
Assessment of the impact of changes to guidelines on the UK Greenhouse Gas Inventory



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Executive summary

From 2015, all Parties reporting emissions under the United Nations Framework Convention on Climate Change will be required to report using a new set of reporting guidelines, which incorporate new methodology guidelines from the Intergovernmental Panel on Climate change.

This project has been carried out to assess the likely impact of these changes on the UK inventory. Starting with the inventory submitted in 2014, updates have been made to:

- Include new sources (e.g. N₂O from anaesthesia)
- Update existing sources (e.g. where new default emission factors are available)
- Use new GWP values

Box 1: Key findings from the comparison of the updated inventory with the 2014 submission

Key findings:

- Total GHG emissions are 1.1% higher in 1990 and 0.3% higher in 2012
- Carbon dioxide emissions are largely unchanged; inventory uses mostly higher tier methods and country specific data, therefore changes to default methods not relevant
- Methane emissions are lower in 1990 and higher in 2012 when compared with the 2014 submission, however including the GWP change leads to an increase across the time series
- Nitrous oxide emissions are lower across the time series, and the revised GWP value is also smaller, increasing the impact of the changes in emissions
- Total emissions of F-gases on a GWP basis are higher across the time series due to the inclusion of new sources and gases, changes to the GWP values and updates to existing sources. F-gases remain a small contributor to total emissions

Although this work is intended to assess the changes to be expected due to the updated guidelines, it should be noted that these results are indicative only. Further work is ongoing during 2014 to improve waste and industrial processes sector estimates. In addition, a review of the 2014 submission will be carried out by the UNFCCC in September 2014, and relevant recommendations from this review may lead to further changes in the UK inventory. Furthermore, changes can also occur due to data revisions or data availability changes during a typical inventory compilation cycle.

LULUCF estimates have been considered separately, see Appendix 2.

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- Appendix 1 Impact of changes to the agriculture sector
- Appendix 2 Impact of changes to the LULUCF sector

1 Introduction

From 2015, all Annex I Parties to the United Nations Framework Convention on Climate Change will be required to report national greenhouse gas emissions inventories using updated reporting guidelines (Decision 24/CP.19. Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention¹). These were formally adopted at COP19, and set out how Parties are to report, incorporating new sources and methodologies set out in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The Guidelines also set out which set of Global Warming Potential (GWP) values to use for reporting inventories, and a revised data reporting structure (the Common Reporting Format, CRF),

This report summarises the work that has been carried out during 2014 to:

- Estimate emissions for new sources not previously accounted for in the UK inventory
- Update emissions from existing sources where default factors in the IPCC Guidelines have been updated
- Assess the impact of these changes (and the GWP updates), by re-compiling the 2014 submission.

Although this work is intended to estimate the overall impact of the changes, it should be noted that further work is ongoing during 2014 which was not be available in time to be used for this analysis.

LULUCF estimates have been considered separately, see Appendix 2. Since this sector makes a small contribution to the national total, changes to LULUCF will not significantly change the headline results of this analysis.

¹ <http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf>

2 New sources

A number of new sources of GHGs have been introduced, for which there were no methods available in the 1996 IPCC Guidelines or 2000 IPCC Good Practice Guidance. A brief summary of the data and methods for these new sources is included below.

2.1 N₂O used as anaesthetic

The 2006 IPCC Guidelines (the 2006 GLs) for National Greenhouse Gas Inventories advises that it is good practice to report the emission of N₂O from this source using data on the quantities of N₂O provided by the manufacturers and distributors². In an effort to achieve this Ricardo-AEA undertook a stakeholder consultation exercise with the key suppliers of N₂O to the National Health Service (NHS) in the UK.

The following information was requested from each supplier:

- The total quantity of N₂O provided to the NHS by their organisation per annum
- An estimation of the total medical N₂O consumed in the UK per annum; and
- Any further detail which would aid in the calculation of N₂O emissions arising from this source.

However, as none of the suppliers agreed to provide data on the quantities of supplied N₂O, it has been necessary to adopt an alternative approach for the estimation of anaesthetic N₂O emissions.

2.1.1 Method and data sources

Emissions have been calculated using the outcomes of a study by the NHS's Sustainable Development Unit which assessed the 'Carbon Footprint from Anaesthetic gas use'³. This report calculates the total N₂O emissions based on the number of bed-days in NHS England 2011 – 2012, multiplied by the EU GHG inventory derived emission factor of 10.3 kg N₂O/bed/year⁴. This provides an estimated total N₂O emission of 1,641,147 kg per annum, arising from the use of anaesthetic at NHS England facilities.

In order to expand this figure to incorporate all emissions within the United Kingdom a per-capita N₂O emission of 0.031 kg per annum has been derived from the total N₂O figure provided in the Carbon Footprint report. This has then been applied to the total population for the England, Wales, Scotland and Northern Ireland between 1990 and 2012 to provide a time-series of emissions.

2.1.2 Consideration of uncertainties

As the duration of a patient's hospital stay can vary considerably, the use of bed-days as an indicator of N₂O should be considered to have a high degree of uncertainty; therefore data from N₂O suppliers is likely to provide a more accurate representation of emissions.

The time series estimate does not consider the uptake of Low Flow Anaesthesia, which reduces the level of consumption by recirculating inhaled gas through a cylinder of carbon dioxide, or Total Intravenous Anaesthesia, where a patient receives an anaesthetic drug intravenously, removing the requirement for N₂O. However it can be assumed that the influence of these practices on consumption has been reflected by the estimated total N₂O

² http://www.ipcc-nggip.iges.or.jp/public/2006_GL/pdf/3_Volume3/V3_8_Ch8_Other_Product.pdf

³ http://www.sduhealth.org.uk/documents/publications/Anaesthetic_gases_research_v1.pdf

⁴ <http://www.eea.europa.eu/publications/european-union-greenhouse-gas-inventory-2013>

emission during 2012, provided in the Carbon Footprint report. Further research is required into the development of these techniques and the level of uptake within the UK. If these methods prove to be a recent development, earlier emissions of anaesthetic N₂O may be higher than current estimates.

2.2 CO₂ Emissions from Road Transport – Urea Based Catalysts (1A3bvi)

A method for estimating CO₂ emissions from urea based catalysts is specified in the 2006 GLs.

2.2.1 Method and data sources

The method in the 2006 GLs involves estimating the amount of urea consumed by vehicles with relevant types of catalytic converters. Consumption is estimated as a proportion of the amount of fuel consumed. The same method is given in the EMEP/EEA Emissions Inventory Guidebook (2013), but the EMEP Guidebook is more instructive as it provides the means for estimating urea consumption as a proportion of fuel consumed by the specific types of heavy duty vehicles using urea. This information is not given in the 2006 IPCC Guidelines. The EMEP Guidelines also recommend, if possible, estimating emissions directly from statistics on urea sales. This would give a more accurate estimate. However, our enquiries have found that no such data are readily available in the UK.

Urea is consumed by some (not all) HGVs and buses manufactured to Euro IV and V standards. These standards came into effect from 2006. The method involved estimating fuel consumed by these vehicles. This was done with the road transport emissions model used for estimating other pollutant emissions, normalised to fuel sales in DUKES. The estimations involve the use of vehicle km activity and fleet composition data from DfT. Following figures given in the EMEP/EEA Guidebook for estimating other pollutant emissions, an assumption was made that 75% of Euro V HGVs and buses are equipped with Selective Catalytic Reduction (SCR) – the catalyst system that uses urea. The same assumption was also applied to Euro IV vehicles. Following the EMEP/EEA Guidebook, urea consumption is assumed to be 4% of fuel consumption for a Euro IV HGV and bus and 6% for a Euro V HGV and bus. Our independent assessment from suppliers of urea and vehicle manufacturers supports these assumptions. Note that this is higher than the range of 1-3% given in the IPCC Guidelines.

These assumptions allowed the time-series for consumption of urea by UK road transport to be estimated. No urea was consumed before 2006.

A constant emission factor of 0.238 kgCO₂/kg urea solution, as given in the EMEP/EEA Guidebook was used. This is consistent with the factor and emission equation given in the 2006 IPCC Guidelines, assuming urea is used as a 32.5% aqueous solution which is the norm.

2.2.2 Consideration of uncertainties

We believe the inventory estimates are upper limits for the following reasons:

- The fuel normalisation method used in the calculation of fuel consumption by road transport applies an uplift to the estimate for HGVs to bring consistency with DUKES.
- There is greater uncertainty in the proportion of Euro IV vehicles that use SCR and urea. The EMEP/EEA Guidebook only considers consumption by Euro V vehicles. Industry sources suggest SCR is extensively used by Euro IV vehicles, but the requirement to do so is not as strong because alternative technological approaches

can achieve the modest NO_x emission reductions needed to meet Euro IV standards. A conservative assumption was made that the same proportions of Euro IV vehicles use SCR and urea as Euro V.

2.3 Off grid waste water treatment

The 2006 GLs provide a method for calculating emissions from off grid waste water treatment, such as septic tanks. These emissions were previously not considered in the UK inventory.

2.3.1 Method and data sources

An estimate of the number of households that are likely to be using off-grid systems in the UK in 2013 has been made based on data provided by the Environment Agency, the Scottish Environmental Protection Agency, the Northern Ireland Department of the Environment and Natural Resources Wales.

A time series of emissions has been developed using population data. This time series of number of households has been combined with ONS data for average household occupancy and the calculated volume of waste produced per person per year based on water company statistics to produce an estimate of total waste water being disposed of via off-grid systems.

The long term trend is dominated by the population-linked number of private systems, whereas the short term trends are dominated by the calculated waste per person which could be affected by fluctuations in annual flood water.

The emissions are then calculated following the method set out in the 2006 guidelines Volume 5, Chapter 6: Wastewater treatment and discharge. Equation 6.2 in the GLs, reproduced below, calculates the emission factor.

$$EF_j = B_o * MCF_j$$

Where

EF_j = emission factor, kg CH₄/kg BOD (Biochemical Oxygen Demand)

j = each treatment/discharge pathway or system

B_o = maximum CH₄ producing capacity, kg CH₄/kg BOD

MCF_j = methane correction factor (fraction), See Table 6.3 of the GLs.

Table 2.1 lists the parameters which were used and the calculated EF. The MCF of 0.5 was the default factor for septic tanks. The team did not have enough data to establish the activity by waste treatment process. As the vast majority of private waste management systems observed were septic tanks, and the septic tank factor is conservative when compared to other systems that could be used, it was decided that it would be the most appropriate factor to apply.

Table 2.1 New emission factors added as a result of completeness checks

Parameter	Description	Units	Value
B _o	Maximum CH ₄ producing capacity	kg CH ₄ /kg BOD	0.6
MCF	Methane correction factor	Fraction	0.5
EF	Emission factor	kg CH ₄ /kg BOD	0.3

The emission factor is then combined with total amount of organically degradable material in the waste water (TOW), expressed as kg BOD/year, which is calculated using Equation 6.3 in the 2006 GLs:

$$TOW = P \cdot BOD \cdot 0.001 \cdot I \cdot 365$$

Where:

- TOW = total organics in wastewater in inventory year, kg BOD/yr
- P = country population in inventory year, person
- BOD = country-specific per capita BOD in inventory year, g/person/day
- 0.001 = conversion from grams BOD to kg BOD
- I = correction factor for additional industrial BOD discharged into sewers (for collected the default is 1.25, for uncollected the default is 1.00).

The population figure used is for only the proportion of the population using septic tanks. The BOD value is calculated from the water company returns.

2.3.2 Consideration of uncertainties

The data we received from the UK environmental agencies only included 'snap shots' of the situation, with Natural Resource Wales's estimates being based on an investigation they did in 2007 and the Northern Ireland Department of the Environment and the Scottish Environmental Protection Agency providing us with data that reflected the situation in the present. None of the organisations recorded when private waste management systems closed, and most of them had fragmentary records. As a result the number of households using private waste management systems is highly uncertain.

The per capita BOD however, is based on well documented and recorded data from the major water companies in the UK and is consistent with the per capita BOD which is suggested in the IPCC guidelines for countries similar to the UK.

The emission factor could be improved with better knowledge of what kinds of private waste management systems are in use, but the current assumption, assuming all systems are septic tanks, is likely to be fairly representative and conservative.

2.4 F-gases

A study has been commissioned to look at emissions of F-gases from existing sources, and to make estimates for new sources and gases included in the 2006 guidelines.

New emissions have been included for:

- Refrigerant cylinders
- AWACS (military Airborne Warning and Control Systems)
- Particle accelerators and
- Tracer testing.

Emissions have also been included for new gases:

- NF₃ from electronics
- Two new HFCs, HFC-245fa and HFC-365mfc from foam blowing

Full details of the methodology and data sources for these new emissions are included in the report *Review of data and methodologies used in the calculation of UK emissions from F-Gases* (ICF, 2014), available online⁵.

2.5 Completeness checks

As part of the emission factor review (see section 3.1), fuel combustion sources were checked for completeness i.e. where carbon dioxide emissions were included, but N₂O or CH₄ emissions were missing from the inventory, either because no default emission factors were available in the previous IPCC guidance, or by omission. The table below lists the source and activity combinations for which new emission factors (and therefore emissions) have been included, and for which GHGs.

Table 2.2 New emission factors added as a result of completeness checks

Emission source	Activity data	GHG
Collieries - combustion	Coke oven gas	N ₂ O
Domestic combustion	Petroleum coke	N ₂ O, CH ₄
Gas production	Colliery methane	N ₂ O
Gas production	OPG	N ₂ O
N ₂ O use as an anaesthetic	Population	N ₂ O
Other industrial combustion	Petroleum coke	N ₂ O
Other industrial combustion	Waste solvent	N ₂ O, CH ₄
Power stations	OPG	N ₂ O
Refineries - combustion	Burning oil	N ₂ O, CH ₄
Refineries - combustion	OPG	N ₂ O
Cement production - combustion	Waste oils	CH ₄
Cement production - combustion	Waste solvent	CH ₄
Domestic combustion	Petroleum coke	CH ₄

⁵ http://uk-air.defra.gov.uk/assets/documents/reports/cat07/1404301320_Tender3_F-GasReview_FINALREPORT_14_04_14.pdf

3 Updates to existing sources

3.1 Emission factor review

An emission factor review has been carried out to a) identify emission factors based on defaults from earlier IPCC or other inventory guidance, which can be updated and b) to assess the validity of country specific factors and either provide text justifying their use, or, recommend an alternative emission factor.

The findings of this review have been incorporated into the UK inventory database. As part of the implementation of these findings, a completeness check of the inventory has been undertaken. This included adding emission factors for methane and/or N₂O where fuel use and CO₂ emissions have been included in the inventory, but emission factors for other GHGs were missing.

Since default emission factors are largely used for smaller emission sources (largely methane and nitrous oxide from fuel combustion), the impact of these changes is small.

A full description of this work, including a list of all sources and fuel types or other activities for which the emission factors have been updated is included in the report *Review of UK-specific GHG Emission Factors & Update of IPCC Default Emission Factors* (Aether, 2014).

3.2 Industrial waste water treatment

The equation set out for the emission factors for industrial waste water treatment has been amended and clarified in the 2006 GL. This amended equation has been used to re calculate emissions from this source. This has increased methane emissions by 43kt in 1990 and 41kt in 2012.

The IPCC 2000 Good Practice Guidance (2000 GPG) states:

“As mentioned previously, the degradable carbon in organic waste can be measured either as BOD or COD, and the COD-based value should be converted into a BOD-based value by multiplying by a default factor of 2.5.”

The IPCC 2006 guidelines state:

“a COD-based value of B_o can be converted into a BOD-based value by multiplying with a factor of 2.4.”

The conversion factor has changed from 2.5 to 2.4, but more significantly, the 2006 Guidelines clarifies that this is when discussing B_o , an emission factor with units kg CH₄/kg BOD or kg CH₄/kg COD. This means that the ratio for converting the activity in the inverse of this i.e. COD=BOD*2.4.

This correction has been made to the calculations, in addition to updating the conversion factor from 2.5 to 2.4.

3.3 F-gases

As part of the study *Review of data and methodologies used in the calculation of UK emissions from F-Gases* (ICF, 2014), updates were made to emissions of F-gases from the following categories:

- Electronics
- Fire fighting
- Magnesium cover gas
- Solvents

The updates were made based on a review of the new IPCC Guidelines (to ensure that the methods used for the UK GHG inventory are compliant) and available data. A full description of the data sources and methods is available in the report online⁶.

⁶ http://uk-air.defra.gov.uk/assets/documents/reports/cat07/1404301320_Tender3_F-GasReview_FINALREPORT_14_04_14.pdf

4 Agriculture

A full review of the agriculture sector has been conducted by Rothamsted Research. This has considered new emission sources and updated default emission factors and parameters. Details of the changes to the guidelines and parameters are described below. A detailed analysis of the impact of the changes can be found in Annex 1.

4.1 Summary of the key changes in the IPCC 2006 Guidelines

4.1.1 Emissions from livestock and manure management

4.1.1.1 Methane emissions from enteric fermentation

- The coefficient for calculating net energy for maintenance from lactating cattle (Dairy cows category, C_i) has been increased from 0.335 (Table 4.4, 2000 GPG) to 0.386 $\text{MJ d}^{-1} \text{kg}^{-1}$ (Table 10.4, 2006 GLs).
- The methane conversion rate (Y_m) has been increased for all cattle from 0.06 (Table 4.8, 2000 GPG) to 0.065 (Table 10.12, 2006 GL).
- Following the 2006 GLs (p. 10.20), the net energy for pregnancy calculation has been weighted by the proportion of mature cows that go through gestation in a year (90%) and the percentage of time spent grazing revised in-line with the NH_3 inventory.
- The enteric emission factor (EF) for 'other cattle', i.e. all cattle other than dairy and beef cows, has been updated to 57 kg/hd/yr (Table 10.11, 2006 GLs). Previously, an EF of 48 kg/hd/yr was applied to dairy and beef heifers, dairy replacements and all other beef >1 yr (Table 4.4, IPCC 1996) and 32.8 kg/hd/yr was applied to dairy and beef calves.

4.1.1.2 Methane emissions from manure management

Prior to the 2006 GL, only one methane conversion factor (MCF) value was reported for all liquid storage systems, separate MCF's are now provided for liquid stores with/without natural crust cover. Thus, the liquid storage systems MCF was decreased from 39% (Table 4.10, 2000 GPG) to 10% and 17% for systems with and without natural crust cover, respectively (Table 10.17, 2006 guidelines, values for cool climate and $<10^\circ\text{C}$). The fraction of cattle and pig liquid storage systems assumed to have a natural cover is 80% and 0%, respectively. The deep litter (previously solid storage) MCF was decreased from 39% (Table 4.11, 2000 GPG) to 17% (Table 10.17, 2006 GL, value for Pit storage below animal confinements for $<10^\circ\text{C}$ and > 1 month).

The deer manure management EF has been revised from 0.26 kg/hd/yr and 0.13 kg/hd/yr for stags & hinds and deer calves (Sneath et al., 1997 and NIR, 2014), respectively, to 0.22 kg/hd/yr for all deer (Table 10.16, 2006 GLs). Tier 2 manure management system (MMS) EFs have been affected by amendments in Volatile Solids (VS) and B_o values which have also been disaggregated for swine and poultry (Table 4.1). The VS value for dairy and beef cows has been recalculated according to equation 10.24 in the 2006 GL.

Table 4.1 Manure characteristics for manure management methane EF derivation

Manure Management System	VS (kg/hd/d)			B ₀ (m ³ kg ⁻¹ VS)		
	IPCC 1996 (Table B-1)	2006 GL (Table 10A-9)		IPCC 1996 (Table B-1)	2006 GL (Table 10A-9)	
Dairy cattle	5.08		5.1	0.24		0.24
Non-dairy: Mature male cattle	3.04		2.6	0.17		0.18
Non-dairy: Young replacements	2.99		2.6	0.17		0.18
Non-dairy: Young calves	1.46		2.6	0.17		0.18
Non-dairy: Average	2.65		2.6	0.17		0.18
Swine	0.5	breeding	0.46	0.45	breeding	0.45
		market	0.3		market	0.45
Sheep	0.4		0.4	0.19		0.19
Goats	0.28		0.3	0.17		0.18
Horses	1.72		2.13	0.33		0.30
Poultry	0.1	layers	0.02	0.32	layers	0.39
		broilers	0.01		broilers	0.36
		turkeys	0.07		turkeys	0.36
		ducks	0.02		ducks	0.36

4.1.1.3 Nitrous oxide emissions from manure management

Revised default EFs for direct N₂O emissions from manure management are detailed in the table below. The fraction of cattle and pig liquid storage systems assumed to have a natural cover is 80 and 0%, respectively.

Table 4.2 Changes to N₂O EFs for Animal Waste Management System

MMS	N ₂ O EF ₃ (kg N ₂ O-N/kg N excreted)		
	IPCC, 1996 (Table 4.22)	2006 GL (Table 20.21)	
Liquid	0.001	With natural crust cover	0.005
		Without natural crust cover	0
Deep litter	0.02		0.01
Pasture, range & paddock	0.02	Cattle, poultry & pigs	0.02
		Sheep & other animals	0.01
Poultry manure – with bedding	0.02		0.001
Poultry manure – without bedding	0.005		0.001

The 2006 GLs introduced the estimation of indirect N₂O emissions from N volatilisation and leaching/runoff from manure management systems (2006 GL Eq. 10.29), along with default fractions for N loss due to volatilisation of NH₃ and NO_x, disaggregated by manure management system (Frac_{GasMS}, 2006 GLs, Table 10.22). The leaching/runoff component has been omitted due to the difficulty in obtaining representative country-specific data.

Coordination with reporting for N₂O emissions from managed soils

A significant proportion of the total N excreted by animals in managed systems is lost prior to final application to managed soils. The estimate of managed manure N available for application to managed soils is based on equation 10.34 in the 2006 GLs which takes

account of the total nitrogen loss from manure management (F_{LossMS}) and N added in the form of bedding, disaggregated by manure management system.

4.1.2 N₂O emissions from managed soils

4.1.2.1 Main changes in the estimation of direct N₂O emissions

- Synthetic N fertiliser (F_{SN}): The amount of applied mineral nitrogen fertilisers is no longer adjusted for the amounts of NH₃ and NO_x volatilisation after application to soil. EF₁ for N additions has been changed from 0.0125 to 0.01 kg N₂O-N/kg N input (Table 11.1 2006 GL).
- Organic N applied as fertiliser (e.g. animal manure, sewage sludge) (F_{ON}): The amount of applied organic nitrogen fertiliser is no longer adjusted for the amounts of NH₃ and NO_x volatilisation after application to soil (F_{ON} applied to soils is adjusted using eq. 10.34 of the 2006 GL as described above).
- Urine and dung deposited on pasture, range and paddock by grazing animals (F_{PRP}): The emission factor to estimate direct N₂O emissions from grazing animals has been revised (see Table 4.2).
- N in crop residues F_{CR} : The crop residue N calculation has been modified to account for the contribution of the below-ground nitrogen to the total input of nitrogen from crop residues. EF₁ for N additions has been changed from 0.0125 to 0.01 kg N₂O-N/kg N input.
- N mineralisation associated with loss of soil organic matter resulting from change of land use or management of mineral soils has been included in the 2006 GLs (F_{SOM} , 2006 GL Eq. 11.1). This has historically been calculated as part of the LULUCF sector inventory, so this change in the 2006 GLs represents a reallocation between sectors rather than an additional source. The impact of this has therefore not been included in this assessment).
- Removal of biological fixation as a direct source of N₂O because of the lack of evidence of significant emissions arising from the fixation process.

4.1.2.2 Main changes in the estimation of indirect N₂O emissions

The sources of indirect N₂O emission follow the same sources as previously with the following key changes:-

- To include indirect emissions from crop residue N (above-and below ground as in the estimation of direct N₂O emission). N from crop residues is only included in the leaching/runoff component of indirect N₂O emission (2006 GLs, Eq. 11.10).
- To include N mineralisation associated with loss of soil organic matter resulting from change of land use or management on mineral soils (not assessed here)
- The default EF for leached N (EF₅, 2006 GLs, Table 11.3) has been decreased from 0.025 to 0.0075 kg N₂O-N/kg N leaching/runoff.

4.1.2.3 Biomass burning (agricultural residues)

The method for calculating CH₄ and N₂O emissions from the burning of agricultural residues has been much simplified and is now determined using Eq. 2.27, 2006 GLs.

5 Indirect N₂O

The new UNFCCC reporting guidelines request that Parties report indirect emissions of N₂O resulting from the atmospheric deposition of NO_x and NH₃. The 2006 IPCC guidelines provide the equation (Equation 7.1, Volume 1) and parameters to calculate these emissions from inventories of NO_x and NH₃. Indirect emissions are already included in the agriculture sector and so emissions from this sector are excluded from the calculation. Emissions are to be reported as a memo item and will therefore not contribute to the UK's national total.

Equation 5.1 Calculation of indirect emissions of N₂O

$$N_2O_{(i)} = [(NO_x-N_{(i)} + NH_3-N_{(i)})] \cdot EF_4 \cdot 44/28$$

Where:

- N₂O_(i) = N₂O produced from atmospheric deposition of N from NO_x and NH₃ emissions from source i, in Gg
- NO_x-N_(i) = Nitrogen content of NO_x emissions from source i assuming that NO_x is reported in NO₂ equivalents (Gg NO_x-N or Gg NO₂ • 14/46)
- NH₃-N_(i) = Nitrogen content of NH₃ emissions from source i (Gg NH₃-N or Gg NH₃ • 14/17)
- EF₄ = Emission factor for N₂O emissions from atmospheric deposition of N on soils and water surfaces (kg N₂O-N/kg NH₃-N or NO_x-N emitted).

For 2012, indirect N₂O emissions amount to 5.7 Gg N₂O, the parameters used for the calculation are set out in table 5.1 below.

Table 5.1 Calculation of indirect N₂O emissions

	Emissions of NO _x and NH ₃ (Gg)	N fraction	EF ₄	Conversion to N ₂ O	Indirect N ₂ O emission, Gg
NO _x	1,065.84	14/46	0.01	44/48	5.1
NH ₃	50.14	14/17	0.01	44/48	0.6
Total					5.7

6 GWP changes

The table below sets out the GWP values used for reporting under the current UNFCCC reporting guidelines, alongside the new values to be used from 2015. These are from the IPCC's Second Assessment Report (SAR), and the Fourth Assessment Report (AR4), respectively, and express the GWP relative to carbon dioxide, on a 100 year horizon.

Table 6.1 GWP values from SAR and AR4

Short name	Full Name	SAR	AR4
CH ₄	Methane	21	25
N ₂ O	Nitrous Oxide	310	298
HFC-152a	HFC-152a	140	124
HFC-134a	HFC-134a	1300	1430
HFC-23	HFC-23	11700	14800
HFC-32	HFC-32	650	675
HFC-125	HFC-125	2800	3500
HFC-143a	HFC-143a	3800	4470
HFC-227ea	HFC-227ea	2900	3220
HFC-43-10mee	HFC-43-10mee	1300	1640
HFC-134	HFC-134	1000	1100
HFC-245fa	HFC-245fa		1030
HFC-365mfc	HFC-365mfc		794
HFC-41	HFC-41	150	92
HFC-143	HFC-143	300	353
HFC-152	HFC-152		53
HFC-161	HFC-161		12
HFC-236ea	HFC-236ea		1370
HFC-236fa	HFC-236fa	6300	9810
HFC-245ca	HFC-245ca	560	693
HFC-236cb	HFC-236cb		1340
CF ₄	PFC-14	6500	7390
C ₂ F ₆	PFC-116	9200	12200
C ₃ F ₈	PFC-218	7000	8830
C ₄ F ₈	PFC-318	8700	10300
C ₄ F ₁₀	PFC-3-1-10	7000	8860
C ₅ F ₁₂	PFC-4-1-12	7500	9160
C ₆ F ₁₄	PFC-5-1-14	7400	9300
C ₁₀ F ₁₈	PFC-9-1-18		>7500
SF ₆	Sulphur Hexafluoride	23900	22800
NF ₃	Nitrogen trifluoride		17200

7 Impact of changes

7.1 Overall impact

Table 7.1 below shows the overall impact of the changes by gas, on a mass basis (therefore not including the impact of GWP changes).

There is very little change to emissions of carbon dioxide, since the only change is the addition of emissions from urea use as a fuel additive, which only affects the latter part of the time series. For methane, the decreases in the agriculture sector have been largely cancelled out by increases from waste water treatment (changes to industrial waste water, the inclusion of off grid waste water treatment), and emissions are slightly smaller in the base year and slightly higher in the latest year. Emissions of N₂O have decreased due to the changes in the agriculture sector. The inclusion of N₂O from anaesthesia, new emissions introduced as a result of the completeness checks, and emission factor changes in the energy sector have had a much smaller impact.

For f-gases, three new gases have been introduced, and four new sources, in addition to updates to existing gases and sources. Further details on the causes of the changes can be seen in sections 7.2.4 to 7.2.7.

Table 7.1 Comparison of total emissions by gas on a mass basis (Gg)^{7,8}

	Base year old	Base year new	% change	2012 Old	2012 New	% change
Carbon dioxide	592,515	592,515	0.0%	475,712	475,775	0.0%
CH ₄	4977	4953	-0.5%	2420	2438	0.7%
N ₂ O	225	186	-17.7%	116	85	-27.2%
C ₂ F ₆	0.01	0.01	-6.9%	0.01	0.01	-5.5%
C ₃ F ₈	0.00	0.00	0.0%	0.01	0.01	0.2%
C ₄ F ₁₀	0.00	0.00	0.0%	0.00	0.00	N/A
C ₄ F ₈	0.00	0.00	-66.7%	0.00	0.00	-63.9%
CF ₄	0.04	0.04	8.7%	0.01	0.01	53.1%
HFC-125	0.01	0.03	144.4%	1.11	1.12	1.0%
HFC-134	0.00	0.00	N/A	0.01	0.01	0.0%
HFC-134a	1.00	1.02	2.2%	5.95	5.97	0.4%
HFC-143a	0.01	0.02	144.1%	0.64	0.65	1.1%
HFC-152a	0.01	0.01	0.0%	0.13	0.13	0.0%
HFC-227ea	0.00	0.00	-67.7%	0.09	0.11	19.9%
HFC-23	1.19	1.19	0.0%	0.00	0.00	-38.2%
HFC-245fa		0.00	New gas		0.03	New gas
HFC-32	0.00	0.01	101.8%	0.44	0.45	0.9%
HFC-365mfc		0.00	New gas		0.14	New gas
HFC-43-10mee	0.00	0.00	N/A	0.08	0.02	-70.2%
NF ₃		0.00	New gas		0.00	New gas
SF ₆	0.05	0.06	10.3%	0.02	0.03	15.9%

⁷ Due to rounding some of the % changes do not reflect the apparent changes

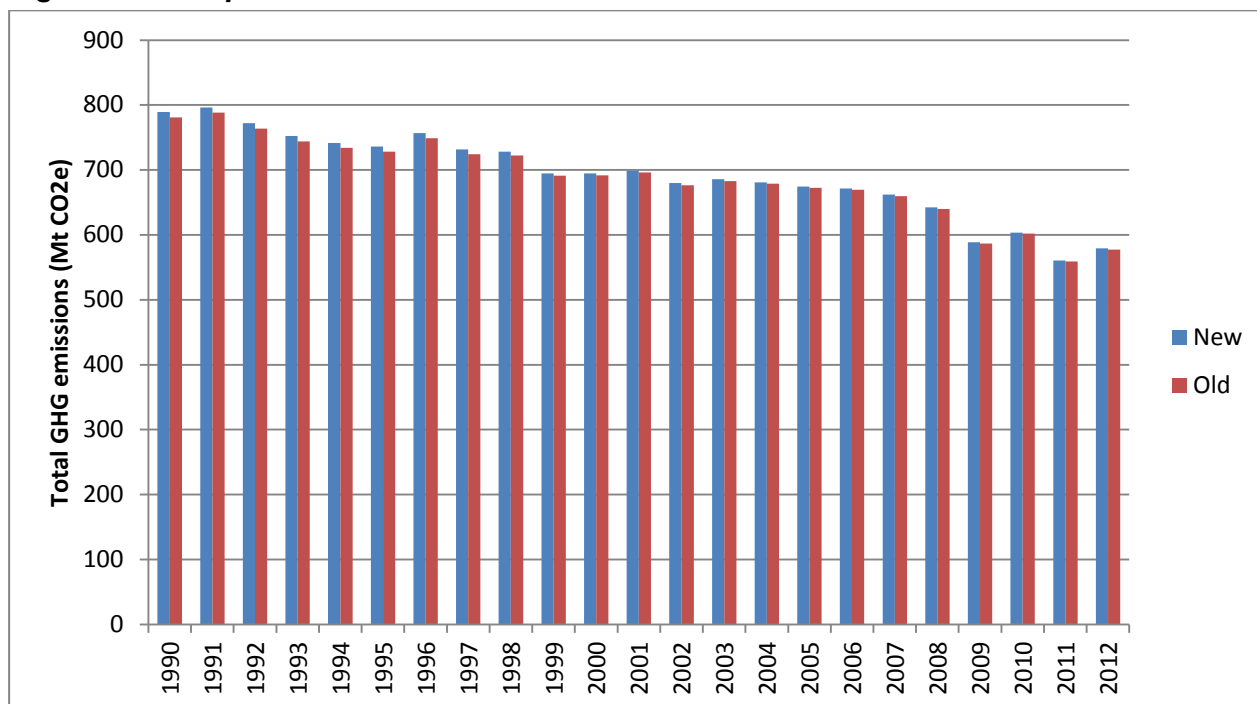
⁸ Where emissions were not previously reported it is impossible to calculate a % change, these cases are denoted "new gas." Where emissions from a previously included gas were estimated to be zero, the % change is noted as "N/A"

Table 7.2 includes the impact of the GWP changes. The final column indicates whether the change (compared to the emissions on a mass basis) is in the same direction but larger or smaller, in the opposite direction, or where the difference relates only to the GWP (in the latest year). This comparison cannot be made for the unspiciated PFCs or for the total since these cannot be presented as totals by mass.

Table 7.2 Comparison of total emissions by gas on a CO₂ equivalent basis (Mt CO₂e)^{7,8}

	Base year new	Base year old	% change	2012 New	2012 Old	% change	Comparison to mass based change
Carbon dioxide	593	593	0.0%	476	476	0.0%	No change
CH ₄	124	105	18.5%	61	51	19.9%	Larger
N ₂ O	55	70	-20.9%	25	36	-30.0%	Larger
C ₂ F ₆	0.16	0.13	23.4%	0.09	0.07	25.3%	Opposite Direction
C ₃ F ₈	0.00	0.00	26.1%	0.10	0.08	26.4%	Larger
C ₄ F ₁₀	0.00	0.00	26.6%	0.00	0.00	N/A	
C ₄ F ₈	0.00	0.00	-60.5%	0.00	0.00	-57.3%	Smaller
CF ₄	0.33	0.26	23.6%	0.10	0.06	74.1%	Larger
Unspiciated PFCs	0.09	0.07	23.4%	0.00	0.00	23.4%	
HFC-125	0.11	0.04	205.5%	3.93	3.11	26.2%	Larger
HFC-134	0.00	0.00	N/A	0.01	0.01	10.0%	Change to GWP only
HFC-134a	1.46	1.30	12.4%	8.54	7.73	10.5%	Larger
HFC-143a	0.11	0.04	187.1%	2.90	2.44	18.9%	Larger
HFC-152a	0.00	0.00	-11.4%	0.02	0.02	-11.4%	Change to GWP only
HFC-227ea	0.00	0.00	-64.1%	0.36	0.27	33.2%	Larger
HFC-23	17.65	13.95	26.6%	0.02	0.02	-21.8%	Smaller
HFC-245fa	0.00		New gas	0.03		New gas	
HFC-32	0.01	0.00	109.6%	0.30	0.29	4.8%	Larger
HFC-365mfc	0.00		New gas	0.11		New gas	
HFC-43-10mee	0.00	0.00	N/A	0.04	0.11	-62.4%	Smaller
NF ₃	0.00		New gas	0.00		New gas	
SF ₆	1.26	1.20	5.2%	0.60	0.54	10.5%	Smaller
Total	793	784	1.1%	579	577	0.3%	

Figure 7.1 illustrates the difference at total level across the time series. The “old” inventory (original 2014 submission) uses the GWP values from the SAR and the “new” inventory (based on this work) uses the GWP values from AR4. The new inventory estimates are slightly higher across the time series.

Figure 7.1 Comparison of total emissions


7.2 Comparisons by gas

7.2.1 Carbon dioxide

The only change to the carbon dioxide emission total is the inclusion of emissions from urea use as a fuel additive. Changes have been made to reporting categories, but this does not impact on the totals. Carbon dioxide is not affected by the GWP changes.

Table 7.3 Breakdown of changes to carbon dioxide (Mt)

	1990	2012
Old total	592.51	475.71
New total	592.51	475.77
Difference		0.06
Of which:		
Urea consumption		0.06

Figure 7.2 below shows the time series comparison. Emissions are identical for much of the time series, and the small differences from 2007 onwards are not large enough to show clearly on the chart.

Figure 7.2 Time series comparison of CO₂ emissions

7.2.2 Methane

The table below details the comparison of methane emissions between the 2014 inventory submission, and the revisions as part of this work. In 1990, the most significant changes are to emissions from the agriculture sector. These are described in more detail in Annex 1 of this report. In 2012, the agriculture changes are smaller (due to declining emissions in the sector as a whole), and the largest change is from industrial waste water treatment.

Table 7.4 Breakdown of changes to methane (kt)

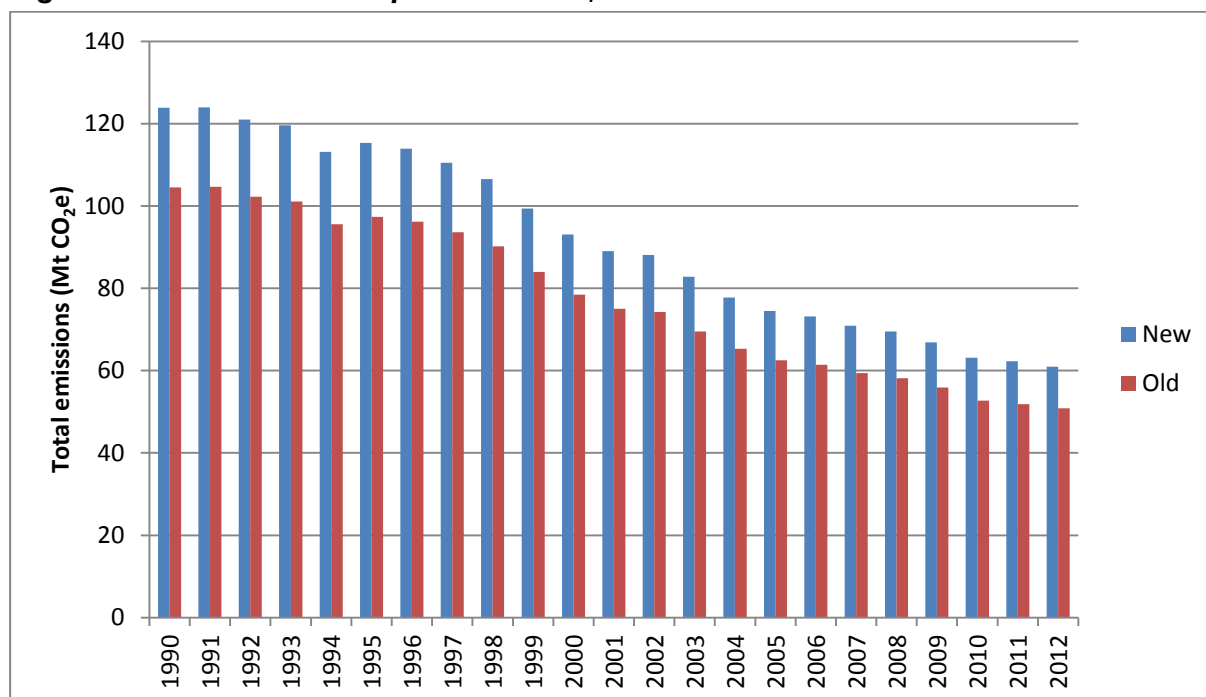
	1990	2012

Old total	4977.26	2420.18
New total	4953.15	2437.53
Difference	-24.11	17.35
Of which:		
<i>New sources</i>		
Off grid waste water treatment	10.41	10.67
New EFs in energy sector	0.62	1.73
<i>Updates to existing sources</i>		
Agriculture	-72.05	-29.45
Industrial waste water treatment	43.27	41.20
Emission factor updates	-6.36	-6.80

On a mass basis, the difference between the original submission and the updated version is between -1 and +1% for all years. Including the GWP changes, emissions based on the new reporting guidelines are +18 to +20% higher than the 2014 submission across the time series.

Figure 7.3 below illustrates the difference, including the GWP change, across the time series. The new estimates are higher than the original 2014 submission for all years.

Figure 7.3 Time series comparison of CH₄ emissions



7.2.3 Nitrous Oxide

The table below shows the comparison of N₂O emissions between the 2014 submission and the revised inventory. The changes are dominated by the changes in the agriculture sector, detailed in Annex 1.

Table 7.5 Breakdown of changes to nitrous oxide (kt)

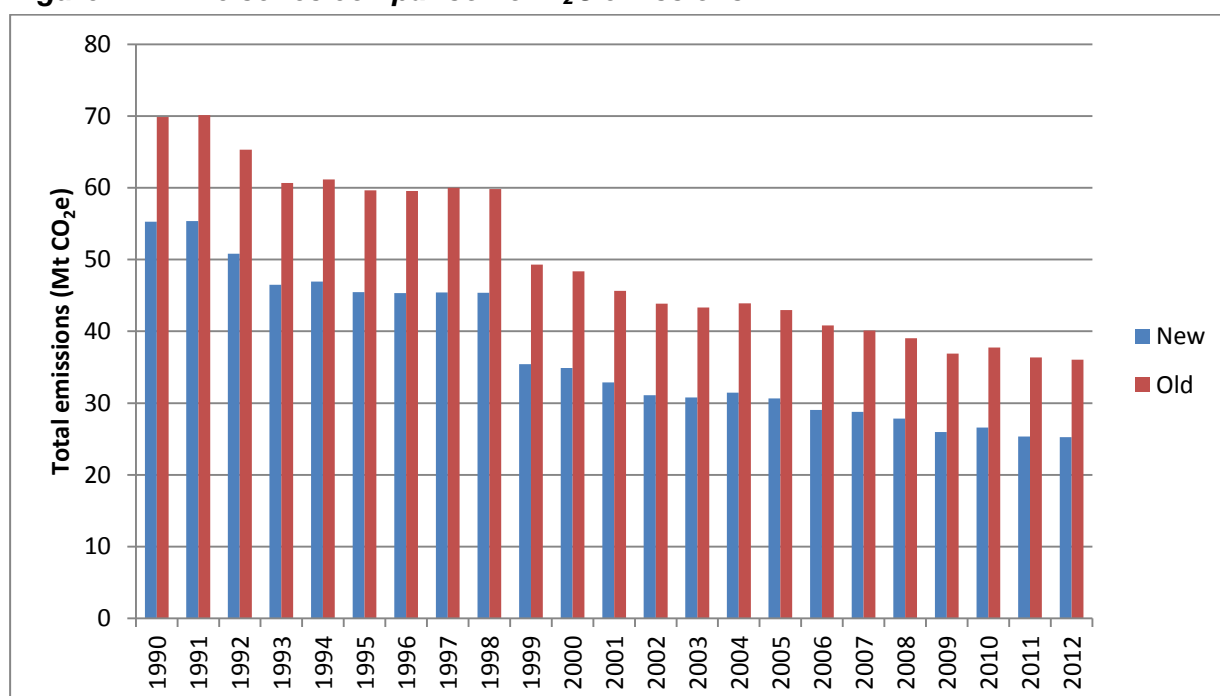
	1990	2012
Old total	225.40	116.30
New total	185.51	84.71
Difference	-39.89	-31.59
Of which:		
<i>New sources</i>		

N ₂ O from anaesthesia	1.76	1.95
New EFs in energy sector	0.02	0.02
<i>Updates to existing sources</i>		
Agriculture	-41.27	-32.97
Emission factor updates	-0.40	-0.60

On a mass basis, the difference between the original submission and the updated version is between -18 and -27% across the time series, with the difference increasing from 1990 to 2012. Including the GWP changes, the difference is between -21 and -30%.

Figure 7.4 shows the time series comparison for N₂O, including the impact of the GWP changes. The new emissions estimates are consistently lower than the original inventory submission. This difference largely cancels out the increase in the CH₄ emissions.

Figure 7.4 Time series comparison of N₂O emissions



7.2.4 HFCs

Changes to HFC emissions are detailed in the table below. For HFC-134 and HFC-152a, no changes have been made to the emissions estimates. HFC-245fa and HFC-365mfc are new gases for reporting from 2015. All emissions of these gases are from foam blowing. The impact of the GWP changes, by gas, can be seen in Table 7.2.

Table 7.6 Breakdown of changes to HFC emissions, by species (tonnes)

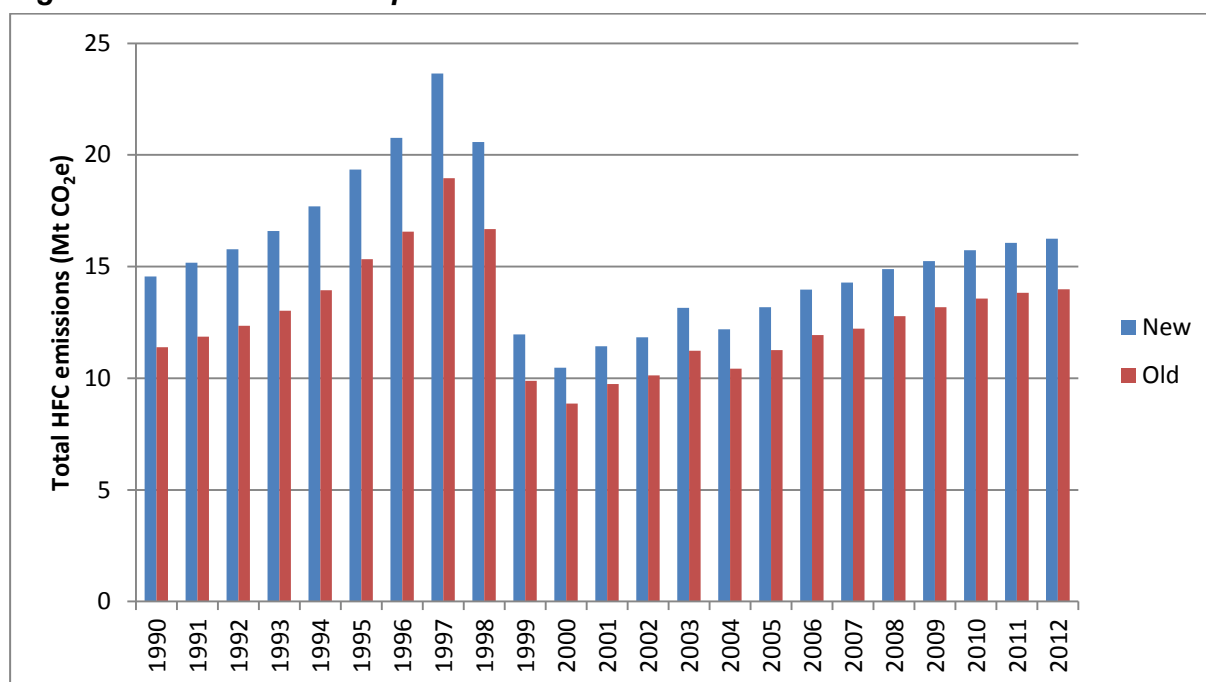
	1995	2012
HFC-125		
Old total	12.90	1111.47
New total	31.52	1122.53
Difference	18.62	11.06
Of which:		
<i>New sources</i>		
Refrigerant containers	18.62	11.06
HFC-134a		
Old total	997.97	5946.12

New total	1019.97	5972.33
Difference	22.00	26.21
Of which:		
<i>New sources</i>		
Refrigerant containers	22.00	26.22
<i>Updates to existing sources</i>		
Magnesium cover gas	0.00	-0.01
HFC-143a		
Old total	10.20	641.33
New total	24.90	648.29
Difference	14.70	6.95
Of which:		
<i>New sources</i>		
Refrigerant containers	14.70	6.95
HFC-227ea		
Old total	1.00	92.55
New total	0.32	111.00
Difference	-0.68	18.45
Of which:		
<i>Updates to existing sources</i>		
Firefighting	-0.68	18.45
HFC-23		
Old total	1192.03	2.03
New total	1192.59	1.25
Difference	0.56	-0.78
Of which:		
<i>New sources</i>		
Semiconductors	0.59	0.89
<i>Updates to existing sources</i>		
Firefighting	-0.03	-1.66
HFC-32		
Old total	4.63	441.08
New total	9.34	445.10
Difference	4.71	4.02
Of which:		
<i>New sources</i>		
Refrigerant containers	4.71	4.02
HFC-43-10mee		
Old total	0.00	82.50
New total	0.00	24.61
Difference	0.00	-57.89
Of which:		
<i>Updates to existing sources</i>		
Solvents	0.00	-57.89

Figure 7.5 below shows the difference in HFC emissions between the two inventories, including the impact of the GWP changes. Emissions are higher across the time series

based on the new data, with the difference being larger in the earlier years. Total HFC emissions now account for 2-3% of total emissions across the time series, compared with 1-2% based on the 2014 submission.

Figure 7.5 Time series comparison of total HFC emissions



7.2.5 PFCs

Changes to estimates of PFC emissions are detailed below. For C₄F₁₀ (PFC-3-1-10), no changes have been made. No new sources or gases have been added for PFCs, but updates have been made to estimates for semiconductors. The impact of the GWP changes, by gas, can be seen in Table 7.2.

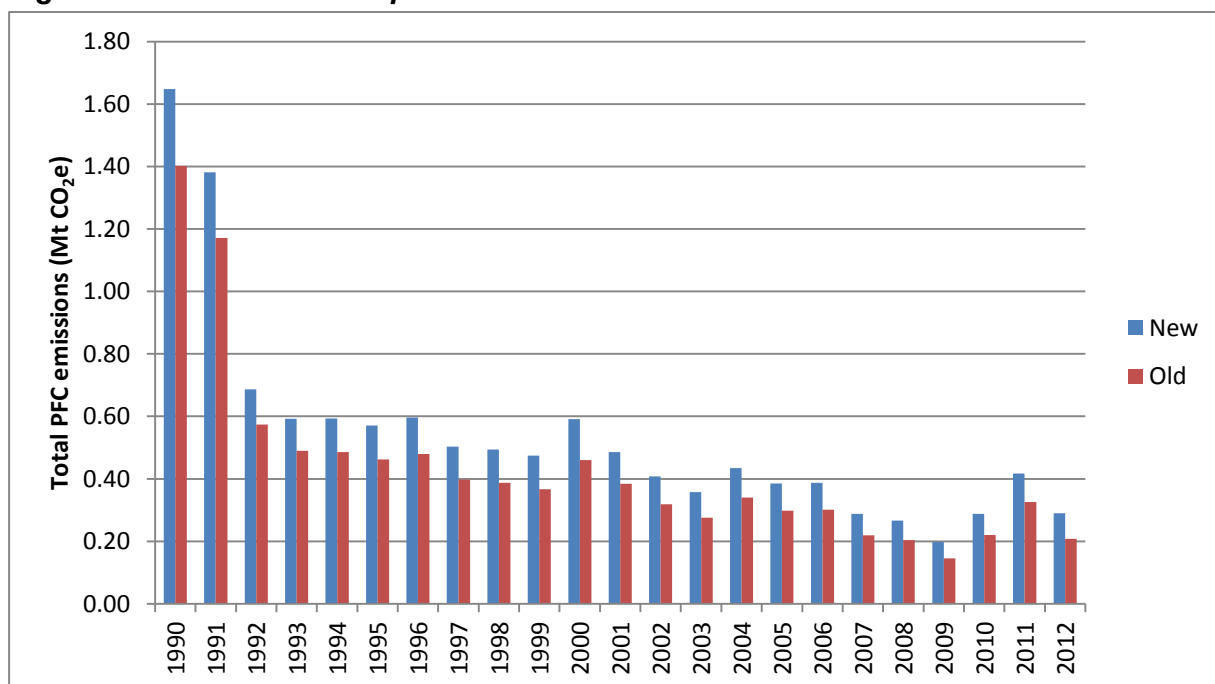
Table 7.7 Breakdown of changes to PFC emissions, by species (tonnes)

	1995	2012
C₂F₆ (PFC-116)		
Old total	13.73	7.38
New total	12.78	6.98
Difference	-0.95	-0.41
Of which:		
<i>Updates to existing sources</i>		
Semiconductors	-0.95	-0.41
C₃F₈ (PFC-218)		
Old total	0.16	11.40
New total	0.16	11.42
Difference	0.00	0.02
Of which:		
<i>Updates to existing sources</i>		
Semiconductors	0.00	0.02
C₄F₈ (PFC-318)		
Old total	0.01	0.01
New total	0.00	0.00

Difference	-0.01	-0.01
Of which:		
<i>Updates to existing sources</i>		
Semiconductors	-0.01	-0.01
CF ₄ (PFC-14)		
Old total	40.49	8.95
New total	44.01	13.71
Difference	3.53	4.75
Of which:		
<i>Updates to existing sources</i>		
Semiconductors	3.53	4.75

Figure 7.6 below shows the difference in PFC emissions between the two inventories, including the impact of the GWP changes. Emissions are higher across the time series based on the new data, with the difference being larger in the earlier years. Total PFC emissions remain a very small proportion of total emissions (0.03 – 0.21%).

Figure 7.6 Time series comparison of total PFC emissions



7.2.6 Sulphur Hexafluoride

The table below provides a breakdown of the changes made to the SF₆ inventory. The largest change is the inclusion of AWACs (military Airborne Warning and Control Systems).

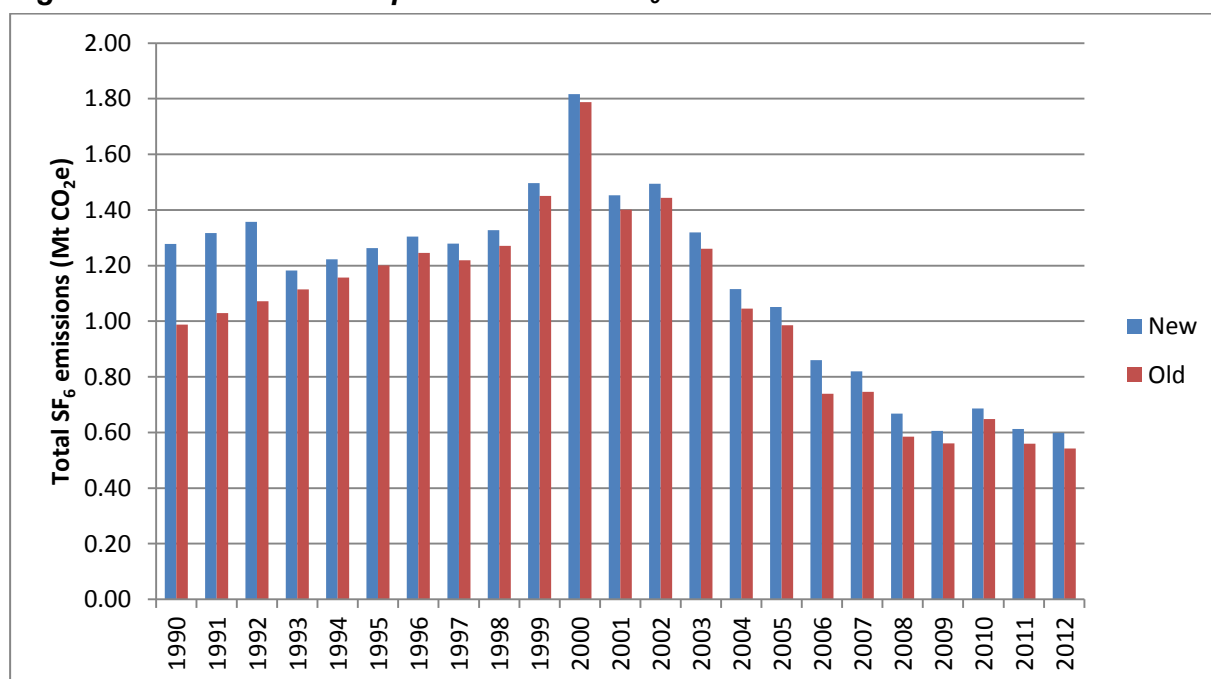
Table 7.8 Breakdown of changes to SF₆ emissions, by species (tonnes)

	1995	2012
Old total	50.25	22.68
New total	55.41	26.28
Difference	5.16	3.60
Of which:		
<i>New sources</i>		

AWACS	5.18	5.18
Particle accelerators	0.30	0.21
<i>Updates to existing sources</i>		
SF ₆ used as a tracer gas	0.01	0.03
Magnesium cover gas	-0.05	-1.45
Semiconductors	-0.28	-0.37

Figure 7.7 shows the impact of the changes to the SF₆ inventory, including the GWP changes. The biggest difference is in the early 1990s, due to high emissions from the particle accelerators source category in these years. The high emission is from the operation of a single large facility, which closed in 1992.

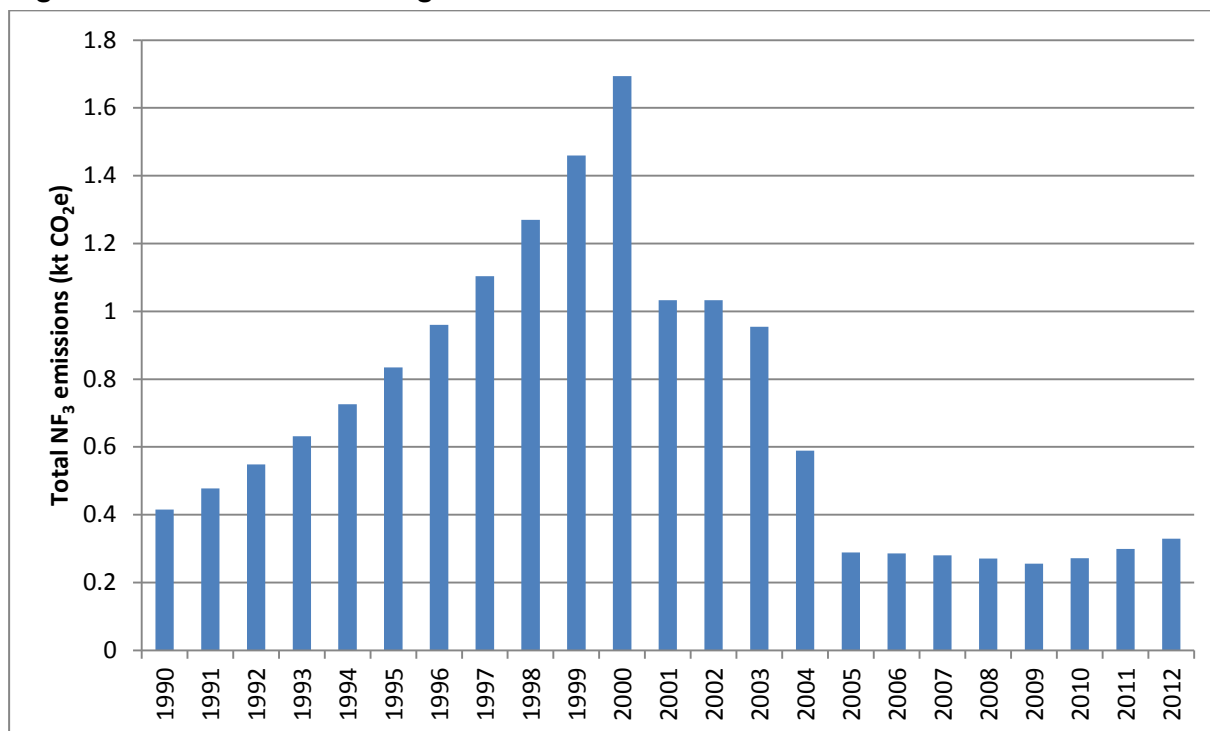
Figure 7.7 Time series comparison of total SF₆ emissions



7.2.7 Nitrogen Trifluoride

Emissions of nitrogen trifluoride (NF₃) are included for the first time under the new UNFCCC reporting and IPCC methodology guidelines. Emissions have been identified and estimated for semiconductors. These emissions amount to 0.05 tonnes in 1995 and 0.02 in 2012, which equates to 0.8 and 0.3 kt CO₂ equivalent.

Figure 7.8 Emissions of nitrogen trifluoride



7.3 Reporting category changes

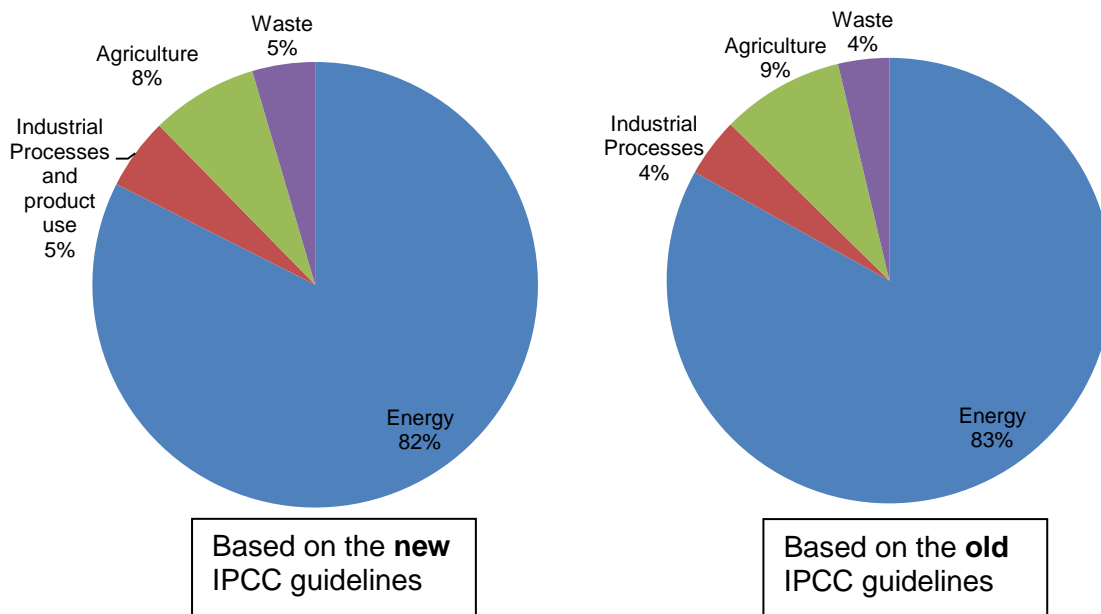
The new reporting guidelines divide the inventory into five categories:

- Energy
- Industrial Processes and Product Use (IPPU)
- Agriculture
- Land Use, Land Use Change and Forestry (LULUCF)
- Waste

The IPCC Guidelines combine agriculture and LULUCF into a single sector (AFOLU), however this has not been implemented in the UNFCCC reporting guidelines. The Industrial Processes, and Solvents and Other Product Use sectors have been combined into the IPPU sector, in both the IPCC Guidelines and the UNFCCC reporting guidelines. Since no direct GHG emissions were reported in the UK inventory, the creation of the IPPU category has had very little impact on the inventory, although some emissions have moved between the IPPU and Energy sectors.

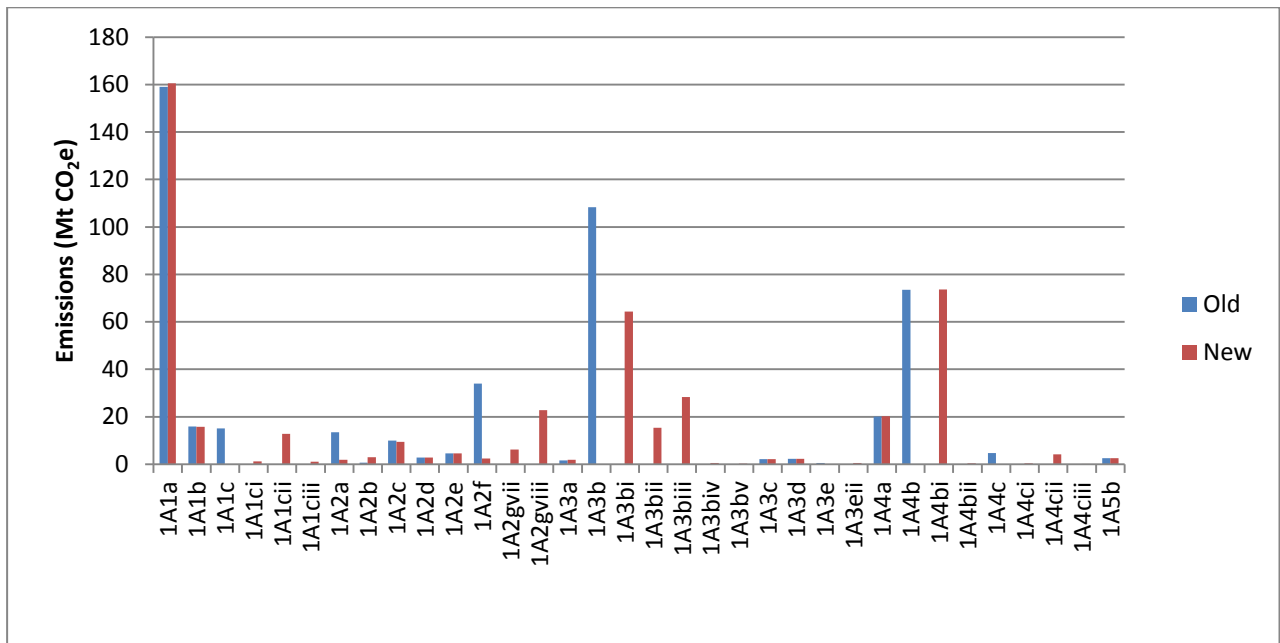
The “high level view” of the inventory is very similar, 2012 emissions based on the new (left) and old (right) guidelines are set out in the figure below and the percentage contribution of each of the sectors is broadly similar.

Figure 7.9 Sector contributions to emissions total (excluding LULUCF)



The reorganisation of reporting categories within the sectors has been more significant. The Energy sector is illustrated below:

Figure 7.10 Changes to reporting categories within the energy sector



Most of the category changes within the energy sector further disaggregate emissions. For example, previously for road transport, total emissions were reported, split only by petrol or diesel, in category 1A3b. The new reporting categories break down emissions by vehicle type (cars, LGVs, HGVs etc.) – categories 1A3bi – 1A3bv.

Although the reporting categories used for official submissions to the UNFCCC have changed, the UK inventory database will still be able to produce statistics using the old categories or using National Communication categories, for UK statistical releases.

8 References

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Appendices

Appendix 1: Impact of changes to the agriculture sector

Appendix 2: Impact of changes to the LULUCF sector

Appendix 1 – Impact of changes to the agriculture sector

Emissions from livestock and manure management

Methane emissions from enteric fermentation

The estimate of enteric CH₄ emission increased by 21% for the inventory year 2012 as highlighted in Table 3. The change in default EFs caused a blanket increase across all tier 1 cattle categories. In addition, the increase in the methane conversion rate (Y_m) and the coefficient for calculating net energy for maintenance (C_f) further increased the estimate of emissions from cattle. Emission estimates from all other livestock categories remained unchanged.

Methane emissions from manure management

A change in the method of calculation for the VS from dairy and beef cows saw an increase in the estimate of emissions from cattle as did the increase in coefficient for calculating net energy for maintenance. However this increase was by far outweighed by the lower MCF values for liquid/slurry and deep litter systems and the changes in default VS and B₀ values resulting in an overall 57% (2012) decrease in CH₄ emissions from manure management.

UK greenhouse gas emissions using the 2000GPG vs. the 2006 GL, kt

Year	1990		2012	
	2000 GPG	2006 GLs	2000 GPG	2006 GLs
CH₄	1333.18	1261.13	1050.63	1021.19
Enteric	894.04	1075.10	736.38	887.52
Manure management	426.48	177.81	314.26	133.67
Field burning	12.66	8.22	0.00	0.00
N₂O	119.74	78.48	95.96	62.99
Manure management	10.79	8.08	8.58	6.22
Direct	10.79	5.02	8.58	3.84
Indirect	n/a	3.06	n/a	2.38
Soils	108.95	70.40	87.38	56.77
Direct	68.90	54.24	56.67	44.05
Fertiliser	28.11	24.99	19.86	17.65
Grazing returns	21.78	17.81	18.77	15.40
Manure application	8.36	4.99	6.41	3.85
Crop residues	7.06	4.34	8.06	4.68
Biological fixation	0.85	n/a	0.38	n/a
Improved grassland	0.57	n/a	0.57	n/a
Histosols	1.89	1.89	1.89	1.89
Sewage sludge	0.28	0.23	0.73	0.58
Indirect	39.80	15.95	30.70	12.72
Leaching	33.39	10.22	25.63	8.16
Fertiliser	18.74	5.62	13.24	3.97
Grazing returns	8.17	2.45	7.04	2.11
Manure application	6.27	1.12	4.80	0.87
Crop residues	n/a	0.96	n/a	1.04

Year	1990		2012	
Sewage sludge	0.21	0.06	0.55	0.16
Deposition	6.41	5.73	5.07	4.56
Fertiliser	2.50	2.50	1.77	1.77
Grazing returns	2.18	2.18	1.88	1.88
Manure application	1.67	1.00	1.28	0.77
Sewage sludge	0.06	0.06	0.15	0.15
Field burning	0.26	0.21	0.00	0.00

Nitrous oxide emissions from manure management

The effect of implementing the 2006 GL on the UK N₂O emission from manure management was a blanket reduction in emission estimates across all categories. A reduction of 55% in direct N₂O emissions from animal waste management systems due to changes to EF₃ (Table 2) was partially offset by the addition of indirect N₂O emissions from N volatilisation from manure management systems (Table 3), which in turn reduced the N available for application to managed soils.

N₂O emissions from managed soils

Direct N₂O emissions

The estimate of N₂O emission from applied mineral N fertiliser was lower because of the reduction in EF₁, although this was mitigated by not adjusting for losses via NH₃ and NO_x. N₂O from manure application was also lower because of the combination of the above two changes and the introduction of Frac_{LossMS}. Direct N₂O emissions from grazing were reduced by the introduction of a lower EF₃ value for sheep and other animals. The inclusion of below-ground crop residues did not serve to increase the overall N₂O emission estimate from this source because of the availability of new data on the N content of crop residues, by each crop type, in combination with the lower EF₁ value. Previously the IPCC default values of 0.015 kg N/kg DM for non-legumes and 0.03 kg N/kg DM for legumes were applied to above-ground crop residue N; both defaults being higher than the 2006 GL value for the majority of crops. Emission from crop residues from grass <5 years has not yet been included due to lack of grass production data.

Removal of biological fixation as a direct source of N₂O had little effect on the overall emission estimate because of the small contribution that it makes to the total UK emission.

Indirect N₂O emissions

Estimates of indirect emissions via leaching and runoff were much lower as a result of implementing the 2006 GL, even with the addition of indirect N₂O emission from crop residues and non-adjustment for NH₃ and NO_x volatilisation, due to the reduction in the value of the nitrogen leaching/runoff factor (EF₅) in the 2006 GL. No changes were made to the N deposition factor (EF₄) leaving deposition emission estimates unchanged with the exception of those from manure application due to accounting for the of the total nitrogen loss from manure management (Frac_{LossMS}) before application to land.

Biomass burning (agricultural residues)

Estimates of emissions from the burning of agricultural residues have decreased for both CH₄ and N₂O as a result of changes in the calculation methodology (Table 3).

Summary

Implementation of the 2006 GL resulted in a 5% and 3% overall decrease in the estimate of CH₄ emission from UK agriculture for 1990 and 2012, respectively. Although there was a large increase in the estimate for enteric emissions, this was offset by a larger decrease in estimated CH₄ emissions from manure management. The impact of the 2006 GL on the UK estimate of N₂O emission was a 34% decrease in both 1990 and 2012. Estimated emissions of N₂O from all sources were reduced or remained the same. However, indirect emissions from crop residues and manure management were added as new sources of N₂O. The total emissions expressed as CO₂eq. were 7.5 MtCO₂eq less when following the 2006 GL. This was influenced by the use of the updated GWP of 25 and 298 for CH₄ and N₂O respectively as opposed by the previous values of 21 and 310.

Appendix 2 – Impact of changes to the LULUCF sector

The impact of implementing the IPCC 2006 Guidelines for National Greenhouse Gas Inventories for the Land Use, Land Use Change and Forestry sector (LULUCF) has been assessed against the submitted LULUCF estimates for 1990-2009 (published in the national inventory report in April 2011). The assessment has been made for the 1990, 2008 and 2009 emissions. The overall impact has been a reduction in emissions of carbon dioxide and methane and an increase in emissions of nitrous oxide. The total emissions in carbon dioxide equivalents have reduced by 3%, resulting in the LULUCF sector being a smaller net source in 1990 and a larger net sink in 2008 and 2009.

Note that the outcomes from this study have not been included in the main analysis presented in this report, and that the baseline for this study was an earlier inventory. Since the contribution of the LULUCF sector to total UK emissions is small, the impact of changes to this sector will not have a significant effect on the overall UK total. This study also pre-dates the improvements made to the LULUCF inventory in 2014.

Summary of the key changes in the IPCC 2006 Guidelines

The 2006 Guidelines combine the Agriculture and LULUCF sectors into a single sector: Agriculture, Forestry and Other Land Use (AFOLU). This is subdivided into 3A Livestock, 3B Land and 3C Aggregate sources and non-CO₂ emission sources on land. The sub-divisions that relate to the LULUCF sector are:

- 3B1 Forest Land
- 3B2 Cropland
- 3B3 Grassland
- 3B4 Wetlands
- 3B5 Settlements
- 3B6 Other Land
- 3C1 GHG emissions from biomass burning
- 3C2 Liming
- 3C4 Direct N₂O emissions from managed soils
- 3D1 Harvested Wood Products

(Note that there was no default methodology for 3C3 Urea Application in the IPCC 1996 Guidelines and these estimates are not currently reported in the UK greenhouse gas inventory).

The sub-divisions 3B1-3B6 are the same as those in the 2003 Good Practice Guidance for LULUCF, which is used for the current reporting of LULUCF emissions and removals in the UK. The UK uses Tier 3 approaches for reporting the carbon stock changes in these sub-divisions (the exception is the Wetlands category where the IPCC 2006 Guidelines have already been implemented, as reported in the April 2011 national inventory report). As a consequence, there will be no immediate impact on the carbon stock changes in these categories from using the IPCC 2006 Guidelines. However, the living biomass carbon pool has now been split into above-ground biomass and below-ground biomass for reporting, and development work will be required to implement this reporting structure.

Emissions from biomass burning

- The methodology for fires used in the IPCC 1996 Guidelines is currently used, with a pre-fire fuel biomass of 240 t ha⁻¹ (for deforestation) or the average forest biomass per hectare for forest wildfires.
- The emission factors (g kg⁻¹ dry matter burnt) for forest burning have changed for carbon dioxide (to 1569), methane (to 4.7) and nitrous oxide (to 0.26). Previously, emissions were estimated from the amount of carbon released using emission ratios and gas-specific factors.
- The combustion factors (proportion of pre-fire fuel biomass consumed) have changed from a default of 0.5 to 0.51 for land clearing fires on temperate forests (used for controlled burning associated with deforestation) and to 0.45 for all other temperate forests.
- Calculated emissions of carbon dioxide and methane have fallen for forest wildfires and controlled fires associated with deforestation.
- Calculated emissions of nitrous oxide have increased for forest wildfires and controlled fires associated with deforestation.

Emissions from liming

- The IPCC emission factor for dolomite has changed from 0.1202 to 0.13 t C t⁻¹ applied. The UK has used an emission factor of 0.1302 to date. The emission factor for limestone has remained the same.
- Calculated emissions of carbon dioxide from dolomite application to cropland and grassland have fallen very slightly.

Emissions of nitrous oxide associated with land use conversion to cropland

- Emissions of nitrous oxide associated with land use conversion to cropland were reported for the first time in the 1990-2009 inventory using the IPCC 2006 Guidelines methodology. Consequently, the change in the emission factor is already accounted for in the published inventory.

Emissions of nitrous oxide from nitrogen fertilization of forest land

- The emission factor used for nitrous oxide emissions from this source was updated to that used in the IPCC 2006 Guidelines in the 1990-2009 inventory. Consequently, the change in the emission factor is already accounted for in the published inventory.

Emissions from Wetlands

- Carbon dioxide emissions from on-site peat extraction and off-site emissions from horticultural peat and nitrous oxide emissions from wetland drainage as part of peat production were reported for the first time in the 1990-2009 inventory.
- These emissions were calculated using a Tier 1 approach from the IPCC 2006 Guidelines, so any changes in the emission factors between the previous and latest guidance are already accounted for in the published inventory.

Overall impact

The reduction in emissions from the LULUCF sector results from the reduction in emissions from biomass burning, particularly carbon dioxide.

Comparison of overall emissions reported in the 1990- 2009 and recalculated using the IPCC 2006 Guidelines (where appropriate) for UK and Overseas Territories and Crown Dependencies

	2009 inventory	IPCC 2006 GL	% change	2009 inventory	IPCC 2006 GL	% change	2009 inventory	IPCC 2006 GL	% change
	1990			2008			2009		
Carbon dioxide	3102	3022	-2.6%	-4648	-4780	2.9%	-4746	-4867	2.5%
Methane	1.232	0.304	-75%	1.672	0.640	-62%	1.406	0.511	-64%
Nitrous oxide	2.560	2.568	0.3%	2.098	2.122	1.1%	2.057	2.075	0.9%
Carbon dioxide equivalents	3922	3824	-2.5%	-3962	-4109	3.7%	-4079	-4213	3.3%

Carbon dioxide equivalents are calculated using a GWP of 21 for methane and 310 for nitrous oxide.

Including the impact of the GWP changes reduces the reduction in methane emissions on a GWP basis, but also changes the increase in N₂O to a decrease. The overall change on a GWP basis is about -3.2% in 1990 and +3.8% in 2009.

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