Planned methodology changes for UK greenhouse gas emissions statistics 1990-2021
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Introduction

National Statistics on the UK’s territorial greenhouse gas emissions for 1990-2021 will be published on 7th February 2023. The dataset of greenhouse gas emissions estimates is known as the UK’s Greenhouse Gas Inventory. Every year, we apply methodological improvements to the way that emissions are estimated and revise the historical figures accordingly. This note sets out the main methodology changes that we have made this year, and their estimated impact on emissions. The figures in this note are not an indication of the revisions to the statistics as a whole, as it only includes methodology changes and does not include any annual revisions to the data sources used to estimate the UK’s emitting activities, for example national fuel use. Figures presented in this report are provisional, and in addition to the UK also include emissions in the Crown Dependencies and Overseas Territories that the UK is required to report on under the United Nations Framework Convention on Climate Change (UNFCCC)\(^1\).

The impacts of each methodology change on the 2020 totals and the 1990 baseline are given in Table 1 and the combined impact of them on each sector that we report on in Table 2. The estimated impacts are also reported as a percentage of the total emissions in last year’s Greenhouse Gas Inventory. Emissions estimates are expressed in million tonnes of carbon dioxide equivalents (MtCO\(_2\)e), with emissions from each gas weighted based on its global warming potential\(^2\). The ‘1990 baseline’ is used for the UK’s domestic greenhouse gas emission targets and is 1990 for carbon dioxide (CO\(_2\)), methane (CH\(_4\)) and nitrous oxide (N\(_2\)O), and 1995 for fluorinated gases (F-gases).

Changes to the estimates can be prompted by the availability of new research or datasets, in response to internal or external reviews which suggest improvements, or when required by revisions to the international reporting guidelines for greenhouse gases. They can also be a result of revisions to the datasets which have been used in their compilation, for example the UK energy statistics published in the Digest of UK Energy Statistics, although those revisions are not summarised in this document.

These changes are applied back through the time series to 1990, to ensure that the trend in emissions from 1990 to the present is based on a consistent method. It is therefore not appropriate to compare different years’ inventory submissions. However, the latest inventory represents a single consistent data series going back to 1990, and this therefore allows year-on-year comparisons to be made.

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1 The Crown Dependencies are the Bailiwick of Jersey, the Bailiwick of Guernsey and the Isle of Man. Only overseas territories that are party to the UK ratification of the UNFCCC are included in these statistics, which are the Cayman Islands, Bermuda, the Falkland Islands and Gibraltar.

2 The global warming potentials (GWPs) used are from table 8.A.1 (without climate-carbon feedback) of Working Group 1 of the IPCC Fifth Assessment Report: Climate Change 2013 and summarised in a table published on the following page: [https://www.gov.uk/government/publications/uk-greenhouse-gas-emissions-explanatory-notes](https://www.gov.uk/government/publications/uk-greenhouse-gas-emissions-explanatory-notes). Note that this is a change from previous inventories, as described in more detail on page 7.
Impact of changes

Table 1 shows the impact of methodological changes made this year on our emissions estimates.

Table 1 – Provisional effect of individual changes: UK, Crown Dependencies and Overseas Territories3,4,5,6

<table>
<thead>
<tr>
<th>Change</th>
<th>Reason for change</th>
<th>Change in emissions (MtCO₂e)</th>
<th>1990 baseline</th>
<th>2020</th>
<th>Impact on national total from previous inventory (%)</th>
<th>1990 baseline</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Global Warming Potentials</td>
<td>Implementing international agreement</td>
<td>7.65</td>
<td></td>
<td>3.22</td>
<td>0.94%</td>
<td></td>
<td>0.79%</td>
</tr>
<tr>
<td>Thermal Renewables</td>
<td>New data available</td>
<td>~0.00</td>
<td>-0.04</td>
<td>~0.00%</td>
<td>-0.01%</td>
<td>~0.00%</td>
<td>-0.01%</td>
</tr>
<tr>
<td>Non-road mobile machinery use of gas oil</td>
<td>Review of data sources available</td>
<td>0.86</td>
<td></td>
<td>0.24</td>
<td>0.11%</td>
<td></td>
<td>0.06%</td>
</tr>
<tr>
<td>Non-road mobile machinery use of LPG</td>
<td>Review of data sources available</td>
<td>~0.00</td>
<td>~0.00</td>
<td>~0.00%</td>
<td>~0.00%</td>
<td>~0.00%</td>
<td>~0.00%</td>
</tr>
<tr>
<td>Non-road mobile machinery use of road fuels</td>
<td>Review of data sources available</td>
<td>-0.03</td>
<td></td>
<td>0.10</td>
<td>~0.00%</td>
<td></td>
<td>0.02%</td>
</tr>
<tr>
<td>Non-medical aerosols</td>
<td>Advice from industry experts</td>
<td>0.00</td>
<td></td>
<td>-0.03</td>
<td>0.00%</td>
<td></td>
<td>-0.01%</td>
</tr>
<tr>
<td>Refrigerant containers</td>
<td>New data available</td>
<td>-0.01</td>
<td></td>
<td>-0.01</td>
<td>~0.00%</td>
<td></td>
<td>~0.00%</td>
</tr>
<tr>
<td>Wastewater pre-processing review</td>
<td>Review of data sources available</td>
<td>-0.18</td>
<td></td>
<td>-0.10</td>
<td>-0.02%</td>
<td></td>
<td>-0.02%</td>
</tr>
<tr>
<td>Small-scale waste burning</td>
<td>New data available</td>
<td>0.17</td>
<td></td>
<td>0.13</td>
<td>0.02%</td>
<td></td>
<td>0.03%</td>
</tr>
<tr>
<td>Land use, land use change and forestry modelling changes</td>
<td>New data available and review of existing data sources</td>
<td>-2.33</td>
<td></td>
<td>-2.90</td>
<td>-0.29%</td>
<td></td>
<td>-0.71%</td>
</tr>
<tr>
<td><strong>TOTAL7</strong></td>
<td></td>
<td>6.14</td>
<td></td>
<td>0.63</td>
<td>0.75%</td>
<td></td>
<td>0.15%</td>
</tr>
</tbody>
</table>

3 The ‘1990 baseline’ is used for the UK’s domestic greenhouse gas emission targets and consists of emissions from 1990 for all gases except fluorinated gases, for which it uses emissions values from 1995.
4 ~0.00 indicates where a value is non-zero but is less than either 0.005 MtCO₂e or 0.005% in magnitude. 0.00 indicates a value that has not changed.
5 A positive number indicates an increase on last year’s emissions estimates; a negative number indicates a decrease.
6 All figures indicate an increase on last year’s emissions estimates; a negative number indicates a decrease.
7 Totals may not sum due to rounding.
Table 2 summarises the estimated impact on emissions from the methodology changes for each sector.

Table 2 – Provisional effect of changes by sector: UK, Crown Dependencies and Overseas Territories $^{8,9,10,11}$

<table>
<thead>
<tr>
<th>National Communication Sector</th>
<th>Change in emissions (MtCO$_2$e)</th>
<th>Impact on national total from the previous inventory (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1990 baseline</td>
<td>2020</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.97</td>
<td>1.30</td>
</tr>
<tr>
<td>Business</td>
<td>-0.99</td>
<td>-0.68</td>
</tr>
<tr>
<td>Energy Supply</td>
<td>3.96</td>
<td>0.47</td>
</tr>
<tr>
<td>Industrial Processes</td>
<td>-5.51</td>
<td>-0.01</td>
</tr>
<tr>
<td>Land Use, Land Use Change and Forestry (LULUCF)</td>
<td>-2.03</td>
<td>-2.51</td>
</tr>
<tr>
<td>Public</td>
<td>1.76</td>
<td>~0.00</td>
</tr>
<tr>
<td>Residential</td>
<td>0.29</td>
<td>0.09</td>
</tr>
<tr>
<td>Transport</td>
<td>0.45</td>
<td>0.37</td>
</tr>
<tr>
<td>Waste Management</td>
<td>7.23</td>
<td>1.59</td>
</tr>
<tr>
<td><strong>TOTAL</strong>$^{12}$</td>
<td><strong>6.14</strong></td>
<td><strong>0.63</strong></td>
</tr>
</tbody>
</table>

$^8$ The ‘1990 baseline’ is used for the UK’s domestic greenhouse gas emission targets and consists of emissions from 1990 for all gases except fluorinated gases, for which it uses emissions values from 1995.

$^9$ ~0.00 indicates where a value is non-zero but is less than either 0.005 MtCO$_2$e or 0.005% in magnitude. 0.00 indicates a value that has not changed.

$^{10}$ A positive number indicates an increase on last year’s emissions estimates; a negative number indicates a decrease.

$^{11}$ All figures have been rounded to 2 decimal places.

$^{12}$ Totals may not sum due to rounding.
Summary of individual changes

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

Change in Global Warming Potentials (GWPs)

So that emissions of different greenhouse gases can be reported on a consistent basis the UK’s estimated emissions of each greenhouse gas (carbon dioxide, methane, nitrous oxide, fluorinated gases) are expressed in terms of carbon dioxide equivalent (CO\textsubscript{2}e), based on estimates of the different global warming potentials (GWP) of each gas. The GWP for each gas is defined as its warming influence in relation to that of carbon dioxide over a 100-year period.

Figures for GWPs are set out in Intergovernmental Panel on Climate Change (IPCC) Assessment Reports (AR). In last year’s publication, emissions estimates were based on GWPs from Working Group 1 of the IPCC Fourth Assessment Report: Climate Change 2007 (AR4), consistent with international reporting up to 2020. In November 2021 it was agreed by the international community at COP26 that greenhouse gas emissions shall be reported under the Paris Agreement transparency framework using GWPs (without climate-carbon feedback) from Working Group 1 of the IPCC Fifth Assessment Report: Climate Change 2014 (AR5)\textsuperscript{13}. Therefore this year’s emissions estimates will be based on 100-year AR5 GWPs.

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

Thermal renewables balance

As of the most recent publication of the Digest of UK Energy Statistics (DUKES)\textsuperscript{14}, the granularity available in Chapter 6 regarding renewable energy usage has expanded to cover a greater number of sectors. As a result of this it is now possible to not only accommodate this extra detail in the years where it is available, but also use the data to create a consistent timeseries back to 1990 where appropriate.

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

Though many of the sectors now listed in DUKES do not currently have any energy consumption data associated with them, the structural changes to the model due to this

\textsuperscript{13} https://unfccc.int/documents/311138

improvement item mean that going forward the inventory is ready to incorporate any such data as it becomes available.

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

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

Non-road mobile machinery use of gas oil

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

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

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

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

1. Separate out sources which should not be factored into the reconciliation (e.g. because they are well understood, like rail, or because the inventory is deviating from DUKES for the sector as a whole, such as national navigation), and establish the quantity of gas oil which is available for the sectors being reconciled (notably including ‘unclassified’ gas oil in the DUKES balance).
2. Always use the de minimis data on stationary fuel use from established (but likely incomplete) data such as the EU and UK Emission Trading Schemes; this includes values for cement, commercial, public, iron and steel, agriculture and other industry.
3. Always use NRMM fuel use which coincides with DUKES allocations after removing the de minimis for stationary use (e.g. if mining and quarrying NRMM is less than or equal to the DUKES minerals industry minus operator reported cement stationary use, then keep the mining and quarrying fuel use as is).

4. If there is not enough fuel in the DUKES balance to allocate to bottom-up NRMM estimates, then scale the amount which exceeds each DUKES sector. This effectively means that where the bottom-up estimates agree with DUKES, then there is no scaling, and there is more scaling when there is more disagreement.

5. When there is enough fuel for all bottom-up estimates from the inventory, split the remaining fuel by the residual of each sector which is not thought to be NRMM, capped at the DUKES allocation to each sector.

6. If there is still fuel left in ‘unallocated’ after all fuel has been allocated in the previous step, then allocate this remainder to ‘other industry’.

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

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

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

Defra has commissioned new research for estimates of emissions from non-road mobile machinery (NRMM), including from LPG use in NRMM. This has been introduced to the inventory as a new source, with the fuel reallocated from the “other industry” category to maintain the overall balance with DUKES. This is a reallocation within the business category, with the only impact of the change being small revisions to CH₄ and N₂O.

Non-road mobile machinery use of road fuels

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

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

Non-medical aerosols

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

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

We expect that the majority of 134a applications went to hydrocarbons and that the rest have changed to HFO-1234ze, which has low flammability but is more expensive than hydrocarbons. In future, it is anticipated that the aerosols sector will go towards using compressed air/nitrogen/CO₂ for applications that need to be non-flammable rather than towards another F-gas.

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

Refrigerant containers

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

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

Wastewater pre-processing review

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

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

Small-scale waste burning

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

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

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

The emissions factors for CH$_4$ and N$_2$O also come from the IPCC 2006 guidelines. The CH$_4$ emission factors are constant, and N$_2$O vary with the dry matter content of the waste.

Land use, land use change and forestry modelling changes

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

- A new CO$_2$ emission factor has been incorporated for cropland on wasted peat (peat <40cm) in England of 15.98 tonnes CO$_2$ per hectare per year, which is lower than the 28.60 tonnes CO$_2$ per hectare per year used in last year’s inventory. This was from new flux tower data collected as part of an ongoing BEIS-funded study to support the development of Tier 2 emission factors for cropland and intensive grassland on wasted peat.
- A number of new emission factors have been incorporated following an updated Tier 2 analysis of organic soil emission factors from a Defra project to align emission factors in the Peatland Code with the UK Greenhouse Gas Inventory. This update incorporates new UK datasets, including data from the UK flux tower network, as well as international data from 15 https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html
climatically similar regions. Existing data and classifications used in the emission factors database were also reviewed and revised, with the exclusion of several cropland and grassland flux data for methodological reasons, and of data from ‘flooded’ sites that were not representative of desirable restored sites. Particulate organic carbon emission factors were updated for all soil categories using an IPCC Tier 1 methodology (IPCC 2014 Appendix Eq.2A.1). Note that there are some slight differences between emission factors used in the inventory and those in the Defra Peatland Code, where the inventory has maintained a requirement for Tier 2 emission factors to be calculated from at least four different primary locations to replace Tier 1 values.

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

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

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

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

In total, the changes made to the methods for the 1990-2020 greenhouse gas emission statistics increase emissions in the 1990 baseline by 6.0 MtCO$_2$e and increase emissions in 2020 by 0.6 MtCO$_2$e. This compares to a decrease in the 1990 baseline by 1.9 MtCO$_2$e and a decrease in 2019 by 2.5 MtCO$_2$e from the methodological changes in last year’s statistics.

The figures in this note are not an indication of the revisions to the statistics as a whole, as it only includes methodology changes and does not include any annual revisions to the data sources used to estimate the UK’s emitting activities, for example national fuel use. It should also be noted that these figures are not yet finalised and are subject to change.