



## Annex 1: 2021 UK greenhouse gas emissions, final figures by end user and uncertainty estimates

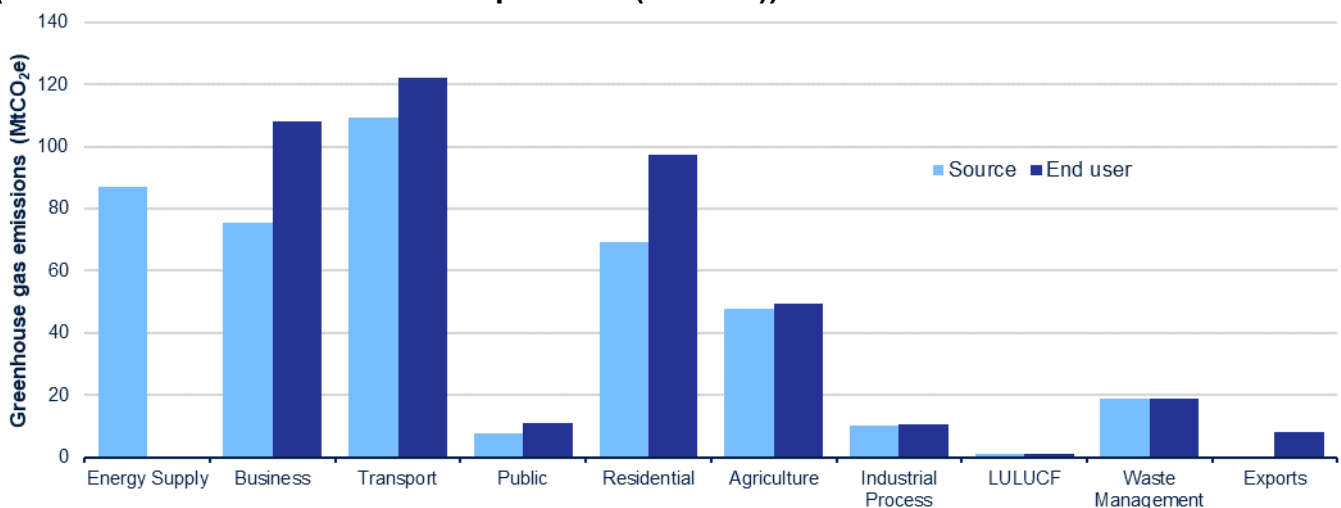
30 March 2023

National Statistics

This publication is an extension of the UK territorial greenhouse gas emission estimates by source for 1990-2021 published in February 2023. It provides the latest estimates of 1990-2021 territorial greenhouse gas emissions in the UK for end users, which are presented in carbon dioxide equivalent units throughout this statistical release. The end user breakdown reallocates emissions by source to where the “end-use” occurred. This means that emissions from the energy supply sector, such as those from power stations, are reallocated to other sectors based on their energy use. The total emissions presented here are consistent with the data published in February by source sector. Uncertainty estimates for UK territorial greenhouse gas emissions are also presented by gas and by source sector.

- In 2021 it is estimated that 29% of greenhouse gas emissions were from transport, making it the sector with the largest emissions on an end user basis. 25% of emissions were from the business sector, 23% from the residential sector and 12% from agriculture. The remainder were attributable to the industrial processes, public, waste management, land use, land use change & forestry (LULUCF), and exports sectors.

**Figure 1: Greenhouse gas emissions by source sectors and end user sectors, UK 2021 (million tonnes carbon dioxide equivalent (MtCO<sub>2</sub>e))**



Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

- Uncertainty in UK greenhouse gas emissions estimates is around 2%, based on uncertainty analysis of the 2021 emissions estimates which were published in February 2023. The uncertainty of UK greenhouse gas emissions estimates varies considerably by gas and sector. Carbon dioxide estimates have the least uncertainty associated with them while nitrogen trifluoride and perfluorocarbons estimates are the most uncertain. At sector level, LULUCF emissions estimates have the highest uncertainty, followed by waste management and agriculture.

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# Introduction

This Annex contains final estimates of 1990 to 2021 UK territorial greenhouse gas emissions by end user sector, as well as uncertainty estimates for 2021 emissions by source sector and gas. These are a follow up to, and are consistent with, the final estimates of 1990 to 2021 emissions by source sector which were published on 7<sup>th</sup> February 2023.

Emissions by end user and the uncertainty estimates have now been incorporated as updates into the data tables published alongside the [Final UK Greenhouse Gas Emissions Statistics](#). Tables 7.1 to 7.6 present emissions by end user category overall and for each gas, and in a change from previous years have been included in a separate file from the other tables published as part of this publication. Uncertainty analysis for 2021 emissions by gas and by sector are shown in tables 4.1 and 4.2 respectively. A csv dataset of the end user estimates has also been included in the publication.

The geographic coverage of emissions by end user in this report is UK only. For the purposes of reporting, greenhouse gas emissions are allocated into National Communication (NC) sectors as follows:

- Energy supply
- Business
- Transport
- Public
- Residential
- Agriculture
- Industrial processes
- Land use, land use change, and forestry (LULUCF)
- Waste management

When emissions are reported by source, emissions are attributed to the sector that emits them directly. The end user breakdown reallocates emissions by source to where the “end-use” occurred. The main impact is to reallocate emissions from the energy supply sector to other sectors that use the energy. Some emissions are also allocated to an “exports” category in the end user breakdown where the end-use is outside the UK. This is for emissions within the UK from the production of fuels (for example from a refinery or coal mine), which are subsequently exported or sent to bunkers for use outside the UK. This makes it possible to see the full emissions impact within the UK of a particular end-use sector or sub-sector (although emissions that occur outside the UK are excluded). This also enables the emissions to be further geographically disaggregated. Devolved administration and local authority emissions estimates, based on the end user breakdown, will be published in June 2023.

The uncertainty estimates are used to prioritise further research into improving emissions estimates, and more generally give users an indication of the robustness of the emissions estimates for different sectors. The geographic coverage of the uncertainty estimates includes the UK, Crown Dependencies and Overseas Territories.

Note that 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](mailto:GreenhouseGas.Statistics@beis.gov.uk).

# 1990-2021 total greenhouse gas emissions by end user

In the [data tables](#) accompanying this publication, table 7.1 shows overall UK greenhouse gas emissions since 1990 by end user sector and source, while tables 7.2 to 7.5 show this breakdown for each individual gas.

These results are based on and consistent with the breakdown by gas and sector of 2021 emissions by source which was published on 7<sup>th</sup> February 2023. Total greenhouse gas emissions in the UK in 2021 were 426.5 million tonnes carbon dioxide equivalent (MtCO<sub>2e</sub>).

The end user breakdown reallocates emissions by source to where the “end-use” occurred. The main impact is to reallocate emissions from the energy supply sector to other sectors, particularly the business and residential sectors. For example, emissions occurring at power stations in generating electricity are reallocated to where the electricity is consumed. It should be noted that the results shown by this breakdown are based on a number of assumptions, and we would therefore expect them to be subject to greater uncertainty than the breakdown of emissions by source.

When looked at by end user sector, 29% of greenhouse gas emissions in the UK in 2021 were from transport, 25% from the business sector, 23% from the residential sector and 12% from agriculture. The remainder were attributable to the industrial processes, public, waste management, land use, land use change and forestry (LULUCF), and exports sectors. No emissions are reallocated to the waste management or land use, land use change and forestry (LULUCF) sectors and hence they are assumed to be equal to the by source emissions.

**Figure 2: Proportion of net greenhouse gas emissions in each end user sector, UK 2021**

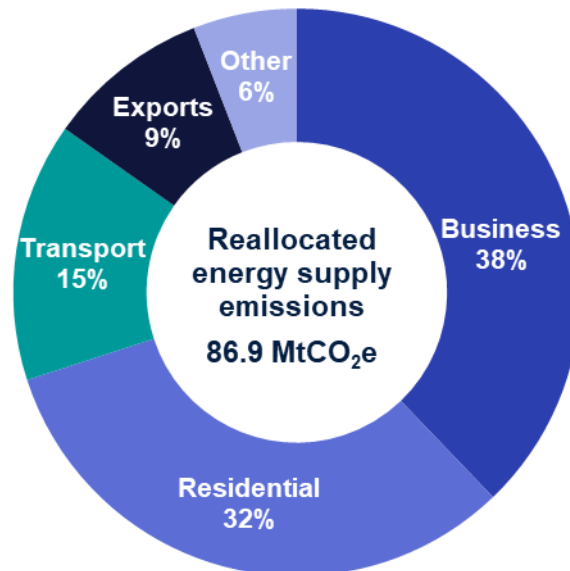


Source: Table 7.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

Note: Other includes Public, Industrial Processes and the Land Use, Land Use Change and Forestry (LULUCF) sectors. The percentages may not sum to 100% due to rounding.

The majority of emissions from energy supply are reallocated to two sectors, with business accounting for 38% and the residential sector accounting for 32% of reallocated emissions as shown in figure 3 below.

**Figure 3: Breakdown of greenhouse gas emissions reallocated from the energy supply sector to the end user sectors, UK 2021**



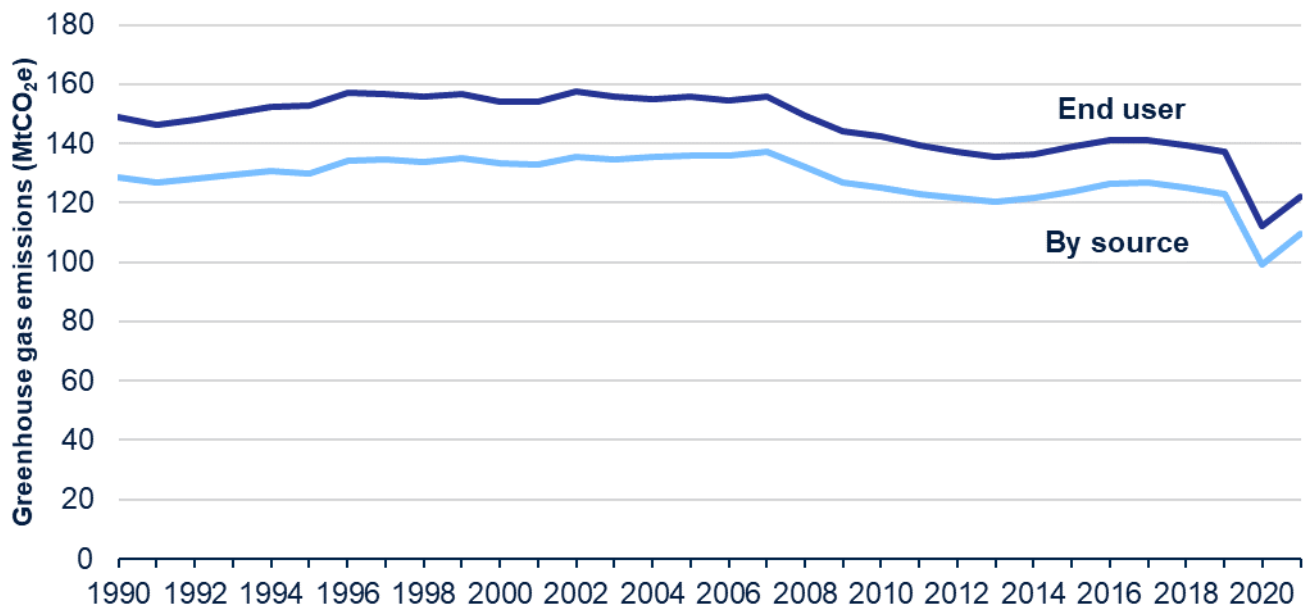
Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

Details of changes over time for each sector are set out in the following sections of this statistical release. The commentary in these sections focuses on the differences between the end user and by source breakdowns. Further information on trends of emissions by source sector can be found in the statistics release of the [Final UK Greenhouse Gas Emissions Statistics](#).

## Transport

The transport sector was responsible for around 29% of UK greenhouse gas end user emissions in 2021, almost entirely through carbon dioxide emissions, making it the highest emitting sector on an end user basis. 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. The main source of emissions from this sector is the use of petrol and diesel in road transport.

End user emissions from the transport sector are between 13 and 23 MtCO<sub>2</sub>e higher than emissions by source across the time series, so follow a very similar trend. Between 1990 and 2019 there was relatively little overall change in the level of greenhouse gas emissions from the transport sector, with rising road traffic balancing out improvements in fuel efficiencies, but in 2020 there was a large fall of 18% in transport emissions on an end user basis due to the reduction in travel throughout much of the year due to the COVID-19 pandemic. Emissions then increased by 9% in 2021 as COVID-19 restrictions were eased during the year and people were able to travel more freely.

**Figure 4: Greenhouse gas end user emissions from transport, UK 1990-2021 (MtCO<sub>2</sub>e)**

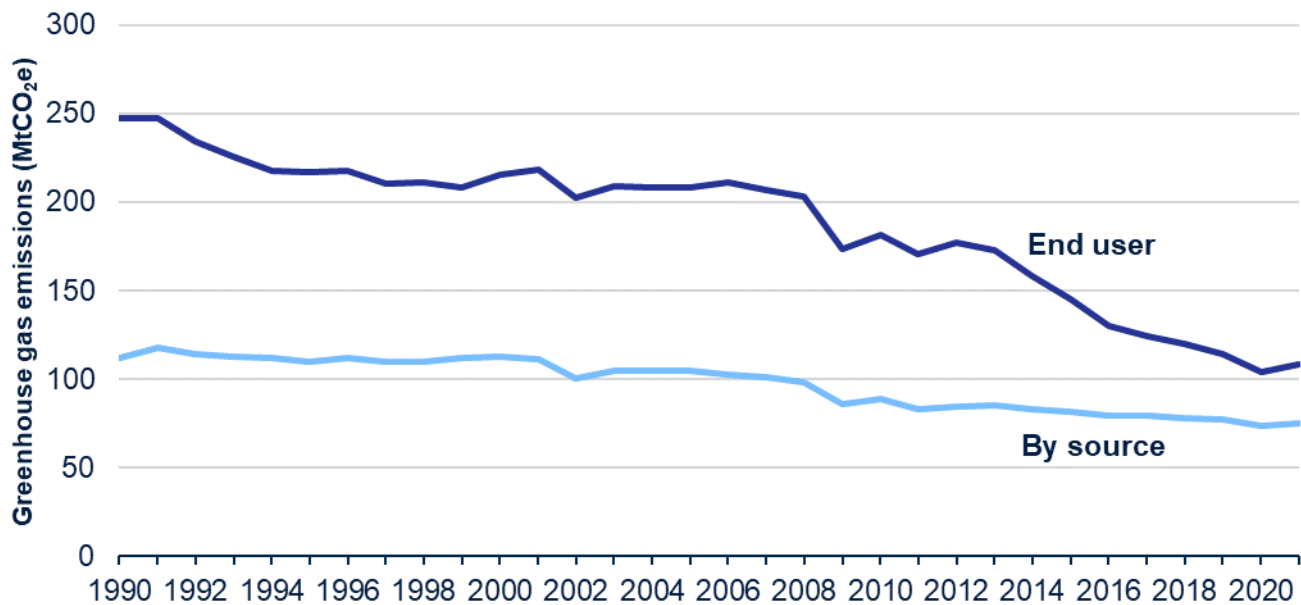
Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

## Business

The business sector was responsible for 25% of UK greenhouse gas end user emissions 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 fluorinated gases (F gases) from the use of fluorinated compounds in certain applications, particularly refrigeration and air-conditioning, are significant. The business sector is responsible for most emissions of F gases.

Between 1990 and 2021 there was a general downward trend in greenhouse gas end user emissions from the business sector, resulting in an overall decrease of 56%. After a 9% reduction in 2020 when business activity reduced following the start of the COVID-19 pandemic, emissions increased by 4% (3.8 MtCO<sub>2</sub>e) between 2020 and 2021, though were still below their 2019 level. This increase in 2021 is larger than the increase of 2% (1.4 MtCO<sub>2</sub>e) seen in emissions by source from this sector over this period, mainly due to an increase in emissions from electricity generation reallocated to this sector from the energy supply sector for the end user breakdown. These emissions increased due to both increased electricity consumption and less favourable weather conditions for wind, hydro and solar generation that meant there was an increase in the fossil fuels needed for electricity generation.

Overall, end user emissions have fallen more quickly since 1990 than emissions by source, particularly since 2012. They were 39% lower in 2021 than in 2012, compared to an 11% fall in emissions by source over this period. This is due to the large reduction in emissions from power supply as a result of a shift away from the use of coal in electricity generation, resulting in a lower level of emissions being reallocated to this sector from the energy supply sector.

**Figure 5: Greenhouse gas end user emissions from business, UK 1990-2021 (MtCO<sub>2</sub>e)**

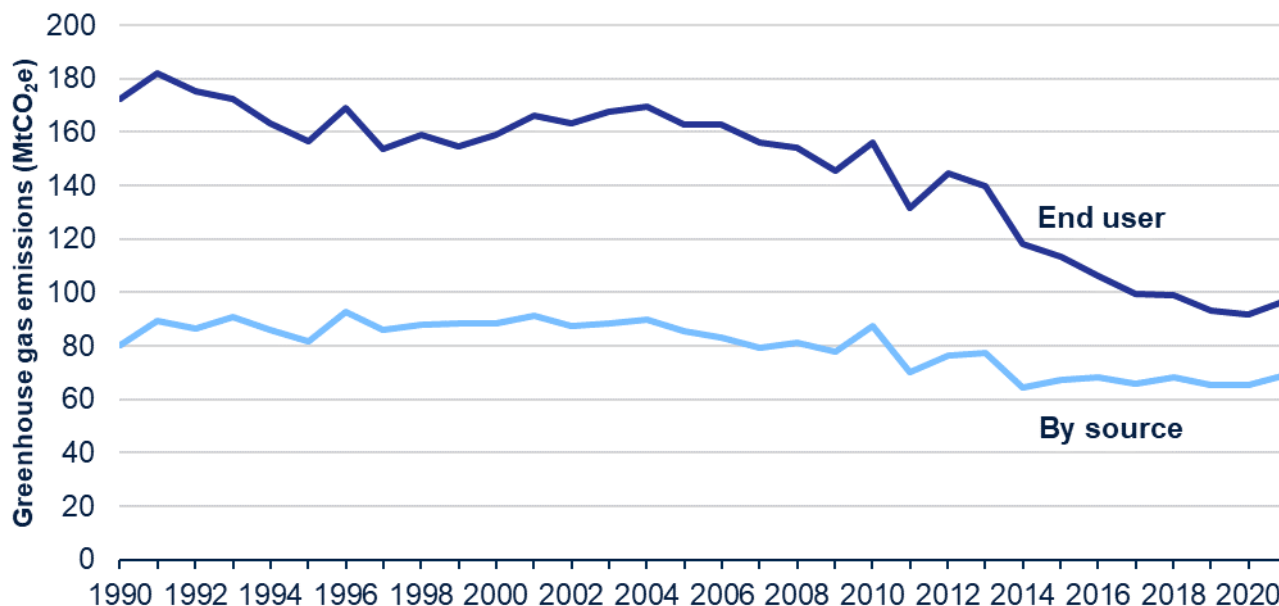
Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

## Residential

The residential sector was responsible for around 23% of UK greenhouse gas end user emissions in 2021, with carbon dioxide being the most prominent gas for this sector. Unlike emissions by source, which only cover activities related to residential fossil fuel use, emissions reported by end user also include emissions from residential electricity use which have been re-allocated from the energy supply sector.

Between 1990 and 2021, there has been considerable variation in greenhouse gas end user emissions from year to year in the residential sector. Both the end user and by source emissions from this sector are heavily influenced by external temperatures. End user emissions have seen a bigger overall decrease since 1990 than by source emissions, due to a decrease in emissions from electricity generation reallocated to this sector from the energy supply sector for the end user breakdown. This is a result of changes in the mix of fuels being used to generate electricity, with a shift away from coal towards gas and an increase in the use of renewables over this period.

Between 2020 and 2021, end user emissions in the residential sector increased by 5.6 MtCO<sub>2</sub>e (6%), similar to the 6% increase in residential emissions by source. This increase is likely to be largely due to a combination of the colder temperatures in 2021 resulting in more energy being used to heat homes and an increase in emissions from electricity generation reallocated to this sector from the energy supply sector for the end user breakdown emissions.

**Figure 6: Greenhouse gas end user emissions from the residential sector, UK 1990-2021 (MtCO<sub>2</sub>e)**

Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

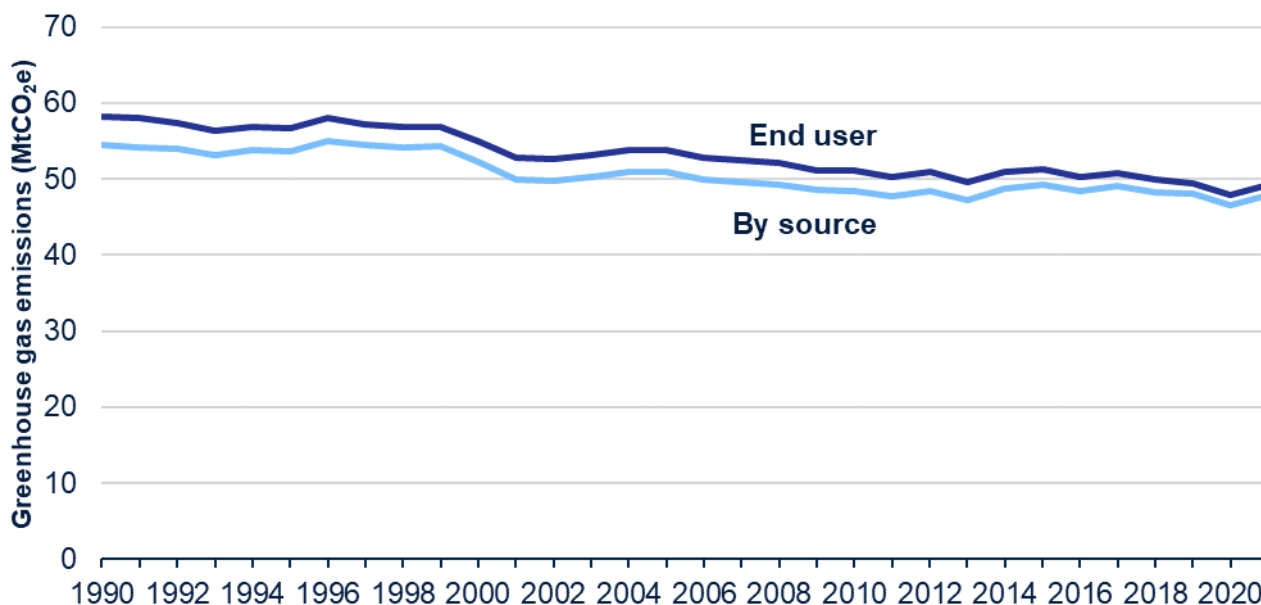
## Agriculture

The agriculture sector was responsible for 12% of UK greenhouse gas end user emissions in 2021. Emissions of methane (57%) and nitrous oxide (28%) dominate this sector. End user and by source emissions are very similar for this sector as only a small proportion of emissions are from energy use. The most significant sources are emissions of methane due to enteric fermentation from livestock, particularly cattle, and nitrous oxide emissions related to the use of fertilisers on agricultural soils.

End user emissions follow a similar trend to by source emissions. Emissions have decreased by 15% since 1990 largely due to a fall in animal numbers over the period, together with a decrease in synthetic fertiliser use. 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.



**Figure 7: Greenhouse gas end user emissions from agriculture, UK 1990-2021 (MtCO<sub>2</sub>e)**



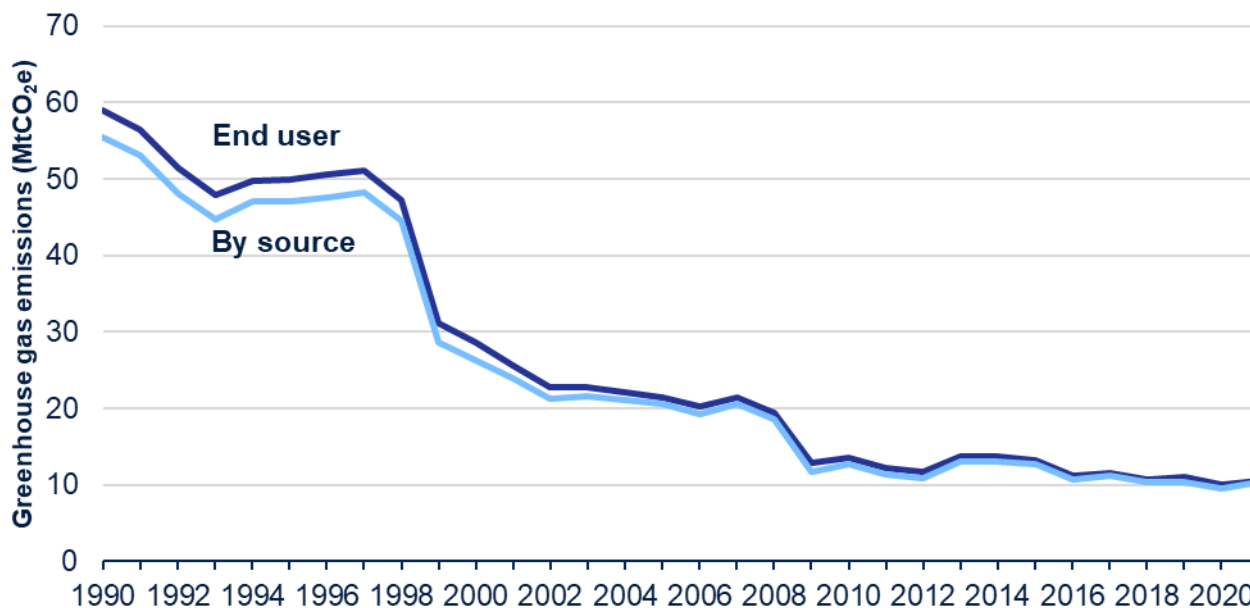
Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

## Industrial processes

The industrial processes sector was responsible for 2% of UK greenhouse gas end user emissions in 2021. The main source of emissions is cement production, with other processes such as sinter, lime, iron and steel production also contributing significantly.

The end user emissions from this sector are only slightly higher than emissions by source, and follow a very similar trend, with a decrease in end user emissions of around 82% since 1990. This is mainly due to a large reduction in emissions from adipic acid production and halocarbon production between 1998 and 1999 (combined emissions from which are now almost zero). There was a large fall in 2009 following the recession, but since then industrial process emissions in the UK have remained at a similar level.

**Figure 8: Greenhouse gas end user emissions from industrial processes, UK, 1990-2021 (MtCO<sub>2</sub>e)**

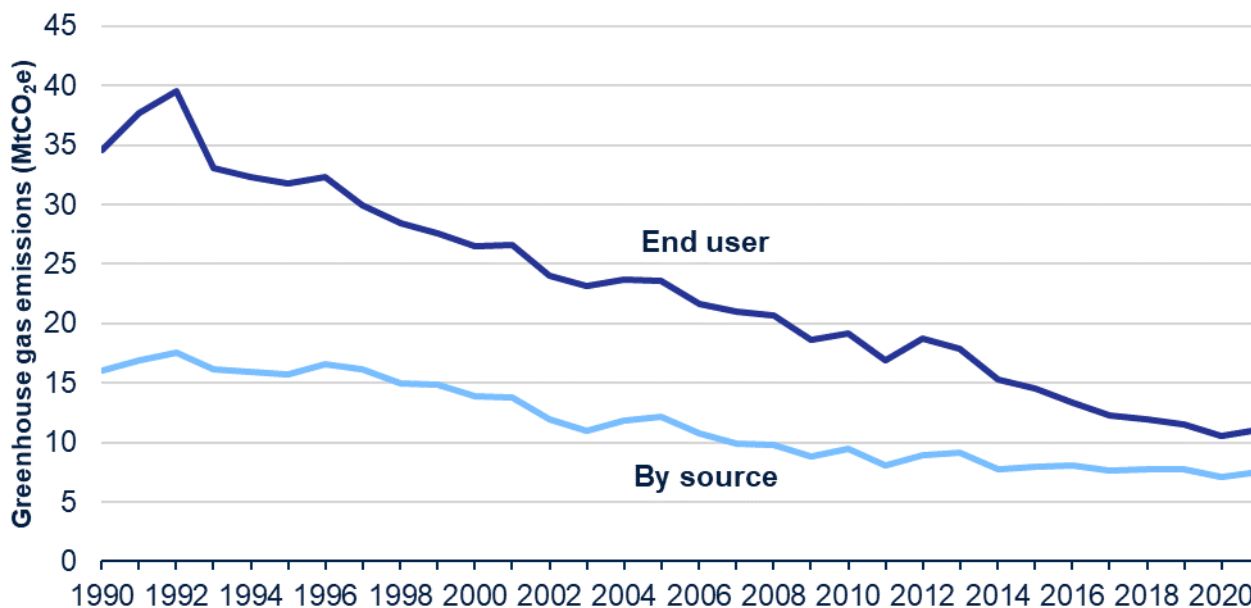


Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

## Public sector

The public sector was responsible for 3% of UK greenhouse gas end user emissions in 2021, with carbon dioxide making up almost all of these emissions. Emissions can fluctuate from year to year as they are influenced by external temperatures.

End user emissions from the public sector were approximately double the emissions by source across much of the time series, but end user emissions have fallen more quickly than by source emissions since around 2012 and in 2021 were only 47% higher. This is due to the inclusion of emissions from electricity generation in the end user breakdown, which have fallen considerably in recent years due to the shift away from coal in power stations, resulting in a lower level of emissions being reallocated to this sector from the energy supply sector.

**Figure 9: Greenhouse gas end user emissions from the public sector, UK, 1990-2021 (MtCO<sub>2</sub>e)**

Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

## Waste management and Land Use, Land Use Change and Forestry (LULUCF)

For the waste management and LULUCF sectors, emissions measured by end user are the same as those measured by source, since no emissions from the energy supply sector are reallocated to these sectors.

## Exports

The exports sector represents emissions associated with the production of fuels within the UK (for example, from a refinery or a coal mine) which are subsequently exported or sent to bunkers for use outside the UK. It also includes emissions from generating electricity in the UK that is exported. Since this energy is ultimately used for activities which occur outside the UK it would not be appropriate to allocate the emissions from their production to any of the other end user sectors, so they are reported under a separate, additional sector.

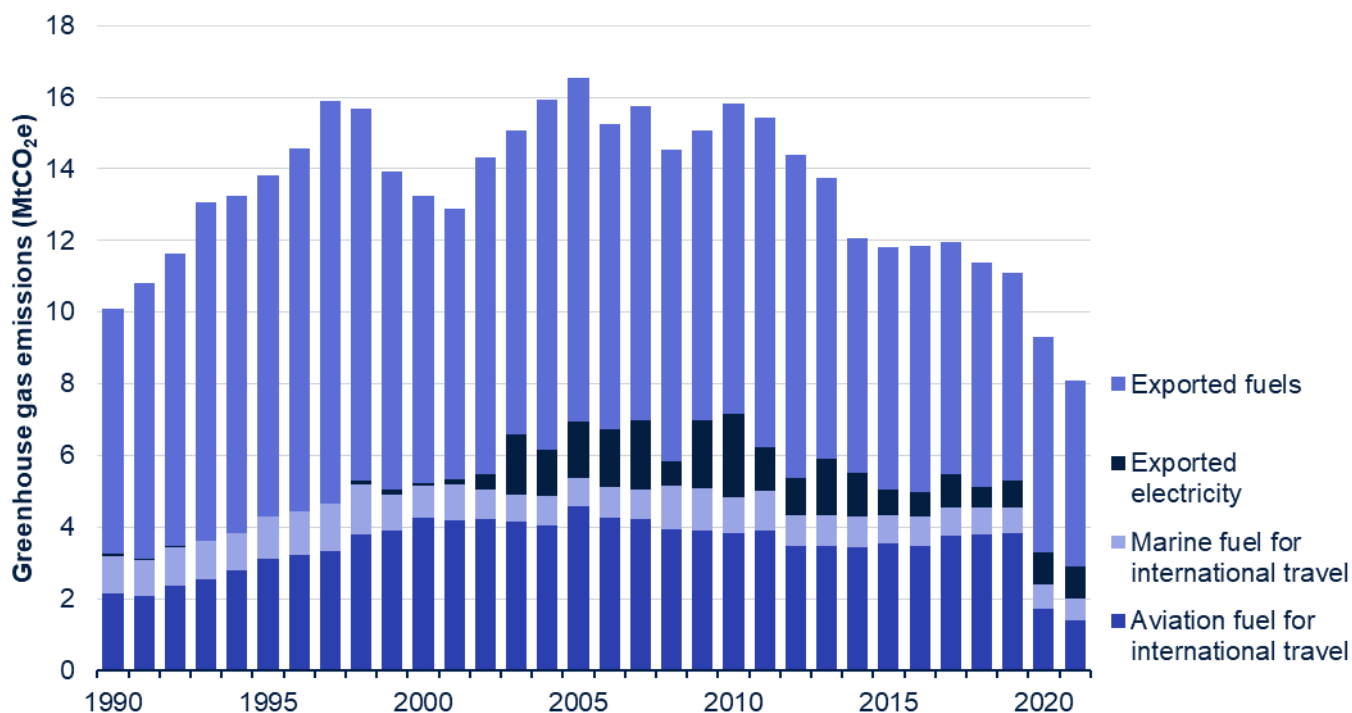
The exports sector was responsible for around 2% of UK greenhouse gas end user emissions in 2021, with carbon dioxide representing the majority of these emissions.

Emissions from the exports sector increased during most of the 1990s, largely driven by changes in throughput<sup>1</sup> at refineries, which fed through to increased exports rather than increased deliveries to the domestic market. Since then, the overall trend has varied, with emissions having fallen in recent years compared to the peaks in the mid to late 2000s.

<sup>1</sup> The capacity for refining crude oil over a given period of time

Between 2020 and 2021 emissions from the exports sector decreased by 13% to a level 27% lower than they were in 2019, the last full year before the COVID-19 pandemic. The fall in 2020 was predominantly due to a large reduction in the supply of aviation fuel for international travel, because of the large fall in air travel that resulted from the COVID-19 pandemic. These emissions saw a further fall in 2021, although the largest factor in the reduction in emissions from the exports sector in 2021 was a fall in emissions from the supply of fuels that were exported.

**Figure 10: Greenhouse gas end user emissions from the exports sector, UK, 1990-2021 (MtCO<sub>2</sub>e)**



Source: Table 7.1 Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

# Uncertainties around the 2021 estimates

In the [data tables](#) accompanying this publication, table 4.1 shows the uncertainty in the 2021 UK greenhouse gas emissions estimates by gas and table 4.2 shows it by source sector.

This section sets out the uncertainty ranges associated with the final 2021 emissions estimates by source, which were published on 7<sup>th</sup> February 2023. The geographic coverage of the uncertainty estimates includes the UK, its Crown Dependencies and those Overseas Territories that are included in the UK's reporting to the United Nations Framework Convention on Climate Change (i.e. the Cayman Islands, Bermuda, the Falkland Islands and Gibraltar). Uncertainties are not calculated for different geographical coverages, but uncertainty estimates for the UK only would be expected to be very similar.

Estimates of uncertainty are produced each year, broken down by sector (on a source basis) and gas. The emissions estimates are compiled such that uncertainty is reduced as much as possible, meaning that estimates should not be consistently more or less than the actual totals. Estimates of uncertainty allow users to see how reliable the emissions estimates are and give them an idea of what we do and do not know. 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. They are expressed as a single percentage value, which is calculated as  $0.5 \cdot R/E$  where R is the difference between the 2.5 and 97.5 percentiles and E is the mean.

The uncertainty analysis takes into account a number of different known sources of uncertainty associated with emissions factors and activity data, for example, the statistical difference<sup>2</sup> between energy supply and demand reported in the [Digest of UK Energy Statistics](#). The different sources of uncertainty are then entered into a model using specialist software which produces uncertainty estimates by running the model a large number of times.

The uncertainty estimates vary a lot between different sectors and gases. 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. At sector level, the land use, land use change and forestry (LULUCF), waste management and agriculture sectors are the most uncertain; as shown in figure 13.

The overall uncertainty around total greenhouse gas emissions for 2021 is estimated to be around 2%. There is an ongoing programme to improve this uncertainty and the uncertainty estimates help guide decisions on improvements that are carried out in to the emissions estimates. Further details can be found in the UK's National Inventory report which is due to be published on 15<sup>th</sup> April 2023<sup>3</sup>.

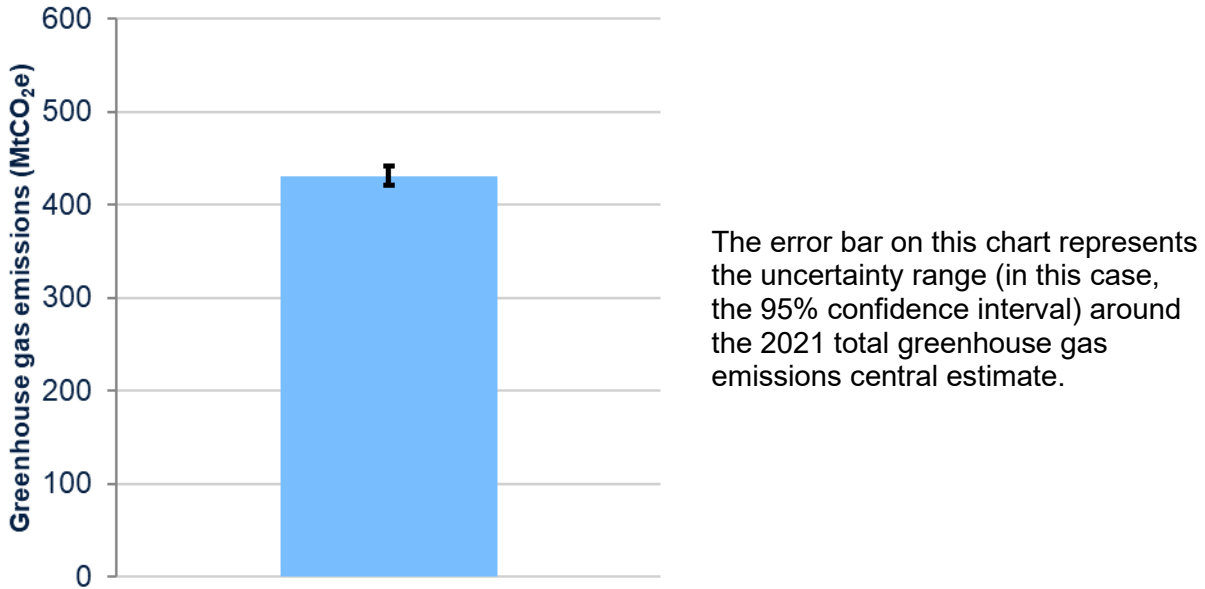
The uncertainty in the trend in emissions reductions between 1990 and 2021, expressed as a 95% confidence interval, is estimated to be a percentage reduction of between 45% and 50%, with a central estimate of a 47% reduction in emissions from 1990 to 2021. Note that this is the

<sup>2</sup> Statistical difference is explained on page 5 of the Energy Balance: Methodology note: <https://www.gov.uk/government/publications/energy-balance-methodology-note>

<sup>3</sup> Previous UK National Inventory Report: [https://naei.beis.gov.uk/reports/reports?report\\_id=1072](https://naei.beis.gov.uk/reports/reports?report_id=1072)

central estimate from the uncertainty model and differs slightly from the actual emissions estimates presented elsewhere.

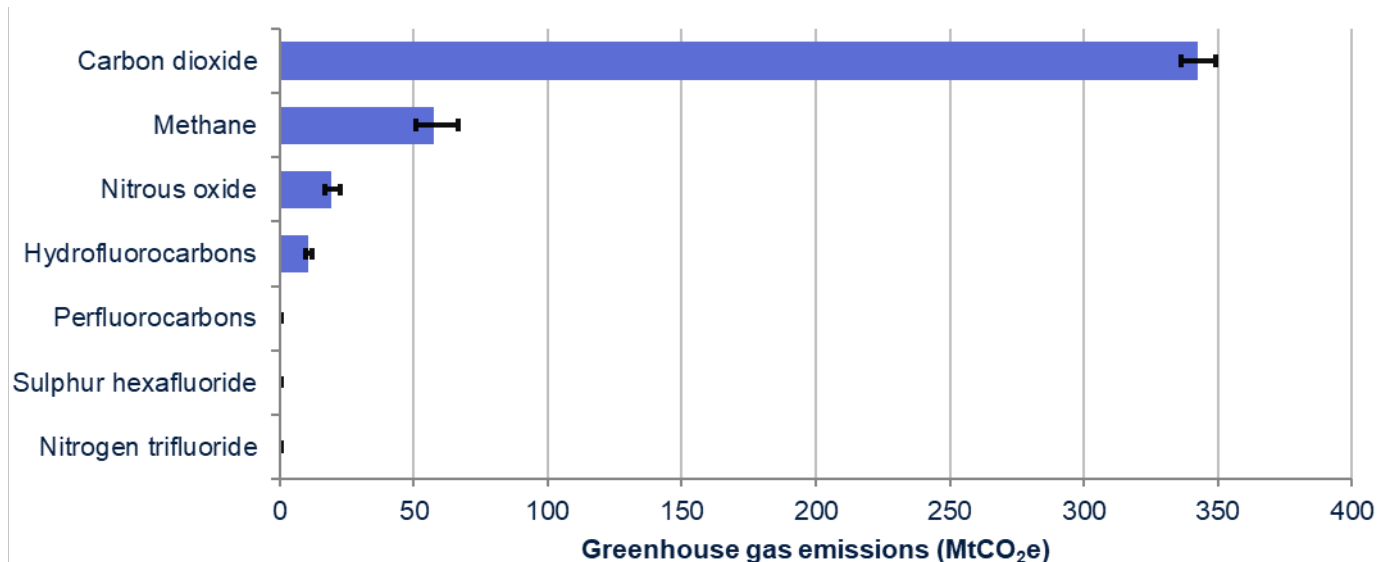
**Figure 11: Illustration of uncertainty in estimates of UK greenhouse gas emissions, UK, Crown Dependencies and Overseas Territories, 2021 (MtCO<sub>2</sub>e)**



Source: Table 4.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

**Figure 12: Illustration of uncertainty in estimates of UK greenhouse gas emissions by gas**

UK, Crown Dependencies and Overseas Territories, 2021 (MtCO<sub>2</sub>e)

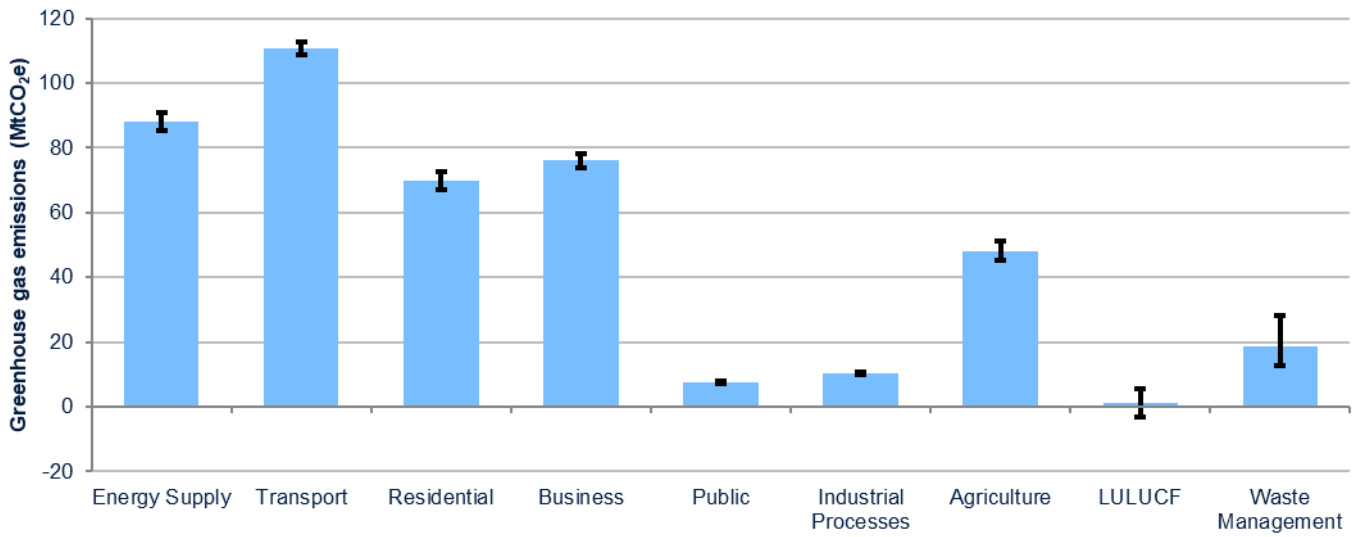


Source: Table 4.1, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

Note: The error bars on the chart represent the uncertainty range (in this case, the 95% confidence interval) around the 2021 total greenhouse gas emissions central estimates for each gas.

**Figure 13: Illustration of uncertainty in estimates of UK greenhouse gas emissions by source sector**

UK, Crown Dependencies and Overseas Territories, 2021 (MtCO<sub>2</sub>e)



Source: Table 4.2, Final UK greenhouse gas emissions national statistics 1990-2021 Excel data tables

Note: The error bars on the chart represent the uncertainty range (in this case, the 95% confidence interval) around the 2021 total greenhouse gas emissions central estimates for each sector.

# Technical information

## Revisions to the estimates of end user emissions

It should be noted that the historical time series of emissions by end user is revised each year to reflect any revisions made to either the estimates of emissions by source or the other energy consumption data used in the end user emissions calculation. In this publication, this has resulted in revisions to end user emissions figures for all years up to and including 2020. Further details of these revisions can be found in the main [Final UK Greenhouse Gas Emissions Statistics report](#), which covered 2021 UK greenhouse gas emissions by source.

## Embedded emissions

These territorial end user emissions estimates do not take account of the emissions “embedded” within the manufactured goods and services which the UK imports, only energy supply emissions that occur within the UK get reallocated to end users. Embedded emissions are instead captured in what is referred to as the UK’s “carbon footprint”. This calculation of emissions on a “consumption” basis, reporting on emissions embedded in goods and services across international borders, is considerably more challenging. Statistics on [the UK’s carbon footprint](#) are available from the Department for Environment, Food and Rural Affairs (Defra).

# Further information

## Future updates to greenhouse gas emissions estimates

On Thursday 29 June 2023 the Department for Energy Security and Net Zero 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 the Department for Energy Security and Net Zero will also publish estimates of greenhouse gas emissions by local authority for 2021.

In February 2024 final 1990-2022 UK greenhouse gas emissions estimates will be published by source sector.

In March 2024 the 1990-2022 UK emissions estimates will be updated to include estimates by end user and uncertainty estimates, and provisional 2023 greenhouse gas emissions estimates will be published.



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