Department for Energy Security & Net Zero

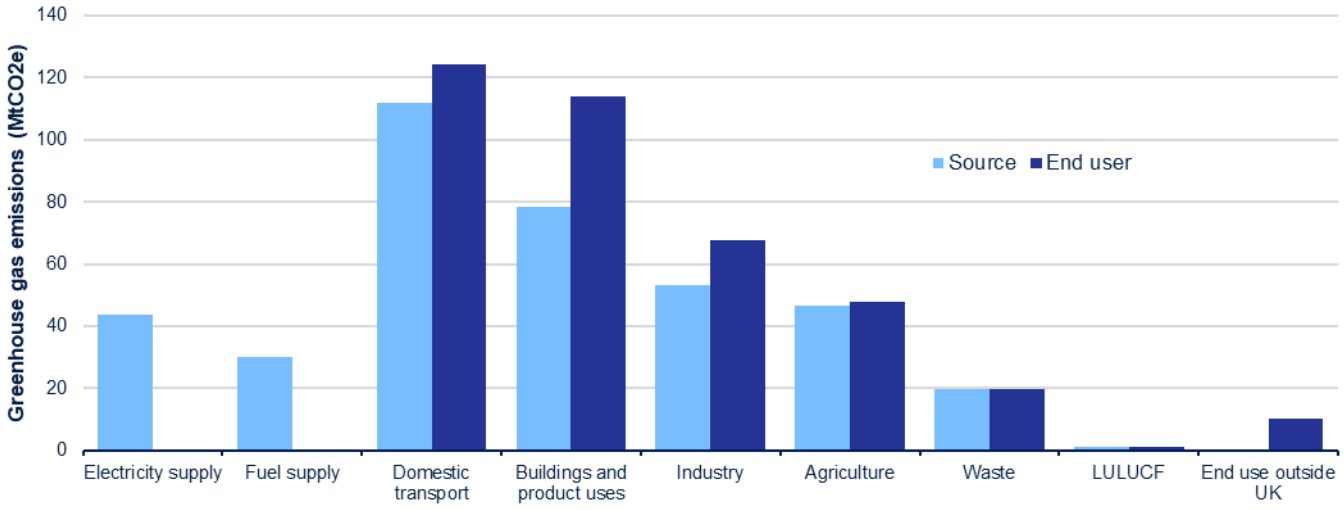
Annex 1: 2023 UK greenhouse gas emissions, final figures with energy supply on an end user basis and uncertainty estimates

27 March 2025 **Accredited Official Statistics**

This publication is an extension of the UK territorial greenhouse gas emission estimates by source for 1990-2023 published in February 2025. It provides the latest estimates of 1990-2023 territorial greenhouse gas emissions with energy supply emissions presented on an end user basis rather than a by source basis. This means that emissions from electricity and fuel supply, e.g. from power stations and refineries, have been reallocated to other sectors based on where the "end-use" of the energy occurred. 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. Figures are presented in carbon dioxide equivalent units throughout this statistical release.

- It is estimated that 32% of net greenhouse gas emissions in the UK in 2023 were from domestic transport and a further 30% from buildings and product uses, making them the largest sectors when energy supply is on an end user basis. 18% of emissions were from industry and 12% from agriculture. The rest were attributable to the waste and the land use, land use change and forestry (LULUCF) sectors, or had their end use outside the UK.

Figure 1: Greenhouse gas emissions by source sectors and end user sectors, UK 2023 (million tonnes carbon dioxide equivalent (MtCO2e))



Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2023 Excel data tables

- Uncertainty in the total UK greenhouse gas emissions estimate, expressed as a 95% confidence interval, is ±3%, based on uncertainty analysis of the 2023 emissions estimates which were published in February 2025. 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, perfluorocarbons and nitrous oxide estimates are the most uncertain. At sector level, LULUCF emissions estimates have the highest uncertainty, followed by waste, fuel supply and agriculture.

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Introduction

This Annex contains final estimates of 1990 to 2023 UK territorial greenhouse gas emissions with energy supply on an end user basis, as well as uncertainty estimates for 2023 emissions by source sector and gas. These are a follow up to, and are consistent with, the final estimates of 1990 to 2023 emissions by source sector which were published on 6 February 2025.

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 7.5 present emissions by end user category overall and for each gas, and are included in a separate file from the other tables published as part of this publication. Uncertainty analysis for 2023 emissions by gas and by sector are shown in tables 4.1 and 4.2 respectively. A 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. In these statistics, emissions are allocated into Territorial Emissions Statistics (TES) sectors on an end-user basis as follows:

- Domestic transport
- Buildings and product uses
- Industry
- Agriculture
- Waste
- Land use, land use change, and forestry (LULUCF)
- End use outside UK

When emissions are reported by source, emissions are attributed to the sector that emits them directly. In the end user breakdown, emissions related to energy supply are reallocated to the sectors where the “end-use” of the energy occurred. The emissions reallocated include the whole of the electricity supply and fuel supply source sectors, along with a small number of sources in the industry sector (in particular autogeneration of electricity exported to the grid and coke production). Some emissions are also allocated to an “end use outside UK” category. This is for emissions within the UK from the production of fuels (e.g. from a refinery or coal mine) or electricity generation, which are subsequently exported or sent to bunkers for use outside the UK.

These estimates make it possible to see the full emissions impact within the UK of a particular end-use sector or sub-sector, although it should be noted that emissions that occur outside the UK from the supply of energy used in the UK are excluded, such as where fuels or electricity have been imported. 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 2025.

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 greenhouse gas emissions estimates for different sectors. 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).

1990-2023 total greenhouse gas emissions with energy supply on an end user basis

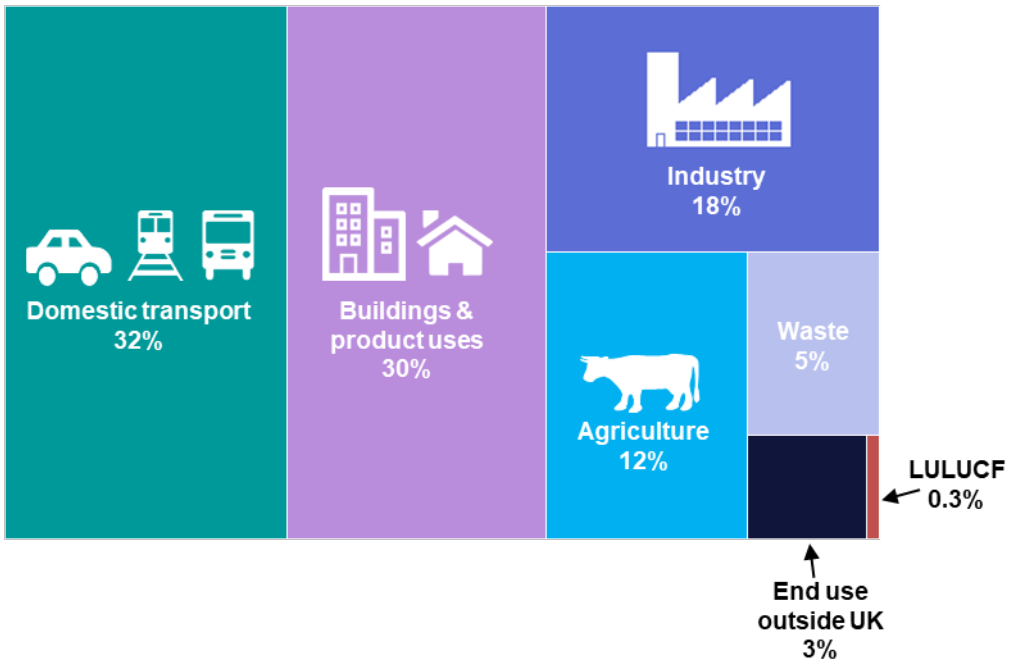
In the data tables accompanying this publication, table 7.1 shows overall UK greenhouse gas emissions since 1990 by end user sector and source, while tables 7.2 to 7.5 show this breakdown for each individual gas.

These results are based on and consistent with the breakdown by gas and sector of 2023 emissions by source which was published on 6 February 2025. Total greenhouse gas emissions in the UK in 2023 were 385 million tonnes carbon dioxide equivalent (MtCO2e).

The end user breakdown reallocates emissions related to energy supply to where the "end-use" of that energy occurred. This means that emissions from the supply of electricity and fuels are reallocated to other sectors. For example, emissions occurring at power stations in generating electricity are reallocated to where the electricity is used. The reallocation process is explained in the Methodology section later in this report. 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, 32% of greenhouse gas emissions in the UK in 2023 were from domestic transport, 30% from buildings and product uses, 18% from industry and 12% from agriculture. The remainder were attributable to the waste and the land use, land use change and forestry (LULUCF) sectors, or had their end use outside the UK. No energy supply emissions are reallocated to the waste or LULUCF sectors and hence they are equal to the by source emissions.

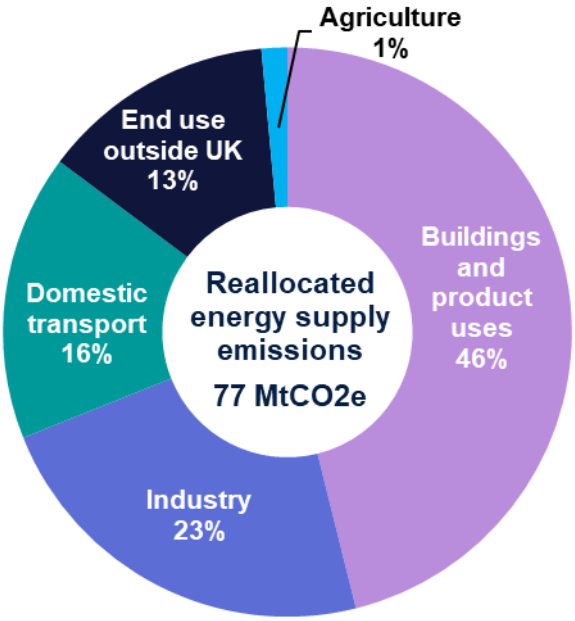
Figure 2: Proportion of net greenhouse gas emissions in each end user sector, UK 2023



Source: Table 7.1, Final UK greenhouse gas emissions national statistics 1990-2023 Excel data tables
Note: The percentages may not sum to 100% due to rounding.

Nearly half (46%) of energy supply emissions are reallocated to the buildings and product uses sector, with the industry sector accounting for 23% of reallocated emissions and domestic transport 16%, as shown in figure 3 below. Note that 3 MtCO2e of the reallocated emissions in 2023 came from sources in the industry sector related to energy supply, so unlike other sectors this sector both loses some emissions and gains some as part of the reallocation process.

Figure 3: Breakdown of greenhouse gas emissions reallocated from energy supply to the end user sectors, UK 2023

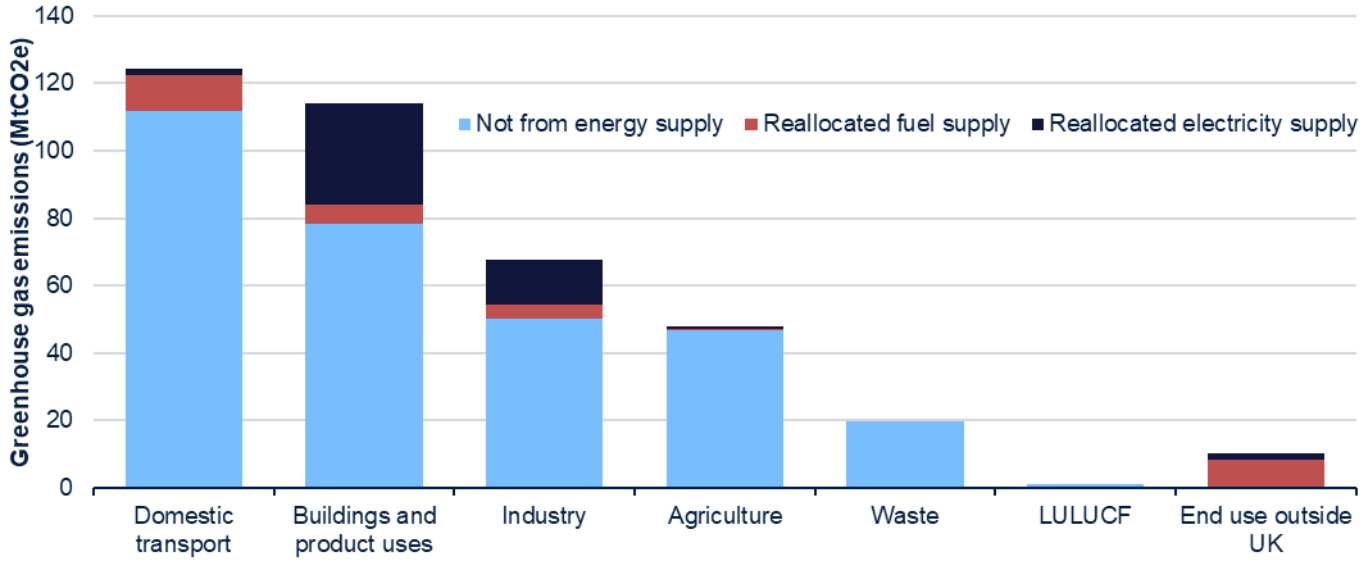


Source: Table 7.1, Final UK greenhouse gas emissions national statistics 1990-2023 Excel data tables
Note: The percentages may not sum to 100% due to rounding.

Figure 4 shows the amount of end user emissions in each sector that have been reallocated from electricity supply and from fuel supply, and the amount emitted directly in that sector (i.e. emissions that are not related to energy supply). Emissions from fuel supply that have been reallocated to end users have been identified separately in the tables that we publish for the first time this year, having previously been included in the same category as the fuel combustion that they relate to. Reallocated emissions from electricity supply were already shown separately. The emissions that are reallocated to the buildings and product use sector and the industry sector are largely from electricity supply, while those reallocated to the domestic transport sector and to end uses outside the UK are mostly from fuel supply.

It should be noted that the reallocated fuel supply and reallocated electricity supply totals shown here do not sum to the electricity supply and fuel supply TES sector totals. This is for two reasons. Firstly, some emissions in the industry sector that relate to energy supply are also reallocated in the end user estimates (meaning that the industry 'Not from energy supply' total in Figure 4 is also slightly lower than the industry total on a by source basis). Secondly, it is because fuel use in electricity generation and electricity use in the supply of fuels means that some emissions from the electricity supply sector are considered fuel supply emissions in the end user allocation and some emissions from the fuel supply sector are considered electricity supply emissions.

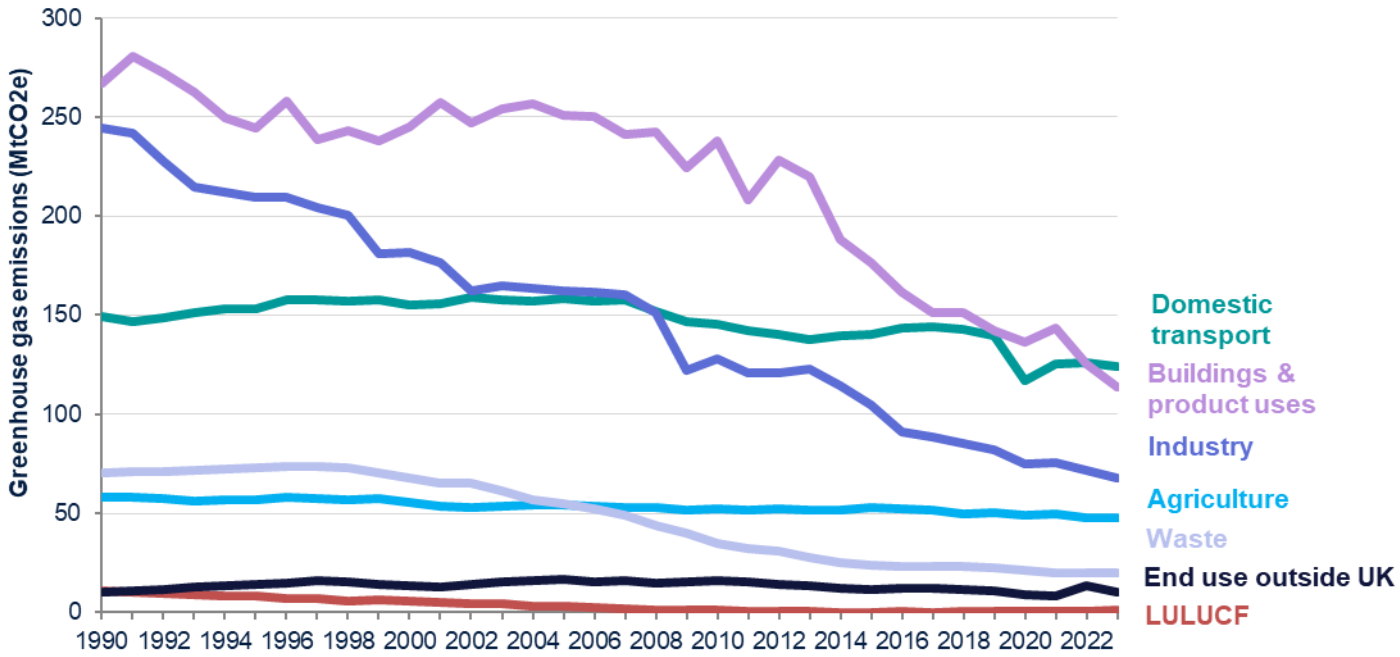
Figure 4: Greenhouse gas emissions by end user sector and whether reallocated, UK 2023 (MtCO2e)



Source: Table 7.1, Final UK greenhouse gas emissions national statistics 1990-2023 Excel data tables

The buildings and product use sector has been the sector with the highest emissions on an end user basis in all years throughout the time series since 1990 until 2022, since when the domestic transport sector has been higher.

Figure 5: Greenhouse gas emissions by end user sector, UK 1990-2023 (MtCO2e)



Source: Table 7.1, Final UK greenhouse gas emissions national statistics 1990-2023 Excel data tables

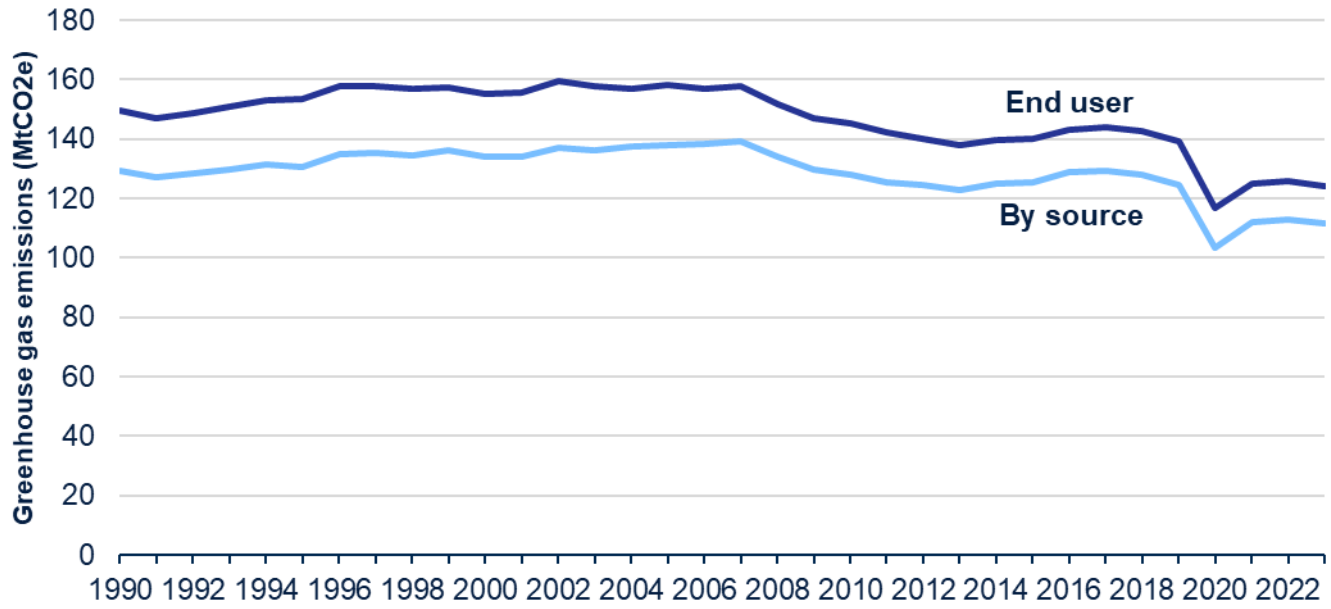
Details of changes over time for each sector are set out in the following sections of this statistical release. The commentary in these sections focuses on the differences between the end user and by source breakdowns. Further information on trends of emissions by source sector can be found in the statistics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

Domestic transport

The domestic transport sector was responsible for around 32% of UK greenhouse gas end user emissions in 2023, almost entirely through carbon dioxide emissions. It was the highest emitting sector on an end user basis (124 MtCO2e) for the second year running. 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 domestic transport are between 13 and 23 MtCO2e higher each year 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 sector, with rising road traffic balancing out improvements in fuel efficiencies, but in 2020 there was a large fall of 16% in domestic 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 increased over the subsequent two years as COVID-19 restrictions were eased and people were able to travel more freely but did not return to their previous level, and in 2023 were 11% lower than they were in 2019, the last full year before the pandemic.

Figure 6: Greenhouse gas end user emissions from domestic transport, UK 1990-2023 (MtCO2e)



Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2023 Excel data tables

Buildings and product uses

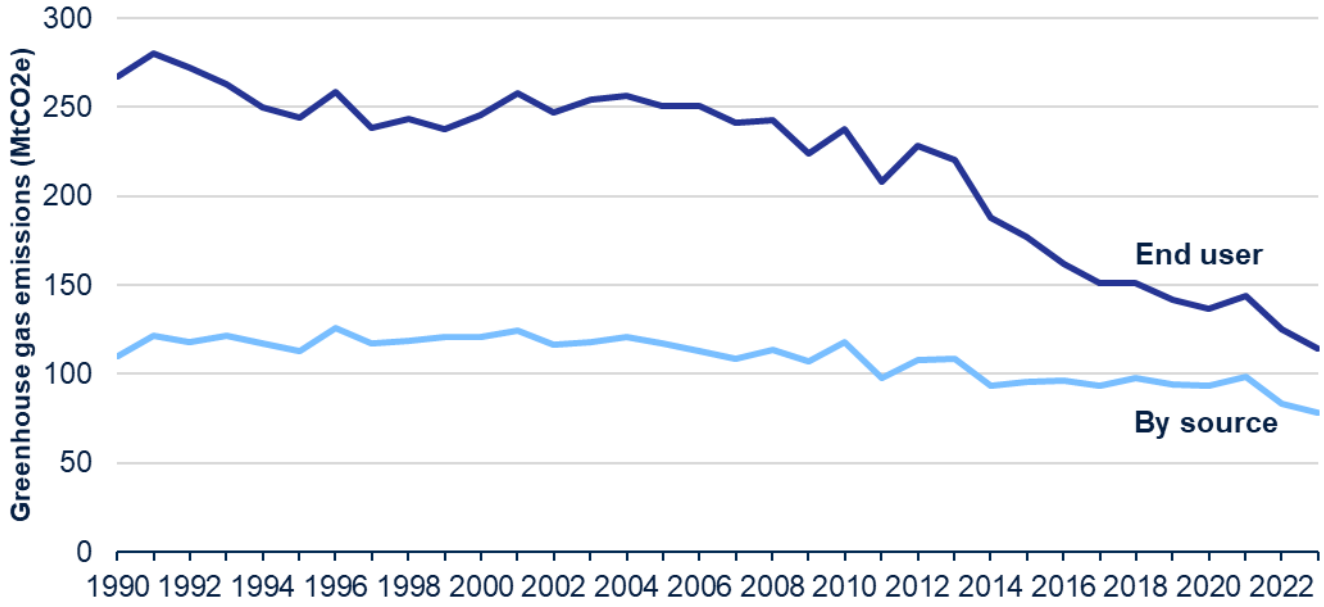
The buildings and product uses sector was responsible for 30% of UK greenhouse gas end user emissions in 2023. This is the second year since the start of the time series in 1990 that it was not the sector with the highest greenhouse gas emissions when energy supply is presented on an end user basis, as emissions from domestic transport have been higher in the last two years. Carbon dioxide was the most prominent gas. Emissions from this sector primarily come from fuel combustion and electricity use in buildings. Other sources include

emissions that directly arise from the use of products such as refrigeration & air conditioning, garden machinery, anaesthetics, metered dose inhalers and aerosols. Residential buildings, including electricity use, were responsible for 63% of emissions in this sector in 2023, and 19% of all UK territorial emissions.

There was a 9% (11 MtCO2e) decrease in end user emissions from the buildings and product uses sector between 2022 and 2023. High energy and other costs are likely to be one of the main factors in the fall in the latest year, having reduced demand for gas for heating and demand for electricity, as well as a reduction in emissions from electricity generation due to higher shares from renewables and being imported. This decrease in 2023 is larger than the decrease of 6% (5 MtCO2e) seen in emissions by source from this sector over this period.

Between 1990 and 2023, there has been considerable variation in greenhouse gas end user emissions from year to year in the buildings and product uses sector. Both the end user and by source emissions from this sector are heavily influenced by external temperatures. End user emissions from this sector have fallen by 57% since 1990 and have seen a bigger overall decrease than by source emissions, particularly since 2012. They were 50% lower in 2023 than in 2012, compared to a 27% fall in emissions by source over this period. This is due to the large reduction in emissions from electricity 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 electricity supply sector.

Figure 7: Greenhouse gas end user emissions from buildings and product uses, UK 1990-2023 (MtCO2e)



Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2023 Excel data tables

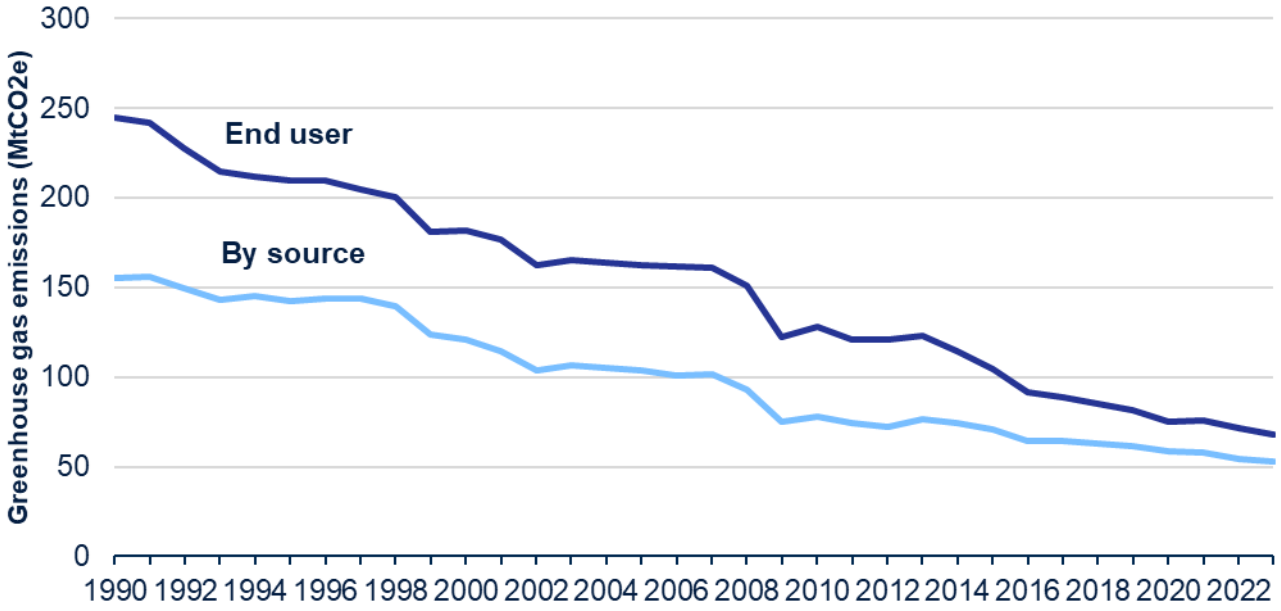
Industry

The industry sector was responsible for 18% of UK greenhouse gas end user emissions in 2023. This sector includes emissions from fuel combustion and electricity use at industrial sites and from industrial machinery, emissions resulting from industrial processes and emissions of fluorinated gases from industrial uses such as in refrigeration systems.

Between 1990 and 2023 there was a general downward trend in greenhouse gas end user emissions from industry, resulting in an overall decrease of 72%. Emissions decreased by 6% (4 MtCO2e) between 2022 and 2023. This decrease is larger than the decrease of 2% (1 MtCO2e) seen in emissions by source from this sector over this period, largely because of a reduction in emissions from electricity generation due to higher shares from renewables and being imported.

Overall, end user emissions have fallen more quickly since 1990 than emissions by source, particularly since 2012. They were 44% lower in 2023 than in 2012, compared to a 27% fall in emissions by source over this period. This is due to the large reduction in emissions from electricity 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 electricity supply sector.

Figure 8: Greenhouse gas end user emissions from industry, UK, 1990-2023 (MtCO2e)



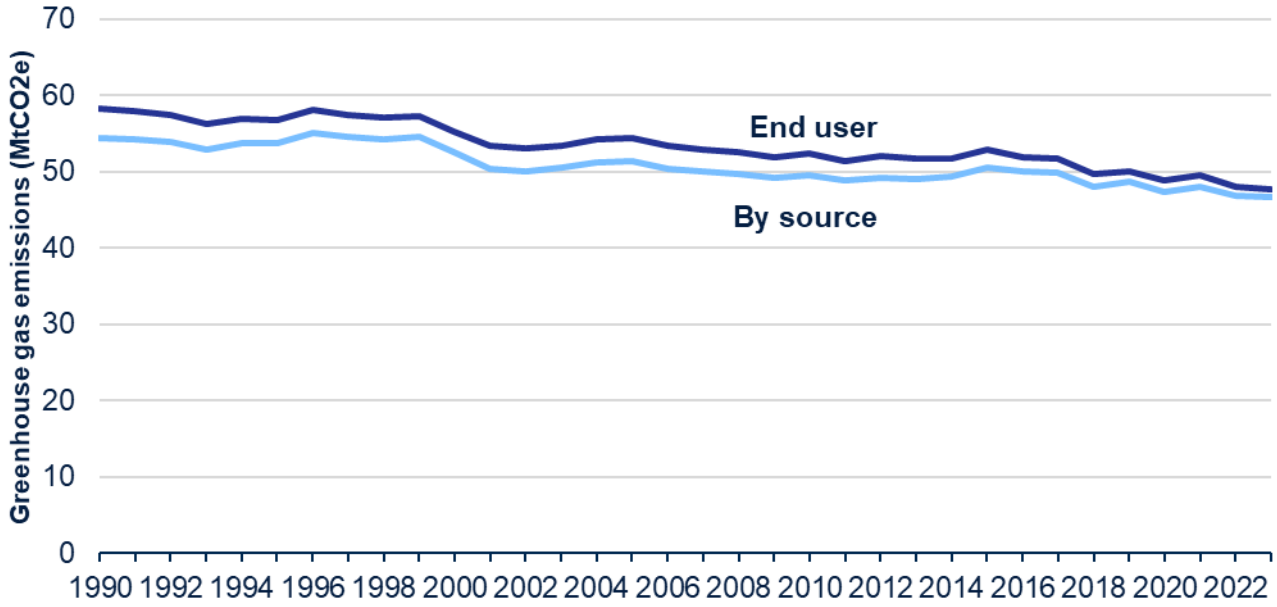
Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2023 Excel data tables

Agriculture

The agriculture sector was responsible for 12% of UK greenhouse gas end user emissions in 2023. Emissions of methane (57%) and nitrous oxide (26%) 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 18% since 1990 largely due to a fall in animal numbers over the period, together with a decrease in synthetic fertiliser use. Between 2022 and 2023 there was a 1% decrease in emissions from the agriculture sector largely due to a reduction in livestock emissions.

Figure 9: Greenhouse gas end user emissions from agriculture, UK 1990-2023 (MtCO2e)



Source: Tables 1.2 and 7.1, Final UK greenhouse gas emissions national statistics 1990-2023 Excel data tables

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

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

Emissions from energy supply with end use outside the UK

The end use outside the UK 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 aviation or shipping 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.

Around 3% of UK territorial greenhouse gas emissions in 2023 were from energy supply that had its end user outside the UK, with carbon dioxide representing the majority of these emissions.

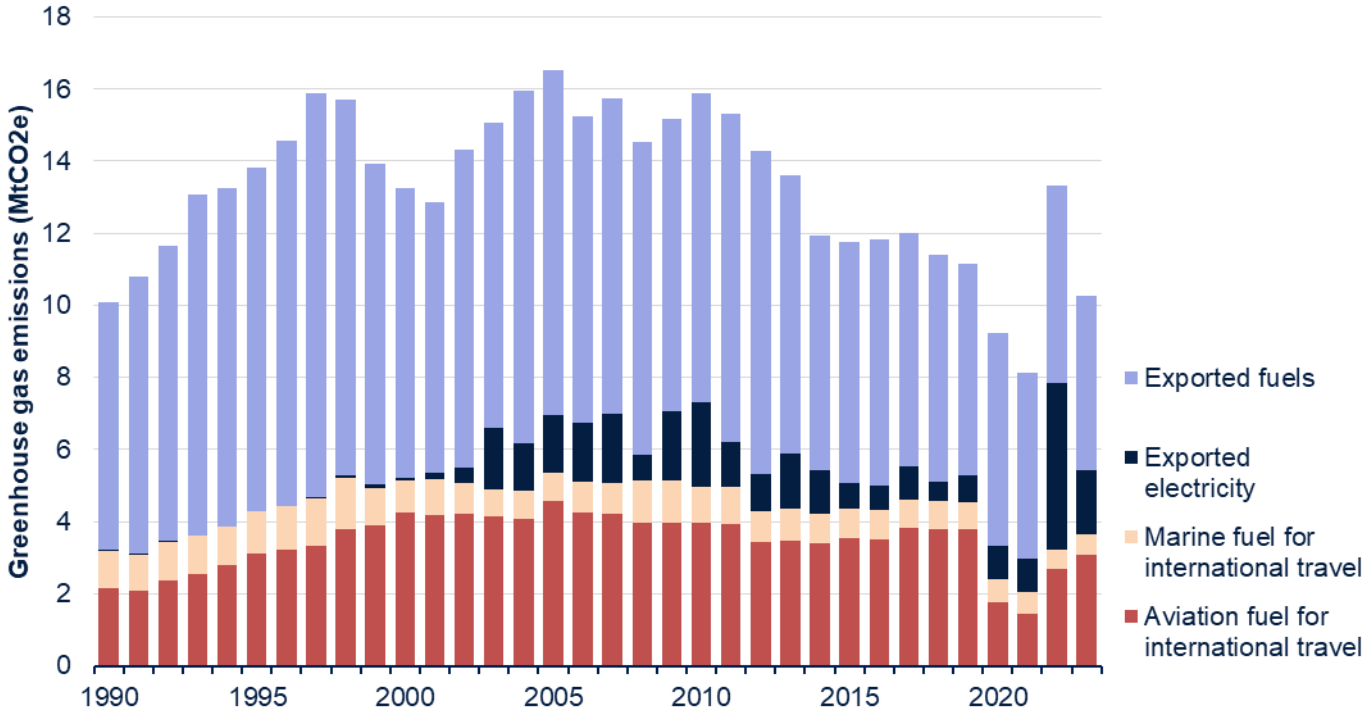
Emissions from the end use outside the UK sector increased during most of the 1990s, largely driven by changes in throughput[1] at refineries, which fed through to increased exports rather

[1] The capacity for refining crude oil over a given period of time

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.

After falls in 2020 and 2021 largely due to reduced use of aviation fuel during the COVID-19 pandemic, emissions from energy supply with its end use outside the UK saw a large increase in 2022 due to a large rise in electricity exported to a higher than usual level, before a 23% reduction in 2023 as electricity exports reduced back down. Conversely, the recovery in international air travel following the easing of COVID-19 pandemic restrictions continued, resulting in higher emissions from supplying aviation fuel than in the previous three years.

Figure 10: UK greenhouse gas emissions from energy supply with end use outside the UK, 1990-2023 (MtCO2e)



Source: Table 7.1 Final UK greenhouse gas emissions national statistics 1990-2023 Excel data tables

Uncertainties around the 2023 estimates

In the data tables accompanying this publication, table 4.1 shows the uncertainty in the 2023 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 2023 emissions estimates by source, which were published on 6 February 2025. 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*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[2] 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, perfluorocarbons and nitrous oxide estimates are the most uncertain. At sector level, the land use, land use change and forestry (LULUCF), waste, fuel supply and agriculture sectors are the most uncertain; as shown in figure 13.

The overall uncertainty around total greenhouse gas emissions for 2023 is estimated to be around 3%. There is an ongoing programme to reduce this uncertainty and the uncertainty estimates help guide decisions on improvements that are carried out for the emissions estimates. Further details can be found in the UK's national inventory submission to the United Nations Framework Convention on Climate Change (UNFCCC) which is due to be published on 15 April 2025[3].

The uncertainty in the trend in emissions reductions between 1990 and 2023, expressed as a 95% confidence interval, is estimated to be a percentage reduction of between 50% and 55%,

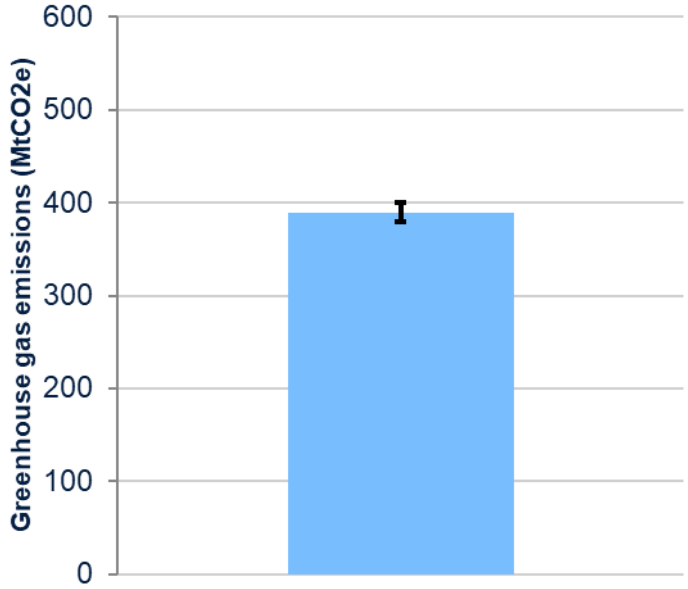
[2] Statistical difference is explained on page 5 of the Energy Balance: Methodology note: https://www.gov.uk/government/publications/energy-balance-methodology-note

[3] Previous UK National Inventory Report: https://naei.energysecurity.gov.uk/reports/uk-greenhouse-gas-inventory-1990-2022-annual-report-submission-under-framework-convention

with a central estimate of a 52% reduction in emissions from 1990 to 2023. Note that this is the central estimate from the uncertainty model and may differ 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, 2023 (MtCO2e)

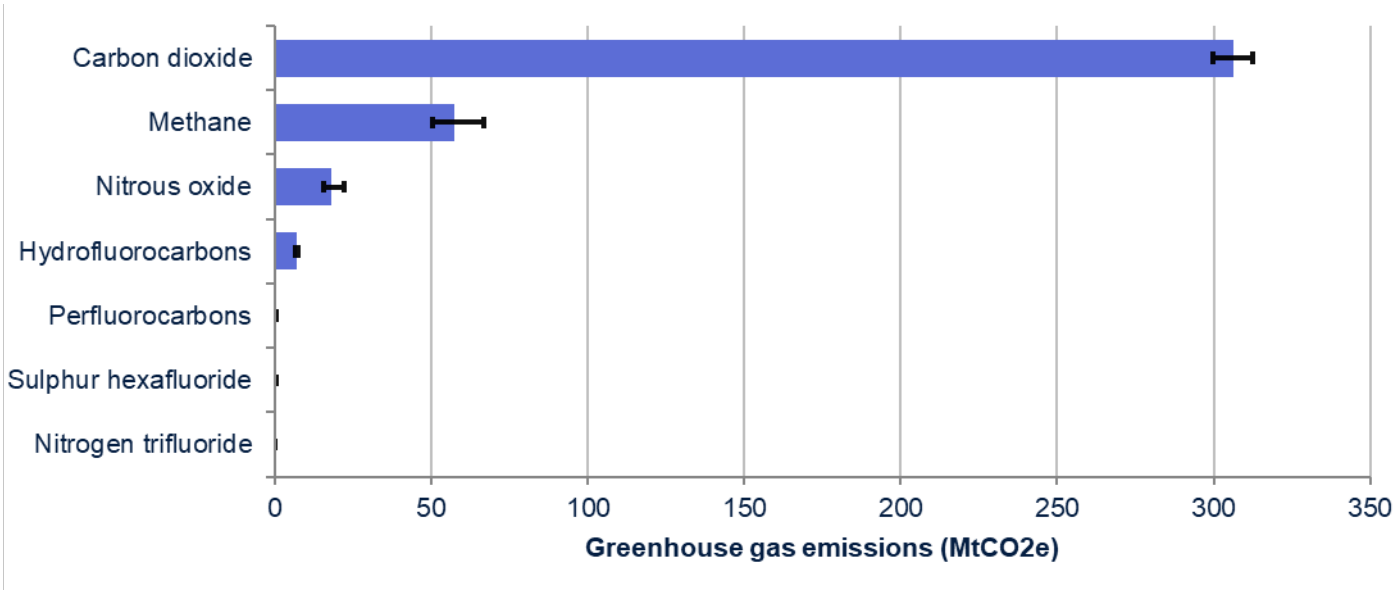


The error bar on this chart represents the uncertainty range (in this case, the 95% confidence interval) around the 2023 total greenhouse gas emissions central estimate.

Source: Table 4.1, Final UK greenhouse gas emissions national statistics 1990-2023 Excel data tables

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

UK, Crown Dependencies and Overseas Territories, 2023 (MtCO2e)

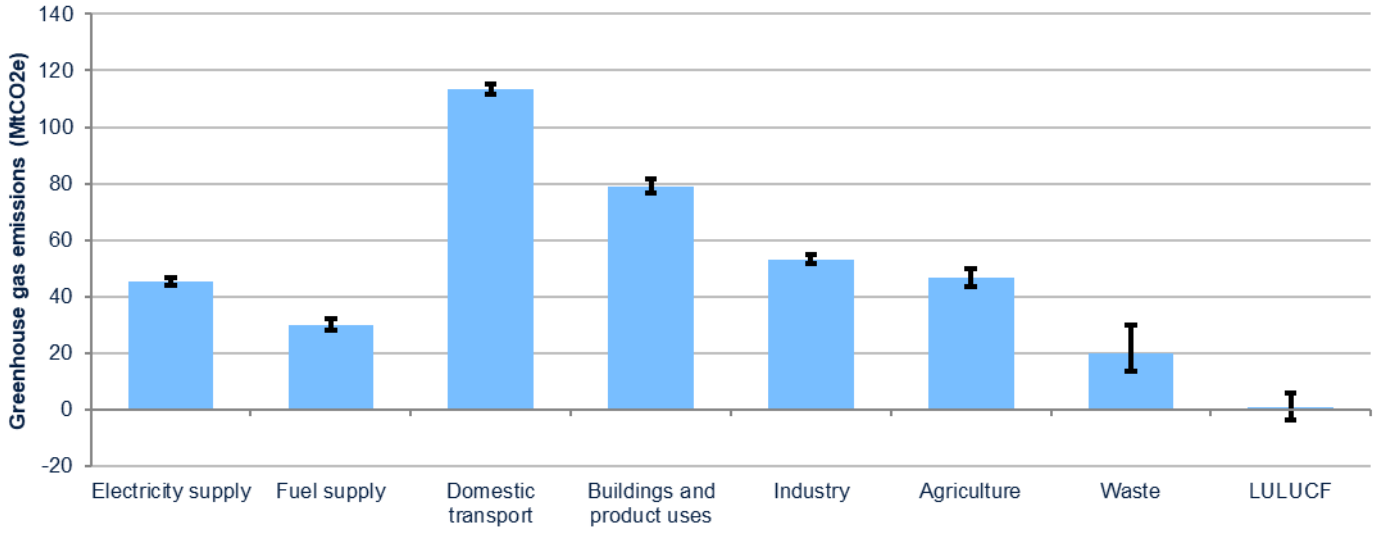


Source: Table 4.1, Final UK greenhouse gas emissions national statistics 1990-2023 Excel data tables

Note: The error bars on the chart represent the uncertainty range (in this case, the 95% confidence interval) around the 2023 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, 2023 (MtCO2e)



Source: Table 4.2, Final UK greenhouse gas emissions national statistics 1990-2023 Excel data tables

Note: The error bars on the chart represent the uncertainty range (in this case, the 95% confidence interval) around the 2023 total greenhouse gas emissions central estimates for each sector.

Technical information

Methodology

The approach we use to estimate end user emissions is summarised in the three steps below:

1. Emissions are calculated for each sector for each fuel.

2. Emissions from fuel and electricity producers are then distributed to those sectors that use the fuel according to the energy content of the fuel they use (these sectors can include other fuel and electricity producers). This distribution is based on inventory fuel consumption data and DUKES electricity consumption data.

3. This distribution will have allocated most emissions to end users but some to fuel and electricity producers. Therefore, an iterative approach is used, meaning the process is repeated a number of times until only a negligible amount of emissions are still allocated to fuel and electricity producers, and the rest to end users.

The methodology divides fuel user emissions into 7 fuel categories, with each energy supply emissions source allocated to one of these categories based on the type of fuel/energy being supplied:

1. Coke
2. Coal
3. Natural gas
4. Electricity
5. Petroleum
6. Solid Smokeless Fuels
7. Charcoal.

For each of these groups, energy supply source categories are distributed to energy users in proportion to the total energy consumption of the group of fuels being supplied. For example, for the coal group, the emissions of each source category associated with coal supply are distributed to end users according to the energy use of anthracite and coal combined.

The emissions included in the end user categories can be illustrated with an example of two end users - residential buildings and road transport:

- Emissions in the residential buildings end user TES subsector include:

    1. All direct emissions from domestic premises, for example, from burning gas, coal or oil for space heating.
    2. A portion of indirect emissions used by domestic consumers from: power stations generating electricity; emissions from refineries including refining, storage, flaring and extraction; emissions from coal mines (including emissions due to fuel use in the mining industry itself and fugitive emissions of methane from the mines); and emissions from the extraction, storage and distribution of mains gas.

- Emissions in the road transport end user TES subsector include:

1. Direct emissions from motor vehicle exhausts.
2. A portion of indirect emissions from: refineries producing motor fuels, including refining, storage, flaring and extraction of oil; the distribution and supply of motor fuels; and power stations generating the electricity used by electric vehicles.

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 2022. Further details of these revisions can be found in the main Final UK Greenhouse Gas Emissions Statistics report, which covered 2023 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 26 June 2025 the Department for Energy Security and Net Zero will publish estimates of 1990-2023 UK territorial emissions by Standard Industrial Classification (SIC), to supplement the sector breakdown included in this publication.

On Thursday 26 June 2025 the Department for Energy Security and Net Zero will also publish estimates of greenhouse gas emissions by local authority for 2023.

In February 2026 final 1990-2024 UK greenhouse gas emissions estimates will be published by source sector.

In March 2026 the 1990-2024 UK emissions estimates will be updated to include estimates by end user and uncertainty estimates, and provisional 2025 greenhouse gas emissions estimates will be published.

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