



Department for  
Business, Energy  
& Industrial Strategy



# Employment Based Energy Consumption Mapping in the UK

A report of the National Atmospheric  
Emissions Inventory 2019

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# 1 Introduction

Data on energy use by large industrial and commercial sites (also known as Point Sources) are collected and compiled within the National Atmospheric Emissions Inventory (NAEI). These data include fuel consumption estimates from Industrial Emissions Directive (IED) Annex I installations<sup>1</sup> regulated in the UK, all installations covered by the EU Emissions Trading Scheme (EU-ETS) and other sites that are significant sources of air pollution. The method used to compile these estimates is documented in the Technical Report for the UK local and regional carbon dioxide (CO<sub>2</sub>) emissions<sup>2</sup>.

The energy used by smaller industrial and commercial sites is significant in terms of overall energy consumption from the industrial<sup>3</sup>, commercial and public sectors in the UK. These smaller facilities represent about 61% of CO<sub>2</sub> emissions in 2019. However, energy consumption data for these sites are not available in a consistent format across the UK and therefore, proxy data on employment and energy use are used to estimate energy use and emissions at these locations.

This report describes the methods used to estimate the energy use at the UK level by the smaller industrial, commercial, and public sectors facilities and to model the distribution of energy use across the UK at 1x1km resolution and at Local Authority level. The methods described in this report replace those previously used for the NAEI. The approach taken is similar to that used previously: combining employment data from the Inter-Departmental Business Register<sup>4</sup> (IDBR) database and national energy statistics by industrial and commercial sector<sup>5</sup>.

The outputs of this work are used in the generation of detailed 1x1km resolution emission maps for air quality and greenhouse gases as well as for other spatially disaggregated NAEI outputs such as Local and Regional CO<sub>2</sub> statistics, Devolved Administration Inventories, and sub-national energy statistics for solid and liquid fuels<sup>6</sup>.

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<sup>1</sup> Installations regulated under UK legislation implementing on industrial emissions (IED)

<sup>2</sup> [UK local authority and regional carbon dioxide emissions national statistics - GOV.UK \(www.gov.uk\)](https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics)

<sup>3</sup> Where 'industry' excludes large energy intensive industrial processes such as iron and steel, cement etc.

<sup>4</sup> [Inter-Departmental Business Register \(IDBR\) - Office for National Statistics \(ons.gov.uk\)](https://ons.gov.uk/business-and-industry/inter-departmental-business-register)

<sup>5</sup> [Energy consumption in the UK - GOV.UK \(www.gov.uk\)](https://www.gov.uk/government/statistics/energy-consumption-in-the-uk)

<sup>6</sup> [Sub-national residual fuel consumption data - GOV.UK \(www.gov.uk\)](https://www.gov.uk/government/statistics/sub-national-residual-fuel-consumption-data)

## 2 Data sources

This section of the report describes the data sets used as inputs to the modelling process for energy use from industrial, commercial, and public sector facilities that are not included in the NAEI point source database.

### 2.1 Employment data

The Inter-Departmental Business Register (IDBR) database provides detailed data on number of employees at each registered UK business entity. This database has 2.1 million businesses listed and covers approximately 99% of economic activities across the UK.

An extract from the IDBR was obtained from the Office for National Statistics (ONS), with the data fields as shown in Table 1. The grid reference attribute was used to aggregate total numbers of employees for each 1x1km grid square by Standard Industry Classification<sup>7</sup> (SIC) sector.

**Table 1 Information held on the IDBR for each business.**

|                |   |
|----------------|---|
|                |   |
| Local Unit     | Local Unit Reference Code                                 |
| Enterprise     | Enterprise Reference Code                                 |
| Reporting Unit | Reporting Unit Reference Code                             |
| Name           | Local Unit Name   |
| Address        | Local Unit Address  |
| Postcode       | Local Unit Postcode                                       |
| Employment     | Total number of employees figure plus working proprietors |
| Employees      | Total number of people employed, excluding proprietors    |
| SIC2007        | UK Standard Industry Classification 2007                  |
| GOR            | Regions (Former Government Offices for the Regions)       |
| Grid Reference | Locations on map using Cartesian coordinates              |

The 2007 SIC is used to assign a 5-digit code of economic activity type to each business. Appendix 1 shows the higher-level 2-digit activity Divisions of the SIC that

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<https://www.ons.gov.uk/methodology/classificationsandstandards/ukstandardindustrialclassificationofeconomicactivities/uksic2007>

are used for this study and the sectors they have been assigned to. The business entities are classified into Local units and Enterprise Units.

## 2.2 Energy statistics

Sector specific fuel use statistics are available on an annual basis from BEIS via the Energy Consumption in the UK (ECUK) publication (BEIS, 2019)<sup>8</sup>. This study makes heavy use of the Industrial data tables, and Service sector data tables. These data tables are compiled from the Purchases Inquiry (PI) survey, a sub-survey of the ONS's Annual Business Inquiry. As part of this survey a sample of 6,000 businesses is conducted to collect information on the monetary value of purchases of fuel and electricity. The ECUK User Guide (BEIS, 2019) explains how the survey data were aggregated to cover all businesses in each sector.

Table 2 below presents a breakdown of the fuel consumption in industrial sectors in 2019 as provided from the ECUK tables described above. A time-series of statistics was produced using the following ECUK tables:

- Industrial final energy consumption at 2-digit SIC2007 level by fuel type, for the years 2009-2019;
- Service sector final energy consumption by sub-sector, for the years 2005-2019

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<sup>8</sup> [Energy consumption in the UK - GOV.UK \(www.gov.uk\)](http://www.gov.uk)

**Table 2 Industrial energy consumption by fuel type in 2019 (thousand tonnes of oil equivalent) based on ECUK Table C3.**

|    |   |       |       |      |      |        |        |
|----|---|-------|-------|------|------|--------|--------|
|    |   |       |       |      |      |        |        |
| 08 | Other mining and quarrying  | 33.3  | 0.726 | 8.00 | 8.63 | 604    | 546    |
| 10 | Manufacture of food products  | 32.4  | 53.7  | 26.4 | 2.6  | 1397.5 | 786.2  |
| 11 | Manufacture of beverages  | 7.8   | 12.9  | 6.3  | 0.6  | 335.1  | 188.6  |
| 12 | Manufacture of tobacco products   | -     | -     | -    | -    | 7.1    | 11.7   |
| 13 | Manufacture of textiles   | 30.0  | -     | 24.4 | -    | 159.0  | 148.4  |
| 14 | Manufacture of wearing apparel  | 8.6   | -     | 18.6 | -    | 75.5   | 64.9   |
| 15 | Manufacture of leather and related products   | -     | -     | -    | -    | 9.3    | 15.8   |
| 16 | Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials | -     | -     | 9.4  | -    | 154.2  | 222.2  |
| 17 | Manufacture of paper and paper products   | 56.0  | -     | 28.3 | -    | 330.1  | 563.3  |
| 18 | Printing and publishing of recorded media and other publishing activities   | -     | -     | 3.8  | -    | 59.2   | 311.5  |
| 20 | Manufacture of chemicals and chemical products  | 30.9  | -     | 85.9 | 25.5 | 1556.9 | 1165.3 |
| 21 | Manufacture of basic pharmaceutical products and pharmaceutical preparations  | 3.2   | -     | 8.9  | 2.7  | 162.2  | 121.4  |
| 22 | Manufacture of rubber and plastic products  | 284.7 | -     | 8.0  | -    | 353.6  | 907.7  |
| 23 | Manufacture of other non-metallic mineral products  | 394.4 | -     | 41.1 | -    | 1114.4 | 411.5  |

## Employment Based Energy Consumption Mapping in the UK

|    |  |      |     |       |      |       |       |
|----|--|------|-----|-------|------|-------|-------|
|    |  |      |     |       |      |       |       |
| 24 | Iron and steel   | 17.5 | 0.7 | 0.5   | 8.5  | 344.7 | 210.1 |
| 25 | Manufacture of fabricated metal products, except machinery and equipment | 6.7  | -   | 0.2   | -    | 595.5 | 328.8 |
| 26 | Manufacture of computer, electronic and optical products                 | 2.9  | -   | 0.5   | -    | 120.4 | 323.1 |
| 27 | Manufacture of electrical equipment                                      | -    | -   | 0.3   | -    | 149.5 | 204.2 |
| 28 | Manufacture of machinery and equipment (not elsewhere classified).       | -    | -   | 0.2   | -    | 358.3 | 221.2 |
| 29 | Manufacture of motor vehicles, trailers and semi-trailers                | 32.5 | -   | 106.0 | 4.6  | 370.7 | 248.5 |
| 30 | Manufacture of other transport equipment                                 | -    | -   | 63.4  | 8.5  | 153.4 | 144.3 |
| 31 | Manufacture of furniture   | -    | -   | 1.4   | -    | 59.2  | 84.9  |
| 32 | Other manufacturing  | -    | -   | 1.9   | -    | 79.9  | 114.7 |
| 36 | Water collection, treatment and supply                                   | -    | -   | 2.2   | -    | 23.0  | 455.8 |
| 38 | Waste collection, treatment and disposal activities; materials recovery  | -    | -   | 16.8  | -    | 16.1  | 52.2  |
| 42 | Civil engineering/construction   | 3.5  | -   | 210.5 | 16.9 | 417.1 | 118.9 |

## 2.3 Point sources

Data on location specific (Point Source) fuel consumption are collated in the NAEI point source database. They are compiled from data for regulated processes reported in the Environment Agency's Pollution Inventory, the Scottish Pollution Release Inventory (SPRI), the Northern Ireland Environment Agency Pollution Inventory, Inventory of Statutory Releases, the EU-ETS and from other data obtained by the NAEI. The Local and Regional CO<sub>2</sub> technical report<sup>9</sup> describes in more detail the methodology used to calculate fuel use at point sources.

## 2.4 Gas consumption data for England, Wales, Scotland and Northern Ireland

Data on gas consumption and the distribution of gas consumption for industry and commerce is available from BEIS within the sub-national gas consumption data collection<sup>10</sup>. For this exercise, gas consumption data have been used at Middle Super Output Areas (MSOA) for England and Wales and Intermediate Geography Zones (IGZ) for Scotland (hereafter both datasets will be referred to as the MSOA gas data as they are in effect equivalent statistical geographies<sup>11</sup>).

Furthermore, a dataset of 1x1km resolution gas consumption by non-domestic users was obtained from BEIS for the purpose of this modelling. This data set enabled the production of a map to show the extent of the gas network (presence or absence of gas supply) and was used as an indicator for gas availability to industry and commercial sites.

## 2.5 Off-gas postcodes

In order to identify sites with no gas connection, even though they are within areas of gas availability, the Xoserve Off-Gas Postcode dataset<sup>12</sup> was used to filter the businesses which may be using a fuel other than natural gas.

## 2.6 Employment time-series

A time-series of employment activity was back-calculated with the use of Business Register data and Employment Survey (BRES) annual employment estimates<sup>13</sup>. The time-series was calculated at a regional level for each Broad Industry Group (SIC2007).

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<sup>9</sup> [UK local authority and regional carbon dioxide emissions national statistics - GOV.UK \(www.gov.uk\)](http://www.gov.uk)

<sup>10</sup> [Sub-national gas consumption data - GOV.UK \(www.gov.uk\)](http://www.gov.uk)

<sup>11</sup> [Lower and Middle Super Output Areas gas consumption - GOV.UK \(www.gov.uk\)](http://www.gov.uk)

<sup>12</sup> <https://www.xoserve.com/media/2687/off-gas-postcodes-v2.xlsx> (Version 2.0 December 2017)

<sup>13</sup> [Employees in the UK Statistical bulletins - Office for National Statistics \(ons.gov.uk\)](http://ons.gov.uk)

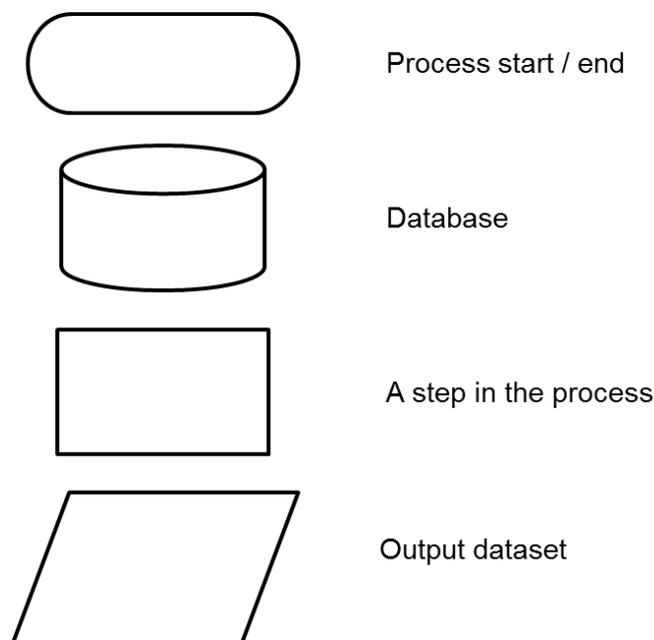
## 3 Analysis

This section describes the methods used to analyse and combine the datasets to model the distribution of energy consumption across the UK by fuel type. Estimates of gas consumption were compared with and corrected against detailed metered data at Local Authority and MSOA level. These were produced for the latest NAEI year at 1x1km level (to support the air quality and greenhouse gas maps for the latest inventory) and for 2010<sup>14</sup> to 2019 at local authority level for use in the LA CO<sub>2</sub> and LA Residual Fuels datasets. However, estimates of consumption of other fuels (oils and coal) are more uncertain because there are no consistent data sets on actual consumption of these fuels. For these datasets additional analysis steps were made, in order to create time-series for BEIS's Local Authority level statistics.

### 3.1 Process flow diagrams

In Figure 1 a brief explanation of the diagrams building blocks used in the subsequent Figure 2 and Figure 3, to graphically summarise the data flows and modelling processes implemented for each fuel type considered.

**Figure 1 Legend for the process flow diagrams below.**



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<sup>14</sup> Pre-2010 non-domestic gas consumption at MSOA level was unavailable

Figure 2 Non-domestic gas use allocation process.

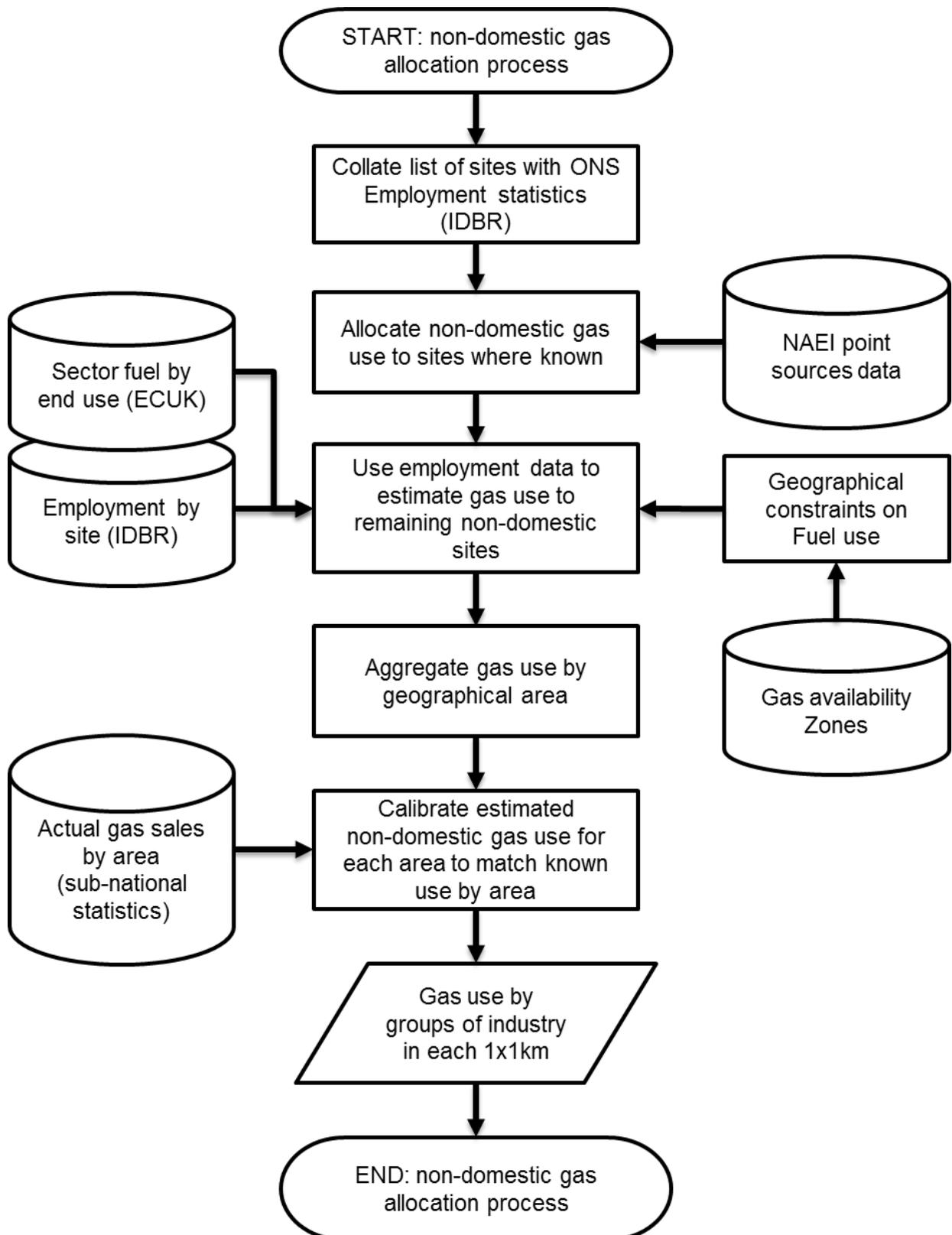
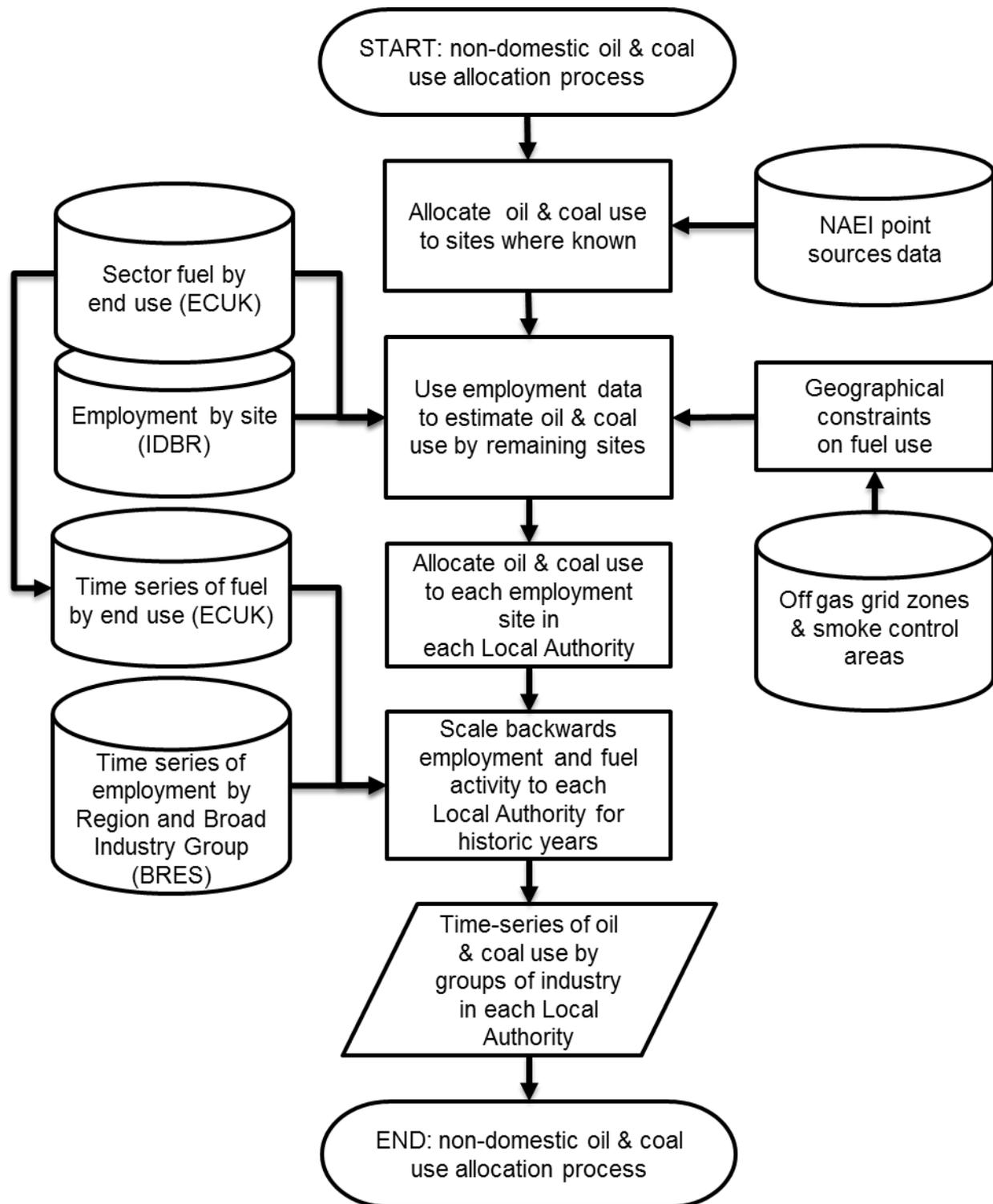


Figure 3 Non-domestic oil and coal use allocation process.



## 3.2 Matching point sources to employment data

Overlaps between the NAEI point source database and the IDBR database were identified and flagged. This was necessary to prevent double counting of energy consumption at the national level and at the detailed spatial level.

To enable data matching, the NAEI point sources were allocated to SIC codes. The total energy consumption associated with these point sources were then calculated at 2-digit SIC code level using bottom-up fuel use estimates in the NAEI point source database.

Subsequently, the locations of each of the NAEI point sources were matched to records in the IDBR using information in the location organisation name, SIC code and postcode on both datasets. This matching allowed employment records to be removed from the modelling to minimise double counting.

## 3.3 Matching NAEI sectors to SIC codes

Allocation of SIC codes in the energy and employment datasets to NAEI sectors enabled the aggregation of fuel use estimates to NAEI sectors and a comparison of energy consumption totals. This procedure also facilitated the generation of maps that were consistent with NAEI sector boundaries for distributing emissions data. The two main NAEI sectors relevant to the fuel use mapping are 'Other industry' (i.e. not the largest industrial emitters such as iron and steel or the cement industry) and Commercial and Public sector.

## 3.4 Calculation of non-point source residential energy consumption

The comparison of energy data grouped by SIC code and NAEI sector provided an estimate of the total residual energy consumption, i.e. the energy not used at the identified sites. This residual energy was identified for re-distribution using the employment data.

The comparison and calculation of residual energy at this level supported the highest level of cross-checks across emissions subsectors to be retained for energy consumption mapping.

## 3.5 Energy intensity factors

Estimates of fuel intensity per employee were used to distribute residual energy by sector across the IDBR employment sites and create maps of fuel use. Total UK employee numbers in the IDBR were aggregated to an equivalent sector level to the BEIS energy statistics which is at SIC 2007 2-digit code level for industrial sectors

but at a higher level for commercial and service sectors. The total numbers of employees by SIC code (4, 3, or 2-digit codes as appropriate) were then calculated from the IDBR database, excluding the allocated sites identified in **section 3.2**. This calculation also took account of the geographical areas appropriate to the relevant fuels.

The total residual energy by SIC code (as described above) and total number of employees for the same codes were then used to derive to a national average energy intensity factor per employee for each fuel type for each sector for these residual energy locations.

The fuel intensity factors were then applied across the employment distribution from the IDBR to create maps of fuel use by industry sector.

### 3.6 Gas consumption to adjust the distribution of gas predicted by the employment and energy intensity data

For gas consumption estimates model outputs are adjusted using real gas consumption data using an iterative approach of comparison and adjustment.

The BEIS and 1x1km gas data sets were compared with initial modelled estimates of gas using calibration factors to improve the initial estimates and ensure modelled and measures estimates were consistent as far as possible. This correction was possible at the MSOA level for most locations and at combined MSOAs in other locations owing to different levels of reporting of gas data in the BEIS dataset. The reason for this is the aggregation of MSOA gas consumption across multiple MSOAs to prevent disclosure of sensitive data. In both cases, the gas calculated from point sources were removed from the MSOA totals.

The BEIS dataset does not provide a distribution of gas consumption in Northern Ireland. Data were added using information on gas consumption by industry and commerce at district level from Energy providers (i.e. SSE Airtricity<sup>15</sup>, Firmus<sup>16</sup>) to adjust the modelled estimates in each Northern Ireland Local Authority.

### 3.7 Other fuels

The other fuels modelled using this method are coal and oil (with fuel oil and gas oil modelled separately for industrial sectors). The calculations for these two types of fuels is simpler than those for gas (but more uncertain) because no metered data exist for these fuels.

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<sup>15</sup> [Business - Gas supplier to homes and businesses in the Greater Belfast area \(airtricitygasni.com\)](https://www.airtricitygasni.com)

<sup>16</sup> [Natural gas for home & business N.Ireland NI | firmus energy/](https://www.firmusenergy.com)

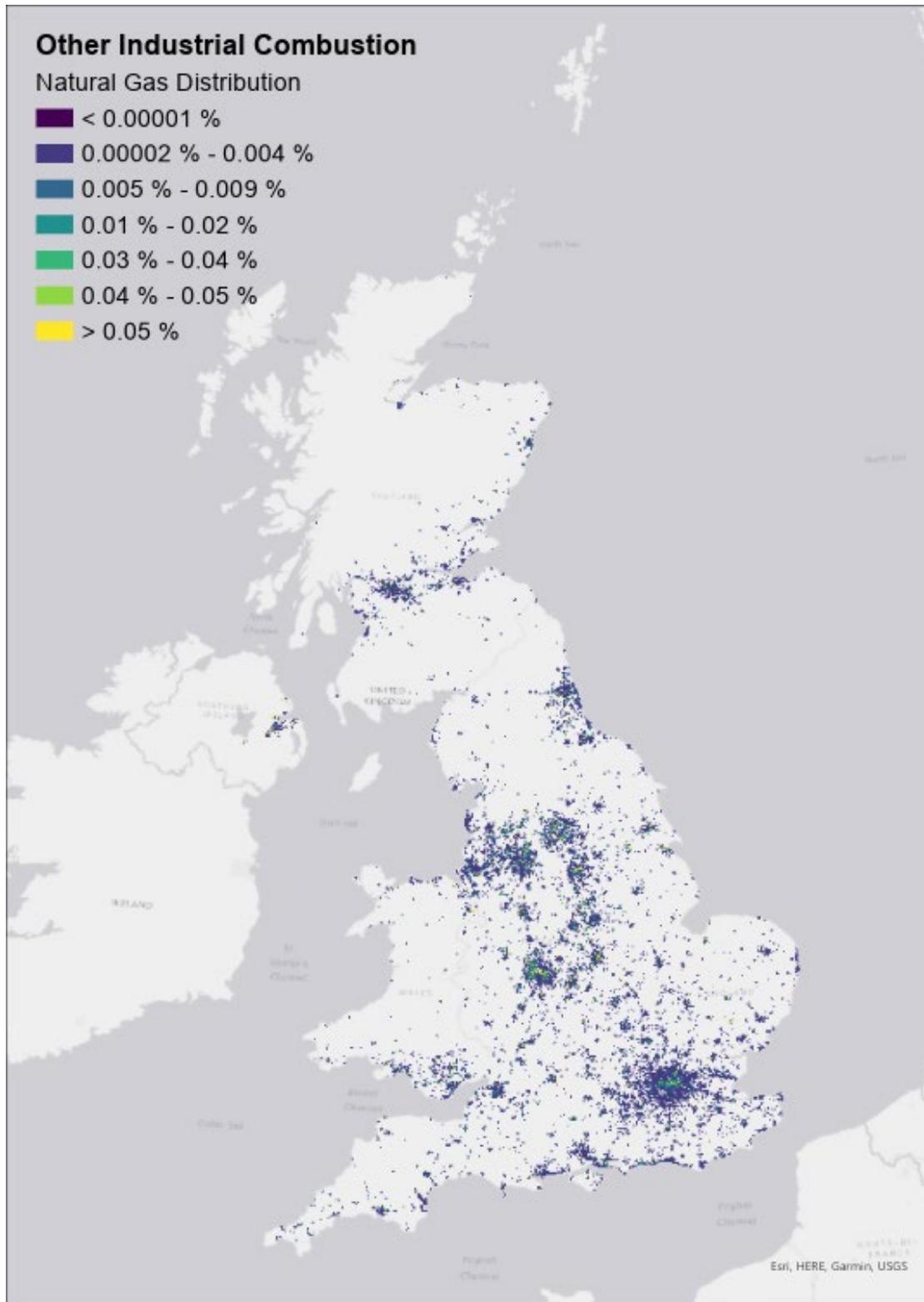
Based on expert knowledge of fuel used by industry and businesses the distributions of fuel oil and gas oil have been modified so that consumption per employee is lower in grid squares covered by gas supply using a weighting factor.

The distribution of coal has also been limited to areas outside large urban areas. This presumption of coal distribution is particularly uncertain, and it is recommended that this should be reviewed for the next mapping exercise.

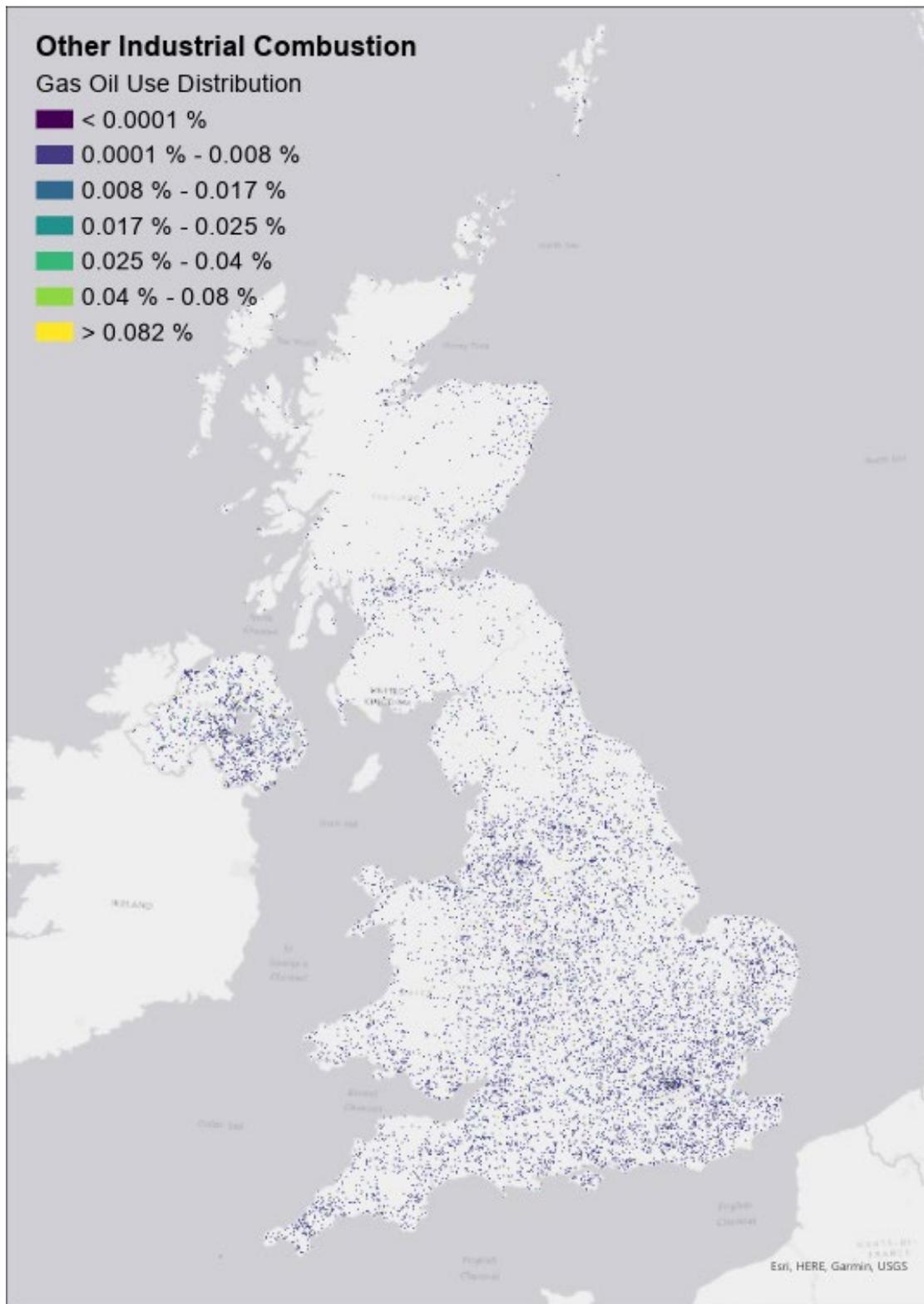
## 4 Outputs

Figures 4 to 6 below show respectively the modelled distribution of natural gas and gas oil and solid fuel use across the UK.

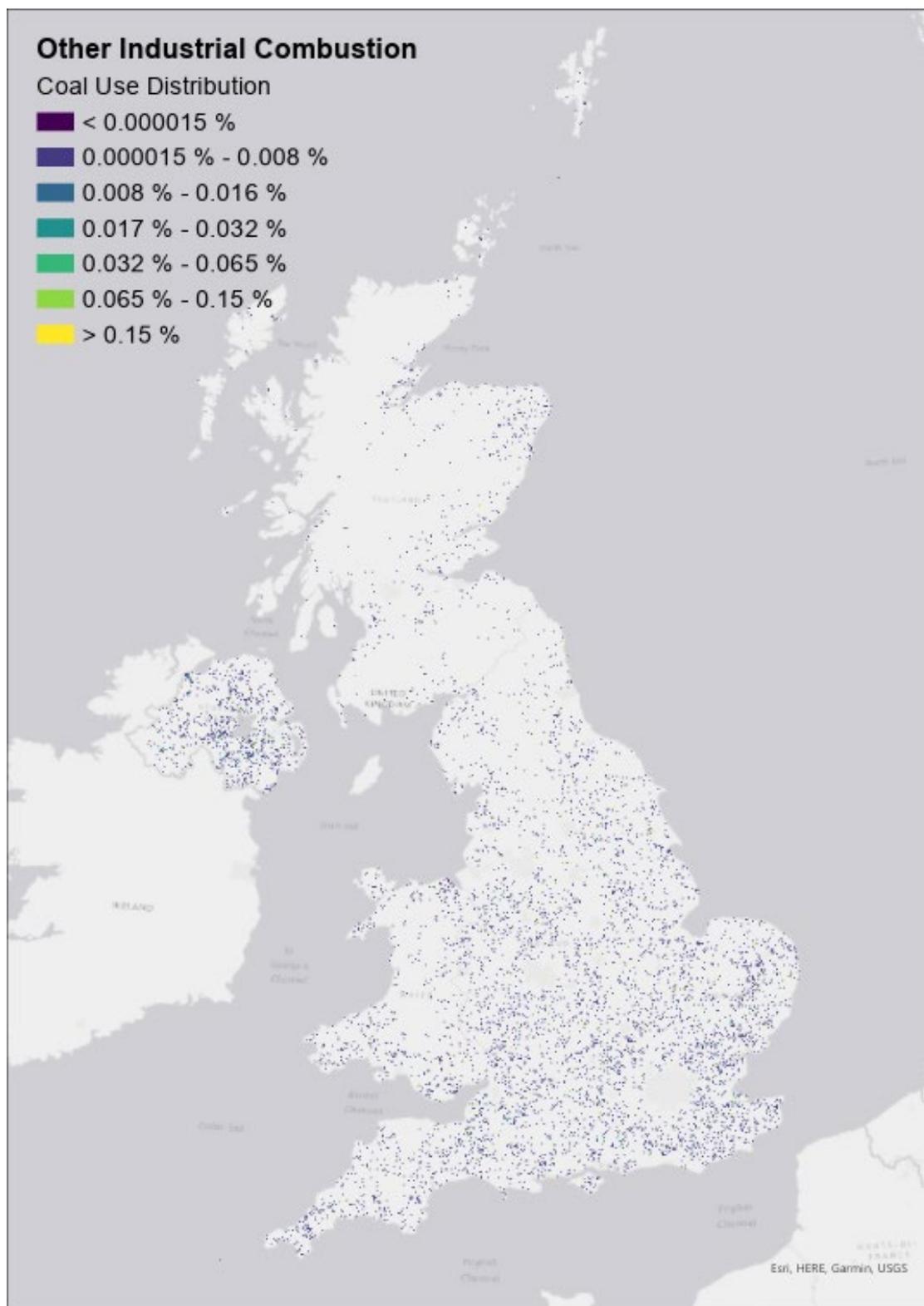
**Figure 4 Modelled distribution of natural gas across the UK.**



**Figure 5 Modelled distribution of gas oil across the UK.**



**Figure 6 Modelled distribution of coal use across the UK.**



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## Appendix 1 - 2-digit Standard Industrial Classification 2007

| SIC (2007) codes | Description   | Sector     |
|------------------|---|------------|
| 1                | Crop and animal production, hunting and related service activities  | Commercial |
| 2                | Forestry and logging  | Commercial |
| 3                | Fishing and aquaculture   | Commercial |
| 5                | Mining of coal and lignite  | Industry   |
| 6                | Extraction of crude petroleum and natural gas   | Industry   |
| 7                | Mining of metal ores  | Industry   |
| 8                | Other mining and quarrying  | Industry   |
| 9                | Mining support service activities   | Industry   |
| 10               | Manufacture of food products  | Industry   |
| 11               | Manufacture of beverages  | Industry   |
| 12               | Manufacture of tobacco products   | Industry   |
| 13               | Manufacture of textiles   | Industry   |
| 14               | Manufacture of wearing apparel  | Industry   |
| 15               | Manufacture of leather and related products   | Industry   |
| 16               | Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials | Industry   |
| 17               | Manufacture of paper and paper products   | Industry   |
| 18               | Printing and reproduction of recorded media   | Industry   |
| 20               | Manufacture of chemicals and chemical products  | Industry   |
| 21               | Manufacture of basic pharmaceutical products and pharmaceutical preparations  | Industry   |
| 22               | Manufacture of rubber and plastic products  | Industry   |
| 23               | Manufacture of other non-metallic mineral products  | Industry   |
| 24               | Manufacture of basic metals   | Industry   |
| 25               | Manufacture of fabricated metal products, except machinery and equipment  | Industry   |
| 26               | Manufacture of computer, electronic and optical products  | Industry   |
| 27               | Manufacture of electrical equipment   | Industry   |
| 28               | Manufacture of machinery and equipment n.e.c.   | Industry   |
| 29               | Manufacture of motor vehicles, trailers and semi-trailers   | Industry   |
| 30               | Manufacture of other transport equipment  | Industry   |
| 31               | Manufacture of furniture  | Industry   |
| 32               | Other manufacturing   | Industry   |
| 33               | Repair and installation of machinery and equipment  | Commercial |
| 35               | Electricity, gas, steam and air conditioning supply   | Industry   |
| 36               | Water collection, treatment and supply  | Industry   |
| 37               | Sewerage  | Industry   |
| 38               | Waste collection, treatment and disposal activities; materials recovery   | Industry   |
| 39               | Remediation activities and other waste management services.   | Industry   |
| 41               | Construction of buildings   | Commercial |
| 42               | Civil engineering   | Industry   |
| 43               | Specialised construction activities   | Commercial |
| 45               | Wholesale and retail trade and repair of motor vehicles and motorcycles   | Commercial |

## Employment Based Energy Consumption Mapping in the UK

| SIC (2007) codes | Description  | Sector     |
|------------------|--|------------|
| 46               | Wholesale trade, except of motor vehicles and motorcycles  | Commercial |
| 47               | Retail trade, except of motor vehicles and motorcycles   | Commercial |
| 49               | Land transport and transport via pipelines   | Commercial |
| 50               | Water transport  | Commercial |
| 51               | Air transport  | Commercial |
| 52               | Warehousing and support activities for transportation  | Commercial |
| 53               | Postal and courier activities  | Commercial |
| 55               | Accommodation  | Commercial |
| 56               | Food and beverage service activities   | Commercial |
| 58               | Publishing activities  | Commercial |
| 59               | Motion picture, video and television programme production, sound recording and music publishing activities | Commercial |
| 60               | Programming and broadcasting activities  | Commercial |
| 61               | Telecommunications   | Commercial |
| 62               | Computer programming, consultancy and related activities   | Commercial |
| 63               | Information service activities   | Commercial |
| 64               | Financial service activities, except insurance and pension funding   | Commercial |
| 65               | Insurance, reinsurance and pension funding, except compulsory social security                              | Commercial |
| 66               | Activities auxiliary to financial services and insurance activities  | Commercial |
| 68               | Real estate activities   | Commercial |
| 69               | Legal and accounting activities  | Commercial |
| 70               | Activities of head offices; management consultancy activities  | Commercial |
| 71               | Architectural and engineering activities; technical testing and analysis                                   | Commercial |
| 72               | Scientific research and development  | Commercial |
| 73               | Advertising and market research  | Commercial |
| 74               | Other professional, scientific and technical activities  | Commercial |
| 75               | Veterinary activities  | Commercial |
| 77               | Rental and leasing activities  | Commercial |
| 78               | Employment activities  | Commercial |
| 79               | Travel agency, tour operator and other reservation service and related activities                          | Commercial |
| 80               | Security and investigation activities  | Commercial |
| 81               | Services to buildings and landscape activities   | Commercial |
| 82               | Office administrative, office support and other business support activities                                | Commercial |
| 84               | Public administration and defence; compulsory social security  | Commercial |
| 85               | Education  | Commercial |
| 86               | Human health activities  | Commercial |
| 87               | Residential care activities  | Commercial |
| 88               | Social work activities without accommodation   | Commercial |
| 90               | Creative, arts and entertainment activities  | Commercial |
| 91               | Libraries, archives, museums and other cultural activities   | Commercial |
| 92               | Gambling and betting activities  | Commercial |
| 93               | Sports activities and amusement and recreation activities  | Commercial |
| 94               | Activities of membership organisations   | Commercial |
| 95               | Repair of computers and personal and household goods   | Commercial |

| SIC (2007) codes | Description   | Sector     |
|------------------|---|------------|
| 96               | Other personal service activities   | Commercial |
| 96               | Other personal service activities   | Commercial |
| 97               | Activities of households as employers of domestic personnel                                 | Commercial |
| 98               | Undifferentiated goods- and services-producing activities of private households for own use | Commercial |
| 99               | Activities of extraterritorial organisations and bodies                                     | Commercial |

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This publication is available from: <https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2019>

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