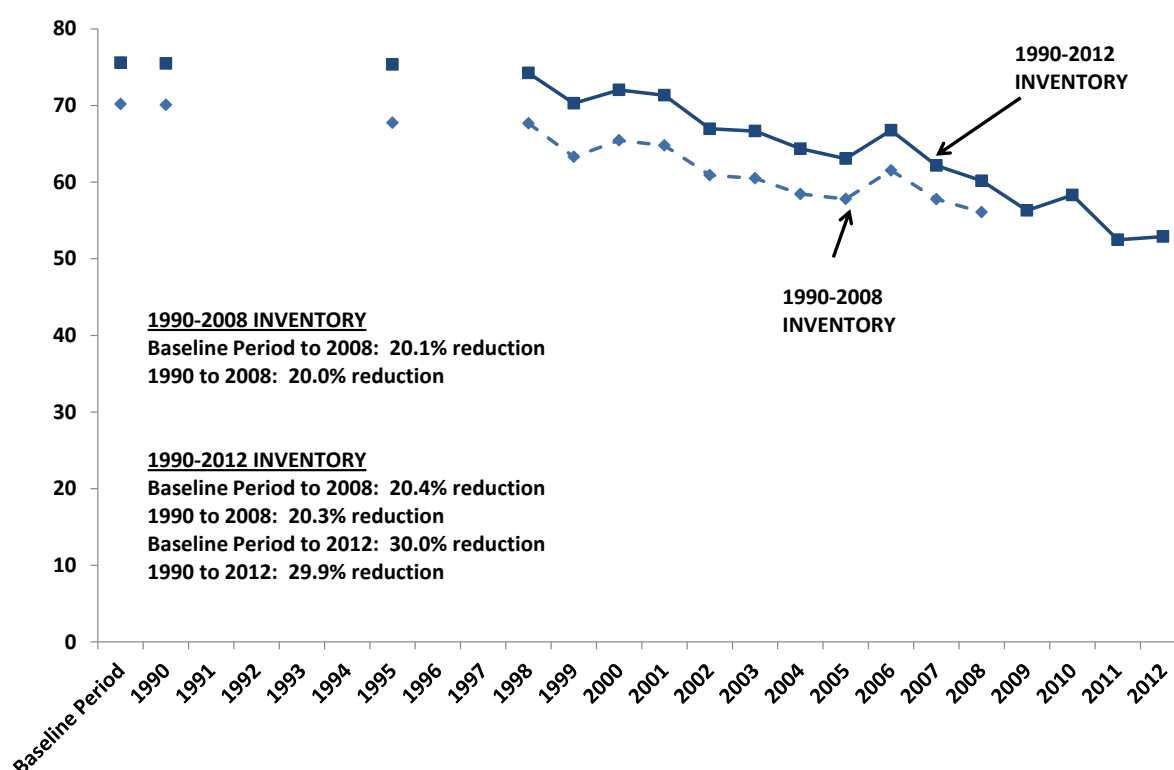


Scottish Greenhouse Gas Emissions 2012

Key Revisions since 2008

This paper provides a breakdown of the key revisions to the Scottish Greenhouse Gas Emissions Official Statistics publications over successive years from the 1990-2008 inventory to the latest (1990-2012) inventory. The most recent publication provides estimates of greenhouse gas emissions in Scotland for the years 1990 to 2012 and is referred to as the 1990-2012 inventory. The overall estimate of emissions in each successive annual inventory is revised to incorporate methodological improvements; and new or updated data.

Scottish Greenhouse Gas Emissions, Comparison of 1990-2008 and 1990-2012 Inventories.
Values in Mt CO₂e



Net greenhouse gas emissions in the baseline period have been revised upwards by 5.4 Mt CO₂e (7.7 per cent) between the 1990-2008 and 1990-2012 inventories, from 70.2 Mt CO₂e to 75.6 Mt CO₂e. Emissions in 2008 have also been revised upwards between the 1990-2008 and 1990-2012 inventories by 4.1 Mt CO₂e (7.3 per cent), from 56.1 Mt CO₂e to 60.2 Mt CO₂e. This paper discusses the main methodological changes which have led to revisions in each successive year. This is with a view to understanding and improving the methodologies used in the compilation of the inventory and the rationale for these successive revisions.

Section A states how the greenhouse gases are compiled and categorised. The Scottish greenhouse gas inventory contains estimates of all greenhouse gas emissions and removals from 1990 to the latest available year of reporting, currently 2012. The latest statistics were published in June 2014 and were reported on in the Scottish Government Official Statistics publication “Scottish Greenhouse Gas Emissions 2012” and on the National Atmospheric Emissions Inventory website.

Section B provides a summary of the cumulative effect of upwards revisions to the greenhouse gas inventory from 1990-2008 to the latest inventory. All the Scottish Government source sectors have seen a net upwards revision to Baseline emissions between 1990-2008 and 1990-2012 apart from Transport (excluding international aviation and shipping) and Development emissions. The source sectors which have seen the greatest absolute increases between the inventories have been Agriculture and Related Land Use, Forestry and Business and Industrial Processes. All of these sectors have seen net increases to the Baseline of greater than 1 Mt CO₂e, in the 1990-2012 data when compared to the 1990-2008 data.

Public sector emissions have seen the largest percentage increase in the Baseline between the 1990-2008 and 1990-2012 inventories (30 per cent), although this sector contributed to the smallest share of emissions in the Baseline in the 1990-2008 inventory. Conversely, the Energy Supply sector was by far the largest contributor to the Baseline in 1990-2008 and it has been the most stable sector in terms of revisions, with a 0.2 per cent increase between this inventory and the latest inventory.

Section C provides information on the main revisions between successive inventories.

Section D consists of charts showing the impact of successive revisions to the greenhouse gas inventory across the time series for each of the sectors. Section E consists of data tables and results from each successive inventory from 1990-2008 to 1990-2012, broken down by sector.

Summary of causes of main upwards revisions between 1990-2008 and 1990-2012 Inventories

FORESTRY. Introduction of a new forestry accounting model, which allows for a greater representation of tree species, growth rates and forest management practices. This has increased emissions in the Baseline, but it has decreased values in later years.

AGRICULTURE AND RELATED LAND USE. Incorporation of updated land use change data as a result of the use of Countryside Survey data for 2007, which is updated on an infrequent basis. This has had a particular impact on estimated emissions from land converted to cropland. There has been more detailed data on the sources of nitrous oxide emissions from the use of fertilisers in agricultural soils.

BUSINESS AND INDUSTRIAL PROCESSES. There have been upward revisions to underlying energy statistics (for both the UK and Scotland) following research to use more detailed data on petroleum fuels in the business and industrial process sources. There have also been more improvements to the analysis of detailed point source data in the inventory in later years, for example to use newly available employment and census data. However, the bulk of the revisions are due to access to new data for the highest-emitting installations in Scotland, through the operation of Phase II of the EU Emissions Trading System (EU ETS).

WASTE MANAGEMENT. Revisions and updates to the models used to estimate methane emissions from landfill sites, in particular to reflect recent Scotland-specific research on waste composition and disposal practices.

INTERNATIONAL AVIATION AND SHIPPING. There has been a reallocation of some shipping emissions from domestic navigation to international shipping as a result of further research. There has been a corresponding fall in other transport emissions, which exclude international aviation and shipping.

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Section A. Introduction and Background

Purpose of this paper

The “Scottish Greenhouse Gas Emissions” Official Statistics publication contains the results of the Scottish Greenhouse Gas Inventory. The overall estimate of greenhouse gas emissions within the latest year’s inventory are revised every year, due to new data sources, methodological improvements and scientific developments. Some of these changes occur as a result of changes in international reporting as stipulated by the United Nations Framework Convention on Climate Change (UNFCCC), or changes to the methodology guidelines by the Intergovernmental Panel on Climate Change (IPCC).

The Scottish greenhouse gas inventory contains estimates of all greenhouse gas emissions and removals from 1990 to the latest available year of reporting, currently 2012. The latest statistics were published in June 2014 and were reported on in the Scottish Government Official Statistics publication “Scottish Greenhouse Gas Emissions 2012” and on the National Atmospheric Emissions Inventory website. Data from the Scottish Greenhouse Gas Inventory have a number of uses. For instance, they are used for the reporting against and tracking of emissions reduction targets – both percentage targets and fixed targets. The inventory is also used for monitoring the effectiveness of policies for the abatement of greenhouse gas emissions. It is therefore important that key revisions to the inventory are understood to identify which sectors have seen revisions and which ones have remained stable over successive inventories. This paper examines revisions made in each inventory between the 1990-2008 inventory and the latest inventory (1990-2012). The 1990-2008 inventory has been chosen as the first inventory in this paper as it was used as the basis for setting Scotland’s fixed Annual Climate Change Targets. This paper discusses the main methodological changes which have led to revisions in each successive year. This is with a view to understanding and improving the methodologies used in the compile of the inventory.

Compilation of the Greenhouse Gas Inventory

The greenhouse gas inventory covers a wide variety all anthropogenic sources of greenhouse gas emissions and therefore a wide variety of emissions sources which require different approaches to their estimation. There are a large number of data sources used in its compilation, obtained from Government statistics, regulatory agencies, trade associations, individual companies, surveys and censuses. The methods used to compile the greenhouse gas inventory are consistent with international guidance on national inventory reporting from the Intergovernmental Panel on Climate Change.

Most emission estimates are compiled by combining activity data (such as fuel use) with a suitable emission factor (such as amount of CO₂ emitted per unit of fuel used). Estimates of emissions from the industrial sector are often compiled based on plant-specific emissions data. Emissions from some sectors are based on more complicated models - such as the model used to estimate emissions from landfill, and the model used to estimate the carbon dynamics in soils when trees are planted. Much of the data on net emissions from agriculture and related land use, land use change and forestry emissions are based on modelled data for Scotland, which are consistent with, but not constrained to, the UK totals and thus are known as “bottom up” estimates.

Many of the remaining emissions sources within the inventory have been collated on a “top down” approach where estimates of emissions have been apportioned to Scotland using proportions of energy use in the Department of Energy and Climate Change (DECC) Publication “Digest of UK Energy Statistics (DUKES)”. This approach is prompted by data availability on emissions being more limited at the sub-UK level.

Interpretation of revisions to the inventory

The latest published Scotland greenhouse gas inventory (currently 1990-2012) represents the best available data at the time and these supersede any previous data, which should be disregarded. Very few revisions to the Greenhouse Gas Inventories arise as a result of 'errors' in the popular sense of the word. In fact, the compilation of the inventory is governed by a rigorous quality assurance process¹ and is subject to a great deal of third party scrutiny, particularly by the UNFCCC at a UK level. All estimates, by definition, are subject to a degree of statistical 'error' but in this context it relates to the uncertainty inherent in any process or calculation that uses sampling, estimation or modelling. Work is underway to explore options to improve the assumptions and data sources used in the uncertainty analysis.

1

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/310779/UK_National_Inventory_Report_Main_1990-2012.pdf

Other revisions to the inventory reflect either the adoption of new statistical techniques, advances in climate science, or simply the incorporation of new information which allows the 'error' contained in previously released estimates to be reduced. For these reasons, we would encourage users to view revisions to the inventory as a positive step; as not simply inevitable but rather, desirable.

Reporting of emissions in the Baseline Period and 1990

A baseline period is used for reporting progress against Scotland's Climate Change Targets and this has been used in the context of this report. This is referred to as the "Baseline Period" when referring to changes over time in the charts, tables and text. The Baseline Period for reporting against Climate Change Targets is:

- 1990 for carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O)
- 1995 for Fluorinated gases (F gases): hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆)

Within this paper, data are estimated for the Baseline Period; and for the years 1990, 1995 and all years from 1998 to 2012.

Emission Source Sectors

The sector breakdown used in this report is primarily based on the National Communication (NC) sectors, which are reported in the DECC Official Statistics publication “UK Greenhouse Gas Emissions”. However, in order to associate emissions from conversion of grassland to and from cropland, and liming of agricultural land with other agricultural activities, we have generated three new sectors from the previous two sectors *Land Use, Land Use Change and Forestry* (LULUCF) and *Agriculture*. The first new sector, *Agriculture and related land use*, includes all emissions in the NC sector Agriculture together with those LULUCF emissions associated with agricultural practices. The remaining LULUCF emissions are grouped into *Forestry* (changes in emissions relating mainly to stock changes resulting from afforestation, deforestation and harvested wood products) and *Development* (changes in emissions resulting from land use change to settlements). These new sectors are the same as those that were reported in the Scottish Government publication “[Low Carbon Scotland - Meeting the Emissions Reductions Targets 2013-2027](#)”. A detailed mapping between the sectors used in this report and the NC sectors and Intergovernmental Panel on Climate Change (IPCC) sectors is given in [Section E](#).

For the purposes of reporting, greenhouse gas emissions are allocated into sectors as follows:

Energy supply - Emissions from fuel combustion for electricity and other energy production sources, and fugitive emissions from fuels (such as from mining or oil and gas extraction activities).

Business and industrial processes - Emissions from industry and from those in combustion in industrial/commercial sectors, industrial off-road machinery, process sources from decarbonisation of raw materials (such as from limestone use in cement plants) and refrigeration and air conditioning.

Transport - Emissions from domestic aviation, road transport, railways, domestic navigation, fishing and aircraft support vehicles.

Public - Emissions from combustion of fuel in public sector buildings.

Residential - Emissions from fuel combustion for heating/cooking, garden machinery and fluorinated gases released from aerosols/metered dose inhalers.

Agriculture and Related Land Use - Net emissions from cropland, grassland livestock, agricultural soils, stationary combustion sources and off-road machinery.

Development - Net emissions from settlements and from land converted to settlements.

Forestry - Changes in emissions relating mainly to stock changes, resulting from afforestation, deforestation and harvested wood products.

Waste management - Emissions from waste disposed of to landfill sites, waste incineration, and the treatment of waste water.

Where emissions are reported by source, emissions are attributed to the sector that emits them directly. These high-level sectors are made up of a number of more detailed sectors, which follow the definitions set out by the Intergovernmental Panel on Climate Change (IPCC), and which are used in international reporting tables which are submitted to the United Nations Framework Convention on Climate Change (UNFCCC) every year. Section E contains a more detailed mapping of what is included in each source.

Section B. Summary of Revisions, from the 1990-2008 Inventory to the Latest Inventory to the Latest Inventory

Cumulative revisions since the 1990-2008 inventory indicate the scale of total revisions since the establishment of fixed annual Climate Change targets. Chart B1 shows that the average annual increase in Baseline emissions between the 1990-2008 inventory and the latest inventory has been 1.3 Mt CO₂e.

Chart B1. Revisions to the Baseline, from the 1990-2008 Inventory, to the Latest Inventory. Impact of Successive Revisions. Values in Mt CO₂e

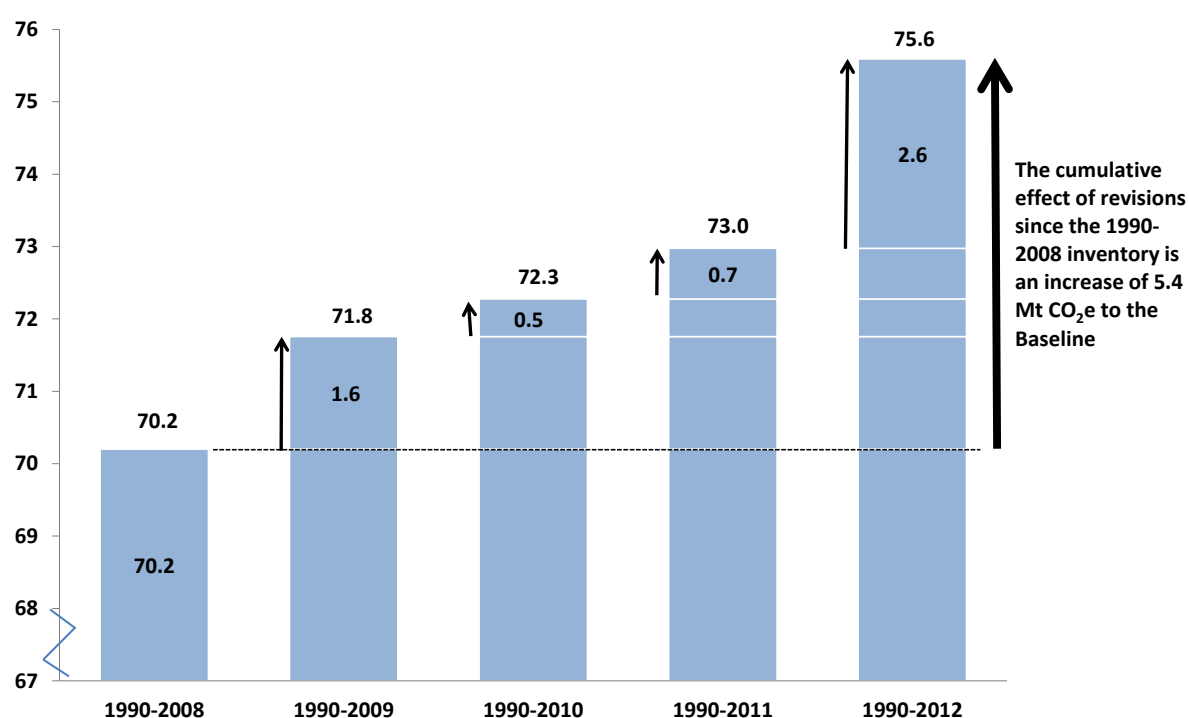
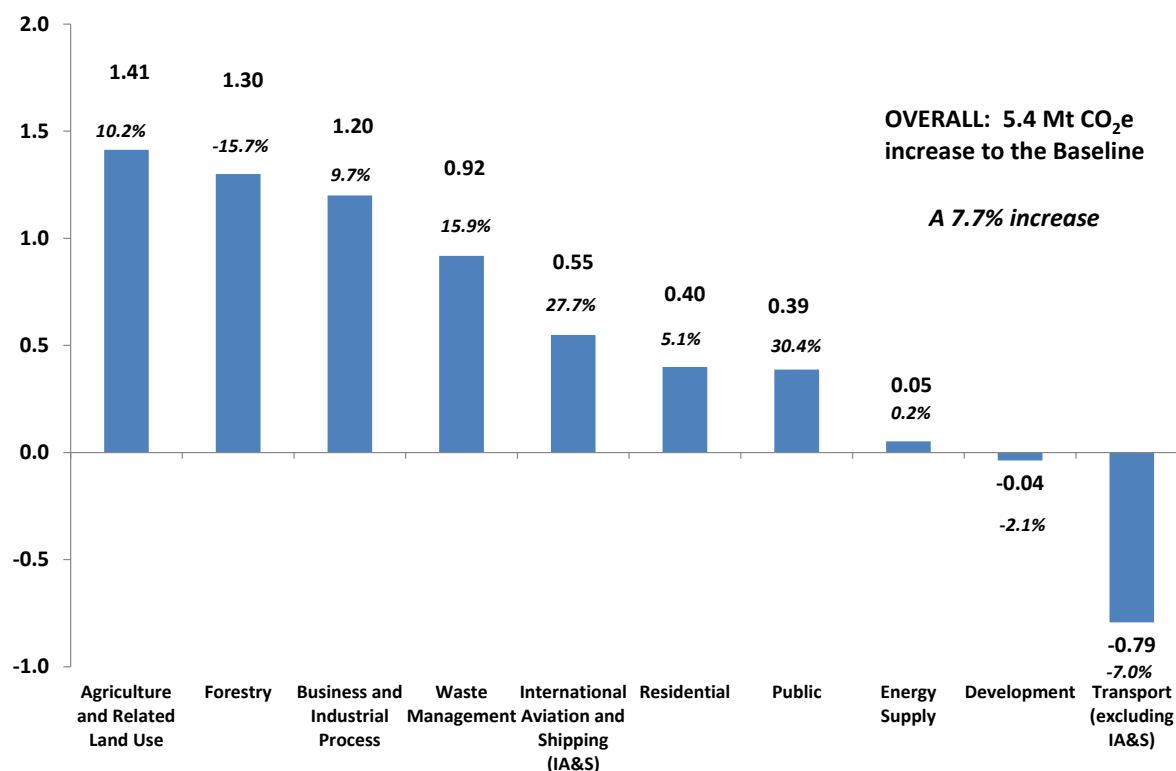


Chart B2 shows the breakdown by source sector in the cumulative upward revisions in emissions between the 1990-2008 inventory and the latest inventory.

Chart B2. Revisions to the Baseline, from the 1990-2008 Inventory to the Latest Inventory (1990-2012), by source sector. Impact of Successive Revisions. Values in Mt CO₂e, and percentage changes²



Main Points

- Revisions to the Agriculture and Related Land Use sector have resulted in an increase to the Baseline emissions of 1.41 Mt CO₂e between the 1990-2008 inventory and the latest inventory. The publication and incorporation of data from the Countryside Survey 2007 has led to increased Baseline emissions. This is due to changes to the assumptions on the area of land that is converted to cropland. There have also been revisions to the allocation of manure in various cattle management systems.
- Revisions to the Forestry sector have resulted in an increase to Baseline net emissions of 1.30 Mt CO₂e. The size of the net CO₂ removals from forestry has fallen. This is due to the introduction of a new forestry accounting model, which allows for a greater representation of tree species, growth rates and forest management practices.

² Unlike for other source sectors, upwards revisions to net emissions from forestry are presented as a negative percentage change. This is because forestry causes a net removal of emissions. This means that an upwards revision from forestry will cause a negative percentage change in the quantity of emissions removed.

- The Business and Industrial Process sector has seen an increase of 1.20 Mt CO₂e in Baseline emissions – caused by revisions to UK and Scotland energy statistics, such as the revision of emissions from the use petroleum fuels in industrial sectors.
- Waste Management emissions have increased by 0.92 Mt CO₂e – caused by a revision to the modelling of methane emissions from landfill.
- International Aviation and Shipping emissions have increased by 0.55 Mt CO₂e – much of this has been due to a reclassification of some domestic navigation emissions to the International Aviation and Shipping sector. This has resulted in a corresponding decrease in other Transport emissions.
- Residential emissions in the Baseline have been revised upwards by 0.40 Mt CO₂e due to an increase in estimated use of solid and petroleum fuels in the residential sector through revisions to UK energy statistics. New housing survey and census data have also been used to improve energy modelling for solid fuels.
- The table on the next page shows that revisions to the Agriculture and Related Land Use and Forestry sectors accounted for a half of the total revisions to the Baseline emissions between the 1990-2008 and 1990-2012 inventories.

Revisions to the Baseline, from the 1990-2008 Inventory to the Latest Inventory (1990-2012), by source sector. Impact of Successive Revisions, percentage share, by source sector

Sector	% share by sector	Main drivers for change
Total	100.0%	
Agriculture and Related Land Use	26.2%	3 main revisions –(1) Updates to Countryside Survey – land converted to Cropland; (2) Update to data on fertiliser in agricultural soils; (3) update to data on manure storage
Forestry	24.1%	1 Main Revision – to forestry accounting model in the 1990-2012 inventory
Business and Industrial Process	22.3%	Inclusion of additional emissions from petroleum fuels in industrial sectors.
Waste Management	17.0%	(1) Development of new Landfill Waste Model – improvements took place over successive inventories; (2) Inclusion of Industrial Waste Water emissions
International Aviation and Shipping (IA&S)	10.2%	(1) Reallocation of some domestic shipping figures to international shipping figures due to better quality data on domestic navigation
Residential	7.4%	An increase in solid fuel emissions in the residential sector
Public	7.2%	Use of Scottish proxy data for Display Energy Certificates in public sector buildings and revisions to UK energy statistics for public sector gas use for the 1990-2012 inventory.
Energy Supply	1.0%	Greater use of EU Emissions Trading System data within inventory compilation.
Development	-0.7%	
Transport (excluding IA&S)	-14.7%	(1) Reallocation of some domestic shipping figures to international shipping figures due to better quality data on domestic navigation. (2) Improved representation of the road transport estimate of vehicle fleet in Scotland, through access to detailed vehicle licensing information, which has reduced emissions

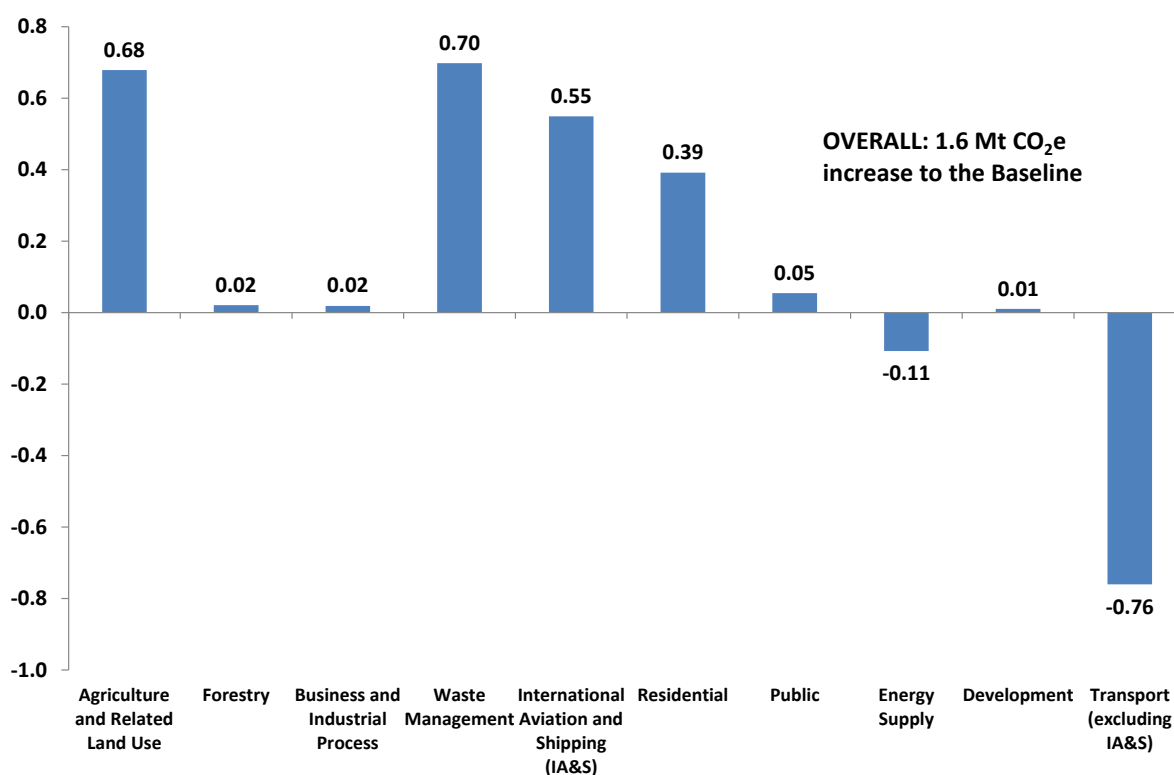
Section C. Annual Revisions to the Inventory,

Key Revisions to baseline emissions

Revisions to the Baseline from the 1990-2008 Inventory to the 1990-2009 Inventory

The Baseline was revised upwards from 70.2 Mt CO₂e in the 1990-2008 inventory to 71.8 Mt CO₂e in 1990-2009 – an increase of 1.6 Mt CO₂e.

Chart C1. Revisions to the Baseline from the 1990-2008 Inventory to the 1990-2009 Inventory, by source sector. Values in Mt CO₂e



The most notable revisions between the 1990-2008 and 1990-2009 inventories are listed below:

Waste Management

Methane (CH₄) emissions from landfill sites were revised upwards in the Baseline and downwards in later years in the series. This is because the model which was used to estimate methane emissions from waste from landfill sites was altered to incorporate a range of data specific to the devolved administrations, rather than data for the UK as a

whole. This included figures on waste composition and municipal solid waste arisings which were obtained from waste surveys and compositional studies.

Agriculture and Related Land Use

Emissions in the agriculture and related land use sector were revised upwards and affected nitrous oxide (N₂O) emissions. Data on land use change was updated, with the publication and incorporation of data from the Countryside Survey 2007. Previous inventories based the rates of land use change around changes between 1990 and 1998, for this year the rates of change were recalculated using rates of change for 2000-2007 and extrapolated forward for 2008 and 2009. This led to revisions to data on the amount of land converted to cropland. These figures acted to increase baseline emissions and decreased emissions later in the series.

There were further upward revisions of nitrous oxide (N₂O) in this sector as data on emissions from sewage sludge used as fertiliser in agricultural soils were included in the inventory for the first time. This increased emissions fairly consistently across the time series. The revised calculation involved estimating the amount of nitrogen contained per dry matter unit of sludge and applying IPCC emission factors to generate estimates of emissions.

Energy Supply

There was a small net downward revision in the Baseline and upward revisions in later years in the series. This was due to the use of European Union Emissions Trading System (EU ETS) Phase II data. This change meant that it became possible to calculate emissions from a larger number of point sources than in the previous inventory, rather than modelled emissions from the Digest of UK Energy Statistics (DUKES). In particular, there were large revisions due to improved EU ETS data on combustion in petroleum refineries. This caused an upward revision in later years, but back-casting these revisions to the Baseline resulted in a downwards revision to the Baseline.

International Aviation and Shipping

There was a reallocation of navigation emissions from national navigation to international shipping (0.55 Mt CO₂e). This related to the introduction of a new methodology used in the UK inventory for estimating coastal and international emissions from shipping. Since this time, International shipping fuel data have been estimated using fuel use estimates derived from a study³ of UK shipping movements, and the total gas oil and fuel oil use by shipping reported within the Digest of United Kingdom Energy Statistics (DUKES). DUKES contains annual data for gas oil and fuel oil use in national navigation (domestic shipping) and marine bunkers (international shipping). The revised method estimated domestic navigation on better quality data on national ship movements and assigned the remaining emissions to international shipping.

Transport (excluding International Aviation and Shipping)

The reallocation of navigation emissions from navigation to international shipping resulted in a corresponding fall in national transport emissions. National transport emissions also fell due to the incorporation of more Scotland-specific fleet information for road transport in the inventory. In particular, the use of Department for Vehicle Licensing Authority (DVLA) data indicated that there were more newer cars than previously estimated for Scotland and that there were more small engine-sized cars (<1,400cc) registered in Scotland than the GB average.

Residential

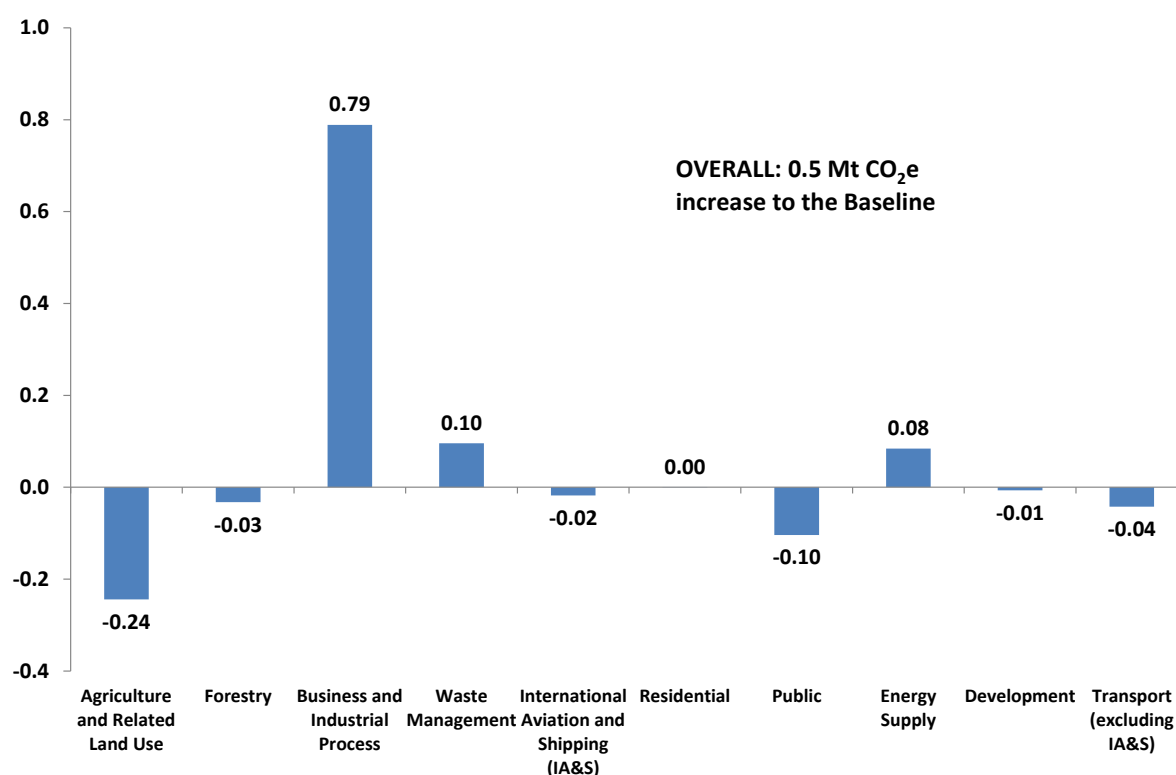
Residential emissions in the Baseline year were revised upwards due to revised estimates in the source data for fuel consumption by households – specifically larger estimates of non-gas fuel use (such as solid fuels). This revised treatment better reflected the growth in gas use observed between 1990 and 1995, and took greater consideration of the observed trends in overall household energy use (and in the energy efficiency of housing stock) through data from the Scottish Housing Condition Survey.

³ http://uk-air.defra.gov.uk/assets/documents/reports/cat15/1012131459_21897_Final_Report_291110.pdf

Revisions to the Baseline from the 1990-2009 Inventory to the 1990-2010 Inventory

The Baseline was revised upwards from 71.8 Mt CO₂e in the 1990-2009 inventory to 72.3 Mt CO₂e in 1990-2010 – an increase of 0.5 Mt CO₂e.

Chart C2. Revisions to the Baseline, from the 1990-2009 Inventory to the 1990-2010 Inventory, by source sector. Values in Mt CO₂e



Net upward revisions across the time series between the 1990-2009 and 1990-2010 inventories were largely due to revision in the Business and Industrial Process sector.

Business and Industrial Process

The whole time series for this sector was revised upwards due to a revision to the allocation of 'other petroleum gas' use in Scotland. The need to introduce a revised allocation method was identified through analysis of EU Emissions Trading System point source data in later years in the series, which estimated higher emissions than those obtained previously from modelled estimates in the Digest of UK Energy Statistics (DUKES). The increase identified in later years was estimated for the earlier part of the time-series and applied to create a consistent series. The use of point source EU ETS data allowed for greater understanding of where emissions were actually taking place and the types of installations responsible for the emissions.

There was also an improvement to the sectoral classification of number of installations. In particular, some installations previously assigned to the IPCC category: “Manufacturing Industry & Construction: Other”, were reclassified into four new categories (“Non-ferrous metals”, “Chemicals”, “Pulp Paper Print”, “Food drink tobacco”). The disaggregation of this IPCC category was largely based on DUKES data and prompted by comments from the greenhouse gas inventory reviewers who are appointed by the UNFCCC reviewers (and from the EU). In later years in the series, there were further upward revisions resulting from the use of new data on UK sectoral energy use; and an updated Inter-Departmental Business Register which was used to inform the sectoral classification of installations.

Finally, a revision to the UK-wide model for hydrofluorocarbons (released from refrigeration and air conditioning equipment) was incorporated at this time, which had a greater impact on later years in the time series.

The net result of these considerable refinements to the data and methodological approach was an increase in emissions across the time series.

Agriculture and Related Land Use

The Baseline was revised downwards for this sector in the 1990-2010 inventory. The principal reason for this was due to improvements in the source data used in the estimation process. It was possible at this time to use Scotland level data on crop areas and crop production, instead of the UK level data, which had previously been used.

Additionally, there were routine updates to data on animal numbers which, in turn, affected emissions from digestion and manure management. The net effect of these revisions was a further slight downwards revision to Baseline values for the Agriculture and Related Land Use sector.

Public Sector

The Baseline was revised slightly downwards as a result of routine revisions to source data.

Energy Supply

There was little change to the Baseline figure for this sector. However In later years, there was a small upward revision because of revised data on petroleum fuels in refining and for the allocation of gas and oil to the upstream oil and gas sector.

Waste Management

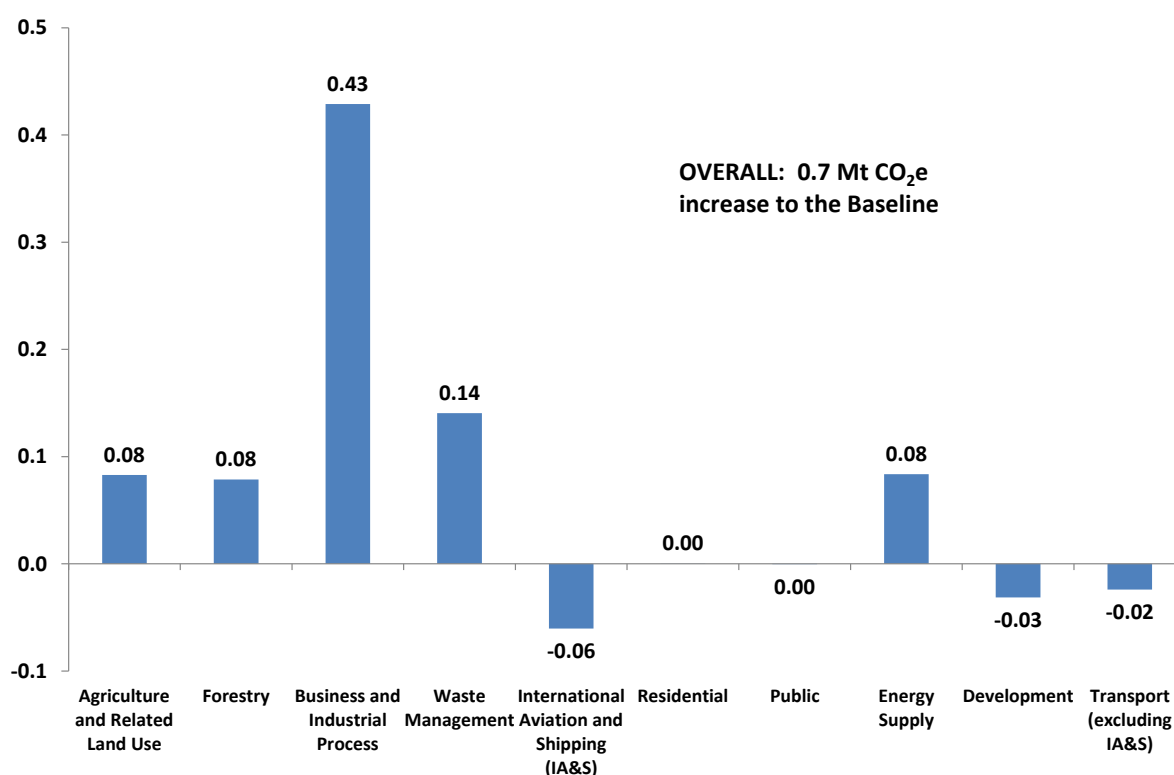
The UK landfill model was further revised in the 1990-2010 inventory to utilise improved data for waste disposals to landfill for the devolved administrations. This caused a further upwards revision across the time series although the magnitude of the revision was greater in later years in the series; (0.1 Mt CO₂e in the Baseline estimate; 0.15 Mt CO₂e in the 2009

estimate). Consultation with waste sector experts led to the collation of new information from new waste survey and compositional studies, such as a municipal solid waste composition study for Scotland.

Revisions to the Baseline from the 1990-2010 Inventory to the 1990-2011 Inventory

The Baseline was revised upwards from 72.3 Mt CO₂e in the 1990-2010 inventory to 73.0 Mt CO₂e in 1990-2011 – an increase of 0.7 Mt CO₂e.

Chart C3. Revisions to the Baseline, from the 1990-2010 Inventory to the 1990-2011 Inventory, by source sector. Values in Mt CO₂e



The main upwards revisions were again due revisions to the Business and Industrial Process sector.

Business and Industrial Process

The Baseline was revised upwards due to the incorporation of new estimates in the UK inventory for the use of petroleum fuels in industrial boilers. This change was prompted by greater scrutiny of the EU ETS data to identify the use of off-gases from petrochemical production processes being used in boilers on specific industrial sites. The annual estimates for these sites are based on operator-reported emission totals through EU ETS and IPPC during the 2000s, back-cast across the time series using plant capacity data. A further improvement related to the greater use of point source data on gas use in other industrial combustion.

Other, minor, upward revisions took place in this sector due to a number of factors. The overall effect of these small revisions affects data in the later part of the series to greater extent than in the baseline. There were also UK-wide revisions to gas and oil allocations and

a revision to Devolved Administration allocations of fuel use in industrial off-road machinery⁴.

Furthermore, it was possible to incorporate new UK-wide estimates for emissions from biomass use as a fuel in this inventory. The use of this new data source impacted upon both the Scottish Inventory and the Digest of UK Energy Statistics (DUKES) activity data for gas-fired autogeneration.

Waste Management

Emissions from this sector were revised upwards from the previous inventory. This was because emissions from industrial waste-water treatment had been included in the UK and devolved administration inventories for the first time. This information was collected for the Scottish inventory by Scottish Water.

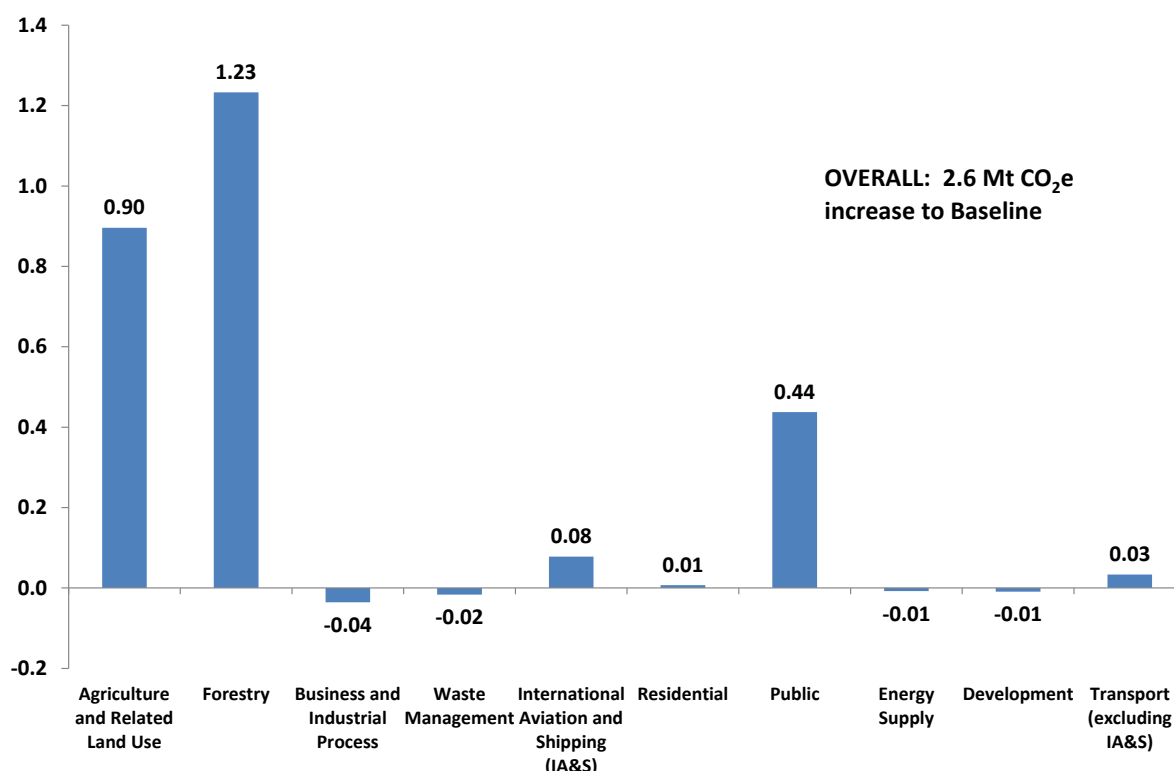
In addition, a revision was made to the methane emissions factors for waste water treatment, sludge treatment and disposal of sewage sludge to land. This revision was based on emissions data reported by the water companies. Incorporating these revised factors led to an increase in emissions in the early part of the time series.

⁴ Resulting from the use of updated energy mapping analysis consistent with the Department of Energy and Climate Change (DECC) sub-national energy statistics.

Revisions to the Baseline from the 1990-2011 Inventory to the 1990-2012 Inventory

In the latest inventory (1990-2012), the Baseline has been revised upwards from 73.0 Mt CO₂e in the 1990-2011 inventory to 75.6 Mt CO₂e – an increase of 2.6 Mt CO₂e.

Chart C4. Revisions to the Baseline, from the 1990-2011 Inventory to the 1990-2012 Inventory, by source sector. Values in Mt CO₂e



Agriculture and Related Land Use

Estimates of methane (CH₄) emissions have increased. This is due to the revision in the allocation of manure in various cattle management systems. Previous information about the treatment of this waste has been superseded with improved data, with a knock-on effect on the quantity of methane emissions attributed to Scotland.

Waste Management

There have been higher estimates of methane (CH₄) emissions from landfills in recent years (with much lower revisions for the early part of the time series). This is because data are now available on methane from landfill gas collected and burnt in landfill gas engines and flares. Previously, recovery rates were estimated using energy statistics on landfill gas use in generation, landfill gas capture rate assumptions and derived gas flaring volumes. The

decrease in the estimated amount of gas recovered has led to an increase in emissions across the time series.

Forestry

Revisions affect the size of the net CO₂ sink from forestry, which have led to a net reduction in removals in the Baseline period – thus increasing the Baseline value. This is due to a change in the methodology in models of forest land area. There is now a better representation of forest areas which have been existence before 1920. There is a better distribution of tree species, growth rates and forest management practices and a better estimation of the capture and storage of carbon within forest soils.

Public Sector

Revisions affect CO₂ emissions. There has been an increase in public sector emissions since 2008 to take into account a revision in the natural gas consumption data. This revision has been caused by a reallocation of the economic classification of some buildings which consume natural gas in the underlying energy statistics. This has led to an increase in buildings classed as public sector, with a corresponding decrease in other buildings. Additionally, there have been improvements in energy mapping analysis such as the inclusion of new datasets such as Display Energy Certificates. These have over-written previous energy modelling assumptions on building energy demand, have led to a higher allocation of public sector emissions to Scotland than was previously estimated.

Business and Industrial Processes

The revisions affect CO₂ emissions. There has been an increase in emissions from industrial and commercial buildings due to improved energy modelling using new data such as those on Energy Performance Certificates. The extent of this increase has not been as great as for public sector combustion from 2008 onwards, as some consumers of natural gas have been reallocated from commercial businesses to public sector combustion in the underlying energy statistics.

There has been some reallocation of emissions within the Business and Industrial Processes sector, from Manufacturing and Industry to the Chemical Industries, to maintain overall consistency in reporting of the greenhouse gas inventory and underlying energy statistics. This reallocation has been requested by reviewers from the United Nations Framework Committee on Climate Change (UNFCCC). These emissions relate to those from petrochemical and chemical industry use of various process gases and residues.

Section D. Impact of revisions to the time series, from the 1990-2008 Inventory to the Latest Inventory, by source sector

Energy Supply

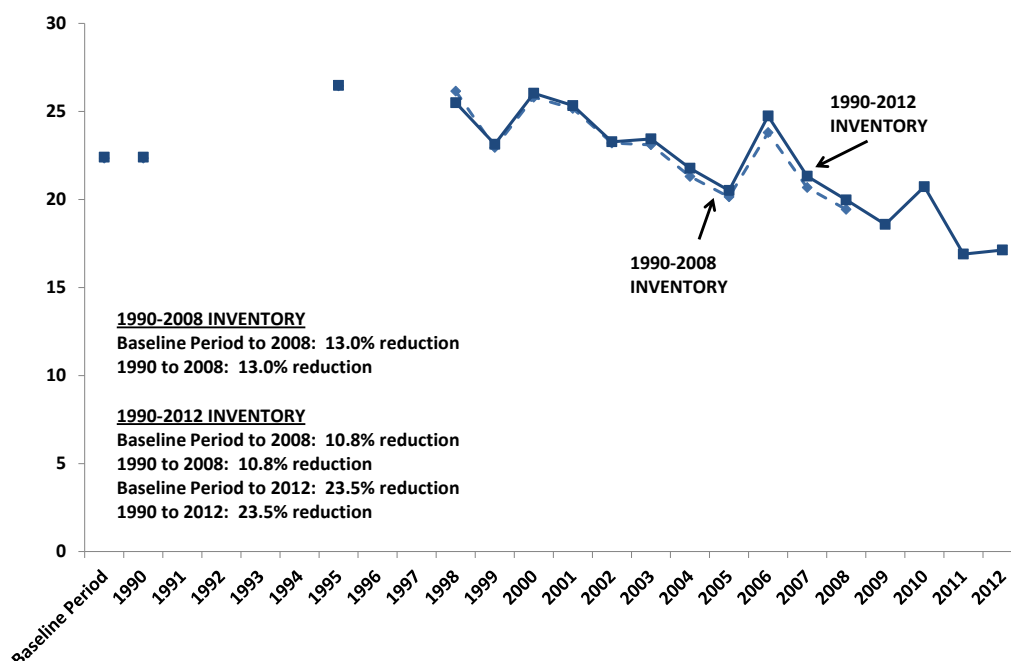
The 1990-2008 inventory has been chosen as the first inventory in this paper as it was used as the basis for setting Scotland's fixed Annual Climate Change Targets. The 1990-2012 inventory is the most recent inventory for which data are available. For the Energy supply sector, the Baseline emissions are equal to those for 1990.

The Baseline value was revised upwards by 0.1 Mt CO₂e (0.2 per cent) from 22.3 Mt CO₂e in the 1990-2008 inventory, to 22.4 Mt CO₂e in the latest inventory.

2008 emissions were revised upwards by 0.5 Mt CO₂e (2.8 per cent) from 19.4 Mt CO₂e in the 1990-2008 inventory, to 20.0 Mt CO₂e in the latest inventory, with the 2012 figure estimated to be 17.1 Mt CO₂e.

Compared to other sectors, the extent of revisions to the Energy Supply sector has been very small. This is partly because much of the energy supply emissions are estimated using point source emissions data, which are direct measures of the inputs and outputs of significant emitters in Scotland. As a result, these estimates rely less upon modelling or estimation using proxy indicators. In effect, we can be more certain about these estimates than most other parts of the inventory. The main factor leading to revisions in this sector was the use of EU ETS Phase II data, which introduced a greater reliance on point source data rather than previously modelled estimates. There have been very small changes in successive inventories – the largest of which took place in the 1990-2009 inventory.

Chart D1. Greenhouse Gas Emissions: 1990-2008 and 1990-2012 Inventories: ENERGY SUPPLY. Values in Mt CO₂e



Agriculture and Related Land Use

The 1990-2008 inventory has been chosen as the first inventory in this paper as it was used as the basis for setting Scotland's fixed Annual Climate Change Targets. The 1990-2012 inventory is the most recent inventory for which data are available. For the Agriculture and Related Land Use sector, the Baseline emissions are equal to those for 1990.

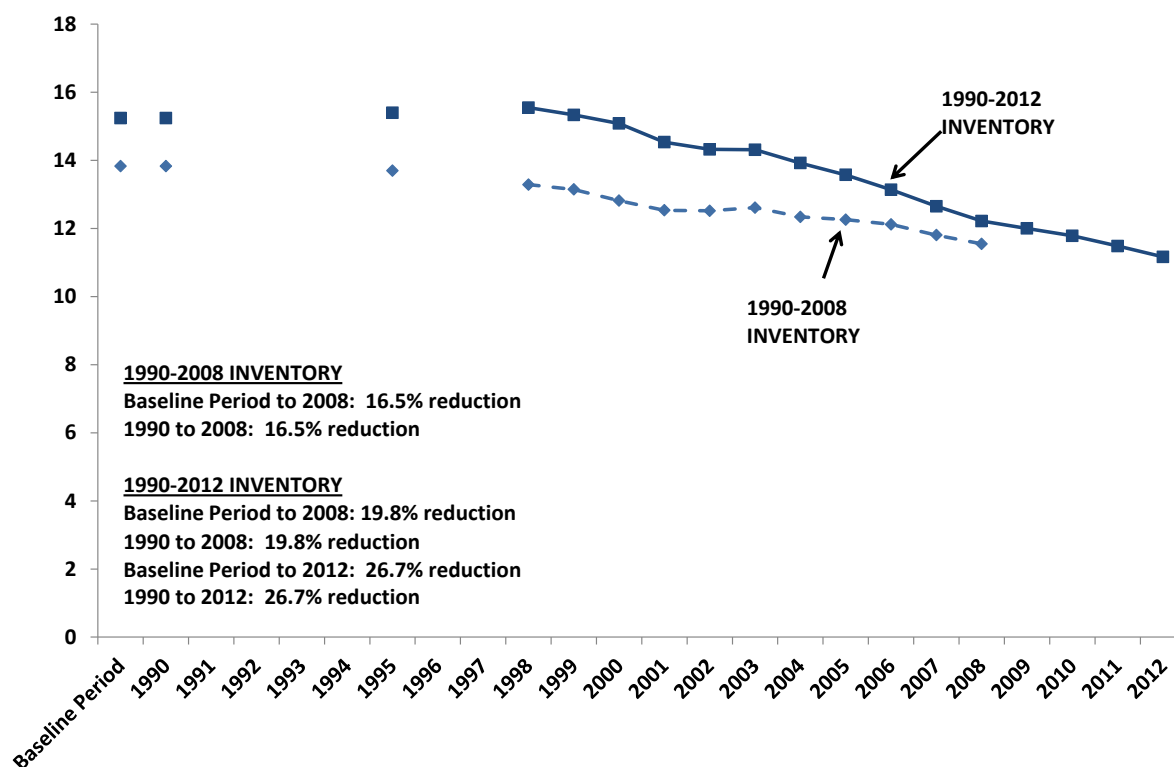
The Baseline value was revised upwards by 1.4 Mt CO₂e (10.2 per cent) from 13.8 Mt CO₂e in the 1990-2008 inventory to 15.2 Mt CO₂e in the latest inventory.

2008 emissions were revised upwards by 0.7 Mt CO₂e (5.8 per cent) from 11.5 Mt CO₂e in the 1990-2008 inventory to 12.2 Mt CO₂e in the latest inventory, with the 2012 figure being 11.2 Mt CO₂e.

As these estimates rely heavily on models which have been undergoing near-continuous improvement, revisions have been apparent in every inventory. The main changes occurred in the 1990-2009 inventory (revised emissions data on land converted to cropland and data on sewage being used as a fertiliser on agricultural soils). There was also a large change in the 1990-2012 inventory, where there were revised assumptions regarding emissions produced by the storage of animal manure.

Chart D2 shows the impact of these revisions on the Agriculture and Related Land Use emissions time series. There has been a greater percentage reduction in the 1990-2012 inventory compared with the 1990-2008 inventory.

**Chart D2. Net Greenhouse Gas Emissions: 1990-2008 and 1990-2012 Inventories:
AGRICULTURE AND RELATED LAND USE. Values in Mt CO₂e**



Business and Industrial Process

The 1990-2008 inventory has been chosen as the first inventory in this paper as it was used as the basis for setting Scotland's fixed Annual Climate Change Targets. The 1990-2012 inventory is the most recent inventory for which data are available. For the Business and Industrial Process sector, there are some emissions of F gases. The Baseline Period for F gases is 1995 rather than 1990, as for the other greenhouse gases⁵. This means that the Baseline emissions for the Business and Industrial Process sector are different from the 1990 emissions, and this is shown in Chart D3 which outlines percentage changes in emissions using different inventories.

The Baseline value was revised upwards by 1.2 Mt CO₂e (9.7 per cent) from 12.4 Mt CO₂e in the 1990-2008 inventory to 13.6 Mt CO₂e in the latest inventory.

⁵ The Baseline Period for reporting against Climate Change Targets is:

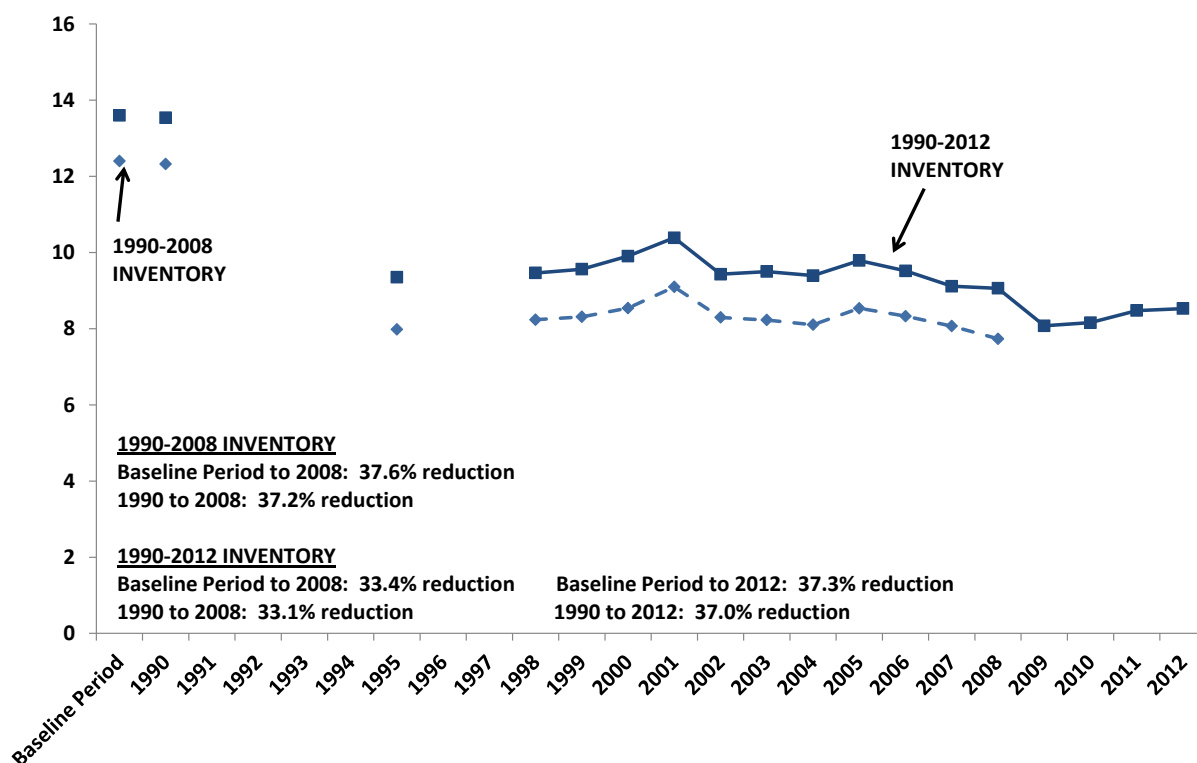
- 1990 for carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O)
- 1995 for Fluorinated gases (F gases): hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆)

2008 emissions were revised upwards by 1.3 Mt CO₂e (17.1 per cent) from 7.7 Mt CO₂e in the 1990-2008 inventory to 9.1 Mt CO₂e in the latest inventory, with the 2012 figure being 8.5 Mt CO₂e.

The main revisions took place in the 1990-2010 and 1990-2011 inventories. These were due to revisions to the use of petroleum fuels in boilers, through greater use of point source information from the EU ETS. Use of EU ETS data has also identified new data sources on industrial combustion in 1990-2010.

Chart D3 shows the impact of these revisions on the Business and Industrial Process emissions time series. Although the absolute level of emissions has increased by successive revisions, the effect on the trend (emissions reduction trajectory) is marginal.

Chart D3. Greenhouse Gas Emissions: 1990-2008 and 1990-2012 Inventories: BUSINESS AND INDUSTRIAL PROCESS. Values in Mt CO₂e



Residential

The 1990-2008 inventory has been chosen as the first inventory in this paper as it was used as the basis for setting Scotland's fixed Annual Climate Change Targets. The 1990-2012 inventory is the most recent inventory for which data are available. For the Residential sector, there are some emissions of F gases. The Baseline Period for F gases is 1995 rather than 1990, as for the other greenhouse gases⁶. This means that the Baseline emissions for the Residential sector are different from the 1990 emissions, and this is shown in Chart D4 which outlines percentage changes in emissions using different inventories.

The Baseline value was revised upwards by 0.4 Mt CO₂e (5.1 per cent) from 7.8 Mt CO₂e in the 1990-2008 inventory to 8.2 Mt CO₂e in the latest inventory.

2008 emissions were revised upwards by 0.1 Mt CO₂e (2.0 per cent) from 7.6 Mt CO₂e in the 1990-2008 inventory to 7.7 Mt CO₂e in the latest inventory, with the 2012 figure being 7.3 Mt CO₂e.

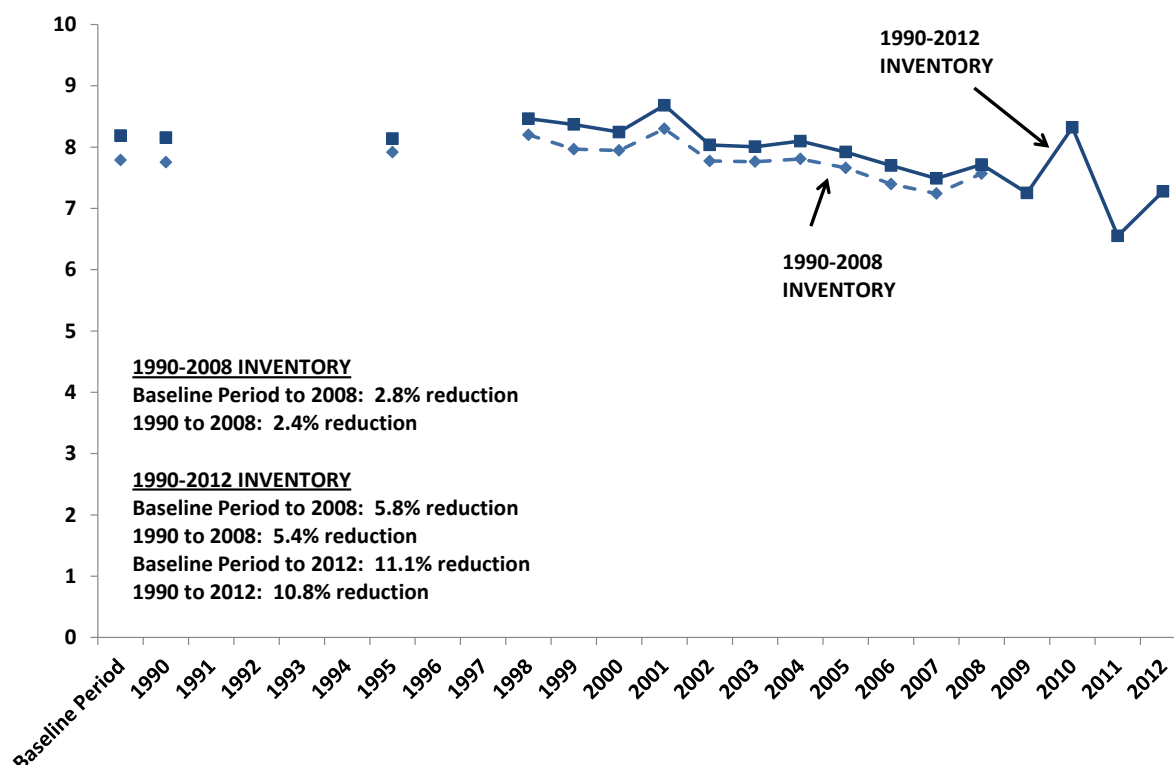
There were two changes in emissions from this sector (both in the 1990-2009 inventory). This was due to revisions to the mapping grids in residential combustion, which have led to an increase in solid and petroleum fuel emissions in the residential sector. The revisions appear to have affected the Baseline slightly more than the later parts of the series.

Chart D4 shows the impact of these revisions on the Residential emissions time series.

⁶ The Baseline Period for reporting against Climate Change Targets is:

- 1990 for carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O)
- 1995 for Fluorinated gases (F gases): hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆)

**Chart D4. Greenhouse Gas Emissions: 1990-2008 and 1990-2012 Inventories:
RESIDENTIAL. Values in Mt CO₂e**



Waste Management

The 1990-2008 inventory has been chosen as the first inventory in this paper as it was used as the basis for setting Scotland's fixed Annual Climate Change Targets. The 1990-2012 inventory is the most recent inventory for which data are available. For the Waste Management sector, the Baseline emissions are equal to those for 1990.

The Baseline value was revised upwards by 0.9 Mt CO₂e (15.9 per cent) from 5.8 Mt CO₂e in the 1990-2008 inventory to 6.7 Mt CO₂e in the latest inventory.

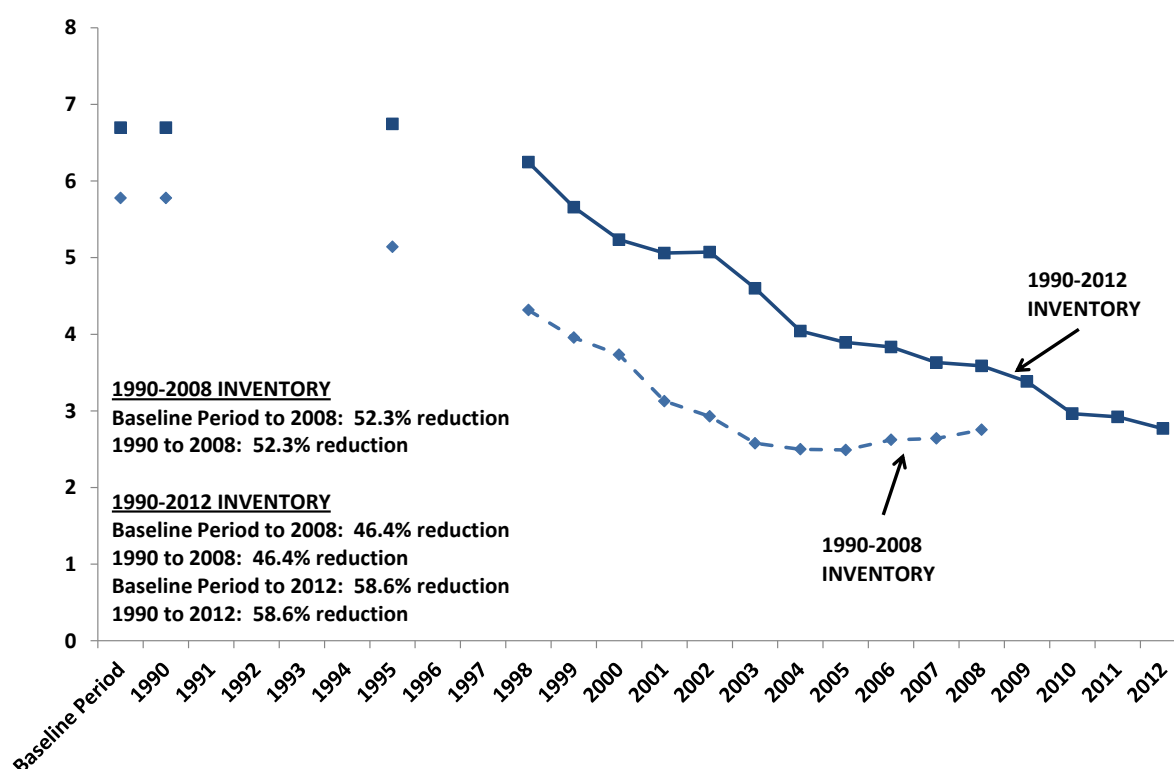
2008 emissions were revised upwards by 0.8 Mt CO₂e (30.3 per cent) from 2.8 Mt CO₂e in the 1990-2008 inventory to 3.6 Mt CO₂e in the latest inventory, with the 2012 figure being 2.8 Mt CO₂e.

Much of the data used to estimate waste management emissions are based on modelled data. As a result, waste management revisions have occurred over successive inventories. This is largely due to two factors. The first of these has been the implementation a revised UK model of landfill and subsequent improvements, which incorporates more Scotland-specific data. The largest changes have occurred in 1990-2009 (due to the introduction of the new model). The second factor has been a change to the landfill model to estimate

methane captured from landfill in the 1990-2012. The overall effect of these revisions is to increase the percentage reductions observed in the sector from the 1990-2008 inventory to the latest inventory.

Chart D5 shows the impact of these revisions on the Waste Management emissions time series.

Chart D5. Greenhouse Gas Emissions: 1990-2008 and 1990-2012 Inventories: WASTE MANAGEMENT. Values in Mt CO₂e



Transport (Including International Aviation and Shipping)

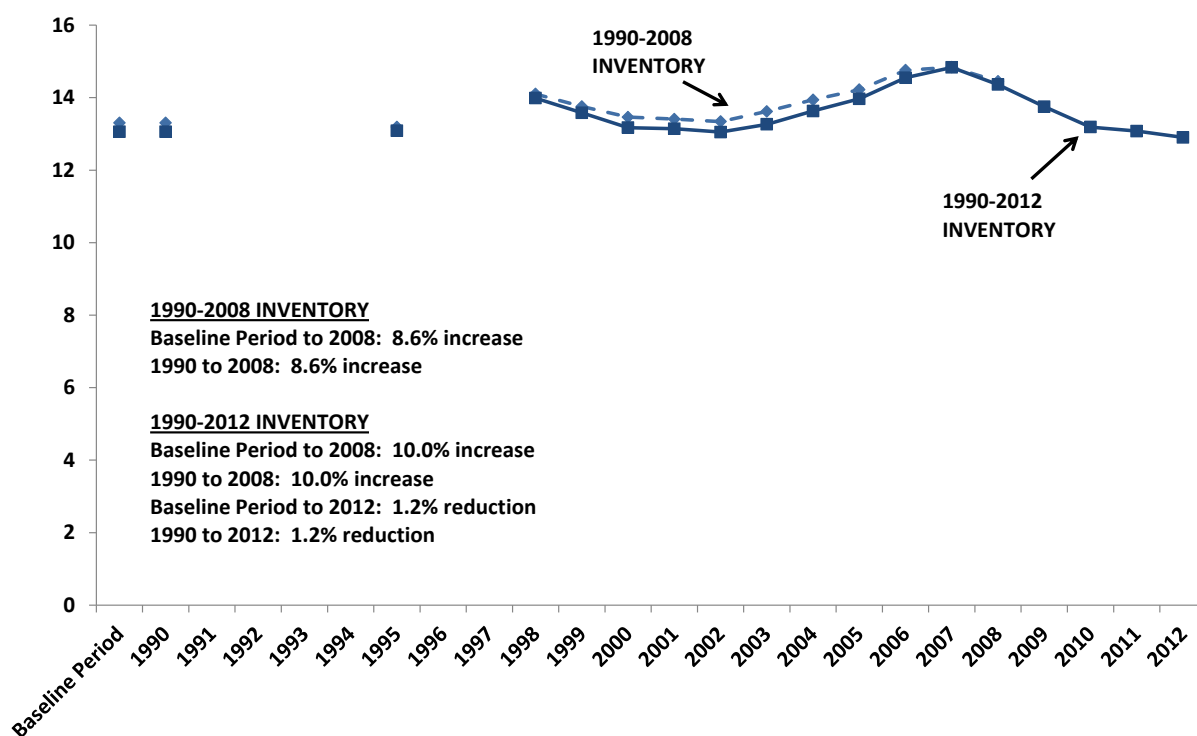
The 1990-2008 inventory has been chosen as the first inventory in this paper as it was used as the basis for setting Scotland's fixed Annual Climate Change Targets. The 1990-2012 inventory is the most recent inventory for which data are available. For the Transport sector (including International Aviation and Shipping), the Baseline emissions are equal to those for 1990.

The Baseline value was revised downwards by 0.2 Mt CO₂e (1.8 per cent reduction) from 13.3 Mt CO₂e in the 1990-2008 inventory to 13.1 Mt CO₂e in the latest inventory.

2008 emissions were revised downwards by 0.1 Mt CO₂e (0.6 per cent reduction) from 14.4 Mt CO₂e in the 1990-2008 inventory to 14.4 Mt CO₂e in the latest inventory, with the 2012 figure being 12.9 Mt CO₂e.

Chart D6 shows the impact of these revisions on the transport time series.

Chart D6. Greenhouse Gas Emissions: 1990-2008 and 1990-2012 Inventories: TRANSPORT (INCLUDING INTERNATIONAL AVIATION AND SHIPPING). Values in Mt CO₂e



Transport (Excluding International Aviation and Shipping)

The 1990-2008 inventory has been chosen as the first inventory in this paper as it was used as the basis for setting Scotland's fixed Annual Climate Change Targets. The 1990-2012 inventory is the most recent inventory for which data are available. For the Transport sector (excluding International Aviation and Shipping), the Baseline emissions are equal to those for 1990.

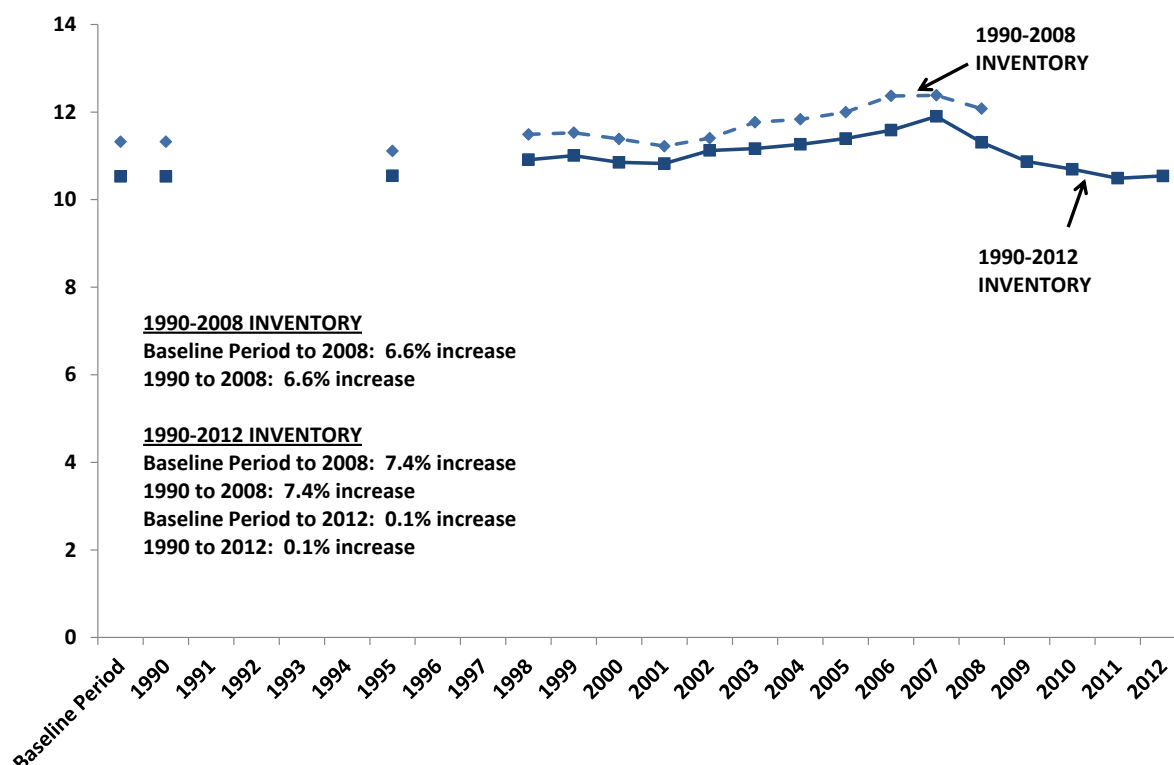
The Baseline value was revised downwards by 0.8 Mt CO₂e (7.0 per cent reduction) from 11.3 Mt CO₂e in the 1990-2008 inventory to 10.5 Mt CO₂e in the latest inventory.

2008 emissions were revised downwards by 0.8 Mt CO₂e (6.4 per cent reduction) from 12.1 Mt CO₂e in the 1990-2008 inventory to 11.3 Mt CO₂e in the latest inventory, with the 2012 figure being 10.5 Mt CO₂e.

There have been small revisions downwards across much of the series, and these have been broadly consistent across the series. These have taken place in the 1990-2009 inventory, and have been due to two changes. One was the introduction of a new model for estimating emissions from international shipping, which has reallocation of many domestic shipping emissions to international shipping. The other was the use of Scottish level road vehicle fleet data which has lower emissions associated with them, rather than using UK level fleet data.

Chart D7 shows the impact of these revisions on the time series. There has been little change in the overall trend.

Chart D7. Greenhouse Gas Emissions: 1990-2008 and 1990-2012 Inventories: TRANSPORT (EXCLUDING INTERNATIONAL AVIATION AND SHIPPING). Values in Mt CO₂e



International Aviation and Shipping

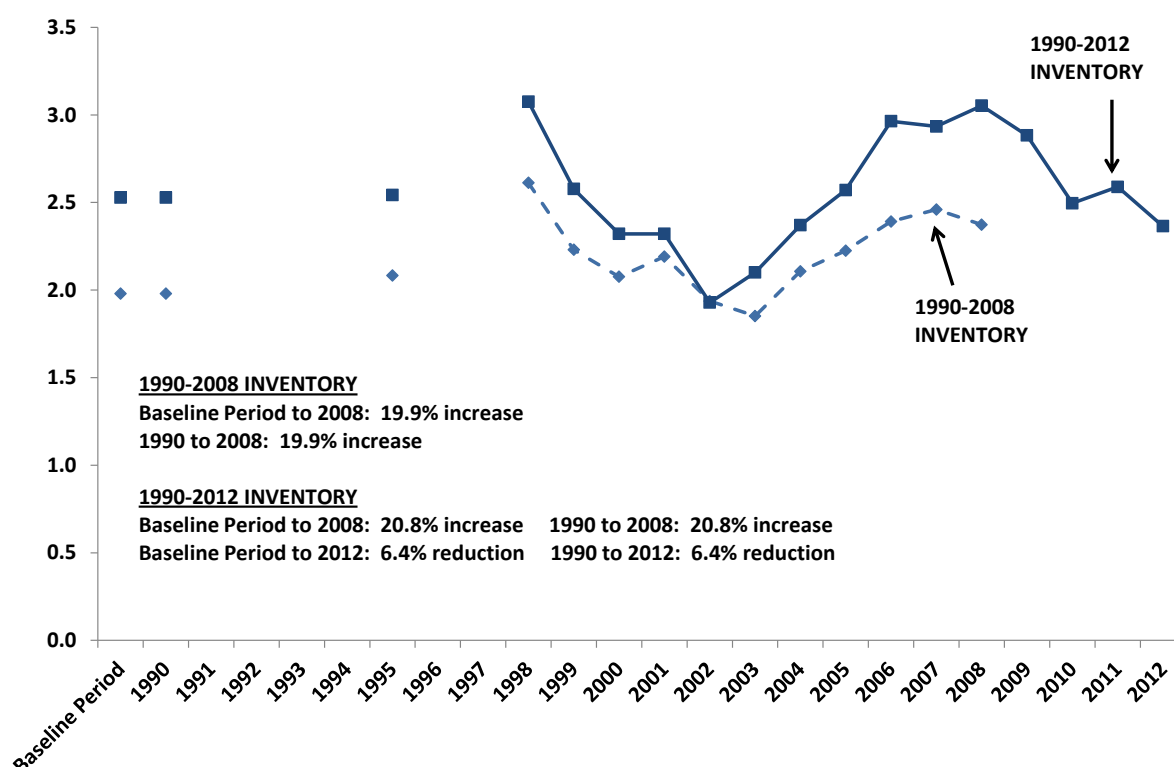
The 1990-2008 inventory has been chosen as the first inventory in this paper as it was used as the basis for setting Scotland's fixed Annual Climate Change Targets. The 1990-2012 inventory is the most recent inventory for which data are available. For International Aviation and Shipping, the Baseline emissions are equal to those for 1990. The Baseline value was revised upwards by 0.5 Mt CO₂e (27.7 per cent) from 2.0 Mt CO₂e in the 1990-2008 inventory to 2.5 Mt CO₂e in the latest inventory.

2008 emissions were revised upwards by 0.7 Mt CO₂e (28.6 per cent) from 2.4 Mt CO₂e in the 1990-2008 inventory to 3.1 Mt CO₂e in the latest inventory, with the 2012 figure being 2.4 Mt CO₂e.

There have been upwards revisions across much of the series, and these have been fairly consistent across the series. These have taken place in the 1990-2009 inventory, and have been due to the introduction of a new model for estimating emissions from international shipping, which has reallocation of many domestic shipping emissions to international shipping.

Chart D8 shows the impact of these revisions on the time series. As these data are modelled and based on marine fuel bunkers, the time series is very volatile, although the revisions have not changed the overall trend in the series.

Chart D8. Greenhouse Gas Emissions: 1990-2008 and 1990-2012 Inventories: INTERNATIONAL AVIATION AND SHIPPING. Values in Mt CO₂e



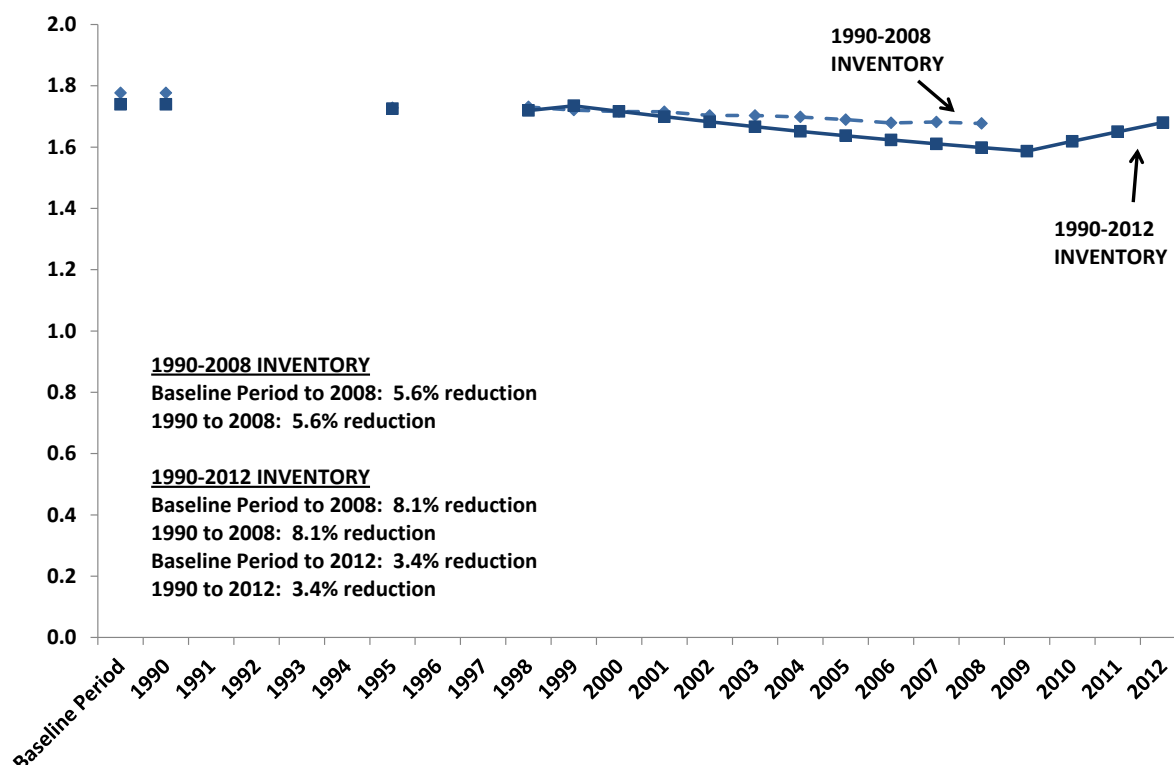
Development

The 1990-2008 inventory has been chosen as the first inventory in this paper as it was used as the basis for setting Scotland's fixed Annual Climate Change Targets. The 1990-2012 inventory is the most recent inventory for which data are available. For the Development sector, the Baseline emissions are equal to those for 1990. The Baseline value was revised downwards by 0.0 Mt CO₂e (2.1 per cent decrease) from 1.8 Mt CO₂e in the 1990-2008 inventory to 1.7 Mt CO₂e in the latest inventory.

2008 emissions were revised downwards by 0.1 Mt CO₂e (4.7 per cent decrease) from 1.7 Mt CO₂e in the 1990-2008 inventory to 1.6 Mt CO₂e in the latest inventory, with the 2012 figure being 1.7 Mt CO₂e.

Chart D9 shows the impact of these revisions on the time series. Revisions are due to changes in land converted to settlements (1990-2009 inventory). These changes are very small in the context of the overall inventory, and have made the emissions reduction trajectory slightly more pronounced than before.

**Chart D9. Greenhouse Gas Emissions: 1990-2008 and 1990-2012 Inventories:
DEVELOPMENT. Values in Mt CO₂e**



Public Sector

The 1990-2008 inventory has been chosen as the first inventory in this paper as it was used as the basis for setting Scotland's fixed Annual Climate Change Targets. The 1990-2012 inventory is the most recent inventory for which data are available. For Public sector emissions, the Baseline emissions are equal to those for 1990.

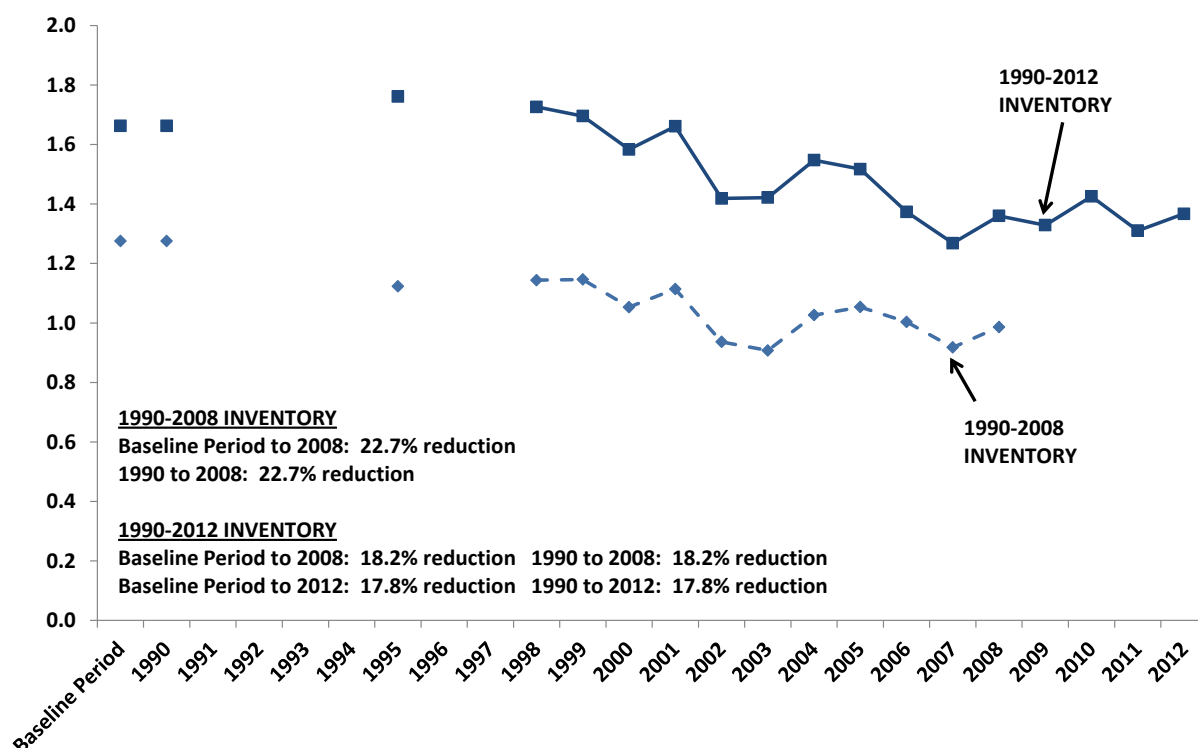
The Baseline value was revised upwards by 0.4 Mt CO₂e (30.4 per cent) from 1.3 Mt CO₂e in the 1990-2008 inventory to 1.7 Mt CO₂e in the latest inventory.

2008 emissions were revised upwards by 0.4 Mt CO₂e (37.9 per cent) from 1.0 Mt CO₂e in the 1990-2008 inventory to 1.4 Mt CO₂e in the latest inventory, with the 2012 figure being 1.4 Mt CO₂e.

There have been two major upwards revisions to the time series, both of which have occurred in the 1990-2012 inventory. One has affected the entire time series – a use of Scottish proxy data for Display Energy Certificates in public sector buildings. The other has been due to the reallocation of the economic classification of some buildings in the underlying energy statistics at a UK level, leading to an increase in those classed as public sector. This affects later parts of the time series.

Chart D10 shows the impact of these revisions on the time series. The emissions reductions trajectory is less in the 1990-2012 inventory than for the 1990-2008 inventory.

Chart D10. Greenhouse Gas Emissions: 1990-2008 and 1990-2012 Inventories: PUBLIC SECTOR. Values in Mt CO₂e



Forestry

The 1990-2008 inventory has been chosen as the first inventory in this paper as it was used as the basis for setting Scotland's fixed Annual Climate Change Targets. The 1990-2012 inventory is the most recent inventory for which data are available. For the Forestry sector, the Baseline value is equal to the 1990 value.

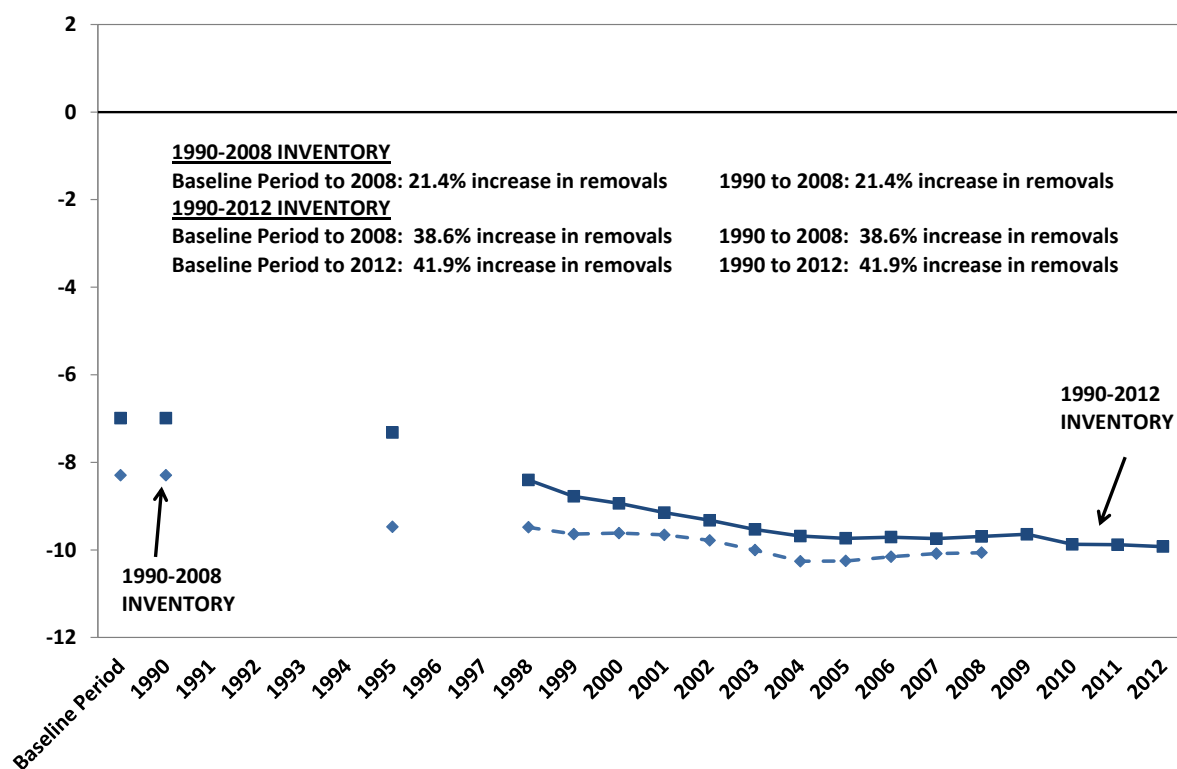
The Baseline value was revised upwards by 1.3 Mt CO₂e from -8.3 Mt CO₂e in the 1990-2008 inventory to -7.0 Mt CO₂e in the latest inventory, leading to a net reduction in removals in the Baseline period of 15.7 per cent.

2008 net emissions were revised upwards by 0.4 Mt CO₂e from -10.1 Mt CO₂e in the 1990-2008 inventory to -9.7 Mt CO₂e in the latest inventory, leading to a net reduction in removals of 3.7 per cent. The 2012 figure was -9.9 Mt CO₂e.

There was one major upwards revision to net emissions in this sector. This took place in the 1990-2012 inventory and was caused by the introduction of a new carbon accounting model which estimates the sequestration of forestry from a much greater range of tree species and ages than used previously.

Chart D11 shows the impact of these revisions on the Forestry time series. The effect of this revision is to increase the trajectory of removals from the 1990-2008 inventory to the latest inventory.

**Chart D11. Net Greenhouse Gas Emissions: 1990-2008 and 1990-2012 Inventories:
FORESTRY. Values in Mt CO₂e**



Section E. Data Tables

Table 1. Scottish Greenhouse Gas Emissions by Source Sector, Successive Inventories from 1990-2008 to 1990-2012. Values in Mt CO₂e

	Baseline Period	1990		1995		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total																				
1990-2008	70.2	70.1		67.8		67.7	63.3	65.5	64.8	60.9	60.5	58.5	57.8	61.5	57.8	56.1				
1990-2009	71.8	71.6		68.6		68.5	64.3	66.0	65.4	61.2	60.7	58.5	57.5	61.2	56.9	54.8	51.0			
1990-2010	72.3	72.2		69.8		70.0	65.8	67.5	67.0	62.6	62.0	59.8	58.7	62.6	58.3	56.6	52.7	55.7		
1990-2011	73.0	72.9		70.9		70.3	66.8	69.0	68.2	63.8	63.3	61.1	60.3	63.9	59.4	58.1	54.2	56.9	51.3	
1990-2012	75.6	75.5		75.4		74.2	70.3	72.0	71.3	67.0	66.7	64.4	63.1	66.8	62.2	60.2	56.3	58.3	52.5	52.9
Energy Supply																				
1990-2008	22.3	22.3		26.5		26.2	23.0	25.8	25.2	23.2	23.1	21.3	20.1	23.8	20.7	19.4				
1990-2009	22.2	22.2		26.4		26.2	23.1	25.9	25.3	23.3	23.4	21.6	20.5	24.4	21.1	19.6	18.2			
1990-2010	22.3	22.3		26.5		26.3	23.2	26.0	25.5	23.4	23.4	21.7	20.5	24.7	21.3	19.8	18.5	20.7		
1990-2011	22.4	22.4		26.5		25.5	23.1	26.0	25.3	23.3	23.4	21.8	20.4	24.4	21.1	19.9	18.6	20.7	16.9	
1990-2012	22.4	22.4		26.5		25.5	23.1	26.0	25.3	23.3	23.4	21.8	20.5	24.7	21.3	20.0	18.6	20.7	16.9	17.1
Agriculture and Related Land Use																				
1990-2008	13.8	13.8		13.7		13.3	13.1	12.8	12.5	12.5	12.6	12.3	12.3	12.1	11.8	11.5				
1990-2009	14.5	14.5		14.4		14.1	14.0	13.4	12.9	12.7	12.6	12.1	11.9	11.6	11.1	10.7	10.6			
1990-2010	14.3	14.3		14.4		14.4	14.3	13.6	13.2	13.1	13.1	12.6	12.1	11.9	11.3	10.9	10.7	10.5		
1990-2011	14.3	14.3		14.4		14.5	14.3	13.7	13.2	13.0	13.0	12.6	12.2	11.8	11.3	10.9	10.7	10.4	10.1	
1990-2012	15.2	15.2		15.4		15.5	15.3	15.1	14.5	14.3	14.3	13.9	13.6	13.1	12.7	12.2	12.0	11.8	11.5	11.2

	Baseline Period	1990		1995		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Business and Industrial Process																				
1990-2008	12.4	12.3		8.0		8.2	8.3	8.5	9.1	8.3	8.2	8.1	8.5	8.3	8.1	7.7				
1990-2009	12.4	12.3		8.0		8.2	8.3	8.6	9.1	8.3	8.3	8.1	8.4	8.2	7.9	7.7	6.8			
1990-2010	13.2	13.1		8.7		8.8	8.9	9.2	9.7	8.9	8.9	8.7	9.2	8.9	8.6	8.9	7.8	7.9		
1990-2011	13.6	13.6		9.5		9.7	9.8	10.4	11.0	10.2	10.1	9.9	10.6	10.2	9.7	10.2	9.1	9.1	9.2	
1990-2012	13.6	13.5		9.3		9.5	9.6	9.9	10.4	9.4	9.5	9.4	9.8	9.5	9.1	9.1	8.1	8.2	8.5	8.5
Residential																				
1990-2008	7.8	7.8		7.9		8.2	8.0	7.9	8.3	7.8	7.8	7.8	7.7	7.4	7.2	7.6				
1990-2009	8.2	8.1		8.1		8.5	8.4	8.3	8.7	8.1	8.1	8.2	8.0	7.8	7.5	7.8	7.3			
1990-2010	8.2	8.1		8.1		8.5	8.4	8.3	8.7	8.1	8.1	8.2	8.0	7.8	7.6	7.8	7.3	8.4		
1990-2011	8.2	8.1		8.1		8.5	8.4	8.3	8.7	8.1	8.1	8.2	8.0	7.8	7.6	7.8	7.3	8.4	6.6	
1990-2012	8.2	8.2		8.1		8.5	8.4	8.2	8.7	8.0	8.0	8.1	7.9	7.7	7.5	7.7	7.3	8.3	6.6	7.3
Waste Management																				
1990-2008	5.8	5.8		5.1		4.3	4.0	3.7	3.1	2.9	2.6	2.5	2.5	2.6	2.6	2.8				
1990-2009	6.5	6.5		5.1		4.1	3.7	3.5	2.9	2.7	2.3	2.2	2.2	2.2	2.2	2.2	2.1			
1990-2010	6.6	6.6		5.7		4.7	4.3	4.0	3.5	3.2	2.8	2.6	2.5	2.4	2.4	2.3	2.2	2.2		
1990-2011	6.7	6.7		5.8		4.8	4.4	4.1	3.6	3.3	2.9	2.7	2.6	2.5	2.5	2.4	2.3	2.2	2.2	
1990-2012	6.7	6.7		6.7		6.2	5.7	5.2	5.1	5.1	4.6	4.0	3.9	3.8	3.6	3.6	3.4	3.0	2.9	2.8
Transport (including International Aviation and Shipping)																				
1990-2008	13.3	13.3		13.2		14.1	13.8	13.5	13.4	13.3	13.6	13.9	14.2	14.8	14.8	14.4				
1990-2009	13.1	13.1		13.1		13.9	13.6	13.3	13.2	13.1	13.3	13.7	14.0	14.5	14.6	14.3	13.6			
1990-2010	13.0	13.0		13.0		13.9	13.5	13.2	13.2	13.1	13.3	13.6	13.9	14.5	14.6	14.3	13.6	13.2		
1990-2011	12.9	12.9		12.9		13.8	13.4	13.1	13.1	13.0	13.3	13.6	13.9	14.5	14.7	14.3	13.6	13.1	13.0	
1990-2012	13.1	13.1		13.1		14.0	13.6	13.2	13.1	13.1	13.3	13.6	14.0	14.5	14.8	14.4	13.8	13.2	13.1	12.9

	Baseline Period	1990		1995		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Transport (excluding IA&S)																				
1990-2008	11.3	11.3		11.1		11.5	11.5	11.4	11.2	11.4	11.8	11.8	12.0	12.4	12.4	12.1				
1990-2009	10.6	10.6		10.6		10.9	11.1	10.9	10.8	11.1	11.2	11.2	11.3	11.5	11.6	11.2	10.7			
1990-2010	10.5	10.5		10.5		10.9	11.0	10.8	10.8	11.1	11.1	11.2	11.3	11.5	11.6	11.3	10.8	10.7		
1990-2011	10.5	10.5		10.5		10.9	11.0	10.8	10.8	11.1	11.1	11.2	11.4	11.6	11.8	11.3	10.9	10.7	10.5	
1990-2012	10.5	10.5		10.5		10.9	11.0	10.9	10.8	11.1	11.2	11.3	11.4	11.6	11.9	11.3	10.9	10.7	10.5	10.5
International Aviation and Shipping (IA&S)																				
1990-2008	2.0	2.0		2.1		2.6	2.2	2.1	2.2	1.9	1.9	2.1	2.2	2.4	2.5	2.4				
1990-2009	2.5	2.5		2.5		3.0	2.5	2.4	2.4	2.0	2.2	2.4	2.6	3.0	3.0	3.0	2.8			
1990-2010	2.5	2.5		2.5		3.0	2.5	2.4	2.4	2.0	2.2	2.4	2.6	3.0	3.0	3.0	2.8	2.5		
1990-2011	2.4	2.4		2.4		2.9	2.5	2.3	2.3	1.9	2.1	2.4	2.6	3.0	2.9	3.0	2.8	2.4	2.5	
1990-2012	2.5	2.5		2.5		3.1	2.6	2.3	2.3	1.9	2.1	2.4	2.6	3.0	2.9	3.1	2.9	2.5	2.6	2.4
Development																				
1990-2008	1.8	1.8		1.7		1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7				
1990-2009	1.8	1.8		1.7		1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.5			
1990-2010	1.8	1.8		1.8		1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.6		
1990-2011	1.7	1.7		1.7		1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.7	
1990-2012	1.7	1.7		1.7		1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.7
Public																				
1990-2008	1.3	1.3		1.1		1.1	1.1	1.1	1.1	0.9	0.9	1.0	1.1	1.0	0.9	1.0				
1990-2009	1.3	1.3		1.2		1.1	1.2	1.1	1.1	0.9	0.9	1.0	1.1	1.0	0.9	0.9	0.8			
1990-2010	1.2	1.2		1.1		1.1	1.1	1.0	1.1	0.9	0.9	1.0	1.1	1.0	0.9	0.9	0.8	0.9		
1990-2011	1.2	1.2		1.1		1.1	1.1	1.0	1.1	0.9	0.9	1.0	1.1	1.0	0.9	1.0	0.8	0.9	0.7	
1990-2012	1.7	1.7		1.8		1.7	1.7	1.6	1.7	1.4	1.4	1.5	1.5	1.4	1.3	1.4	1.3	1.4	1.3	1.4

	Baseline Period	1990		1995		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Forestry																				
1990-2008	-8.3	-8.3		-9.5		-9.5	-9.6	-9.6	-9.7	-9.8	-10.0	-10.3	-10.3	-10.2	-10.1	-10.1				
1990-2009	-8.3	-8.3		-9.4		-9.4	-9.6	-9.6	-9.6	-9.7	-10.0	-10.2	-10.2	-10.1	-10.0	-10.0	-10.0			
1990-2010	-8.3	-8.3		-9.5		-9.5	-9.6	-9.6	-9.6	-9.8	-10.1	-10.4	-10.2	-10.1	-10.0	-10.0	-10.0	-9.6		
1990-2011	-8.2	-8.2		-9.1		-9.3	-9.6	-9.5	-9.5	-9.7	-10.0	-10.3	-10.1	-9.9	-9.9	-9.9	-9.8	-9.6	-9.1	
1990-2012	-7.0	-7.0		-7.3		-8.4	-8.8	-8.9	-9.1	-9.3	-9.5	-9.7	-9.7	-9.7	-9.7	-9.7	-9.6	-9.9	-9.9	-9.9

Table 2. Percentage changes in emissions by source sector. Comparison of 1990-2008 and 1990-2012 inventories. Values in Mt CO₂e

	Baseline Period	1990	2008	2012	% change between Baseline Period and 2008	% change between 1990 and 2008	% change between Baseline Period and 2012	% change between 1990 and 2012
Total								
1990-2008	70.2	70.1	56.1		-20.1%	-20.0%		
1990-2012	75.6	75.5	60.2	52.9	-20.4%	-20.3%	-30.0%	-29.9%
Difference between 1990-2008 and 1990-2012	5.4	5.4	4.1					
Energy Supply								
1990-2008	22.3	22.3	19.4		-13.0%	-13.0%		
1990-2012	22.4	22.4	20.0	17.1	-10.8%	-10.8%	-23.5%	-23.5%
Difference between 1990-2008 and 1990-2012	0.1	0.1	0.5					
Agriculture and Related Land Use								
1990-2008	13.8	13.8	11.5		-16.5%	-16.5%		
1990-2012	15.2	15.2	12.2	11.2	-19.8%	-19.8%	-26.7%	-26.7%
Difference between 1990-2008 and 1990-2012	1.4	1.4	0.7					
Business and Industrial Process								
1990-2008	12.4	12.3	7.7		-37.6%	-37.2%		
1990-2012	13.6	13.5	9.1	8.5	-33.4%	-33.1%	-37.3%	-37.0%
Difference between 1990-2008 and 1990-2012	1.2	1.2	1.3					
Residential								
1990-2008	7.8	7.8	7.6		-2.8%	-2.4%		
1990-2012	8.2	8.2	7.7	7.3	-5.8%	-5.4%	-11.1%	-10.8%
Difference between 1990-2008 and 1990-2012	0.4	0.4	0.1					
Waste Management								
1990-2008	5.8	5.8	2.8		-52.3%	-52.3%		
1990-2012	6.7	6.7	3.6	2.8	-46.4%	-46.4%	-58.6%	-58.6%
Difference between 1990-2008 and 1990-2012	0.9	0.9	0.8					
Transport (including International Aviation and Shipping)								
1990-2008	13.3	13.3	14.4		8.6%	8.6%		
1990-2012	13.1	13.1	14.4	12.9	10.0%	10.0%	-1.2%	-1.2%
Difference between 1990-2008 and 1990-2012	-0.2	-0.2	-0.1					

	Baseline Period	1990	2008	2012	% change between Baseline Period and 2008	% change between 1990 and 2008	% change between Baseline Period and 2012	% change between 1990 and 2012
Transport (excluding IA&S)								
1990-2008	11.3	11.3	12.1		6.6%	6.6%		
1990-2012	10.5	10.5	11.3	10.5	7.4%	7.4%	0.1%	0.1%
Difference between 1990-2008 and 1990-2012	-0.8	-0.8	-0.8					
International Aviation and Shipping (IA&S)								
1990-2008	2.0	2.0	2.4		19.9%	19.9%		
1990-2012	2.5	2.5	3.1	2.4	20.8%	20.8%	-6.4%	-6.4%
Difference between 1990-2008 and 1990-2012	0.5	0.5	0.7					
Development								
1990-2008	1.8	1.8	1.7		-5.6%	-5.6%		
1990-2012	1.7	1.7	1.6	1.7	-8.1%	-8.1%	-3.4%	-3.4%
Difference between 1990-2008 and 1990-2012	0.0	0.0	-0.1					
Public								
1990-2008	1.3	1.3	1.0		-22.7%	-22.7%		
1990-2012	1.7	1.7	1.4	1.4	-18.2%	-18.2%	-17.8%	-17.8%
Difference between 1990-2008 and 1990-2012	0.4	0.4	0.4					
Forestry								
1990-2008	-8.3	-8.3	-10.1		21.4%	21.4%		
1990-2012	-7.0	-7.0	-9.7	-9.9	38.6%	38.6%	41.9%	41.9%
Difference between 1990-2008 and 1990-2012	1.3	1.3	0.4					

Table 3. Year-on-year changes to the Baseline since the 1990-2008 inventory, by source sector. Values in Mt CO₂e

	Change from 1990-2008 to 1990-2012	1990- 2009	1990- 2010	1990- 2011	1990- 2012
Total	5.39	1.55	0.52	0.70	2.62
Agriculture and Related Land Use	1.41	0.68	-0.24	0.08	0.90
Forestry	1.30	0.02	-0.03	0.08	1.23
Business and Industrial Process	1.20	0.02	0.79	0.43	-0.04
Waste Management	0.92	0.70	0.10	0.14	-0.02
International Aviation and Shipping (IA&S)	0.55	0.55	-0.02	-0.06	0.08
Residential	0.40	0.39	0.00	0.00	0.01
Public	0.39	0.05	-0.10	0.00	0.44
Energy Supply	0.05	-0.11	0.08	0.08	-0.01
Development	-0.04	0.01	-0.01	-0.03	-0.01
Transport (excluding IA&S)	-0.79	-0.76	-0.04	-0.02	0.03

Table 4. Mapping between Scottish Government sectors, National Communication sectors, International Panel for Climate Change sectors and source

SG Sector	NC Category	IPCC Sector	Source Name
Energy Supply	Energy Supply	1A1a Public Electricity & Heat Production	Miscellaneous industrial/commercial combustion
			Power stations
			Public sector combustion
		1A1b Petroleum Refining	Refineries - combustion
		1A1ci Manufacture of Solid Fuels-coke	Coke production
			Solid smokeless fuel production
		1A1cii Other Energy Industries	Collieries - combustion
			Gas production
			Nuclear fuel production
			Town gas manufacture
			Upstream Gas Production - fuel combustion
			Upstream oil and gas production - combustion at gas separation plant
			Upstream Oil Production - fuel combustion
		1B1a Post-MiningActivities	Coal storage and transport
		1B1a Surface Mines	Open-cast coal
		1B1a Underground Mines	Deep-mined coal
		1B1b Solid Fuel Transformation	Charcoal production
			Coke production
			Iron and steel - flaring
			Solid smokeless fuel production
		1B1c Closed Coal Mines	Closed Coal Mines
		1B2a Oil Exploration	Upstream Oil Production - Offshore Well Testing
		1B2a Oil Other	Upstream Oil Production - Onshore Oil Loading
		1B2a Oil Production	Upstream Oil Production - process emissions
		1B2a Oil Transport	Upstream Oil Production - Offshore Oil Loading
		1B2a Refining/Storage	Petroleum processes
			Upstream Oil Production - Oil terminal storage
		1B2b Distribution	Gas leakage
		1B2b Gas Exploration	Upstream Gas Production - Offshore Well Testing
		1B2b Gas Production	Upstream Gas Production - Gas terminal storage
			Upstream Gas Production - process emissions
		1B2b Transmission	Gas leakage

SG Sector	NC Category	IPCC Sector	Source Name
		1B2c Flaring Gas	Upstream Gas Production - flaring
		1B2ci Venting Gas	Upstream Gas Production - venting
		1B2ci Venting Oil	Upstream Oil Production - venting
		1B2cii Flaring Oil	Upstream Oil Production - flaring
		2A3 Limestone & Dolomite Use	Power stations - FGD
Business and Industrial process	Business	1A2a Manufacturing Industry&Construction:I&S	Blast furnaces
			Iron and steel - combustion plant
		1A2b Non-Ferrous Metals	Non-Ferrous Metal (combustion)
		1A2c Chemicals	Ammonia production - combustion
			Chemicals (combustion)
		1A2d Pulp Paper Print	Pulp, Paper and Print (combustion)
		1A2e Food drink tobacco	Food & drink, tobacco (combustion)
		1A2f Manufacturing Industry&Construction:Other	Autogeneration - exported to grid
			Autogenerators
			Cement production - combustion
			Lime production - non decarbonising
			Other industrial combustion
		1A2fii Manufacturing Industry&Construction:Off-road	Industrial engines
			Industrial off-road mobile machinery
		1A4a Commercial/Institutional	Miscellaneous industrial/commercial combustion
		2B5 Carbon from NEU of products	Other industrial combustion
		2F1 Refrigeration and Air Conditioning Equipment	Commercial Refrigeration
			Domestic Refrigeration
			Industrial Refrigeration
			Mobile Air Conditioning
			Refrigerated Transport
			Stationary Air Conditioning
		2F2 Foam Blowing	Foams
		2F3 Fire Extinguishers	Firefighting
		2F5 Solvents	Other PFC use
			Precision cleaning - HFC
		2F9 Other	SF ₆ used as a tracer gas
		2F9 Other (one component foams)	One Component Foams
		2F9 Other (semiconductors electrical sporting goods)	2F9 other

SG Sector	NC Category	IPCC Sector	Source Name
	Industrial Process	1A2a Manufacturing Industry&Construction:I&S	Sinter production
		2A1 Cement Production	Cement - decarbonising
		2A2 Lime Production	Lime production - decarbonising
		2A3 Limestone & Dolomite Use	Basic oxygen furnaces
			Sinter production
		2A7 (Fletton Bricks)	Brick manufacture - Fletton
		2A7 Glass Production	Glass - general
		2B1 Ammonia Production	Ammonia production - feedstock use of gas
		2B2 Nitric Acid Production	Nitric acid production
		2B3 Adipic Acid Production	Adipic acid production
		2B5 Chemical Industry Other	Chemical industry - ethylene
			Chemical industry - general
			Chemical industry - methanol
		2C1 Iron&Steel	Electric arc furnaces
			Iron and steel - flaring
			Ladle arc furnaces
		2C3 Aluminium Production	Primary aluminium production - general
			Primary aluminium production - PFC emissions
		2C4 Cover gas used in Al and Mg foundries	Magnesium cover gas
		2E1 Production of Halocarbons and Sulphur Hexafluoride	Halocarbons production - by-product
		2E2 Production of Halocarbons and Sulphur Hexafluoride	Halocarbons production - fugitive
		3 Solvent and Other Product Use	Solvent use
Transport (excluding international aviation and shipping)	Transport	1A3aii Civil Aviation Domestic	Aircraft - domestic cruise
			Aircraft - domestic take-off and landing
		1A3b Road Transportation	Road transport - all vehicles LPG use
			Road transport - buses and coaches - motorway driving
			Road transport - buses and coaches - rural driving
			Road transport - buses and coaches - urban driving
			Road transport - cars - cold start
			Road transport - cars - motorway driving
			Road transport - cars - rural

SG Sector	NC Category	IPCC Sector	Source Name
			driving
			Road transport - cars - urban driving
			Road transport - HGV articulated - motorway driving
			Road transport - HGV articulated - rural driving
			Road transport - HGV articulated - urban driving
			Road transport - HGV rigid - motorway driving
			Road transport - HGV rigid - rural driving
			Road transport - HGV rigid - urban driving
			Road transport - LGVs - cold start
			Road transport - LGVs - motorway driving
			Road transport - LGVs - rural driving
			Road transport - LGVs - urban driving
			Road transport - mopeds (<50cc 2st) - urban driving
			Road transport - motorcycle (>50cc 2st) - rural driving
			Road transport - motorcycle (>50cc 2st) - urban driving
			Road transport - motorcycle (>50cc 4st) - motorway driving
			Road transport - motorcycle (>50cc 4st) - rural driving
			Road transport - motorcycle (>50cc 4st) - urban driving
			Road vehicle engines
		1A3c Railways	Rail - coal
			Railways - freight
			Railways - intercity
			Railways - regional
		1A3dii National Navigation	Inland goods-carrying vessels
			Marine engines
			Motorboats / workboats (e.g. canal boats, dredgers, service boats, tourist boats, river boats)
			Personal watercraft e.g. jet ski
			Sailing boats with auxiliary engines
			Shipping - coastal
		1A3e Other Transportation	Aircraft - support vehicles

SG Sector	NC Category	IPCC Sector	Source Name
		1A4a Commercial/Institutional	Railways - stationary combustion
		1A4ciii Fishing	Fishing vessels
		1A5b Other:Mobile	Aircraft - military
			Shipping - naval
Residential	Residential	1A4bi Residential	Domestic combustion
		1A4bii Residential:Off-road	House and garden machinery
		2B5 Chemical Industry Other	Non-aerosol products - household products
		2F4 Aerosols	Aerosols - halocarbons
			Metered dose inhalers
		6C Waste Incineration	Accidental fires - vehicles
Public	Public	1A4a Commercial/Institutional	Public sector combustion
Waste Management	Waste Management	6A1 Managed Waste Disposal on Land	Landfill
		6B1 Industrial Wastewater Handling	Industrial Waste Water Treatment
		6B2 Wastewater Handling	Sewage sludge decomposition
		6C Waste Incineration	Incineration
			Incineration - chemical waste
			Incineration - clinical waste
			Incineration - sewage sludge
Agriculture and related land use	Agriculture	1A4ci Agriculture/Forestry/Fishing:Stationary	Agriculture - stationary combustion
			Miscellaneous industrial/commercial combustion
		1A4cii Agriculture/Forestry/Fishing:Off-road	Agricultural engines
			Agriculture - mobile machinery
		2B5 Chemical Industry Other	Agriculture - agrochemicals use
		4A10 Enteric Fermentation Deer	Agriculture livestock - deer enteric
		4A1a Enteric Fermentation Dairy	Agriculture livestock - dairy cattle enteric
		4A1b Enteric Fermentation Non-Dairy	Agriculture livestock - other cattle enteric
		4A3 Enteric Fermentation Sheep	Agriculture livestock - sheep enteric
		4A4 Enteric Fermentation Goats	Agriculture livestock - goats enteric
		4A6 Enteric Fermentation Horses	Agriculture livestock - horses enteric

SG Sector	NC Category	IPCC Sector	Source Name
		4A8 Enteric Fermentation Swine	Agriculture livestock - pigs enteric
		4B10 Manure Management Deer	Agriculture livestock - deer wastes
		4B12 Liquid Systems	Agriculture livestock - manure liquid systems
		4B13 Solid Storage and Drylot	Agriculture livestock - manure solid storage and dry lot
		4B14 Other	Agriculture livestock - manure other
		4B1a Manure Management Dairy	Agriculture livestock - dairy cattle wastes
		4B1b Manure Management Non-Dairy	Agriculture livestock - other cattle wastes
		4B3 Manure Management Sheep	Agriculture livestock - sheep goats and deer wastes
		4B4 Manure Management Goats	Agriculture livestock - goats wastes
		4B6 Manure Management Horses	Agriculture livestock - horses wastes
		4B8 Manure Management Swine	Agriculture livestock - pigs wastes
		4B9 Manure Management Poultry	Agriculture livestock - broilers wastes
			Agriculture livestock - laying hens wastes
			Agriculture livestock - other poultry wastes
		4D Agricultural Soils	Agricultural soils
		4F1 Field Burning of Agricultural Residues	Field burning
		4F5 Field Burning of Agricultural Residues	Field burning
	Land Use, Land Use Change and Forestry	5B Cropland (Biomass Burning - controlled)	Cropland - Biomass Burning\Controlled Burning
		5B Cropland (Biomass Burning - wildfires)	Cropland - Biomass Burning\Wildfires
		5B Liming	Cropland - Liming
		5B1 Cropland Remaining Cropland	Cropland remaining Cropland
		5B2 Land Converted to Cropland	Land converted to Cropland
		5B2 N ₂ O emissions from disturbance associated with land-use conversion to cropland	N ₂ O emissions from disturbance associated with land-use conversion to cropland
		5C Grassland (Biomass burning - controlled)	Grassland - Biomass Burning\Controlled Burning
		5C Grassland (Biomass Burning - wildfires)	Grassland - Biomass Burning\Wildfires

SG Sector	NC Category	IPCC Sector	Source Name
		5C Liming	Grassland - Liming
		5C1 Grassland Remaining Grassland	Grassland remaining Grassland
		5C2 Land converted to grassland	Land converted to Grassland
		5D1 Wetlands remaining wetlands	Wetlands remaining Wetland
		5D2 Land converted to wetlands	Land converted to Wetland
		5D2 Non-CO ₂ emissions from drainage of soils and wetlands	Non-CO ₂ emissions from drainage of soils and wetlands
Development (land use change)	Land Use, Land Use Change and Forestry	5E Settlements (Biomass burning - controlled)	Settlements - Biomass Burning\Controlled Burning
		5E1 Settlements remaining settlements	Settlements remaining Settlements
		5E2 Land converted to settlements	Land converted to Settlements
Forestry	Land Use, Land Use Change and Forestry	5A Forest Land (Biomass Burning - wildfires)	Forest Land - Biomass Burning\Wildfires
		5A Forest Land (Drainage of soils)	Forest Land - Drainage of Organic Soils
		5A1 Forest Land Remaining Forest Land	Forest Land remaining Forest Land
		5A2 Forest Land (N fertilisation)	Direct N ₂ O emission from N fertilisation of forest land
		5A2 Land Converted to Forest Land	Land converted to Forest Land
		5G Other (Harvested wood)	Harvested Wood Products
International Aviation and Shipping	International Aviation and Shipping	International aviation	Aircraft - international cruise
			Aircraft - international take-off and landing
			Aircraft between UK and CDs - Cruise
			Aircraft between UK and CDs - TOL
			Aircraft between UK and Gibraltar - Cruise
			Aircraft between UK and Gibraltar - TOL
			Aircraft between UK and other OTs (excl Gib.) - Cruise
			Aircraft between UK and other OTs (excl Gib.) - TOL
			Shipping - international IPCC definition
		International shipping	Shipping between UK and Gibraltar
			Shipping between UK and OTs (excl. Gib)

Acknowledgements

We would like to thank our contractors, Ricardo-AEA, in consortium with Aether, Rothamsted Research and the Centre for Ecology & Hydrology for their invaluable support in compiling and improving the Scottish greenhouse gas inventory every year. Links to the Devolved Administrations inventories for each inventory from 1990-2008 to 1990-2012 are found here: http://naei.defra.gov.uk/reports/reports?report_id=799

We would also like to thank colleagues in the Scottish Government who have produced and contributed to the Official Statistics publication: “Scottish Greenhouse Gas Emissions” in the years from 2008 to 2012. Links to the Scottish Greenhouse Gas Emissions Official Statistics publications for each year from 2008 to 2012 are found here:

<http://www.scotland.gov.uk/Topics/Statistics/Browse/Environment/Publications>

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How to access background or source data

The data collected for this publication:

- ☐ are available in more detail through Scottish Neighbourhood Statistics
- ☒ are available from National Atmospheric Emissions Inventory website and from a separate Excel workbook accompanying this publication
- ☐ may be made available on request, subject to consideration of legal and ethical factors. Please contact <email address> for further information.
- ☐ cannot be made available by Scottish Government for further analysis as Scottish Government is not the data controller.

Complaints and suggestions

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