



Department
of Energy &
Climate Change

Projected emissions of methane, nitrous oxide and F-gases

A report to accompany the Spring 2013 update
to the UK's projections of non-CO₂ Kyoto
Protocol greenhouse gas emissions



Executive summary

This report presents the Spring 2013 update to DECC's projections of methane (CH₄), nitrous oxide (N₂O) and F-gases (non-CO₂ greenhouse gases (GHG's)), the methodologies used to derive them and the associated uncertainties.

The following have been updated since the previous non-CO₂ projections (DECC, 2012), hereafter referred to as 'the Autumn 2012 update', was published:

- The inclusion of and rebaselining to the new Greenhouse Gas Inventory (1990-2011);
- Updated Agriculture projections, provided by Defra.

Non-CO₂ GHG's are now estimated to be 69 MtCO₂e in 2030; representing a projected 22% decrease between 2011 and 2030. This would represent a 60% reduction on 1990 levels. The two greatest contributors to this projected reduction are methane emissions from waste management, where emissions reductions of 6.1 MtCO₂e are estimated at 2030 compared with 2011, and a reduction of approximately 9.6 MtCO₂e in business sector HFC emissions.

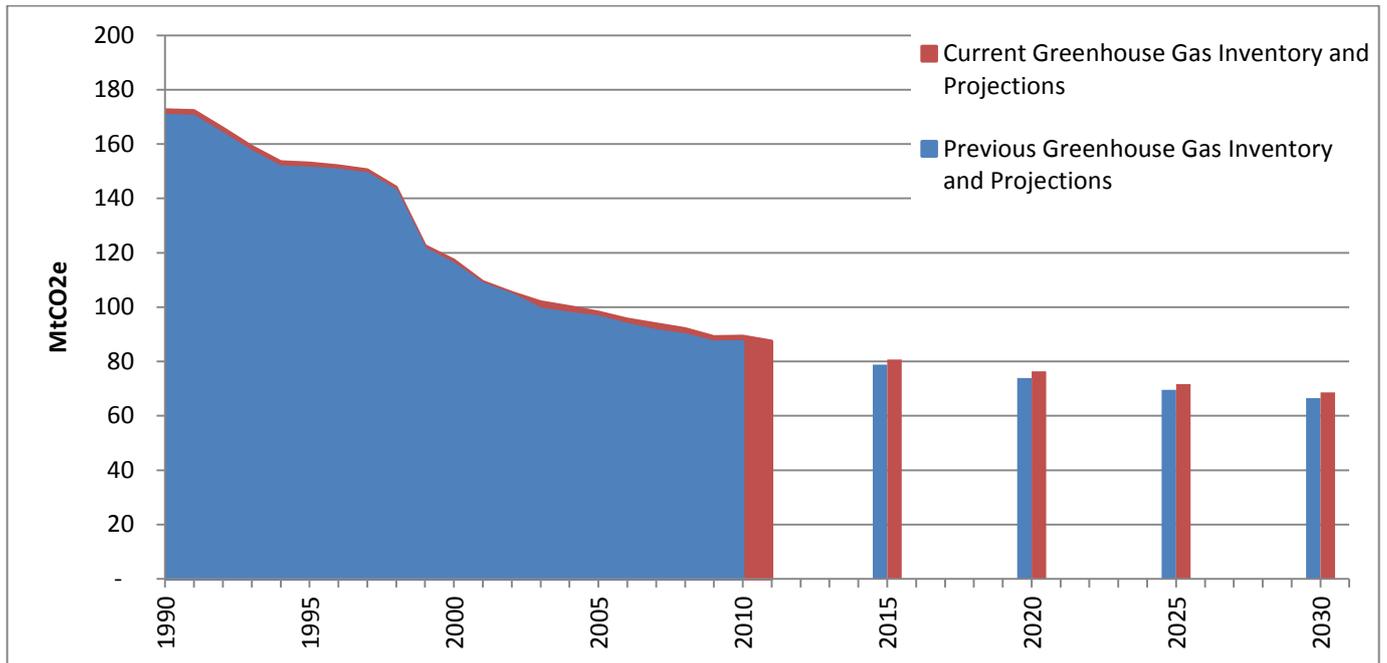
The Spring 2013 non-CO₂ GHG projections predict that UK emissions will decrease at a marginally slower rate between 2011 and 2030 than was projected in the Autumn 2012 update. The magnitude of this change results in projected emissions in 2015 being approximately 2% higher, and in 2030 being approximately 3% higher than in the Autumn 2012 update.

The most significant change since the Autumn 2012 publication has been the inclusion of the new Greenhouse Gas Inventory for the historic years 1990-2011. This new Inventory has had the effect of increasing base year emissions for many of the projections, the most significant of which is N₂O from the waste management sector. Additionally, new projections of CH₄ and N₂O from the agriculture sector have been calculated with the effect being an increase in projected emissions in this sector of 0.5 MtCO₂e and 1.2 MtCO₂e respectively in 2030.

Summary of projected non-CO₂ emissions in the Autumn 2012 update, MtCO₂e

	UK GHG Inventory		Projections			
	1990	2011	2015	2020	2025	2030
CH₄	94	40	37	35	32	30
N₂O	64	32	32	32	32	32
HFCs	11	15	11	9	6	5
PFCs	1	0	0	0	0	0
SF₆	1	1	1	1	1	1
Total	173	87	81	76	72	69

Figure 1: A comparison of total non-CO₂ GHG emissions in the Autumn 2011 projections and the Spring 2012 projections



Acknowledgements

We are grateful for the advice and support of the non-CO₂ GHG emissions projections Steering Group. We are also grateful for the contributions and support provided by Ricardo-AEA and other members of staff at DECC, Defra and other government departments.

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1 Introduction

1.1 Overview

Projections of greenhouse gases

Emissions projections are used as a way of monitoring progress towards the UK's emission reduction targets. The UK government has set targets for reductions in greenhouse gas emissions out to 2050. Therefore a regularly updated set of projections is required as UK policy and understanding of likely future emissions evolves. The UK is also required to submit projected emissions of greenhouse gases biennially under the European Union Monitoring Mechanism, and periodically in the form of National Communications to the UNFCCC.

1.2 Gases considered

The projections which accompany this report are for the non-CO₂ component of the Kyoto Protocol's basket of greenhouse gases (GHG) and are collectively referred to as the non-CO₂ GHG's. These are:

- Methane (CH₄);
- Nitrous oxide (N₂O);
- Hydrofluorocarbons (HFCs);
- Perfluorocarbons (PFCs); and,
- Sulphur hexafluoride (SF₆).

* The HFCs, PFCs and SF₆ are also collectively known as the "F-Gases"

Projected emissions of CO₂ are reported in DECC's Updated Emissions Projections (UEP, [DECC 2012B](#)) and are not included within the coverage of this report or associated projections.

This report contains descriptions of the methodologies, data and assumptions used to estimate emissions of the above listed non-CO₂ GHG from all UK anthropogenic (man-made) sources out to 2030. Projected emissions are presented in CO₂ equivalent (CO₂e), according to Global Warming Potentials (GWP) set out in the International Panel on Climate Change (IPPC) Second Assessment Report (SAR).

1.3 Current UK GHG emissions

As part of the UK's commitments for reporting its GHG emissions a national inventory is produced each year containing estimates for the UK's GHG emissions from all anthropogenic sources. The latest GHG Inventory was published in February 2013 and contains estimates for emissions from 1990-2011 ([DECC, 2013](#)). Total UK emissions in 2011 were estimated at approximately 550 MtCO₂e (excluding EU ETS). Of this, non-CO₂ GHG's consistent with the coverage of this report represented 87.5 MtCO₂e. Based on the data in the most recent Inventory, the current situation with each of the non-CO₂ GHGs is as follows:

Methane (CH₄)

The Agriculture sector as a whole accounts for approximately 45% of all CH₄ emissions; the Waste Management sector accounts for approximately and additional 40%. The remaining 15% of CH₄ emissions are largely attributed to the Energy Supply sector.

Nitrous oxide (N₂O)

The majority of N₂O emissions, approximately 89%, are attributed to the Agriculture sector. The remaining 11% are split relatively evenly between Business, Energy Supply, Industrial Processes, Transport, Waste, and LULUCF sectors. An additional minor (0.02%) fraction originates from the Residential sector

F-Gases (HFC's, SF₆ and PFC's)

HFC's comprise the majority of the combined F-gas emissions, accounting for 94% of emissions as total Carbon Dioxide equivalent (CO₂e).

Refrigeration and air conditioning account for 70% of HFC emissions; this includes mobile air conditioning HFC emissions which alone account for 34% of all HFC emissions. Other significant HFC emissions sources include aerosols and metered dose inhalers (MDIs, e.g. asthma inhalers), both of which comprise between 8 and 7% of total HFC emissions each.

SF₆ emissions accounted for approximately 4% of F-gas emissions, attributable largely to electrical insulation. See also the projection tables for more detailed information.

PFC's comprised the remaining 2% of all F-gas emissions (CO₂e); the major sources of PFC emissions are primary aluminium production and the electronics industry.

1.4 Updates to the calculation methods used for the GHG Inventory

The data and compilation methods used in the UK GhG Inventory are reviewed annually and where appropriate the estimation methodologies are revised and improved. Updates to the methodology used to calculate the UK Greenhouse Gas Inventory have subsequent effects on the projections, as the historical emissions time-series provides the baseline for the emissions projections. Section 2.1 below gives further details of how previous projections are re-baselined in order to account for the updated GhG Inventory.

There are therefore, two sources of change in the UK GhG Inventory; the first is the change in activity between consecutive years, for instance the number of vehicles on the road between 2010 and 2011, the second is the methodological changes which affect the whole time series, for instance a recalculated emissions factor for a specific activity.

The main methodological changes in the latest UK GhG Inventory (1990-2011) which have an impact on the non-CO₂ GHG projections are laid out in the relevant chapters of this report. And a series of more detailed descriptions of these changes are available in the UK Greenhouse Gas National Inventory Report which will be published in April 2013 and available on the UNFCCC website¹.

¹ http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/6598.php

1.5 UK emissions reduction targets

The UK has both international and domestic targets for reducing greenhouse gas emissions.

These can be summarised as follows:

Kyoto Protocol target

The Kyoto Protocol uses a base year which is comprised of 1990 for CO₂, CH₄ and N₂O, and 1995 for fluorinated compounds. To meet its commitment under the Protocol, the UK has agreed a legally binding target to reduce its greenhouse gas emissions to 12.5 per cent below the base year level over the period 2008-2012.

In July 2007, on completion of the review of the UK Inventory, the UK's Kyoto base year figure was set at 779.9 million tonnes CO₂ equivalent, based on the 2006 UK Inventory submission. This means that to meet the UK's Kyoto commitment, greenhouse gas emissions must be below 682.4 million tonnes CO₂ equivalent on average per year over the first five year commitment period of the Protocol (2008-2012).

In accordance with this average yearly target, the Kyoto Protocol target for the UK was then set at 3,412 million tonnes carbon dioxide equivalent over the full five year period - this is now the UK's *Assigned Amount*.

For more details of the UK's Kyoto commitment, see the UK Initial Report under the Kyoto Protocol ([Defra, 2006](#))

UK Climate Change Act

This Act includes a legally binding target for the UK to reduce its greenhouse gas emissions by at least 80 per cent below base year levels by 2050. It also establishes a system of binding five-year carbon budgets to set the trajectory towards these targets.

Like the Kyoto Protocol, the Act uses a base year which is comprised of 1990 for CO₂, CH₄ and N₂O, and 1995 for fluorinated 25 compounds. However, this base year figure differs from that used for reporting against the Kyoto Protocol in that the baseline is revised each year to incorporate revisions made subsequent to the UK's Kyoto Protocol assigned amount having been fixed.

The Government set the first three carbon budgets in May 2009, covering the periods 2008-12, 2013-17 and 2018-2022. The fourth carbon budget, covering the period 2023-27, was set in June 2011. The first of these budgets requires that total UK greenhouse gas emissions do not exceed 3,018 million tonnes CO₂ equivalent over the five-year period 2008-12, which is about 22 per cent below the base year level on average over the period. The fourth carbon budget was set so as to require a reduction in emissions of 50 per cent below base year levels over the period 2023-2027.

Please note that these targets encompass all GhG emissions, not just the non-CO₂ component projected in this report.

1.6 Spread sheet of tables of data accompanying this report

There are detailed tables of projections in a spread sheet that accompanies this report and is available on the DECC website; see spread sheet [Non-CO₂ GHG emission projections summary tables Spring 2013.xls](#) .

2 Projections methodology

This section provides descriptions of the approaches taken and general methodology used to produce the non-CO₂ GHG emissions projections. Detailed methodologies used to project individual source category emissions are available in [ANNEX A](#) of this report.

2.1 Overview of method and database used

General approach to estimating emissions projections

Emissions in the historic greenhouse gas and air quality pollutant inventories are calculated by the GHG Inventory Agency (currently a consortium led by Ricardo-AEA) under contract to DECC using a central database (the NAEI database), containing activity data (e.g. fuel use, livestock numbers) and emission factors (e.g. kg pollutant / tonne fuel used, / head livestock). In order to maintain consistency with the historic inventory, projected emissions are calculated with reference to the most recent GHG Inventory data. This means that the base year for the projections is taken to be the latest year in the GHG inventory – this is important, since the historic estimates can be revised each year to account for any new information, recalculations or methodologies that become available.

As well as utilising the NAEI database, the DECC non-CO₂ GHG projections are also based on a number of independently produced emissions projections, available from various sources. The emissions projections from these sources will change in the future depending on variations in:

- Activity data (AD), for example projected changes to livestock numbers or changes in behaviour affecting the waste sector.
- Emission factors (EF), for example due to improvements to technology for the abatement of emissions.
- A combination of both factors.

Predicted changes in either the emissions factors or activity data for each sector will be reflected in the projections which form the basis of the DECC model.

These updates are rebaselined against the most recent GHG Inventory emissions estimate for that year. The ‘rebaselining factor’ is then applied to all future emissions estimates in that time series. [Table 2.1](#) illustrates this process with a simple example.

Table 2.1 Simple rebaselining example

Rebaselining process	2011	2015	2020	2025	2030
GHG Inventory estimate (baseline)	675				
Previous projections		624	495	395	320
<i>New projections (before rebaselining)</i>	<i>645</i>	<i>600</i>	<i>475</i>	<i>320</i>	<i>250</i>
Rebaselining factor (previous interpolated 2011/ ‘new’ 2011)	1.05				
New time series rebaselined to the 2013 GHG Inventory (rebaselining factor × ‘new’ time series)	675	628	497	335	262

Projections scenarios and nomenclature

The central projection estimate

The UNFCCC Guidelines for the preparation of National Communications² require that policies and measures included in the central projection must correspond to those policies and measures that are implemented and adopted.

Implemented policies and measures are those for which one or more of the following applies: (a) national legislation is in force; (b) one or more voluntary agreements have been established; (c) financial resources have been allocated; (d) human resources have been mobilized. These are termed ‘with measures’ emissions projections, or sometimes referred to as “firm and funded”. Adopted policies and measures are those for which an official government decision has been made and there is a clear commitment to proceed with implementation. Planned policies and measures are not included in the central projection; these are defined as options under discussion and having a realistic chance of being adopted and implemented in future.

The emissions projections included in this report are based on all currently implemented and adopted policies and measures in accordance with the UNFCCC reporting guidelines. They are distinct from ‘with additional measures’ projections that encompass planned policies and measures, and distinct from ‘without measures’ projections that excludes all policies and measures implemented, adopted or planned after the base year.

2.2 QA/QC procedures

A wide range of data are used in the projections and each source is quality assured. New data sources are required to be publicly available for scrutiny for a minimum period of two weeks prior to being included in the projections, and where possible data are subject to peer review.

Data (activity data, emission factors and calculated emissions) that are part of the core GHG inventory are subject to rigorous QA/QC processes within the annual inventory compilation cycle by the Inventory Agency, a consortium led by AEA, using a set of QC procedures developed over a number of years. These procedures are documented in Chapter 1 of the UK’s latest National Inventory Report (NIR).

The changes incorporated into this Spring 2013 update have been quality checked, and overseen by the non-CO₂ GHG emissions projections Steering Group.

2.3 Coverage of emissions in the non-CO₂ GHG projections

The non-CO₂ projections consider all anthropogenic (man-made) sources of emissions with the exception of those excluded due to the reasons explained below.

For the purposes of reporting, greenhouse gas emissions are allocated into National Communication (NC) sectors. These are a small number of broad, high-level sectors, and are as follows: energy supply, business, transport, public, residential, agriculture, industrial processes, land use land use change and forestry (LULUCF), and waste management.

² FCCC/CP/1999/7

These high-level sectors are made up of a number of more detailed sectors that follow the definitions set out by the IPCC for GHG inventories, and are used in international reporting tables submitted to the UNFCCC every year.

A complete mapping of IPCC sectors to National Communication sectors is available on the DECC website ([DECC, 2012C](#)).

The sectoral assignment in this report are based on the source of the emissions as opposed to where the end user activity occurred.

Since the Autumn 2011 update, some categories of non-CO₂ GHG projections are excluded, where their projected trend is reliant on information within DECC's Updated Energy Projections (UEP). This decision was taken to improve the quality and processes involved in the production of both CO₂ and non-CO₂ GHG projections. Examples of these categories include CH₄ and N₂O emissions from power stations and oil and gas production, which are driven by energy consumption, as well as a number of business categories such as 'combustion from iron and steel plants', 'auto-generators' and 'blast furnaces', which had previously been projected using UEP growth indexes as the drivers. A full list of categories which are included in DECC's UEP is given in [ANNEX B](#). These projections are produced and presented in DECC's UEP publications.

Categories will remain under review and additional categories may be added or removed. New categories which have been added to the 2013 GHG inventory which for methodological were deemed to be better suited to production of the UEP, have also been transferred. These categories are also included in the table in [ANNEX B](#).

In order to maintain consistency and prevent a step change in the historical time series due to the removal of these categories, the transferred sectors have been removed from the time series as a whole.

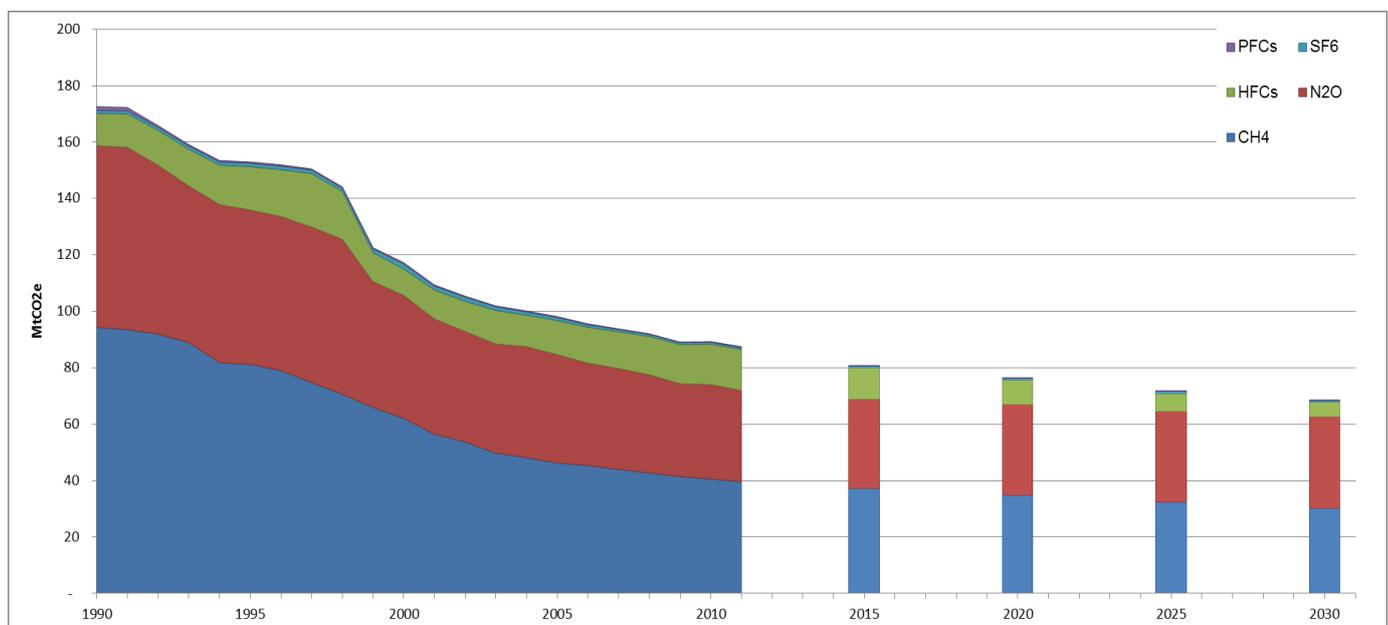
2.4 Geographical coverage and UK projections

The projections of non-CO₂ GHG emissions in this report include the emissions from the Crown Dependencies (CDs): Guernsey, Jersey, Isle of Man, but exclude the emissions from the Overseas Territories (OTs): Bermuda, Cayman Islands, Falkland Islands, Montserrat and Gibraltar. This coverage is consistent with the geographical coverage of the UK energy projections.

3 Summary of Spring 2013 non-CO₂ GHG projections

The historic trend in non-CO₂ GHG emissions shows a significant reduction from 1990 to 2011 levels, decreasing by approximately 49% in this period. The Spring 2013 update projects non-CO₂ GHG's to be approximately 69 MtCO₂e in 2030; representing a projected 22% decrease between 2011 and 2030. This projected trend would represent a 60% reduction on 1990 levels. The historic reduction comes from decreases in nitrous oxide (N₂O) and methane (CH₄) emissions, whereas the majority of the projected reduction is predicted to come from decreases in CH₄ emissions, and also some decreases in HFC emissions, as shown in [Figure 3.1](#).

Figure 3.1 Summary of projected non-CO₂ GHG emissions by gas (MtCO₂e)



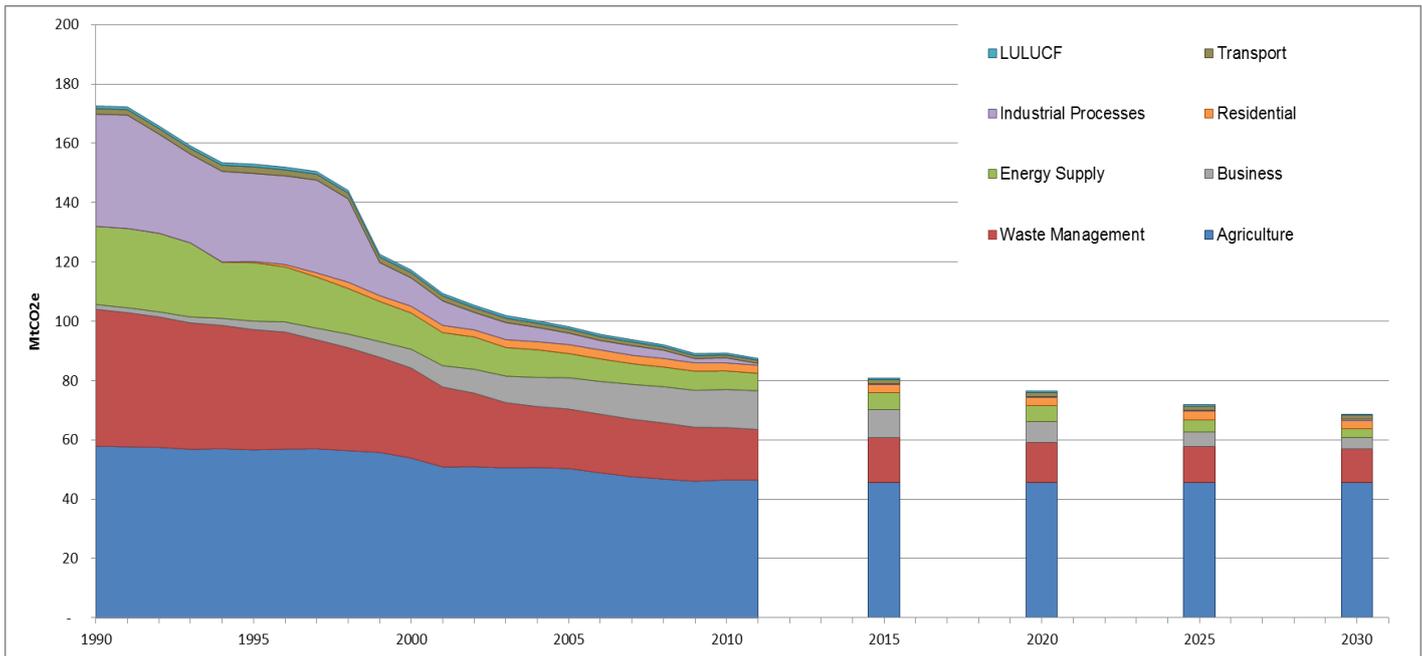
The historic reduction is attributable to emissions from a number of sectors ([Figure 3.2](#)) – Waste Management, Industrial Processes and Energy Supply have all seen large decreases in emissions from 1990-2011.

Projected reductions from 2010 to 2030 are anticipated to come from:

- Waste Management (a result of a decrease in the volume of waste sent to landfill);
- Business (as HFCs are replaced with lower GWP refrigerants);
- Energy Supply (as a result of the decrease in the quantity of coal produced and the replacement of cast-iron pipes with plastic in the gas distribution system).

In addition to these anticipated reductions but of smaller magnitude (~1Mt CO₂e reduction) a series of significant savings in absolute terms are expected in the agriculture sector primarily due to its contraction.

Figure 3.2 Summary of projected non-CO₂ GHG emissions by National Communication sector (MtCO₂e)



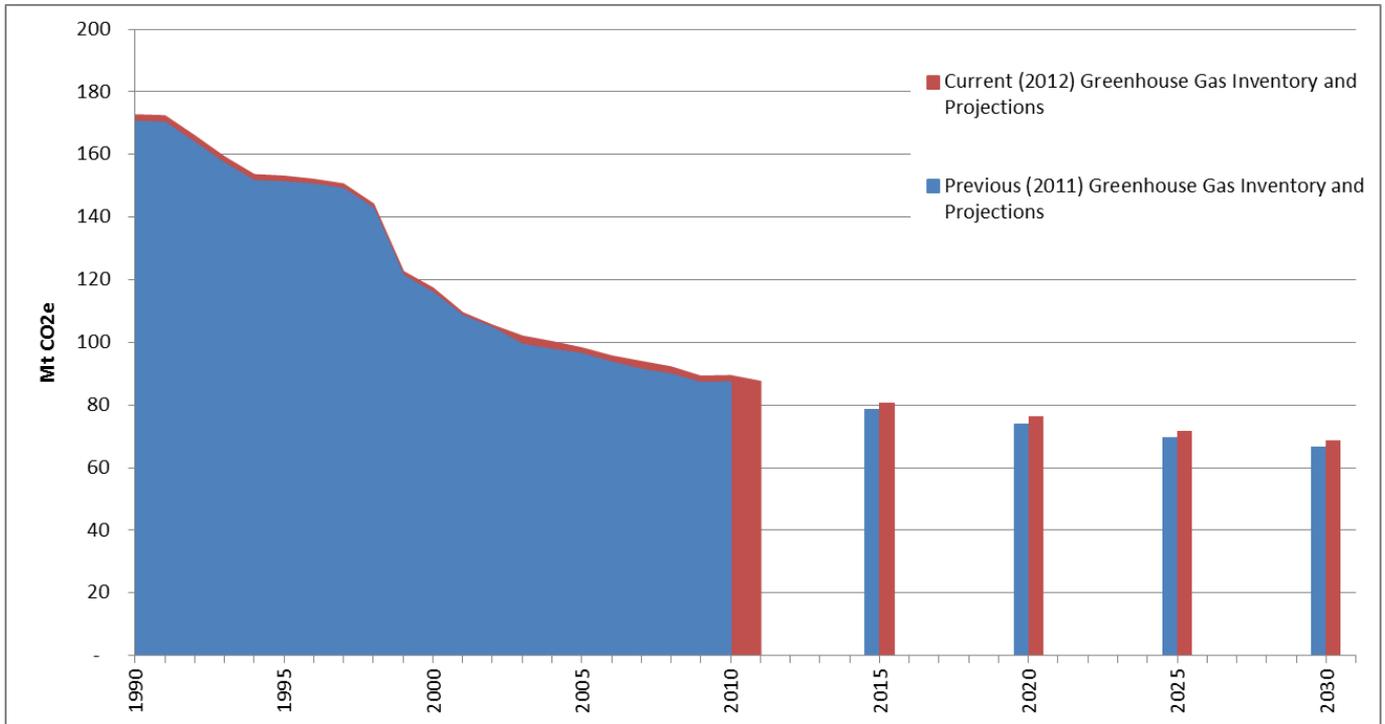
The Spring 2013 non-CO₂ GHG projections predict that UK emissions will decrease at a marginally slower rate between 2010 and 2030 than was projected in the Spring 2012 update. The magnitude of this change results in projected emissions in 2015 being approximately 2% higher, and in 2030 being approximately 3% lower than in the Autumn 2012 update (see [Figure 3.3](#)).

The most significant changes since the Spring 2012 update are due to:

- The inclusion of and rebaselining to the new Greenhouse Gas Inventory (1990-2011);
- Updated Agriculture projections, provided by Defra.

Details of the effects of each of these changes are laid out in the relevant sector specific chapters below.

Figure 3.3 A comparison of the total non-CO₂ GHG emissions in the Autumn 2011 and Spring 2012 projections



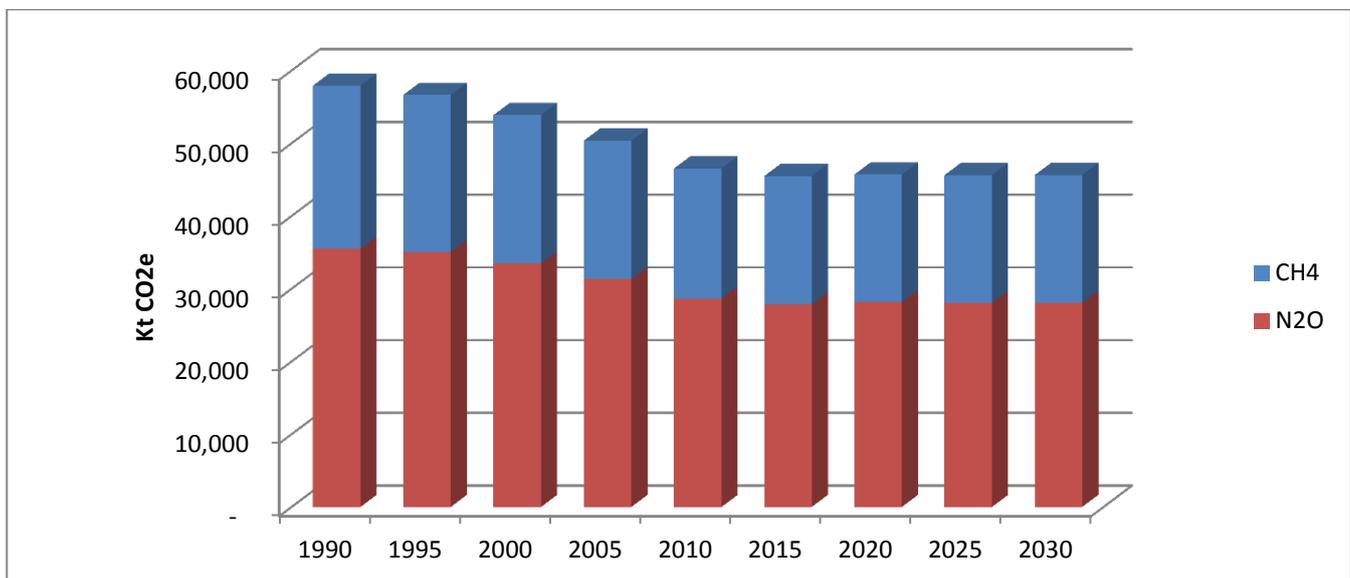
Projections of non-CO₂ GHG by National Communication Sector

4 Agriculture Sector

The Agriculture sector is the single largest contributor to overall non-CO₂ greenhouse gas emissions presented in this report. In 2011 non-CO₂ emissions from agriculture were approximately 46.5 MtCO₂e which represented approximately 53% of the UK's total non-CO₂ emissions. Two gases represent the non-CO₂ contribution to emissions from this sector, nitrous oxide (N₂O) and methane (CH₄).

Since the Autumn 2012 update to the projections a new set of agriculture projections have been produced by Defra and have been included in this update as well as the effects of the new GhG Inventory, see [Section 4.1](#) for further details.

Figure 4.1 – Overall Agriculture sector emissions projections



Overall emissions from the agricultural sector are projected to be approximately 45.6 MtCO₂e in 2030 which corresponds to reduction in emissions of approximately 3% on the 2011 level.

Emissions are predicted to decline until 2015 at which point they remain at a fairly constant level. The presence of the flat line in emissions is due to limitations in Defra's agriculture projections, which only projects activity from the sector out to 2020 ([Defra 2013](#)).

The key driver for the reduction in emissions during the projected time series is the anticipated contraction in the UK's agriculture sector, leading to a reduction in land area used for arable

farming and, therefore, associated fertilizer application, as well as reductions in the nation's beef, dairy and pig herds.

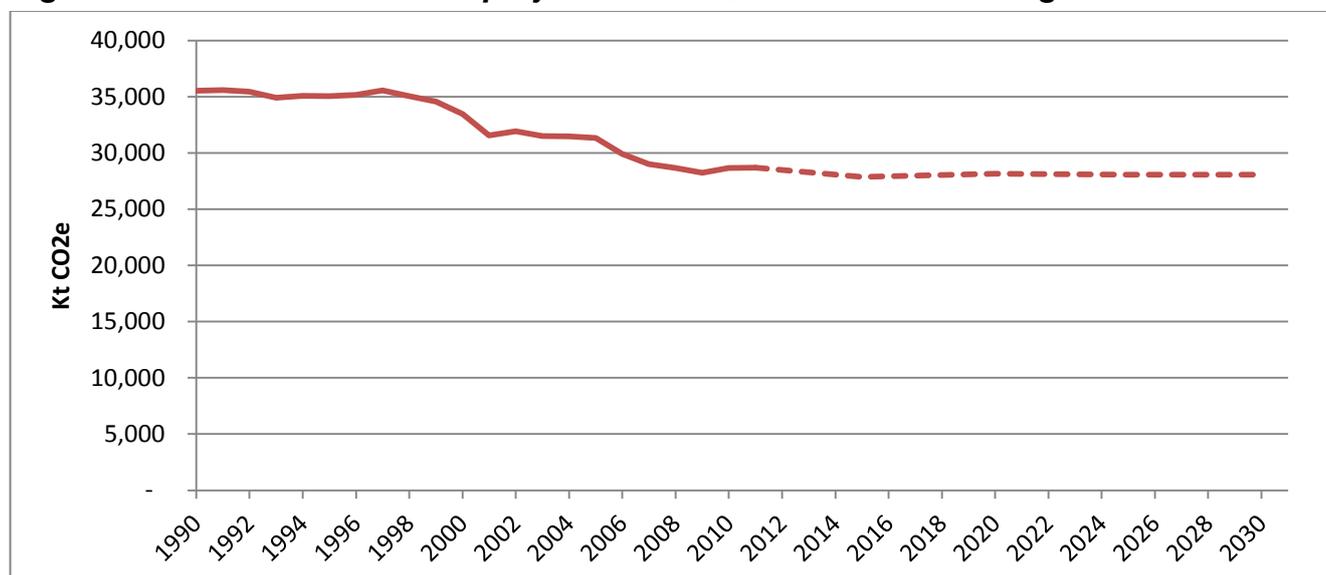
These reductions are the result of macroeconomic assumptions that impact on the UK agriculture sector. A key driver for the changes is the pound sterling to Euro exchange rate with the pound projected to strengthen against the Euro over the period. This will affect UK agriculture in a number of ways: i) through a reduction in the prices paid to UK farmers relative to European farmers and associated relative returns; ii) through a reduction in demand for UK exports as these become less competitive with European products; and, iii) through reductions in the domestic value of the single farm payment which is set in Euros.

In line with the methodology adopted by Defra, the effects of the industry led, voluntary Agricultural Action Plan for emissions reductions have not been taken into account in these projections.

4.1 Agriculture sector nitrous oxide emissions

Agricultural N₂O represents the most significant contributor to overall UK N₂O emissions, and represents approximately 87% of the total N₂O emissions in the non-CO₂ GHG projections. Emissions of N₂O in the agriculture sector come from a variety of sources such as agricultural soils, manure management systems and field burning. The most significant contributor of these is agricultural soils which represents approximately 94% of agricultural N₂O emissions in 2011 and 82% of total N₂O from all sectors covered by this report.

Figure 4.2 Historical trend and projections of N₂O emissions from agriculture



N₂O from the agriculture sector is projected to decline from approximately 29 MtCO₂e in 2011 to approximately 28 MtCO₂e in 2020; the trend then flat-lines to 2030 due to the limitations of the Defra FAPRI-UK model, see [Figure 4.2](#).

Defra's agriculture projections estimate approximately 10% reduction in total UK fertiliser application by 2020. This is driven by a small reduction (2%) in arable area as well as significantly reduced application rates to grasslands through better nutrient advice. This contributes to the overall reduction in N₂O emissions from the sector. Decreases in the number of livestock out to 2020 also impact the level of N₂O emissions by leading to fewer N₂O emissions from manure management.

Since 2011 Defra have used an updated methodology for their projections for agricultural emissions in order to make use of the AFBI FAPRI model of UK agriculture (DEFRA, 2011). The FAPRI-UK model has greatly increased the accuracy of the activity drivers behind Defra’s emissions projections.

Changes in agriculture sector nitrous oxide emissions since the previous update

Changes due to the new GhG Inventory

As outlined in the introduction, changes in the methodology of the GhG Inventory will affect the non-CO₂ projections during the re-baselining process. The most significant changes which have affected the projections of N₂O in the agriculture sector are as follows:

- Changes to emissions from agricultural soils due to recommendations following the 2012 UNFCCC inventory review.
- Revisions to fertiliser application data

Changes due to updated agriculture projections

Since the Autumn 2012 update Defra have produced a new set of projections for N₂O and CH₄ from the agricultural sector. Defra’s agriculture projections are now based on activity data from the latest FAPRI modelling of activity drivers in the agriculture sector. These projections have been incorporated into the Spring 2013 update.

Figure 4.3 Spring 2013 and Autumn 2012 agriculture sector N₂O projections

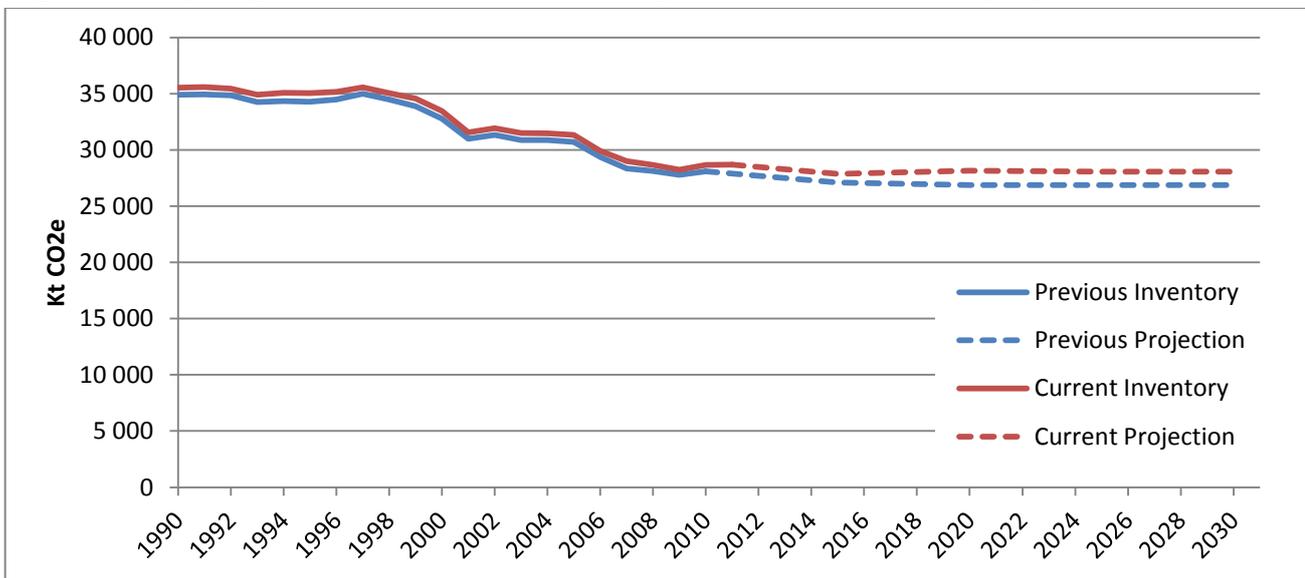


Figure 4.3 above highlights the changes the Defra projections update and the new GhG Inventory have had on agricultural N₂O emissions going forward. The Defra projections have been produced with the latest GHG Inventory as their baseline.

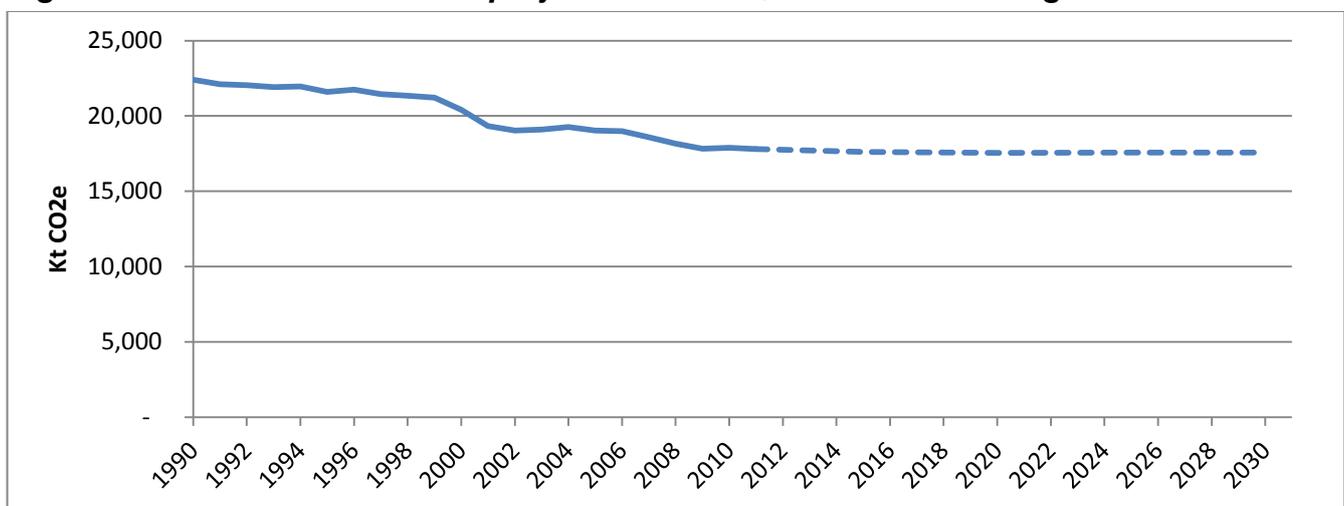
A slower than previously projected decline in the number of dairy cattle, as well as a faster growth in the number of sheep and poultry are the significant updates to these projections

The total effect of these changes to the Defra projections and the Inventory is to increase the projected emissions of N₂O by approximately 0.8 MtCO₂e in 2015 and 1.1 MtCO₂e in 2020, before remaining at this level out to 2030 due to the flat-lining process explained above.

4.2 Agriculture sector methane emissions

As with N₂O emissions, agriculture is the highest contributing sector to total CH₄ emissions for the UK, representing approximately 45% of total CH₄ emissions from the sectors considered in this report in 2011. Major sources of CH₄ in the agriculture sector are enteric fermentation by livestock, particularly cattle, which accounts for approximately 65% of total CH₄ emissions from this sector, and livestock wastes which account for a further 15%.

Figure 4.4. Historical trend and projections of CH₄ emissions from agriculture



Methane emissions from the agriculture sector have declined in an almost linear fashion since 1990, with emissions in 2011 being approximately 20% lower than the base year (see [Figure 4.4](#)).

Methane from the agriculture sector is projected to decline from approximately 18 MtCO₂e in 2011 to approximately 17 MtCO₂e in 2020, a reduction of just over 2%. This is due to an overall reduction in activity in the sector as explained above. The decrease in the projected trend is specifically due to an anticipated reduction in the size of livestock herds and therefore their associated enteric fermentation and waste emissions. As is the case with the agricultural N₂O emissions, the trend then flat lines to 2030 due to limitations in the Defra FAPRI-UK model.

Changes in agriculture sector CH₄ emissions since the previous update

Changes due to the new GhG Inventory

As outlined in the introduction, changes in the methodology of the GhG Inventory will affect the non-CO₂ projections during the re-baselining process. The most significant changes which have affected the projections of CH₄ in the agriculture sector are as follows:

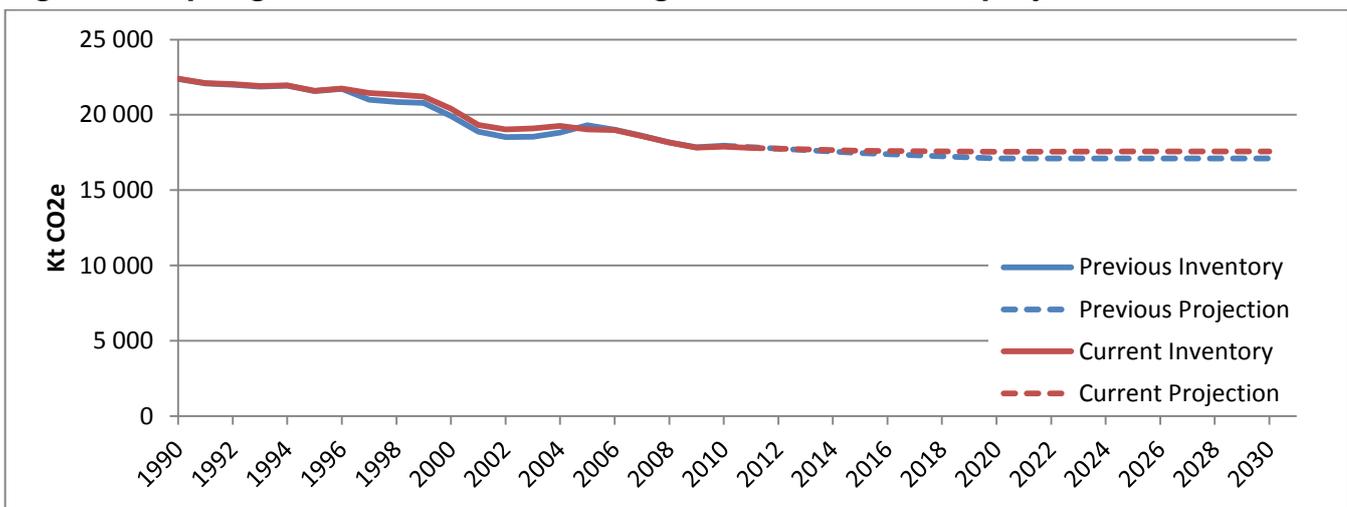
- a reduced cow milk yield for 2010 leading to a reduction in emissions of CH₄ in recent years,
- a higher level of feed digestibility resulting in a lower emissions factor for dairy cattle, which has decreased historic emissions

- An upwards revision to the lifespan of lambs, which has resulted in a small decline in waste emissions from lambs but a much larger increase in enteric fermentation emissions from this source.

Changes due to updated agriculture projections

As highlighted in [Section 4.1](#) above, changes to the agricultural projections produced by Defra have had some impact on the projections presented. The revisions to the projections which have impacted N₂O emissions are also applicable to CH₄

Figure 4.5 Spring 2013 and Autumn 2012 agriculture sector CH₄ projections



The new Defra projections for agricultural emissions as well as the new GhG Inventory have been included in this update to the non-CO₂ emissions projections. [Figure 4.5](#) highlights the differences these changes have had on the agriculture sector’s CH₄ emissions.

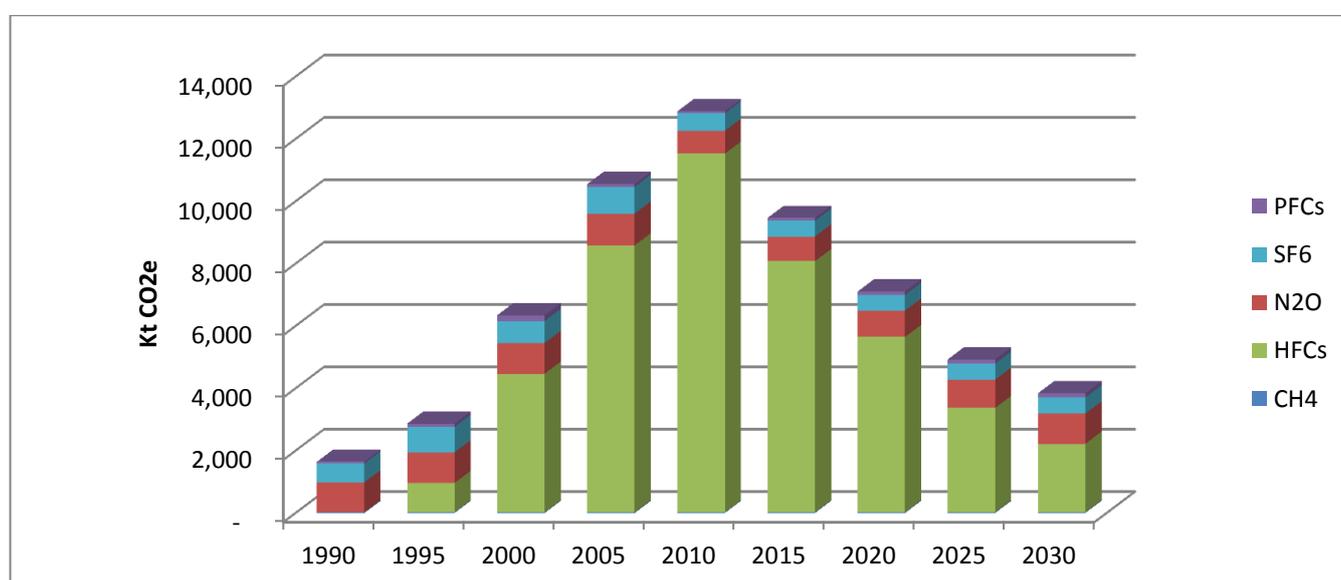
The update has resulted in projections for CH₄ from the agriculture sector being approximately 160 Kt CO₂e higher in 2015 and 470 Kt CO₂e higher in 2020 when compared with the Spring 2012 update; increases of approximately 1% and 3% respectively.

5 Business Sector

In 2011 non-CO₂ greenhouse gas (GHG) emissions from the business sector were approximately 13.1 MtCO₂e, representing around 15% of the UK's total non-CO₂ emissions. All non-CO₂ GHG's contribute to emissions from this sector: Nitrous oxide (N₂O), methane (CH₄) and the F-gases (HFC, PFC & SF₆). **Figure 5.1** highlights how each of the gases considered account for non-CO₂ emissions from this sector.

The incorporation of the new GHG Inventory is the only change from the Autumn 2012 publication which has been made in the sector.

Figure 5.1 – Non-CO₂ GHG emissions projections for the business sector



Overall emissions from the business sector are projected to be approximately 4 MtCO₂e in 2030 which will correspond to a decrease in emissions of approximately 71% from 2011. Historically, business sector emissions have increased by 11.4 MtCO₂e since 1990, reaching their highest point in 2011.

5.1 Business sector F-Gas emissions

F-gas emissions were estimated to be approximately 12 MtCO₂e in 2011, representing 95% of non-CO₂ GHG emissions from the business sector. These emissions result mainly from refrigeration and air conditioning, with contributions also from foams, fire fighting, solvents, electronics, electrical insulation and sporting goods. Emissions of f-gases have increased rapidly since 1990 due to the phasing out of CFC's as a result of the Montreal Protocol, and the use of HFC's as replacement gases in a growing refrigeration and air conditioning sector. F-gas emissions are projected to decline by approximately 9.5 MtCO₂e, or 77%, between 2011 and 2030. We project this reduction to be largely driven by the impact of the EU F-gas regulation driving the replacement of HFC's with new lower GWP refrigerants, and because leakage rates from refrigeration equipment are now much better controlled than in the 1990s, thus reducing fugitive emissions.

Emissions of **HFC's** were approximately 11.7 MtCO₂e in 2011, representing 90% of non-CO₂ GHG emissions from the business sector. The majority of these emissions were from

refrigeration and air conditioning (RAC). Emissions of HFCs can occur at various stages of the RAC product life-cycle:

- During the refrigeration equipment manufacturing process;
- Over the operational lifetime of the refrigeration or air-conditioning unit; and
- At disposal of the refrigeration or air-conditioning units.

RAC emissions are estimated using a model developed by ICF International ([ICF, 2011](#)), based on industry input and a modelling approach consistent with IPCC guidance. The model is organized into 13 end-uses, and uses a bottom-up approach based on equipment stocks and average charge size from available market data. The model has been validated by comparing estimated refrigerant consumption (calculated as the amount of refrigerant used to manufacture new equipment produced in the UK plus the amount used to service leaking equipment) with annual refrigerant sales data from the British Refrigeration Association (BRA).

The historic trend for HFC emissions is beginning to show a levelling off in trajectory, consistent with its expected future trend. HFC emissions are visualised in [Figure 5.2](#) below.

Emissions of **SF6** ([Figure 5.3](#)), all of which are attributable to semiconductor manufacture, electrical and sporting goods, were 0.5 MtCO₂e in 2011. They are projected to decrease by approximately 3% between 2011 and 2030.

Emissions of **PFCs** ([Figure 5.4](#)), which are also wholly attributable to semiconductors, electrical and sporting goods, were 76 ktCO₂e in 2011. They are projected to increase by approximately 77% between 2011 and 2030.

Figure 5.2 - HFC emissions projections for the business sector

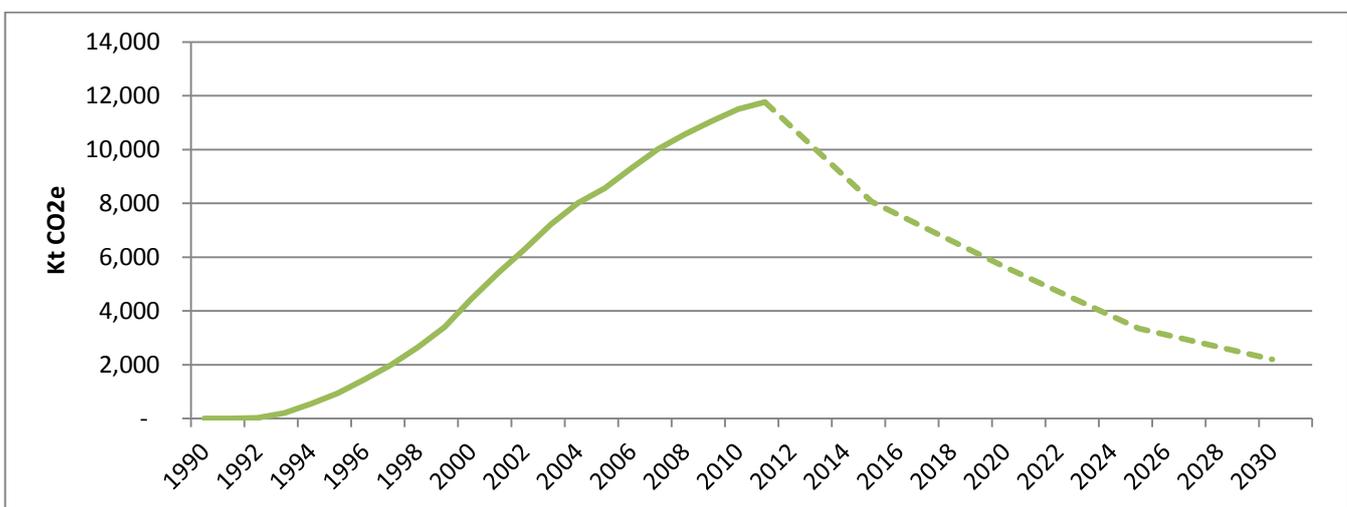


Figure 5.3 – SF6 emissions projections for the business sector

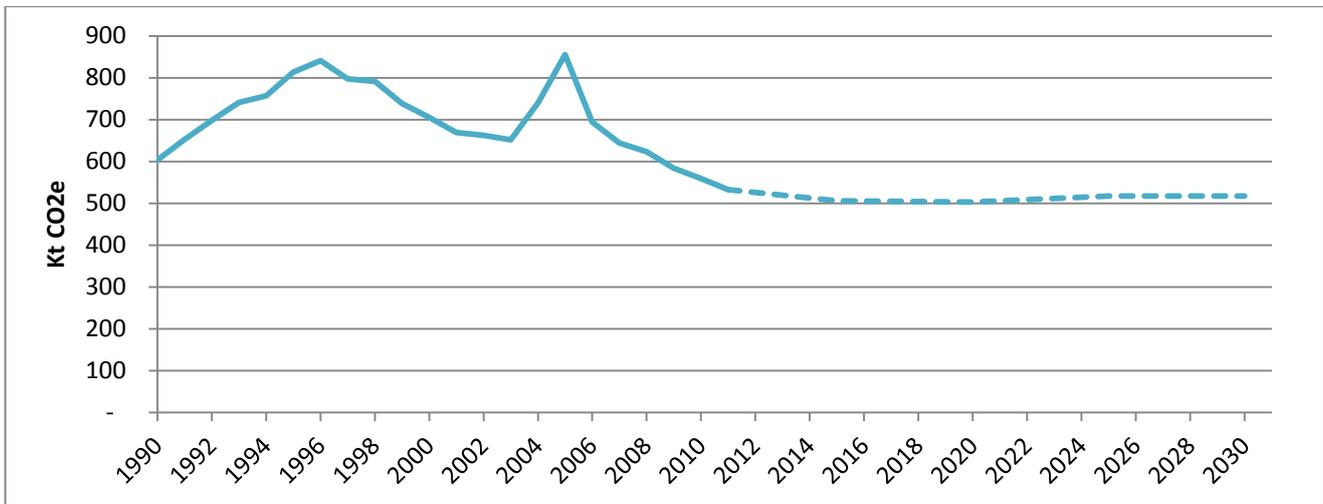
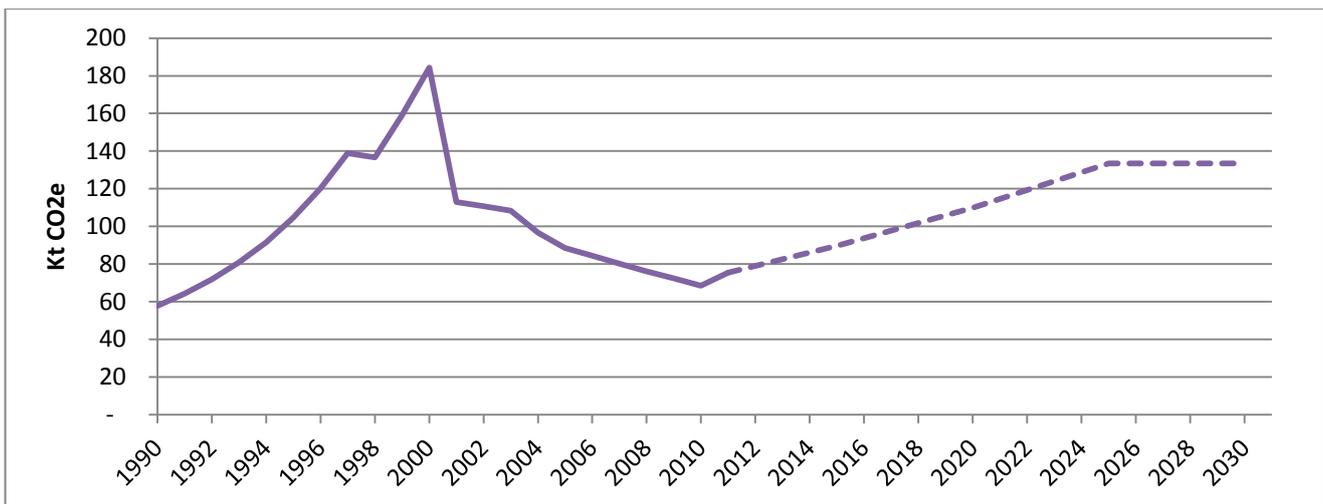


Figure 5.4 - PFC emissions projections for the business sector



Changes in business sector F-Gas emissions since the previous update

As outlined above the only source of change between the business sector projections in the Autumn 2012 update and this set of projections has been the inclusion of the new GhG Inventory.

The most significant changes which have affected the projections of F-Gases in the business sector are as follows:

- The inclusion of Crown Dependency level data has been added across the time series. CD’s data are estimated pro-rata based on GDP.

Figures 5.5 to 5.7 highlight the differences this revisions to the GhG Inventory have had on the projections of F-Gases for the business sector. The results of these revisions is that emissions for HFCs and SF₆ are now projected to be lower than in the Autumn 2012 update (8% and 4%, respectively in 2030). PFCs are now projected to be approximately 5% higher in 2030 when compared with the Autumn 2012 publication.

Figure 5.5 Comparison of Spring 2013 and Autumn 2012 business sector HFC projections

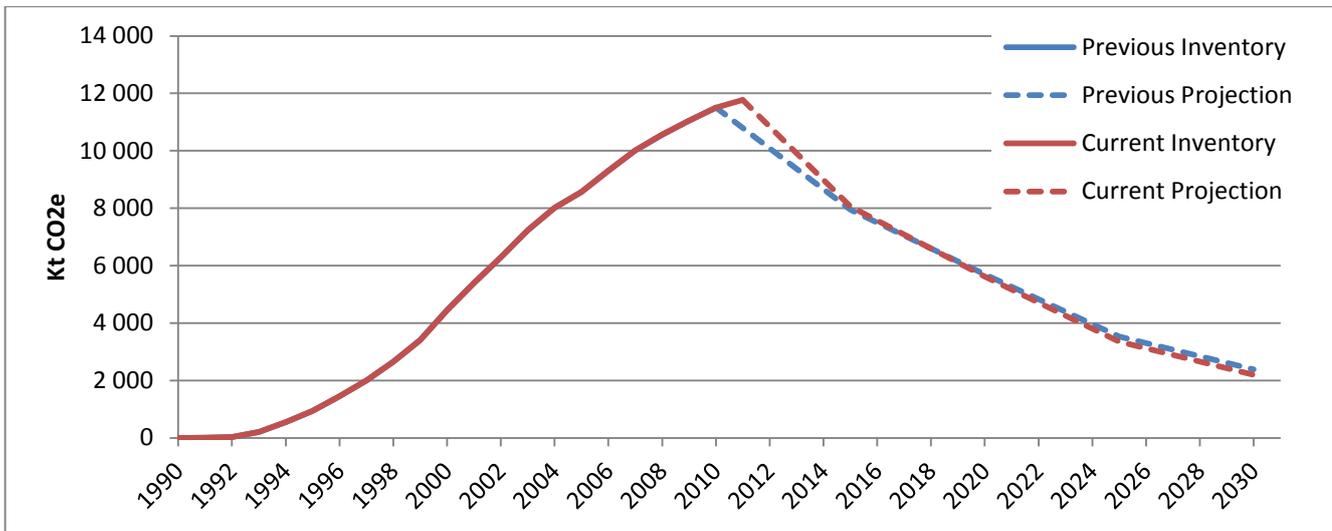


Figure 5.6 Comparison of Spring 2013 and Autumn 2012 business sector SF6 projections

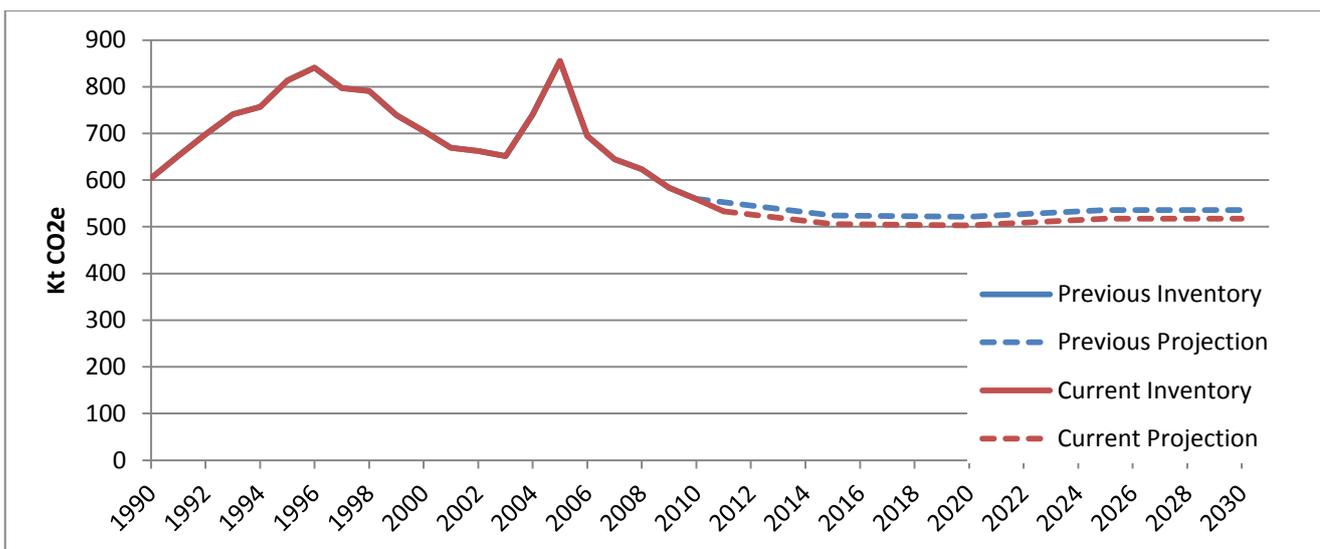
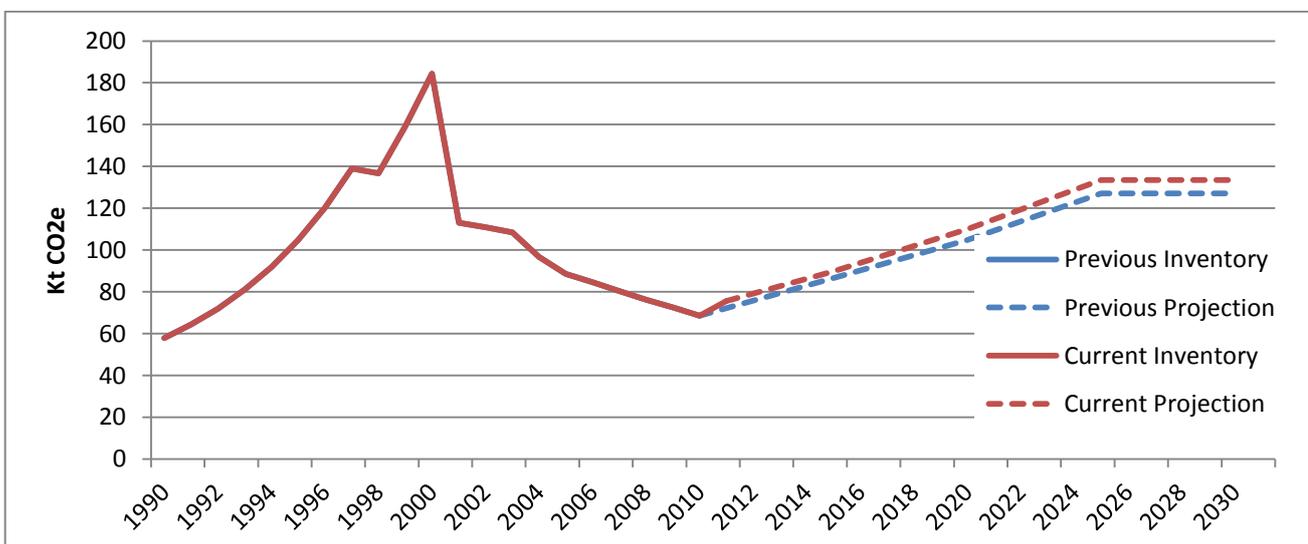


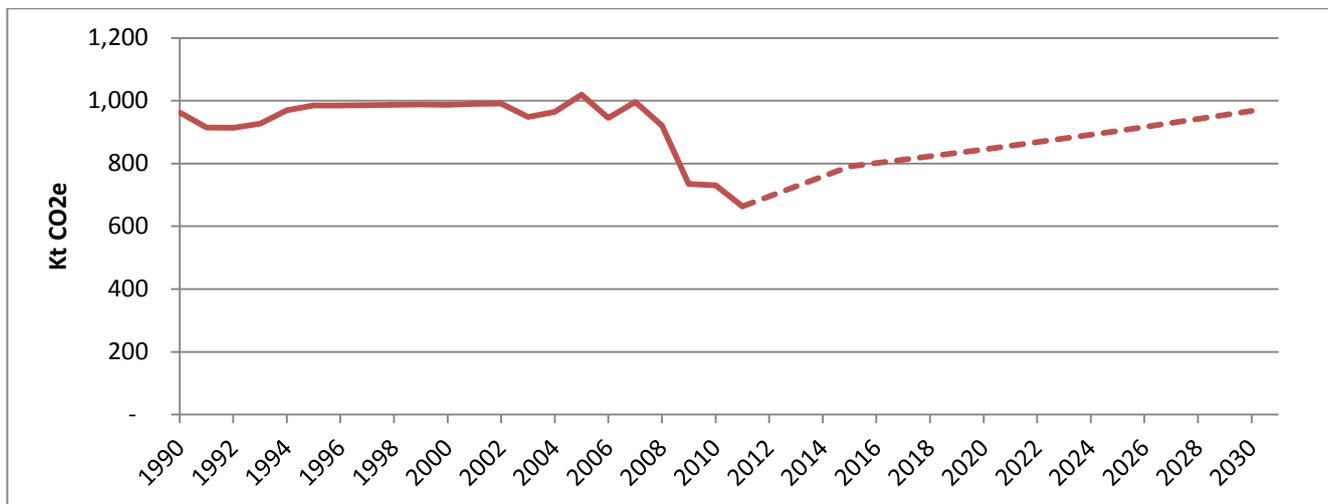
Figure 5.7 Comparison of Spring 2013 and Autumn 2012 business sector PFC projections



5.2 Business nitrous oxide emissions

Nitrous oxide emissions were estimated to be 0.7 MtCO₂e in 2011 (Figure 5.8), representing approximately 5% of non-CO₂ GHG emissions from the business sector. These emissions result from iron and steel combustion, and other industrial and commercial combustion. Emissions have generally been flat since 1990 with a sharp downturn from 2007. As year-on-year fluctuations in emissions are small in terms of absolute values, it is difficult to attribute the changes to a particular cause. Emissions are projected to increase by approximately 0.3 MtCO₂e, or 46%, between 2011 and 2030.

Figure 5.8 – N₂O emissions projections for the business sector



Changes in business sector N₂O emissions since the previous update

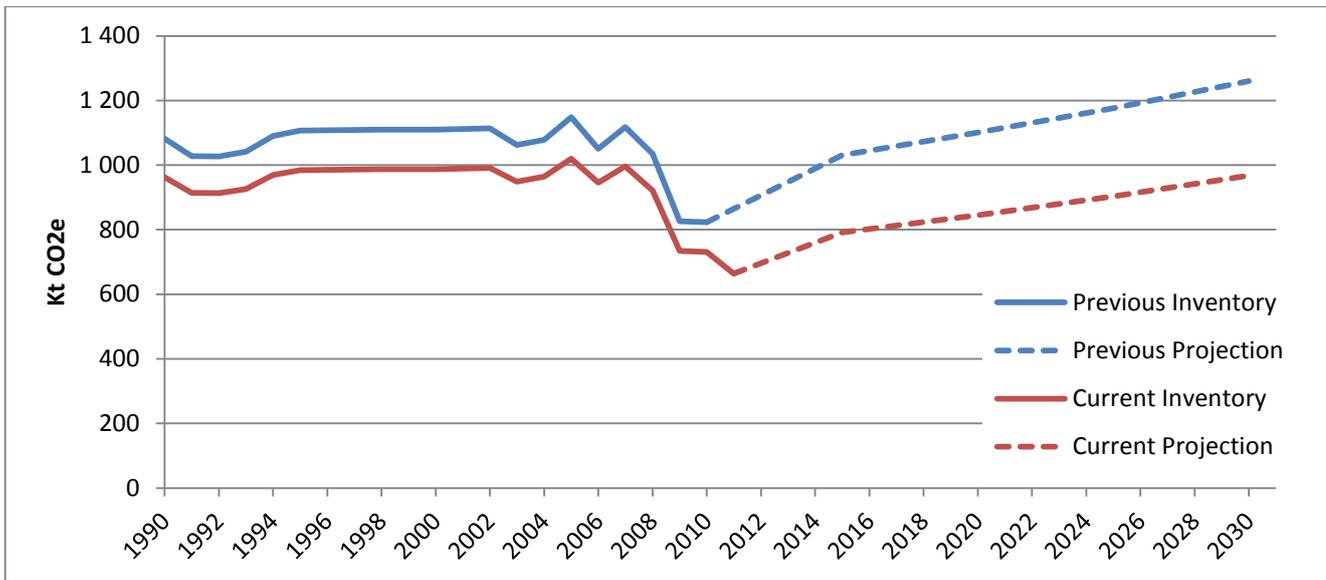
As outlined above the only source of change between the business sector projections in the Autumn 2012 update and this set of projections has been the inclusion of the new GhG Inventory.

The most significant changes to the Inventory which have affected the projections of N₂O in the business sector are as follows:

- Amendments to activity data and emissions factors for industrial off-road mobile machinery.

Figure 5.9 highlights the difference this revision has made to the overall emissions of N₂O from the business sector. The results of the revision to the industrial off-road mobile machinery source in the inventory is that N₂O emissions from the business sector are now approximately 300 kt CO₂e lower in 2030 than in the Autumn 2012 publication.

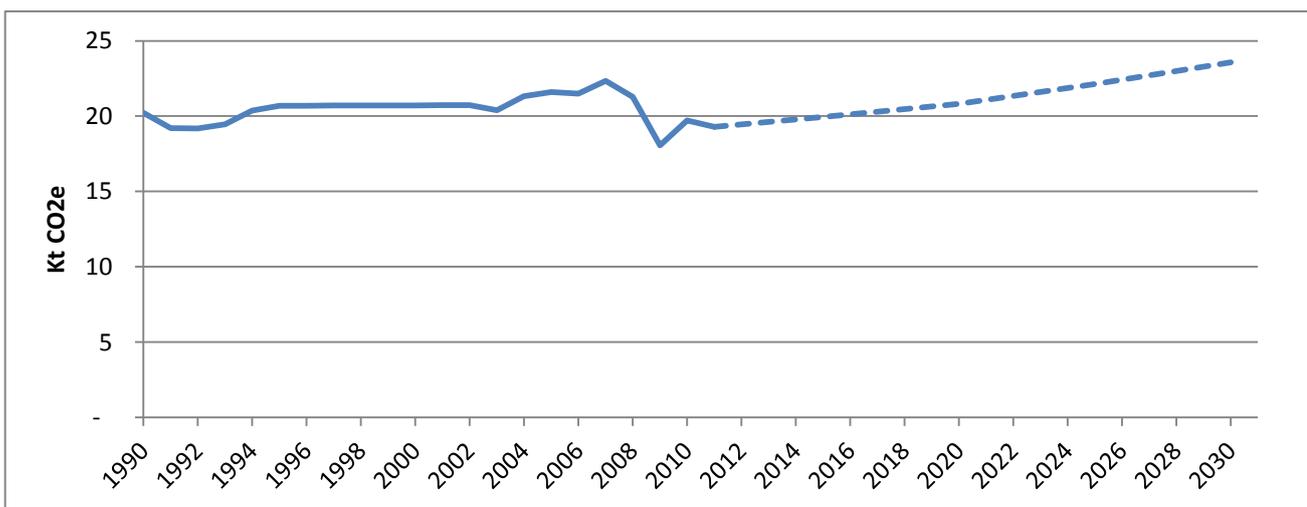
Figure 5.9 Comparison of Spring 2013 and Autumn 2012 business sector N₂O projections



5.3 Business methane emissions

Methane emissions were estimated to be 19 ktCO₂e in 2011 (Figure 5.10), representing less than 1% of non-CO₂ GHG emissions from the business sector. These emissions result from iron and steel combustion, and other industrial and commercial combustion. There has been no significant change in the emissions trend since 1990, except for a slight decrease in 2009. Emissions are projected to increase by approximately 4 MtCO₂e, or 22%, between 2011 and 2030. These percentage increases may be misleading though, as the absolute emissions values are very small.

Figure 5.10 – CH₄ emissions projections for the business sector



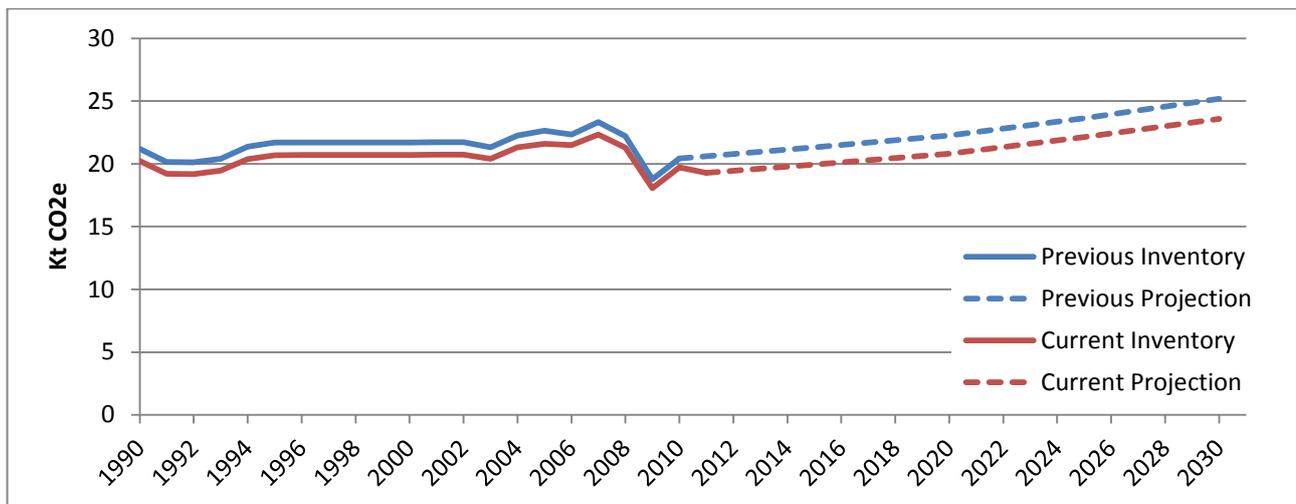
Changes in business sector CH₄ emissions since the previous update

As outlined above the only source of change between the business sector projections in the Autumn 2012 update and this set of projections has been the inclusion of the new GhG Inventory.

The most significant changes to the Inventory which have affected the projections of CH₄ in the business sector are the same as those relevant to N₂O from this sector, namely the new emissions factors and activity data for industrial off-road mobile machinery.

Figure 5.11 highlights the difference this revision has made to the overall emissions of CH₄ from the business sector. These revisions have had the effect of reducing CH₄ emissions from the business sector by approximately 2 kt CO₂e or 6% in 2030 when compared to the Autumn 2012 publication.

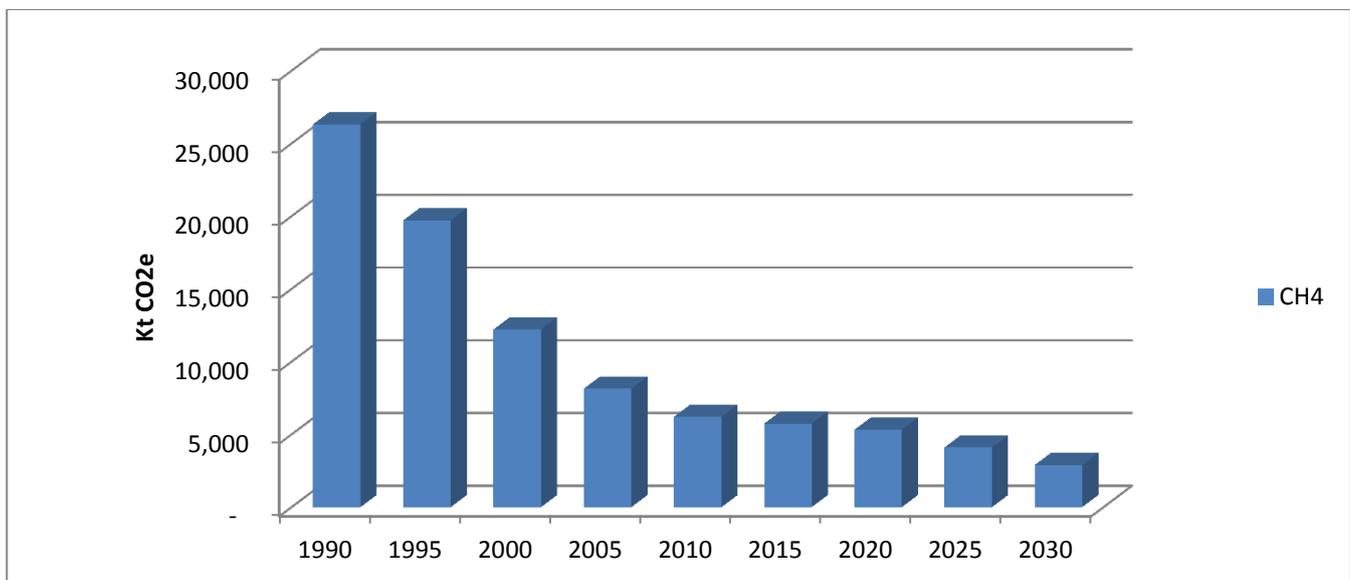
Figure 5.11 Comparison of Spring 2013 and Autumn 2012 business sector CH₄ projections



6 Energy Sector

In 2011 non-CO₂ greenhouse gas (GHG) emissions from the energy sector were approximately 6 MtCO₂e, representing around 7% of the UK's total non-CO₂ emissions. Methane (CH₄) is the only non-CO₂ GHG contributing to emissions from this sector as defined by the coverage of this report.

Figure 6.1 – Non-CO₂ GHG emissions projections for the energy sector

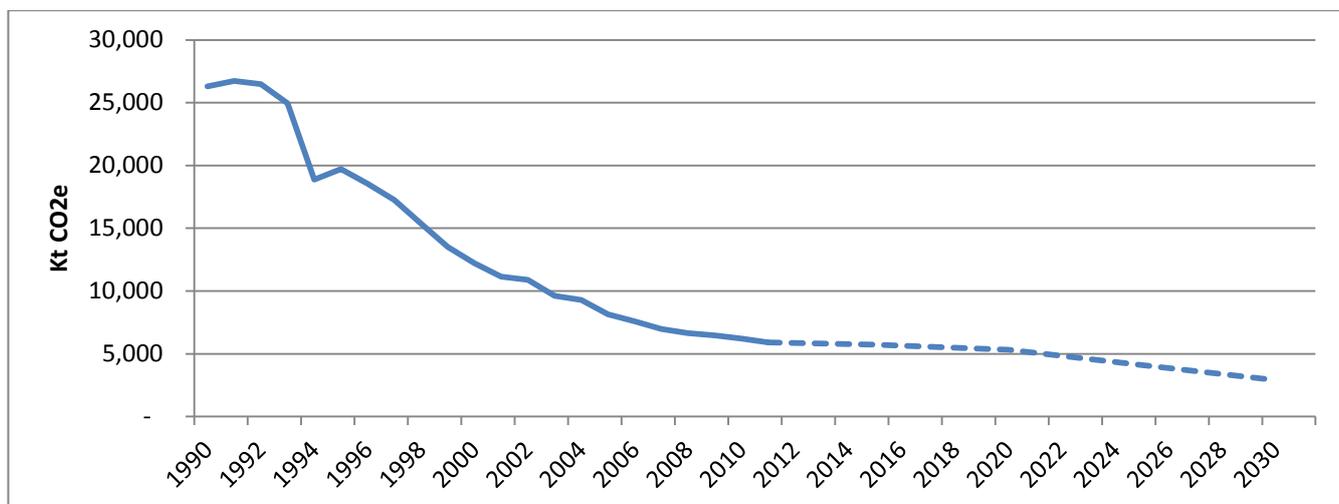


Overall emissions from the energy sector are projected to be approximately 3 MtCO₂e in 2030 which will correspond to a decrease in emissions of approximately 51% since 2011 (Figure 6.1). This is predominantly due to reduced emissions from natural gas leakage and from deep mined coal. Historically, energy sector emissions have decreased by approximately 20 MtCO₂e since 1990.

The incorporation of the new GHG Inventory, which includes one new emissions category, is the only change from the Autumn 2012 publication which has been made in the sector.

6.1 Energy methane emissions

Methane emissions in the energy sector result from natural gas leakage, operational and closed coal mines, and coke production. Historically, the decreasing trend in emissions is as a result of a reduction in emissions from natural gas leakage of around 48% and deep mined coal of around 92%; both of which are the dominant contributors to emissions in this sector (still comprising around 89% of emissions in 2011). Emissions are projected to continue to decrease from natural gas leakage and deep mined coal to 2030 (see Figure 6.2), because of an expected decrease in the quantity of coal produced, and the replacement of cast-iron pipes in the gas distribution system. Note that these projections are also influenced by limitations in the projected time-series for deep mined coal emissions, which only extends to 2025.

Figure 6.2 – CH₄ emissions projections for the energy sector

Closed coal mine CH₄ emissions are the third most significant source in this sector. Projections of these emissions were recently updated ([WSP ENVIRONMENTAL, 2011](#)). The model uses a bottom-up approach incorporating physical properties of individual mines and mine areas, includes actual closure and re-commissioning dates up to 2010, and uses a single-value long-term emissions factor obtained from abandoned mine CH₄ reserves of eight UK mines, and flow rate of CH₄ from those mines. Emissions are estimated to have already been significantly reduced and likely to remain approximately constant out to 2030.

Changes in the energy sector's CH₄ emissions since the previous update

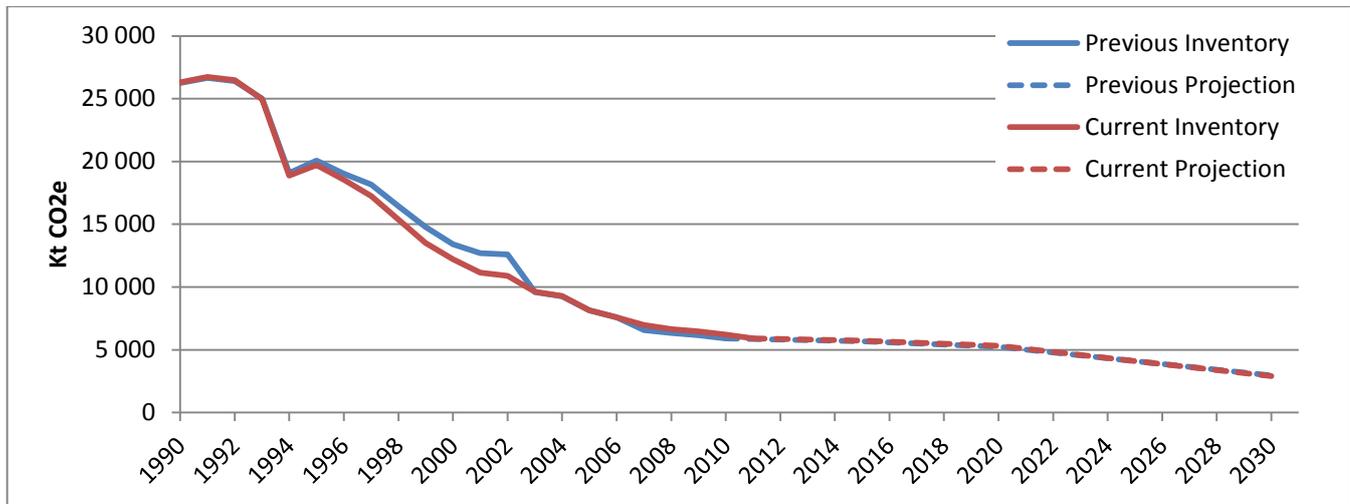
As outlined above the only source of change between the energy sector projections in the Autumn 2012 update and this set of projections has been the inclusion of the new GhG Inventory.

The most significant changes to the Inventory which have affected the projections of CH₄ in the energy sector are as follows:

- An update to coal mine estimates in order to incorporate data from sites previously not captured by the Inventory. This has led to slightly higher emissions since 2007.
- The inclusion of emissions from charcoal production which had not previously been captured in the Inventory. Emissions from this source are approximately 3 ktCO₂e p.a. and expected to remain constant going forward.
- An update to the model used to calculate emissions from natural gas leakage and to also take account of pre-ignition losses from gas fired cookers and heaters.

Figure 6.3 highlights the difference these revisions have made to the overall emissions of CH₄ from the energy sector. These revisions have had the effect of reducing CH₄ emissions from the energy sector by approximately 2% in 2030 when compared to the Autumn 2012 publication.

Figure 6.3 Comparison of Spring 2013 and Autumn 2012 business sector CH₄ projections

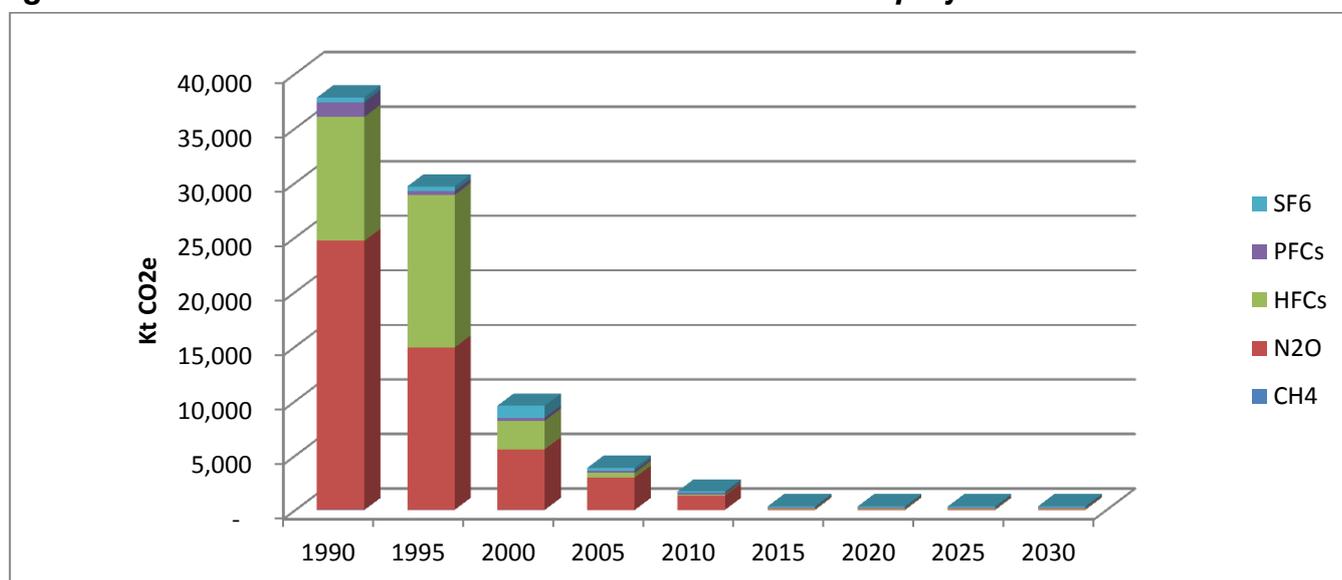


7 Industrial Processes Sector

The industrial processes sector has historically been a significant contributor to emissions, producing the equivalent of approximately 22% of the UK's total non-CO₂ emissions in 1990. However, by 2011 emissions from the industrial process sector have reduced to less than 1% of total non-CO₂ emissions. Industrial processes do remain a source of nitrous oxide (N₂O), methane (CH₄) and F-gas emissions, albeit on a much smaller scale than historically.

Since the Autumn 2012 update to the projections, projections from this sector have been updated to reflect the changes in the new GhG Inventory. Further details of this update are present in the sections below.

Figure 7.1 – Overall Industrial Processes sector emissions projections



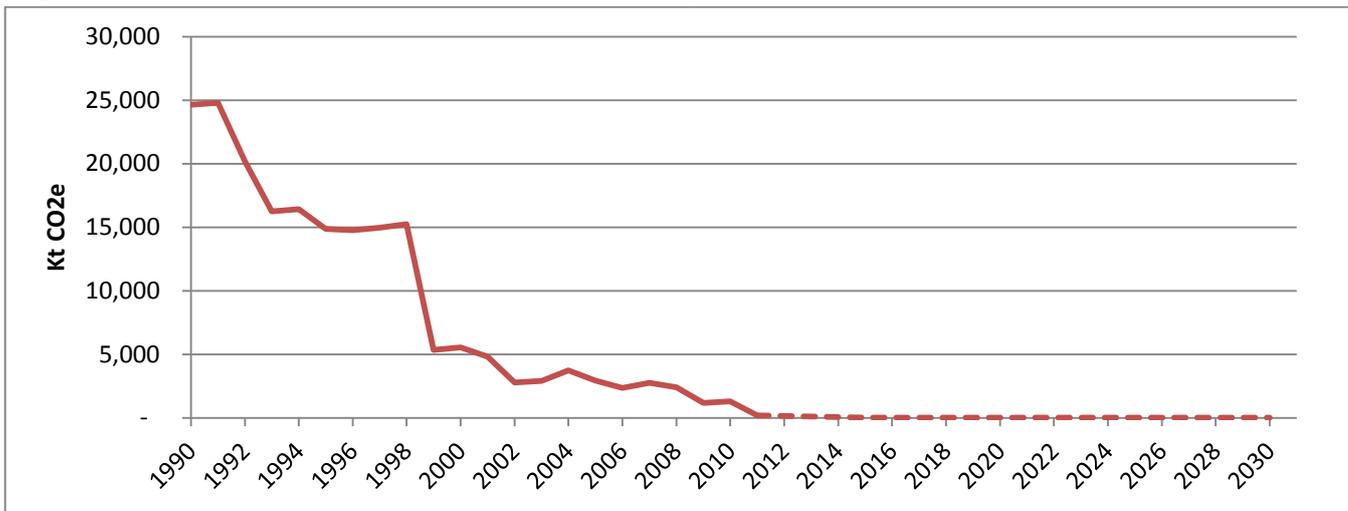
Overall emissions from the industrial processes sector are projected to be 0.3 MtCO₂e in 2030, representing a reduction of approximately 47% between 2011 and 2030 (see Figure 7.1). Historically, N₂O emissions from nitric acid and adipic acid production have contributed significantly to overall emissions from this sector, as well as by-product emissions from the production of HFCs. Changes in industrial activity and the adoption of improved abatement technology has led to the significant reductions seen in this sector. Historically emissions have decreased 98% from 1990 to 2011.

7.1 Industrial Processes nitrous oxide emissions

Historically, N₂O emissions from industrial processes have been significantly higher than they are today and are projected to be in the future. In 2030, these emissions are projected to be 0.1 MtCO₂e. **Figure 7.2** shows the historical and projected trend for N₂O from this sector.

The key driver of N₂O emissions from this sector has historically been the production of adipic and nitric acids. The UK's only adipic acid production facility ceased operation in 2009 and plant closures coupled with early adoption of emissions abatement technology in the production of nitric acid has resulted in significant reductions from these sources.

Figure 7.2 Comparison of N₂O emissions projections from the Industrial Processes sector



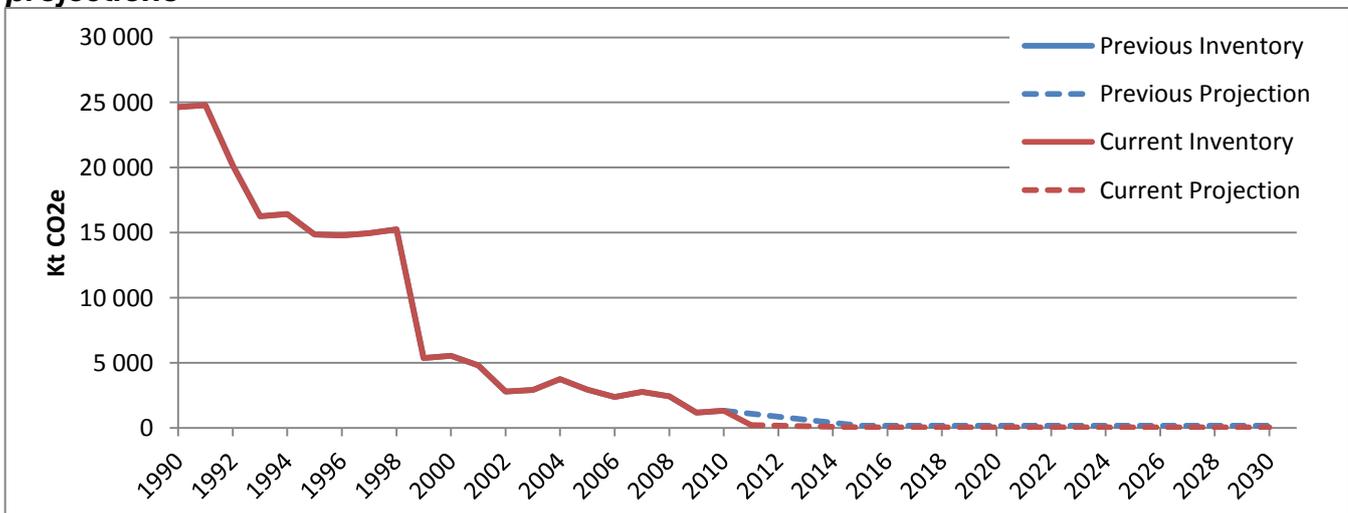
Changes in the industrial processes sector’s N₂O emissions since the previous update

As outlined above the only source of change between the industrial process sector projections in the Autumn 2012 update and this set of projections has been the inclusion of the new GhG Inventory.

The only significant change to the Inventory which has affected the projections of N₂O in the industrial processes sector is the reduction in the emissions factor used to calculate emissions from the production of nitric acid. This is as a result of N₂O reducing abatement technology being fitted to all three of the UK’s nitric acid production plants between 2010 and 2011.

Figure 7.3 highlights the difference this revision has made to overall N₂O emissions from the industrial processes sector. The effect of this change is to reduce emissions more quickly and to a lower level than projected in the Autumn 2012 publication. As a result, projections of N₂O from the industrial processes sector are now approximately 160 Kt CO₂e lower from 2015 forwards.

Figure 7.3 Comparison of Spring 2013 and Autumn 2012 industrial processes sector N₂O projections



7.2 Industrial Processes F-Gas emissions

F-gas emissions from the industrial processes sector have, as with other gases, reduced markedly since 1990. F-gas emissions were approximately 13 MtCO₂e in 1990, estimated at 0.4 MtCO₂e in 2011, and are projected to be 0.3 MtCO₂e by 2030. These emissions are predominantly as a result of HFC by-product emissions from halo-carbon production as well as PFC emissions from the primary production of aluminium.

The projected trend for each of the F-gases is expected to remain approximately flat from 2011 (Figures 7.4 to 7.6) as the majority of abatement measures expected in this sector are already in place. Abatement technology has been fitted to two of the three UK producers of HCFCs, significantly reducing by-product emissions.

Emissions of PFCs in this sector are driven by the primary production of aluminium, with a smaller contribution from fugitive emissions from halocarbon production. SF₆ emissions are as a result of its use as a cover gas in the manufacture of magnesium alloy by die-casting.

Figure 7.4 HFC emissions projections from the Industrial Processes sector

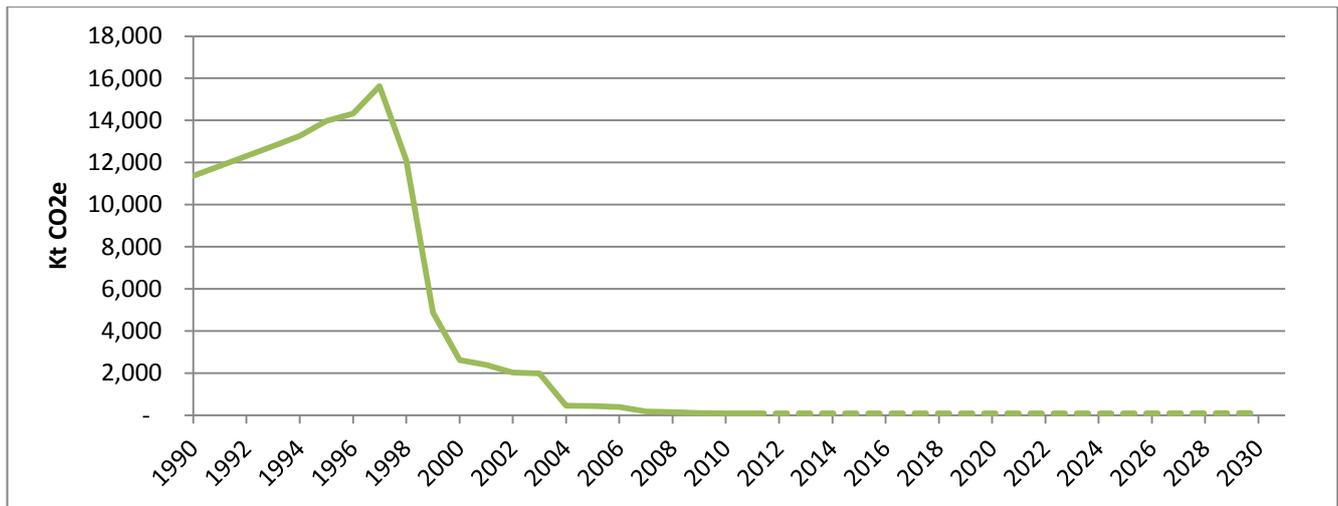


Figure 7.5 PFC emissions projections from the Industrial Processes sector

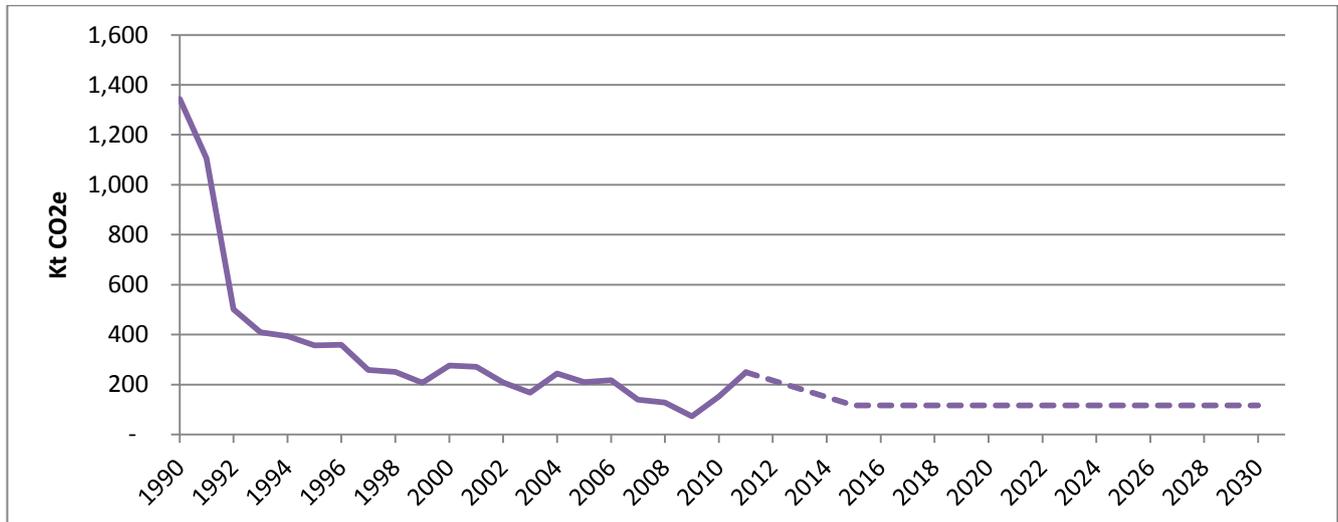
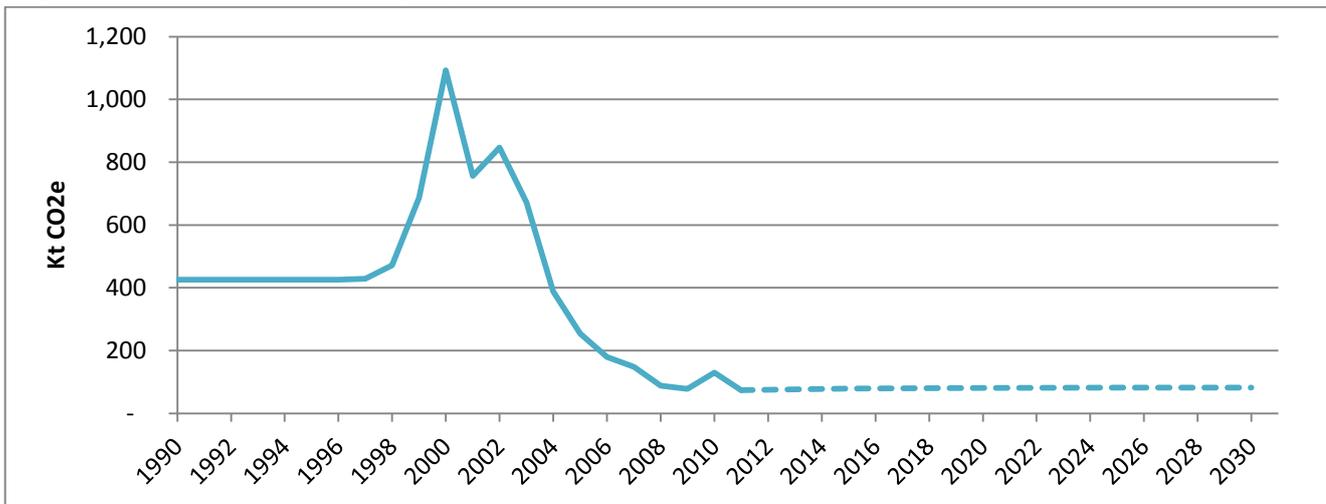


Figure 7.6 SF₆ emissions projections from the Industrial Processes sector



Changes in industrial processes sector F-gas emissions since the previous update

As outlined above the only source of change between the industrial process sector projections in the Autumn 2012 update and this set of projections has been the inclusion of the new GhG Inventory.

The new inventory contains only one revision which has impacted the emissions of F-gases from the industrial processes sector, a slight alteration of emissions of PFCs from the primary production of aluminium. This revision, coupled with the new 2011 data, has resulted in the following overall changes to projections:

- HFC emissions are now projected to be approximately 13 Kt CO₂e lower across the time series,
- PFC emissions are now projected to be approximately 60 Kt CO₂e higher across the time series and;
- SF₆ emissions are now projected to be approximately 60 Kt CO₂e lower across the time series.

Figures 7.7 to 7.9 visualise the effects these changes have had on the projections of the different F-gas families by comparing the Autumn 2012 projections with the new Spring 2013 update.

Figure 7.7 Comparison of Spring 2013 and Autumn 2012 industrial processes sector HFC projections

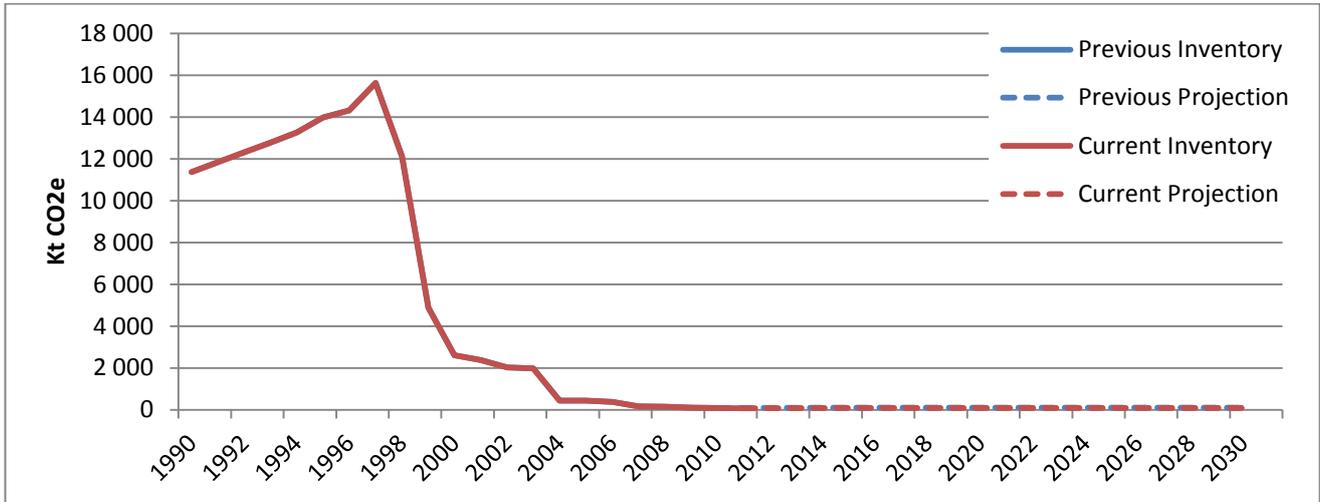


Figure 7.8 Comparison of Spring 2013 and Autumn 2012 industrial processes sector PFC projections

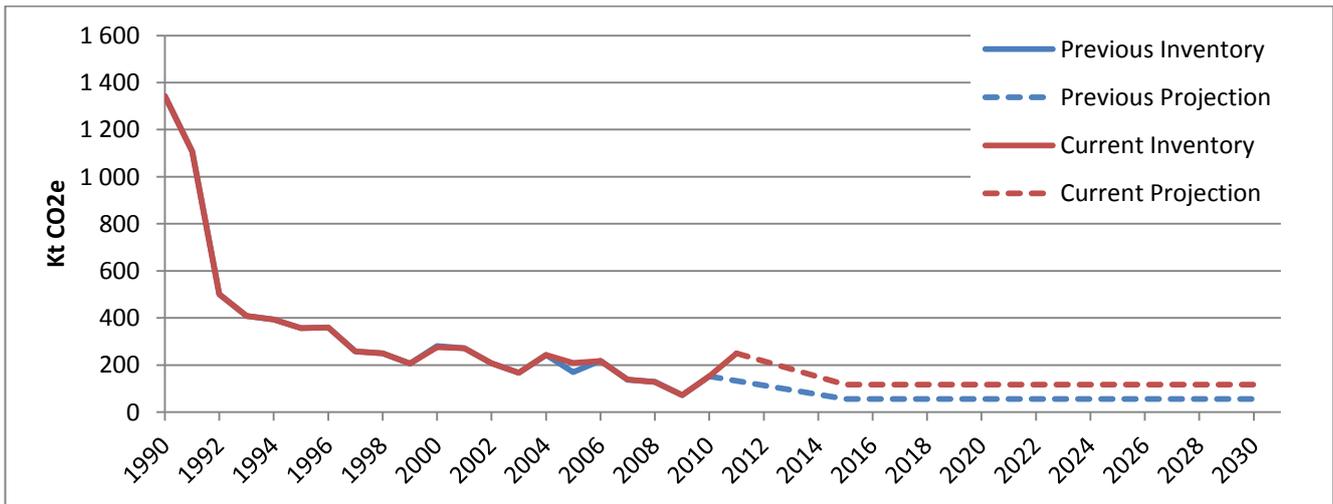
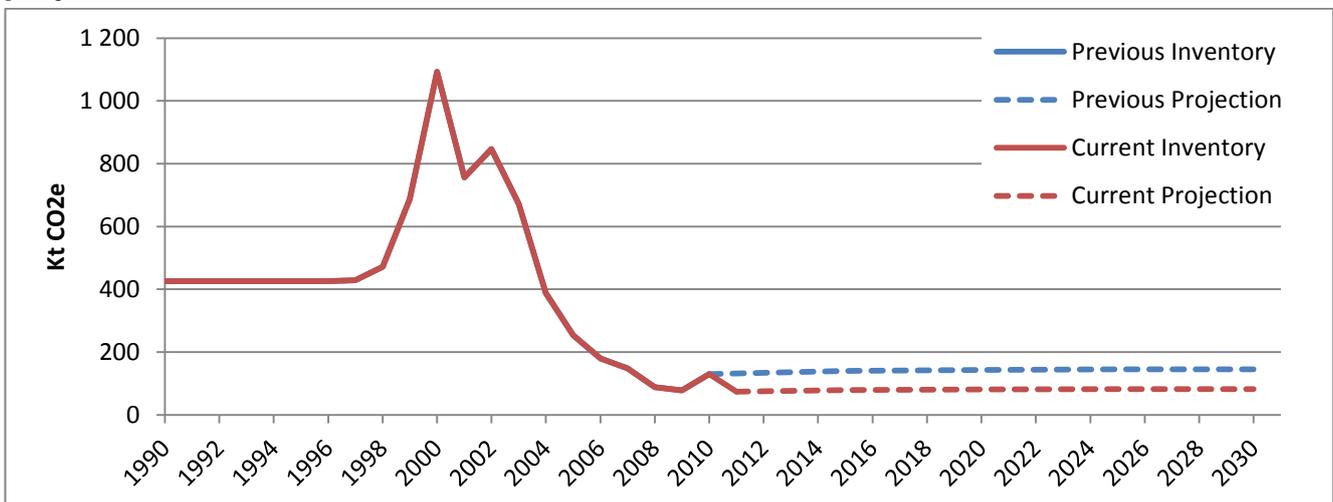


Figure 7.9 Comparison of Spring 2013 and Autumn 2012 industrial processes sector SF₆ projections

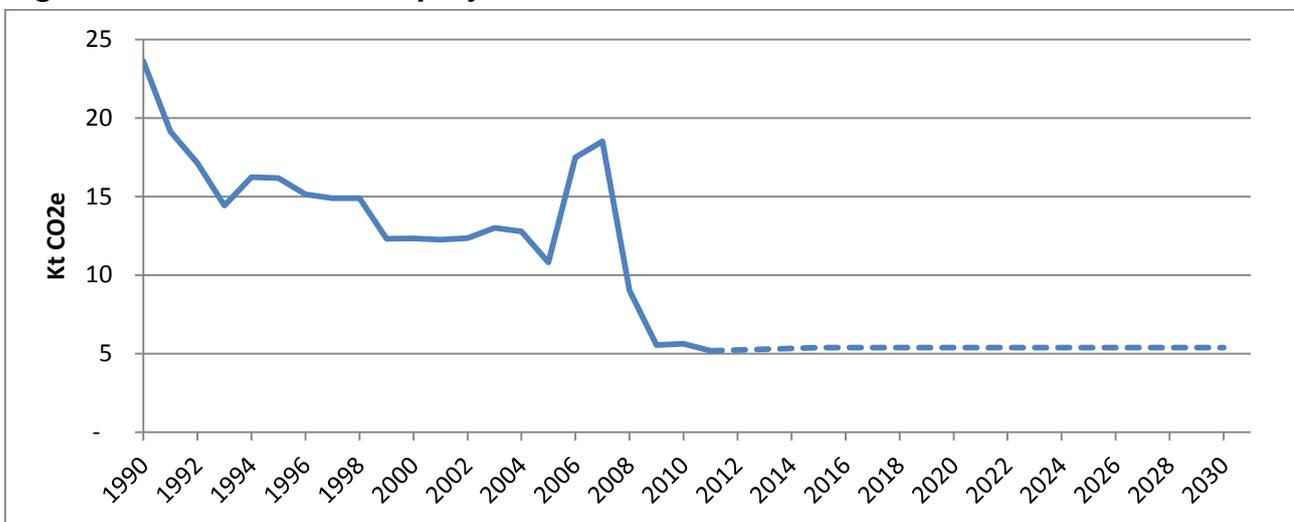


7.3 Industrial Processes sector methane emissions

Methane emissions from the industrial processes sector originates exclusively from fletton brick manufacture. Methane has historically contributed a relatively small amount to overall emissions from the Industrial Processes sector. **Figure 7.10** shows the historical and projected trend for CH₄ emissions from the Industrial Processes sector.

Similar to the business sector, reductions in emissions in the 2007 to 2009 time frame could be associated with a slowdown in overall economic activity due to the recession. However, fluctuations of this small magnitude are difficult to attribute to a single cause. Projections are expected to remain flat going forward due to the relatively small emissions from this gas in this sector and relatively high inter-annual variability.

Figure 7.11 CH₄ emissions projections from the Industrial Processes sector

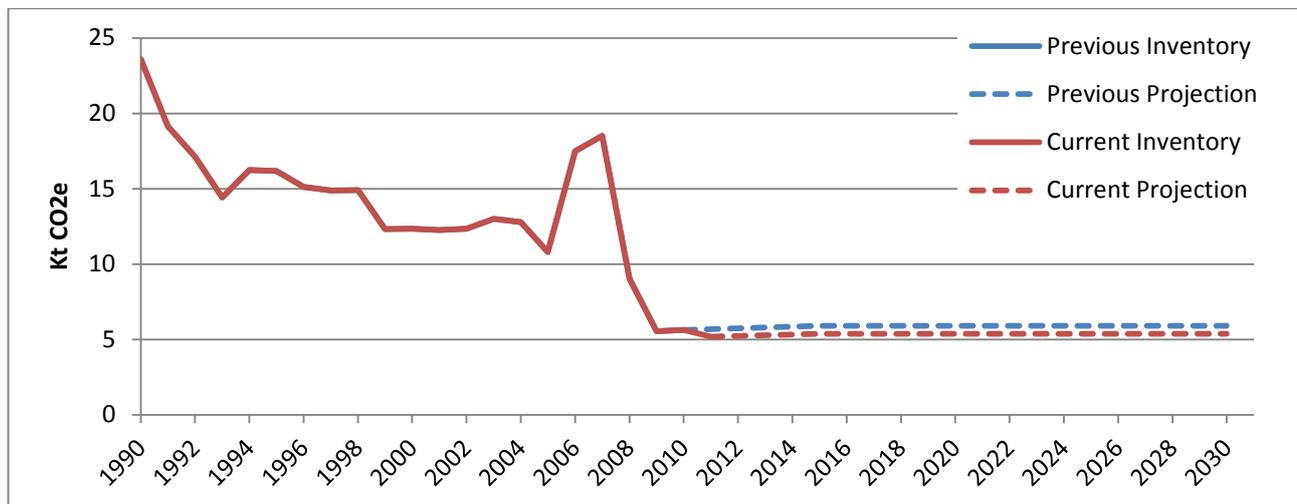


Changes in industrial processes sector F-gas emissions since the previous update

As outlined above the only source of change between the industrial process sector projections in the Autumn 2012 update and this set of projections has been the inclusion of the new GhG Inventory.

As there have been no revisions to the historic emissions associated with fletton brick manufacture, the only change between the Autumn 2012 publication and this update is the re-baselining of the projections against the latest Inventory year. This has had the effect of marginally reducing emissions of CH₄ from the industrial processes sector by approximately 1 Kt CO₂e for each projected year. **Figure 7.12** highlights the effect this change has made.

Figure 7.11 Comparison of Spring 2013 and Autumn 2012 industrial processes sector CH₄ projections

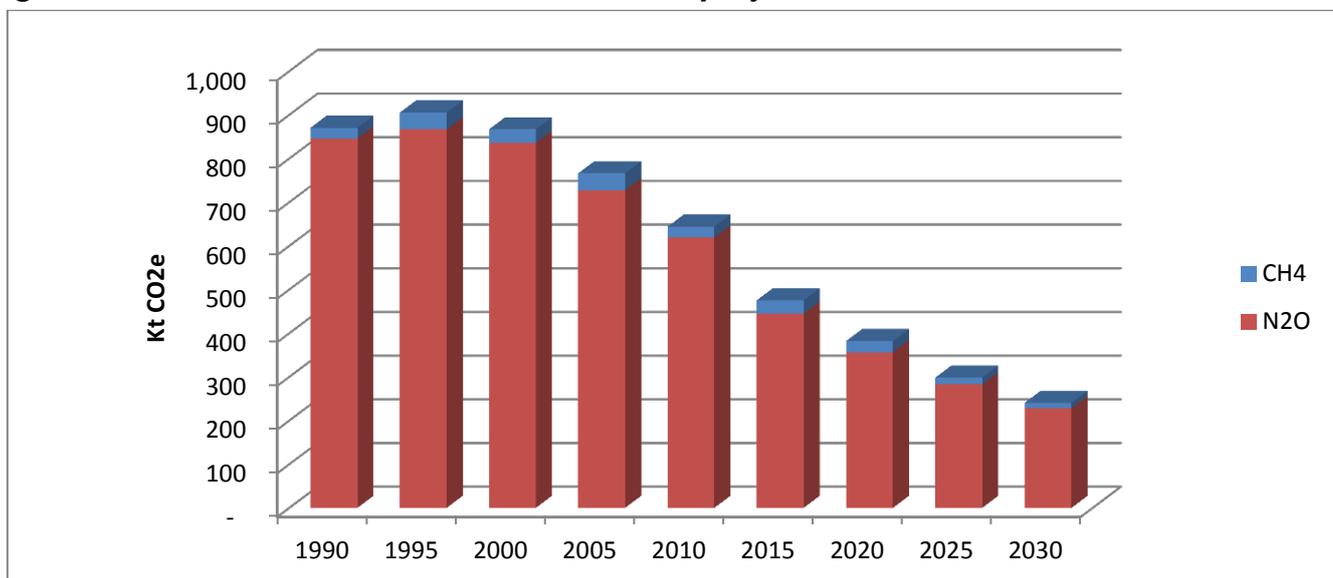


8 LULUCF Sector

The land use/land use change (LULUCF) sector is the smallest sector in terms of contribution to overall non-CO₂ emissions considered in this report. Emissions in 2011 were approximately 0.6 MtCO₂e, of which approximately 95% were from nitrous oxide (N₂O), which equates to approximately 0.7% of total non-CO₂ emissions from all sectors. Remaining emissions are from methane (CH₄).

Since the Autumn 2012 update to the projections, projections from this sector have been updated to reflect the changes in the new GhG Inventory. Further details of this update are present in the sections below. LULUCF sub-sectors in the 1990-2011 GhG Inventory have undergone a broad restructure. New projections for LULUCF will be published in the spring and will be incorporated into the Autumn 2013 projections.

Figure 8.1 – Overall LULUCF sector emissions projections



Overall emissions from LULUCF are projected to be approximately 0.2 MtCO₂e in 2030, representing a reduction of approximately 61% on the 2011 level and 72% on the 1990 level (see [Figure 8.1](#)). The decline in emissions is predominantly due to reduced land disturbance from the conversion of land to crop-land.

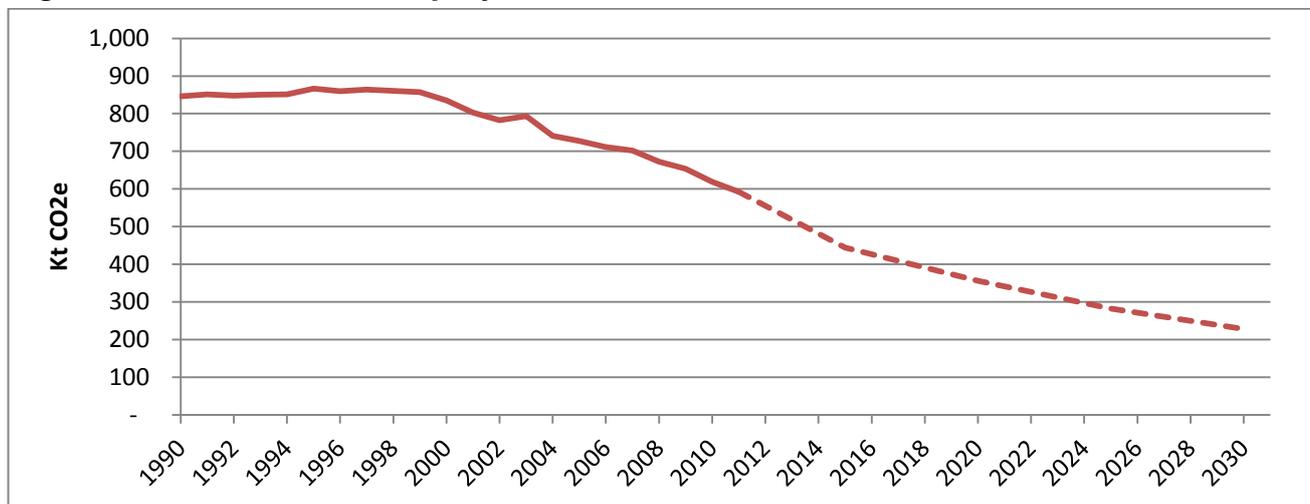
8.1 LULUCF Sector nitrous oxide emissions

Emissions of N₂O accounts for approximately 95% of non-CO₂ GHG emissions in the LULUCF sector. The major source of N₂O is the conversion of land to crop land and the associated disturbance of soil. This source alone results in approximately 87% of N₂O emissions from LULUCF, with the remaining being the result of drainage of organic soils, biomass burning and the application of nitrogen based fertiliser to forested land.

Nitrous oxide emissions had remained broadly static from 1990 until 2000 before declining to approximately 70% of the 1990 level by 2011. This trend is projected to continue at a roughly even pace to 2030, when N₂O emissions are projected to be 0.2 MtCO₂e (see [Figure 8.2](#)). The slow reduction in projected emissions from this source is due to an estimated slow decline in the

rate at which land is converted to crop land, specifically in Wales. The total area of crop land in Scotland, England and Northern Ireland is expected to remain unchanged beyond 2011.

Figure 8.2 – N₂O emissions projections for the LULUCF sector



Changes in LULUCF sector N₂O emissions since the previous update

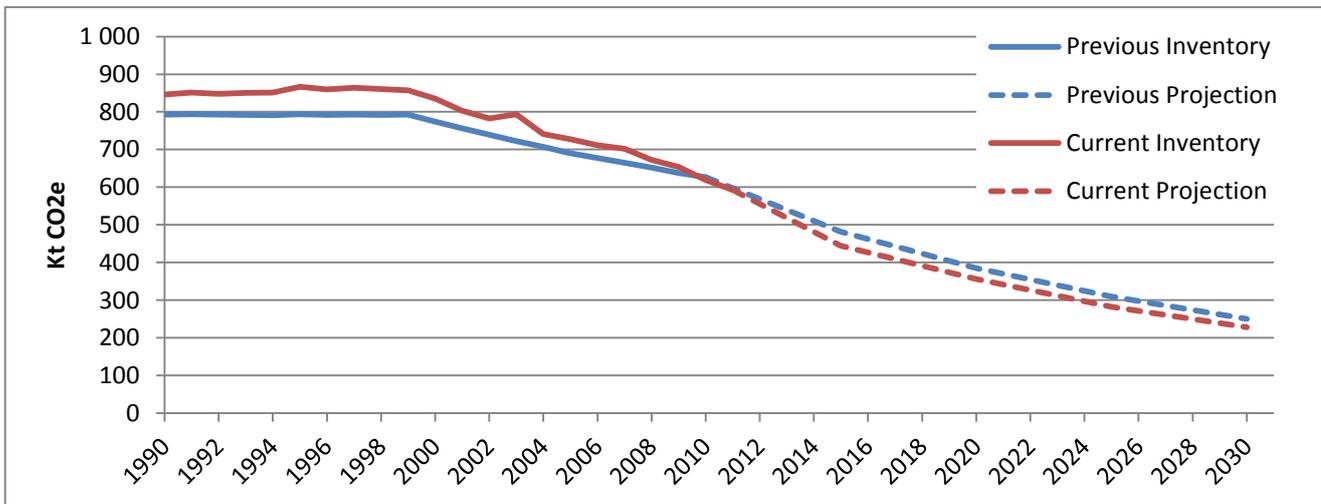
As outlined above the only source of change between the LULUCF sector projections in the Autumn 2012 update and this set of projections has been the inclusion of the new GhG Inventory.

There have been a series of revisions to the inventory in this sector. Those revisions which have the largest impact on the projections are the following:

- New activity data on the drainage of forest soils, which has been included for the first time,
- New methodology and activity data for the calculation of non-forest wildfires and biomass burning.

The combined effects of these changes to the LULUCF inventory have raised the N₂O emissions from this sector in the early part of the time series, emissions in 1990 are now approximately 7% higher than in the previous inventory. However, emissions then decline so that 2010 is approximately 1% lower than the previous inventory. This decline continues into the projected trend with emissions of N₂O now projected to be 0.2 MtCO₂e in 2030, a reduction of approximately 9% on the Autumn 2012 projections. [Figure 8.3](#) highlights the effect of this update on the time series.

Figure 8.3 Comparison of Spring 2013 and Autumn 2012 LULUCF sector N₂O projections

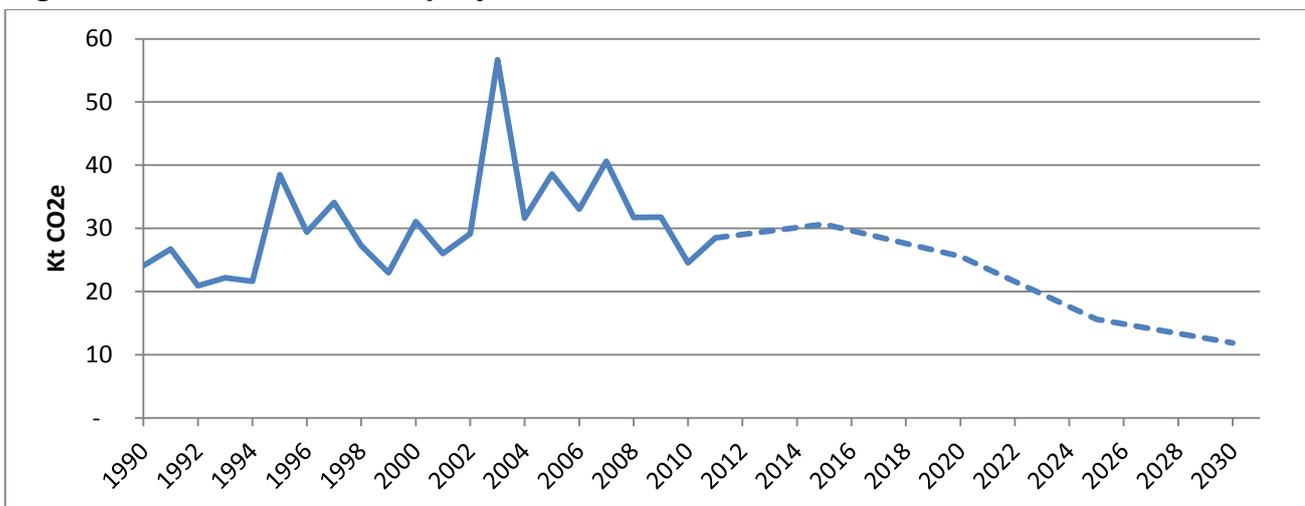


8.2 LULUCF Sector methane emissions

Methane is comparatively a small contributor to overall emissions from LULUCF, representing approximately 5% of emissions in 2011. Emissions of CH₄ from LULUCF are largely driven by biomass burning (wildfires) and deforestation, both of which have large inter-annual variability. **Figure 8.4** highlights this high level of inter-annual variability in the historic inventory data. In order to account for this in projecting wildfire emissions, an extrapolated trend and associated probability distribution function with lagged terms are fitted to 1990 Forestry Commission data, which is reported to the Food and Agriculture Organisation of the United Nations as part of the Global Forest Resource Assessment.

In order to account for variability in the deforestation rate, it is assumed that rates remain constant to 2030, with emissions projected to be 12 kt CO₂e in 2030.

Figure 8.4 – CH₄ emissions projections for the LULUCF sector

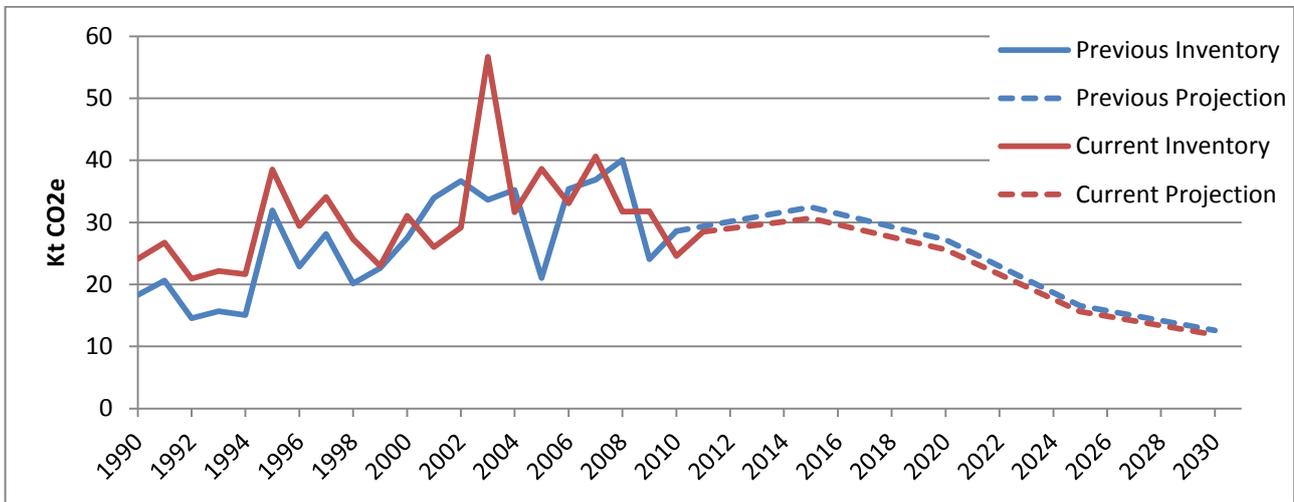


Changes in LULUCF sector CH₄ emissions since the previous update

As outlined above the only source of change between the LULUCF sector projections in the Autumn 2012 update and this set of projections has been the inclusion of the new GhG Inventory. As with N₂O, changes to emissions calculations for biomass burning and wildfires have had the largest effect on the projected emissions

As a result of the changes to these sources in the inventory, projected emissions of CH₄ from the LULUCF sector are now expected to be approximately 2 KtCO₂e lower across the time series in the Spring 2013 update when compared to the Autumn 2012 publication. **Figure 8.5** highlights the effects of these changes.

Figure 8.5 Comparison of Spring 2013 and Autumn 2012 LULUCF sector CH₄ projections

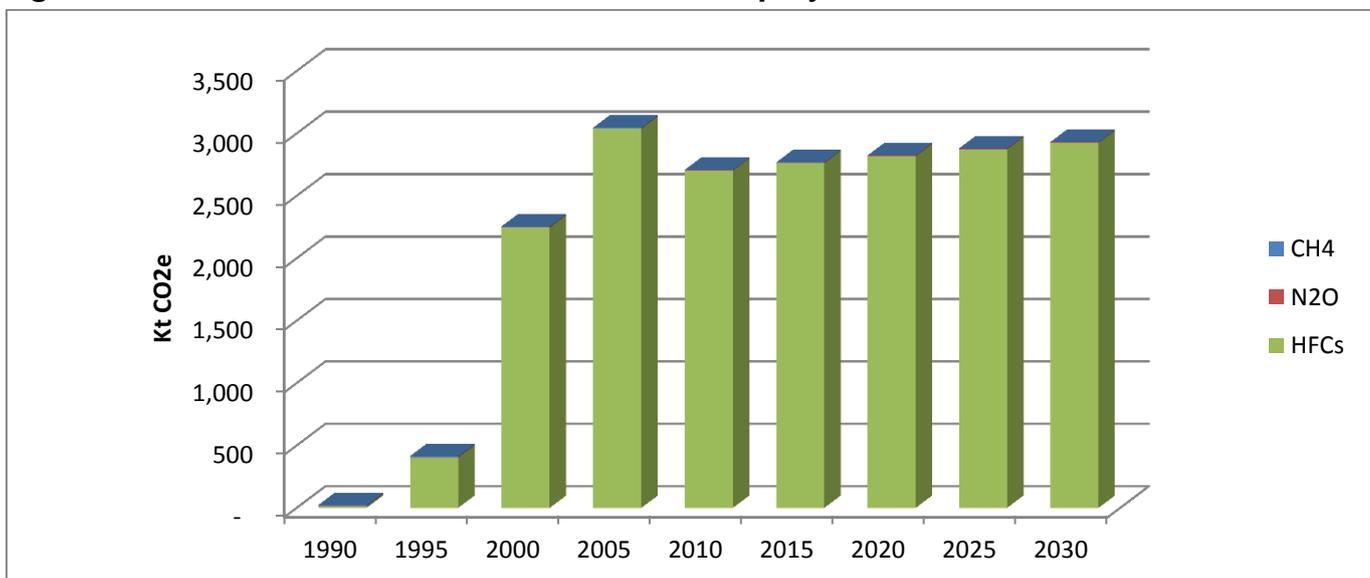


9 Residential Sector

In 2011 non-CO₂ greenhouse gas (GHG) emissions from the residential sector were approximately 2.7 MtCO₂e, representing around 3% of the UK's total non-CO₂ emissions. Nitrous oxide (N₂O), methane (CH₄) and HFC's contribute to non-CO₂ GHG emissions from this sector.

Since the Autumn 2012 update to the projections, projections from this sector have been updated to reflect the changes in the new GhG Inventory. Further details of this update are present in the sections below.

Figure 9.1 – Overall Residential sector emissions projections



Overall emissions from the residential sector are projected to be approximately 2.9 MtCO₂e in 2030. From 2011, they are projected to increase approximately by 8% until 2030, due to a projected increase in HFC emissions. Historically, residential sector emissions have increased approximately 2.7 MtCO₂e since 1990.

9.1 Residential Sector Hydrofluorocarbon emissions

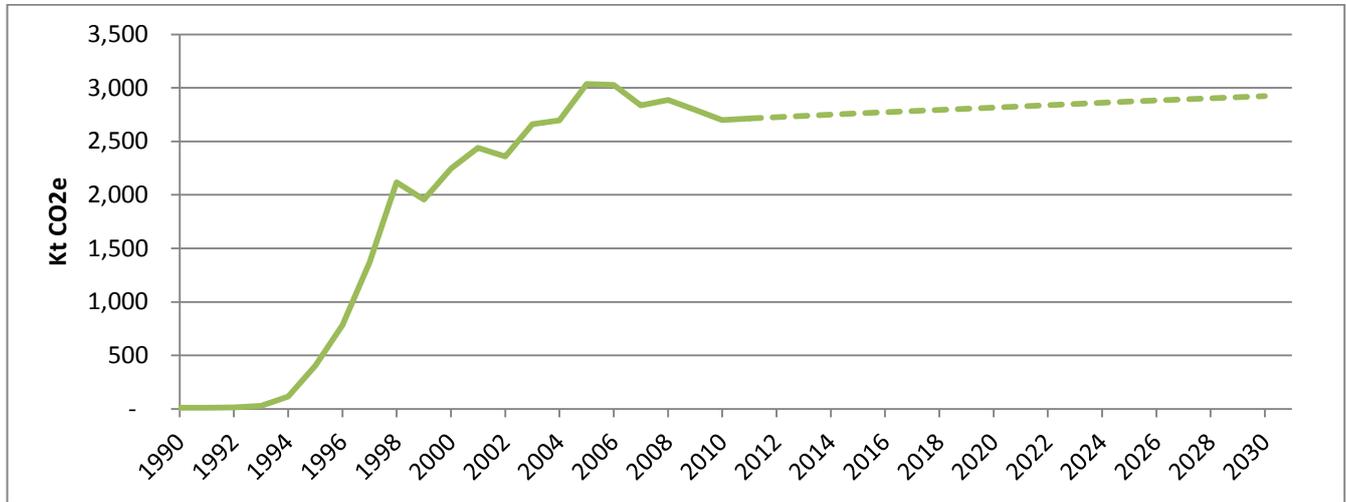
Non-CO₂ emissions from the residential sector are dominated by HFCs. Emissions of HFCs in the residential sector were estimated to be 2.7 MtCO₂e in 2011, representing approximately 99.7% of non-CO₂ GHG emissions from the residential sector, ([Figure 9.2](#)).

These emissions result from aerosols and metered dose inhalers (MDI). Emissions of HFC's have increased rapidly since 1990 due to the phasing out of CFC's due to the Montreal Protocol, resulting in the use of HFC's as replacement gases. Residential HFC emissions are projected to increase by approximately 0.2 MtCO₂e, or 8%, between 2010 and 2030, due to increased emissions from MDI as a result of increased UK population size ([AEA, 2008](#)).

The EU's F-gas regulation is not expected to drive the replacement of HFC's with new lower GWP replacement gases in this specific sector, because no alternative compounds have been identified that meet the stringent criteria for delivering inhaled medication. Emissions from

aerosols are expected to remain constant because no clear trend in emissions is observed in the historic time-series (AEA, 2010).

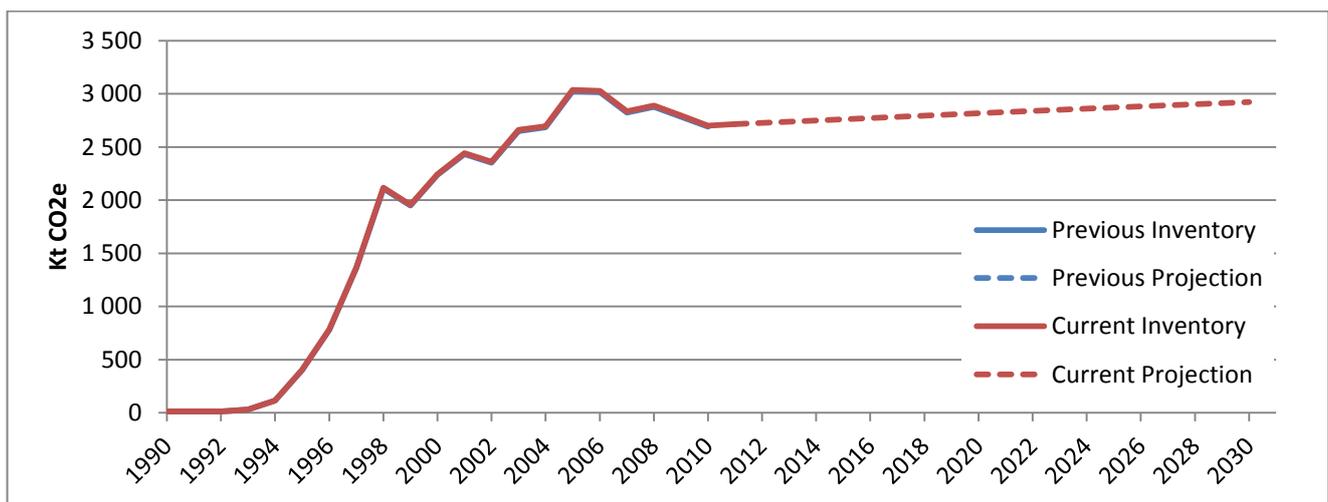
Figure 9.2 – HFC emissions projections for the Residential sector



Changes in Residential sector HFC emissions since the previous update

There have been no significant changes to the projections of HFCs from this sector. The incorporation of the new GhG Inventory has led to a slight decrease in projections of approximately 20 ktCO₂e in 2030. This is due to rebaselining against the latest inventory year. Figure 9.3 highlights this very small change.

Figure 9.3 Comparison of Spring 2013 and Autumn 2012 Residential sector HFC projections



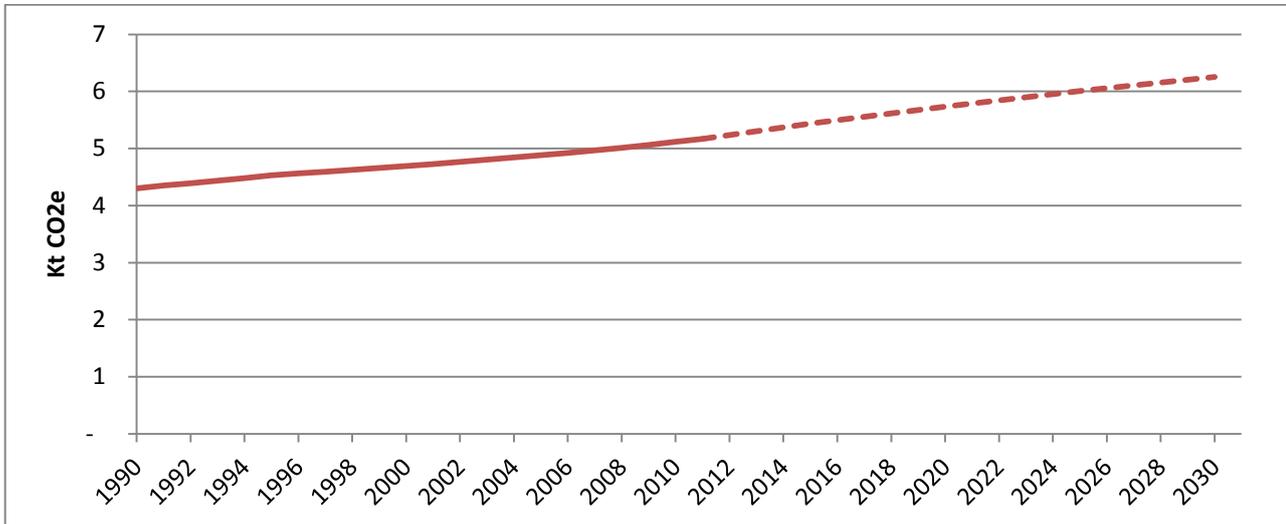
9.2 Residential Sector nitrous oxide emissions

Nitrous oxide emissions were estimated to be 5.1 ktCO₂e in 2011, representing approximately 0.2% of non-CO₂ GHG emissions from the residential sector. These emissions result from the use of house and garden machinery.

Historically, N₂O emissions have increased approximately 19% since 1990. Emissions are projected to increase by approximately 1.2 ktCO₂e, or 22%, between 2010 and 2030 (see

Figure 9.4). These percentage increases may be misleading though, as the absolute emissions values are very small.

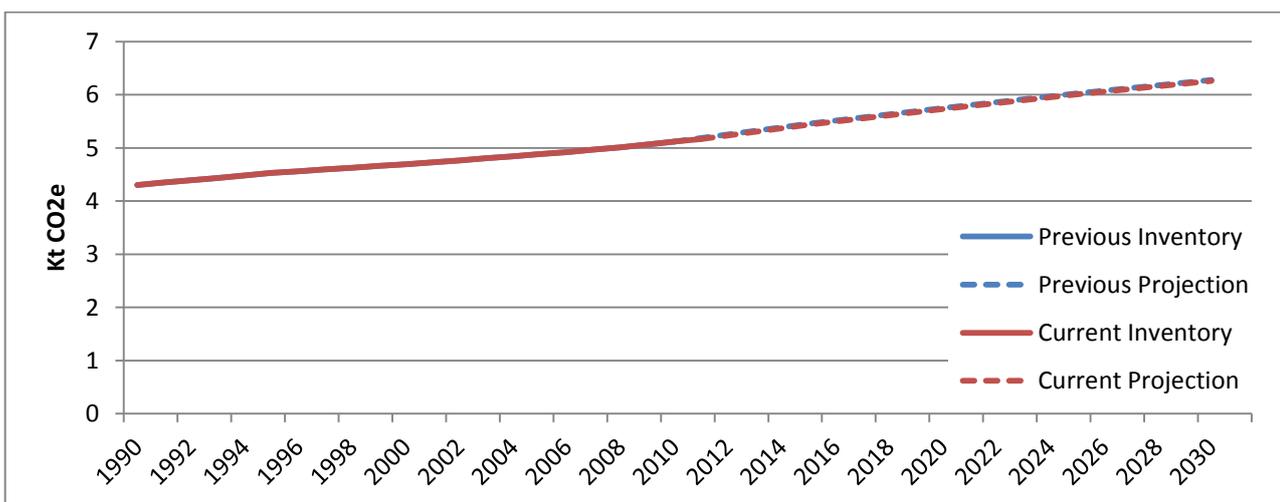
Figure 9.4 – N₂O emissions projections for the Residential sector



Changes in Residential sector N₂O emissions since the previous update

There have been no significant changes to the projections of N₂O from this sector. The incorporation of the new GhG Inventory has led to an almost negligible increase in projections of approximately 0.4 ktCO₂e in 2030. This is due to rebaselining against the latest inventory year. Figure 9.5 highlights this very small change.

Figure 9.5 Comparison of Spring 2013 and Autumn 2012 Residential sector N₂O projections

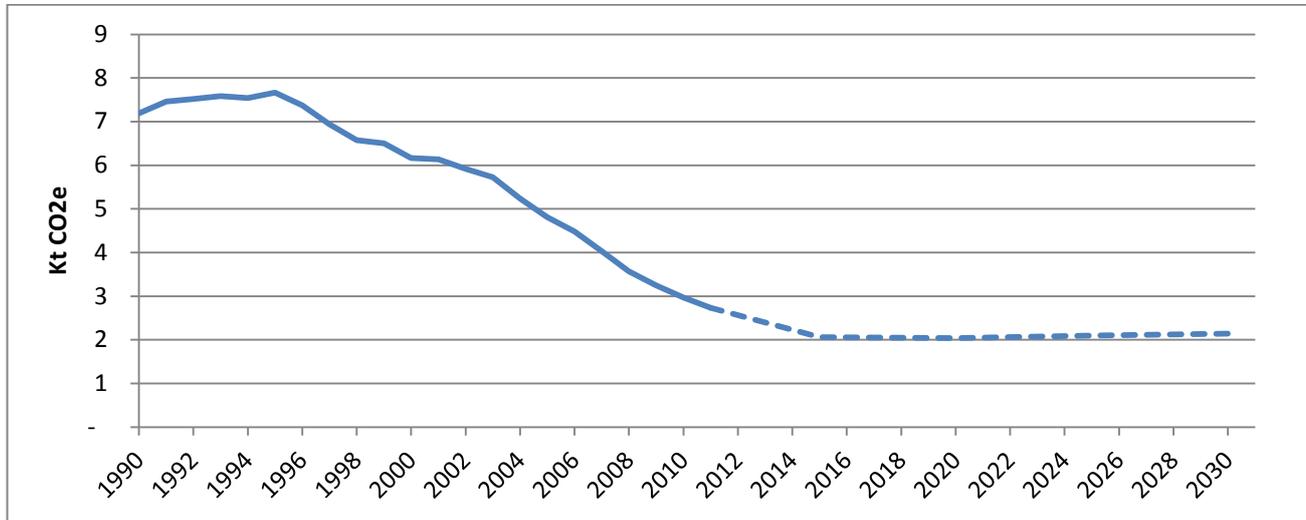


9.3 Residential Sector methane emissions

Methane emissions were estimated to be 3 ktCO₂e in 2011, representing approximately 0.1% of non-CO₂ GHG emissions from the residential sector. These emissions result from house and garden machinery, and accidental fires in vehicles. Historically, CH₄ emissions have decreased approximately 59% since 1990. Emissions are projected to decrease by approximately 0.6 ktCO₂e, or 26%, between 2011 and 2030. These percentage increases may be misleading

though, as the absolute emissions values are very small. **Figure 9.6** highlights the latest historic and projected trends for residential sector CH₄ emissions.

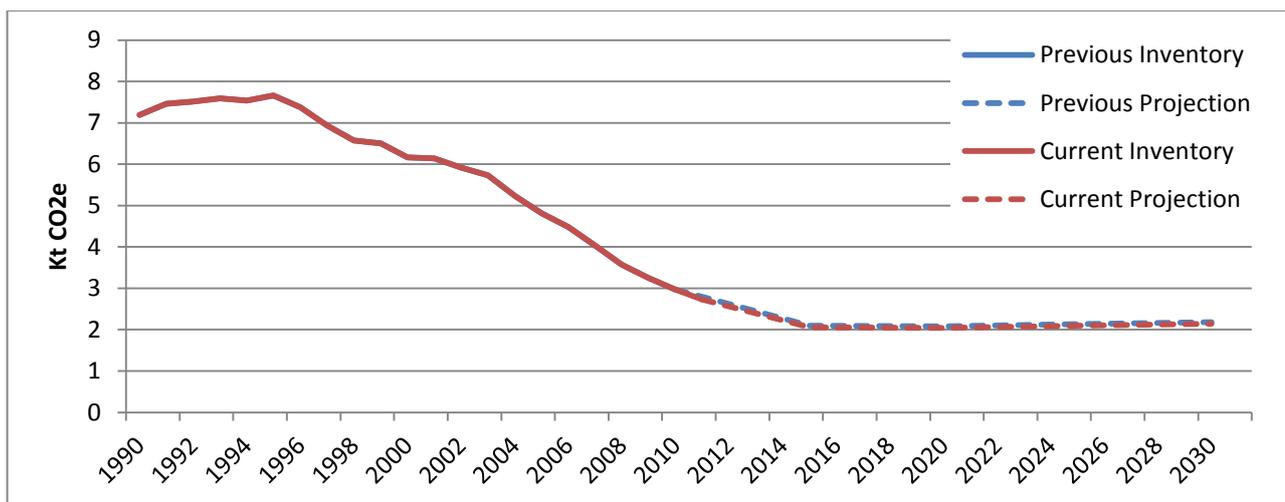
Figure 9.6 – CH₄ emissions projections for the Residential sector



Changes in Residential sector CH₄ emissions since the previous update

There have been no significant changes to the projections of CH₄ from this sector. The incorporation of the new GhG Inventory has led to an almost negligible decrease in projections of approximately 0.04 kt CO₂e by 2030. This is due to rebaselining against the latest inventory year. **Figure 9.7** highlights this very small change.

Figure 9.7 Comparison of Spring 2013 and Autumn 2012 Residential sector N₂O projections

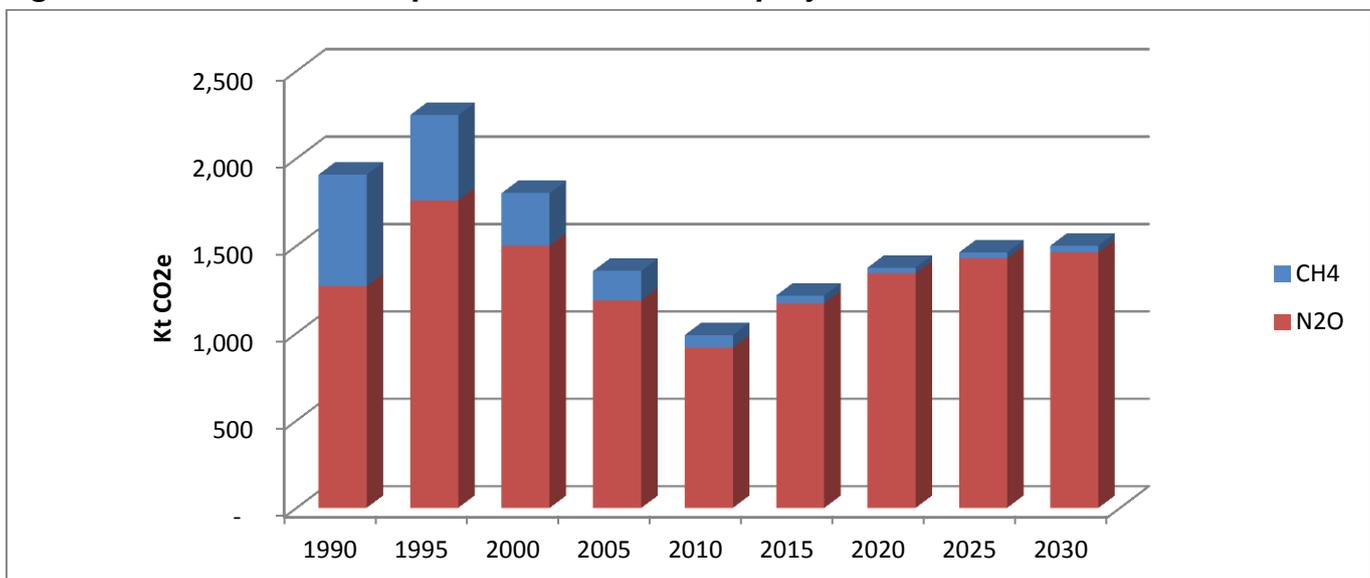


10 Transport Sector

The transport sector is the second smallest contributor of total non-CO₂ emissions. In 2011 it represented approximately 1 MtCO₂e, equivalent to approximately 1% of total non-CO₂ greenhouse gas emissions. Two gases represent the non-CO₂ contribution to emissions from this sector, nitrous oxide (N₂O) and methane (CH₄).

Since the Autumn 2012 update to the projections, projections from this sector have been updated to reflect the changes in the new GhG Inventory. Further details of this update are present in the sections below.

Figure 10.1 – Overall Transport sector emissions projections



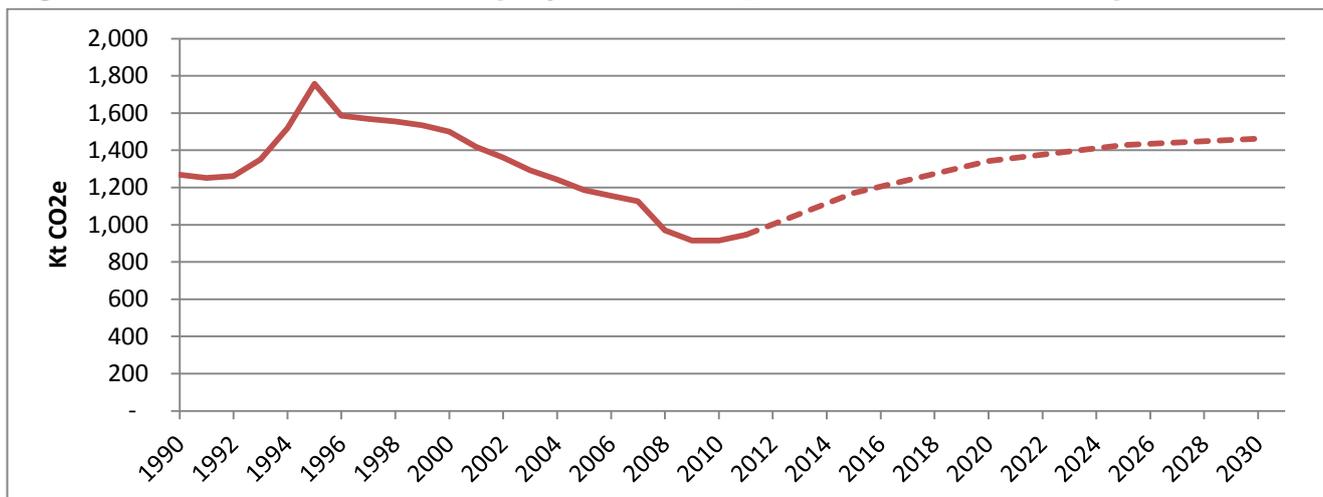
Overall emissions from the transport sector are projected to be approximately 1.5 MtCO₂e in 2030, which corresponds to a projected increase in emissions of approximately 48% on the 2011 level (See Figure 10.1). However, overall emissions from the transport sector have decreased by 47% from 1990 level, resulting in projected emissions in 2030 being approximately 21% lower than in 1990.

The increase in projected overall emissions from the transport sector is being driven by N₂O emissions from new road transport vehicles with emissions constraints on nitrogen oxides (NO_x), which emit higher amounts of N₂O. Further explanation of this is contained in [Section 10.1](#).

10.1 Transport sector nitrous oxide emissions

Nitrous oxide provides by far the most significant contribution to non-CO₂ emissions from the transport sector. In 2011 N₂O represents approximately 94% of non-CO₂ emissions from transport, rising to approximately 98% by 2030.

Road transport, particularly cars, are the highest contributor to the transport sector's N₂O emissions across the projections time series, emitting approximately 80% of the N₂O from transport in 2011, this proportion remains relatively static out to 2030 as a decline in petrol car emissions is compensated by a rise in those from diesel.

Figure 10.2 Historical trend and projections of N₂O emissions from transport

N₂O from the transport sector is projected to increase from approximately 1 MtCO₂e in 2011 to approximately 1.5 MtCO₂e in 2030 (see [Figure 10.2](#)). This projected rise is predominantly being driven by changes in the road transport categories.

The trends in projected emissions from road transport cannot be explained by a single factor but are dictated by a combination of factors. These are mainly the rate of traffic growth for each vehicle type, the relative differences in emission factors for each vehicle type and across the Euro classes and the turnover in the vehicle fleet. There can be both combining and competing effects on the trends.

N₂O emissions from road vehicles are affected by technologies introduced to control other air pollutant emissions which are regulated, especially NO_x. In particular, the Euro standards for petrol cars require the fitting of three-way catalyst systems. Initially, these led to higher N₂O emissions as a result of the unintended formation of N₂O as a by-product of the NO_x reduction process on the catalyst surface. Improved catalyst formulations are most likely to be the cause of the lower factors for more recent Euro standards, however, other factors may be driving the trend. This is reflected in the fall in emissions in the 2000's.

With respect to HGVs and buses, emissions factors have been increasing since the introduction of new vehicles registered since around 2005. The reason for this is again likely to be due to measures aimed at controlling NO_x and in particular the use of Selective Catalytic Reduction (SCR) which involves injecting urea (a nitrogen compound) into the exhaust stream. This can cause the unintended formation of N₂O in the NO_x reduction process.

The steeper rise in projections from 2011 is mainly due to the increased proportion of diesel powered cars in the car fleet and penetration of higher emitting new HGVs in the fleet which eventually levels off causing the rate of increase to slow down.

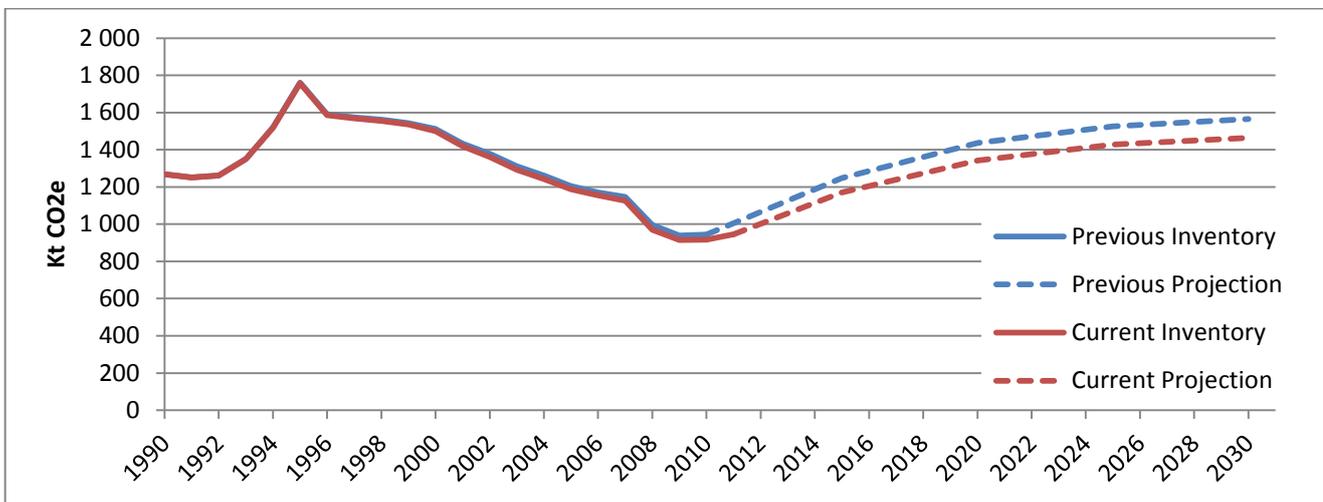
Changes in transport sector nitrous oxide emissions since the previous update

As mentioned above, the only update to this sector since the publication of the Autumn 2012 projections has been the inclusion and rebaselining to the latest GhG inventory. There have been a number of revisions to the transport sector in the latest inventory which have impacted these projections. Of these revisions, the most significant are:

- Updated vehicle km data, particularly for minor roads and a new vehicle km time series for motorcycles,
- Updated motorcycle sales data,
- New data on vehicle km travelled by HGV's, split by weight class,
- New data on the London bus fleet, providing vehicle km splits by weight class,
- A series of updates to the N₂O emissions factors for HGVs, coaches and London buses,
- Revised data on petrol and diesel sales from 2007 to 2010.

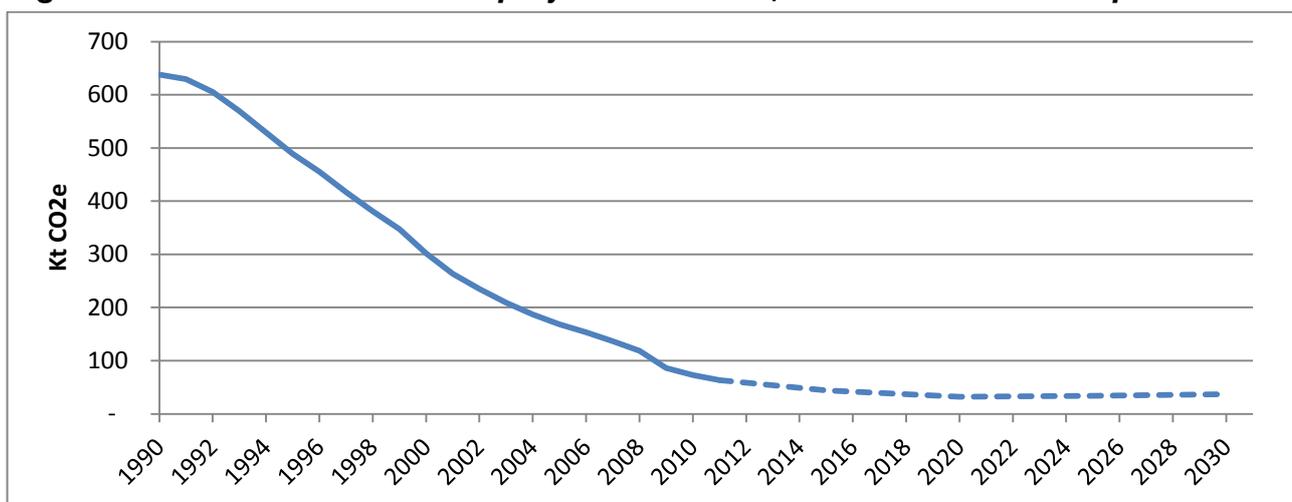
The combined effect of these revisions to N₂O emissions from the transport sector have resulted in projected emissions being lower when compared with the Autumn 2012 publication. **Figure 10.3** below highlights the effects of this change. Emissions are now projected to be approximately 6% lower across the time series when compared to the Autumn 2012 publication

Figure 10.3 Spring 2013 and Autumn 2012 transport sector N₂O projections



10.2 Transport sector methane emissions

Methane contributes a marginal proportion of the total non-CO₂ greenhouse gas emissions from the transport sector, representing approximately 6% of emissions from this sector in 2011 and declining to approximately 2% in 2030. As with N₂O from the transport sector, road transport is the most significant contributor to CH₄ emissions, representing approximately 90% of CH₄ emissions from the transport sector in 2030. Air transport, including military, by comparison account for approximately 8%.

Figure 10.4 Historical trend and projections of CH₄ emissions from transport

Emissions of CH₄ from the transport sector have declined markedly since 1990, displaying a 90% reduction between 1990 and 2011. The projected trend is for CH₄ emissions to continue to reduce, albeit by a much slower rate, a further 4% lower on 1990 levels by 2030. Emissions are therefore projected to be approximately 37 ktCO₂e in 2030.

Methane emissions from road vehicles are not regulated by the Euro emission standards but are affected by technologies introduced to control other air pollutant emissions which are regulated, especially total hydrocarbons. These measures include three-way catalysts for petrol vehicles and oxidation catalysts for diesel vehicles, and general improvements in engine design and management. Thus, CH₄ emission factors broadly fall across the projected time series in line with the reductions in hydrocarbon emissions.

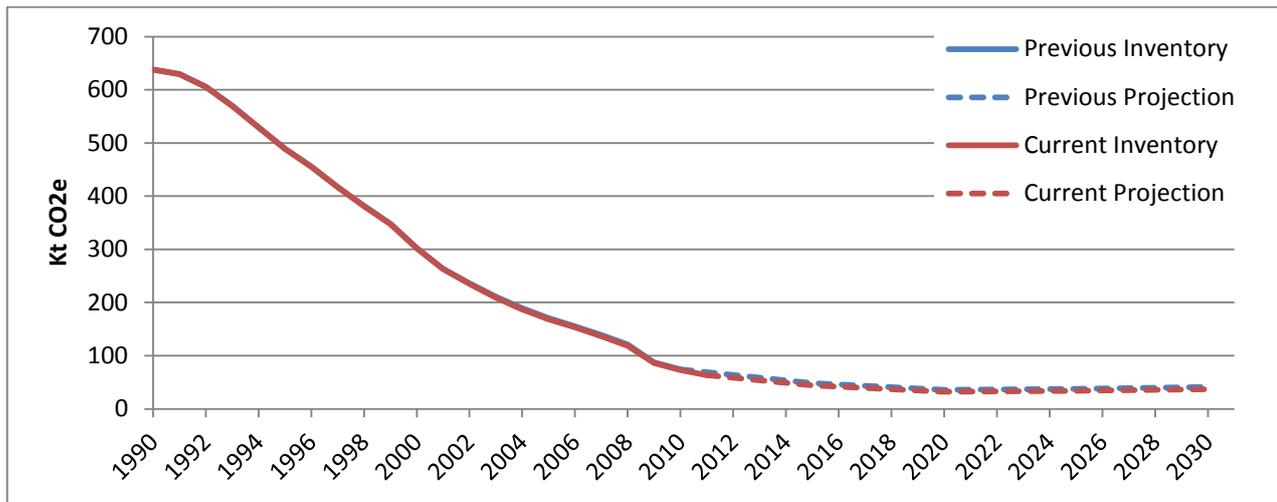
The trends in projected emissions from road transport cannot be explained by a single factor but are dictated by a combination of factors. These are mainly the rate of traffic growth for each vehicle type, the relative differences in emission factors for each vehicle type and across the Euro classes and the turnover in the vehicle fleet. There can be both combining and competing effects on the trends. The combination of these factors leads to the trend displayed in [Figure 10.4](#) above, projecting only a slight further decrease in transport CH₄ emissions going forward.

Changes in transport sector methane emissions since the previous update

As detailed in the section on transport emissions of N₂O above, the new GhG inventory contains a series of revisions which impact the projections. The revisions listed in the N₂O section are applicable with reference to CH₄, with the exception of revisions to the N₂O emissions factors.

The effects of these revisions are to marginally decrease the projected emissions of CH₄ from the transport sector, when compared with the Autumn 2012 projections. [Figure 10.5](#) below highlights the difference these changes have made. Projections are now expected to be approximately 9% or 3 ktCO₂e lower from 2015 to 2030 when compared with the previous estimates.

Figure 10.5 Spring 2012 and Autumn 2012 transport sector CH₄ projections

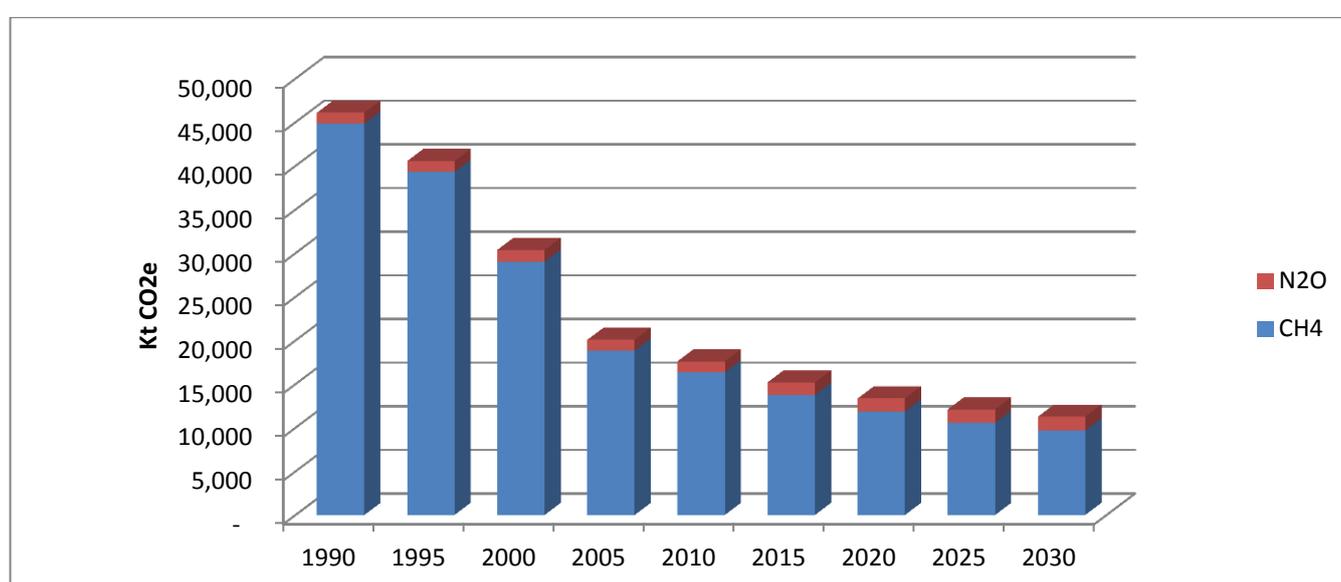


11 Waste Management Sector

In 2011 non-CO₂ greenhouse gas (GhG) emissions from the waste management sector were approximately 17 MtCO₂e, representing around 19% of the UK's total non-CO₂ emissions. Two gases represent the non-CO₂ contribution to emissions from this sector, nitrous oxide (N₂O) and methane (CH₄). **Figure 11.1** below highlights the breakdown in emissions by gases for the waste management sector.

The only change which has been made to this sector since the previous publication of the non-CO₂ projections has been the inclusion of the latest GhG Inventory.

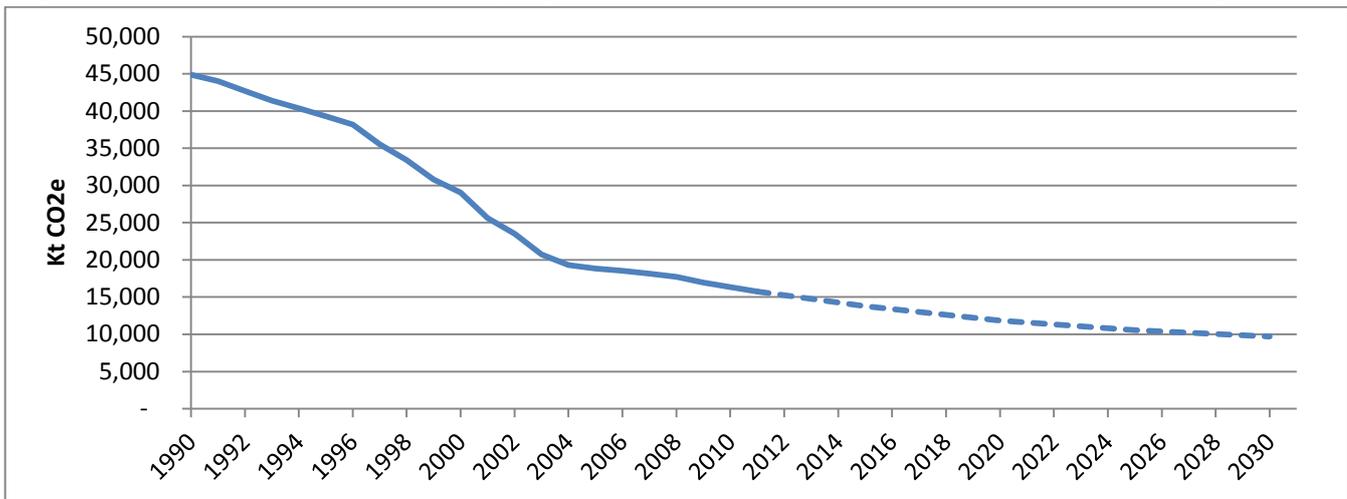
Figure 11.1 Non-CO₂ GHG emissions projections for the waste management sector



Overall emissions from the waste management sector are projected to be approximately 11 MtCO₂e in 2030, which corresponds to a decrease in emissions of approximately 34% from 2011. Historically, waste management emissions have decreased by 29 MtCO₂e since 1990, which equates to a reduction of approximately 63%. Both historic and projected emissions reductions are dominated by significant reductions in landfill waste emissions.

11.1 Waste management methane emissions

Emissions of CH₄ were estimated to be approximately 16 MtCO₂e in 2011, representing approximately 93% of non-CO₂ GHG emissions from the waste management sector. Emissions from landfill waste represent approximately 90% of waste management CH₄, with industrial waste water treatment and sewage sludge decomposition also contributing. There has been a significant reduction in the historic emissions trend since 1990 of around 65%. Emissions are projected to decrease by approximately 6 MtCO₂e, or 39%, between 2011 and 2030 (see **Figure 11.2**). This is expected as a result of reductions in the amount of waste sent to landfill.

Figure 11.2 Historical trend and projections of CH₄ emissions from waste management


Projected CH₄ emissions from **landfill waste** are estimated using a model, MELMod, which is based on the first-order decay International Panel on Climate Change (IPCC) methodology, and is summarised in the UK's National Inventory Report (NIR).

Emissions from landfill are dominated by emissions from waste already sent to landfill, i.e. historical waste. The decay of this waste drives the observed reduction of approximately 45% in CH₄ emissions from this source. Methane emitted from waste already in landfill will reduce over time, particularly from waste in older landfill sites with little or no CH₄ capture technology.

With respect to future waste sent to landfill it is projected that mass of waste sent to landfill will decrease by approximately 15% from 2011 to 2030, based on projections of waste arisings from Local Authority Collected Waste (LACW) to 2019, and Commercial & Industrial (C&I) waste to 2014. As no additional information is available on projected emissions from this category beyond 2019 and 2014, volumes of landfill waste are assumed to remain constant after these respective years.

Projected CH₄ emissions from waste water treatment are based on a model used in the historic inventory (Hobson, 1996). Projections to 2030 are based on implied emission factors for various disposal routes and projected changes to the amount disposed of to each route (e.g. due to the Landfill Directive), and population growth. The assumptions made on sewage sludge disposal routes in 2020 have been taken from an Entec report (Entec, 2006a+b), also used in the Autumn 2012 and previous publications.

Projected CH₄ emissions from **waste incineration** (not for power generation, and including the categories of accidental vehicles fires, incineration, incineration of clinical waste, and incineration of sewage sludge) are assumed to remain constant as the future levels of activities in these categories is unknown.

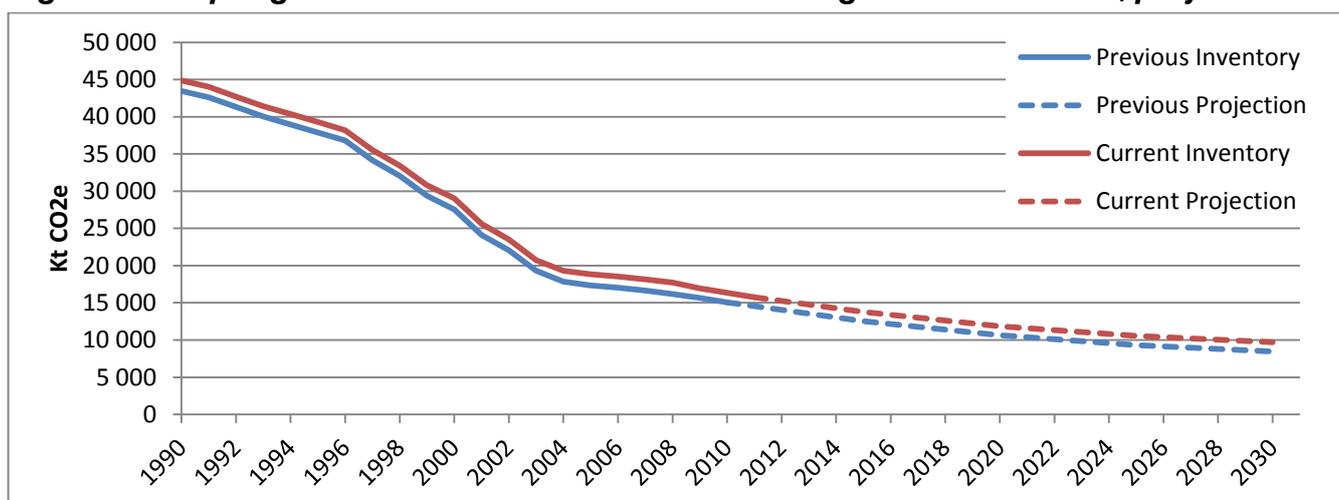
Changes in waste management sector methane emissions since the previous update

The only source of change between this update and the previous projections has been the inclusion of the latest GhG inventory. As explained in the methodology section of this report, the projections have been rebaselined against the latest GhG inventory. Revisions to the waste inventory which have impacted the projections of CH₄ are as follows:

- The inclusion of waste water treatment as a new category across the time series. In the absence of more detailed data, this source is projected to flat line going forwards,
- Improved coverage of data from UK water companies which has had the effect of increasing the emissions factor for CH₄ from municipal waste water treatment. There has also been an increase in the emissions factor used to calculate CH₄ emissions from sewage sludge disposed on agricultural land.

The effect of these changes to the inventory has been to increase the projected trend in emissions across the time series, by approximately 9% in 2015, rising to 11% in 2030. **Figure 11.3** highlights the effects of these changes.

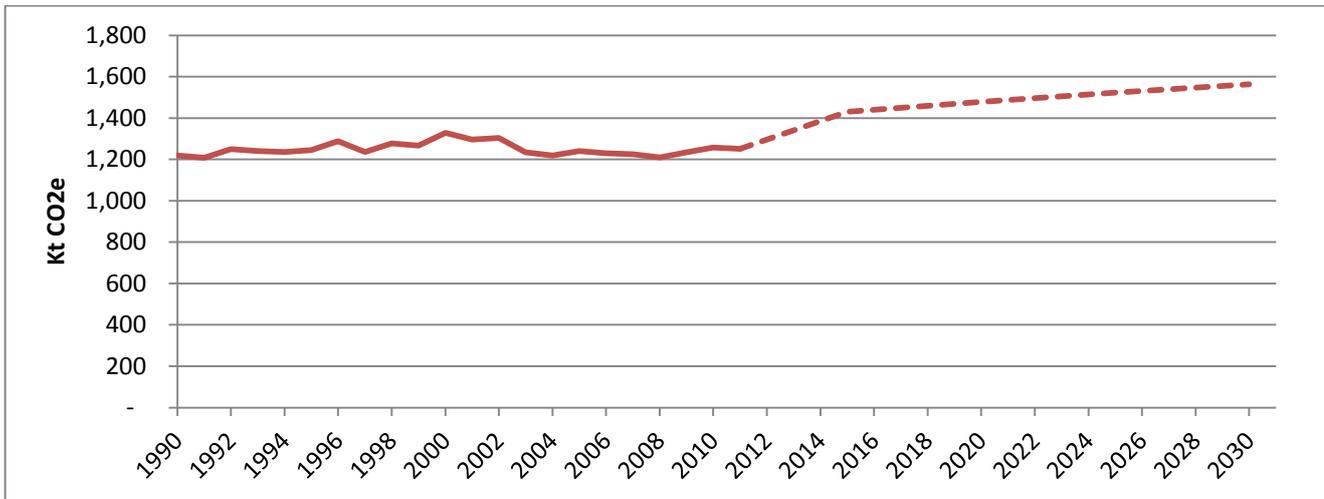
Figure 11.3 Spring 2012 and Autumn 2012 waste management sector CH₄ projections



11.2 Waste management nitrous oxide emissions

Emissions of N₂O were estimated to be approximately 1.3 MtCO₂e in 2011, representing approximately 7% of non-CO₂ GHG emissions from the waste management sector. These emissions result mainly from sewage sludge decomposition, incineration of sewage sludge, and other incineration. There has been no significant change in the emissions trend since 1990. Emissions are projected to increase by approximately 300 ktCO₂e, or 25%, between 2011 and 2030 due to a projected increase in sewage sludge decomposition in line with population growth (see **Figure 11.4**).

Figure 11.4 Historical trend and projections of nitrous oxide emissions from waste management



Projections of N₂O emissions from **waste water treatment** are based on a constant emission factor per head of population ([GAD, 2008](#)). The historic inventory is based on protein consumption and population data. The projections assume that protein consumption will remain unchanged going forwards.

Projected emissions from **waste incineration** (not for power generation, and including the categories of accidental vehicles fires, incineration, incineration of clinical waste, and incineration of sewage sludge) are assumed to remain constant as the future levels of activities in these categories is unknown.

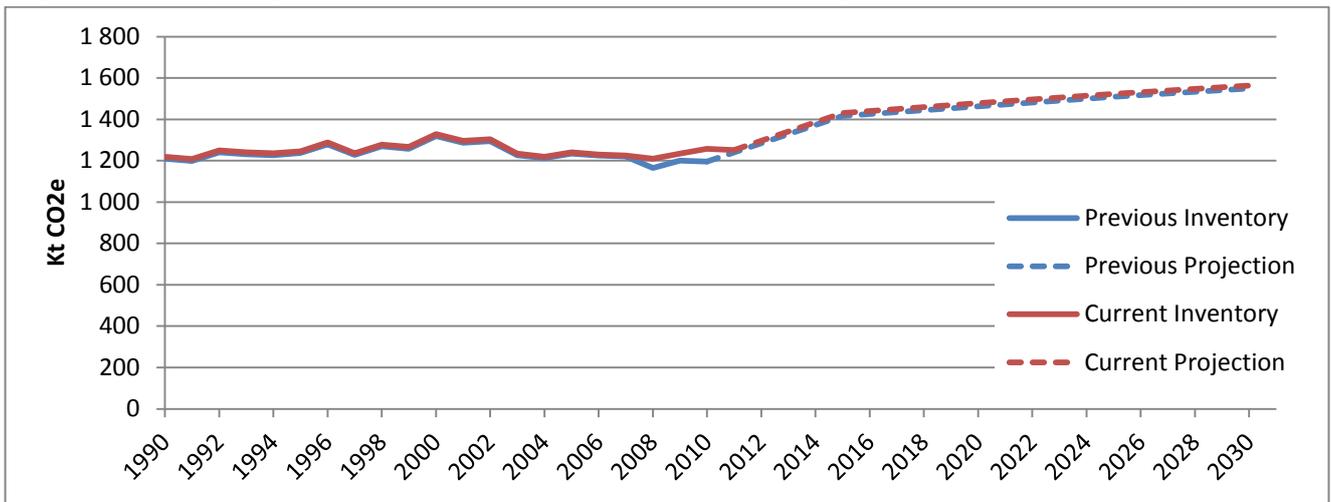
Changes in waste management sector nitrous oxide emissions since the previous update

As was the case with CH₄ from the waste management sector, the only update which has been included in the Spring 2013 update has been the rebaselining to the latest GhG inventory. The only significant revision to the inventory which has had an impact on the projections is as follows:

- N₂O emissions from the incineration of chemical waste had previously been excluded, these are now included. The projected trend has been flatlined in the absence of more detailed data,

The effect of this change has been to increase N₂O emissions from the waste management sector by approximately 1% across the projected time series. [Figure 11.5](#). highlights the effects of these revisions on the historic and projected time series.

Figure 11.5 Spring 2012 and Autumn 2012 waste management sector N₂O projections



12 Uncertainties

12.1 Uncertainties methodology/approach

The DECC non-CO₂ projections model contains an uncertainties module which comprises a simplified Monte Carlo simulation run at the National Communication level in order to quantify uncertainties in the emissions projections.

This module assumes that the latest inventory year has no associated uncertainty, and the uncertainties in future years relate only to how different the inventory estimate is likely to be to the projected estimate in that year, ignoring the uncertainty associated with the inventory method; see [AEA 2010b](#) for further detailed explanation of the methodology.

The GHG Inventory uncertainty values are disregarded in this analysis due to the magnitude of the Inventory uncertainties. Including the GHG Inventory uncertainties (specifically N₂O uncertainty: -74% / +263%, see [DECC 2011c](#)) for the non-CO₂ GHGs would result in these larger uncertainties dominating the Monte Carlo simulation and effectively hiding the much smaller (typically +/- 10 to 30% for most sectors at 2020, up to +/- 50% at 2030) uncertainties in the projected trend.

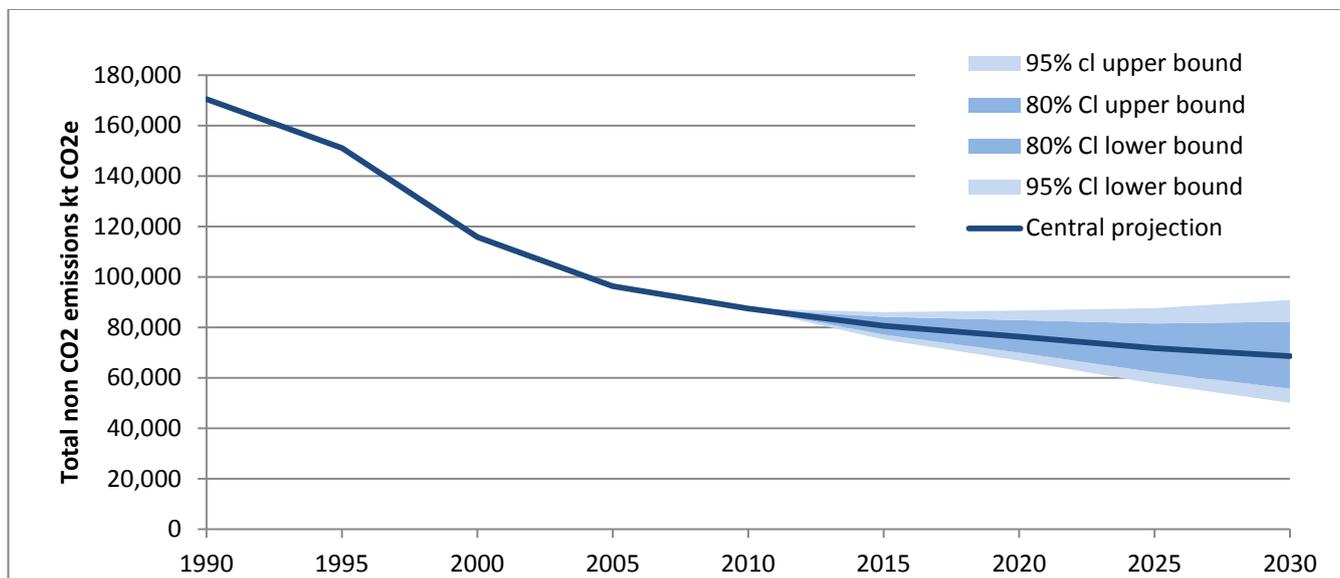
Since the Autumn 2011 update to the projections, the uncertainty on the growth (positive or negative) of the emissions is used as input for the Monte Carlo simulation rather than the uncertainty around each data point, as was used in prior updates. This conclusion logically follows our stated intention to model uncertainty in the trend without incorporating uncertainty in the historic data which is the basis of the trend.

12.2 Uncertainty results

The uncertainty analysis indicated approximately +/- 5% total uncertainty in the emissions for 2011, increasing gradually to around +/- 13% uncertainty at 2020. Beyond 2020 the uncertainty region becomes noticeably asymmetric so at 2030 the lower bound is 27% below the central estimate and the upper bound is approximately 32% above.

This asymmetry is an artefact of analysing the uncertainty in the growth rates rather than on absolute values, and reflects the effect of compounding a percentage increase compared with a percentage decrease: e.g. a 10% increase year on year for 5 years yields a 60% increase whereas a 10% decrease year on year for 5 years results in just a 40% decrease. [Figure 12.1](#) below highlights the uncertainty analysis results around the central projection estimate.

Figure 12.1 Uncertainty analysis for projections used in the Spring 2012 update, as 80% and 95% confidence intervals



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Annex A: Summary of methods used to estimate emissions projections

Methodology for the derivation of projections for each sector are provided below. Where a sector has been updated, each individual sectoral update is explained more fully in the relevant sector chapters.

IPCC Source Categories 4A, 4B, 4D & 4F

4A, 4B & 4D – Agricultural livestock and agricultural soils

Agriculture projections used in this update are based on updated DEFRA projections ([DEFRA 2013](#)), which are in turn based on agricultural activity projections produced by the FAPRI model ([FAPRI 2012](#)) of UK agriculture.

The FAPRI-UK modelling system was created, and is maintained, by Agri-Food Biosciences Institute (AFBI) at Queen's University Belfast. The model represents the UK agricultural sector via supply and demand equations and is broken down to the Devolved Administration level. Key variables modelled are production, consumption, net-trade and prices for the following commodities: Dairy, Beef, Sheep, Pigs, Poultry, Wheat, Barley, Oats, Rapeseed and Liquid Biofuels. Livestock numbers and crop areas are also modelled. The model is fully incorporated within the EU GOLD (Grain, Oilseeds, Livestock & Dairy) system which is run by FAPRI-Missouri. Consequently, the UK model gives projections to 2020 which are consistent with the equilibrium at EU level.

GHG emissions factors, taken from the National Atmospheric Emissions Inventory (NAEI), are then applied to these activity projections to produce GHG emissions estimates.

DEFRA have used the FAPRI projections to 2020 as the basis of their projections to 2030. Methane and N₂O emissions are projected to decline slowly from 2010 to 2019 and then remain constant from 2020 to 2030 under DEFRA's assumptions.

4F1 & 4F5 – Field burning

In the absence of further data, these projections are projected to remain the same as the most up to date Inventory year.

IPCC Source Category 1A2f

1A2f - Industrial off-road mobile machinery

Emissions projections are calculated from a bottom-up approach by the Inventory Agency using machinery- or engine-specific emission factors in g/kWh based on the power of the engine and estimates of the UK population and annual hours of use of each type of machinery. For Industrial machinery, ONS construction statistics and DECC Construction, Industry and Energy growth indexes are used as projections drivers. The methodology follows the Tier 3 methodology described in the latest EMEP/CORINAIR emission inventory guidebook.

IPCC Source Categories 2E and 2F

2F1 – Refrigeration and air conditioning

Refrigeration/air conditioning emissions are estimated using an updated model developed by ICF International ([ICF, 2011](#)), based on revised industry input and a more transparent, robust modelling approach consistent with IPCC guidance. The model has been reorganized from 9 to 13 end-uses, using detailed assumptions to utilise a fully bottom-up approach based on equipment stocks and average charge size from available market data. In the previous model, produced by AEA ([AEA 2010](#)) most end-uses were modelled using a top-down approach based on total refrigerant sales data. This updated model improves the accuracy of emissions allocated to end-uses and improves the understanding of the end-uses to better inform policy.

The updated model was reviewed and validated by comparing estimated refrigerant consumption (calculated as the amount of refrigerant used to manufacture new equipment produced in the UK plus the amount used to service leaking equipment) with annual refrigerant sales data from the British Refrigeration Association (BRA). A full description of the methodology, sources, input assumptions and uncertainties used to update emission estimates by end-use is contained in the above referenced ICF report.

2E & 2F2-2F9 – Production of Halocarbons and SF₆ foam blowing, fire fighting equipment, MDIs, solvents, semiconductors, electrical components, sporting goods and one component foams

Projections from these activities have been calculated using a bottom-up approach based on industry data and growth rates anticipated by industry experts. Full details on the methods and assumptions used to produce these forecasts can be obtained from a series of reports produced by AEA ([AEA, 2008 and 2010](#)) and from the most recent Greenhouse Gas Inventory, to be published in April 2013.

Source category 1B1 – Solid fuels

1B1a - Open coal mines

Projected emissions from working coal mines utilise the DECC model and have been estimated based on projected coal production data (open cast and deep mined). Up to date emission factors from the GHG inventory have been applied to these activity projections for mining, and coal storage and transport.

1B1a - Closed coal mines

Emissions from closed coal mines are calculated using a model by WSP Environmental ([WSP, 2011](#)), which updates an older model produced by White Young Green (WYG). The updates to the model incorporate refinements and additional data sources as well as upgrades to the assumptions made by WYG. Further details of the model can be found in the referenced paper.

1B1b - Solid Smokeless Fuel (SSF) and coke production

All 1B1b categories which are covered in this report ('coke production' and 'solid smokeless fuel production') have been assumed constant in lieu of any appropriate projections data; emissions from these sources are extremely small, <0.01% of total non-CO₂ GHG emissions.

Source category 1B2 – Oil and natural gas

1B2b Gas production

Emissions of methane from leakage from the gas distribution network is the largest methane source in the UK inventory outside of the Agriculture and Waste sectors, comprising approximately 10% of all methane emissions in 2011.

Emissions in this category are projected to decline due to a 30 yr programme (started 2002) to reduce leakage from the gas distribution network by 70%. Projected changes in methane content of natural gas are not considered sufficiently meaningful fluctuations to take account of in the non-CO₂ GHG projections.

Ofgem is currently conducting a consultation on the next round of licensing for the gas distribution network. It is likely that the granting of these licenses will contain commitments on the further reduction of fugitive emissions going forward.

All other emissions in these categories are reported in DECC's UEP publications; see [Annex B](#) for more details.

Source category 2A7 – Other

Emissions from fletton brick production are predicted to remain constant from the current inventory year onwards, having decreased since 2008 due to the closure of one of the two manufacturing plants. Emissions from these sources only contribute a small amount to the emissions totals.

Source category 2B – Chemical industries

2B2 – Nitric acid production

Nitric acid production has been a significant source of N₂O in the UK. Previous consultation with Industry representatives from all operating plants in the UK concluded that nitric acid production is expected to remain constant. Following a DECC consultation (for published documents see [DECC 2011e](#)) the decision was taken for the UK to choose an early opt-in of emissions from nitric acid production into the EU Emissions Trading Scheme (EU ETS). As a result of this, best available technology (BAT) abatement technology is now fitted at the two remaining UK plants, and this is projected to significantly reduce N₂O from the end of 2012, as stated in the Impact Assessment which accompanies the Consultation document.

2B3 – Adipic acid production

In 2009 the last remaining Adipic Acid production plant in the UK closed; emissions from this source are projected to be zero in from 2010 onwards.

Source category 2C – Metal production

2C4 – Magnesium cover gas

Emissions estimates from this source are based on data and information obtained from plant operators and industry experts. Reduction in the use of SF₆ as a cover gas is expected to

continue with the replacement of it's use with that of HFCs. Further information on the methodology employed can be found in a report produced by AEA ([AEA, 2010](#)) and the National Inventory Report, expected to be published in April 2013.

Sector 5 – Land Use, Land Use Change and Forestry

Estimates of N₂O emissions due to disturbance associated with land use conversion to cropland, N₂O emissions from drained wetlands used for peat extraction and non-CO₂ GHG emissions from biomass burning are calculated using IPCC Tier 1 methodologies. Details of activity data and emission factors are given in Annex 3.7 of the 1990-2009 UK greenhouse gas inventory. Emissions of methane and N₂O from the LULUCF sector are supplied by the Centre for Ecology and Hydrology ([CEH, 2011](#)).

Sector 6 – Waste

6A1 - Waste disposed to landfill

The current set of projections are based on a recent update to the data in the UK model used to estimate emissions from managed waste disposal on land, MELMod 2012 v1.1. The model is based on the first-order decay (FOD) methodology described in the IPCC Good Practice Guidance and IPCC Uncertainty Management in National Greenhouse Gas Inventories, and is summarised in the UK's 2009 National Inventory Report (NIR).

6B2 - Wastewater treatment

Emissions of methane from waste water treatment to 2010 have been taken from the Hobson model report ([Hobson, 1996](#)). This is the same data source used for the historic inventory. Projections to 2030 are based on implied emission factors for various disposal routes and projected changes to the amount disposed of to each route (e.g. due to the Landfill Directive), and population growth.

The assumptions made on sewage sludge disposal routes in 2020 have been taken from an Entec, also used in the Spring 2012 and previous publications.

Projections of N₂O emissions from waste water treatment are based on a constant emission factor per head of population. The historic inventory is based on protein consumption and population data. The projections assume that protein consumption will remain unchanged going forwards.

6C - Waste incineration

Estimated projected emissions from waste incineration (not for power generation, and including the categories of accidental vehicles fires, incineration, incineration of clinical waste, and incineration of sewage sludge) are assumed to remain constant as the future levels of activities in these categories is unknown.

Annex B: Categories now reported as part of DECC's Energy Projections

Prior to the Autumn 2011 projections update, all non-CO₂ GHG projections publications had reported emissions estimates as given in the most recently published GHG Inventory for all CH₄, N₂O, HFC, PFC and SF₆ sources for all IPCC categories where they occur.

From the Autumn 2011 set of projections forward, new updates exclude a selection of IPCC categories whose projected trend is reliant on information within DECC's UEP publication. These projections will continue to be produced and presented in DECC's UEP publications.

A full list of categories which contain emissions of non-CO₂ gases but are not reported in the non-CO₂ GHG projections is presented below.

Categories will be continually reviewed and further additional categories may be added or removed.

Table B.1 Summary by Gas / IPCC category of non-CO₂ GHG emissions to be produced and reported in DECC's UEP

Gas	NC Sector	IPCC Category	SourceName	Gas	NC Sector	IPCC Category	SourceName
CH4	Agriculture	1A4c	Agriculture - mobile machinery	N2O	Agriculture	1A4c	Agriculture - mobile machinery
			Agriculture - stationary combustion				Agriculture - stationary combustion
			Miscellaneous industrial/commercial combustion				Miscellaneous industrial/commercial combustion
	Business	1A2a-1A2f	Blast furnaces		Business	1A2a-1A2f	Blast furnaces
			Iron and steel - combustion plant				Iron and steel - combustion plant
			1A2b Non-Ferrous Metal (combustion)				1A2b Non-Ferrous Metal (combustion)
			1A2c Ammonia production - combustion				1A2c Ammonia production - combustion
			Chemicals (combustion)				Chemicals (combustion)
			1A2d Pulp, Paper and Print (combustion)				1A2d Pulp, Paper and Print (combustion)
			1A2e Food & drink, tobacco (combustion)				1A2e Food & drink, tobacco (combustion)
			1A2f Autogeneration - exported to grid				1A2f Autogeneration - exported to grid
			Autogenerators				Autogenerators
			Cement production - combustion				Cement production - combustion
			Lime production - non decarbonising				Lime production - non decarbonising
			Other industrial combustion				Other industrial combustion
			1A4a Miscellaneous industrial/commercial combustion				1A4a Miscellaneous industrial/commercial combustion
			Energy Supply				1A1a-1B2cii
	Power stations	Power stations					
	Public sector combustion	Public sector combustion					
	1A1b Refineries - combustion	1A1b Refineries - combustion					
	1A1c Coke production	1A1c Coke production					
	Collieries - combustion	Collieries - combustion					
	Gas production	Gas production					
	Nuclear fuel production	Nuclear fuel production					
	Solid smokeless fuel production	Solid smokeless fuel production					
	Town gas manufacture	Upstream Gas Production - fuel combustion					
	Upstream Gas Production - fuel combustion	Upstream oil and gas production - combustion at gas separation plant					
Upstream oil and gas production - combustion at gas separation plant	Upstream Oil Production - fuel combustion						
Upstream Oil Production - fuel combustion	1B1b Iron and steel - flaring						
1B2a Petroleum processes	1B2a Upstream Oil Production - Offshore Well Testing						
Upstream Oil Production - Offshore Oil Loading	1B2b Upstream Gas Production - Offshore Well Testing						
Upstream Oil Production - Offshore Well Testing	1B2cii Upstream Gas Production - flaring						
Upstream Oil Production - Oil terminal storage	Upstream Oil Production - flaring						
Upstream Oil Production - Onshore Oil Loading							
Upstream Oil Production - process emissions							
1B2b Upstream Gas Production - Gas terminal storage							
Upstream Gas Production - Offshore Well Testing							
Upstream Gas Production - process emissions							
1B2ci Upstream Gas Production - venting							
Upstream Oil Production - venting							
1B2cii Upstream Gas Production - flaring							
Upstream Oil Production - flaring							
Industrial Process	1A2a, 2B5, 2C1	Sinter production	Industrial Process	1A2a, 2C1	Sinter production		
		Chemical industry - ethylene			Electric arc furnaces		
		Chemical industry - general			Iron and steel - flaring		
		Chemical industry - methanol					
		2C1 Electric arc furnaces					
Iron and steel - flaring							
Public	1A4a	Public sector combustion	Public	1A4a	Public sector combustion		
Residential	1A4b	Domestic combustion	Residential	1A4b	Domestic combustion		
Transport	1A3c, 1A3d, 1A4a, 1A4c	Rail - coal	Transport	1A3c, 1A3d, 1A4a, 1A4c	Rail - coal		
		Railways - freight			Railways - freight		
		Railways - intercity			Railways - intercity		
		Railways - regional			Railways - regional		
		1A3d Inland goods-carrying vessels			1A3d Inland goods-carrying vessels		
		Motorboats / workboats (e.g. canal boats, dredgers, service boats, tourist boats, river boats)			Motorboats / workboats (e.g. canal boats, dredgers, service boats, tourist boats, river boats)		
		Personal watercraft e.g. jet ski			Personal watercraft e.g. jet ski		
		Sailing boats with auxiliary engines			Sailing boats with auxiliary engines		
		Shipping - coastal			Shipping - coastal		
		1A4a Railways - stationary combustion			1A4a Railways - stationary combustion		
1A4c Fishing vessels	1A4c Fishing vessels						

Annex C: Summary of Updated Projections

Tables C.1 and C.2 below contains a summary of the updated Autumn 2012 projections. The projections have been split by gas and by sector. For a more detailed disaggregation of the projections, please see the spreadsheet published alongside this report and available from the following link <https://www.gov.uk/government/publications/non-co2-greenhouse-gas-emissions-projections-report-spring-2013>

Table C.1 Summary of non-CO₂ GHG projections by gas (Kt CO₂e)

Pollutant	NC Sector	UK GHG Inventory		Projections			
		1990	2011	2015	2020	2025	2030
CH ₄	Agriculture	22 406	17 808	17 626	17 555	17 564	17 564
	Business	20	19	20	21	22	24
	Energy Supply	26 311	5 920	5 743	5 319	4 109	2 899
	Industrial Process	24	5	5	5	5	5
	Land Use Change	24	28	31	26	16	12
	Residential	7	3	2	2	2	2
	Transport	638	64	44	32	34	37
	Waste Management	44 869	15 761	13 759	11 868	10 569	9 688
CH₄ Total		94 299	39 608	37 231	34 828	32 320	30 230
N ₂ O	Agriculture	35 519	28 688	27 864	28 150	28 064	28 064
	Business	963	664	791	845	903	968
	Industrial Process	24 641	207	31	31	31	31
	Land Use Change	846	593	445	356	283	228
	Residential	4	5	5	6	6	6
	Transport	1 268	946	1 171	1 343	1 427	1 463
	Waste Management	1 219	1 252	1 430	1 478	1 523	1 564
N₂O Total		64 461	32 355	31 737	32 208	32 237	32 324
HFCs	Business	0	11 766	8 056	5 625	3 350	2 194
	Industrial Process	11 374	86	92	93	95	96
	Residential	12	2 715	2 760	2 816	2 872	2 923
HFCs Total		11 386	14 566	10 909	8 535	6 317	5 214
PFCs	Business	58	76	90	110	133	133
	Industrial Process	1 344	250	116	116	116	116
PFCs Total		1 402	325	206	226	250	250
SF ₆	Business	604	533	506	503	517	517
	Industrial Process	426	74	79	81	82	82
SF₆ Total		1 030	607	585	584	599	599
Grand Total		172 577	87 462	80 667	76 381	71 722	68 616

Table C.2 Summary of non-CO₂ GHG projections by NC Sector (Kt CO₂e)

NC Sector	Gas	UK GHG Inventory		Projections			
		1990	2011	2015	2020	2025	2030
Agriculture	CH ₄	22 406	17 808	17 626	17 555	17 564	17 564
	N ₂ O	35 519	28 688	27 864	28 150	28 064	28 064
Agriculture Total		57 925	46 496	45 490	45 705	45 628	45 628
Business	CH ₄	20	19	20	21	22	24
	HFCs	0	11 766	8 056	5 625	3 350	2 194
	N ₂ O	963	664	791	845	903	968
	PFCs	58	76	90	110	133	133
	SF ₆	604	533	506	503	517	517
Business Total		1 645	13 058	9 463	7 104	4 926	3 836
Energy Supply	CH ₄	26 311	5 920	5 743	5 319	4 109	2 899
Energy Supply Total		26 311	5 920	5 743	5 319	4 109	2 899
Industrial Process	CH ₄	24	5	5	5	5	5
	HFCs	11 374	86	92	93	95	96
	N ₂ O	24 641	207	31	31	31	31
	PFCs	1 344	250	116	116	116	116
	SF ₆	426	74	79	81	82	82
Industrial Process Total		37 808	622	324	327	329	331
Land Use Change	CH ₄	24	28	31	26	16	12
	N ₂ O	846	593	445	356	283	228
Land Use Change Total		870	622	475	382	298	240
Residential	CH ₄	7	3	2	2	2	2
	HFCs	12	2 715	2 760	2 816	2 872	2 923
	N ₂ O	4	5	5	6	6	6
Residential Total		23	2 722	2 768	2 824	2 880	2 931
Transport	CH ₄	638	64	44	32	34	37
	N ₂ O	1 268	946	1 171	1 343	1 427	1 463
Transport Total		1 906	1 009	1 215	1 375	1 461	1 500
Waste Management	CH ₄	44 869	15 761	13 759	11 868	10 569	9 688
	N ₂ O	1 219	1 252	1 430	1 478	1 523	1 564
Waste Management Total		46 088	17 012	15 189	13 346	12 092	11 251
Grand Total		172 577	87 462	80 667	76 381	71 722	68 616

Annex D: Comparison of previous projections with the GHG Inventory

The production of the previous (2012) UK Greenhouse Gas Inventory allowed the first opportunity to directly compare emissions estimates between the Inventory and the non-CO₂ projections for the same year. The 2012 GHGI contains the first emissions estimate for 2010; the non-CO₂ projections have, prior to the publication of 2012 GHGI, projected emissions for 2010 through 2030 in five year intervals. It is now therefore, possible to compare the GHGI with earlier non-CO₂ projections estimates for the year 2010.

The following charts are presented as the results of the comparison between the emissions estimates.

Figure 13.1 shows the percentage differences in emissions between the estimates for 2010 in the 2012 GHGI and the earlier projections for 2010, split by gas. The gases with the highest percentage changes are HFCs and PFCs, with estimates in the projections being approximately 25% and 20% lower respectively, than the inventory.

Figure 13.1 Percentage difference between GHGI and Autumn 2011 projections for 2010, by gas

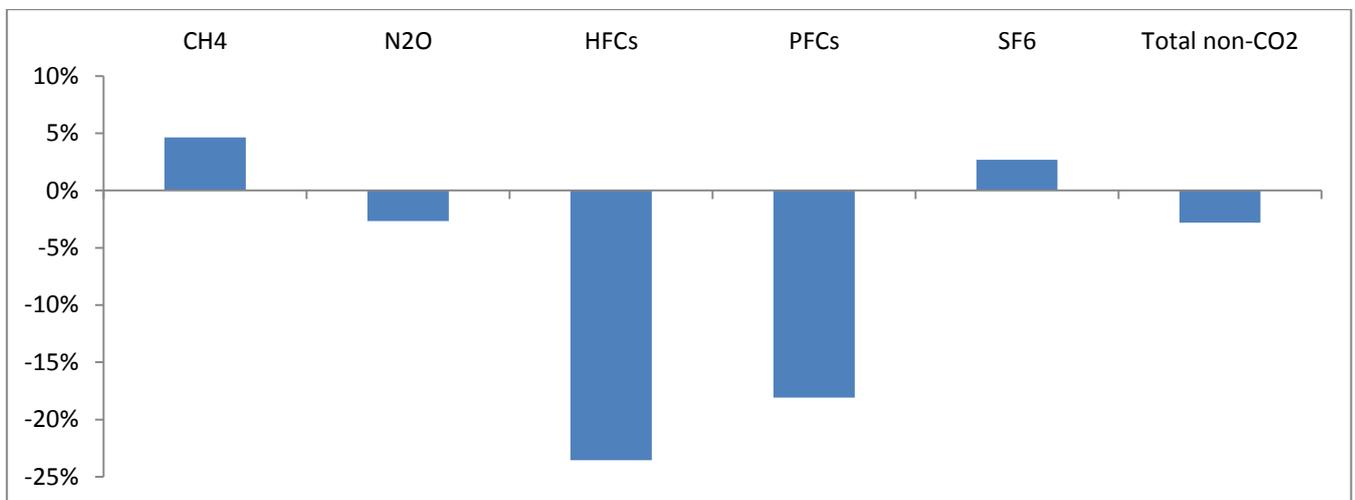
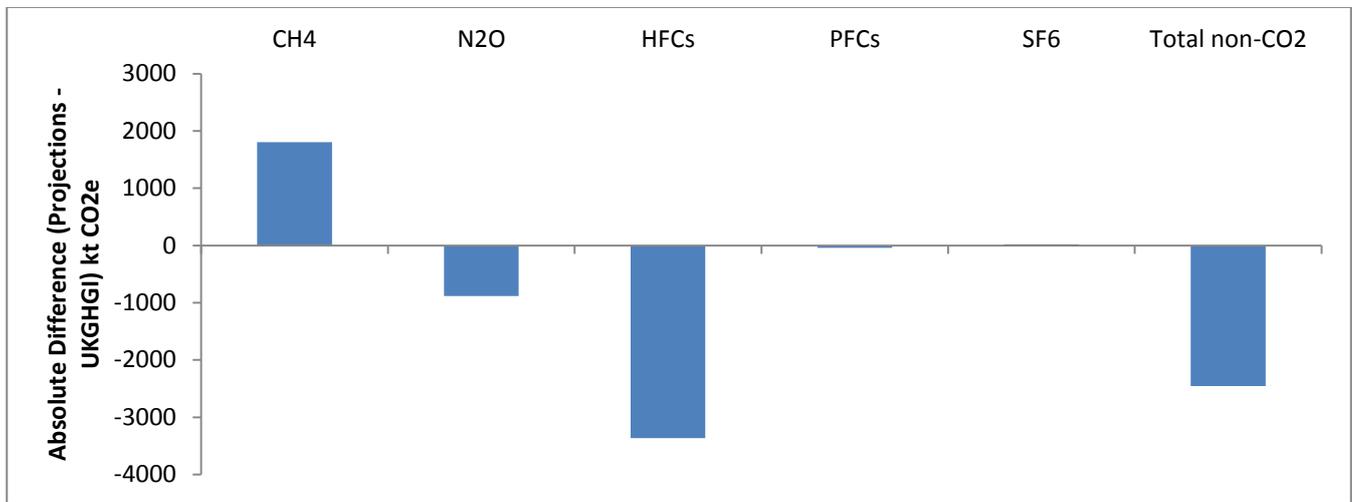


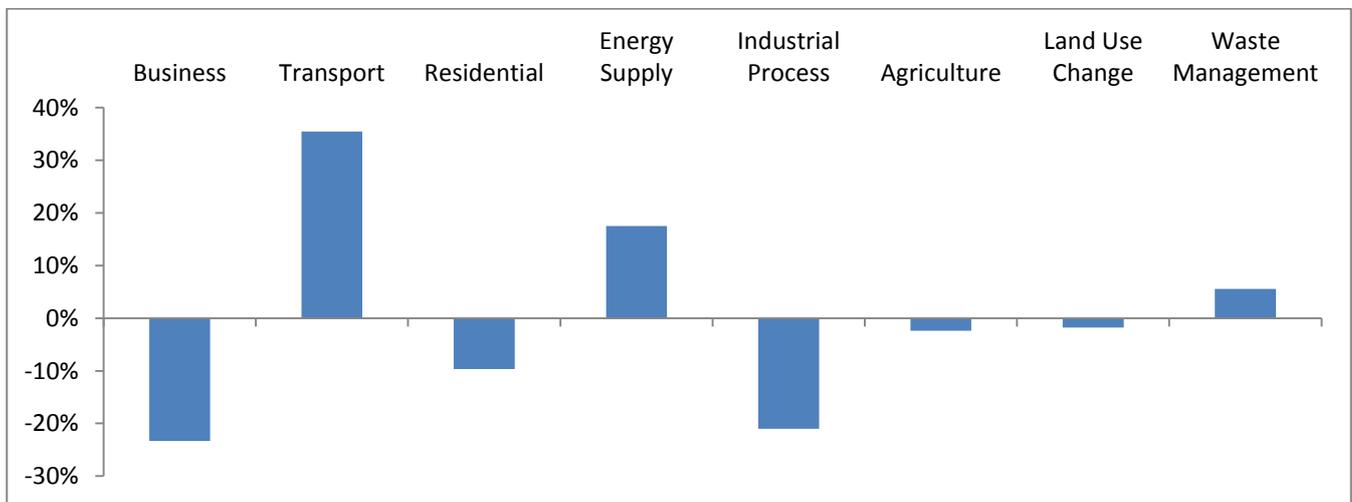
Figure 13.2 presents the same comparison between gases, however, this time on an absolute difference basis. Actual emissions for 2010, as reported in the 2012 GHGI, were approximately 3.5 MtCO₂e higher than the final set of non-CO₂ projections for that year.

Figure 13.2 Absolute differences between GHGI and Autumn 2011 projections for 2010, by gas



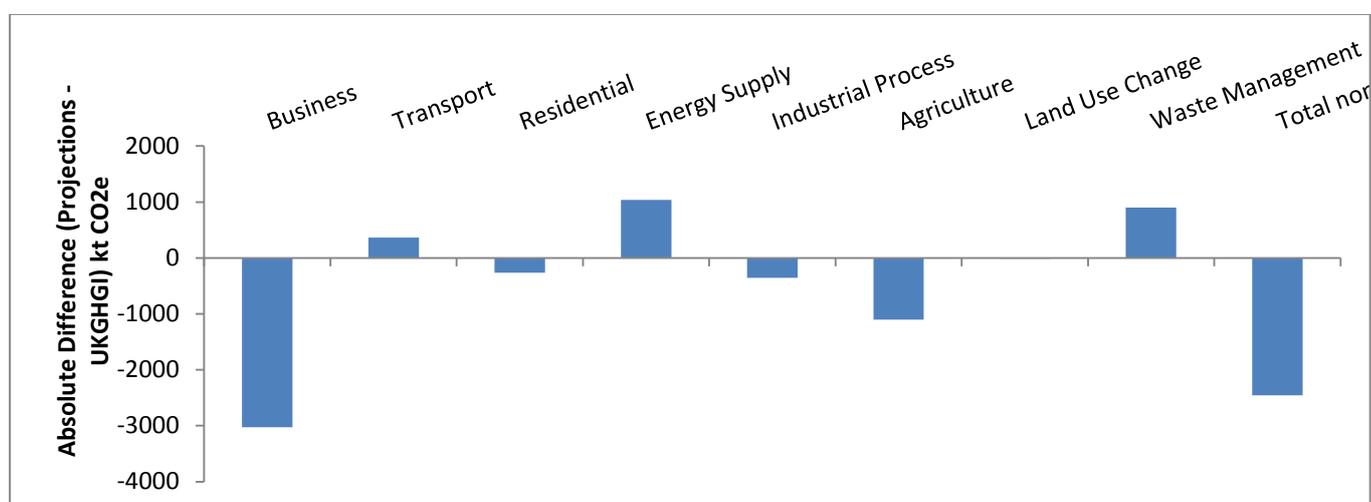
The same analysis was then conducted by National Communication (NC) sector as opposed to gas. **Figure 13.3** presents the percentage difference in estimates for each of the NC categories:

Figure 13.3. Percentage difference between GHGI and Autumn 2011 projections for 2010, by sector



In **Figure 13.3** we can see that estimates of emissions from the transport sector are approximately 35% higher in the non-CO₂ projections estimate for 2010 when compared with the GHGI, with business and industrial process estimate being approximately 20% lower in the projections when compared to the GHGI. However, when we consider the differences in absolute terms (**Figure 13.4**), we see that the business is the key driver in the mismatch between the estimates. The difference in the business sector is approximately 3 MtCO₂e.

Figure 13.4. Absolute difference between GHGI and Autumn 2011 projections for 2010, by sector



On the basis of the absolute values presented in these charts therefore, it would be appropriate to imply that the largest contribution to the mismatch between the non-CO₂ projections and the GHGI for the year 2010 is driven by an underestimation of HFCs from the business sector.

The next stage of the analysis looks at what the source of this approximate 3 Mt difference is. [Table 13.5](#) shows the IPCC categories which make up the HFC contribution to the Business sector and includes the values for 2010 from both the Autumn 2011 Non-CO₂ Projections and the 2012 GHGI. The most significant source of this difference between the projections and the GHGI are the refrigeration and air conditioning categories, particularly mobile air conditioning.

Table 13.5 HFC IPCC categories in the business NC sector

Gas	NC Sector	IPCC Category	GhGI 2010	Projections 2010	Difference
HFCs	Business	2F1 Commercial Refrigeration	3094.34	3535.40	441.05
HFCs	Business	2F1 Domestic Refrigeration	223.49	9.38	-214.12
HFCs	Business	2F1 Industrial Refrigeration	230.44	940.86	710.42
HFCs	Business	2F1 Mobile Air Conditioning	4648.93	1858.27	-2790.66
HFCs	Business	2F1 OvTerr F-gas emissions (all)- Guernsey, Jersey, IOM	54.87	30.95	-23.92
HFCs	Business	2F1 Refrigerated Transport	853.85	131.60	-722.25
HFCs	Business	2F1 Stationary Air Conditioning	1782.66	1271.12	-511.54
HFCs	Business	2F2 Foams	298.88	300.49	1.62
HFCs	Business	2F3 Firefighting	203.55	203.55	0.00
HFCs	Business	2F5 Precision cleaning - HFC	107.25	107.25	0.00
HFCs	Business	2F9 One Component Foams	0.00	0.00	0.00
Totals			11498.27	8388.87	-3109.40

A new model for calculating emissions from refrigeration and air conditioning had been developed and used for the calculation of historic and projected figures (ICF model). This model was used in the 2012 GHGI and in projections produced in spring and autumn 2012; but not in the autumn 2011 projections used for this comparison.

Once the difference caused by the adoption of the ICF model in the GHGI are removed, the overall difference between the inventory and the projections is reconciled quite significantly.

Overall difference between the GHGI and the non-CO₂ projections then becomes less than half of a percent (+0.48%)

Smaller differences between the GHGI and the projections were found in most of the other categories, with LULUCF showing the closest alignment. Given the mismatch between the methodologies used for the Autumn 2011 projections and the 2012 GHGI already identified for refrigeration and air conditioning, it seems likely that some of these discrepancies are due to methodological changes implemented in the 2012 GHGI but not available for the autumn 2011 projections.

It will also be possible to further investigate the agreement between the projections and the inventory using back calculation techniques. This technique may be employed to conduct further analysis in the future.

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