Department for Business, Energy & Industrial Strategy

UK SUB-NATIONAL RESIDUAL FUEL CONSUMPTION FOR 2005 – 2020

Methodology summary

This document has been prepared by Ricardo Energy & Environment on behalf of the Department for Business, Energy & Industrial Strategy (BEIS)

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Contents

1. Introduction

1.1 Background

Estimates for gas, electricity and road transport energy consumption at Local Authority level are already available[1]. This work provides estimates for 'residual fuels' at Local Authority level, that is fuels used for purposes other than gas, electricity and road transport. A time series relative to a 2005 base year is calculated annually. This forms part of the co-funded Defra/BEIS National Atmospheric Emissions Inventory (NAEI) work programme which uses Geographic Information Systems (GIS) tools to derive spatially resolved energy consumption estimates.

This report accompanies the detailed Local Authority (LA) specific data and in this report we provide methodological details and highlight key features of the reported data and trends for the years 2005-2020. Datasets prepared for 2003 and 2004 are also available (BERR, 2008), but are not internally consistent with data presented in this report.

1.2 Quality Assurance and Quality Control (QA/QC)

A rigorous set of QA/QC procedures are applied across the NAEI work programme to minimise the risk of errors in all UK and sub-national energy and emissions outputs. Specific quality checks have been implemented in the compilation of this dataset, to complement the QA/QC conducted in the compilation of the national inventory database and upstream datasets such as the Digest of UK Energy Statistics (DUKES), from which the underlying methods and datasets are derived. The primary quality checks that are specific to the Local Authority energy statistics outlined in this report are as follows:

1. **Completeness and time-series consistency**. Data checks are conducted to verify that the scope of the sub-national 'residual fuels' estimates cover all of the fuels and economic sectors that are required to ensure complete coverage of energy use, with no double-counting of activity when considered in conjunction with other sub-national energy datasets (e.g. for transport fuels, gas and electricity). Checks are conducted to review the time-series of these data for UK Local Authorities, and any outliers or major revisions to the statistics since the previous (2005-2019) dataset are investigated and documented.
2. **Geographical allocation of fuels**. Checks are conducted to verify that postcode-derived coordinates are correct and that energy use at installations is therefore allocated to the correct LA.
3. **Consistency of national and sub-national energy totals**. Checks are conducted to ensure that for every emission source (i.e. by economic sector) and fuel, the sum of the reported sub-national energy statistics is consistent with the national totals from the NAEI and DUKES.

In order to ensure that the sub-national energy datasets are **transparent** to users in their scope and usefulness, this report provides an explanation of the data sources, methods and key assumptions us

ed to compile the sub-national energy estimates.

[1] https://www.gov.uk/government/collections/sub-national-electricity-consumption-data

1.21. Data limitations

Good quality energy use data exist across the time series for many high-emitting energy and industrial installations, which can be readily allocated to a specific location and hence Local Authority. However, for smaller-scale energy users such as residential and commercial sectors, there are limited bottom-up data, and hence an array of energy modelling approaches and assumptions concerning the use of fuels across the UK are applied in the derivation of these sub-national energy data estimates.

It is important that all users of the sub-national energy statistics understand the limitations of the data. If detailed local energy datasets are available, it is recommended that these are used for policy decision-making. The sub-national energy statistics team encourage users to contribute new data sources that may lead to future improvements to the UK-wide sub-national statistics by contacting:
EnergyEfficiency.Stats@beis.gov.uk

1.3 Method overview: energy mapping for key sectors

Ricardo Energy & Environment compiles fuel consumption and emissions estimates for a large number of sources at 1x1km and Local Authority level on an annual basis. This work forms part of the NAEI and Greenhouse Gas Inventory (GHGI) programme of work for Defra and BEIS. Estimates of the distribution of fuel consumption from sources other than gas, electricity and road transport are available from the mapping work currently undertaken within this contract. The methodology used to compile these maps is described in the NAEI's mapping methodology report (Tsagatakis, et al., 2022).

Source sector and fuel combinations mapped by this study are shown in Table 1. It is recognised, however, by BEIS and Ricardo Energy & Environment that it is not meaningful to allocate energy consumption locally or regionally for some activities. Therefore, fuel consumption from aviation, shipping and power stations are excluded from this study. In addition, for some fuel & sector combinations, no information is available for spatial mapping purposes. Where possible, fuels used for fuel transformation are excluded, (e.g. coal used in coke ovens and blast furnaces, and coal and oils used in power stations). However, actual end-use of fuels is not always obvious from the raw datasets available.

Table 1 Sources and fuels that are mapped within the NAEI and used to derive sub-national energy estimates

Fuel	Source
Petroleum	Industrial
	Domestic
	Rail
	Public Administration
	Commercial
	Agriculture[2]
Coal	Industrial
	Domestic

[2] Excludes the consumption of propane.

	Rail
	Public Administration
	Commercial
	Agriculture
Manufactured Solid Fuels	Industrial
	Domestic
Bioenergy & Wastes[3]	Industrial
	Domestic

Sections 2 to 4 of this report describe the methodology used to prepare the estimates of the fuel consumption in LA areas throughout the UK.

The main steps of the method are to:

1. Obtain the national total fuel consumption for selected fuel types and sectors (Section 2);
2. Spatially disaggregate the national totals onto a 1x1km grid or other geographical levels[4] covering the UK (Section 3);
3. Assign fuel activity to the relevant LA and calculate total fuel consumption at LA level (Section 4).

The results are mapped in Section 5 and provided in detail in a National Statistics dataset that accompanies this report. Section 5 also provides a summary of the effects of the methodological changes implemented since the data were last published.

1.4 National Statistics designation

National Statistics status means that our statistics meet the highest standards of trustworthiness, quality and public value, and it is our responsibility to maintain compliance with these standards.

The continued designation of these statistics as National Statistics was confirmed in September 2018 following a compliance check by the Office for Statistics Regulation. The statistics last underwent a full assessment against the Code of Practice for Statistics in 2014.

Since the latest review by the Office for Statistics Regulation, we have continued to comply with the Code of Practice for Statistics, and have made the following improvements:

- Improved the accuracy of the estimates throughout the time series by continuing to make methodological changes to them.
- Expanded the number of categories provided in the data tables to provide greater detail of fuel breakdowns.

[3] Excludes bioenergy and wastes used for electricity generation.
[4] Such as middle layer super output area (MSOA), lower layer super output area (LSOA), Postcode etc.

2 National total fuel consumption by sector and fuel type

The NAEI calculates the total fuel consumption data for the fuel types and sectors considered in this study. The fuel types and sectors are listed in Table 2.

Table 2 **NAEI fuel types and sectors reported in the 'sub-national consumption of residual fuels' dataset**

Fuel types	Sector	NAEI source names
Bioenergy & Wastes	Commercial	Miscellaneous industrial/commercial combustion
	Domestic	Domestic combustion
	Industrial	Cement production - combustion
		Chemicals (combustion)
		Food & drink, tobacco (combustion)
		Incineration - clinical waste
		Lime production - non decarbonising
		Other industrial combustion
		Pulp, Paper and Print (combustion)
		Refineries - combustion
	Public Administration	Public sector combustion
Coal	Agriculture	Agriculture - stationary combustion
	Commercial	Miscellaneous industrial/commercial combustion
	Domestic	Domestic combustion
	Industrial	Cement production - combustion
		Chemicals (combustion)
		Collieries - combustion
		Food & drink, tobacco (combustion)
		Iron and steel - combustion plant
		Lime production - non decarbonising
		Non-Ferrous Metal (combustion)
		Other industrial combustion

Fuel types	Sector	NAEI source names
		Pulp, Paper and Print (combustion)
		Sinter production
	Public Administration	Public sector combustion
	Rail	Rail - coal
Manufactured Solid Fuels	Domestic	Domestic combustion
	Industrial	Brick manufacture - all types
		Cement production - combustion
		Chemical industry - soda ash
		Chemical industry - titanium dioxide
		Chemicals (combustion)
		Electric arc furnaces
		Iron and steel - combustion plant
		Lime production - non decarbonising
		Other industrial combustion
		Refineries - combustion
		Sinter production
Petroleum	Agriculture	Agriculture - mobile machinery
		Agriculture - stationary combustion
	Commercial	Miscellaneous industrial/commercial combustion
	Domestic	Domestic combustion
		House and garden machinery
	Industrial	Aircraft - support vehicles
		Cement production - combustion
		Chemicals (combustion)
		Collieries - combustion
		Food & drink, tobacco (combustion)
		Industrial off-road mobile machinery
		Iron and steel - combustion plant
		Landfill gas combustion
		Lime production - non decarbonising

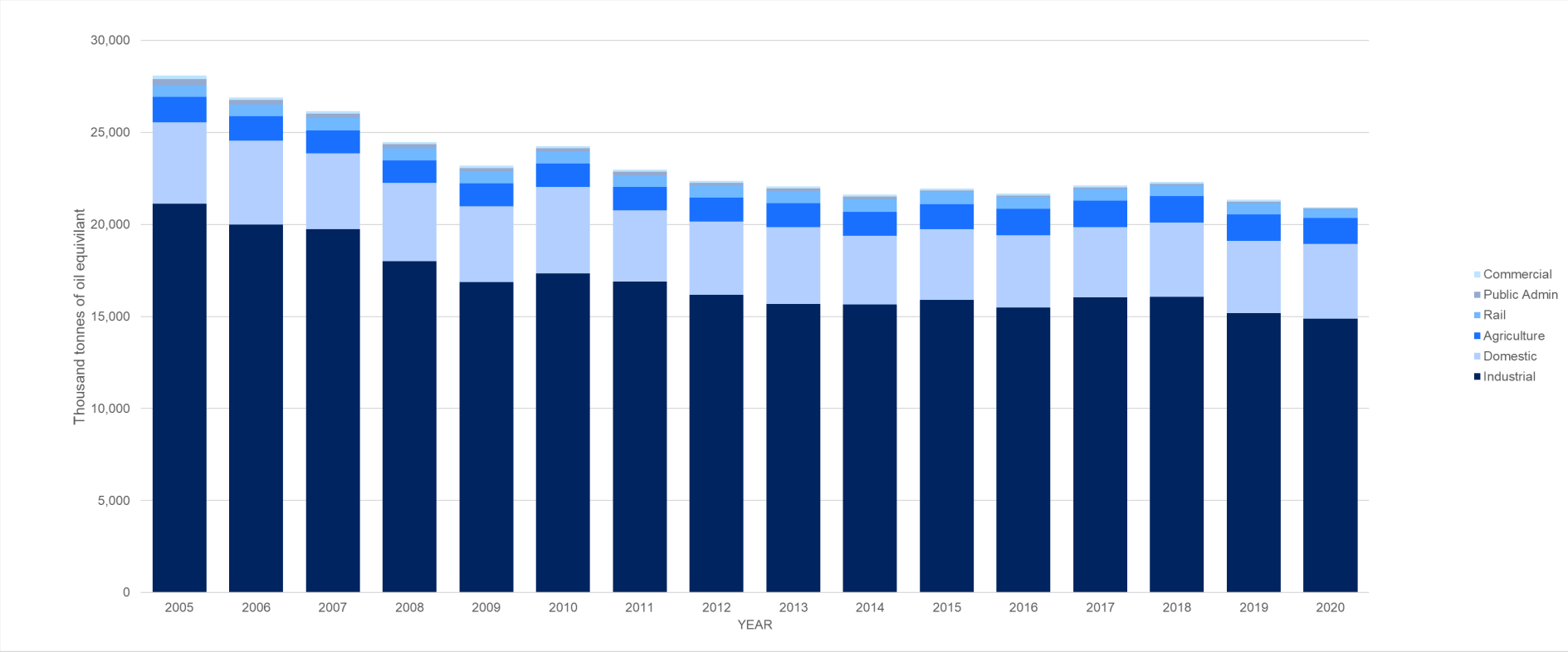
Fuel types	Sector	NAEI source names
		Non-Ferrous Metal (combustion)
		Other industrial combustion
		Pulp, Paper and Print (combustion)
		Refineries - combustion
	Public Administration	Public sector combustion
	Rail	Railways - freight
		Railways - intercity
		Railways - regional

The NAEI obtains data on national fuel consumption from the Digest of UK Energy Statistics (DUKES). National totals based on these data are further refined for the industrial and energy generation sector taking into account other more detailed data. The UK Greenhouse Gas Inventory 1990-2020 report (Brown P, 2022) describes the methods used to adjust the DUKES totals in detail. The following sections provide a summary of the adjustments made.

This study has utilised data that underpinned the UK 1990-2020 GHGI which, in turn derived its data from the 2020 statistics presented in DUKES (BEIS, 2022).

Based on the GHGI, Figure 1 indicates the UK total residual fuel use trend 2005 – 2020 by each sector.

Figure 1 National total 'residual fuel use' trend by sector, 2005 – 2020 from GHGI data



2.1 Key differences between GHGI and DUKES

This section of the report sets out the key differences between the GHGI and DUKES estimates of fuel consumption. The GHGI includes three types of deviation compared with DUKES.

The first concerns fuel used for heat generation. The GHGI and Local Authority datasets do not include heat generation as a separate category. Instead, fuel reported in DUKES for heat generation is re-allocated to final user sectors using data supplied by the BEIS Energy Statistics team. Therefore, the fuel consumption data for 'industry' and 'other' in the GHGI are higher than the values published in DUKES. Details of the heat generation fuel reallocation are shown in table J1 of DUKES (BEIS, 2022).

The other two types of deviation relate to the allocation of fuels to individual sectors due to alternative data to DUKES being used in the GHGI. As well as DUKES, the inventory team has access to alternative energy data such as that collected for the purposes of the EU Emissions Trading System, as well as data provided directly by industry. There are instances where these alternative data are both considered highly reliable, and also higher than DUKES figures. In these cases, the inventory team therefore adopts the conservative approach of using the higher, alternative, data in preference to the lower values from DUKES. Conversely, where the alternative energy data are lower than DUKES, then the inventory team will always use the DUKES figures. This approach of using the higher, more conservative data in each case leads to two different situations:

- Alternative data for one or more sectors suggests that fuel use is higher than given in DUKES, but the overall UK demand figure is considered by the inventory team to be correct. Therefore, fuel is simply re-allocated between sectors so that while the sectoral allocations may differ to DUKES, the overall fuel use remains consistent. This is the most common type of deviation from DUKES.

- Alternative data for one or more sectors suggests that fuel use is higher than given in DUKES, but the sum of fuel consumption is also higher than the total UK demand figures given in DUKES. In this case it is impossible to reconcile the alternative data with the UK demand figures in the energy statistics, and therefore both the sectoral allocation and the overall UK demand figure have to deviate from DUKES. This type of deviation is only necessary for a small number of fuels, including gas oil, coke oven coke, and petroleum coke.

The UK Greenhouse Gas Inventory 1990-2020 report[5] (Brown P, 2022) provides, in Annex 4, a full description of re-allocations for major fuels, including tables that quantify each re-allocation for the latest inventory year. A summary of the re-allocations for each fuel type used in the residual fuel statistics is given below.

2.1.1 Coal

Alternative data are used for coal burnt in cement kilns and lime kilns, as are operator data for coal use in coke ovens. These adjustments relative to DUKES are balanced by reducing coal usage by the source category 'other industry'. As with other major fuels, consumption for heat generation is re-allocated to final users. The overall consumption of coal assumed in the GHGI remains the same as given in DUKES.

[5] https://naei.beis.gov.uk/reports/reports?report_id=1072

In the GHGI point source data, there is a further difference to both the GHGI itself and DUKES. Those both identify fuel consumed by autogenerators, whereas this is not possible in the point source data. Within DUKES, autogenerators are considered as a transformation fuel use and so they do not contribute to final consumption. However, autogenerators cannot be distinguished from 'other' industrial users in the datasets that underpin NAEI and GHGI mapping outputs and therefore we are unable to include autogeneration as a distinct source in the point source data. As a result, point source data for industrial coal use will include an indeterminate quantity of coal used for autogeneration. And because autogeneration and non-autogeneration coal use cannot be separated in the points, autogeneration is also not treated as a separate source in the final residual fuels outputs.

2.1.2 Petroleum

The GHGI includes many re-allocations for petroleum fuels. The most important sectoral re-allocations are described below. As with coal, it is not possible to identify autogenerators in the point source data for oils, and therefore autogeneration is not treated as a separate category for any petroleum fuels. In this, it is consistent with the UK GHGI which also does not include autogeneration as a separate source for any petroleum fuel. DUKES, however, reports autogeneration using fuel oil, gas oil, and other petroleum gases: this fuel instead appears as industrial fuel use in the GHGI and inventory mapping outputs.

2.1.2.1 Oils used at power stations

The quantities of oils reported in DUKES as burnt in power stations are generally smaller than the figures reported by the operators either directly to the NAEI or via the EU Emissions Trading System (EU ETS). The GHGI assumes that the larger quantities reported by operators to the NAEI or in EU ETS are correct, rather than the lower figures given in the energy statistics. The inventory therefore uses these higher values but ensures that the total UK consumption of oils by industrial and other stationary source sectors is still consistent with DUKES figures by lowering the consumption in some sectors relative to DUKES by an equal and opposite amount to the changes for the power sector, so the various changes cancel each other out. For fuel oil, gas oil and burning oil, we make these balancing reductions to fuel used by the manufacturing industry sector.

2.1.2.2 Other uses of gas oil

The GHGI allocations of gas oil also deviate from DUKES because of the need to identify transport/mobile machinery and stationary sources separately in the inventory, whereas UK energy statistics just report total gas oil use by each economic sector. It is a requirement of national inventory reporting that for several economic sectors further detail should be reported, as the emission characteristics of mobile plants differ from stationary combustion plants. The main examples are that the NAEI must report emissions from gas oil and Diesel Engine Road Vehicle (DERV) used in road vehicles, off-road vehicles and mobile machinery, primarily in the industrial and agriculture sectors.

In addition, data available to the inventory from other sources, such as EU ETS, indicate that some reallocations of fuel compared with DUKES are necessary (for example, the changes to power station gas oil use already mentioned in Section 2.1.2.1).

The total UK demand figures also deviate from DUKES due to the use of a shipping model in the GHGI which estimates significantly higher consumption of gas oil by shipping than is reported in DUKES.

As a result of this restructuring of gas oil consumer categories and reallocations of fuels between categories compared to DUKES, the GHGI data are very different to those given in DUKES when compared at a detailed level. The deviation for shipping also ensures that the overall gas oil demand figures in the GHGI are higher than in DUKES. However, the total consumption of gas oil in the GHGI for non-shipping sources is identical to the total consumption of gas oil given in DUKES for non-shipping sources. The same can be said for DERV.

Detailed descriptions of the methodology used to generate the inventory fuel consumption estimates are given in other inventory method statement documentation by Murrells et al. (2011).

2.1.2.3 Liquefied petroleum gas (LPG) and other petroleum gases

The GHGI reports all of the LPG reported in DUKES for the public, commercial, and agricultural sectors as industrial usage. This approach reflects the non-availability of data for the earlier part of the inventory time-series. Overall demand figures are, however, kept consistent with DUKES.

For other petroleum gases, overall energy demand figures in the GHGI are higher than in DUKES. This is for two reasons:

- EU ETS data for crude oil refineries suggest higher use of these fuels than is given in DUKES (for many but not all years where we have EU ETS data).
- The GHGI includes off-gases used as fuels at petrochemical works, the most significant of which are off-gases generated and then burnt at ethylene crackers. These process off-gases are by-products of the use of chemical feedstocks to manufacture ethylene and other chemicals. Because the chemical feedstocks are already reported in DUKES as non-energy use, DUKES does not include the subsequent use of the off-gases as an energy use, since this would duplicate reporting. Whereas the inventory only needs to include all emissive sources and therefore just includes the fuel use.

2.1.3 Manufactured solid fuels

2.1.3.1 Coke oven coke and related fuels derived from coal

The DUKES aggregated energy balance includes all coal-based manufactured solid fuels (coke oven coke, coke breeze, and patent fuel) as well as benzole, tars, coke oven gas and blast furnace gas. In the GHGI, all use of benzole and coal tars is treated as non-energy consumption, whilst coke oven gas and blast furnace gas are categorised as transformation fuel uses. Some deviations from DUKES for both sectoral and UK demand figures are necessary for coke oven coke. DUKES gives relatively little detail on sectoral usages of this fuel but the GHGI needs to provide detail on industrial uses so uses a more detailed set of consumer categories. Since users identified in EU ETS and other datasets are estimated to consume more coke oven coke than the UK demand figure in DUKES in some years, deviations from those demand figures are necessary.

2.1.3.2 Petroleum coke

DUKES reports petroleum coke used by major power producers and crude oil refineries for energy purposes, as well as providing data for some years on consumption in manufactured fuels and use as a fuel by industry. All other deliveries of petroleum coke are reported as non-energy use within DUKES.

The GHGI includes estimates of the petroleum coke used in many sectors based on information made available from industry either directly to the NAEI or via the EU ETS, including various industrial processes, such as brickmaking, titanium dioxide manufacture and steel production. For some years, the NAEI estimates of petroleum coke consumption exceed the quantities given in DUKES for energy applications, and it is necessary to deviate from the energy use allocation in DUKES in order to maintain consistency with the high-quality data in EU ETS and other sources. For 2005-2007, 2009, and 2015-2020, the NAEI estimates of petroleum coke consumption exceed not only the energy uses in DUKES but even the combined energy and non-energy uses in DUKES, and so for these years only, the NAEI has a higher use of petroleum coke than given by DUKES.

2.1.4 Bioenergy & Wastes

The GHGI estimates for waste solvents and tyre consumption refer to their use as fuel in the cement industry and various other sectors and are based on data from the Mineral Products Association and from EU ETS. Estimates for other wastes used as fuels are derived from the EU ETS data. There are no directly equivalent data in DUKES, although the energy statistics do include aggregated figures for industrial use of wastes and renewables that may cover some or all of the usages by individual sites reported in the EU ETS.

3 Spatial disaggregation of fuel consumption

This section of the report describes how the national estimates of fuel consumption are spatially disaggregated throughout the United Kingdom.

3.1 Site-specific data for industrial and commercial consumers

The NAEI receives detailed data on individual 'point sources' in the industrial and commercial sectors. A point source is an emission source at a known location, which has grid references and therefore it can be mapped directly.

Point source emissions are compiled using a variety of data sources and techniques. The point source database is regularly updated to include new data reported through the EU ETS, and this study also takes account of relevant point source data reported after the GHGI (Brown P, 2022) was prepared. More information on data sources can be found in the UK Emission Mapping Methodology[6] (Tsagatakis, et al., 2022).

The data presented in this report are not fully consistent with the GHGI and DUKES because of the use of site-specific data in preference to UK-level data, in order to provide better information on the fuels used at individual industrial and commercial sites. The methodology used to calculate fuel use at site-specific sources is described in detail in the UK local and regional greenhouse gas emissions technical report (Pearson, et al., 2022), which includes information on where the differences between site-specific data and GHGI and DUKES are most significant.

3.2 Other industrial, commercial and public sector consumers

The consumption of fuels at specific sites described above represents a substantial proportion of the total industrial and commercial fuel consumption. Subtracting the site-specific fuel consumption from the NAEI sector total derives an estimate of remaining fuel consumption. This residual fuel consumption is allocated to each Local Authority in the UK using distribution maps derived from employment statistics for each sector.

The document *Employment based energy consumption mapping in the UK* (Tsagatakis, et al, 2022) describes how the distribution maps were prepared. In summary:

1. Data on sectoral and site-specific fuel consumption, and employment estimates for regions and business types were used to develop fuel use distribution maps of the UK;
2. Point sources were matched to individual businesses by sector to give a residual amount of fuel consumption;
3. This residual amount was then combined with sectoral employment data to give a measure of employee-level fuel intensity for different fuels within each sector;
4. Employment totals at Local Authority resolution were then multiplied by the relevant employee fuel intensity to give fuel-use distribution across the UK;

[6] https://uk-air.defra.gov.uk/assets/documents/reports/cat09/2207041059_UK_Spatial_Emissions_Methodology_for_NAEI_2020_v1.pdf

5. This distribution was then refined by overlaying various additional datasets and applying expert knowledge to adjust fuel consumption.

3.3 Domestic

Domestic oil and solid fuel use distributions were created by spatially resolving detailed local information on central heating and house type data from the 2011 census with data from the BEIS National Household Model (NHM), which provides average household energy consumption estimates across 13 regions in England, Wales and Scotland. England is split into 9 regions following the regional classification scheme, Wales is treated as one region and Scotland is split into three regions following the Met Office 3-tier regional (Northern, Eastern and Western) classification so as to represent the spatial shifts in climate (MetOffice, 2016). The census data were combined with full-address matched dwelling locations from Ordnance Survey data to give a more accurate distribution of households at LA level.

Solid fuel use was assigned to solid fuel burnt in boilers and non-boiler appliances (such as open fireplaces, closed stoves). It was assumed that solid fuel activity for boilers was used in properties which, according to Census 2011, had solid fuel central heating. Solid fuel activity for non-boiler appliances was assumed to be used in houses and bungalows with no central heating. Supplementary heating from the same technologies was considered more likely to be located in houses and bungalows only. Apartments were excluded for solid fuel use to be consistent with BEIS NHM assumptions on wood use. The number of supplementary heating users for wood was calibrated at regional level, urban status and smoke control area status by comparing the total wood user count (as derived from all the above assumptions) against the counts from the DEFRA domestic solid fuel use survey[7].

As NHM does not include data for Northern Ireland, details of central heating use from the 2011 census provided the basis of the domestic fuel distributions.

Further information on the datasets and methodology used to develop the domestic model can be found in the *UK Emission Mapping Methodology* (Tsagatakis, et al., 2022).

3.4 Other sources

The national fuel emissions also include contributions from rail and agriculture sectors and from industrial off-road mobile machinery. Rail sector diesel consumption is compiled for three journey types: freight, intercity and regional.

The rail methodology was updated for the 2020 NAEI. Fuel use was spatially disaggregated based on a recent Rail Safety and Standards Board (RSSB) project that mapped 2019 emission estimates for each line in Great Britain for passenger and freight trains. Activity along each rail link between Timing Point Locations (TIPLOCs) were assumed to be uniform along the length of the rail link, as no information on either load variation or when engines were on or off is yet available on a national basis. Rail fuel consumption across Northern Ireland is based on 2019 data from Translink on the number of services run on different routes. These data are for passenger trains only as there is no freight activity in Northern Ireland.

Coal-based emissions from heritage railways are considered separately.

7 http://sciencesearch.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=20159&FromSearch=Y&Publisher=1&SearchText=burning%20in%20UK%20Homes&SortString=ProjectCode&SortOrder=Asc&Paging=10

Industrial off-road mobile machinery emissions are mapped using a distribution of employment in heavy industries. The employment dataset has been reviewed to identify and remove unrealistically high industrial employment in urban areas, which is more likely to be associated with the location of company offices or headquarters rather than sites of industrial activity.

Agricultural stationary combustion has been mapped using employment data, with the geographic distribution of solid and liquid fuels controlled by the location of smoke control areas and the geographical distribution of gas availability. Agricultural off-road data are distributed using a combination of arable, pasture and forestry land use data combined with information on the number of hours tractors and other machinery are used on these land use types.

More detailed descriptions of the data and methodologies used to develop estimates of fuel emissions totals for these source categories can be found in the *UK Emission Mapping Methodology* (Tsagatakis, et al., 2022).

4 Aggregation of fuel consumption to Local Authority level

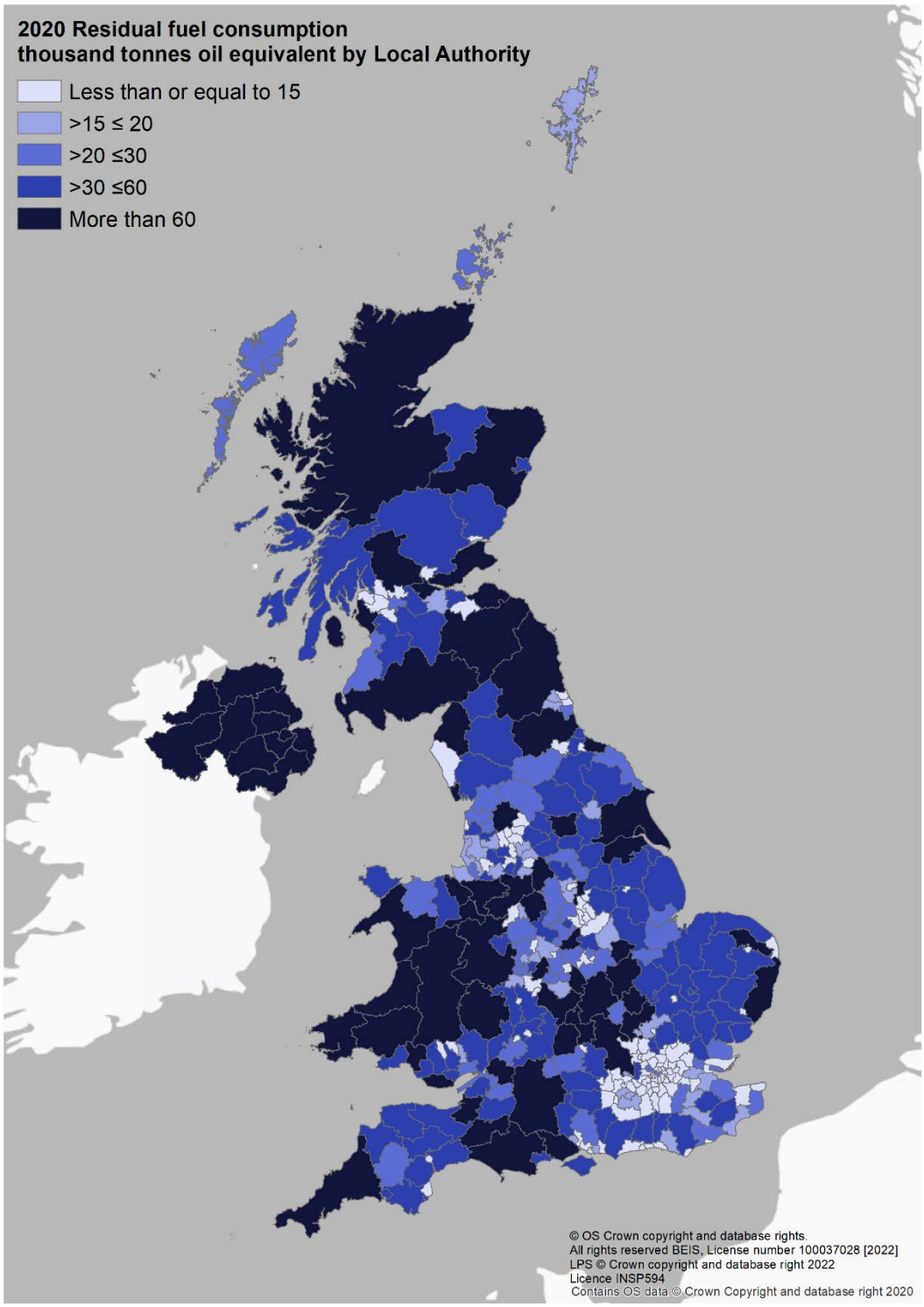
The calculations of fuel consumption by sector were made using the NAEI distribution maps and energy consumption estimates for point sources at known locations. A map of Local Authority boundaries has been used to assign mapped fuel consumption estimates to a Local Authority. Maps for each sector and fuel are generated by summing the spatially distributed NAEI / GHGI national totals.

Prior to the aggregation of the fuel consumption data to Local Authority level, data are converted to a common unit of energy. The fuel consumption data provided by the NAEI is available either in units of mega tonnes (solid or liquid fuels) or mega therms (gaseous fuels); these are converted to thousand tonnes of oil equivalent using the average gross calorific value of fuels and unit conversions presented in table A2 of DUKES (BEIS, 2022).

5 Results

This section displays the mapped results of this study, comments on the changes to the methodology and data, and compares the sub-national other energy statistics with other published national and sub-national datasets. Figure 2 shows residual fuel consumption by Local Authority in 2020.

Figure 2 UK map of sub-national consumption of residual fuels in 2020



A spreadsheet of detailed Local Authority level data is published on the GOV.UK website[8]. The spreadsheet contains a detailed breakdown of fuel consumption by sector and by fuel for 2005-2020.

5.1 The effect of changes to the methodology and datasets

Each year, the GHGI data, which underpin the fuel consumption estimates presented in this report, are updated and extended.

Updating entails revision of emission estimates, most commonly because of revision to the core energy statistics presented in DUKES but may also cover adoption of revised methodologies. Updates, particularly involving revised methodologies, may affect the whole time-series, so estimates of emissions for a given year may differ from estimates of emissions for the same year reported previously. Therefore, comparisons between estimates made in different years should take account of whether there have been changes to the methodology, the activity data, or the spatial distribution.

The time series of the inventory is *extended* by including a new inventory year.

For the 2020 dataset, there was an update to the spatial distribution of fuel use from non-domestic, domestic and rail sources. Energy consumption from non-domestic sources is distributed using employment data, specifically the Inter-Departmental Business Register (IDBR) and Energy Consumption in the UK (ECUK). A change in method this year involved gas consumption being utilised at postcode level rather than MSOA and 1x1km level. Full details of this update can be found in *Employment based energy consumption mapping in the UK*[9]. The domestic combustion and rail sectors were updated to utilise more recent data, full details of which can be found in the NAEI's mapping methodology report (Tsagatakis, et al., 2022). For further details on the updates to the 2020 GHGI datasets see the latest National Inventory Report (NIR) (Brown P, 2022) or the 2020 UK Greenhouse Gas Emissions, Final Figures (GOV.UK, 2022).

5.2 Comparison with other national and sub-national data

5.2.1 DUKES, GHGI & sub-national residual fuels statistics

Although DUKES, the GHGI and Local Authority fuel consumption estimates are well-correlated, these datasets are not fully internally consistent. This arises from both the utilisation of the EU ETS datasets in the GHGI and sub-national data, and the re-allocation of gas and fuel oil between combustion sectors. Data from the EU ETS and direct from plant operators in some cases provides more accurate, detailed information on the fuels used at industrial and commercial sites, which may not have been available when the GHGI or DUKES were compiled.

5.2.2 Coverage of national and sub-national statistics

A comparison of the sectoral and geographic coverage of sub-national residual fuel, NAEI, GHGI and LA greenhouse gas emissions dataset is provided in Table 3 below. The Local Authority greenhouse gas emissions dataset is a spatial disaggregation of the GHGI on an end user basis. This means that emissions from the production and processing of fuels (including electricity) are reallocated to users of these fuels to reflect total emissions for each type of fuel consumed.

[8] https://www.gov.uk/government/collections/sub-national-consumption-of-other-fuels
[9] Employment based energy consumption in the UK, 2020 (publishing.service.gov.uk)

Table 3 Comparison of the sub-national residual fuel statistics with other NAEI outputs

		UK Air Quality Emissions Inventory	UK Greenhouse Gas Inventory	Local Authority Greenhouse Gas Emissions	Sub-national Residual Fuel Statistics
Published Data	Air Quality Pollutants	✓	✗	✗	✗
	Greenhouse Gases	✗	✓	✓	✗
	Energy	✗	✓	✗	✓
Data Types	Point of Release	✓	✓	✗	✓
	End-User	✗	✓	✓	✗
Report System	UNECE[10]	✓	✗	✗	✗
	UNFCCC[11]	✗	✓	✗	✗
Mapping Resolution	1x1 Km	✓	✓	✗	✗
	Devolved Administrations	✓	✓	✓	✓
	Local Authorities	✗	✗	✓	✓
Sectors and Regions Included	Power Stations	✓	✓	✓[12]	✗
	Shipping	✓	✓	✗	✗
	Aviation	✓	✓	✗	✗
	Rail	✓	✓	✓	✓
	Off-Shore Users	✓	✓	✗	✗
	Crown Dependencies[13]	✓	✓	✗	✗
	Overseas territories	✓[14]	✓	✗	✗

[10] United Nations Economic Commission for Europe
[11] United Nations Framework Convention on Climate Change
[12] Emissions from power stations have been reallocated to the end user national estimate, which then is allocated back to local authorities depending on the sector use and not according to the location of the power stations
[13] Crown Dependencies are: Isle of Man, Guernsey and Jersey
[14] Gibraltar only

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