Office for National Statistics

Article

Developing quarterly greenhouse gas emissions accounts, UK: December 2022

Update on work to develop a measure of quarterly UK greenhouse gas (GHG) emissions on a residency basis, and future development and publication plans.

Contact:
Sumit Dey-Chowdhury and Gemma Thomas
environment.accounts@ons.gov.uk
+44 1633 456660

Release date:
16 December 2022

Next release:
To be announced

Table of contents

1 . Main points

- Since our publication in May, we have improved our initial method of estimating UK residence-based greenhouse gas (GHG) emissions by switching to a method that allows multiple predictor indicators.

- Residence based emissions are used to compare with economic data and are different to those used to monitor UK emissions targets.

- Using our current method, UK GHG emissions (seasonally adjusted) on a residence basis for Quarter 2 (Apr to Jun) 2022 were estimated to be 3.1% lower than in Quarter 1 (Jan to Mar) 2022.

- We are continuing to improve our methodology by identifying better predictor indicators, refining our modelling, and developing estimates for certain industries.

- We plan to publish experimental estimates using our improved methodology by April 2023, covering the period up to Quarter 4 (Oct to Dec) 2022.

2 . Developing quarterly greenhouse gas emissions

Greenhouse gas (GHG) emissions on a residence basis are currently published annually in the UK, with provisional estimates released nine months after the end of the year and final estimates after 18 months. One of the main advantages of emissions estimates on a residence basis is that they can be compared with economic data, a range of which are available on a more timely basis.

We have explored the feasibility of modelling more timely and frequent estimates of GHG emissions in response to user need by using related, more frequently available data. In our article, Developing quarterly greenhouse gas emissions accounts, UK: May 2022, we set out a framework for how we proposed to do this, using movements in higher-frequency indicators, known as predictor indicators, to split the annual emissions series into quarterly estimates. This process is known as temporal disaggregation. As these predictor indicators are also more timely, they can be used to extrapolate the GHG emissions series to provide estimates for time periods beyond what is currently available.

There are three official measures of greenhouse gas emissions in the UK. This article uses greenhouse gases on a residence basis, taken from the Office for National Statistics (ONS) Environmental Accounts. These are different to territorial emissions, which are used to inform progress on UK-wide emissions targets. An article on these three different measures can be found on the UK Climate Change Statistics Portal: Measuring UK greenhouse gas emissions.

Choice of predictor indicators

The majority of greenhouse gas emissions are directly related to energy use, so UK energy data can be used as predictor indicators. Statistics on all major aspects of energy in the UK are published in the Department for Business, Energy and Industrial Strategy's (BEIS) quarterly bulletin, Energy Trends. These are published one quarter after the reference period, allowing us to estimate figures for UK greenhouse gas emissions for that time period. Provisional estimates for Quarter 2 (Apr to Jun) of 2022 were released in September 2022.

Since our last publication we have improved our proposed modelling by switching to a method that allows for multiple predictors, rather than one. This enables us to make the most of the available information on energy trends in the UK, improving the model's performance and giving more accurate estimates. The initial choice of predictor indicators was made on a conceptual basis, where we judged this would capture the activity associated with GHG emissions. Then we used backwards elimination regression to identify predictors that are statistically significant within the model, meaning that we ran the regression using our choice of predictor indicators. We then removed indicators that were not significant in the model one at a time, until we were left with a model where all the predictors were significant.

To make best use of available data, temporal disaggregation would ideally take place at the highest level of detail possible. We are in the process of identifying the best predictor indicators at industry level and for specific gases; this is discussed further in Section 4, Industry-level estimates. For the purposes of the estimates in this article, temporal disaggregation has taken place at the top level, that is for total emissions, with final energy consumption by fuel type (shown in this BEIS spreadsheet (XLS 1.05MB)) used as the predictor indicators. Energy consumption from bioenergy and waste has been included, as emissions from renewable and waste-derived fuels are included in residence-based estimates of greenhouse gas emissions from the Environmental Accounts.

3 . Initial estimates

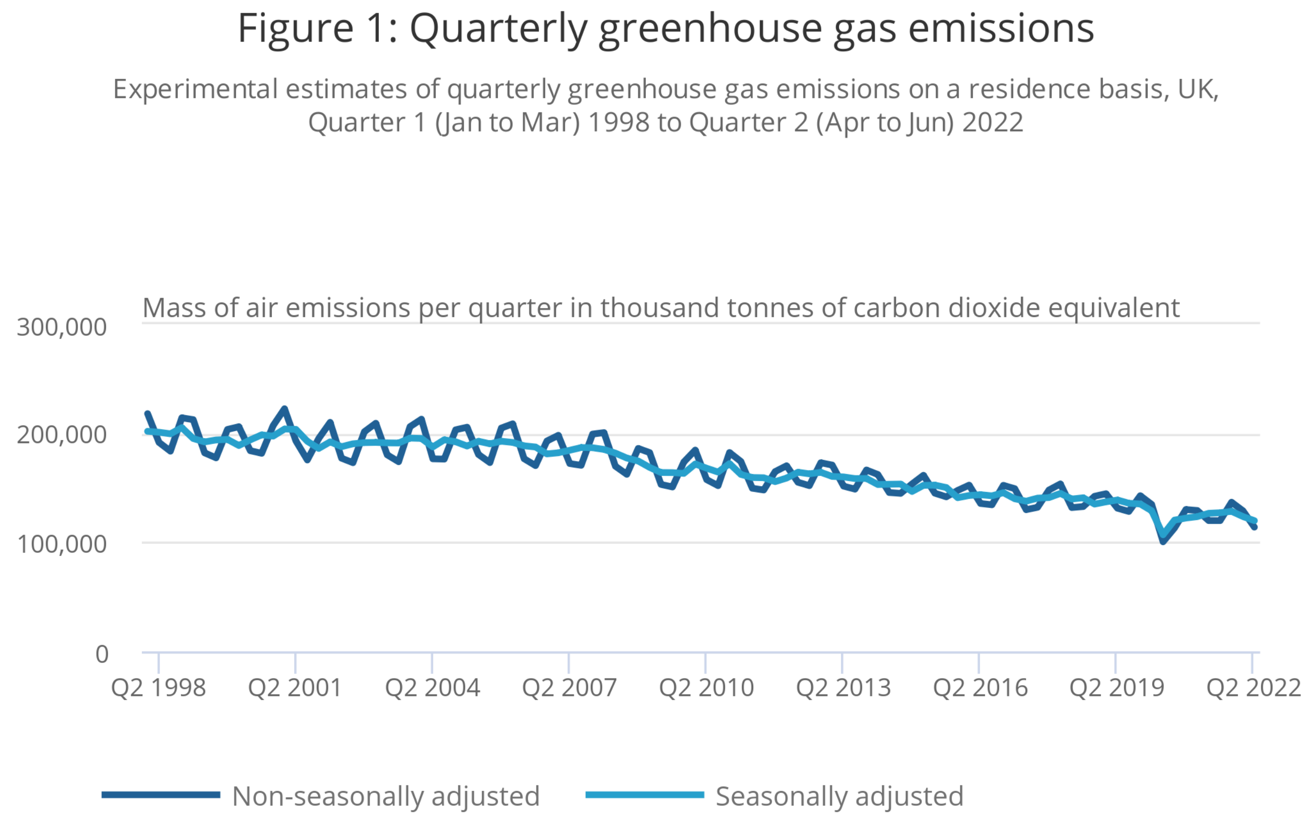
We have developed models to estimate both total quarterly greenhouse gas (GHG) and carbon dioxide (CO_2) emissions, on a residence basis up to Quarter 2 (Apr to Jun) 2022. Estimates for GHG emissions are shown in Figure 1, with estimates for both CO_2 and GHG available in the accompanying dataset. To aid interpretation of changes over time, seasonally adjusted figures are included. These estimates have not been temperature adjusted, a technique which is often used when looking at GHG emissions. We will consider how we approach this as part of our future development.

Figure 1 shows that there was a fall in GHG emissions (seasonally adjusted) in both Quarter 1 and Quarter 2 of 2022, 3.7% and 3.1%, respectively. GHG emissions in Quarter 2 of 2022 were 5.0% lower when compared with the same period in 2021. This is reflective of both the reduction in energy consumption seen in the predictor indicators used and the increase in renewable energy generation. These trends can both be seen in the GOV.UK statistical release, Energy trends: September 2022.

It should be noted that these estimates are subject to uncertainty, both in the underlying estimates used with the model and through uncertainty introduced by the modelling itself. More information can be found in Section 7: Data sources and quality.

Figure 1: Quarterly greenhouse gas emissions

Experimental estimates of quarterly greenhouse gas emissions on a residence basis, UK, Quarter 1 (Jan to Mar) 1998 to Quarter 2 (Apr to Jun) 2022



Source: Office for National Statistics – Environmental Accounts, Department for Business, Energy and Industrial Strategy – Energy Trends

Notes:

1. These estimates have been modelled using the Chow-Lin regression based temporal disaggregation method.

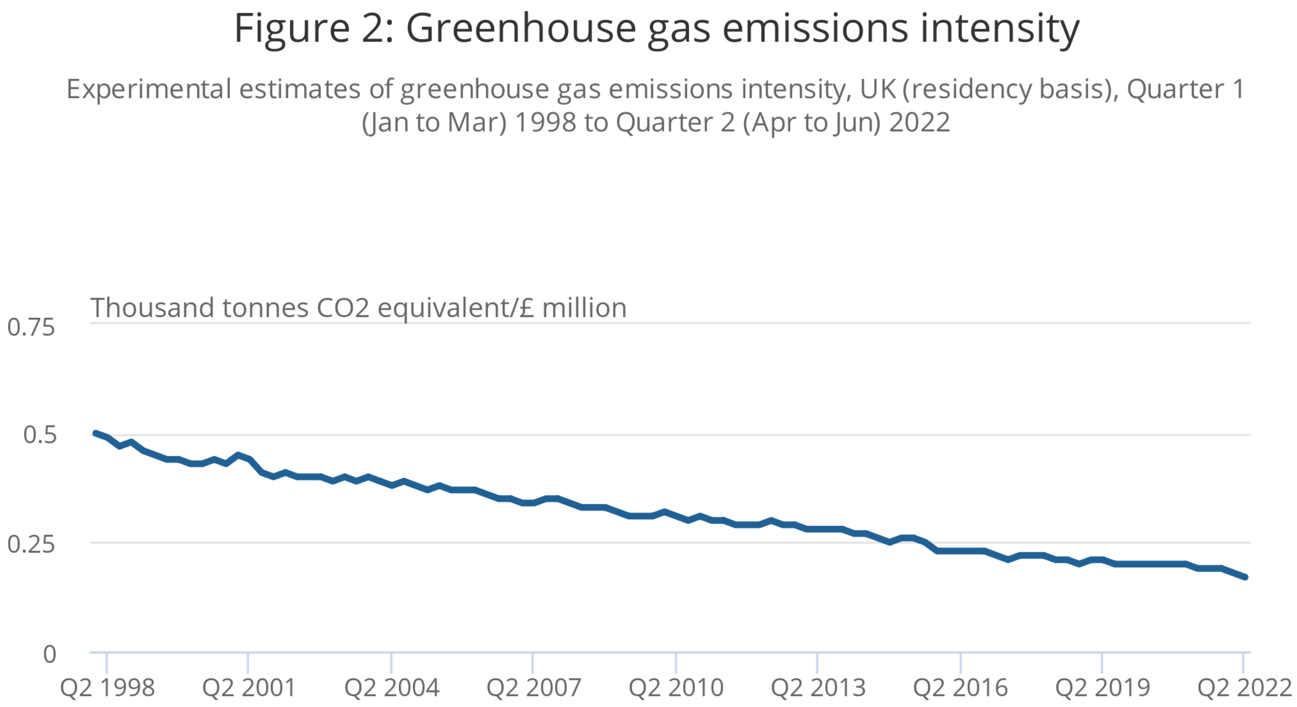
2. For seasonal adjusted estimates, the predictor indicators used within the modelling were seasonally adjusted using X-13ARIMA-SEATS.

As mentioned above, one of the main advantages of emissions estimates on a residence basis is that we can compare them with economic data. GHG intensity measures the level of emissions per unit of gross value added (GVA) and can be used to examine the relationship between economic growth and greenhouse gas emissions. For example, a reduction in overall UK GHG emissions intensity indicates the UK is moving towards a lower carbon economy. This could be through individual industries becoming more efficient in their processes and emitting fewer GHGs per unit of GVA. At the same time, it may also reflect changes to the structure of the economy, for example, a change from manufacturing to services, which produce fewer GHG emissions. As can be seen in Figure 2, GHG emissions intensity has been falling steadily since 1998.

The models used in our calculations had higher levels of uncertainty than for total GHG and CO2 emissions. We will be looking into this with a view to improving the models.

Figure 2: Greenhouse gas emissions intensity

Experimental estimates of greenhouse gas emissions intensity, UK (residency basis), Quarter 1 (Jan to Mar) 1998 to Quarter 2 (Apr to Jun) 2022



Source: Office for National Statistics

Notes:

1. Greenhouse gas emissions intensity is calculated by dividing the level of greenhouse gas emissions by Gross Value Added (GVA). GVA is the difference between output and intermediate consumption for any given industry. This means the difference between the value of goods and services produced (output) and the cost of raw materials and other inputs, which are used up in production (intermediate consumption). GVA are chained volume measures, in constant prices with 2019 as the base and reference year. All emissions intensity figures are calculated excluding consumer expenditure.

2. Intensity figures have been calculated on seasonally adjusted estimates of greenhouse gas emissions excluding consumer expenditure. These GHG estimates have been modelled using the Chow-Lin regression based temporal disaggregation method. This model was found to be less reliable than for total CO2 and total GHG, so these estimates should be treated with additional caution.

3. For seasonal adjusted estimates, the predictor indicators used within the modelling were seasonally adjusted using X-13ARIMA-SEATS.

4 . Industry-level estimates

We are also working to identify robust predictor indicators for industry-level estimates, for their own use and for use in overall emissions modelling.

We have initially considered the indicators that the Department for Business, Energy and Industrial Strategy (BEIS) use in their provisional quarterly estimates on a territorial basis, published in their annual report. In addition to being a sensible starting point, using similar predictors wherever possible will also ensure coherence between the estimates. Because of these differences in the scope and structure of the estimates, in certain cases different predictor variables will be needed.

We have initially focused on predictor indicators for the highest-emitting industries. Predictor indicators that have been considered are set out below. The percentage of total greenhouse gases on a residence basis that each sector accounted for in 2021 is given in brackets.

Electricity, gas, steam and air conditioning (17.1%)

From our testing, energy generation data by fuel type appears to be an appropriate predictor indicator for this industry.

Consumer expenditure (26.7%)

Consumer expenditure is split into travel and non-travel in the Environmental Accounts. Consumer expenditure (non-travel) accounted for 14.9% of total greenhouse gas (GHG) emissions on this basis in 2021. As these emissions mostly relate to heating of homes, estimates of quarterly domestic consumption of energy by fuel type – specifically coal, manufactured fuels, petroleum and natural gas – were found to be good predictor indicators.

Consumer expenditure (travel) accounted for 11.8% of total emissions in 2021. As this largely relates to emissions from domestic road vehicles, quarterly consumption of diesel and petrol are likely to be good predictor indicators.

Transport and storage (11.3%)

Predictor indicators for lower-level industries within this category, such as land transport services, water transport services and air transport services, have been identified. These include data on bunker fuels and the quarterly consumption of diesel engine road fuel (DERV). For air transport services it is possible to take direct estimates of CO_2 emissions from the Organisation for Economic Co-operation and Development (OECD) data on air transport CO_2 emissions, although these are only available from 2019 so alternative estimates would need to be developed for earlier in the time series.

Manufacturing (16.9%)

Quarterly demand of total energy industry use by fuel did not prove a reliable model for this industry. We are reviewing other potential predictor indicators, including for sub-sectors, such as the manufacture of other non-metallic minerals and the manufacture of basic metals, which act differently to other manufacturing sectors.

Agriculture, forestry and fishing (9.5%)

Unlike other sectors, the majority of this sector's GHG emissions come from methane. Potential data being considered include livestock numbers, although these are not available on a quarterly basis.

Other (18.5%)

We will continue to review the best predictor indicators for these and other less emitting industries.

We welcome any feedback on these proposed predictor indicators, via email: environment.accounts@ons.gov.uk.

5 . Data

[Experimental estimates of quarterly greenhouse gas emissions](#)
UK Environmental Accounts | Released 15 December 2022
Experimental estimates of quarterly greenhouse gas emissions and carbon dioxide emissions on a residency basis. Includes seasonally adjusted estimates.

[Atmospheric emissions: greenhouse gases by industry and gas](#)
UK Environmental Accounts | Released 1 November 2022
The emissions of carbon dioxide, methane, nitrous oxide hydro-fluorocarbons, perfluorocarbons, sulphur hexafluoride, nitrogen trifluoride and total greenhouse gas emissions, by industry (SIC 2007 group - around 130 categories), UK, 1990 to 2020 and (provisional) 2021

[Energy Trends: September 2022](#)
Department for Business, Energy and Industrial Strategy | Released 29 September 2022
Quarterly bulletin containing statistics on all major aspects of energy in the UK

6 . Glossary

Greenhouse gas emissions

The greenhouse gases (GHG) included in the atmospheric emissions in this article are those covered by the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). These gases contribute directly to global warming and climate change, because of their positive radiative forcing effect. The potential of each GHG to cause global warming is assessed in relation to a given weight of CO_2, so all greenhouse gas emissions are measured as carbon dioxide equivalents (CO_2e).

Residency basis

Estimates compiled on a residency basis include data relating to UK residents and UK-registered businesses, regardless of whether they are in the UK or overseas. Data relating to foreign visitors and foreign businesses in the UK are excluded.

Temporal disaggregation

Temporal disaggregation is the process of deriving high-frequency data (for example, quarterly) from low-frequency data (for example, annual).

7 . Data sources and quality

Uncertainty

Modelling estimates will inevitably lead to uncertainty. Revisions analysis was undertaken on all of the estimates included within this article to provide a measure on the likely size of revisions. Because of the relatively short length of the time series, it was not valid to summarise the revisions with summary statistics. Forecast errors were also calculated to provide an estimate of the reliability of the forecasted values. The mean percentage error (MPE) and mean absolute percentage error (MAPE) for the forecasts were calculated. The MPE provides an estimate of a tendency (bias) to underestimate or overestimate, and the MAPE provides an estimate of how accurate the forecast values are.

Our analysis of the forecast accuracy of the model for total greenhouse gas (GHG) emissions suggests that estimates for the latest year tend to be overestimated by 0.5% and that the forecasts (in this case estimates for 2022) tend to be within a range between negative 2.3% to positive 2.3% of the final estimate.

The model for carbon dioxide (CO2) emissions only produced more reliable estimates, most likely because the predictor indicators used are more appropriate for CO2 than the other GHGs.

Greenhouse gas emissions

The greenhouse gas emissions calculated in this article are on a residency basis and are part of the Environmental Accounts. Details on the methodology used to calculated these, including associated uncertainty, can be found in our air emissions quality and methodology information. The latest year of GHG and CO2 emissions data are provisional, so are likely to be revised. This will be reflected in revisions in any modelled estimates.

Energy trends

The latest quarter of energy trends data used in the predictor indicators are provisional and are subject to revision. Any revisions to these data will be reflected in the modelled estimates. More details on the methodology used to construct energy trends data can be found on the relevant fuel pages of the Department for Business, Energy and Industrial Strategy's Energy Trends.

8 . Future development

Temporal disaggregation should ideally take place at the lowest level possible. We will continue to develop estimates for lower-level industries and individual greenhouse gases, where appropriate. These series can then be considered as predictor indicators for more aggregated data. We will continue to review and identify the best predictor indicators available for different industries and greenhouses gases, such as methane.

We will look to publish experimental estimates with these improvements in April 2023.

One limitation of the method we are using is that it assumes a linear relationship between the predictor indicator and greenhouse gas emissions, which is constant over time. However, this is unlikely to be the case. For example, while coal may be a good predictor indicator for temporally disaggregating the earlier years of greenhouse gas emissions, that is not true in recent years. In the longer term, we will look to develop new methodology to allow for the relationship between emissions and predictor indicators to change over time within the modelling.

9 . Related links

Developing quarterly greenhouse gas emissions accounts, UK: May 2022
Article | Released 12 May 2022
Sets out a potential framework to develop annual greenhouse gas (GHG) emissions accounts on a quarterly basis. Also outlines potential issues and future work.

Greenhouse gas emissions, UK: provisional estimates: 2021
Bulletin | Released 1 November 2022
Measuring the contribution of the environment to the economy, the impact of economic activity on the environment, and society's response to environmental issues.

Measuring UK greenhouse gas emissions
Article | Released 1 November 2021
The UK is required to report its estimated greenhouse gas (GHG) emissions on a range of different bases (territorial, residence and footprint) to fulfil a wide range of international agreements as well as for domestic policy making purposes.

10 . Cite this article

Office for National Statistics (ONS), released 16 December 2022, ONS website, article, Developing quarterly greenhouse gas emissions, UK: December 2022