



AGRICULTURE, ENVIRONMENT AND MARINE

Scottish Greenhouse Gas Emissions 2016

There are two measures of greenhouse gases presented in this release:

SOURCE EMISSIONS



A measure of the actual emissions or removals in Scotland. Includes international aviation and shipping. Used for UK and international comparisons.

38.6 MtCO₂e in 2016



**49.0%
from
1990**



**10.3%
from
2015**

ADJUSTED EMISSIONS: FOR REPORTING AGAINST TARGETS



Emissions adjusted to account for Scotland's participation in EU-wide emissions trading and are used to measure progress against targets.

41.481 MtCO₂e in 2016



**45.2%
from
Baseline
Period**



**2.5%
from
2015**

The Climate Change (Scotland) Act 2009 provides for a fixed annual target for 2016 of 44.933 MtCO₂e, **which has been met**. The Act also contains a 2050 target for at least an 80 per cent reduction from baseline levels and an interim 2020 target for at least a 42 per cent reduction. By 2016 a reduction of 45.2 per cent had been achieved.

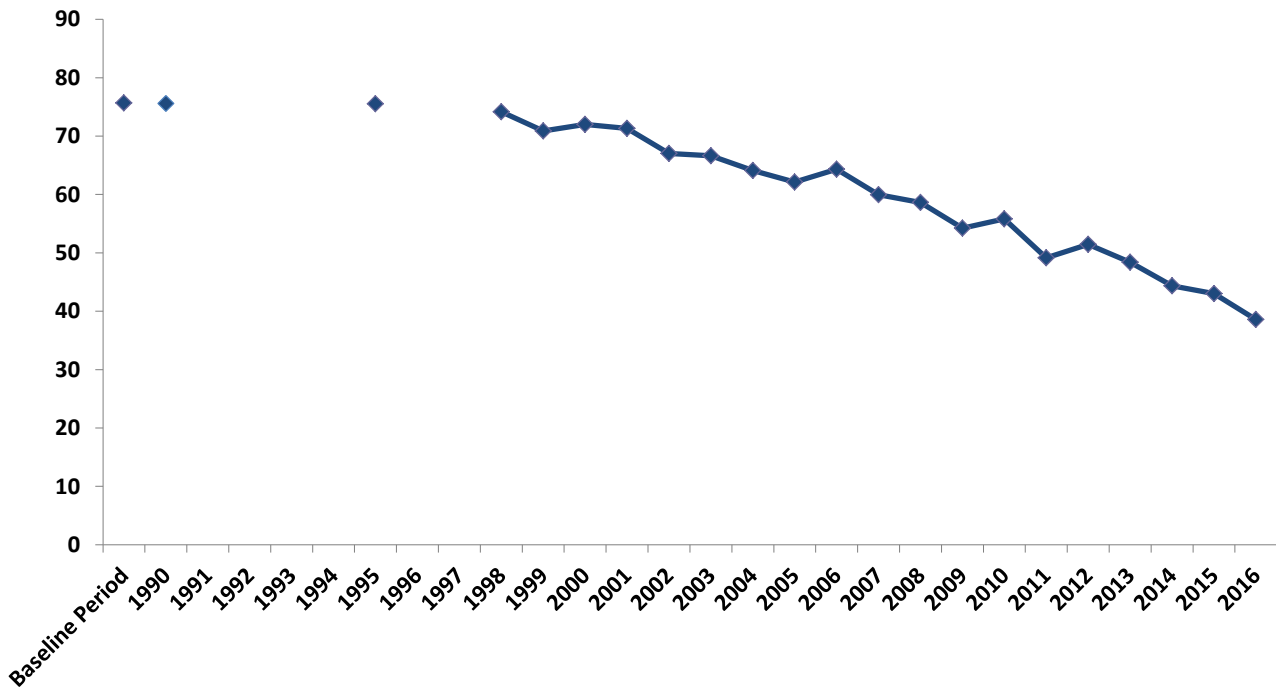
MtCO₂e refers to million tonnes of carbon dioxide equivalent. This is a consistent measure of assessing the contribution of greenhouse gases to global warming.

The Baseline Period uses 1990 for carbon dioxide, methane and nitrous oxide and 1995 for hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride

Figures have been revised since last year's release to incorporate methodological improvements and new data

KEY TREND – SOURCE EMISSIONS

Scottish Greenhouse Gas Emissions, 1990 to 2016. Values in MtCO₂e



In 2016, Scottish emissions of the basket of seven greenhouse gases are estimated to be 38.6 million tonnes carbon dioxide equivalent (MtCO₂e). This is 10.3 per cent lower than the 2015 figure of 43.0 MtCO₂e, a 4.4 MtCO₂e decrease. The main contributors to this reduction between 2015 and 2016 are:

- A fall in Energy Supply emissions driven almost entirely by a decrease of the use of coal in the power generation sector (5.1 MtCO₂e; 41.4 per cent reduction). Additionally this reduction in emissions can be attributed to a reduction in emissions from the combustion of fossil fuels in the chemical industry between 2015 and 2016.

Between 1990 and 2016, there was a 49.0 per cent reduction in estimated emissions, a 37.0 MtCO₂e decrease.

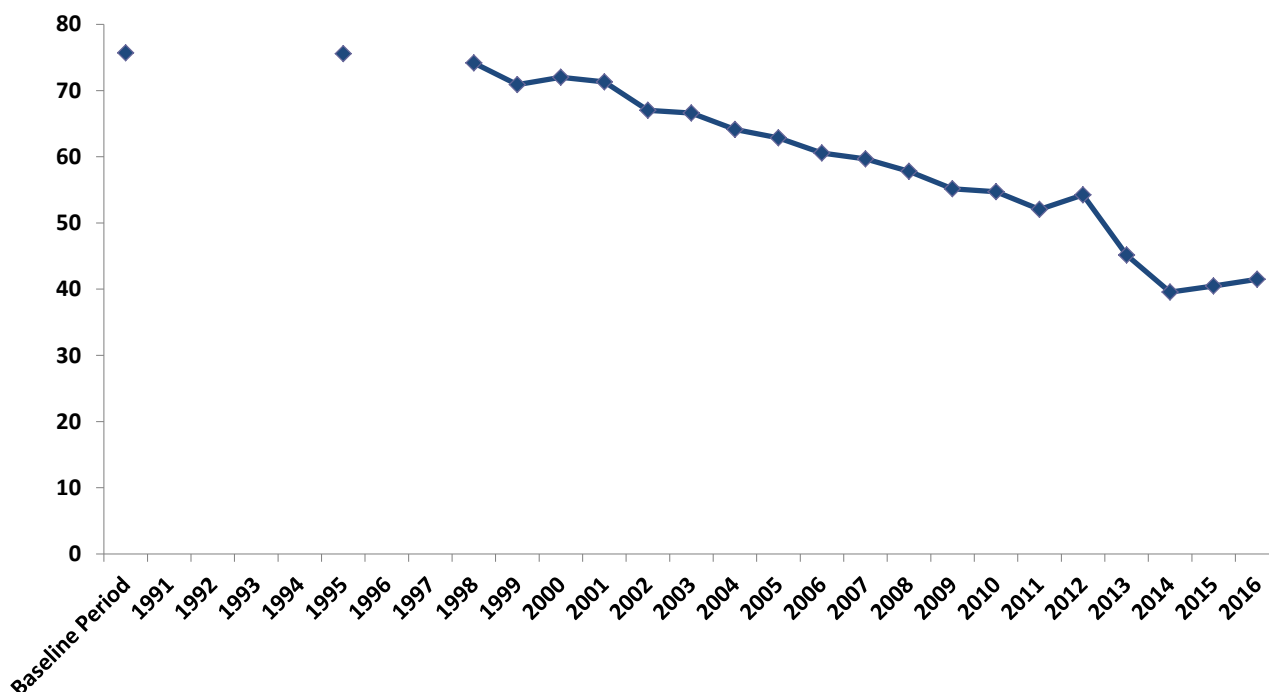
The 3 main contributors to this reduction are:

- Fall in Energy Supply emissions (such as power stations) (15.6 MtCO₂e; 68.5 per cent reduction)
- Fall in Waste Management Emissions (such as Landfill) (4.4 MtCO₂e; 72.8 per cent reduction)
- Fall in Business and Industrial Process (such as manufacturing) (5.8 MtCO₂e; 40.5 per cent reduction)

More details can be found in [Section B](#).

KEY TREND – EU ETS ADJUSTED EMISSIONS

Scottish Greenhouse Gas Emissions, Adjusted for the EU Emissions Trading System, (EU ETS). 1990 to 2016. Values in MtCO_{2e}



- When emissions are adjusted to take account of trading in the EU Emissions Trading System (EU ETS), emissions increased by 2.5 per cent between 2015 and 2016 (from 40.5 MtCO_{2e} to 41.5 MtCO_{2e}). This is the basis against which progress towards the targets outlined within the Climate Change (Scotland) Act 2009 are measured.
- The EU ETS is an EU policy aimed at mitigating climate change by limiting greenhouse gas emissions from large point source emitters (primarily electricity generation and energy-intensive industries) and in aviation. Under accounting rules of the Climate Change (Scotland) 2009 Act, the contribution of those sectors to the annual targets is determined by the Scottish share of emissions allowances in the EU ETS, rather than the actual level of emissions. [Section C](#) provides information on what the EU ETS is and what it means for Scotland's Greenhouse Gas Emissions statistics.
- Compared with the Baseline Period ¹, emissions in 2016 (after taking account of trading in the EU ETS) were 45.2 per cent lower. [Section A](#) contains more information on how the Baseline Period is defined and [Section C](#) contains results in more detail.

¹ The Baseline Period uses 1990 for carbon dioxide, methane and nitrous oxide and 1995 for hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride

REVISIONS TO GREENHOUSE GAS EMISSIONS STATISTICS

Note that as part of this release all of the figures have been revised since the previous publication in June 2017, to incorporate methodological improvements and new data. Comparing the 2016 figures with the 2015 figures published a year ago will therefore give a different year-on-year percentage change; one which is incorrect and should not be used. Details of these revisions can be found later in this statistical release in [Section D](#).

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Section A. Introduction to Greenhouse Gases

Purpose of this Publication

The “Scottish Greenhouse Gas Emissions 2016” Official Statistics publication contains the results of the Scottish Greenhouse Gas Inventory for 1990-2016. The Scottish Greenhouse Gas Inventory is the key data source for understanding the origins and magnitudes of the emissions. The inventory is compiled in line with international guidance from the [Intergovernmental Panel on Climate Change \(IPCC\)](#). Data are reported by source sector (such as energy supply) and by greenhouse gas (such as carbon dioxide). The inventory is also used to report data against targets as required under the Climate Change (Scotland) Act 2009.

Using the Statistics. Which measure to use and when?

The “Scottish Greenhouse Gas Emissions 2016” Official Statistics publication includes data on two categorisations of greenhouse gas emissions.

- **Estimated net source emissions.** These are sometimes referred to as “territorial” emissions, as they are produced within a country’s territory or economic sphere. [Section B](#) contains results using this categorisation.
- **Estimated net source emissions which have been adjusted to take account of trading in the EU Emissions Trading System (EU ETS).** [Section C](#) contains results using this categorisation.

The publication does not contain information on consumption-based emission estimates. This refers to greenhouse gas emissions which are associated with the spending of Scottish residents on goods and services, wherever in the world these emissions arise together with emissions directly generated by Scottish households, through private heating and motoring. This information was most recently published in December 2017 for the years 1998 to 2014 as part as part of the Official Statistics publication: [“Scotland's Carbon Footprint 1998-2014”](#). [Section E](#) contains information on what territorial emissions are excluded from the greenhouse gas inventory.

The table below shows how to use the different categorisations of statistics on greenhouse gas emissions.

	Estimated Source Emissions (Section B)	Estimated Source Emissions Adjusted to take into account of EU Emissions Trading System (Section C)
Adjusted for EU Emissions Trading System	x	✓
Used for reporting progress against Scotland's Climate Change Targets ¹	x	✓
Can be compared with EU countries – note that comparable data for 1990-2016 will not be available for the time of this release	✓	x
Can be compared with UK ²	✓	x
Includes International Aviation and Shipping	✓	✓
Includes Offshore Emissions	x	x
Data on individual greenhouse gases	✓	x
Data on Scottish Government source sectors	✓	✓
Base Year	1990	Baseline Period (Variable)

¹ Further information on Scotland's Climate Change Targets can be found in Section C.

² Direct comparisons between Scotland and the UK can be made by adding up the results for the four Devolved Administrations separately. The UK figure in this case would exclude offshore emissions.

Which greenhouse gases are reported on and how do they contribute to global warming?

The basket of greenhouse gases consists of carbon dioxide, methane, nitrous oxide, and the four F-gases (hydrofluorocarbons- HFCs, perfluorocarbons – PFCs, sulphur hexafluoride- SF₆ and nitrogen trifluoride- NF₃). These gases are weighted by Global Warming Potential (GWP), so that total greenhouse gas emissions can be reported on a consistent basis. The GWP for each gas is defined as its warming influence relative to that of carbon dioxide over a 100 year period. Greenhouse gas emissions are then presented in *carbon dioxide equivalent* (CO₂e) units. In the case of some of the F-gases, the global warming potential is listed as being within a range of values, due to the gases existing as a variety of isotopes with differing GWPs.

Table A1. List of Greenhouse Gases and their contribution to Scotland's net greenhouse gas emissions, 2016

Name of Greenhouse Gas	Chemical Formula	Global Warming Potential (GWP) (Conversion factor to carbon dioxide equivalent) ¹	Contribution to Scotland's Net Greenhouse Gas Emissions in 2016 (in MtCO ₂ e)	Percentage of Scotland's Net Greenhouse Gas Emissions in 2016 (in MtCO ₂ e)	Examples sources of gas
Carbon dioxide	CO ₂	1	27.3	70.9%	All other sources of greenhouse gases, including removals (carbon sinks)
Methane	CH ₄	25	6.5	16.7%	Waste management, enteric fermentation and animal waste
Nitrous oxide	N ₂ O	298	3.4	8.8%	Agricultural soils
F-gases ²			1.4	3.6%	Industrial air conditioning, refrigeration, use as tracer gases, semiconductors
Hydrofluorocarbons	HFC	12 - 14,800	1.2	3.2%	
Perfluorocarbons	PFC	7,390 - 17,340	0.1	0.3%	
Sulphur hexafluoride	SF ₆	22,800	0.0	0.1%	
Nitrogen trifluoride	NF ₃	17,200	0.0	0.0%	
Total Net Greenhouse Gases			38.6	100.0%	

The Global Warming Potentials (GWPs) are based on international reporting standards, as set by the Intergovernmental Panel on Climate Change (IPCC)².

[Section B](#) contains further data on the individual greenhouse gases. [Section D](#) contains a more detailed discussion of the causes and impacts of revisions between the 1990-2015 and 1990-2016 inventories.

Reporting of the Baseline Period and 1990

In this publication, a single 1990 Base Year is used for all estimated source emissions ([Section B](#)). This year is referred to as “1990” in charts, tables and text.

A different baseline is used for the reporting progress against Scotland's Climate Change Targets, using the emissions adjusted for trading in the EU Emissions Trading System (EU ETS). This is referred to as “Baseline Period” when referring to changes over time in the charts, tables and text.

² IPCC's 4th Assessment Report: <http://www.ipcc.ch/report/ar4/>

The Baseline Period for reporting against Climate Change Targets is:

- 1990 for carbon dioxide carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O)
- 1995 for Fluorinated gases (F gases)³: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆), nitrogen trifluoride (NF₃)

Within this publication, data are estimated for the Baseline Period; and the years 1990, 1995 and 1998 to 2016.

What are net emissions and carbon sinks?

The emissions reported are the combination of emissions minus removals from the atmosphere by *carbon sinks*. Carbon sinks are incorporated within the three sectors of agriculture and related land use, development, and forestry, which include both emissions and removals resulting from afforestation, reforestation, deforestation and forest management together with changes in land use. These are known as “removals” as they offset emissions.

³ The Kyoto Protocol allows Parties flexibility to choose either 1990 or 1995 as the base year for the industrial gases. Using a 1995 base year is in line with the approach adopted by the UK Government and many EU Member States.

Sectors

This publication provides the latest estimates of Scotland's greenhouse gas emissions by source from 1990-2016. 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 onshore oil and gas extraction activities). Offshore emissions are not allocated to Scotland⁴.

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 (including International Aviation and Shipping) - Emissions from domestic aviation, road transport, railways, domestic navigation, fishing and aircraft support vehicles. It also includes international aviation and shipping emissions attributed to Scotland.

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

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

Agriculture and Related Land Use - Net emissions from cropland, grassland along with net emissions from land converted to cropland and grassland. It also covers emissions from livestock, agricultural soils, stationary combustion sources and off-road machinery.

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

Forestry - Changes in net 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.

⁴ Emissions of GHGs from offshore oil and gas exploration and production are classified within the Greenhouse Gas Inventory as "Unallocated" emissions and not attributed to any of the devolved administrations.

When 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. It also contains information on which greenhouse gas emissions are excluded from the greenhouse gas inventory and why they are excluded.

The sector breakdowns in this report are primarily based on the National Communication (NC) sectors, which are used in the UK Greenhouse Gas Inventory.

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 made the following changes to the grouping of the *Land Use, Land Use Change and Forestry* (LULUCF) and *Agriculture* sectors in the NC classifications.

Firstly, we have created an *Agriculture and Related Land Use* sector, which includes all emissions in the NC sector Agriculture together with those LULUCF emissions associated with agricultural practices, such as croplands and grasslands. The remaining LULUCF emissions are grouped into a *Forestry* sector (changes in emissions relating mainly to stock changes resulting from afforestation, deforestation and harvested wood products) and a *Development* sector (changes in emissions resulting from land use change to settlements).

These sector definitions were aligned with those that were reported in the Scottish Government publication "[Low Carbon Scotland - Meeting the Emissions Reductions Targets 2013-2027](#)". The sector definitions used in the [Scottish Government's Climate Change Plan](#) publication published earlier in the year differ slightly and consideration will be given to the reporting structure of future Scottish Greenhouse Gas Emissions publications on this basis.

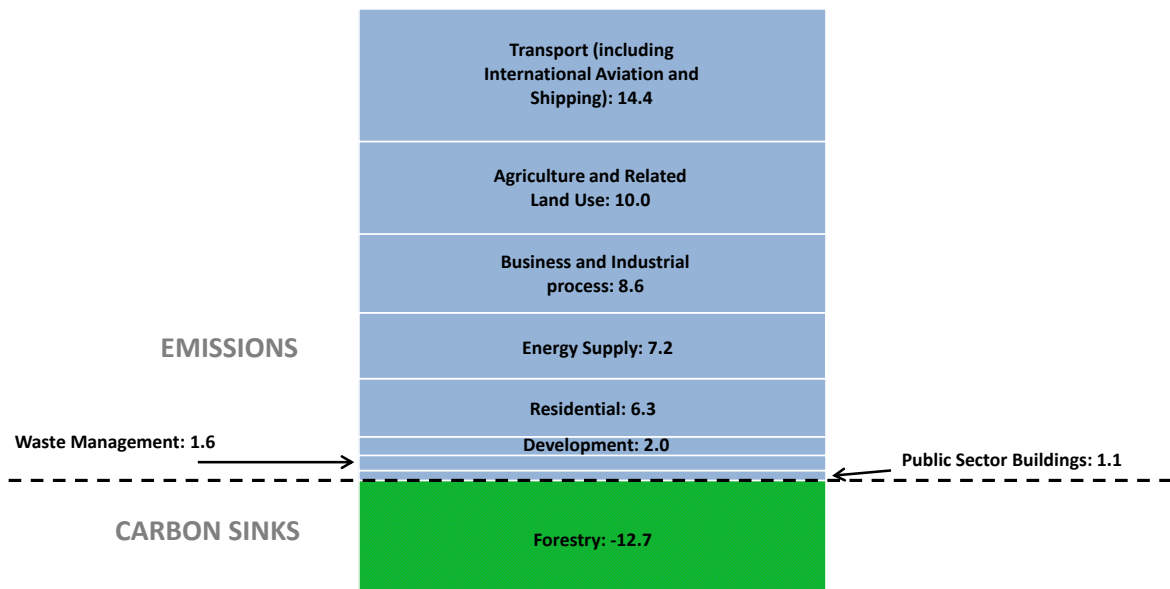
The Scottish Government also reports on International Aviation and Shipping emissions attributed to Scotland, along with other Transport emissions. International Aviation and Shipping emissions are categorised as an IPCC international "Memo" item. A detailed mapping between the sectors used in this report and the NC sectors and Intergovernmental Panel on Climate Change (IPCC) sectors is given in [Section E](#).

Section B. Results – Net Sources of Scottish Greenhouse Gas Emissions

2016 figures

Chart B1 presents the sources and sinks of Scottish Greenhouse Gas Emissions in 2016, grouped by Scottish Government sector.

Chart B1. Sources of Scottish Greenhouse Gas Emissions, 2016. Values in MtCO_{2e}



Main points

- In 2016, Transport (including International Aviation and Shipping) (14.4 MtCO_{2e}) was the largest source of net emissions followed by Agriculture and Related Land Use (10.0 MtCO_{2e}) and Business and Industrial Process (8.6 MtCO_{2e}).
- Forestry was the only aggregate sector in which there has been a net emissions sink (-12.7 MtCO_{2e}).

Table B1. Scottish Greenhouse Gas Emissions by Gas and by Scottish Government Source Sector, 2016. Values in MtCO₂e

	TOTAL	Percentage share by sector	Carbon dioxide	Methane	Nitrous oxide	Fluorinated gases
TOTAL	38.6	100.0%	27.2	6.5	3.4	1.4
Transport (including International Aviation and Shipping)	14.4	37.3%	14.2	0.0	0.2	0.0
<i>Transport (excluding IA&S)</i>	<i>12.6</i>	<i>32.6%</i>	<i>12.4</i>	<i>0.0</i>	<i>0.1</i>	<i>0.0</i>
<i>International Aviation and Shipping (IA&S)</i>	<i>1.8</i>	<i>4.7%</i>	<i>1.8</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>
Energy Supply	7.2	18.6%	6.7	0.4	0.1	0.0
Agriculture and related land use	10.0	26.1%	2.9	4.4	2.7	0.0
Business and Industrial process	8.6	22.2%	7.2	0.0	0.1	1.3
Residential	6.3	16.4%	6.1	0.1	0.0	0.1
Development	2.0	5.2%	1.9	0.0	0.1	0.0
Waste Management	1.6	4.3%	0.0	1.5	0.1	0.0
Public Sector Buildings	1.1	2.8%	1.1	0.0	0.0	0.0
Forestry	-12.7	-32.8%	-12.7	0.0	0.1	0.0

Main points

Carbon dioxide was the main greenhouse gas emitted or removed in most sectors, with the exceptions of the Agriculture and Related Land Use and Waste Management sectors.

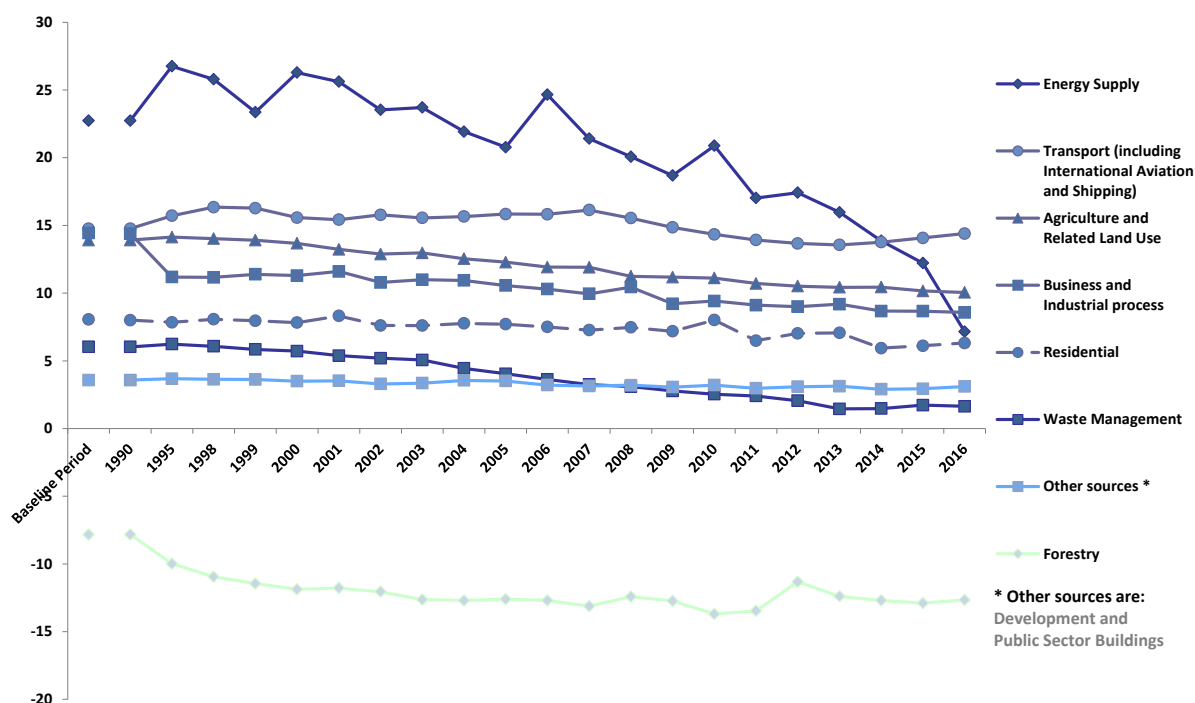
- Methane was the main net gas emitted in the Agriculture and Related Land Use sector (4.4 MtCO₂e), followed by carbon dioxide (2.9 MtCO₂e) and nitrous oxide (2.7 MtCO₂e).
- Almost all emissions in the Waste Management sector were emitted in the form of methane (1.5 MtCO₂e).

Where F gases are emitted, they have been in relatively small amounts via the Business and Industrial Process source sector, as well as in the Residential sector.

Key Trends By Scottish Government Source Sector

Chart B2 presents the main sources of Scottish Greenhouse Gas Emissions in Scotland from 1990 to 2016, broken down by Scottish Government source sector. Note that for the purposes of presentation, some sectors have been grouped together on this chart. Chart B3 and Chart B4 specifically explore the trend in Energy Supply emissions. Chart B5 contains information on the absolute and percentage reductions in greenhouse gas emissions in every Scottish Government source sector over the entire time period, with Chart B6 containing the same information for the latest year.

Chart B2. Main Sources of Greenhouse Gas Emissions in Scotland, 1990 to 2016. Values in MtCO₂e



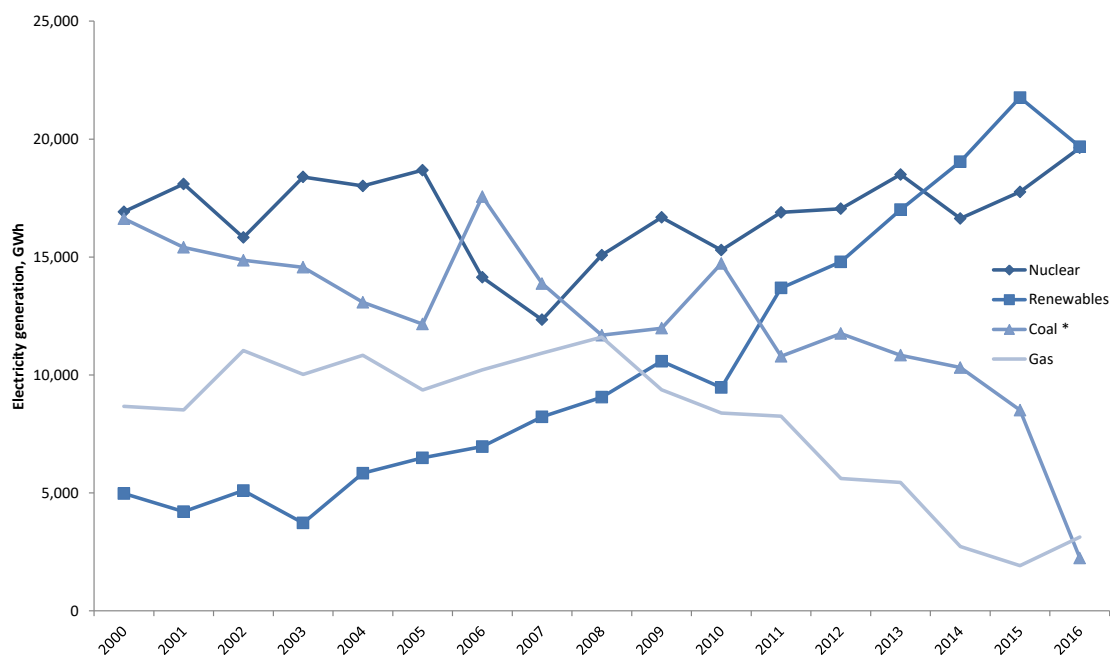
Main Points

Most sectors exhibit a general downwards trend between 1990 and 2016. Between 1990 and 2016:

- Energy Supply emissions have seen the largest decrease in MtCO₂e (15.6 MtCO₂e, 68.5 per cent) followed by Business and Industrial Process (5.8 MtCO₂e, 40.5 per cent) and Waste Management (4.4 MtCO₂e, 72.8 per cent).
- International Shipping and Aviation emissions have increased (0.5 MtCO₂e, 39.7 per cent) along with Development emissions (0.1 MtCO₂e, 7.0 per cent)
- The Forestry sink has increased (4.8 MtCO₂e, 61.8 per cent).

Chart B3 shows that the generation of Scotland's electricity changes over time. Emissions from the electricity supply sector (such as power stations) are associated with these changes.

Chart B3. Generation of Electricity by Fuel, Scotland, 2000 to 2016. GWh of Electricity Generated by Year



Data obtained from BEIS Energy Trends⁵

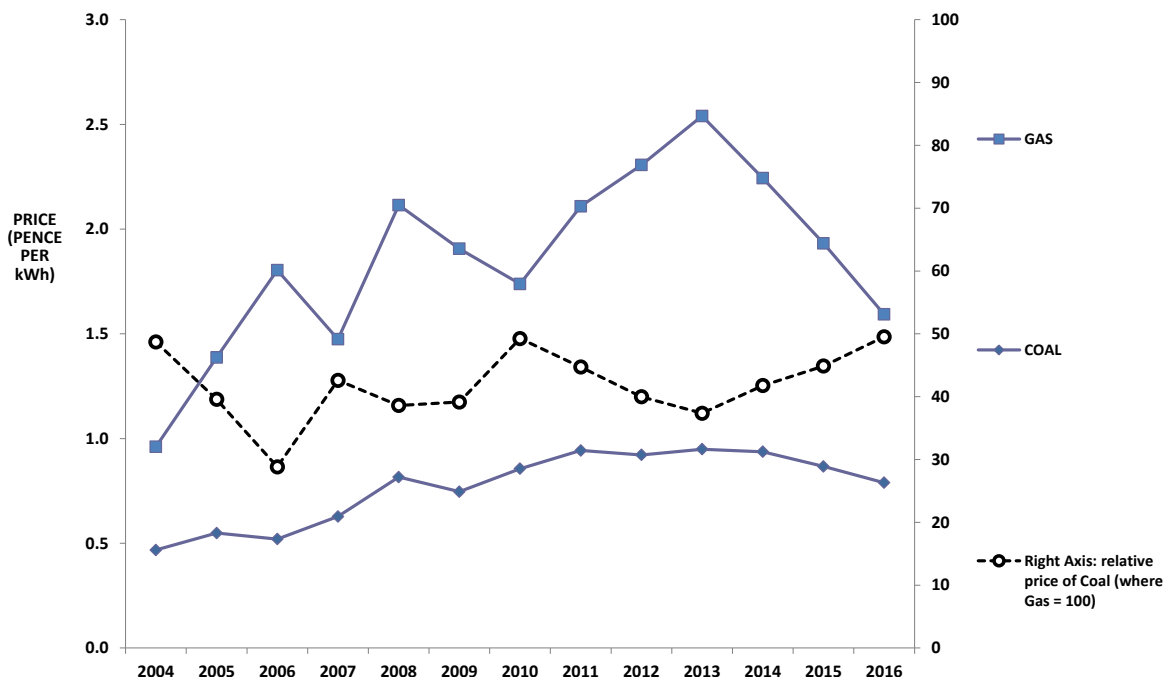
Main Points

Renewables were the single largest source of electricity generated in Scotland in 2016 at 42.9 per cent, closely followed by nuclear generation at 42.8 per cent with fossil fuel generation making up only 13.2 per cent. Overall electricity generation in Scotland decreased by 5,506 GWh to 45,845 GWh in 2016. Since 2000, Scotland has seen a decline in coal and gas electricity generation and an increase in generation from renewables.

⁵ <https://www.gov.uk/government/statistics/energy-trends-december-2017-special-feature-article-electricity-generation-and-supply-figures-for-scotland-wales-northern-ireland-and-england-2>

Chart B4 shows the gas and coal prices for large users in the UK. The use of coal or gas in electricity generation can be sourced to these price effects in many cases. The decline in oil prices between 2013-2016 brought down oil-indexed gas prices, dropping the price of gas around the world. Other potential reasons for lower gas prices include an increase in liquefied natural gas supply and a slowdown in worldwide demand growth.

Chart B4. Gas and Coal Prices for Large Users in the UK (2004 to 2016) – pence per kWh



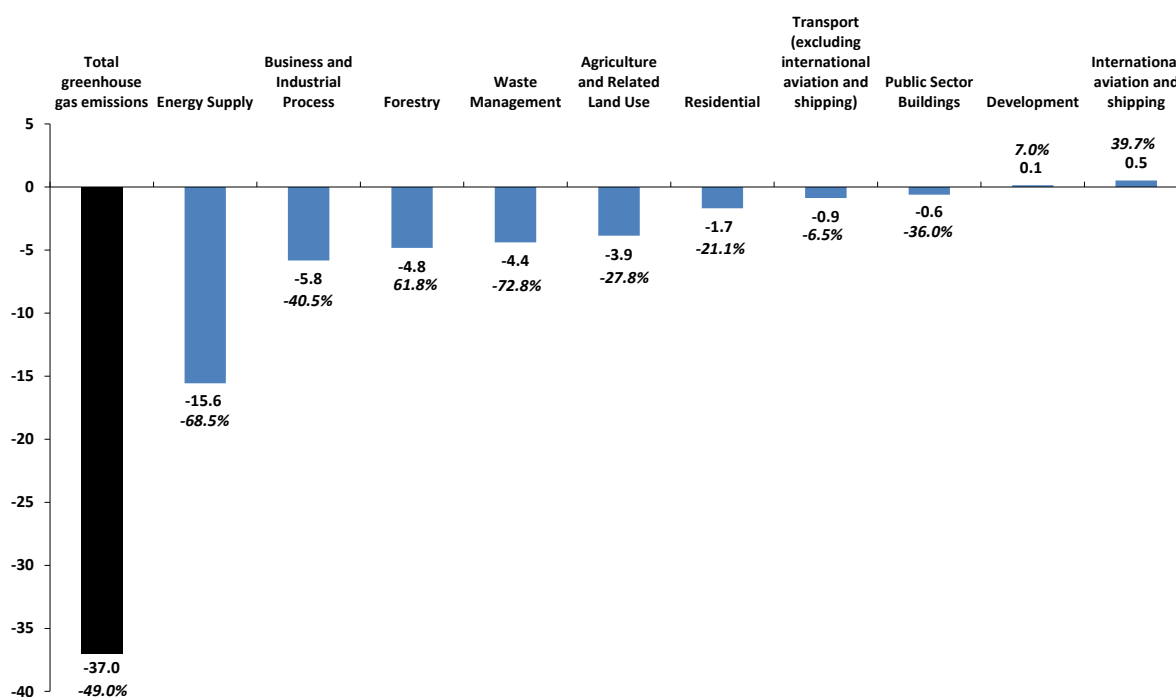
Data obtained from BEIS⁶

⁶ <https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes>

Long term (1990 to 2016) and short term (2015 to 2016) trends by sector

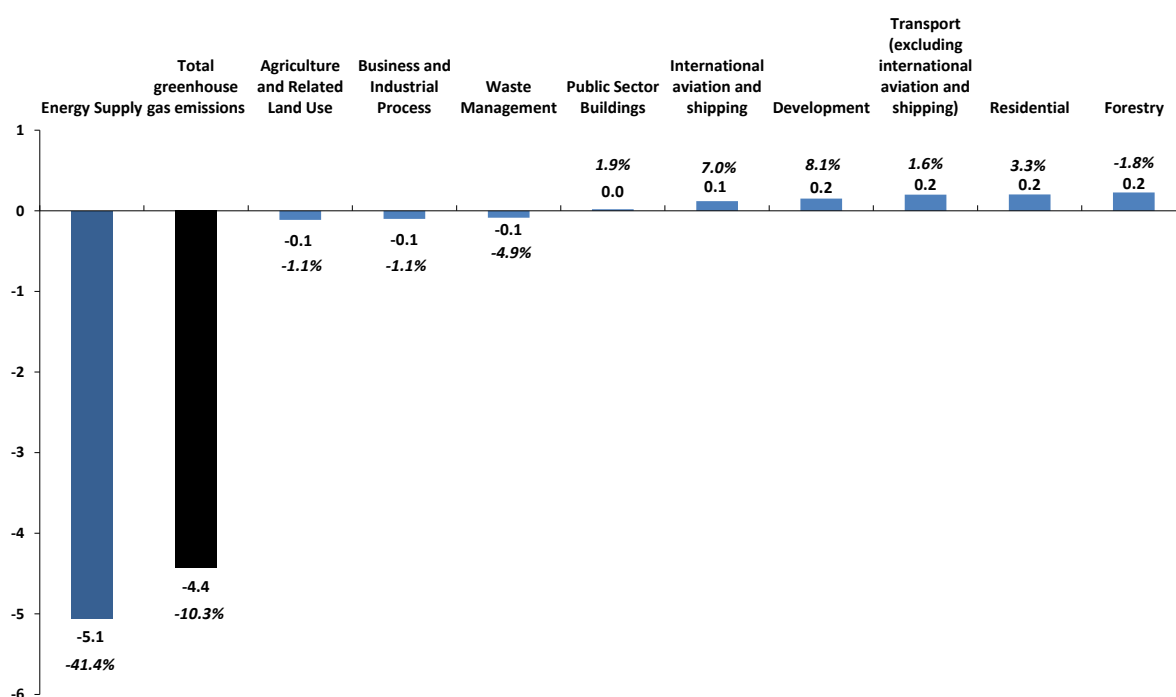
Chart B5 shows how emissions have changed between 1990 and 2016 in all source sectors. Chart B6 shows how emissions have changed between 2015 and 2016.

Chart B5. Change in Net Emissions by Scottish Government Sector Between 1990 and 2016 – in MtCO_{2e}, and percentage changes ⁷



⁷ Unlike for other source sectors, downward changes to net emissions from forestry are presented as a positive percentage change. This is because forestry causes a net removal of emissions

Chart B6. Change in Net Emissions by Scottish Government Sector between 2015 and 2016 - in MtCO₂e, and percentage changes ⁸



Total Emissions

Overall, there has been a 37.0 MtCO₂e (49.0 per cent) decrease in net emissions between 1990 and 2016, and there has been a 4.4 MtCO₂e (10.3 per cent) decrease in net emissions between 2015 and 2016.

Energy Supply (19 per cent of 2016 inventory)

Energy sector emissions have decreased by 41.4 per cent from 2015-2016 from 12.2 MtCO₂e to 7.2 MtCO₂e, and have reduced by 68.5 per cent from 1990. Emissions reductions in this sector are mainly due to reductions in emissions from power stations.

Power station emissions have reduced by 83 per cent due primarily to the shift in fuel mix away from coal to use less carbon intensive fuels for generation, including increased use of nuclear and renewables, with even the use of natural gas now reducing in Scotland. This sector alone accounts for 33 per cent of the decline in Scotland emissions since the base year.

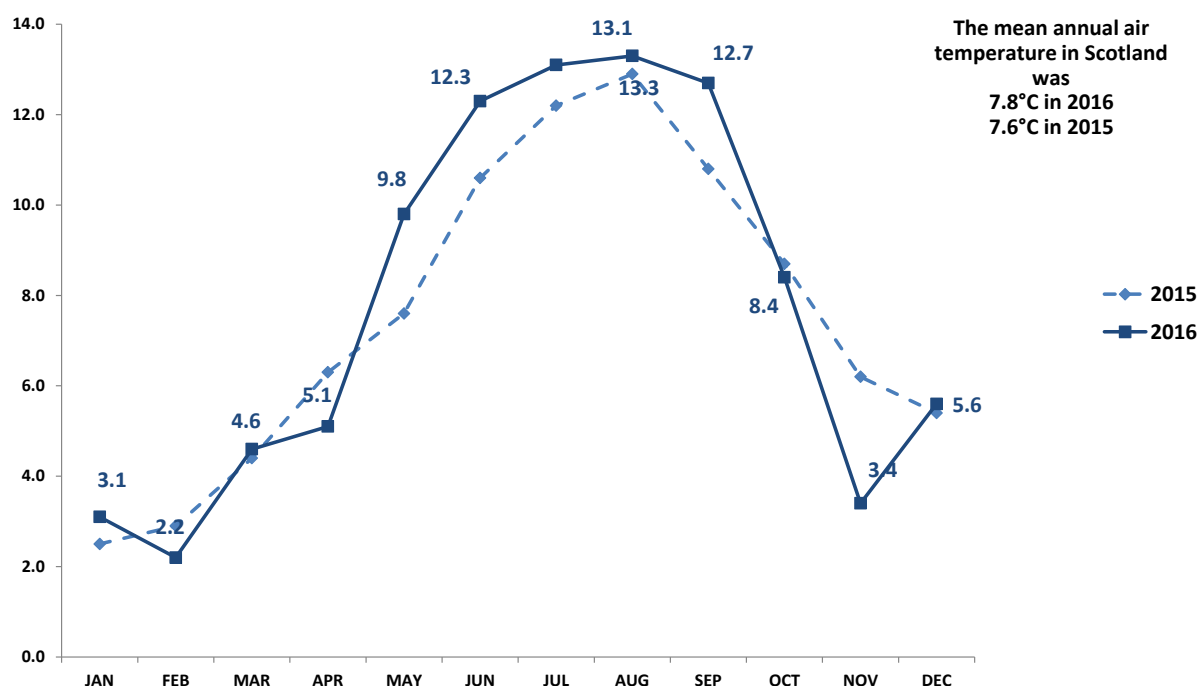
⁸ Unlike for other source sectors, upward changes to net emissions from forestry are presented as a negative percentage change. This is because forestry causes a net removal of emissions

Residential (16 per cent of 2016 inventory)

Residential emissions have increased between 2015 and 2016 from 6.1 MtCO₂e to 6.3 MtCO₂e (3.3 per cent). However, there has been a decrease of 21.1 per cent from 1990-2016. This long-term decrease is mainly due to a switch from less efficient solid and liquid fuels to natural gas for heating, and improvements in energy efficiency.

The main driver for the increase in residential emissions from 2015 to 2016 is an increase in the combustion of fuel in households, dominated by an increase in natural gas use, possibly reflecting cooler mean temperatures in winter and autumn months in 2016 compared to 2015 (Chart B7).

Chart B7. Mean air temperature by month, Scotland. 2015 and 2016.
Values in °C



Data obtained from Met Office⁹

⁹ Source Met Office: <http://www.metoffice.gov.uk/pub/data/weather/uk/climate/datasets/Tmean/date/Scotland.txt>

Waste Management (4 per cent of 2016 inventory)

From 2015 to 2016 waste management decreased from 1.7 MtCO₂e to 1.6 MtCO₂e, a 4.9 per cent reduction. From 1990 to 2016 emissions have reduced by 72.8 per cent. This decrease is largely due to the progressive introduction of methane capture and oxidation systems within landfill management.

Business and Industrial Process (22 per cent of 2016 inventory)

This sector has seen a 5.8 MtCO₂e (40.5 per cent) fall in emissions between 1990 and 2016. As shown in Chart B2, much of this decrease occurred between 1990 and 1995 – linked to a decline in emissions from manufacturing and the iron and steel industry over this time period. There has been a further smaller decrease between 2008 and 2009, coinciding with the recession. There was a decrease (0.1 MtCO₂e; 1.1 per cent) in emissions in this sector between 2015 and 2016. This has been driven by a number of factors, which include a reduction in emissions from manufacturing.

Combustion of fossil fuels in industrial production remains a major emission source in Scotland but shows a strong decline of approximately 59 per cent since 1990. This is due to plant closures, fuel-switching to less carbon intensive fuels and improvements in efficiency of production.

Agriculture and Related Land Use (26 per cent of 2016 inventory)

This sector has seen a 3.9 MtCO₂e (27.8 per cent) fall in net emissions between 1990 and 2016. Between 2015 and 2016, there was a 0.1 MtCO₂e (1.1 per cent) decrease in net emissions of overall greenhouse gases from this sector.

This decrease is mainly due to a decrease in livestock numbers (particularly cattle and sheep).

Forestry (33 per cent of the 2016 inventory)

From 2015 to 2016, the forestry sink has decreased by 1.8 per cent from -12.9 MtCO₂e to -12.7 MtCO₂e. This is mainly due to a decrease in forest land remaining forest land.

Scotland was a net sink of greenhouse gases from Forestry activities from 1990-2016.

The main influences on the trend for the Forestry sector in Scotland is the increasing sink of forest land remaining forest land (a sink of 69 per cent greater magnitude since 1990).

Transport Including International Aviation and Shipping (37 per cent of 2016 inventory)

Transport emissions have increased by 2.3 per cent from 2015 to 2016. Transport emissions decreased by 2.5 per cent from 1990 to 2016. The increase in emissions in 2016 was mainly due to an increase in emissions from road transport, in particular passenger cars and light duty trucks.

In 2016, road transport was the largest source of emissions in Scotland. Road transport emissions have increased by 7 per cent between the 1990 and 2016; this is due to a growth in activity over the period offset partly by improvements in the efficiency of vehicles.

International Aviation (4 per cent of 2016 inventory)

International aviation has increased from 1.3 MtCO₂e in 2015 to 1.4 MtCO₂e in 2016. An increase of 8.0 per cent from 2015 to 2016. Emissions from international aviation from Scotland have increased by 165 per cent since 1990 because of greater demand.

International Shipping (1 per cent of 2016 inventory)

Emissions from international shipping increased slightly by 3.6 per cent from 2015 to 2016. Emissions from international shipping have declined since 1990 by 49 per cent.

Public Sector Buildings (3 per cent of the 2016 inventory)

The main source of emissions from this sector is the use of natural gas for heating public buildings. There was a 0.6 MtCO₂e (36 per cent) fall in emissions from public sector buildings between 1990 and 2016. This has been largely driven by a reduction in the use of oil and coal for space heating. Between 2015 and 2016, there has been a 1.9 per cent increase in emissions from this sector.

Development Emissions (5 per cent of 2016 inventory)

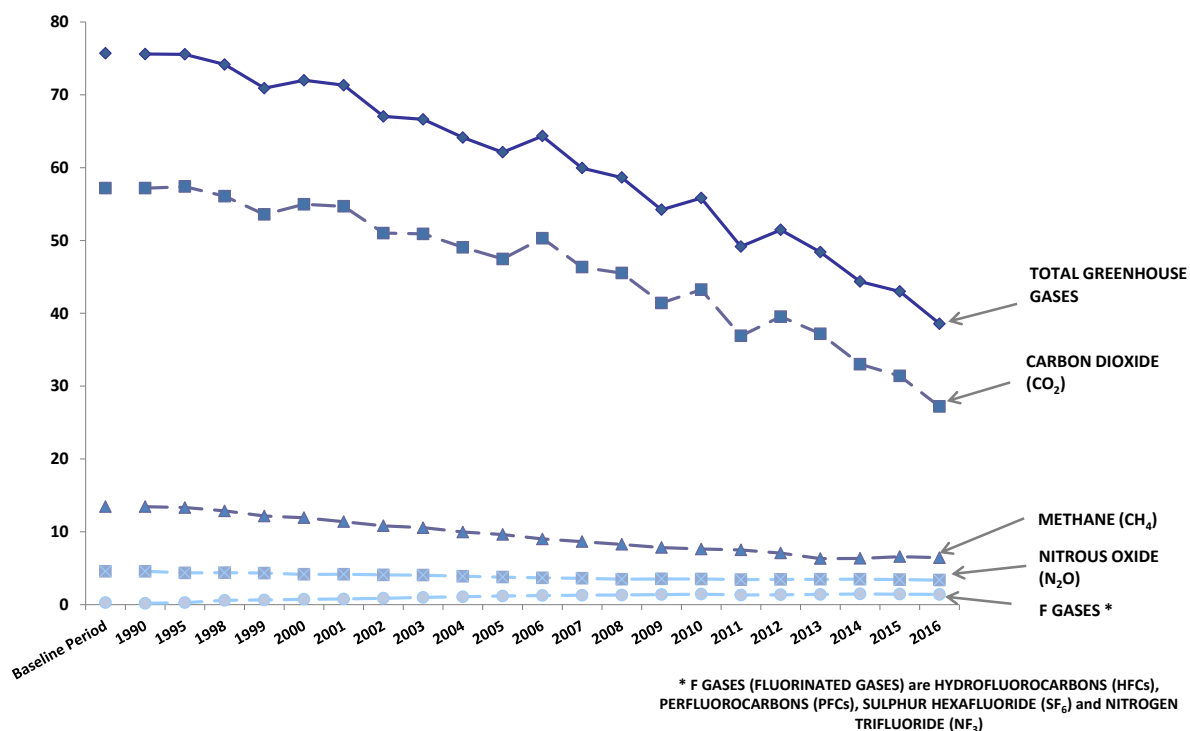
This sector captures net emissions from settlements and from land converted to settlements. In 2009 there was a step change increase in development emissions (e.g. emissions from conversion of land to settlements). The longer term trend from 1990 to 2016 shows a 7 per cent increase.

The increase in emissions in the “Land Converted to Settlement” category in 2009 arises from the “Forest Land to Settlement” subcategory. For the 1990 to 2016 inventory the annual deforestation area dataset was updated using spatial data from the National Forest Inventory. In Scotland, the new dataset estimates that the rates of deforestation for Settlement purposes from 2009 to 2011 were considerably higher than the previous 3 years (2006 to 2008).

Emissions by type of gas

Chart B8 shows the trends in emissions, broken down by gas from 1990 to 2016.

Chart B8. Scottish Greenhouse Gas Emissions, by Gas, 1990-2016.
Values in MtCO₂e



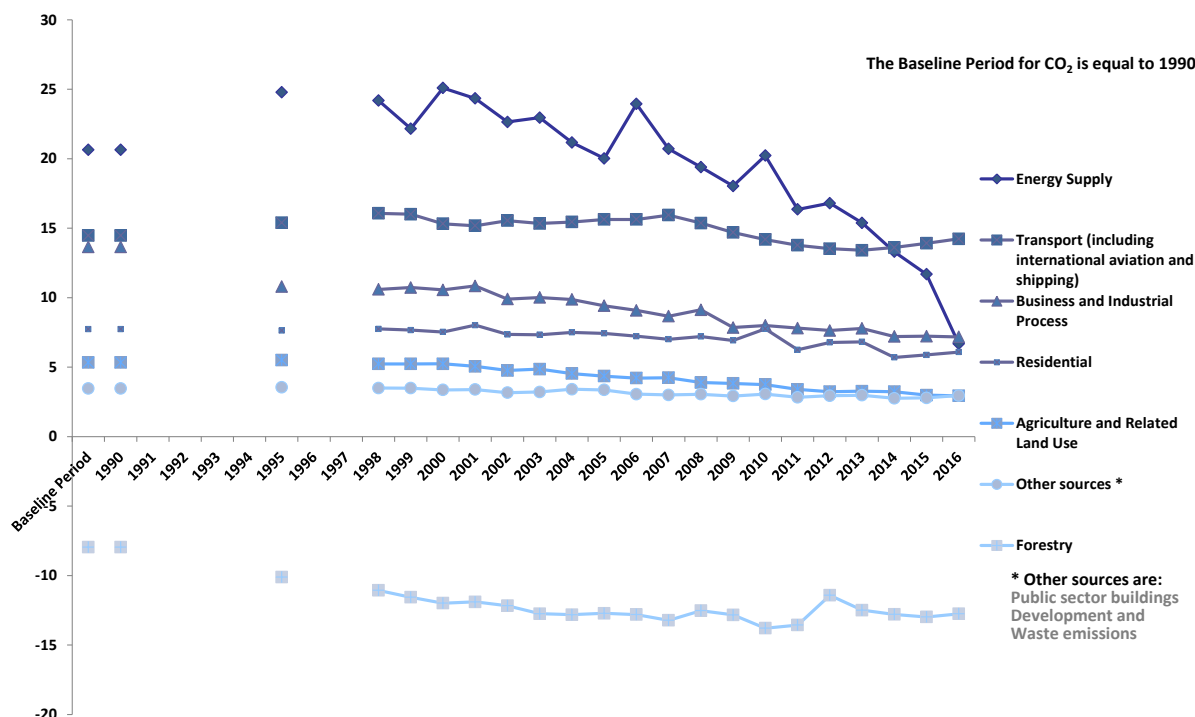
Main Points

- Carbon dioxide is by far the largest contributor to Scottish greenhouse gas emissions in all years (70.5 per cent of all emissions in 2016) and is the most volatile series of all gases – largely driven by changes in energy supply emissions and to a lesser extent, emissions from the residential and business and industrial process sectors.
- Methane is the second most common greenhouse gas in 2016 (16.7 per cent of all net emissions) followed by nitrous oxide (8.8 per cent) and F-gases making up the remainder (3.6 per cent).
- Carbon dioxide has seen the largest percentage reduction from 1990 to 2016 (52.4 per cent). There have also been percentage reductions for both methane (52.1 per cent) and nitrous oxide (26.3 per cent). Emissions from fluorinated gases have shown a large increase from 1990 to 2016 and this increase is driven by the introduction of hydrofluorocarbons (HFCs) from 1995 onwards. These HFCs replace chlorofluorocarbons (CFCs) which were banned by the Montreal Protocol due to their impact on the ozone layer.

Charts B9 to B12 present results on individual gases broken down by main Scottish Government sectors over time. Chart B9 shows how carbon dioxide emissions have changed from 1990 to 2016.

Carbon Dioxide (CO₂)

Chart B9. Carbon Dioxide (CO₂) Emissions by Scottish Government Sector, 1990 to 2016. Values in MtCO₂e



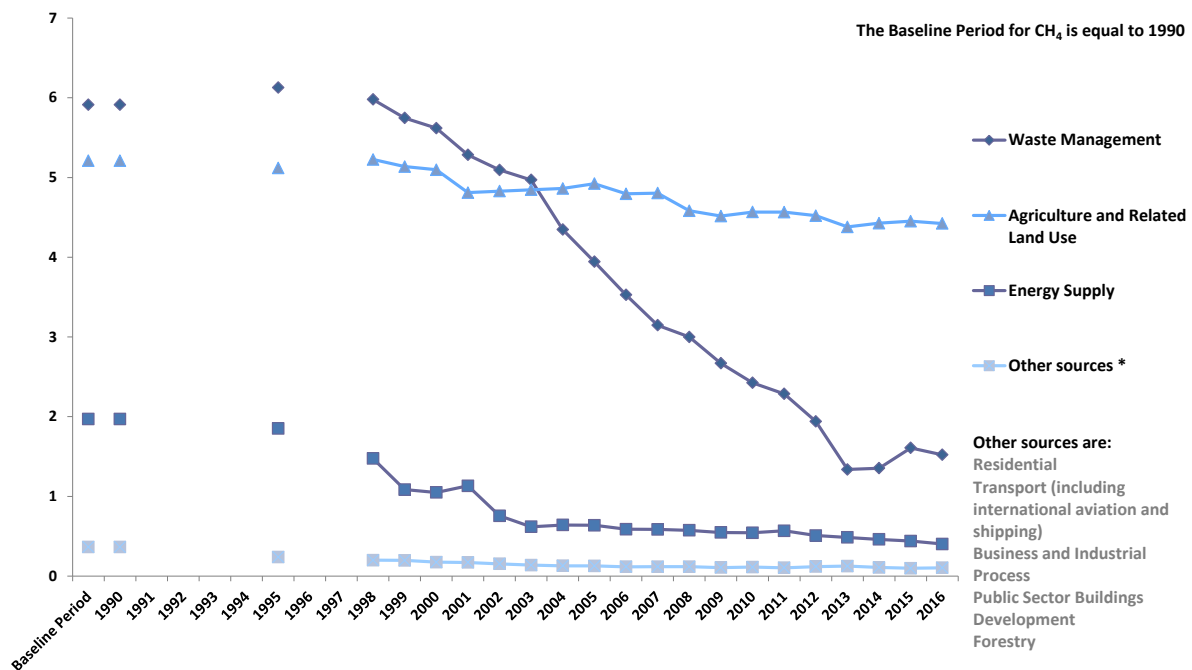
Main Points

- Chart B9 shows that energy supply is a key source of carbon dioxide emissions in all years between 1990 and 2016. Transport (including international aviation and shipping) is the next most common source of carbon dioxide emissions. Transport is 7.5 MtCO₂e higher than energy supply emissions in 2016. In 2014 Transport became the highest source of emissions for the first time in the time series.
- Much of the decrease in carbon dioxide emissions between 1990 and 2016 has been driven by falls in the energy supply sector across the time period and in business and industrial processes between 1990 and 1995. Carbon dioxide emissions from the energy supply sector have been volatile, with the highest emissions occurring between 1995 and 2003, and a spike in 2006, related to a greater use of coal in that year.

- The agriculture and related land use sector has also seen a fall in net emissions of carbon dioxide – largely due to changes in land uses.
- Forestry has been a net sink of carbon dioxide consistently between 1990 and 2016.

Methane (CH₄)

Chart B10. Methane (CH₄) Emissions by Scottish Government Sector, 1990 to 2016. Values in MtCO₂e

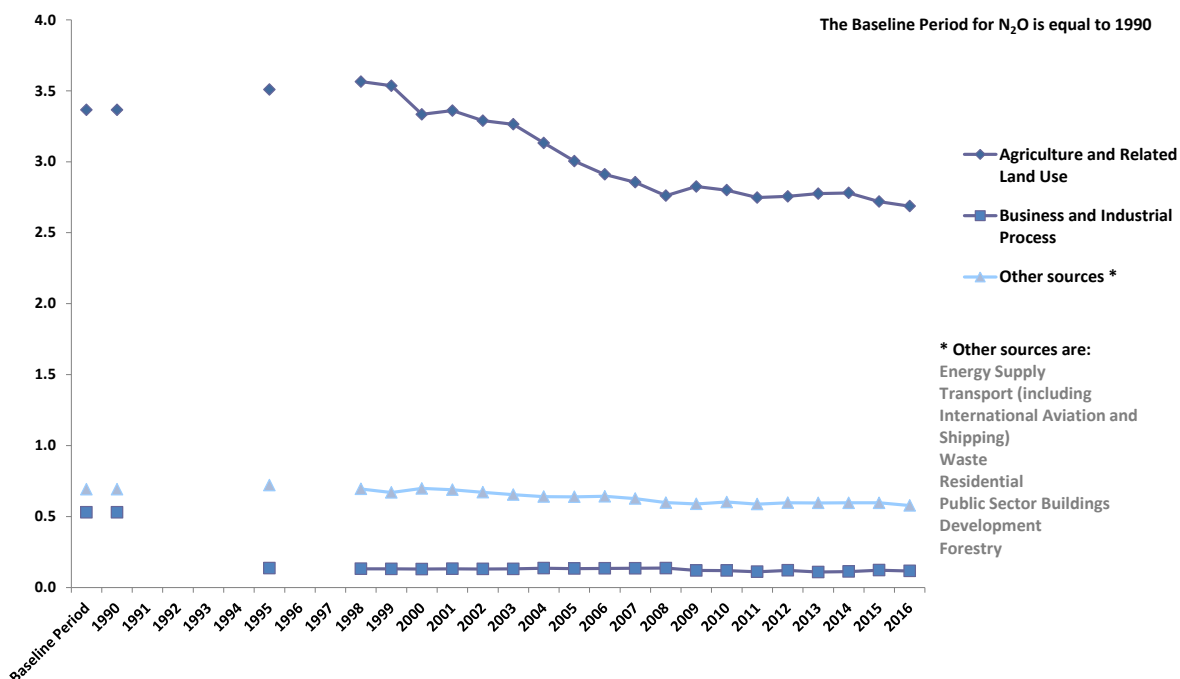


Main Points

- Methane emissions from waste management have fallen from 5.9 MtCO₂e in 1990 to 1.5 MtCO₂e in 2016 (a 74.0 per cent reduction). This is due to the progressive introduction of landfill gas being captured and used for energy. There could also be other factors which contribute to this reduction, such as improvements in the standards of landfill and changes to the types of waste going to landfill.
- Methane emissions in the agriculture and related land use sector have fallen from 5.2 MtCO₂e in 1990 to 4.4 MtCO₂e in 2016 – a 15.0 per cent fall over this time period. This reduction is partly linked to a fall in livestock numbers.
- In the Energy Supply sector, methane emissions have fallen from 2.0 MtCO₂e in 1990 to 0.4 MtCO₂e in 2016, largely due to reductions in emissions from sources such as coal mining.

Nitrous Oxide (N₂O)

Chart B11. Nitrous Oxide (N₂O) Emissions by Scottish Government Sector, 1990 to 2016. Values in MtCO₂e

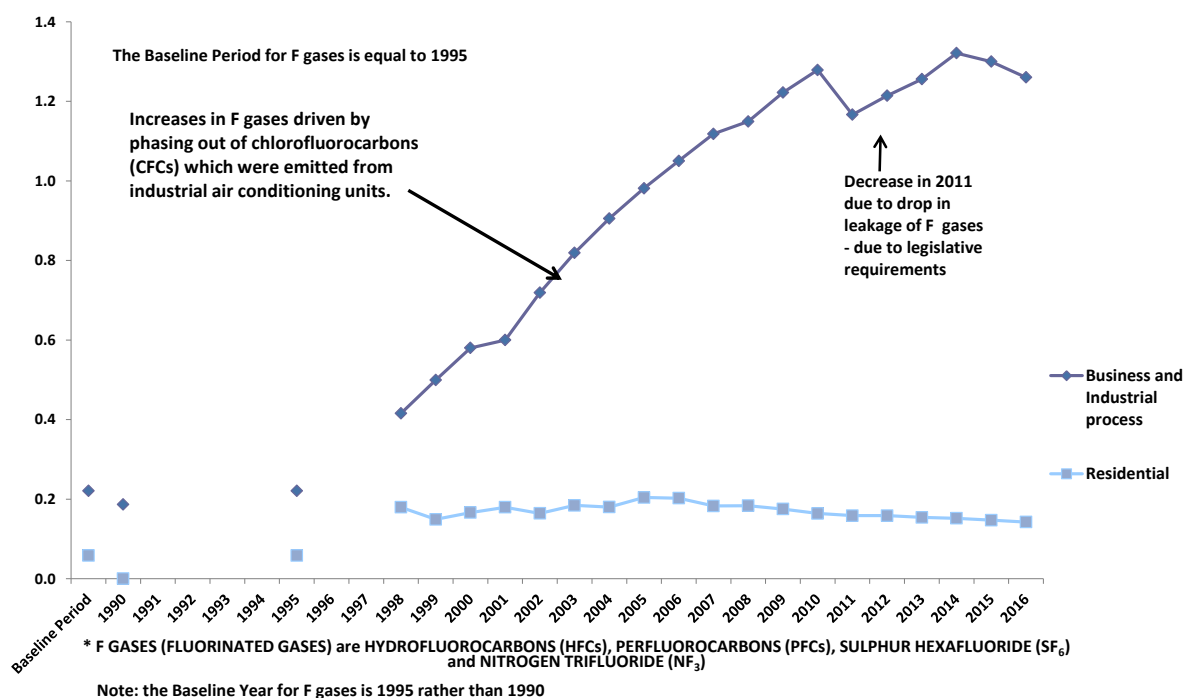


Main Points

- The Agriculture and related land use sector is by far the main contributor to emissions of nitrous oxide. These are largely produced by agricultural practices on soils, and to a lesser extent by animal manures. Emissions of nitrous oxide in this sector have fallen from 3.4 MtCO₂e in 1990 to 2.7 MtCO₂e in 2016.
- Emissions of nitrous oxide in the business and industrial process sector have fallen from 0.5 MtCO₂e in 1990 to 0.1 MtCO₂e in 2016.

Fluorinated gases (F-gases)

Chart B12. F-gas Emissions by Scottish Government Sector, 1990 to 2016. Values in MtCO₂e



Main Points

- F gases are the most potent greenhouse gases with high global warming potentials but they are emitted in very small quantities. As a result, they contribute less to global warming than the other greenhouse gases in Scotland.
- There has been a sharp increase in F gas emissions from business and industrial processes between 1990 and 2016 (from 0.2 MtCO₂e in 1990 to 1.3 MtCO₂e in 2016). This is because F gases were introduced to replace chlorofluorocarbons (CFCs), which were used in appliances such as industrial air conditioning units. CFCs were banned under the Montreal Protocol, as they were contributing to the depletion of the ozone layer.
- F gas emissions in the residential sector are caused by the use of aerosols and asthma inhalers, and represent between 0.15 and 0.20 MtCO₂e in the years between 1998 and 2016.

Section C. Estimated Emissions Adjusted for Trading Within the EU Emissions Trading System (EU ETS)

Introduction

This section of the publication presents data on source greenhouse gas emissions which have been adjusted to take into account of trading in the EU Emissions Trading System (EU ETS). This is the basis on which Scotland's statutory targets are measured against under the Climate Change (Scotland) Act 2009.

What is the EU Emissions Trading System (EU ETS)?

Launched in 2005, the EU ETS is an EU policy aimed at mitigating climate change by limiting greenhouse gas emissions from industry sectors and aviation. Participants include more than 11,000 heavy energy-using installations in power generation, the manufacturing industry and airlines across 31 countries in the European Economic Area (EEA).

How does the EU ETS work?

The EU ETS is a 'cap and trade' system. A limit (cap) is placed on the overall volume of emissions from participants in the system. Within the cap, organisations receive or buy emissions allowances which they can trade (1 emissions allowance equals 1 tCO₂e). Each year, an organisation must surrender enough allowances to cover its emissions. The cap is reduced over time so that by 2020, the volume of emissions permitted within the system will be 21 per cent lower than in 2005. The reducing cap, alongside the financial considerations of trading emissions allowances, incentivises organisations within the system to find the most cost effective way of reducing their emissions. The EU ETS operates as a number of Phases. Phase III of the EU ETS began on 1 January 2013 and will operate until 31 December 2020.

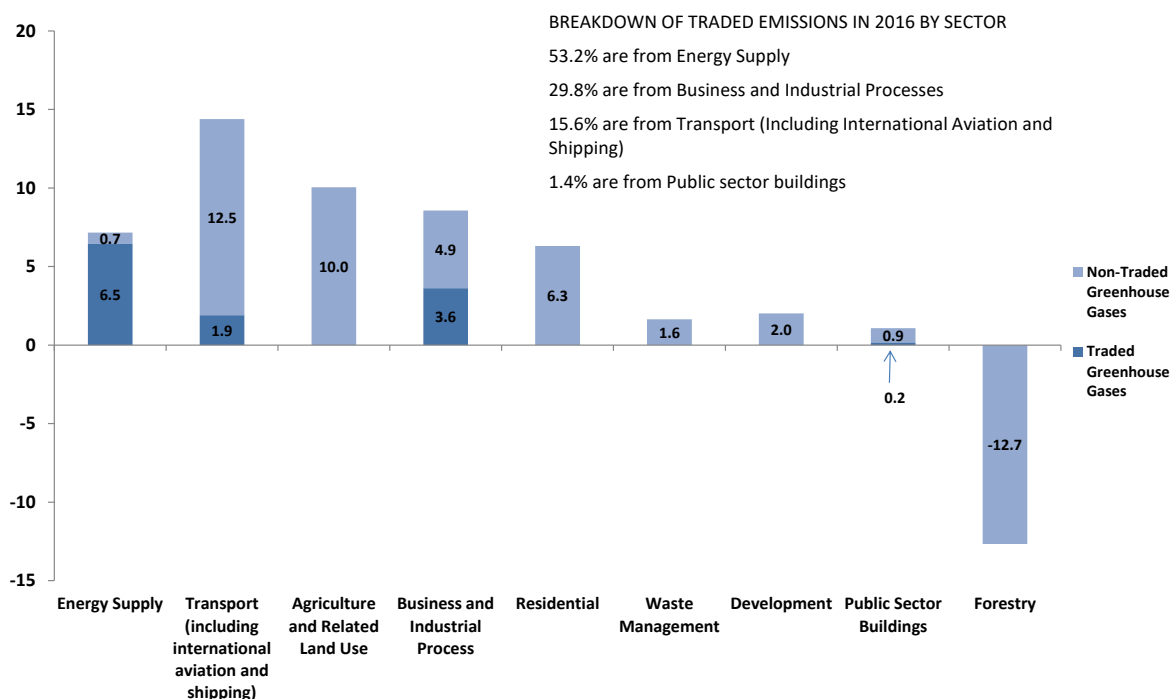
Scotland in the EU ETS

The EU ETS contributes to delivering Scotland's Climate Change Targets through incentivising the reduction in emissions from Scottish organisations participating in the system. In 2016, there were 72 fixed Scottish installations which are regulated by Scottish Environment Protection Agency (SEPA) that surrendered emissions allowances in the EU ETS.

What are 'traded emissions' and 'non-traded emissions'?

In the greenhouse gas inventory, source emissions can be categorised into traded and non-traded. Traded emissions capture those that come from installations covered by the EU ETS, whereas non-traded emissions are those which do not fall within the scope of the EU ETS. The emissions from some sectors, such as the residential sector, are completely non-traded whereas emissions from other sectors, such as energy supply and business and industrial process are a combination of traded and non-traded. For the years 2012 to 2016, CO₂ emissions from domestic and international aviation are classified as being within the traded sector.

Chart C1. Estimate of Traded Emissions Surrendered in the EU Emissions Trading System (EU ETS) and Non-Traded Greenhouse Gas Emissions by Scottish Government Sector, 2016. Values in MtCO₂e



Note that the Scotland figure for the emissions which have been surrendered in the EU ETS is slightly different to that reported for traded emissions in the Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland report produced by Ricardo-AEA and Aether on behalf of the devolved administrations.

There are number of reasons for this:

Firstly, the estimate of surrendered emissions include an estimate of carbon dioxide emissions surrendered from domestic and international aviation. Unlike for fixed installations, it is not possible to accurately estimate Scottish emissions which have been surrendered from aviation directly from aviation

operators. Instead, the Scottish Government has received advice from the Committee on Climate Change to estimate the aviation emissions surrendered in the EU ETS by using figures taken directly from the 1990-2016 greenhouse gas inventory.

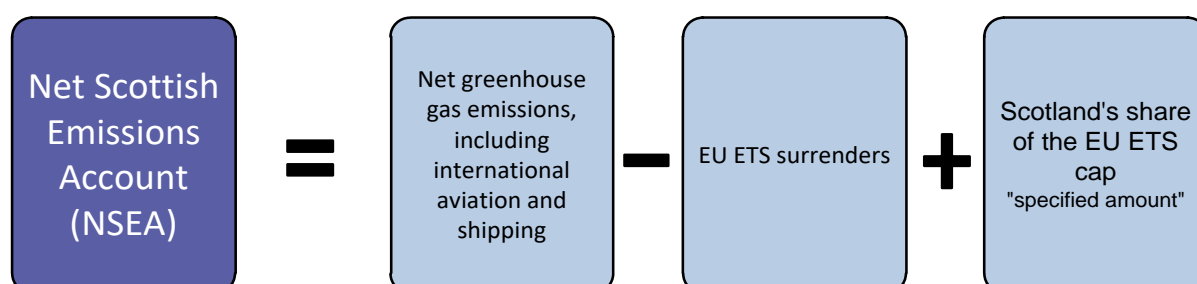
Secondly, operators who participate in the EU ETS must, by 30 April in each year, surrender a number of allowances equal to the annual reportable emissions which the installation made in the previous year. However, as a result of errors or non-compliance in the EU ETS, the figure on surrendered and reported emissions can differ, until both are finalised. These can be ongoing situations throughout each Phase of the EU ETS. By the end of each Phase any difference between the two figures should be rectified.

What are adjusted emissions and the Net Scottish Emissions Account (NSEA)?

The Scottish climate change targets are assessed against the Net Scottish Emissions Account (NSEA), which is detailed in the Climate Change (Scotland) Act 2009 and has been reported for each year from 2010 to 2016 as part of the Act. The NSEA accounts for the greenhouse gas emissions from sources in Scotland, Scotland's share of emissions from international aviation and international shipping, the effect of any relevant emissions removals (e.g. "carbon sinks" such as woodland) and the effect of the sale and purchase of relevant carbon units (tradable emissions allowances) in the EU ETS.

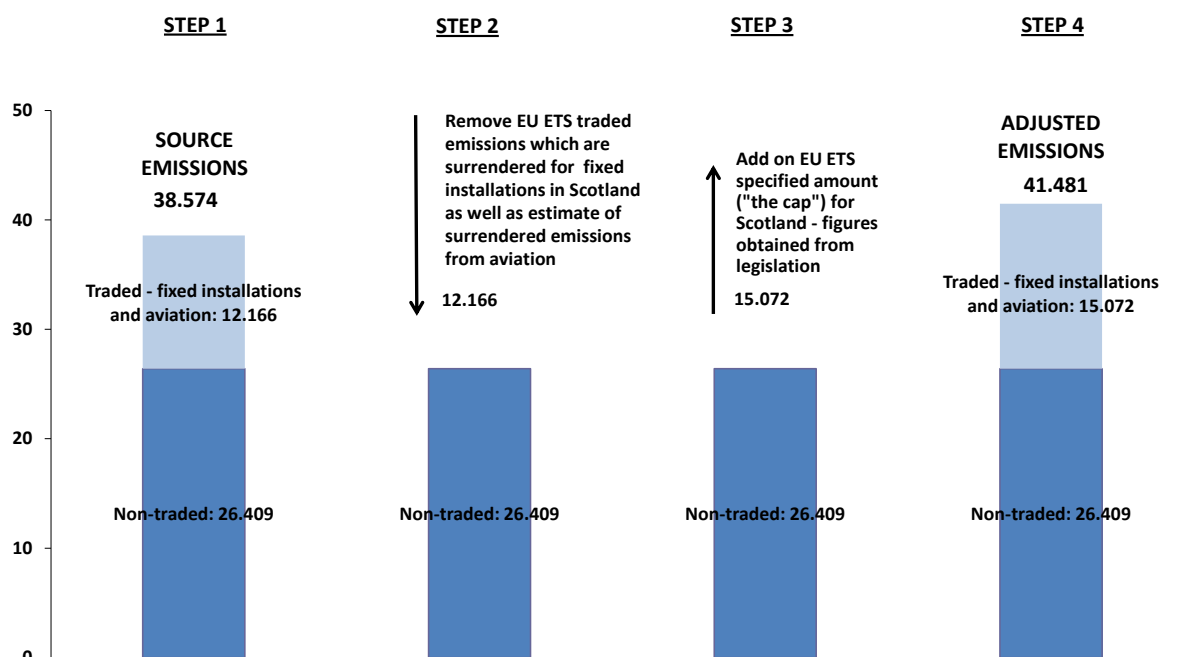
The EU ETS element of the NSEA is calculated by taking the difference between Scotland's notional share of the overall EU ETS cap and the number of emissions allowances surrendered from Scottish fixed installations in a given year, as well as an estimate of CO₂ emissions surrendered from Scotland's share of domestic and international aviation. This amount is then added to non-traded net emissions to get the NSEA.

The NSEA formula is as follows:



The figure for the NSEA are known as adjusted emissions, as they are adjusted to take account of trading within the EU ETS. This adjustment takes the form of a 4-step process, which is outlined in Chart C2.

Chart C2. Calculation of Adjusted Emissions for Trading in the EU Emissions Trading System (EU ETS), 2016. Values in MtCO₂e



Calculation of adjusted emissions

STEP 1

Take the Scottish greenhouse gas emissions from Scottish greenhouse gas inventory (for 2016, it is 38.574 MtCO₂e). This figure is comprised of:

- traded emissions units surrendered - sourced from Scottish Environment Protection Agency (SEPA) for fixed installations (12.166 MtCO₂e)
- an imputed estimate of surrendered CO₂ emissions from domestic aviation (0.478 MtCO₂e) and international aviation (1.425 MtCO₂e) - sourced from the Scottish Greenhouse Gas Inventory for 1990 to 2016
- non-traded emissions from sources such as residential emissions (26.409 MtCO₂e)

STEP 2

Remove an amount relating to surrendered emissions from fixed installations and an estimate of surrendered emissions from domestic and international aviation. This amounts to 10.262 MtCO₂e + 0.478 MtCO₂e + 1.425 MtCO₂e = **12.166 MtCO₂e**.

STEP 3

Add on the value of the EU ETS cap which is outlined within The Carbon Accounting Scheme (Scotland) Amendment Regulations 2016 ¹⁰. The cap reflects an estimate of the Scottish share of the European wide EU ETS cap that is used for emissions accounting.

Total EU ETS cap for Scotland, 2016

The Scottish EU ETS cap for 2016 is **15.072 MtCO_{2e}**. The Scottish Government has published a methodological paper titled [Determining a Scottish EU ETS cap for 2016](#), which documents the calculations that determine how a notional emissions cap has been calculated for: (i) greenhouse gas emissions from fixed installations located in Scotland, and (ii) Scotland's share of emissions from domestic and international aviation.

STEP 4

Adding on the value of the EU ETS cap gives a value of 41.481 MtCO_{2e}. **In 2016, the adjusted emissions which take account of trading in the EU ETS is 41.481 MtCO_{2e}. This is 2.907 MtCO_{2e} higher than the value of estimated source emissions in 2016.** Under the Climate Change (Scotland) Act, 2009 ¹¹, an upward adjustment to source emissions is referred to as a debit from the Net Scottish Emissions Account ¹². **This means that 2,906,763 units have been debited to the Net Scottish Emissions Account in 2016.**

¹⁰ <http://www.legislation.gov.uk/ssi/2016/46/contents/made>

¹¹ <http://www.legislation.gov.uk/asp/2009/12/2009-08-05>

¹² Carbon units that are counted as **credits** reduce the level of the NSEA compared with source emissions.

Carbon units that are counted as **debits** increase the level of the NSEA compared with source emissions.

Scottish Climate Change Targets

Scotland has a number of targets for reducing greenhouse gas emissions contained in legislation, within the Climate Change (Scotland) Act 2009. These targets can be summarised as follows:

The Act creates a statutory framework for greenhouse gas emissions reductions in Scotland by setting an interim target of at least a 42 per cent reduction for 2020, and at least an 80 per cent reduction target for 2050. These reductions are based on a 1990 baseline (1995 for the F-Gases). The Act also requires that Scottish Ministers set fixed annual targets for emissions at least 12 years in advance. In October 2010 the Scottish Parliament passed legislation setting the first batch of annual targets, for the years up to 2022¹³. Targets for 2023-2027 were set in October 2011¹⁴, and will continue to be set at 5-year intervals.

The 2016 target is 44.933 MtCO₂e.

Achievement of Scotland's targets is measured against the level of the Net Scottish Emissions Account (NSEA). There is a limit on the net amount of carbon units that may be credited to the NSEA in addition to those from the EU Emissions Trading System. The Climate Change (Limit on Carbon Units) (Scotland) Order 2010¹⁵ specifies that the net amount of carbon units that may be credited to the Net Scottish Emissions Account for the period 2010-2012 is zero. The Climate Change (Limit on Carbon Units) (Scotland) Order 2011¹⁶ sets limits for the period 2013-2017. For 2016, no additional carbon units were credited to the Net Scottish Emission Account.

¹³ The Climate Change (Annual Targets) (Scotland) Order 2010, SSI 2010 no. 359: <http://www.legislation.gov.uk/ssi/2010/359/contents/made>

¹⁴ The Climate Change (Annual Targets) (Scotland) Order 2011, SSI 2011 no. 353: <http://www.legislation.gov.uk/ssi/2011/353/contents/made>

¹⁵ The Climate Change (Limit on Carbon Units) (Scotland) Order 2010, SSI 2010 no. 217: <http://www.legislation.gov.uk/ssi/2010/217/contents/made>

¹⁶ The Climate Change (Limit on Carbon Units) (Scotland) Order 2011, SSI 2011 no. 440: <http://www.legislation.gov.uk/ssi/2011/440/contents/made>

Chart C3 contains data from the latest (1990-2016) inventory, adjusted for trading in the EU Emissions Trading System as well as data on progress against the 42 per cent and 80 per cent reduction targets. These percentage targets are based on a percentage reduction from the Baseline Period in the latest inventory.

Chart C3. Percentage Reductions Targets – Based on Adjusted Emissions. Values in MtCO₂e

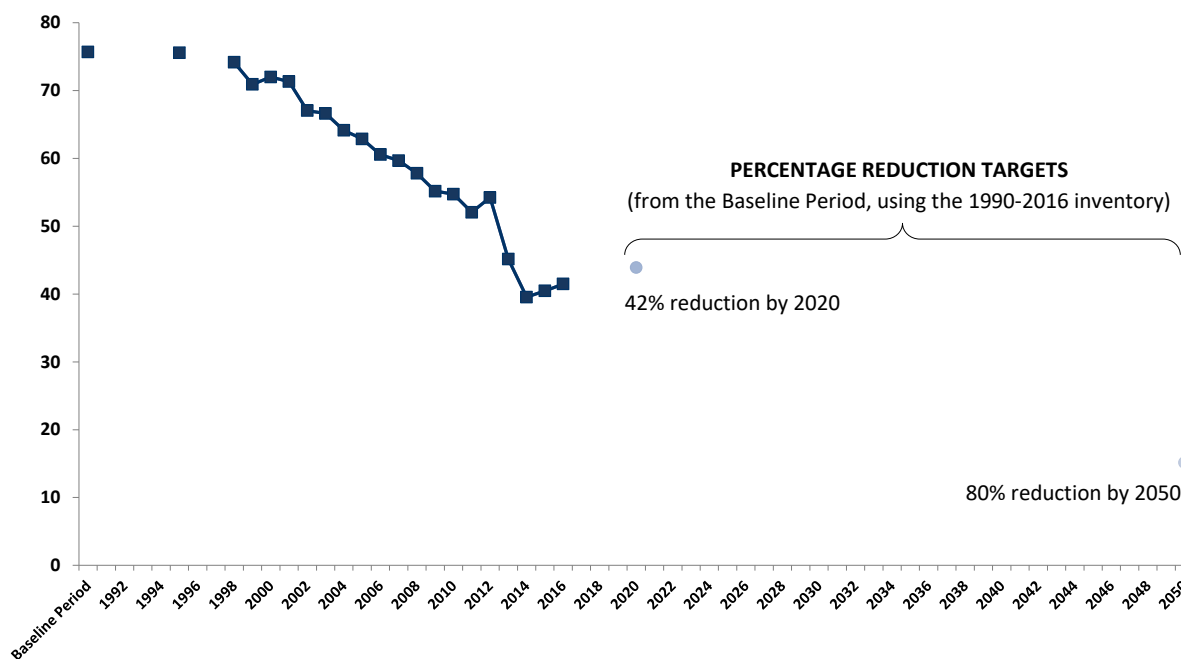
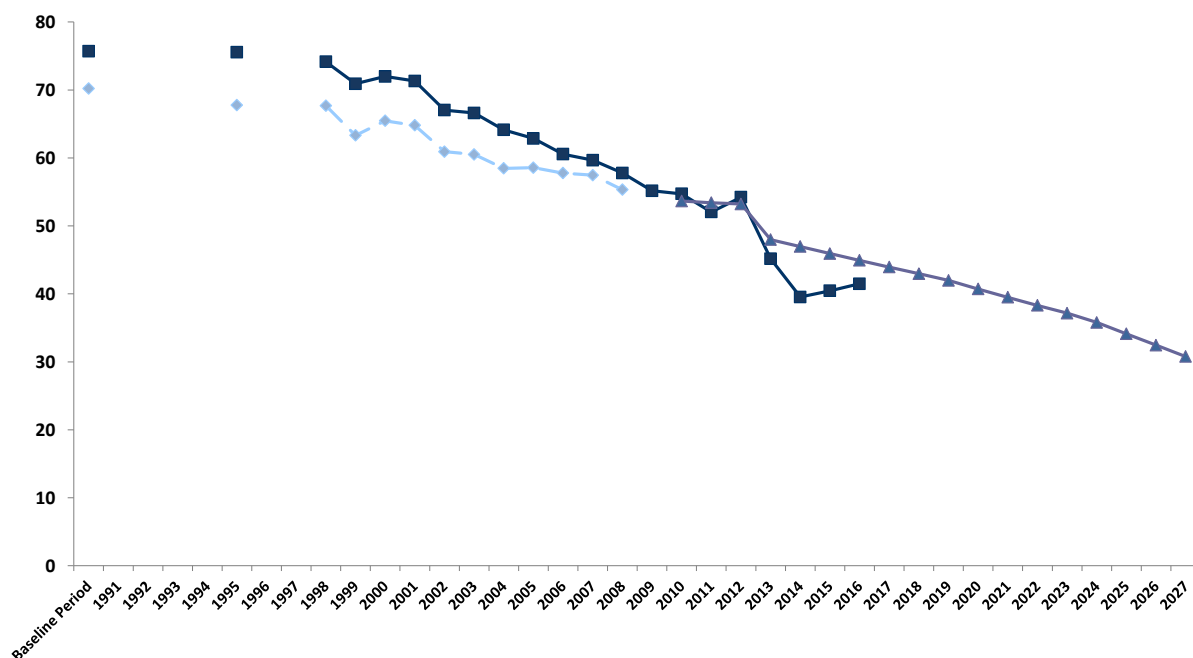


Chart C4 contains data from the latest (1990-2016) inventory, adjusted for trading in the EU Emissions Trading System. The fixed annual targets are also presented on this chart. The fixed annual targets were set at the time of the 1990-2008 inventory. Emissions adjusted for trading in the EU ETS using the 1990-2008 are shown for context.

Chart C4. Comparison of Adjusted Emissions and the Fixed Annual Targets which are based on the 1990-2008 Inventory. Values in MtCO_{2e}



National Performance Framework Sustainability Purpose Targets

In addition to the statutory Climate Change Targets, these statistics are used to monitor progress against the Scottish Government’s Sustainability Purpose Targets.

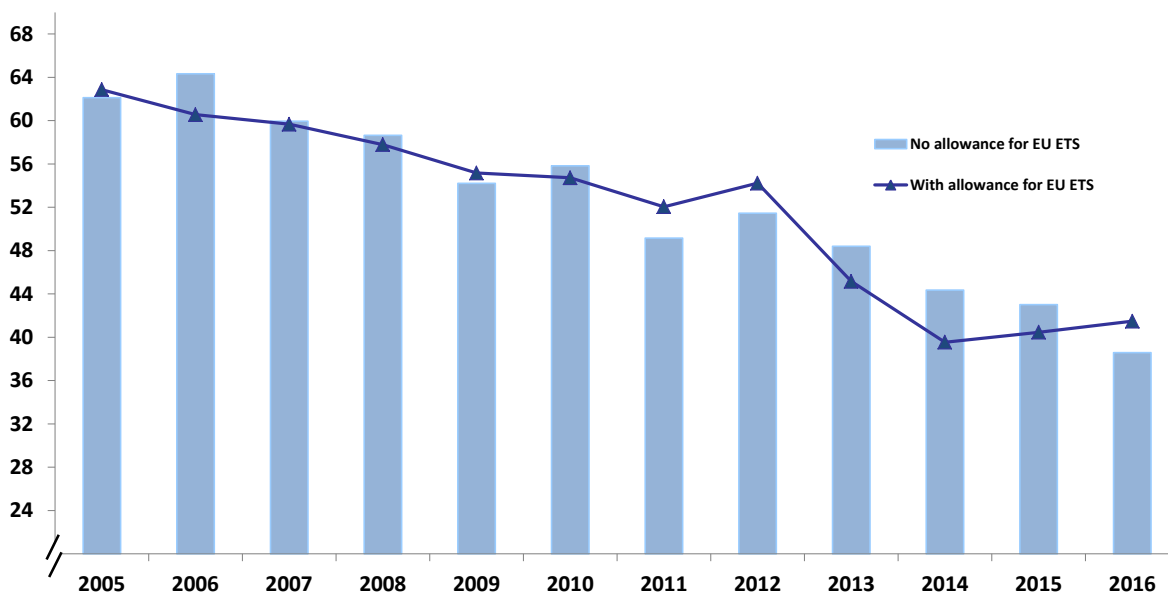
The Sustainability Purpose Targets were refreshed in March 2016 to align with the percentage reduction targets as prescribed in the Climate Change (Scotland) Act 2009. There are two Sustainability Purpose targets:

- The long term target (2050) equates to the 80 per cent reduction target
 - The short term target (2020) equates to the 42 per cent reduction target
- Information on progress towards these targets can be found on the Scottish Government [Scotland Performs](#) website.

Effect of the adjustment to take into account of trading in the EU Emissions Trading System

Chart C5 demonstrates the effect of the adjustment for trading in the EU ETS, for calculation of the Net Scottish Emissions Account (NSEA).

Chart C5. Greenhouse Gas Emissions Adjusted for the Emissions Trading System (EU ETS). Values in MtCO₂e



In five of the last 12 years, the adjustment has increased reported emissions, with 2011, 2012 and 2016 showing sizeable increases from the adjustment. In 2013, 2014, and 2015 the adjustment has seen sizeable decreases for the reported cap. In 2016, the adjustment represented an increase of 2.907 MtCO₂e. This reflects Scotland's notional share of the EU ETS cap in 2016, due to withholding of allowances which can be used within the system at an EU level and the tightening of the EU ETS cap between Phases II and III.

Section D. Revisions to the Inventory and Methodology

This section examines key revisions in estimated source emissions between the latest inventory (1990-2016) and the previous inventory (1990-2015) published in June 2017. It also provides a summary of the cumulative impact of revisions since the 1990-2008 inventory. In October 2015, the Scottish Government published a paper [Scottish Greenhouse Gas Emissions 2013. Key Revisions Since 2008](#), which provides a breakdown of the key revisions to the data within the Scottish Greenhouse Gas Emissions Official Statistics publication over successive years from the 1990-2008 inventory to the 1990-2013 inventory. This section of the publication is intended to build on this revisions paper.

Compilation of the Greenhouse Gas Inventory

The greenhouse gas inventory covers a wide variety of anthropogenic sources of greenhouse gas emissions. There is 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 Business, Energy and Industrial Strategy (BEIS) Publication “Digest of UK Energy Statistics (DUKES)”. This approach is prompted by data availability on emissions being more limited at the sub-UK level.

Impact of Revisions

Revisions between the 1990-2015 and 1990-2016 inventories

Charts D1 to D3 illustrate the impacts of revisions between the 1990-2015 and 1990-2016 inventories. This is followed by a discussion of the reasons for the key revisions.

Chart D1. Scottish Greenhouse Gas Emissions. Comparison of 1990-2015 and 1990-2016 Inventories. Values in MtCO₂e

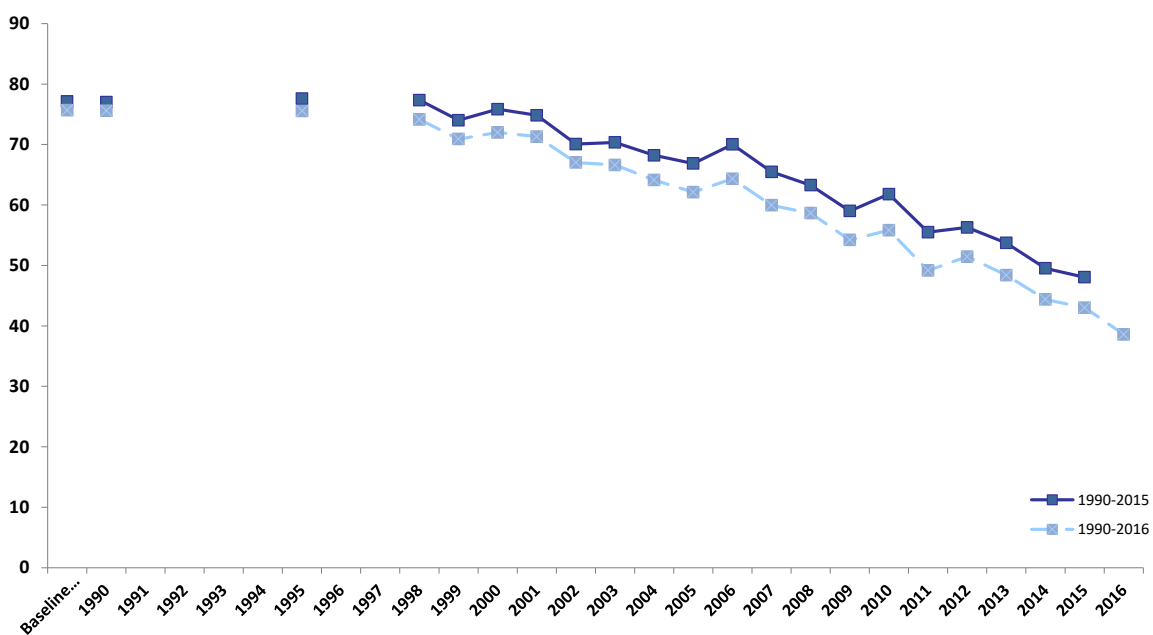


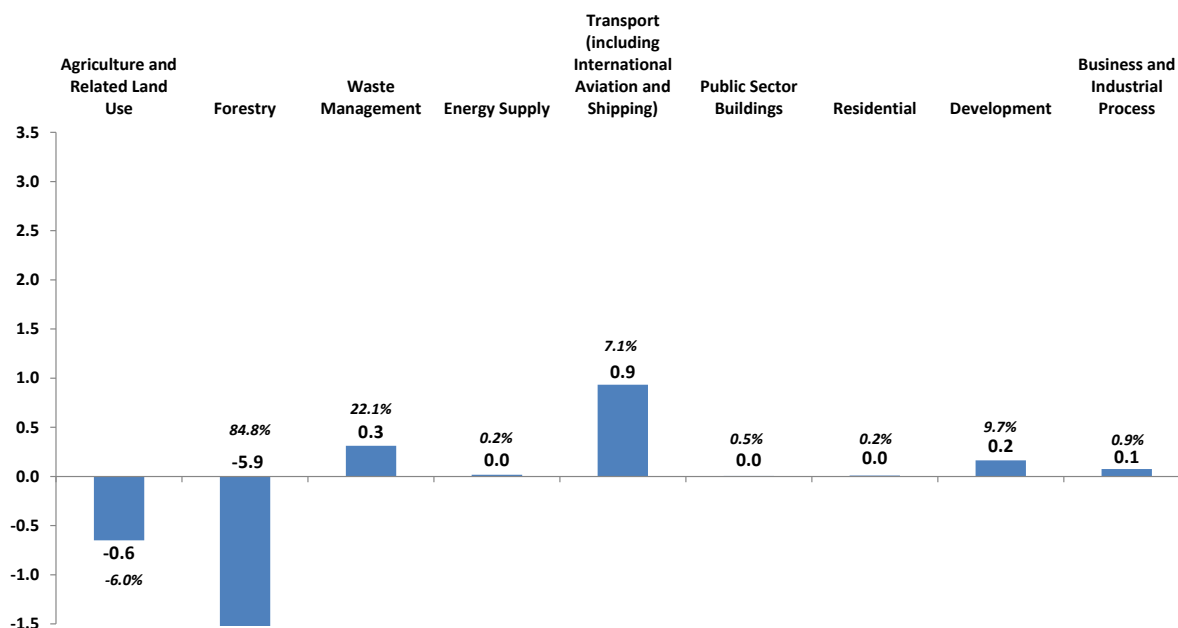
Chart D2 shows that the main downward revision to the Baseline period occurred in the Forestry sector (revised downwards by 2.6 MtCO₂e). Agriculture and Related Land Use saw a small downwards revision to the Baseline period (0.7 MtCO₂e). Other sectors saw very little change between the 1990-2015 and 1990-2016 inventories, with a slight (0.4 MtCO₂e) increase in emissions from Waste Management.

Chart D2. Revisions to emissions in the Baseline Period, from the 1990-2015 inventory to the 1990-2016 inventory, by source sector. Values in MtCO₂e, and percentage changes



Chart D3 shows that the greatest downwards revision in 2016 occurred in the Forestry sector (5.9 MtCO_{2e}). The greatest upwards revision occurred in Transport (including international aviation and shipping) (0.9 MtCO_{2e}).

Chart D3. Revisions to emissions in 2015, from the 1990-2015 inventory to the 1990-2016 inventory, by source sector. Values in MtCO_{2e}, and percentage changes



Details of Main Revisions and Interpretation of Revisions to the Inventory

Revisions to emission inventory estimates reflect the continuous development of scientific understanding of emissive processes, and the improvement to underlying data and methods to generate accurate emission estimates; few revisions to the Greenhouse Gas Inventories arise as a result of 'errors' in the popular sense of the word. The compilation of the inventory is governed by a rigorous quality assurance process and is subject to a great deal of third party scrutiny, such as annual reviews by the UNFCCC of the UK inventory.

The latest published Scotland greenhouse gas inventory (currently 1990-2016) represents the best available data at the time and these supersede any previous data, which should be disregarded.

A complete list of the revisions between the previous and latest inventories can be found in the National Atmospheric Emissions Inventory report Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 - 2016. Details of the most notable revisions are listed below:

1. Forestry.

Methodological change to series has increased the sink. The area reported as forest remaining forest has been revised upwards. There are also changes in the CARBINE model for calculating forest carbon stock. This has resulted in an increase in the magnitude of the sink from forest land across the time series.

2. Shipping

Improvements to the methodology for estimating shipping emissions has resulted in an increase in the estimates for gas oil and fuel oil used in Scotland. This has caused recalculations for emissions from domestic navigation and fishing vessels.

3. Agriculture and Related Land Use

Lower estimated nitrous oxide emissions from agricultural soils and the use of a new emission factor model for enteric fermentation incorporating UK-specific parameters are the largest contributors to recalculations from the agriculture sector in Scotland

Interpretation of uncertainties in the inventory

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.

Estimates of greenhouse gases are compiled by a consortium of contractors. The source emissions are based upon a range of data sources, ranging from model based estimates to point source emission data. As a result, the estimates are subject to a degree of uncertainty. Full analyses of these uncertainties are provided on the [National Atmospheric Emissions Inventory](#) website.

The Scottish Government has commissioned research to overhaul and update the uncertainties model used for the Scottish greenhouse gas inventory. A detailed study was carried out in parallel with the compilation with the 1990-2014 Scottish greenhouse gas inventory to review and improve the uncertainty calculations. A link to this project and to the full report can be found in the [Scottish Greenhouse Gas Inventory Uncertainties Project](#).

Future revisions to the inventory

Every year, greenhouse gas inventories are updated to reflect improvements in the underpinning science, data and modelling which often result in revisions to the entire time series. These revisions also reflect changes to the Intergovernmental Panel on Climate Change (IPCC) guidelines. The Scottish Government is represented at the UK's National Inventory Steering Committee, where improvements to the Scottish and UK inventories are discussed. Some of the changes for the 1990-2017 inventory and for subsequent inventories are already known. However, the exact magnitude and direction of future revisions are not currently clear but on balance we might expect emissions to increase over subsequent inventories.

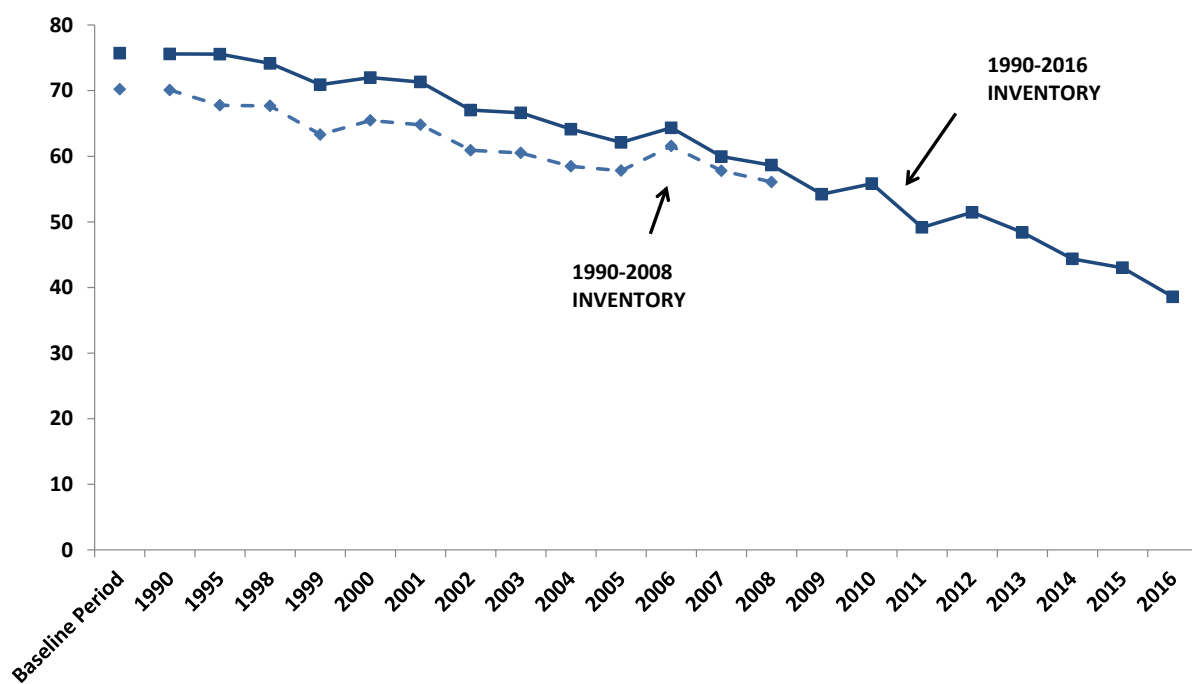
There are a number of projects underway which might result in considerable revisions for future inventories in a number of sectors. For instance:

- The UK and Scotland has elected to include the IPCC (2006) Wetlands Supplement as part of their inventory reporting: <http://www.ipcc-nggip.iges.or.jp/home/wetlands.html> <http://www.ipcc-nggip.iges.or.jp/public/wetlands/>. The Wetlands Supplements will estimate the carbon effects of drainage and rewetting peatland, although these categories will not be fully included in the greenhouse gas inventory for a number of years.

Note that there are likely to be further revisions in the 1990-2017 inventory which have not been noted within this publication.

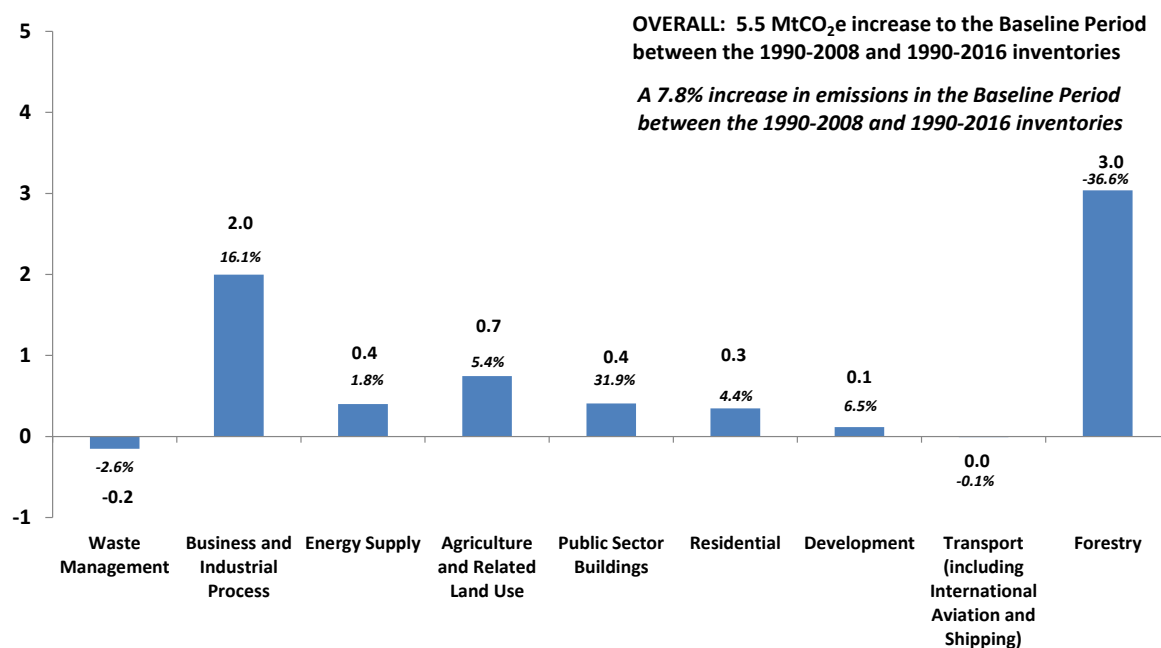
Charts D5 shows the cumulative effect of revisions to the greenhouse gas inventory from 1990-2008 to the latest (1990-2016) inventory across the time series. Chart D6 shows the cumulative effect of revisions to the Baseline from the 1990-2008 inventory, by source sector.

Chart D4. Scottish Greenhouse Gas Emissions, Comparison of 1990-2008 and 1990-2016 Inventories. Values in MtCO₂e



There has been a cumulative upwards revision between 1990-2008 and 1990-2016 across the entire time series. The emissions in the Baseline have been revised upwards by 5.5 MtCO₂e (7.8 per cent).

Chart D5. Revisions to the Baseline, from the 1990-2008 Inventory to the Latest Inventory (1990-2016), by source sector. Impact of Successive Revisions. Values in MtCO₂e, and percentage changes ¹⁷



A discussion of the main causes of the upwards revisions between 1990-2008 and the 1990-2013 inventories can be found within the methodology paper: [Scottish Greenhouse Gas Emissions 2013. Key Revisions Since 2008.](#)

¹⁷ Unlike for other source sectors, downwards revisions to net emissions from forestry are presented as a positive percentage change. This is because forestry causes a net removal of emissions.

Section E. Further information, Glossary and Acknowledgements

Further Information

Methodology and Source data

Full details of the methodology used to estimate Scottish greenhouse gas emissions together with further breakdowns are provided on the National Atmospheric Emissions Inventory website.

Scottish Greenhouse Gas Inventory Uncertainties Project

The Scottish Government commissioned a project to understand the uncertainties associated with the estimates of Scottish Greenhouse gas Emissions in 2013:

<http://www.gov.scot/Topics/Statistics/Browse/Environment/Publications/GHGUncertainties2013Summary>

Scotland's Carbon Footprint

Scottish Greenhouse Gas Emissions on a Consumption Basis ("[Scotland's Carbon Footprint 1998-2014](#)")

Scottish Greenhouse Gas Emissions 2013. Key Revisions since 2008

This paper was published in 2015 and provides a breakdown of the key revisions to the Scottish Greenhouse Gas Emissions Official Statistics publication over successive years from the 1990-2008 inventory to the 1990-2013 inventory.

<http://www.gov.scot/Topics/Statistics/Browse/Environment/Publications/ghgrevisions-2013>

Climate Change (Scotland) Act 2009

This legislation outlines the requirements for percentage reductions targets for 2020 and 2050 and fixed annual targets

<http://www.gov.scot/Topics/Environment/climatechange/scotlands-action/climatechangeact>

Climate Change (Annual Targets) (Scotland) Order 2010

This Order sets the first batch of annual emissions reduction targets, for the period 2010-2022.

<http://www.legislation.gov.uk/ssi/2010/359/introduction/made>

Climate Change (Annual Targets) (Scotland) Order 2011

This Order sets the second batch of annual emissions reduction targets, for the period 2023-2027.

<http://www.gov.scot/Topics/Environment/climatechange/scotlands-action/climatechangeact/order2011>

The Climate Change (Annual Targets) (Scotland) Order 2016

This Order sets annual emissions reduction targets for the period 2028-2032.

<http://www.legislation.gov.uk/ssi/2016/328/contents/made>

The Carbon Accounting Scheme (Scotland) Regulations 2010

These Regulations establish the scheme for monitoring compliance with the annual emissions reduction targets set for 2010-2012.

<http://www.legislation.gov.uk/ssi/2010/216/contents/made>.

The Carbon Accounting Scheme (Scotland) Amendment Regulations 2015

These Regulations establish the scheme for monitoring compliance with the annual emissions reduction targets set for 2013.

<http://www.legislation.gov.uk/ssi/2015/189/contents/made>

The Carbon Accounting Scheme (Scotland) Amendment Regulations 2016

These Regulations establish the scheme for monitoring compliance with the annual emissions reduction targets set for 2014.

<http://www.legislation.gov.uk/ssi/2016/46/contents/made>

The Carbon Accounting Scheme (Scotland) Amendment Regulations 2017

These Regulations establish the scheme for monitoring compliance with the annual emissions reduction targets set for 2015.

<http://www.legislation.gov.uk/ssi/2017/121/contents/made>

The Carbon Accounting Scheme (Scotland) Amendment Regulations 2018

These Regulations establish the scheme for monitoring compliance with the annual emissions reduction targets set for 2016.

<http://www.legislation.gov.uk/ssi/2018/40/made>

The Climate Change (Additional Greenhouse Gas) (Scotland) Order 2015

This legislates for the inclusion of the new greenhouse gas (nitrogen trifluoride) to be added to the basket of gases in Scotland's greenhouse gas inventory.

<http://www.legislation.gov.uk/ssi/2015/197/contents/made>

National Performance Framework Sustainability Purpose Targets

<http://www.gov.scot/About/Performance/scotPerforms/purpose/sustainability>

Department of Business, Energy and Industrial Strategy (BEIS) statistics

<https://www.gov.uk/government/organisations/department-of-energy-climate-change/about/statistics#emissions-and-climate-change-statistics>

UK greenhouse gas inventory national system

<https://www.gov.uk/government/publications/uk-greenhouse-gas-emissions-statistics-user-guidance>

UK greenhouse gas inventory summary factsheets

<https://www.gov.uk/government/publications/uk-greenhouse-gas-inventory-summary-factsheets>

Committee on Climate Change (CCC)

The CCC is an independent body established under the Climate Change Act to advise the UK Government and devolved administrations on reducing greenhouse gas emissions.

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

United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty. The objective of the treaty is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The treaty itself set no binding limits on greenhouse gas emissions for individual countries and contains no enforcement mechanisms. In that sense, the treaty is considered legally non-binding. Instead, the treaty provides a framework for negotiating specific international treaties (called "protocols") that may set binding limits on greenhouse gases. <http://unfccc.int/>

Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) assesses the scientific, technical and socio-economic information relevant for the understanding of the risk of human-induced climate change. They provide advice to the UNFCCC on the scientific evidence and developments which are used to inform National Inventories.

<http://www.ipcc.ch/>

Meteorological Office (Met Office)

The Meteorological (Met Office) publishes mean monthly and annual air temperature figures for Scotland from 1910 to 2015.

<http://www.metoffice.gov.uk/pub/data/weather/uk/climate/datasets/Tmean/date/Scotland.txt>

EU Emissions Trading System (EU ETS)

Further information can be found in the BEIS website.

<https://www.gov.uk/participating-in-the-eu-ets>

Scottish Government Methodology Paper: Determining the Scottish EU ETS cap for 2016

This documents the calculations which determine the 'specified amounts' for emissions from (i) fixed installations located in Scotland and covered by the EU emissions trading system (EU-ETS) and (ii) aviation covered by the EU-ETS.

<http://www.gov.scot/Topics/Statistics/Browse/Environment/Publications/EUETScap2016>

Scottish Energy Statistics

The Scottish Government's [Energy in Scotland 2018](#) statistics compendium publication presents statistics on the energy sector in Scotland. It presents statistics and analysis for the following topics

- An overview of the energy sector in Scotland – including an Energy Balance for Scotland
- Energy Consumption
- Electricity
- Heat
- Transport
- Oil and Gas
- Energy Prices
- Climate Change
- Low Carbon Economy

Scottish Transport Statistics

These statistics are produced by Transport Scotland on an annual basis, as part of a compendium publication on a wide range of transport issues.

<http://www.gov.scot/Topics/Statistics/Browse/Transport-Travel/TablesPublications/ScottishTransportStats>

Why are some greenhouse gas emissions not considered in this statistics release?

The methods used to compile the Scottish Greenhouse Gas Inventory are consistent with international reporting and are therefore comparable to the greenhouse gas emission estimates reported by all other EU Member States and other Annex 1 parties¹⁸ to the UNFCCC. All countries estimate and submit their greenhouse gas inventory estimates to be consistent with methods set out in international guidance for national inventory methods from the Intergovernmental Panel on Climate Change (IPCC), known as the [IPCC \(2006\) guidelines](#). The IPCC (2006) guidelines state that national inventories should report on all anthropogenic (human) emissions and removals of greenhouse gas emissions, as a result of human activities within a country's territorial sphere.

However, there are some emissions and removals of carbon dioxide that occur as a result of short-cycle biogenic processes. This biocarbon has only recently been abstracted from the atmosphere before it is then re-released as carbon dioxide. In accordance with the IPCC (2006) guidelines, these emissions and sinks are therefore excluded from the greenhouse gas inventory, as they could lead to double counting. If countries do choose to estimate these biocarbon emissions, they are reported *outside of the national inventory total*, as a memo item to that country's submission to the UNFCCC. This means that some sources and sinks of greenhouse gases are not included in the Scottish and UK inventory totals.

Examples of reasons for why some sources and sinks of greenhouse gases are not included in the greenhouse gas inventory

1. Due to short-cycle biocarbon (carbon only been recently abstracted from the atmosphere)

- **Carbon dioxide (CO₂) emissions from biomass combustion.** For example, this includes CO₂ emissions from biomass power stations
- **Process emissions in food and drink production.** These include CO₂ emissions from brewing, fermenting and malting and in the production of food.
- **CO₂ emissions from biodegradable waste to landfill.** Emissions are not estimated where they arise from biogenic sources of waste such as food. Fossil-derived organic matter (such as plastic) is assumed to be non-biodegradable and there are no emissions associated with its decomposition.

¹⁸ Annex 1 countries are required to submit information on their national greenhouse gas inventories annually to the UNFCCC.

However, methane (CH₄) emissions from biodegradable waste sent to landfill are considered in these greenhouse gas statistics as they are formed by the anaerobic (oxygen-free) decay of organic matter in solid waste disposal sites.

2. Where there has been no anthropogenic influence

- **Natural accumulation and storage of carbon in peatland.** For emissions or removals of peatland to be considered for IPCC reporting, they require humans to alter the peatland – either through wetland drainage, rewetting, peatland extraction or through another land use change. The UK and Scotland has elected to include the IPCC (2006) Wetlands Supplement as part of their inventory reporting: <http://www.ipcc-nggip.iges.or.jp/home/wetlands.html> <http://www.ipcc-nggip.iges.or.jp/public/wetlands/>. The Wetlands Supplements will estimate the carbon effects of drainage and rewetting peatland, although these categories will not be fully included in the greenhouse gas inventory for a number of years.

3. Beyond the territorial definitions as prescribed by the IPCC (2006) reporting requirements

- **“Blue carbon”.** **Blue carbon** refers to the carbon captured by the world's oceans and coastal ecosystems. The carbon captured by living organisms in oceans is stored in the form of biomass and sediments from mangroves, salt marshes and seagrasses. However, it is worth pointing out that coastal wetlands will be included in the IPCC (2006) wetlands supplement when it becomes included in the greenhouse inventory.

Glossary

Adjusted emissions

Greenhouse gas emissions that have taken into account purchases/sales through the EU ETS. Adjusted emissions may be higher or lower than actual emitted emissions depending on the quantity of purchases or sales. Scottish Government emissions reduction targets are assessed using adjusted emissions.

Afforestation

The act or process of establishing a forest on land that has not been forested in recent history.

Baseline Period

Emissions reduction is based on a Baseline Period. For the greenhouse gases CO₂, CH₄ and N₂O, 1990 was specified as the baseline. 1995 is the baseline for emissions of the F-gases.

Carbon dioxide (CO₂)

Carbon dioxide is one of the main gases responsible for climate change. It is mostly emitted through the oxidation of carbon in fossil fuels, e.g. burning coal.

Carbon sink

A carbon sink is a natural or artificial reservoir that accumulates and stores CO₂ for an indefinite period.

Climate change

Climate change is a long-term change in the earth's climate. This can be accelerated by human activity, e.g. by releasing CO₂ into the atmosphere.

Deforestation

The removal of forest stands by cutting and burning to provide land for agricultural purposes, residential or industrial building sites, roads, etc., or the harvesting of trees for building materials or fuel.

EU ETS

The European Union Greenhouse Gas Emissions Trading System (EU ETS) is the largest multi-national emissions trading system in the world. Launched in 2005, the EU ETS is an EU policy aimed at mitigating climate change by limiting greenhouse gas emissions from industry sectors and aviation. Operating across Europe the system is mandatory for large energy-intensive industrial installations. Compared with 2005 levels, the EU ETS aims to deliver a 21 per cent reduction in emissions by 2020 and a 43 per cent reduction by 2030. Participants include more than 11,000 heavy energy-using

installations in power generation, the manufacturing industry and airlines across 31 countries in the European Economic Area (EEA). Over 11,000 installations throughout the EU are covered by the system, accounting for around 45 per cent of the EU's total CO₂ emissions. The EU ETS began in 2005. Phase III started in January 2013 and runs to December 2020.

Fluorinated gases (F-gases)

F-gases are the generic name given to HFCs, PFCs, SF₆ and NF₃. These have been used as replacements for CFCs, which are ozone depleting substances that have been banned under the Montreal Protocol. They have very high global warming potentials.

Greenhouse effect

The greenhouse effect is the process by which heat from the sun is trapped within the Earth's atmosphere by greenhouse gases. This process is also known as *radiative forcing*.

Greenhouse gas

A greenhouse gas is a gas which absorbs infrared radiation emitted from the surface of the Earth, helping to retain a portion of that energy in the atmosphere as heat.

Global warming potential (GWP)

GWP is a measure of how much a greenhouse gas is estimated to contribute to global warming. It is a relative scale which compares the potency of each gas to CO₂.

Hydrofluorocarbons (HFCs)

HFCs are produced commercially as a substitute for chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). HFCs are largely used in refrigeration and insulating foam. Their Global Warming Potentials range from 12 to 14,800 times that of CO₂, depending on the gas type.

Inventory

The inventory contains greenhouse gas emissions estimates for Scotland and the UK. The Inventory is a disaggregation of the UK Inventory, which is based on five major sectors: energy, industrial processes, agriculture, land-use, land-use change and forestry, and waste.

IPCC

The Intergovernmental Panel on Climate Change (IPCC) assesses the scientific, technical and socio-economic information relevant for the understanding of the risk of human-induced climate change. They provide advice to the UNFCCC on the scientific evidence and developments which are used to inform National Inventories.

LULUCF

Estimates of emissions and removals from land use, land use change and forestry (LULUCF) depend critically on assumptions made on the rate of loss or gain of carbon in Scotland's carbon rich soils. In Scotland, LULUCF activities, taken as a whole, acts as a sink, absorbing more greenhouse gas emissions than it releases.

Methane (CH₄)

Methane is a greenhouse gas that is around 25 times more potent in the atmosphere than CO₂ over a 100-year time horizon. Main sources include agriculture and landfill.

National Communication (NC) Sectors

The UK NC sectors are agreed groupings of the more detailed sectors reported to the United Nations Framework Convention on Climate Change by the UK. This report uses Scottish Government sectors. Mapping of these to NC sectors and IPCC sectors can be seen in [Section E](#).

Nitrogen trifluoride (NF₃)

Nitrogen trifluoride is a greenhouse gas that is around 17,200 times more potent in the atmosphere than CO₂ over a 100-year time horizon. The main source of nitrogen trifluoride is in the making of semiconductors.

Nitrous oxide (N₂O)

Nitrous oxide is a greenhouse gas that is around 298 times more potent in the atmosphere than CO₂ over a 100-year time horizon. The main source is agricultural soil.

Other Petroleum Gas (OPG)

This consists mainly of ethane plus some other hydrocarbons, excluding butane and propane.

Perfluorocarbons (PFCs)

PFCs are a by-product of aluminium smelting. They are also the replacement for CFCs in manufacturing semiconductors. The Global Warming Potentials of PFCs ranges from 7,390 - 17,340 times that of CO₂ over a 100-year time horizon.

Radiative forcing

An externally imposed perturbation in the radiative energy budget of the Earth's atmosphere. Such a perturbation can be brought about by changes in the concentrations of radiatively active species (e.g. greenhouse gases), changes in the solar irradiance incident upon the planet, or other changes that affect the radiative energy absorbed by the surface (e.g. changes in surface reflection properties).

Sequestration

The process by which carbon sinks remove carbon dioxide (CO₂) from the atmosphere.

Source (UNFCCC definition)

Any process or activity which releases a greenhouse gas or a precursor greenhouse gas to the atmosphere.

Sulphur hexafluoride (SF₆)

It is largely used in heavy industry to insulate high-voltage equipment and to assist in the manufacturing of cable-cooling systems. Its global warming potential is 22,800 times that of CO₂ over a 100-year time horizon.

UNFCCC

In 1992, the UNFCCC was adopted as the basis for a global response to climate change. The ultimate objective of the Convention is to stabilise greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system.

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http://naei.defra.gov.uk/reports/reports?section_id=4

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How to access background or source data

The data collected for this <statistical bulletin >:

- 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.

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