



Department for  
Energy Security  
& Net Zero



# UK Greenhouse Gas Emissions: Provisional Estimates

Methodology Summary

March 2024



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# Introduction

This document summarises how the provisional 2023 UK greenhouse gas (GHG) emissions estimates were derived, including the quarterly and temperature adjusted estimates that are included in this publication. The estimates show UK territorial GHG emissions, meaning emissions that occur within the UK's borders. The annual emissions estimates for years up to 2022 in this publication match those in the [final UK greenhouse gas emissions national statistics: 1990 to 2022](#), and information about how those estimates were produced can be found in that publication.

The Department for Energy Security and Net Zero currently publishes the final UK GHG emissions estimates 13 months after the end of the reference year. However, we are able to provide more timely provisional UK GHG emissions estimates, which are usually published at the end of March, 3 months after the end of the reference year. These are based on the energy use statistics published in [Energy Trends](#) (for carbon dioxide (CO<sub>2</sub>) emissions), and the latest published [Energy & Emissions Projections](#) (EEP, for non-CO<sub>2</sub> GHG emissions).

The provisional figures include breakdowns by Territorial Emissions Statistics (TES) sector and (for CO<sub>2</sub> only) fuel type, but not the detailed breakdowns by TES category or activity that are available in the final estimates as the provisional estimates are made at a higher level of aggregation. For the *Buildings and product uses* sector a breakdown by subsector is shown since the estimates are made at this level in this sector.

The provisional UK greenhouse gas emissions publication also includes:

- Quarterly greenhouse gas emissions estimates for the years 2008 onwards
- Temperature adjusted greenhouse gas emissions for the years 2008 onwards

Provisional estimates are also made for emissions from UK-based international aviation and shipping bunkers, which are not included in the UK GHG emissions totals. These are also based on energy use statistics from Energy Trends, with the same method used to estimate CO<sub>2</sub> and non-CO<sub>2</sub> gases.

Only UK emissions are included in the provisional estimates. The Crown Dependencies and Overseas Territories for which estimates are made in the final GHG emissions publication are not included.

# Provisional UK greenhouse gas emissions estimates

For the purpose of producing the provisional UK estimates, GHG emissions are classified into three categories:

1. Carbon dioxide (CO<sub>2</sub>) emissions based on energy use data
2. CO<sub>2</sub> emissions not based on energy use data
3. Other greenhouse gas emissions (non-CO<sub>2</sub>).

When deriving the provisional annual UK GHG emissions estimates and the quarterly estimates a different approach is taken for each of these three categories of emissions, as summarised in Table A.

**Table A: The approaches taken for estimating provisional annual UK GHG emissions and quarterly emissions**

	<b>Provisional annual estimates</b>	<b>Quarterly estimates</b>
<b>CO<sub>2</sub> emissions based on energy use data</b>	For individual activities/fuel types, year on year growth factors are applied to the latest final emissions figures to derive provisional estimates for the following year. These are based on looking at year on year changes in energy use for the closest corresponding sector/fuel type included in the <i>Energy Trends</i> publication.	For a given activity/ fuel type, annual emissions are allocated to individual quarters within each year in proportion to the quarterly energy use. This is based on the looking at same sector/fuel types in <i>Energy Trends</i> as for the provisional annual estimates.
<b>CO<sub>2</sub> emissions not based on energy use data</b>	For these activities/fuel types, the provisional figures are taken to be the same as the final figures for the previous year, so no change is assumed between the two years.	For each year in the series these emissions are allocated equally between the four quarters.
<b>Non-CO<sub>2</sub> greenhouse gas emissions</b>	For each sector and gas, a growth factor is applied to the final emissions total for the previous year. This growth factor is based on the year-on-year growth in the emissions forecast for that sector and gas in the latest published <i>Energy and Emissions Projections</i> .	For each year in the series these emissions are allocated equally between the four quarters.

## Carbon dioxide emissions derived from energy use

For the vast majority of net CO<sub>2</sub> emissions (94% in the 2022 final UK figures), the provisional emissions estimates are based on provisional energy use data published in *Energy Trends* on the same day that the provisional GHG emissions estimates are published. To produce the estimates, it is assumed that the percentage change in CO<sub>2</sub> emissions between the latest two

years is the same as the change in energy use for a particular activity and fuel between the latest two years. E.g. if the volume of gas used in power stations has reduced by 5% in the energy data, we assume that CO<sub>2</sub> emissions from the use of gas in power stations reduced by 5%.

The emissions that are scaled this way are put into 28 groups based on the source sectors and fuels shown in Table B, and a scaling factor is calculated for each one from the energy use data. For a small number of sources, emissions from energy use are kept flat if there is no suitable data available in Energy Trends to scale it by. All agriculture CO<sub>2</sub> emissions are also kept flat, since energy use only makes up a small proportion of emissions in this sector.

**Table B: Emission and fuel categories for which scaling factors are produced from Energy Trends data to estimate provisional CO<sub>2</sub> emissions**

<b>Emissions</b>	<b>Fuel</b>
Power stations	Coal
Power stations	Other solid fuels
Power stations	Oil
Power stations	Gas
Other energy industry	Coal
Other energy industry	Other solid fuels
Other energy industry	Oil
Other energy industry	Gas
Transport	Motor Spirit
Transport	DERV
Transport	Gas (road vehicles)
Transport	Aviation fuels
Transport	Other fuels
Public sector buildings	Coal
Public sector buildings	Oil
Public sector buildings	Gas
Residential buildings	Coal
Residential buildings	Other solid fuels
Residential buildings	Oil
Residential buildings	Gas
Commercial buildings	Coal
Commercial buildings	Oil
Commercial buildings	Gas
Industry	Coal
Industry	Oil
Industry	Gas
Industry	Coke oven gas
Industry	Other solid fuels

## Carbon dioxide emissions not derived from energy use

The remainder of CO<sub>2</sub> emissions are assumed to have remained unchanged from the previous year. While this is only the case for 6% of net CO<sub>2</sub> (based on the 2022 final UK figures) this is particularly relevant for some sectors. For the *agriculture, waste, and land use, land use change and forestry* (LULUCF) sectors, all CO<sub>2</sub> emissions are treated in this way, even if they relate to energy use. This is also the case for all CO<sub>2</sub> emissions from the *Other buildings and product uses* subsector, which is shown in the statistics. Based on the final 2022 UK emissions estimates, Table C shows for each sector the proportion of CO<sub>2</sub> emissions for which the provisional estimates are not derived from energy use, and are therefore taken to be unchanged from the previous year.

**Table C: Percentage of CO<sub>2</sub> emissions for which the provisional emissions estimates are not derived from energy use data, based on the final 2022 UK emissions**

Sector	Percentage of CO <sub>2</sub> emissions not derived from energy use data
Electricity supply	11%
Fuel supply	9%
Domestic Transport	0%
Buildings and product uses	1%
<i>Residential buildings</i>	0%
<i>Commercial buildings</i>	0%
<i>Public sector buildings</i>	0%
<i>Other buildings and product uses</i>	100%
Industry	14%
Agriculture	100%
Waste	100%
LULUCF	100%
<b>Total CO<sub>2</sub> emissions</b>	<b>6%</b>

## Non-carbon dioxide emissions

Non-CO<sub>2</sub> GHG emissions make up around a fifth of total GHG emission in the UK when measured on a carbon dioxide equivalent basis. We derive the provisional annual totals for each sector and gas for non-CO<sub>2</sub> emissions by applying a year on year growth factor to the previous year's total, based on looking at the percentage change between the projections for the two years for that sector and gas in the reference scenario in the latest published [Energy & Emissions Projections \(EEP\)](#). E.g. if the latest EEP projection for methane in the agriculture sector is a 1% fall in the year for which the provisional estimates are being produced, we will assume that methane emissions in the agriculture sector have fallen by 1%.

We first introduced this approach for the 2018 provisional estimates for the non-CO<sub>2</sub> overall total, and applied it at a sector and gas level for the 2023 provisional estimates when provisional greenhouse gas totals were presented by sector for the first time. Prior to the 2018

provisional estimates we had instead assumed that the total non-CO<sub>2</sub> emissions remained unchanged from the previous year. But as they had been consistently falling in recent years, and this was projected to continue, this approach was found to be consistently overestimating non-CO<sub>2</sub> emissions and using the projections would have been more reliable.

For the 2023 provisional estimates the sectors used for these calculations were the National Communication (NC) sectors as these were the sectors used in the 2022-2040 EEP publication, but the provisional statistics were presented using the newly developed Territorial Emissions Statistics (TES) sectors.

Table D shows for each TES sector the proportion of the greenhouse gas total for which the provisional estimates are CO<sub>2</sub> emissions where we derive the estimates from energy use data, the most reliable approach used in these estimates, and what proportion are either CO<sub>2</sub> emissions not derived from energy data or are non-CO<sub>2</sub> gases. As non-CO<sub>2</sub> gases make up the majority of emissions for the *agriculture, waste* and *LULUCF* sectors, as well as for the *Other buildings and product uses* subsector, we mark these figures as estimates in the published tables to denote that these totals are based on projections rather than historic energy use data, so are less reliable than the totals for other sectors.

**Table D: Percentage of GHG emissions for which the provisional emissions estimates are derived from each approach, based on the final 2022 UK emissions**

<b>Sector</b>	<b>Percentage of GHG emissions that are CO<sub>2</sub> and derived from energy use data</b>	<b>Percentage of GHG emissions that are CO<sub>2</sub> and not derived from energy use data</b>	<b>Percentage of GHG emissions that are non-CO<sub>2</sub></b>
Electricity supply	88%	11%	1%
Fuel supply	76%	8%	16%
Domestic Transport	98%	0%	2%
Buildings and product uses	92%	~0%	8%
<i>Residential buildings</i>	99%	0%	1%
<i>Commercial buildings</i>	100%	0%	~0%
<i>Public sector buildings</i>	100%	0%	~0%
<i>Other buildings and product uses</i>	0%	7%	93%
Industry	83%	14%	3%
Agriculture	0%	15%	85%
Waste	0%	2%	98%
LULUCF	0%	-825%	925%
<b>Total greenhouse gas emissions</b>	<b>75%</b>	<b>4%</b>	<b>20%</b>

Notes:

1. As the net CO<sub>2</sub> total for LULUCF is negative the LULUCF figures in this table can be negative and greater than 100%.
2. ~0% indicates where a value is non-zero but is less than 0.5% in magnitude. 0% indicates a zero value.



## The reliability of the provisional annual GHG emissions figures

Table E looks at the estimated year on year growth in GHG emissions (both total GHG emissions and total CO<sub>2</sub> emissions), comparing the results based on the provisional figures with those based on the final figures published almost a year later. Overall, the year-on-year percentage change indicated by the provisional figures has usually been within a percentage point of the change shown by the final figures.

**Table E: Differences between provisional and final GHG emissions estimates**

	Year on year percentage change					
	CO <sub>2</sub> emissions			Total GHG emissions		
	Provisional estimate	Final estimate	Percentage point difference	Provisional estimate	Final estimate	Percentage point difference
2012	+4.5%	+4.4%	<b>+0.1</b>	+3.4%	+3.2%	<b>+0.2</b>
2013	-2.1%	-1.8%	<b>-0.3</b>	-1.9%	-2.4%	<b>+0.5</b>
2014	-9.7%	-8.9%	<b>-0.8</b>	-8.4%	-7.7%	<b>-0.7</b>
2015	-4.1%	-4.1%	<b>0.0</b>	-3.4%	-3.8%	<b>+0.4</b>
2016	-7.4%	-5.9%	<b>-1.5</b>	-6.0%	-5.0%	<b>-1.0</b>
2017	-3.2%	-3.3%	<b>+0.1</b>	-2.6%	-2.7%	<b>+0.1</b>
2018	-2.4%	-2.2%	<b>-0.2</b>	-2.5%	-2.1%	<b>-0.4</b>
2019	-3.9%	-3.3%	<b>-0.6</b>	-3.6%	-2.8%	<b>-0.8</b>
2020	-10.7%	-10.6%	<b>-0.1</b>	-8.9%	-9.5%	<b>+0.6</b>
2021	+6.3%	+6.6%	<b>-0.3</b>	+4.7%	+5.0%	<b>-0.3</b>
2022	-2.4%	-3.8%	<b>+1.4</b>	-2.2%	-3.5%	<b>+1.3</b>

## Temperature adjusted emissions estimates

Carbon dioxide emissions are indirectly influenced by external temperatures. During the winter months, emissions are generally higher than in summer months, due to higher demand for fuel for space heating. During a particularly cold winter for example, it is likely that more fuel will be burnt for domestic or commercial use than during an average winter, and therefore emissions will be higher due to the additional fuel consumption.

Temperature adjusted quarterly emissions estimates therefore remove the effect of external temperatures. In a particularly cold winter quarter, for example, this will result in temperature adjusted emissions being lower than actual emissions, reflecting the lower fuel consumption which would have occurred if temperatures had been at average levels. The temperature adjustment makes use of figures on the number of heating degree days, and how they deviate from the long-term average for the given time of year. This information is published in the *Weather* section of *Energy Trends*: [www.gov.uk/government/statistics/energy-trends-section-7-weather](http://www.gov.uk/government/statistics/energy-trends-section-7-weather)

Emissions are only temperature adjusted for certain activities and fuel types, as not all emissions are affected by external temperatures. To decide whether emissions from a given activity/fuel type should be temperature adjusted or not, and if so by how much, the following procedure has been followed:

- A simple linear regression is established between the quarterly emissions for a given sector/fuel type and the quarterly average heating degree days, from 2002 to 2019 (later years are not currently included because of the behavioural changes seen during the COVID-19 pandemic).
- Identify the coefficient of determination ( $R^2$ ), which measures how well the regression line approximates the data points. This takes a value between 0 and 1. The closer the  $R^2$  is to 1, the stronger the correlation between the emissions from the given sector/fuel type and the number of heating degree days, while values closer to 0 indicate little to no correlation between them.
- Conduct a statistical test on the coefficient of each individual regression. If the coefficient is statistically significantly different from zero, and the  $R^2$  is sufficiently high, then emissions for that given activity/fuel type are temperature adjusted. Otherwise, there is assumed to be no temperature effect, and therefore no adjustment required.

- CO<sub>2</sub> emissions are adjusted for each sector and fuel by using the gradient from the regression model as an estimate of the additional emissions per additional heating degree day. For a given quarter we look at the number of heating degree days by which it deviated from the typical amount of heating required in that quarter of the year (as given by the long-term average for the period 1991-2020).
- Multiplying this deviation by our estimate of the additional emissions per additional heating degree day for the given sector/fuel type gives the estimated temperature effect on CO<sub>2</sub> emissions. This temperature effect is then removed to give the temperature adjusted emissions for that quarter.

It should be noted that the temperature adjustment is intended to remove the effect of temperatures varying between years, and it does not adjust for the usual within-year seasonal variation in temperatures. So the temperature adjusted estimate for a particular quarter reflects what we estimate emissions would have been if the temperatures that quarter had been in line with the long-term average for that quarter.

The long-term average we use in the temperature adjustment is based on the 30-year period 1991-2020. We typically update the 30-year period used every decade, with the most recent change being made in Energy Trends from June 2022. The time period used will affect the absolute level of the temperature adjusted emissions values, but this should not have a significant effect on the trends derived from the adjusted data since all years are adjusted based on the same long-term average. More information about the most recent change can be found in the article about long term mean temperatures in the [March 2022 Energy Trends](#).

The non-CO<sub>2</sub> GHG emissions estimates and estimates of emissions from UK-based international aviation and shipping bunkers are not temperature adjusted.

## Emissions from UK-based international aviation and shipping bunkers

Emissions from international aviation and shipping can be estimated from refuelling from bunkers<sup>1</sup> at UK airports and ports, whether by UK or non-UK operators. Under the reporting guidelines agreed by the United Nations Framework Convention on Climate Change (UNFCCC), these emissions are not included in the UK's emissions total that is submitted to the UNFCCC each year but are reported as memo items in national greenhouse gas inventories. They are therefore shown in a separate table from the UK territorial GHG emissions estimates in the final and provisional UK GHG emissions publications.

Provisional estimates of GHG emissions from UK-based international aviation and shipping bunkers were first included in the provisional 2022 UK GHG emission estimates. These estimates are made following the same approach used for carbon dioxide emissions derived from energy use in the UK provisional totals, using Energy Trends data. To produce the estimates it is assumed that the percentage change in emissions between the latest two years is the same as the change in the equivalent energy use between those two years. For emissions from international shipping the marine bunkers estimates from Energy Trends are used; and for emissions from international aviation bunkers we use the estimates for aviation fuels (the large majority of which are used for international aviation). This approach is used for all three greenhouse gases for which we produce estimates, not just carbon dioxide.

Quarterly and temperature adjusted emissions estimates are not made for these emissions.

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<sup>1</sup> A large container or compartment that stores fuel for ships or aircraft.

# The reporting of the greenhouse gas emissions

## Emissions by source and end-user

The provisional, quarterly and temperature adjusted greenhouse gas (GHG) emissions figures are all presented on a “by source” basis only. This means that emissions are attributed to the sector that emits them directly.

This is different from emissions on a “by end-user” basis, where emissions from energy production are re-allocated to the final user of the energy. For example, all GHG emissions produced by a power station are allocated to the power station when reporting on a by source basis. However, when applying the end-user method, these emissions are re-allocated to the users of this electricity, e.g. households and businesses.

The final GHG emissions figures are published on both a “by source” and a “by end-user” basis.

## Territorial Emissions Statistics sectors

For the purposes of reporting, we allocate greenhouse gas emissions to Territorial Emissions Statistics (TES) sectors. This small number of high-level sectors is listed in Table F. We first used these sectors in the final 2022 UK greenhouse gas emissions statistics, in place of the National Communication (NC) sectors that we used previously. Details of this change can be found in the [Final UK greenhouse gas emissions national statistics: 1990 to 2022](#).

These high-level sectors are made up of a number of more detailed categories, which largely follow the definitions set out by the [Intergovernmental Panel on Climate Change \(IPCC\)](#) and which are used in international reporting tables, submitted to the United Nations Framework Convention on Climate Change (UNFCCC) each year.

**Table F: Emissions included in each Territorial Emissions Statistics (TES) sector**

<b>Electricity supply</b>	Emissions from power stations for electricity generation, including incinerators generating energy from waste. Excludes emissions from organisations generating their own electricity (autogeneration) even when exported to the electricity grid. These emissions are instead included in the sector in which they occur.
<b>Fuel supply</b>	Emissions from the supply of fuels, e.g. oil, gas and coal. Includes activities such as extraction, production, venting, flaring, processing (e.g. oil refining) and distribution. Excludes emissions from coke production which are instead included in the <i>industry</i> sector as coke is primarily used in the iron and steel industry.
<b>Domestic transport</b>	Emissions from road vehicles, domestic aviation and shipping (including military), fishing vessels, and railways. Also includes emissions from transport related mobile machinery (e.g. at airports and ports) and F-gases from mobile air conditioning and refrigeration. International aviation and shipping emissions are not included in the national total, though are reported separately.
<b>Buildings and product uses</b>	Emissions from fuel combustion in residential, public, and commercial buildings, largely for heating. Also includes emissions from house and garden mobile machinery, anaesthetics, F-gases from air conditioning, refrigeration, heat pumps, aerosols as well as other product uses. Excludes emissions from industrial buildings which are instead included in the <i>industry</i> sector.
<b>Industry</b>	Emissions from fuel combustion in the manufacturing and construction industries, industrial processes, and F-gases from industrial refrigeration. Emissions from coke production are included in this sector as coke is primarily used in the iron and steel industry. Includes emissions from organisations generating their own electricity and heat (autogeneration) even when exported to the electricity grid or used in heat networks.
<b>Agriculture</b>	Emissions from agricultural machinery and fuel combustion, livestock (enteric fermentation and manure management) and agricultural soils (excluding carbon stock changes which are included in the <i>LULUCF</i> sector).
<b>Waste</b>	Emissions from the treatment and disposal of waste, such as landfill, composting, incineration without energy recovery and wastewater handling. Excludes emissions from incinerators generating energy from waste as these are reported in the <i>electricity supply</i> sector.
<b>Land use, land use change and forestry (LULUCF)</b>	Includes emissions and removals of CO <sub>2</sub> from changes in the carbon stock in forestland, cropland, grassland, wetlands, settlements and harvested wood products, and emissions 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. As impacts of carbon stock changes are included in this sector, CO <sub>2</sub> emissions of biogenic origin (e.g. burning biomass for energy) are excluded from other sectors to avoid double counting.

This publication is available from: <https://www.gov.uk/government/statistics/provisional-uk-greenhouse-gas-emissions-national-statistics-2023>

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