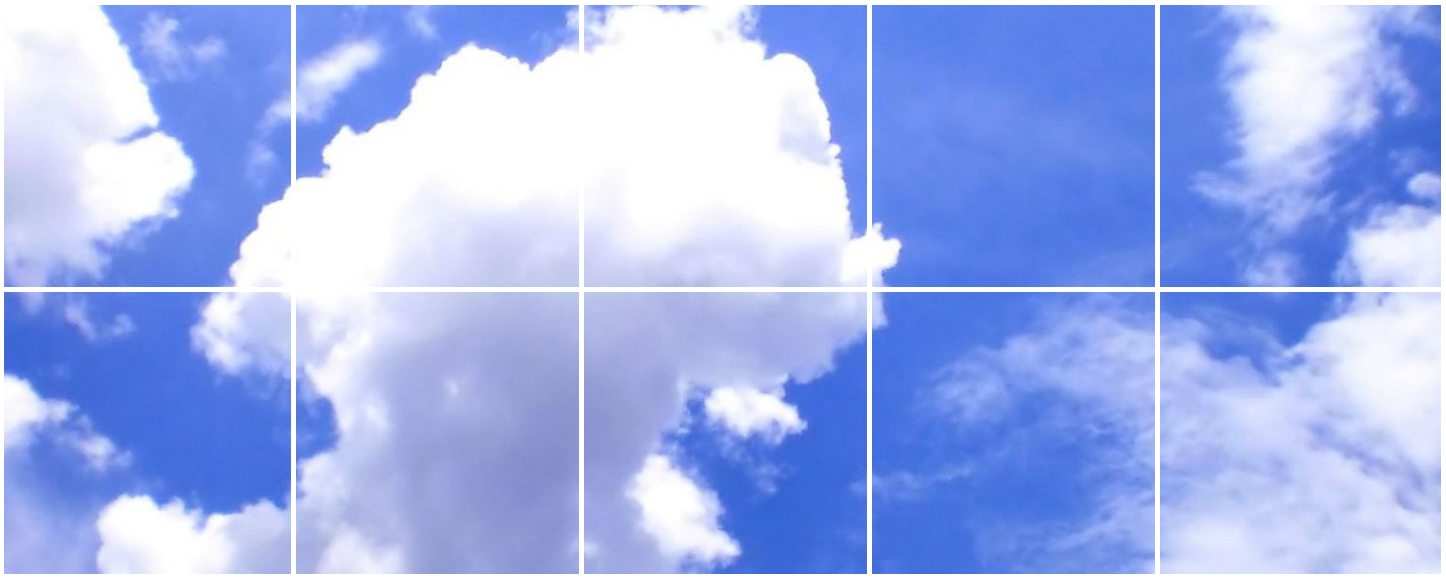
National Atmospheric Emissions Inventory



Appendices

Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 – 2013

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

June 2015

Aether RICARDO-AEA

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

A1.1 Introduction

The uncertainties in the UK Inventory are estimated using a Monte Carlo simulation. Eggleston *et al.* (1998) and Salway *et al.* (2001) describe this 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 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 for fuel use are estimated on the basis of the statistical differences between fuel supply and demand data reported in the energy statistics. However, such data is not available for the DA-specific activity data used. Moreover, for some sources, no direct activity data is available at all, and it has been necessary to distribute the UK data using surrogate data (e.g. employment statistics). In such cases, it is impossible to say whether the surrogate statistics are an accurate indicator of fuel consumption and uncertainties are assumed to be higher as a result.

A1.2 Uncertainty Estimation Methodology

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

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

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

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

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

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

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

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

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

A1.3 Trend Uncertainty Analysis

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

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

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

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

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

A1.4 Uncertainty Analysis Results

As a result of the activity data gaps in the DA inventories, the estimates will be more uncertain than for the UK inventory. The difference in emissions coverage will also mean the uncertainties calculated for the UK in the DA inventory will be different than that for the UK in the UK inventory. Expert judgement has been used to assess the degree of additional uncertainty due to the use of proxy activity data, informed by the comparison of the new datasets such as the European Union Emissions Trading Scheme (EU ETS) and the DECC regional energy statistics with historical data. 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 1990-2013 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, 2013 and Trend

	Base Year[2]		Latest Year (2013)		Trend (Base Year to 2013)		
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
Scotland							
Carbon Dioxide CO_2	54,893	21%	36,984	17%	-32%	-48%	-12%
Methane CH_4	17,657	30%	7,872	20%	-54%	-69%	-37%
Nitrous Oxide N_2O	5,343	78%	4,211	79%	-22%	-35%	-6%
HFC	163	9%	1,325	6%	713%	627%	808%
PFC	116	19%	98	56%	-14%	-62%	37%
SF_6	36	19%	36	19%	2%	-23%	33%
NF_3	1	44%	0	47%	-46%	-75%	-1%
Total	78,208	17%	50,527	14%	-35%	-47%	-21%
Wales							
Carbon Dioxide CO_2	44,082	3%	42,237	4%	-4%	-9%	1%
Methane CH_4	10,193	20%	5,402	16%	-47%	-59%	-33%
Nitrous Oxide N_2O	3,041	88%	2,417	80%	-20%	-32%	-4%
HFC	84	10%	655	6%	683%	599%	776%
PFC	172	5%	7	59%	-96%	-98%	-94%
SF_6	83	16%	37	15%	-55%	-64%	-45%
NF_3	0	44%	0	47%	-23%	-64%	42%
Total	57,654	6%	50,755	5%	-12%	-17%	-7%
Northern Ireland							

Gas (kt CO_2e)	Base Year[2]		Latest Year (2013)		Trend (Base Year to 2013)		
	Central Estimate[3]	Uncertainty Introduced on total	Central Estimate	Uncertainty Introduced on total	Central Estimate[3]	2.5 Percentile	97.5 Percentile
Carbon Dioxide CO_2	17,913	7%	15,059	8%	-16%	-25%	-6%
Methane CH_4	5,624	19%	4,382	17%	-21%	-40%	0%
Nitrous Oxide N_2O	3,104	82%	2,507	85%	-20%	-32%	-9%
HFC	52	9%	417	6%	697%	614%	789%
PFC	1	20%	0	50%	-87%	-94%	-80%
SF_6	5	32%	6	28%	19%	-25%	81%
NF_3	-	N/A	-	N/A	N/A	N/A	N/A
Total	26,699	11%	22,371	12%	-16%	-24%	-8%
England							
Carbon Dioxide CO_2	466,733	3%	358,702	2%	-23%	-26%	-20%
Methane CH_4	101,296	26%	37,185	20%	-63%	-74%	-50%
Nitrous Oxide N_2O	45,348	54%	18,147	75%	-59%	-75%	-41%
HFC	19,255	9%	13,743	6%	-28%	-36%	-20%
PFC	308	7%	148	17%	-52%	-61%	-43%
SF_6	1,140	16%	522	15%	-54%	-63%	-43%
NF_3	0	44%	0	47%	-69%	-86%	-42%
Total	634,080	6%	428,448	4%	-32%	-37%	-28%
Unallocated							
Carbon Dioxide CO_2	12,909	13%	12,951	8%	1%	-13%	18%
Methane CH_4	1,932	84%	1,139	31%	400%	-73%	160%
Nitrous oxide N_2O	249	104%	232	103%	16%	-75%	236%
HFC	-	N/A	-	N/A	N/A	N/A	N/A
PFC	-	N/A	-	N/A	N/A	N/A	N/A
SF_6	-	N/A	-	N/A	N/A	N/A	N/A
NF_3	-	N/A	-	N/A	N/A	N/A	N/A
Total	15,089	16%	14,322	8%	-4%	-19%	14%
UK							
Carbon Dioxide CO_2	596,530	2%	465,934	2%	-22%	-24%	-19%
Methane CH_4	136,701	25%	55,980	18%	-58%	-70%	-45%
Nitrous Oxide N_2O	57,085	56%	27,513	76%	-52%	-68%	-34%
HFC	19,553	9%	16,144	6%	-17%	-26%	-8%
PFC	596	7%	254	32%	-57%	-71%	-44%
SF_6	1,263	16%	602	15%	-52%	-62%	-41%
NF_3	1	44%	0	47%	-54%	-79%	-15%
Total	811,728	6%	566,427	5%	-30%	-34%	-26%

Notes

1. Uncertainty is defined as $\pm$ 2×(standard deviation)/mean %, which closely approximates the 95% confidence interval.
2. Base years are 1990 for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O); 1995 for NF_3, HFCs, PFCs and SF_6.
3. The uncertainty model takes emission estimates by gas for each source, applies an uncertainty distribution for that source and calculates a statistical mean, presented above as the central estimate. The emissions data in this table are taken from the Monte Carlo model output. The central estimates by gas for 1990 and the latest inventory year are very similar but not identical to the emission estimates in the DA inventories.

A1.5 Uncertainty Model Improvements

Following initial research in 2014 to explore the sensitivity of the DA uncertainty model to changes in the model scope, i.e. excluding specific sources and activities known to contribute significantly to the overall level of uncertainty in the DA inventories (e.g. nitrous oxide emissions from agricultural soils), further research has been commissioned by the Scottish Government to overhaul and update the DA uncertainty model.

This improvement project is currently ongoing, with a final project report due to be published in June 2015. The research analysis has led to a redevelopment of the DA uncertainty model as a whole, but has focussed resources specifically on updating and improving the uncertainty parameters applicable to Scottish emission sources.

The DA uncertainty model that was used to derive the current estimates presented in Table A1.1 above has been used as the starting point for new estimates from an updated model that takes account of new information on source category uncertainty parameters. The project reviewed and updated the uncertainty parameters for all emission sources through consultation with key data providers and inventory compilers. In addition, the model structure and functionality has been improved to enable more detailed consideration of the uncertainties associated with emissions data from the EU ETS. The model can now be run to deliver uncertainty estimates at DA level that can either be constrained to be consistent with the overall UK GHGI uncertainty model outputs, or to derive unconstrained uncertainty estimates (i.e. that allow total DA uncertainties for a given source category to deviate from the UK uncertainty total).

In order to test the impacts of model design and functionality, and to determine the sensitivity of the model to uncertainty estimates and correlations across different sources, the project team has run the revised DA uncertainty model for a range of scenarios to assess the overall uncertainty by gas for Scotland. These scenarios have included model sensitivity tests for:

- Uncertainty by gas and overall when all LULUCF sources are excluded;
- Uncertainty by gas and overall when all agricultural sources are excluded;
- Uncertainty by gas and overall for only the traded sector emissions, and for only the non-traded sector emissions;

The initial findings of this research confirm that, despite improvements, the Scottish inventory uncertainties are still dominated by the impacts of LULUCF emission sources and sinks (on the CO_2 inventory) and by the agricultural sources in the methane and nitrous oxide inventories. This is entirely expected, as these emission sources and sinks are typically the most uncertain sources within any GHG inventory, due to the scientific uncertainty of emission factors (for agricultural sources) and carbon fluxes (for LULUCF).

The revisions to the Scotland uncertainties model do however indicate that the overall level of uncertainty is notably lower than that cited in the table above. This is not the case for all individual GHGs, but the overall estimates of the Scotland GHGI uncertainty in 2013 from the revised model are summarised below.

Table A1.2 Estimated Uncertainty in the 2013 Scottish GHG Inventory: Comparison of Current and Revised Model Outputs

Greenhouse Gas	Uncertainty for Scotland 2013		Comment on relative change in uncertainty
	Revised Model	Original Model	
Carbon dioxide	11%	17%	Lower CO_2 uncertainties in the revised model, driven by revisions to the LULUCF uncertainty estimates, based on updated parameters from CEH.
Methane	30%	20%	Higher methane uncertainties due to revisions to uncertainty parameters for key sources, and the impact of the revised approach to the allocation of uncertainty to Scotland and other countries.
Nitrous Oxide	67%	79%	Comparable nitrous oxide uncertainties, slightly lower in the revised model due to revised uncertainty distributions provided by Rothamsted Research.
HFCs	29%	6%	Significantly higher HFC uncertainties due to revisions to the assumptions for RAC sources, and the impact of the revised approach to the allocation of uncertainty to Scotland and the other countries.
PFCs	52%	56%	Comparable PFC uncertainties.
NF_3	55%	47%	Comparable NF_3 uncertainties.
SF_6	23%	19%	Comparable SF_6 uncertainties.
Total	**11%**	**14%**	Overall lower uncertainties, driven down by the lower CO_2 emission uncertainties.

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

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

A2.1 Introduction

The UK Greenhouse Gas Inventory compiles national estimates of greenhouse gas emissions for submission to the UN Framework Convention on Climate Change under the requirements of the Kyoto Protocol. The most recent version of the inventory, published in April 2014, presents UK greenhouse gas emission estimates for the period 1990 to 2012 (Webb *et al*, 2014). The UK GHG inventory report for 1990-2013 data is yet to be published, due to delays in the international reporting cycle.

This report presents separate inventories of greenhouse gas emissions for England, Scotland, Wales and Northern Ireland for the years 1990, 1995 and 1998 to 2013 that are consistent with the 1990 to 2013 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); and
- Sulphur hexafluoride (SF_6).

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

A2.2 Reporting Format

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

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

A2.3 General Approach

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

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

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

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

where

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

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

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

[Equation 2]

where

E_i = Emission (in tonnes) from either England (1),Scotland (2), Wales (3), Northern Ireland (4) or "Unallocated" (5)
d_i = A driver representing the contribution of the region to UK emissions
i = 1, 2, 3, 4, 5

The driver, d_i can be any one of:

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

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

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

Thus the compilation of the greenhouse gas inventories for the constituent countries of the UK reduces to the estimation of a set of drivers, each appropriate to emissions from a specific source. In compiling the 1990-2013 inventories, over 230 drivers have been calculated.

Subsequent sections discuss the estimation of the drivers for each source category. Most of the detailed discussion is concentrated on the more complex categories, whilst simpler sources are summarised in Tables A2.1 to A2.10. The IPCC classification is used throughout (IPCC, 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 2012. The derivation of drivers sometimes differs between years depending on data availability.

A2.4.1 Electricity Production

Emissions are based on fuel consumption data provided by the major power generators in Great Britain and the Northern Ireland Office for 1990 to 1999: Scottish Power (2004), Scottish and Southern Energy (2004), Innogy (2004), PowerTech (2004), AES Drax (2004). From 2000 onwards, emissions data from the Pollution Inventory (Environment Agency, 2014a) the Scottish Pollution Release Inventory (SEPA, 2014a) and the Northern Ireland Pollution Inventory (Northern Ireland Environment Agency, 2014a) has been used to estimate DA emissions. For emissions in 2005 onwards, fuel use and emissions data reported within the EU ETS (Environment Agency, 2014b; SEPA, 2014b; Northern Ireland Environment Agency, 2014b) 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, 2014b) 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 2013)

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 – 2013 (UKPIA, 2014), 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 1990-2013 GHG inventory, the activity data reported in the EU ETS (EA, 2013b) for petroleum coke and other petroleum gases (OPG) use in refineries has been used in preference to activity data reported in DUKES. Emissions for 1998 are based on carbon dioxide emissions reported in the Pollution Inventory (EA: 1999a).

A2.4.3 Manufacture of Solid Fuels

This category comprises the production of coke and solid smokeless fuel (SSF). Country-specific data on coke ovens in the iron and steel industry are reported in detail by ISSB (2014), and emissions data for integrated steel works are reported via the PI and EU ETS (Environment Agency, 2014b). Two coke ovens in England and Wales are not attached to an integrated iron and steel facility, and the consumption of coal by these ovens is estimated from WO (1998) and UK data (DECC: 1991, 2000-2014). 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 2013, 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: 2014a) and EU ETS (EA: 2014b).

The generic driver for coke oven fuel consumption is the regional consumption of coking coal (ISSB, 2014). 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, 2014b). 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, 2014) until 2004 and from 2005 data on BFG emissions from the EU ETS (EA, 2014b).Small amounts of colliery methane are consumed in the manufacture of solid fuels and this was judged to occur entirely in England where coking occurs in close proximity to deep mining. Small amounts of coke breeze are also used, and this has been disaggregated using data on other coke consumption from ISSB.

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

A2.4.4 Other Energy Industries

This category consists of a number of small emissions from collieries, the gas industry, the nuclear fuel industry and emissions from the upstream oil and gas exploration and production sector which comprises offshore rigs and vessels as well as onshore terminals. In the DA inventories, emissions from oil and gas terminals and offshore rigs and vessels are based on data provided by DECC (2014e). 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 2014e); the emission factor for these emissions has been revised to reflect that the “OPG” in these terminals is predominantly ethane rather than the mixture of gases derived from refineries that is also known as “OPG”. Data on LPG and OPG use at oil and gas terminals is reported within EU ETS (SEPA 2014b and EA 2014b) 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 mis-allocation within DUKES. Therefore in the 1990-2013 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 2014b, SEPA 2014b); 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 A2.3.

A2.5.1 Iron and Steel

The ISSB (2014) provides annual report of detailed regional consumption of fuel by the steel industry and these data are used to inform regional iron and steel sector consumption of fuels such as natural gas which is used across many of the smaller production sites in the UK. Access to the detailed data for the steel sector from the Climate Change Agreement reporting system (Personal Communication: Hodges, 2013), has provided clarifications on fuel use and site allocations within the Ricardo-AEA point source dataset, to complement the EU ETS dataset (EA, 2014b) 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, 2014b), 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 2013)

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 (2013)
	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 (2013)
		Coke oven gas	To 2004: Coal feed to coke ovens, ISSB, WS. 2005 onwards: EU ETS data supplemented by information from Tata Steel (2013)
		Coke	To 2004: Coke use in blast furnaces, ISSB, WO. 2005 onwards: EU ETS data supplemented by information from Tata Steel (2013)
		Other fuels	Regional fuel use data (ISSB): fuel oil, gas oil, LPG, coal, natural gas supplemented by information from Tata Steel (2013)
Other Industrial combustion	Non-ferrous metals	All fuels	Emissions analysis for 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. 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-AEA point source data, analysed to minimise double-counting.
		Colliery Methane	Deep mined coal production, British Coal Authority
		Coal, coke	Sub-national energy statistics, DECC; Coal consumption, WO, NIO
		Coke oven gas	Coal feed to coke ovens, ISSB, WO, WS
		SSF	Sub-national energy statistics, DECC
		Wood	GDP data.
	Cement	All fuels	Regional cement capacity, BCA; For 2002 onwards, based on emissions reported to the EU ETS, PI, SPRI and NIPI (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 2014.
		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 2012, with gas and electricity data available up to 2013 within the DECC publication *Energy Trends December 2014* (DECC 2014b). The sub-national data are used to extrapolate estimates back across the time-series (assuming UK trends across all DAs) in many instances where more detailed data for the earlier years is absent. Hence the emission estimates & trends from solid and liquid fuels within the industrial combustion categories remain amongst the more uncertain estimates within the DA inventories, due to uncertainties from the modelling approach to derive the source activity data and the back-casting of emission estimates for the earlier years.

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

The driver for emissions from lubricant use is based on regional lubricant sales (DECC, 2014a) with England and Wales being disaggregated based on regional manufacturing employment statistics (ONS, 2014a). 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 (2014c) 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) (2014) for 1999 onwards, Firmus Energy (2014) Energia (2014) and Vayu Ltd. (2014). 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: 2009a, SEPA: 2009a, NIDoE: 2009a), 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: 2014b, SEPA: 2014b, NIEA: 2014b) 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, 2013b). 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 A2.4.

A2.6.1 Aviation

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

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

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

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

The DA emission estimates for domestic and international aviation are associated with low uncertainty; the emission estimates are based on a database of UK flight movements and detailed calculations of emissions from different phases of flights (take off, cruise, landing cycles). In the 1990-2013 inventory update, revised data on flight distances has led to minor re-allocations of fuel use estimates and emissions between the flights originating at UK airports, leading to small revisions in the DA estimates.

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 2014a), 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 2012 are used, which are derived from applying trends in port movement data as proxies for changes in activities of different types of vessels;
- Fuel consumption and emissions are calculated separately for naval shipping from data provided by the MoD;
- Fuel consumption and emissions are calculated separately for inland waterways from estimates of vessel population and activities;

- Fuel consumption and emissions are calculated separately for fishing which takes place in non-UK waters by UK vessels;
- Fuel consumption and emissions are calculated separately for shipping movements between the UK and Overseas Territories;
- A reconciliation with fuels data in DUKES is made whereby the difference between the sum of the currently reported fuel deliveries for marine bunkers and national navigation in DUKES and the sum of the fuel consumption estimate for domestic coastal shipping taken from AMEC 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, 2014). The same approach is taken for the allocation of the international shipping emissions to each DA. As with the international aviation data, the Scottish Government GHG reduction targets take account of the Scottish share of international shipping, whereas for England, Wales and Northern Ireland the international shipping data are merely a memo item that are accounted for separate to the main DA by source dataset.

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

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

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

A2.6.3 Road Transport

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

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

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

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

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

UK emissions of carbon dioxide from road transport are reported to IPCC on the basis of fuel sales. However, basing road transport emissions on fuel sales in each constituent country of the UK does not provide a representative picture of trends in road transport emissions at regional level, due to issues of cross-border fuel sales (especially between Northern Ireland – Republic of Ireland) and sales data accounting issues within the UK (e.g. "supermarket sales" in Scotland allocated to original point of sale in northern England).

Estimates based on fuel consumption calculated from traffic data in each DA are therefore regarded as a more representative approach, and are consistent with the CORINAIR (now EMEP/EEA) guidance.

Table A2.5: 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, 2014) Fuel consumption: Digest of UK Energy Statistics (1990)
Road Transport	Road Transport	Petrol, Diesel oil	Road fuel sales, DECC; vehicle km, DfT Traffic data: National Traffic Census, DfT Dept of Regional Development (NI: 1990) Fuel consumption: Digest of UK Energy Statistics (1990)
Railways	Railways	Gas oil	The DfT Rail Emissions Model, calibrated against total train kilometres figures for 2009/10 taken from ORR's National Rail Trends Yearbook. DA estimates from 2010 back-cast to 1990, assuming DAs follow UK trend. Fuel consumption: Digest of UK Energy Statistics (1990-2014).
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 2013)

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, 2014) Fuel consumption: Digest of UK Energy Statistics (DECC, 2014)
Road Transport	Road Transport	Petrol, Diesel oil, LPG	Vehicle km, DfT, NI DRD Emission factors: Boulter et al. (2009) COPERT 4 (EEA, 2010) Fuel efficiency: Road Freight Statistics, (DfT, 2014) Composition of fleet: Vehicle Licensing Statistics Report, DfT (GB) Dept of Regional Development (NI). Traffic data: National Traffic Census, DfT (England, Scotland, Wales: 1990-2013) Dept of Regional Development (NI: 1990-1999), Traffic Census Report (NI: 2000), Vehicle Kilometres of Travel Survey of Northern Ireland Annual Report (NI: 2001), Traffic and Travel Information, DRDNI (NI: 2002- 2012) Fuel consumption: Digest of UK Energy Statistics (DECC, 2014), 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, 2014)
Navigation	Coastal shipping	Gas oil, Fuel oil	Back calculated from 2007 estimates by Entec based on detailed shipping movements. Backcasting and forewardcasting done from 2007 using trends in port movement data, DfT Maritime Statistics Fuel consumption: Digest of UK Energy Statistics (DECC, 2014)
Other	Aircraft Support	Gas oil	Regional aircraft movements, DfT Fuel consumption: Digest of UK Energy Statistics (DECC, 2014)

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 1990-2013 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 2013 were estimated by Ricardo-AEA based on the reported 2012-2013 GB road traffic trends, using DfT data, and applying the trend to historical Northern Ireland data for 2012.

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 unchanged and they are developed by TRL on behalf of DfT (Boulter et al., 2009), expressed as speed-related functions for cars and LGVs and single average factors for HGVs, buses and motorcycles for urban, rural and motorways.

Nitrous oxide emission factors remain the same as those used in the last DA GHG inventory (except corrections have been made for coaches, London buses and HGVs 3.5-7.5t and 7.5-12t weight classes). They are based on factors obtained from the Emissions Inventory Guidebook (EEA, 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 also unchanged and are based on the fuel consumption-speed relationships for detailed categories of vehicles compiled by TRL on behalf of DfT. They are used in conjunction with fleet-average fuel efficiency and vehicle CO_2 factors from other sources. These include fuel efficiency factors for HGVs and buses from sources in DfT. Further details on fuel consumption factors for other vehicle types will be provided in the UK GHG inventory report when it is published later in 2015.

Tables A2.4.1 to A2.4.3 show the fuel consumption and emission factors used for the inventory broken down by vehicle type, road type and emission standard which the vehicle was compliant with when manufactured and first registered. Tables A2.4.4 and A2.4.5 present the fleet-averaged fuel consumption factors for rigid and articulated HGVs, buses and coaches respectively from 1990-2013 for urban, rural and motorway conditions. For the other vehicle types and pollutants, CH_4 and N_2O, where the original source of the factors provided them as speed-emission factor equations, emission factors are calculated at average speeds typical of the road types shown in the tables A2.4.1 to A2.4.3. The average speeds used were same as those used in the last DA inventory as described below.

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

Age and composition of the fleet

Automatic Number Plate Recognition (ANPR) data provided by DfT (2014b, pers comm) are used to define the UK's vehicle fleet composition on the road. The ANPR data has been collected annually (since 2007) over 256 sites in the UK on different road types (urban and rural major/minor roads, and motorways) and regions. Measurements are made at each site on one weekday and one half weekend day in June, capturing approximately 1.4-1.7 million observations from all the sites each year. The data cover various vehicle and road characteristics such as fuel type, age of vehicle (which can be associated with its Euro standard), engine sizes, vehicle weight and road types.

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

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

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

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

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

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

Traffic data

The preferred indicators for road transport activity in emission inventories are traffic data in terms of vehicle kilometres travelled per year disaggregated by vehicle and road type. For the NAEI, vehicle kilometre data for the road network in Great Britain are provided by DfT for each vehicle type on roads classified as trunk, principal and minor roads in built-up areas (urban) and non-built-up areas (rural) and motorways (DfT, 2014c). 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 2013 by road type and vehicle type for England, Wales and Scotland was provided by DfT (DfT, 2014c). Vehicle km data for 1993 was scaled to derive the 1990 values for England, Wales and Scotland, based on the GB trend between 1990 and 1993. As mentioned previously, the minor traffic estimates have been revised between 2000 and 2010 for England and Wales as a result of a planned benchmarking exercise. The revision does not affect minor road estimates for Scotland.

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

Estimation of Emissions of Methane and Nitrous Oxide

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

Estimation of Road Transport Carbon Dioxide Emissions

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

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

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

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

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

Table A2.7: Fuel Consumption Factors for Road Transport (in g fuel/km)

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

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

g fuel /km		Urban	Rural	Motorway
	Euro 2	71.5	77.5	106.0
	Euro 3	63.2	69.8	104.0
	Euro 4	63.2	69.8	104.0
Mopeds, <50cc, 2st	Pre-Euro 1	25.5		
	Euro 1	15.3		
	Euro 2	12.3		
	Euro 3	10.7		
Motorcycles, >50cc, 2st	Pre-Euro 1	27.5	30.2	
	Euro 1	25.3	27.8	
	Euro 2	25.3	27.8	
	Euro 3	25.3	27.8	
Motorcycles, >50cc, 4st	Pre-Euro 1	35.3	35.1	53.9
	Euro 1	33.5	33.2	46.9
	Euro 2	31.6	31.9	49.3
	Euro 3	31.6	31.9	49.3

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

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

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

Table A2.9: N_2O Emission Factors for Road Transport (in mg/km)

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

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

Table A2.10: Fuel Consumption Factors for HGVs (in g fuel/km)

g fuel/km	Rigid HGVs			Artic HGVs		
	urban	rural	m-way	urban	rural	m-way
1990	272.4	217.7	231.5	438.8	337.1	343.6
1995	263.3	212.2	225.9	395.5	304.6	310.5
2000	247.8	204.8	219.2	370.2	287.7	293.2
2005	250.7	205.0	217.4	360.9	279.7	285.2
2006	261.9	213.1	225.5	363.4	281.4	286.9
2007	270.1	218.5	230.7	365.9	283.1	288.7
2008	279.6	226.0	238.5	379.8	293.5	299.3
2009	281.8	228.0	240.8	381.1	294.3	300.1
2010	285.3	229.9	242.5	384.9	296.9	302.7
2011	284.7	229.2	241.6	384.4	296.0	301.8
2012	284.6	228.9	241.3	384.6	295.9	301.8
2013	285.8	229.6	242.0	385.8	296.7	302.5

Table A2.11: Average fuel consumption factors for buses and coaches (in g fuel/km) in the fleet based on DfT's BSOG data

g fuel/km	Urban	Rural	Motorway
1990	268.9	167.8	190.9
1995	260.8	163.3	187.0
2000	277.0	176.7	206.4
2005	322.7	207.1	244.3
2008	338.2	216.2	255.4
2009	340.8	217.5	257.2
2010	337.5	215.1	254.5
2011	336.8	214.4	253.8
2012	326.3	207.4	245.7
2013	327.1	207.6	246.1

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

They are described in the following sections:

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

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

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

Direct Calculation of DA Emissions: Unconstrained Method:

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

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

Any change in the methodologies or the factors used to calculate fuel consumption will affect the magnitude of the difference between calculated fuel consumption at national level and sales figures from DUKES and so, in turn, it will affect the disparity between the DA carbon dioxide emissions from the constrained and unconstrained approaches. In 2012, the bottom-up method underestimates petrol and diesel consumption by less than 8%. This is considered well within the uncertainty of the factors used to derive the bottom-up estimates.

The trend in road transport carbon dioxide emissions for each DA and the UK calculated by the constrained and unconstrained methods across the time series is shown in 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 Webb et al., 2014.

Note that emissions of methane and nitrous oxide both at UK level and for the DAs are calculated directly from vehicle km data and emission factors, and then are also normalised to match the fuel sales data involved.

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 2013 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, 2014b), 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 (1992), but for later years (1995 to date) UK National Grid has provided data for regional gas use in the 73-732 MWh range. The UK National Grid source provides the closest data available for commercial and institutional consumers, but the total is lower than UK data reported by DECC (2014a). 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, 2014), Firmus Energy providing sales data for 2005 onwards (Firmus Energy, 2014), Energia (2014) and Vayu Ltd providing sales data for 2010 onwards (Vayu, 2014). 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 2013, 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 (2014a) 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 A2.12: Other Sectors (Base Year – 1990)

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

Table A2.13: Other Sectors (1995; 1998 to 2013)

[3] Used to calculate non-CO_2 emissions

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 2013), 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, 2014)
	Railways (Stationary)	Oil and coal	Regional gas oil consumption, Network Rail (GB) and Translink (NI)
		Natural gas	Assumed as all England
Residential	Domestic	Wood[4]	Domestic wood mapping grid
		Peat	Domestic peat consumption data, CEH
		SSF, coke, LPG	Sub-national energy statistics (SSF), DECC, 2009 mapping grid, using Housing Condition Survey data, NI HECA, DEMScot model, census data
		Natural gas	Domestic Gas sub-national split for GB from DECC, Transco & UK gas network operators, Data from Phoenix Gas, Vayu Ltd. and Firmus Energy (NI)
		Burning oil, gas oil,	Sub-national energy statistics (oil) from DECC, 2009 mapping grid using Housing Condition Survey data, NI HECA, DEMScot model, census.
		Coal, anthracite	Sub-national energy statistics (coal, anthracite), DECC, 2009 mapping grid using Housing Condition Survey data, NI HECA, DEMScot model, census.
		Fuel oil	Regional population, ONS
	House & Garden	DERV, petrol	Regional dwellings, ONS
Agriculture, Forestry & Fishing	Agriculture – stationary 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: 2014; Firmus Energy: 2014; Vayu Ltd.: 2014; Energia: 2014) and these data have been used to estimate the residential emissions in 2013. The gas use estimates for Scotland, Wales and England are derived from the DECC sub-national energy statistics (DECC, 2014a) 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, 2014a) 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 have been 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 2005-2013 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, 2013a). Domestic use of wood is estimated across the time-series using the latest mapping grid information on wood use (NAEI mapping, 2011). Domestic peat use estimates by DA are provided by the Centre for Ecology & Hydrology (Personal Communication: CEH, 2013).

A2.7.3 Agriculture, Forestry & Fisheries

Emissions from solid fuel use in the agriculture sector are not very significant, whilst regional gas use data in this sector are not available for Great Britain; in Northern Ireland the gas suppliers do provide an estimate of gas use in the agriculture sector and these data are used directly to inform Northern Ireland emission estimates for gas use, whilst in GB the emissions from agricultural sources are allocated on the basis of regional employment figures from DEFRA (2014a).

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

A2.7.4 Military

Emissions from military aircraft and naval vessels are allocated across the DAs based on regional GVA data (ONS, 2014a). 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 (2014), BGS (2014), WO (1998), SO (1999), BERR (1996). A small emission occurs from coal storage and transport, which is based on deep mined coal production. Data suggests that only small amounts of coal are transported outside of the region of production and no attempt has been made to allow for this. Hence coal storage and transport emissions are distributed according to deep-mined production (Coal Authority, 2014).

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 (2014e) EEMS data for 1995, 1998-2013. 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 2000-2013 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, 2014d). 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 1998-2013. 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 (2014) and the other gas network operators: Northern Gas Networks (2014), Scotia Gas Networks (2014), Airtricity (2014) and Wales & West Utilities (2014). Estimates are provided by Local Distribution Zones, enabling direct allocation to each of the constituent countries.

Table A2.14: 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 A2.15 Fugitive Emissions from Fuels (1995; 1998 to 2013)

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 2013b)
	Flaring	Coke oven gas	Coal feed to coke ovens, ISSB, WS, DECC and (1999-2004) PI. 2005 onwards: EU ETS (EA, SEPA, NIEA 2013b)
	SSF production	Coal, Petrocoke	Coal feed to SSF plant, DECC, WS
Oil and gas production	Offshore Oil & Gas	NA	Oil & Gas UK GHG emissions from Terminals, DECC EEMS
	Oil Terminal Storage	NA	Data from storage emissions, DECC EEMS
	Onshore Loading	Oil loaded	Data from loading emissions, DECC EEMS
Venting & Flaring	Flaring	Volume gas flared	Flaring at terminals and onshore fields, Oil & Gas UK, DECC
	Venting	NA	Data from venting emissions, DECC EEMS
Natural Gas	Gas Leakage	Natural gas leakage	National Grid (Transco), Northern Gas Networks, Scotia Gas Networks, Wales & West Utilities, 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 A2.8.

A2.9.1 Minerals Industries

Large emissions of carbon dioxide arise from the degradation of limestone used in cement and lime kilns. Cement emissions are estimated from the production of cement clinker, with regional emission estimations based on plant capacity data supplied by the British Cement

Association[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 2013 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. 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, 2014).

Limestone, dolomite and soda ash are also used in glass production. Emissions were previously disaggregated using plant capacity and carbon dioxide emissions data from British Glass for 1990, 1995, 1998 and subsequently extrapolated for 1999 and 2000. However, the improvement of data supplied via the Pollution Inventory (Environment Agency, 2014) 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 2013 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 2013 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 A2.16: 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
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	

[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
	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 A2.17: Industrial Processes (1995; 1998 to 2012)

IPCC Category	NAEI Sources	Activity Data	Data used for deriving DA estimates from UK totals / Comments
Cement Production	Cement (decarbonising)	Clinker production	Point source data from 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	

IPCC Category	NAEI Sources	Activity Data	Data used for deriving DA estimates from UK totals / Comments
	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 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 are 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 (Environment Agency, 2014a), SPRI (SEPA, 2014a) 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.

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, 2014).

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, 2014) up to 2004, and then using plant-specific data from the EU ETS for 2005 onwards (EA, SEPA, NIEA 2014b) verified using data from operators (Tata, 2013).

Emissions of carbon dioxide from iron and steel making are estimated from a mass balance on the coke consumed in blast furnaces; the blast furnace gas produced; the pig iron produced; the pig iron used in steel making and the crude steel produced. The emissions are distributed using appropriate drivers for each source and sink taken from ISSB (2014) 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 (2004), for years up to 2002. The DA emissions data for 2003 onwards are based on PI and SPRI data (EA, 2014a; SEPA, 2014a). 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 are 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, 2014).

A2.9.4 Use of Halocarbons and Sulphur Hexafluoride

The UK emissions of halocarbons and sulphur hexafluoride (SF_6) were based on estimates from a model prepared initially by Enviros March (1999). This model was updated by Ricardo-AEA (Haydock et al, 2003), with further updates at UK level for the refrigeration and air conditioning sectors during 2008-9 (Personal Communication: MacCarthy, 2010) and again during 2011 (Brown et al, 2012). For some sources, the emission is equal to the consumption of fluid (e.g. aerosols). For other sources the emissions occur during product manufacture, leakage during product lifetime, and at product disposal (e.g. refrigerators). In these cases emissions are estimated from a time dependent model of the bank of fluid held in products, accounting for unit production and disposal.

Data for HFC emissions from metered dose inhalers in the UK are now taken from NHS prescription records which are available for each DA (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 (2014a). 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-AEA 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-AEA model (2003), with all production located in England & Wales.

Emissions data for regional emissions from semiconductor wafer manufacture are estimated from manufacturing data and consultation with relevant trade associations, and incorporated within the Ricardo-AEA model (2003). Within the 1990-2013 GHG inventories, for the first time this source includes 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

Annual consumption of synthetic fertilizer is estimated based on crop areas from the Devolved Administrations[6] and the British Survey of Fertiliser Practice (plus country-specific data for Northern Ireland provided by Paul Caskie, DARDNI). Crop production data were provided by Lindsay Holmes and Jim Holding, DEFRA (England & Wales), Nicola Kerr, The Scottish Government and Conor McCormack, DARDNI.

Emissions include: the use of inorganic fertilizer, 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, mineralisation, 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 NOx and NH_3, emission of N_2O from leaching and run-off of agricultural nitrate.

For animal manures applied to land, the summation is for all animal types and manure previously stored in categories defined as a) liquid, b) deep bedding and c) poultry manure without bedding and poultry manure with bedding (bedding) and destined for incineration. Similarly, for urine and dung deposited by grazing animals, the IPCC default emission factor is used for pasture range and paddock and country specific data for the fraction of livestock N excreted and deposited onto soil during grazing.

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 emission factors. Emissions from the ploughing in of crop residues are calculated using the 2006 IPCC Guidelines methodology and IPCC default emission factors. Emissions from mineralisation refer of soil organic matter on land converted to Cropland more than 20 years ago.

The area of cultivated histosols is estimated at 285,700 ha. Indirect emissions of N_2O from the atmospheric deposition of ammonia and NOx are estimated according to the 2006 IPCC Guidelines. We also report CO_2 emissions from liming (data compiled by CEH) and from urea application (new source under the 2006 Guidelines).

A2.10.2 Livestock Enteric Fermentation and Manure Management

The dairy cattle emission factors (for dairy cows only) are estimated following the IPCC Tier 2 procedure (IPCC, 2000), using country-specific data for dairy cow live weight, milk yield, milk fat content, feed digestibility and activity (proportion of the year spent grazing) and vary from year to year.

Livestock population data are reported annually as statistical outputs of the four Devolved Administrations of the UK (i.e. England, Wales, Scotland and Northern Ireland), based on the annual June Agricultural Survey for each country[1]. Milk production and fat in milk are obtained from Agriculture in the UK (Defra, 2013), with common values used across the DAs. Dairy cows live weights 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 2008-2012 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. A country-specific value for the digestibility of feed (DE),

[6] England: https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june and Jennie Blackburn (DEFRA). Scotland: http://www.scotland.gov.uk/Resource/0045/00455080.xls; http://www.scotland.gov.uk/Resource/0043/00436132.xls and Graeme Kerr (The Scottish Government). Wales: http://wales.gov.uk/docs/statistics/2013/131128-survey-agricultural-horticulture-june-2013-en1.xls and John Bleasdale (Welsh Government). 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).Northern Ireland: http://www.dardni.gov.uk/june-agricultural-census-final-results and Paul Caskie, DARDNI

expressed as a percentage of the gross energy, for dairy cows is used of 74.5%. This value is on the high side of the IPCC (2006) default value for Western Europe of 55-75% for pasture fed animals, but is based on typical diets for cows over the lactating and non-lactating period, combining forage and concentrates, with energy values for the various feeds according to MAFF (1990). 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 this 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 considering options 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 other cattle. 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 2008-2012 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 timeseries and data for 2013 were estimated by applying the ratio of the existing UK slaughter data2 to the estimated beef live weights for 2008-2012. 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 EF (2006 IPCC Guidelines). The following eight groups are included: dairy cows, beef cows, 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 emission factor for enteric fermentation for all mature sheep (> 1 year old). The UK uses a country-specific emission factor for enteric fermentation for lambs at 40% of that of an adult sheep (Sneath et al. 1997) together with a reduction factor reflecting the reduced lifespan of lambs 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 emission factors for 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 (Bo) parameters for each livestock type (except for dairy and beef cows, where a Tier 2 calculation is used to determine VS), 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). For deer the IPCC default EF (2006 IPCC Guidelines) is used.

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).

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 2013.

Estimation of indirect N_2O emissions from manure management has been introduced to the 2006 IPCC Guidelines. N volatilisation from manure management systems has been calculated using Equation 10.27 (IPCC 2006 Guidelines), along with default fractions for N loss due to volatilisation of NH3 and NOx, disaggregated by manure management system (FracGasMS, 2006GL Table 10.22). Emissions of N_2O from the leaching/runoff associated with the storage of deep bedding as field heaps have been estimated using Equation 10.29 (IPCC 2006 Guidelines), using a country-specific Fracleach value of 0.03 (Nicholson et al., 2011).

A2.10.3 Reasons for changes

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

- Implementation of 2006 IPCC Guidelines;
- New source identified in the 2006 IPCC Guidelines, CO_2 emissions from urea application.

Further details can be found in Appendix 6.

A2.10.4 Planned improvements to the inventory

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

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

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

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

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

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

The Land Use, Land Use Change and Forestry (LULUCF) sector includes carbon stock changes, emissions of greenhouse gases (carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)) by sources and removals of CO_2 by sinks from land use, land use change and forestry (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 will be provided upon publication of the 1990-2013 UK Greenhouse Gas Inventory Report later in 2015, which will become available on the National Atmospheric Emissions Inventory website http://naei.defra.gov.uk/. Additional information on LULUCF and KP-LULUCF inventory reporting has been made available at http://ecosystemghg.ceh.ac.uk/.

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 has been revised and updated during the 1990-2013 inventory cycle. The methodology for calculating methane production in landfill sites has been updated. Waste composition and commercial and industrial waste data has been 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 will be provided in detail within the UK GHG National Inventory Report which will be published later in 2015.

The Ricardo-AEA 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.[7] 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 1990-2013 UK GHGI. The following section explains the method.

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

Local Authority Collected Waste (LACW)

- LACW estimates of landfilling by waste type are available for each country from 1995 to 2020.
- The time series of data were extrapolated back from 1995 and forward to 2013;
- The data time series was extrapolated back from 1995 for each country by applying the UK figures in MELMod pre-1995 to each country's share of overall LACW landfilling in 1995.
- The data time series was projected forward to 2013 by flat-lining.

Commercial and Industrial Waste (C&I[8])

- DA-specific C&I waste data is very limited or not available at all; the method uses the available estimates of overall UK compositions of C&I (and C&D) waste landfilled in different years, based on waste surveys, and combines the UK-wide data with DA-specific estimates of total landfilling of commercial, and industrial, waste for given years (interpolated from the available survey evidence).
- Using the estimates over country-specific landfilling of both commercial and industrial waste, and applying the estimated UK C&I landfill composition allows a calculation of country specific estimates of the quantity and type of waste landfilled.
- Due to data limitations, the Eunomia revision only went as far back as 1997. A similar backwards extrapolation to that for LACW was performed, according to each country's relative share of combined commercial and industrial landfilling in 1997.
- As the C&I estimates are not country-specific in the revision, forward projections to 2013 are estimated on a country basis by taking the most recent year's data (at the time of the revision) – 2008/09 – for each country's share of commercial, and industrial, landfilling, and multiplying by the assumed overall UK composition for that year.
- The estimation of country-specific C&D landfilling (which feeds into the 'C&I' section of MELMod) followed the same process as set out above for C&I.

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

A2.12.2 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 have been 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.

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, 2014a) 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

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

and sewage sludge treatment and disposal options are derived from operator information provided for the UK GHGI compilation process (UKWIR, 2014).

There has been some 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) has been 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 (2014a) 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, 2014a).

Emissions from clinical waste incineration are allocated to the regions based on a set of plant capacity data for 1998. Emissions data from chemical waste incineration are available for England and Wales only, based on data taken from the Pollution Inventory (Environment Agency, 2014a), and these data are used for the DA estimates also. Some chemical waste incineration takes place in Scotland but no emissions data are available, and hence the emissions contributed from this source are currently omitted from the Scottish inventory data. No chemical incinerators have been identified in Northern Ireland.

Appendix 3: Methods Used for Calculating End User Emissions

A3.1 Introduction

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

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

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

A3.2 End User Methodology

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

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

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

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

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

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

In order to allocate the energy supply emissions to all sources, additional estimates have been required for the disaggregation of electricity use, and for the exports[9] category. Table A3.1 summarises the data used to derive DA estimates for sector-specific electricity use and exports.

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

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

Assumptions for Electricity and Exports		
Source Name	Activity Name	Description
Public sector	Electricity	Northern Ireland public sector electricity use for 2003 onwards is taken from the Public Sector Energy Campaign dataset (DFPNI 2014), 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 2014 (for 2005 to 2013), December 2008 for 2003 and 2004, and from REEIO analysis for 1990. Scotland 1990 data are estimated by back-casting reported trends in domestic electricity use from the Scottish Housing Condition Survey. England, Wales and Northern Ireland data retain the % share from the REEIO analysis. No Northern Ireland data were available in the December 2014 Energy Trends, however, so the Northern Ireland domestic electricity in 2013 was estimated assuming that the domestic sector share of total NI electricity consumption was the same as in 2011.
Iron and steel - combustion plant, and Blast Furnaces	Electricity	Country-specific electricity use data for 2003 onwards is derived from ISSB regional energy statistics (ISSB, 2014), and 1990 electricity use is estimated from ISSB regional production statistics.
Railways	Electricity	The DfT Rail Emission Model indicates that there are no electrified lines in Wales or Northern Ireland, and has been used to estimate the UK share of total rail electricity use in England and Scotland.
Gas production	Electricity	Overall annual gas throughput via each of the Low Pressure Distribution Zones has been used as an indicator of regional electricity use in this sector. The LDZ throughput data are available from the gas network operators (National Grid, 2014; Northern Gas Networks, 2014; Wales and West Utilities, 2014; Scotia Gas, 2014, Airtricity, 2014).
Refineries - combustion	Electricity	Carbon dioxide emissions from refineries are used to estimate the DA share of UK sector electricity consumption. (UKPIA, 2014)
Collieries - combustion	Electricity	Regional coal production data are used to estimate the DA share of UK electricity use by collieries. (UK Coal Authority, 2014)
Exports	Electricity	DA data on electricity exports are published within the periodic DECC publication “Energy Trends”. However, we note that the data published are the “net” import-export balance and the actual data on electricity exports from England, Wales and Northern Ireland have been obtained through personal communication with the DECC energy statistics team in 2015. (Personal communication: Vanlint, 2015)
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 has been updated since the 1990-2012 DA GHG inventory report, with data and method improvements to further develop the DA end user estimates, to build upon new information and data. There have therefore been recalculations of the end user estimates as a result of these data updates. The key differences in the approach used for the DA end user calculation this year compared with last year are summarised below:

- Revisions to the total DA electricity sales data for 2012 are evident within DECC Energy Trends December 2014; the 2010-2012 total electricity use allocations for England and Northern Ireland have been revised;
- Electricity estimates for the public sector in 2012 and 2013 were revised based on new data from the Northern Ireland Public Sector Energy Campaign (DFPNI, 2014);
- New information on electricity exports to the EU from Wales (to the Republic of Ireland) have become available from DECC, indicating that Wales has been exporting electricity since 2012.

A3.3.1 End User Analysis by National Communication Sector

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

Note that the application of UK-wide factors to derive end user emission estimates for electricity consumption in the UK has a notable impact on the re-distribution of power sector emissions from the by source inventory dataset, and affects the comparisons with overall DA source emissions. For example, the power sector emissions in Scotland in the by source inventory are lower per unit GWh generated than the rest of the UK, but a UK-wide factor is applied to all UK electricity consumption. This leads to an oddity in the comparison of by source and end user emissions, as Scotland in 2013 is a net exporter of electricity, but a net importer of electricity-related emissions in the end user model.

Business

The business sector includes industrial and commercial energy use sources, in addition to a number of non-energy sources such as the use of fluorinated gases. Across the UK in 2013 the end user estimates for the business sector are 196% 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 2013 in the by source inventory the business sector represents 16% 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 2013 the UK end user estimates for the residential sector are 181% 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 2013 in the by source inventory the residential sector represents 14% of national GHG emissions, but on an end user basis this increases to 25%, highlighting the importance of the residential sector for energy efficiency policy implementation.

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

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

Public Sector

This sector contains emissions from the combustion of fuel, and electricity use, within the public sector. The percentage increase in the end users data compared to the by source data for the public sector is 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 2013 the UK public sector only represents 3.2% of the national GHG emissions total.

Transport

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

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

Other Sectors

Emissions from the Land Use, Land Use Change and Forestry (LULUCF) and Waste Management sectors are unchanged between the by source and end user approaches, since there are no emissions from energy use allocated to these sources. The end user increment within the Industrial Process sector is limited to the use of fuels in ammonia production (feedstock use of natural gas), and iron and steel (where emissions are allocated to process use, rather than combustion). For Agriculture, the increase in emissions using the end user approach is limited to the emissions from energy use within the sector.

A3.3.1 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 2013, 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, 2006-2013, $MtCO_2e$

NC Category	2006	2007	2008	2009	2010	2011	2012	2013
Agriculture	0.30	0.30	0.30	0.27	0.28	0.26	0.27	0.24
Business	6.58	6.36	6.18	5.19	5.34	5.09	5.40	5.10
Energy Supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.00	0.00	0.00	0.00	0.00	0.00	0.07	1.11
Industrial Process	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Public	0.49	0.51	0.50	0.45	0.44	0.41	0.45	0.40
Residential	3.37	3.14	3.06	2.82	2.86	2.58	2.87	2.62
Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wales Total	**10.74**	**10.32**	**10.04**	**8.73**	**8.93**	**8.34**	**9.06**	**9.46**

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 industry, the commercial sector, public sector and residential sector;
- transport emissions;
- agricultural emissions;
- Land Use Change and Forestry emissions / sinks;
- Waste sector emissions.

The small-scale fuel combustion sources are usually sources where comprehensive accurate data on energy use and / or emissions are not available at DA level. DA emissions in the traded sector are much more certain, since the mechanism for trading requires site-specific reporting of detailed emissions, activity and emission factor data. The current approach to deriving the non-traded fuel combustion emission estimates is therefore by difference from the total DA GHG inventory for energy emissions and the 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 2013 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. The EU ETS data for 2013 onwards are now Phase III, which is a slightly larger scope than in Phase II (2008-12); however, the overall increase in emissions covered within EU ETS is not significantly greater in the UK in Phase III compared to Phase II as only a small number of additional installations and process sources are within EU ETS now, compared to Phase II.

A4.2 Data Quality and Reporting Format Issues

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

Sector activity data (fuel use, mineral use) from the 2013 EU ETS are analysed against the data reported in the national energy statistics within DUKES, and EU ETS fuel quality information by sector are used within the derivation of UK GHGI estimates for several high-emitting sectors. Direct comparison of EU ETS data and alignment with DUKES sectors and GHG inventory IPCC sector reporting format is problematic for a number of reasons:

- **Disparity between EU ETS and national activity statistics**. For most economic sectors, the EU ETS does not cover 100% of sites and fuel use in the UK, and therefore the sum of EU ETS activity data for most sectors is expected to be lower than the national statistics published by DECC DUKES (for energy use) and the British Geological Survey (for mineral use such as limestone, dolomite, clays). There were several industrial sectors where large differences were evident in the 2013 fuel allocations within DUKES, compared to the data reported by operators under EU ETS. The activity data from EU ETS are generally considered to be of good quality, having been subject to a rigorous data checking and verification process. The EU ETS does not always cover 100% of sites within a sector, however. *There were a number of instances where the EU ETS fuel use data were higher than the data reported within DUKES; source-activity combinations where EU ETS data were therefore used within the UK and DA GHG inventory compilation, deviating from the national statistics included refinery and industrial use of other petroleum gases (OPG), upstream oil and gas use of liquefied petroleum gas (LPG) and OPG.*
- **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 2008-2013, 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 (2008-2013)

The traded and non-traded emission estimates for each of the DAs for 2008 to 2013 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, 2008-2013

Country	Emissions scope (all units: kt CO_2e)	2008	2009	2010	2011	2012	2013
ENGLAND	Traded Emissions	193,390	168,549	169,373	160,313	169,199	160,785
	Non-Traded Emissions	308,174	287,169	295,373	270,321	275,496	267,659
	Total inventory emissions	501,564	455,718	464,746	430,634	444,695	428,443
	Traded Share	*38.6%*	*37.0%*	*36.4%*	*37.2%*	*38.0%*	*37.5%*
SCOTLAND	Traded Emissions	23,765	21,962	24,041	20,056	20,349	19,434
	Non-Traded Emissions	37,446	34,930	34,951	32,176	32,193	31,124
	Total inventory emissions	61,211	56,892	58,992	52,232	52,543	50,558
	Traded Share	*38.8%*	*38.6%*	*40.8%*	*38.4%*	*38.7%*	*38.4%*
WALES	Traded Emissions	26,611	21,846	24,069	22,616	24,705	29,644
	Non-Traded Emissions	24,584	22,643	23,152	21,427	21,313	21,117
	Total inventory emissions	51,196	44,489	47,221	44,043	46,018	50,761
	Traded Share	*52.0%*	*49.1%*	*51.0%*	*51.4%*	*53.7%*	*58.4%*
N IRELAND	Traded Emissions	5,864	4,332	4,627	4,383	4,505	4,708
	Non-Traded Emissions	18,222	18,039	18,743	17,737	17,862	17,671
	Total inventory emissions	24,086	22,370	23,370	22,120	22,367	22,379
	Traded Share	*24.3%*	*19.4%*	*19.8%*	*19.8%*	*20.1%*	*21.0%*
UNALLOCATED	Traded Emissions	15,231	15,064	15,124	13,356	12,327	12,415
	Non-Traded Emissions	1,832	2,093	1,940	1,966	2,327	1,910
	Total inventory emissions	17,064	17,157	17,064	15,322	14,654	14,325
	Traded Share	*89.3%*	*87.8%*	*88.6%*	*87.2%*	*84.1%*	*86.7%*
UNITED KINGDOM	Traded Emissions	264,861	231,753	237,234	220,723	231,085	226,985
	Non-Traded Emissions	390,259	364,874	374,158	343,627	349,192	339,482
	Total inventory emissions	655,120	596,627	611,392	564,351	580,276	566,467
	Traded Share	*40.4%*	*38.8%*	*38.8%*	*39.1%*	*39.8%*	*40.1%*

A4.2.2 Analysis of Emissions 2008-2013

- 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 40% in 2008, down to 39% 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 12.5% 2008-9) than the non-traded emissions (down 6.5% 2008-9). As the economy then picked up in 2009-10 combined cold winters at the start and end of 2010, the non-traded emissions grew at a 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 7-8% and then increased between 2011 and 2012, with traded emissions increasing by almost 5% and non-traded by 2%. In 2012-13, traded emissions have fallen slightly, by 1.8%, with a greater fall in non-traded emissions at down 2.8%.
- In **Northern Ireland**, the non-traded share of GHG emissions declined by only 1% between 2008-2009, and then grew by only 4% in 2009-10; note that there is greater uncertainty in the non-traded emission estimates in Northern Ireland due to the much greater reliance on solid and liquid fuel use within the economy, the estimates of which are more uncertain than those for metered fuels (gas, electricity). Nevertheless, this notably lower reduction in the non-traded share in Northern Ireland in 2008-9 and lesser growth in 2009-10 may reflect the greater impact on emissions related to the energy-intensive industries evident in GB, where a lesser demand for fuels within a shrinking UK economy would be expected to have a knock-on effect to ancillary services to the energy sector (for example, a reduction in energy and heavy industry transport-related emissions, which are within the non-traded sector). Trends in the non-traded sector since 2010 are similar to the UK with a 5% reduction to 2011, a 1% growth to 2012 and then a 1% decline to 2013 (compared to a UK decline of 2.8%)
- The data for **Wales** show that the coverage of the EU ETS is consistently higher than the UK average, which reflects the high share of heavy industries in Wales; Wales exports electricity to England and has a high percentage of UK refinery capacity and iron and steel manufacture. As a result, the non-traded sector in Wales (which is the focus for WG Climate Change Strategy policy actions and targets) is around 50% of total GHG emissions, compared to the UK average of around 40% of emissions in the non-traded sector.
- In 2007 (the last year of Phase I of the EU ETS) the non-traded share of **Wales** carbon dioxide emissions was estimated to be around 48% of the total inventory; the expansion of the coverage of sites and sources within EU ETS in Phase II of the scheme (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 an estimated 58% of the Wales GHGI total. 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 14% of UK refinery sector emissions in 2013 whilst oil and gas terminals in Scotland account for 54% of total UK onshore sector traded emissions.
- The **Northern Ireland** inventory has a much higher non-traded element compared to GB, with only 21% of inventory emissions within the EU ETS in 2013, compared to the 40% UK average; this reflects the lower level of heavy industry in Northern Ireland, where there are no refineries, oil & gas terminals or iron and steel works for example. Analysis of the 2013 EU ETS data shows that Northern Ireland has a 2.8% share of the power sector traded emissions, whilst the only sectors where Northern Ireland has a higher share are in the cement sector (3.3% of UK sector traded emissions), glass sector (3.8% of UK sector emissions), food and drink sector (4.7% of UK sector emissions) and the other industrial combustion sector (3.0% of UK sector traded emissions) in 2013.

- **England** traded share of emissions is around 38% of the inventory total in recent years, which is a few percentage lower than the UK average of around 40%. There are many industrial and commercial sectors where England has a high share of the UK traded emissions in 2013; for example, sites in England account for 78% of power generation EU ETS emissions, 86% of public sector traded emissions, 83% of food and drink sector traded emissions and 76% of cement sector traded emissions. England has a lower representative share of EU ETS emissions in the iron and steel sector (60%), refinery (63%) and (onshore) oil & gas sectors (44%), reflecting the high incidence of such sites in Wales and Scotland.

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

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

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

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)
			Other industrial 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
		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 aplications	N2O use as an anaesthetic
		5C2.2b Non-biogenic: Other	Accidental fires - other buildings
	Refrigeration and air conditioning	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
		2F1f Stationary air conditioning	Stationary Air Conditioning
		2F6b Other Applications: Contained-Refrigerant containers	Refrigerant containers
	Use of fluorinated gases	2E1 Integrated circuit or semiconductor	Electronics - HFC
			Electronics - NF3
		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
		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
	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
		2D3 Non-energy products from fuels and solvent use: Solvent Use	Solvent use
Agriculture	Crop growing and fertilizer 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
	Field burning of agricultural wastes	3F Field burning	Field burning

Sector	Graph Categories	IPCC sectors	Source Name
	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
		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 goats and deer 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
			Miscellaneous industrial/commercial combustion
		1A4cii Agriculture/Forestry/Fishing: Off-road	Agriculture - mobile machinery
		2D1 Lubricant Use	Agricultural engines
	Urea application	3H Urea application	Agriculture - application of urea
Land Use Change	Creation and maintenance of forests	4A Forest Land (Biomass Burning - wildfires)	Forest Land - Biomass Burning\Wildfires
		4A Forest Land (organic soils drainage)	Forest Land - Drainage of Organic Soils
		4A1 Forest Land Remaining Forest Land	Forest Land remaining Forest Land
		4A2 Forest Land-Direct N2O emission from N fertilisation	Direct N2O emission from N fertilisation of forest land
		4A2 Land Converted to Forest Land	Land converted to Forest Land
	Creation and maintenance of settlements	4E Settlements (Biomass burning - controlled)	Settlements - Biomass Burning\Controlled Burning
		4E Settlements-Direct N2O emission from N fertilisation	Settlements - Direct N2O Emissions from N Mineralization/Immobilisation
		4E1 Settlements remaining settlements	Settlements remaining Settlements
		4E2 Land converted to settlements	Land converted to Settlements
	Land converted to grass, crop and/or wetlands	4B Cropland (Biomass Burning - controlled)	Cropland - Biomass Burning\Controlled Burning
		4B2 Land Converted to Cropland	Direct N2O Emissions from N Mineralization/Immobilisation
			Land converted to Cropland
		4C Grassland (Biomass burning - controlled)	Grassland - Biomass Burning\Controlled Burning
		4C Grassland-Direct N2O emission from N Mineralization/Immobilization	Grassland - Direct N2O Emissions from N Mineralization/Immobilisation
		4C2 Land converted to grassland	Land converted to Grassland
		4D2 Land converted to wetlands	Land converted to Wetland
		4D2 Non-CO2 emissions from drainage of soils and wetlands	Non-CO2 emissions from drainage of soils and wetlands
	Land maintained as crops, grass and wetlands	4B Cropland (Biomass Burning - wildfires)	Cropland - Biomass Burning\Wildfires
		4B1 Cropland Remaining Cropland	Cropland remaining Cropland
		4B2 4(III) Direct N2O Emissions from N Mineralization/Immobilization	Cropland - Drainage and rewetting and other management of organic and mineral soils
		4C Grassland (Biomass Burning - wildfires)	Grassland - Biomass Burning\Wildfires
		4C Grassland Drainage rewetting other management of organic and mineral soils	Grassland - Drainage and rewetting and other management of organic and mineral soils
		4C1 Grassland Remaining Grassland	Grassland remaining Grassland
		4D1 Wetlands remaining wetlands	Wetlands remaining Wetland
	Wood products	4G Harvested wood products	Harvested Wood Products
Waste Management	Biological treatment	5B1a composting municipal solid waste	Total composting (non-household)

Sector	Graph Categories	IPCC sectors	Source Name
		5B2a Anaerobic digestion municipal solid waste	Anaerobic Digestion (other)
			Mechanical Biological Treatment
	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 decomposistion in private systems
			Sewage sludge decomposition
		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
	International shipping	Marine Bunkers	Shipping - international IPCC definition
			Shipping between UK and Gibraltar
			Shipping between UK and OTs (excl. Gib)

Appendix 6: Recalculations between last year's (2014) and this year's (2015) Devolved Administrations' Greenhouse Gas estimates

This provides details of recalculations between 1990-2012 Devolved Administrations' (DA) greenhouse gas (GHG) Inventory estimates (Salisbury et al., 2014) and the latest 1990-2013 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 1990-2013 DA GHGI datasets, the inventory methods and data sources for several GHG emission source sectors have been revised and improved.

This is the first year for which the inventory has been compiled using the 2006 IPCC Guidelines (IPCC, 2006), and reported using the revised UNFCCC reporting guidelines. This has led to changes in the global warming potential (GWP) values used for all Kyoto greenhouse gases in line with the IPCC's Fourth Assessment Report. This has also led to the inclusion of new sources, and changes to methodologies and emission factors.

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 (2014) and this year's (2015) GHG estimates for 2012, by Sector

		England		Scotland		Wales		Northern Ireland	
Total Change ($ktCO_2e$ and %)		2,970 **0.62%**		2,044 **3.86%**		192 **0.41%**		1,401 **6.51%**	
Sector	Reasons for change	Significance of change (%, 2012)	Change in emissions for 2012 ($ktCO_2e$)	Significance of change (%, 2012)	Change in emissions for 2012 ($ktCO_2e$)	Significance of change (%, 2012)	Change in emissions for 2012 ($ktCO_2e$)	Significance of change (%, 2012)	Change in emissions for 2012 ($ktCO_2e$)
Agriculture	Emission factors and methodologies have been updated from the 1996 IPCC Guidelines to the 2006 IPCC Guidelines. The effect of these changes is dependent on the relative importance of livestock vs. crop sectors in each DA. Livestock emissions have, through the various changes under 2006 IPCC Guidelines, increased whilst emissions from crops have decreased.	30%	-3,506.13	19%	535.82	10%	123.07	10%	217.58
Business	Implementation of a revised time-series for the group of petroleum fuels that are regarded as non-energy use (NEU) due to their use in petrochemical manufacture, which led to an increase in emissions in all years. There has also been incorporation of Phase III ETS data which has led to improvements in the completeness and allocation of the inventory for chemical sites.	15%	1,700.42	12%	349.31	24%	-304.55	0%	-7.26
Energy Supply	DUKES allocation for gas use in energy industries has been revised up significantly, which re-allocates emissions (across all DAs) to the Energy Supply sector. In addition, the allocation of emissions from Lynemouth coal-fired power station has been corrected (from autogeneration to power generation) to be consistent with DUKES. This reduces the power sector allocation in England and slightly increases the power sector emissions in Wales, Scotland and Northern Ireland.	4%	484.69	13%	364.70	29%	367.53	2%	39.25
Exports	Minor changes to the quantity of fuel allocated to international aviation.	0%	53.28	1%	31.97	0%	0.83	0%	7.62
Industrial Process	A review of the IPPU sector to ensure consistency with the 2006 IPCC guidelines has resulted in a number of changes. Several sources have been included for the first time, such as: use of carbonates and other carbonaceous materials in brick-making; titanium dioxide manufacture; non-coke related emissions for soda ash manufacture. In addition, several emission sources have been re-allocated from the Energy sector (OPG, coke and petcoke use in several industries: NFM, chemicals) and emissions from use of lubricants.	6%	688.28	0%	-3.79	3%	-35.96	0%	0.54

		England		Scotland		Wales		Northern Ireland	
Total Change ($ktCO_2e$ and %)		2,970 **0.62%**		2,044 **3.86%**		192 **0.41%**		1,401 **6.51%**	
Sector	Reasons for change	Significance of change (%, 2012)	Change in emissions for 2012 ($ktCO_2e$)	Significance of change (%, 2012)	Change in emissions for 2012 ($ktCO_2e$)	Significance of change (%, 2012)	Change in emissions for 2012 ($ktCO_2e$)	Significance of change (%, 2012)	Change in emissions for 2012 ($ktCO_2e$)
Land Use Change	Revised data has become available on the area of Cropland and improved Grassland on drained organic soils. Previously data on the area of drained organic soils was only available for Cropland in England. This has enabled emissions from improved Grassland on drained organic soils to be reported for the first time, and allowed more complete reporting on emissions from Cropland on drained organic soils. There has also been refinement to the CARBINE input data for areas of deforestation due to better activity data derived from the National Forest Inventory leading to decreases in Wales. Emissions of nitrous oxide from soil mineralisation following land use change and drainage of Forest soils have been estimated for the first time which as increased reported emissions.	2%	173.28	23%	650.02	11%	-144.51	60%	1,355.36
Public	Significant reductions in the DUKES allocation of natural gas to the public sector has led to lower emission estimates across England, Scotland and Wales (as Northern Ireland gas use for public sector is reported directly).	6%	-682.46	4%	-128.18	4%	-53.31	0%	-1.40
Residential	Natural gas data have been revised in DUKES. Also the estimation method for domestic combustion of non-gas fuels (i.e. coal, oil, SSF) has been revised to incorporate more detailed data on primary and secondary fuels from 2011 census data, scaled across 2005-2013 using DA-specific housing stock data. The time series back to 1990 has been revised on the basis of the 2005-2012 revisions to maintain time series consistency. Emission estimates for carbon dioxide from detergents have been removed since this is not identified as a source in 2006 IPCC Guidelines.	4%	419.90	10%	-272.91	0%	4.91	18%	-413.56
Transport	Estimates of emissions from domestic aviation have been increased through method improvements including revisions to flight distance calculations, which impact upon the estimated domestic-international split for consumption of aviation turbine fuel. Minor reductions for rail due to availability of fuel consumption data for both passenger and freight trains for the years 2011, 2012 and 2013, and a reduction in the quantity of fuel oil allocated to railway stationary combustion.	1%	-90.43	3%	79.42	1%	-10.20	2%	38.83
Waste Management	New data on landfill methane flaring from site operators and regulators has improved methane recovery data. The method to estimate methane formation within landfills has been improved to incorporate new data, e.g. revised biodegradability content and waste composition, revised decay rates and revised assumptions on landfill gas engine efficiency. The industrial waste water treatment method was revised to be consistent with 2006 IPCC Guidelines and a calculation error identified and corrected, which	32%	3,729.10	15%	437.95	19%	244.59	7%	163.78

		England		Scotland		Wales		Northern Ireland	
Total Change ($ktCO_2e$ and %)		2,970 **0.62%**		2,044 **3.86%**		192 **0.41%**		1,401 **6.51%**	
Sector	Reasons for change	Significance of change (%, 2012)	Change in emissions for 2012 ($ktCO_2e$)	Significance of change (%, 2012)	Change in emissions for 2012 ($ktCO_2e$)	Significance of change (%, 2012)	Change in emissions for 2012 ($ktCO_2e$)	Significance of change (%, 2012)	Change in emissions for 2012 ($ktCO_2e$)
	increased emissions across the time series for this source. Domestic waste water treatment and sludge disposal estimates have also been revised to comply with the 2006 IPCC Guidelines and to include new data from water companies; the main change is an increase in methane emission estimates for the early part of the time series for all DAs.								

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 (2013)
- Energy generation data for each Devolved Administration by fuel type (2006-2013)
- Generation of electricity from renewable sources for each Devolved Administration by source type (2013)
- Carbon dioxide emissions data for the two methodological approaches presented for Road Transport (1990-2013)

Table A7.1 – Methane emissions from livestock by type ($ktCO_2e$, 2013)

	England	Scotland	Wales	Northern Ireland
Cattle	11,673	3,695	2,393	3,381
Deer	10.7	3.05	0.49	1.34
Goats	11.0	0.55	1.44	0.44
Horses	396	39	48	17.4
Pigs	681	51.5	4.22	80.0
Poultry	61.5	7.01	4.02	9.06
Sheep	1,951	884	1,209	251

Table A7.2 – Energy generation data from Major Power Producers for each Devolved Administration by fuel type (GWh, 2006-2013)

	2006	2007	2008	2009	2010	2011	2012	2013
England	273,714	279,551	264,268	259,093	266,462	255,071	252,766	246,651
Coal	116,263	111,318	97,310	79,473	81,542	86,485	115,105	105,319
Gas	98,220	118,370	129,165	125,415	135,063	111,346	73,773	71,466
Nuclear	54,300	45,001	30,327	46,295	41,315	46,725	49,214	47,785
Oil	2,158	2,469	3,793	3,484	1,992	862	933	563
Renewables & Hydro	2,773	2,393	3,673	4,426	6,550	9,653	13,741	21,518
Northern Ireland	9,786	8,563	9,234	7,629	7,128	7,320	6,573	6,706
Coal	2,701	1,833	2,040	1,371	1,817	1,414	2,367	2,606
Gas	6,799	6,576	6,537	5,642	4,840	5,301	3,609	3,457
Nuclear	0	0	0	0	0	0	0	0
Oil	286	154	334	78	73	52	44	21
Renewables & Hydro	0	0	323	538	398	553	553	622
Scotland	44,343	41,338	44,055	44,198	43,401	44,275	44,214	46,155
Coal	17,488	13,802	11,591	11,896	14,653	10,728	11,867	10,802
Gas	8,346	8,938	9,822	7,430	6,618	6,227	3,680	3,497
Nuclear	14,141	12,344	15,079	16,681	15,293	16,892	17,050	18,498
Oil	914	379	431	278	206	160	155	161
Renewables & Hydro	3,454	5,875	7,132	7,913	6,631	10,268	11,462	13,197
Wales	29,576	27,111	33,563	27,762	27,646	22,741	21,672	21,293
Coal	8,859	5,121	9,364	6,547	5,929	6,170	10,824	11,478
Gas	13,272	15,461	16,059	14,111	15,227	9,880	5,167	3,985
Nuclear	7,010	5,684	7,080	6,122	5,532	5,364	4,141	4,326
Oil	0	0	0	0	0	0	0	0
Renewables & Hydro	435	845	1,060	982	958	1,327	1,540	1,504

Table A7.3 – Generation of electricity from renewable sources, GWh, 2013 (DECC, 2014g)

	Wind	Wave and tidal	Solar PV	Hydro	Landfill gas	Sewage gas	Other bioenergy	Total
England	14,233.9	0.2	1,720.6	83.5	4,344.8	685.3	11,349.1	32,417.4
Scotland	11,145.3	2.5	92.4	4,366.0	562.8	30.2	768.2	16,967.4
Wales	1,702.0	-	115.3	227.5	200.5	45.1	373.4	2,663.8
Northern Ireland	1,345.2	3.1	26.9	21.1	60.5	0.7	73.3	1,530.7

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 57 of the December 2014 Energy Trends publication from DECC (DECC 2014b), 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.

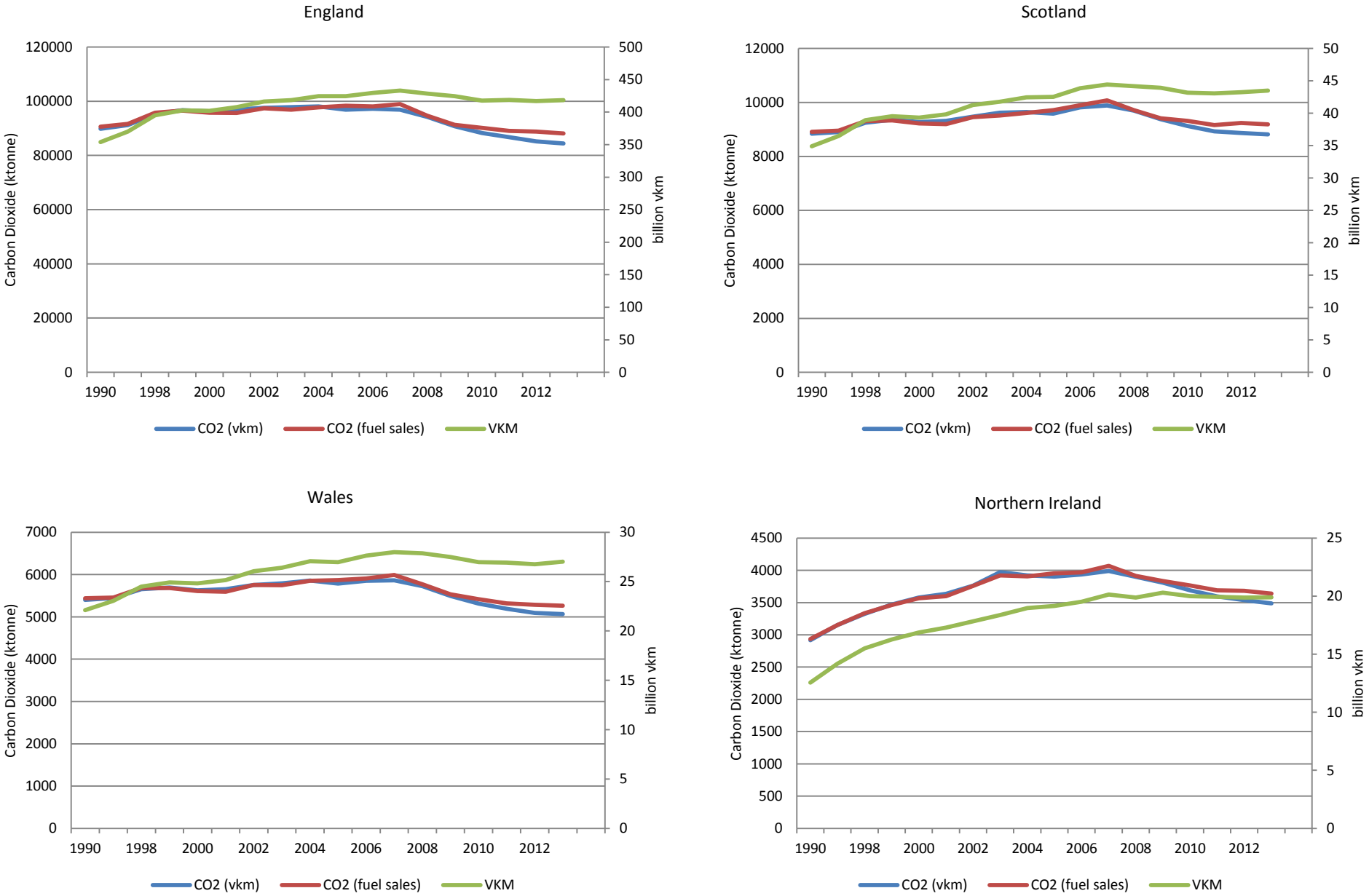
Table A7.4 – Carbon dioxide emissions data for the two methodological approaches presented for Road Transport (1990-2013)

England		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
CO_2 (vkm)	Cars	59,415	60,235	61,984	62,634	61,872	61,838	62,232	61,241	61,123	60,179	59,687	58,488	56,723	55,372	52,686	51,622	50,485	49,121
	LGVs	7,902	8,958	10,390	10,525	10,699	10,991	11,118	11,568	12,075	12,309	12,675	13,106	12,705	12,346	12,390	12,589	12,703	13,037
	HGVs	19,305	18,784	19,378	19,888	19,968	20,446	20,301	20,807	20,688	20,092	20,459	20,744	20,557	18,801	19,083	18,668	18,418	18,585
	Buses	2,718	2,911	3,073	3,211	3,244	3,251	3,384	3,686	3,715	3,798	3,908	4,023	3,760	3,730	3,715	3,444	3,169	3,238
	Motorcycles	534	366	430	474	470	491	512	565	518	540	515	547	498	504	446	444	427	404
	TOTAL	89,875	91,253	95,255	96,733	96,253	97,017	97,548	97,867	98,119	96,917	97,245	96,908	94,243	90,753	88,320	86,768	85,203	84,385
CO_2 (fuel sales)	Cars	59,414	59,071	61,381	62,605	62,403	62,157	63,126	61,927	62,147	61,799	60,849	60,505	58,973	56,668	54,135	53,189	52,413	51,255
	LGVs	7,902	8,874	10,355	10,523	10,721	11,003	11,146	11,587	12,101	12,345	12,702	13,151	12,752	12,371	12,417	12,618	12,739	13,076
	HGVs	20,005	20,444	20,567	19,719	18,963	18,788	19,251	19,107	19,290	19,842	20,142	20,717	18,660	17,982	19,482	19,378	20,065	20,088
	Buses	2,718	2,911	3,073	3,211	3,244	3,251	3,384	3,686	3,715	3,798	3,908	4,023	3,760	3,730	3,715	3,444	3,169	3,238
	Motorcycles	534	358	425	474	475	494	521	572	529	559	529	573	527	521	465	466	454	434
	TOTAL	90,573	91,658	95,801	96,533	95,806	95,694	97,429	96,879	97,781	98,344	98,130	98,968	94,673	91,273	90,214	89,095	88,839	88,090
Scotland		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
CO_2 (vkm)	Cars	5,670	5,714	5,820	5,849	5,776	5,774	5,890	5,821	5,827	5,732	5,795	5,686	5,533	5,402	5,127	5,003	4,939	4,821
	LGVs	786	891	1,080	1,103	1,089	1,108	1,137	1,184	1,225	1,256	1,311	1,378	1,352	1,318	1,331	1,343	1,362	1,399
	HGVs	1,985	1,894	1,919	1,951	1,945	1,970	1,937	2,064	2,071	2,057	2,160	2,228	2,240	2,078	2,091	2,038	2,050	2,065
	Buses	374	385	407	428	436	441	476	514	490	504	518	557	540	542	551	515	484	501
	Motorcycles	29	22	25	28	28	29	33	37	35	35	34	36	35	35	31	32	31	30
	TOTAL	8,844	8,905	9,251	9,359	9,274	9,322	9,472	9,621	9,649	9,583	9,817	9,885	9,700	9,376	9,131	8,932	8,866	8,816
CO_2 (fuel sales)	Cars	5,670	5,606	5,765	5,846	5,824	5,803	5,972	5,885	5,923	5,883	5,905	5,877	5,746	5,524	5,263	5,150	5,121	5,022
	LGVs	786	883	1,076	1,103	1,091	1,109	1,140	1,186	1,228	1,259	1,314	1,383	1,357	1,321	1,334	1,346	1,366	1,404
	HGVs	2,057	2,061	2,037	1,935	1,848	1,810	1,836	1,896	1,931	2,031	2,126	2,225	2,034	1,987	2,135	2,116	2,233	2,232
	Buses	374	385	407	428	436	441	476	514	490	504	518	557	540	542	551	515	484	501
	Motorcycles	29	21	24	28	28	30	33	37	36	36	34	38	37	36	33	33	33	32
	TOTAL	8,916	8,956	9,309	9,339	9,227	9,193	9,458	9,518	9,608	9,714	9,898	10,080	9,713	9,411	9,315	9,160	9,237	9,191

Table A7.4 (continued) – Carbon dioxide emissions data for the two methodological approaches presented for Road Transport (1990-2013)

Wales		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
CO_2 (vkm)	Cars	3,638	3,675	3,742	3,774	3,722	3,725	3,802	3,781	3,819	3,735	3,755	3,698	3,588	3,473	3,293	3,216	3,142	3,079
	LGVs	510	578	668	684	694	711	735	767	800	817	841	866	853	833	843	851	854	879
	HGVs	1,057	1,001	1,044	1,024	995	1,002	986	995	998	985	996	1,033	1,030	933	927	892	882	886
	Buses	172	172	178	189	193	193	202	220	216	222	233	240	230	229	227	206	191	198
	Motorcycles	25	18	21	23	24	24	26	28	26	28	26	28	27	27	23	24	23	22
	TOTAL	5,402	5,444	5,653	5,694	5,627	5,654	5,752	5,790	5,859	5,785	5,852	5,865	5,728	5,494	5,313	5,190	5,092	5,064
CO_2 (fuel sales)	Cars	3,638	3,605	3,707	3,772	3,752	3,743	3,854	3,821	3,879	3,829	3,824	3,818	3,721	3,549	3,378	3,307	3,254	3,203
	LGVs	510	573	666	684	696	712	737	768	802	819	843	869	856	835	845	853	857	882
	HGVs	1,096	1,089	1,108	1,016	945	921	935	913	931	972	981	1,032	935	892	946	926	961	958
	Buses	172	172	178	189	193	193	202	220	216	222	233	240	230	229	227	206	191	198
	Motorcycles	25	17	20	23	24	25	26	28	27	29	27	29	28	28	24	25	25	24
	TOTAL	5,440	5,457	5,680	5,684	5,609	5,592	5,755	5,750	5,854	5,871	5,908	5,988	5,771	5,532	5,420	5,318	5,286	5,265
Northern Ireland		1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
CO_2 (vkm)	Cars	2,275	2,458	2,589	2,684	2,758	2,778	2,733	2,735	2,823	2,805	2,786	2,822	2,701	2,769	2,664	2,601	2,559	2,500
	LGVs	116	136	152	159	165	169	240	246	230	227	261	254	294	235	217	221	220	226
	HGVs	490	519	541	578	600	635	737	933	811	811	836	851	844	738	747	702	695	696
	Buses	30	34	36	39	43	45	42	43	45	46	39	48	47	55	50	59	55	57
	Motorcycles	7	6	8	9	9	10	11	15	13	14	14	16	14	14	12	12	11	10
	TOTAL	2,918	3,152	3,326	3,470	3,576	3,637	3,763	3,971	3,922	3,903	3,936	3,990	3,900	3,811	3,690	3,595	3,538	3,488
CO_2 (fuel sales)	Cars	2,275	2,413	2,566	2,683	2,779	2,790	2,765	2,760	2,862	2,867	2,830	2,901	2,790	2,822	2,725	2,667	2,641	2,594
	LGVs	116	135	152	159	165	170	241	246	230	227	261	254	295	235	217	222	220	226
	HGVs	508	565	574	573	570	584	698	857	756	801	823	849	766	706	763	729	757	753
	Buses	30	34	36	39	43	45	42	43	45	46	39	48	47	55	50	59	55	57
	Motorcycles	7	6	8	9	9	10	11	15	14	15	15	16	14	14	13	12	11	10
	TOTAL	2,936	3,153	3,336	3,464	3,567	3,598	3,758	3,921	3,906	3,955	3,967	4,069	3,913	3,832	3,767	3,688	3,683	3,640

Figure A7.1: Road transport CO_2 emission trends calculated by constrained and unconstrained methodologies and vehicle kilometres trends, 1990-2013



Appendix 8: Emissions and Removals of Greenhouse Gases from Land Use, Land Use Change and Forestry (LULUCF) for England, Scotland, Wales and Northern Ireland: 1990-2013

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A8.1 Executive Summary

This report presents a summary of the net emissions and removals of greenhouse gases for 1990-2013 by the Land Use, Land Use Change and Forestry (LULUCF) sector of the UNFCCC National Inventory for each of the Devolved Administrations (England, Scotland, Wales and Northern Ireland). The full report for the UK for the 1990-2013 UK Greenhouse Gas Inventory has been delayed this year, due to issues at the UNFCCC reporting level. The statistical release for the UK emissions is available at https://www.gov.uk/government/statistics/final-uk-emissions-estimates. Note that net emissions from the LULUCF sector can be positive (net emissions to the atmosphere) or negative (net removals from the atmosphere).

- The LULUCF sector in **England** was a net sink of GHG emissions in 2013 (-0.9 Mt CO_2e). Between 1990 and 2004 it was a net source (greatest at 2.6 Mt CO_2e in 1999). From 2004-2013 emissions declined steadily to 2008 (-0.8 Mt CO_2e), thereafter remaining stable at between -0.7 and -0.9 Mt CO_2e.
- The LULUCF sector in **Scotland** was a net sink of GHG emissions in 2013 (-5.2 Mt CO_2e) and has been a net sink since 1991. In 1990 the Scotland LULUCF sector was a small net source at 0.09 Mt CO_2e and gradually declined to the 1994 level of -0.3 Mt CO_2e. Net removals decreased to -0.2 Mt CO_2e in 1995, but since then have steadily increased to 2013.
- The LULUCF sector in **Wales** was a small net sink of GHG emissions in 2013 (-0.6 Mt CO_2e). In 1990 Wales was a small net source (0.1 Mt CO_2e), becoming a small net sink in 1991 with net removals gradually increasing thereafter until 2007 (0.6 Mt CO_2e). Emissions since 2007 show small annual fluctuations in the size of the net sink between -0.7 Mt CO_2e and -0.5 Mt CO_2e.
- The LULUCF sector in **Northern Ireland** was a net source in 2013 (1.5 Mt CO_2e). It has remained a small net source throughout the time period, falling from 1.5 Mt CO_2e in 1990 to 1.2 Mt CO_2e in 1999, before increasing again to a peak of 1.6 Mt CO_2e in 2012.

There have been changes in the Devolved Administration-level emissions compared to the 1990-2012 inventory. These are due to the changes in reporting using the 2006 IPCC Guidelines reporting structure (resulting in the removal of some activities from the LULUCF sector and the addition of others), the reporting of some new activities (the inclusion of emissions from drained organic soils has significantly affected the Grassland estimates) and the re-running of the land use change (LUC) soils and biomass model to use extrapolated rather than projected rates of LUC from 2010 onwards (affecting Settlements in particular).

A8.2 Introduction

A8.2.1 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 (LULUCF) 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, and a work programme to develop methods and datasets for reporting these activities is underway.

LULUCF emissions estimates are reported as part of the UK Greenhouse Gas Inventory Report, available on the National Atmospheric Emissions Inventory website http://naei.defra.gov.uk/reports/ (the latest report has been delayed due to UNFCCC reporting issues). 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[10] approaches, based on activity data for each of the UK Devolved Administrations 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.

A8.2.2 UK Administration Reporting

This report details net emissions and removals for each Devolved Administration for the 1990-2013 inventory and provides an explanation of changes since the previous edition of this report (1990-2012). In the main text, the trends in CO_2 emissions/removals are presented and discussed for each Devolved 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, 2012 and 2013 are given for each country in Appendix 8A, and for LULUCF emissions/removals under the Kyoto Protocol in Appendix 8B. A full set of GHG emissions/removals and associated areas and annual land use change matrices for each country are published with this report at http://naei.defra.gov.uk/reports/. The data sources used in the compilation of the inventory are described in Appendix 8C.

A8.2.3 LULUCF Sector Description

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 (2006 IPCC 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.

[10] 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.

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 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. CO_2 emissions from liming of cropland are now reported in the Agriculture sector of the UK's GHG inventory, following a change in the IPCC guidance. Biomass carbon stock changes due to yield improvements have been removed from reporting, as the evidence base did not support the continued inclusion of this activity. Soil carbon stock changes from cropland management are included in the 1990-2013 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, 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. The inclusion of emissions from drained organic soils is new, and is a substantial emissions source. CO_2 emissions from liming of grassland are now reported in the Agriculture sector of the UK's GHG inventory, following a change in the IPCC guidance. 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 http://naei.defra.gov.uk/reports/. 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.

A8.2.4 Changes to LULUCF Sector since the 1990-2012 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 1990-2012 inventory is provided in Table 1.

The largest changes were in the Grassland and Cropland categories, due to the removal of agricultural liming from the LULUCF inventory to the Agriculture sector (in line with new IPCC guidance) and new data for emissions from drained organic soils. The new organic soils dataset includes areas under improved grassland and for Scotland, Wales and Northern Ireland for the first time. The LUC soils and biomass models were also re-run to use the extrapolated rates of LUC for 2010-2013 rather than projected rates: this affected emissions/removals from Cropland, Grassland and Settlements.

A detailed description of the changes in method and datasets can be found in Annex 3.6 of the 1990-2013 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 1.

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

IPCC Sector	Method and data revisions
4A Forest Land	Refinement of the CARBINE input data and updating of the deforestation activity data have led to minor changes.
4B Cropland	The agricultural liming and yield improvement activities been removed from the LULUCF sector. Carbon stock changes due to cropland management are included for the first time. Emissions from drained organic soils under cropland have been revised. The LUC soils and biomass model has been re-run using extrapolated rather projected rates of LUC for 2010-2013. Areas of deforestation for 2000-2013 have been revised.
4C Grassland	Emissions from drained organic soils under Grassland are reported for the first time as new activity data has become available. The agricultural liming activity has been removed from the LULUCF sector. The LUC soils and biomass model has been re-run using extrapolated rather projected rates of LUC for 2010-2013. Areas of deforestation for 2000-2013 have been revised. The wildfires activity data has been revised to correct errors.
4D Wetlands	Correct 2012 activity data for horticultural peat extraction now available. Emissions from reservoir creation are included for the first time, although numbers are very small.
4E Settlements	The LUC soils and biomass model has been re-run using extrapolated rather projected rates of LUC for 2010-2013. Areas of deforestation for 2000-2013 have been revised. N_2O emissions from N mineralisation associated with LUC are included for the first time.
4G Harvested Wood Products	Refinement of the CARBINE input data and updating of the deforestation activity data have led to minor changes.

A8.3 England: LULUCF Emissions and Removals

A8.3.1 Trends

The 1990-2013 Inventory shows England is a net sink of greenhouse gases from LULUCF activities since 2005. In 1990 the England LULUCF sector was a net source at 2.3 Mt CO_2e rising to a peak of 2.6 Mt CO_2e in 1999, followed by a steady decline to -0.8 Mt CO_2e in 2008. The trend then remained steady between -0.7 and -0.9 Mt CO_2e to 2013.

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 are low for England relative to other emissions due to the relatively small areas of peat extraction, as are removals from Harvested Wood Products.

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 5.3 Mt CO_2e in 2013. Emissions from Cropland include those from land use change and cropland management activities affecting soil carbon, biomass burning and drainage on organic soils. Work is in progress to develop reporting of cropland management affecting biomass carbon. The Settlement category is a net source showing a declining trend from 4.0 Mt CO_2e in 1990 to 3.0 Mt CO_2e in 2013.

The Forest land and Grassland categories are net sinks throughout the whole time series from 1990 to 2013. Net removals from Forest land were greatest in 1990 at -6.8 Mt CO_2e, with removals decreasing to -4.9 Mt CO_2e in 1999, followed by an increase to 2006 (-6.4 Mt CO_2e) and a reduction again to 2013 (-5.4 Mt CO_2e). Net removals from Grassland have increased from -2.0 Mt CO_2e in 1990 to -3.5 Mt CO_2e in 2013.

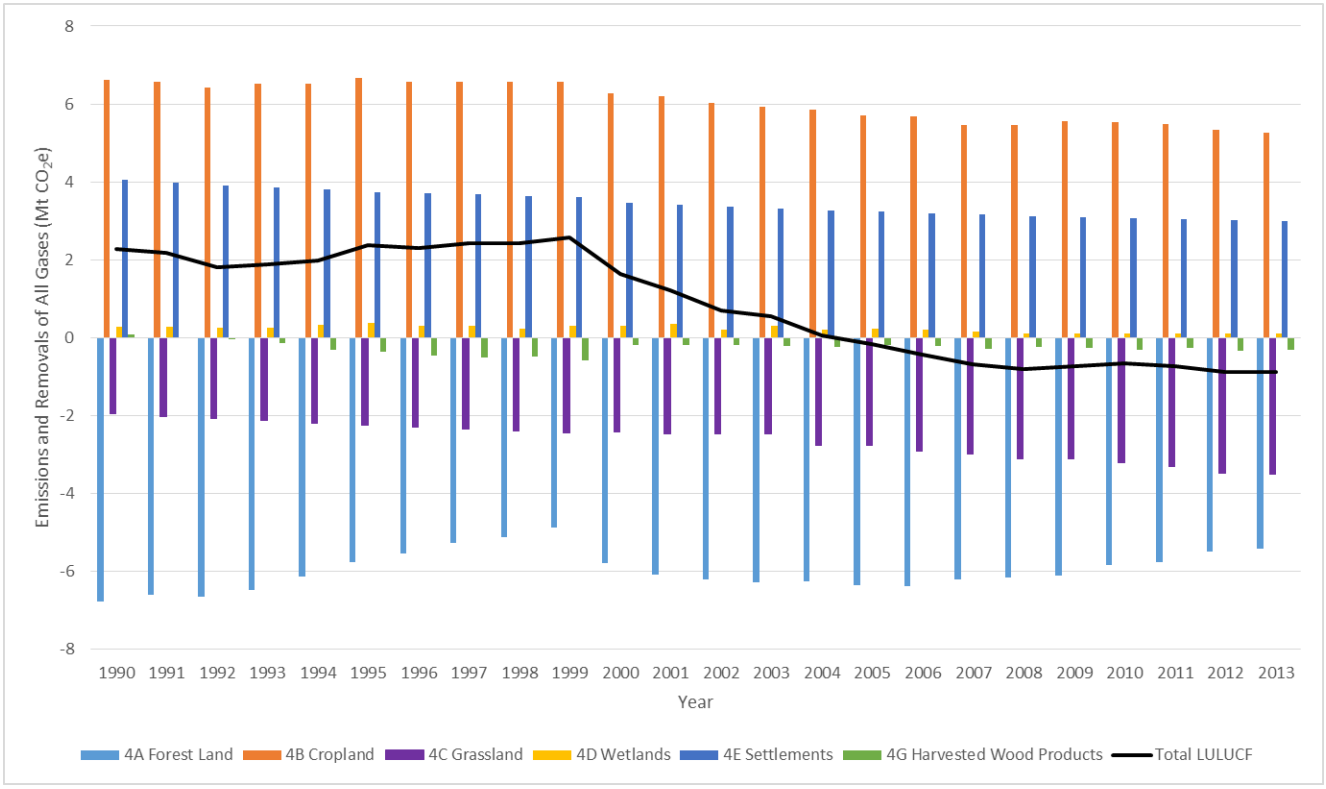

Figure A8.1: Emissions and removals of all gases by category for the LULUCF sector in England 1990-2013

A8.3.2 Category Trends

The Forest land category for England is a net sink for 1990-2013. 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 1990-1999. 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. 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.

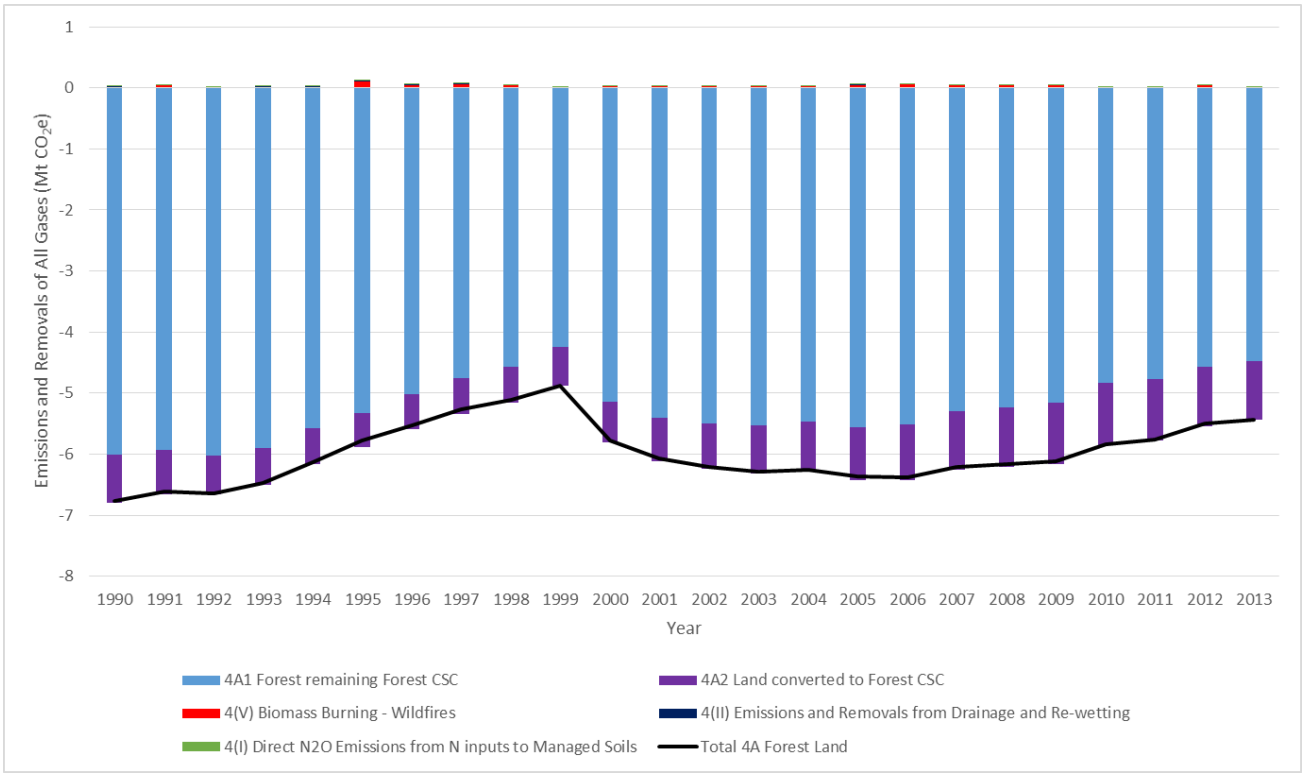

Figure A8.2: Emissions and removals of all gases by category for the 4A Forestry category in England 1990-2013

The Cropland category for England is a net, albeit shrinking, source between 1990 and 2013. Emissions arising from Land converted to Cropland (carbon stock changes and N_2O emissions from N mineralisation) are the largest contributor, 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 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 arising from cropland management (e.g. inputs of fertiliser, manure and crop residues). Other GHG emissions from biomass burning are insignificant.

The Grassland category for England is a net, increasing sink for 1990-2013. 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. Carbon emissions from drained organic soils under improved grassland are a constant and significant 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.

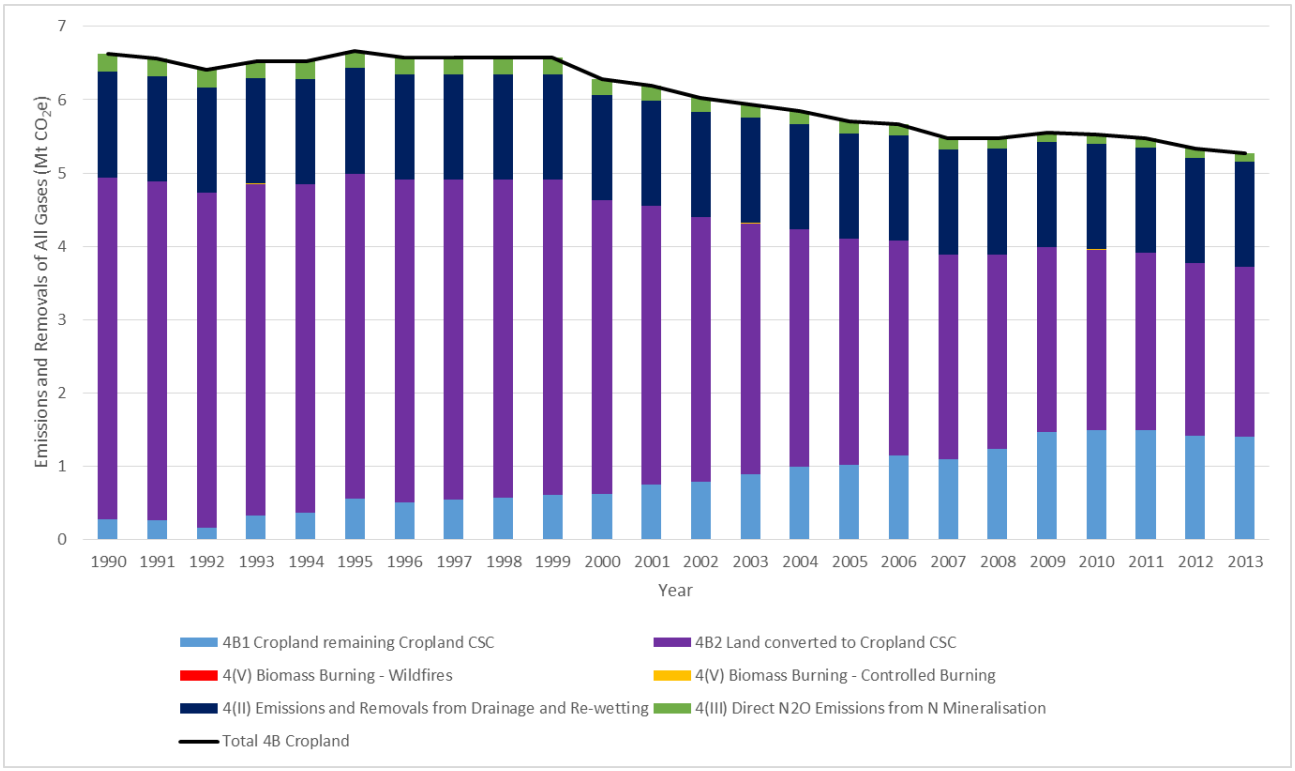

Figure A8.3: Emissions and removals of all gases by category for the 4B Cropland category in England 1990-2013

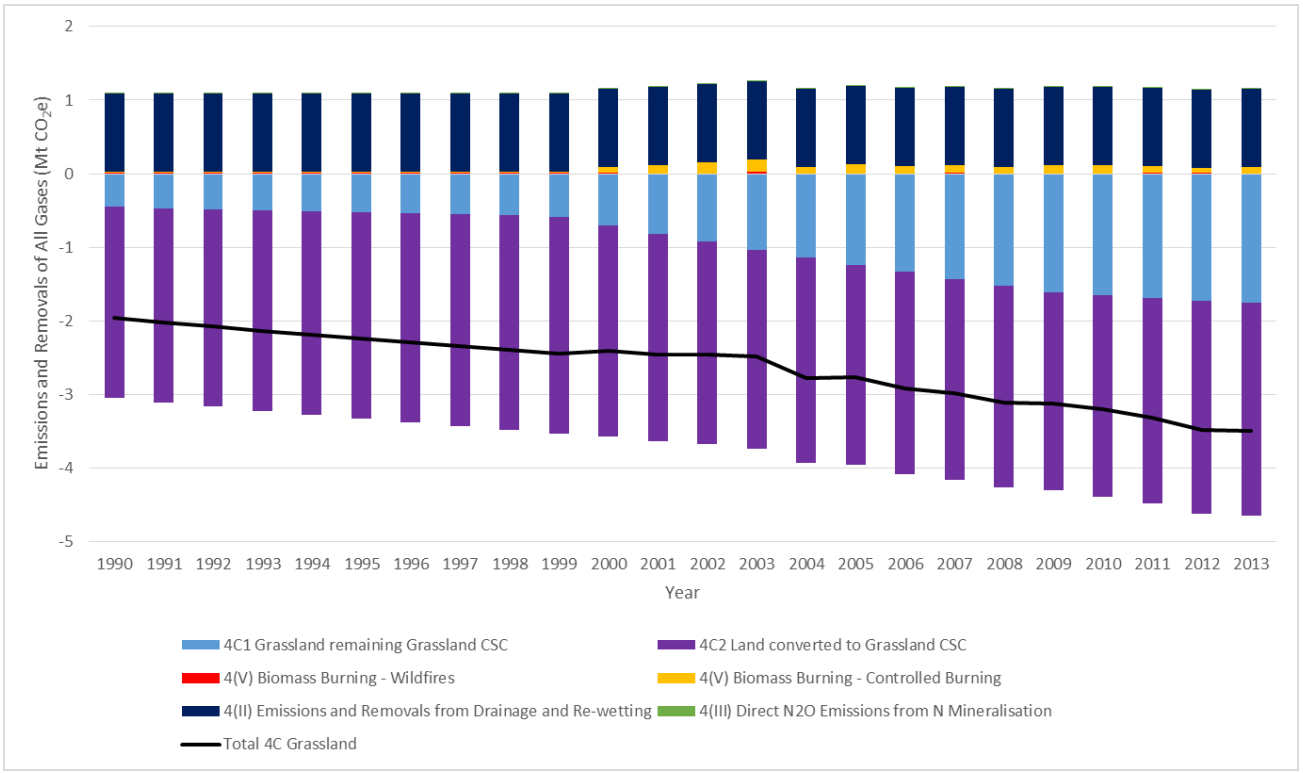

Figure A8.4: Emissions and removals of all gases by category for the 4C Grassland category in England 1990-2013

The Wetland category is a minor and decreasing source in England. 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 4.8 kha in 2013. There are also insignificant contributions to emissions from land converted to peat extraction and to flooded land (reservoirs).

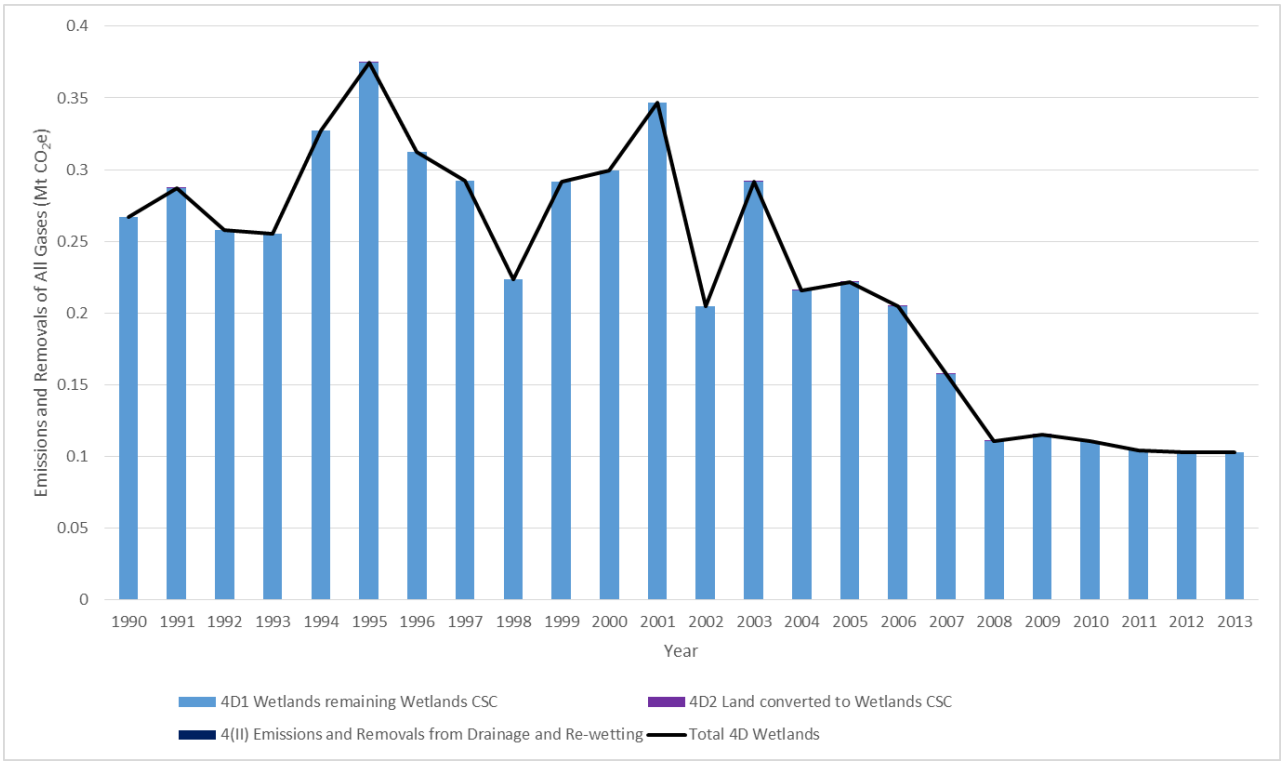

Figure A8.5: Emissions and removals of all gases by category for the 4D Wetland category in England 1990-2013

The Settlements category 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 (historical LUC). 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 is a net sink for England, except for 1990. 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.

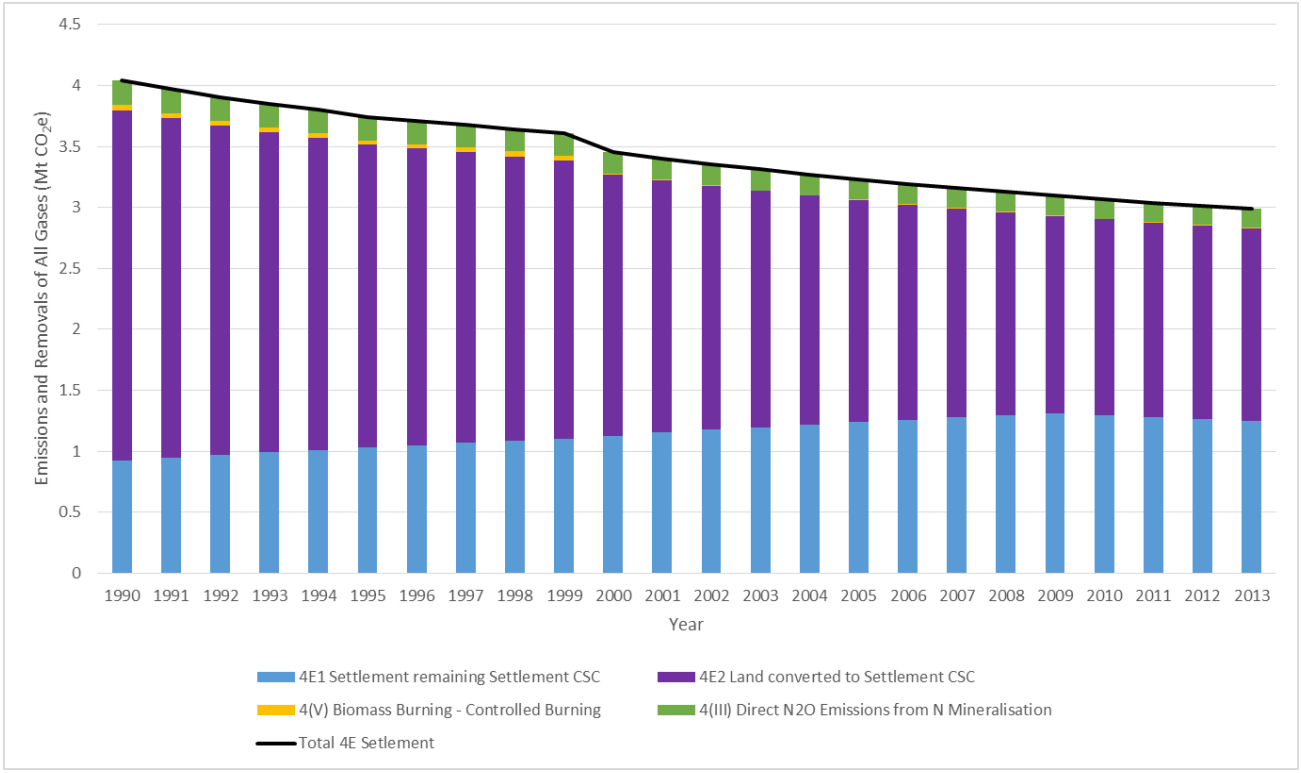

Figure A8.6: Emissions and removals of all gases by category for the 4E Settlement category in England 1990-2013

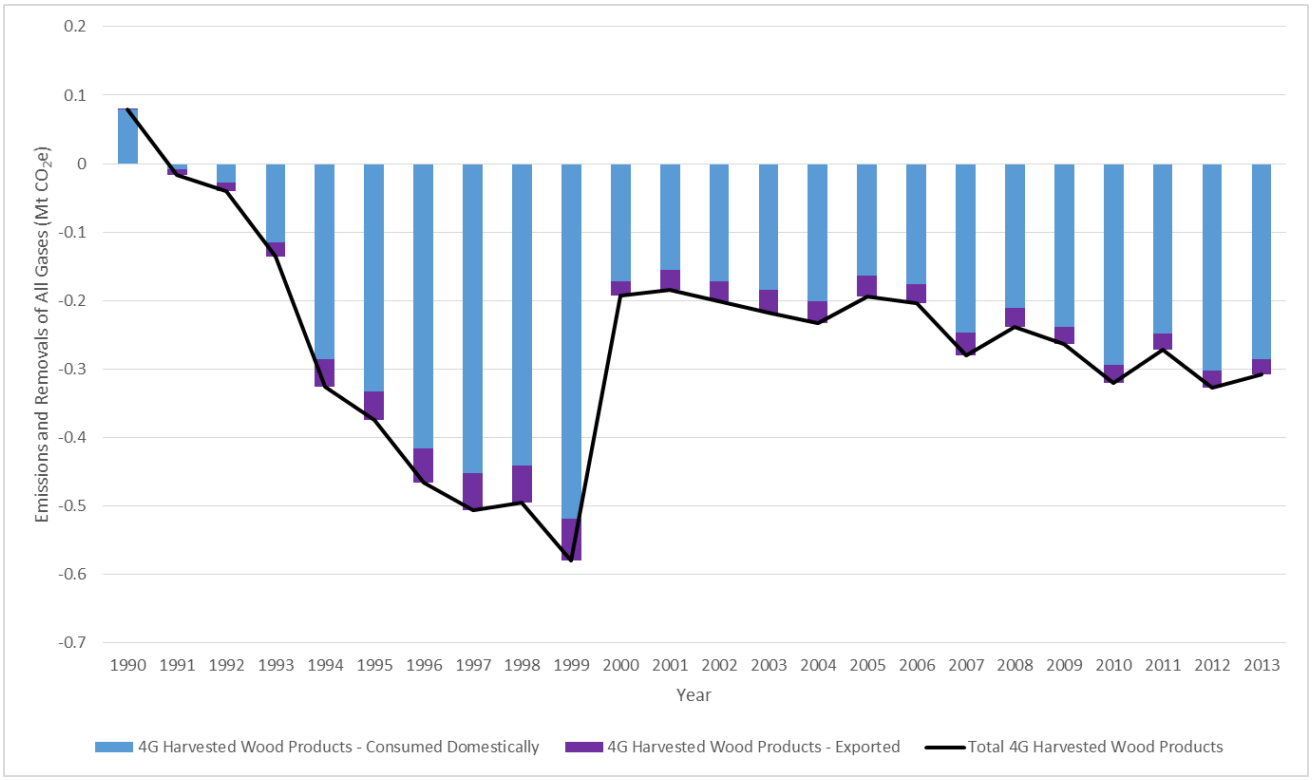

Figure A8.7: Emissions and removals of all gases by category for the 4G Harvested Wood Products category in England 1990-2013

A8.3.3 Comparison with 2012 inventory

Net emissions from the LULUCF sector for England in the 1990-2013 inventory are slightly lower than the 1990-2012 inventory for 1990-1997 (except for 1993) and slightly higher for the remainder of the time period. These revised estimates reflect changes in estimated emissions from the Cropland and Grassland categories, particularly the inclusion of carbon emissions from drained organic soils under improved grassland and the removal of agricultural liming to the Agriculture sector inventory. Compared to the 1990-2012 Inventory, net emissions of greenhouse gases in the 1990-2013 inventory in 1990 have decreased by 0.2 Mt CO_2e, a decrease of 10%. Emissions in 2012 have increased by 0.2 Mt CO_2e. Differences between the 2012 and 2013 inventories for CO_2e in each category are presented in Figure 4A-F. Differences between the 2012 and 2013 inventories for non-CO_2 for England are presented in Figures 5 and 6.

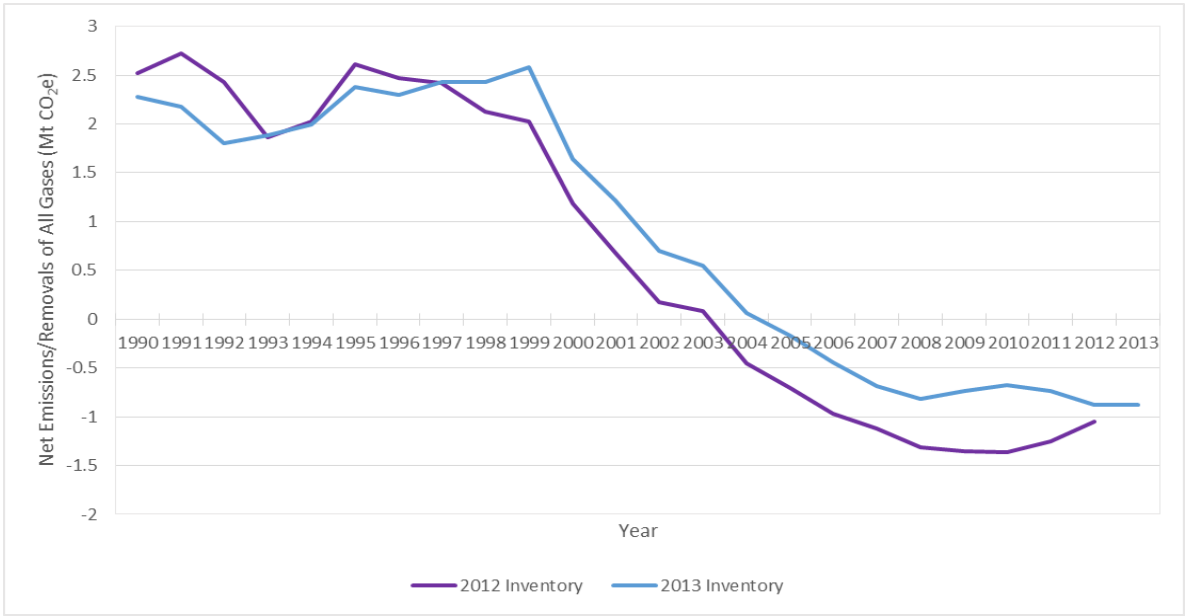

Figure A8.8: Changes in net emissions of all gases across all LULUCF categories 1990-2013 between the 2012 Inventory and 2013 Inventory for England

Net removals in the Forest Land category in England have changed little since the previous inventory. The reduction in removals from 1990-1999 reflects the harvesting of conifers planted in the 1920-1930s coinciding with a reduction in conifer planting during the 1990s.

In the Cropland category emissions for England are lower than in the 2012 inventory until 2010. This is mostly due to a combination of the removal of agricultural liming emissions to the Agriculture sector inventory (average emission 0.5 Mt CO_2e p.a.), the addition of cropland management (average removal -0.5 Mt CO_2e p.a.) and the revision to emissions from drained organic soils (now a constant 1.4 Mt CO_2e p.a. where previously the emission estimate decreased from 1.65 Mt CO_2e in 1990 to 1.05 Mt CO_2e p.a. in 2012). The re-running of the LUC model also affected emissions from 2010-2013.

In the Grassland category estimates for net removals for England have decreased over the time series by an average of 0.6 Mt CO_2e or 19%. Although emissions from agricultural liming have been removed (average emission 0.3 Mt CO_2e p.a.), emissions from drained organic soils under improved grassland have been introduced (1.1 Mt CO_2e p.a.). Estimated areas of deforestation were revised, affecting Land Use Change to Grassland and emissions from controlled burning, but this did not have a consistent positive or negative impact on net emissions. The re-running of the LUC model also affected emissions from 2010-2013.

In the Wetland category estimates for emissions for England remain the same as the previous inventory.

In the Settlements category estimates for emissions for England have slightly increased for 1990-2013. This is due to the inclusion of N_2O emissions from N mineralisation due to land use change for the first time under the 2006 IPCC Guidance. The area of deforestation to Settlement was revised downwards, which reduced net emissions after 2000. The re-running of the LUC model also affected emissions from 2010-2013.

Net removals in the Harvested Wood products category in England have changed little since the previous inventory. The reduction in removals between 1999 and 2000 reflect lower amounts of timber entering the HWP pool (planting rates dropped steeply during the 1940s, reducing the timber available for harvesting in the 2000s).

The CH_4 emission trend has changed slightly, mainly due to updated activity data for wildfires and controlled burning following deforestation after 2000. N_2O emissions have increased as N_2O emissions from N mineralisation due to land use change are now reported for settlements and grassland as well as for cropland (although emissions from Cropland have decreased as N_2O emissions from N mineralisation from land use change over 20 years ago is now reported in the Agriculture sector).

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

IPCC Sector	Difference between 2013 and 2012 inventory estimates, Gg CO_2e	
	1990	2012
4A Forest Land	-42	-93
4B Cropland	-983	377
4C Grassland	554	33
4D Wetlands	0	-2
4E Settlements	232	-161
4G Harvested Wood Products	-4	18

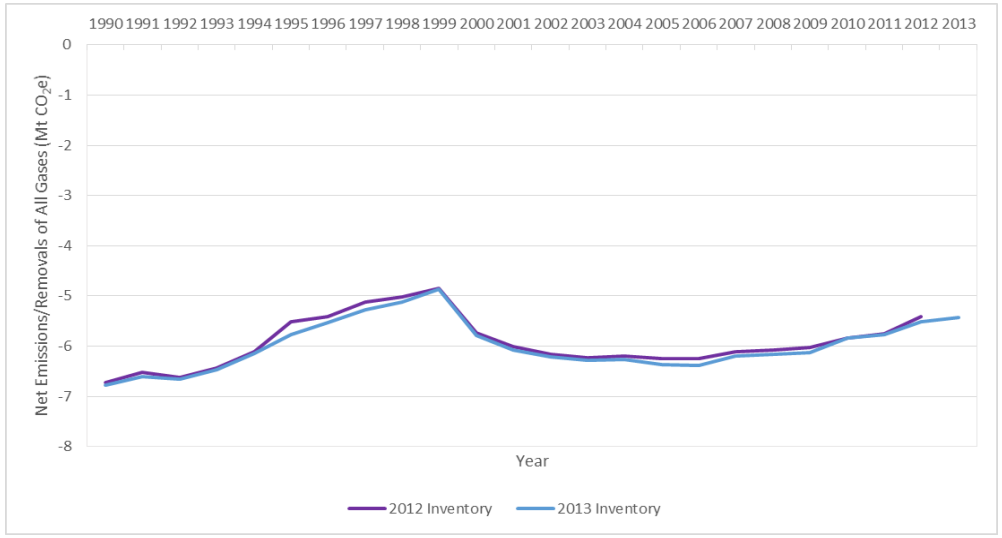

Figure A8.9 Forest Land - England

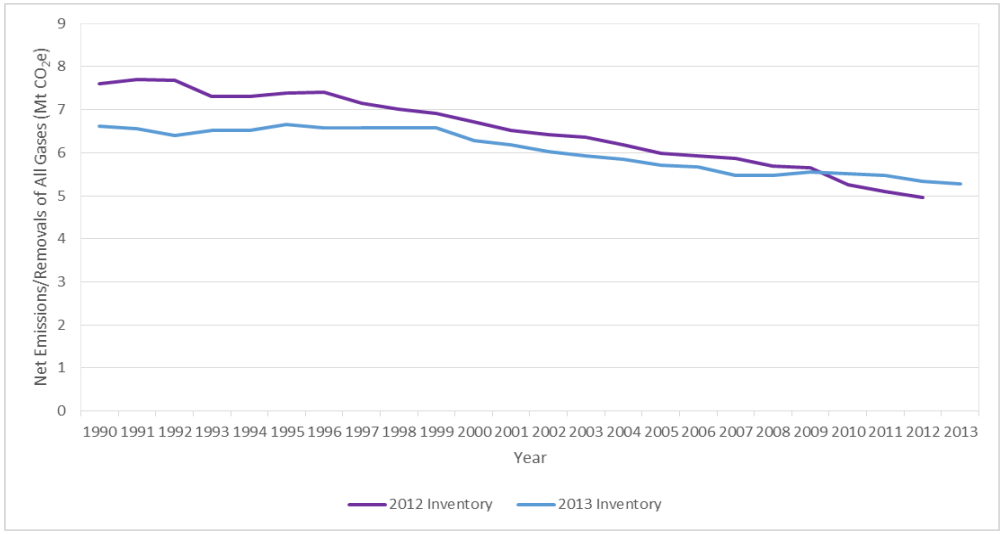

Figure A8.10 Cropland - England

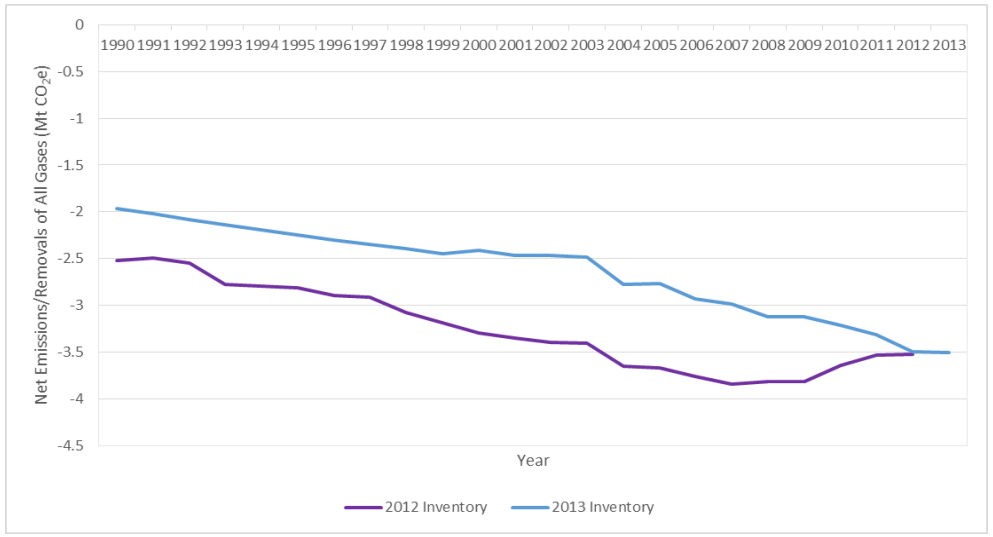

Figure A8.11 Grassland - England

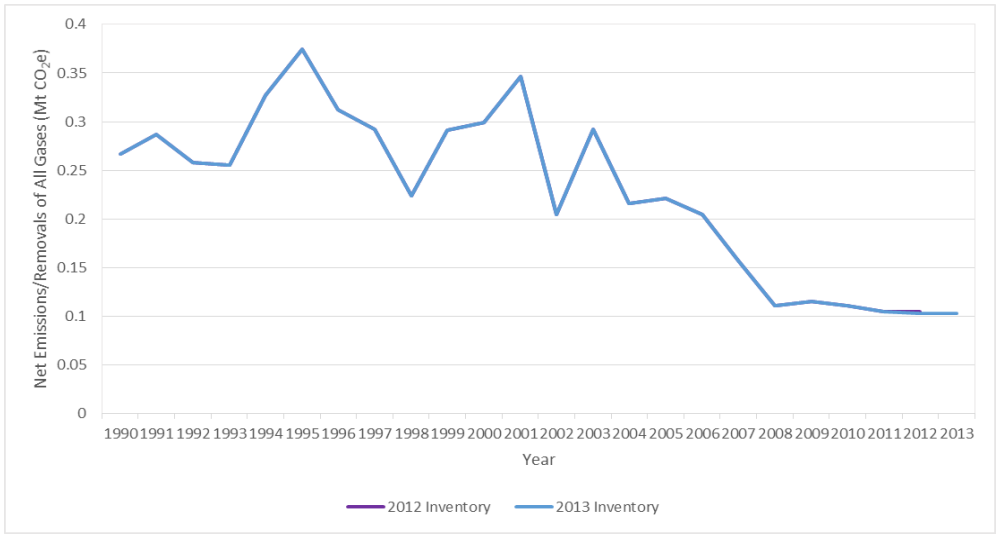

Figure A8.12 Wetlands - England

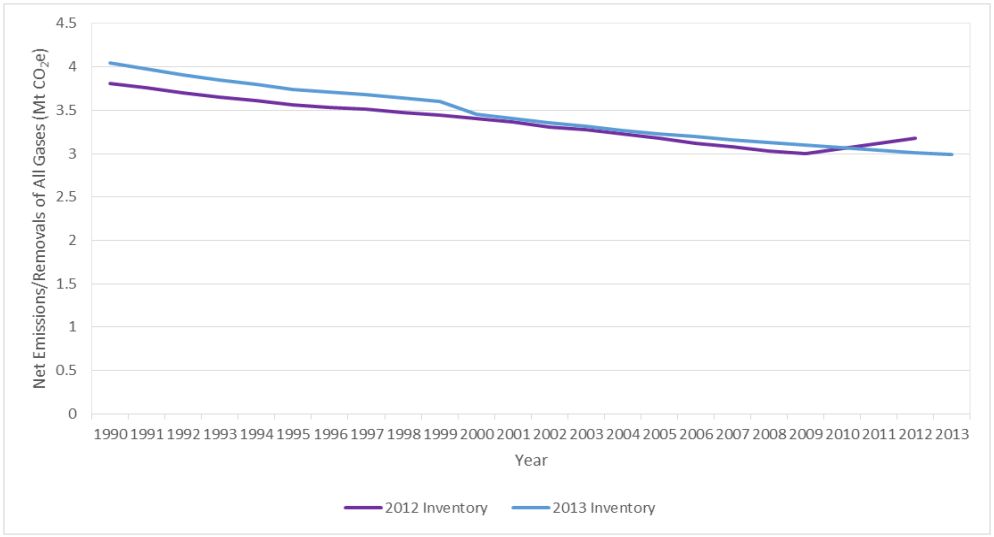

Figure A8.13 Settlements - England

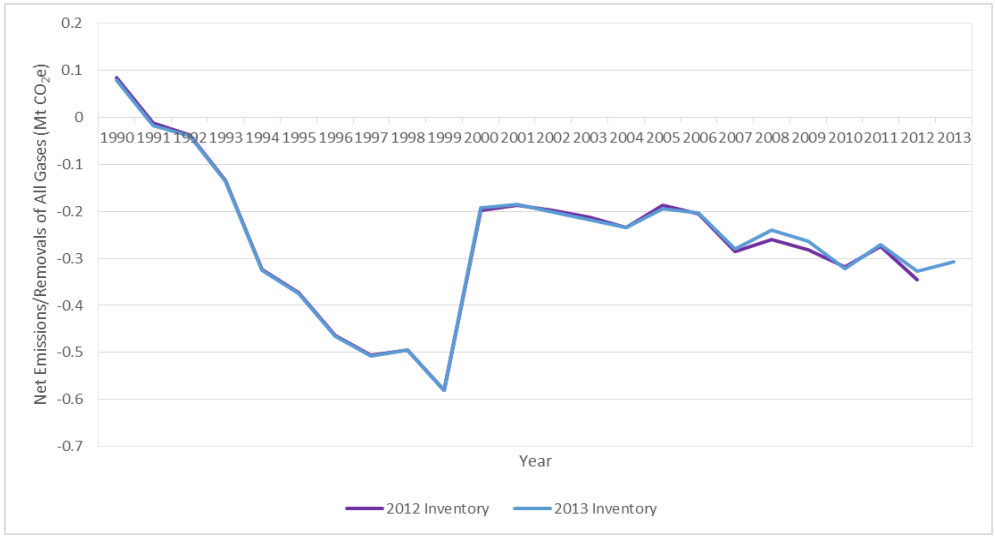

Figure A8.14 Harvested Wood Products - England

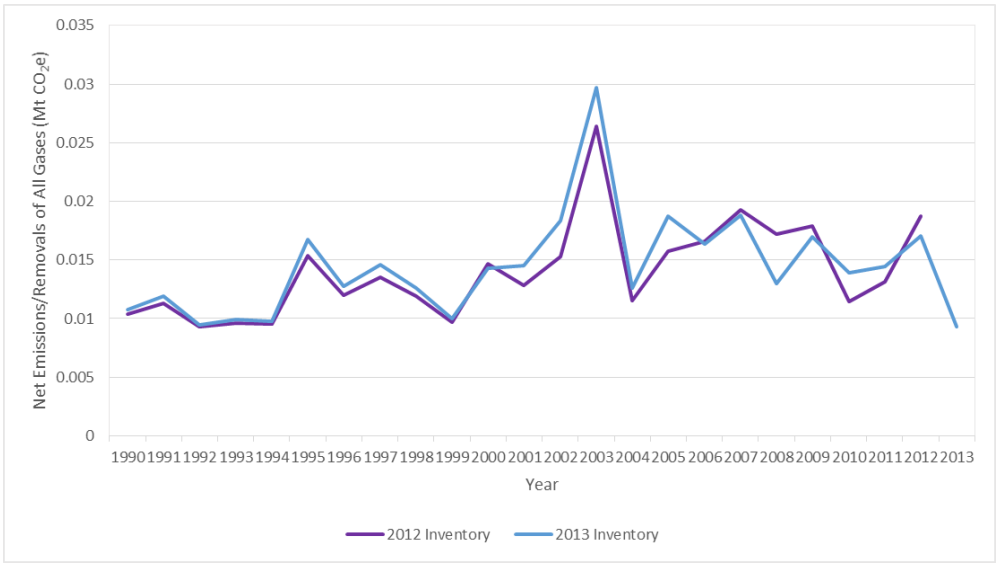

Figure A8.15: Changes in net emissions of CH_4 only 1990-2013 between the 2012 Inventory and 2013 Inventory for England LULUCF

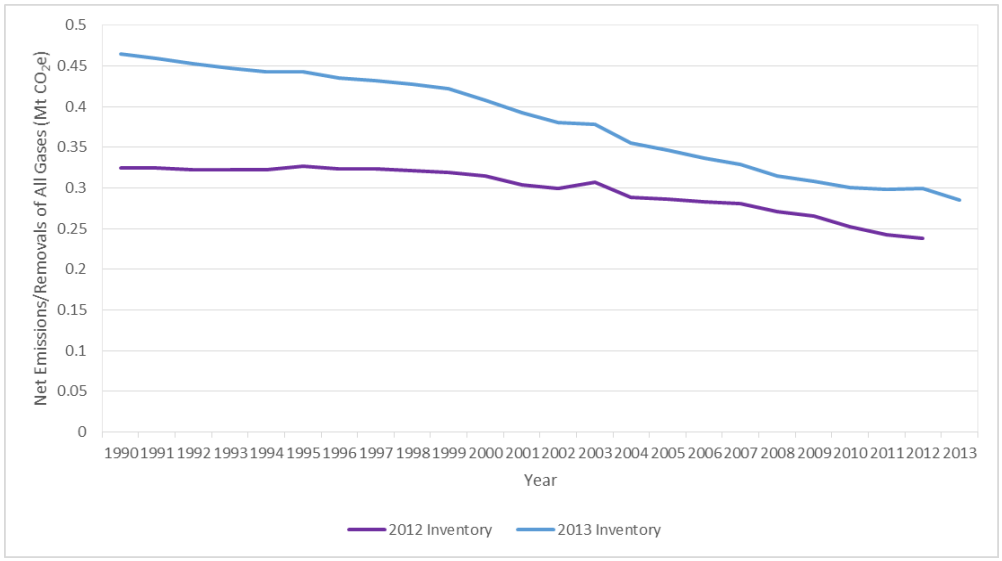

Figure A8.16: Changes in net emissions of N_2O only 1990-2013 between the 2012 Inventory and 2013 Inventory for England LULUCF.

A8.4 Scotland: LULUCF Emissions and Removals

A8.4.1 Trends

The 1990-2013 Inventory shows that Scotland was a net sink of greenhouse gases from LULUCF activities from 1991 onwards. In 1990 net emissions from the LULUCF sector in Scotland were a small source of 0.1 Mt CO_2e, they declined slowly to 1995 (-0.2 Mt CO_2e) and then steadily to -5.2 Mt CO_2e in 2013.

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 are low for Scotland relative to other emissions, as are removals from Harvested Wood Products.

Cropland produces the largest emissions source in Scotland: this peaked at 7.0 6.1 Mt CO_2e in 1999 and has since steadily reduced to 5.1 Mt CO_2e in 2013. 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 2013.

Forest land is the largest net sink in Scotland, increasing from -7.0 Mt CO_2 in 1990 to -9.5 Mt CO_2 in 2005, since when it has been relatively stable (-9.4 Mt CO_2 in 2013). The Grassland net sink have fluctuated between -1.2 Mt CO_2e and -1.9 Mt CO_2e between 1990 and 2013.

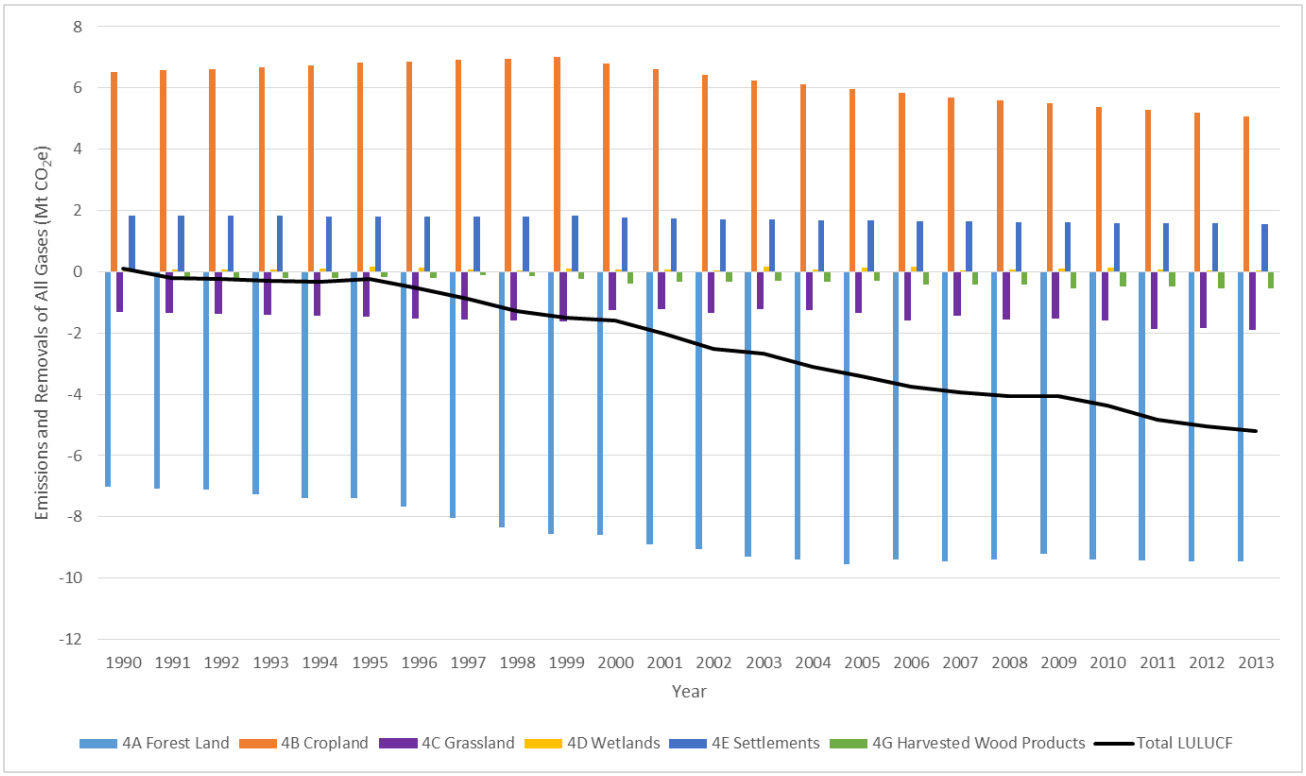

Figure A8.17: Emissions and removals of all gases by category for the LULUCF sector in Scotland 1990-2013

A8.4.2 Category Trends

The Forest land category for Scotland is a net sink for 1990-2013. 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 shrank between 1990 and 2005, during which time there was 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.

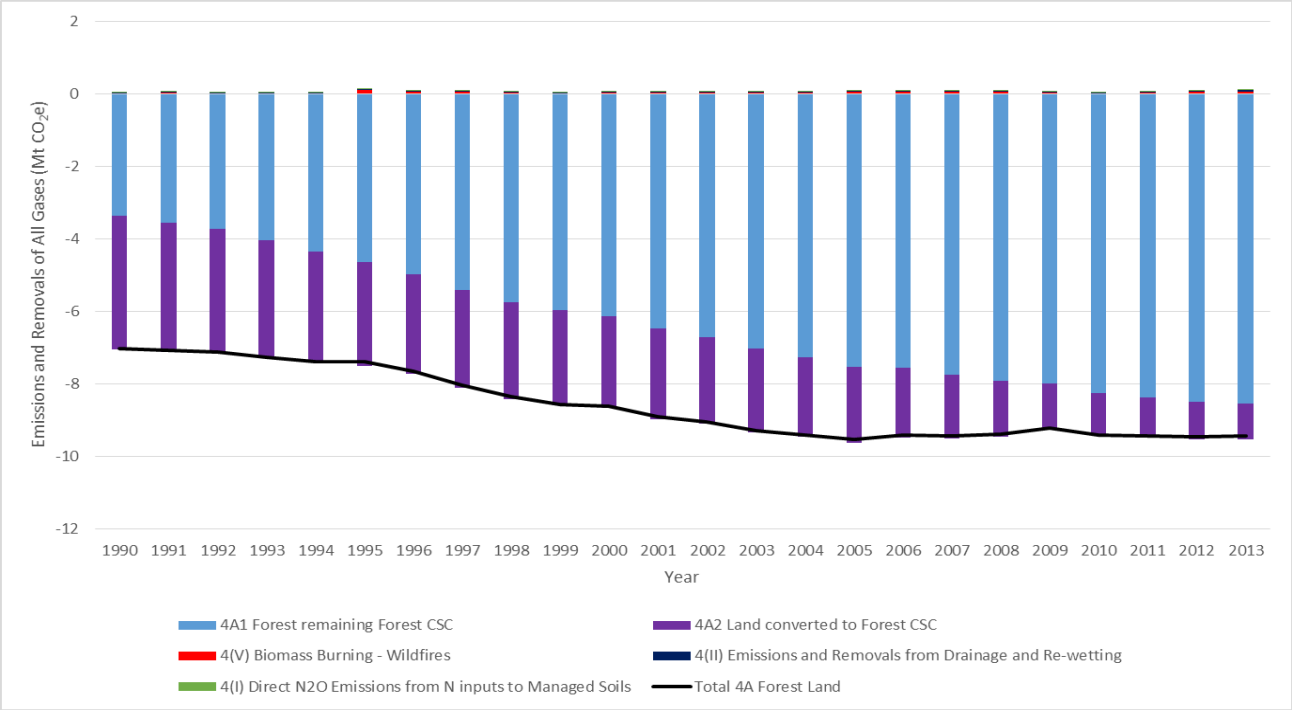

Figure A8.18: Emissions and removals of all gases by category for the 4A Forestry category in Scotland 1990-2013

The Cropland category for Scotland is a net source for 1990-2013. 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. These emissions are the result of recent conversion from grassland and other land uses, although the rate of land use change 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 carbon stock changes arising from cropland management (e.g. inputs of fertiliser, manure and crop residues). Other GHG emissions from drained cropland organic soils and from biomass burning are small.

The Grassland category for Scotland is a net sink for 1990-2013. Removals from carbon stock changes in Grassland remaining Grassland and Land converted to Grassland are counter-balanced by emissions from drained organic soils under improved grassland and biomass burning. 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.

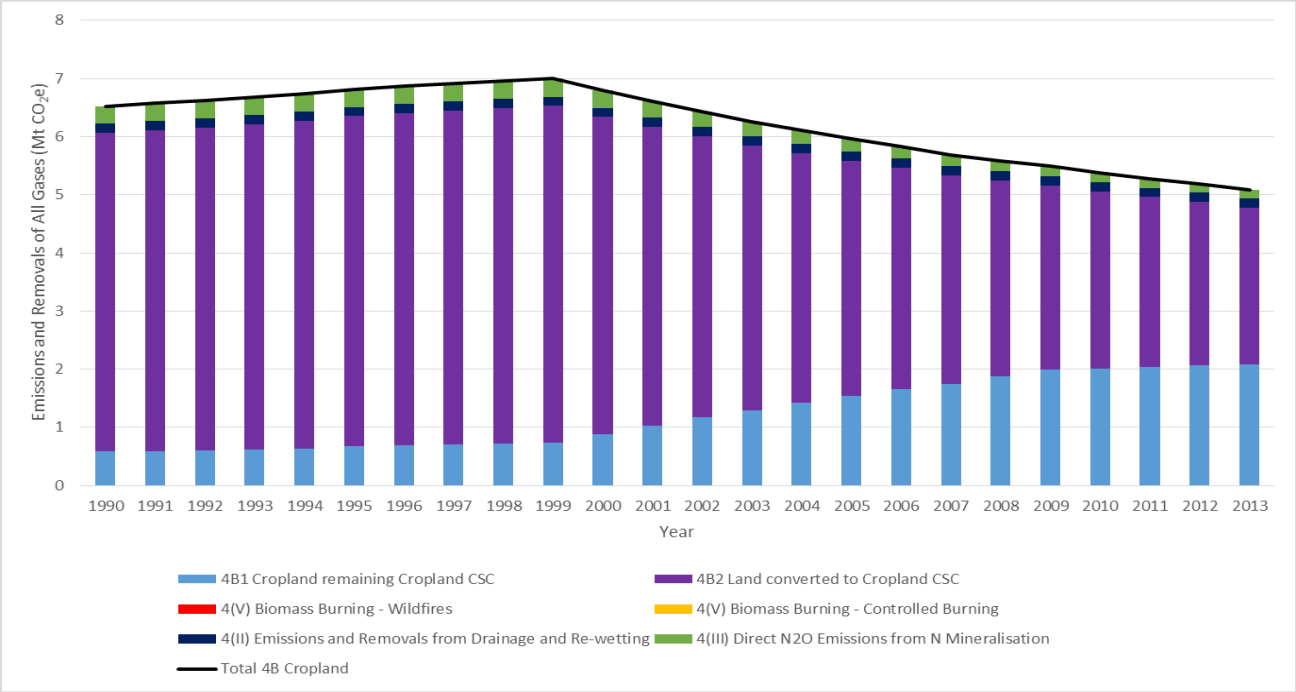

Figure A8.19: Emissions and removals of all gases by category for the 4B Cropland category in Scotland 1990-2013

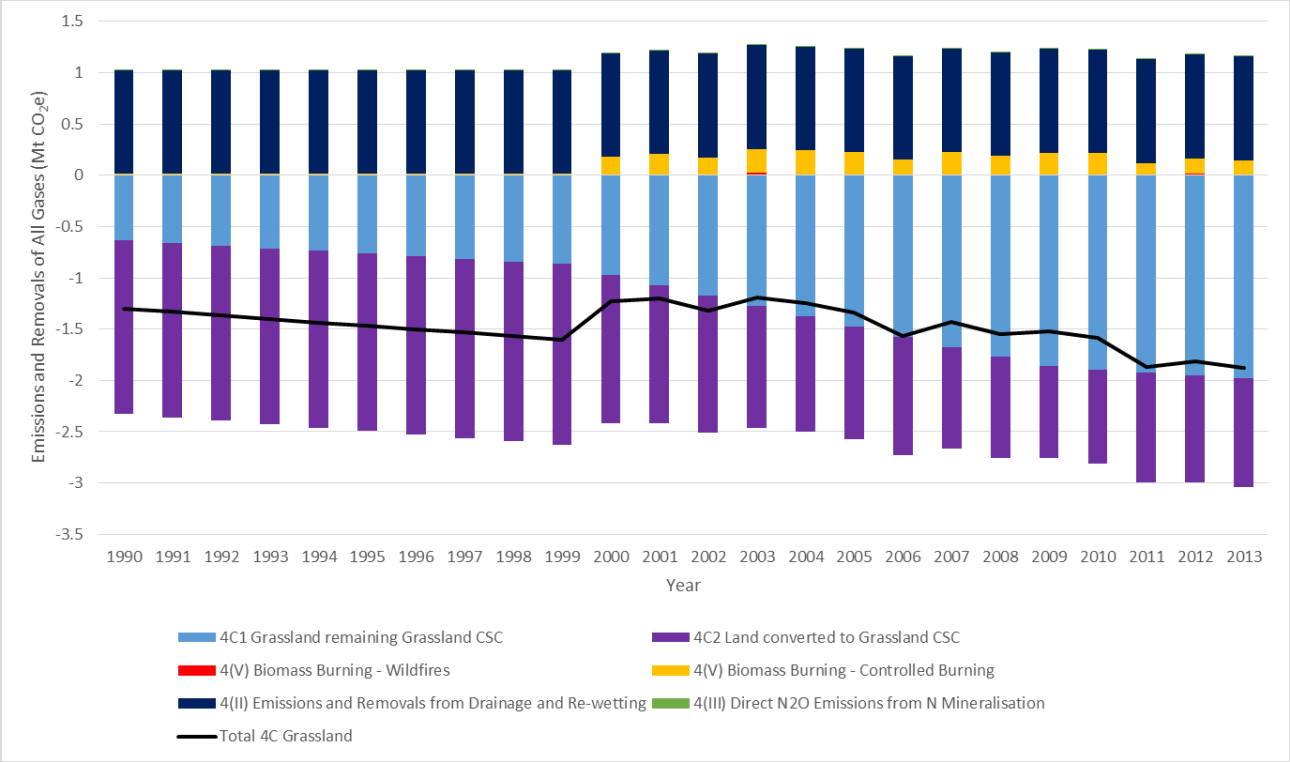

Figure A8.20: Emissions and removals of all gases by category for the 4C Grassland category in Scotland 1990-2013

The Wetland category is a fluctuating source of emissions for Scotland. These emissions are from commercial peat extraction, and this is largely dependent upon the weather and product demand, hence the fluctuating trend. Between 1990 and 2013, the land area in Scotland undergoing commercial peat extraction was estimated to be 1.6kha. 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).

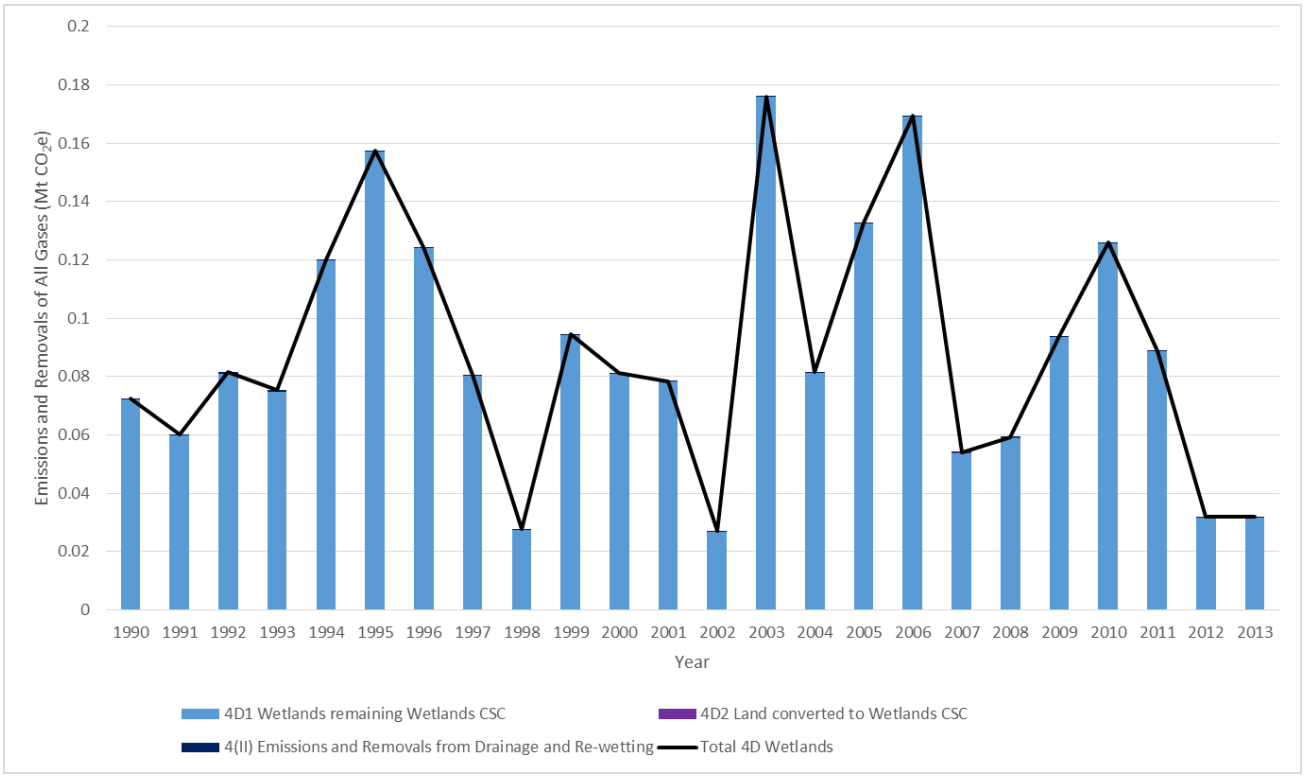

Figure A8.21: Emissions and removals of all gases by category for the 4D Wetland category in Scotland 1990-201

The Settlements category 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 (historical LUC). 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 is a net sink of CO_2 for Scotland. 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.

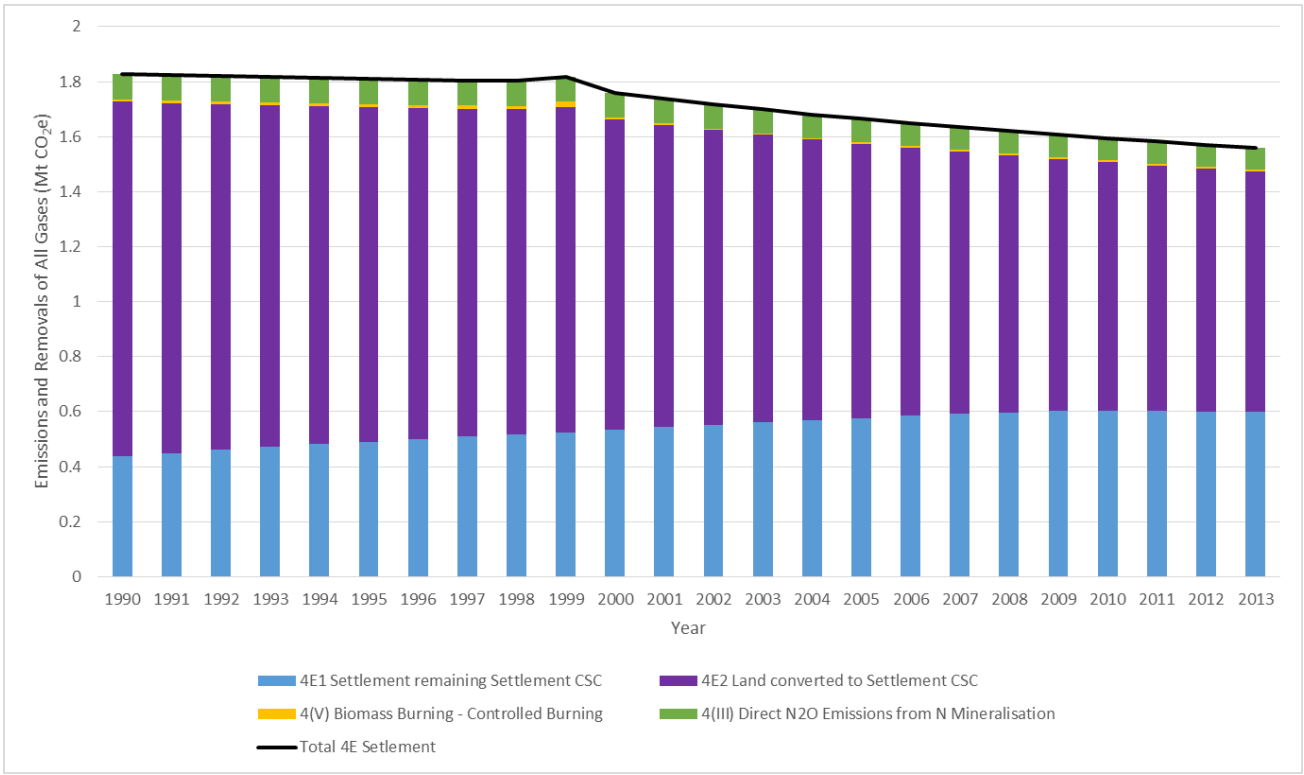

Figure A8.22: Emissions and removals of all gases by category for the 4E Settlement category in Scotland 1990-2013

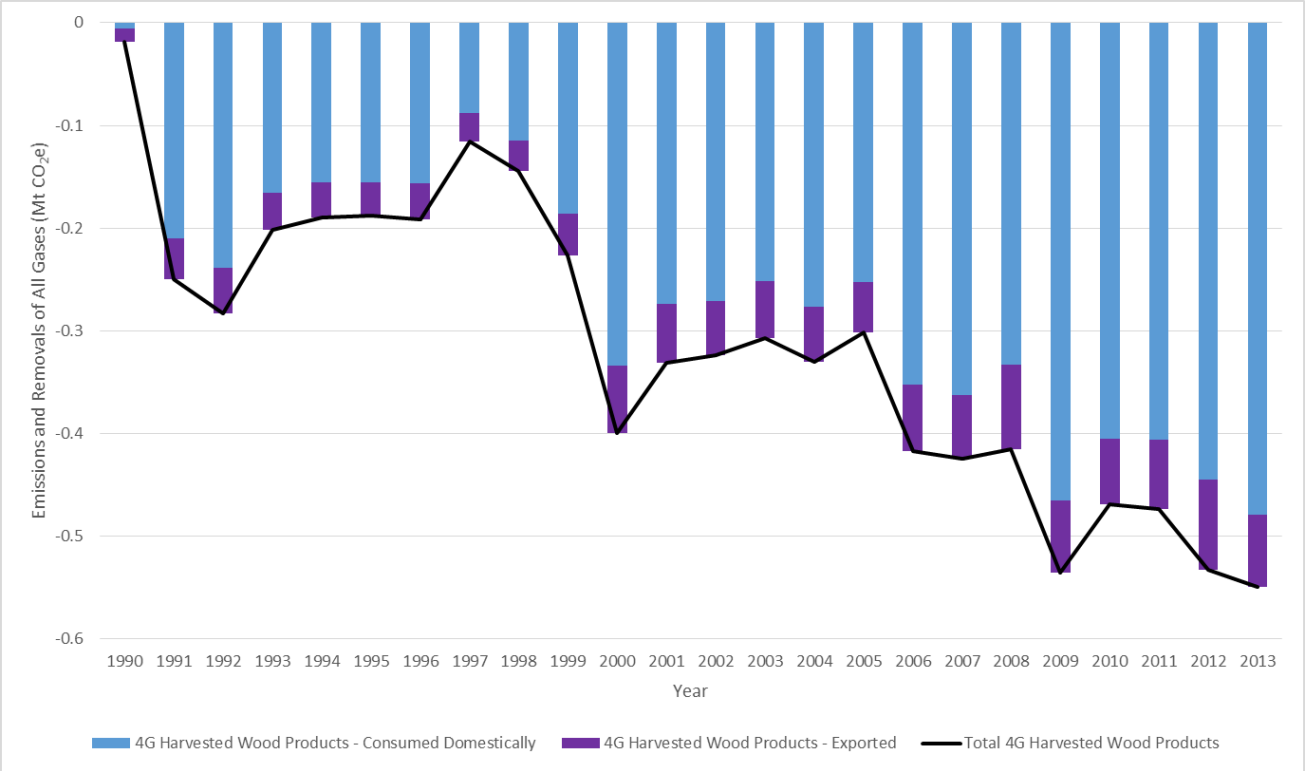

Figure A8.23: Emissions and removals of all gases by category for the 4G Harvested Wood Products category in Scotland 1990-2013

A8.4.3 Comparison with 2012 inventory

Net emissions from the LULUCF sector for Scotland in the 1990-2013 inventory are higher than the 1990-2012 inventory, although the trend towards being an increasing sink is the same. The revised estimates reflect changes in estimated emissions from the Grassland category, and to a lesser extent changes in the Settlement category. Compared to the 1990-2012 inventory, net emissions of greenhouse gases in the current inventory have increased by 0.9 Mt CO_2e in 1990 and 0.7 Mt CO_2e in 2012. Differences between the 2012 and 2013 inventories for CO_2e in each category are presented in Figure 10A-F. Differences between the 2012 and 2013 inventories for non-CO_2 emissions for Scotland are presented in Figures 11 and 12.

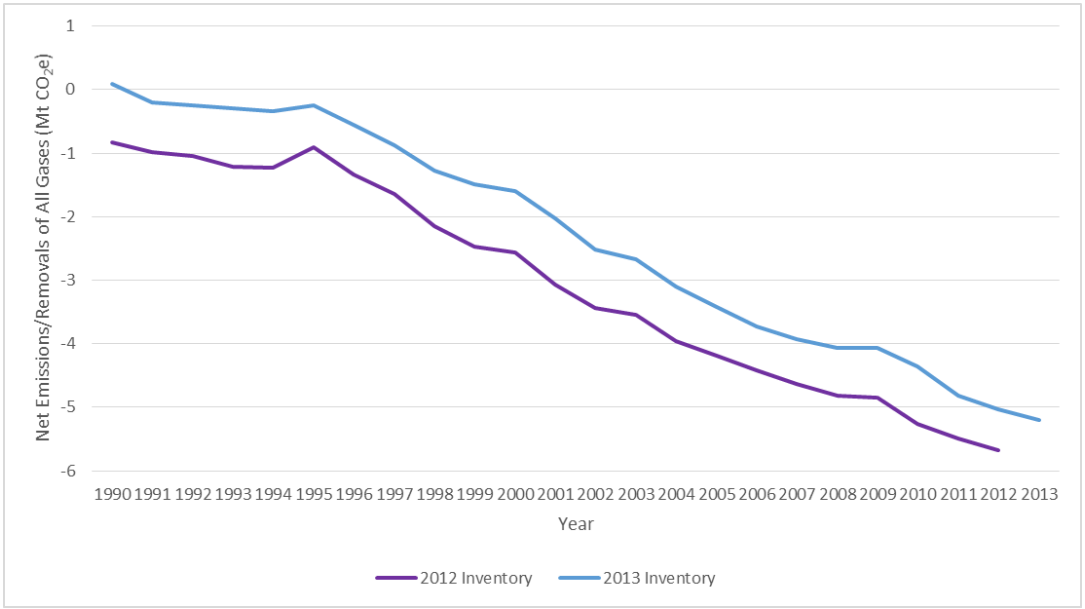

Figure A8.24: Changes in net removals of all gases 1990-2013 between the 2012 Inventory and 2013 LULUCF Inventory for Scotland

Net removals in the Forest Land category in Scotland have changed little since the previous inventory.

In the Cropland category estimates for emissions for Scotland have changed little over the time period. The transfer of agricultural liming emissions to the Agriculture sector inventory (average emission 0.1 Mt CO_2e p.a.), is counter-balanced by the addition of cropland management (average removal -0.1 Mt CO_2e p.a.) and emissions from drained organic soils (0.15 Mt CO_2e p.a.). The re-running of the LUC model also affected emissions from 2010-2013.

In the Grassland category estimates for net removals for Scotland have decreased markedly over the time series by an average of 0.87 Mt CO_2e or 63%. Although emissions from agricultural liming have been removed (average emission 0.1 Mt CO_2e p.a.), emissions from drained organic soils under improved grassland have been introduced (1.0 Mt CO_2e p.a.). Estimated areas of deforestation were revised, affecting Land Use Change to Grassland and emissions from controlled burning, but this did not have a consistent positive or negative impact on net emissions. The re-running of the LUC model also affected emissions from 2010-2013.

In the Wetland category estimates for emissions for Scotland remain the same as the previous inventory, except for 2012 where updated peat extraction data has become available.

In the Settlements category estimates for emissions for Scotland have slightly increased by an average of 3% for 1990-2009 and decreased after 2010. This is due to the inclusion of N_2O emissions from N mineralisation due to land use change for the first time under the 2006 IPCC Guidance, offset by a reduction in the area of deforestation to Settlement after 2000. The re-running of the LUC model also affected emissions from 2010-2013.

Net removals in the Harvested Wood products category in Scotland have changed little since the previous inventory (see Figure 10F and Table 1 for data revisions).

The CH_4 emission trend has changed slightly, mainly due to updated activity data for wildfires and controlled burning following deforestation after 2000. N_2O emissions have increased compared to the 1990-2012 inventory up to 2002 but decreased after that. This is due to the increased emissions due to the inclusion of N_2O emissions from N mineralisation following land use change to Settlement being offset by reduced N_2O emissions from Cropland (N_2O emissions from N mineralisation from land use change to cropland over 20 years ago is now reported in the Agriculture sector).

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

IPCC Sector	Difference between 2013 and 2012 inventory estimates, Gg CO_2e	
	1990	2012
4A Forest Land	-35	-111
4B Cropland	56	313
4C Grassland	815	582
4D Wetlands	0	-57
4E Settlements	89	-110
4G Harvested Wood Products	-9	33

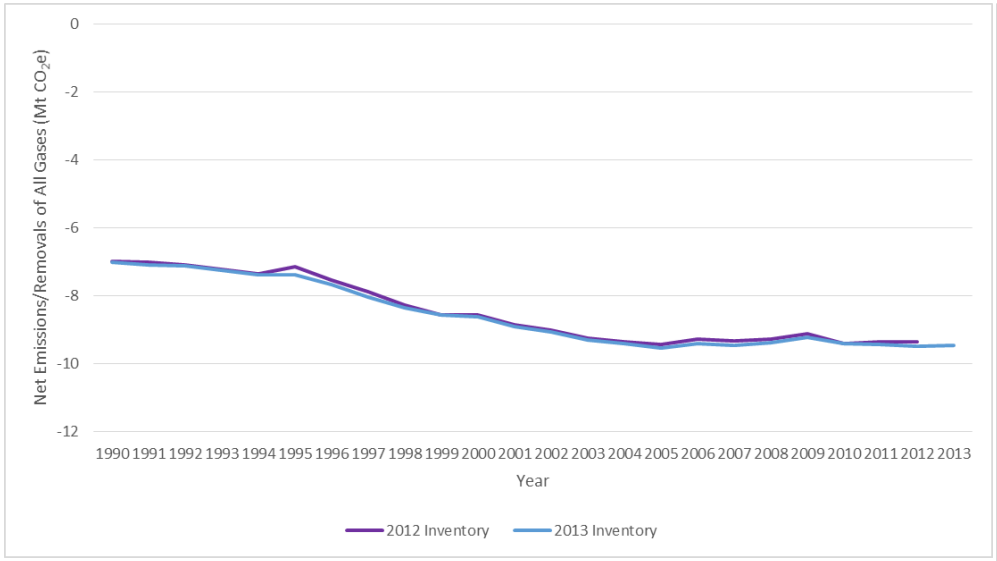

Figure A8.25 Forest Land - Scotland

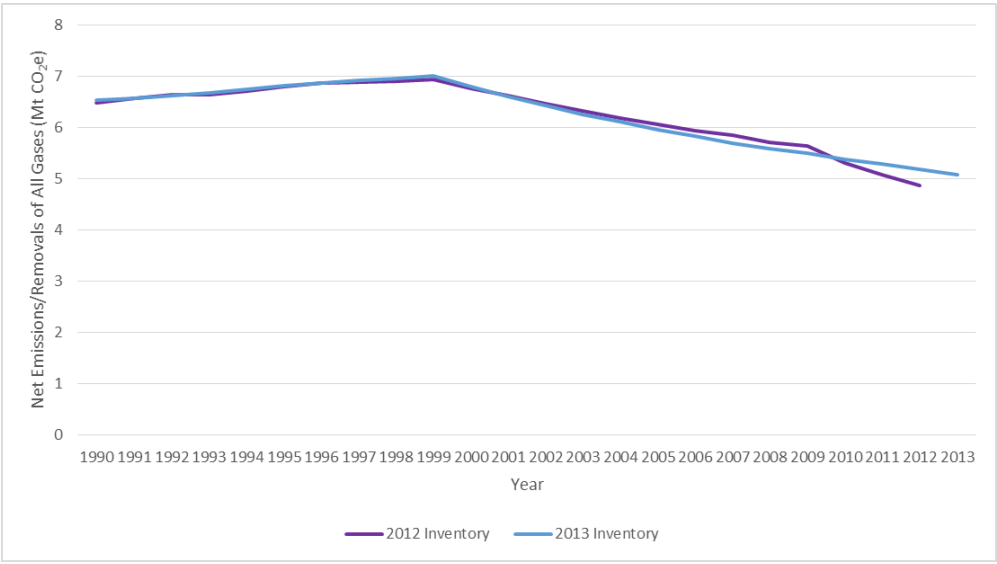

Figure A8.26 Cropland - Scotland

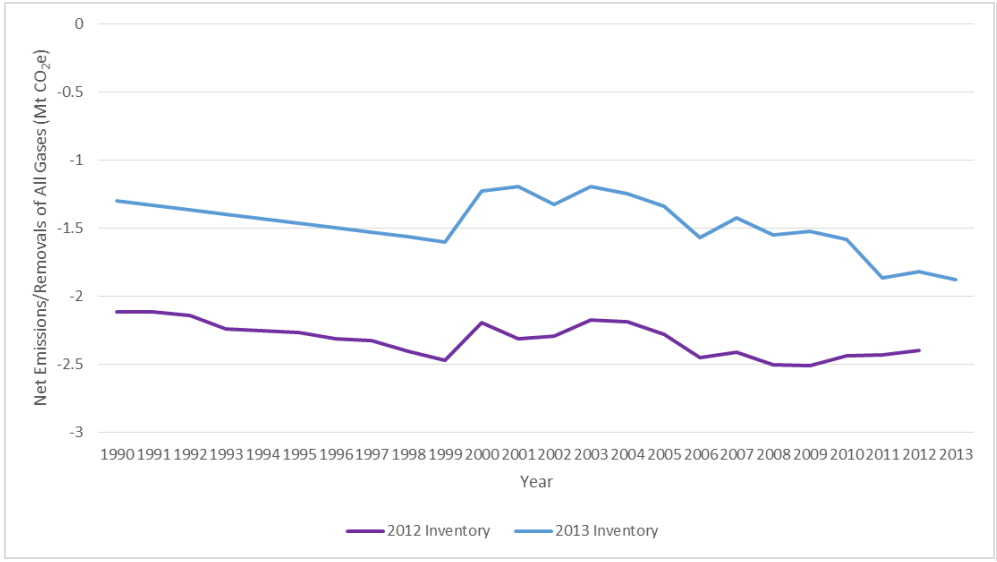

Figure A8.27 Grassland - Scotland

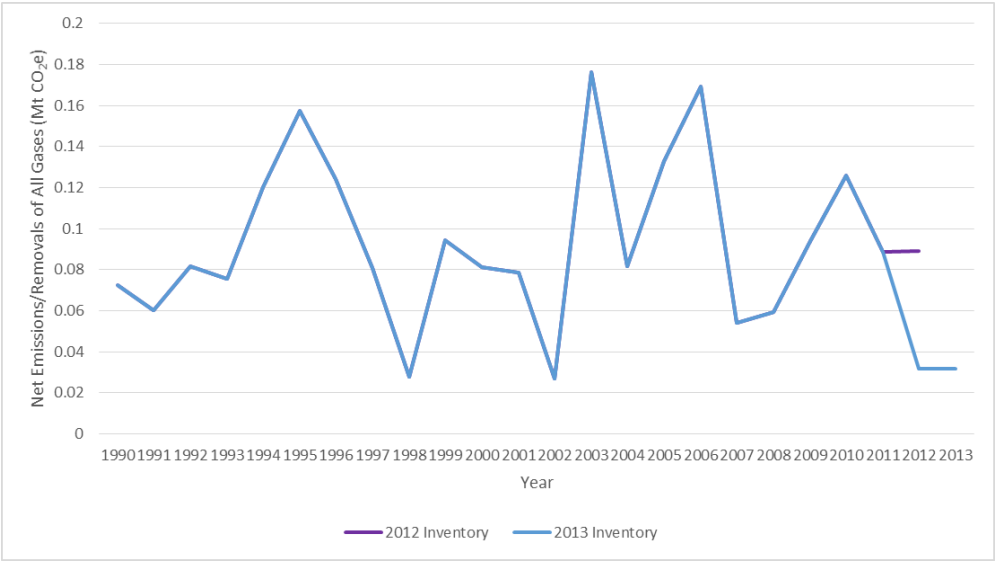

Figure A8.28 Wetlands - Scotland

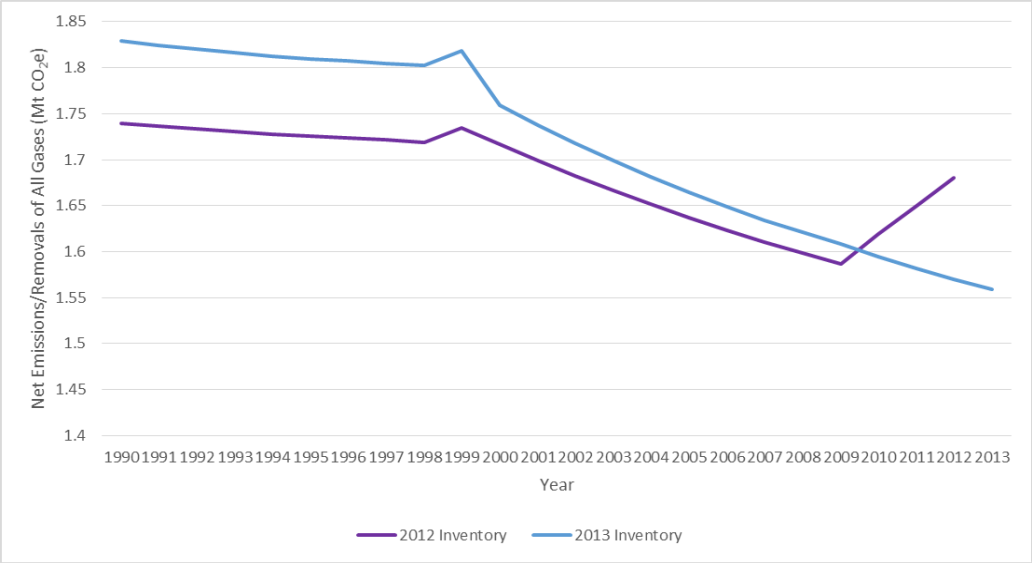

Figure A8.29 Settlements - Scotland

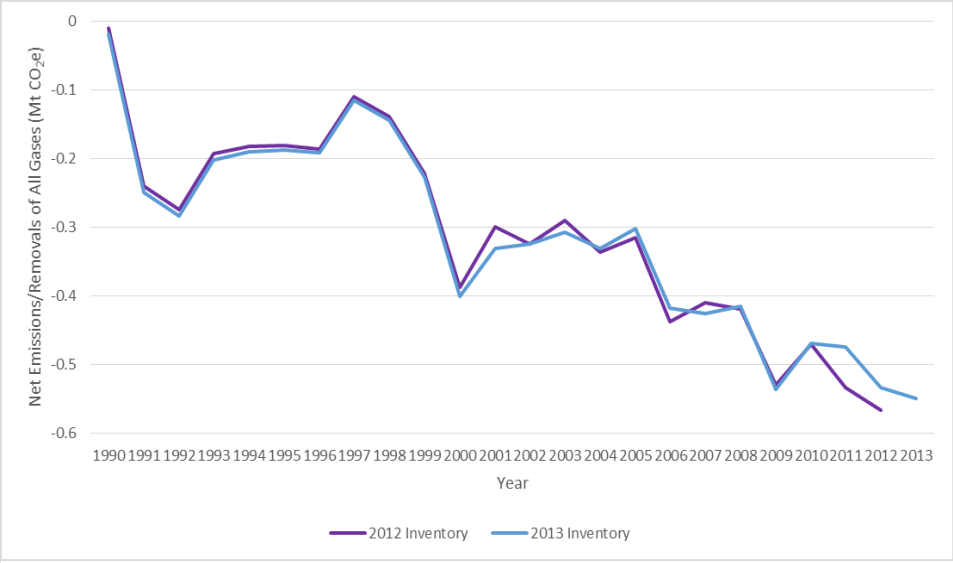

Figure A8.30 Harvested Wood Products - Scotland

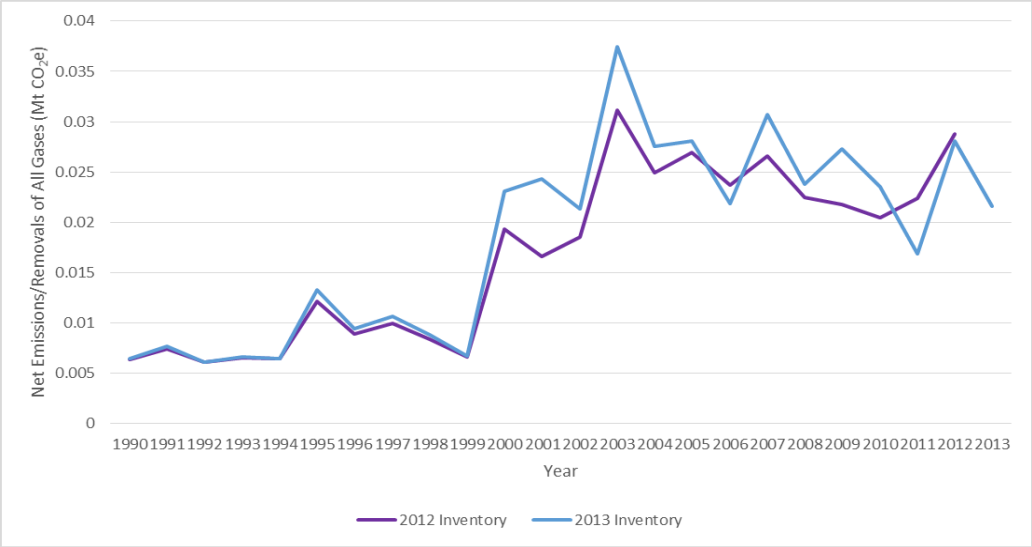

Figure A8.31: Changes in net emissions of CH_4 only 1990-2013 between the 2012 Inventory and 2013 Inventory for Scotland LULUCF

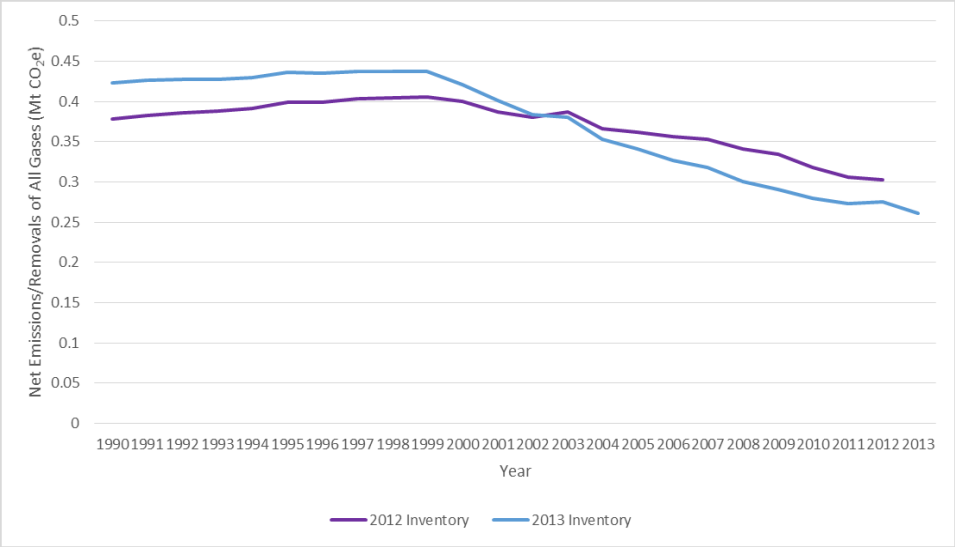

Figure A8.32: Changes in net emissions of N_2O only 1990-2013 between the 2012 Inventory and 2013 Inventory for Scotland LULUCF.

A8.5 Wales: LULUCF Emissions and Removals

A8.5.1 Trends

The 1990-2013 Inventory shows Wales was a small net sink of greenhouse gases from LULUCF activities from 1991 onwards. In 1990 Wales was a small source at 0.1 Mt CO_2e, becoming a small net sink in 1991 and net removals gradually increased thereafter to a maximum of -0.7 Mt CO_2e in 2011, reducing slightly to -0.6 Mt CO_2e in.

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 are small for Wales relative to other emissions, as are removals from Harvested Wood Products.

Cropland produces the largest emissions source in Wales: this peaked at 1.26 Mt CO_2e in 1999 and has since steadily reduced to 0.93 Mt CO_2e in 2013. The Settlement category is a net source that has declined from a peak of 0.83 Mt CO_2e in 1999 to 0.66 Mt CO_2e in 2013.

The Forest land and Grassland categories are net sinks from 1990 to 2013. Forest land was a generally increasing sink in Wales increasing from -1.43 Mt CO_2e in 1990 to -1.80 Mt CO_2e in 1999 and remaining fairly constant until 2005. After 2006, net removals gradually reduced to -1.51 Mt CO_2e in 2013. Grassland net removals have fluctuated between -0.46 Mt CO_2e and -0.58 Mt CO_2e between 1990 and 2013.

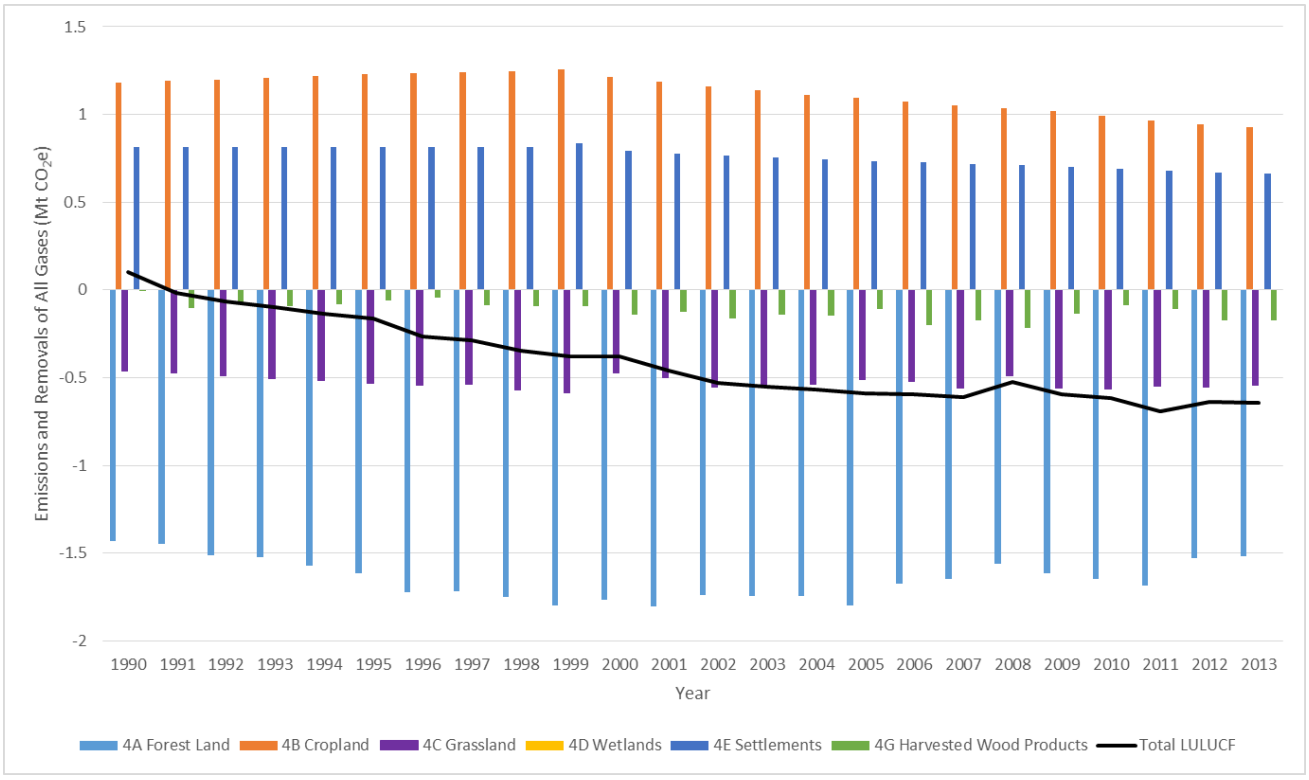

Figure A8.33: Emissions and removals for all gases by category for the LULUCF sector in Wales 1990-2013

A8.5.2 Category Trends

The Forest land category for Wales is a net sink for 1990-2013. 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. Forest wildfires show high inter-annual variability.

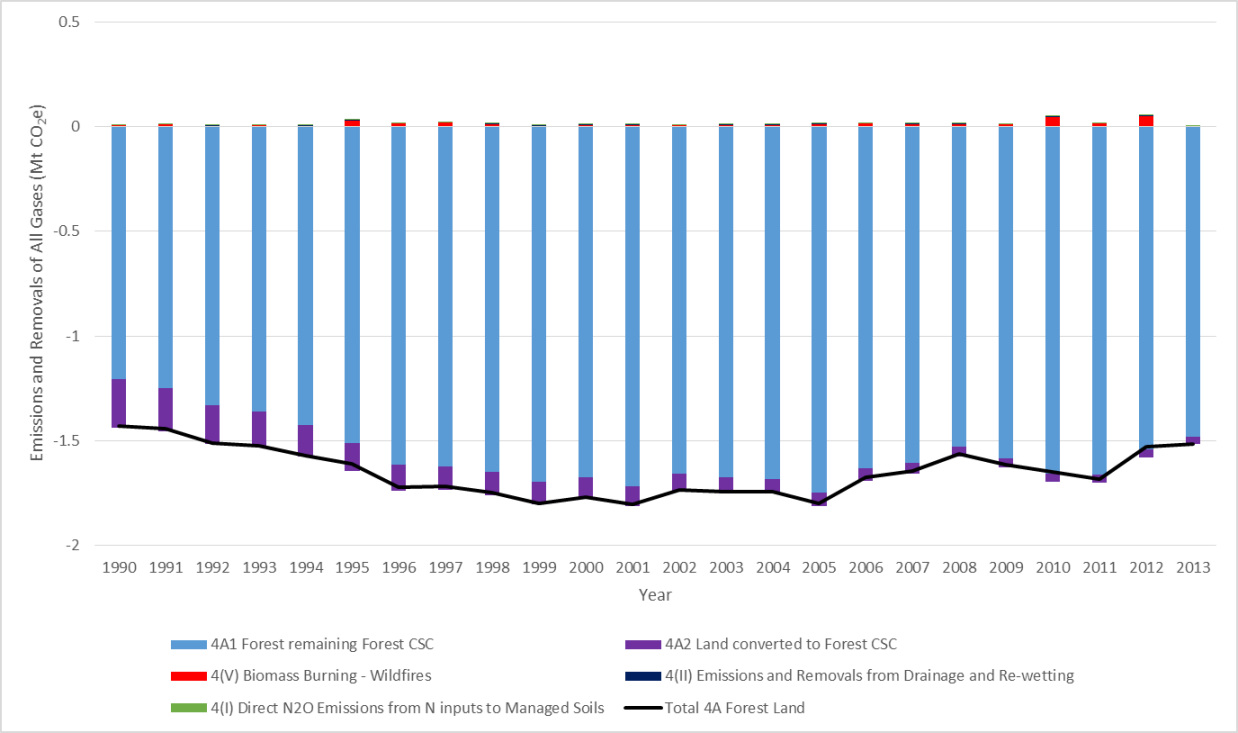

Figure A8.34: Emissions and removals of all gases by category for the 4A Forestry category in Wales 1990-2013

The Cropland category 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, 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 carbon stock changes arising from cropland management (e.g. inputs of fertiliser, manure and crop residues). Other GHG emissions from drained cropland organic soils are small.

The Grassland category for Wales is a net sink for 1990-2013. Removals from carbon stock changes in Grassland remaining Grassland and Land converted to Grassland are counter-balanced by emissions from drained organic soils under improved grassland and biomass burning. 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.

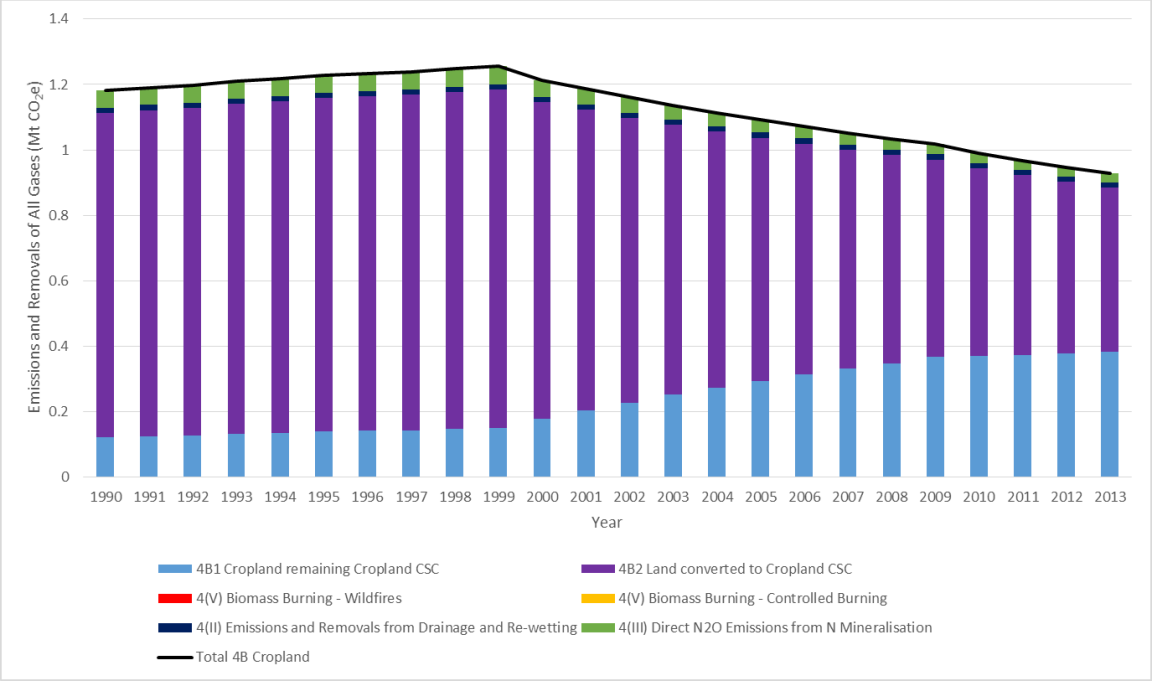

Figure A8.35: Emissions and removals of all gases by category for the 4B Cropland category in Wales 1990-2013

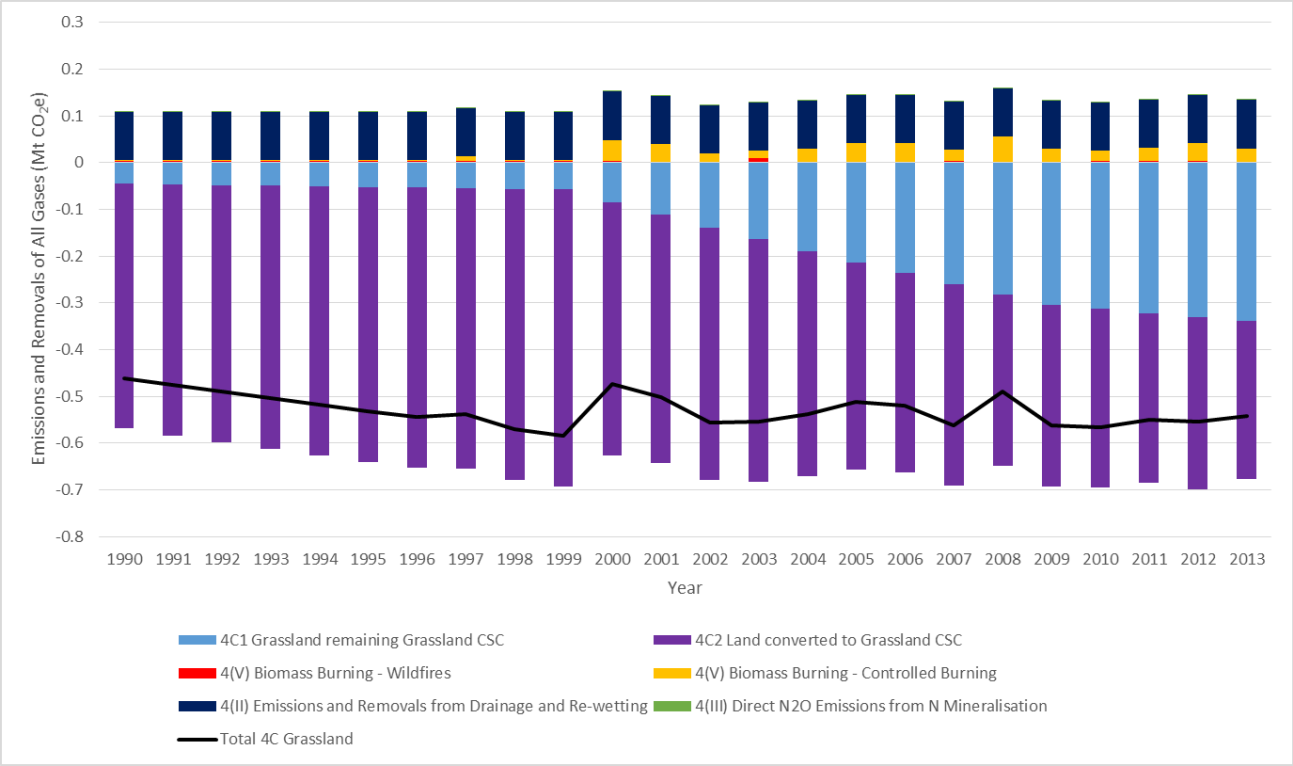

Figure A8.36: Emissions and removals of all gases by category for the 4C Grassland category in Wales 1990-2013

The Wetland category is a minor source for Wales, with the smallest emissions from peat extraction in the UK, at <0.00 Mt CO_2e. The peak in 1991 is due to carbon stock losses resulting from reservoir construction (Trawsfynydd). Between 1990 and 2013, approximately 0.5 kha was estimated to be emitting carbon dioxide as a result of historical commercial peat extraction in Wales. There was no new peat extracted and sold in Wales for the horticultural industry.

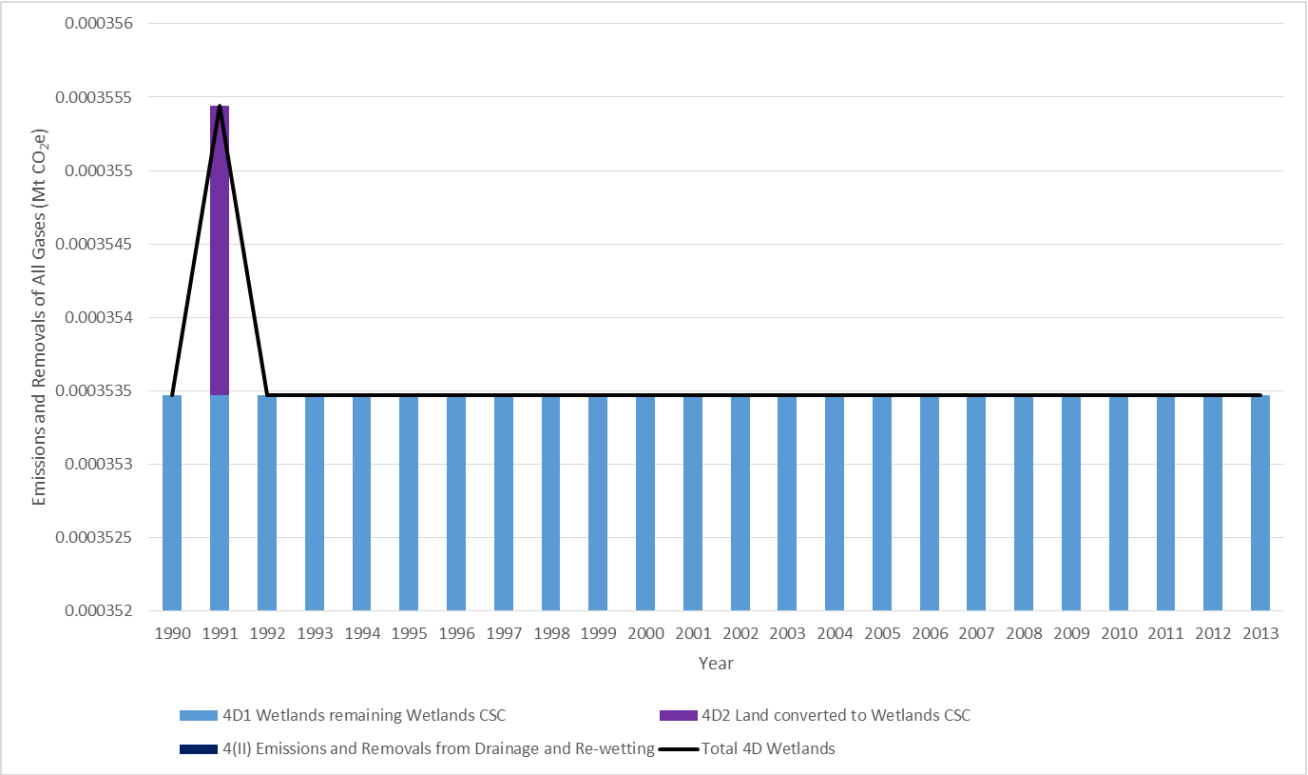

Figure A8.37: Emissions and removals of all gases by category for the 4D Wetland category in Wales 1990-2013

The Settlements category 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 (historical LUC). 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 is a net sink of CO_2 for Wales. 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.

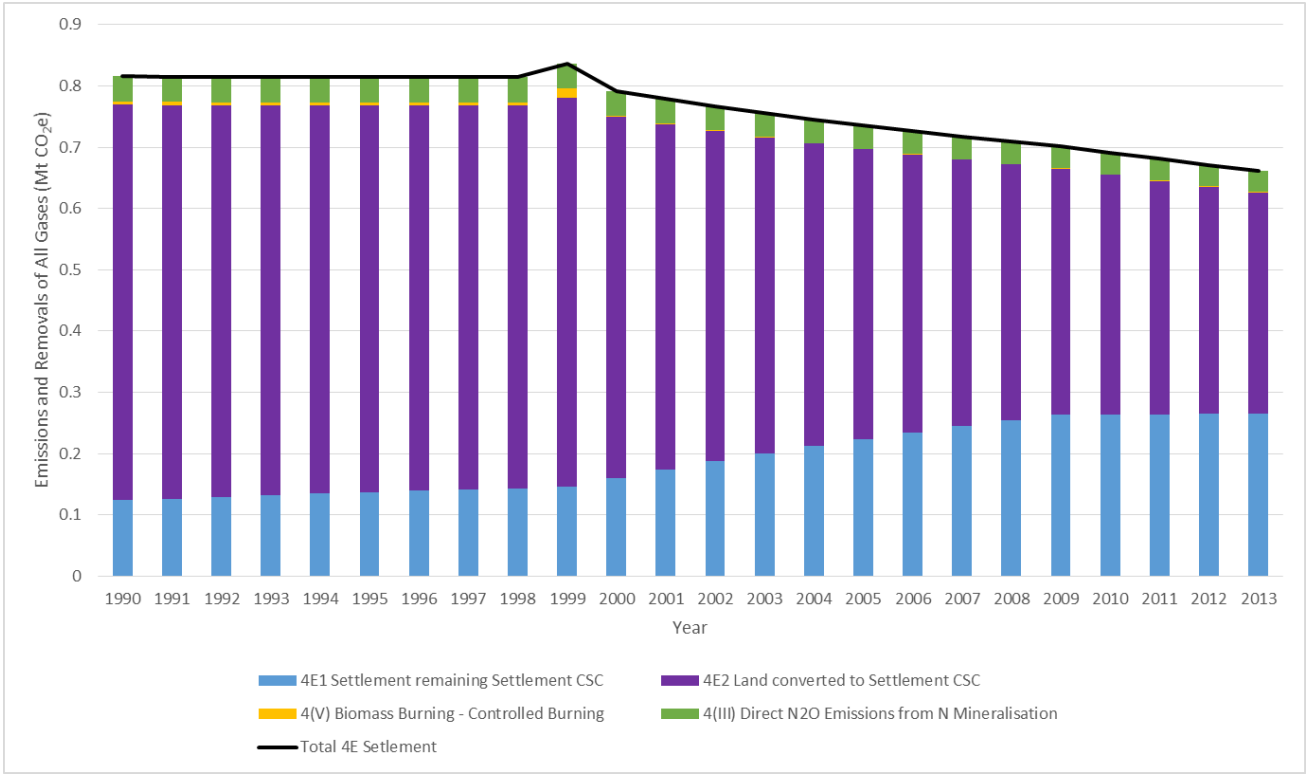

Figure A8.38: Emissions and removals of all gases by category for the 4E Settlement category in Wales 1990-2013

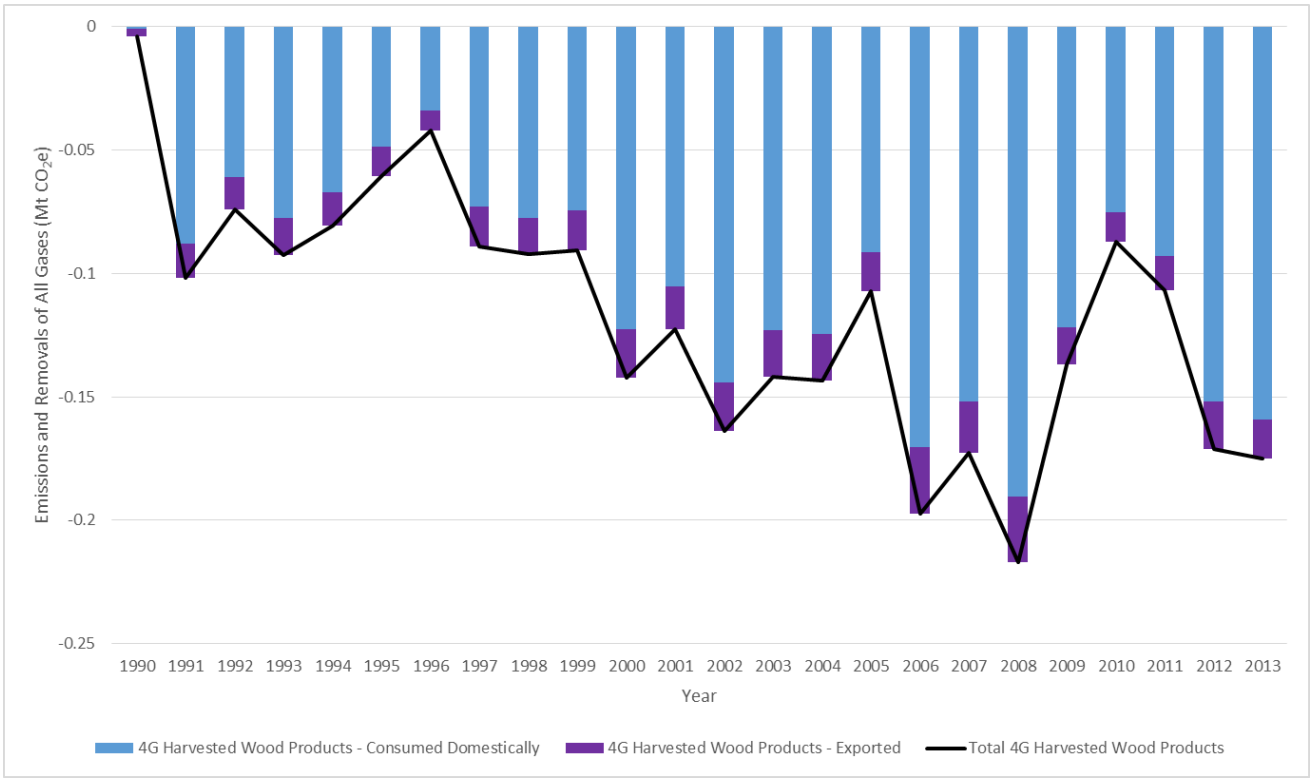

Figure A8.39: Emissions and removals of all gases by category for the 4G Harvested Wood Products category in Wales 1990-2013

A8.5.3 Comparison with 2012 inventory

Net emissions from the LULUCF sector in Wales have changed slightly from those in the 1990-2012 inventory but there is no clear pattern of net increase or decrease. The differences are due to a combination of changes in all sub-categories. Compared to the 1990-2012 inventory, net emissions of greenhouse gases in the current inventory have increased by 0.03 Mt CO_2e in 1990 and decreased by 0.11 Mt CO_2e in 2012. Differences between the 2012 and 2013 inventories for CO_2 in each category are presented in Figure 16A-F. Differences between the 2012 and 2013 inventories for non-CO_2 for Wales are presented in Figure 17 and 18.

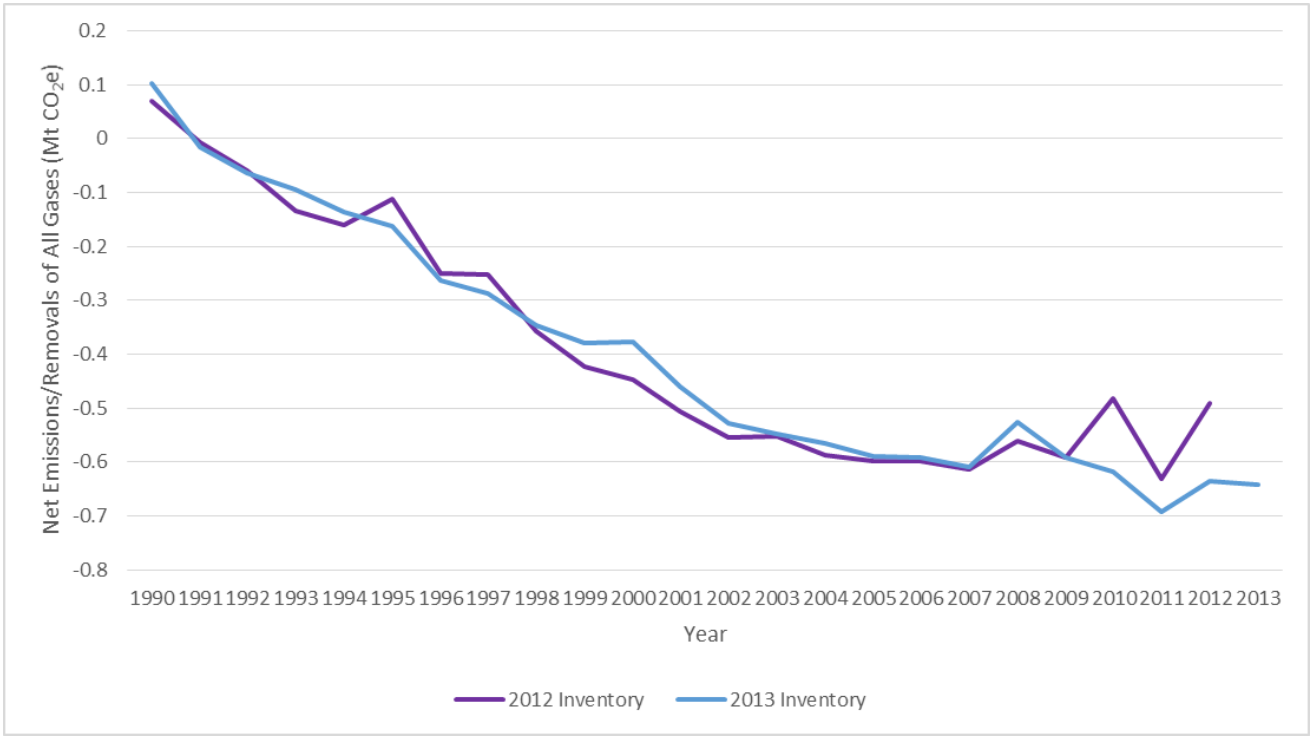

Figure A8.40: Changes in net emissions and removals of all gases 1990-2013 between the 2012 Inventory and 2013 Inventory for Wales

Net removals in the Forest Land category in Wales have changed little since the previous inventory (an increase in removals of 2% on average), although there has been some refinement of the CARBINE input data.

In the Cropland category estimates for emissions for Wales have changed little over the time period. Agricultural liming has been transferred to the Agriculture sector inventory (average emission 0.09 Mt CO_2e p.a.) and cropland management (average removal -0.002 Mt CO_2e p.a.) and emissions from drained organic soils (0.02 Mt CO_2e p.a.) have been introduced.

In the Grassland category estimates for removals in Wales have increased by an average of 4% in the 1990-2013 inventory for 1990-1998 (-0.002 Mt CO_2e p.a.), but decreased by an average of 9% for 1999-2012 (0.053 Mt CO_2e p.a.), although the difference is not consistent. Although emissions from agricultural liming have been removed (average emission 0.076 Mt CO_2e p.a.), emissions from drained organic soils under improved grassland have been introduced (0.103 Mt CO_2e p.a.). Estimated areas of deforestation were revised for 2000 onwards, affecting Land converted to Grassland and emissions from controlled burning, but this did not have a consistent positive or negative impact on net emissions. The re-running of the LUC model also affected emissions from 2010-2013.

In the Wetland category estimates for emissions for Wales remain the same as the previous inventory, except for 1991 when there is a spike in emissions due to carbon stock losses resulting from reservoir construction (Trawsfynydd).

In the Settlements category estimates for emissions for Wales have slightly increased by an average of 5% for 1990-1999 and decreased after 2000 (by an average of 2%). This is due to the inclusion of N_2O emissions from N mineralisation due to land use change for the first time under the 2006 IPCC Guidance (average of 0.039 Mt CO_2e p.a.), offset by a large reduction in the area of deforestation to Settlement after 2000 (from 133 ha/yr to 9 ha/yr). The re-running of the LUC model also affected emissions from 2010-2013.

Net removals in the Harvested Wood products category in Wales have changed little since the previous inventory.

The CH_4 emission trend has changed slightly, mainly due to updated activity data for wildfires and controlled burning following deforestation after 2000. N_2O emissions have increased compared to the 1990-2012 inventory. This is due to the increased emissions from the inclusion of N_2O emissions from N mineralisation following land use change to Settlement being offset by reduced N_2O

emissions from Cropland (N_2O emissions from N mineralisation from land use change to Cropland over 20 years ago is now reported in the Agriculture sector).

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

IPCC Sector	Difference between 2013 and 2012 inventory estimates, Gg CO_2e	
	1990	2012
4A Forest Land	-12	-120
4B Cropland	23	3
4C Grassland	-18	18
4D Wetlands	0	0
4E Settlements	45	-44
4G Harvested Wood Products	-5	-2

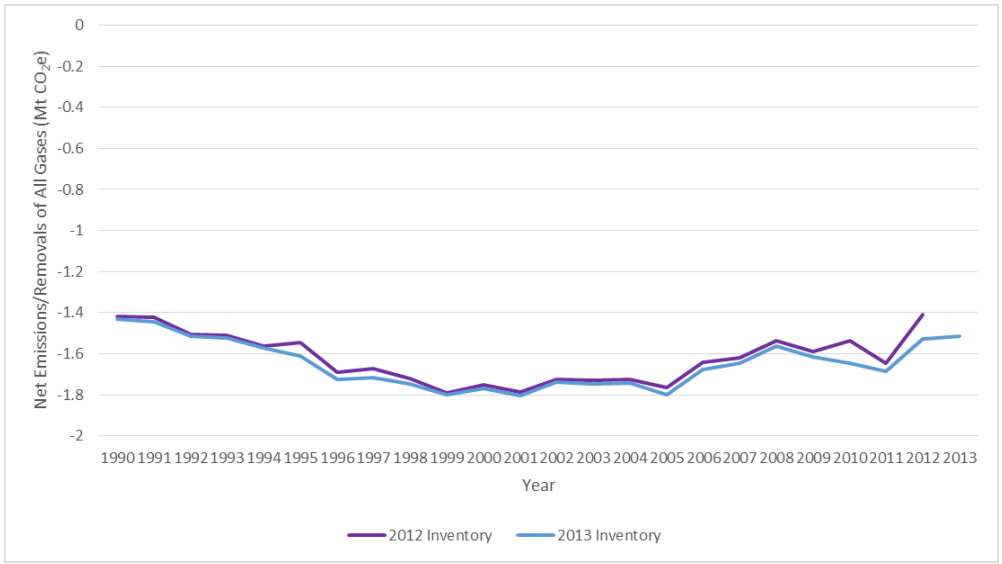

Figure A8.41 Forest Land – Wales

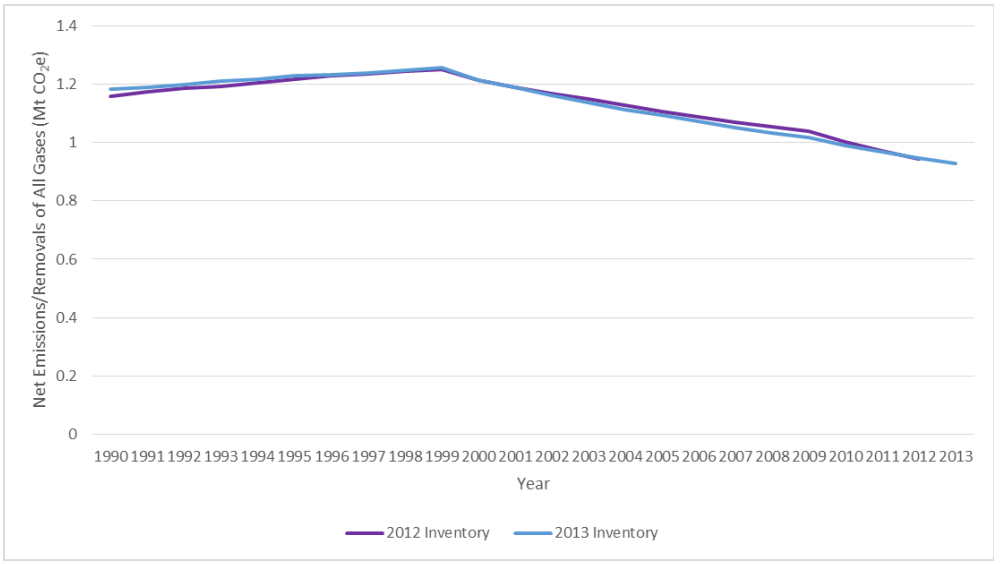

Figure A8.42 Cropland - Wales

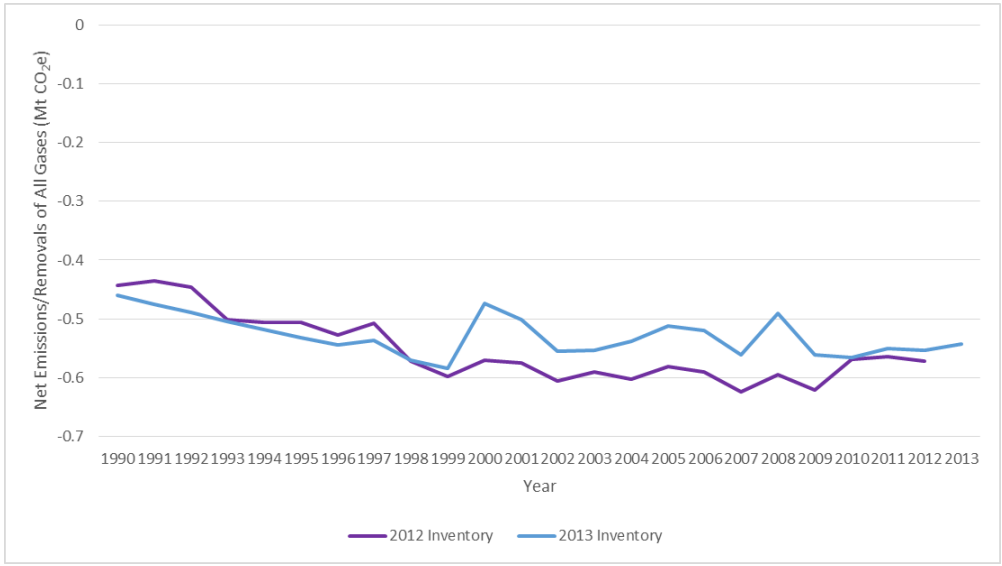

Figure A8.43 Grassland – Wales

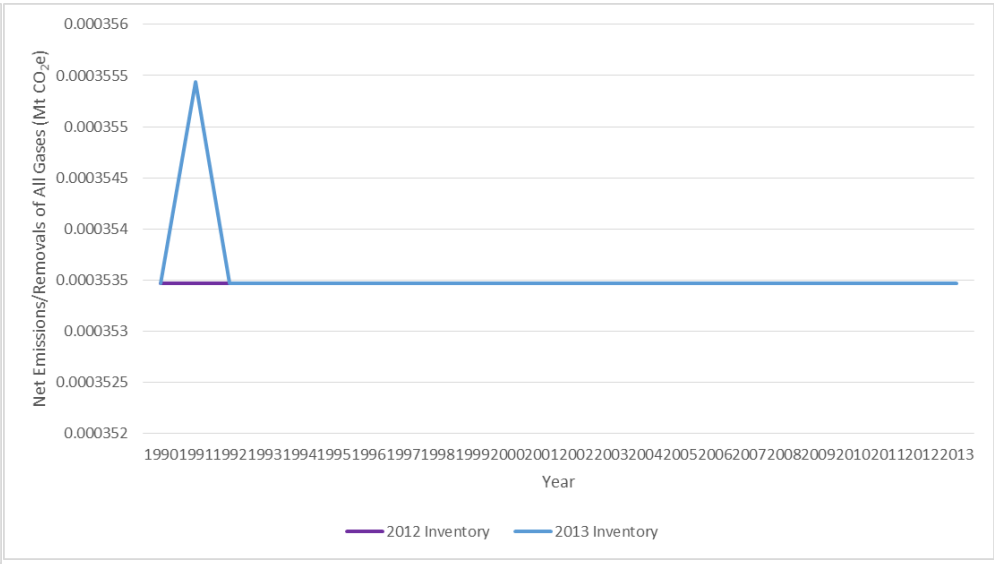

Figure A8.44 Wetlands - Wales

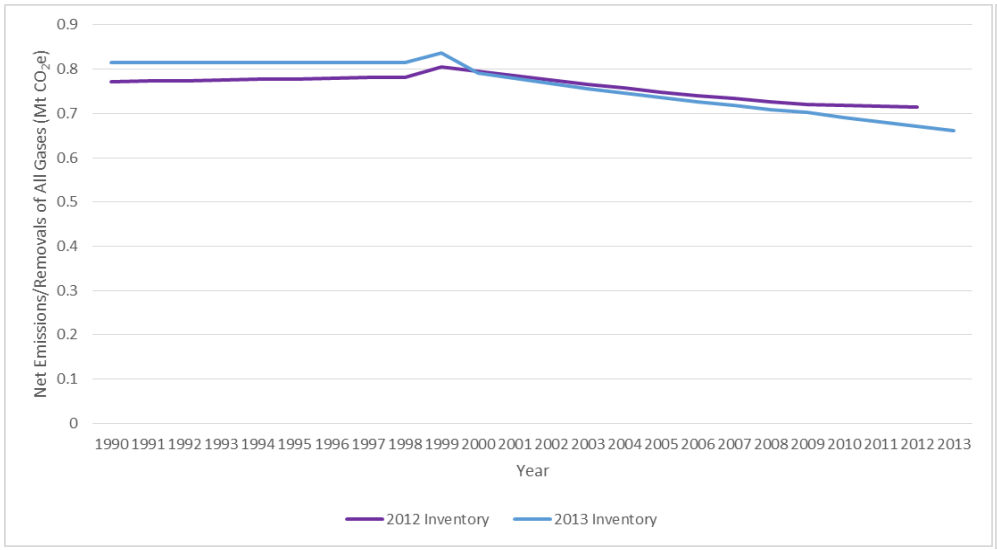

Figure A8.45 Settlements – Wales

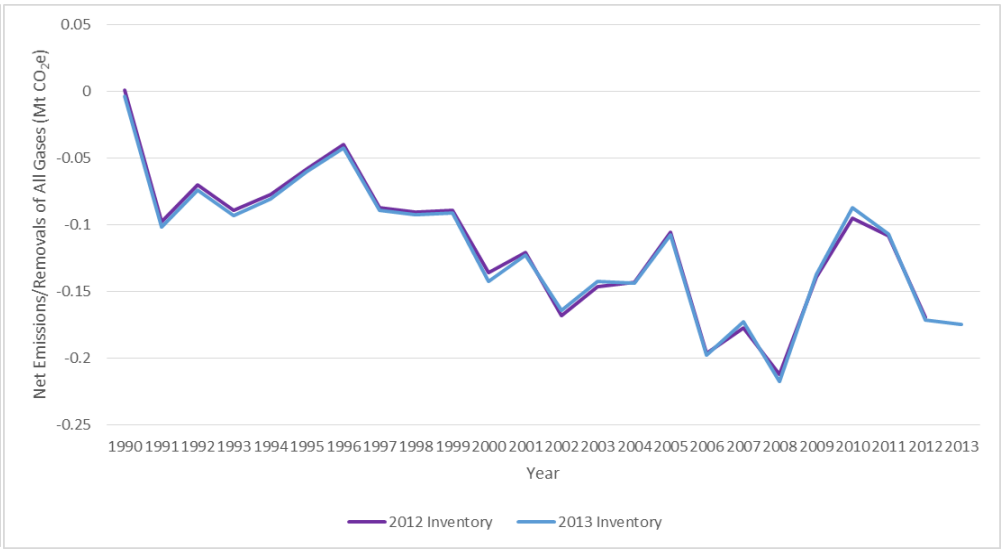

Figure A8.46 Harvested Wood Products - Wales

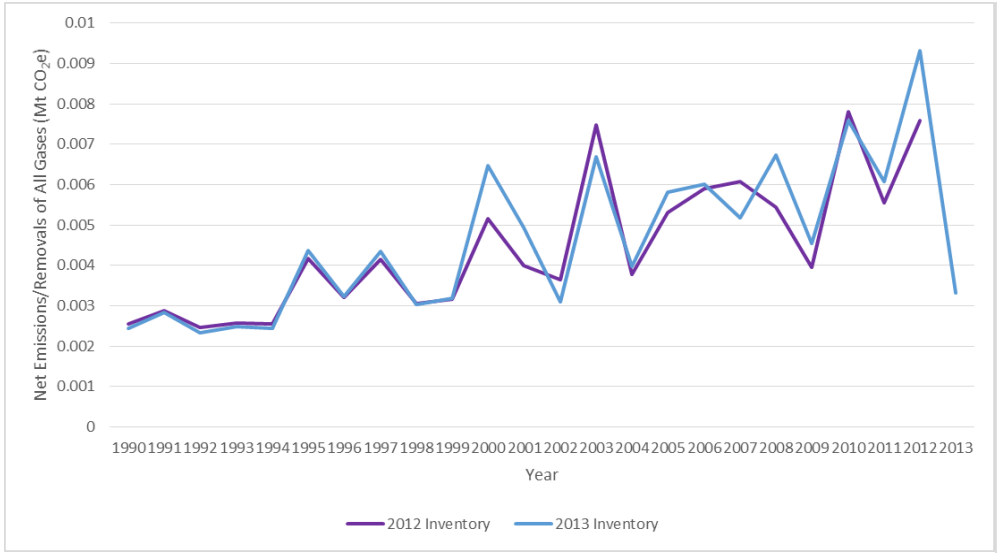

Figure A8.47: Changes in net emissions of CH_4 only 1990-2013 between the 2012 Inventory and 2013 Inventory for Wales LULUCF

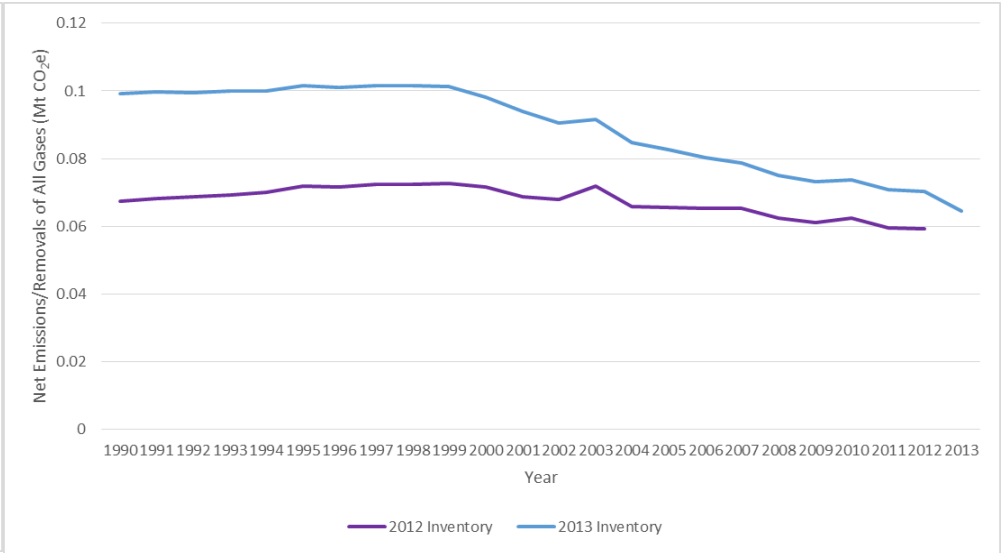

Figure A8.48: Changes in net emissions of N_2O only 1990-2013 between the 2012 Inventory and 2013 Inventory for Wales LULUCF.

A8.6 Northern Ireland: LULUCF Emissions and Removals

A8.6.1 Trends

The 1990-2013 Inventory shows that Northern Ireland was a small net source of emissions of greenhouse gases from LULUCF activities throughout the 1990-2013 time period. In 1990 Northern Ireland was a small source at 1.52 Mt CO_2e, falling to 1.19 Mt CO_2e by 1999, then gradually increasing to a peak of 1.58 Mt CO_2e in 2012; the net source in 2013 was 1.47 Mt CO_2e.

The main influences on the LULUCF sector in Northern Ireland are emissions from Cropland and Settlement, and removals from Forest land. Removals from Grassland have changed from a substantial sink to a small source compared with previous inventories, due to changes in reporting categories in the new IPCC guidance. Emissions from Wetland and Grassland are low for Northern Ireland relative to other emissions, as are removals from Harvested Wood Products.

Cropland is the largest source of LULUCF emissions in Northern Ireland, although between 1990 and 2013 levels gradually decreased from 1.43 Mt CO_2e in 1990 to 1.16 Mt CO_2e in 2013. The Settlement category is a net source of approximately 0.58 Mt CO_2e for 1990-1998, gradually increasing to 0.95 Mt CO_2e in 2013. Grasslands and Wetlands are small net sources (annual averages of 0.06 Mt CO_2e and 0.16 Mt CO_2e respectively).

The size of the Forest land sink increased from -0.71 Mt CO_2e in 1990 to -0.94 Mt CO_2e in 2006. It decreased to -0.70 Mt CO_2e in 2012 and was -0.82 Mt CO_2e in 2013. Removals from Harvested Wood Products have increased from -0.02 Mt CO_2e in 1990 to -0.09 Mt CO_2e in 2013.

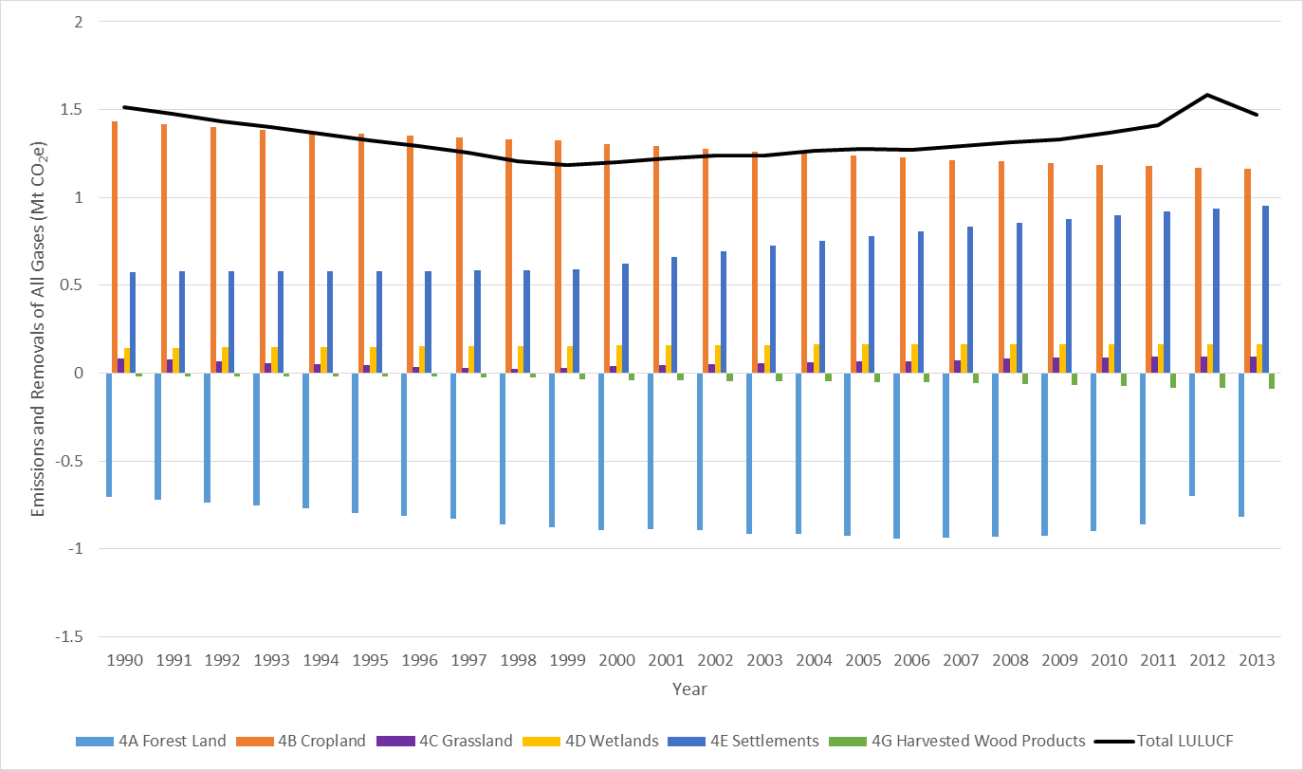

Figure A8.49: Emissions and removals for all gases by category for the LULUCF sector in Northern Ireland 1990-2013

A8.6.2 Category Trends

The Forest land category (see 2.2) for Northern Ireland is a net sink for 1990-2013. 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. The exception is a spike in emissions from forest wildfires in 2012: the wildfire area that year was 704 ha, 14 times the 1990-2011 forest wildfire average for Northern Ireland and the greatest total forest wildfire area in the UK in 2012.

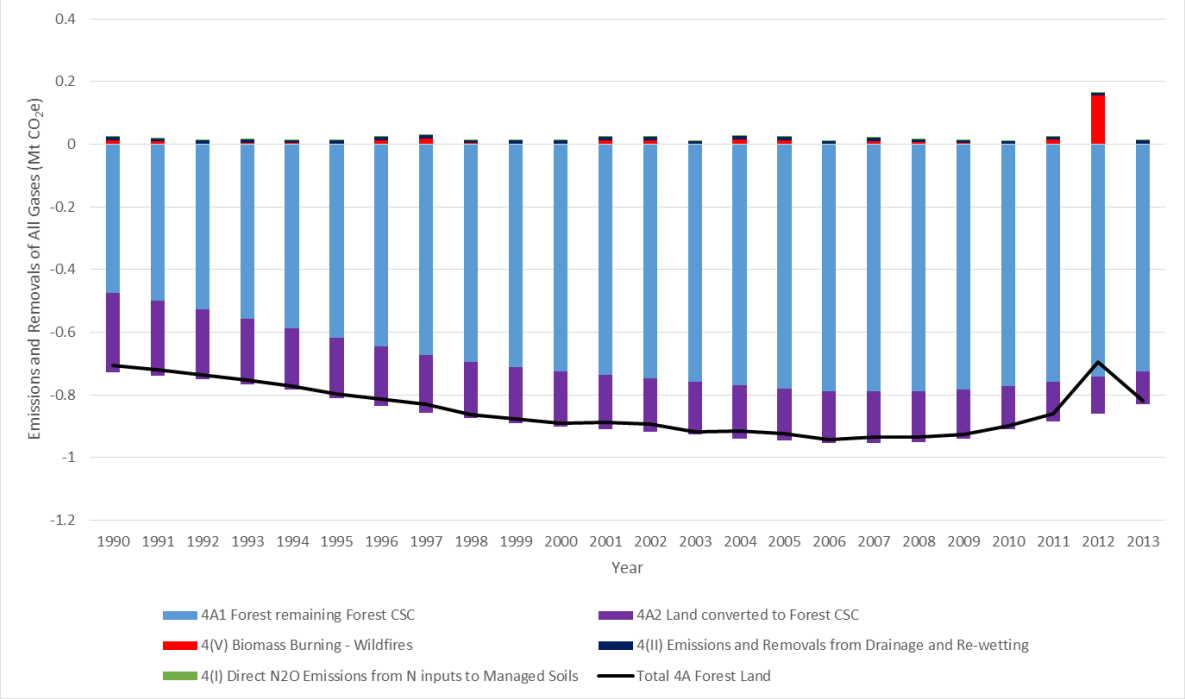

Figure A8.50: Emissions and removals of all gases by category for the 4A Forestry category in Northern Ireland 1990-2013

The Cropland category 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, 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 carbon stock changes arising from cropland management (e.g. inputs of fertiliser, manure and crop residues). Emissions from drained organic cropland soils area also included, although these are not large.

The Grassland category for Northern Ireland is now a small net source for 1990-2013, having previously been a net sink. Removals from land conversion to grassland (from Cropland) due to either historical change (reported in Grassland remaining Grassland) or recent conversion (Land converted to Grassland) are counter-balanced by large emissions from drained organic soils under improved grassland. Other sources of emissions (wildfires, N_2O emissions from N mineralisation following land use change and controlled burning following deforestation) are insignificant.

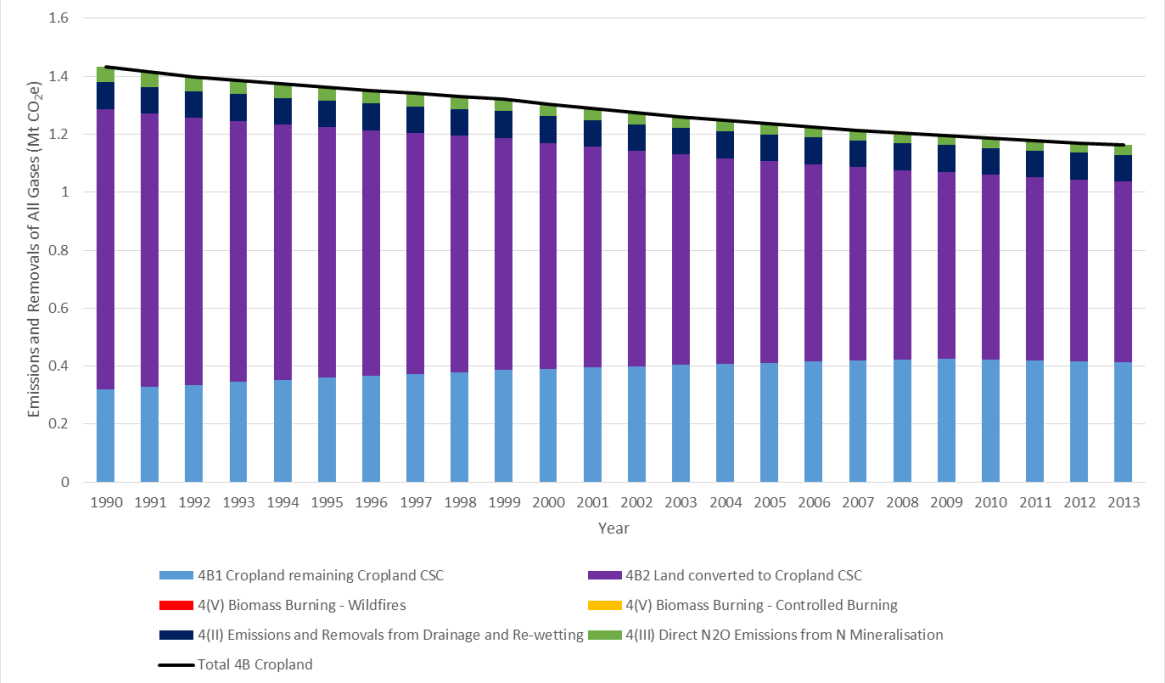

Figure A8.51: Emissions and removals of all gases by category for the 4B Cropland category in Northern Ireland 1990-2013

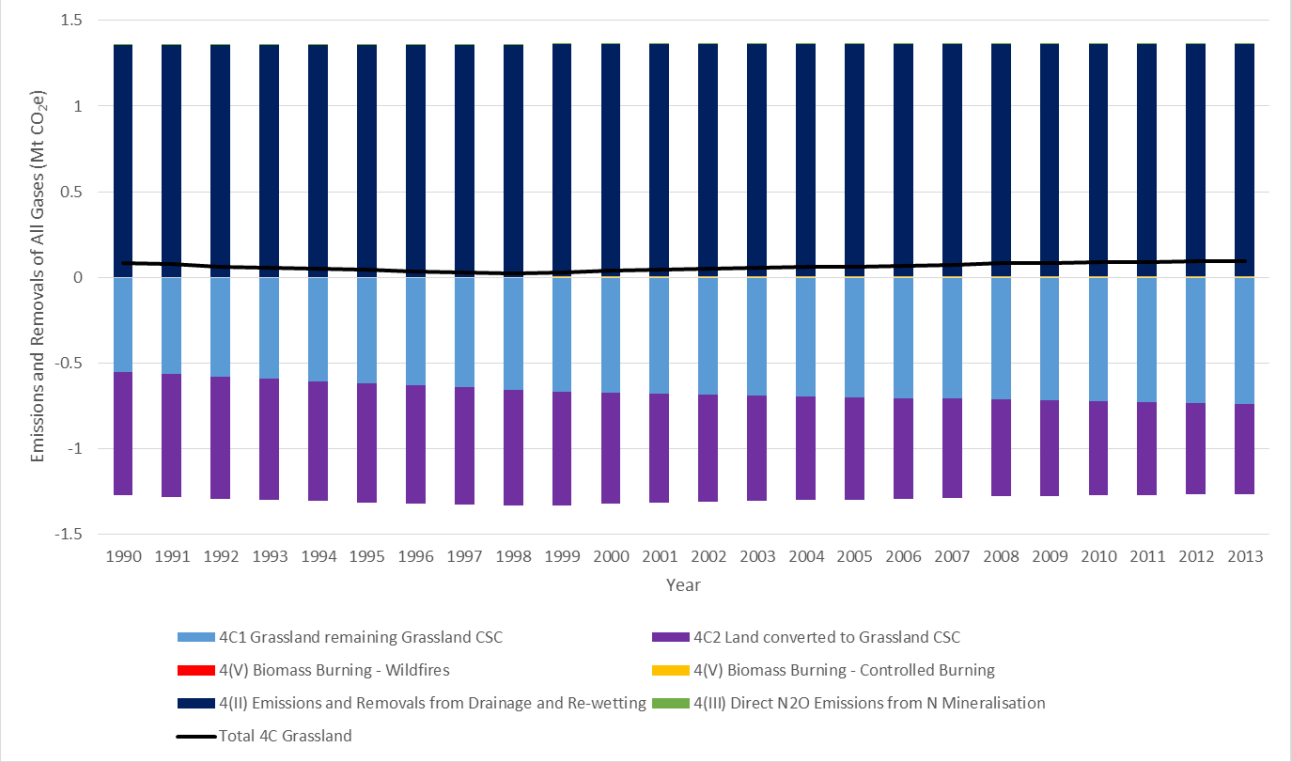

Figure A8.52: Emissions and removals of all gases by category for the 4C Grassland category in Northern Ireland 1990-2013

The Wetland category is a net source for Northern Ireland. In 1990 approximately 4.5 kha was estimated to be emitting carbon dioxide as a result of commercial peat extraction. This has gradually decreased to 1.0 kha in 2007-2013. An estimated 71% 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.

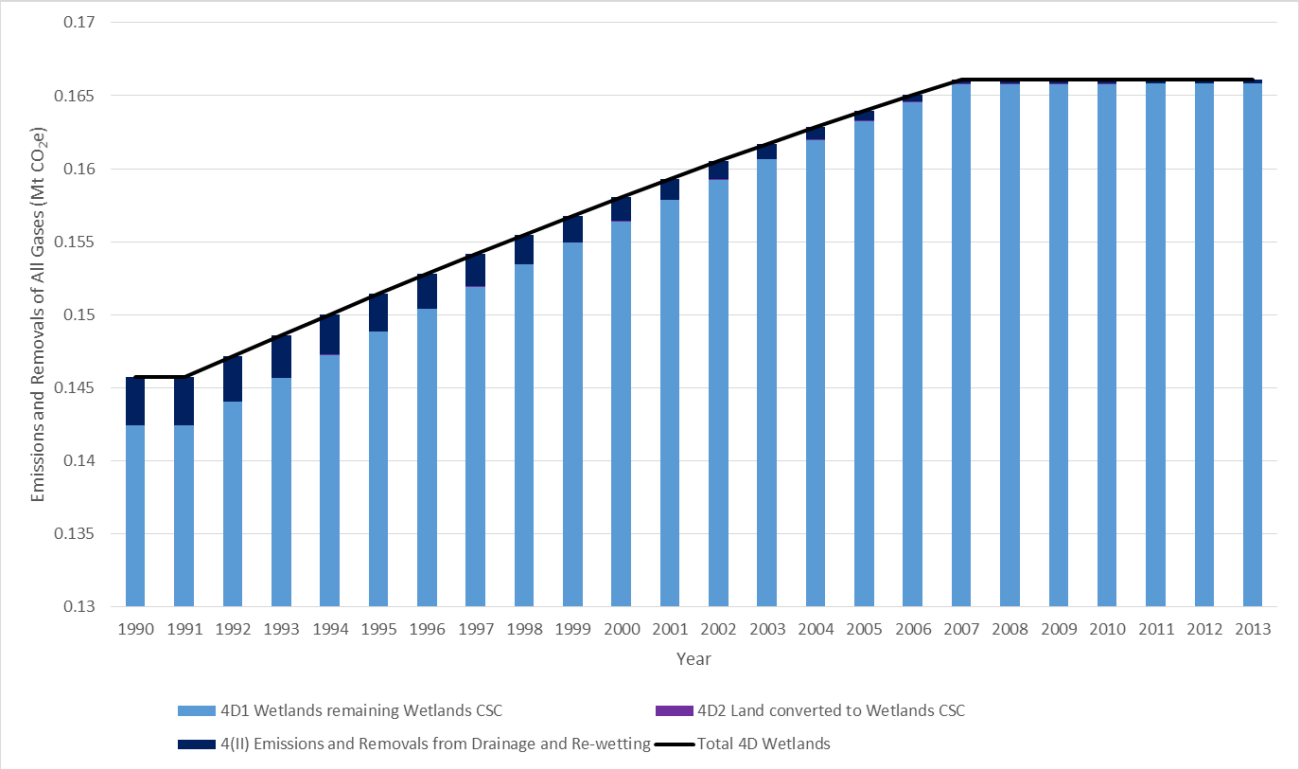

Figure A8.53: Emissions and removals of all gases by category for the 4D Wetland category in Northern Ireland 1990-2013

The Settlements category 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 (historical LUC). There are also related N_2O emissions from N mineralisation following land use change. The majority of

emissions are from Grassland converted to Settlements (72%). There are a small amount of GHG emissions resulting from controlled biomass burning during deforestation to Settlements.

The Harvested Wood Products category is a net sink of CO_2 for Northern Ireland. 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.

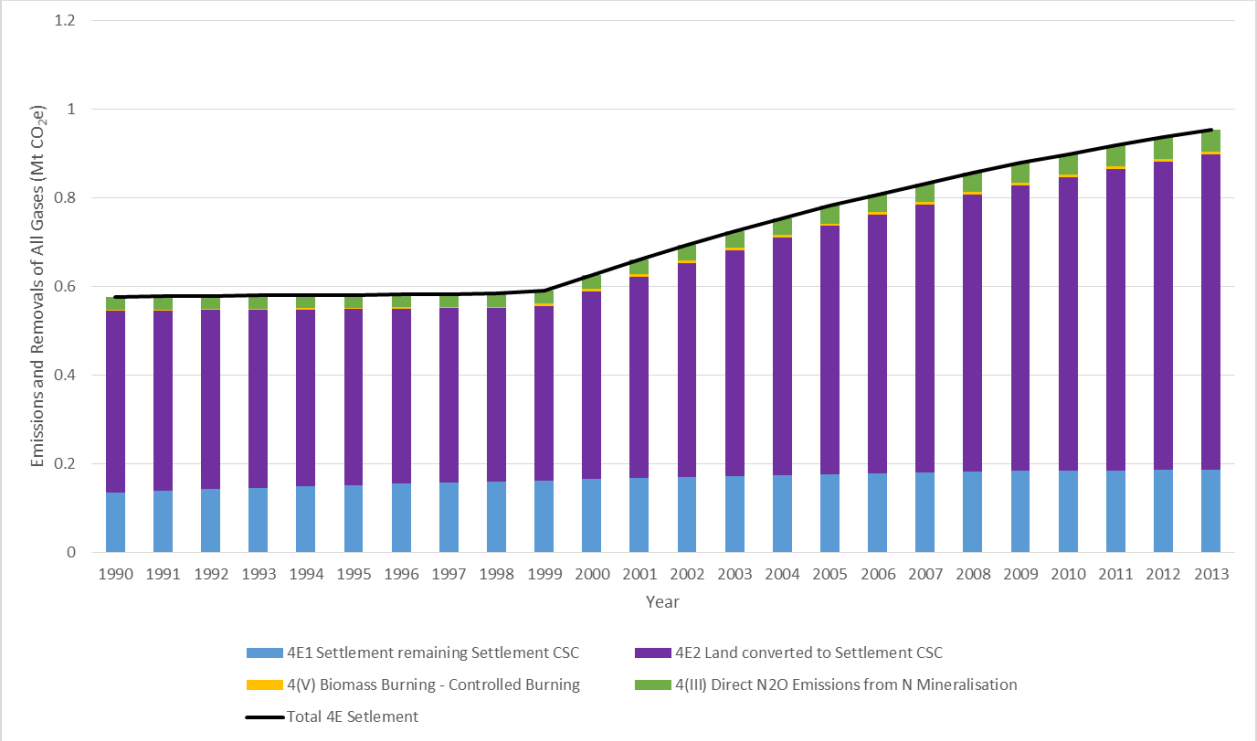

Figure A8.54: Emissions and removals of all gases by category for the 4E Settlement category in Northern Ireland 1990-2013

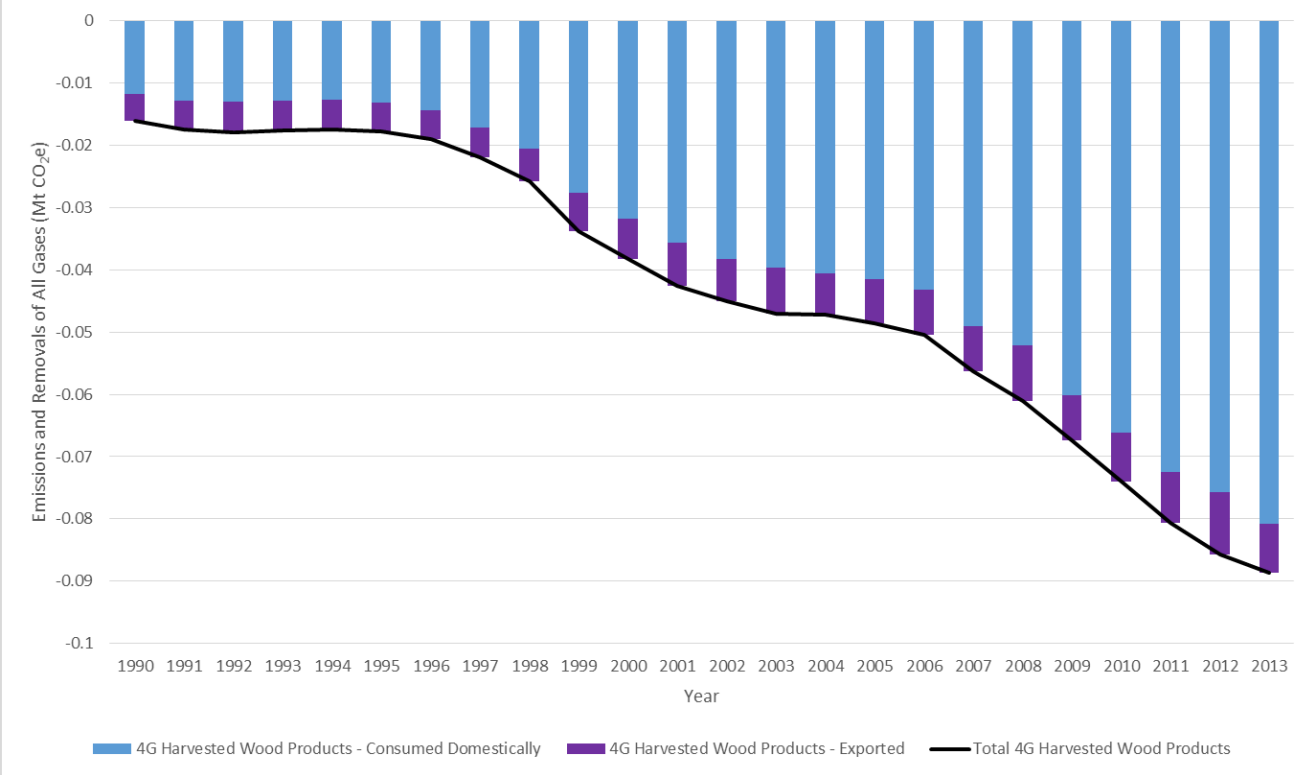

Figure A8.55: Emissions and removals of all gases by category for the 4G Harvested Wood Products category in Northern Ireland 1990-2013

A8.6.3 Comparison with 2012 inventory

The LULUCF sector in Northern Ireland for the 1990-2013 inventory has moved from being an overall small net sink to a net source of GHG emissions. Compared to the 1990-2012 Inventory, net emissions have increased by an average of 1.44 Mt CO_2e per year (1.37-1.54 Mt CO_2e). The revised estimates primarily reflect changes in estimated emissions from the Grassland category, and to a lesser extent changes in the Cropland and Settlement categories. Differences between the 2012 and 2013 inventories for CO_2e in each category are presented below as are differences between the 2012 and 2013 inventories for non-CO_2 emissions for Northern Ireland.

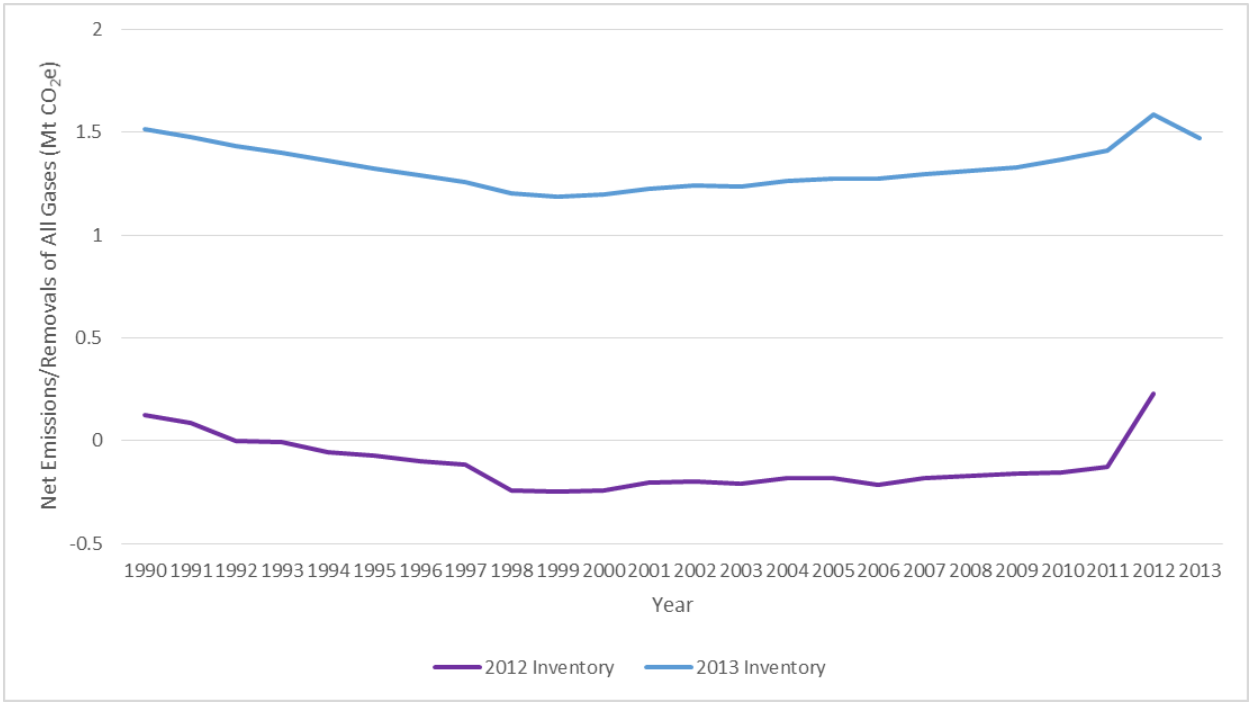

Figure A8.56: Changes in net emissions of all gases 1990-2013 between the 2012 Inventory and 2013 Inventory for Northern Ireland

Net removals in the Forest land category in Northern Ireland have not changed substantially between 1990 and 2011 (2% on average) (see Table 2 for data revisions), although the trend has been smoothed somewhat. There has been an increase in estimated removals in 2012 (0.28 Mt CO_2e), due to adjusted forest planting data.

In the Cropland category estimates for emissions for Northern Ireland have increased by 9% for 1990-2009. The transfer of agricultural liming emissions to the Agriculture sector inventory (average emission 0.007 Mt CO_2e p.a.), is counter-balanced by the addition of emissions from drained organic cropland soils (0.092 Mt CO_2e p.a.). The re-running of the LUC model also affected emissions from 2010-2013.

The Grassland category for Northern Ireland has moved from being a large net sink (-1.243 Mt CO_2e p.a. 1990-2012) to a small net source (0.061 Mt CO_2e p.a. 1990-2013), a difference of 1.3 Mt CO_2e p.a. on average. Although emissions from agricultural liming have been removed (average emission 0.05 Mt CO_2e p.a.), emissions from drained organic soils under improved grassland have been introduced (1.36 Mt CO_2e p.a.). The re-running of the LUC model also affected emissions from 2010-2013.

In the Wetland category estimates for emissions for Northern Ireland remain the same as the previous inventory.

In the Settlements category estimates for emissions for Northern Ireland have increased slightly by an average of 6% for 1990-2009. This is due to the inclusion of N_2O emissions from N mineralisation due to land use change for the first time under the 2006 IPCC Guidelines (average of 0.036 MtCO_2e per year). The re-running of the LUC model also affected emissions from 2010-2013.

Net removals in the Harvested Wood products category in Northern Ireland have changed little since the previous.

The CH_4 emission trend has changed little, mainly due to updated activity data for wildfires. N_2O emissions have increased compared to the 1990-2012 inventory, due to the increased emissions from the inclusion of N_2O emissions from N mineralisation following land use change to Settlement being offset by reduced N_2O emissions from Cropland (N_2O emissions from N mineralisation from land use change to cropland over 20 years ago is now reported in the Agriculture sector).

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

IPCC Sector	Difference between 2013 and 2012 inventory estimates, Gg CO_2e	
	1990	2012
4A Forest Land	-31	-277
4B Cropland	120	226
4C Grassland	1271	1236
4D Wetlands	0	0
4E Settlements	29	170
4G Harvested Wood Products	0	0

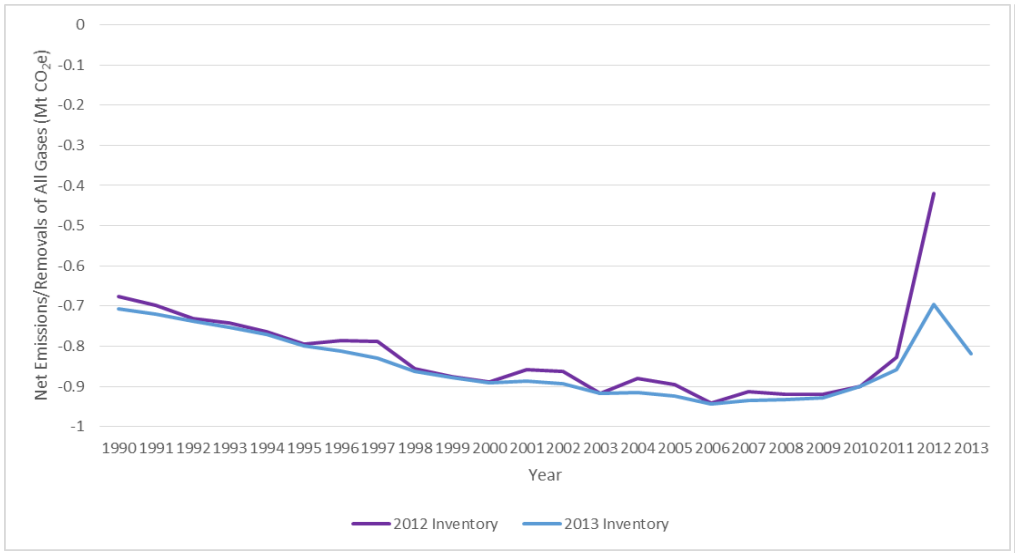

Figure A8.57 Forest Land - Northern Ireland

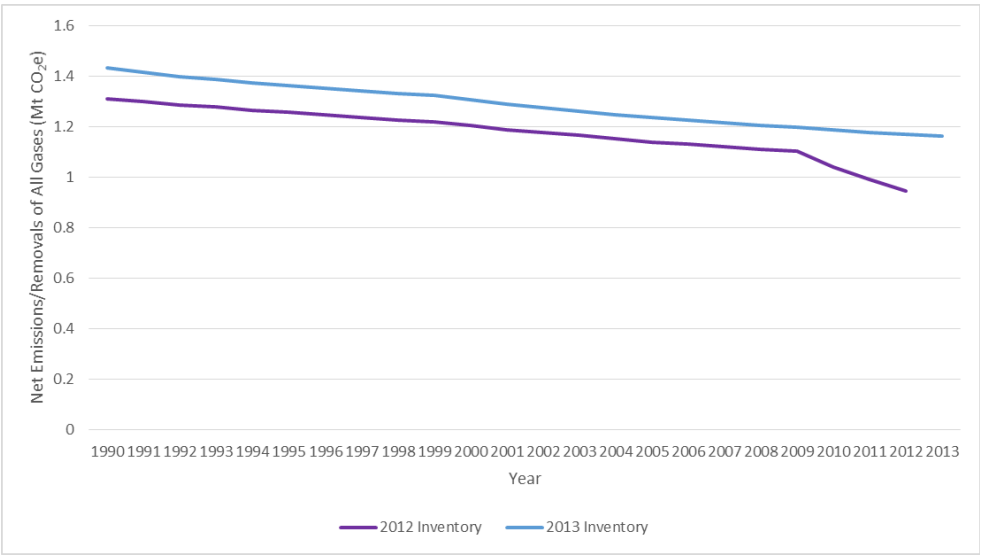

Figure A8.58 Cropland - Northern Ireland

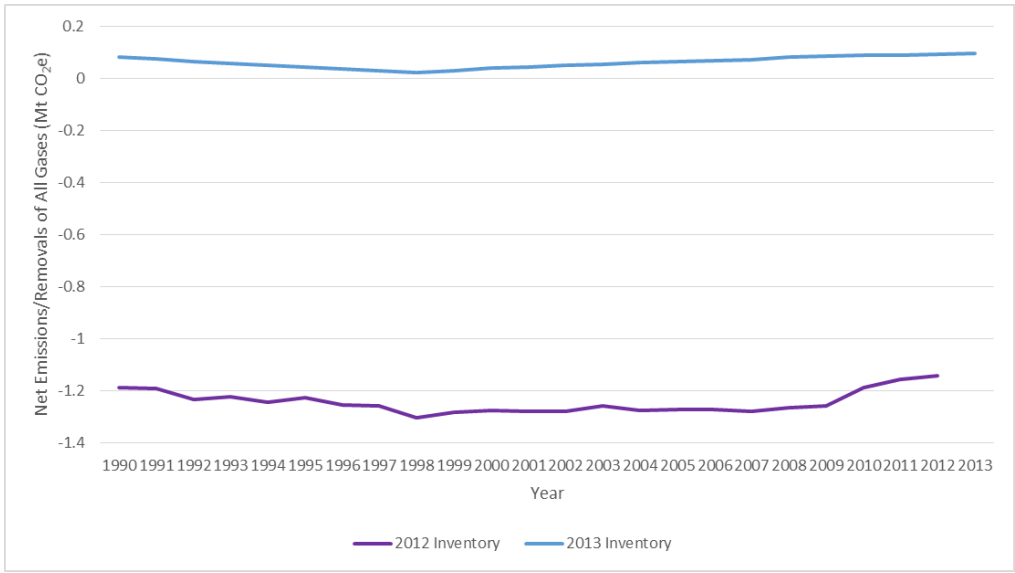

Figure A8.59 Grassland - Northern Ireland

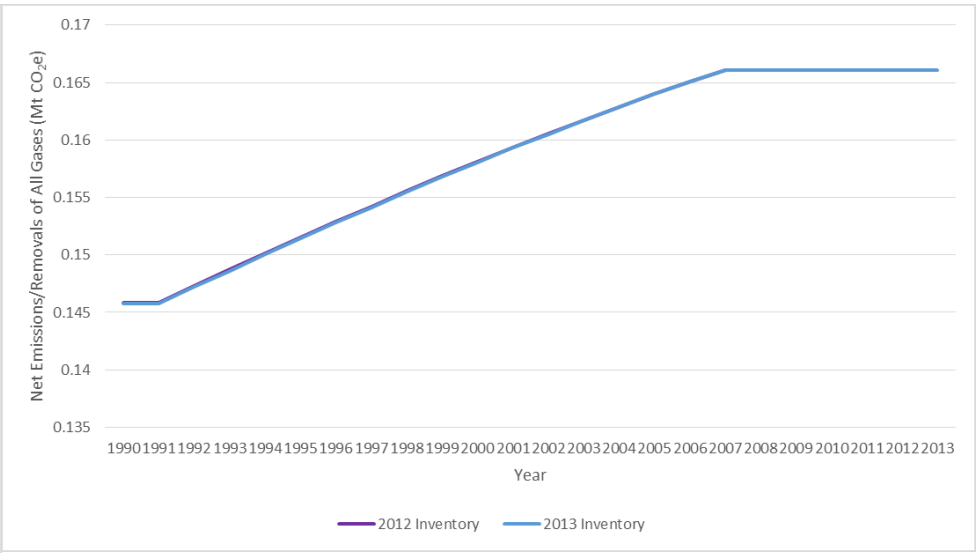

Figure A8.60 Wetlands - Northern Ireland

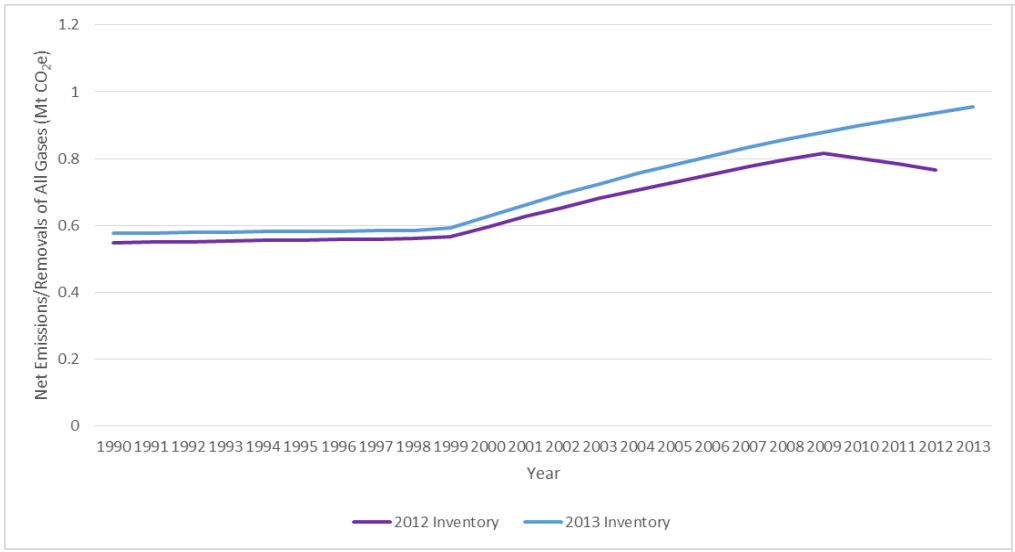

Figure A8.61 Settlements - Northern Ireland

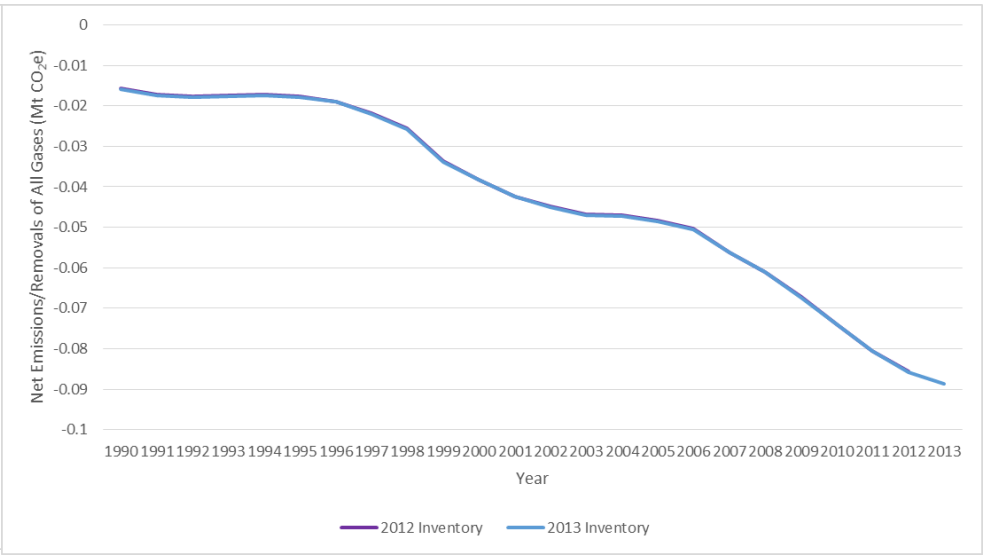

Figure A8.62 Harvested Wood Products - Northern Ireland

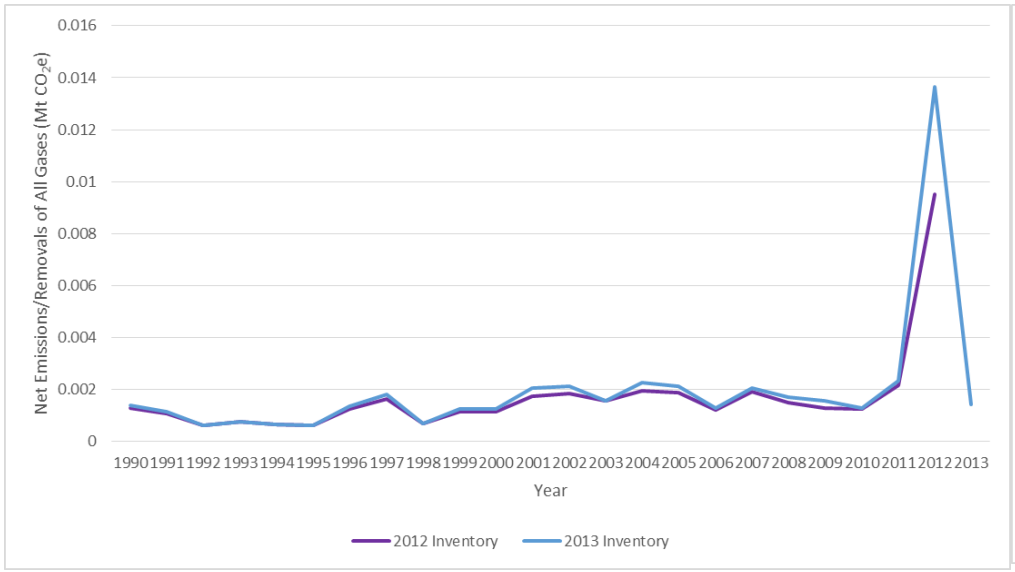

Figure A8.63: Changes in net emissions of CH_4 only 1990-2013 between the 2012 Inventory and 2013 Inventory for Northern Ireland LULUCF

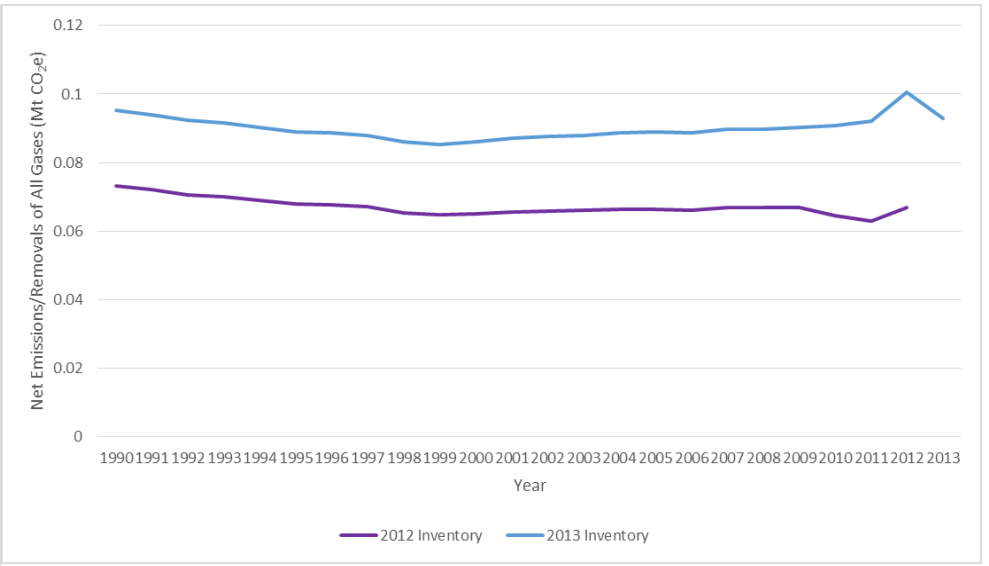

Figure A8.64: Changes in net emissions of N_2O only 1990-2013 between the 2012 Inventory and 2013 Inventory for Northern Ireland LULUCF.

A8.7 LULUCF Summary Tables

The following tables provide the LULUCF inventories for the Devolved Administrations. The data in the tables are given as kilotonnes of the respective greenhouse gases; the totals are given in CO_2e.

Table A8.6: England LULUCF emissions (kilotonnes)

Category	1990	1995	2000	2005	2010	2012	2013
A. Forest Land CO_2e	**-6771.013**	**-5772.530**	**-5783.790**	**-6366.851**	**-5839.859**	**-5505.968**	**-5429.245**
Carbon	-6781.059	-5794.954	-5795.182	-6381.617	-5848.168	-5518.989	-5437.547
CH_4	0.054	0.339	0.070	0.149	0.000	0.114	0.000
N_2O	0.029	0.047	0.032	0.037	0.028	0.034	0.028
B. Cropland CO_2e	**6625.261**	**6662.926**	**6281.124**	**5701.683**	**5521.977**	**5331.974**	**5270.161**
Carbon	6378.151	6428.996	6067.084	5538.023	5392.572	5208.774	5149.771
CH_4	0.004	0.005	0.002	0.002	0.001	0.002	0.003
N_2O	0.829	0.785	0.718	0.549	0.434	0.413	0.404
C. Grassland CO_2e	**-1966.649**	**-2245.359**	**-2414.337**	**-2763.002**	**-3207.510**	**-3490.018**	**-3503.193**
Carbon	-1976.338	-2255.507	-2432.166	-2781.777	-3225.453	-3513.898	-3513.780
CH_4	0.201	0.205	0.482	0.578	0.534	0.544	0.349
N_2O	0.016	0.017	0.019	0.015	0.015	0.034	0.006
D. Wetlands CO_2e	**266.883**	**374.892**	**299.324**	**221.405**	**110.691**	**102.702**	**102.700**
Carbon	266.883	374.892	299.324	221.405	110.691	102.702	102.700
E. Settlements CO_2e	**4044.852**	**3739.555**	**3453.786**	**3231.051**	**3065.581**	**3013.769**	**2990.092**
Carbon	3836.260	3546.415	3274.597	3063.310	2906.304	2857.157	2834.699
CH_4	0.172	0.122	0.018	0.019	0.021	0.022	0.022
N_2O	0.686	0.638	0.600	0.561	0.533	0.524	0.520
G. Harvested Wood Products CO_2e	**79.114**	**-375.162**	**-192.894**	**-193.534**	**-321.055**	**-327.755**	**-307.867**
Carbon	79.114	-375.162	-192.894	-193.534	-321.055	-327.755	-307.867
Grand Total CO_2e	**2278.448**	**2384.321**	**1643.213**	**-169.249**	**-670.176**	**-875.296**	**-877.352**

Table 8.7: Scotland LULUCF emissions (kilotonnes)

Category	1990	1995	2000	2005	2010	2012	2013
A. Forest Land CO_2e	**-7018.636**	**-7377.444**	**-8605.492**	**-9539.986**	**-9405.845**	**-9467.727**	**-9441.482**
Carbon	-7045.853	-7415.079	-8634.003	-9571.939	-9430.983	-9498.640	-9475.046
CH_4	0.042	0.306	0.069	0.156	0.000	0.129	0.197
N_2O	0.088	0.101	0.090	0.094	0.084	0.093	0.096
B. Cropland CO_2e	**6526.705**	**6817.255**	**6792.873**	**5960.282**	**5378.952**	**5185.720**	**5081.982**
Carbon	6229.063	6509.677	6496.767	5740.747	5213.929	5033.569	4935.771
CH_4	0.000	0.000	0.002	0.002	0.003	0.003	0.003
N_2O	0.999	1.032	0.993	0.736	0.554	0.510	0.490
C. Grassland CO_2e	**-1298.817**	**-1467.582**	**-1226.679**	**-1341.008**	**-1582.082**	**-1817.056**	**-1881.406**
Carbon	-1308.775	-1478.146	-1255.412	-1372.132	-1613.154	-1856.626	-1903.854
CH_4	0.177	0.182	0.833	0.940	0.913	0.963	0.636
N_2O	0.019	0.020	0.027	0.026	0.028	0.052	0.022
D. Wetlands CO_2e	**72.584**	**157.375**	**81.137**	**132.767**	**125.951**	**31.824**	**31.824**
Carbon	72.096	157.018	80.923	132.578	125.762	31.615	31.615
E. Settlements CO_2e	0.002	0.001	0.001	0.001	0.001	0.001	0.001
Carbon	**1828.753**	**1809.810**	**1758.906**	**1664.621**	**1594.705**	**1570.300**	**1559.104**
CH_4	1734.545	1716.621	1668.189	1578.767	1512.462	1489.317	1478.700
N_2O	0.036	0.043	0.021	0.024	0.026	0.027	0.028
G. Harvested Wood Products CO_2e	0.313	0.309	0.303	0.286	0.274	0.269	0.267
Carbon	**-18.574**	**-187.580**	**-399.992**	**-302.070**	**-469.027**	**-533.150**	**-549.260**
Grand Total CO_2e	-18.574	-187.580	-399.992	-302.070	-469.027	-533.150	-549.260

Table 8.8: Wales LULUCF emissions (kilotonnes)

Category	1990	1995	2000	2005	2010	2012	2013
A. Forest Land CO_2e	**-1430.998**	**-1611.913**	**-1767.319**	**-1798.067**	**-1647.809**	**-1529.092**	**-1514.848**
Carbon	-1434.333	-1618.278	-1770.886	-1802.428	-1656.318	-1538.049	-1517.649
CH_4	0.013	0.087	0.018	0.038	0.138	0.149	0.000
N_2O	0.010	0.014	0.010	0.011	0.017	0.018	0.009
B. Cropland CO_2e	**1182.043**	**1227.371**	**1213.364**	**1092.353**	**991.032**	**946.545**	**927.965**
Carbon	1129.418	1173.367	1161.321	1052.544	960.229	918.404	901.044
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	0.103	0.094	0.090
C. Grassland CO_2e	**-460.291**	**-531.259**	**-474.078**	**-511.915**	**-565.328**	**-553.305**	**-542.588**
Carbon	-463.677	-534.733	-482.154	-518.105	-571.679	-561.193	-546.410
CH_4	0.066	0.067	0.236	0.191	0.161	0.219	0.128
N_2O	0.006	0.006	0.007	0.005	0.008	0.008	0.002
D. Wetlands CO_2e	**0.353**	**0.353**	**0.353**	**0.353**	**0.353**	**0.353**	**0.353**
Carbon	0.353	0.353	0.353	0.353	0.353	0.353	0.353
E. Settlements CO_2e	**815.834**	**814.597**	**791.982**	**735.665**	**691.578**	**671.091**	**661.637**
Carbon	773.631	772.473	751.047	697.627	655.859	636.426	627.459
CH_4	0.019	0.021	0.004	0.004	0.004	0.005	0.005
N_2O	0.140	0.140	0.137	0.127	0.119	0.116	0.114
G. Harvested Wood Products CO_2e	**-3.718**	**-60.422**	**-142.231**	**-107.182**	**-86.962**	**-171.257**	**-174.827**
Carbon	-3.718	-60.422	-142.231	-107.182	-86.962	-171.257	-174.827
Grand Total CO_2e	**103.222**	**-161.272**	**-377.927**	**-588.793**	**-617.137**	**-635.664**	**-642.307**

Table 8.9: Northern Ireland LULUCF emissions (kilotonnes)

Category	1990	1995	2000	2005	2010	2012	2013
A. Forest Land CO_2e	**-706.321**	**-797.859**	**-889.931**	**-923.109**	**-899.432**	**-695.603**	**-817.929**
Carbon	-717.700	-808.341	-900.583	-935.167	-909.915	-725.505	-828.596
CH_4	0.039	0.006	0.003	0.037	0.000	0.468	0.005
N_2O	0.035	0.035	0.036	0.037	0.035	0.061	0.035
B. Cropland CO_2e	**1431.732**	**1363.304**	**1304.390**	**1236.675**	**1186.763**	**1169.814**	**1162.368**
Carbon	1379.905	1317.097	1262.620	1199.484	1152.684	1136.255	1129.044
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	0.113	0.112
C. Grassland CO_2e	**83.113**	**41.968**	**39.130**	**63.457**	**87.271**	**93.616**	**94.507**
Carbon	82.761	41.605	38.276	62.680	86.486	91.493	93.748
CH_4	0.007	0.008	0.026	0.025	0.026	0.052	0.026
N_2O	0.001	0.001	0.001	0.001	0.000	0.003	0.000
D. Wetlands CO_2e	**145.734**	**151.421**	**158.051**	**163.977**	**166.109**	**166.109**	**166.109**
Carbon	142.395	148.844	156.426	163.305	165.818	165.818	165.818
E. Settlements CO_2e	0.011	0.009	0.005	0.002	0.001	0.001	0.001
Carbon	**577.062**	**581.719**	**625.927**	**782.347**	**899.368**	**936.807**	**954.040**
CH_4	547.318	551.746	593.610	742.001	853.020	888.538	904.888
N_2O	0.008	0.010	0.021	0.023	0.025	0.025	0.026
G. Harvested Wood Products CO_2e	0.099	0.100	0.107	0.133	0.153	0.160	0.163
Carbon	**-15.976**	**-17.812**	**-38.317**	**-48.541**	**-73.983**	**-85.760**	**-88.679**
Grand Total CO_2e	-15.976	-17.812	-38.317	-48.541	-73.983	-85.760	-88.679

A8.8 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[11]: 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. Methods and data for these additional activities are being developed, so no estimates are reported for these activities 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.

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

- England's share of the FMRL is approximately 35%, based on 2013 Forest Management net removals.
- Scotland's share of the FMRL is approximately 53%, based on 2013 Forest Management net removals.
- Wales's share of the FMRL is approximately 9%, based on 2013 Forest Management net removals.
- Northern Ireland's share of the FMRL is approximately 3%, based on 2013 Forest Management net removals.

Table A8.10: England LULUCF areas and emissions estimates related to the first commitment period of the Kyoto Protocol

Activity		1990	2013
3.3 Afforestation & Reforestation	Area, kha	4.335	103.002
	Net carbon stock change, kt CO_2	-16.785	-1242.695
	GHG emissions from biomass burning, kt CO_2e	0.077	0.000
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	0.009	0.214
	N_2O emissions from N fertilization, kt CO_2e	0.334	0.286
	N_2O emissions from N mineralisation, kt CO_2e*	0.025	0.658
	Harvested Wood Product kt CO_2e	0.000	-17.475
3.3 Deforestation	Area, kha	0.622	18.020
	Net carbon stock change, kt CO_2	92.090	158.393
	GHG emissions from biomass burning, kt CO_2e	59.364	91.596
	N_2O emissions from N mineralisation, kt CO_2e*	0.195	1.184
3.4 Forest Management	Area, kha	964.389	946.991
	Net carbon stock change, kt CO_2	-4806.972	-5037.921
	GHG emissions from biomass burning, kt CO_2e	17.001	0.000
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	1.897	1.756
	N_2O emissions from N mineralisation, kt CO_2e*	5.542	5.389
	Harvested Wood Product kt CO_2e	0.000	-987.968
3.4 Cropland management	Under development		
3.4 Grazing Land Management	Under development		
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"

[11] 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

Table A8.11: Scotland LULUCF areas and emissions estimates related to the first commitment period of the Kyoto Protocol

Activity		1990	2013
3.3 Afforestation & Reforestation	Area, kha	14.341	208.485
	Net carbon stock change, kt CO_2	-0.082	-1664.402
	GHG emissions from biomass burning, kt CO_2e	0.189	13.084
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	0.140	2.273
	N_2O emissions from N fertilization, kt CO_2e	3.715	0.731
	N_2O emissions from N mineralisation, kt CO_2e*	0.152	2.664
	Harvested Wood Product kt CO_2e	0.000	-89.822
3.3 Deforestation	Area, kha	0.233	27.832
	Net carbon stock change, kt CO_2	26.322	289.340
	GHG emissions from biomass burning, kt CO_2e	14.829	151.876
	N_2O emissions from N mineralisation, kt CO_2e*	0.228	3.410
3.4 Forest Management	Area, kha	1069.552	1041.953
	Net carbon stock change, kt CO_2	-8512.067	-7736.328
	GHG emissions from biomass burning, kt CO_2e	13.931	52.307
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	10.277	9.089
	N_2O emissions from N mineralisation, kt CO_2e*	11.186	10.649
	Harvested Wood Product kt CO_2e	0.000	-1752.143
3.4 Cropland management	Under development		
3.4 Grazing Land Management	Under development		
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"

Table A8.12: Wales LULUCF areas and emissions estimates related to the first commitment period of the Kyoto Protocol

Activity		1990	2013
3.3 Afforestation & Reforestation	Area, kha	0.559	12.150
	Net carbon stock change, kt CO_2	-0.001	-59.551
	GHG emissions from biomass burning, kt CO_2e	0.009	0.000
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	0.002	0.049
	N_2O emissions from N fertilization, kt CO_2e	0.071	0.055
	N_2O emissions from N mineralisation, kt CO_2e*	0.003	0.075
	Harvested Wood Product kt CO_2e	0.000	-6.324
3.3 Deforestation	Area, kha	0.079	4.792
	Net carbon stock change, kt CO_2	11.387	51.020
	GHG emissions from biomass burning, kt CO_2e	7.193	31.697
	N_2O emissions from N mineralisation, kt CO_2e*	0.036	0.204
3.4 Forest Management	Area, kha	273.822	269.109
	Net carbon stock change, kt CO_2	-1667.288	-1218.938
	GHG emissions from biomass burning, kt CO_2e	4.490	0.000
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	1.087	1.035
	N_2O emissions from N mineralisation, kt CO_2e*	1.617	1.587
	Harvested Wood Product kt CO_2e	0.000	-450.484
3.4 Cropland management	Under development		
3.4 Grazing Land Management	Under development		
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"

Table A8.13: Northern Ireland LULUCF areas and emissions estimates related to the first commitment period of the Kyoto Protocol

Activity		1990	2013
3.3 Afforestation & Reforestation	Area, kha	1.321	15.901
	Net carbon stock change, kt CO_2	-0.013	-179.235
	GHG emissions from biomass burning, kt CO_2e	0.259	0.393
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	0.161	2.196
	N_2O emissions from N fertilization, kt CO_2e	0.457	0.013
	N_2O emissions from N mineralisation, kt CO_2e*	0.021	0.326
	Harvested Wood Product kt CO_2e	0.000	-9.555
3.3 Deforestation	Area, kha	0.031	1.677
	Net carbon stock change, kt CO_2	3.816	19.669
	GHG emissions from biomass burning, kt CO_2e	2.538	12.785
	N_2O emissions from N mineralisation, kt CO_2e*	0.002	0.033
3.4 Forest Management	Area, kha	67.522	65.876
	Net carbon stock change, kt CO_2	-776.685	-401.633
	GHG emissions from biomass burning, kt CO_2e	12.962	1.234
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	8.070	6.902
	N_2O emissions from N mineralisation, kt CO_2e*	1.040	1.025
	Harvested Wood Product kt CO_2e	0.000	-159.537
3.4 Cropland management	Under development		
3.4 Grazing Land Management	Under development		
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"

Table A8.14: United Kingdom LULUCF areas and emissions estimates under the first commitment period of the Kyoto Protocol

Activity		1990	2013
3.3 Afforestation & Reforestation	Area, kha	20.557	339.926
	Net carbon stock change, kt CO_2	-16.881	-3145.883
	GHG emissions from biomass burning, kt CO_2e	0.534	13.477
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	0.312	4.733
	N_2O emissions from N fertilization, kt CO_2e	4.577	1.085
	N_2O emissions from N mineralisation, kt CO_2e*	0.201	3.722
	Harvested Wood Product kt CO_2e	0.000	-123.176
3.3 Deforestation	Area, kha	0.965	52.321
	Net carbon stock change, kt CO_2	133.615	518.422
	GHG emissions from biomass burning, kt CO_2e	83.924	287.953
	N_2O emissions from N mineralisation, kt CO_2e*	0.461	4.831
3.4 Forest Management	Area, kha	2379.767	2328.396
	Net carbon stock change, kt CO_2	-15763.012	-14394.821
	GHG emissions from biomass burning, kt CO_2e	48.385	53.542
	Non-GHG emissions from drained and rewetted organic soils, kt CO_2e	21.331	18.782
	N_2O emissions from N mineralisation, kt CO_2e*	19.385	18.649
	Harvested Wood Product kt CO_2e	0.000	-3350.132
3.4 Cropland management	Under development		
3.4 Grazing Land Management	Under development		
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"

A8.9 Data sources

Activity/Data-set	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 foret 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	Historical 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-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)
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.

Activity/Data-set	Organisation	Update Frequency	Further details
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[12] 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
Stop the Clock	Carbon dioxide	11.198	13.632	10.958	11.254	10.864	10.848
	Methane	0.005	0.005	0.002	0.002	0.002	0.002
	Nitrous oxide	0.106	0.129	0.104	0.106	0.103	0.103
UK GHGI	Carbon dioxide	32.448	37.777	33.690	35.054	34.086	33.877
	Methane	0.007	0.006	0.003	0.003	0.003	0.003
	Nitrous oxide	0.307	0.357	0.319	0.332	0.322	0.321
Stop the clock % share	Total GHGs	34.5%	36.1%	32.5%	32.1%	31.9%	32.0%

[12] "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 Regulation	Carbon dioxide	9.674	12.005	9.359	9.602	9.351	9.369
	Methane	0.005	0.004	0.002	0.002	0.002	0.002
	Nitrous oxide	0.092	0.114	0.089	0.091	0.088	0.089
UK GHGI	Carbon dioxide	32.448	37.777	33.690	35.054	34.086	33.877
	Methane	0.007	0.006	0.003	0.003	0.003	0.003
	Nitrous oxide	0.307	0.357	0.319	0.332	0.322	0.321
2014 Regulation % share	Total GHGs	29.8%	31.8%	27.8%	27.4%	27.4%	27.7%

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 a between 76-79% of the Scotland aviation inventory total.
- Since 2010 the *2014 Regulation* scope has been around 70% of the Scotland total, with a slightly higher percentage in earlier years.

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

	GHG	2000	2005	2010	2011	2012	2013
Stop the Clock	Carbon dioxide	1.224	1.503	1.184	1.259	1.222	1.238
	Methane	0.001	0.001	0.000	0.000	0.000	0.000
	Nitrous oxide	0.012	0.014	0.011	0.012	0.012	0.012
Scotland GHGI	Carbon dioxide	1.459	1.911	1.534	1.611	1.584	1.631
	Methane	0.001	0.001	0.000	0.000	0.000	0.000
	Nitrous oxide	0.014	0.018	0.015	0.015	0.015	0.015
Stop the clock % share	Total GHGs	83.9%	78.7%	77.2%	78.2%	77.2%	75.9%

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

	GHG	2000	2005	2010	2011	2012	2013
2014 Regulation	Carbon dioxide	1.134	1.401	1.082	1.127	1.105	1.123
	Methane	0.001	0.001	0.000	0.000	0.000	0.000
	Nitrous oxide	0.011	0.013	0.010	0.011	0.010	0.011
Scotland GHGI	Carbon dioxide	1.459	1.911	1.534	1.611	1.584	1.631
	Methane	0.001	0.001	0.000	0.000	0.000	0.000
	Nitrous oxide	0.014	0.018	0.015	0.015	0.015	0.015
2014 Regulation % share	Total GHGs	77.7%	73.3%	70.5%	70.0%	69.8%	68.9%

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