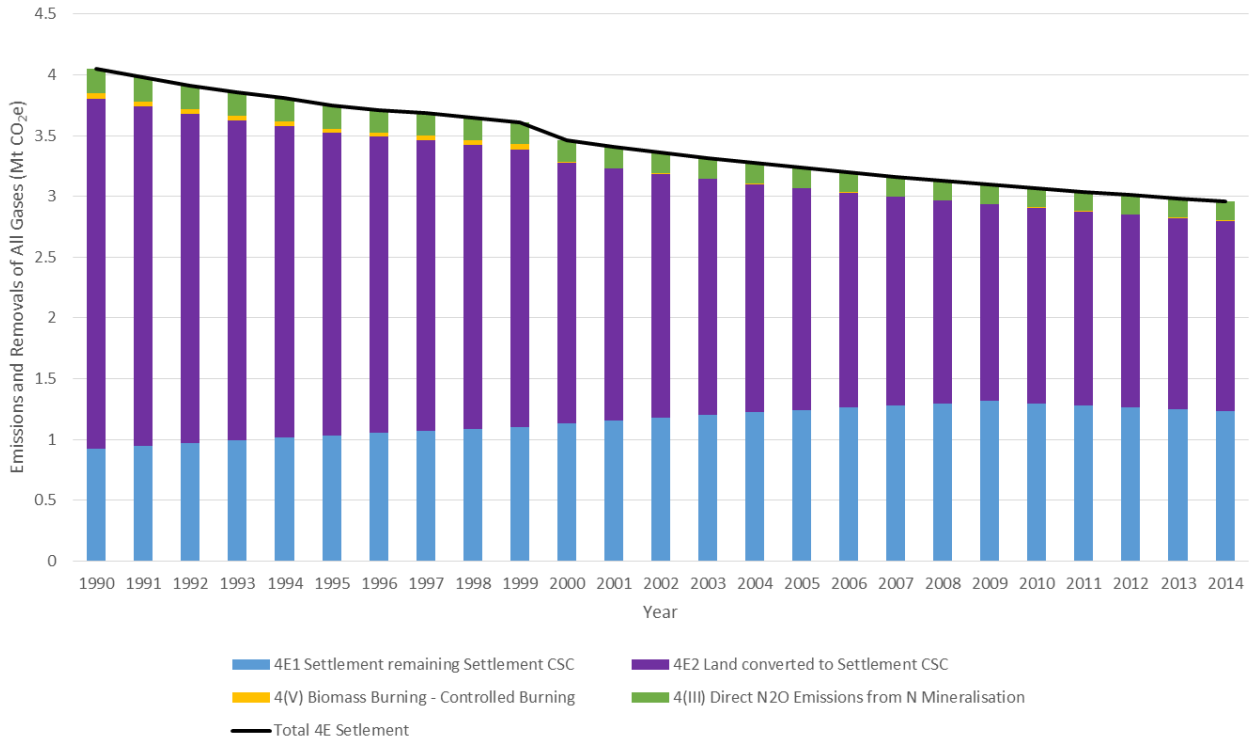

Figure A8. 2E: Emissions and removals of all gases by category for the 4E Settlement category in England 1990-2014

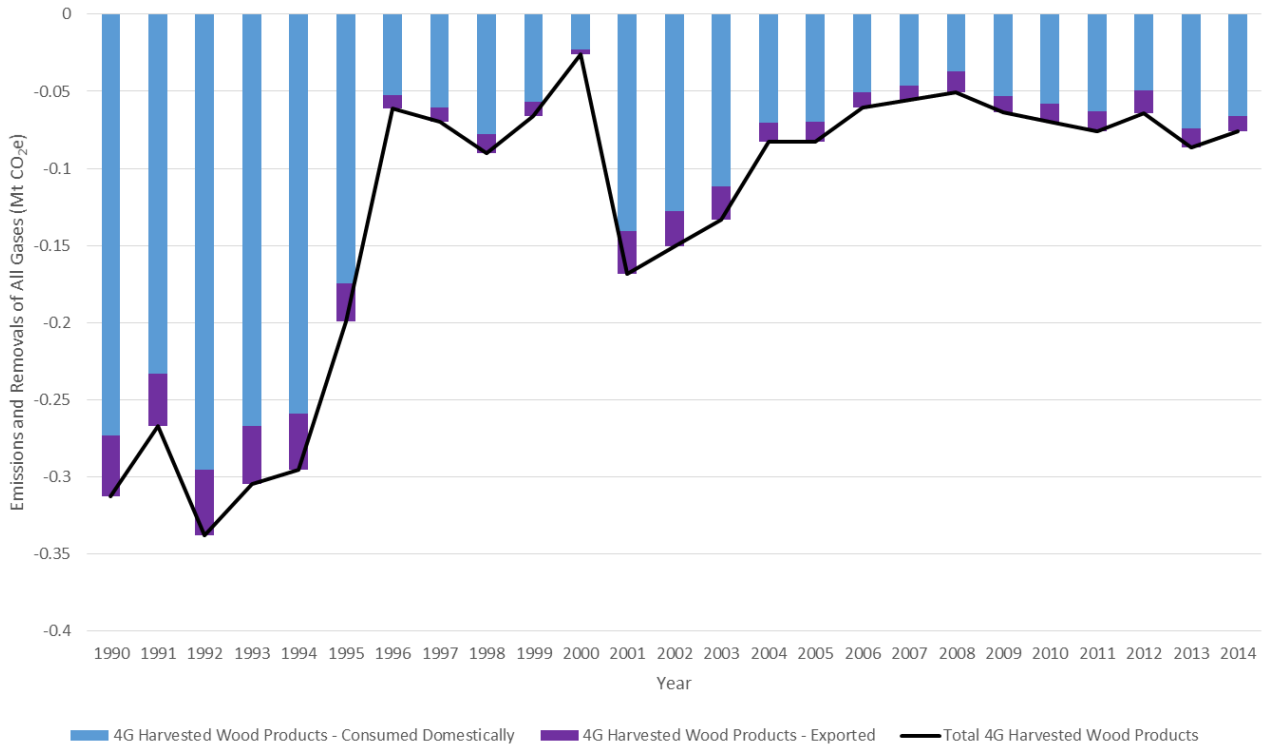

Figure A8. 2F: Emissions and removals of all gases by category for the 4G Harvested Wood Products category in England 1990-2014

A8.2.3 England LULUCF comparison with 2013 inventory

Net emissions from the LULUCF sector for England in the 1990-2014 inventory are slightly higher than the 1990-2013 inventory for 1990-1995 and slightly lower for the remainder of the time period. These revised estimates reflect changes in estimated emissions from the Forest, Grassland and Harvested Wood Products categories, arising from the revision of the CARBINE forest model output, the correction of the grassland drainage emission factor and the inclusion of biomass carbon stock changes from grassland management. Compared to the 1990-2013 Inventory, net emissions of greenhouse gases in the 1990-2014 inventory in 1990 have increased by 0.5 Mt CO_2e, an increase of 22% (Figure A8. 3). Removals in 2013 have increased by 1.6 Mt CO_2e. Differences between the 2013 and 2014 inventories for CO_2e in each category are presented in Figure A8. 4A-F. Differences between the 2013 and 2014 inventories for non-CO_2 for England are presented in Figures A8. 5 and A8. 6.

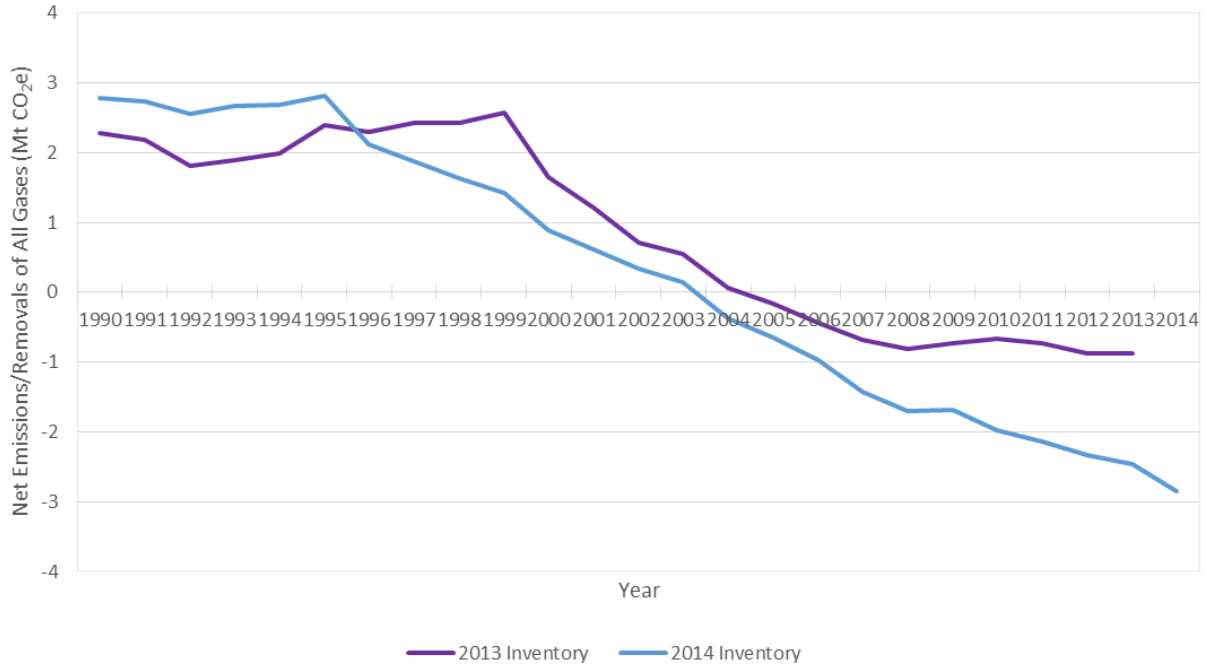

Figure A8. 3: Changes in net emissions of all gases across all LULUCF categories 1990-2014 between the 2013 Inventory and 2014 Inventory for England

Net removals in the Forest Land category in England have changed in trend since the previous inventory due to the correction of the CARBINE model output (Figure A8. 4A, see

Table A8. 2 for data revisions).

In the Cropland category (see section A8.2.3, A8.3.2, Figure A8. 4B) emissions for England are very similar between the 2013 and 2014 inventories. The addition of biomass carbon stock change arising from cropland management activities and the corrections to soil carbon stock change and controlled burning emissions following deforestation all have a minor impact on the category overall.

In the Grassland category (see section A8.2.3, A8.3.2, Figure A8. 4C) estimates for net removals for England have increased over the time series by an average of -1.1 Mt CO_2e or 41%. The majority of the change arises from correction of the emissions factor for drainage of grassland on organic soil, which significantly reduces the emissions from this source. The changes from deforestation soil and controlled burning and the inclusion of biomass carbon stock change from grassland management also have an effect, but this is minor in comparison.

In the Wetland category (see section A8.2.3, A8.3.2, Figure A8.4D) estimates for emissions for England remain the same as the previous inventory, with the exception of the 2013 value which now uses 2013 activity data instead of 2012 data rolled forward.

In the Settlements category (see section A8.2.3, A8.3.2, Figure A8.4E) estimates for emissions for England are very similar between the 2013 and 2014 inventories. The corrections to soil carbon stock change and controlled burning emissions following deforestation have a minor impact on the category overall.

Net removals in the Harvested Wood products category in England have changed since the previous inventory (Figure A8.4F, see Table A8. 1 for data revisions). This is a result of the revision to the output from the CARBINE model so that Harvested Wood Products from Forest remaining Forest areas are now allocated to the correct year.

The CH_4 emissions have changed slightly, due to using the 2006 IPPC guidance methodology and emissions factors for estimating emissions from controlled burning following deforestation (Figure A8. 5). N_2O emissions have increased slightly due to the change to controlled burning methodology and the revision of the soil model output for deforested areas (as N_2O emissions from N mineralisation due to land use change are calculated from the soil model output).

Table A8. 2: Effects of improvements in the source data and/or methodology on Inventory data for England

IPCC Sector	Difference between 2014 and 2013 inventory estimates, Gg CO_2e	
	1990	2013
4A Forest Land	1881	-845
4B Cropland	-21	33
4C Grassland	-1012	-1044
4D Wetlands	0	56
4E Settlements	7	-7
4G Harvested Wood Products	-392	222

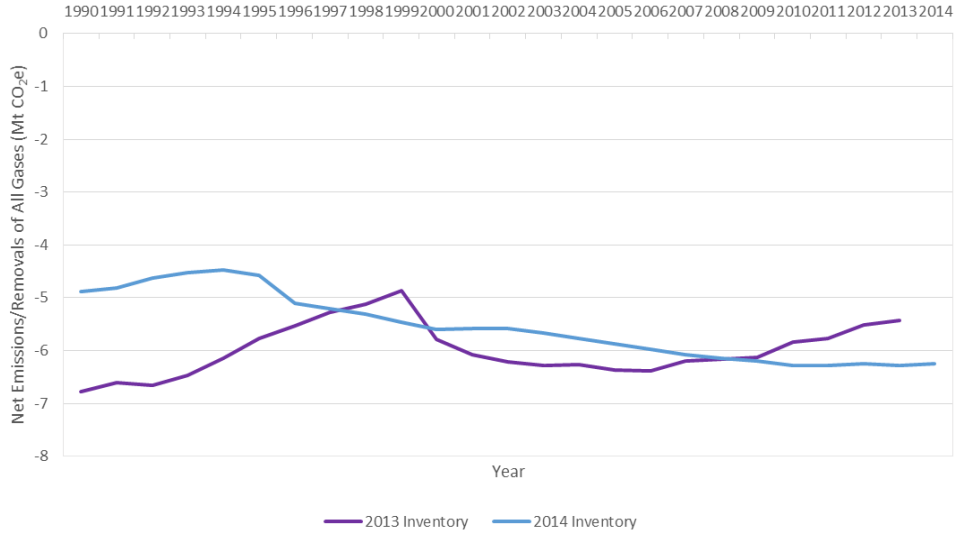

Figure A8. 4A: Forest Land – England

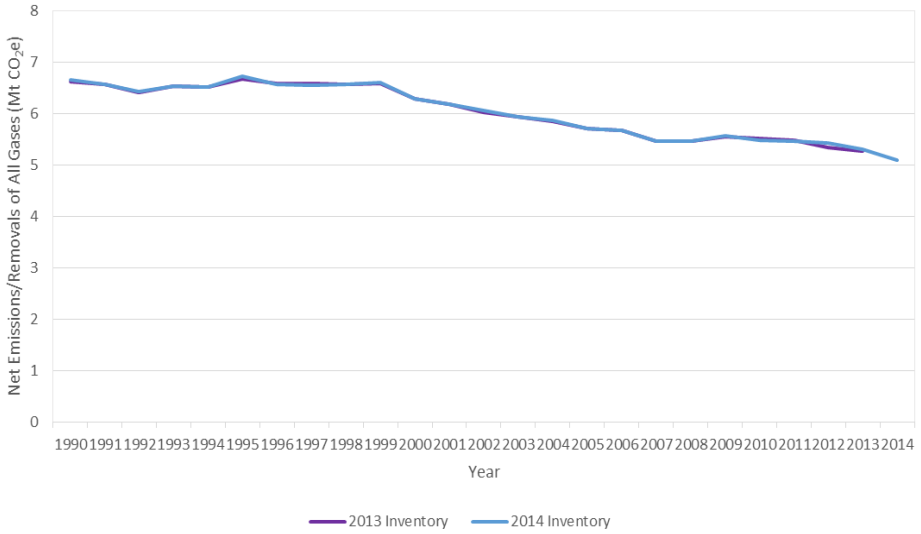

Figure A8. 4B: Cropland – England

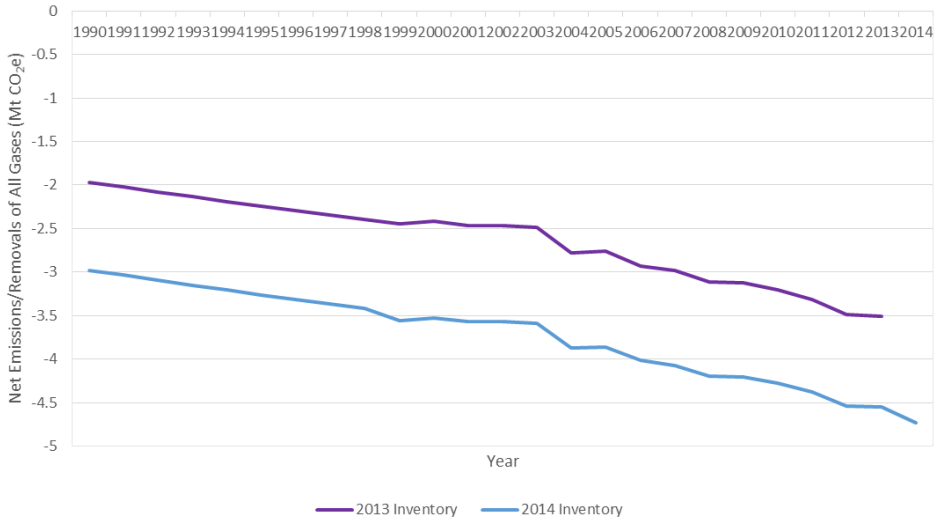

Figure A8. 4C: Grassland – England

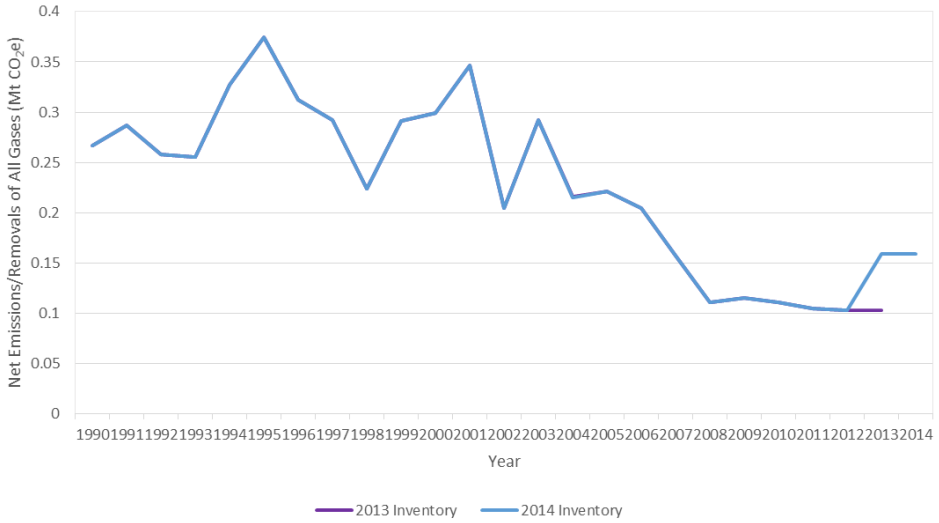

Figure A8. 4D: Wetlands - England

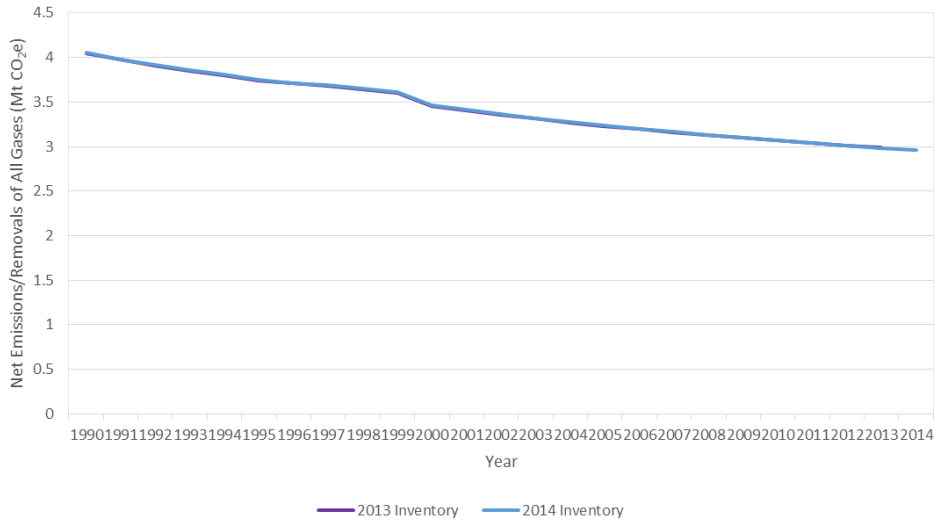

Figure A8. 4E: Settlements - England

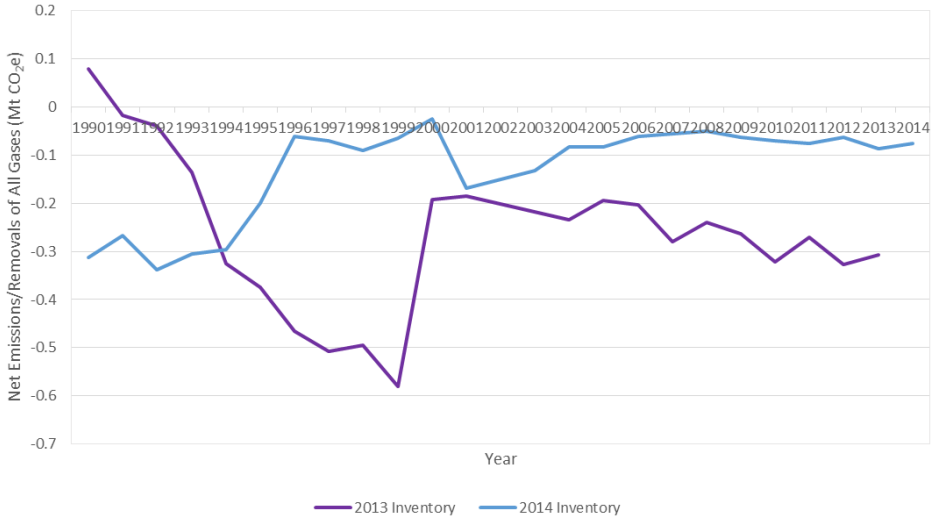

Figure A8. 4F: Harvested Wood Products – England

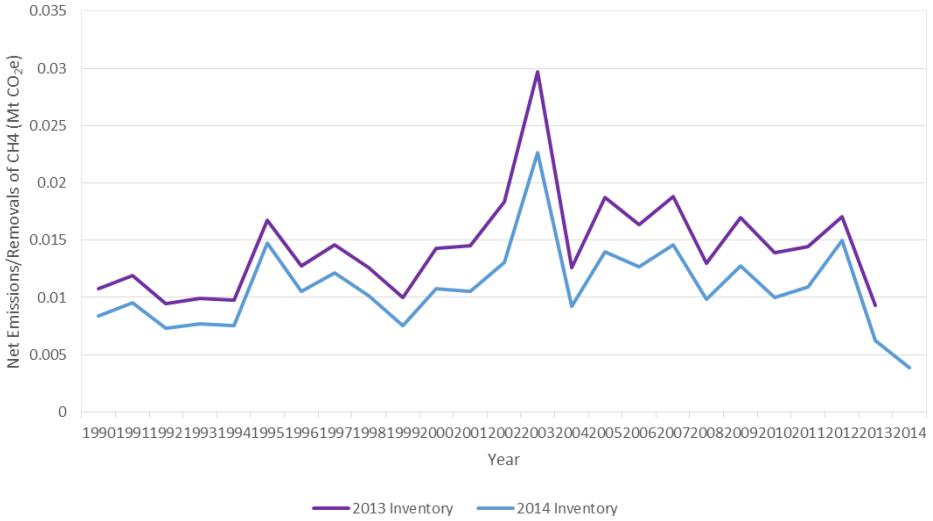

Figure A8. 5: Changes in net emissions of CH_4 only 1990-2014 between the 2013 Inventory and 2014 Inventory for England LULUCF

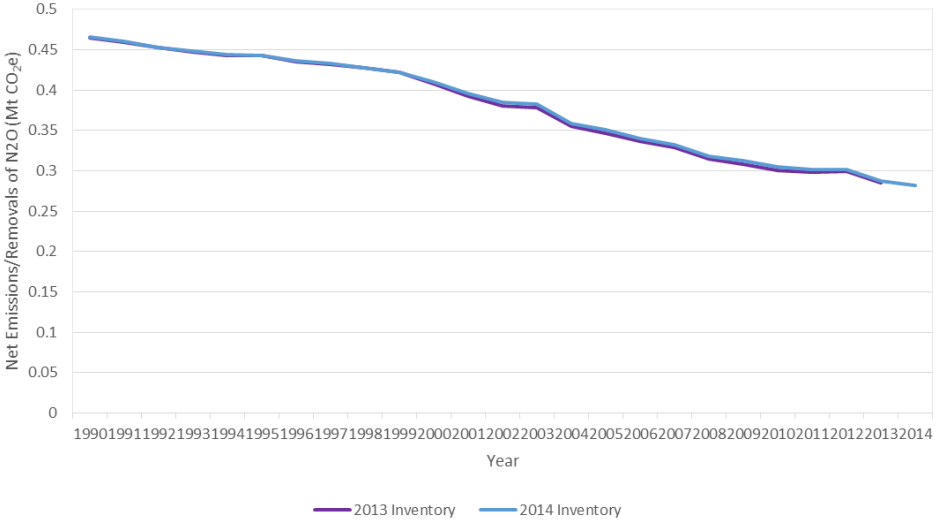

Figure A8. 6: Changes in net emissions of N_2O only 1990-2014 between the 2013 Inventory and 2014 Inventory for England LULUCF.

A8.3 LULUCF Emissions and Removals in Scotland

A8.3.1 Scotland LULUCF Trends

The 1990-2014 Inventory shows that Scotland was a net sink of greenhouse gases from LULUCF activities for the whole time series (Figure A8.7). In 1990 net emissions from the LULUCF sector in Scotland were -2.3 Mt CO_2e, declining steadily to -6.2 Mt CO_2e in 2014 (see section A8.6 for emissions / removals by LULUCF category and gas).

The main influences on the trend for the LULUCF sector in Scotland are emissions from Cropland and Settlement, outweighed by removals from Forest land and Grassland. Emissions from Wetland (see section A8.2.2) are low for Scotland relative to other emissions, as are removals from Harvested Wood Products (Figure A8.7).

Cropland produces the largest emissions source in Scotland: this peaked at 7.0 Mt CO_2e in 1999 and has since steadily reduced to 5.0 Mt CO_2e in 2014. The Settlement category is a net source that has declined from a peak of 1.8 Mt CO_2e in 1999 to 1.6 Mt CO_2e in 2014.

Forest land is the largest net sink in Scotland, increasing from -8.4 Mt CO_2 in 1990 to -10 Mt CO_2 in 1999, then gradually decreasing to -9.3 Mt CO_2 in 2014. The Grassland net sink has overall increased gradually from -2.0 Mt CO_2e in 1990 to -2.7 Mt CO_2e in 2014.

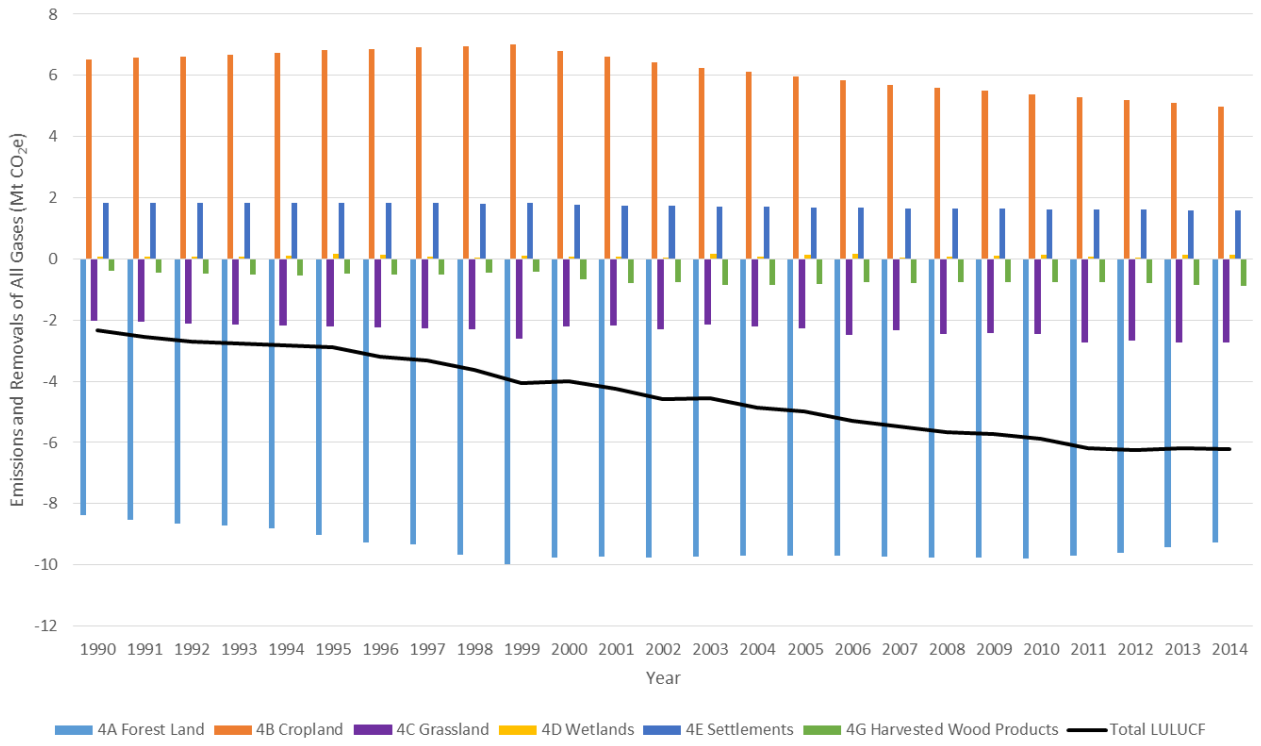

Figure A8.7: Emissions and removals of all gases by category for the LULUCF sector in Scotland 1990-2014

A8.3.2 Scotland LULUCF Category Trends

The Forest land category (see section A8.2.3) for Scotland is a net sink for 1990-2014 (Figure A8. 8A). The majority of the sink arises from the large area of conifer plantation, which is subject to active forest management such as thinning and varying harvesting rotations. Removals from the Land converted to Forest land decrease over the time series due to a declining rate of forest planting. GHG emissions in the category (from wildfires, nitrogen fertilisation and N_2O emissions from drainage) are very small compared to the carbon sink in forest soils and biomass.

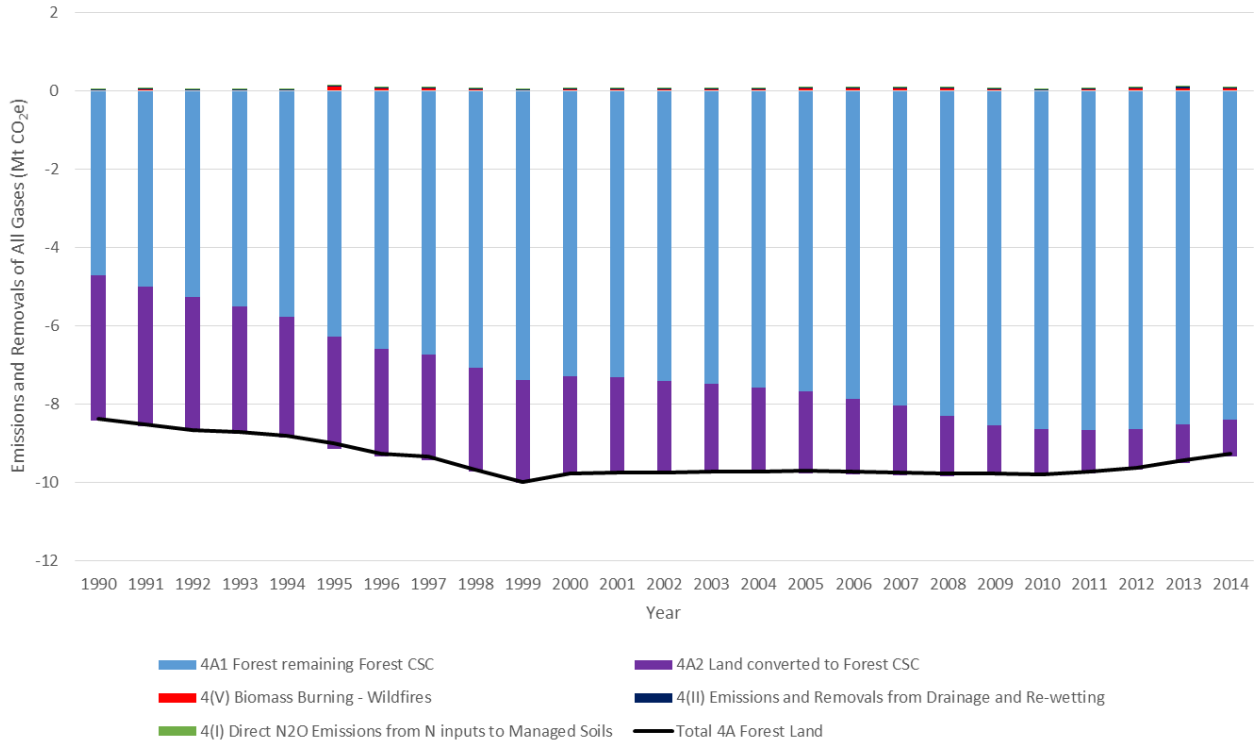

Figure A8. 8A: Emissions and removals of all gases by category for the 4A Forestry category in Scotland 1990-2014

The Cropland category (see section A8.2.3) for Scotland is a net source for 1990-2014. Land converted to Cropland (carbon stock changes and N_2O emissions from N mineralisation) accounts for the highest emissions from Cropland in Scotland for LULUCF (Figure A8.8B). These emissions are the result of recent conversion from grassland and other land uses, although the rate of land use change to Cropland has decreased over time. Emissions from Cropland remaining Cropland are increasing over time, as continuing carbon stock losses from historical land use change move across from the Land converted to Cropland sub-category after 20 years. The Cropland remaining Cropland category also includes biomass and soil carbon stock changes arising from cropland management (e.g. inputs of fertiliser, manure and crop residues, and change between cropland types). Other GHG emissions from drained cropland organic soils and from biomass burning are small.

The Grassland category (see section A8.2.3) for Scotland is a net sink for 1990-2014. Removals from carbon stock changes due to land use change in Grassland remaining Grassland and Land converted to Grassland are slightly reduced by emissions from drained organic soils under improved grassland and biomass burning (Figure A8. 8C). Grassland remaining Grassland also now includes carbon sock change in biomass from grassland management (e.g. change between shrubby and non-shrubby grassland types,). Emissions from biomass burning increased substantially after 2000, due to increased conversion from Forest land (deforestation of conifers for habitat restoration and construction for renewable energy generation). Other sources of emissions (wildfires and N_2O emissions from N mineralisation following land use change) are insignificant.

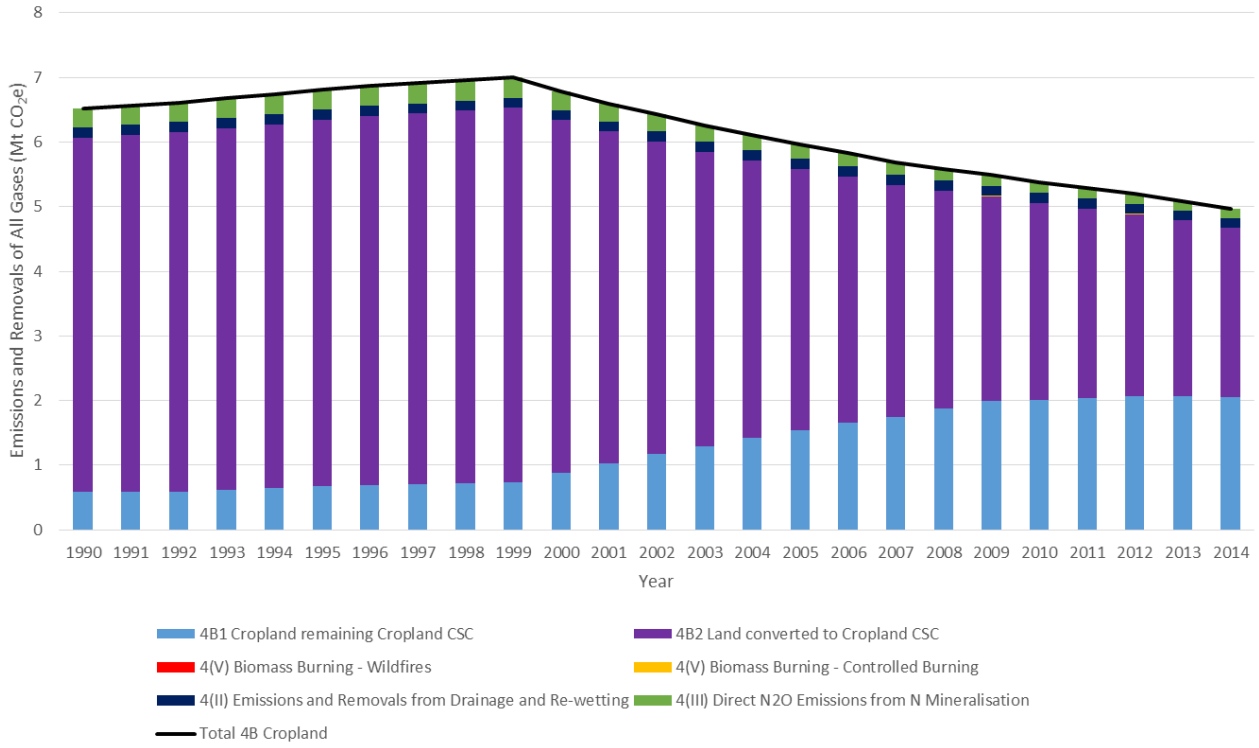

Figure A8. 8B: Emissions and removals of all gases by category for the 4B Cropland category in Scotland 1990-2014

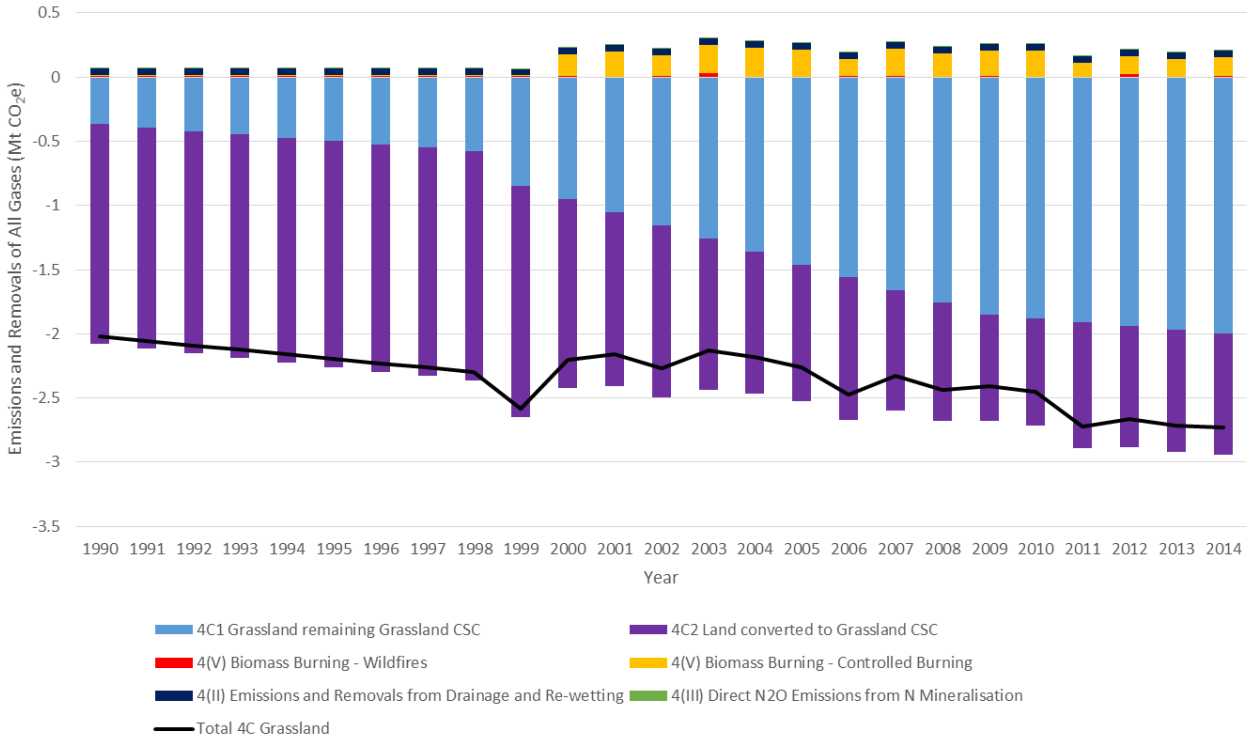

Figure A8. 8C: Emissions and removals of all gases by category for the 4C Grassland category in Scotland 1990-2014

The Wetland category (see section A8.2.3) is a fluctuating source of emissions for Scotland (Figure A8. 8D). These emissions are predominantly from commercial peat extraction, and this is largely dependent upon the weather and product demand, hence the fluctuating trend. Between 1990 and 2014, the land area in Scotland undergoing commercial peat extraction fell from 1.7 kha to 1.4 kha. More than 85% of the volume of peat sold in Scotland was for the horticultural industry. There are also insignificant contributions to emissions from land converted to peat extraction and to flooded land (reservoirs).

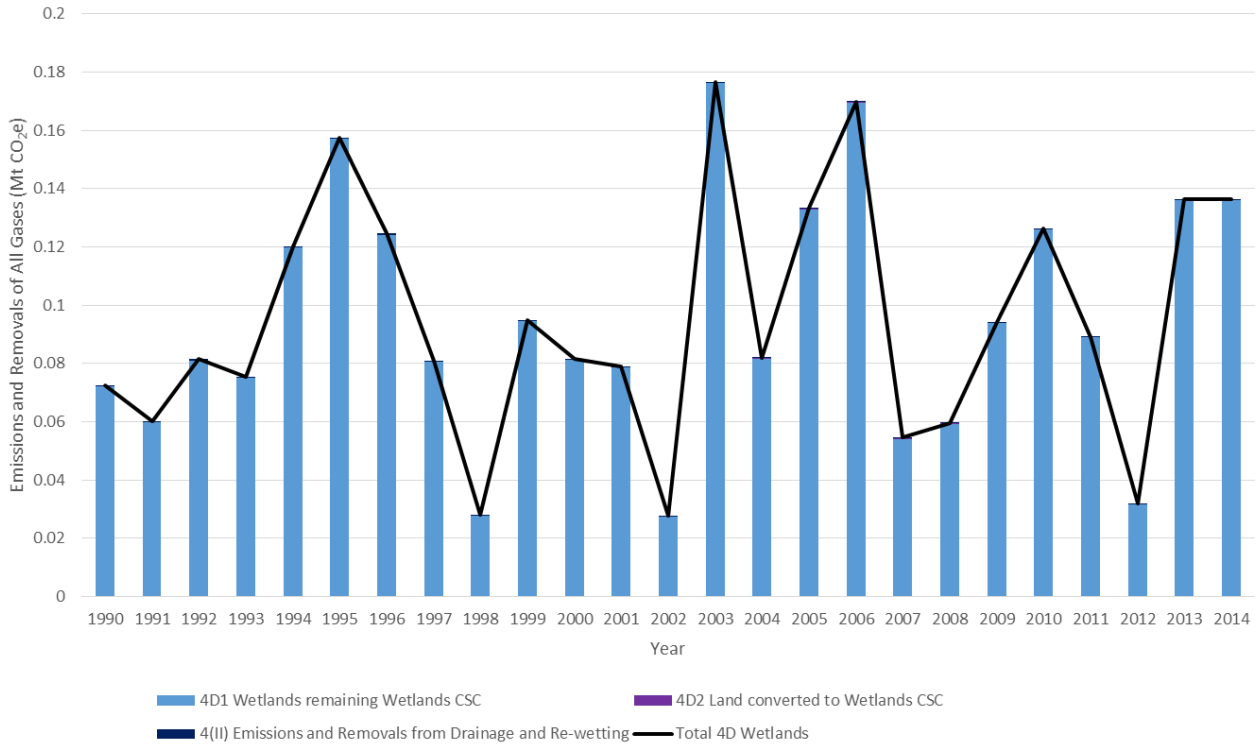

Figure A8.8D: Emissions and removals of all gases by category for the 4D Wetland category in Scotland 1990-2014

The Settlements category (see section A8.2.3) is the second largest emissions source in Scotland, after Cropland. Most emissions are from soil carbon stock losses following land use change on Land converted to Settlements (recent LUC) and Settlement remaining Settlement (historic LUC) (Figure A8.8E). There are also related N_2O emissions from N mineralisation following land use change. There are a small amount of GHG emissions resulting from controlled biomass burning during deforestation to Settlement.

The Harvested Wood Products category (see section A8.2.3) is a net sink of CO_2 for Scotland (Figure A8.8F). It is variable over time (the model is driven by both forest management and timber production statistics) and the majority of the products are consumed domestically in the UK.

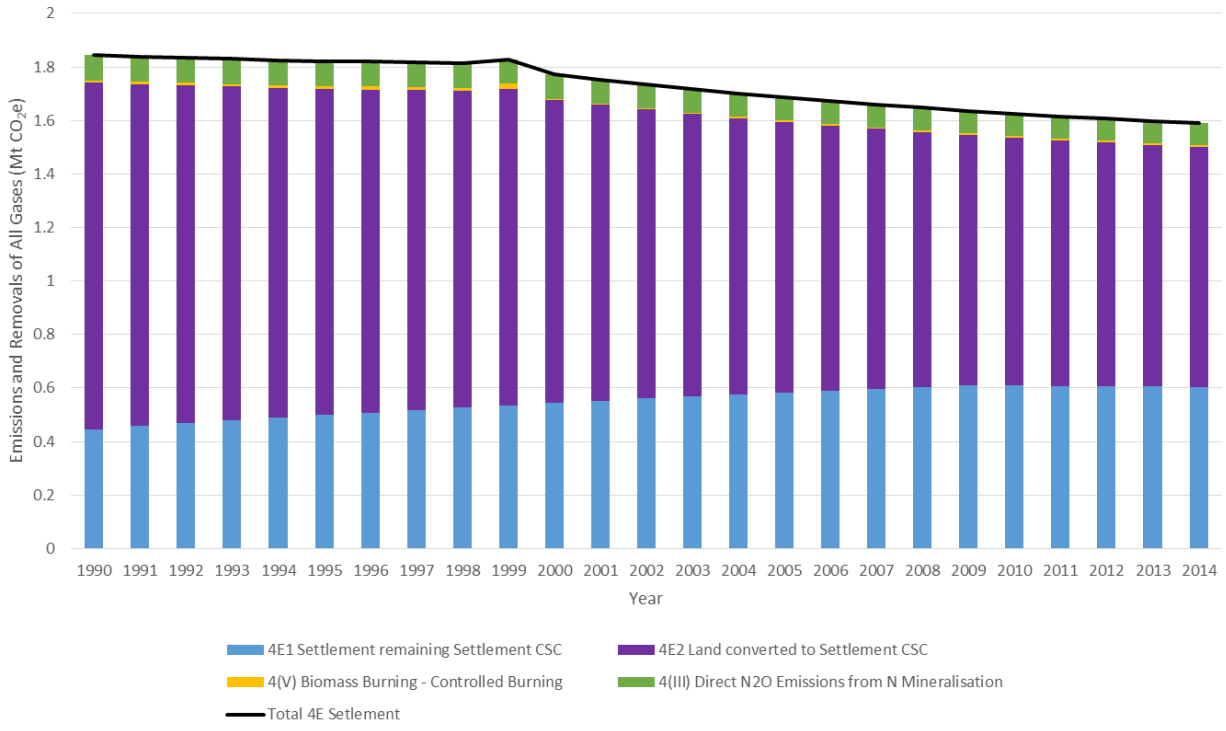

Figure A8.8E: Emissions and removals of all gases by category for the 4E Settlement category in Scotland 1990-2014

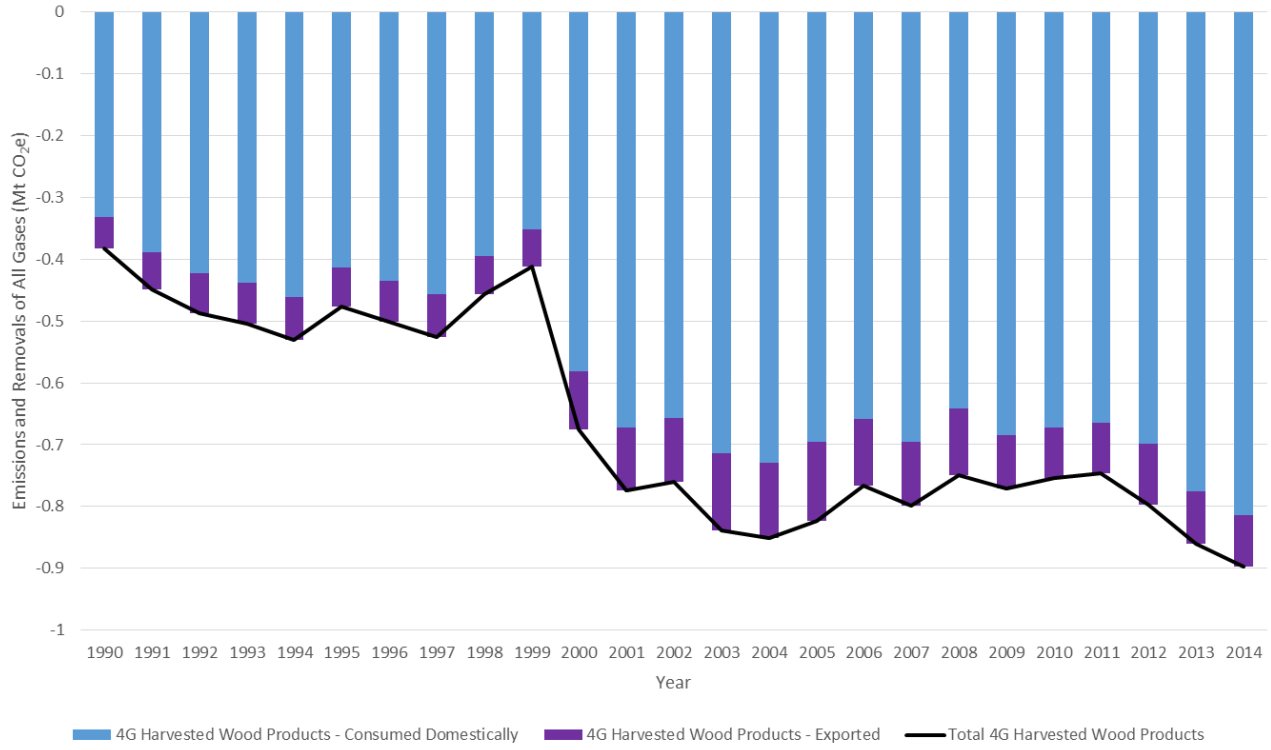

Figure A8.8F: Emissions and removals of all gases by category for the 4G Harvested Wood Products category in Scotland 1990-2014

A8.3.3 Scotland LULUCF comparison with 2013 inventory

Net removals from the LULUCF sector for Scotland in the 1990-2014 inventory are greater than the 1990-2013 inventory, although the trend towards being an increasing sink is predominantly the same (Figure A8. 9). The revised estimates reflect changes in estimated emissions from the Forest, Grassland and Harvested Wood Products categories, and to a lesser extent changes in the Settlement category. Compared to the 1990-2013 inventory, net removals of greenhouse gases in the current inventory have increased by 2.4 Mt CO_2e in 1990 and 1.0 Mt CO_2e in 2013. Differences between the 2013 and 2014 inventories for CO_2e in each category are presented in Figures A8. 10A-F. Differences between the 2013 and 2014 inventories for non-CO_2 emissions for Scotland are presented in Figures A8. 11 and A8. 12.

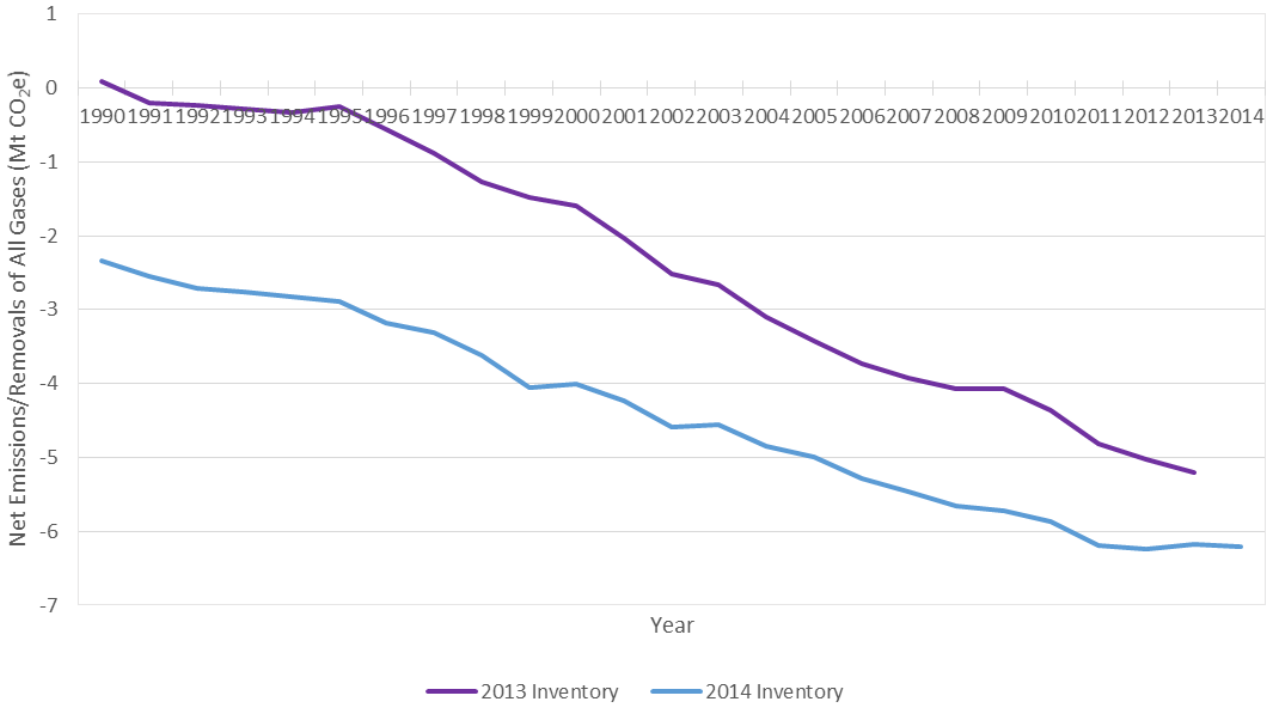

Figure A8.9: Changes in net removals of all gases 1990-2014 between the 2013 Inventory and 2014 LULUCF Inventory for Scotland

Net removals in the Forest Land category in Scotland have increased and changed in trend since the previous inventory due to the correction of the CARBINE model output (Figure A8. 10A, see

Table A8. 2 for data revisions).

In the Cropland category (see sections A8.2.3, A8.4.2, Figure A8. 8B) estimates for emissions for Scotland have remained stable over the time period (Figure A8. 10B). The addition of biomass carbon stock change arising from cropland management activities and the corrections to soil carbon stock change and controlled burning emissions following deforestation all have a minor impact on the category overall.

In the Grassland category (see sections A8.2.3, A8.4.2, Figure A8. 8C) estimates for net removals for Scotland have increased over the time series by an average of 0.8 Mt CO_2e or 58% (Table A8. 3, Figure 10C). The majority of the change arises from correction of the emissions factor for drainage of grassland on organic soil, which significantly reduces the emissions from this source. The changes from deforestation soil and controlled burning and the inclusion of biomass carbon stock change from grassland management also have an effect, but this is minor in comparison. In the Wetland category (see sections A8.2.3, A8.4.2, Figure A8. 8D) estimates for emissions for Scotland remain the same as the previous inventory, except for 2013 where updated peat extraction data has become available (Table A8. 3, Figure A8.10D).

In the Settlements category (see sections A8.2.3, A8.4.2, Figure A8. 8E) estimates for emissions for Scotland have slightly increased by an average of 1% for 1990-2013 (Table A8. 3, Figure A8. 10E). This is due to the corrections to soil carbon stock change and controlled burning emissions following deforestation.

Net removals in the Harvested Wood products category in Scotland have changed increased by an average of 0.3 Mt CO_2e since the previous inventory (see Figure A8. 10F and Table A8. 1 for data revisions). This is a result of the revision to the output from the CARBINE model so that Harvested Wood Products from Forest remaining Forest areas are now allocated to the correct year.

The CH_4 emissions have decreased due to using the 2006 IPPC guidance methodology and emissions factors for estimating emissions from controlled burning following deforestation (Figure A8. 11). N_2O emissions have increased compared to the 1990-2013 inventory from 2000 onwards (Figure A8. 12). This is due to the change to controlled burning methodology and the revision of the soil model output for deforested areas (as N_2O emissions from N mineralisation due to land use change are calculated from the soil model output).

Table A8. 3: Effects of improvements in the source data and/or methodology on Inventory data for Scotland

IPCC Sector	Difference between 2014 and 2013 inventory estimates, kt CO_2e	
	1990	2013
4A Forest Land	-1360	20
4B Cropland	-1	8
4C Grassland	-718	-834
4D Wetlands	0	105
4E Settlements	15.1	39
4G Harvested Wood Products	-364	-310

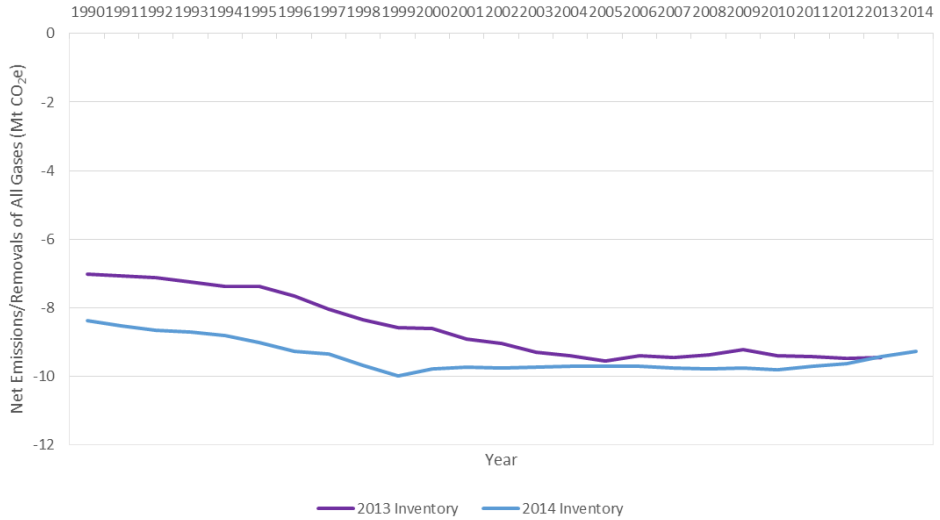

Figure A8. 10A: Forest Land – Scotland

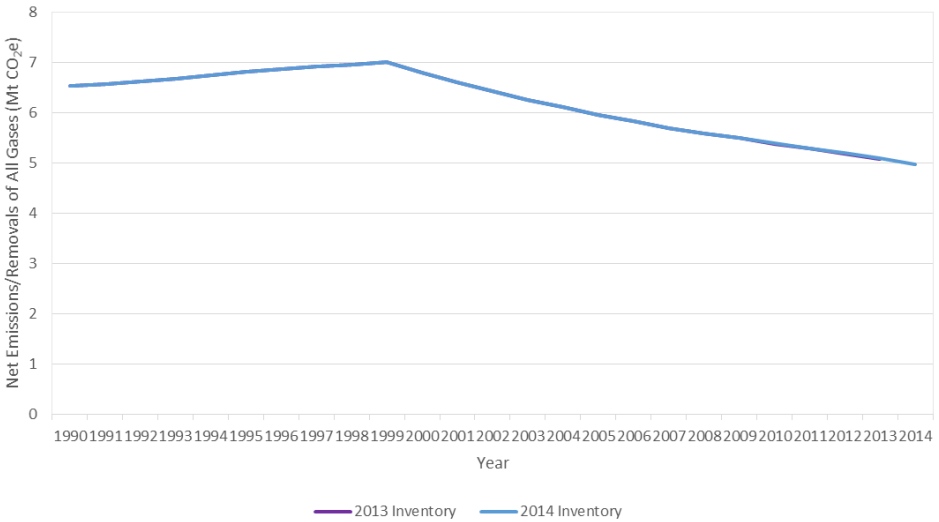

Figure A8. 10B: Cropland - Scotland

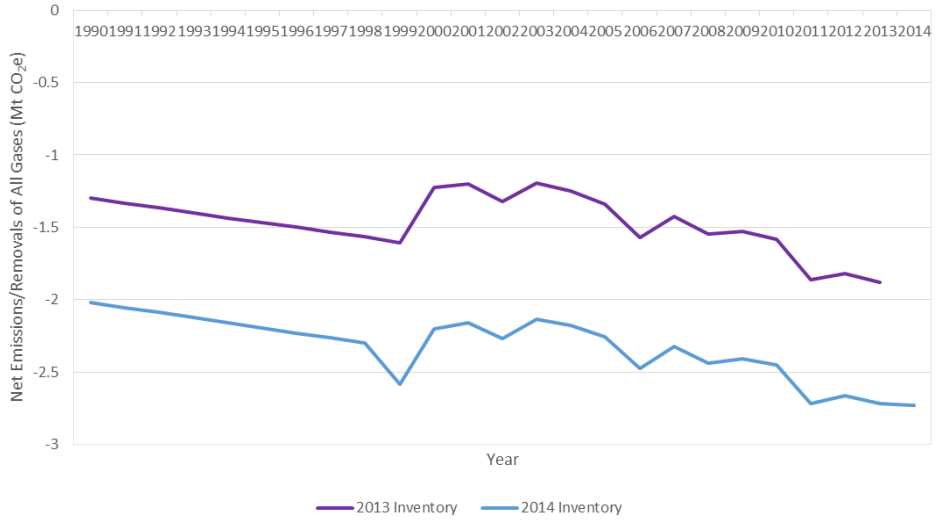

Figure A8. 10C: Grassland – Scotland

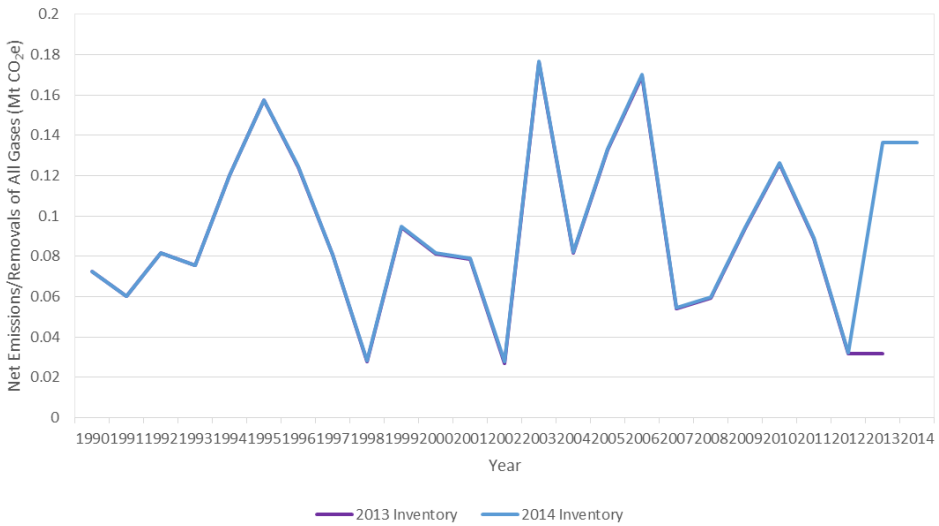

Figure A8. 10D: Wetlands - Scotland

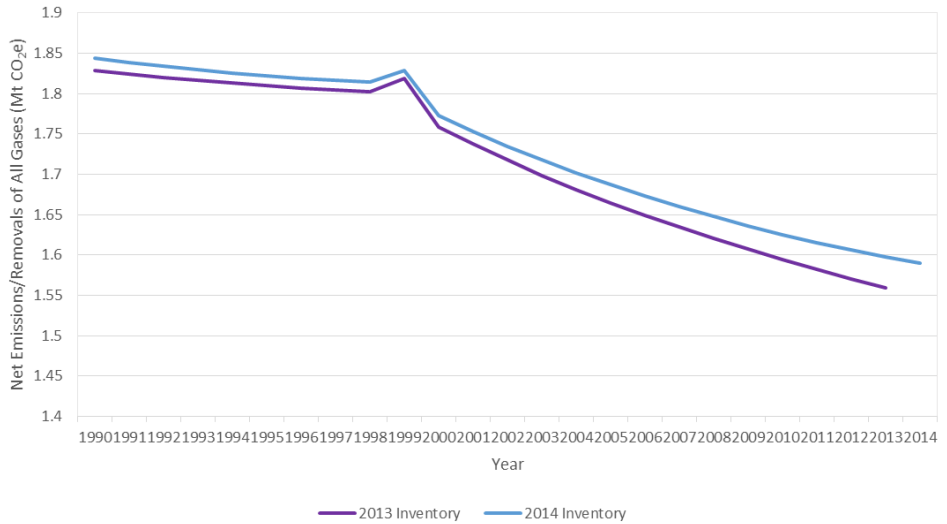

Figure A8. 10E: Settlements – Scotland

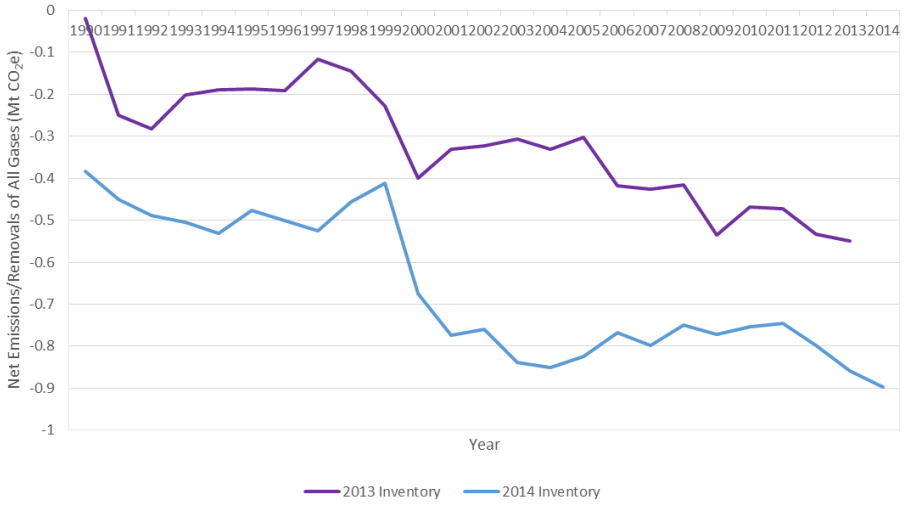

Figure A8.10F: Harvested Wood Products - Scotland

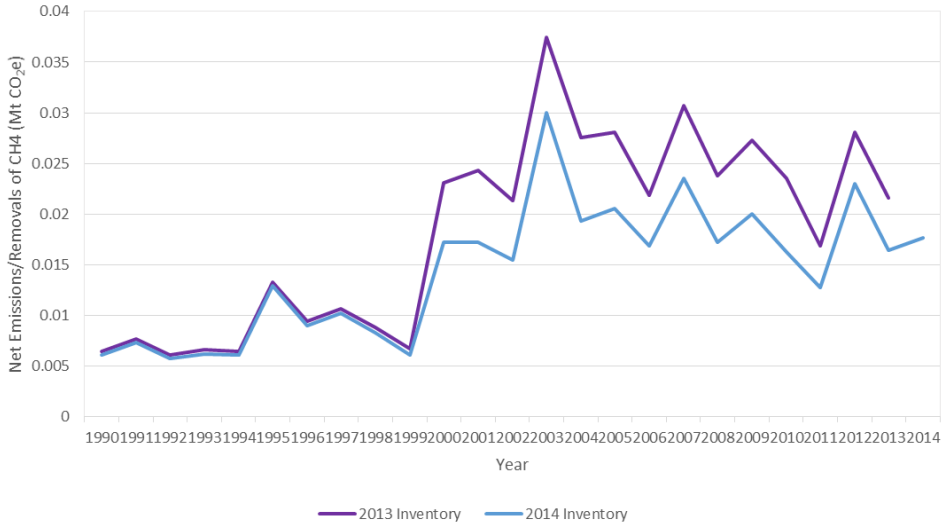

Figure A8. 11: Changes in net emissions of CH_4 only 1990-2014 between the 2013 Inventory and 2014 Inventory for Scotland LULUCF

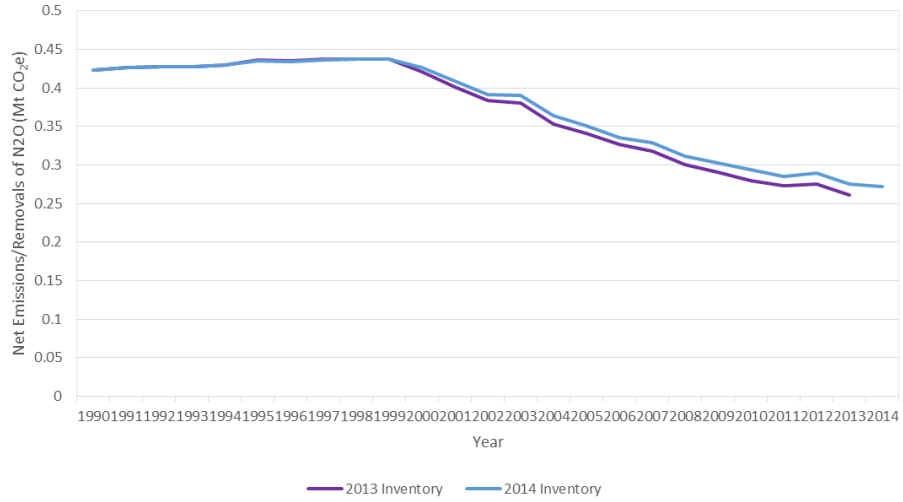

Figure A8. 12: Changes in net emissions of N_2O only 1990-2014 between the 2013 Inventory and 2014 Inventory for Scotland LULUCF.

A8.4 LULUCF Emissions and Removals in Wales

A8.4.1 Wales LULUCF Trends

The 1990-2014 Inventory shows Wales was a small net sink of greenhouse gases from LULUCF activities from 1990-1998 and from 2003 onwards, rising to a small net source in between (Figure A8. 13). In 1990 Wales was a small sink at -0.3 Mt CO_2e, rising to a peak source in 2000 of 0.2 Mt CO_2e and decreasing again to a sink of -0.3 Mt CO_2e in 2014 (see section A8.6 for emissions / removals by LULUCF category and gas).

The main influences on the trend for the LULUCF sector in Wales are emissions from Cropland and Settlement, outweighed by removals from Forest land and Grassland. Emissions from Wetland (see section A8.2.2) are small for Wales relative to other emissions, as are removals from Harvested Wood Products (Figure A8.13).

Cropland produces the largest emissions source in Wales: this peaked at 1.3 Mt CO_2e in 1999 and has since steadily reduced to 0.9 Mt CO_2e in 2014. The Settlement category is a net source that has declined from a peak of 0.8 Mt CO_2e in 1999 to 0.7 Mt CO_2e in 2014.

The Forest land and Grassland categories are net sinks from 1990 to 2013. Forest land is generally a decreasing sink in Wales from -1.7 Mt CO_2e in 1990 to -1.2 Mt CO_2e in 2014. Between 1990 and 2014, Grassland net removals have fluctuated between -0.5 Mt CO_2e and -0.6 Mt CO_2e.

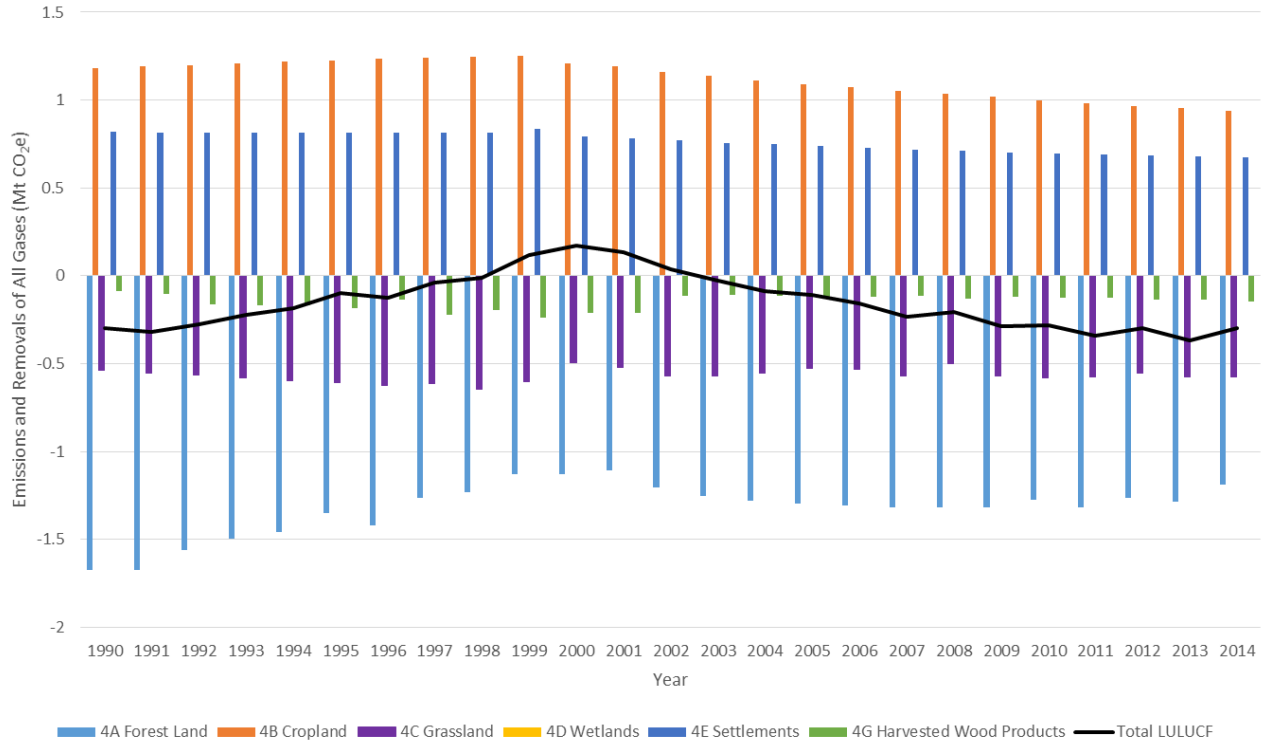

Figure A8. 13: Emissions and removals for all gases by category for the LULUCF sector in Wales 1990-2014

A8.4.2 Wales LULUCF Category Trends

The Forest land category (see section A8.2.3) for Wales is a net sink for 1990-2014. The sink arises from a combination of broadleaf forest (not subject to forest management) and conifer plantations (subject to active forest management such as thinning and varying harvesting rotations). There has been a gradual decline in Land converted to Forest since 1990. GHG emissions in the category (from wildfires, nitrogen fertilisation and N_2O emissions from drainage) are very small compared to the carbon sink in forest soils and biomass. (Figure A8. 14A). Forest wildfires show high inter-annual variability.

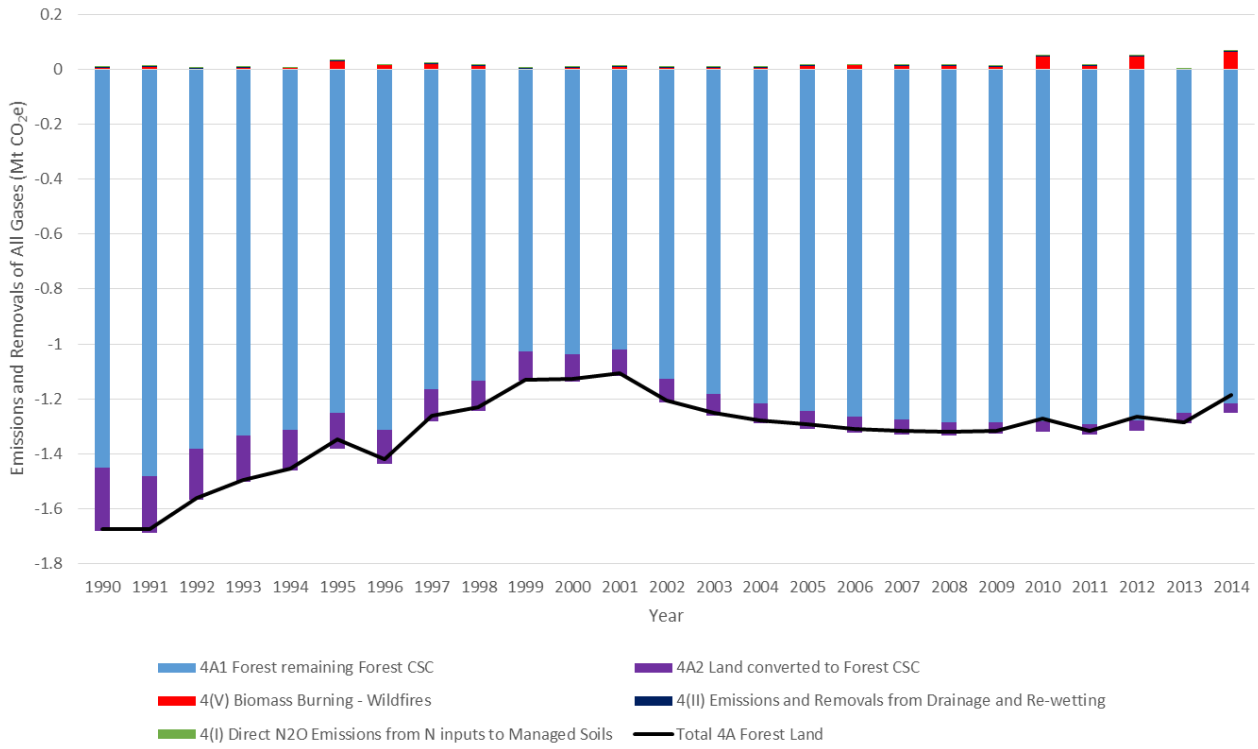

Figure A8. 14A: Emissions and removals of all gases by category for the 4A Forestry category in Wales 1990-2014

The Cropland category (see section A8.2.3) for Wales is an emission source throughout the time series. Land converted to Cropland (carbon stock changes and N_2O emissions from N mineralisation) accounts for the highest emissions from Cropland in Wales for LULUCF (Figure 14B), although these have been decreasing since 1999. Emissions from Cropland remaining Cropland are increasing over time, as continuing carbon stock losses from historical land use change move across from the Land converted to Cropland sub-category after 20 years. The Cropland remaining Cropland category also includes biomass and soil carbon stock changes arising from cropland management (e.g. inputs of fertiliser, manure and crop residues, and change between cropland types). Other GHG emissions from drained cropland organic soils are small.

The Grassland category (see section A8.2.3) for Wales is a net sink for 1990-2014. Removals from carbon stock changes in Grassland remaining Grassland and Land converted to Grassland are reduced by emissions from drained organic soils under improved grassland and biomass burning (Figure A8.14C). Grassland remaining Grassland also now includes carbon sock change in biomass from grassland management (e.g. change between shrubby and non-shrubby grassland types). Emissions from biomass burning increased after 2000, this is due to increased conversion from Forest land (deforestation of conifers for habitat restoration). Other sources of emissions (wildfires and N_2O emissions from N mineralisation following land use change) are small.

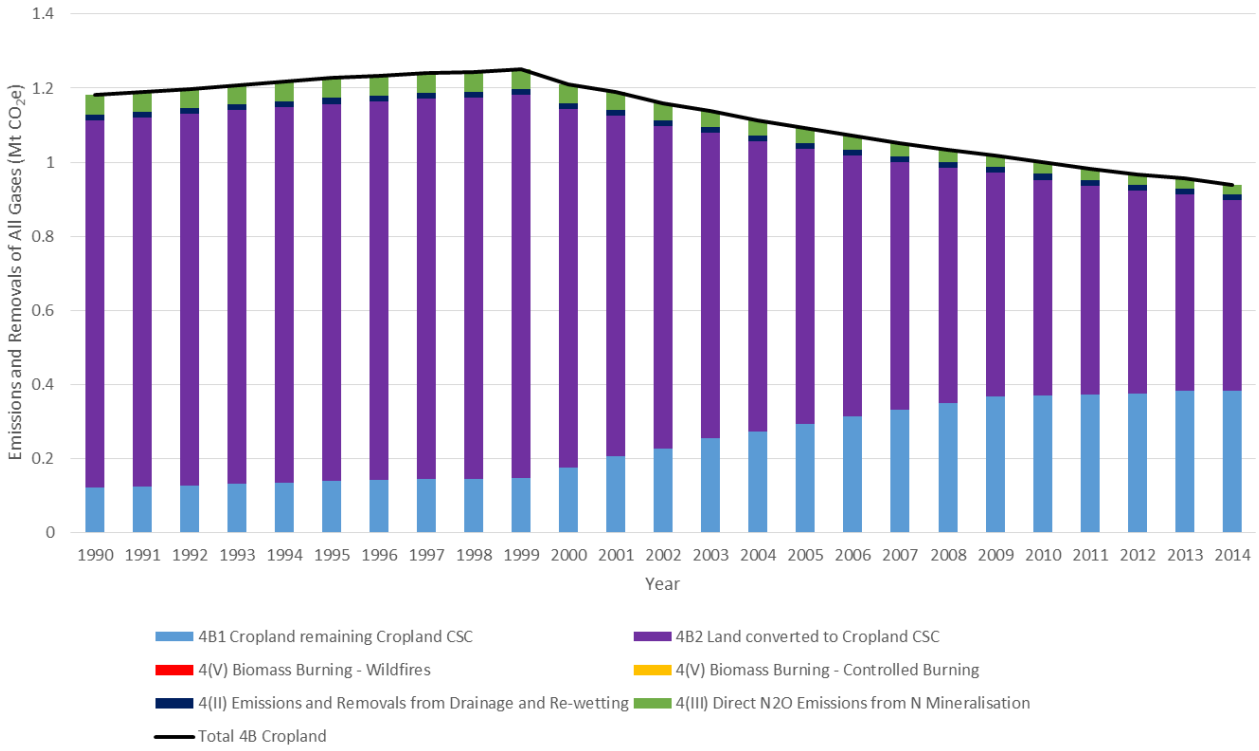

Figure A8. 14B: Emissions and removals of all gases by category for the 4B Cropland category in Wales 1990-2014

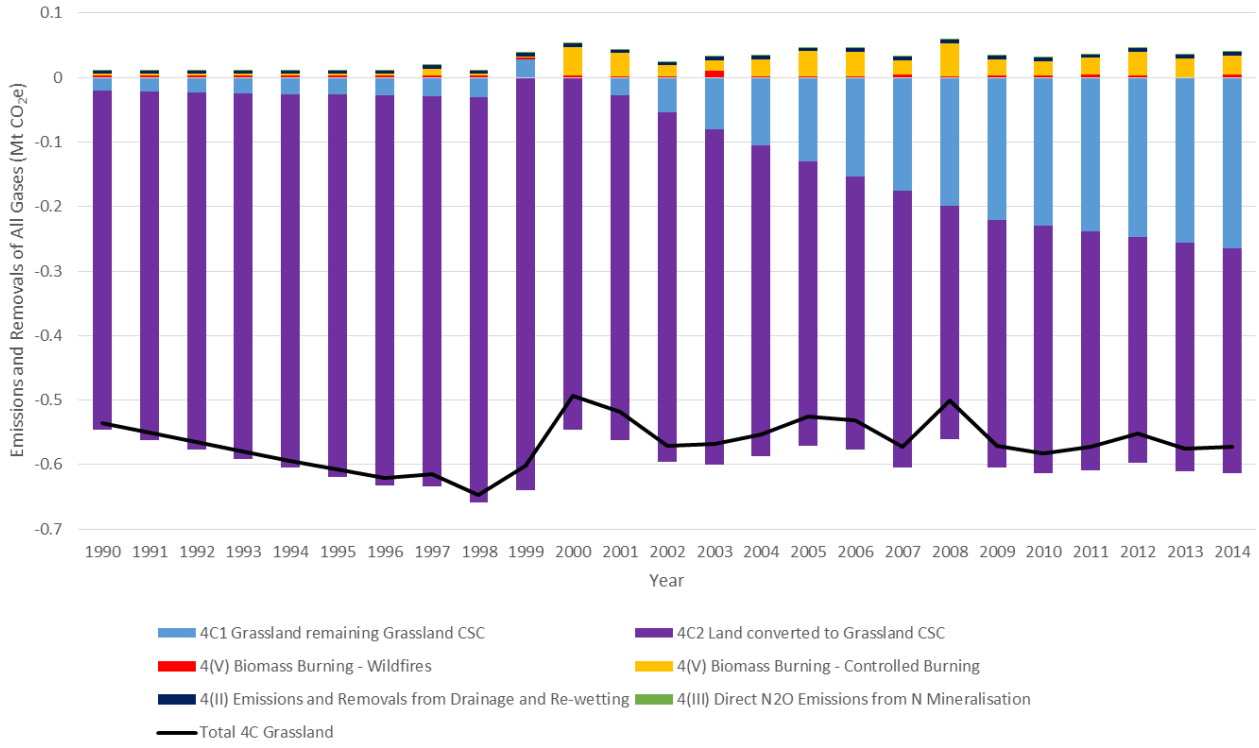

Figure A8. 14C: Emissions and removals of all gases by category for the 4C Grassland category in Wales 1990-2014

The Wetland category (see section A8.2.3) is a minor source for Wales (Figure A8.14D), with the smallest emissions from peat extraction in the UK, at <0.001 Mt CO_2e. The peak in 1991 is due to carbon stock losses resulting from reservoir construction (Trawsfynydd). Between 1990-2014, approximately 0.3 kha was estimated to be emitting carbon dioxide as a result of historic commercial peat extraction in Wales. There was no new peat extracted and sold in Wales for the horticultural industry.

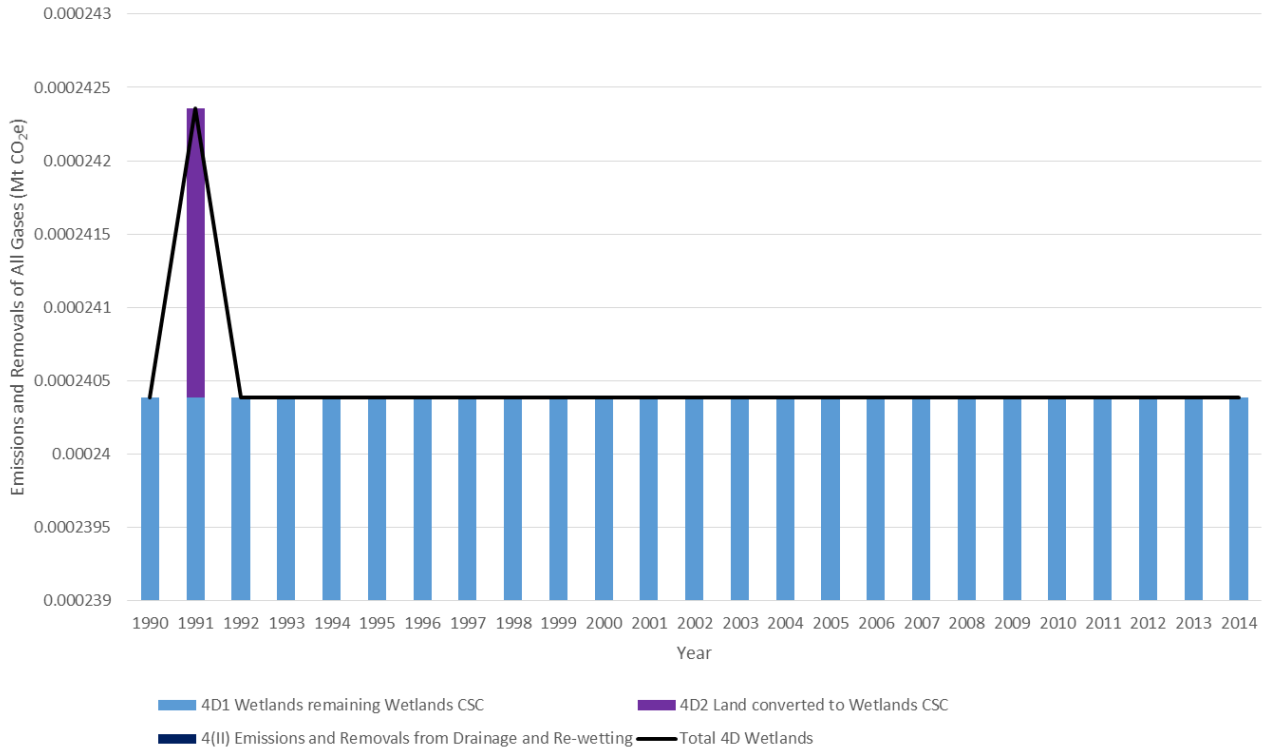

Figure A8. 14D: Emissions and removals of all gases by category for the 4D Wetland category in Wales 1990-2014

The Settlements category (see section A8. 2.3) is the second largest emissions source in Wales, after Cropland. Most emissions are from soil carbon stock losses following land use change on Land converted to Settlements (recent LUC) and Settlement remaining Settlement (historic LUC) (Figure A8. 14E). There are also related N_2O emissions from N mineralisation following land use change. There are a small amount of GHG emissions resulting from controlled biomass burning during deforestation to Settlement.

The Harvested Wood Products category (see section A8. 2.3) is a net sink of CO_2 for Wales (Figure A8. 14F). It is variable over time (the model is driven by both forest management and timber production statistics) and the majority of the products are consumed domestically in the UK.

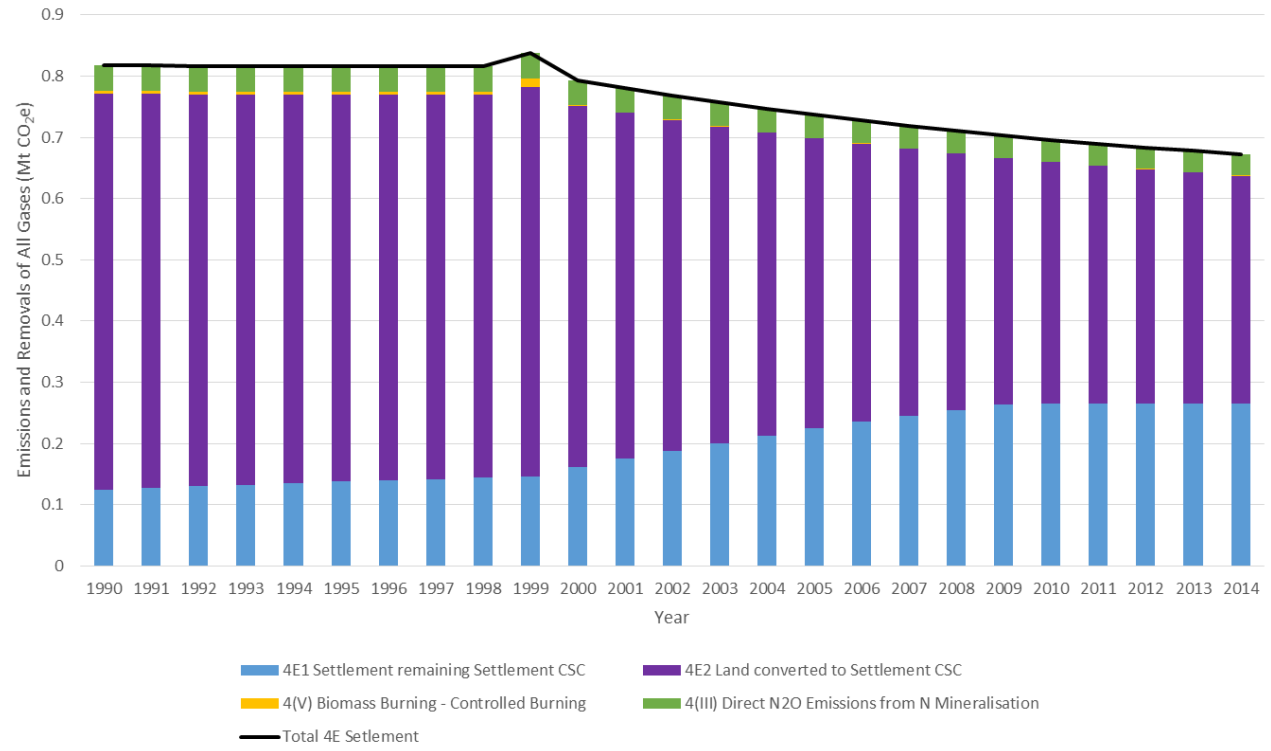

Figure A8. 14E: Emissions and removals of all gases by category for the 4E Settlement category in Wales 1990-2014

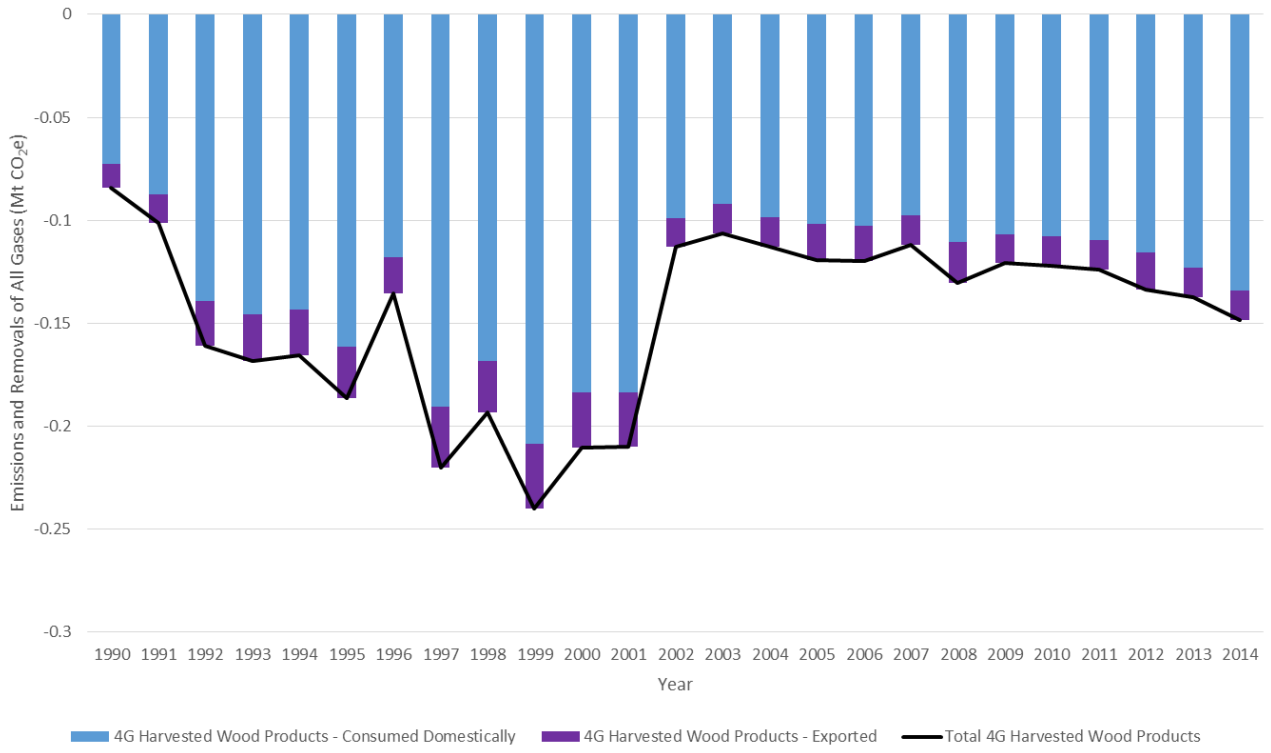

Figure A8. 14F: Emissions and removals of all gases by category for the 4G Harvested Wood Products category in Wales 1990-2014

A8.4.3 Wales LULUCF comparison with 2013 inventory

Net emissions from the LULUCF sector in Wales have changed from those in the 1990-2013 inventory but there is no clear pattern of net increase or decrease (Figure A8. 15). The differences are due to a combination of changes predominantly from the Forest and Grassland categories. Compared to the 1990-2013 inventory, net emissions of greenhouse gases in the current inventory have decreased by 0.4 Mt CO_2e in 1990 and increased by 0.3 Mt CO_2e in 2013. Differences between the 2013 and 2014 inventories for CO_2 in each category are presented in Figure 16A-F. Differences between the 2013 and 2014 inventories for non-CO_2 for Wales are presented in Figures A8. 17 and A8. 18.

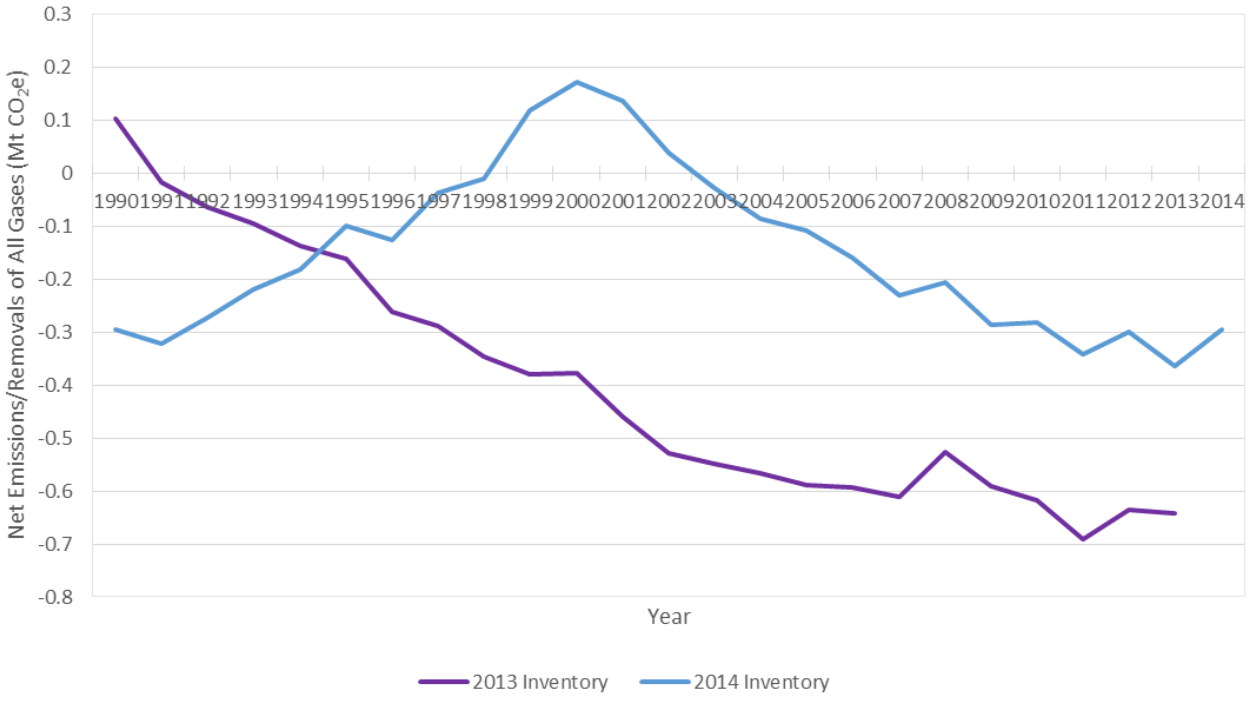

Figure A8. 15: Changes in net emissions and removals of all gases 1990-2014 between the 2013 Inventory and 2014 Inventory for Wales

Net removals in the Forest Land category in Wales have reduced since the previous inventory due to the correction of the CARBINE model output.

In the Cropland category (see sections A8. 2.3, A8. 5.2, Figure A8. 14B) estimates for emissions for Wales have changed little over the time period (Table A8. 4, Figure A8. 16B). The addition of biomass carbon stock change arising from cropland management activities has a minor impact on the category overall.

In the Grassland category (see sections A8.2.3, A8.5.2, Figure A8. 14C) estimates for removals in Wales have increased by an average of 7% in the 1990-2014 inventory over the time period (Figure A8. 16C). The majority of the change arises from correction of the emissions factor for drainage of grassland on organic soil, which significantly reduces the emissions from this source. The changes from deforestation soil and controlled burning and the inclusion of biomass carbon stock change from grassland management also have an effect.

In the Wetland category (see sections A8.2.3, A8.5.2, Figure A8.14D) estimates for emissions for Wales are reduced by approximately 30% compared to the previous inventory (Table A8. 4, Figure A8. 16D), although this emission source is very small, this large percentage change only represents a very small change in absolute emissions . The change is due to the improvements to the methodology used for tracking areas converted to and from peat extraction.

In the Settlements category (see section A8.2.3, A8.5.2, Figure A8.14E) estimates for emissions for Wales have very slightly increased. This is due to the corrections to soil carbon stock change and controlled burning emissions following deforestation.

Net removals in the Harvested Wood products category in Wales have changed in trend since the previous inventory (see Figure A8. 16F and Table A8. 1 for data revisions). This is a result of the revision to the output from the CARBINE model so that Harvested Wood Products from Forest remaining Forest areas are now allocated to the correct year.

The CH_4 emissions have changed slightly, due to using the 2006 IPPC guidance methodology and emissions factors for estimating emissions from controlled burning following deforestation (Figure A8. 17). N_2O emissions have increased slightly compared to the 1990-2013

inventory (Figure A8. 18). This is due to the change to controlled burning methodology and the revision of the soil model output for deforested areas (as N_2O emissions from N mineralisation due to land use change are calculated from the soil model output).

Table A8. 4: Effects of improvements in the source data and/or methodology on Inventory data for Wales

IPCC Sector	Difference between 2014 and 2013 inventory estimates, kt CO_2e	
	1990	2013
4A Forest Land	-243	229
4B Cropland	-1	28
4C Grassland	-75	-33
4D Wetlands	-0.1	-0.1
4E Settlements	2	17
4G Harvested Wood Products	-80	38

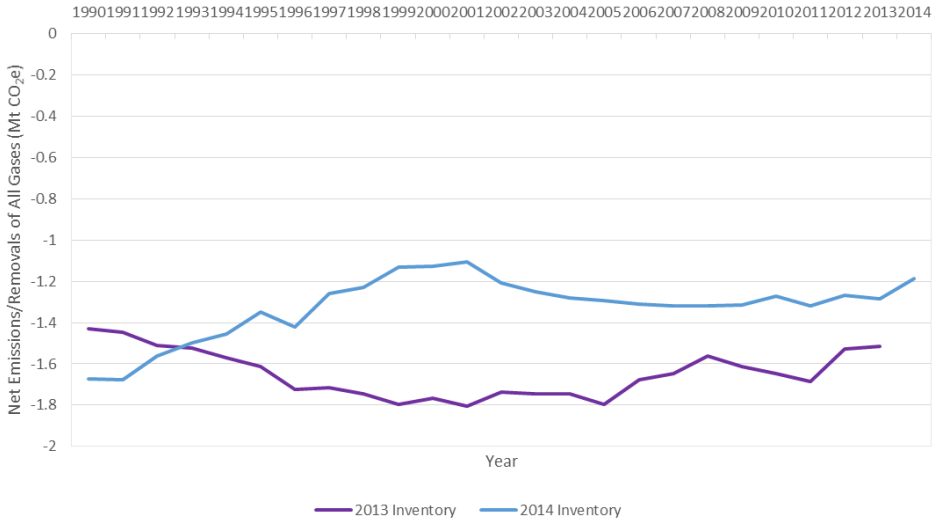

Figure A8. 16A: Forest Land – Wales

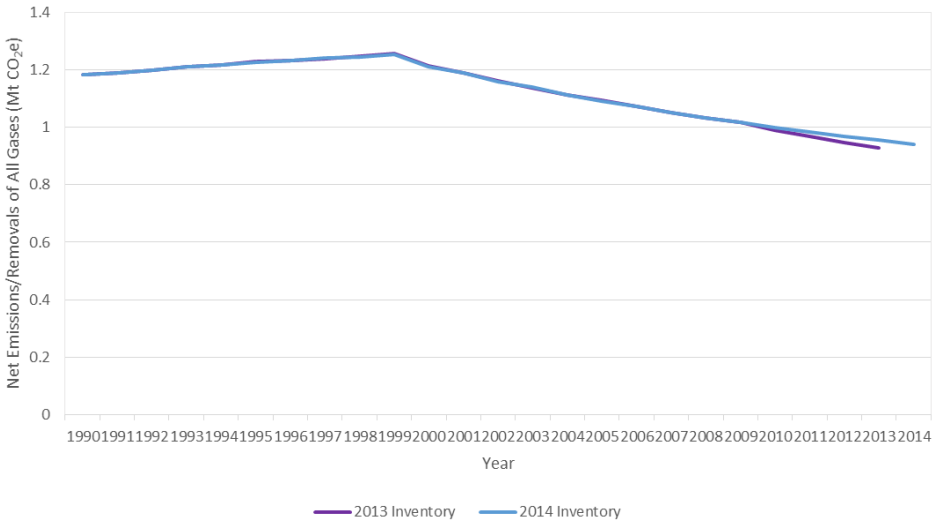

Figure A8. 16B: Cropland - Wales

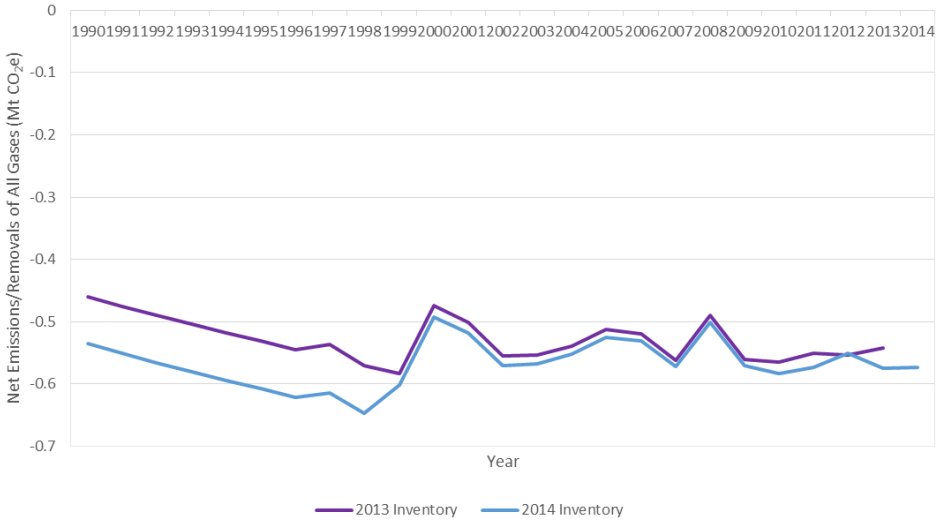

Figure A8. 16C: Grassland – Wales

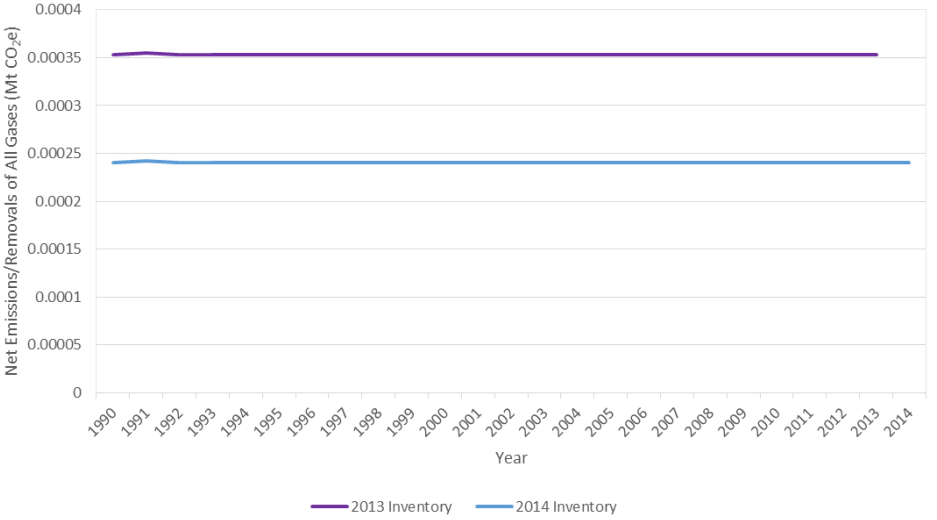

Figure A8. 16D: Wetlands - Wales

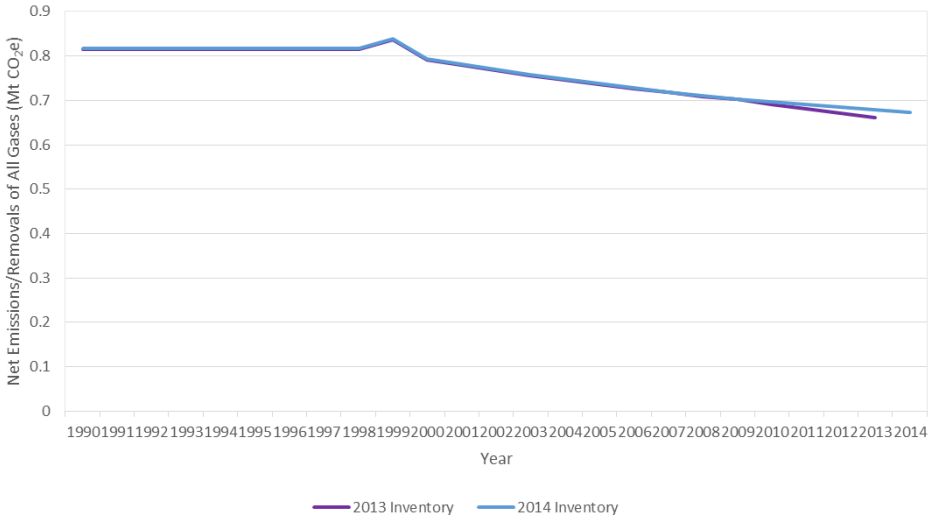

Figure A8. 16E: Settlements – Wales

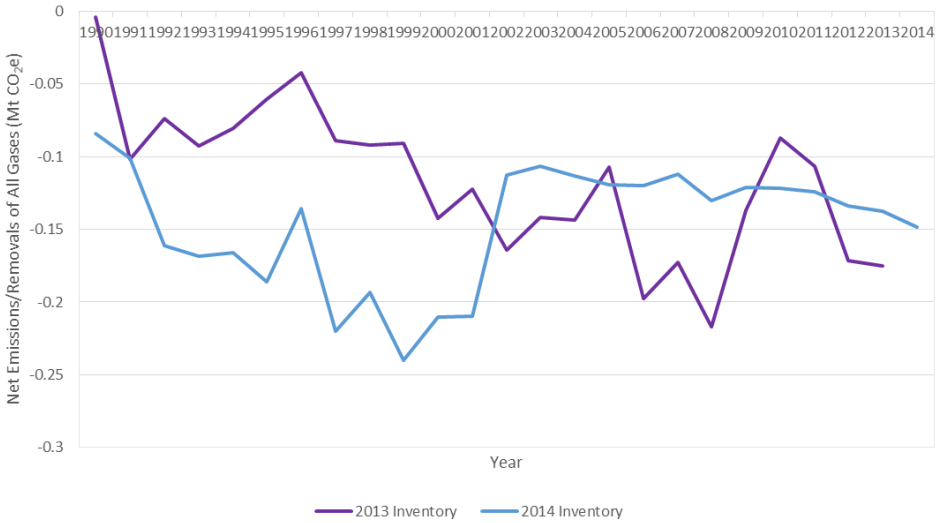

Figure A8. 16F: Harvested Wood Products - Wales

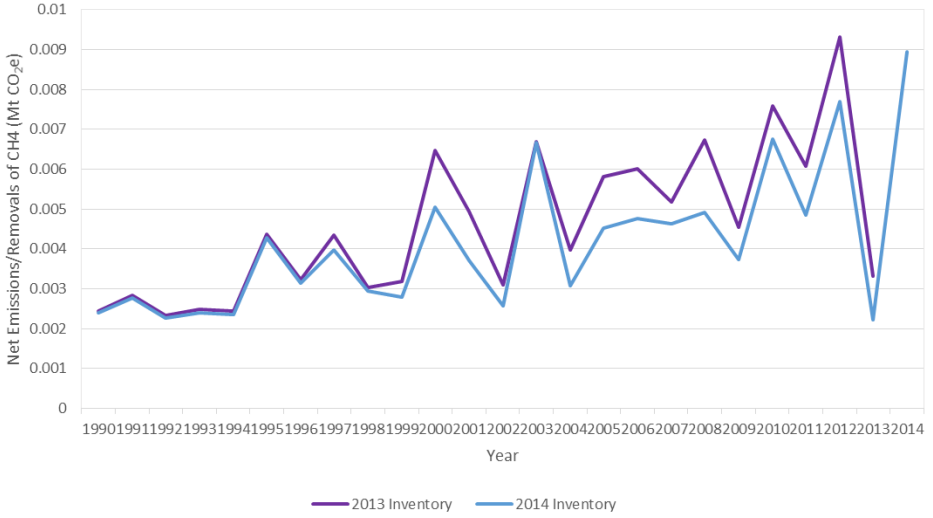

Figure A8. 17: Changes in net emissions of CH_4 only 1990-2014 between the 2013 Inventory and 2014 Inventory for Wales LULUCF

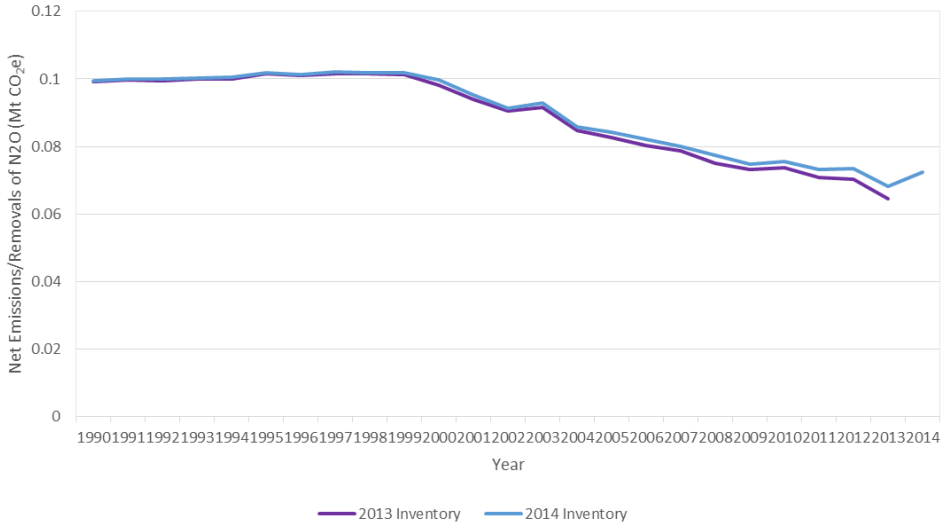

Figure A8. 18: Changes in net emissions of N_2O only 1990-2014 between the 2013 Inventory and 2014 Inventory for Wales LULUCF.

A8.5 LULUCF Emissions and Removals in Northern Ireland

A8.5.1 Northern Ireland LULUCF Trends

The 1990-2014 Inventory shows that Northern Ireland was a small net source of emissions of greenhouse gases from LULUCF activities throughout the time period, with the exception of 1999 (Figure A8. 19). In 1990 Northern Ireland was a small source at 0.1 Mt CO_2e, falling to -0.002 Mt CO_2e by 1999, then gradually increasing to a peak of 0.5 Mt CO_2e in 2012; the net source in 2014 was 0.4 Mt CO_2e.

The main influences on the LULUCF sector in Northern Ireland are emissions from Cropland and Settlement, and removals from Forest and Grassland. Emissions from Wetland (see section A8.2.2) are low for Northern Ireland relative to other emissions, as are removals from Harvested Wood Products (Figure A8. 19).

Cropland is the largest source of LULUCF emissions in Northern Ireland, although between 1990 and 2013 levels gradually decreased from 1.4 Mt CO_2e in 1990 to 1.2 Mt CO_2e in 2014. The Settlement category is a net source of approximately 0.6 Mt CO_2e for 1990-1998, gradually increasing to 1.0 Mt CO_2e in 2014. Wetlands are a small net source decreasing from 0.2 Mt CO_2e in 1990 to 0.1 Mt CO_2e in 2014.

The size of the Forest land sink decreased from -0.8 Mt CO_2e in 1990 to -0.6 Mt CO_2e in 2014. Grassland has remained a relatively constant sink of about -1.2 Mt CO_2e. Removals from Harvested Wood Products have fluctuated slightly around an average of -0.08 Mt CO_2e.

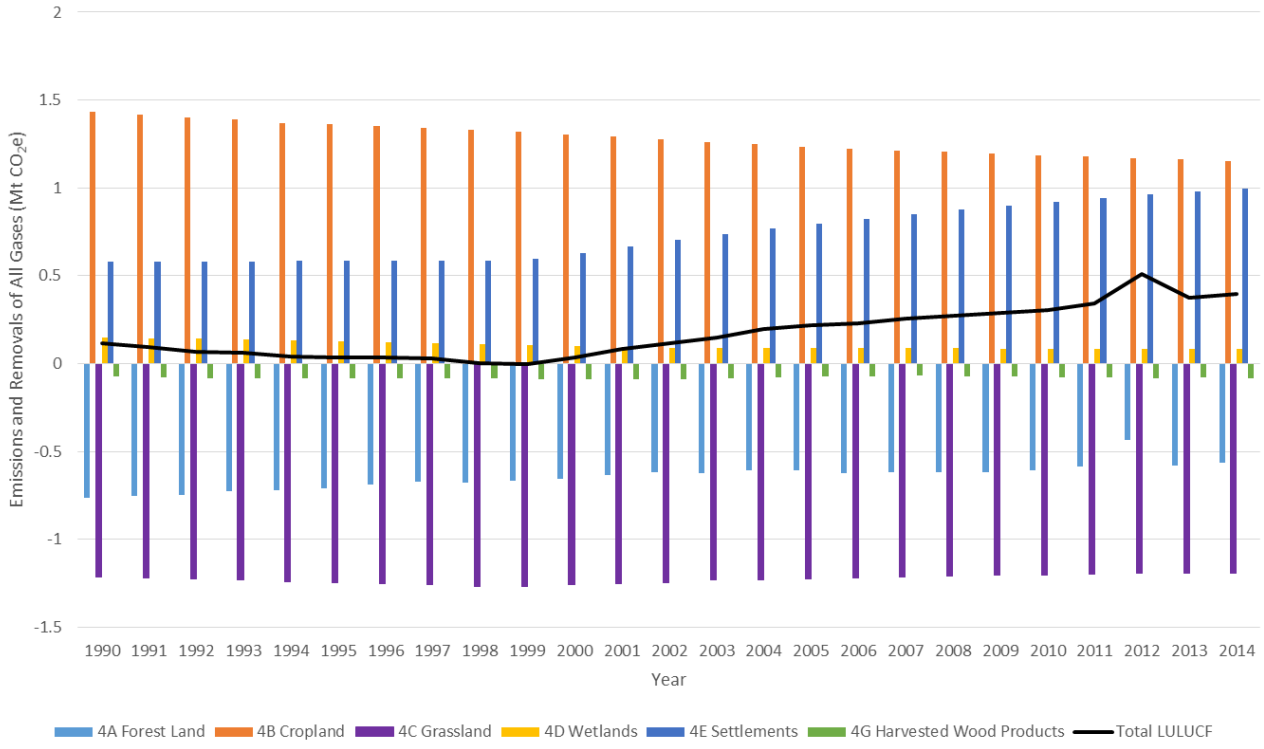

Figure A8. 19: Emissions and removals for all gases by category for the LULUCF sector in Northern Ireland 1990-2014

A8.5.2 Northern Ireland LULUCF Category Trends

The Forest land category (see section A8.2.2) for Northern Ireland is a net sink for 1990-2014. The majority of the sink arises from broadleaf forest planted after 1900, estimates do not include pre-1900 forest. There has been a gradual decline in Land converted to Forest since 1990. GHG emissions in the category (from wildfires, nitrogen fertilisation and N_2O emissions from drainage) are generally small compared to the carbon sink in forest soils and biomass (Figure A8. 20A). The exception is a spike in emissions from forest wildfires in 2012. Emissions were significantly affected by a large wildfire in 2011 that spanned an area of 704ha, 14 times the average for Northern Ireland and the greatest total forest wildfire area in the UK in 2011. Forest activity data uses fiscal years, so this event is seen in the emission estimates for 2012.

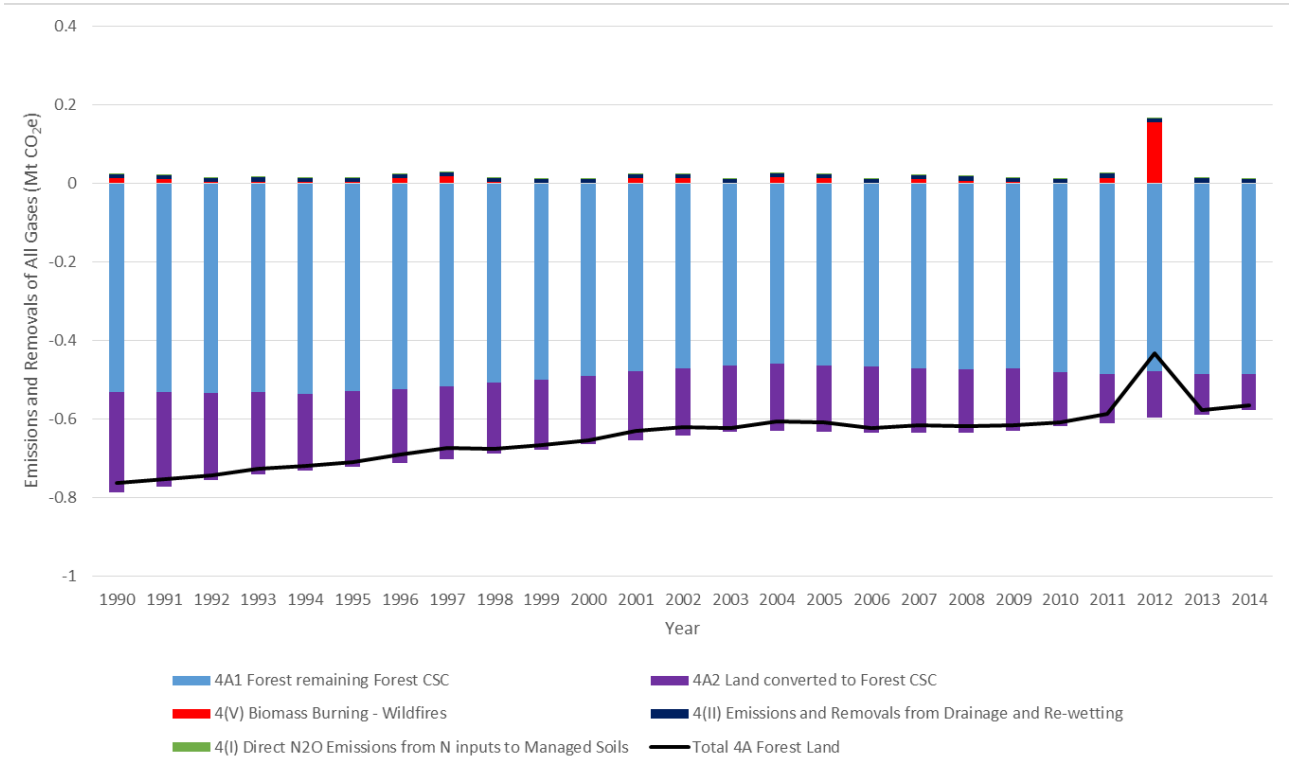

Figure A8. 20A: Emissions and removals of all gases by category for the 4A Forestry category in Northern Ireland 1990-2014

The Cropland category (see section A8.2.3) for Northern Ireland is an emission source throughout the time period. Land converted to Cropland (carbon stock changes and N_2O emissions from N mineralisation, mostly from Grassland) accounts for the highest emissions from Cropland in Northern Ireland (Figure A8. 20B), although these have decreased since 1990. Emissions from Cropland remaining Cropland have gradually increased, as continuing carbon stock losses from historical land use change move across from the Land converted to Cropland sub-category after 20 years. The Cropland remaining Cropland category also includes soil and biomass carbon stock changes arising from cropland management (e.g. inputs of fertiliser, manure and crop residues, and change between cropland types). Emissions from drained organic cropland soils area also included, although these are not large.

The Grassland category (see section A8.2.3) for Northern Ireland is now a net sink for 1990-2014. Removals from land conversion to grassland (from Cropland) due to either historic change (reported in Grassland remaining Grassland) or recent conversion (Land converted to Grassland) are slightly reduced by emissions from drained organic soils under improved grassland (Figure A8.20C). Grassland remaining Grassland also now includes carbon stock change in biomass from grassland management (e.g. change between shrubby and non-shrubby grassland types). Other sources of emissions (wildfires, N_2O emissions from N mineralisation following land use change and controlled burning following deforestation) are insignificant.

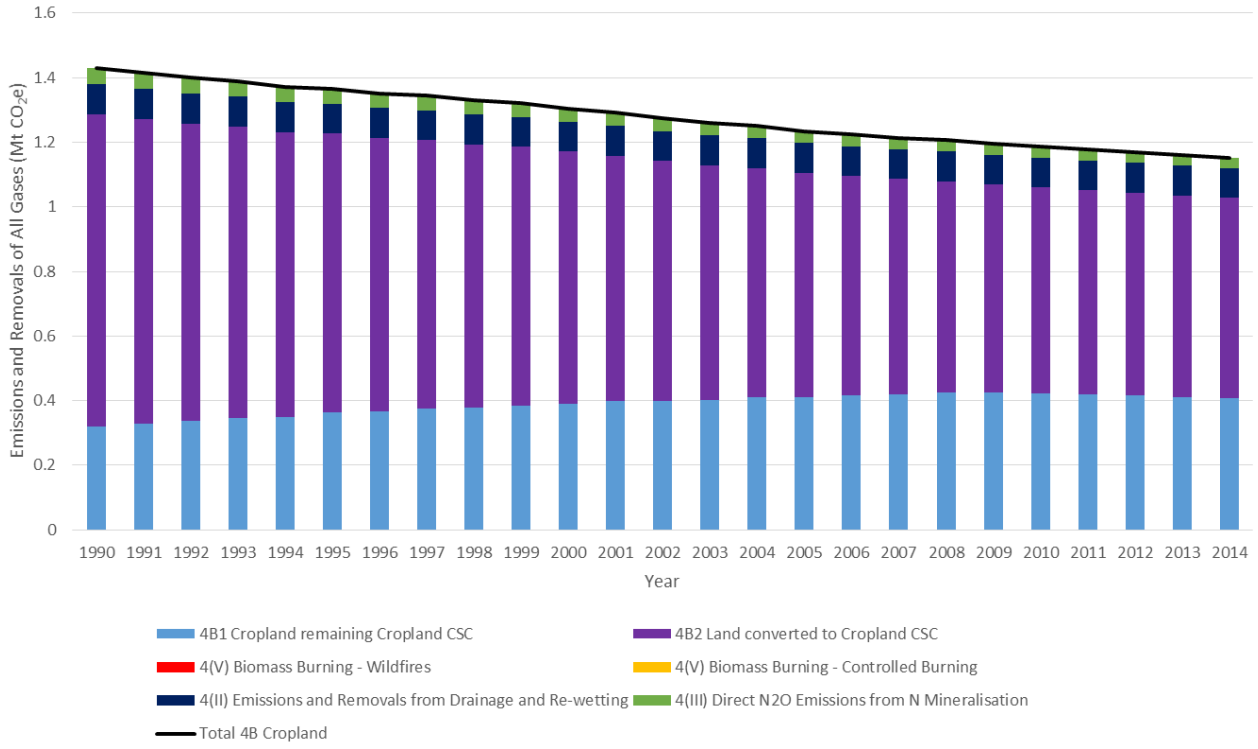

Figure A8.20B: Emissions and removals of all gases by category for the 4B Cropland category in Northern Ireland 1990-2014

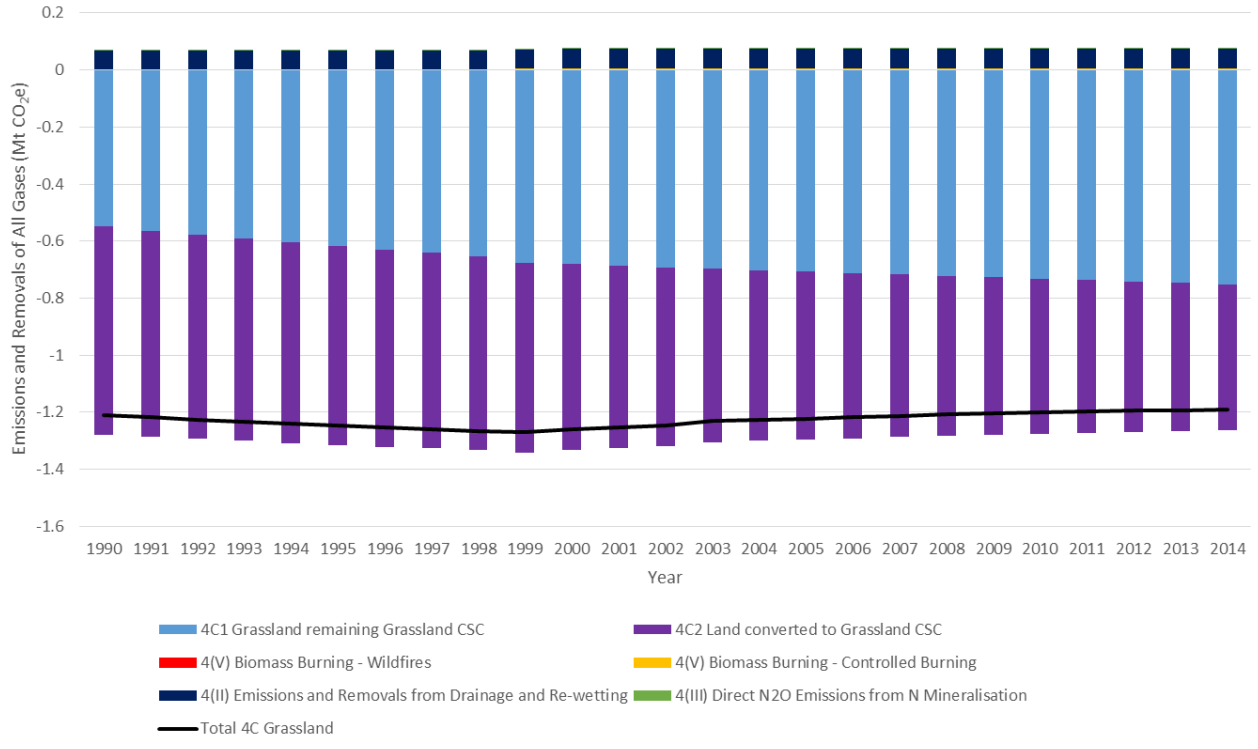

Figure A8.20C: Emissions and removals of all gases by category for the 4C Grassland category in Northern Ireland 1990-2014

The Wetland category (see section A8.2.3) is a net source for Northern Ireland (Figure A8.20D). In 1990 approximately 4.9 kha was estimated to be emitting carbon dioxide as a result of commercial peat extraction. This has gradually decreased to 0.4 kha in 2010-2014. An estimated 75% of the UK fuel peat extraction occurs in Northern Ireland. There were small N_2O emissions (< 1%) from drainage on peat extraction areas. No land (over a 1 km^2 threshold) has been converted to flooded land (reservoirs) in Northern Ireland since 1990.

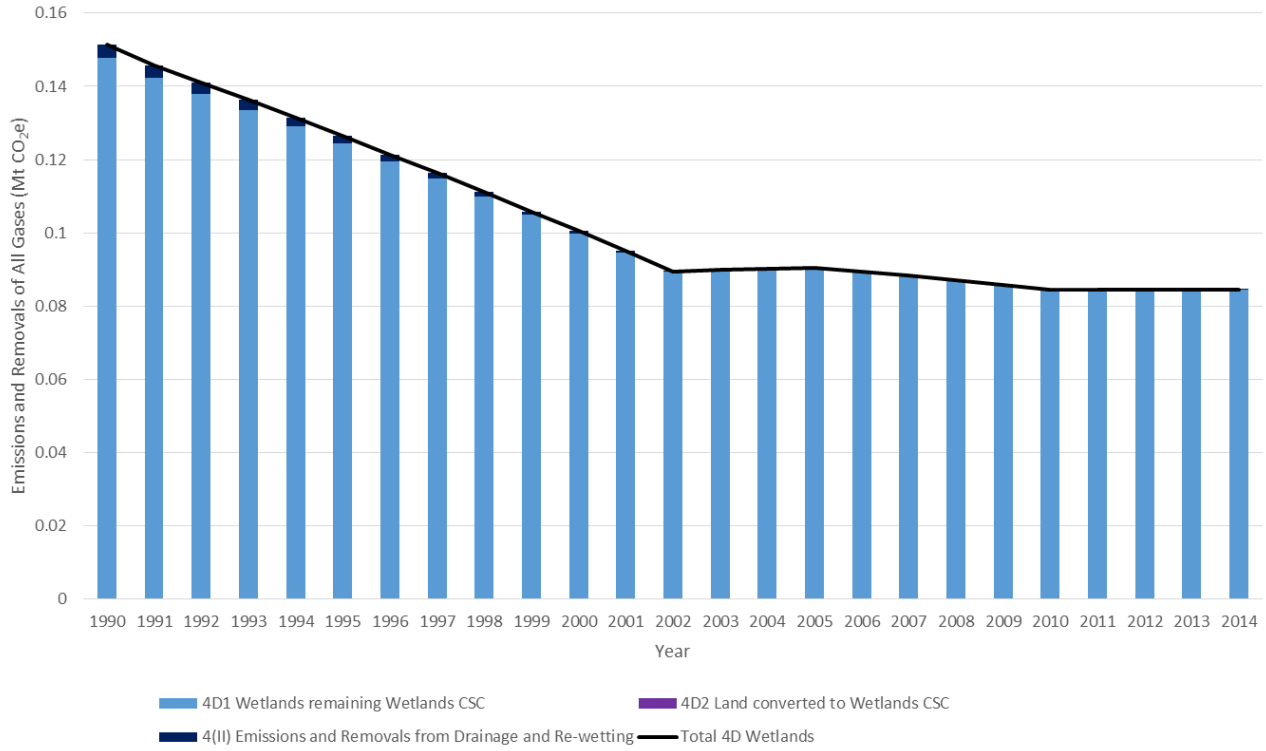

Figure A8.20D: Emissions and removals of all gases by category for the 4D Wetland category in Northern Ireland 1990-2014

The Settlements category (see section A8.2.2) is the second largest LULUCF emissions source in Northern Ireland, after Cropland. Most emissions are from soil carbon stock losses following land use change on Land converted to Settlements (recent LUC) and Settlement remaining Settlement (historic LUC) (Figure 20E). There are also related N_2O emissions from N mineralisation following land use change. The majority of emissions are from Grassland converted to Settlements (71%). There are a small amount of GHG emissions resulting from controlled biomass burning during deforestation to Settlements.

The Harvested Wood Products category (see section A8.2.3) is a net sink of CO_2 for Northern Ireland (Figure A8.20F). It is variable over time (the model is driven by both forest management and timber production statistics) and the majority of the products are consumed domestically in the UK.

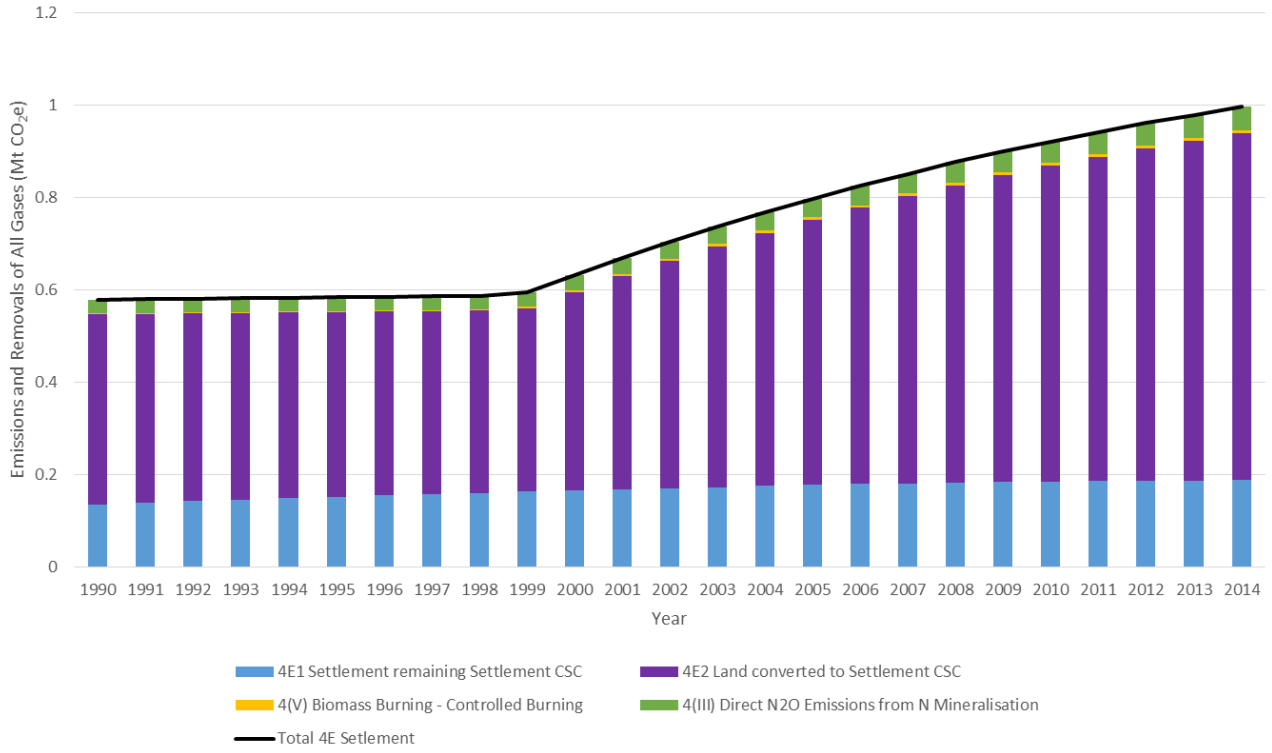

Figure A8.20E: Emissions and removals of all gases by category for the 4E Settlement category in Northern Ireland 1990-2014

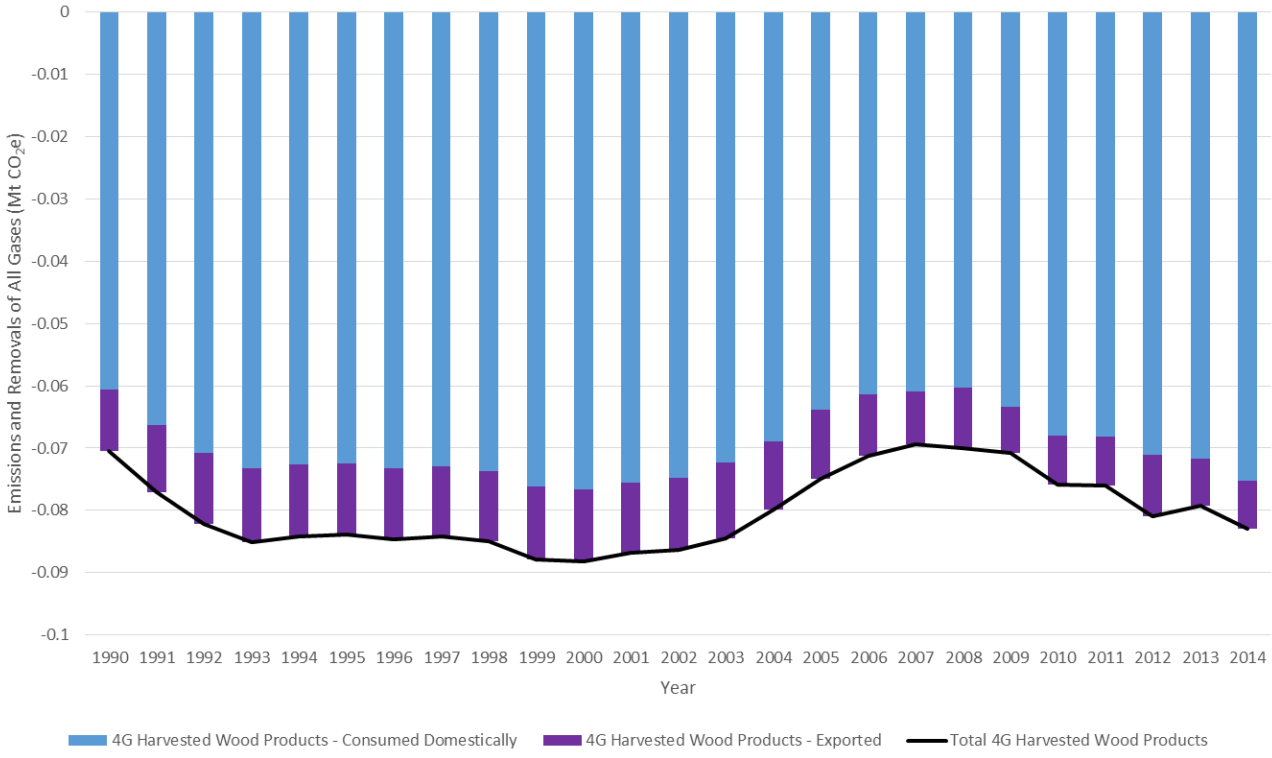

Figure A8.20F: Emissions and removals of all gases by category for the 4G Harvested Wood Products category in Northern Ireland 1990-2014

A8.5.3 Northern Ireland LULUCF comparison with 2013 inventory

The LULUCF sector in Northern Ireland for the 1990-2014 inventory is a small net source of GHG emissions. Compared to the 1990-2013 Inventory, net emissions have decreased by an average of 1.2 Mt CO_2e per year (1.0-1.4 Mt CO_2e) (Figure A8.21). The revised estimates primarily reflect changes in estimated emissions from the Forest, Grassland and Harvested Wood Products categories, and to a lesser extent changes in the Wetland and Settlement categories (although these have a greater effect on the second half of the time series). Differences between the 2013 and 2014 inventories for CO_2e in each category are presented in Figure 22A-F. Differences between the 2013 and 2014 inventories for non-CO_2 emissions for Northern Ireland are presented in Figures A8.23 and A8.24.

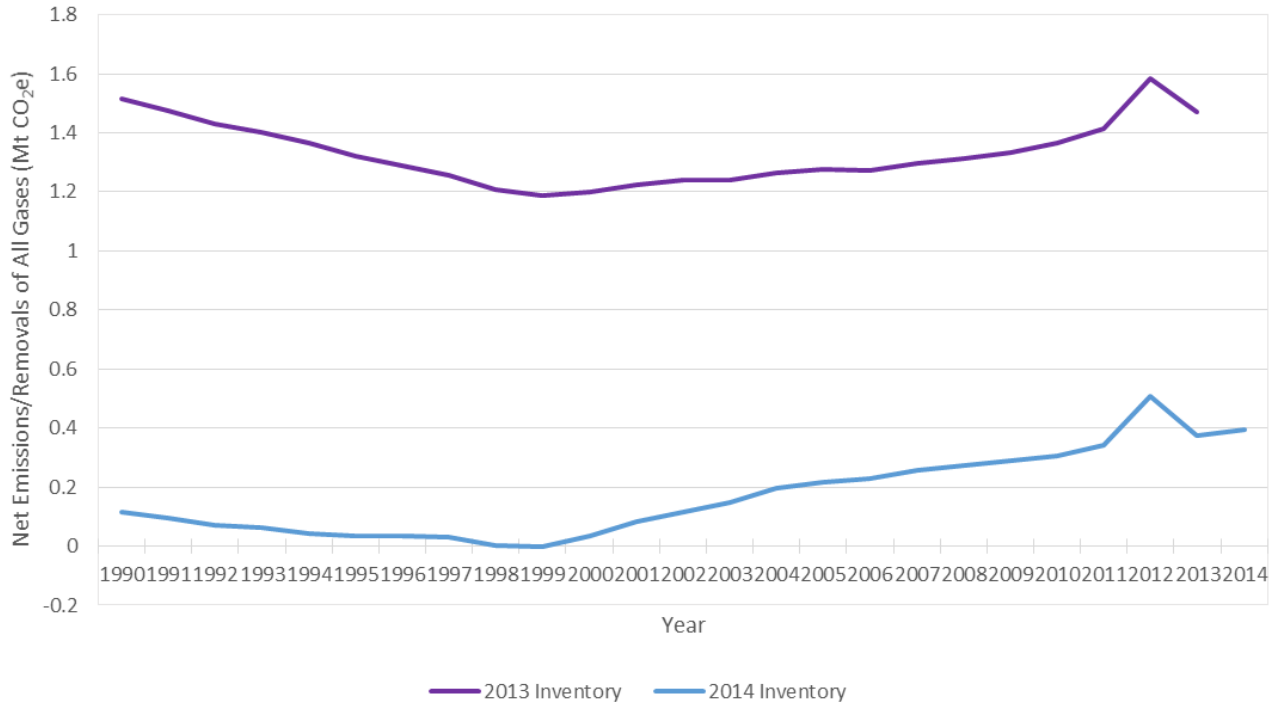

Figure A8. 21: Changes in net emissions of all gases 1990-2014 between the 2013 Inventory and 2014 Inventory for Northern Ireland

Net removals in the Forest land category in Northern Ireland have reduced since the previous inventory (Figure A8. 22A) due to the correction of the CARBINE model output (see Table A8. 1 for data revisions)

In the Cropland category (see sections A8.2.3, A8.6.2, Figure A8. 20B) estimates for emissions for Northern Ireland have changed little over the time period (Table A8. 5, Figure A8.22B). The addition of biomass carbon stock change arising from cropland management activities have a minor impact on the category overall.

The Grassland category (see sections A8.2.3, A8.6.2, Figure A8. 20C) for Northern Ireland has moved from being a small net source (0.06 Mt CO_2e p.a. 1990-2013) to a net sink (-1.23 Mt CO_2e p.a. 1990-2014) (Table A8. 5, Figure A8. 22C). The majority of the change arises from correction of the emissions factor for drainage of grassland on organic soil, which significantly reduces the emissions from this source. The changes from deforestation soil and controlled burning and the inclusion of biomass carbon stock change from grassland management also have an effect.

In the Wetland category (see sections A8.2.2, A8.6.2, Figure A8. 20D) estimates for emissions for Northern Ireland are reduced compared to the previous inventory by an average of 33% (greater towards the end of the time series) (Table A8. 5, Figure A8.22D). This is due to more detailed activity data for peat extraction areas in Northern Ireland becoming available.

In the Settlements category (see sections A8.2.3, A8.6.2, Figure A8. 20E) estimates for emissions for Northern Ireland have very slightly increased (Table A8. 5, Figure A8. 22E). This is due to the corrections to soil carbon stock change and controlled burning emissions following deforestation.

Net removals in the Harvested Wood products category in Northern Ireland have increased by an average of 158% and changed in trend since the previous inventory (see Figure A8. 22F and Table A8. 1 for data revisions). This is a result of the revision to the output from the CARBINE model so that Harvested Wood Products from Forest remaining Forest areas are now allocated to the correct year.

The CH_4 emissions have decreased slightly, due to using the 2006 IPPC guidance methodology and emissions factors for estimating emissions from controlled burning following deforestation (Figure A8. 23). N_2O emissions have increased slightly compared to the 1990-

2013 inventory (Figure A8. 24). This is due to the change to controlled burning methodology and the revision of the soil model output for deforested areas (as N2O emissions from N mineralisation due to land use change are calculated from the soil model output).

Table A8. 5: Effects of improvements in the source data and/or methodology on Inventory data for Northern Ireland

IPCC Sector	Difference between 2014 and 2013 inventory estimates, kt CO_2e	
	1990	2013
4A Forest Land	-57	240
4B Cropland	-1	-1
4C Grassland	-1294	-1287
4D Wetlands	6	-82
4E Settlements	2	26
4G Harvested Wood Products	-55	9

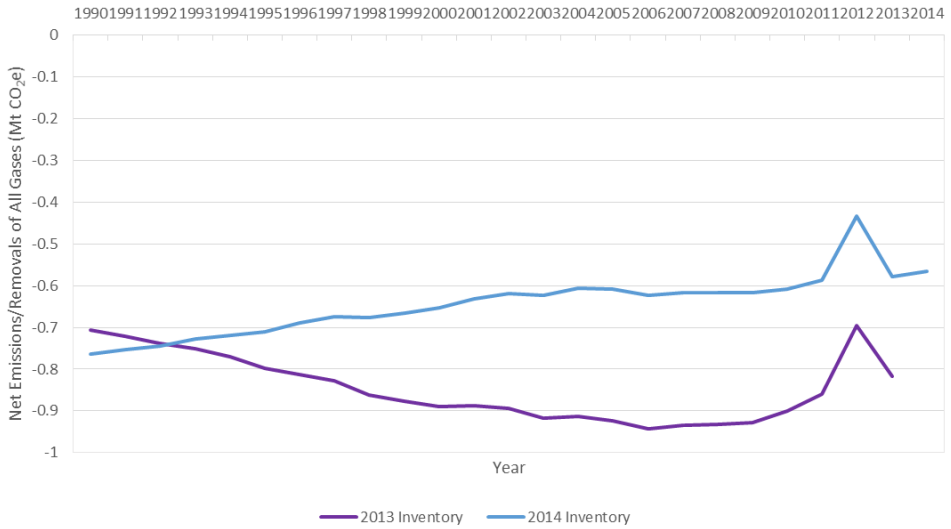

Figure A8. 22A: Forest Land - Northern Ireland

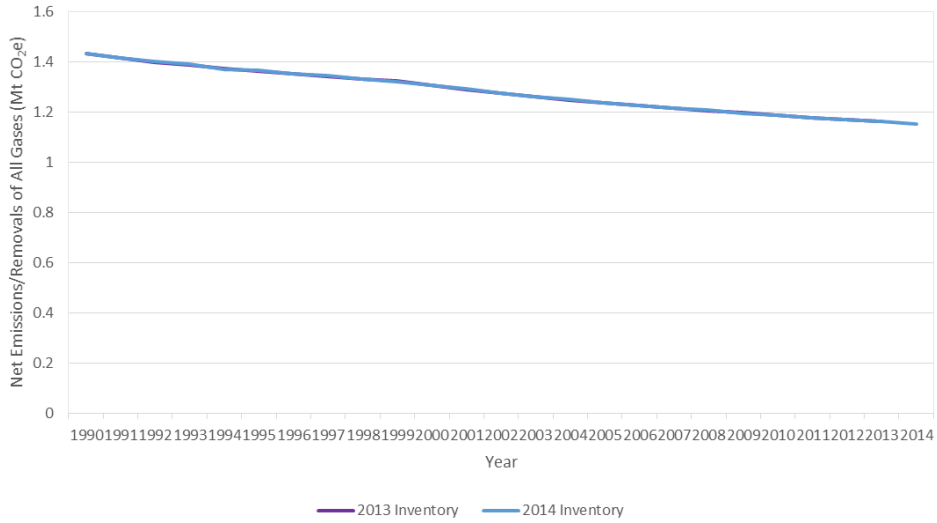

Figure A8. 22B: Cropland – Northern Ireland

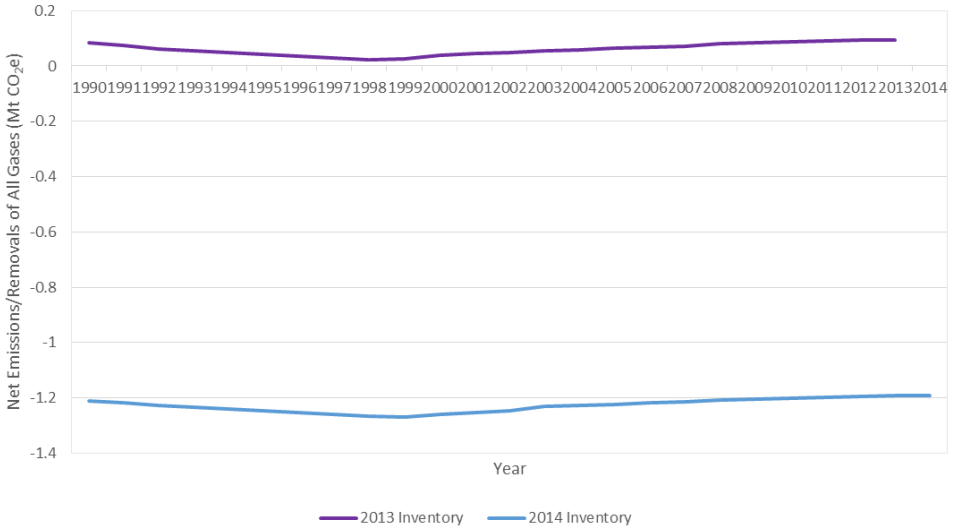

Figure A8. 22C: Grassland – Northern Ireland

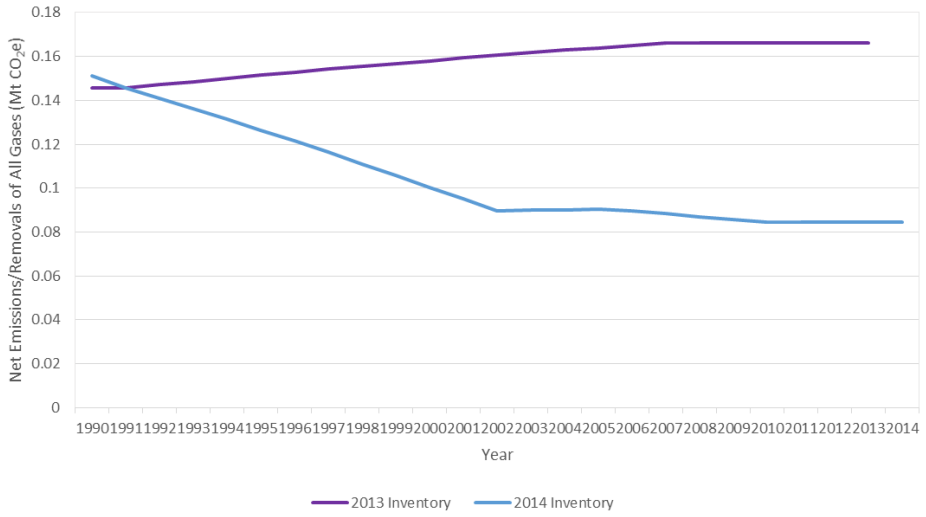

Figure A8. 22D: Wetlands – Northern Ireland

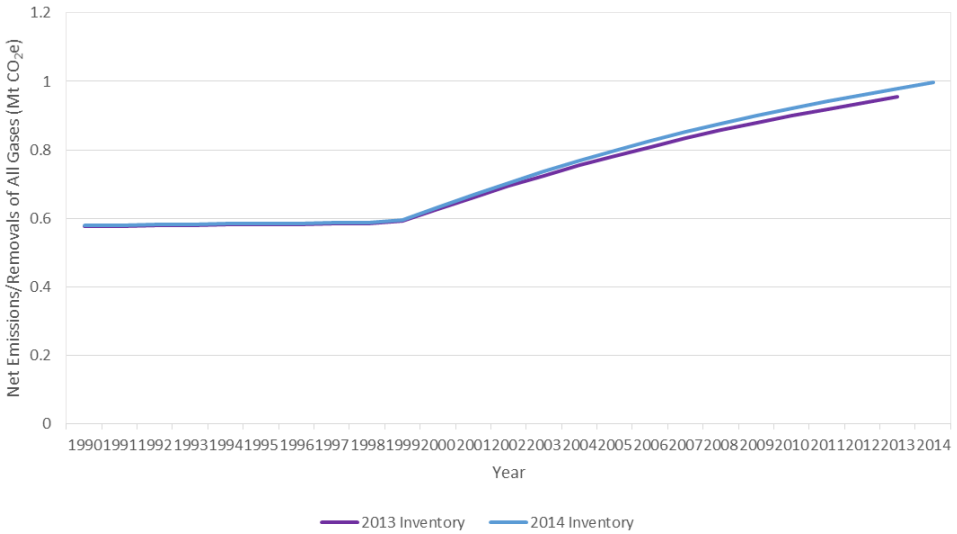

Figure A8. 22E: Settlements – Northern Ireland

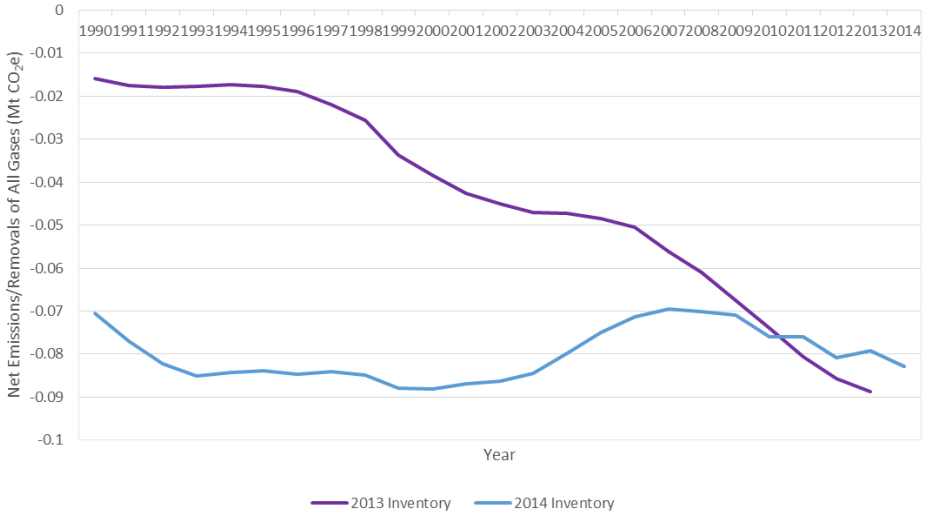

Figure A8. 22F: Harvested Wood Products - Northern Ireland

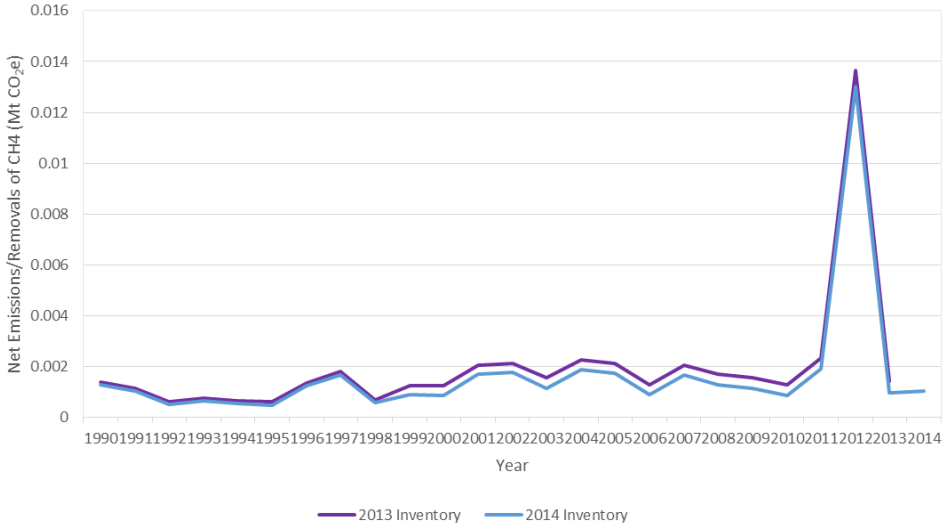

Figure A8. 23: Changes in net emissions of CH_4 only 1990-2014 between the 2013 Inventory and 2014 Inventory for Northern Ireland LULUCF

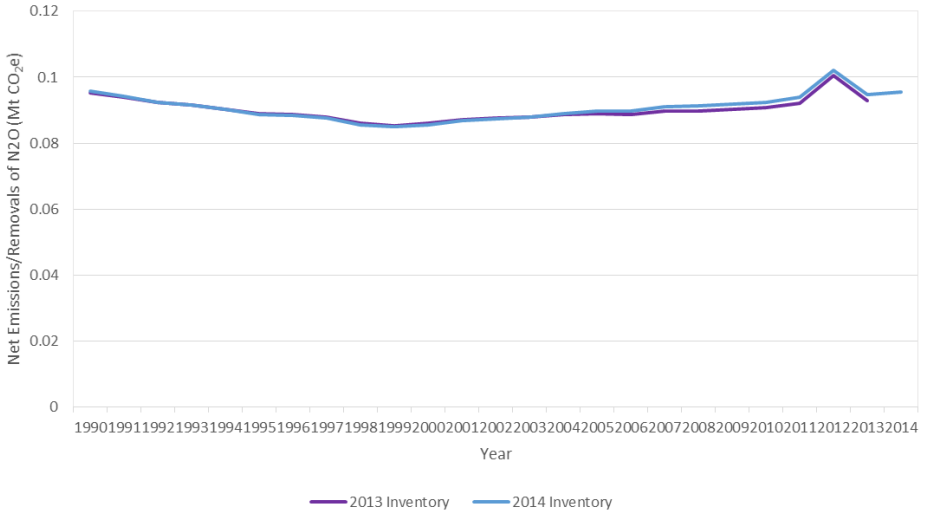

Figure A8. 24: Changes in net emissions of N_2O only 1990-2014 between the 2013 Inventory and 2014 Inventory for Northern Ireland LULUCF.

A8.6 LULUCF Summary Tables

A8.6.1 England (all units in kilotonnes of respective gases)

Category	1990	1995	2000	2005	2010	2013	2014
A. Forest Land CO_2e	**-4890.110**	**-4568.418**	**-5605.494**	**-5865.602**	**-6288.293**	**-6274.292**	**-6245.414**
Carbon	-1336.413	-1252.055	-1531.886	-1603.744	-1717.263	-1713.443	-1705.719
CH_4	0.054	0.339	0.070	0.149	0.000	0.000	0.012
N_2O	0.029	0.047	0.032	0.037	0.028	0.028	0.029
B. Cropland CO_2e	**6646.410**	**6716.660**	**6288.081**	**5703.607**	**5481.963**	**5303.239**	**5086.922**
Carbon	1745.290	1768.051	1656.592	1510.919	1459.897	1413.856	1355.671
CH_4	0.003	0.003	0.002	0.001	0.001	0.002	0.002
N_2O	0.829	0.784	0.718	0.549	0.433	0.399	0.390
C. Grassland CO_2e	**-2978.709**	**-3262.337**	**-3524.666**	**-3857.398**	**-4273.245**	**-4547.002**	**-4733.644**
Carbon	-814.611	-891.993	-965.632	-1056.982	-1170.498	-1243.262	-1293.060
CH_4	0.164	0.167	0.348	0.396	0.384	0.233	0.127
N_2O	0.014	0.014	0.024	0.028	0.030	0.019	0.015
D. Wetlands CO_2e	**266.897**	**374.871**	**299.269**	**221.312**	**110.623**	**158.712**	**158.681**
Carbon	72.790	102.238	81.619	60.358	30.170	43.285	43.277
E. Settlements CO_2e	**4051.344**	**3746.063**	**3460.838**	**3236.688**	**3068.069**	**2983.509**	**2958.427**
Carbon	1047.897	968.861	894.887	836.898	793.279	771.404	764.915
CH_4	0.113	0.079	0.012	0.013	0.014	0.014	0.015
N_2O	0.692	0.643	0.602	0.563	0.534	0.519	0.515
G. Harvested Wood Products CO_2e	**-312.931**	**-199.232**	**-25.769**	**-82.696**	**-69.741**	**-86.141**	**-76.204**
Carbon	-85.345	-54.336	-7.028	-22.553	-19.020	-23.493	-20.783
Total CO_2e	**2782.900**	**2807.606**	**892.259**	**-644.088**	**-1970.623**	**-2461.975**	**-2851.233**

A8.6.2 Scotland (all units in kilotonnes of respective gases)

Category	1990	1995	2000	2005	2010	2013	2014
A. Forest Land CO_2e	**-8379.098**	**-9011.003**	**-9771.922**	**-9690.018**	**-9792.379**	**-9421.709**	**-9272.933**
Carbon	-2292.637	-2467.816	-2672.851	-2651.453	-2677.511	-2578.703	-2537.517
CH_4	0.042	0.306	0.069	0.156	0.000	0.197	0.134
N_2O	0.088	0.101	0.090	0.094	0.084	0.096	0.094
B. Cropland CO_2e	**6525.647**	**6815.523**	**6790.562**	**5960.040**	**5382.815**	**5090.150**	**4968.086**
Carbon	1698.553	1774.912	1771.236	1565.596	1422.978	1348.136	1316.330
CH_4	0.000	0.000	0.001	0.002	0.002	0.002	0.002
N_2O	0.999	1.032	0.993	0.737	0.554	0.493	0.475
C. Grassland CO_2e	**-2017.110**	**-2194.701**	**-2199.220**	**-2258.314**	**-2453.042**	**-2715.989**	**-2730.012**
Carbon	-552.616	-601.084	-607.388	-624.914	-678.639	-748.547	-754.006
CH_4	0.178	0.181	0.606	0.649	0.629	0.441	0.551
N_2O	0.016	0.016	0.043	0.056	0.066	0.059	0.070
D. Wetlands CO_2e	**72.602**	**157.587**	**81.614**	**133.334**	**126.335**	**136.394**	**136.379**
Carbon	19.666	42.871	22.178	36.286	34.378	37.121	37.117
N_2O	0.002	0.001	0.001	0.001	0.001	0.001	0.001
E. Settlements CO_2e	**1843.848**	**1822.340**	**1772.353**	**1687.012**	**1625.460**	**1597.608**	**1589.380**
Carbon	476.954	471.401	458.434	436.359	420.440	413.237	411.109
CH_4	0.023	0.028	0.013	0.015	0.017	0.018	0.018
N_2O	0.317	0.313	0.306	0.291	0.280	0.275	0.274
G. Harvested Wood Products CO_2e	**-383.001**	**-476.041**	**-675.631**	**-823.541**	**-754.435**	**-859.670**	**-897.026**
Carbon	-104.455	-129.829	-184.263	-224.602	-205.755	-234.455	-244.643
Total CO_2e	**-2337.112**	**-2886.294**	**-4002.246**	**-4991.487**	**-5865.247**	**-6173.216**	**-6206.126**

A8.6.3 Wales (all units in kilotonnes of respective gases)

Category	1990	1995	2000	2005	2010	2013	2014
A. Forest Land CO_2e	**-1674.338**	**-1348.931**	**-1127.964**	**-1292.897**	**-1272.027**	**-1286.248**	**-1186.950**
Carbon	-457.548	-369.627	-308.600	-353.798	-349.238	-351.558	-326.595
CH_4	0.013	0.087	0.018	0.038	0.138	0.000	0.187
N_2O	0.010	0.014	0.010	0.011	0.017	0.009	0.020
B. Cropland CO_2e	**1181.387**	**1227.083**	**1210.953**	**1092.075**	**999.250**	**955.623**	**939.447**
Carbon	307.848	319.935	316.070	286.984	264.023	252.918	248.743
CH_4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N_2O	0.177	0.181	0.175	0.134	0.105	0.095	0.092
C. Grassland CO_2e	**-535.667**	**-607.720**	**-493.115**	**-525.334**	**-582.713**	**-575.313**	**-572.956**
Carbon	-147.068	-166.728	-136.739	-145.045	-160.726	-158.048	-158.581
CH_4	0.070	0.071	0.181	0.140	0.130	0.086	0.168
N_2O	0.006	0.006	0.013	0.010	0.011	0.007	0.014
D. Wetlands CO_2e	**0.240**	**0.240**	**0.240**	**0.240**	**0.240**	**0.240**	**0.240**
Carbon	0.066	0.066	0.066	0.066	0.066	0.066	0.066
E. Settlements CO_2e	**817.610**	**816.158**	**793.830**	**737.260**	**696.326**	**678.250**	**672.863**
Carbon	211.446	211.074	205.311	190.677	180.086	175.410	174.017
CH_4	0.012	0.014	0.003	0.003	0.003	0.003	0.003
N_2O	0.141	0.141	0.137	0.128	0.121	0.117	0.117
G. Harvested Wood Products CO_2e	**-84.012**	**-186.241**	**-210.533**	**-119.325**	**-121.955**	**-137.225**	**-148.389**
Carbon	-22.912	-50.793	-57.418	-32.543	-33.261	-37.425	-40.470
Total CO_2e	**-294.780**	**-99.411**	**173.411**	**-107.981**	**-280.879**	**-364.672**	**-295.744**

A8.6.4 Northern Ireland (all units in kilotonnes of respective gases)

Category	1990	1995	2000	2005	2010	2013	2014
A. Forest Land CO_2e	**-763.308**	**-710.243**	**-653.725**	**-608.711**	**-608.382**	**-578.030**	**-565.025**
Carbon	-211.278	-196.561	-181.194	-169.301	-168.781	-160.555	-156.971
CH_4	0.039	0.006	0.003	0.037	0.000	0.005	0.001
N_2O	0.035	0.035	0.036	0.037	0.035	0.035	0.035
B. Cropland CO_2e	**1431.050**	**1364.946**	**1304.969**	**1234.452**	**1185.874**	**1161.039**	**1152.768**
Carbon	376.152	359.656	344.509	326.526	314.127	307.563	305.369
CH_4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N_2O	0.174	0.155	0.140	0.125	0.114	0.112	0.111
C. Grassland CO_2e	**-1210.865**	**-1245.855**	**-1258.511**	**-1222.240**	**-1200.885**	**-1192.643**	**-1189.883**
Carbon	-330.322	-339.867	-343.464	-333.603	-327.819	-325.585	-324.909
CH_4	0.006	0.006	0.018	0.017	0.018	0.017	0.022
N_2O	0.001	0.001	0.001	0.002	0.002	0.002	0.003
D. Wetlands CO_2e	**151.368**	**126.457**	**100.430**	**90.528**	**84.392**	**84.392**	**84.392**
Carbon	40.289	33.907	27.221	24.686	23.012	23.012	23.012
N_2O	0.012	0.007	0.002	0.000	0.000	0.000	0.000
E. Settlements CO_2e	**579.339**	**584.617**	**631.473**	**797.814**	**922.134**	**979.949**	**997.225**
Carbon	149.857	151.225	163.326	206.362	238.529	253.488	257.958
CH_4	0.006	0.007	0.014	0.015	0.016	0.017	0.017
N_2O	0.100	0.101	0.108	0.137	0.158	0.168	0.171
G. Harvested Wood Products CO_2e	**-70.485**	**-83.849**	**-88.200**	**-74.897**	**-75.898**	**-79.228**	**-82.882**
Carbon	-19.223	-22.868	-24.055	-20.427	-20.699	-21.608	-22.604
Total CO_2e	**117.100**	**36.074**	**36.435**	**216.945**	**307.234**	**375.478**	**396.595**

A8.6.5 United Kingdom (all units in kilotonnes of respective gases)

Category	1990	1995	2000	2005	2010	2013	2014
A. Forest Land CO_2e	**-15706.854**	**-15638.595**	**-17159.106**	**-17457.227**	**-17961.081**	**-17560.279**	**-17270.322**
Carbon	-4297.877	-4286.060	-4694.531	-4778.296	-4912.793	-4804.258	-4726.803
CH_4	0.149	0.738	0.160	0.380	0.138	0.202	0.334
N_2O	0.162	0.196	0.168	0.180	0.165	0.169	0.178
B. Cropland CO_2e	**15784.494**	**16124.212**	**15594.565**	**13990.174**	**13049.902**	**12510.050**	**12147.223**
Carbon	4127.843	4222.554	4088.407	3690.025	3461.026	3322.474	3226.112
CH_4	0.003	0.003	0.003	0.003	0.003	0.004	0.004
N_2O	2.178	2.152	2.026	1.544	1.206	1.099	1.067
C. Grassland CO_2e	**-6742.351**	**-7310.614**	**-7475.513**	**-7863.287**	**-8509.885**	**-9030.947**	**-9226.496**
Carbon	-1844.618	-1999.673	-2053.224	-2160.545	-2337.682	-2475.442	-2530.557
CH_4	0.418	0.425	1.153	1.203	1.161	0.777	0.869
N_2O	0.036	0.037	0.081	0.096	0.109	0.088	0.102
D. Wetlands CO_2e	**491.107**	**659.155**	**481.552**	**445.416**	**321.591**	**379.739**	**379.692**
Carbon	132.811	179.081	131.084	121.396	87.625	103.484	103.471
N_2O	0.014	0.008	0.003	0.001	0.001	0.001	0.001
E. Settlements CO_2e	**7292.141**	**6969.179**	**6658.494**	**6458.773**	**6311.988**	**6239.316**	**6217.896**
Carbon	1886.154	1802.561	1721.958	1670.297	1632.335	1613.538	1607.999
CH_4	0.154	0.128	0.041	0.046	0.050	0.052	0.053
N_2O	1.250	1.197	1.153	1.118	1.092	1.080	1.076
G. Harvested Wood Products CO_2e	**-850.429**	**-945.364**	**-1000.134**	**-1100.459**	**-1022.030**	**-1162.264**	**-1204.501**
Carbon	-231.935	-257.826	-272.764	-300.125	-278.735	-316.981	-328.500
Total CO_2e	**268.108**	**-142.025**	**-2900.141**	**-5526.611**	**-7809.515**	**-8624.386**	**-8956.508**

A8.7 Kyoto Protocol LULUCF Summary Tables

The first commitment period of the Kyoto Protocol ran from 2008-2012. The second commitment period is for 2013-2020. There have been significant changes to reporting KP-LULUCF for the second period[14]: with the modification of categories, the inclusion of Harvested Wood Products and the use of a Forest Management Reference Level rather than a Forest Management cap. The UK has also elected three additional Article 3.4 activities: Cropland Management, Grazing Land Management and Wetland Drainage and Rewetting. Cropland Management and Grazing Land Management have been reported for the first time in the 1990-2014 inventory. Methods and activity data for Wetland Drainage and Rewetting (and additional components of Grazing Land Management) are being developed, so no estimates are reported for this category at the present time.

The Forest Management Reference Level (FMRL) is a quantified amount against which a country can compare their performance during the commitment period. The FMRL reflects expected emissions and removals from business-as-usual forest management (including policies in place by December 2009). Removals in excess of the FMRL will result in a credit under the KP, whereas those below the FMRL will result in a debit (this is calculated at the end of the commitment period over the entire period). The UK's Forest Management Reference Level during the second commitment period (2013-2020) is -3.442 Mt CO_2e/yr, or -8.268 Mt CO_2e/yr when harvested wood products are included. A Technical Correction to the FMRL has been calculated to reflect the revised methods and activity data used for calculating emissions and removals from Forest Management. The Technical Correction for the second commitment period (2013-2020) is -9.275 Mt CO_2e/yr, or -5.658 Mt CO_2e/yr when harvested wood products are included.

Note that the United Kingdom is the official Party to the Kyoto Protocol, so areas and emissions estimates are presented here for the Devolved Administrations and England for information only.

[14] A useful primer for the changes in the Kyoto Protocol reporting is Iversen P., Lee D., and Rocha M., (2014) "Understanding Land Use in the UNFCCC" http://www.climateandlandusealliance.org/uploads/PDFs/Understanding_Land_Use_in_the_UNFCCC.pdf

A8.7.1 England

England's share of the FMRL and Technical Correction is approximately 34%, based on the average of the 2013 and 2014 Forest Management net removals.

Activity		1990	2013	2014
3.3 Afforestation & Reforestation	Area, kha	4.335	103.054	105.708
	Net carbon stock change, kt CO_2	-14.442	-1240.090	-1298.119
	GHG emissions from biomass burning, kt CO_2e	0.077	0.000	0.417
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	0.009	0.215	0.220
	N_2O emissions from N fertilization, kt CO_2e	0.334	0.285	0.344
	N_2O emissions from N mineralisation, kt CO_2e*	0.025	0.662	0.681
	Harvested Wood Product kt CO_2e	0.000	-3.019	-3.705
3.3 Deforestation	Area, kha	0.622	18.020	18.327
	Net carbon stock change, kt CO_2	90.112	182.894	110.131
	GHG emissions from biomass burning, kt CO_2e	56.765	87.585	39.927
	N_2O emissions from N mineralisation, kt CO_2e*	0.088	2.521	2.604
3.4 Forest Management	Area, kha	963.666	945.154	944.820
	Net carbon stock change, kt CO_2	-4848.754	-5018.511	-4954.085
	GHG emissions from biomass burning, kt CO_2e	17.001	0.000	3.314
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	1.897	1.755	1.749
	N_2O emissions from N mineralisation, kt CO_2e*	5.568	5.412	5.409
	Harvested Wood Product kt CO_2e	NA	-987.842	-956.017
3.4 Cropland management	Area, kha	4374.365	4305.903	4270.350
	Net carbon stock change, kt CO_2	-152.287	2858.576	2734.970
	GHG emissions from biomass burning, kt CO_2e	0.032	0.047	0.030
	N_2O emissions from N mineralisation, kt CO_2e*	26.126	262.347	265.172
3.4 Grazing Land Management	Area, kha	6202.699	6153.432	6183.365
	Net carbon stock change, kt CO_2	-184.147	-2203.613	-2298.612
	GHG emissions from biomass burning, kt CO_2e	6.683	0.754	1.900
	N_2O emissions from N mineralisation, kt CO_2e*	10.511	102.418	103.384
	Area, kha	4.335	103.054	105.708
3.4 Wetlands Drainage and Rewetting	Under development			

* The full title of this activity is "N_2O emissions from N mineralisation/immobilisation due to carbon loss/gain associated with land-use conversions and management change in mineral soils"

A8.7.2 Scotland

Scotland's share of the FMRL and Technical Correction is approximately 53%, based on the average of the 2013 and 2014 Forest Management net removals.

Activity		1990	2013	2014
3.3 Afforestation & Reforestation	Area, kha	14.341	208.385	216.136
	Net carbon stock change, kt CO_2	-3.568	-1666.986	-1788.655
	GHG emissions from biomass burning, kt CO_2e	0.190	13.114	9.308
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	0.140	2.279	2.367
	N_2O emissions from N fertilization, kt CO_2e	3.715	0.688	0.940
	N_2O emissions from N mineralisation, kt CO_2e*	0.152	2.672	2.794
	Harvested Wood Product kt CO_2e	0.000	-18.765	-19.324
3.3 Deforestation	Area, kha	0.233	27.832	29.104
	Net carbon stock change, kt CO_2	23.311	438.216	457.133
	GHG emissions from biomass burning, kt CO_2e	14.180	145.226	151.510
	N_2O emissions from N mineralisation, kt CO_2e*	0.065	11.472	11.966
3.4 Forest Management	Area, kha	1068.541	1039.077	1037.732
	Net carbon stock change, kt CO_2	-8531.594	-7711.685	-7385.917
	GHG emissions from biomass burning, kt CO_2e	13.931	52.278	35.381
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	10.277	9.084	8.996
	N_2O emissions from N mineralisation, kt CO_2e*	11.205	10.653	10.621
	Harvested Wood Product kt CO_2e	NA	-1752.393	-1715.932
3.4 Cropland management	Area, kha	644.741	600.437	603.349
	Net carbon stock change, kt CO_2	309.126	3196.316	3166.262
	GHG emissions from biomass burning, kt CO_2e	0.000	0.000	0.000
	N_2O emissions from N mineralisation, kt CO_2e*	34.285	279.094	279.851
3.4 Grazing Land Management	Area, kha	5712.808	5582.641	5571.468
	Net carbon stock change, kt CO_2	267.644	-629.715	-679.765
	GHG emissions from biomass burning, kt CO_2e	7.073	3.852	7.233
	N_2O emissions from N mineralisation, kt CO_2e*	7.182	75.768	76.742
	Area, kha	14.341	208.385	216.136
3.4 Wetlands Drainage and Rewetting	Under development			

* The full title of this activity is "N_2O emissions from N mineralisation/immobilisation due to carbon loss/gain associated with land-use conversions and management change in mineral soils"

A8.7.3 Wales

Wales's share of the FMRL and Technical Correction is approximately 9%, based on the average of the 2013 and 2014 Forest Management net removals.

Activity		1990	2013	2014
3.3 Afforestation & Reforestation	Area, kha	0.559	12.051	12.360
	Net carbon stock change, kt CO_2	-0.066	-59.655	-65.858
	GHG emissions from biomass burning, kt CO_2e	0.009	0.000	2.875
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	0.002	0.049	0.050
	N_2O emissions from N fertilization, kt CO_2e	0.071	0.050	0.060
	N_2O emissions from N mineralisation, kt CO_2e*	0.003	0.075	0.077
	Harvested Wood Product kt CO_2e	0.000	-1.074	-1.045
3.3 Deforestation	Area, kha	0.079	4.792	5.033
	Net carbon stock change, kt CO_2	11.039	60.609	61.631
	GHG emissions from biomass burning, kt CO_2e	6.878	30.309	30.657
	N_2O emissions from N mineralisation, kt CO_2e*	0.017	0.711	0.736
3.4 Forest Management	Area, kha	273.720	268.736	268.485
	Net carbon stock change, kt CO_2	-1686.049	-1200.559	-1159.588
	GHG emissions from biomass burning, kt CO_2e	4.490	0.000	59.579
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	1.087	1.035	1.033
	N_2O emissions from N mineralisation, kt CO_2e*	1.621	1.590	1.592
	Harvested Wood Product kt CO_2e	NA	-450.025	-437.215
3.4 Cropland management	Area, kha	239.528	185.881	187.500
	Net carbon stock change, kt CO_2	69.379	631.980	628.240
	GHG emissions from biomass burning, kt CO_2e	0.000	0.000	0.000
	N_2O emissions from N mineralisation, kt CO_2e*	6.260	54.130	54.327
3.4 Grazing Land Management	Area, kha	1408.746	1433.214	1430.392
	Net carbon stock change, kt CO_2	9.496	-2.666	-7.961
	GHG emissions from biomass burning, kt CO_2e	3.320	0.420	4.670
	N_2O emissions from N mineralisation, kt CO_2e*	3.167	33.676	34.132
	Area, kha	0.559	12.051	12.360
3.4 Wetlands Drainage and Rewetting	Under development			

* The full title of this activity is "N_2O emissions from N mineralisation/immobilisation due to carbon loss/gain associated with land-use conversions and management change in mineral soils"

A8.7.4 Northern Ireland

Northern Ireland's share of the FMRL and Technical Correction is approximately 3%, based on the average of the 2013 and 2014 Forest Management net removals.

Activity		1990	2013	2014
3.3 Afforestation & Reforestation	Area, kha	1.322	15.906	16.135
	Net carbon stock change, kt CO_2	-0.785	-179.479	-188.482
	GHG emissions from biomass burning, kt CO_2e	0.259	0.393	0.117
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	0.161	2.200	2.233
	N_2O emissions from N fertilization, kt CO_2e	0.457	0.016	0.025
	N_2O emissions from N mineralisation, kt CO_2e*	0.021	0.327	0.333
	Harvested Wood Product kt CO_2e	0.000	-2.056	-2.281
3.3 Deforestation	Area, kha	0.031	1.677	1.770
	Net carbon stock change, kt CO_2	4.059	51.923	53.557
	GHG emissions from biomass burning, kt CO_2e	2.427	12.225	12.384
	N_2O emissions from N mineralisation, kt CO_2e*	0.015	1.781	1.856
3.4 Forest Management	Area, kha	67.523	65.805	65.709
	Net carbon stock change, kt CO_2	-775.017	-400.772	-382.855
	GHG emissions from biomass burning, kt CO_2e	12.962	1.234	0.358
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	8.070	6.900	6.861
	N_2O emissions from N mineralisation, kt CO_2e*	1.040	1.025	1.024
	Harvested Wood Product kt CO_2e	NA	-159.631	-150.473
3.4 Cropland management	Area, kha	168.492	119.419	117.126
	Net carbon stock change, kt CO_2	102.803	731.642	740.275
	GHG emissions from biomass burning, kt CO_2e	0.000	0.000	0.000
	N_2O emissions from N mineralisation, kt CO_2e*	6.129	60.079	60.882
3.4 Grazing Land Management	Area, kha	1046.531	1050.618	1050.658
	Net carbon stock change, kt CO_2	-28.336	86.586	94.161
	GHG emissions from biomass burning, kt CO_2e	0.277	0.079	0.333
	N_2O emissions from N mineralisation, kt CO_2e*	2.553	62.317	64.217
	Area, kha	1.322	15.906	16.135
3.4 Wetlands Drainage and Rewetting	Under development			

* The full title of this activity is "N_2O emissions from N mineralisation/immobilisation due to carbon loss/gain associated with land-use conversions and management change in mineral soils"

A8.7.5 United Kingdom

The UK's Forest Management Reference Level during the second commitment period (2013-2020) is -3.442 Mt CO_2e/yr, or -8.268 Mt CO_2e/yr when harvested wood products are included and the Technical Correction to the Forest Management Reference Level is -9.275 Mt CO_2e/yr, or -5.658 Mt CO_2e/yr when harvested wood products are included.

Activity		1990	2013	2014
3.3 Afforestation & Reforestation	Area, kha	20.557	339.396	350.339
	Net carbon stock change, kt CO_2	-18.861	-3146.211	-3341.113
	GHG emissions from biomass burning, kt CO_2e	0.534	13.507	12.717
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	0.312	4.742	4.870
	N_2O emissions from N fertilization, kt CO_2e	4.577	1.039	1.370
	N_2O emissions from N mineralisation, kt CO_2e*	0.202	3.736	3.886
	Harvested Wood Product kt CO_2e	0.000	-24.914	-26.355
3.3 Deforestation	Area, kha	0.965	52.321	54.234
	Net carbon stock change, kt CO_2	128.520	733.643	682.452
	GHG emissions from biomass burning, kt CO_2e	80.250	275.346	234.478
	N_2O emissions from N mineralisation, kt CO_2e*	0.185	16.485	17.163
3.4 Forest Management	Area, kha	2373.450	2318.772	2316.746
	Net carbon stock change, kt CO_2	-15841.414	-14331.526	-13882.444
	GHG emissions from biomass burning, kt CO_2e	48.385	53.511	98.632
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	21.331	18.775	18.640
	N_2O emissions from N mineralisation, kt CO_2e*	19.433	18.680	18.646
	Harvested Wood Product kt CO_2e	NA	-3349.892	-3259.636
3.4 Cropland management	Area, kha	5427.126	5211.640	5178.325
	Net carbon stock change, kt CO_2	329.022	7418.514	7269.747
	GHG emissions from biomass burning, kt CO_2e	0.032	0.047	0.030
	N_2O emissions from N mineralisation, kt CO_2e*	72.800	655.649	660.232
3.4 Grazing Land Management	Area, kha	14370.784	14219.905	14235.883
	Net carbon stock change, kt CO_2	64.657	-2749.408	-2892.177
	GHG emissions from biomass burning, kt CO_2e	17.353	5.105	14.136
	N_2O emissions from N mineralisation, kt CO_2e*	23.412	274.179	278.475
	Area, kha	20.557	339.396	350.339
3.4 Wetlands Drainage and Rewetting	Under development			

* The full title of this activity is "N_2O emissions from N mineralisation/immobilisation due to carbon loss/gain associated with land-use conversions and management change in mineral soils"

A8.8 Data sources

Activity/ Dataset	Organisation	Update Frequency	Further details
4A Afforestation-Forest Planting	Forestry Commission	Annual	National Inventory of Woodland and Trees: http://www.forestry.gov.uk/forestry/HCOU-54PG9U Forestry Statistics: http://www.forestry.gov.uk/statistics
4A Afforestation-Forest Planting	Forestry Commission	Quinquennial	National Forest Inventory http://www.forestry.gov.uk/forestry/INFD-89Q9TY
4A,4G CARBINE model	Forest Research	Annual	The Forest Research carbon accounting model, CARBINE, calculates gains and losses in pools of carbon in standing trees, litter and soil in conifer and broadleaf forests and in harvested wood products. The model can represent different forest management regimes and is driven by Forestry Commission planting and management data. http://www.forestry.gov.uk/fr/INFD-633DXB
4B/4C/4E Deforestation – Area data	Forestry Commission & Forest Research	Annual	Compiled from multiple data sources by forestry experts (Forestry Commission felling licences, Ordnance Survey change data for non-rural areas, Countryside Survey, National Forest Inventory forest loss, habitat restoration, forest management plans).
4B/4C/4E Land Use Change-Countryside Survey	Centre for Ecology & Hydrology	Decadal (1984, 1990, 1998, 2007).	GB: http://www.countrysidesurvey.org.uk Northern Ireland Countryside Survey: http://www.ni-environment.gov.uk/biodiversity/nh-research/nicountrysidesurvey-2/nics_2007_results.htm
4B/4C/4E Land Use Change-Monitoring Landscape Change	Monitoring Landscape Change	1947 and 1980	Historic land use change data for Great Britain. (Pre-1990 data for Northern Ireland is compiled from Agricultural Census and Forest Service data)
4B/4C/4E Land Use Change - Soils Data	James Hutton Institute/ Cranfield Soil and AgriFood Institute (CSAI),	One off dataset (2005)	Database of soil carbon density for the UK. *Bradley, R. I., R. Milne, et al. (2005). "A soil carbon and land use database for the United Kingdom." Soil Use and Management 21(004): 363-369.*
4B Cropland Management/4C Grassland Management - Agricultural Census	Defra/DARDNI/Scottish Government/Welsh Government	Annual	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/Topics/Statistics/Browse/Agriculture-Fisheries/PubFinalResultsJuneCensus Wales: http://wales.gov.uk/statistics-and-research/survey-agricultural-horticulture/?lang=en#/statistics-and-research/survey-agricultural-horticulture/?tab=previous&lang=en Northern Ireland:http://www.dardni.gov.uk/index/statistics/statistical-reports/agricultural-census-ni.htm
4B Cropland Management – GB British Survey of Fertiliser Practice	Department for Environment Food and Rural Affairs	Annual	https://www.gov.uk/government/collections/fertiliser-usage
4B/4C Drainage on organic soils	ADAS (personal communication)	One off dataset (2014).	Spatial extent of cultivated organic soils (on cropland and improved grassland in all DAs)

Activity/ Dataset	Organisation	Update Frequency	Further details
4A/4B/4C Wildfires – IRS Data	Fire and Rescue Service	Annual	The fire Incidence and Reporting Systems (IRS) includes wildfires on all land use categories for GB for 2010 onwards. Pre-2010 wildfire area has been estimated using Forestry Commission and Forest Service data for forest wildfires and extrapolation based on satellite proxy data for non-forest wildfires. Non-forest wildfires in Northern Ireland are estimated using the same rates of grassland burning as in Scotland and grassland areas from the 2007 Countryside Survey.
4B/4C Drainage on organic soils	ADAS (personal communication)	One off dataset.	Spatial extent of cultivated organic soils (on cropland and improved grassland in all DAs)
4D Peat Extraction – Mineral Extraction in Great Britain	Office of National Statistics	Annual	Annual peat production in Great Britain is inferred from extractor sales by volume https://www.gov.uk/government/statistics/mineral-extraction-in-great-britain-2012
4D Peat Extraction– Directory of Mines and Quarries	British Geological Survey	Every 3-4 years (latest in 2014)	The directory gives the location of active commercial extraction sites in GB. http://www.bgs.ac.uk/mineralsuk/mines/dmq.html. Current areas of commercial extraction are measured from Google Earth satellite imagery (approximately 2010 dates) using the site location data.
4D Peat Extraction– Extraction data Northern Ireland	Scientific Reports	*Ad hoc* updates.	Cruickshank, M. M., and R. W. Tomlinson (1997), Carbon loss from UK peatlands for fuel and horticulture, in Carbon Sequestration in Vegetation and Soils, edited by M. G. R. Cannell, Department on Environment, London. Tomlinson, R. W. (2010). "Changes in the extent of peat extraction in Northern Ireland 1990–2008 and associated changes in carbon loss." Applied Geography, 30: 294-301.
4D Flooded Lands- Reservoir construction	Environment Agency/SEPA/Northern Ireland personal communication	Annual	England and Wales: Public Register of Large Raised Reservoirs provided by the Environment Agency. Scotland: SEPA Water Body Classification database (of water bodies > 0.5 km^2) and the associated Water Body data sheets. It was established through discussion with local experts that no new large reservoirs had been built in Northern Ireland since the 1950s.

Appendix 9: Aviation Data in the EU ETS

Greenhouse Gas (GHG) emissions from civil aviation are reported within the UK Greenhouse Gas Inventory (GHGI) and also within GHG inventories prepared for the constituent countries of the UK: Scotland, Wales, Northern Ireland and England. The emissions from domestic flights are accounted within national inventory totals, whilst emissions from international flights are reported as memo items to the UK inventory.

Each of the devolved Governments tailors their climate change policy legislation and policies to focus on specific local and regional priorities. The Climate Change (Scotland) Act identifies that the scope of net Scottish GHG emissions account shall include all existing anthropogenic sources and sinks of emissions in Scotland, as well as a "Scottish share" of GHG emissions from international shipping and also from international aviation.

The UK and Devolved Administration (DA) aviation emission estimates for both domestic and international flights are based on flight data from the Civil Aviation Authority (CAA) and fuel use in the aviation sector reported within the UK energy statistics, the Digest of UK Energy Statistics (DUKES), which are published annually by the Department of Energy and Climate Change (DECC).

From 2012 onwards, emissions from aviation have also been included within the scope of the EU Emissions Trading System (EU ETS). The scope of EU ETS for aviation includes flights within the EU zone to and from a wide range of countries, not only flights that originate and land within the EU Member States.

In order that DECC and the Scottish Government can assess the impacts of aviation emissions being accounted within the EU ETS and therefore subject to economic drivers to reduce emissions over time, it is essential that the baseline level and trend of all aviation emissions that fall within the scope of EU ETS can be determined.

In 2014, a short project[15] was therefore commissioned by DECC and the Scottish Government to re-work the UK GHG civil aviation emissions analysis to exclude the emissions that are outside the scope of EU ETS, i.e. those flights to/from countries that are not within the EU ETS scope.

The tables below are an update to that analysis, reflecting the improvements to DA aviation analysis in the current inventory cycle.

The UK aviation emissions are presented below in

Table A9. 1 for the Stop the Clock scope and Table A9. 2 for the 2014 Regulation scope.

- From 2010 onwards the *Stop the Clock* scope is around 32% of the UK aviation inventory total, with slightly variable and higher percentages in earlier years.
- Since 2010 the *2014 Regulation* scope is 27 - 28% of the UK total, with a slightly higher percentage in earlier years.

Table A9. 1: UK aviation emissions under the Stop the Clock Scope (Mt CO_2e)

	GHG	2000	2005	2010	2011	2012	2013	2014
Stop the Clock	Carbon dioxide	11.181	13.623	10.947	11.252	10.858	11.002	11.103
	Methane	0.005	0.005	0.002	0.002	0.002	0.002	0.002
	Nitrous oxide	0.106	0.129	0.104	0.106	0.103	0.104	0.105
UK GHGI	Carbon dioxide	32.448	37.777	33.690	35.054	34.087	34.377	34.489
	Methane	0.007	0.006	0.003	0.003	0.003	0.003	0.003
	Nitrous oxide	0.307	0.357	0.319	0.332	0.322	0.325	0.326
Stop the clock % share	Total GHGs	34.5%	36.1%	32.5%	32.1%	31.9%	32.0%	32.2%

[15] "UK and Scottish Aviation Emissions within the Scope of EU ETS", Ricardo-AEA report to DECC and the Scottish Government, Ricardo-AEA/R/ED59803017 (August 2014)

Table A9. 2: UK aviation emissions under the 2014 Regulation Scope (Mt CO_2e)

	GHG	2000	2005	2010	2011	2012	2013	2014
2014 Regulation	Carbon dioxide	9.658	11.993	9.352	9.599	9.343	9.502	9.506
	Methane	0.005	0.004	0.002	0.002	0.002	0.002	0.002
	Nitrous oxide	0.091	0.113	0.088	0.091	0.088	0.090	0.090
UK GHGI	Carbon dioxide	32.448	37.777	33.690	35.054	34.087	34.377	34.489
	Methane	0.007	0.006	0.003	0.003	0.003	0.003	0.003
	Nitrous oxide	0.307	0.357	0.319	0.332	0.322	0.325	0.326
2014 Regulation % share	Total GHGs	29.8%	31.8%	27.8%	27.4%	27.4%	27.6%	27.6%

The Scotland aviation emissions are presented below in Table A9. 3 for the *Stop the Clock* scope and Table A9. 4 for the *2014 Regulation* scope.

- From 2005 onwards the *Stop the Clock* scope is between 74-79% of the Scotland aviation inventory total.
- Since 2010 the *2014 Regulation* scope has been between 66-73% of the Scotland total.

Table A9. 3: Scotland aviation emissions under the Stop the Clock Scope (Mt CO_2e)

	GHG	2000	2005	2010	2011	2012	2013	2014
Stop the Clock	Carbon dioxide	1.223	1.503	1.185	1.260	1.222	1.256	1.248
	Methane	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	Nitrous oxide	0.012	0.014	0.011	0.012	0.012	0.012	0.012
Scotland GHGI	Carbon dioxide	1.458	1.912	1.535	1.611	1.584	1.654	1.697
	Methane	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	Nitrous oxide	0.014	0.018	0.015	0.015	0.015	0.016	0.016
Stop the clock % share	Total GHGs	83.9%	78.6%	77.2%	78.2%	77.2%	75.9%	73.6%

Table A9. 4: Scotland aviation emissions under the 2014 Regulation Scope (Mt CO_2e)

	GHG	2000	2005	2010	2011	2012	2013	2014
2014 Regulation	Carbon dioxide	1.133	1.401	1.082	1.128	1.106	1.118	1.139
	Methane	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	Nitrous oxide	0.011	0.013	0.010	0.011	0.010	0.011	0.011
Scotland GHGI	Carbon dioxide	1.458	1.912	1.535	1.611	1.584	1.697	1.654
	Methane	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	Nitrous oxide	0.014	0.018	0.015	0.015	0.015	0.016	0.016
2014 Regulation % share	Total GHGs	77.7%	73.3%	70.5%	70.0%	69.8%	65.9%	68.9%

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