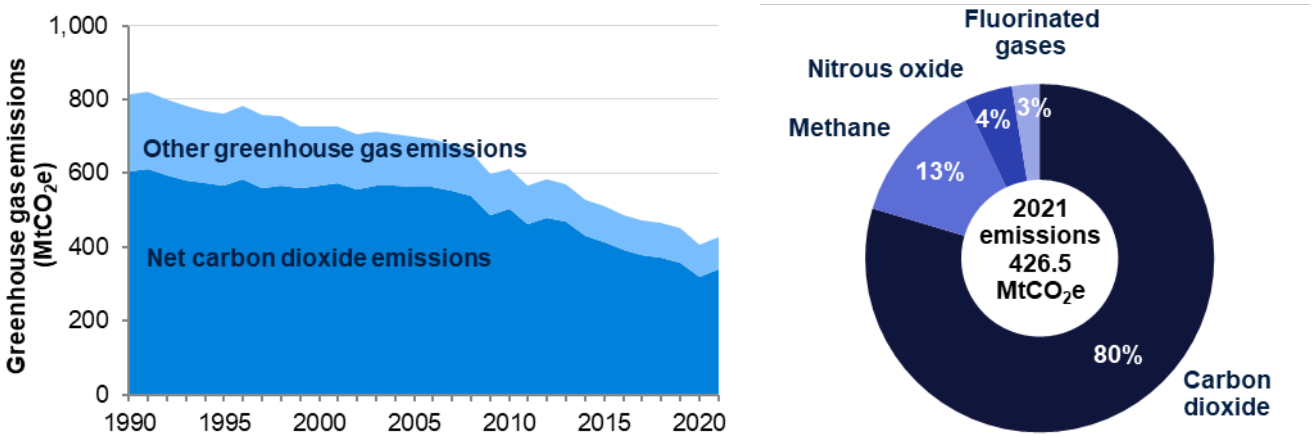
Department for Business, Energy & Industrial Strategy

2021 UK Greenhouse Gas Emissions, Final Figures

7 February 2023 **National Statistics**

The coronavirus (COVID-19) pandemic and the resulting restrictions introduced across the UK in 2020 and 2021 had a significant impact on greenhouse gas emissions. In 2021, net territorial greenhouse gas emissions in the UK were estimated to be 426.5 million tonnes carbon dioxide equivalent ($MtCO_2e$), an increase of 5.0% from the 2020 figure of 406.3 million tonnes, but still 5.3% lower than in 2019, the most recent pre-pandemic year. Total greenhouse gas emissions were 47.6% lower than they were in 1990. Carbon dioxide made up 80% of the 2021 total.

UK territorial greenhouse gas emissions, 1990-2021



- This increase in 2021 is primarily due to the increase in the use of road transport as nationwide lockdowns were eased, along with increases in emissions from power stations and the residential sector. Greenhouse gas emissions from transport rose 10.3% in 2021, accounting for around half of the overall increase from 2020. Transport was the largest emitting sector, responsible for 26% of all greenhouse gas emissions in the UK.

- Emissions from the residential sector increased 6.4% due to the colder weather in 2021 compared to 2020, while emissions from energy supply rose by 2.9% largely due to increased demand for electricity and the first increase in the use of fossil fuels for electricity generation since 2012.

What you need to know about these statistics:
This publication provides the latest estimates of 1990-2021 UK territorial greenhouse gas emissions, meaning emissions that occur within the UK's borders. Figures for all years since 1990 have been revised since the last publication to incorporate methodological improvements and new data, so the estimates presented here supersede previous ones.

Greenhouse gas emissions are presented in carbon dioxide equivalent units (CO_2e) throughout this statistical release and cover seven greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

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Introduction

This publication provides the latest annual estimates of UK territorial greenhouse gas emissions from 1990-2021. The geographic coverage of this report is UK only unless stated otherwise. The figures in this statistical release are used as the basis for reporting against UK greenhouse gas emissions reduction targets and provide information for users on the drivers of emissions trends since 1990. Emissions are estimated following the guidance set out by the Intergovernmental Panel on Climate Change (IPCC)[1], as required for the UK's submissions to the United Nations Framework Convention on Climate Change (UNFCCC) each year.

The estimates present emissions on a "territorial" basis, so include emissions which occur within the UK's borders, including offshore areas over which the UK has jurisdiction. They therefore exclude emissions from UK businesses and residents that occur abroad, including from international aviation and shipping, and any emissions embedded within the supply chain of manufactured goods and services imported into the UK (while including emissions that occur in the UK resulting from exported goods and services).

Two additional approaches to estimating UK emissions are also published and the Office for National Statistics (ONS) has published an article that compares these different measures of the UK's greenhouse gas emissions in more detail. The alternative measures are:

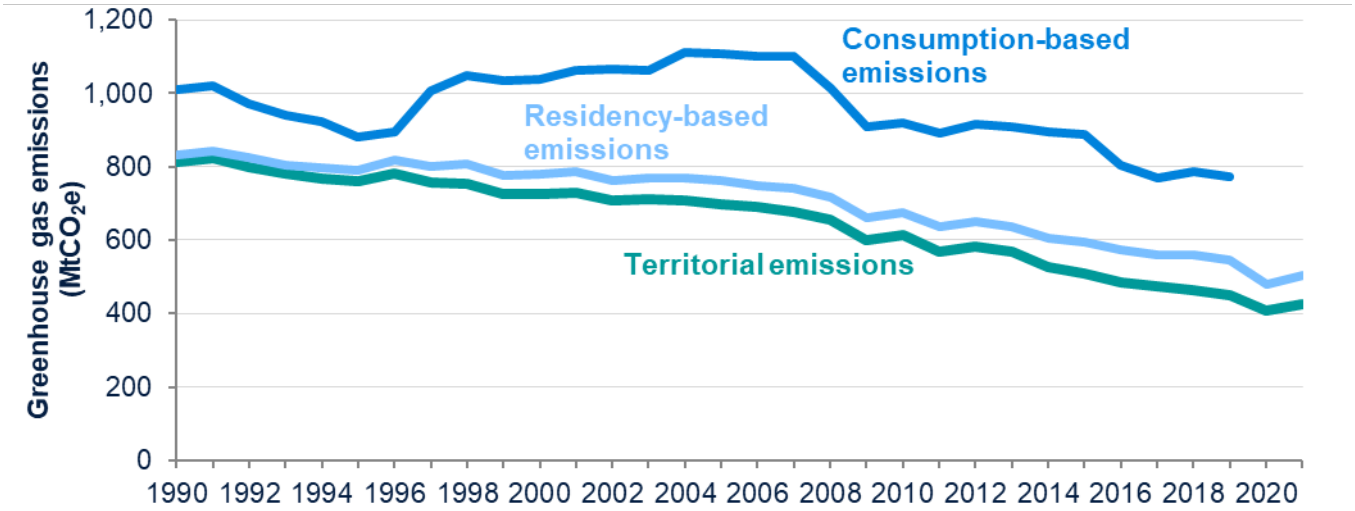
- ONS publishes emissions on a "residency" basis in the UK Environmental Accounts. The figures represent emissions caused by UK residents and businesses whether in the UK or abroad but exclude emissions within the UK which can be attributed to overseas residents and businesses.

- The Department for Environment, Food and Rural Affairs (Defra) publishes the UK's carbon footprint. This estimates emissions on a "consumption" basis, meaning it covers emissions associated with the consumption of goods and services by households in the UK. It includes estimates of emissions associated with each stage of the supply chain for those goods and services, regardless of where they occur, while excluding emissions occurring in the UK that are associated with the consumption of goods and services by households outside the UK.

Figure 1 shows how the estimates of UK territorial emissions in this publication compare to the most recent estimates of UK emissions on a residency and a consumption basis. The estimates are not directly comparable as there are differences in definitions and methodologies and both the consumption-based and residency-based estimates do not incorporate the latest methodology changes made to the territorial estimates, for example the use of updated global warming potentials. However, this does give a good indication of the relative sizes and trends in each of these estimates, for example the UK's consumption-based emissions are considerably higher than its territorial emissions and followed a different trend over this period, peaking in 2004 and not falling as far as the territorial and residency-based estimates have since 1990.

[1] 2006 IPCC Guidelines for National Greenhouse Gas Inventories: https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html; 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement): https://www.ipcc-nggip.iges.or.jp/public/wetlands/index.html; 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP Supplement): https://www.ipcc-nggip.iges.or.jp/public/kpsg/index.html

Figure 1: UK territorial, residency-based and consumption-based greenhouse gas emissions, 1990-2021



Sources: Table 1.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables
UK's carbon footprint, Defra: https://www.gov.uk/government/statistics/uks-carbon-footprint
Atmospheric emissions: greenhouse gases by industry and gas, ONS: https://www.ons.gov.uk/economy/environmentalaccounts/datasets/ukenvironmentalaccountsatmosphericemissionsgreenhousegasemissionsbyeconomicsectorandgasunitedkingdom

The estimates in this publication are based on the source of the emissions rather than where the end-user activity occurred, so for example emissions related to electricity generation are attributed to power stations, where the emissions occur, rather than homes and businesses where the electricity is used. A breakdown of UK territorial emissions by end-user sector will be published as an annex to this publication on Thursday 30 March 2023[2].

These estimates cover seven gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). The last four gases are collectively referred to as fluorinated gases or F gases. In accordance with international reporting protocols, emissions of each gas are weighted by its global warming potential (GWP)[3], so that total greenhouse gas emissions can be reported on a consistent basis. The GWP for each gas is defined as its warming influence in relation to that of carbon dioxide over a 100-year period. Emissions are then presented in carbon dioxide equivalent units (CO_2e). The GWPs used in these statistics have been updated this year, more information about this change can be found on page 33.

Carbon dioxide is reported in terms of net emissions, which means total emissions minus total removals of carbon dioxide from the atmosphere by carbon sinks. Carbon sinks are defined by the UNFCCC as “any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere”.

References to the ‘UK Greenhouse Gas Inventory’ refer to the consistent time series of emissions from 1990 to the most recent year which is updated annually and reported to the UNFCCC. The figures in these statistics are consistent with the UK’s Greenhouse Gas Inventory for 1990-2021, although the inventory reported to the UNFCCC includes emissions from the UK’s Crown Dependencies and certain Overseas Territories which are excluded from these statistics except where specifically stated.

[2] The Annex for 1990-2020 UK greenhouse gas emissions final figures by end-user published in March 2022 can be found here: https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2020
[3] The global warming potentials (GWPs) used are from Working Group 1 of the IPCC Fifth Assessment Report: Climate Change 2014 and summarised in table 6.4 in the data tables accompanying this publication.

Note that as part of this release the 1990-2020 emissions figures have been revised since the previous publication in February 2022, to incorporate methodological improvements and new data, and the 2021 figures have been revised from the provisional estimates published in March 2022. Details of these revisions can be found later in this statistical release.

For the purposes of reporting, greenhouse gas emissions are allocated into sectors known as National Communication (NC) sectors as follows:

Energy Supply	Emissions from electricity generation and other energy production activities such as mining, refining, and manufacturing fuels. In the end-user estimates these emissions are instead assigned between the other sectors based on where the electricity/fuel is used, or to the *Exports* sector where they are used abroad.
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 but not business-related transport emissions, which are included in the *Transport* sector.
Transport	Emissions from road transport, domestic aviation, railways, and domestic shipping. Only includes emissions from vehicles and not from transport related infrastructure or from air conditioning. International aviation and shipping emissions are not included in national totals.
Public	Emissions from the combustion of fuel in public sector buildings, e.g. hospitals and schools. Emissions from public transport are included in the *Transport* sector.
Residential	Emissions from residential properties, including from consumer product use. Primarily consists of fuel combustion for heating/cooking, garden machinery, and fluorinated gases released from aerosols and metered dose inhalers.
Agriculture	Emissions of greenhouse gases from livestock, agricultural soils (excluding carbon stock changes which are included in the *LULUCF* sector) and agricultural machinery.
Industrial processes	Emissions resulting from industrial processes, except for those associated with fuel combustion which are included in the *Business* sector.
Land use, land use change and forestry (LULUCF)	Emissions/removals of CO_2 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 CO_2 from burning biomass (regardless of the country of origin) are excluded from other sectors to avoid double counting them.
Waste management	Emissions resulting from the treatment and disposal of solid and liquid waste, for example from landfill, incineration, and composting. Emissions from incineration with energy recovery are instead reported in the *Energy Supply* sector and emissions from residential composting are included in the *Residential* sector.

We are proposing to replace the NC sectors in next year's publication. Please see the separate document published alongside this publication and send us any feedback you have at GreenhouseGas.Statistics@beis.gov.uk.

2021 total greenhouse gas emissions

In the data tables accompanying this publication, table 1.1 shows UK greenhouse gas emissions since 1990 by gas and table 1.7 shows emissions by fuel type.

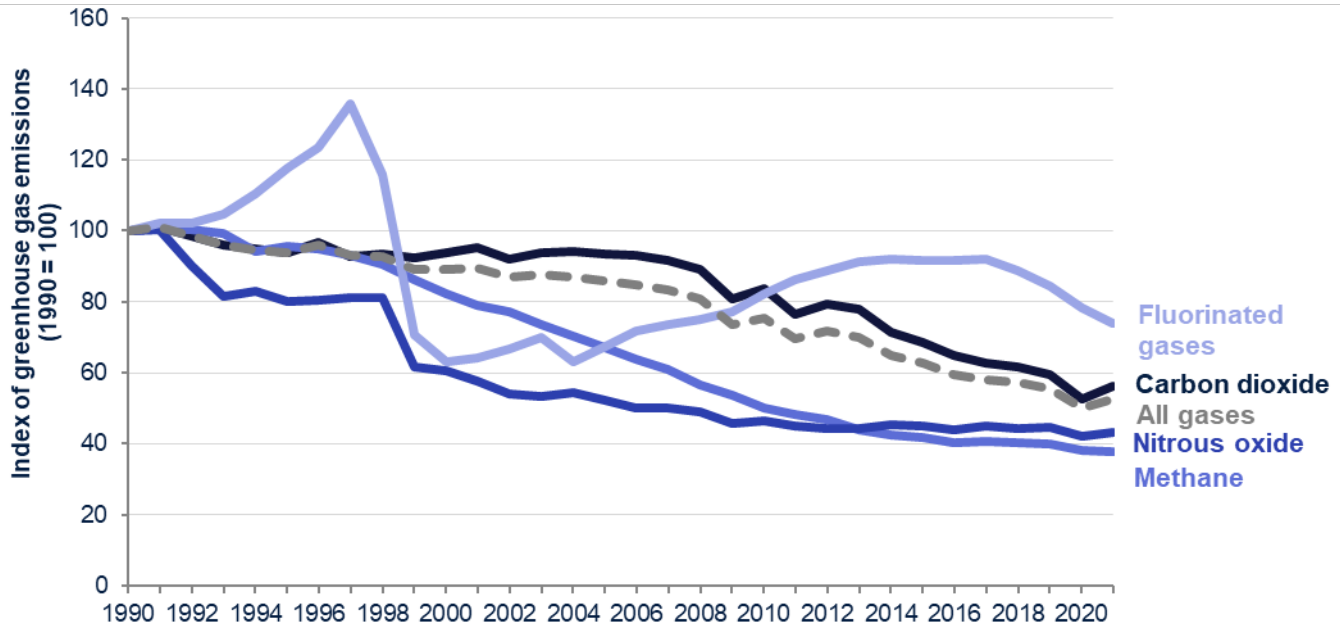
In 2021, emissions in the UK of the basket of seven greenhouse gases covered by the Kyoto Protocol were estimated to be 426.5 million tonnes carbon dioxide equivalent ($MtCO_2e$), an increase of 5.0% compared to the 2020 figure of 406.3 million tonnes. This is both the largest proportional rise and the largest rise in absolute terms in UK greenhouse gas emissions in a single year since the start of the data series in 1990. However, greenhouse gas emissions in 2021 are still 5.3% lower than in 2019 and are estimated to be 47.6% lower than they were in 1990.

In 2021, the coronavirus (COVID-19) pandemic and continuing restrictions implemented across the UK had a major impact on various aspects of UK society and the economy. As a result, COVID-19 will have had a significant impact on greenhouse gas emissions in the UK, particularly from transport and businesses, although less so compared to 2020 as restrictions were gradually eased throughout the year. However, 2021 figures are still down from 2019, in part reflecting continued impact of the COVID-19 pandemic. It is not possible to identify the exact size of this effect as other factors will have also played a part in the changes seen during 2021.

When broken down by gas, UK emissions are dominated by carbon dioxide, which is estimated to have accounted for about 80% of greenhouse gas emissions in the UK in 2021. Weighted by global warming potential, methane accounted for about 13% and nitrous oxide for about 4% of UK emissions in 2021. Fluorinated gases accounted for the remainder, around 3%.

Carbon dioxide has always been the dominant greenhouse gas emitted in the UK. Emissions of CO_2 have reduced by 43.8% (around 264.5 $MtCO_2$) since 1990 to 339.5 $MtCO_2$ in 2021, mainly due to decreases in emissions from power stations. Emissions of methane have seen a larger proportional fall (62.1% since 1990) than those of CO_2, and so have emissions of nitrous oxide (56.9% since 1990). Fluorinated gas (F gas) emissions are estimated to be 26.2% lower now than they were in 1990, with hydrofluorocarbons (HFCs) being the dominant F gas.

Figure 2: Index of territorial UK greenhouse gas emissions by gas, 1990-2021

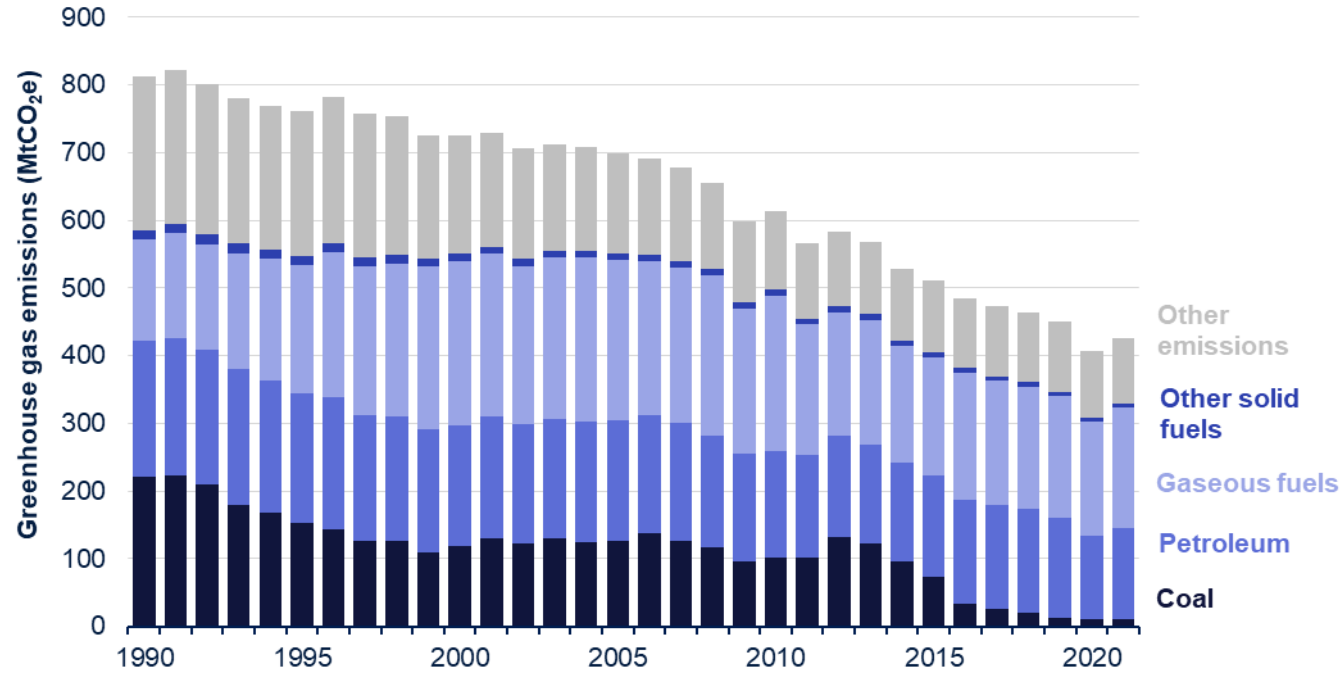


Source: Table 1.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

In 2021, 77.3% of greenhouse gas emissions in the UK came from the use of fossil fuels. Emissions from fossil fuels increased by 6.7% compared to 2020 but were still 4.9% down compared to 2019 and 43.7% lower than in 1990. Fossil fuel emissions in 2021 predominantly came from the use of gaseous fuels and petroleum, which accounted for 41.6% and 31.7% of all UK emissions respectively. Gaseous fuel use in the UK is dominated by the use of natural gas for heating buildings and for electricity generation, while most petroleum use is in road vehicles.

Use of coal accounted for 2.6% of emissions in the UK in 2021. Emissions from the use of coal have fallen by 95.0% since 1990, at which point they were responsible for 27.2% of UK emissions as it was the main fuel used for electricity generation.

Figure 3: Territorial UK greenhouse gas emissions by fuel type, 1990-2021 ($MtCO_2e$)



Source: Table 1.7, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

UK performance against emissions reduction targets

In the data tables accompanying this publication, tables 2.1 and 2.2 show the UK's progress against domestic and international emissions reduction targets respectively.

Domestic Targets

The Climate Change Act 2008

The UK has domestic targets for reducing greenhouse gas emissions under the Climate Change Act 2008 (CCA)[4]. The CCA established a long-term legally binding framework to reduce emissions, initially by at least 80% below a 1990/95 baseline by 2050. In June 2019, following the IPCC's Special Report on Global Warming of 1.5°C and advice from the UK Climate Change Committee, the CCA was amended to commit the UK to achieving at least a 100% reduction in net emissions by 2050 (Net Zero).

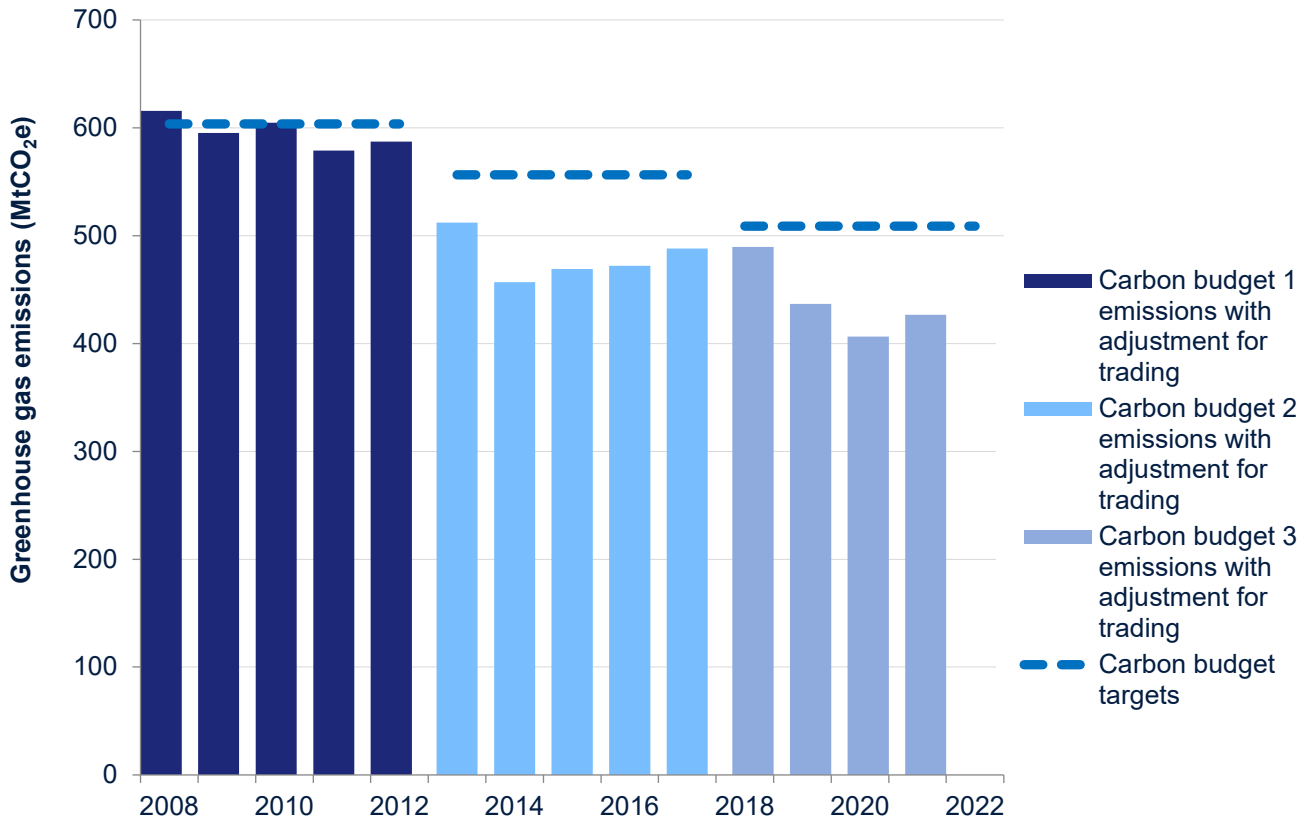
The CCA also introduced carbon budgets. These are legally binding limits on the total amount of greenhouse gas emissions the UK can emit over five-year periods and are required to be set 12 years in advance of the start of each period[5]. The first carbon budget ran from 2008-12. In 2014, it was confirmed the UK had met the budget with emissions 36 $MtCO_2e$ below the cap of 3,018 $MtCO_2e$[6]. The second carbon budget ran from 2013-17. In 2019, it was confirmed the UK had met the budget with emissions 384 $MtCO_2e$ below the cap of 2,782 $MtCO_2e$[7]. A final statement for the third carbon budget, covering the period 2018-22, will be published in May 2024.

Compliance with carbon budgets is not assessed by directly comparing the budget level against UK greenhouse gas emissions. Instead, the budget level is compared to the net UK carbon account, which takes account of international emissions trading and is defined for each period in carbon accounting regulations[8]. Up to 2020, the net UK carbon account included adjustments for net trading from UK operators participating in the EU Emissions Trading System (EU ETS)[9]. The UK left the EU ETS on 31 December 2020, and so adjustments for trading are no longer applicable.

Projected performance against current and future carbon budgets can be found in UK energy and emissions projections[10].

[4] Climate Change Act 2008: http://www.legislation.gov.uk/ukpga/2008/27/contents
[5] Carbon budgets: https://www.gov.uk/guidance/carbon-budgets
[6] Final statement for the first carbon budget period: https://www.gov.uk/government/statistics/final-statement-for-the-first-carbon-budget-period
[7] Final statement for the second carbon budget period: https://www.gov.uk/government/statistics/final-statement-for-the-second-carbon-budget-period
[8] Carbon Accounting Regulations: https://www.legislation.gov.uk/uksi/2009/1257/contents/made
[9] The EU Emissions Trading System (EU ETS): https://ec.europa.eu/clima/policies/ets_en
[10] Energy and emissions projections: https://www.gov.uk/government/collections/energy-and-emissions-projections

Figure 4: UK's progress towards meeting carbon budgets



Source: Table 2.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

The latest figures show the 2021 net UK carbon account was 426.5 $MtCO_2e$. 2021 represents the fourth year of the third carbon budget. The net UK carbon account must be on average lower than 508.8 $MtCO_2e$ each year for the UK to meet the third carbon budget.

Detailed information on how the 2021 net UK carbon account is calculated will be published in the Annual Statement of Emissions for 2021, due to be published by BEIS by the end of March 2023[11].

International Targets

Pre-2020: targets under the Kyoto Protocol

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) is an international agreement.[12]

First Commitment Period (2008-2012)

The UK met its emissions reductions target for the first commitment period of the Kyoto Protocol. Under the first commitment period of the Kyoto Protocol (2008-12), the EU and its Member States, Iceland and Norway collectively made a commitment to reduce greenhouse

[11] Annual Statement of Emissions: https://www.gov.uk/government/collections/annual-statements-of-emissions
[12] UNFCCC page on the Kyoto Protocol: https://unfccc.int/kyoto_protocol

gas emissions across the EU by 8% on 1990 levels by 2012. As part of this, the UK undertook to reduce total greenhouse gas emissions by 12.5% below base year levels over the five-year period 2008-12[13].

UK emissions of the basket of greenhouse gases covered by the Kyoto Protocol were an average 600.6 $MtCO_2e$ per year (exclusive of emissions trading) over the first commitment period (2008-12), 23% lower than base year emissions[14]. The UK's total emissions over the period were 372.5 $MtCO_2e$ lower than the Assigned Amount allocation (see table 2.2(a) in excel data tables).

Second Commitment Period (2013-2020)

Emission targets under the second commitment period of the Kyoto Protocol (2013-2020) are set out in the Doha Amendment.[15] These targets are translated into emission allocations called Assigned Amount Units (AAUs), as set out in each Party's 'initial report'.[16]

Joint Fulfilment with the EU

The EU had a target to reduce emissions by 20% relative to the reference year (1990) over the second commitment period. This is being fulfilled jointly with Member States and other participating countries (UK and Iceland) in accordance with Article 4 of the Kyoto Protocol. In line with this target, emissions are split into (i) 'traded sector' emissions, covered by the EU Emissions Trading System (EU ETS) which gives an overall EU-wide 'cap' on emissions from participating sectors; and (ii) 'non-traded sector' emissions, which are covered by country-level targets. Countries' emissions from the traded sector are managed centrally by the Union and are not counted towards individual targets under the Kyoto Protocol. Only emissions outside the scope of the EU ETS are counted towards individual country-level targets.

Under the terms of the Withdrawal Agreement, the UK remains committed to its shared target with the EU under the Kyoto Protocol as part of the Joint Fulfilment Agreement.

UK targets under the EU Effort Sharing Decision

The EU Effort Sharing Decision (ESD) was agreed as part of the EU's 2020 Climate and Energy package, which came into force from January 2013. Under the terms of the Withdrawal Agreement, the UK remains committed to its targets under the EU ESD due to its shared target with the EU under the Kyoto Protocol.

The ESD sets out targets for participating countries to either reduce or limit emissions by a certain percentage in the non-traded sector (i.e. covering most sectors not included in the EU ETS[17]), by 2020 from a 2005 baseline. Each country's national emission target has been translated into binding quantified Annual Emission Allocations (AEAs) for the period 2013–2020. The UK's 2020 target, based on relative GDP per capita, was to reduce emissions by 16% from 2005 levels, to be achieved through a declining limit for emissions for each year from 2013-2020[18].

[13] Council Decision (2002/358/EC) of 25 April 2002: http://www.eea.europa.eu/policy-documents/council-decision-2002-358-ec
[14] A record of UK base year emissions is published on the following page: https://www.gov.uk/government/publications/uk-greenhouse-gas-emissions-explanatory-notes
[15] https://unfccc.int/process/the-kyoto-protocol/the-doha-amendment
[16] Parties' initial reports for the second commitment period of the Kyoto Protocol: https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-the-kyoto-protocol/second-commitment-period/initial-reports
[17] ESD targets do not include emissions from LULUCF sectors.
[18] Annual emission allocations, European Commission: https://ec.europa.eu/clima/eu-action/effort-sharing-member-states-emission-targets/annual-emission-allocations-2013-2020-and-flexibilities_en

In October 2022 the European Commission confirmed for each participating country their performance against ESD for 2020[19]. UK greenhouse gas emissions for 2020 under the ESD were confirmed to be 298.9 $MtCO_2e$[20], 52.0 $MtCO_2e$ below the UK's annual limit for 2020 of 350.9 $MtCO_2e$, meaning that the UK met its eighth annual target in the period. The UK therefore has met all its annual targets under the EU ESD for 2013-2020, as shown in Table 1 below and in table 2.2(c) of the excel data tables.

Table 1: Progress towards the EU Effort Sharing Decision

UK and Gibraltar, 2013-2020								$MtCO_2e$
	2013	2014	2015	2016	2017	2018	2019	2020
Total greenhouse gas emissions excl. LULUCF and NF_3 (A)	566.5	524.0	503.5	482.8	470.5	460.3	449.2	402.1
Total verified emissions from stationary installations under the EU ETS (B)	225.3	197.9	175.9	147.4	136.8	128.9	118.6	102.6
CO_2 emissions from civil aviation (C)	1.7	1.6	1.6	1.5	1.6	1.5	1.5	0.6
Total ESD emissions (D = A - B - C)	339.5	324.4	326.0	333.9	332.1	329.9	329.1	298.9
Annual emissions allocation (E)	358.7	354.2	349.7	345.2	360.4	357.2	354.1	350.9
Difference (E - D)	**19.3**	**29.8**	**23.7**	**11.3**	**28.4**	**27.4**	**25.0**	**52.0**

Source: Table 2.2(c), Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables.

UK target under the Doha Amendment

Parties submitted 'initial reports' to facilitate the calculation of their allocated emission units permitted under their Kyoto targets.[21] The UK's initial report translates the UK's targets for the non-traded sectors into Assigned Amount Units (AAUs). [22] Particular rules for the accounting of the LULUCF sectors are used (KP-LULUCF), and some minor LULUCF sources are also excluded from accounting.[23]

[19] Commission Implementing Decision (EU) 2022/1953 of 7 October 2022 on greenhouse gas emissions covered by Decision No 406/2009/EC of the European Parliament and of the Council for the year 2020 for each Member State: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022D1953&qid=1670425322264

[20] ESD dataset 2022, EEA website: https://www.eea.europa.eu/data-and-maps/data/esd-4

[21] 'Initial Reports' for the second commitment period of the Kyoto Protocol: https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-the-kyoto-protocol/second-commitment-period/initial-reports

[22] UK Initial Report for the second commitment period of the Kyoto Protocol: https://unfccc.int/files/national_reports/initial_reports_under_the_kyoto_protocol/second_commitment_period_2013-2020/application/zip/gbk-cp2-ir-29aug2017.zip

[23] Kyoto Protocol https://unfccc.int/sites/default/files/resource/docs/cop3/l07a01.pdf ; Decision 2/CMP.7 https://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf; IPCC 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol https://www.ipcc-nggip.iges.or.jp/public/kpsg/index.html

As of 28 October 2020, 147 Parties have deposited their instrument of acceptance (including the UK), therefore the threshold for entry into force of the Doha Amendment has been met[24]. These statistics contain indicative figures for the UK's progress against its targets under the Doha Amendment (see table 2.2(b) in excel data tables) which show the UK will meet its target. These figures are based on the UK's 1990-2020 greenhouse gas inventory, published in 2022, as this will be used to assess compliance with the UK's targets under the Doha Amendment. The second commitment period of the Kyoto Protocol concluded in December 2020, and final reporting of all emissions over the commitment period has now taken place, but compliance with the Kyoto target will not be finalised until the 'true-up' process in 2023.

Beyond 2020: targets under the Paris Agreement

Following the 21st Conference of the Parties (COP21) of the UNFCCC in Paris in December 2015, 195 countries committed to adopt a global climate change Agreement. The Paris Agreement entered into force on 4 November 2016 and was ratified by the UK on 18 November 2016. Parties to the Paris Agreement are required to prepare, communicate, and maintain successive Nationally Determined Contributions (NDCs).

On 12 December 2020, the UK communicated its NDC under the Paris Agreement.
The NDC commits the UK to reducing economy-wide greenhouse gas emissions by at least 68% by 2030, compared to 1990 levels.[25]

Emissions Trading

Under the UNFCCC and Kyoto Protocol, three flexible mechanisms were established to provide for trading of national allowances and project-based credits by Governments and emitters. These are International Emissions Trading, the Clean Development Mechanism (CDM), and Joint Implementation (JI). In reporting emissions reductions against all its targets, the UK needs to take account of emissions trading through these flexible mechanisms. Up until 31 December 2020, the UK participated in the EU ETS. The other mechanisms for trading of national allowances were not in operation in the UK, although it should be noted that EU ETS participants may also use credits generated under CDM and JI projects, subject to certain limits, in order to comply with their obligations.

European Union Emissions Trading System (EU ETS)

The EU ETS covers around 40% of EU greenhouse gas emissions and limits emissions from around 10,000 installations in the power sector and manufacturing industry, as well as airlines operating between member states.

The EU ETS works on the 'cap and trade' principle. A cap is set on the total amount of certain greenhouse gases that can be emitted by the installations covered by the system. The cap is reduced over time so that total emissions fall. Within the cap, installations buy or receive emissions allowances, which they can trade with one another as needed. The limit on the total number of allowances available ensures that they have a value. After each year, an installation

[24] UNFCCC Doha Amendment: https://unfccc.int/process/the-kyoto-protocol/the-doha-amendment. Information on the acceptance and entry into force of the Doha Amendment: https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-c&chapter=27&clang=_en

[25] UK Nationally Determined Contribution under the Paris Agreement: https://www.gov.uk/government/publications/the-uks-nationally-determined-contribution-communication-to-the-unfccc

must surrender enough allowances to cover its emissions. If an installation reduces its emissions, it can keep the spare allowances to cover its future needs or else sell them to another installation that is short of allowances. Trading brings flexibility that ensures emissions are cut where it costs least to do so. A robust carbon price also promotes investment in innovative, low-carbon technologies.

Phase II of the EU ETS coincided with the first Carbon budget period and Kyoto Protocol first commitment period (2008-12). During this period each member state held a specific quantity of allowances based on their EU-approved National Allocation Plan (NAP). This then resulted in net “sales” or “purchases” of emissions allowances reported from UK installations depending on whether total emissions were below or above the UK’s allocation.

The EU ETS was revised for phase III (2013-20) to make a greater contribution to tackling climate change. The system shifted away from NAPs in favour of an EU-wide cap on the number of available allowances. In the absence of a UK-specific allocation, a notional UK cap has been estimated so that carbon budget performance can take account of emissions trading through the EU ETS. Further details of this methodology are laid out in Annual Statements of Emissions[26].

In 2012, aviation was included in the EU ETS for the first time, and aircraft operators were required to report their annual emissions and surrender an equivalent number of allowances for all flights within the European Economic Area (EEA). However, as UK carbon budgets only cover domestic aviation (aviation within the UK) a separate notional cap for UK domestic aviation has been estimated, so that carbon budget performance only takes account of domestic aviation emissions trading through the EU ETS.

The UK needs to take account of emissions trading through the EU ETS when reporting against carbon budgets. Net adjustments to the net UK carbon account from UK installations and aviation operators trading in the EU ETS (up until 2020) are provided in table 2.1 of the tables accompanying this publication.

[26] Note that a negative net value indicates that the reported emissions from UK installations in the EU ETS were below the cap, i.e. there was a net selling or withholding of units by UK installations. This means that emissions are either emitted elsewhere or emitted at a later stage, so they may not be used to offset UK emissions. The opposite occurs when reported emissions from EU ETS installations exceed the cap.

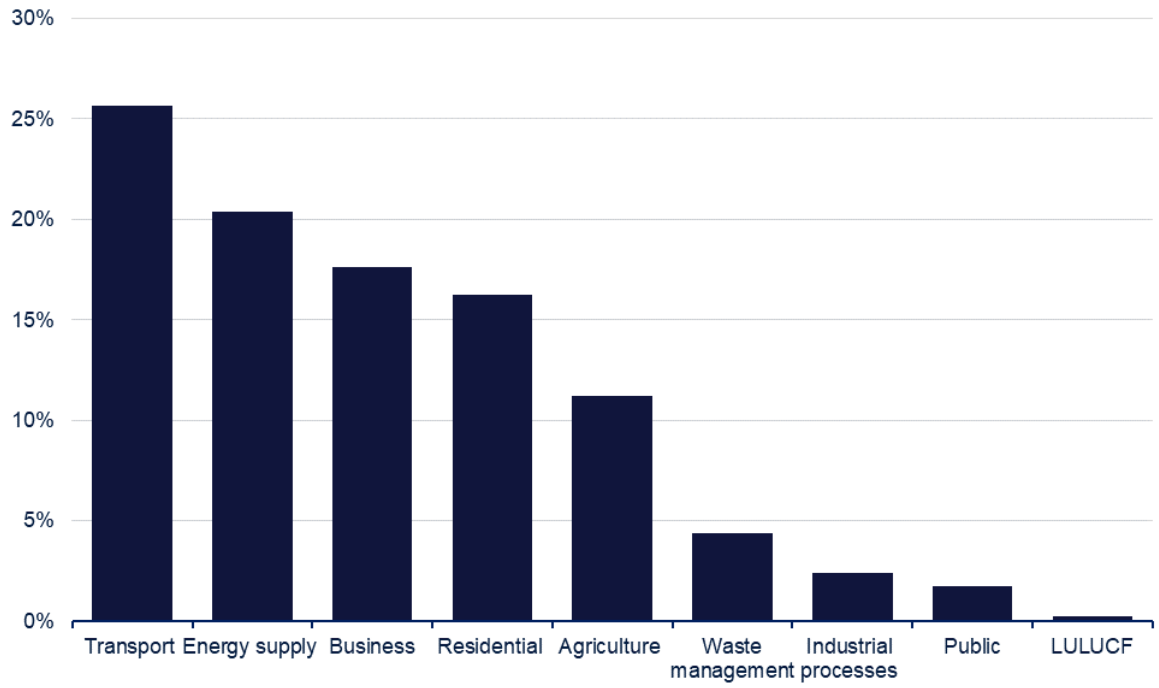
Emissions by sector

In the data tables accompanying this publication, table 1.2 shows overall UK greenhouse gas emissions since 1990 by sector and source, while tables 1.3 to 1.6 show this breakdown for each individual gas.

All the sectoral breakdowns below show emissions by source, meaning emissions are attributed to the sector that emits them directly, as opposed to where the end-user activity occurred. E.g. emissions from power stations are included in the energy supply sector rather than being recorded against the sectors that use the electricity. A breakdown of 1990-2021 UK territorial emissions by end-user sector will be published as an annex to this publication on Thursday 30 March 2023, in which emissions from energy supply will be reallocated to the sectors that use the energy.

In 2021, 26% of net greenhouse gas emissions in the UK were estimated to be from the transport sector, 20% from energy supply, 18% from business, 16% from the residential sector and 11% from agriculture. The other 9% was attributable to the remaining sectors: waste management, industrial processes, the public sector and the land use, land use change and forestry (LULUCF) sector. The LULUCF sector includes both sinks and sources of emissions.

Figure 5: Net territorial UK greenhouse gas emissions by NC sector, 2021 (%)

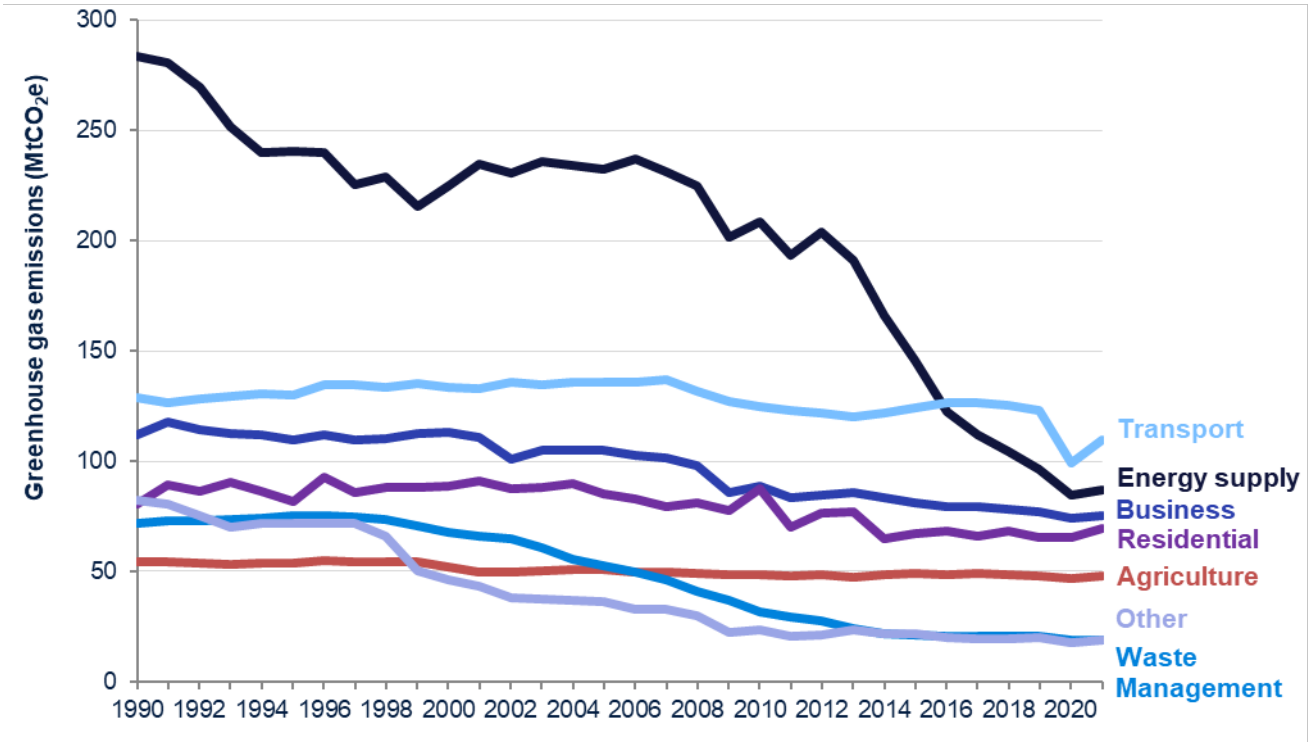


Source: Table 1.2, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

Note: LULUCF is land use, land use change and forestry.

Historically, the energy supply sector had the highest greenhouse gas emissions, but the large reductions over the last decade in emissions from power stations in particular mean that since 2016 the transport sector has had the highest emissions.

Figure 6: Territorial UK greenhouse gas emissions by NC sector, 1990-2021 ($MtCO_2e$)



Source: Table 1.2, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

Note: Other includes Public, Industrial Processes and the Land Use, Land Use Change and Forestry (LULUCF) sectors.

Transport

The transport sector consists of emissions from road transport, railways, domestic aviation, shipping, fishing, and aircraft support vehicles. It is estimated to have been responsible for around 26% of greenhouse gas emissions in the UK in 2021, almost entirely through carbon dioxide emissions. The main source of emissions from this sector is the use of petrol and diesel in road transport.

In 2020 transport was significantly impacted by COVID-19, as people were instructed to stay at home as much as possible. In 2021, COVID-19 restrictions were eased and people were able to travel more freely, resulting in an increase in greenhouse gas emissions from transport of 10% to 109.5 $MtCO_2e$ in 2021, although this was still 11% lower than in 2019, the last full year before the pandemic. For most of the period since 1990 the transport sector was the second most emitting sector; however, reductions over time in what was the largest sector (energy supply) mean that since 2016 transport has been the sector with the highest emissions and remains so in 2021, despite the lower level of emissions in the last two years.

Before 2020 there had been relatively little overall change in the level of greenhouse gas emissions from the transport sector over the previous three decades, with emissions only 4% lower in 2019 than they were in 1990. Between 1990 and 2007 (when emissions peaked) there was a general increasing trend, with some fluctuations year to year. After this peak, emissions declined most years, other than a period of increase between 2013 and 2017. The impact of the COVID-19 pandemic means emissions are estimated to have been around 15% lower in 2021 than in 1990.

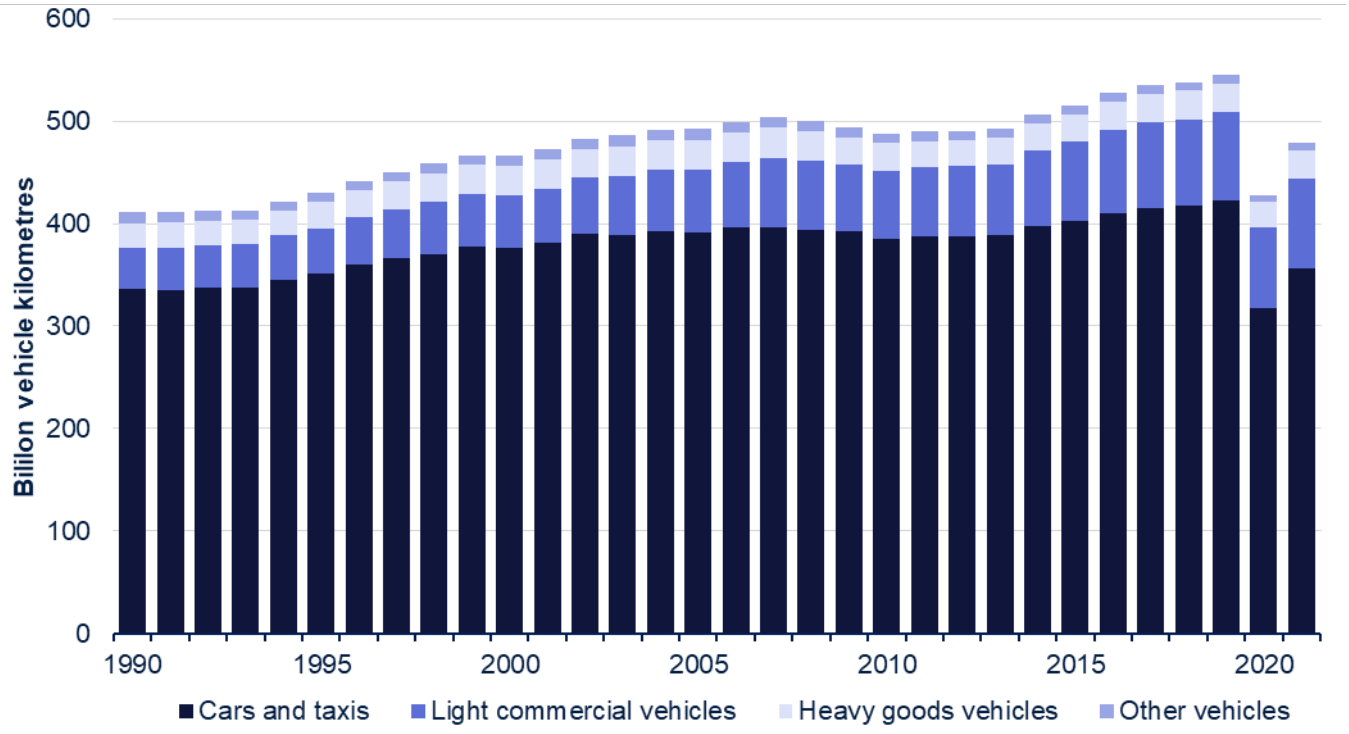
Road transport is the most significant source of emissions in this sector, in particular passenger cars; and the changes which have been seen over the period were heavily

influenced by this category. Figure 7 shows how the volume of traffic on the roads has changed over time in Great Britain, which reflects the trend seen for the UK as a whole. Motor vehicle traffic volumes have generally increased throughout this period, other than a fall seen between 2007 and 2010 following the recession. Again, the COVID-19 pandemic has had a dramatic impact on the level of road traffic in the last two years, with motor vehicles seeing a fall in total vehicle kilometres of around 21% in 2020 from 2019, and the 2021 total was still 12% lower than in 2019.

With lower petrol consumption outweighing an increase in diesel consumption[27] and improvements in fuel efficiency of both petrol and diesel cars[28], the volume of emissions from passenger cars has generally decreased since the mid-2000s. Although (pre-pandemic) this has been partially offset by an increase in emissions from light commercial vehicles. Emissions of carbon dioxide are closely related to the amount of fuel used, whilst nitrous oxide and methane emissions are influenced more by the vehicle type and age.

Domestic aviation emissions fell by more than half in 2020 compared to 2019, the largest proportional fall of any mode of transport, and in 2021 were still 49% lower than in 2019. Emissions from domestic shipping were 12% lower in 2021 than in 2019, having remained at a similar level to where they fell to in 2020, and emissions from railways were 15% lower than in 2019, having seen a partial recovery from their 2020 level.

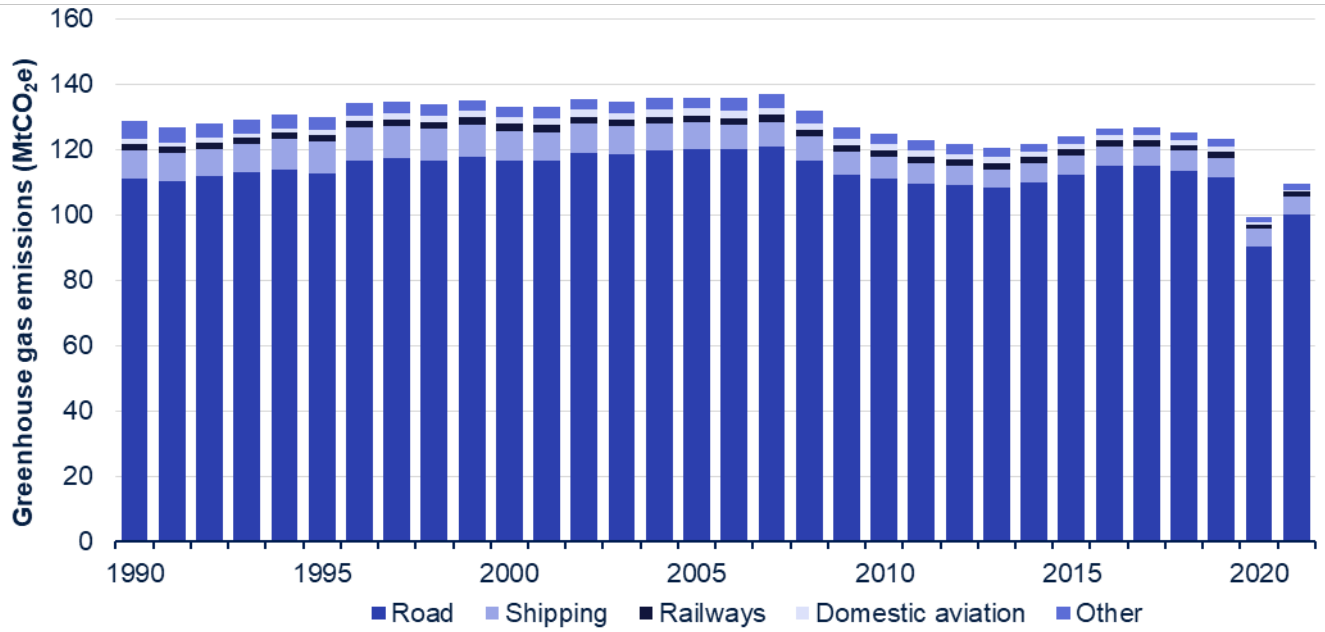
Figure 7: Motor vehicle traffic, Great Britain 1990-2021 (Billion vehicle kilometres)



Source: Transport Statistics Great Britain, Roads and traffic (TSGB07), Table TSGB0702 (TRA0201) Road traffic by vehicle type in Great Britain, annual from 1949: https://www.gov.uk/government/statistical-data-sets/tsgb07

[27] Transport Statistics Great Britain, Energy and environment (TSGB03), Table TSGB0301 (ENV0101) Petroleum consumption by transport mode and fuel type: United Kingdom from 2000: https://www.gov.uk/government/statistical-data-sets/tsgb03
[28] Transport Statistics Great Britain, Energy and environment (TSGB03), Table TSGB0303 (ENV0103) Average new car fuel consumption: Great Britain from 1997: https://www.gov.uk/government/statistical-data-sets/tsgb03

Figure 8: Greenhouse gas emissions from transport, UK 1990-2021 ($MtCO_2e$)



Source: Table 1.2, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

Energy supply

The energy supply sector consists of emissions from fuel combustion for electricity generation and other energy production sources. It is estimated to have been responsible for 20% of UK greenhouse gas emissions in 2021, with carbon dioxide being by far the most prominent gas for this sector (93%). The main source of emissions from this sector is the combustion of fuels in electricity generation from power stations.

There was a 3% increase in emissions from the energy supply sector between 2020 and 2021, although this was still 10% lower than in 2019. This means that between 1990 and 2021 they have reduced by 69%. This decrease has resulted mainly from changes in the mix of fuels being used for electricity generation, including the growth of renewables; together with greater efficiency resulting from improvements in technology. In 2020 there was lower demand for electricity and other fuels as a result of the COVID-19 pandemic and the increase in 2021 was driven by an increase in demand for electricity as COVID-19 restrictions were eased, combined with less favourable weather conditions for wind, hydro and solar generation that meant there was an increase in the fossil fuels needed for electricity generation. The energy supply sector had historically been the sector with the largest emissions. However, these reductions mean that since 2016 it has been the second largest sector presented in these statistics (the largest being transport).

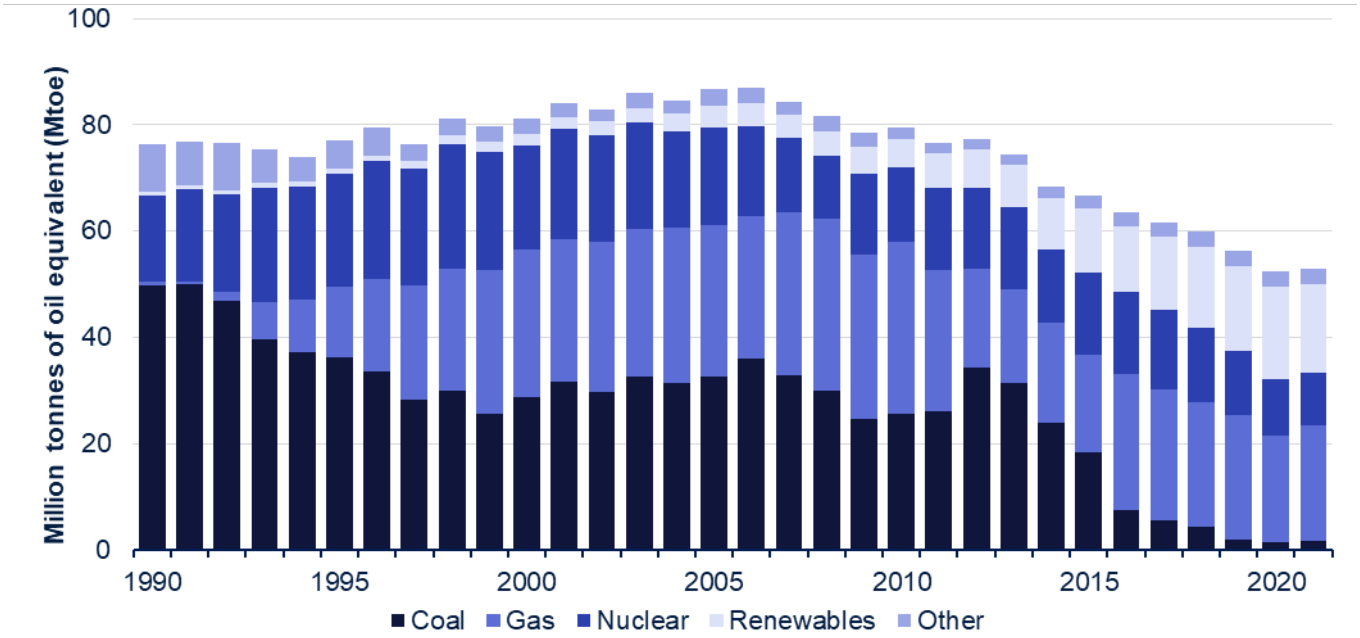
Since 1990 there has been a decline in the use of coal at power stations and an increase in the use of gas, which has a lower carbon content so results in fewer emissions. Coal use in generation reduced by 97% between 1990 and 2021, and now makes up only 3% of the fuel used for UK electricity generation compared to 65% in 1990[29]. Electricity supplied was 1% lower in 2021 than in 1990, having peaked in 2005 and decreased since then[30]. In 2021 the

[29] Digest of United Kingdom Energy Statistics, Table 5.1.1 Fuel input for electricity generation, 1970 to 2021
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904820/DUKES_5.1.1.xls
[30] Digest of United Kingdom Energy Statistics, Table 5.1.3 Electricity generated and supplied, 1970 to 2021
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904822/DUKES_5.1.3.xls

use of gas for electricity generation increased 9% from 2020 and the use of coal by 14%, whereas renewables saw a 4% decrease. In 2021, total greenhouse gas emissions from power stations, at 55.1 $MtCO_2e$, accounted for 13% of all greenhouse gas emissions in the UK.

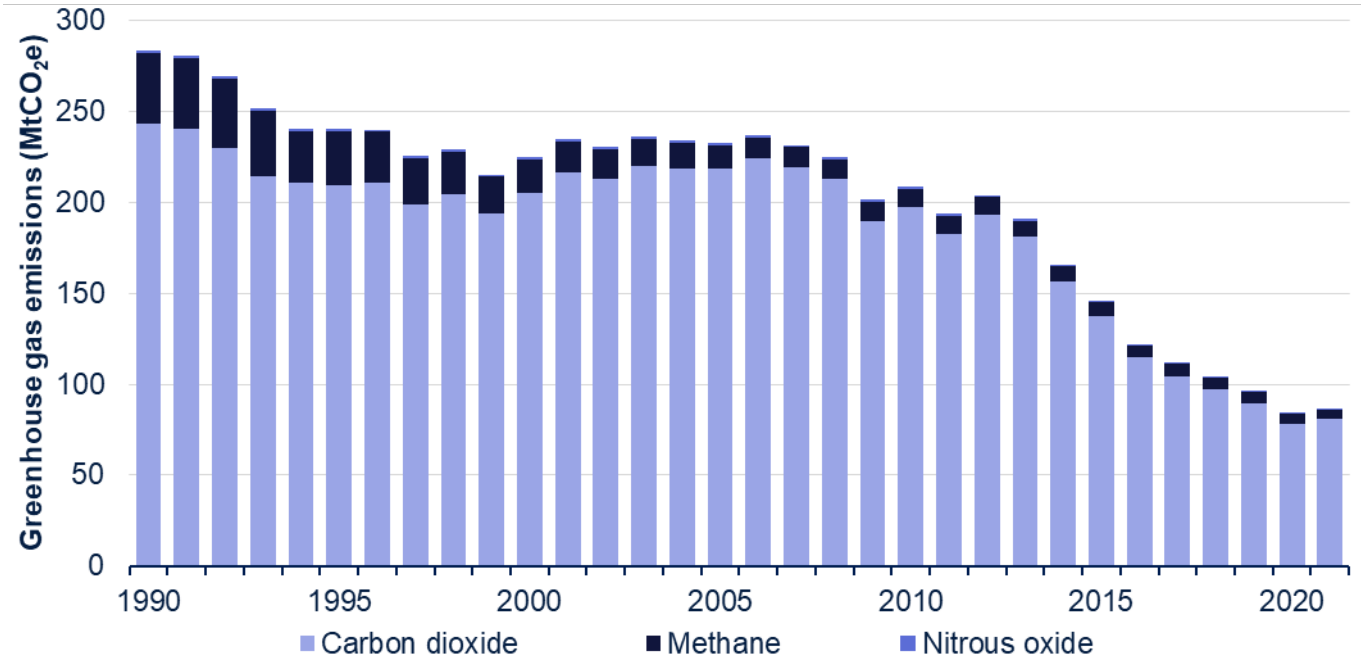
The other main factor which has noticeably contributed to the long-term decline in emissions in the energy sector has been in relation to coal mining. The production of deep-mined coal in particular has declined steadily over the period, with the last three large deep mines all closing in 2015. Emissions from coal mining and handling have fallen from 24.4 $MtCO_2e$ in 1990 to only 0.5 $MtCO_2e$ in 2021.

Figure 9: Fuel used for UK electricity generation, UK 1990-2020 (Million tonnes of oil equivalent (Mtoe))



Source: Digest of United Kingdom Energy Statistics, Table 5.1.1 Fuel input for electricity generation, 1970 to 2021
https://www.gov.uk/government/statistics/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes

Figure 10: Greenhouse gas emissions from energy supply, 1990-2021 ($MtCO_2e$)



Source: Tables 1.2 to 1.6, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

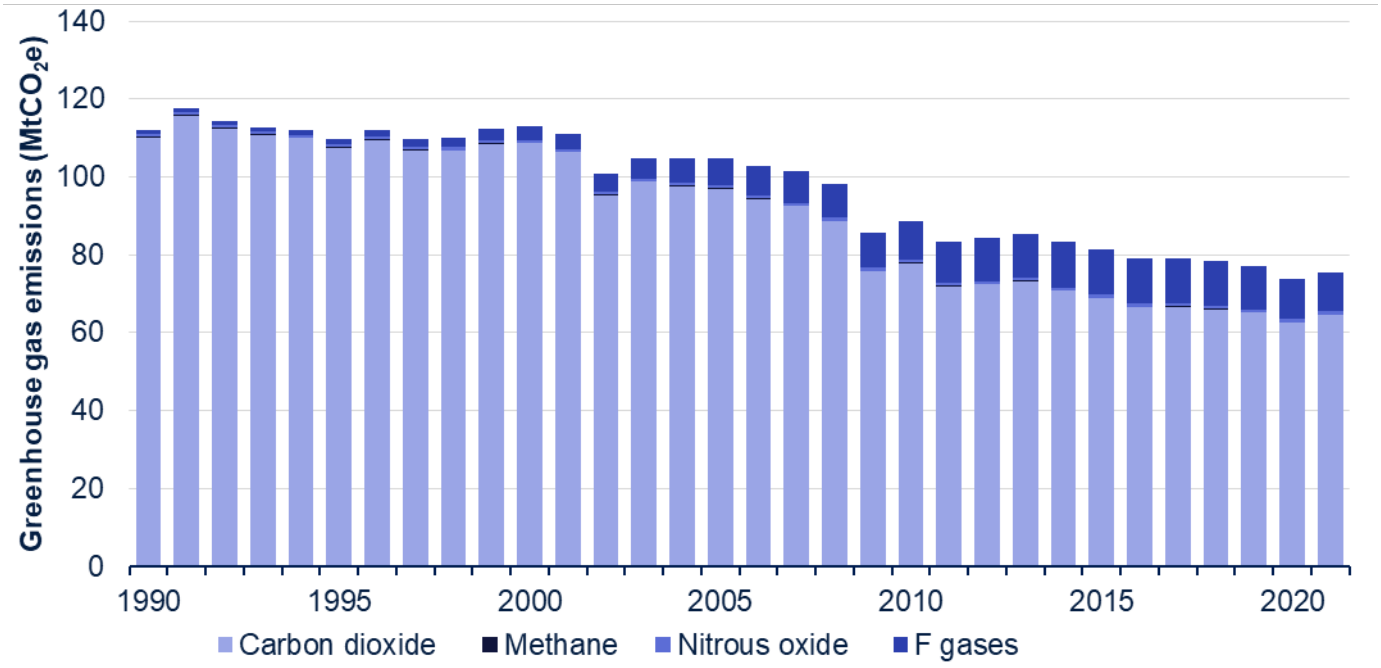
Business

The business sector consists of emissions from combustion in industrial/commercial sectors, industrial off-road machinery, and refrigeration & air conditioning. Between 2020 and 2021 there was a 2% increase in emissions from the business sector, largely because of emissions from industrial and commercial combustion returning to close to their 2019 level after a reduction in 2020 when business activity reduced following the start of the COVID-19 pandemic. The business sector is estimated to have been responsible for 18% of greenhouse gas emissions in the UK in 2021, with carbon dioxide being the most prominent gas. Emissions from this sector primarily relate to fossil fuel combustion in industry and commerce, although emissions of F gases from the use of fluorinated compounds in certain applications, particularly refrigeration & air-conditioning, are also significant. The business sector is responsible for the majority of emissions from F gases.

In 2021, emissions from the business sector were 33% lower than 1990 emissions. Most of this decrease came between 2001 and 2009, with a significant drop in 2009 likely driven by economic factors. There has been a gradual decline in emissions in more recent years. The main driver of the decrease in emissions since 1990 is a reduction in emissions from industrial combustion (including iron and steel) which has led to a 41% reduction in carbon dioxide emissions since 1990.

However, emissions from F gases have increased significantly, mainly due to an increase in emissions from refrigeration & air-conditioning as HFCs replaced ozone depleting substances which were previously used as refrigerants. This increasing trend has reversed in recent years following the introduction of the HFC phase down as part of the EU's 2014 F-Gas Regulation, and F gas emissions have fallen by 16% since their peak in 2016.

Figure 11: Greenhouse gas emissions from business, UK 1990-2021 ($MtCO_2e$)



Source: Tables 1.2 to 1.6, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

Residential

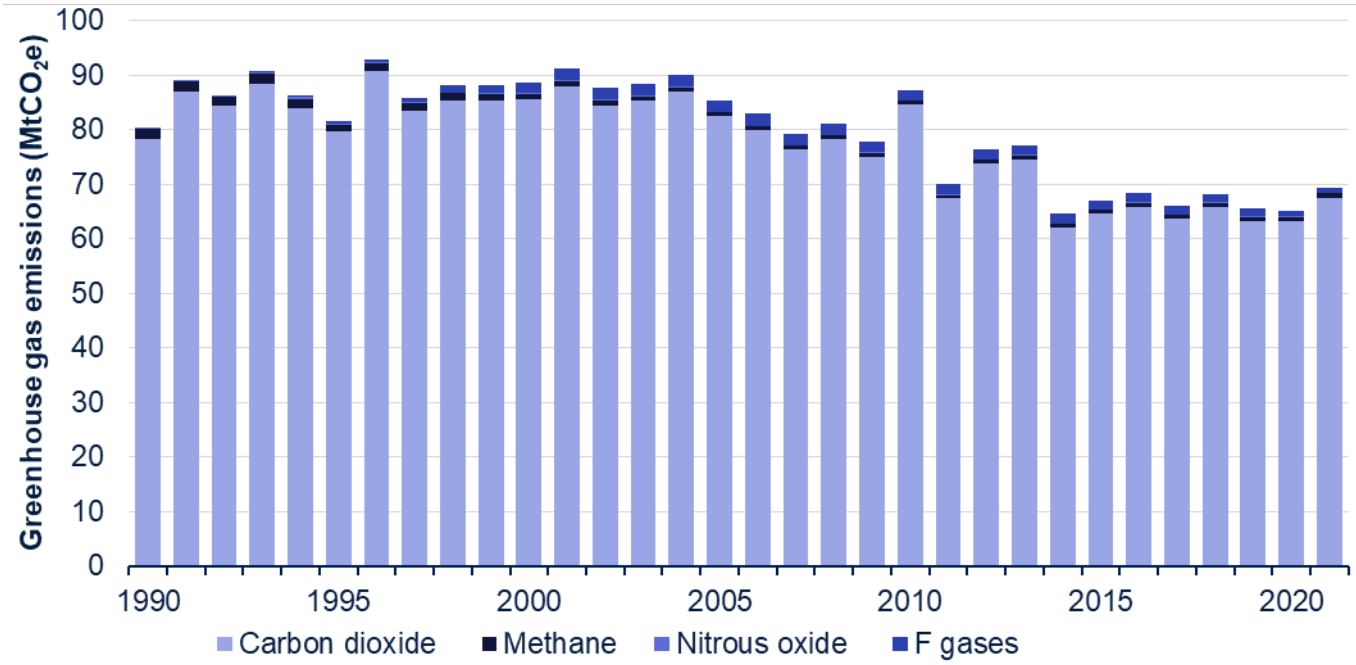
The residential sector consists of emissions from fuel combustion for heating and cooking, garden machinery, and fluorinated gases released from aerosols and metered dose inhalers. It is estimated to have been responsible for around 16% of greenhouse gas emissions in the UK in 2021, with carbon dioxide being the most prominent gas for this sector (97%). The main source of emissions from this sector is the use of natural gas for heating and cooking.

It should be noted that since these figures are estimates of emissions by source, emissions related to residential electricity use – including electricity use for heating – are attributed to power stations and are therefore included in the energy supply sector rather than the residential sector.

Between 1990 and 2021 there has been considerable variation in greenhouse gas emissions from year to year in the residential sector. In general, emissions from this sector are particularly heavily influenced by external temperatures, with colder temperatures driving higher emissions due to increased use of heating.

There was a 6% increase in residential emissions between 2020 and 2021, with the colder temperatures in 2021 likely to be the main factor, resulting in more energy being used to heat homes. The average temperature across the year was 0.4 degrees Celsius lower in 2021 than in 2020[31]. Further information on the impact of external temperatures on emissions can be found later in this statistical release.

Figure 12: Greenhouse gas emissions from the residential sector, UK 1990-2021 ($MtCO_2e$)



Source: Tables 1.2 to 1.6, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

[31] Energy Trends: Weather Table ET 7.1 Average temperatures, heating degree days and deviations from the long-term mean https://www.gov.uk/government/statistics/energy-trends-section-7-weather

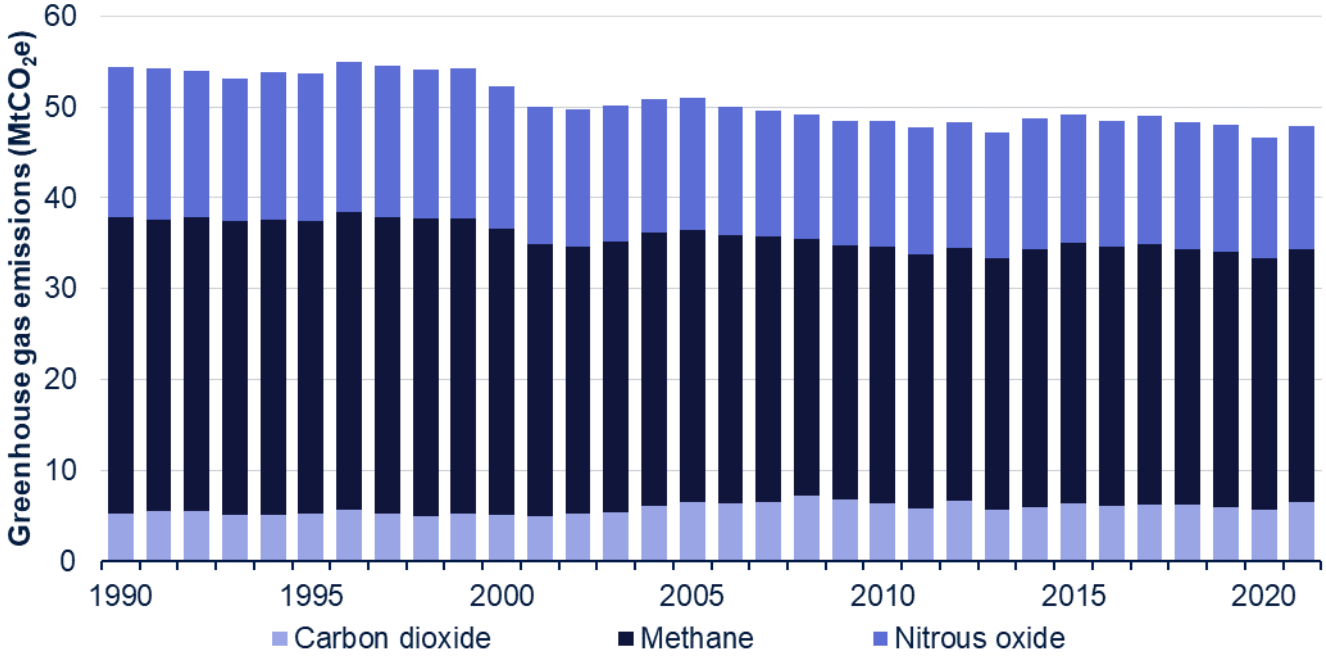
Agriculture

The agriculture sector consists of emissions from livestock, agricultural soils, stationary combustion sources and off-road machinery. It is estimated to have been responsible for 11% of greenhouse gas emissions in the UK in 2021. Emissions of methane (58%) and nitrous oxide (28%) dominate this sector. The most significant sources here are emissions of methane due to enteric fermentation (digestion processes) from livestock, particularly cattle; and nitrous oxide emissions related to the use of fertilisers on agricultural soils.

Between 2020 and 2021 there was a 3% increase in emissions from the agriculture sector, largely due to an increase in emissions from agricultural machinery and an increase in both direct and indirect soil emissions of nitrous oxide, following a reduction in 2020 when less fertiliser was used due to wet weather reducing the planting of winter crops.

Between 1990 and 2021, greenhouse gas emissions from agriculture decreased by around 12%. Most of this fall happened during the 2000s, since when emissions have remained at a similar level. The reduction in emissions was driven by a fall in animal numbers over the period, together with a decrease in synthetic fertiliser use.

Figure 13: Greenhouse gas emissions from agriculture, UK 1990-2021 ($MtCO_2e$)



Source: Tables 1.2 to 1.6, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

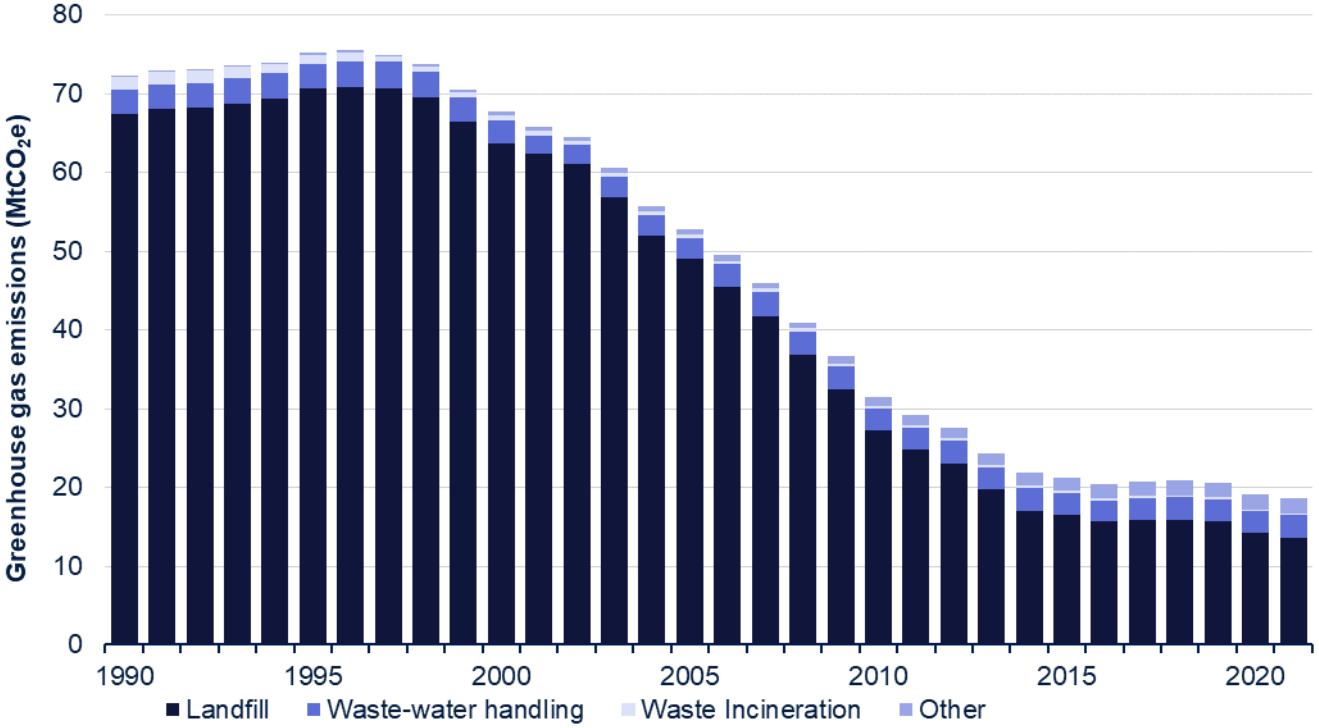
Waste management

The waste management sector consists of emissions from the treatment and disposal of solid and liquid waste, including from waste disposed of to landfill sites, waste incineration, and the treatment of wastewater. It is estimated to have been responsible for around 4% of greenhouse gas emissions in the UK in 2021, with methane being by far the most prominent gas (accounting for 90% of emissions). Most of these emissions are from landfill sites.

Emissions in the waste management sector decreased by 2% between 2020 and 2021 due mainly to reduced emissions from landfill. Between 1990 and 2020, greenhouse gas emissions from the waste management sector decreased by 74%. This was due to a combination of

factors, including improvements in the standards of landfilling, changes to the types of waste going to landfill (such as reducing the amount of biodegradable waste), and an increase in the amount of landfill gas being used for energy.

Figure 14: Greenhouse gas emissions from waste management, UK 1990-2021 ($MtCO_2e$)



Source: Table 1.2, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

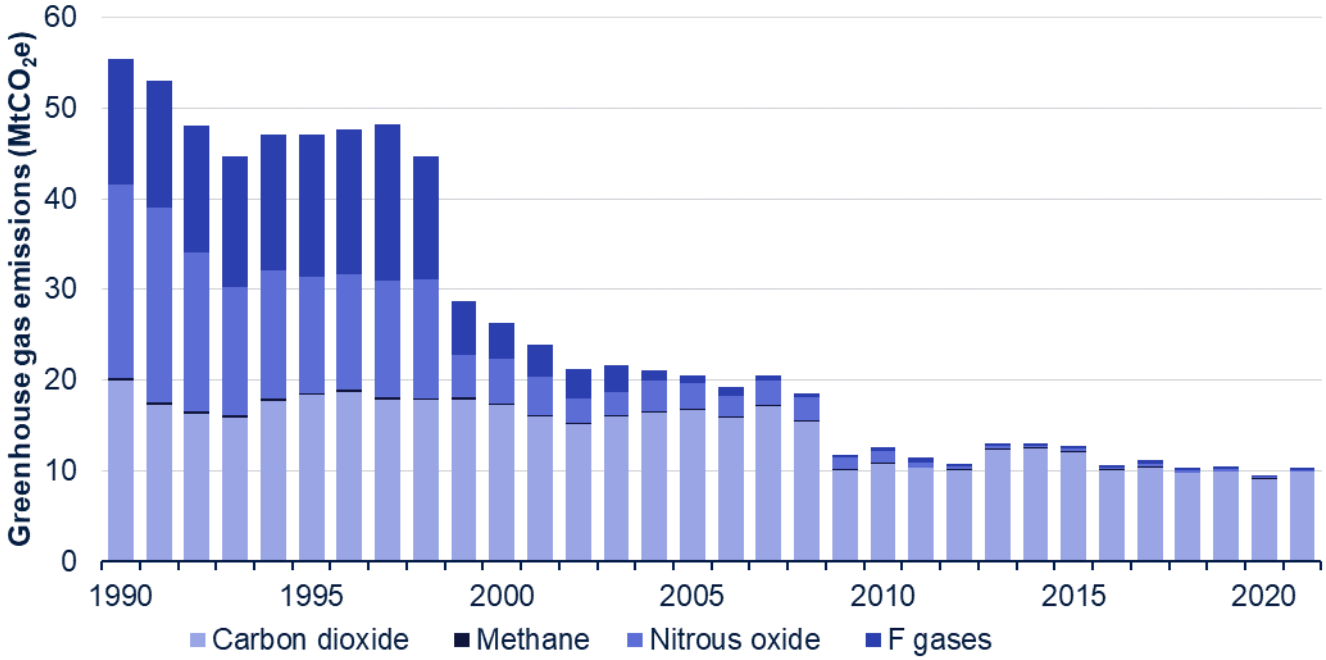
Industrial processes

The industrial processes sector consists of emissions from industry except for those associated with fuel combustion, which are included in the business sector. It is estimated to have been responsible for 2% of greenhouse gas emissions in the UK in 2020, with carbon dioxide being the most prominent gas. The largest source of emissions was cement production, with other processes such as sinter, lime, and ammonia production also contributing significantly.

Between 1990 and 2021, there was a large reduction in greenhouse gas emissions from the industrial processes sector, with an overall decrease of 81%. This was most notably due to a large reduction in emissions from adipic acid production and halocarbon production between 1998 and 1999 following the fitting of abatement equipment at production facilities.

Emissions in the industrial processes sector increased by 9% in 2021 compared to 2020, returning to a similar level as in 2019. Increases were seen in emissions from most industrial processes in 2021 as businesses had reduced activities during the pandemic.

Figure 15: Greenhouse gas emissions from industrial processes, UK 1990-2021 ($MtCO_2e$)



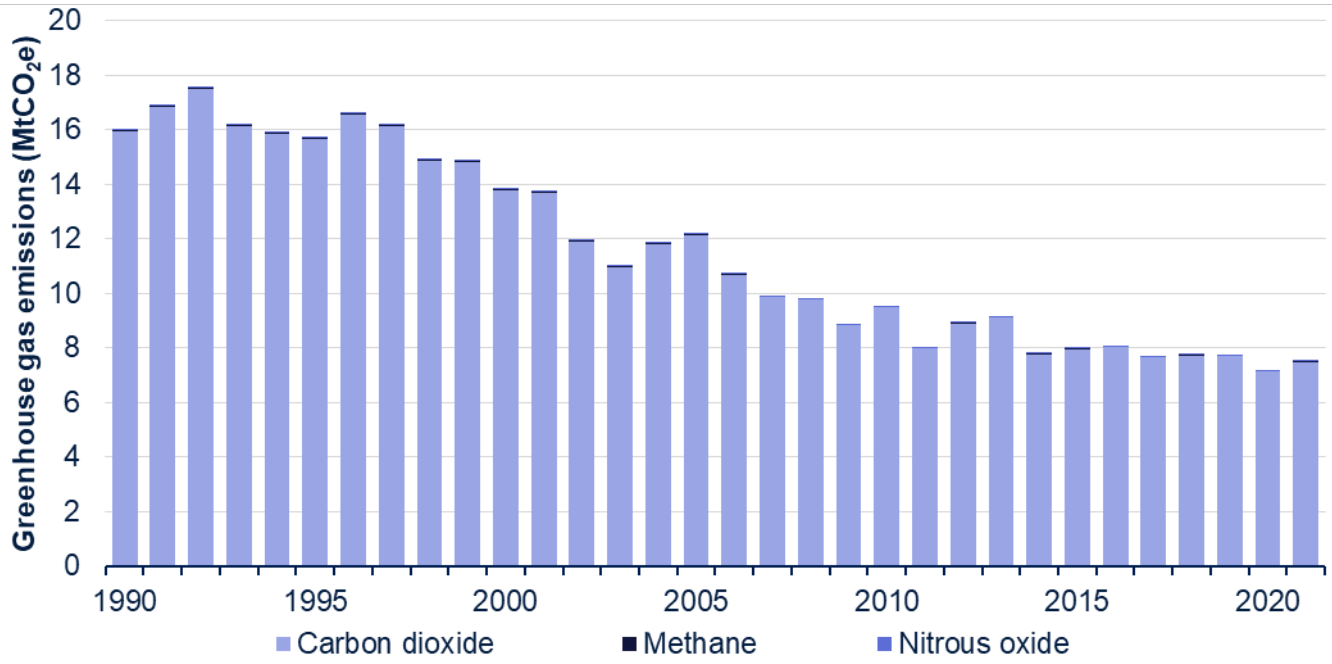
Source: Tables 1.2 to 1.6, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

Public

The public sector consists of emissions from combustion of fuel in public sector buildings, such as schools, hospitals, and offices. It is estimated to have been responsible for around 2% of greenhouse gas emissions in the UK in 2021, with carbon dioxide making up almost all these emissions. The main source of emissions from this sector is the use of natural gas for heating public buildings. It should be noted that these totals do not include emissions from the generation of electricity consumed by the public sector as these emissions are included in the energy supply sector, while emissions from public transport are included in the transport sector.

Between 1990 and 2021 there has been a general downward trend in greenhouse gas emissions from the public sector, which have fallen by 53% over this period. This has been driven by a change in the fuel mix, with less use of coal and oil, and more use of natural gas. Between 2020 and 2021 emissions increased by 5% in the public sector. This is likely to be due to a combination of the colder temperatures in 2021 compared to 2020, which will have increased demand for heating, and increased use of public sector buildings following the COVID-19 restrictions that were in place for much of 2020.

Figure 16: Greenhouse gas emissions from the public sector, UK 1990-2021 ($MtCO_2e$)



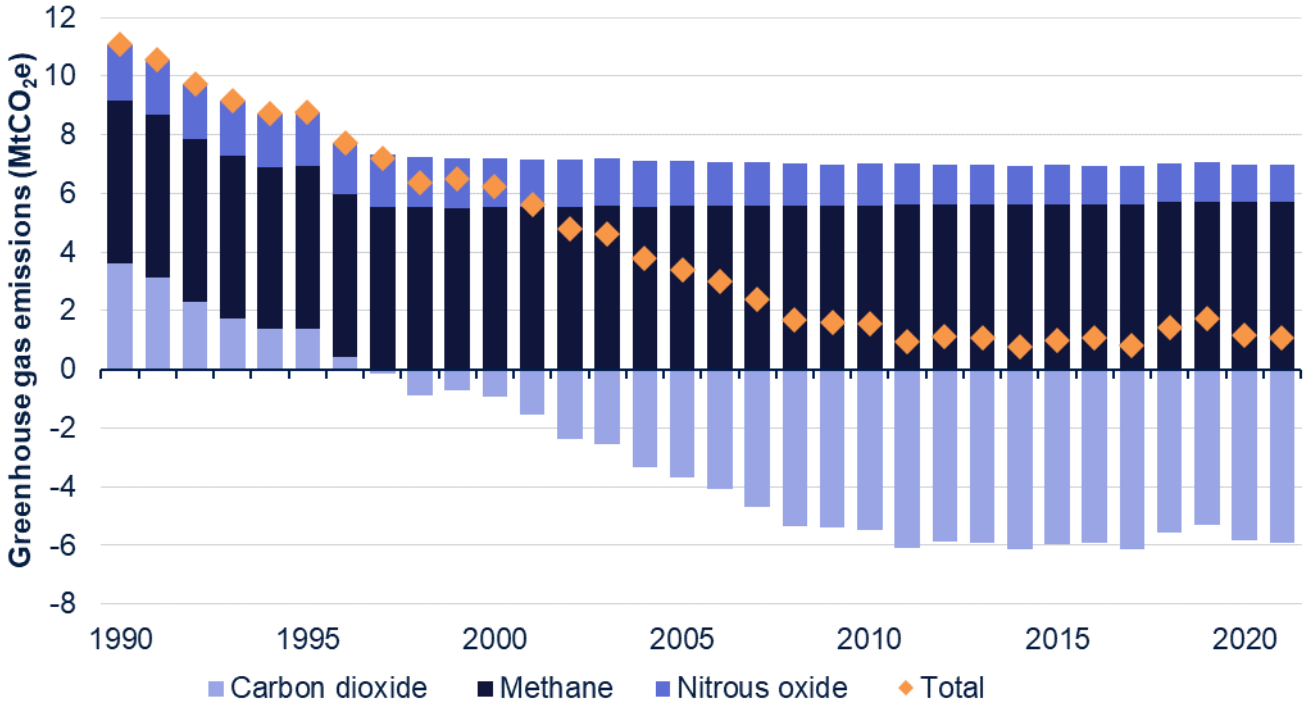
Source: Tables 1.2 to 1.6, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

Land use, land use change and forestry (LULUCF)

The LULUCF sector consists of emissions and removals from forest land, cropland, grassland, wetlands, settlements and harvested wood products. It is the only sector that includes emission removals, although we estimate the sector as a whole to be a net source of greenhouse gas emissions in each year from the start of the data series in 1990. In general, cropland is the largest source of greenhouse gas emissions, while forest land is the dominant sink. Settlements, wetlands, and grasslands are estimated to have been net sources of emissions throughout the data series.

The LULUCF sector is estimated to have had net emissions of 1.1 $MtCO_2e$ in 2021. This is a slight decrease from 1.2 $MtCO_2e$ in 2020 and down from a total of 11.1 $MtCO_2e$ in 1990. The largest factor in this long-term fall has been an increase in the sink provided by forest land, with an increasing uptake of carbon dioxide by trees as they reach maturity, in line with the historical planting pattern. There has also been a reduction in net emissions from grassland, cropland, and settlements. The estimates for emissions across the LULUCF sector have seen a notable fall across the time series from last year due to updated emission factors for Cropland on Wasted Peat (peat <40cm depth), and emission factors for multiple categories of deep peats.

Figure 17: Greenhouse gas emissions from the LULUCF sector, UK 1990-2021 ($MtCO_2e$)



Source: Tables 1.2 to 1.6, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

International comparison

UK territorial greenhouse gas emissions account for around 1% of the global total, based on a range of estimates produced by the UN, the International Energy Agency, and the World Resources Institute amongst others. Under the United Nations Framework Convention on Climate Change (UNFCCC), the UK and a number of other countries (known as the Annex I parties to the Convention[32]) report their territorial emissions each year to the UNFCCC, while other countries report theirs every few years. This allows for comparisons to be made between different countries' emission estimates following consistent approaches in line with the guidance set out by the Intergovernmental Panel on Climate Change (IPCC)[33].

Figure 18 shows the most recent territorial greenhouse gas emissions estimates reported to the UNFCCC for the UK and other members of the G20, and figure 19 shows this in terms of annual emissions per person in the population. To be consistent with other countries the UK emissions shown are the 2020 estimates submitted to the UNFCCC last year, so do not include the revisions to the estimates shown elsewhere in this publication. The members of the G20 account for around 85% of world GDP and about two thirds of the world's population[34].

The year the data relates to for each country is shown in the charts, for Annex I countries this is 2020. As these are territorial emissions, they only include emissions within a country's borders, so do not reflect any emissions resulting from the production of goods imported into a country or any international travel by its residents. The estimates shown include emissions and removals from the LULUCF sector. The coronavirus (COVID-19) pandemic and the resulting worldwide restrictions had different impact on different countries but have in general contributed to reduced greenhouse gas emissions in 2020 in most of the countries with data available, compared to previous years.

Countries' emissions tend to reflect their size, with the highest emissions coming from the countries with the largest populations and land areas. China is the country with the highest greenhouse gas emissions, of around 11,200 $MtCO_2e$ in 2014 (the latest year of data available), followed by the United States, which had emissions of 5,200 $MtCO_2e$ in 2020. The European Union (EU 27) had emissions in 2020 of 3,100 $MtCO_2e$.

When adjusted for population, Saudi Arabia has the highest emissions of G20 countries with 21 tonnes of CO_2e per person in 2020, while Australia, Canada, and the United States also each had emissions of over 15 tCO_2e per person in their latest available data. India has the lowest emissions per person in the G20, at around 2 tCO_2e per person in its latest data from 2016. The UK had emissions of around 6 tCO_2e per person in 2020. Higher emission rates can be associated with several factors, such as significant heavy industry, a large manufacturing sector, or the use of more carbon intensive fuels such as coal for electricity generation.

[32] Annex I parties' submissions in 2022 showing greenhouse gas emissions in 2020 are available here: https://unfccc.int/ghg-inventories-annex-i-parties/2022
[33] 2006 IPCC Guidelines for National Greenhouse Gas Inventories: https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html
[34] https://www.g20.org/en/about-g20/#overview

Figure 18: Most recent annual territorial greenhouse gas emissions reported to the UNFCCC: G20 countries ($MtCO_2e$)

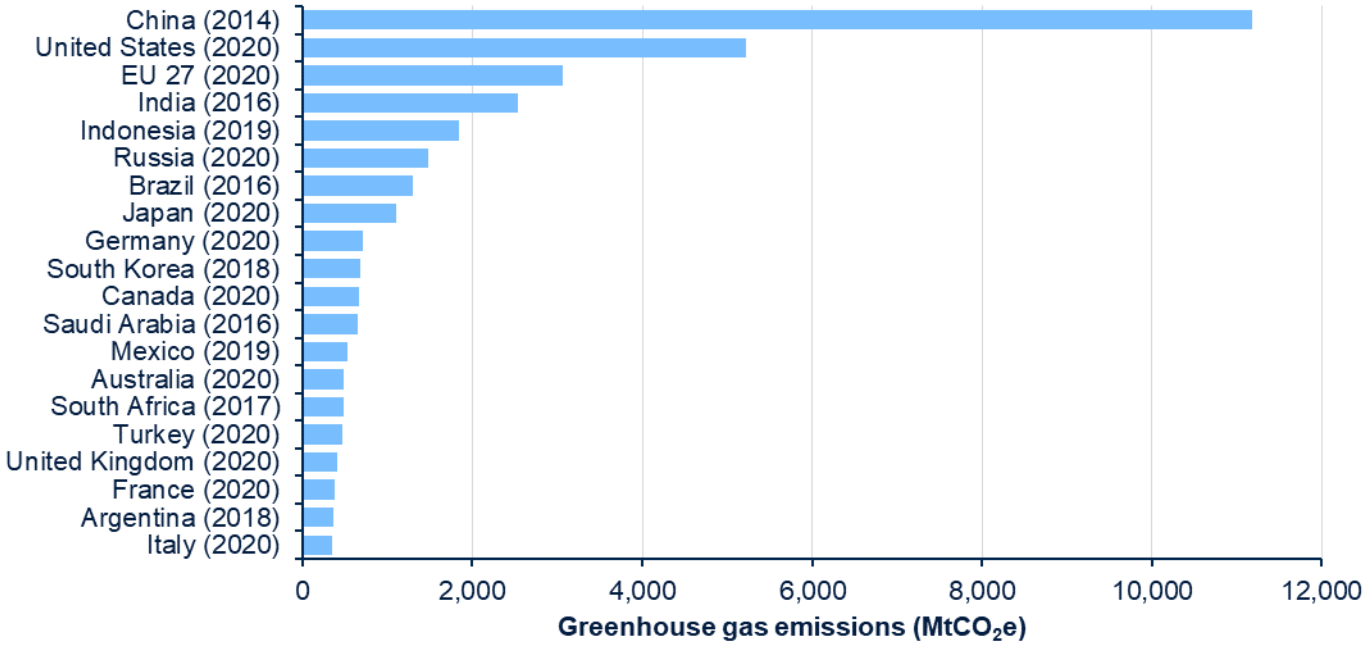
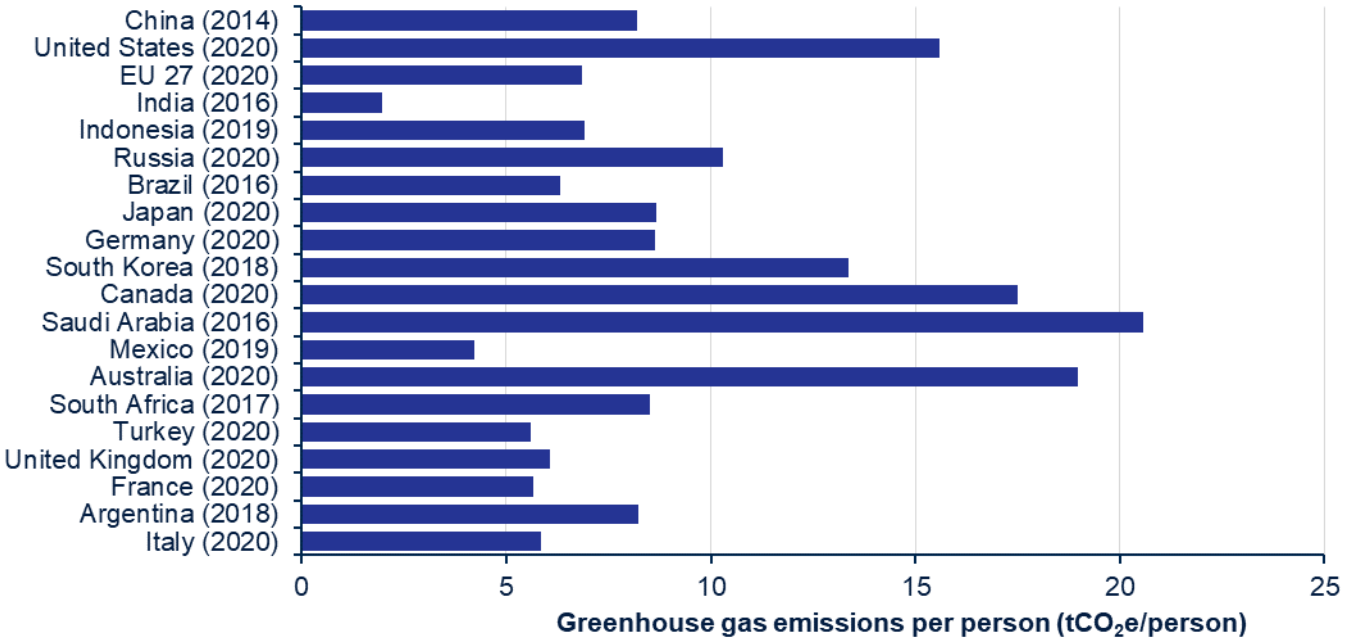


Figure 19: Annual territorial greenhouse gas emissions per person: G20 countries (tCO_2e per person)



Source: Countries' submissions to the UNFCCC

Notes:

1. The year the data relates to for each country is shown next to their name in the charts.
2. All emissions totals include emissions and removals from the LULUCF sector.
3. The UK figures include Crown Dependencies and certain Overseas Territories in line with its international reporting requirements, although they only make up around 1% of the UK emissions total.
4. The UK figures are the 2020 emissions estimates submitted to the UNFCCC in 2022 so do not incorporate the data updates and methodology changes made to the 2020 estimate in this publication.
5. The UK was included in the EU submission to the UNFCCC for 2020 but has been removed from the EU figures for this comparison. The EU total includes France, Germany, and Italy despite them also being shown separately.
6. In its last submission, Saudi Arabia reported its emissions for each gas separately in absolute terms. These figures have been converted to CO_2e using the same Global Warming Potentials as used for the UK figure to produce a combined total for this comparison.

Emissions from UK-based international aviation and shipping bunkers

In the data tables accompanying this publication, table 5.1 shows greenhouse gas emissions arising from use of fuels from UK international aviation and shipping bunkers since 1990.

Emissions from international aviation and shipping can be estimated from refuelling from bunkers[35] at UK airports and ports, whether by UK or non-UK operators. Under the reporting guidelines agreed by the UNFCCC, these emissions are not included in the UK's emissions total that is submitted to the UNFCCC but are reported as memo items in national greenhouse gas inventories. In line with international reporting requirements, the UK's 2030 emissions reduction target under the Paris Agreement (known as the UK's Nationally Determined Contribution) does not include emissions from international aviation and shipping. Parties to the UNFCCC are required to act to limit or reduce emissions from international services working through the International Civil Aviation Organization (ICAO) and International Maritime Organization (IMO).

It is important to note that whether emissions from refuelling at UK-based international aviation and shipping bunkers can be used as an accurate estimate of UK international aviation and shipping emissions will depend on what assumptions are being made about how to allocate international aviation and shipping emissions to different countries.

In the International Civil Aviation Organization, 193 states have agreed to implement a sectoral approach to tackling international aviation emissions, in the form of a "global market-based measure" known as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which does not allocate emissions to states. Under the scheme, airlines will offset their international aviation emissions covered by the scheme with reductions from other sectors, with the aim of delivering carbon-neutral growth of the sector from 2020[36]. In October 2022, ICAO member states agreed that the baseline above which international aviation emissions will be offset would be set at 85% of 2019 emissions from 2024. This is expected to result in offsetting beginning in 2024. They also agreed to strive to achieve a collective long-term global aspirational goal of net-zero carbon emissions by 2050. This goal does not attribute specific obligations or commitments to individual states[37].

In relation to the International Maritime Organization, the 2018 Initial Strategy on Reduction of GHG Emissions from Ships[38] commits its 175 Member States to, among other ambitions, peak greenhouse gas emissions from international shipping as soon as possible and to reduce the total annual greenhouse gas emissions by at least 50% by 2050 compared to 2008 while pursuing efforts towards phasing them out as soon as possible this century. The Initial Strategy is due to be revised in 2023.

In June 2021, the UK government set the Sixth Carbon Budget (covering 2033-37) to include the UK's share of international aviation and shipping emissions, as recommended by the

[35] A large container or compartment that stores fuel for ships or aircraft.
[36] https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx
[37] https://www.icao.int/environmental-protection/Documents/Assembly/Resolution_A41-21_Climate_change.pdf
[38] https://unfccc.int/sites/default/files/resource/250_IMO submission_Talanoa Dialogue_April 2018.pdf

Climate Change Committee. This is the first time emissions from international aviation and shipping will be included in the UK's domestic carbon budget targets.

In 2021, emissions from international aviation fuel use from UK bunkers were estimated to be 13.3 $MtCO_2e$. This was 10.2% lower than in 2020, when it was 14.8 $MtCO_2e$, 63.8% lower than in 2019, when it was 36.7 $MtCO_2e$ and is the lowest annual figure since these estimates begin in 1990. This was due to the continued fall in air traffic that commenced following the start of the COVID-19 pandemic, with the number of international flights landing or taking off from UK airports 9.1% lower in 2021 than in 2020 and 66.9% lower than in 2019[39]. Between 1990 and 2006, emissions more than doubled from 15.5 $MtCO_2e$ to 35.6 $MtCO_2e$. After 2006, emissions dipped slightly, then increased again above the 2006 peak between 2017 and 2019, before the fall in 2020. High altitude aviation has a greater greenhouse effect due to the formation of persistent condensation trails (contrails) over and above that of carbon dioxide emissions from fuel alone, but this is not reflected in these estimates.

Emissions from UK international shipping bunkers were estimated to be 6.2 $MtCO_2e$ in 2021, an increase of 2.9% from the 2020 level, but still a decrease of 15.3% from the 2019 figure. Although not as pronounced a drop as aviation, these emissions remain at lower levels following the large fall in shipping traffic that occurred following the start of the COVID-19 pandemic. Since 1990, emissions from UK shipping bunkers have fluctuated, as can be seen in the chart below, but in recent years before the reduction in 2020 had been at around the same level that they were in 1990.

Figure 20: Greenhouse gas emissions from UK-based international aviation and shipping bunkers, 1990-2021 ($MtCO_2e$)

Source: Table 5.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

Note that in the provisional 2022 UK greenhouse gas emission estimates that we will publish on 30 March 2023 we will include provisional estimates of emissions arising from use of fuels from UK international aviation and shipping bunkers in 2022, based on provisional energy statistics that will be published on the same day. This will be the first time we have published provisional estimates of these emissions.

[39] AVI0102: Air traffic by type of service, operator and airport
https://www.gov.uk/government/statistical-data-sets/aviation-statistics-data-tables-avi

Revisions from provisional estimates of greenhouse gas emissions

Provisional estimates of 2021 UK greenhouse gas and carbon dioxide emissions were published in March 2022, based on early estimates of energy consumption for the year. Differences between the provisional and final estimates arise primarily due to revisions to other statistics on which these estimates were based, use of actual data to estimate non-CO_2 emissions which are only estimated in a simplistic way in the provisional estimates, and methodological changes to the way emissions are calculated.

Typically, the provisional estimates provide a better indication of emissions trends than of absolute emissions, as they do not take account of any methodological improvements that may be made to the way emissions are calculated and which can lead to revisions to the whole emissions time series from 1990 onwards. More information on revisions to the time series can be found in the next section.

It was provisionally estimated that total greenhouse gas emissions in 2021 for the UK would be 424.5 $MtCO_2e$, representing a 4.7% increase on 2020 emissions. The final estimates show that 2021 emissions were 426.5 $MtCO_2e$, representing a 5.0% increase on 2020 emissions. Therefore, the provisional greenhouse gas emissions estimates underestimated the total greenhouse gas emissions in 2021 (by 0.5%) and underestimated the percentage increase in emissions from 2020 to 2021 (by 0.3 percentage points). The difference in the total is largely explained by methodology changes made this year and revisions to the energy data used in producing the estimates.

The provisional estimates are focused on carbon dioxide emissions from the energy sector, and only provide a simplistic estimate of non-CO_2 gases which assumed that the 2021 emissions for non-CO_2 gases changed from the 2020 total in line with the percentage difference between the estimates for 2020 and 2021 of total non-CO_2 emissions in the 2019 Energy and Emissions Projections[40] published by BEIS. Focusing on carbon dioxide emissions, it was provisionally estimated that net UK carbon dioxide emissions in 2021 were 341.5 million tonnes. The final 2021 figure of 339.5 million tonnes indicates that the provisional estimate overestimated CO_2 emissions by 0.6%. This was largely due to methodology changes in the final estimates and revisions to the energy data used in producing the estimates.

The provisional estimate for emissions of non-CO_2 gases in 2021 was 83.1 $MtCO_2e$ and the final estimate is 87.0 $MtCO_2e$, so these emissions were underestimated by 4.5% in the provisional estimates. This was largely due to the change this year to the Global Warming Potentials that are used in these estimates to present emissions of non-CO_2 gases in carbon dioxide equivalent units.

[40] Energy and emissions projections: https://www.gov.uk/government/collections/energy-and-emissions-projections

Table 2: Comparison of 2021 provisional and final estimates

UK, 2020-2021 $MtCO_2e$

	2021 Provisional estimates	2021 Final estimates	Difference between final and provisional	Provisional 2020 to 2021 % change	Final 2020 to 2021 % change
Total CO_2	341.5	339.5	-1.9	6.3%	6.6%
Non-CO_2 gases	83.1	87.0	3.9	-1.6%	-0.9%
All greenhouse gases	424.5	426.5	2.0	4.7%	5.0%

Source: Table 1.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables
Table 1, Provisional UK greenhouse gas emissions national statistics 2021 Excel data tables

Revisions to the UK's Greenhouse Gas Inventory

In the data tables accompanying this publication, table 4.3 shows how our estimates of greenhouse gas emissions in the UK since 1990 have been revised from year to year.

The UK Greenhouse Gas Inventory (the time series of emissions from 1990 onwards which is the basis for these statistics), is reviewed every year internally and externally (including a review by the UNFCCC), and the whole historical data series is revised where necessary to incorporate methodological improvements, changes to international reporting guidelines or new data. This takes into account revisions to the datasets which have been used in its compilation, most notably the UK energy statistics published in the Digest of UK Energy Statistics (DUKES). The methodological changes to the UK Greenhouse Gas Inventory can also impact future emissions projections. Full details of the methods used to produce the latest greenhouse gas emissions estimates will be published in the UK's National Inventory Report[41] (NIR).

These changes are applied back through the time series to 1990 to ensure that the trend in emissions from 1990 to the latest year is based on a consistent method. Therefore, it is not appropriate to compare the emissions time series from one year with that from another. However, the latest inventory represents a single consistent data series going back to 1990, and this therefore allows year-on-year comparisons to be made. Estimates of carbon dioxide emissions between 1970 and 1989 are also published in these statistics, but these no longer get updated each year and do not include estimates of some of the emission sources included in the data from 1990 onwards as earlier data are not available.

[41] Previous UK NIRs can be found here: https://naei.beis.gov.uk/reports/reports?section_id=3 and the latest NIR covering 1990-2021 emissions will be submitted to the UNFCCC on 15th April 2023.

Table 3: Revisions in the 1990-2021 Greenhouse Gas Inventory, by sector

UK, 1990 and 2020 $MtCO_2e$

	1990 emissions			2020 emissions		
	1990-2020 inventory	1990-2021 inventory	Change	1990-2020 inventory	1990-2021 inventory	Change
Energy supply	279.5	283.5	4.0	84.0	84.5	0.5
Transport	128.1	128.6	0.5	98.8	99.3	0.5
Business	113.2	111.9	-1.3	73.4	73.9	0.5
Residential	80.0	80.3	0.3	66.3	65.2	-1.1
Agriculture	53.6	54.4	0.8	44.8	46.6	1.8
Waste management	64.9	72.1	7.2	17.6	19.0	1.5
Industrial processes	60.4	55.4	-5.0	9.5	9.5	-0.1
Public	13.3	16.0	2.7	7.4	7.2	-0.3
LULUCF	13.1	11.1	-2.0	3.7	1.2	-2.5
Total	**806.3**	**813.4**	**7.1**	**405.5**	**406.3**	**0.8**

~0.0 indicates where a value is non-zero but is less than 0.05 $MtCO_2e$ in magnitude.
Source: Table 1.2, Final UK greenhouse gas emissions national statistics 1990-2021 Data tables
Table 1.2, Final UK greenhouse gas emissions national statistics 1990-2020 Data tables

The most notable methodological change to the historical series since the 1990-2020 Greenhouse Gas Inventory was published is the change in the Global Warming Potentials used to present emissions of non-CO_2 gases in carbon dioxide equivalent units, which generally increased the emission estimates other than in the industrial processes sector which saw a notable downward revision to the early part of the time series. There have also been several methodological changes in the LULUCF sector that reduced the net emission totals across the time series for this sector. Revisions to the datasets used in producing these estimates have also led to changes across most sectors for more recent years. Details of the changes made to estimates of 1990 and 2020 emissions are given in Table 3. Revisions to other years of the time series are generally of a similar scale.

Within the sectors there have also been some changes made to the source categories presented in the tables compared to the previous publication. These are summarised below.

NC category	NC Sector	Reason for change
Small-scale waste burning	Residential	This is a new category this year that includes emissions from the burning of waste, which are being included in these statistics for the first time this year.
Public sector combustion	Public	This is a renaming of the '*Public'* category from previous publications to make it clearer what it covers. The coverage is unchanged.

Details of the methodological changes made to the emissions estimates this year are given below.

Change in Global Warming Potentials (GWPs)

So that emissions of different greenhouse gases can be reported on a consistent basis the UK's estimated emissions of each greenhouse gas (carbon dioxide, methane, nitrous oxide, fluorinated gases) are expressed in terms of carbon dioxide equivalent (CO_2e), based on estimates of the different global warming potentials (GWP) of each gas. The GWP for each gas is defined as its warming influence in relation to that of carbon dioxide over a 100-year period.

Figures for GWPs are set out in Intergovernmental Panel on Climate Change (IPCC) Assessment Reports (AR). In last year's publication, emissions estimates were based on GWPs from Working Group 1 of the IPCC Fourth Assessment Report: Climate Change 2007 (AR4), consistent with international reporting up to 2020. In November 2021 it was agreed by the international community at COP26 that greenhouse gas emissions shall be reported under the Paris Agreement transparency framework using GWPs (without climate-carbon feedback) from Working Group 1 of the IPCC Fifth Assessment Report: Climate Change 2014 (AR5)[42].Therefore this year's emissions estimates will be based on 100-year AR5 GWPs.

As carbon dioxide emissions dominate the national emissions total and are not impacted by changes to GWPs this only has a limited impact on the national total, increasing it by around 1% each year. But it has a larger impact on the emission totals for sectors like agriculture and waste management that are predominantly other gases.

Thermal renewables balance

As of the most recent publication of the Digest of UK Energy Statistics (DUKES)[43], the granularity available in Chapter 6 regarding renewable energy usage has expanded to cover a greater number of sectors. As a result of this it is now possible to not only accommodate this extra detail in the years where it is available, but also use the data to create a consistent timeseries back to 1990 where appropriate.

As such this improvement item first restructured the steps to bring the DUKES data into the model to allow for the newly disaggregated data and then analysed the available data and reconciled it across the timeseries to ensure consistency.

Though many of the sectors now listed in DUKES do not currently have any energy consumption data associated with them, the structural changes to the model due to this improvement item mean that going forward the inventory is ready to incorporate any such data as it becomes available.

For the sectors that do have data, the improved granularity in recent years has enabled us to improve the gap filling and reallocation processes that are used in the model for the earlier years. This means that there are some small changes to the total energy balance in the pre-1998 years but overall, the improvement item has simply been a reallocation of energy across solid biomass and biogas across the sectors.

Therefore, the impact of this improvement on the UK's total greenhouse gas emissions estimates is minimal but the disaggregation from DUKES means that we can split out the energy across a greater number of sources, providing value to users who may need to utilise it.

[42] https://unfccc.int/documents/311138
[43] https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2022

Non-road mobile machinery use of gas oil

Defra has commissioned new research for estimates of emissions from non-road mobile machinery (NRMM). This has included revised estimates for gas oil use in agricultural and industrial NRMM.

Gas oil can be used for small stationary and mobile applications, and a wide range of sectors. DUKES does not specify whether fuel is used in mobile or stationary engines, and until recently a large proportion of fuel was allocated to 'unclassified' due to the users being unknown.

Previously, where available the inventory used bottom-up data for NRMM, but when there was not sufficient fuel left in the DUKES balance to assign to all end uses, industrial NRMM was scaled to maintain consistency with DUKES. However, the recent study on NRMM use yielded a much higher estimate of fuel use estimated for agricultural NRMM, meaning that it appeared unfeasible to use the existing approach to reconciling the gas oil balance, as very little fuel would be left over for industrial NRMM.

Now, when there is not enough fuel to allocate to bottom-up estimates, the new approach adjusts all bottom-up NRMM estimates, including agricultural NRMM depending on the degree to which those bottom-up estimates agree with DUKES allocations to sectors which use those types of machinery. The logic of the new reconciliation approach can be summarised as follows:

1. Separate out sources which should not be factored into the reconciliation (e.g. because they are well understood, like rail, or because the inventory is deviating from DUKES for the sector as a whole, such as national navigation), and establish the quantity of gas oil which is available for the sectors being reconciled (notably including 'unclassified' gas oil in the DUKES balance).
2. Always use the de minimis data on stationary fuel use from established (but likely incomplete) data such as the EU and UK Emission Trading Schemes; this includes values for cement, commercial, public, iron and steel, agriculture and other industry.
3. Always use NRMM fuel use which coincides with DUKES allocations after removing the de minimis for stationary use (e.g. if mining and quarrying NRMM is less than or equal to the DUKES minerals industry minus operator reported cement stationary use, then keep the mining and quarrying fuel use as is).
4. If there is not enough fuel in the DUKES balance to allocate to bottom-up NRMM estimates, then scale the amount which exceeds each DUKES sector. This effectively means that where the bottom-up estimates agree with DUKES, then there is no scaling, and there is more scaling when there is more disagreement.
5. When there is enough fuel for all bottom-up estimates from the inventory, split the remaining fuel by the residual of each sector which is not thought to be NRMM, capped at the DUKES allocation to each sector.
6. If there is still fuel left in 'unallocated' after all fuel has been allocated in the previous step, then allocate this remainder to 'other industry'.

While most of these changes have little impact on total carbon dioxide estimates due to being the same fuel allocated to a different sector, there is one change which increases the total gas oil estimated to be used: we now consider port machinery to be captured in what DUKES allocate to national navigation (i.e. shipping). This results in an increase to which the inventory

deviates from DUKES with respect to national navigation (this deviation was established in a previous inventory where new shipping estimates were implemented).

Note that this methodology retains a limitation of the previous approach in that we expect that stationary fuel use is underestimated. In the absence of a complete bottom-up estimate of stationary gas oil use, we don't have any reference to give weight to, and therefore assign gas oil to stationary applications.

Non-road mobile machinery use of liquefied petroleum gas (LPG)

Defra has commissioned new research for estimates of emissions from non-road mobile machinery (NRMM), including from LPG use in NRMM. This has been introduced to the inventory as a new source, with the fuel reallocated from the "other industry" category to maintain the overall balance with DUKES. This is a reallocation within the business category, with the only impact of the change being small revisions to CH_4 and N_2O.

Non-road mobile machinery use of road fuels

The NRMM updates have also impacted bottom-up estimates of petrol and diesel (DERV) use in NRMM. Both emission factors and the total fuel allocated has been revised.

Road transport fuel use is estimated from DUKES as DUKES transport fuel use minus fuel use from NRMM and inland waterways. The improvements made to the NRMM model have significantly revised the estimates of petrol and DERV from NRMM and so had a knock-on impact for the petrol and DERV allocation for road transport. DERV use is most affected as it was previously assumed that some industrial machinery used DERV, but we now assume that those machines use gas oil only.

Non-medical aerosols

Our estimates previously assumed that the gas HFC-152a had seen an increase in use to replace HFC-134a in non-medical aerosols. In consultation with the British Aerosol Manufacturers' Association, we found that this has not been the case for the following reasons:

- 152a is more flammable than 134a
- 152a is not as cheap as using hydrocarbon replacements.

We expect that the majority of 134a applications went to hydrocarbons and that the rest have changed to HFO-1234ze, which has low flammability but is more expensive than hydrocarbons. In future, it is anticipated that the aerosols sector will go towards using compressed air/nitrogen/CO_2 for applications that need to be non-flammable rather than towards another F-gas.

Therefore, it is now assumed that the use of HFC-152a only continued at the level that it was used before the ban on 134a use rather than increasing.

Refrigerant containers

Containers (cylinders or cans) are used to transport F-gases from manufacturing sites to their use in refrigerating or air-conditioning systems. Gases may leak during the process of filling and emptying these containers and these emissions are captured in the Container Model.

The input to the Container Model is the quantity of gases that are required to be transported each year, which had previously come from the ICF International model of F-gas usage (2015). This input has been updated to come from the HFC Outlook model, which has been used for the UK's refrigerating or air-conditioning F-gas emission estimates since 2021. Using the HFC Outlook model provides more up to date estimates of quantities of F-gases transported, as well as aligning the inputs for transportation modelling with modelling of many other sources of F-gas emissions.

Wastewater pre-processing review

Reporting of wastewater data have changed substantially multiple times since 1990, meaning that substantial pre-processing of these data is required to determine a consistent time-series of each of the types of activity relating to municipal wastewater management. This pre-processing was reviewed following a new change in the format of data received from water companies. Notable changes made because of this review include:

- Revising assumptions about the uptake of advanced digestion in the early 1990s. Previously an assumption based on data for later years was used, but now the strong increasing trend in the available data has been utilised to justify assigning much less advanced digestion in early years.
- Interpolations, extrapolations, and splicing is now done at a company level first where available, and then a regional level. Previously some of these data were aggregated further before splicing, extrapolating, or interpolating, which might have lost some of the company, or region-specific features. This has a particularly large impact on the gap filling approach to estimating untreated wastewater disposed to sea.

Small-scale waste burning

Greenhouse gas emissions from the burning of domestic, commercial, industrial, and construction and demolition waste have not been estimated previously in the Greenhouse Gas Inventory, despite emissions of air quality pollutants in the UK having been estimated for several years for these sources.

Carbon and bio-carbon emission factors were calculated using information on a variety of waste types, (e.g. plastics, paper) from Chapters 5.2 and 5.5 in the IPCC 2006 guidelines[44] on the:

- Dry matter content proportion of the wet weight,
- Total carbon content
- Fossil carbon content.

The emissions factors for CH_4 and N_2O also come from the IPCC 2006 guidelines. The CH_4 emission factors are constant, and N_2O vary with the dry matter content of the waste.

Land use, land use change and forestry modelling changes

There have been several methodological updates to the land use, land use change and forestry (LULUCF) estimates, including:

[44] https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

- A new CO_2 emission factor has been incorporated for cropland on wasted peat (peat <40cm) in England of 15.98 tonnes CO_2 per hectare per year, which is lower than the 28.60 tonnes CO_2 per hectare per year used in last year's inventory. This was from new flux tower data collected as part of an ongoing BEIS-funded study to support the development of Tier 2 emission factors for cropland and intensive grassland on wasted peat.

- A number of new emission factors have been incorporated following an updated Tier 2 analysis of organic soil emission factors from a Defra project to align emission factors in the Peatland Code with the UK Greenhouse Gas Inventory. This update incorporates new UK datasets, including data from the UK flux tower network, as well as international data from climatically similar regions. Existing data and classifications used in the emission factors database were also reviewed and revised, with the exclusion of several cropland and grassland flux data for methodological reasons, and of data from 'flooded' sites that were not representative of desirable restored sites. Particulate organic carbon emission factors were updated for all soil categories using an IPCC Tier 1 methodology (IPCC 2014 Appendix Eq.2A.1). Note that there are some slight differences between emission factors used in the inventory and those in the Defra Peatland Code, where the inventory has maintained a requirement for Tier 2 emission factors to be calculated from at least four different primary locations to replace Tier 1 values.

- Revision of the assumed planting on organic soils to adjust for deforestation, so that the total reported forest land on organic soils matches the estimates from the peat map (for 2013 in England, 1990 in Scotland and Wales, and 2007 in Northern Ireland), including 1880-1899 planting on organic soils in Northern Ireland. This area was previously assigned to mineral soil in the 1990-2020 inventory, as the previous Northern Ireland methodology had no pre-1900 planting. This also has a knock-on effect to the harvested wood products. Assumed management was revised to best match to the updated data (including new estimates of wood production in Northern Ireland).

- Revisions to the organic soils maps were included from a BEIS project to edit and check the geometry of the maps and clarify activity data and the assumptions used to create the maps in Evans et al. 2017. This resulted in a revision of the restoration data for intensive grassland, where an error was identified in the Peatland Compendium dataset, which overestimated intensive grassland to rewetted fen restoration in south-west England. Updated restoration data were supplied by Natural England and the RSPB.

- Carbon stock change from Cropland for the Falkland Islands was recalculated to correctly take account of ley grassland within Cropland. The only way to use available data from the Falkland Islands agricultural census along with the UNFCCC twenty-year transition periods is to assume that some of the Cropland area is ley grassland.

- The annual increase in Grassland converted to Settlement in the Falkland Islands from 1991 onwards was reduced to correct a transcription error in the area required per dwelling.

Accompanying tables

The following tables are available in Excel and ODS format on the department's statistics website, alongside a CSV dataset of UK territorial greenhouse gas emissions. Note that tables in sections 5, 6 and 7 of the data tables have been renumbered from last year's publication as the tables on an end-user basis will now be published in a separate file on 30th March 2023.

UK territorial emissions

Table 1.1	Estimated territorial greenhouse gas emissions by gas, UK 1990-2021
Table 1.2	Estimated territorial greenhouse gas emissions by source category, UK 1990-2021
Table 1.3	Estimated territorial emissions of carbon dioxide (CO_2) by source category, UK 1990-2021
Table 1.4	Estimated territorial emissions of methane (CH_4) by source category, UK 1990-2021
Table 1.5	Estimated territorial emissions of nitrous oxide (N_2O) by source category, UK 1990-2021
Table 1.6	Estimated territorial emissions of fluorinated gases (F gases) by source category, UK 1990-2021
Table 1.7	Estimated territorial greenhouse gas emissions by type of fuel, UK 1990-2021
Table 1.8	Estimated territorial emissions of carbon dioxide (CO_2) by source category, UK 1970-1990

UK territorial emissions targets

Table 2.1	UK territorial greenhouse gas emissions: progress towards the UK Carbon Budget targets
Table 2.2	UK territorial greenhouse gas emissions: progress towards the Kyoto Protocol first commitment period, Kyoto Protocol second commitment period and EU Effort Sharing Decision

UK territorial emissions for international reporting, including Crown Dependencies & Overseas Territories

Table 3.1	Estimated territorial greenhouse gas emissions by geographical coverage and gas, UK, Crown Dependencies & Overseas Territories, 1990-2021
Table 3.2	Estimated territorial greenhouse gas emissions for the UK, Crown Dependencies and Overseas Territories by source category, 1990-2021
Table 3.3	Estimated territorial greenhouse gas emissions in the UK, Crown Dependencies & Overseas Territories, and totals reported to the UNFCCC, 1990-2021
Table 3.4	Estimated territorial greenhouse gas emissions for the UK, Crown Dependencies and Overseas Territories by type of fuel, 1990-2021

Uncertainty of territorial emission estimates and past revisions

Table 4.1	Uncertainty in estimates of territorial greenhouse gas emissions by gas, UK, Crown Dependencies and Overseas Territories: 1990/2020 *(will be updated on 30th March 2023 with 2021 estimates)*
Table 4.2	Uncertainty in estimates of territorial greenhouse gas emissions by source sector, UK, Crown Dependencies and Overseas Territories: 1990/2020 *(will be updated on 30th March 2023 with 2021 estimates)*
Table 4.3	Estimated territorial greenhouse gas emissions: changes over successive Greenhouse Gas Inventories from 1990-2008 to 1990-2021

Emissions from the use of fuels from UK international aviation and shipping bunkers (not included in UK territorial emission totals)

Table 5.1	Estimated greenhouse gas emissions arising from the use of fuels from UK international aviation and shipping bunkers, 1990-2021

Reference tables

Table 6.1	Sectoral definitions and inclusions: relationships between source categories as defined by the IPCC and the categories used in this publication
Table 6.2	Sectoral details, methodologies, and data sources
Table 6.3	Fuel categories used in greenhouse gas emissions statistics
Table 6.4	List of Global Warming Potentials (GWP) of greenhouse gases used in UK emissions estimates

UK territorial emissions on an end-user basis *(will be added in a separate file on 30th March 2023)*

Table 7.1	Estimated territorial greenhouse gas emissions by end user category, UK 1990-2021
Table 7.2	Estimated territorial emissions of carbon dioxide (CO_2) by end user category, UK 1990-2021
Table 7.3	Estimated territorial emissions of methane (CH_4) by end user category, UK 1990-2021
Table 7.4	Estimated territorial emissions of nitrous oxide (N_2O) by end user category, UK 1990-2021
Table 7.5	Estimated territorial emissions of fluorinated gases (F gases) by end user category, UK 1990-2021
Table 7.6	Estimated territorial emissions of carbon dioxide (CO_2) by end user category, UK 1970-1990

UK territorial emissions by Standard Industrial Classification (SIC)
Tables showing emissions by Standard Industrial Classification (SIC) will be added to this publication in a separate file on 29th June 2023.

Technical information

Methodology for producing greenhouse gas emissions estimates

It is impractical to directly measure emissions from every exhaust, chimney, and acre of land in the UK, so greenhouse gas emission estimates are based on a series of models that estimate emissions from different sources. The source data and methods used to derive UK greenhouse gas emission estimates have been developed to be consistent with methods defined within international guidance[45]. All countries that report to the UNFCCC are required to use these estimation methods to ensure that the emissions for each country are complete and comparable.

The basic equation for estimating most sources of emissions is:

$$Emission\ Factor\ \times Activity\ Data = Emission\ Estimate$$

For example, to estimate CO_2 emissions from vehicles the activity data might be the total number of kilometres travelled by that type of vehicle and the emission factor the amount of CO_2 emitted per kilometre.

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

The UK Greenhouse Gas Inventory uses the best available data from UK and international research for each emission source. The approach used is largely defined by the availability of data and the significance of the emission source in the overall UK inventory: more detailed

[45] 2006 IPCC Guidelines for National Greenhouse Gas Inventories: https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html
2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement): https://www.ipcc-nggip.iges.or.jp/public/wetlands/index.html
2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP Supplement): https://www.ipcc-nggip.iges.or.jp/public/kpsg/index.html

methods are used for the high-emitting sources, whilst simpler methods can be used for minor sources, consistent with international guidance.

For some sources, the calculation of emissions is more complicated, and therefore a more complex model is used to estimate emissions. For example, emissions of methane from waste disposed to landfills are estimated using a model that reflects the fact that the emissions occur over a long timeframe from the initial disposal of the waste, and that emissions are affected by the level of capture and utilisation of the landfill methane produced. The CO_2 emissions and removals from land use, land use change and forestry are also modelled.

Table 6.2 in the data tables accompanying this publication summarises the methods and data sources used to estimate emissions from each source, and there are factsheets published on the NAEI website[46] that summarise the main data sources and methods used for each sector. More detailed methodology information for each source can be found in the National Inventory Report submitted to the UNFCCC each year. The report for the 1990-2021 inventory will be published on 15 April 2023, so the report for the 1990-2020 inventory[47] is the most recently available at the time of this publication.

BEIS also runs a programme to monitor atmospheric concentrations of greenhouse gases, which is used to verify the emission estimates made in the Greenhouse Gas Inventory[48].

Estimating emissions on a temperature adjusted basis

In our provisional 2021 UK greenhouse gas emission statistics[49] we published estimates of temperature adjusted emissions, which give an idea of overall trends in emissions without fluctuations due to changes in external temperatures. The provisional emissions series is estimated based on UK provisional energy consumption data published by BEIS and is not as accurate as the estimates in this statistical release, which are derived from our annual Greenhouse Gas Inventory. We can compare the latest provisional unadjusted and temperature adjusted emissions with the final estimates now available.

On a temperature adjusted basis, net carbon dioxide emissions in 2020 and 2021 were estimated to be 338.0 Mt and 349.5 Mt respectively. The increase in carbon dioxide emissions between 2020 and 2021 in the temperature adjusted figures is therefore 11.5 Mt, which is less than the increase seen in the provisional non-temperature adjusted figures, as can be seen in the table below. This suggests that the underlying change between 2020 and 2021 when adjusted for temperature would be less than the 6.6% shown.

[46] Sector, Gas and Uncertainty Summary Factsheets: https://naei.beis.gov.uk/overview/ghg-overview
[47] UK National Inventory Report 1990-2020: https://naei.beis.gov.uk/reports/reports?report_id=1072
[48] Monitoring and verification of long term UK atmospheric measurement of greenhouse gas emissions: https://www.gov.uk/government/publications/uk-greenhouse-gas-emissions-monitoring-and-verification
[49] Provisional 2021 UK greenhouse gas emissions: https://www.gov.uk/government/statistics/provisional-uk-greenhouse-gas-emissions-national-statistics-2021

Table 4: Comparison of provisional UK carbon dioxide emissions estimates with final estimates, 2020-2021

UK 2020-2021 $MtCO_2$

	2020 CO_2 emissions (Mt)	2021 CO_2 emissions (Mt)	Absolute change (Mt)	Percentage change
Final estimates ➢ unadjusted emissions	318.5	339.5	21.0	6.6%
Provisional estimates ➢ unadjusted emissions	321.1	341.5	20.4	6.3%
Provisional estimates ➢ Temperature adjusted emissions	338.0	349.5	11.5	3.4%

Source: Table 1.1, Final UK greenhouse gas emissions national statistics 1990-2021 Data tables
Table 3 & 4, Provisional UK greenhouse gas emissions national statistics 2021 Excel data tables

Note: The provisional emissions estimates differ from the emissions estimates shown elsewhere in this publication because they were published before the 2021 figures presented were finalised.

Uncertainties

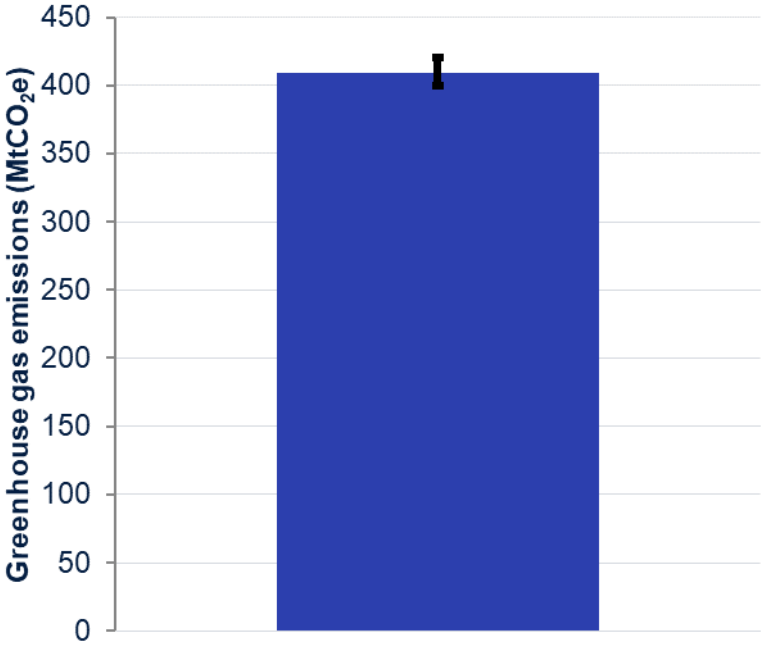
In the data tables accompanying this publication, table 4.1 shows the uncertainty in the 2020 UK greenhouse gas emissions estimates by gas and table 4.2 shows it by NC sector. These will be updated to show the equivalent 2021 estimates on 30 March 2023.

Estimates of greenhouse gas emissions have an inherent uncertainty due to uncertainty in the underlying data used to calculate the emissions, and due to uncertainty in the applicability, completeness, and application of that data. Uncertainty analysis is conducted by modelling the uncertainty in the underlying emission factors, activity data, and other variables within models, or in the overall model output. The uncertainties are expressed as a 95% confidence interval. This means that in the uncertainty model 95% of the simulated values fell between the intervals shown.

The overall uncertainty around total greenhouse gas emissions for 2020 is estimated to be around 3%, as shown in Figure 21 (which is based on uncertainty analysis of 2020 emissions, as published in 2022). The geographic coverage of the uncertainty estimates includes the UK, Crown Dependencies and Overseas Territories, but uncertainty estimates for the UK only would be expected to be very similar. Estimates of 2021 uncertainties will be published on 30 March 2023.

The uncertainty of greenhouse gas emissions estimates varies considerably by sector. LULUCF emissions estimates are the most uncertain, followed by waste management and agriculture. Among the different greenhouse gases, carbon dioxide estimates have the lowest uncertainty associated with them while nitrogen trifluoride and perfluorocarbons estimates are the most uncertain.

Figure 21: Illustration of uncertainty in UK greenhouse gas emissions, UK, Crown Dependencies and Overseas Territories, 2020 ($MtCO_2e$)



The error bar on this chart represents the uncertainty range (in this case, the 95% confidence interval) around the 2020 total greenhouse gas emissions central estimate.

Source: Table 4.1, Final UK greenhouse gas emissions national statistics 1990-2020 Excel data tables

Further information

Future updates to these statistics

On Thursday 30 March 2023 BEIS will publish a breakdown of 1990-2021 UK territorial emissions by end-user sector to supplement the source sector breakdown included in this publication and estimates of the uncertainty in the 2021 emission estimates.

On Thursday 30 March 2023 BEIS will also publish provisional estimates of UK greenhouse gas emissions for 2022. This will coincide with the publication of Energy Trends statistics, which will include estimates of 2022 UK energy consumption.

On Thursday 29 June 2023 BEIS will publish estimates of 1990-2021 UK territorial emissions by Standard Industrial Classification (SIC), to supplement the sector breakdown included in this publication.

On Thursday 29 June 2023 BEIS will also publish estimates of greenhouse gas emissions by local authority for 2021.

Final estimates of UK greenhouse gas emissions for 2022 will be published in February 2024.

Related publications

- This statistical release and the related data tables are the first release of data from the National Atmospheric Emissions Inventory (NAEI) for 1970-2021, produced for BEIS and

the Devolved Administrations by Ricardo Energy & Environment. Additional results will be released as they become available. For further information on the UK Greenhouse Gas Inventory, see the NAEI website.

- The UK's National Inventory Report (NIR) for 1990-2021 will be submitted to the United Nations Framework Convention on Climate Change (UNFCCC) on 15th April 2023. The report will contain national territorial greenhouse gas emissions estimates for 1990-2021 and descriptions of the methods used to produce the estimates. Previous reports can be found on the NAEI website.

- The background quality report provides a summary of quality issues relating to statistics on UK territorial greenhouse gas emissions.

- There are uncertainties associated with all estimates of greenhouse gas emissions. Although for any given year considerable uncertainties may surround the emissions estimates for a pollutant, it is important to note that trends over time are likely to be much more reliable. For more information on these uncertainties see the uncertainties factsheet on the NAEI website.

- Estimates of territorial greenhouse gas emissions in the four countries of the UK are published on the NAEI website and for local authority areas on gov.uk. In both cases estimates of emissions in 2021 will be published in June 2023.

- BEIS also publishes UK territorial emissions projections based on assumptions of future emission reduction policies, economic growth, fossil fuel prices, electricity generation costs, UK population and other key variables.

- Further information about the Kyoto Protocol and the Paris Agreement can be found on the UNFCCC's website.

- Further details of the European Union Emissions Trading System can be found on the European Commission website.

- Under the Climate Change Act, the Annual Statement of Emissions for 2021 must be laid before Parliament and published no later than 31st March 2023. This will give details of the net UK carbon account for 2021, which is used to determine compliance with the targets and budgets under the Act.

- ONS publishes emissions on a "residency" basis in the UK Environmental Accounts. The figures represent emissions caused by UK residents and businesses whether in the UK or abroad but exclude emissions within the UK which can be attributed to overseas residents and businesses.

- Defra publishes the UK's carbon footprint. This estimates emissions on a "consumption" basis, meaning it covers emissions associated with the consumption of goods and services by households in the UK. It includes estimates of emissions associated with each stage of the supply chain for those goods and services, regardless of where they occur, while excluding emissions occurring in the UK that are associated with the consumption of goods and services by households outside the UK.

- The latest UK energy statistics, including revisions to earlier years' data, can be found in the Digest of UK Energy Statistics.

- Detailed UK temperature data can be found on both the Met Office website and the Weather Statistics section of the gov.uk website.

- Similar results for non-greenhouse gas atmospheric pollutants are published by Defra in its statistics on Emissions of air pollutants in the UK.

Revisions policy

The BEIS statistical revisions policy sets out the revisions policy for these statistics, which has been developed in accordance with the UK Statistics Authority Code of Practice for Statistics.

Uses of these statistics

The UK's territorial greenhouse gas emission estimates are used by central government departments, devolved governments and local authorities to understand emissions in the areas they are responsible for, to develop policies to reduce emissions and to set targets. They are the basis for the UK's domestic and international emissions targets and are required to be reported each year to the UNFCCC.

Outside government the statistics are used by the media and the public to understand the level of greenhouse gas emissions in the UK and trends over time. They provide detailed emissions data on gases, sectors and sub-sectors that may of interest to users (particularly academics) with a focus on a particular area of emissions. The data are also the basis of emission conversion factors that are used by companies and other organisations to report their greenhouse gas emissions.

Information about user needs for greenhouse gas emission statistics is published in our background quality report.

User engagement

Users are encouraged to provide comments and feedback on how these statistics are used and how well they meet user needs. Comments on any issues relating to this statistical release are welcomed and should be sent to: GreenhouseGas.Statistics@beis.gov.uk

The BEIS statement on statistical public engagement and data standards sets out the department's commitments on public engagement and data standards as outlined by the Code of Practice for Statistics.

National Statistics designation

National Statistics status means that our statistics meet the highest standards of trustworthiness, quality and public value, and it is our responsibility to maintain compliance with these standards.

The continued designation of these statistics as National Statistics was confirmed in September 2018 following a compliance check by the Office for Statistics Regulation. The statistics last underwent a full assessment against the Code of Practice for Statistics in 2014.

Since the latest review by the Office for Statistics Regulation, we have continued to comply with the Code of Practice for Statistics, and have made the following improvements:

- Improved the accuracy of the historic emissions estimates by continuing to make methodological changes to the UK's Greenhouse Gas Inventory.
- Provided more methodological and background information about the statistics in the statistical release and included international comparisons.
- Published more detailed datasets alongside the Excel tables that we publish and new tables showing territorial emissions by Standard Industrial Classification (SIC).

Pre-release access to statistics

Some ministers and officials receive pre-release access to these statistics up to 24 hours before release. Details of the arrangements for doing this and a list of the ministers and officials that receive pre-release access to these statistics can be found in the BEIS statement of compliance with the Pre-Release Access to Official Statistics Order 2008.

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This publication is available from: https://www.gov.uk/government/collections/uk-territorial-greenhouse-gas-emissions-national-statistics

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