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Department of Energy & Climate Change

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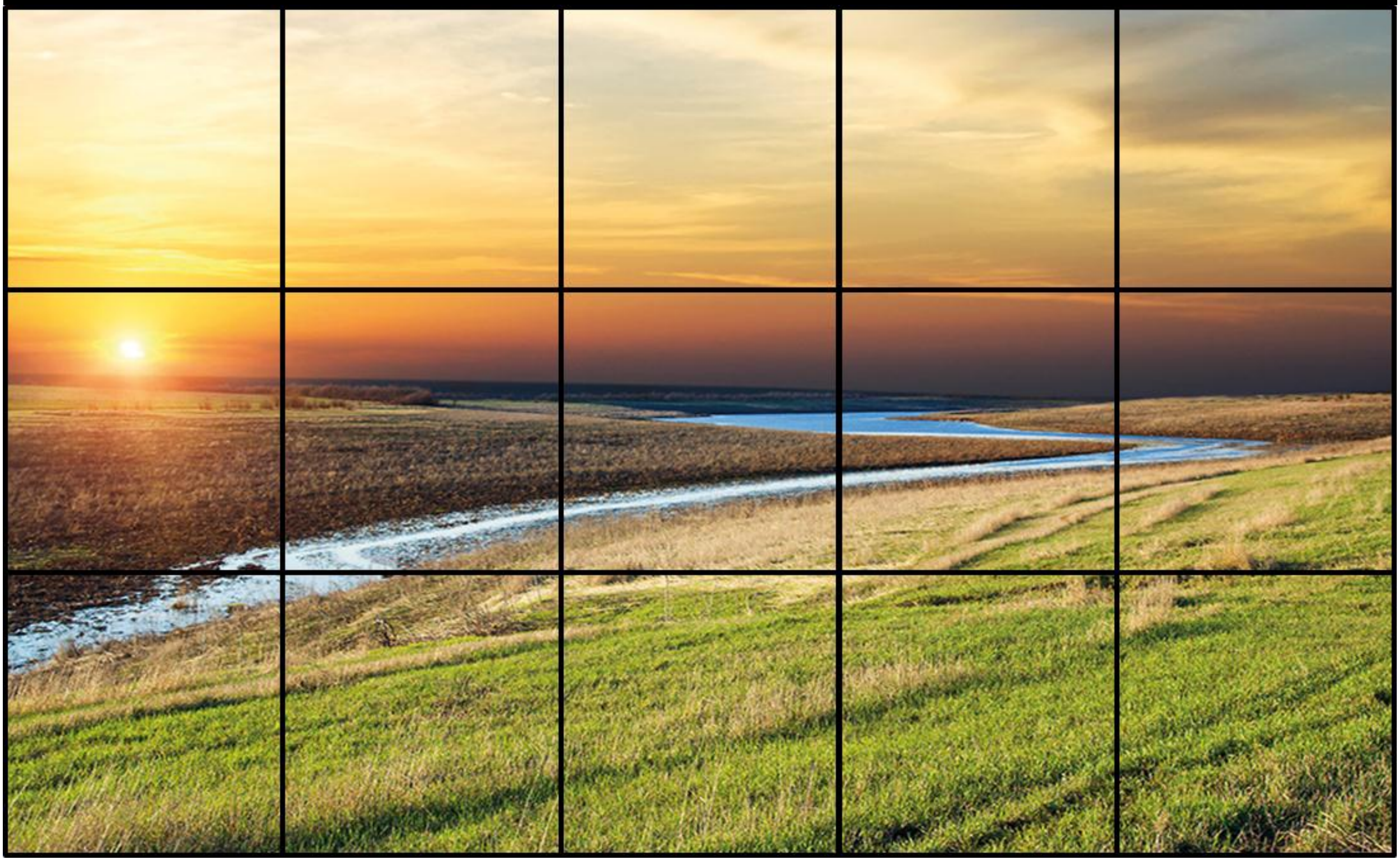
An Introduction to the UK's Greenhouse Gas Inventory



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Executive Summary

This report is a companion to the UK National Inventory Report and is a simple introduction to the origins and use of data used in the compilation of the UK Greenhouse Gas Inventory, which underpins the UK's national and international reporting requirements for greenhouse gases.

The UK inventory contains estimates of all greenhouse gas emissions by sources and removals by sinks from 1990 to the latest available year of reporting, currently 2012. The inventory includes the Kyoto 'basket' of six greenhouse gases, which are: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. The gases are discussed in more detail in the guide. Important features of the UK's Greenhouse Gas Inventory include:

- The UK's emissions of the basket of six greenhouse gases fell by 26% between the 1990 and 2012.
- Carbon dioxide emissions accounted for 82.4% of total greenhouse gas emissions in 2012, making carbon dioxide the most important greenhouse gas emitted by the UK. The main sources of carbon dioxide emissions are from fuel combustion in particular from power stations and road transport.
- Methane emissions accounted for around 8.8% of total greenhouse gas emissions in 2012. Significant sources include emissions from landfills and the agriculture sector.
- Nitrous oxide emissions accounted for 6.3% of total greenhouse gas emissions in 2012. The most significant source of nitrous oxide emissions is agricultural soils.
- Emissions of hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride (collectively known as "F-gases") are small in relation to the other gases, accounting for 2.6% of emissions in 2012. Emissions arise from a variety of sources, including refrigeration and air conditioning.

The main reason for the downward trend in emissions since 1990 has been the change in the fuel mix used for power generation, moving away from coal to less carbon-intensive fuels such as natural gas, together with the growth in renewable power generation. Emissions of methane and nitrous oxide have also decreased significantly since 1990 due to declining animal numbers in the agriculture sector, abatement improvements in the industrial processes sector and improvements to waste management practices.

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1. Introduction

This short report summarises the mechanisms used in the UK to estimate greenhouse gas emissions and the procedures used for reporting national emissions. It explains where to find the official datasets of UK greenhouse gas emissions and is intended as a companion to the National Inventory Report, which forms part of the official UK submission to the United Nations Framework Convention on Climate Change (UNFCCC). The guide is short and is not intended to cover all technical and reporting aspects in full detail. For further information, Section 7 provides links to resources and publications where more detail about the UK's greenhouse gas inventory can be found.

2. About the UK Greenhouse Gas Inventory

2.1 What is the UK Greenhouse Gas Inventory?

The Greenhouse Gas (GHG) Inventory contains the UK's official reported greenhouse gas emission estimates. It is the key tool for understanding the origin and magnitude of UK emissions. The Greenhouse Gas Inventory covers the six direct greenhouse gases under the Kyoto Protocol. These are:

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

The last three of these gases are collectively known as the F-gases. From the 2015 inventory onwards Nitrogen trifluoride (NF_3) will also be reported.

Each of these gases has been assigned a global warming potential (GWP). In simple terms, the GWP defines how potent each greenhouse gas is compared with CO_2. CO_2 has a GWP of 1; the remaining greenhouse gases in the list above have much greater effects on global warming per unit and so have much larger GWPs. HFCs and PFCs are groups of gases rather than single species, and they have a range of large GWPs. Once the emissions of greenhouse gases are converted into their GWP equivalents, the emissions can be summed and presented as CO_2 equivalent emissions, sometimes referred to as CO_2 eq.

The Greenhouse Gas Inventory contains estimates of all greenhouse gas emissions by sources and removals by sinks from 1990 to the latest available year of reporting, which at the time this guide was written, was 2012. The UK National Statistics report emissions in nine National Communication (NC) sectors, which are listed below:

+ Agriculture

- Business
- Energy Supply
- Industrial Processes
- Land Use, Land Use Change and Forestry (LULUCF)
- Public
- Residential
- Transport
- Waste Management

The NC sectors are agreed groupings of the more detailed sectors reported to the UNFCCC. Each of the NC sectors contains all emissions associated with direct fuel use within the sector, for example, gas combustion for cooking and heating in the residential sector, or petrol use in the transport sector. Emissions associated with the extraction and processing of fuels, or the production of secondary energy sources such as electricity are included within the energy supply sector. The waste management and LULUCF sectors do not contain any emissions associated with fuel combustion.

2.2 Why do we need to report the Greenhouse Gas Inventory?

2.2.1 What is the Greenhouse Gas Inventory used for?

The Greenhouse Gas Inventory is a tool that provides insight into the sources of greenhouse gas emissions in the UK. It is used by Government to help formulate policies to mitigate emissions. The Greenhouse Gas Inventory reflects the response to policies that are implemented and enables the assessment of the overall progress towards emission targets. The emission estimates presented in the UK Greenhouse Gas Inventory are used to assess progress towards domestic goals to reduce greenhouse gas emissions, the UK's commitments under the Kyoto Protocol and the Framework Convention on Climate Change, and the UK's contribution to the EU's targets under the Kyoto Protocol. From now on, the inventory will also be used to assess compliance against annual emission allowances for the UK during 2013 to 2020, set by the EU under the Effort Sharing Decision.

2.2.2 To who is the Greenhouse Gas Inventory reported?

The Greenhouse Gas Inventory is reported to:

- The United Nations Framework Convention on Climate Change and under the Kyoto Protocol
- The European Union Monitoring Mechanism
- UK Government
- The Devolved Administrations

The UK has signed up to international agreements for reducing greenhouse gas emissions. In the early 1990's a number of countries joined the United Nations Framework Convention on Climate Change (UNFCCC) treaty in an effort to begin discussions on how to mitigate and adapt to climate change, with the aim of returning emissions of greenhouse gases to 1990 levels by the year 2000. In 1997, an addition to this treaty – the **Kyoto Protocol** – was adopted.

A country's progress against its Kyoto Protocol target is monitored through mandatory reporting to the United Nations Framework Convention on Climate Change (UNFCCC). Under the Kyoto Protocol, the European Union also has an emission reduction target. For the first commitment period (2008-2012), the UK's share of this was a reduction in emissions of the six greenhouse gases by 12.5% against a base line of emissions in 1990 (for carbon dioxide, methane and nitrous oxide) and 1995 (for the F-gases). The sum of these emissions in 1990 and 1995 is called the **base year** emissions. Treatment of LULUCF is slightly different to the UNFCCC for the Kyoto Protocol, and the **base year** is a fixed amount, based on the 2006 inventory submission. Progress towards targets under the Kyoto Protocol are therefore calculated on a slightly different basis to the emissions reductions that can be calculated from each annual inventory submission.

The second commitment period of the Kyoto Protocol will run from 2013-2020. The EU has made a commitment to reduce emissions by 20 per cent below base year levels on average over the period.

The UK has also set tough, legally binding national targets to reduce greenhouse gas emissions. These targets are in the form of **carbon budgets**. Introduced in the Climate Change Act, carbon budgets set legally binding limits on the total greenhouse gas emissions allowed from the UK over a period of five years. The first of the budgets ran from 2008 to 2012, with subsequent budgets set for 2013-2017, 2018-2022 and 2023-2027. These budgets require the UK to reduce emissions of greenhouse gases by 34% on 1990 levels by 2020, with a long term target of an 80% reduction by 2050.

The Greenhouse Gas Inventory is also presented for direct public access online[1].

[1]https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/uk-greenhouse-gas-emissions

2.3 How do we calculate emissions?

The source data and methods used to derive UK GHG emission estimates have been developed to be consistent with methods defined within international guidance provided to all countries via the Inter-governmental Panel on Climate Change; all countries that report to the UNFCCC are required to use these estimation methods from the agreed guidelines and good practice to ensure that the GHG emissions for each country are complete and comparable.
The basic equation used for calculating most emissions is:

Emission = Emission factor x Activity

The UK inventory uses the best available data from UK and international research for each emission source. The approach used is largely defined by the availability of data and the significance of the emission source in the overall UK inventory: more detailed methods are used for the high-emitting sources, whilst simpler methods can be used for minor sources, consistent with international guidance. Typical example calculations for emission sources include:

For fuel combustion:
Amount of fuel burned x emission factor per unit fuel

For emissions from livestock:
Numbers of animals x emission factor per animal

For emissions from vehicles:
Kilometres travelled x emission factor per kilometre

The emission factor is the emission per unit of activity. Emission factors for energy sources are either dependent on the fuel characteristics (for emissions of CO_2) or how the fuel is burned, for example the size and efficiency of equipment used. For other sources, the emission factor can be dependent on a range of parameters, such as feed characteristics for livestock or the chemical reactions taking place for industrial process emissions. Emission factors are typically derived from measurements on a number of representative sources and the resulting factor applied to all similar sources in the UK.

For some sources, the calculation of emissions is more complicated, and therefore a model is used to estimate emissions. For example, emissions of methane from waste disposed to landfills are estimated using a model that reflects the fact that the emissions occur over a long timeframe from the initial disposal of the waste, and that emissions are affected by the level of capture and utilisation of the landfill methane produced. The carbon fluxes (emissions and sinks) from land use, land use change and forestry are also modelled.

For an overview of the source estimation methods in the UK inventory, see **Chapter 4**.

2.4 Guidelines and principles

2.4.1 Guidelines

The UK Greenhouse Gas Inventory compilers follow detailed guidance produced by the Intergovernmental Panel on Climate Change (IPCC). The function of the IPCC is to publish reports and guidelines relevant to the implementation of the UN Framework Convention on Climate Change. As part of this function, the IPCC produce the Guidelines for National Greenhouse Gas Reporting and these are then adopted by the UNFCCC. These guidelines set out the acceptable methods for estimating greenhouse gases for reporting to the UNFCCC. This guidance is periodically updated and the Greenhouse Gas Inventory must change accordingly. The guidelines do not pre-empt the accounting choices that are used currently, for example under the Kyoto Protocol, and that which might be used in the future. All countries must adhere to these guidelines and each year every submission is reviewed and checked to ensure these standards are met.

2.4.2 Overarching principles

The compilation of the UK GHG inventory is conducted in accordance with international protocols and methodological guidance, which are designed to ensure that all country inventories attain similar standards and are therefore comparable. The underlying principles of inventory compilation are defined within IPCC guidance and can be summarised as follows:

+ **Accuracy.** Accuracy is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, so far as can be judged, and that uncertainties are reduced so far as is practicable. Appropriate methodologies conforming to guidance on good practices should be used to promote accuracy in inventories.
+ **Completeness.** Completeness means that an inventory covers all sources and sinks for the full geographic coverage, as well as all gases included in the IPCC Guidelines in addition to other existing relevant source/sink categories which are specific to individual Parties (and therefore may not be included in the IPCC Guidelines).

+ **Transparency.** Transparency means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the reported information. The transparency of inventories is fundamental to the success of the process for the communication and consideration of information.

+ **Comparability.** Comparability means that national inventory estimates should be comparable among Parties. This is achieved by all countries following the reporting guidance and presenting their data in a set format. The EU and UN then review the country inventories to check that the guidance has been followed, and finalised national inventories can easily be compared as they all present the same level of information for each emission source.

+ **Consistency.** Consistency means that an inventory should be internally consistent in all its elements over a period of years, to make sure that reported emission trends are as accurate as they can be. Ideally, emission estimates should be calculated using one method across all reported years, and the UK inventory therefore relies heavily on long-term National Statistics such as energy balance data to underpin the estimates.

3. Emissions data and trends

3.1 Differences in reported totals

There are various totals of UK greenhouse gases which are reported to the different authorities. All totals are valid and so it is important to understand the differences, ensuring that the correct data are used for specific purposes of reporting or analysis.

Firstly, differences arise in the totals reported to the UNFCCC and the Kyoto Protocol, which centre on the Land Use, Land Use Change and Forestry sector. Under the UNFCCC, all emissions and removals from this sector are included, whereas under the Kyoto Protocol, only selected emissions and removals are included. This report does not go into more detail about these reporting differences, but the executive summary of the UK National Inventory Report contains more information.

Secondly, different geographical coverages are reported. The UK Greenhouse Gas Inventory defines the UK using differing geographical coverages, depending on the reporting requirements. Overseas Territories and Crown Dependencies that are associated with the UK are sometimes included or excluded from the emissions totals. The list below sets out the three main geographical coverages of the Greenhouse Gas Inventory:

1. **UK National Statistics** – The geographical coverage of these statistics is based on the UK and the Crown Dependencies of Jersey, Guernsey and the Isle of Man

2. **Kyoto Protocol commitment** – The UK's progress against the Kyoto Protocol commitment is based on a geographical coverage of the UK, the Crown Dependencies of Jersey, Guernsey and the Isle of Man and the Overseas Territories that have ratified the Kyoto Protocol (Cayman Islands, Falkland Islands, Bermuda, Montserrat and Gibraltar).

3. **Commitment under the EU Monitoring Mechanism** – Coverage only includes parts of the UK which are also parts of the EU – the UK and Gibraltar. All Crown Dependencies and other Overseas Territories are excluded.

For the purposes of this report, unless otherwise stated, the emission estimates reported correspond to the coverage of the UK plus Crown Dependencies.

3.2 Tracking progress against targets

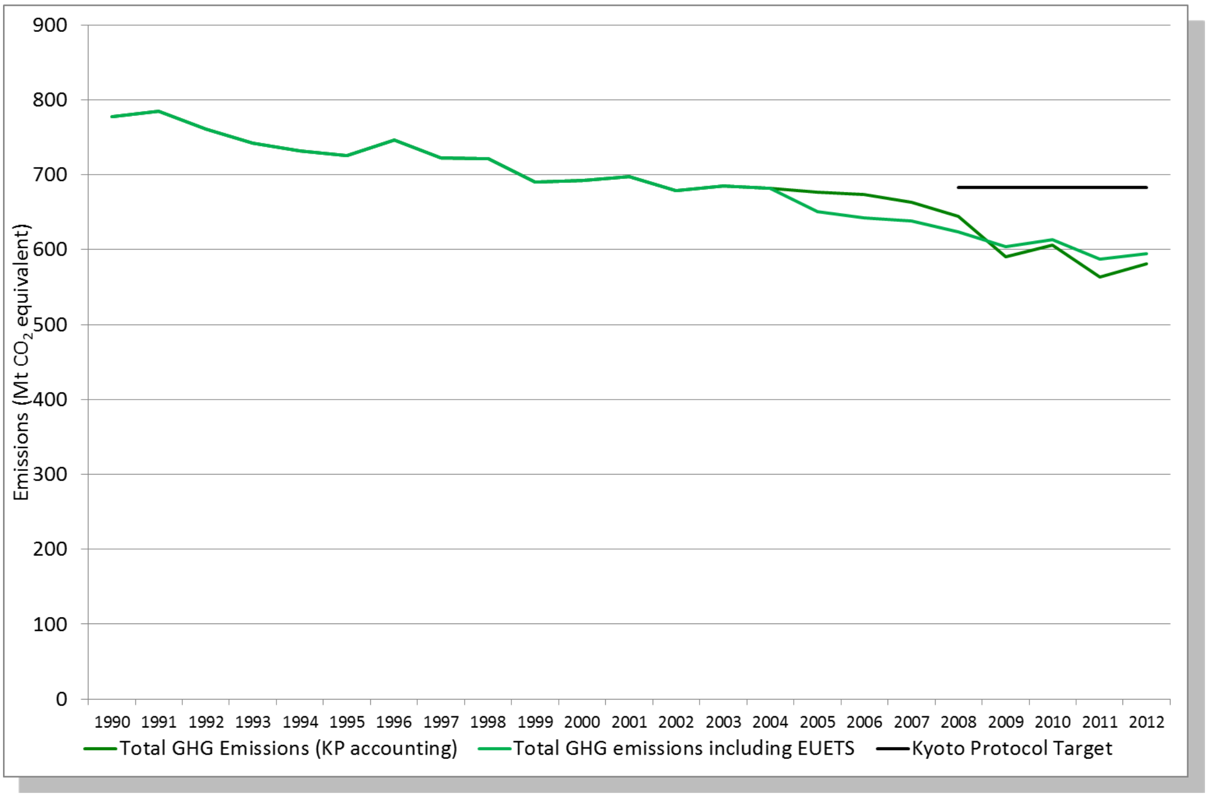
Progress towards the UK's Kyoto Protocol reduction commitment is assessed against base year emissions. An assigned amount is calculated using the base year emission estimate. Emissions in the base year from the UK are calculated from the sum of emissions in 1990 (for carbon dioxide, methane and nitrous oxide) and in 1995 (for the F-gases). The base year total used for the UK was calculated from the last version of the 2004 greenhouse gas inventory presented in the 2006 National Inventory Report and is now fixed. This is referred to as the **fixed base year**.

Each year, the UK Greenhouse Gas Inventory is updated and existing activity data and/or emissions factors may be revised. It is also extended to include a new inventory year. The updates may affect the estimates of emissions in 1990 and 1995, and so the base year emissions quoted in each release of the Greenhouse Gas Inventory may change, but the fixed base year will not alter.

3.3 Headline results

For tracking progress towards the UK's Kyoto Protocol target, total emissions are calculated to include only certain components of land use, land use change and forestry, and the full geographical coverage of the UK, Crown Dependencies and those Overseas Territories that have ratified the Kyoto Protocol. In addition, emissions can be traded with other parties through the EU Emissions Trading System (EU ETS). Traded emissions allowances are accounted for as an increase in UK emissions (allowances sold) or a decrease (allowances bought). On this basis, net emissions in 2012 were **594.9 Mt CO_2 equivalent**. Progress towards the Kyoto Protocol target is measured against a fixed base year figure of **779.9 Mt CO_2 equivalent**; emissions in 2012 were **23.7% lower** than the base year. The UK's target under the first commitment period of the Kyoto Protocol (2008-2012) is an average 12.5% reduction against base year emissions. The UK's achievement against this target will be finalised in 2015, following an end of commitment 'true-up' period.

Figure 3.1 UK emissions of greenhouse gases and progress towards the Kyoto Protocol target

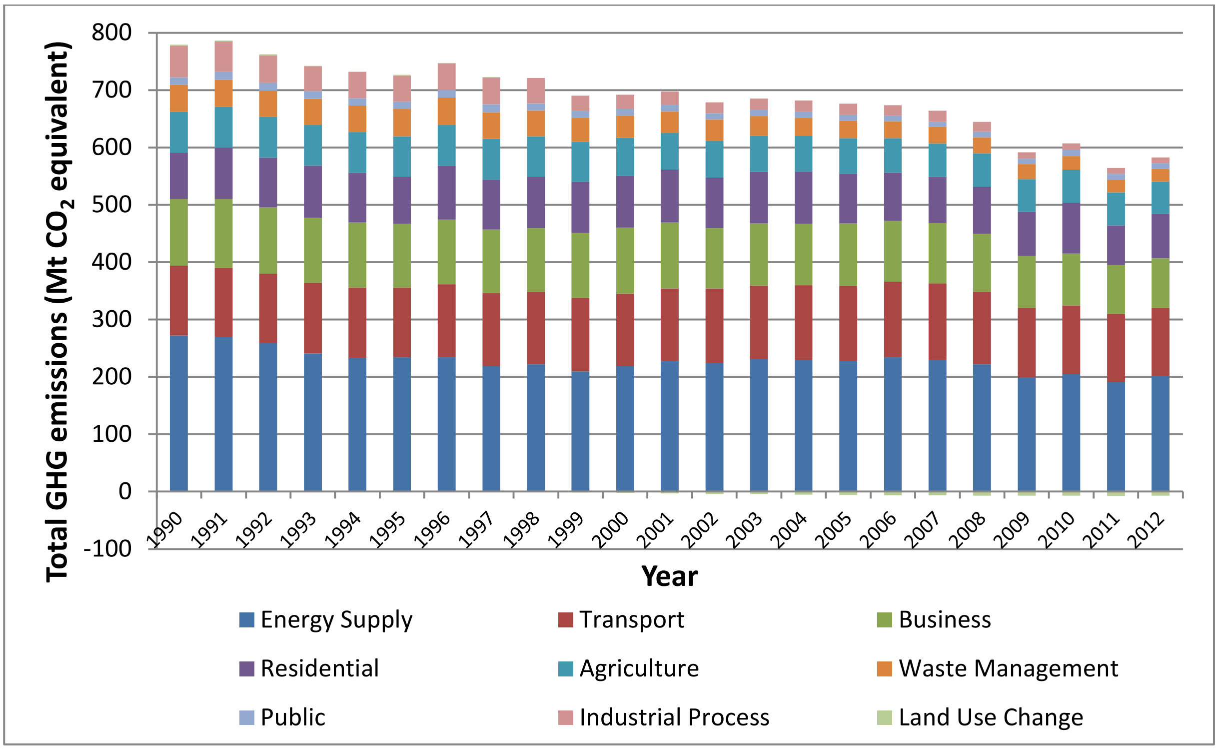


3.4 Trends in emissions

3.4.1 Total emissions of greenhouse gases

Figure 3.2 shows the total greenhouse gas emissions in the UK between 1990 and 2012 divided into nine national communication sectors. The largest contribution to emissions arises from the energy supply sector.

Figure 3.2 Trends in total UK greenhouse gas emissions, 1990 to 2012



Key statistics

- Total emissions have decreased by 26% since 1990.
- The sectors contributing most to the decrease between 1990 and 2012 were:
  - Energy Supply– emissions have decreased by 26%, predominantly due to fuel switching in the power generation sector, reduced emissions of methane from coal mines and upgrades and reduced leakage from the natural gas distribution network.
  - Industrial Processes– 82% decrease mainly due to plant closures and abatement equipment fitted at major nitric acid and F-gas manufacturing plants.
  - Business– 25 % decrease driven by the decline of fuel intensive industries like manufacturing and construction and switching fuels.
  - Waste Management– 54% decrease primarily due to the implementation of methane recovery systems at landfill sites.
- Emissions in the transport sector are similar to 1990 levels (3% lower than 1990).
- Residential sector emissions have decreased by 4% since 1990, however it should be noted that the time series is temperature

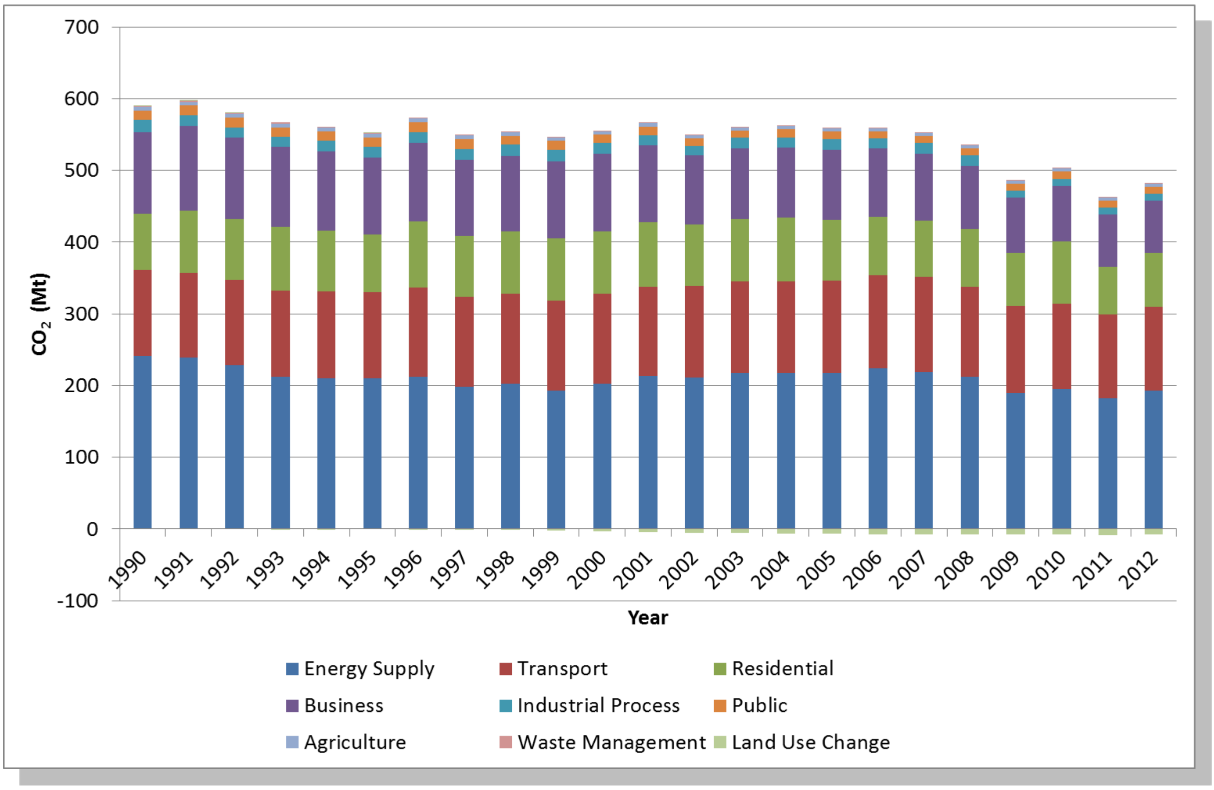
dependent and can therefore be highly variable from year to year. For example, emissions in 2012 are 12% higher than in 2011 primarily due to 2012 being a colder year on average than 2011.

- The Land Use, Land Use Change and Forestry sector was a net source of emissions in 1990, and a net sink in 2012. Therefore, emissions from this sector have decreased by more than 100%.
- In addition to continued switching of fuels and temperature variations, the recent economic downturn has led to further decreases in GHG emissions.

3.4.2 Carbon dioxide

Figure 3.3 shows carbon dioxide emissions in the UK between 1990 and 2012 divided into the nine National Communication (NC) sectors.

Figure 3.3 Trends in UK emissions of carbon dioxide, 1990 to 2012



Key statistics

- CO_2 emissions accounted for around 82% of total greenhouse gas emissions in 2012.
- Total emissions of CO_2 have decreased by 20% since 1990.
- Over half of the reduction in CO_2 emissions has been achieved between 2008 and 2012; the particularly high reduction in emissions over this period is influenced by the economic downturn.
- The five most significant sources of CO_2 in 2012 were:
  - Power stations
  - Road transport
  - Residential combustion
  - Industrial combustion (part of the Business sector)
  - Refineries
- Together, these five sources made up around 86% of total CO_2 emissions in 2012.
- All of these five sources have decreased from 1990 to 2012.
  - Power station emissions have decreased the most out of all sources (by 45 Mt across the period) primarily due to the move away from coal-fired generation towards the use of natural gas and renewable fuels.
  - Road transport emissions have decreased by 0.7 Mt; the 2012 level of emissions is very close to the 1990 level.
  - Residential combustion emissions have decreased, although recent trends in emissions are highly temperature dependent; 2012 was colder than 2011, which lead to a higher demand for fuel for heating and therefore increase emissions.

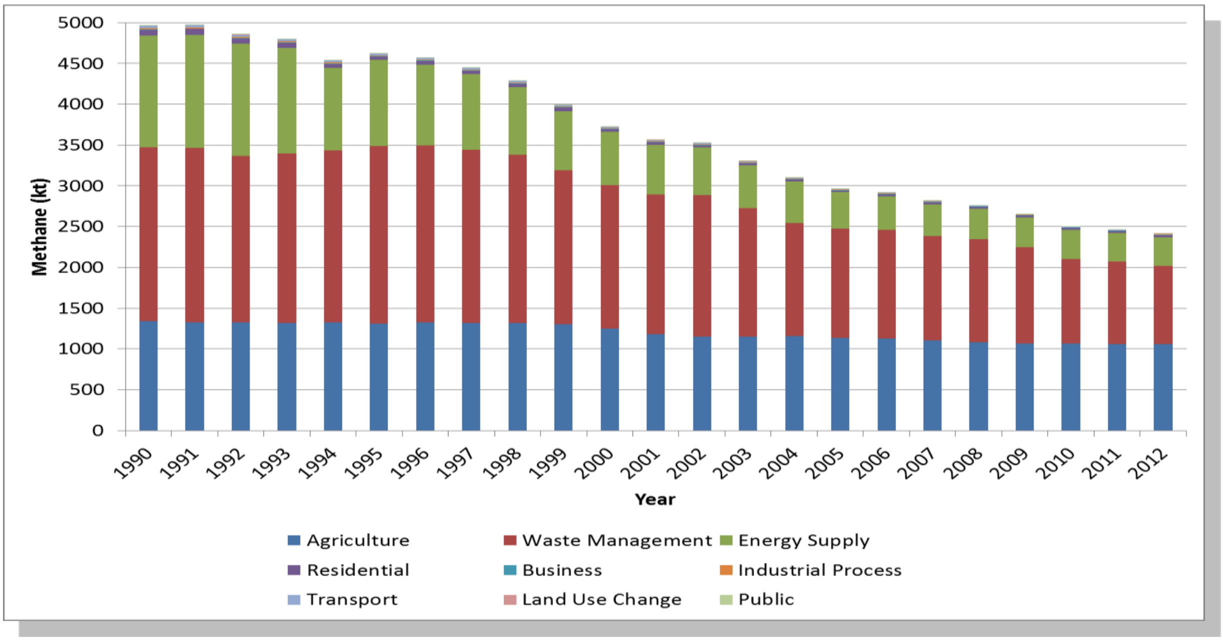
- Industrial combustion emissions have decreased due to decreased fuel use, in part due to improvements in energy efficiency and fuel-switching to gas.
- Emissions from refineries have decreased by about 2% across the time series.

The chart shows that carbon dioxide emissions have decreased over time, but have fluctuated rather than declining steadily. The overall trend is dominated by the power generation sector, where emissions have decreased predominantly due to fuel switching from coal to less carbon-intensive fuels such as natural gas, and the growth in renewable energy generation. There are two relatively significant peaks in the time series, in 1996 and 2001. The years 1996, 2010 and 2012 were colder than average therefore emissions in the power generation and domestic sectors were higher. In 2001 and 2012, relatively high gas prices made coal-fired power generation more financially competitive compared to gas, leading to higher emissions in the energy sector.

3.4.3 Methane

Figure 3.4 shows methane emissions in the UK between 1990 and 2012 divided into the nine NC sectors.

Figure 3.4 Trends in UK emissions of methane, 1990 to 2012



Key statistics

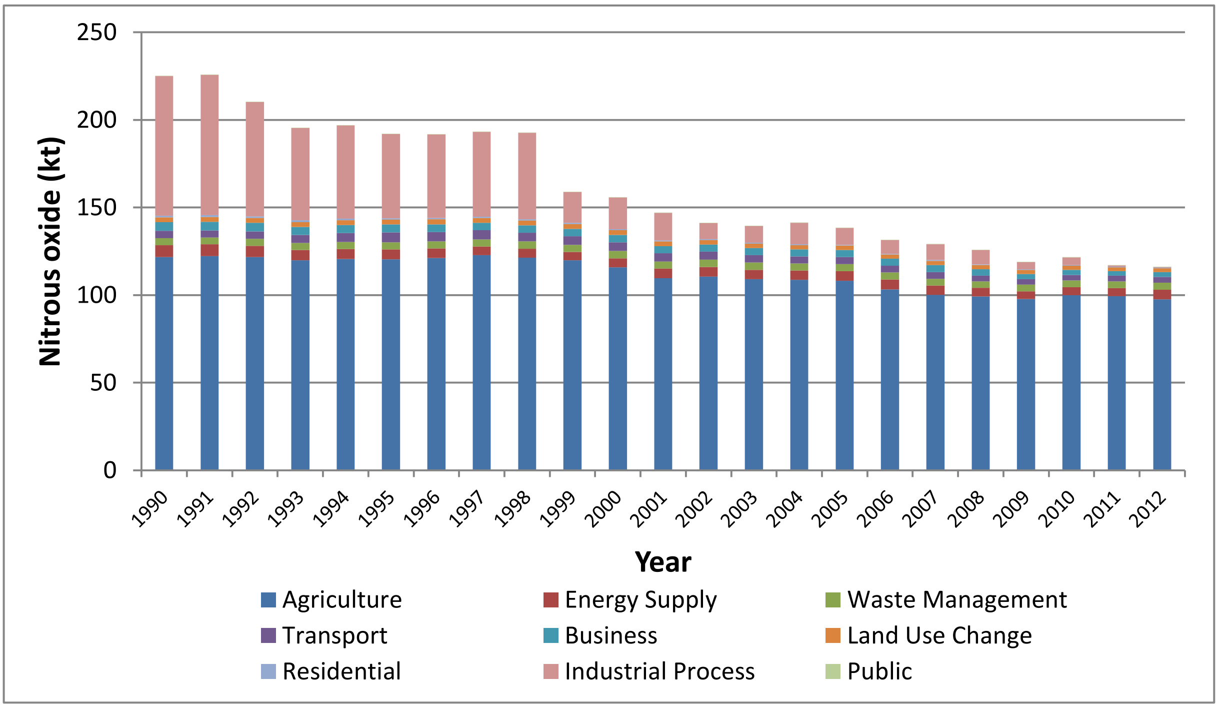
- Methane emissions accounted for around 8.8% of total greenhouse gas emissions in 2012.
- Total emissions of methane have decreased by around 51.4% since 1990.
- The five most significant sources of methane in both 1990 and 2012 were:
  - Landfills.
  - Enteric fermentation – cattle.
  - Leakage from the gas distribution network.
  - Enteric fermentation – sheep.
  - Coal mining.
- Together, these five sources made up around 85% of total methane emissions in 1990 and 78% in 2012.
- All of these sources have decreased significantly across the time series.
  - The largest reduction is from landfills. Emissions have decreased by 24 Mt CO_2 equivalent since 1990, due to tighter regulation of landfills and increased utilisation of landfill methane in gas flares and engines.
  - Emissions from cattle and sheep have decreased due to a decline in animal numbers.
  - Leakage from the gas distribution network has declined due to improvement work on the network, including the replacement of old pipes.
- No significant sources of methane have increased across the time series.

The overall trend in methane emissions is a relatively steady decline. The main contributors to this decline are falling emissions from waste management and coal mining. Methane emissions from coal mining have declined in line with the decline in UK coal production.

3.4.4 Nitrous oxide

Figure 3.5 shows nitrous oxide emissions in the UK between 1990 and 2012 divided into the nine NC sectors.

Figure 3.5 Trends in UK emissions of nitrous oxide, 1990 to 2012



Key statistics

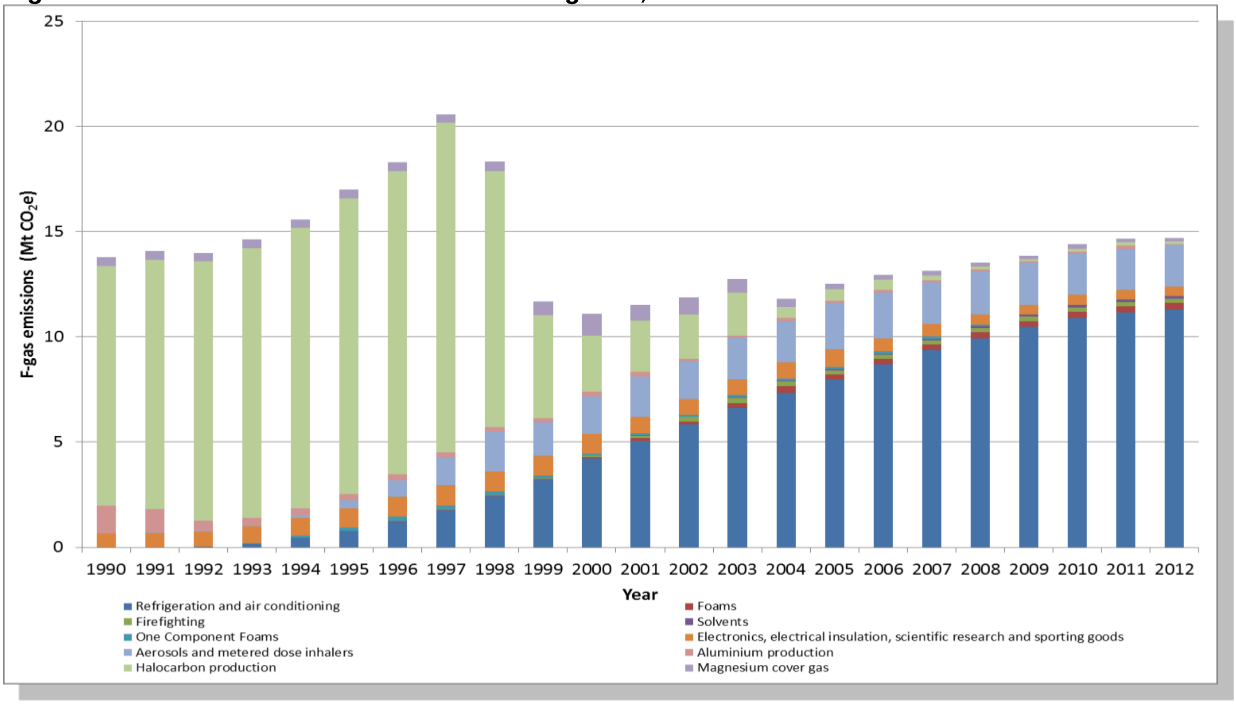
- Nitrous oxide emissions accounted for around 6% of total greenhouse gas emissions in 2012.
- Total emissions of nitrous oxide have decreased by 48% since 1990.
- By far the largest source of nitrous oxide in 2012 is agricultural soils, accounting for around 75% of total nitrous oxide emissions, despite declining by 20% since 1990 due to improvements in farm management practices.
- In 1990, adipic acid manufacture was also a major source of nitrous oxide emissions in the UK. Emissions from this source declined significantly in 1998 following the installation of abatement equipment at the UK's only adipic acid plant, the impact of which can clearly be seen in the graph above (see industrial processes). The adipic acid plant closed in 2009.
- Emissions of nitrous oxide from nitric acid manufacture are another key component of the Industrial Process sector emissions, and these emissions have also declined since 1990 due to plant closures and consolidation of nitric acid production across UK sites, as well as the recent installation of emission abatement equipment.
- No sources of nitrous oxide have shown a large increase across the time series.

The main feature in the time series of nitrous oxide emissions is the large decline from industrial processes from 1998 to 1999, following the introduction of abatement equipment at the UK's only adipic acid manufacturing plant, which has since ceased production in early 2009.

3.4.5 F-gases

Figure 3.6 shows combined emissions of F-gases in the UK between 1990 and 2012. These sectors are different to those in the figures reporting emissions from carbon dioxide, methane and nitrous oxide. The sectors in this figure are sub-sectors in the business, residential and industrial process sectors. This is due to the small number of F-gas emission sources relative to other gases.

Figure 3.6 Trends in UK emissions of F-gases, 1990 to 2012



Key statistics

- Collectively, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) and known as F-gases.
- HFCs and PFCs are mostly used as replacements for ozone-depleting substances. The F-gases are all used for specific, specialised applications.
- In 1995 (the base year for the F-gases), the major emissions source was HFC and HCFC manufacture, accounting for 83% of F-gas emissions.
- Due to the installation of abatement equipment at both UK HFC and HCFC manufacturing sites, this source no longer appears in the top five F-gas sources. In 2012, these were:
  - Mobile air conditioning.
  - Commercial refrigeration.
  - Stationary air conditioning.
  - Metered dose inhalers.
  - Aerosols
- The F-gases only accounted for around 2.6% of total greenhouse gas emissions in 2012.
- Emissions have decreased by 13.5% since 1995, predominantly due to the installation of abatement at F-gas manufacturing facilities.

The overall trend in F-gas emissions is determined by a number of competing factors. The sudden decline in total F-gas emissions between 1998 and 1999 was due to the installation of abatement equipment at HFC and HCFC manufacturing sites to mitigate fugitive and by-product emissions.

Countering that reduction, there has been a steady increase in emissions from the refrigeration and air conditioning sectors, aerosols and MDIs, as HFCs were used to replace ozone depleting substances previously used as refrigerants like chlorofluorocarbons (CFC) and hydrochlorofluorocarbons (HCFC). The rate of emission increase from refrigeration and air conditioning has slowed down in recent years due to tighter control on emission leakages from units, the introduction of low GWP replacements on the market and the fact that very little ozone depleting substances continue to need to be replaced by F-gases.

4. Overview of the UK Inventory method

The UK inventory is compiled following the methodologies set out in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories[2], and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories[3]. These guidelines set out multiple approaches for estimating emissions from each inventory source category, as well as guidance, in the form of decision trees, for deciding which method should be used.

The methods in the IPCC guidelines are based around three hierarchical Tiers that range from default data and simple equations to the use of country specific data and models to accommodate national circumstances. These Tiers, if properly implemented, successively reduce uncertainty and increase accuracy. Tier 1 methodologies are the simplest and require the least amount of input data.

[2] http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html
[3] http://www.ipcc-nggip.iges.or.jp/public/gp/english/index.html

Emissions estimates can be calculated based on readily available activity statistics, and default emission factors from literature sources such as the IPCC Guidelines and Good Practice Guidance. Tier 2 methods typically rely on more country specific data, and a Tier 3 method will take into account more information, such as plant specific data for industrial sources.

The decision about which Tier to base estimates on is largely dependent on the significance of the source (in terms of the magnitude, or its impact on the overall trend) and the availability of data. Inventory compilers should strive to reduce the uncertainty in their inventories, which can mean moving to higher tier methodologies for more uncertain sources.

Each year, the UK greenhouse gas inventory is extended (to add another year) and updated to include:

+ Emission estimates for any new sources identified in the UK;
+ Revised estimates for sources where there is an improved understanding of existing

emission sources, e.g. where research identifies that new data are available, or a new, more accurate estimation methodology is developed;

+ Data revisions, for example to energy statistics or updates to UK manufacturing statistics.

Time series consistency is one of the overarching principles of inventory compilation, therefore any changes or improvements that relate to the first two points listed must be applied to the whole time series. Any changes related to data revisions must be applied to all years where the revision has occurred.

The UK inventory has an improvement programme, which is used to manage changes to the inventory. A list is compiled, based on findings from external reviews of the inventory, suggestions from the inventory compilers (e.g. where a new data set has been identified that should be investigated), or input from other stakeholders. The list is prioritised, with items related to the completeness considered most important. Specific research is conducted to address the highest priority improvement items to ensure that the inventory is continually improved, minimising uncertainties and meeting all of the requirements of the UK's international reporting commitments.

The following sections give an overview of the methods used within each of the National Communication sectors. Further information for individual sources can be found in the UK's National Inventory Report[4].

4.1 Energy Supply

The energy supply sector includes emissions from fuel combustion for electricity and other energy production sources, as well as fugitive emissions from coal mines, upstream oil and gas processing, and solid fuel transformation.

Emissions associated with fuel combustion are estimated by using fuel consumption data and appropriate emission factors.

Emission factors for CO_2 are UK specific, based on an analysis of the carbon contents of fuels for the GHG inventory (the Carbon Factors Review), and supplemented with additional data described below and in later sections. In some cases these factors are updated annually, for example, the carbon content of natural gas which is provided by the gas network operators.

The fuel consumption data are taken from DECC's Digest of UK Energy Statistics (DUKES). For carbon dioxide, emission factors are largely based on country specific data from fuel suppliers or trade associations such as the UK Petroleum Industry Association (UKPIA), or from analysis of plant specific data available from the EU ETS. This is consistent with a Tier 3 approach. Carbon dioxide emissions from fuel combustion in the energy supply sector make a large contribution to the UK total emissions and therefore it is important to apply a higher Tier method to calculating emissions from this source. Using the carbon content of the fuel to calculate the CO_2 emissions is very accurate.

Fugitive CH_4 emissions occur from coal mining activities. The calculation for operating mines uses statistics for coal produced (from DUKES), combined with an emission factor calculated from data provided by UK Coal. For closed mines, emissions are modelled based on information about the size of the mine, the type of mine (e.g. open cast or deep), the mine

[4] http://naei.defra.gov.uk/reports/reports?report_id=789

closure date, and any methane recovery systems in operation. This methodology is country specific, and was carried out as a specific research project commissioned by DECC. The detailed report explaining the methodology and data sources can be found online[5].

Emissions from the offshore oil and gas sector are based on data provided by the DECC Offshore Inspectorate, through their annual emissions reporting mechanism called the Environmental Emissions Monitoring System (EEMS). Individual operators are required to report emissions, and these are analysed and aggregated up for reporting in the UK inventory. Methane emissions from leakage from the natural gas transmission and distribution system are modelled by the gas network operators and the data are supplied to the Inventory Agency for inclusion in the GHG inventory.

Emissions are estimated from a number of solid fuel transformation activities. Carbon emissions from coke ovens are based on a detailed carbon balance approach with calculations arranged so that the total carbon emission, plus carbon in products and wastes, corresponds to the carbon content of the input raw materials. The carbon balance model used to estimate emissions from the production and combustion of fuels derived from coal in coke ovens and steelworks has been improved for the 2014 inventory submission. Country-specific carbon factors used in the model have been reviewed and replaced with data from EU ETS where these are available. This is a much improved dataset for inventory estimates, even though the data are only available from 2005 onwards. For process emissions from coke ovens for other GHGs, emissions are estimated either on the basis of total production of coke or the coal consumed. Emissions of carbon from Solid Smokeless Fuel (SSF) production are also based on a carbon balance approach. For other pollutants, estimates are made based on SSF production data and industry specific emission factors. Methane emissions from charcoal production are included in the inventory and are based on UK activity data on charcoal production from the Food and Agriculture Organisation Statistics division (FAOSTAT) Forestry Production and Trade Statistics and default IPCC emission factors.

4.2 Transport

This sector includes emissions from aviation, road transport, railways, shipping (coastal, inland waterways), fishing and aircraft support vehicles.

Emissions of CO_2 from transport can be most accurately estimated by combining fuel use statistics for each mode of transport with an emission factor, based on the carbon content of the fuel. Emission factors for CO_2 are UK specific; see the comment in Section 4.1 on the Carbon Factors Review. Carbon contents for oils are provided by UKPIA, and the energy statistics are largely available from DUKES. However, the Inventory Agency uses a model to make "bottom up" estimates of fuel use data for all sources included in this sector. For road transport and aviation, the modelled fuel use is normalised to the total reported in DUKES. For fishing and shipping, fuel use is modelled using bottom up data for domestic shipping, and the difference between the inventory total and the DUKES total

[5] http://uk-air.defra.gov.uk/reports/cat07/1107080945_1775-ghg-improvement-project-wsp-report.pdf

is allocated to international shipping. Emissions from railways are based on the bottom up calculated fuel use estimates and any differences with the DUKES allocations for railways are reconciled in other inventory sources. No specific data exists in DUKES for aircraft support vehicles, and therefore the bottom up total is used. Total fuel use across all sectors is reconciled with DUKES to ensure completeness of the inventory.

The bottom up models, used for calculating the fuel use and non-CO_2 emissions are briefly described below:

- **Aviation** – a Tier 3 country specific model has been developed, using a detailed database from the UK Civil Aviation Authority of flight movements in and out of the UK. Emission factors and fuel consumption factors are used for each phase of the flight.
- **Road transport** – a Tier 3 country specific model is used. This takes account of variables such as vehicle kilometres travelled by type of vehicle and road type and the age profile of the vehicle fleet, which defines what emission standards the vehicles must adhere to. The activity data is mostly provided by the DfT, and emission factors are a combination of UK specific data and literature sources (e.g. the European COPERT model). Emissions from the model are normalised to the fuel consumption totals reported in DUKES.
- **Rail** – the assumptions from the DfT's Rail Emissions Model have been incorporated into the UK inventory. This accounts for distances travelled by various train types, and typical fuel consumption or pollutant emissions per kilometre travelled.
- **Shipping and fishing** – for coastal shipping and fishing, a bottom up model was developed by Entec, using a detailed database of shipping movements together with statistics for typical fuel use and emissions for each type of vessel. For fishing outside of UK territorial waters, an estimate has been calculated based on statistics such as fish landings, and information about the typical length of trip (both distance and number of days) and types of vessels used, combined with suitable emission factors from literature sources.
- **Aircraft support vehicles** – a one-off study in 2004 used statistics and surveys to estimate the total population of aircraft support vehicles and their typical usage. Annual air passenger movements are used in a fleet turnover model to estimate the annual usage and the typical age profile of the equipment in use, this is combined with fuel consumption and emission factors available from literature sources (largely from the EMEP-EEA Emissions Inventory Guidebook).
- **Inland waterways** – a similar model to that used for aircraft support vehicles is used to estimate emissions and fuel consumption for this source.

Estimates are also made for military aviation and naval shipping. These are based on fuel use data supplied by the MoD and emission factors (either UK-specific carbon contents, or non-CO_2 emission factors from literature sources).

4.3 Residential

Emissions in the residential sector arise from fuel combustion for heating, cooking and from garden machinery, fluorinated gases released from aerosols and metered dose inhalers (MDIs, such as those used for asthma sufferers), and carbon emissions released from the breakdown of consumer products (such as detergents).

Emissions from heating and cooking are estimated by multiplying the fuel use estimates in DUKES by an emission factor. Emission factors are either UK specific (such as gas carbon contents supplied by the gas network operators; see the comment in Section 4.1 on the Carbon Factors Review) or are taken from published inventory guidelines (IPCC and EMEP-EEA, typically for non-CO_2 gases).

For garden machinery, the emissions are modelled in the same way as for aircraft support vehicles, with household numbers used to derive the time series. This source includes lawn mowers, leaf blowers and other small garden machinery.

Emissions from aerosols and MDIs are based on estimates of the total HFCs in aerosols in each year, combined with estimates of how much HFC is released at manufacture, during use, and at disposal. For aerosols, the data are supplied periodically by the British Aerosol Manufacturer's Association. Emissions for MDI are based on data from the NHS.

To calculate carbon emissions from the breakdown of consumer products, estimates of the carbon content of these products are combined with an estimate how much carbon is released to the atmosphere during their breakdown. These estimates are based on a study conducted by Atlantic Consulting, supplemented by sales data from the Cosmetics, Toiletries and Perfumery Association, and data from the US Environmental Protection Agency.

4.4 Business

The business sector includes emissions from stationary combustion in all industrial and commercial sectors (including the combustion of fuel to provide the heat required for certain industrial processes or for heating), industrial off-road machinery, refrigeration and air conditioning, and the use of fluorinated gases for other applications.

Stationary fuel combustion emissions are estimated by multiplying the fuel use estimates in DUKES by an emission factor. Emission factors are either UK specific (see the comment in Section 4.1 on the Carbon Factors Review) or are taken from published inventory guidelines (IPCC and EMEP-EEA). For some sources, independent estimates of fuel use are provided by industry, and therefore the sectoral allocation of fuel presented in DUKES is modified. The total fuel consumption estimates used in the GHG inventory remain consistent with DUKES with two exceptions: petroleum coke, and other petroleum gases.

Emissions from industrial off road machinery are modelled in the same way as aircraft support vehicles and garden machinery. A mixture of data are used to derive the time series, such as the value of new building projects (from the Office for National Statistics) for construction emissions, and amounts of minerals mined for quarrying equipment.

For refrigeration and air conditioning, a detailed bottom up model has been developed as part of a research project commissioned by DECC. This project included literature searches and consultation with industry representatives to develop an estimate of the total population of various equipment types (e.g. domestic refrigerators, industrial refrigeration systems), the typical charge size (amount of refrigerant loaded into new systems) and other information such as typical leakage rates, and the age at which equipment is replaced. The model also considers other important factors which will affect the rate and type of emissions including how equipment leakage rates change over time, and the types of refrigerants that are likely to be used in the future. The detailed report explaining the methodology and data sources can be found online[6].

Emissions from other applications using F-gases are modelled in a similar way. Estimates are made of the amount of equipment or products in use, and the typical leakage rates at each stage of a product's lifetime (production, use and disposal). Estimated emissions are periodically reviewed and updated.

4.5 Industrial Processes

The industrial processes sector contains all emissions from industry except for those associated with fuel combustion. Sources include metal production, mineral products (cement and lime) and chemical production.

Different sources require different methodologies for estimating emissions, dependent on the availability of the data and the significance of the source. Equipment can be installed at industrial plants to reduce emissions of certain pollutants. It is important that the inventory compilers understand what equipment is being used and what impact this will have when estimating emissions, so emission factors or reported data can be used appropriately and effectively.

For limestone and dolomite use, activity data are available from the British Geological Survey, and from British Glass. For lime production, a combination of site specific activity data and information from the British Geological Survey is used. The emission factor for carbon dioxide is based on the chemical balance of the reaction involved, and is therefore known accurately.

For cement production, plant specific clinker production and emissions data are collected by the trade association (the Mineral Products Association). This aggregated data is supplied to the inventory agency and incorporated into the inventory. As an additional verification step, the data supplied by the Mineral Products Association is compared against EU Emissions Trading System data.

For steelworks, UK production statistics are available from the Iron and Steel Statistics Bureau, and emissions data are supplied by the plant operators to calculate the relevant emission factors.

For nitric and adipic acid production, data for certain years (much of the latter part of the time series) is available directly from the plant operators, who supply both production data and emissions data. For the early part of the time series, only production statistics are available. Therefore a country specific emission factor based on the data supplied from the operators for the earliest years

[6] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48250/3844-greenhouse-gas-inventory-improvement-project-deve.PDF

available is used to construct the time series back to 1990.

Emissions from ammonia, aluminium and HFC/HCFC production are also supplied directly by the plant operators. Emissions from the use of fluorinated gases as a cover gas in the magnesium industry, PFC production, and fletton brickworks, as well as other chemical processes are taken directly from the regulators' inventories (such as the Environment Agency's Pollution Inventory). The regulators' inventories include operator reported emissions for all processes covered by IPPC (Integrated Pollution Prevention and Control) permits, and are in some cases based on direct monitoring data.

4.6 Public

Emissions of GHGs from the public sector occur from the combustion of fuel in public sector buildings. The fuel use data is taken from DUKES.

The DUKES category "Public Administration" includes:

- Public administration and defence; compulsory social security;
- Education;
- Health and social work.

It is not possible to further subdivide these categories into more detailed categories based on currently available data. Emissions from public sector transport sources (including ambulances, for example) are not estimated explicitly, and are included in the transport sector of the inventory.

Fuel combustion emissions are estimated by multiplying the fuel use by an emission factor. Emission factors for CO_2 are UK specific; see the comment in Section 4.1 on the Carbon Factors Review. Emission factors for CH_4 and N_2O are based on IPCC default values.

4.7 Agriculture

The agriculture sector includes emissions from livestock and agricultural soils, as well as emissions from stationary combustion sources, off-road machinery (e.g. tractors). There are also very small emissions of CO_2 from the breakdown of pesticides.

Livestock emissions arise from enteric fermentation and manure management. Emissions from enteric fermentation are estimated by combining livestock numbers with appropriate emission factors (either default or UK specific). Methane emissions from animal wastes are estimated using livestock statistics and emission factors (default or UK specific). Nitrous oxide emissions from manure management are based on livestock numbers, nitrogen excretion rates and animal waste management systems used.

Emissions from agricultural soils are modelled using various statistical inputs, such as crop areas and fertiliser use, using the methods set out in the IPCC guidelines.

Work is currently on-going to develop more UK specific data to reduce the uncertainty in non-CO_2 emissions from the agriculture sector. The outcomes from this work will be included in the 2015 GHG inventory submission.

Stationary fuel combustion emissions are estimated by multiplying the fuel use estimates in DUKES by an emission factor. Emission factors are either UK specific (see the comment in Section 4.1 on the Carbon Factors Review) or are taken from published inventory guidelines (IPCC and EMEP-EEA).

Emissions from mobile machinery are modelled in the same way as aircraft support vehicles; the method used for this is described in the section on transport. DUKES statistics on total gas oil consumption in the agriculture sector are used to derive the time series of emissions.

For the breakdown of pesticides, an estimate of the carbon content of these products is combined with an estimate of how much carbon is released to the atmosphere during their breakdown. These estimates are based on data from the US EPA.

4.8 Land Use, Land-Use Change and Forestry

Sources and sinks within this sector include Forestland, Cropland, Grassland, Settlements and Harvested Wood Products. The main datasets which provide areas of land use and land use change are the Countryside Surveys for the UK constituent countries, and statistics published by the Forestry Commission.

The estimates for forest carbon emissions and removals are based largely on activity data from the Forestry Commission, which has carried out inventories of woodlands in Great Britain at 15-20 year intervals since 1924. Annual planting data and management information are used to update the estimate of size and age structure of the national forest estate between the periodic inventories. This information, together with data derived from the growth characteristics of UK forests (so-called 'yield classes') is used in a dynamic carbon accounting model (CARBINE) to estimate annual uptake and storage of atmospheric carbon by trees.

Estimates of land use change emissions rely on separate land use change matrices for each country in the UK. These matrices are derived from surveys on land use conducted in 1947, 1980, 1984, 1990, 1998 and 2007. The matrices show the pattern of land use change between different categories of land which have been grouped into the broad land types of Grassland, Cropland, Forest Land, Settlements and Other Land.

Areas of land use change to forest (afforestation) in GB since 1920 come from planting data provided by the Forestry Commission and areas pre-1920 come from modelling the age class structure of existing forests given by the National Inventory of Woodlands and Trees.

Changes in soil carbon density for the types of land undergoing transition are estimated from soil survey data and used in a dynamic model to estimate annual gains and losses of soil carbon associated with the land use transitions in the matrix.

The CARBINE model is used to calculate the net changes in carbon stocks of harvested wood products (HWP), in the same way as it is used to estimate carbon stock changes in forestland. Changes in carbon stocks from HWP arising from deforestation (conversion of Forest Land to Grassland or Settlement) are estimated using a look-up table of annual HWP stock changes generated by CARBINE.

The use of the CARBINE model is new to this year's inventory. The changes to methodology are related to improvements to represent forest areas in existence before 1920, the distribution of tree species, growth rates and forest management practices observed in the UK. The increased detail and completeness with which Forest Land is now represented has necessitated a move from application of the C-Flow forest carbon accounting model to the more flexible CARBINE model. Estimates of carbon dynamics associated with mineral soils and organic soils have also changed as a result of the application of the CARBINE model. However, estimates of emissions and removals associated with soil carbon of Forest Land are reasonably consistent with those produced by C-Flow model. The improved representation of Forest Land in the LULUCF Sector has increased the estimates of the size of the removals from Forest Land and therefore the LULUCF Sector as a whole is a net sink.

4.9 Waste Management

The waste management sector includes emissions from waste disposed of to landfill sites, waste incineration, and the treatment of waste water.

Landfill emissions in the UK are estimated using a first order decay (Tier 2) methodology based on estimates and historical data of waste quantities, composition and disposal practices that have taken place over several decades. A first-order decay approach in this context assumes that biodegradable carbon in the waste decays to CH_4 with a reaction rate that is proportional to the amount of carbon remaining in the waste. Some methane from landfills is recovered and used as a fuel; this CH_4 is not included as an emission from landfills but emissions from burning landfill gas are included under power generation.

Estimates of CH_4 emitted from domestic wastewater handling are based on activity and emissions data supplied from the water industry annual reporting system. From these, implied emission factors for specific emission sub-sources are derived. These implied emission factors are used together with activity statistics from Defra to compile a full time series of emissions. Estimates of N_2O from domestic wastewater handling are based on human protein consumption data from Defra and emission factors from the IPCC Guidelines.

For industrial waste water handling, CH_4 emissions have been estimated using default parameters from the IPCC Good Practice Guidance and industrial output for the chemicals industry, and data from a specific study for the food and drink industry.

Emissions from waste incineration are estimated from a combination of data reported to the Environment Agency's Pollution Inventory, supplemented with the use of literature based emission factors.

5. Uncertainties and Verification

5.1 Greenhouse Gas Inventory uncertainty analysis

Estimates of greenhouse gas emissions will always have a degree of uncertainty associated with them. Inventory compilers can estimate emissions of CO_2 very accurately, but there is greater uncertainty associated with the emissions of the other five greenhouse gases. This feature is present in most greenhouse gas inventories and is not unique to the UK.

In the UK inventory, the inventory compilers quantify the uncertainties on emission factors and activity data. In turn, this allows uncertainty estimates on the emissions to be produced. To do this, the compilers make use of a wide range of data. This includes uncertainties on the measurements of carbon content of fuels, the statistical difference in fuel use totals reported in UK energy statistics and expert judgement on uncertainties of total emissions from the output of models. These uncertainties on emission factors, activity data, and total emissions are then used in a model to estimate uncertainty on total greenhouse gas emissions, on each greenhouse gas, and on emissions in each sector.

The UK model has to account for the interactions between the uncertainties for different sources. This is important, and if these interactions were omitted, there would be significant errors in the uncertainty analysis. These interactions can be between different sources in the same year, or between different years for the same source.

For example, estimates of emissions from the burning of coal in different sectors in one year are related, and so this needs to be accounted for in the uncertainty model. The uncertainty associated with the activity data is based on the statistical difference (supply versus demand) in the energy statistics, and this is the uncertainty associated with the total UK coal use. The sector specific uncertainties are therefore related since an overestimate in one sector would imply an underestimate in another sector.

Considering the relationship between emission estimates in different years for the same source allows a more accurate estimate of the uncertainty in the trend, which is important when tracking progress against targets that are expressed as a percentage change from a certain year. An example of a source where this relationship has to be considered is for emissions from agricultural soils. The emission factor for this source is highly uncertain, but the uncertainties in 1990 and the latest inventory year are not independent from each other. This means that during the model simulation, high values for the emission factor in 1990 will coincide with high values in the latest year.

Table 5.1 shows the uncertainty on emissions by gas in 1990 and 2012. The uncertainty is expressed as a 95% confidence interval. This means that 95% of the values from the uncertainty model fall within the range plus or minus the uncertainty introduced on the national total.

Table 5.1 Uncertainties in 1990 and 2012

Gas	Uncertainty introduced on national total in 1990	Uncertainty introduced on national total in 2012
CO_2 (net)	2%	2%
CH_4	22%	20%
N_2O	50%	69%
HFC	10%	6%
PFC	5%	21%
SF_6	17%	13%
All	**6%**	**5%**

Table 5.1 shows that emissions estimates for CO_2 are relatively certain, but that estimates for the other gases are more uncertain. The overall uncertainty introduced on the total emissions is 6% in 1990 and 5% in 2012. The change in uncertainty between 1990 and 2012 for each of the gases is mostly a representation of the change in the proportion the uncertain sources account for in the total emission. For example, the most uncertain source of nitrous oxide is agricultural soils. This accounted for 49% of the nitrous oxide total in 1990, but 75% of the total in 2012, which means that the uncertainty in the overall total is higher in 2012 than 1990.

Table 5.2 shows the uncertainty on the trend. This is expressed as the range in which 95% of the values are expected to fall.

Table 5.2 The Uncertainty on the UK Inventory trend from 1990 to 2012

Gas	Change in emissions between 1990 and 2012	Range of likely change between 1990 and 2012	
		2.5 percentile	97.5 percentile
CO_2 (net)	-20%	-21%	-18%
CH_4	-51%	-59%	-41%
N_2O	-49%	-64%	-35%
HFC	24%	11%	40%
PFC	-85%	-88%	-82%
SF_6	-45%	-56%	-32%
All	**-26%**	-29%	-24%

The likely range in the trend is small , ranging from -24 to -29%. The uncertainty in the trend is influenced by the level of correlation between emissions in each year. Correlations can be introduced to the model where the emissions are linked through common methods and data, and these correlations can act to reduce the uncertainty on the trend. One of the key correlations in the inventory model is for emissions from agricultural soils. Now that new research into the uncertainties for this category has been incorporated into the analysis, showing a reduced uncertainty for this category (which has had a large impact on the uncertainty on the national total), the difference between the uncertainty for a given year and for the trend is smaller than previously reported.

5.2 Verification of the UK Greenhouse Gas Inventory

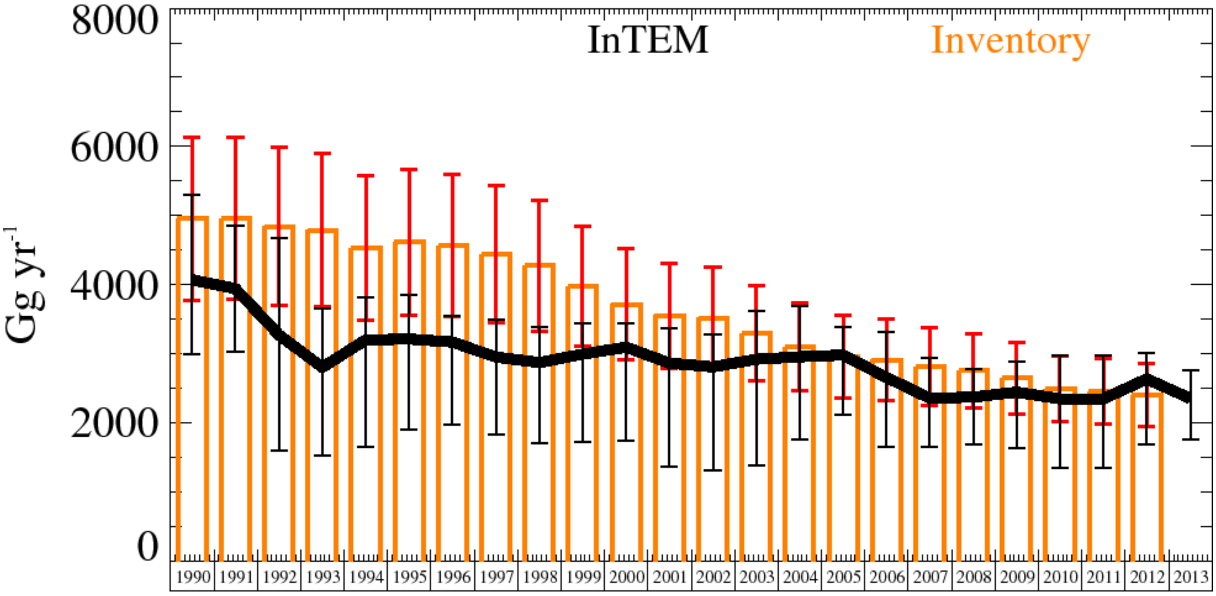
To verify the emission levels and trends reported in the UK Greenhouse Gas Inventory, DECC uses atmospheric observations from four monitoring stations: Mace Head, located on the West coast of Ireland, Angus Tower, in Angus, Scotland, Tacolneston Head in Norfolk and Ridge Hill in Herefordshire. These stations measure high-frequency concentrations of the key greenhouse gases. Measurements from these stations will be used to improve the resolution of the verification process.

Under contract to DECC, the Met Office provides back trajectories of the air up to 10 days prior to its arrival at these sites: air-history maps. The trajectory data enable the observations made to be sorted into those which represent Northern Hemisphere baseline air masses, and regionally polluted air masses from Europe. The sorted data can then be used to estimate the time-varying Northern Hemisphere mid-latitude baseline concentration. Once the baseline has been removed from the observations, an inversion algorithm is used to estimate the magnitude and spatial distribution of European emissions. A methodology called Inversion Technique for Emission Modelling (InTEM) has been developed that uses an iterative best-fit technique which searches a set of random emission maps to determine the one that most accurately mimics the observations.

In the work presented here, the 'top-down' InTEM estimates of UK emissions are compared to the 'bottom-up' GHGI estimates.

The graphs for methane and nitrous oxide verification are shown below. The red and blue vertical bars displayed in both figures 5.1 and 5.2 represent the uncertainty in the numbers for the inventory and the verification estimates respectively. In both cases, the uncertainty is expressed as a 95% confidence interval.

Figure 5.1 Verification of the UK methane inventory



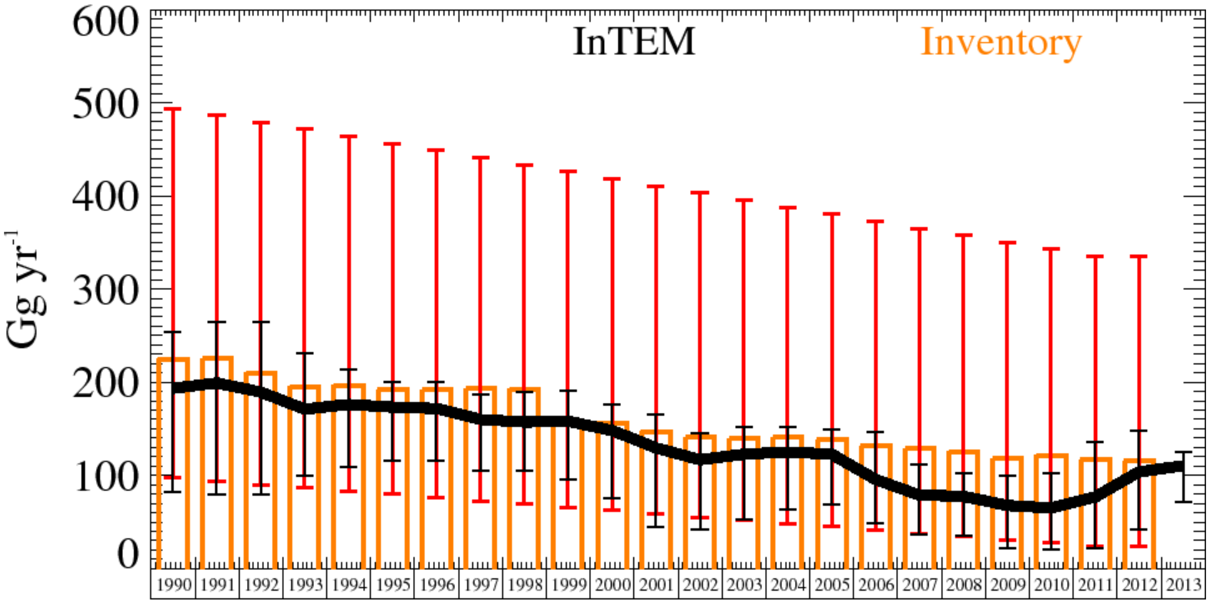
Methane has a natural (biogenic) component and it is estimated that 22% of the annual global emission is released from wetlands[7]. Usually natural emissions are strongly dependent on a range of meteorological factors such as temperature and diurnal, annual, growth and decay cycles. Such non-uniform emissions will add to the uncertainties in the modelling, although in North West Europe the natural emissions are thought to be small compared to the anthropogenic emissions(<5%)[8]. Due to the relatively strong local (within 20km) influence of biogenic emissions at Mace Head, a peat bog area, observations taken when local emissions will be significant (low wind speeds and low boundary layer heights) have been removed from the data set prior to applying the inversion technique.

From 2003 onwards the two emissions estimates show strong agreement, with estimated values well within each other's uncertainty ranges. For the earlier part of the time series, in particular for 1993-1998, the InTEM estimate is significantly lower than the Inventory estimate with the upper uncertainty limit of the InTEM estimate only just overlapping the lower uncertainty limit of the inventory. Because of this there is a notable difference in the trends predicted, with the InTEM estimates suggesting that emissions between 1990 and 2012 have reduced modestly, in comparison to the stronger downwards trend calculated by the inventory.

7 Nilsson, M., C. Mikkela, I. Sundh, G. Granberg, B. H. Svensson, and B. Ranneby, Methane emission from Swedish mires: Natural and regional budgets and dependence on mire vegetation, J. of Geophys. Res., 106, 20847-20860, 2001.

8 Bergamaschi, P., M. Krol, F. Dentener, A. Vermeulen, F. Meinhardt, R. Graul, M. Ramonet, W. Peters, and E. J. Dlugokencky (2005), Inverse modeling of national and European CH4 emissions using the atmospheric zoom model TM5, Atmos. Chem. Phys., 5, 2431-2460.

Figure 5.2 Verification of the UK nitrous oxide inventory



The median InTEM estimates are approximately 30-40 kt lower than the GHGI estimates throughout the whole time period. The trends in the time-series are in good agreement. Both show declining UK totals. The GHGI estimates show a sharp decline (40 Mt) between 1998 and 1999 due to the installation of nitrous oxide abatement equipment at an adipic acid plant in Wilton, north east England. The abatement equipment was estimated to reduce nitrous oxide emissions by 90% from this major industrial source, from 46 thousand tonne yr^{-1} to around 6 thousand tonne yr^{-1} (DEFRA, 2000).

The InTEM estimates, with a longer averaging period, show a more gradual decline from 1998 to 2003 but the overall reduction is similar.

The nature of the nitrous oxide emissions challenges the InTEM technique assumption of uniformity of release both in time and space. Also the point of release to the atmosphere may not coincide with the activity generating the nitrous oxide e.g. the nitrous oxide may be transported from its source, for example by rivers to an ocean, prior to its release to the atmosphere.

6. Summary – Fast Facts

+ **Total** emissions of greenhouse gases in the UK in **2012** were **575.4 Mt CO_2 equivalent**.

+ The UK reports emissions from **nine** main National Communication sectors in its National Statistical release. These are groupings of the IPCC categories used for the National Inventory Report.

+ Emissions are estimated following the methods set out in **IPCC guidelines.**

+ Emissions of greenhouse gases have **decreased 26%** since 1990.

+ United Nations Framework Convention on Climate Change (UNFCCC) treaty was formed in the early 1990's, and the **Kyoto Protocol** (an addition to this treaty), which **sets legally binding targets** for emission reductions entered into force in 2005.

+ **UK was** required to **reduce** total **greenhouse gas emissions by 12.5%** on base year levels over the five-year period 2008-2012 under the Kyoto protocol and the EU burden sharing agreement.

+ The second commitment period of the Kyoto Protocol will run from 2013-2020. The EU has made a commitment to reduce emissions by 20 per cent below base year levels on average over the period. The contribution target for the UK is yet to be agreed

+ UK has set legally binding **domestic targets** to reduce greenhouse gas emissions. This target is a requirement to **reduce** total greenhouse gas emissions by **34%** on base year levels by 2020.

+ **Carbon dioxide** emissions accounted for **82%** of total greenhouse gas emissions in 2012, with main sources including power stations, road transport, residential and industrial combustion.

+ **Methane** emissions accounted for about **9%** of total greenhouse gases emissions in 2012, with the main sources of emissions being landfill sites, agriculture and leakage from the gas distribution network.

+ **Nitrous oxide** emissions accounted for about **6%** of total greenhouse gas emissions in 2012, with the main source of emissions being agricultural soils.

+ **F-gases** (HFC, PFCs, and SF_6) accounted for **2.6%** of total greenhouse gas emissions in 2012. Sources include commercial and industrial refrigeration, mobile air conditioning, metered dose inhalers and aerosols.

+ Emissions from the **energy supply sector** accounted for **35%** of direct greenhouse gas emissions in the UK in 2012.

+ Emissions from the **energy supply** sector have **decreased** by **26% since 1990**.

+ Emissions from **power stations** have **decreased by 22% since 1990**. This reduction in emissions is mainly due to fuel switching from coal to gas and also a reduction in the energy intensity of the economy.

+ **Electricity supply** in the UK **has increased** between1990-2012, but **emissions have decreased**, due to less carbon-intensive fuels being used to generate electricity.

+ The overall **uncertainty** on the emissions in 2012 is **5%.** The uncertainty range around the change in emissions from 1990 to 2012 is between **-24 and -29%**, which indicates that the decreasing **trend is relatively certain**.

+ The UK Greenhouse Gas Inventory is verified using **atmospheric observations** and a modelling approach.

7. Sources of further information

DECC – The homepage for the Department of Energy and Climate Change contains information about what the UK Government is doing about climate change.

https://www.gov.uk/government/organisations/department-of-energy-climate-change

The Committee on Climate Change – the Committee is an independent advisor to the UK Government, set up under the Climate Change Act. It provides advice about setting carbon budgets, and reports progress to parliament.

http://www.theccc.org.uk/

The UNFCCC – provides further information about the Kyoto Protocol and climate change, and official reports from all Parties to the UNFCCC.

http://unfccc.int/

UK National Inventory System – this is part of the NAEI website and contains information about the procedures and arrangements for inventory compilation

http://naei.defra.gov.uk/about/national-inventory-system

The National Atmospheric Emissions Inventory (NAEI) – the NAEI is the UK's air quality pollutant emissions inventory. There is considerable overlap between the air quality and greenhouse gas inventories, and the two projects are carried out together.

http://naei.defra.gov.uk/

The UK Greenhouse Gas Report 1990-2012: Annual report for submission under the Framework Convention on Climate Change

http://naei.defra.gov.uk/reports/reports?report_id=789

The National Statistics releases on UK greenhouse gas emissions

https://www.gov.uk/government/organisations/department-of-energy-climate-change/about/statistics

The Intergovernmental Panel on Climate Change (IPCC) – the IPCC assesses all of the relevant information on climate change to provide the world with a clear view on what is happening now, and what the potential impacts of climate change could be in the future. The IPCC periodically publishes reports on the most recent science, and also publishes guidance for the compilation of emissions inventories.

http://www.ipcc.ch/

Glossary

Activity
Activity data are part of the information required for calculating an emission from a certain source. Activity data in the inventory vary, depending upon source, but two examples are quantities of fuel consumed and animal numbers.

Assigned Amount
The quantity of greenhouse gases that a country is allowed to emit during a commitment period (the first period is 2008-2012).

Carbon budget
A carbon budget is a way of setting targets for future emissions reductions. It sets a limit on the GHG emissions that can be emitted over a fixed period (typically 5 years).

Carbon dioxide (CO_2)
Carbon dioxide is the main gas responsible for anthropogenic climate change. It is mostly emitted through the oxidation of carbon in fossil fuels (e.g. burning coal).

Climate change
Climate change is a long-term change in the earth's climate. This occurs naturally, but is currently believed to be accelerated by human activity.

Emission factor
An emission factor is the amount of greenhouse emitted per unit of activity. Emission factors are used in conjunction with activity statistics to estimate emissions of greenhouse gases.

F-gases
Short for fluorinated gases (HFCs, PFCs and SF_6). Typically used as replacements for ozone-depleting substances. They have very high GWPs.

Geographical coverage
The geographical coverage defines the parts of the UK that are included in the emissions estimates.

Greenhouse gas
A greenhouse gas is a gas which absorbs solar radiation and re-emits it in the thermal infrared range.

Global warming potential (GWP)
Global warming potential is a means of providing a simple measure of the relative radiative effects of the emissions of the various gases. The index is defined as the cumulative radiative forcing between the present and a future time horizon caused by a unit mass of gas emitted now, expressed relative to that of CO_2.

IPCC
The Intergovernmental Panel on Climate Change (IPCC) was established to provide scientific information on climate change. It is the body responsible for producing the official guidelines for reporting greenhouse gas emissions inventories which can then be adopted by the UNFCCC

Kyoto Protocol
This is an international agreement which sets out legally binding emission limits or reduction targets for countries that are signed up to it.

Methane
Methane is a greenhouse gas which is approximately 21 times more potent in the atmosphere than CO_2. Main sources of methane include livestock, agricultural waste management and landfills.

Nitrous oxide
Nitrous oxide is a greenhouse gas which is approximately 310 times more potent in the atmosphere than CO_2. The main source of nitrous oxide in the UK is agricultural soils.

Percentile
A percentile is the value of a variable below which a certain percent of observations fall.

UNFCCC
The United Nations Framework Convention on Climate Change is a treaty which was set up to tackle climate change. Countries that are part of the convention are obliged to report their greenhouse gas emission estimates to the UNFCCC on a regular basis.

For more information on the Greenhouse Gas Inventory please contact:

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