



AGRICULTURE, ENVIRONMENT AND MARINE

Scottish Greenhouse Gas Emissions 2019

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.

47.8 MtCO₂e in 2019



**Down
43.8%
from
1990**



**Down
2.3%
from
2018**



EMISSIONS FOR REPORTING AGAINST TARGETS

The Committee for Climate Change (CCC) recommended a new method of reporting emissions for the purposes of reporting against targets from the June 2020, and future, publications. This is known as the GHG Account and the calculation is detailed in section C.



**51.5%
from
Baseline
Period**



On this adjusted basis, the GHG account reduced by 51.5 per cent between the baseline period and 2019.

The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 specifies a 55.0 per cent reduction over the same period.

Therefore the target for 2019 has not been met.

Laid before the Scottish Parliament by the Scottish Ministers under section 33 of the Climate Change (Scotland) Act 2009 Jun 2021 [SG/2021/136]

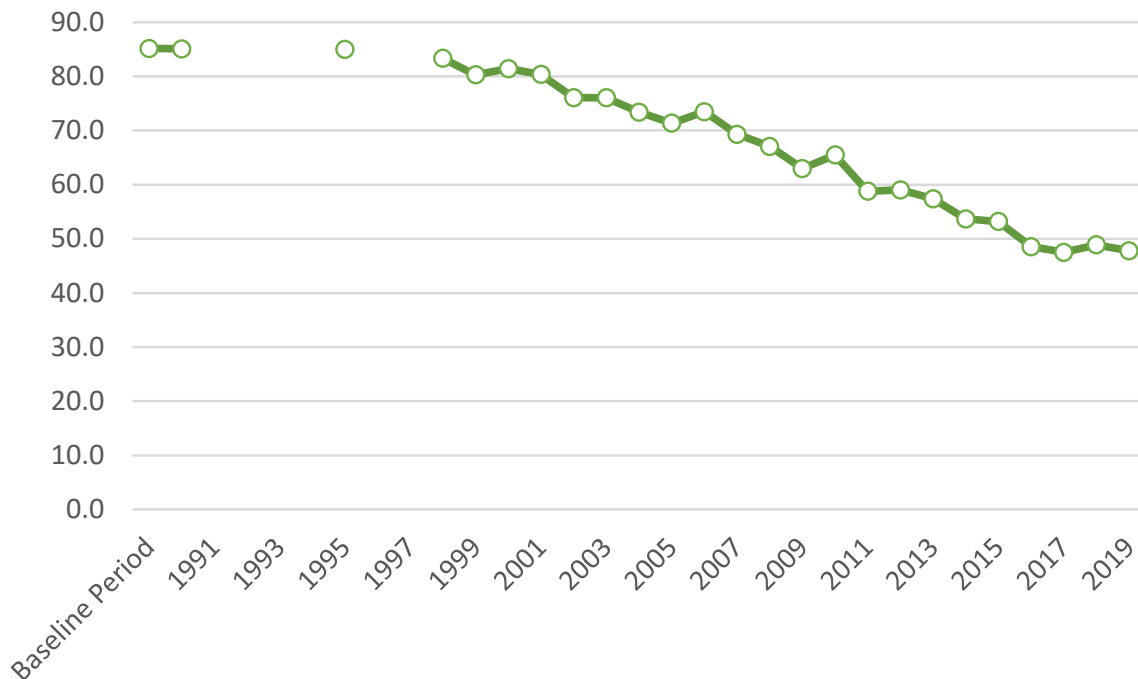
Figures have been revised since last year's release to incorporate methodological improvements and new data

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.

KEY TREND – SOURCE EMISSIONS

Scottish Greenhouse Gas Emissions, 1990 to 2019. Values in MtCO₂e



In 2019, Scottish source emissions of the basket of seven greenhouse gases were estimated to be 47.8 million tonnes carbon dioxide equivalent (MtCO₂e). This is 2.3 per cent lower than the 2018 figure of 48.9 MtCO₂e; a 1.1 MtCO₂e decrease. The main contributors to this decrease between 2018 and 2019 were reductions in emissions in the business (-0.6 MtCO₂e), Energy Supply (-0.4 MtCO₂e), and Domestic Transport (-0.3 Mt CO₂e) sectors. All other sectors demonstrated modest reductions over this period, with the exception of Land Use, Land Use Change and Forestry (LULUCF) which increased by 0.4 MtCO₂e. The Agriculture and International Aviation and Shipping sectors showed essentially no change in emissions in the latest year.

Between 1990 and 2019, there was a 43.8 per cent reduction in estimated emissions, a 37.3 MtCO₂e decrease. The most significant contributors to this overall reduction were:

- Fall in Energy Supply emissions (such as power stations) (-16.3 MtCO_{2e}; 71.8 per cent reduction)
- 'Land Use, Land Use Change And Forestry' (LULUCF) reducing its net emissions over the long run, reducing by 6.4 MtCO_{2e} since 1990.
- Fall in Waste Management emissions (such as Landfill) (-4.3 MtCO_{2e}; a 73.5 per cent reduction)
- Fall in Business emissions (-4.6 MtCO_{2e}; a 36.7 per cent reduction)

All other sectors have demonstrated a reduction in emissions since 1990 with the exception of International Aviation and Shipping which has increased over the period by 0.6 MtCO_{2e} (+46.0 per cent).

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

REVISIONS TO GREENHOUSE GAS EMISSIONS STATISTICS

Note that as part of this release all of the figures have been revised since the previous publication, to incorporate methodological improvements and new data. Comparing these 2019 figures with the 2018 figures published a year ago will therefore give a different year-on-year percentage change; one which is incorrect and should not be used. The correct percentage changes are given in this publication and associated tables. 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 2019” Official Statistics publication contains the results of the Scottish Greenhouse Gas Inventory for 1990-2019. 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 official statistics publication “Scottish Greenhouse Gas Emissions 2019” 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.
- **GHG account.** These are net source emissions which have been adjusted to remove the effect of successive revisions to the data over time. [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 February 2021 for the years 1998 to 2017 as part as part of the Official Statistics publication: [“Scotland's Carbon Footprint 1998-2017”](#). [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)	GHG Account (Section C)
Used for reporting progress against Scotland's Climate Change Targets ¹	✗	✓
Can be compared with EU countries	✓	✗
Can be compared with UK ²	✓	✗
Includes International Aviation and Shipping	✓	✓
Includes North Sea Oil & Gas	✗	✗
Data on individual greenhouse gases	✓	✗
Data on sectoral emissions	✓	✗
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, 2019

Name of Greenhouse Gas	Chemical Formula	Global Warming Potential (GWP) (Conversion factor to carbon dioxide equivalent)	Contribution to Scotland's Net Greenhouse Gas Emissions, 2019 (in MtCO ₂ e)	Percentage of Scotland's Net Greenhouse Gas Emissions, 2019 (in MtCO ₂ e)	Examples sources of gas
Carbon dioxide	CO ₂	1	33.5	70.2%	All other sources of greenhouse gases, including removals (carbon sinks)
Methane	CH ₄	25	9.2	19.3%	Waste management, enteric fermentation and animal waste
Nitrous oxide	N ₂ O	298	3.8	8.0%	Agricultural soils
F-gases ² , of which....			1.2	2.5%	Industrial air conditioning, refrigeration, use as tracer gases, semiconductors
• Hydrofluorocarbons	HFC	12 - 14,800	1.0	2.1%	
• Perfluorocarbons	PFC	7,390 - 17,340	0.2	0.3%	
• Sulphur hexafluoride	SF ₆	22,800	0.04	0.1%	
• Nitrogen trifluoride	NF ₃	17,200	0.0004	0.0%	
Total Net Greenhouse Gases			47.8	100.0%	

The Global Warming Potentials (GWPs) are based on international reporting standards, as set by the Intergovernmental Panel on Climate Change (IPCC)¹.

[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 1990-2018 and 1990-2019 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 GHG account. This is referred to as “Baseline Period” when referring to changes over time in the charts, tables and text.

The Baseline Period for reporting against Climate Change Targets is:

¹ IPCC’s 4th Assessment Report: <http://www.ipcc.ch/report/ar4/>

- 1990 for carbon dioxide carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O)
- 1995 for Fluorinated gases (F gases)²: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆), nitrogen trifluoride (NF₃)

The difference between these definitions of baseline year tend to be small as F gases are a minority contribution to the total emissions in terms of carbon dioxide equivalent.

Within this publication, data are estimated for the Baseline Period; and the years 1990, 1995 and 1998 to 2019.

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 present in the 'Land Use, Land Use Change and Forestry' (LULUCF) category, they are mostly associated with the effects of grasslands and forestry to sequester carbon, as well as the carbon stored in wood products. These are known as “removals” as they offset emissions.

Categories

This publication provides the latest estimates of Scotland’s greenhouse gas emissions by source from 1990-2018. It uses the ‘National Communication’ categories, which are the same categories used for the UK report. **Note that previous publications (prior to the 1990-2018 release) used the Scottish government sectors instead.** This was changed for consistency with other reports. However, the data are still available by Scottish Government sectors in the underlying excel database that accompanies this publication. For the purposes of reporting, greenhouse gas emissions are allocated into categories 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). North Sea oil & gas emissions are not allocated to Scotland³.

² 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.

³ 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.

Business – Emissions from fuel combustion and product use in industrial and commercial sectors, and F gas emissions from refrigeration and air conditioning in all sectors. Includes industrial off-road machinery

Industrial Processes - Emissions resulting from industrial processes, except for those associated with fuel combustion which are included in the Business sector.

Transport (excluding International Aviation and Shipping) - Emissions from domestic aviation, road transport, railways, domestic navigation, fishing and aircraft support vehicles.

International Aviation and Shipping – This category is called “Exports” in some inventories. Includes emissions from international aviation and shipping.

Public - 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 - Emissions from livestock, agricultural soils (excluding carbon stock changes which are included in the LULUCF sector), stationary combustion sources and off-road machinery.

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

Land Use, Land Use Change And Forestry (LULUCF) – Emissions/removals of CO₂ from changes in the carbon stock in forestland, cropland, grassland, wetlands, settlements and harvested wood products, and of other greenhouse gases from drainage (excl. croplands and intensive grasslands) and rewetting of soils, nitrogen mineralisation associated with loss and gain of soil organic matter, and fires. Because the impact of biomass harvest on carbon stocks in ecosystems is included in this sector, any emissions of CO₂ from burning biomass (regardless of the country of origin) are excluded from other sectors to avoid double counting them.

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. The Scottish Government also reports on International Aviation and Shipping emissions attributed to Scotland, along with other Transport

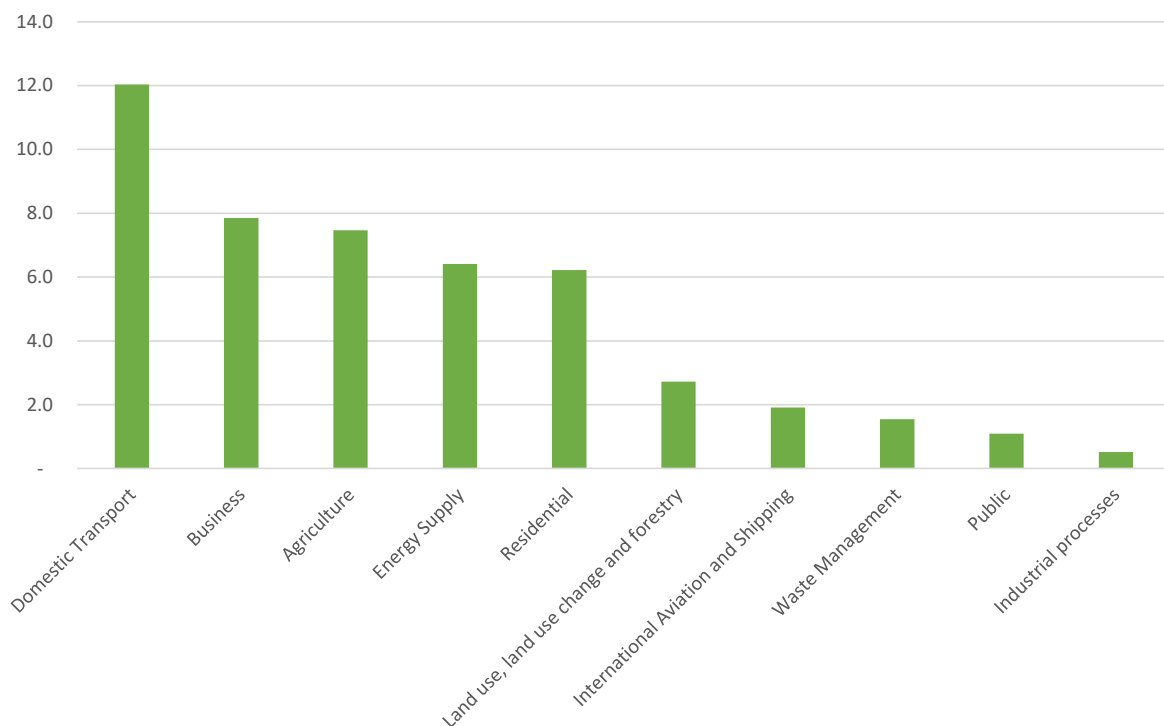
emissions. International Aviation and Shipping emissions are categorised as an IPCC international “Memo” item.

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

2019 results

Chart B1 presents the sources and sinks of Scottish Greenhouse Gas Emissions in 2019, grouped by National Communication category.

Chart B1. Sources of Scottish Greenhouse Gas Emissions, 2019. Values in MtCO₂e



Main points

- In 2019, Domestic transport (excluding International Aviation and Shipping) (12.0 MtCO₂e) was the largest source of net emissions, followed by Business (7.9 MtCO₂e), Agriculture (7.5 MtCO₂e), Energy Supply (6.4 MtCO₂e) and Residential (6.2 MtCO₂e).

Table B1. Scottish Greenhouse Gas Emissions by Gas and by Scottish Government Source Sector, 2019. Values in MtCO_{2e}

NC category	Carbon Dioxide	Methane	Nitrous Oxide	Fluorinated gases	Total
Agriculture	1.1	4.1	2.2		7.5
Business	6.7	0.0	0.1	1.1	7.9
Energy Supply	6.0	0.4	0.1		6.4
Industrial Processes	0.5	0.0	0.0	0.0	0.5
International Aviation and Shipping	1.9	0.0	0.0		1.9
Land Use, Land Use Change And Forestry	-1.7	3.2	1.2		2.7
Public	1.1	0.0	0.0		1.1
Residential	6.0	0.1	0.0	0.1	6.2
Transport	11.9	0.0	0.1		12.0
Waste Management	0.0	1.4	0.1		1.5
Total	33.5	9.2	3.8	1.2	47.8

Main points

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

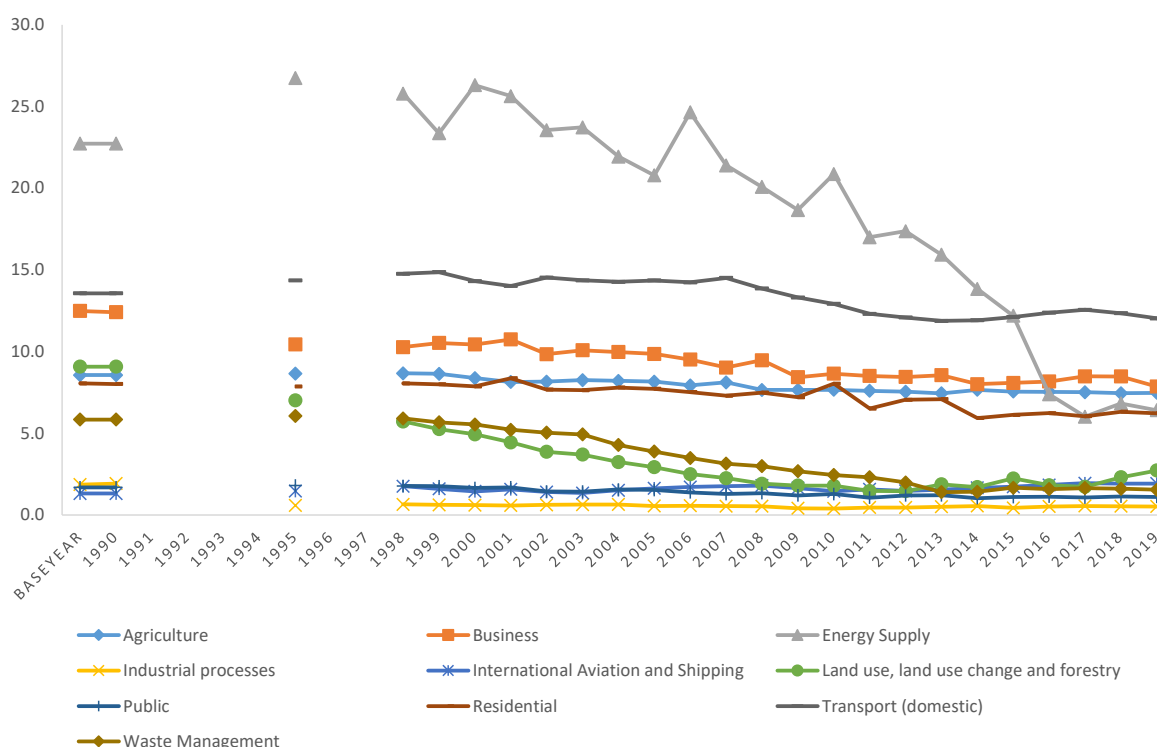
- Methane was the main net gas emitted in the Agriculture (4.1 MtCO_{2e}), followed by nitrous oxide (2.2 MtCO_{2e}) and carbon dioxide (1.1 MtCO_{2e}).
- Almost all emissions in the Waste Management sector were emitted in the form of methane (1.4 MtCO_{2e}).

Where F gases are emitted, they have been in relatively small amounts via the Business and Residential sectors.

Key Trends By Scottish Government Source Sector

Chart B2 presents the main sources of Scottish Greenhouse Gas Emissions from 1990 to 2018, broken down by National Communication categories. Chart B3 and Chart B4 specifically explore the trend in Energy Supply emissions. Chart B5 contains information on the reductions in greenhouse gas emissions in every National Communication category 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 2019. Values in MtCO₂e



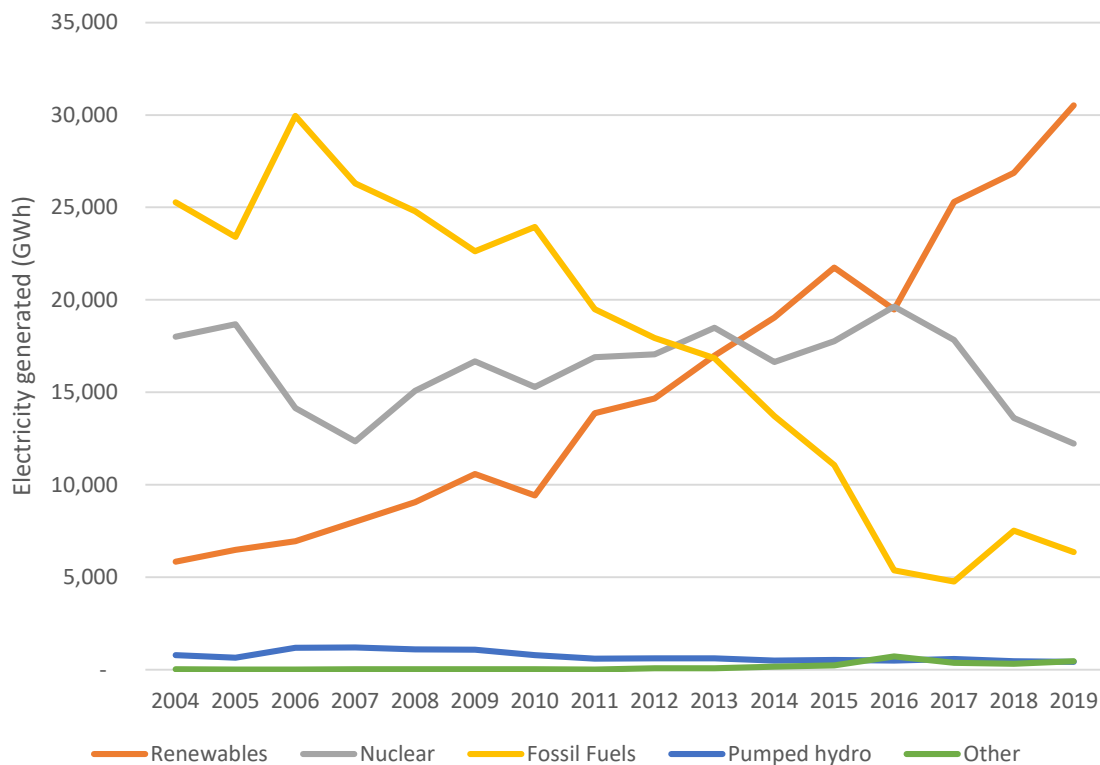
Main Points

Most sectors exhibit a general downwards trend between 1990 and 2019:

- Energy Supply emissions have seen the largest decrease in GHG emissions (-16.3 MtCO₂e, a reduction of 71.8 per cent) followed by LULUCF (-6.4 MtCO₂e, a reduction of 70.0 per cent), Business (-4.6 MtCO₂e, a reduction of 36.7 per cent), and Waste Management (-4.3 MtCO₂e, a reduction of 73.5 per cent)
- International Shipping and Aviation emissions are the only category to have increased (0.6 MtCO₂e, a 46.0 per cent increase) over the period.

Chart B3 shows how the generation of Scotland's electricity has changed 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, 2004 to 2019. GWh of Electricity Generated by Year



Data obtained from Scottish Energy Statistics Database⁴

Main Points

Overall, the gigawatt-hours of electricity generated in Scotland increased by 2.5 per cent between 2018 and 2019. Renewables were the single largest source of electricity generated in Scotland in 2019 at 61.1 per cent, followed by nuclear generation at 24.5 per cent with fossil fuel generation making up only 12.7 per cent.

⁴ <https://scotland.shinyapps.io/sg-scottish-energy-statistics/?Section=RenLowCarbon&Subsection=RenElec&Chart=ElecGen>

Long term (1990 to 2019) and short term (2018 to 2019) trends by category

Chart B4 shows how emissions have changed between 1990 and 2019 in all source categories. Chart B5 shows how emissions have changed between 2018 and 2019.

Chart B4. Change in net emissions by National Communication category between 1990 and 2019

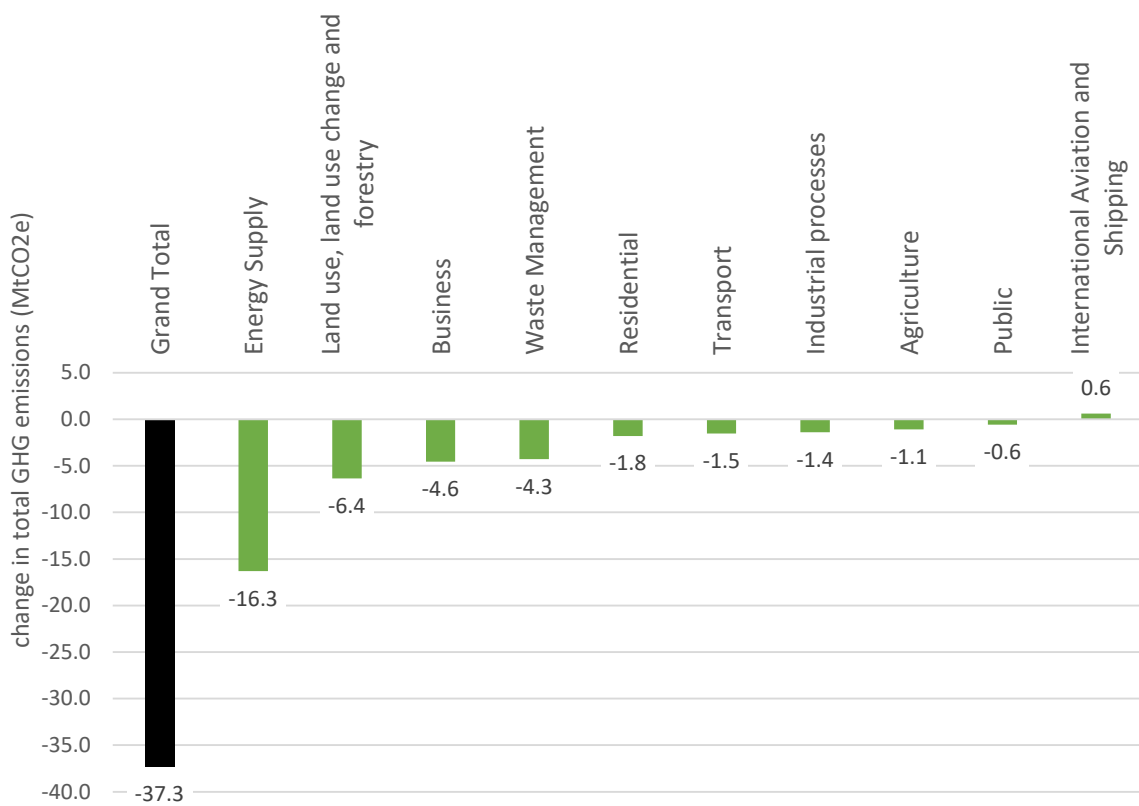
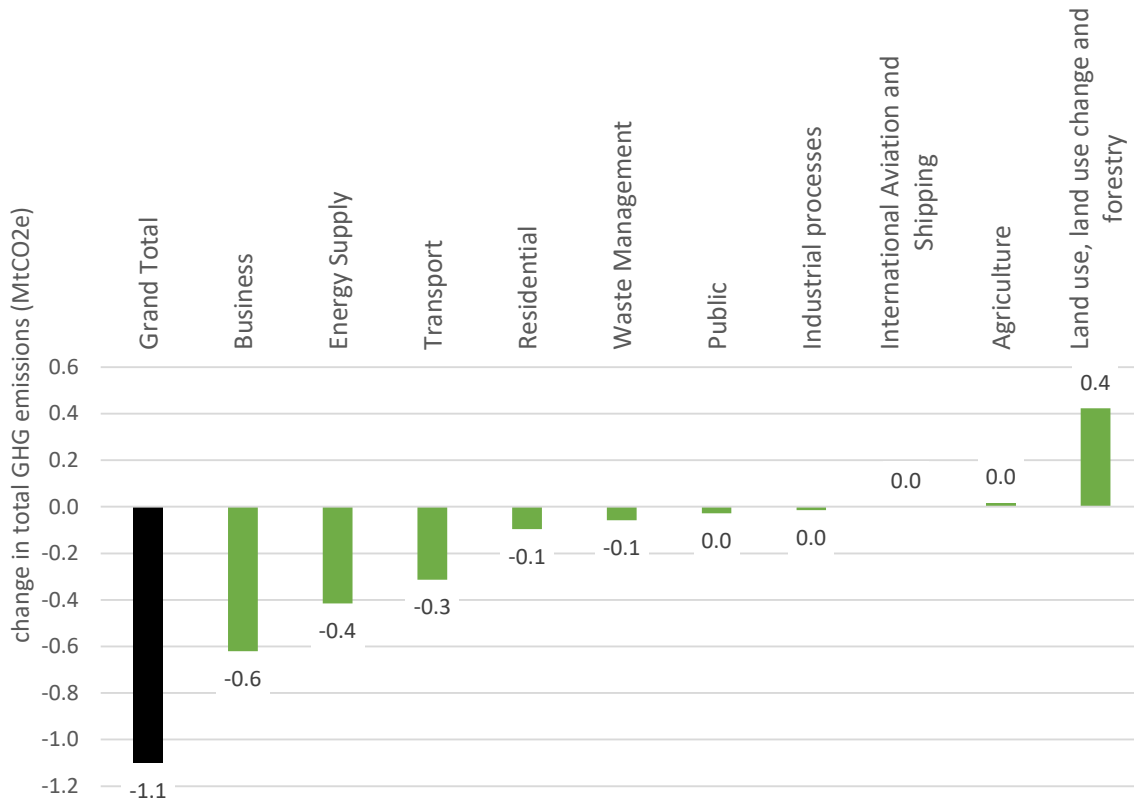


Chart B5. Change in Net Emissions by National Communications Category between 2018 and 2019 - in MtCO_{2e}



Total Emissions

Overall, there has been a 37.3 MtCO_{2e} (43.8 per cent) decrease in net emissions between 1990 and 2019. Total emissions have reduced by 1.1 MtCO_{2e} (2.3 per cent) between 2018 and 2019.

Land Use, Land Use Change And Forestry (LULUCF)

As a result of a major revision to the scope of the GHG inventory in Scotland and the UK in this latest release, LULUCF emissions are now shown to be a net-source of greenhouse gas emissions for all periods. Previously this category has been shown to be a net-sink of GHG emissions. The reason for this revision is the inclusion of the effect of historical drainage and rewetting of peatlands that previously were not included in the data. These revisions are discussed further in section D below. LULUCF is now a net source of GHG emissions in Scotland, emitting 2.7 MtCO_{2e} of emissions in 2019. In 1990 emissions were 9.1 MtCO_{2e}.

Domestic Transport

Domestic Transport has consistently been a large part of Scotland's emissions, with a relatively small decrease of 11.3 per cent between 1990 (13.6 MtCO_{2e}) and 2019 (12.0 MtCO_{2e}). Historically it was second only to Energy Supply, however the decline in Energy Supply emissions has left domestic transport as the leading emitter since 2016.

Transport emissions have decreased by 0.3 MtCO_{2e} (2.5 per cent reduction) between 2018 and 2019.

Energy Supply

Energy Supply was historically the biggest contribution to emissions, but has seen large changes over the period covered by these statistics, reducing from 22.7 MtCO_{2e} in 1990 to 6.4 MtCO_{2e} in 2019 (71.8 per cent reduction). Overall Emissions reductions in this sector are mainly due to reductions in emissions from power stations and the complete cessation of coal use for electricity generation in Scotland.

Between 2018 and 2019 Energy Supply emissions decreased by 0.4 MtCO_{2e} (6.1 per cent decrease). This decrease was driven by an decrease in CO₂ emissions from power stations. Chart B3 shows the decrease in fossil fuel use for power generation in 2019.

Business

This sector has seen a 4.6 MtCO_{2e} (36.7 per cent) fall in emissions between 1990 and 2019. 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 was a further smaller decrease between 2008 and 2009 (1.1 MtCO_{2e} decrease) , coinciding with the recession. Between 2018 and 2019 there was a relatively large 0.6 MtCO_{2e} decrease in business emissions.

Agriculture

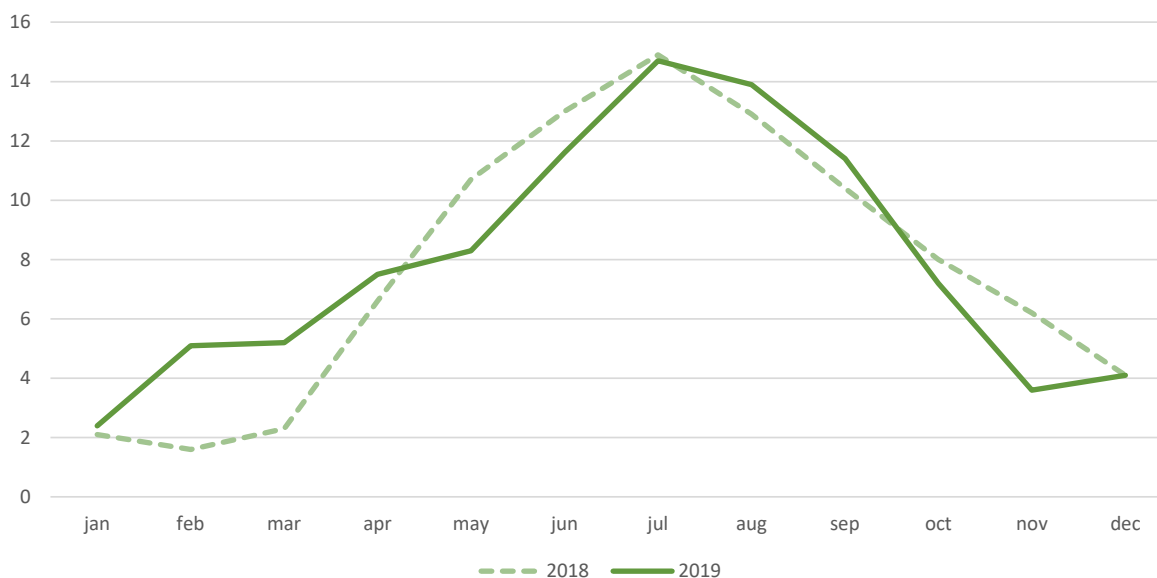
This sector has seen a 1.1 MtCO_{2e} (12.7 per cent) fall in net emissions between 1990 and 2019. Between 2018 and 2019 there was essentially no change in net emissions of overall greenhouse gases from this sector.

Residential

The residential sector is dominated by direct fuel combustion in households. There has been a reduction of 22.3 per cent between 1990 and 2019. 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.

Residential emissions have decreased very slightly between 2018 and 2019 from 6.3 MtCO₂e to 6.2 MtCO₂e (1.5 per cent reduction). This marginal change in emissions was possibly driven by a warmer January-March in 2019 compared to 2018, resulting in less fuel burned for domestic heating (Chart B6).

Chart B6. Mean air temperature by month, Scotland. 2018 and 2019.
Values in °C



Data obtained from Met Office⁵

International Aviation and shipping

International aviation has increased by 0.6 MtCO₂e (46.0 per cent) from 1990 to 2019. There was little change between 2018 and 2019, with the value remaining at 1.9 MtCO₂e.

Waste Management

Waste management emissions tend to be dominated by methane emissions. Emissions from Waste Management have been relatively static over recent years, with a value of 1.5 MtCO₂e for 2019, very slightly down from 1.6 MtCO₂e between 2016-2018. However, between 1990 and 2019 emissions reduced by 4.3 MtCO₂e (73.5 per cent). This decrease is largely due to the progressive introduction of methane capture and oxidation systems within landfill management.

Public

The main source of emissions from this sector is the use of natural gas for heating public buildings. There was a 0.6 MtCO₂e (34.9 per cent) fall in

⁵ Source Met Office: <http://www.metoffice.gov.uk/pub/data/weather/uk/climate/datasets/Tmean/date/Scotland.txt>

emissions from public sector buildings between 1990 and 2019. Emissions over the last few years have been relatively flat, with a value of 1.1 MtCO_{2e} between 2015 and 2019.

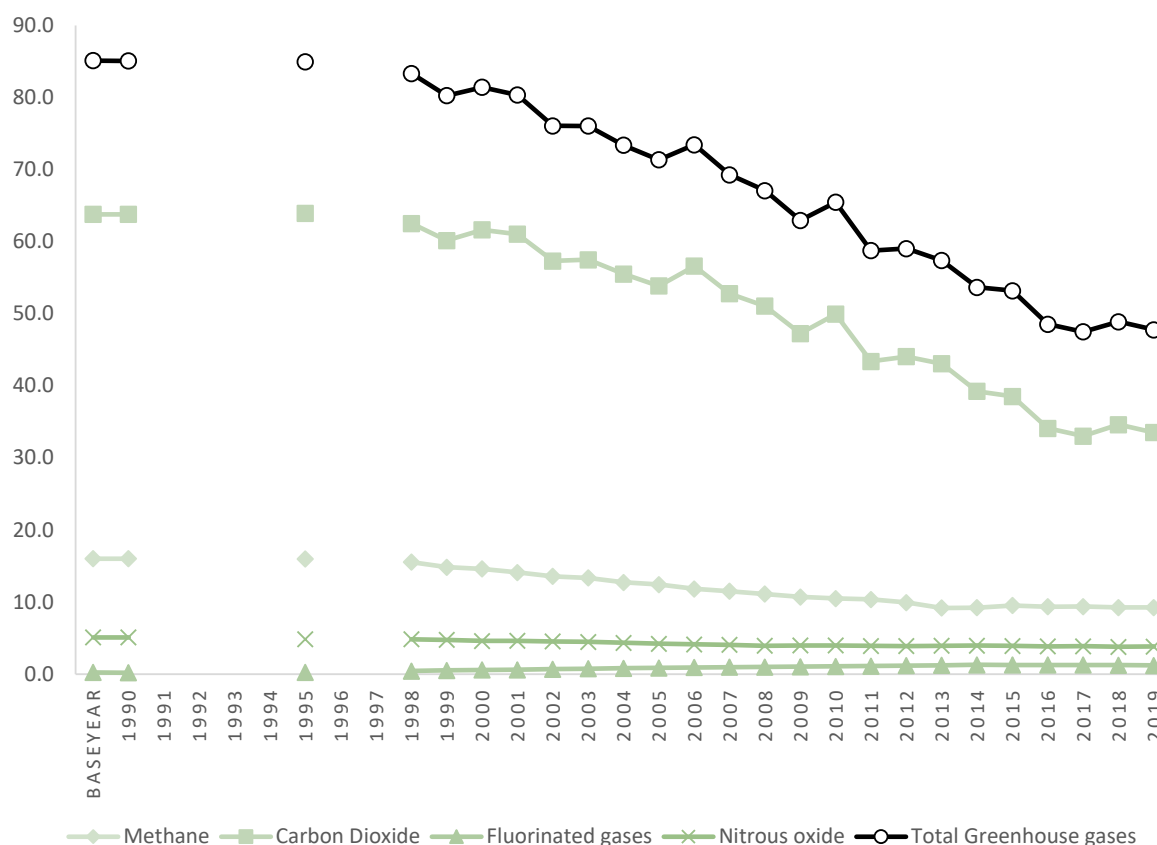
Industrial Processes

This sector has seen a 1.4 MtCO_{2e} (73.1 per cent) decrease from 1990 to 2019. Values have been relatively stable over the last couple of decades, with 2018 having a value of 0.5 MtCO_{2e}. Most of the decrease in the sector happened between 1990 and 1995, and was associated with decreased emissions in the Nitric acid production industry and from a process known as sintering – a process that used to be associated with the iron and steel industry.

Emissions by type of gas

Chart B7 shows the trends in emissions, broken down by gas from 1990 to 2019.

Chart B7. Scottish Greenhouse Gas Emissions, by Gas, 1990-2019.
Values in MtCO_{2e}



Main Points

- Carbon dioxide is by far the largest contributor to Scottish greenhouse gas emissions in all years (70.2 per cent of all emissions in 2019) and is the most volatile series of all gases – largely driven by changes in

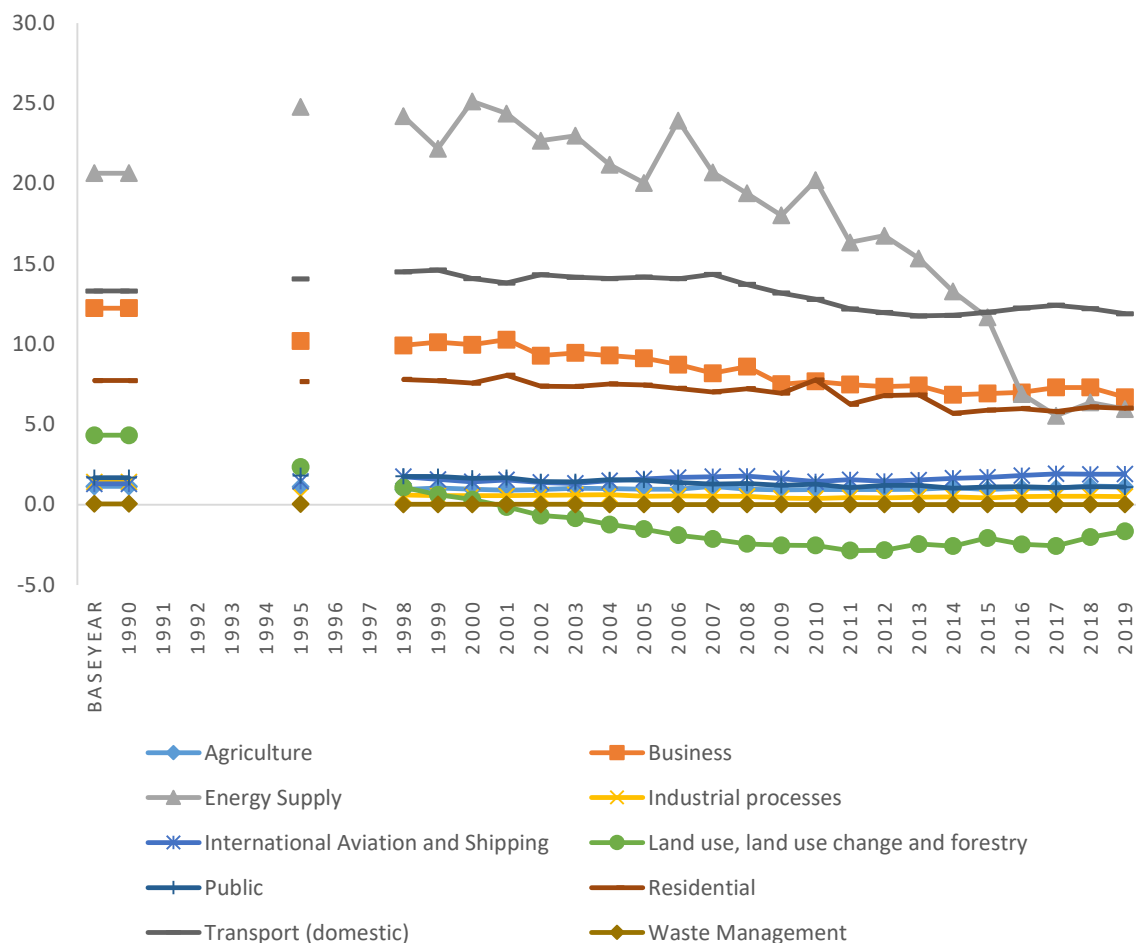
energy supply emissions and to a lesser extent, emissions from the residential and business categories.

- Methane is the second most common greenhouse gas in 2019 (19.3 per cent of all net emissions) followed by nitrous oxide (8.0 per cent) and F-gases making up the remainder (2.5 per cent).
- Carbon dioxide has seen the largest reduction from 1990 to 2019 (30.3 MtCO₂e reduction). There have also been reductions in both methane (6.8 MtCO₂e reduction) and nitrous oxide (1.3 MtCO₂e reduction). Emissions from fluorinated gases have shown a large increase from 1990 to 2019, although they still remain small in absolute terms, 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 B8 to B11 present results on individual gases broken down by main sectors over time. Chart B8 shows how carbon dioxide emissions have changed from 1990 to 2019.

Carbon Dioxide (CO₂)

Chart B8. Carbon Dioxide (CO₂) Emissions by National Communications Category, 1990 to 2019. Values in MtCO₂e



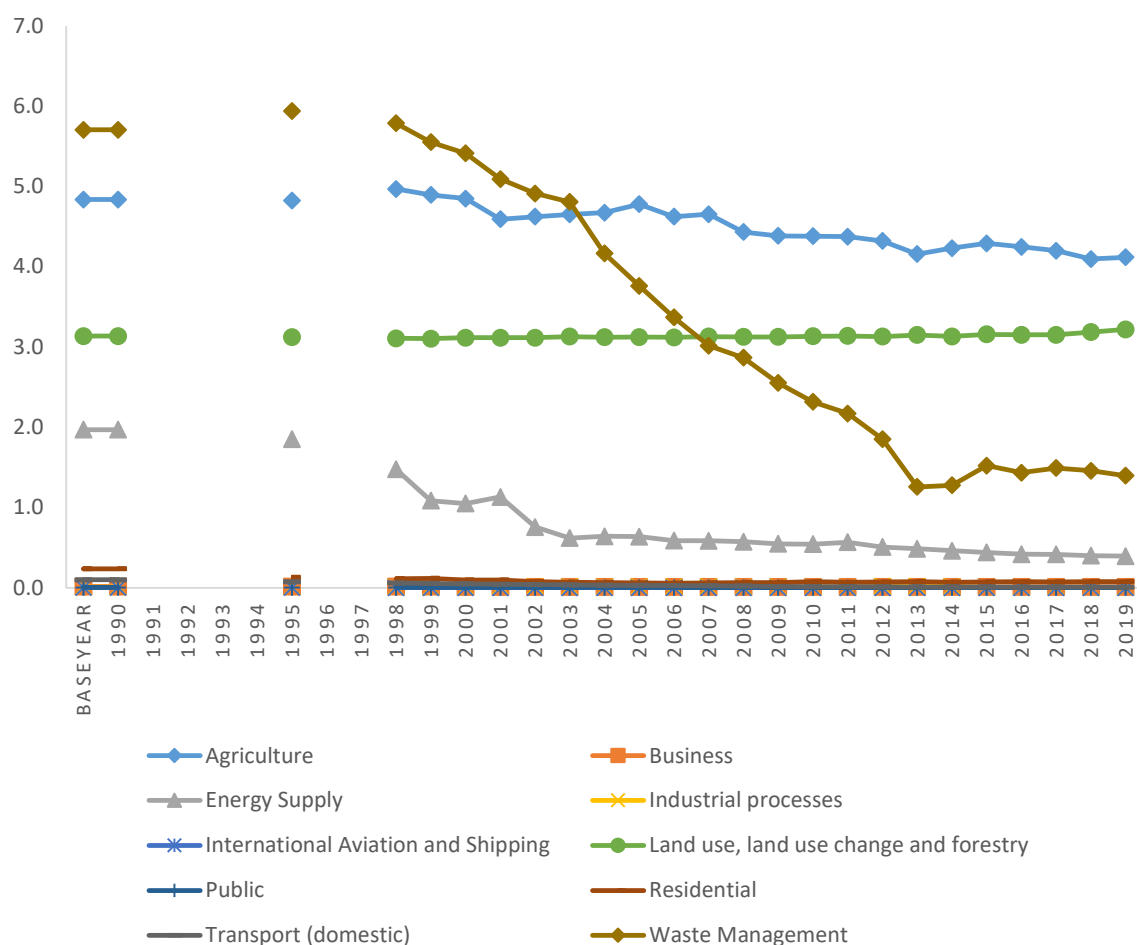
Main Points

- Chart B8 shows that Energy Supply is a key source of carbon dioxide emissions in all years between 1990 and 2015, after which the change in fuels used in electricity generation substantially reduces CO₂ emissions from this source. Change in energy supply emissions is the main driver of changes in total carbon dioxide emissions. Emissions from this category 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.
- Transport (excluding international) is the next most common source of carbon dioxide emissions across the entire time-series. In 2015 Transport became the highest source of emissions for the first time in the time series.
- Despite revisions to total greenhouse gases for the LULUCF sector, it has become a much greater net CO₂ sink for Scotland over the period. In 1990 it emitted 4.3 MtCO₂ of net CO₂ emissions. From 2001, this

sector became a net-CO₂ sink, reaching a maximum in 2011 when it acted to sequester 2.9 MtCO₂. Since that time, this net CO₂ sink has been generally reducing to its current (2019) level where it sequestered 1.7 MtCO₂. These trends reflect forestry planting activities in the early 1990s reaching maturity and gradually reducing its potential to remove CO₂.

Methane (CH₄)

Chart B9. Methane (CH₄) Emissions by National Communications Category 1990 to 2019. Values in MtCO₂e

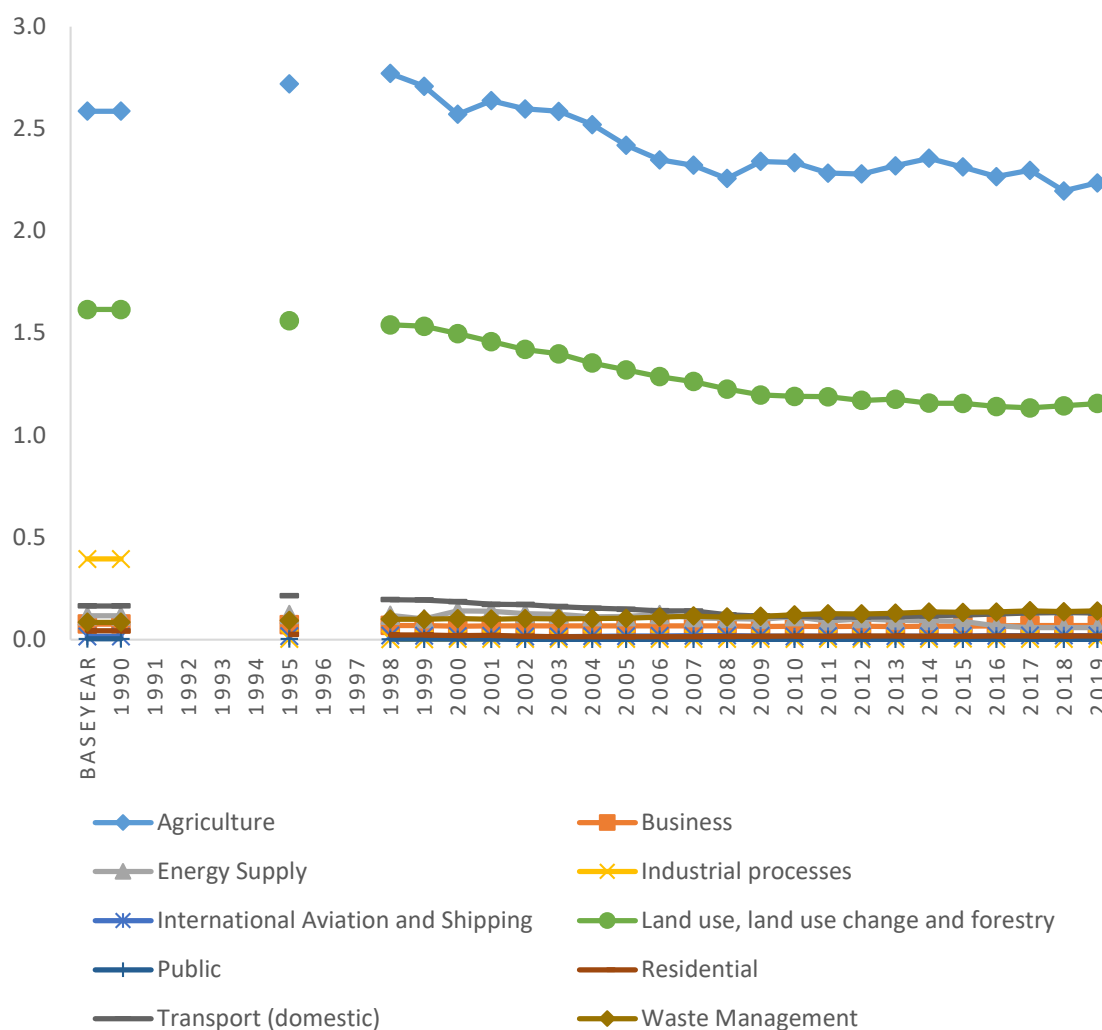


Main Points

- Methane emissions from Waste Management have fallen by 4.3 MtCO₂e between 1990 and 2019 (a 75.5 per cent reduction). This is largely due to the progressive introduction of methane capture and oxidation systems within landfill management.
- Methane emissions in the Agriculture sector have fallen by 0.7 MtCO₂e between 1990 and 2019 (an 14.9 per cent reduction). This is mainly due to a decrease in livestock numbers (particularly cattle and sheep).
- In the Energy Supply sector, methane emissions have fallen by 1.6 MtCO₂e between 1990 and 2019 (a 80.0 per cent reduction), partly due to reductions in emissions from sources such as coal mining.
- Land Use emissions of methane have remained essentially flat over the entire time-series, rising very slightly by 0.1 MtCO₂e.

Nitrous Oxide (N₂O)

Chart B10. Nitrous Oxide (N₂O) Emissions by National Communications Category, 1990 to 2019. Values in MtCO₂e

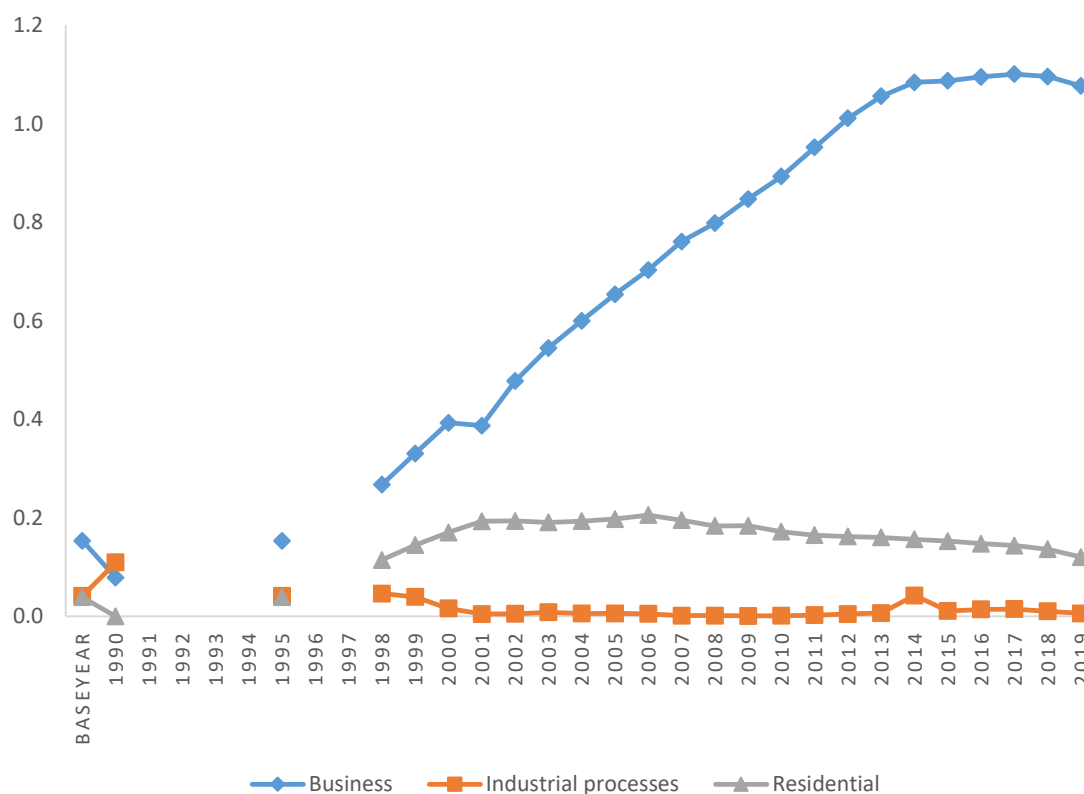


Main Points

- Agriculture 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 by 0.4 MtCO₂e between 1990 and 2019 – A 13.6 per cent reduction.
- ‘Land Use, Land Use Change And Forestry’ fell by 0.5 MtCO₂e (28.5 per cent reduction) between 1990 and 2019.

Fluorinated gases (F-gases)

Chart B11. F-gas Emissions by National Communications Category, 1990 to 2019. Values in MtCO_{2e}



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. (For targets these gases use 1995 as a baseline year rather than 1990)
- There is a sharp increase in HFC gases of 1.0 MtCO_{2e} between 1990 and 2019 (from 0.1 MtCO_{2e} in 1995 to 1.1 MtCO_{2e} in 2019). This change is almost entirely in the Business sector. This increase 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 result from the use of aerosols and asthma inhalers, and represent around 0.1 MtCO_{2e} in 2019.

Table B2. Greenhouse Gas Emissions in Scotland by National Communications Category: 1990 to 2019. Values in MtCO₂e

NC category	Baseline period	1990	2015	2016	2017	2018	2019	Change 1990-2019	% Change 1990-2019	Change 2018-2019	% Change 2018-2019
Agriculture	8.6	8.6	7.5	7.5	7.5	7.5	7.5	- 1.1	-12.7%	0.0	0.2%
Business	12.5	12.4	8.1	8.2	8.5	8.5	7.9	- 4.6	-36.7%	- 0.6	-7.3%
Energy Supply	22.7	22.7	12.2	7.4	6.0	6.8	6.4	-16.3	-71.8%	- 0.4	-6.1%
Industrial Processes	1.9	1.9	0.4	0.5	0.5	0.5	0.5	- 1.4	-73.1%	- 0.0	-2.8%
International Aviation and Shipping	1.3	1.3	1.7	1.8	1.9	1.9	1.9	0.6	46.0%	0.0	0.1%
Land Use, Land Use Change And Forestry	9.1	9.1	2.2	1.8	1.7	2.3	2.7	- 6.4	-70.0%	0.4	18.4%
Public	1.7	1.7	1.1	1.1	1.1	1.1	1.1	- 0.6	-34.9%	- 0.0	-2.4%
Residential	8.0	8.0	6.1	6.2	6.0	6.3	6.2	- 1.8	-22.3%	- 0.1	-1.5%
Transport (domestic)	13.6	13.6	12.1	12.4	12.6	12.3	12.0	- 1.5	-11.3%	- 0.3	-2.5%
Waste Management	5.8	5.8	1.7	1.6	1.6	1.6	1.5	- 4.3	-73.5%	- 0.1	-3.6%
Grand Total	85.1	85.1	53.2	48.5	47.5	48.9	47.8	-37.3	-43.8%	- 1.1	-2.3%

(some early years omitted to fit table on page, full table available in the accompanying excel tables file)

Table B3. Scottish Greenhouse Gases, by gas, 1990 to 2019. Values in MtCO2e

NC category	Baseline period	1990	2015	2016	2017	2018	2019	Change 1990-2019	% Change 1990-2019	Change 2018-2019	% Change 2018-2019
Carbon Dioxide	63.8	63.8	38.5	34.1	33.0	34.6	33.5	-30.3	-47.4%	- 1.1	-3.2%
Methane	16.0	16.0	9.5	9.3	9.4	9.2	9.2	-6.8	-42.4%	- 0.0	-0.1%
Nitrous Oxide	5.1	5.1	3.9	3.8	3.9	3.8	3.8	-1.3	-24.9%	0.1	1.4%
F Gases, of which...	0.2	0.2	1.3	1.3	1.3	1.2	1.2	1.0	539.0%	- 0.0	-3.1%
HFC	0.1	0.0	1.1	1.1	1.1	1.1	1.0	1.0	36215.8%	- 0.0	-4.5%
NF3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	121.0%	0.0	10.0%
PFC	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.0	15.6%	0.0	5.5%
SF6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	-18.9%	- 0.0	-0.2%
Grand Total	85.1	85.1	53.2	48.5	47.5	48.9	47.8	-37.3	-43.8%	- 1.1	-2.3%

(some early years omitted to fit table on page, full table available in the accompanying excel tables file)

Section C. Scotland's GHG Account for assessing progress against statutory targets

Introduction

A full reporting of the figures, required by the statutory requirements of Climate Change (Scotland) Act 2009, is available in Annex A which accompanies this publication.

In December 2017 the Committee on Climate Change (CCC) provided advice on the future measurement and accounting of emissions against Scotland's climate change targets⁶.

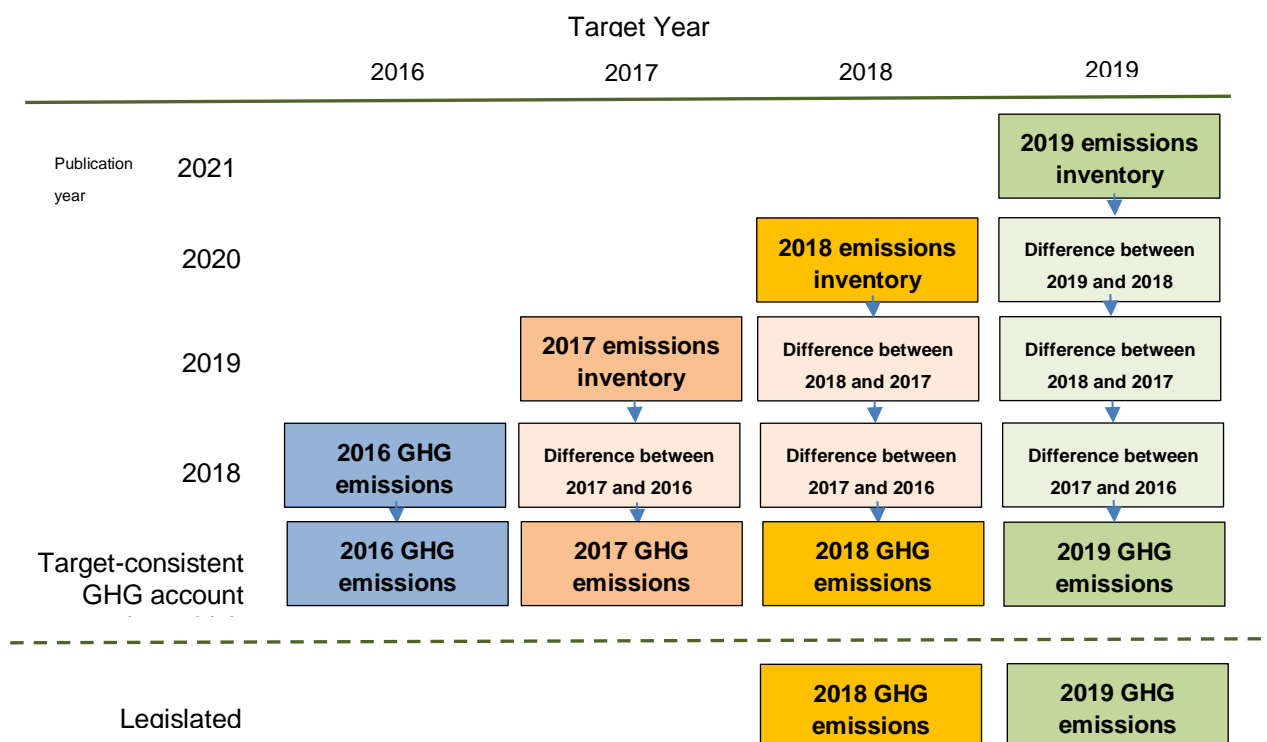
The CCC used the term "GHG Account" to refer to their recommended manner of accounting for emissions, which is intended to better separate the impacts on targets of scientific and methodological improvements to the GHG inventory, from those of 'on-the-ground' policy actions. The Climate Change (Emissions Reductions Targets) (Scotland) Act 2019 requires that Scottish Ministers follow the CCC's most recent advice on the method to be used for reporting on target outcomes, which currently means the GHG Account method set out here.

At the heart of this method is the freezing of inventory methods (the scientific methods used for the measurement and estimation of emissions levels) between the time that target levels are set (or reviewed through independent advice from the CCC) and the time when target outcomes come to be reported. To ensure that the inventory methods used for the purpose of reporting target outcomes do not become too far separated from the best science and evidence, the base inventory will be re-aligned to the most up to date inventory methods at least every 5 years.

⁶ <https://www.theccc.org.uk/publication/letter-lord-deben-roseanna-cunningham-msp-advising-scottish-climate-target-framework/>

Calculating the GHG Account

The calculation of the GHG account for the latest year can be summarised as follows:



2019 GHG Account Calculation

In accordance with advice from the Committee on Climate Change, the calendar year 2016 (for which emissions data was first published in June 2018) has been selected as the base inventory for reporting progress to the 2019 annual target.

Table C1: Calculation of the Scottish GHG Account for 2019

Year	Baseline Period ¹	2016	2017	2018	2019
Inventory data					
A. Base Inventory source emissions data (June 2018 data (1990-2016))	75.7	38.6	N/A	N/A	N/A
B. June 2019 source emissions data (1990-2017 inventory)	76.3	41.9	40.5	N/A	N/A
C. June 2020 source emissions data (1990-2018 inventory)	76.3	42.0	41.0	41.6	N/A
D. June 2021 source emissions data (1990-2019 inventory)	85.1	48.5	47.5	48.9	47.8
Revisions between inventories²					
between A and B	0.6	3.3	3.3	3.3	3.3
between B and C	-0.0	0.1	0.5	0.5	0.5
between C and D	8.8	6.5	6.5	7.3	7.3
Combined revision between successive inventories	9.4	9.9	10.3	11.1	11.1
GHG Account (latest inventory, less combined revision)	75.7	38.6	37.2	37.8	36.7
GHG Account figures, expressed as a percentage reduction from the baseline period.	0.0%	-49.0%	-50.9%	-50.0%	-51.5%

1. The Baseline period uses a 1995 base-year for F-Gas emissions, and 1990 for all other greenhouse gases.

2. Where data do not exist for a particular year, revisions are carried over from the previous complete year (see shaded cells)

Under the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019, annual targets are set for the years from 2018 onwards. A full list of these target levels is available on the Scottish Government website (<https://www.gov.scot/policies/climate-change/reducing-emissions/>), with the 2019 annual target being a 55.0 per cent reduction from baseline levels.

Table C1 shows a 51.5 per cent reduction from baseline levels in 2019. As a result, **the statutory emissions reduction target for 2019 has not been achieved.**

Section D. Revisions to the Inventory and Methodology

This section examines key revisions in estimated source emissions between the latest inventory (1990-2018) and the previous inventory (1990-2017). 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 '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 1990-2018 and 1990-2019 inventories

Charts D1 to D3 illustrate the impacts of revisions between the 1990-2018 and 1990-2019 inventories. This is followed by a discussion of the reasons for the key revisions.

Chart D1. Scottish Greenhouse Gas Emissions. Comparison of the yearly totals for the 1990-2018 and 1990-2019 Inventories. Values in MtCO₂e

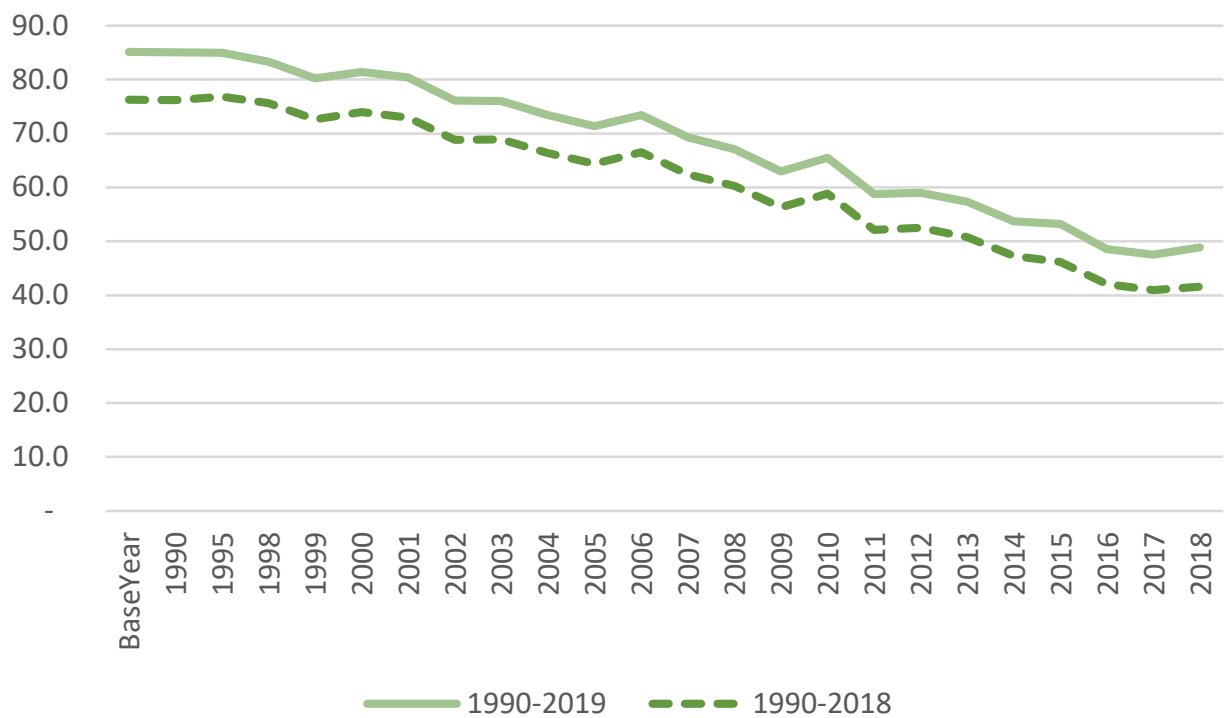


Chart D2 shows revisions to the baseline period, between the two most recent inventories.

Chart D2. Revisions to emissions in the Baseline Period, from the 1990-2018 inventory to the 1990-2019 inventory, by national communications category. Values in MtCO₂e.

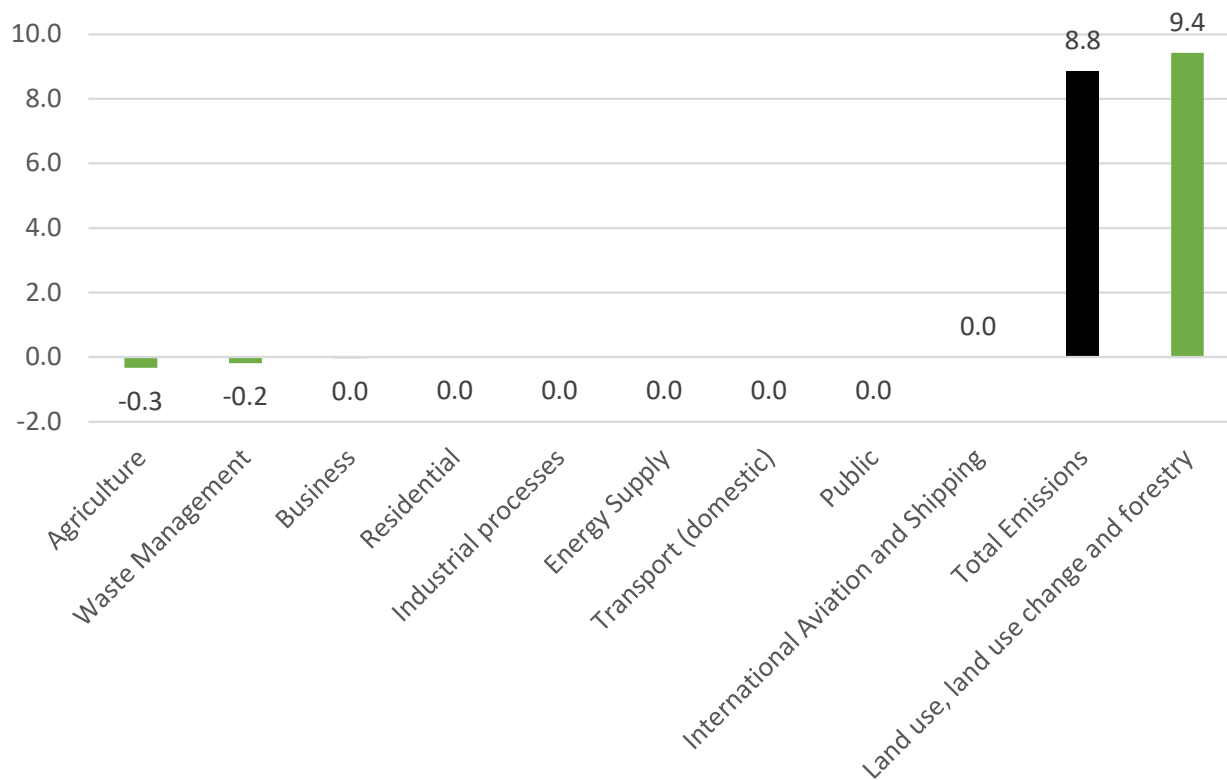
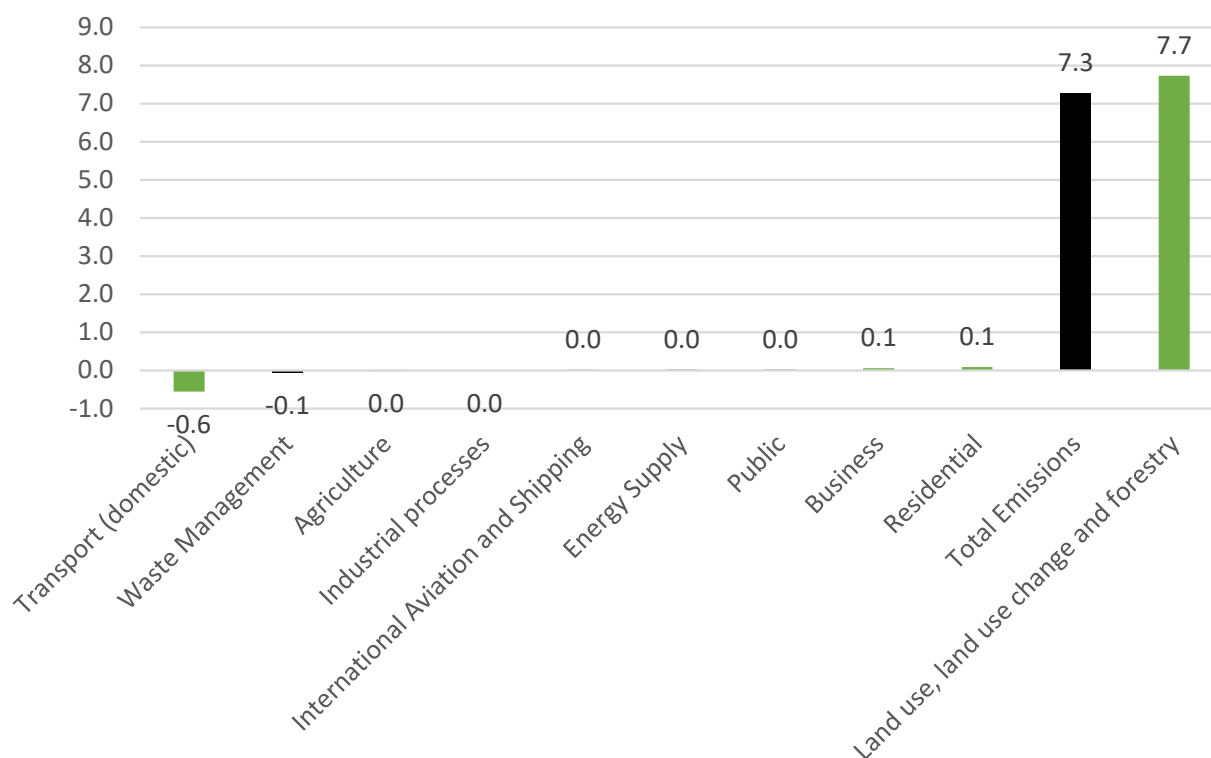


Chart D3 shows revisions to the data for the year 2018, between the two most recent inventories.

Chart D3. Revisions to emissions in 2018, from the 1990-2018 inventory to the 1990-2019 inventory, by national communications category. Values in MtCO₂e.



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 1990-2019) 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 - 2019⁷. Details of the most notable revisions are listed below:

LULUCF revisions

Charts D2 and D3 show a substantial revision to the LULUCF category in both the baseline period and the latest year – affecting all intervening years. As many users will be aware, for a number of years preparations have been made for a fundamental change in the scope of official statistics on emissions for all parts of the UK. These changes were made in response to the implementation into the UK inventory of Intergovernmental Panel on Climate Change (IPCC) 2013 wetlands supplement to the 2006 guidance on the compilation of greenhouse gas emissions data.

This change in scope relates to additional emissions, not previously included in the GHG inventories, associated with the historical drainage and rewetting of peatlands and the impact that such activity has had, and continues to have, on the level of net GHG emissions.

Since the publication of the IPCC wetlands supplement, a programme of research has been undertaken by the UK Government to consider how these new emissions can be measured appropriately. This culminated in the publication of a scientific report in 2019 on the upcoming implementation of wetlands to the GHG inventory.

Agriculture

There have been some relatively small revisions to the early part of the agriculture series', particularly those relating to beef cattle live weights, milk yields, and livestock numbers affect emissions from enteric fermentation and manure management.

Waste management

Emissions estimates have reduced across the whole time-series due to recalculations in Industrial Wastewater Treatment. BEIS commissioned a review of models used to estimate greenhouse gas emissions in 2019 which is now incorporated into the estimates.

Domestic Transport

Emissions from road transport have been revised from 2010 onwards. This is the result of updates to Department for Transport (DfT) minor roads data for these years, which has led to an increase in the estimate of vehicle-kms travelled across all vehicle types on urban and rural roads.

⁷ <https://naei.beis.gov.uk/reports/>

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 website⁸.

The Scottish Government previously 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. There are no significant revisions to future publications known at this time although it is likely that the Scottish GHG inventory will incorporate an adjustment to the global warming potentials for non-CO₂ gases in the relatively near future. Once details of this and other revisions are known, we will issue an occasional paper in advance of the main release to inform users of the likely scale of any revisions.

⁸ https://naei.beis.gov.uk/reports/reports?report_id=1015

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.

<https://naei.beis.gov.uk/reports/>

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. Report:

<https://www.gov.scot/publications/scotlands-carbon-footprint-1998-2017/pages/1/>

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.

[Scottish Greenhouse Gas Emissions 2013. Key Revisions Since 2008](#)

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

<https://nationalperformance.gov.scot/measuring-progress/national-indicator-performance>

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

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

Scottish Energy Statistics

The Scottish Government's publication presents statistics on the energy sector in Scotland.

<https://www.gov.scot/publications/annual-compendium-of-scottish-energy-statistics/>

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.

<https://www.transport.gov.scot/publications/?publicationtype=1271>

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 parties⁹ 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.

⁹ 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 from this release: <http://www.ipcc-nggip.iges.or.jp/home/wetlands.html> As a result, this release, for the first time, estimates the carbon effects of drainage and rewetting of peatland.

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 should be noted that research is underway to being to develop estimates of the environmental changes resulting from changes to coastal wetlands environments.

Glossary

Adjusted emissions

See GHG Account

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.

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*.

GHG Account

The Committee for Climate Change (CCC) recommended a new method of adjusting emissions for the purposes of reporting against targets in this, and future, publications. This adjustment acts to remove the impact of revisions to the historical time-series. This is known as the GHG Account and the calculation is detailed in section C.

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 NC 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.

Acknowledgements

We would like to thank our contractors, Ricardo, 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 year can be found here:

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

Annex A: Information required for reporting under sections 33 and 34 of the Climate Change (Scotland) Act 2009.

Introduction

The following sections summarise, using data from the main sections of this statistics bulletin and other sources, the information required under the requirements of sections 33 and 34 of the Climate Change (Scotland) Act 2009. For ease, the information is interspersed with the wording of the requirements themselves.

Under section 33

Subsection 2 requires the report must state—

(a) the emissions reduction target for the target year

The annual emissions reduction target for 2019 is a 55.0% reduction from the baseline.

(b) whether the emissions reduction target for the target year has been met

The target has not been met.

(c) the percentage by which the net Scottish emissions account for the target year is lower than the baseline,

For the purpose of assessing progress to the 2019 target (on the basis of the 1990-2016 inventory), the net Scottish emissions account was 51.5 per cent lower in 2019 than the baseline.

(d) the amount by which the net Scottish emissions account for the target year is lower or higher than the emissions reduction target for that year

The net Scottish emissions account for 2019 was 2.7 million tonnes of carbon dioxide equivalent (MtCO₂e) higher than the target for that year.

(e) the cumulative amount by which the net Scottish emissions accounts are lower or higher than the corresponding emissions reduction targets, calculated by adding each amount by which an account is lower or higher than the corresponding target for each year in the period beginning with 2018 and ending with the target year.

The cumulative amount by which the net Scottish emissions accounts over the period from 2018 to the current target year (2019) was 5.7 MtCO₂e higher than the targets for those years.

Subsection 3 requires the report must specify the methods used to determine each figure and amount in subsection 2 in accordance with the most up-to-date advice provided by the relevant body (the UK Committee on Climate Change) on the methods to be used for that purpose:

The figure in 2(c) above has been derived using an identical calculation to that recommended by the Committee on Climate Change (CCC) in their advice on the future measurement and accounting of emissions against Scotland’s climate change targets¹⁰. This calculation is shown below, using the 1990-2016 inventory as the reference inventory, and adjusting for cumulative revisions subsequently introduced in the 1990-2017, 1990-2018 and 1990-2019 inventories:

Year	Baseline Period ¹	2016	2017	2018	2019
Inventory data					
A. Base Inventory source emissions data (June 2018 data (1990-2016))	75.7	38.6	N/A	N/A	N/A
B. June 2019 source emissions data (1990-2017 inventory)	76.3	41.9	40.5	N/A	N/A
C. June 2020 source emissions data (1990-2018 inventory)	76.3	42.0	41.0	41.6	N/A
D. June 2021 source emissions data (1990-2019 inventory)	85.1	48.5	47.5	48.9	47.8
Revisions between inventories²					
between A and B	0.6	3.3	3.3	3.3	3.3
between B and C	- 0.0	0.1	0.5	0.5	0.5
between C and D	8.8	6.5	6.5	7.3	7.3
Combined revision between successive inventories	9.4	9.9	10.3	11.1	11.1
GHG Account (latest inventory, less combined revision)	75.7	38.6	37.2	37.8	36.7
GHG Account figures, expressed as a percentage reduction from the baseline period.	0.0%	-49.0%	-50.9%	-50.0%	-51.5%

1. The Baseline period uses a 1995 base-year for F-Gas emissions, and 1990 for all other greenhouse gases.
2. Where data do not exist for a particular year, revisions are carried over from the previous complete year (see shaded cells)

¹⁰ <https://www.theccc.org.uk/publication/letter-lord-deben-roseanna-cunningham-msp-advising-scottish-climate-target-framework/>

Under section 34

All of the information under this section is reported on the basis of the most up to date available greenhouse gas inventory methods, i.e. the 1990 – 2019 inventory.

Subsection 1 requires the report must state — (a) in relation to net Scottish emissions of greenhouse gases—

(i) the baseline,

The Baseline period uses a 1995 base-year for F-Gas emissions, and 1990 for all other greenhouse gases. In the 1990-2019 inventory the baseline amount of emissions was 85.1 MtCO₂e.

(ii) the aggregate amount of net Scottish emissions of greenhouse gases for the year covered by the report,

On the basis of the 1990-2019 inventory, net Scottish emissions in 2019 were 47.8 million tonnes of CO₂ equivalent.

(iii) the percentage by which the aggregate amount of net Scottish emissions of greenhouse gases for the year covered by the report is lower than the baseline,

On the basis of the 1990-2019 inventory, net Scottish emissions in 2018 were 43.9 per cent lower than the baseline¹¹.

(iv) the percentage by which the aggregate amount of net Scottish emissions of greenhouse gases for the year covered by the report is lower or higher than the equivalent amount for the immediately preceding year, and

On the basis of the 1990-2019 inventory, net Scottish emissions in 2019 were 2.3 per cent lower than in 2018.

(v) the methods used to determine the aggregate amount of net Scottish emissions of greenhouse gases, together with details of any changes to those methods,

The aggregate amount of net Scottish emissions set out above has been determined from regional disaggregation of the UK Greenhouse Gas Inventory. Full details of the methodology used in the UK Inventory, together with further breakdowns, are provided in the National Inventory Report¹²

¹¹ This figure is slightly different from the 1990 to 2019 reduction of 43.8%. This difference arises as the figure is reported against baseline year, not 1990. While almost all gases are reported with a baseline year of 1990, F-gases are reported with baseline year 1995, therefore figures reported against the baseline year will vary very slightly from those reported against 1990.

¹² https://naei.beis.gov.uk/reports/reports?report_id=1015

submitted annually by the UK Government to the United Nations Framework Convention on Climate Change (UNFCCC). Of particular note in the latest greenhouse gas inventory (1990-2019) is the incorporation of substantially revised estimates of land use, land use change and forestry emissions. These revisions arise from a fundamental change in the scope of the UK inventory to incorporate, for the first time, the impact of historical drainage and rewetting of organic soils on net emissions. As a result of this, there has been a substantial increase in net emissions across the entire time-series, where this change in isolation has acted to raise emissions by 9.4 MtCO₂e in the baseline and 7.7 MtCO₂e in 2018, when compared to the 1990-2018 greenhouse gas inventory.

(b) in relation to the net Scottish emissions account—

(i) its amount for the year covered by the report,

In 2019, the net Scottish emissions account was 47.8 million tonnes of CO₂ equivalent.

(ii) the percentage by which the account for the year covered by the report is lower than the baseline,

On the basis of the 1990-2019 inventory, the net Scottish emissions account in 2019 was 43.9 per cent lower than the baseline².

(iii) the percentage by which the account for the year covered by the report is lower or higher than the equivalent account for the immediately preceding year, and

On the basis of the 1990-2019 inventory, the net Scottish emissions account in 2019 was 2.3 per cent lower than in 2018.

(iv) the percentage of any reduction in the account for the year covered by the report, relative to the equivalent account for the immediately preceding year, which is accounted for by reductions in net Scottish emissions of greenhouse gases,

All (100%) of the reduction in the net Scottish emissions account between 2018 and 2019 was accounted for by changes in net Scottish emissions of greenhouse gases.

(c) the total amount of carbon units that were—

(i) credited to or debited from the net Scottish emissions account for the year covered by the report,

No carbon units were credited or debited to the net Scottish emissions account for 2019.

(ii) purchased by the Scottish Ministers in the year covered by the report, and

No carbon units were purchased by Scottish Ministers in 2019.

(iii) held by the Scottish Ministers immediately after the end of the year covered by the report and which remained available to offset greenhouse gas emissions for other target years,

No carbon units were held by Scottish Ministers immediately after the end of 2019.

(d) for each target year preceding the year covered by the report—

(i) the aggregate amount of net Scottish emissions of greenhouse gases, and

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Net GHG emissions (MtCO _{2e})	65.5	58.8	59.0	57.4	53.7	53.2	48.5	47.5	48.9

(ii) the amount of the net Scottish emissions account *

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Net Scottish Emissions Account (MtCO _{2e})	64.4*	61.6*	61.8*	54.1*	48.8*	50.6*	51.4*	53.3*	48.9

* The figures set out here for the net Scottish emissions account for the years 2010 to 2017 are consistent with the approach used in previous statutory annual target reports and are on the basis of Scottish emissions adjusted for the operation of the EU Emissions Trading System (EU ETS). The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 has subsequently altered the emissions accounting basis for assessing progress to targets from 2018 onwards, to remove that adjustment. As such, these earlier figures are not directly comparable to those in other columns of the table or other sections of the report.

(e) the fair and safe Scottish emissions budget, and the aggregate amount of net Scottish emissions of greenhouse gases for the period from 2010 to the end of the year covered by the report.

The fair and safe Scottish emissions budget for emissions over the period 2010 to 2050¹³ is 1,240 MtCO_{2e}. The total amount of net Scottish emissions of greenhouse gases over the period from 2010 to 2019 is 540.2 MtCO_{2e}.

¹³ The level of fair and safe Scottish emissions budget is determined directly from the advice of the UK Committee on Climate Change. The Committee's most recent advice on this matter was provided in December 2020: <https://www.theccc.org.uk/publication/letter-lord-deben-climate-change-committee-to-roseanna-cunningham-msp/>

Subsection 3 requires that, if the methods used to determine net Scottish emissions of greenhouse gases change and that change is such as to require adjustment of an amount for an earlier target year, the report must —

(3)

(a) specify the adjustment required and state the adjusted amount, and (b) explain why the adjustment is required.

The latest greenhouse gas inventory (1990-2019) contains some major revisions to previous estimates of emissions in the Land Use, Land Use Change and Forestry category. These revisions arise from a fundamental change in the scope of the UK inventory to incorporate, for the first time, the impact of historical drainage and rewetting of organic soils on net emissions. These changes reflect changes to international guidance of the compilation of greenhouse gas inventories arising from the IPCC wetlands supplement (2013). As a result of this, there has been a substantial increase in net emissions across the entire time-series, where this change in isolation has acted to raise emissions by 9.4 MtCO₂e in the baseline and 7.7 MtCO₂e in 2018, when compared to the 1990-2018 greenhouse gas inventory.

Other, less substantial revisions relate to routine revisions to underlying data and modelling used to construct the greenhouse gas inventory. There have been some relatively small revisions to the early part of the agriculture series', particularly those relating to beef cattle live weights, milk yields, and livestock numbers affect emissions from enteric fermentation and manure management. Waste management emissions have reduced across the whole time-series due to recalculations in Industrial Wastewater Treatment. Emissions from road transport have been revised from 2010 onwards. This is the result of updates to Department for Transport (DfT) minor roads data for these years, which has led to an increase in the estimate of vehicle-kms travelled across all vehicle types on urban and rural roads.

The combined impact of these changes has resulted in the previously published value for emissions in 2018 being raised by 7.3 MtCO₂e to the current level of 48.9 MtCO₂e.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018
1990-2018 inventory	58.9	52.1	52.5	50.8	47.3	46.2	42.0	41.0	41.6
1990-2019 Inventory	65.5	58.8	59.0	57.4	53.7	53.2	48.5	47.5	48.9
Revision	6.6	6.6	6.5	6.6	6.4	7.0	6.5	6.5	7.3

Annex B: Scottish greenhouse gas emissions using categories presented in Scotland's climate change plan.

The Scottish Government's Climate Change Plan was published in February 2018 presenting a strategy to reduce emissions over the period to 2032. The modelling activity supporting this plan used a modified version of the sectoral categories used in the Scottish Greenhouse Gas Emissions publication. The following table presents the latest Scottish emissions data using these alternative categories.

Annex B: Table 1. Scottish GHG emissions using Climate Change Plan emissions categories, All values shown in MtCO₂e.

CCP category	Baseline period	2015	2016	2017	2018	2019
Agriculture	8.6	7.5	7.5	7.5	7.5	7.5
Electricity Generation	14.7	7.7	2.5	1.1	2.1	2.0
Industry	21.0	10.9	11.5	11.9	11.7	10.7
Land use, land use change and forestry	9.1	2.2	1.8	1.7	2.3	2.7
Residential	8.0	6.1	6.2	6.0	6.3	6.2
Services	3.0	3.2	3.2	3.1	3.2	3.2
Transport	14.9	13.8	14.2	14.5	14.3	13.9
Waste Management	5.8	1.7	1.6	1.6	1.6	1.5
All emissions	85.1	53.2	48.5	47.5	48.9	47.8

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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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