# Local and Regional CO2 Emissions Estimates for 2004 for the UK

Report by AEA Energy and Environment for Defra
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AEA Energy & Environment
From the AEA group

# Local and Regional $CO_2$ Emissions Estimates for 2004 for the UK

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**Report to Defra**

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# 1 Introduction

This report describes work undertaken by AEA Energy & Environment (formerly called Netcen) to provide Defra with Local Authority (NUTS4) and Government Office Regions (NUTS1) level carbon dioxide emissions estimates for 2004. The work is an extension of the National Atmospheric Emissions Inventory (NAEI) contract (RMP/2106) with Defra Air and Environmental Quality and Global Atmosphere Divisions, this extension being sponsored by the Environmental Statistics and Indicators Division.

## 1.1 Aim

The aim of this project is to provide nationally consistent carbon dioxide emission estimates at local authority and regional level for the year 2004. This report follows on from a report of emissions in 2003, published in October 2005 (Goodwin et al, 2005). The data represent the primary emissions from the consumption of fuel or other process activities that emit $CO_2$, with the emissions relevant to the production of electricity allocated to their point of consumption. This year the data are also presented separately by End User, i.e. emissions are reallocated from the production and distribution of energy to the users of that energy.

The data presented in this report have been prepared using revised methods and datasets for 2004 estimates. Therefore, these estimates are not directly comparable with estimates for 2003 published in 2005. The data are intended to provide a starting point for further thought on quantifying emissions at a local and regional level, to stimulate discussions regarding local carbon accounting. It is hoped that the continued development of this dataset will facilitate action plans to reduce emissions of carbon. The Climate Change Programme (CCP) (Defra 2006a) outlines intentions to drive and support action at a local as well as a national level. Local Authorities are seen as important contributors to national emissions reductions. "Local authorities are uniquely placed to provide vision and leadership to local communities, raise awareness and help change behaviours. In addition, through their powers and responsibilities (housing, planning, local transport, powers to promote well-being and through activities such as their own local procurement and operations) they can have significant influence over emissions in their local areas." The development of local inventories will help Local Governments to be informed about the important emission sources and priorities for emission reduction, track improvement and design effective policies for further emission reductions. To support this the CCP highlights the introduction of : "…a package of measures to drive additional action for local authorities to include an appropriate focus on action on climate change;"

The estimates presented in this report stretch the bounds of existing methodologies in an attempt to provide estimates for each Local Authority and Region and sector. As such they should be considered indicative. Elements of the data (such as the domestic gas and electricity estimates and the estimates for road transport) are of reasonable certainty as they are based on local meter readings, sales data and traffic counts. Other components of the estimates (including solid and liquid fuels combustion, land use estimates) are much more uncertain as they are based on less well linked spatial data (including population, satellite images and fuel surveys) and incorporate many assumptions.

Despite these limitations the 2003 dataset published in 2005 has been used in the development of to the regional indicators in the Government's Sustainable Development Indicators (Defra 2006b) and the Audit Commission's updated set of Quality of Life indicators. The 2003 dataset has also been used for a number of other studies, by Local Authorities, Regional Observatories and environmental campaigning organisations. Details of existing data users are provided in Annex 1.

The estimates presented in this report are also not directly comparable with the National and Regional Greenhouse Gas Inventories for $CO_2$. This is because more detailed site

specific data on emissions and fuel consumption data have been used, in order to make emissions from large sources more accurate at the local level. The more detailed data, from reports for the EU Emissions Trading Scheme for 2005, were not available in time for the compilation of the National Inventory for 2004 but it is a significant new dataset and has therefore been included in this analysis.

## 1.2 Basis of emissions reporting

The NAEI produces 1km resolution maps of $CO_2$ emissions at source (as shown in Figure 2) whereas the 2003 dataset of Local $CO_2$ emissions published in 2005 resdistributed emissions associated with electricity to the locations of electricity consumption. This alternative method is known as the electricity user basis. This report describes the 2004 dataset, which is also presented on the electricity user basis but additionally emissions have been calculated on the end user basis. These bases are defined in Table 1.

**Table 1** Various definitions of emissions reporting for Local $CO_2$

| Reporting Basis | Definition |
|---|---|
| By Source | Emissions located at the emission source. |
| Electricity User | Emissions located at source except for electricity generation. Emissions from electricity generation allocated to point of electricity consumption. |
| End User | Re-allocation of all emissions from the production and distribution of Energy to the users of that energy (electricity, refineries, oil and gas production, mining). |

A further possible basis for calculating emissions is by consumption as described in the report "Counting Consumption" (WWF, 2006). This takes account of emissions produced during the production of goods both within the UK and abroad, then assigns these emissions to the locations of consumption of the goods. However this methodology is a rather different approach requiring different data and is outside the scope of this project.

Emissions in the UK Crown Dependencies and Overseas Territories are not included in these estimates.

## 1.3 Methodology

The compilation of the 2003 dataset of Local and Regional $CO_2$ emissions was made possible following the publication of new local gas, electricity and road transport fuel consumption estimates by DTI in 2004 (DTI 2004a, DTI 2005b). DTI have published further data for 2004 in the same format (DTI 2005c), which have been used as the basis of the results presented in this report. Together the gas combustion, electricity consumption and road transport sectors represent 80% of energy use in the UK. Estimates of the distribution of $CO_2$ emissions from other fuel use and industrial processes are available from mapping work currently undertaken within the NAEI contract. The methodology used to compile these maps is described in the NAEI mapping methodology report (King et al, 2006).

The DTI electricity consumption data has enabled AEA Energy & Environment to map carbon dioxide emissions from electricity generation to the point of consumption. This is a key difference to the mapped data published by the NAEI for other pollutants where emissions are attributed to the location of emission (e.g. at the power station locations). For this report the "Emissions" from electricity consumption have been estimated using an average UK factor in terms of kT CO2 per GWh. This average allocates equal shares of coal, gas, oil and renewable powered generation to the electricity consumers and is derived from the UK inventory for 2004.

The local $CO_2$ estimates presented in this report are split into four categories: domestic (including electricity use), industrial and commercial (not including power stations) road transport and Land Use, Land Use Change and Forestry (LULUCF). Within each sector there is then further disaggregation by fuel and/or source type which requires further assumptions about the fuel mix and demand. This additional level of detail is given primarily in order to show how the overall estimates are constructed, rather than because the categories shown are necessarily of robust quality or of particular significance. The remainder of the UK emissions such as off shore emissions from oil and gas extraction, aircraft emissions, fishing and coastal shipping, are not included in the local estimates because these could not be spatially disaggregated to LA level.

Further data are also provided to present the $CO_2$ emissions by End User, i.e. emissions from the energy supply sectors are redistributed to the locations where these energy sources are used. The method follows as closely as possible that used for the End Users emissions calculated as part of the NAEI and reported by Defra at the national level (Defra 2005).

This reporting structure used in this report is different from that used for reporting the UK total $CO_2$ emissions for Defra commitments under the UN Framework Convention on Climate Change (in the National Communication Format). A simplified structure has been adopted because of the aggregated nature of the data available from the DTI.

### 1.4 Structure of this report

Official estimates of total UK emissions of $CO_2$ for 2004 are summarised in **Section 2** of this report. The UK National Communication Format sector totals are also compared with the emissions presented in this report. **Section 3** describes the data and calculation methods used to derive the emission estimates at Local Authority and Government Office Region level for this project. Differences in methodology compared with that used for the 2003 data are highlighted. The results are summarised in **Section 4** and provided in detail in a spreadsheet which accompanies this report (LocalRegionalCO2_2004Final.xls). **Section 5** of this report provides explanations of changes between the 2003 dataset and the results for 2004. **Section 6** describes the method used to generate the End User emissions. **Section 7** provides suggestions for improvements to this analysis.

# 2 Summary of $CO_2$ inventory for the UK

An overview of the UK inventory for $CO_2$ in 2004 is presented here. This provides a context for the data presented in this report. Further detail is available in the annual NAEI report (NAEI UK Emissions Inventory 2004).

The major emissions of carbon dioxide arise from the combustion of fossil fuels in power generation, and the transport, domestic and industrial sectors (Figure 1). The emission depends on the fuel mix and the level of fuel consumption. Details of UK fuel consumption are given annually in the Department of Trade and Industry's Digest of United Kingdom Energy Statistics (DTI, 2005). The fuel consumption data used to calculate the pollutant emission totals in the NAEI are given in Table 1; fuels which are used as feedstock in non-combustion activities are omitted (principally natural gas used for the production of ammonia, methanol and acetic acid and some use of LPG and OPG in petrochemical plants). Emissions from such processes are calculated and allocated to the point of emission.

**Figure 1** Time Series of $CO_2$ Emissions from Key Sectors (Mtonnes $CO_2$)

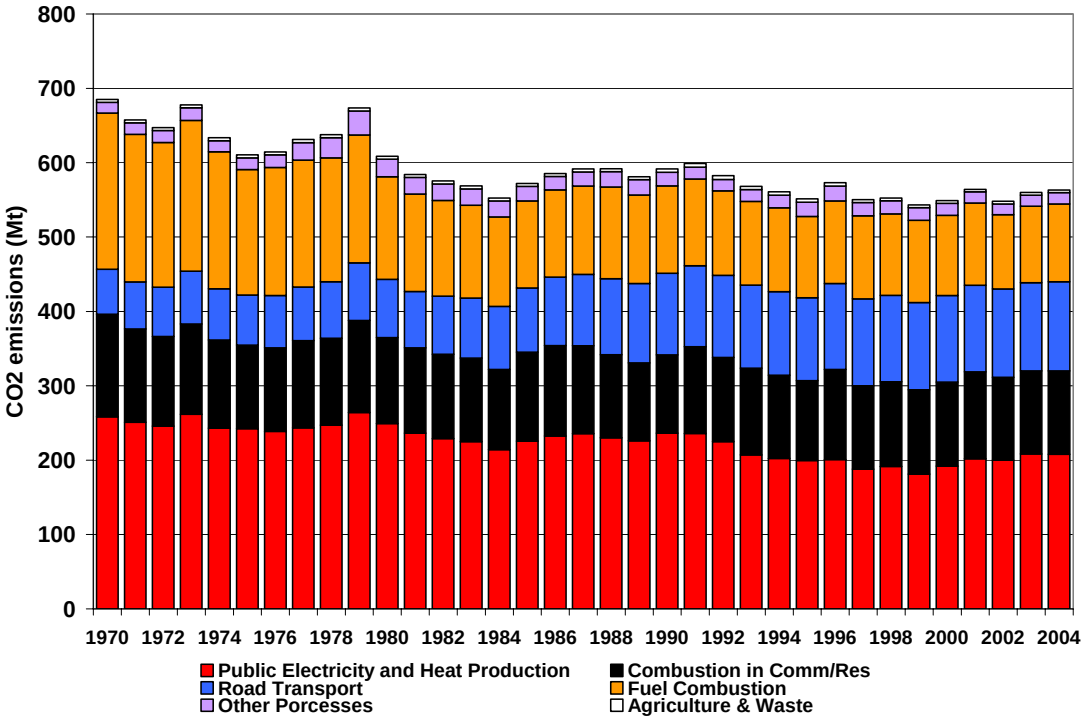



**Table 2** UK Fuel Consumption, 2004

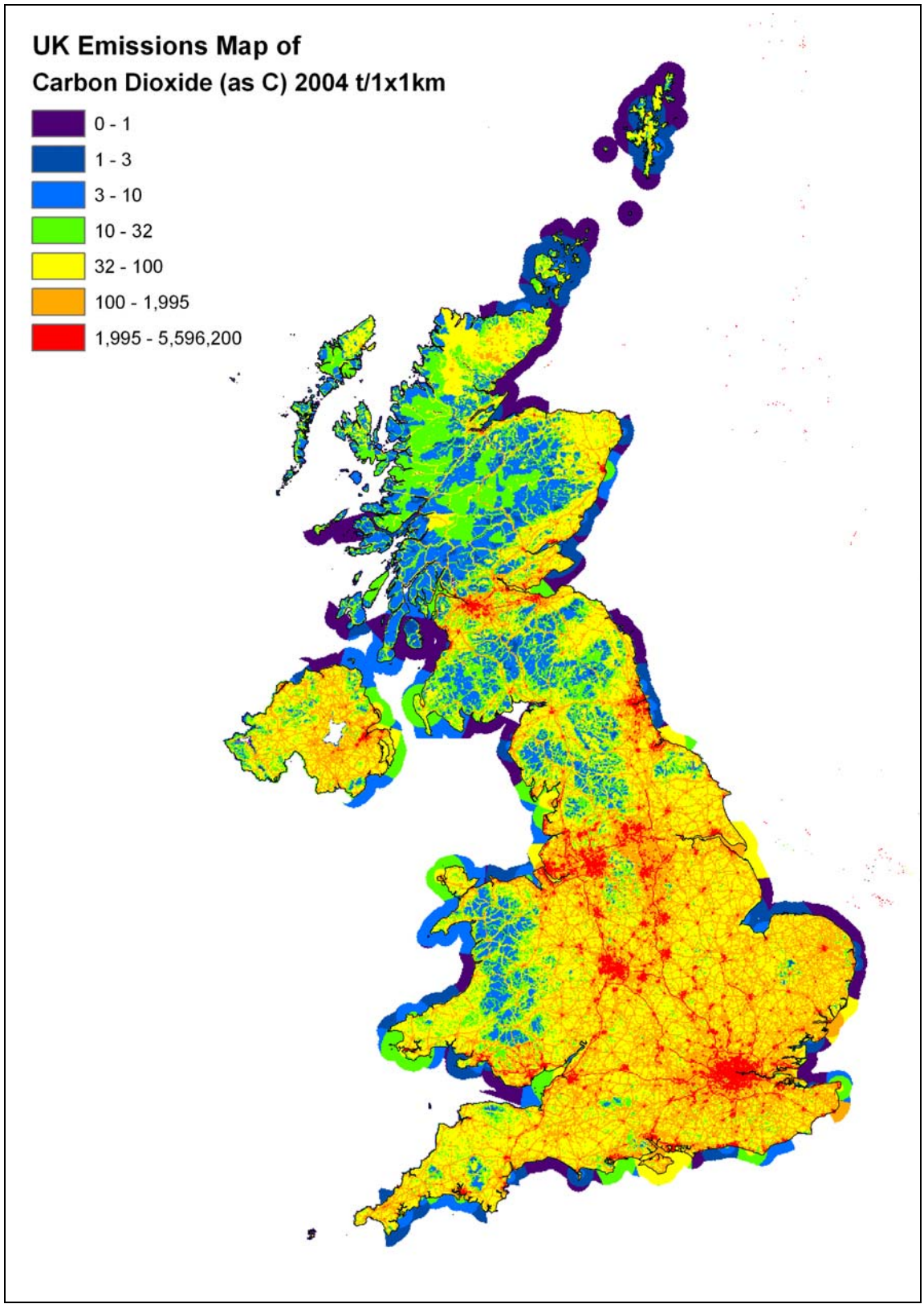
| Fuel | Consumer | Fuel Units | 2004 |
|---|---|---|---|
| Coal | Major Power Prod | Mtonnes | 49.7 |
| Coal | Industry | Mtonnes | 3.2 |
| Coal | Domestic | Mtonnes | 0.8 |
| Coal | Others | Mtonnes | 0.0 |
| Other Solid Fuels | All Consumers | Mtonnes | 2.2 |
| Motor Spirit | Road Transport | Mtonnes | 19.5 |
| Gas Oil | Road Transport | Mtonnes | 18.5 |
| Gas Oil | Industry | Mtonnes | 2.6 |
| Gas Oil | Others | Mtonnes | 2.4 |
| Fuel Oil | Major Power Prod | Mtonnes | 0.9 |
| Fuel Oil | Refineries | Mtonnes | 1.7 |
| Fuel Oil | Industry | Mtonnes | 1.4 |
| Fuel Oil | Others | Mtonnes | 0.1 |
| Orimulsion | Major Power Prod | Mtonnes | 0.0 |
| Burning Oil | Domestic | Mtonnes | 2.4 |
| Burning Oil | Others | Mtonnes | 1.5 |
| Aviation Turbine Fuel | Air Transport | Mtonnes | 12.9 |
| Other Petroleum Products | All Consumers | Mtonnes | 1.5 |
| Petroleum Gases | Refineries | Mtherms | 1264.2 |
| Petroleum Gases | Others | Mtherms | 786.9 |
| Natural Gas | Major Power Prod | Mtherms | 11474.3 |
| Natural Gas | Industry | Mtherms | 9023.4 |
| Natural Gas | Domestic | Mtherms | 13526.3 |
| Natural Gas | Others | Mtherms | 4095.9 |
| Other Gases | All Consumers | Mtherms | 941.3 |

Source: NAEI, based on DUKES with some sectoral reallocation resulting from stakeholder consultation

Figure 2 illustrates the $CO_2$ emissions mapped across the UK on a 1km x 1km grid. Dispersed fuel combustion sources are clearly visible in urban centres and across the road

network. Emissions from power stations have not been assigned to the electricity consumers at this stage of the analysis and occur in relatively few grid squares and therefore their impact is less visible on this map.

**Figure 2** Spatially Disaggregated UK Emissions of $CO_2$



## 2.1 Simplified sector split for Local $CO_2$ estimates

A simplified sector split has been devised for this work on Local $CO_2$ emissions. This simplification has been necessary because of the aggregated nature of the data from DTI, i.e. for both electricity and gas all industry and commercial consumption are aggregated. The DTI data does however provide a high spatial resolution of consumption which has not previously been available. The NAEI sectors included in the four Local $CO_2$ reporting categories are summarised in Table 3 below. The colour coding matches the data in the data spreadsheet.

**Table 3** NAEI emissions sectors in Local $CO_2$ reporting categories

| | |
|---|---|
| Industrial and commercial | Industrial, Commercial and Agriculture Electricity |
| | Industrial, Commercial and Agriculture Gas |
| | Industrial Gas (Large Users) |
| | Industry and Commercial Oil (1) (2) |
| | Industry and Commercial Solid Fuel (2) |
| | Industry and Commercial Wastes And Biomass |
| | Industry Process Gases |
| | Industry Non Fuel |
| | Industry Off-Road Machinery |
| | Agriculture Oil (3) |
| | Agriculture Solid Fuel |
| | Agriculture Non Fuel |
| | Railways |
| Domestic | Domestic Electricity |
| | Domestic Gas |
| | Domestic Oil |
| | Domestic Solid Fuel |
| | Domestic Home And Garden Machinery |
| | Domestic Household Products |
| Road Transport | Road Transport Petrol (Major roads) |
| | Road Transport Petrol (Minor roads) |
| | Road Transport Diesel (Major roads) |
| | Road Transport Diesel (Minor roads) |
| | Road Transport Other |
| Land Use, Land Use Change and Forestry | LULUCF Emissions: Agricultural Soils And Deforestation |
| | LULUCF Emissions: Other |
| | LULUCF Removals |
| Unallocated emissions | Some gas and electricity consumers which cannot be allocated for confidentiality reasons or because of problems with geo-referencing |
| Sectors not included in these estimates | Domestic Aviation (4) |
| | Offshore gas and oil |
| | Shipping (including coastal shipping and fishing) (4) |

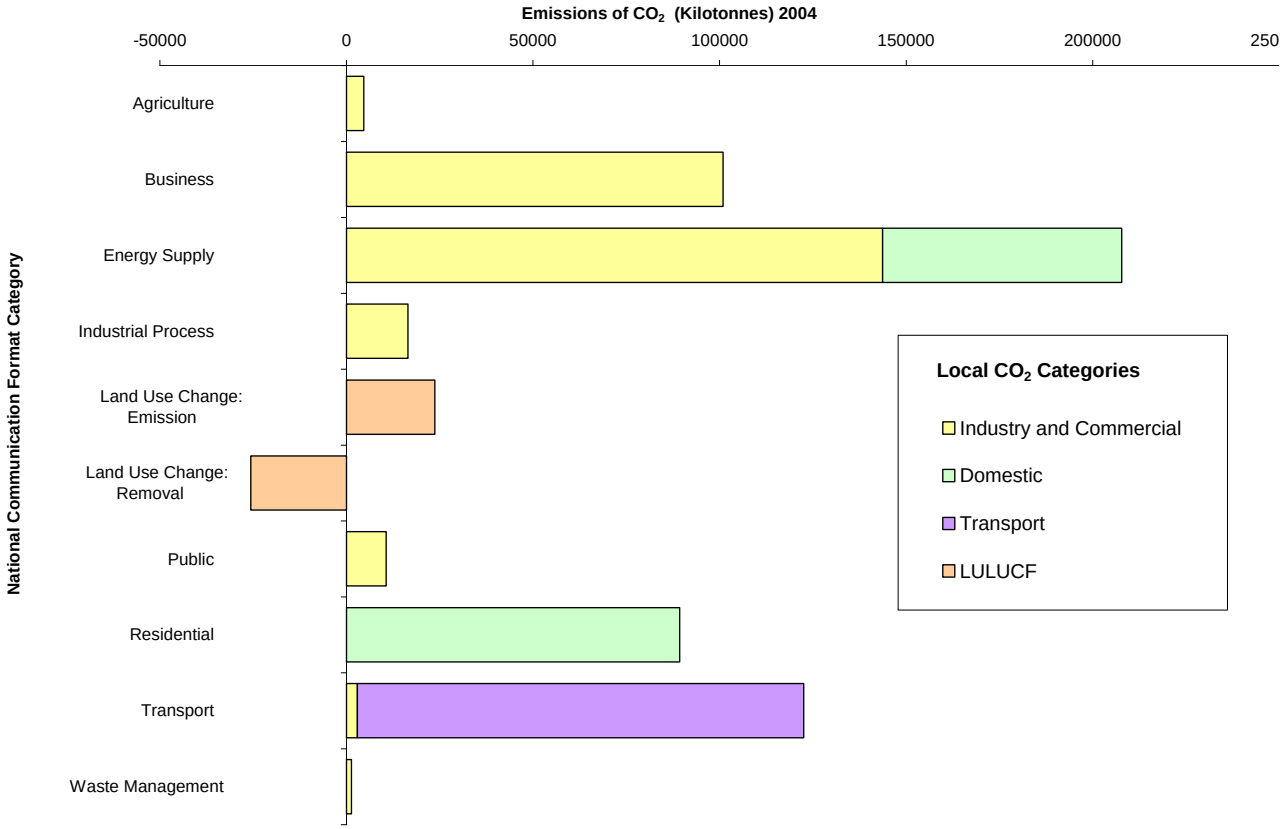
Notes
(1) Includes the management of airports (support vehicles, stationary heating and power)
(2) Includes industry autogeneration of electricity
(3) Includes agricultural off-road machinery
(4) International aviation and shipping are outside scope of the UK inventory

Explanation of the methods use to compile the estimates for each of these sectors is given in the next section.

The emission totals in the NAEI $CO_2$ inventory in the National Communication Format (Defra, 2006c) can be compared with the emissions totals in the Local $CO_2$ reporting

categories. This comparison is shown in Figure 3. A split of contributors to the Local CO2 "Industry and Commercial" sector is provided in Table 4.

**Figure 3** Summary of UK $CO_2$ inventory for 2004




Further comment is provided on this comparison in section 4.3 after the methodology for this work has been explained.

**Table 4** Percentage contribution of sectors to the Local CO2 Industry and Commercial Total (electricity user basis, all fuels)

| Industry and Commercial Sectors | % of total emission | Industry and Commercial Sectors | % of total emission |
|---|---|---|---|
| Other industrial combustion | 40% | Sinter production | 1% |
| Refineries – combustion | 13% | Incineration (clincal, chemical, animal carcases) | 0.7% |
| Iron and steel - combustion plant | 9% | Coke production | 1% |
| Miscellaneous industrial/commercial combustion | 8% | Lime production | 1% |
| Public sector combustion | 7% | Primary aluminium production - general | 0.4% |
| Cement production | 6% | Agriculture - stationary combustion | 0.3% |
| Industrial off-road mobile machinery | 5% | Aircraft - support vehicles | 0.3% |
| Blast furnaces | 3% | Glass - general | 0.2% |
| Agriculture - mobile machinery | 3% | Collieries - combustion | 0.1% |
| Railways | 2% | Other | 2.0% |
| Ammonia production - feedstock use of gas | 1% | | |

# 3 Datasets and methodology

The Local estimates of $CO_2$ emissions presented in this report have been calculated using data from a variety of sources. These are summarised in Table 5 and descriptions of the data and methods are provided in the following sections. Each section is headed by a box showing which Table 5 sectors it includes and the contribution of each of these to the UK total.

**Table 5** Summary of data sources and methods

| Sector | Data source / method summary | % of UK total |
|---|---|---|
| Industrial, Commercial and Agriculture Electricity | DTI electricity consumption data; Surrogate employment data to model NI consumption distribution | 19% |
| Industrial, Commercial and Agriculture Gas | DTI gas consumption data; Further data for Northern Ireland from Phoenix Gas and individual point sources. Additional NAEI point source data for large users. | 11% |
| Industrial Gas (Large users) | | 1.1% |
| Industry and Commercial Oil | Large sources identified as point sources. Remaining emissions distributed using NAEI modelling of fuel use based in employment distributions and fuel intensity by sector. Airport support activities are allocated to airport locations weighted by numbers of aircraft movements at each (direct aircraft emissions are excluded) | 6% |
| Industry and Commercial Solid Fuel | | 3% |
| Industry and Commercial Wastes And Biomass | | 0.5% |
| Industry Process Gases | | 3% |
| Industry Non Fuel | | 1% |
| Industry Off-Road Machinery | Industrial off-road is allocated using a distribution of employment within heavy industries. | 1% |
| Agriculture Oil | NAEI modelling of fuel use based in employment distributions and fuel intensity by sector. Agricultural off-road is allocated according to land use weighted by estimates of machinery usage on different land use types. | 0.7% |
| Agriculture Solid Fuel | | 0.004% |
| Agriculture Non Fuel | $CO_2$ emissions from the breakdown of pesticides applied to agricultural crops. These are distributed using a map of arable land cover as a surrogate for this activity. | 0.007% |
| Diesel Railways | Diesel emissions estimated based on train movements (Methodology updated for 2004 to include NI) | 0.5% |
| Domestic Electricity | DTI electricity consumption data; Surrogate population data to model NI consumption distribution | 12% |
| Domestic Gas | DTI gas consumption data; Further data for Northern Ireland from Phoenix Gas. (Methodology updated for NI) | 15% |
| Domestic Oil | NAEI modelling of fuel use distributions using household distributions and data on household energy demand, locations of Smoke Control Areas and locations of gas use (Methodology updated for 2004) | 2% |
| Domestic Solid Fuel | | 1% |
| Domestic Home And Garden Machinery | Emissions are distributed in proportion to population. | 0.05% |
| Domestic Household Products | | 0.3% |
| Road Transport Petrol (Major roads) | Emissions from fuel combustion in the road transport sector based on detailed DfT traffic census data and NAEI emissions factors. | 8% |
| Road Transport Petrol (Minor roads) | | 4% |
| Road Transport Diesel (Major roads) | | 8% |
| Road Transport Diesel (Minor roads) | | 3% |
| Road Transport Other | | 0.1% |
| LULUCF Emissions: Agricultural Soils And Deforestation | Emissions and removals resulting from land use change distributed using CEH land use change data (Methodology updated for 2004). | 0.2% |
| LULUCF Emissions: Other | | 4% |
| LULUCF Removals | | -5% |

## 3.1 Electricity consumption

| | |
|---|---|
| Industrial, Commercial and Agriculture Electricity | 19% |
| Domestic Electricity | 12% |

The DTI electricity consumption data used in this work was published in Energy Trends (DTI, 2005c). It has been compiled using data from the administrative systems of the electricity companies' data aggregators. The quality of the dataset for 2004 is better than that for 2003 through better geo-referencing of the meter points and refinements to the allocation between domestic and industrial/commercial consumers. Unallocated consumption has fallen from 6.5% in 2003 to 1.5% in 2004.

The $CO_2$ emission for electricity consumption from the NAEI in 2004 (170,607 kilotonnes) was distributed across the Local Authorities based on the consumption data for both domestic and industrial and commercial users.

The domestic electricity consumption data was calculated by DTI from actual or estimated meter readings of 26 million electricity meters across Great Britain. The location of these meters were determined from the Gemserve database of meters MPAS (Meter Point Administration System).

Data for the industrial and commercial sector was also obtained from meters. These include non-half hourly meters classified as industrial and commercial, some nominally domestic meters with consumption of over 100,000kWh and also meters with addresses indicating commercial use such as unmetered, street lighting or temporary builders supplies.

Reconciliation with data in DUKES by DTI found the result to be an over estimate of 6.2% of the GB total domestic electricity consumption (DTI, 2005c Table 1 p37). This is possibly because of the inclusion of some non-domestic users within this dataset as a result of the requirement for the arbitrary cut-off of 100,000 kWh above which the user is assumed to be industrial or commercial. Other reasons for the differences are that the consumption data are not for exactly a calendar year and some consumption is estimated as opposed to actual metered consumption. The statistical difference overall for all users is +1% and is therefore a good match with DUKES totals.

The DTI data also includes 7,400 GWh of electricity as direct sales to high voltage lines that cannot be allocated to any region or Local Authority due to the lack of information. Emissions associated with this electricity consumption are included in Table 8 as an unallocated item. This takes the overall percentage of industrial and commercial electricity consumption unallocated to LAs, either because of geo-referencing problems or because it is direct sales, to 4%.

The DTI dataset does not provide a distribution of electricity consumption in Northern Ireland therefore data were obtained from Northern Ireland Electricity (Fallon *pers comm*.). The total electricity consumption for the domestic sector is 3125 GWh and industrial and commercial sectors 4971 GWh. The distribution of domestic consumption across Northern Ireland has been modelled using population counts by Local Authority, and for the commercial and industry sectors using total employment by Local Authority. This does not provide a true picture of electricity consumption and better data will be sought for future revisions of this dataset.

Northern Ireland is a net importer of electricity (DTI 2005c). It imported 2793 GWh from Scotland in 2004 but also exported 1574 to The Republic of Ireland. The total generating capacity within Northern Ireland is 7410 GWh, of which gas accounted for more that 50% in 2004. Net imports are 16% of total consumption.

## 3.2 Gas consumption

| | |
|---|---|
| Industrial, Commercial and Agriculture Gas | 11% |
| Industrial Gas (Large users) | 1.1% |
| Domestic Gas | 15% |

The gas data published by DTI provides estimates of gas consumption by the domestic sector and the industrial and commercial sector for each Local Authority in Great Britain for 2004 (DTI, 2005c). The estimates have been compiled by DTI using data provided by National Grid Plc at postcode sector level. DTI have allocated each postcode sector in the NGT dataset to one or more Local Authority (LA) area.

**Data quality issues**

There are a number of issues with the National Grid data that reduce the overall quality of the dataset and results in some misallocation of gas use between LAs but it is at present the best available information. The extent of this misallocation is not quantified but this is considered to be one of the more significant sources of uncertainty.

Firstly for reasons of confidentiality some postcode sectors in the National Grid data have been aggregated so that one consumption total is given for a number of postcode sectors.

Secondly in some cases there was not a simple match of postcode sector to LA therefore simple assumptions were used to allocate the gas consumption across LAs. Where local information was received from LAs to provide a better split then this was used.

Thirdly some postcode sectors specified in the National Grid dataset do not appear in the most recent postcode sector to LA lookup file provided by the Office of National Statistics. This is a result of old postcode sector boundaries used by National Grid to locate gas meter points. DTI made simple assumptions to allocate these postcode sectors to LAs which had postcode sectors with similar numbers. DTI have been contacted by some local authorities and have revised their methodology for allocating consumption according to local information.

For this project AEA Energy & Environment has not made any attempt to modify the DTI gas use estimates in the light of the issues raised above. These issues apply equally to the domestic and commercial and industry datasets. Higher resolution (meter point) consumption data has been obtained by DTI since the publication of this data. This will significantly improve the energy consumption and hence carbon estimates from 2005 onwards.

There is one further very significant issue relating to the commercial and industry consumption data. The largest gas users have been excluded from the LA totals for reasons of confidentiality. This exclusion equates to 30% of all gas use and comprises 33 power stations and 16 large industrial users. However the local authority areas in which these 49 users are located are known as is the total gas usage by the large (excluded) users (by Government Office Region) and users in Northern Ireland. AEA Energy & Environment has used site specific emissions data from the Environment Agency's Pollution Inventory and Emissions Trading Scheme database to deduce the locations of these large users and to provide estimates of $CO_2$ associated with them. The method for identifying site specific fuel usage is described in **Annex 2** of this report.

**Gas consumption in Northern Ireland**

Data for Northern Ireland has been added to the DTI dataset using information on total Northern Ireland gas consumption from Phoenix Gas. For the domestic sector the total consumption is 894 GWh and for Commercial and Industry the total is 1,804 GWh (Quinn, 2006). This includes 1,256 GWh used by large users but does not include gas use at Ballylumford power station. Emissions from this station are re-distributed according to electricity consumption along with all other UK power station emissions. The large gas users identified as point sources in the NAEI have a total gas consumption lower than 1,256

GWh. The remaining large user consumption has not been allocated to local authorities as the location is not known.

### $CO_2$ emissions from domestic gas consumption

The gas consumption estimates for the domestic sector have been used to distribute the UK total $CO_2$ emission for the domestic gas sector. It is assumed that emission factors for domestic gas use are constant throughout the country.

### $CO_2$ emissions from commercial and industry gas consumption

In the case of the commercial and industry sector the emissions estimates for the excluded sites have been calculated using the data from the AEA Energy & Environment point source database which uses a combination of public domain emissions data and data from the EU Emissions Trading Scheme reports to regulators to estimate energy use.

AEA Energy & Environment's site specific fuel usage estimates for gas (derived using the method described in Annex 2 of this report) were compared with the data on the location of the 49 gas consumers excluded from the DTI data. The sites identified have been checked by DTI to be consistent with their decisions.

New data from the Environment Agency database of reported emissions in the EU Emissions Trading Scheme has been used to better estimate fuel use in 2004. There are some discrepancies between the DUKES fuel use statistics and those calculated by AEA Energy & Environment. These are described in Annex 2. These differences mean that the data presented here for Industrial and Commercial emissions of $CO_2$ are not consistent with the UK GHGI inventory

Overall agreement between the gas consumption for the excluded sites and gas consumption as estimated by AEA Energy & Environment was good, see Table 6. Northern Ireland is included with power stations in the table below because this is how the numbers were reported by DTI (DTI 2005c Table 1 p32).

**Table 6** Comparison of DTI excluded gas consumption and AEA Energy & Environment calculated gas consumption at large point source and Northern Ireland

| | Gas consumption reported by DTI (GWh) | Gas consumption calculated by AEA Energy & Environment (GWh) |
|---|---|---|
| Power stations + Northern Ireland | 295563 | 300863 |
| Large industrial users | 35100 | 31293 |
| All excluded users | 330663 | 332156 |

These site specific gas use estimates i.e. the AEA Energy & Environment figures in Table 4 were converted into $CO_2$ emissions estimates at each site using sector specific emission factors from the NAEI. The total emission for the excluded sites excluding the power stations (whose emissions are distributed by electricity consumption as discussed above) was 6025 kilotonnes of $CO_2$. The residual UK industry and commercial emission was then calculated (as shown in Table 7) and added to the NAEI domestic $CO_2$ total. This total emission was then distributed using the DTI LA level gas consumption estimates for the Domestic and Commercial and Industry sectors. It is assumed that emission factors for gas use are constant throughout the country.

**Table 7** Calculation of remaining $CO_2$ emission from Commercial and Industry sector after exclusion of large users

| | | kT $CO_2$ |
|---|---|---|
| NAEI emission for Industry and commercial (not including power stations) | | 60658 |
| Agriculture | + | 435 |
| Processes (1) | + | 1329 |
| Total Local $CO_2$ Industry and Commercial gas use emission | | 62422 |
| Large users (not including power stations) excluded from this dataset | - | 6025 |
| Total emission to distribute using the DTI gas data | | 56397 |

(1) Emissions from using natural gas as a feedstock for ammonia production

## 3.3 Other Domestic fuel use

| | |
|---|---|
| Domestic Oil | 2% |
| Domestic Solid Fuel | 1% |

New modelling of domestic fuel use has been undertaken as part of this work. This makes use of new data from DTI and BRE to enable significant improvements to be made to the distributions of domestic fuel use. New distributions of domestic gas, coal, oil and smokeless solid fuels have been produced for Great Britain. These have been combined with existing distributions for Northern Ireland. The method used to compile these maps is provided in **Annex 3** and explained briefly here.

New data were made available to AEA Energy & Environment by DTI this year providing high resolution maps of domestic gas use across Great Britain. This consisted of numbers of gas customers and amounts of gas use per 1km square for 2005, and data on electricity use, specifically type 2 meters (economy 7 type meters).

Data have also been calculated by BRE on behalf of Defra for this work. They have provided data on total energy use by dwelling type and by fuel type, and regional data on the numbers of households using different fuels (BRE 2006). Gas consumption accounts for 72% of domestic non-electricity energy use therefore the new high resolution gas data from DTI provides a huge improvement in understanding the spatial distribution of fuel consumption in Great Britain.

In summary the method calculated the amount of gas use in a 1km square compared to a theoretical gas consumption on the basis of complete gas coverage, i.e. every dwelling using the average gas demand for that dwelling type. The difference between the actual gas consumption and this theoretical amount was then calculated. The number of households represented by this residual energy demand was calculated and these households were apportioned to different fuels. This apportionment was based on Economy 7 electricity use, assumptions about fuel use within and outside smoke control areas and regional data from BRE on fuel usage by household type.

It has been assumed that:

- coal is burnt exclusively outside Smoke Control Areas,
- oil is burnt outside the biggest cities (of greater than 250,000 populations) but inside the smaller cities in grid squares where there is residual demand
- smokeless solid fuels (SSF, coke, anthracite) are burnt exclusively within smoke control areas.

Additionally, wood is assumed to have the same distribution as coal but has been excluded from Northern Ireland and peat has the same distribution as coal but is only burnt in Northern Ireland.

The new maps represent a significant improvement on the previous domestic maps because of new data sources and new modelling techniques. Initial validation of the results (see Annex 3) show a reasonable match between the model results and the BRE regional data. There are still some quite large differences but given the uncertainties in this work this is not surprising. Further validation of these results will be done as part of the continued development of these maps for the 2005 inventory. This will compare the results with other sources of survey data, for example the English house conditions survey.

*Northern Ireland*
The new DTI gas consumption data and BRE fuel use data do not cover Northern Ireland, therefore the distribution grids for Northern Ireland could not be updated in the same way as described in Annex 3. New data is being collected to update the maps in time for the 2005 NAEI inventory maps but the results will not be available for use in this work. Therefore the existing maps of domestic fuel use, carried out in 2003, will be used for Northern Ireland. The fuel use grids have been generated from a wide range of data sources including:

- Northern Ireland Housing Executive household data (from NIHE property database);
- Gas household data (from Phoenix Gas);
- Belfast household data (from fuel use survey undertaken by Belfast City Council);
- Other household data not covered by the above (from number of sources, including Housing Condition Survey (HCS) data).

Based on a bottom up approach, household fuel use figures have been derived from fuel use surveys and applied to data on household numbers and fuel use type from the NIHE database. Full details of this method for Northern Ireland are available in Pye and Vincent (2003).

New data from more recent local fuel surveys have been collated by AEA Energy & Environment. These, together with updates to the datasets listed above, will be used to generate new domestic fuel use distributions for the 2005 local $CO_2$ estimates.

**Other domestic emissions**

| | |
|---|---|
| Domestic Home And Garden Machinery | 0.05% |
| Domestic Household Products | 0.3% |

The NAEI source called Domestic house and garden machinery is also included in the domestic sector for the LA $CO_2$ estimates. Domestic household products includes emissions from the use of petroleum waxes and detergents. These emissions are distributed across the UK Local Authorities according to the population distribution in the 2001 Census.

## 3.4 Road transport

| | |
|---|---|
| Road Transport Petrol (Major roads) | 8% |
| Road Transport Petrol (Minor roads) | 4% |
| Road Transport Diesel (Major roads) | 8% |
| Road Transport Diesel (Minor roads) | 3% |
| Road Transport Other | 0.1% |

Road transport fuel use estimates for 2004 at Local Authority level were compiled this year by AEA Energy & Environment for DTI. The method used is the same as that for the 2003 estimates described in detail in Goodwin et al (2005a).

In summary, emissions on major roads are estimated using detailed vehicle specific traffic census data (annual average daily flows) for 2004 from the Department for Transport and Department for Regional Development in Northern Ireland. This census data is mapped on to Ordnance Survey and Ordnance Survey Northern Ireland detailed road maps. The density of census data in Northern Ireland is significantly lower than that for Great Britain which results in greater uncertainty in the emissions estimates for Northern Ireland. This could be improved in future by increasing the number of locations where traffic is counted.

Fuel use is calculated for each vehicle type on a road link basis using fleet weighted emission factors for each vehicle type and assumptions about speeds on each road type

and in various different parts of the country. Emissions on minor roads are calculated in a similar way but the traffic flow data is more generalised, with average flows applied to all roads of a particular type across each Government Office Region or Devolved Administration.

The LA level fuel use data have been used in this study to estimate road transport $CO_2$ emissions. Total petrol and diesel use in each LA were combined with the appropriate NAEI emission factors for $CO_2$.

One important comment on this dataset is that it represents all fuel use on UK roads by calculating fuel use from 'bottom up' estimates of vehicle kilometres using detailed traffic flow data and assumptions about vehicle fuel efficiency. There are therefore some differences between these estimates and the DTI fuel sales based estimates reported in the NAEI to the UNFCCC and the UNECE. It is thought that some of this difference is from fuel imported from Europe and Ireland but other elements in the estimation method may also contribute. The reported $CO_2$ 2004 emission from petrol and diesel used (based on DTI fuel sales data) in road transport is 119042kT. The additional emission resulting from the bottom up method based on vehicle kilometres and vehicle fuel consumption assumptions is 9484kT an addition of about 8%.

There are two other small sources of emissions from road traffic included in the inventory. These are combustion of waste lubricants and emissions from LPG vehicles. Both of these sources are distributed across LAs using estimates of total vehicle kilometres calculated from the NAEI maps of traffic flows.

## 3.5 Diesel rail transport

| | |
|---|---|
| Diesel Railways | 0.5% |

It is not possible to separate electricity consumed by the railways from that consumed by other commercial and industrial activities in the DTI dataset. Therefore it is not possible to report all rail emissions as a separate sub-sector within the transport sector. Instead both diesel and electric emissions from the rail sector are included in the commercial and industrial sector, and within this only diesel emissions can be shown as a separate sector.

The UK total diesel rail emissions are compiled from three journey types: freight, intercity and regional. Emissions are calculated based on fuel use reported in DUKES. Rail emissions for locomotive diesel are distributed across Great Britain using maps of rail links and details of the number of vehicle kilometres by the three journey types on each rail link. Emissions are distributed across the rail network by assigning an appropriate emission from journey type to each rail link. The emissions along each rail link are assumed to be uniformly along the length of the rail link, as no information on load variations is yet available. The map for Great Britain was compiled in 2000.

The 2003 $CO_2$ estimates included an assumption that all rail $CO_2$ emissions were in Great Britain because data were not available for Northern Ireland. However for the 2004 dataset the NI emissions are now separated and LA estimates for Northern Ireland are included. Rail emissions for locomotive diesel are distributed across Northern Ireland using data from Translink (Smyth 2006) on amounts of fuel used on different sections of track aggregated to Local Authority. These data are for passenger trains only as there is no freight activity in Northern Ireland. The $CO_2$ emission for railways across the UK for 2004 is 2500kT, of which 1.3% or 33kt $CO_2$ are in Northern Ireland (NAEI 2006). This emission has been distributed across the Northern Ireland LAs in proportion to the amount of fuel use reported by Translink for each Local Authority.

## 3.6 Other Industrial and Commercial emissions

| | |
|---|---|
| Industry and Commercial Oil | 6% |
| Industry and Commercial Solid Fuel | 3% |
| Industry and Commercial Wastes And Biomass | 0.5% |
| Industry Process Gases | 3% |
| Industry Non Fuel | 1% |

The industrial sectors in the NAEI are mapped using a combination of site specific (point source) estimates of emissions and area source employment based distributions. For some sectors the site specific emissions totals are equal to the NAEI emissions estimate for that sector. In other cases there are other sources that are not included within the site specific dataset. The remaining emission is then treated as an 'area source' and distributed across the UK using detailed employment and fuel use data. Small industrial combustion is an example of a sector for which the area source distribution is particularly important. The commercial and public service sectors of the NAEI inventory are entirely mapped as area sources.

**Site Specific Emissions**

The site specific data have been compiled from a number of sources:

- Environment Agency Pollution Inventory;
- EU Emissions Trading Scheme Installations that reported emissions to the Environment Agency for 2005;
- SEPA European Pollutant Emission Register;
- Northern Ireland Inventory of Statutory Releases;
- The UK's National Allocation Plan for the EU carbon emission trading scheme;
- And other information obtained from AEA Energy & Environment's industry contacts.

Site specific fuel and $CO_2$ emissions estimates have been made for the following sectors:

- Power stations;
- Other plant regulated as combustion processes under Integrated Pollution Control (IPC);
- Refineries;
- Integrated steelworks;
- Coke ovens;
- Cement clinker manufacture;
- Lime manufacture;
- Other plant regulated under IPC;
- Other sites for which ETS annual emissions data for 2005 were available.

The methodology used to calculate the emissions at point sources is described in Annex 2. The data presented in this report are not fully consistent with the UK Greenhouse Gas Inventory (including the Devolved Administration GHGI) because of the use of emissions data reported by operators and also the ETS dataset. This has provided better information on the fuels used at industrial and commercial sites but the total fuel use across the UK is therefore different from that reported in DUKES. Annex 2 includes details of where these differences are most significant.

For the purposes of reporting emissions by fuel type a simplified classification of fuel types has been used. This is shown in Table 6.

**Table 8** Fuel categories for reporting emissions

| Fuel Name | Fuel Category | Fuel Name | Fuel Category |
|---|---|---|---|
| Colliery methane | Natural gas | Anthracite | Solid fuels |
| Natural gas | Natural gas | Coal | Solid fuels |
| Burning oil | Oils | Coke | Solid fuels |
| DERV | Oils | Petroleum coke | Solid fuels |
| Fuel oil | Oils | SSF | Solid fuels |
| Gas oil | Oils | Landfill gas | Wastes and biofuels |
| LPG | Oils | Sewage gas | Wastes and biofuels |
| Naphtha | Oils | Wood | Wastes and biofuels |
| OPG | Oils | MSW | Wastes and biofuels |
| Orimulsion | Oils | Scrap tyres | Wastes and biofuels |
| Petrol | Oils | Waste oils | Wastes and biofuels |
| Lubricants | Oils | Clinical waste | Wastes and biofuels |
| Blast furnace gas | Process gases | Waste solvent | Wastes and biofuels |
| Coke oven gas | Process gases | Benzole & tars | Wastes and biofuels |
| Sour gas | Process gases | | |

**Employment based distributions for mapping area sources**

To develop emissions distribution maps for the small industrial combustion, public services, commercial and agriculture (stationary combustion) sectors the following data sets are used:

- Office of National Statistics Inter-Departmental Business Register (IDBR) 2005 which provides data on employment at business unit level by Standard Industrial Classification (SIC) code; and
- DTI Energy Consumption in the UK data on industrial and commercial sector fuel usage for 2002. (DTI, undated report, Tables 4.6, 5.2 and 5.5)

The SIC codes in the IDBR database were matched with the DTI energy datasets in order to calculate total employment by DTI energy sector. From this a fuel intensity per employee was calculated. These intensities could then be applied to employment distributions across the UK to make maps of fuel use.

In the case of the industrial sectors this energy intensity calculation was done at the level of 4 figure SIC codes (over 250 separate industry types) to retain the level of detail required for the mapping. Any aggregation of SIC codes would have resulted in a reduction in the quality of the final distribution. The DTI fuel data was reported for coal, manufactured fuel (SSF), LPG, gas oil, fuel oil and natural gas. These were aggregated to calculate industry specific fuel intensities for Coal, SSF, Oil and Gas.

In the case of the commercial and public service sectors the employment data was aggregated to be equivalent to the energy data provided by DTI. These sectors are shown in Table 7. There was not sufficient data to be able to calculate a fuel specific fuel intensity factor for these sectors. Therefore a total fossil fuel intensity factor was calculated.

**Table 9** Service sector energy consumption sub-sectors and NAEI sectors

| Service sector energy consumption sub sectors | NAEI emissions sector |
|---|---|
| Commercial Offices | Commercial |
| Communication and Transport | Commercial |
| Hotel and Catering | Commercial |
| Other | Commercial |
| Retail | Commercial |
| Sport and Leisure | Commercial |
| Warehouses | Commercial |
| Education | Public admin and services |
| Government | Public admin and services |
| Health | Public admin and services |

The IDBR employment data at local unit level were aggregated to 4 figure SIC codes at 1km resolution using grid references provided as part of the database. The employment totals for each sector were then multiplied by the appropriate fuel intensity values to make fuel use distributions across the UK. These were then used to distribute $CO_2$ emissions for the relevant sector from the NAEI for 2004. It has been assumed that fuel intensity for each sector is even across the sector. This is a simplification of reality but necessary because of lack of more detailed estimates of fuel use.

As a result of the lack of detailed information about the fuel types used by the commercial and service sectors, a simple assumption was used to decide where the different fuels were used. Gas is assumed to be used in urban areas where there is a gas supply (based on postcode sector level data from National Grid Transco and a percentage continuous urban land cover at 1km resolution of greater than 10%). For all other areas a mix of fuels is assumed according to the national mix of fuel used in the relevant service sector using data from the NAEI derived from DUKES.

| | |
|---|---|
| Industry Off-Road Machinery | 1% |

### Industrial off-road emissions

For some sectors a simple map of employment has been used instead of fuel use. These are mostly for sectors where process emissions are important but also for estimating the distribution of industrial off-road emissions. These have been mapped using a distribution of employment in heavy industries.

| | |
|---|---|
| Agriculture Oil | 0.7% |
| Agriculture Solid Fuel | 0.004% |
| Agriculture Non Fuel | 0.007% |

### Agriculture

Agriculture fuel use (not including gas) is mapped using employment distributions as described in the section above.

Agriculture off-road emissions are distributed using a combination of arable, pasture and forestry land use data. Each of these land cover classes was weighted according to the off-road machinery activity on each land use. This used data on the number of hours of use of tractors and other machinery on these land use types, sourced by AEA Energy & Environment for improving the UK inventory in this sector.

The agriculture non-fuel sector consists of $CO_2$ emissions from the breakdown in the atmosphere of pesticides applied to crops. These are distributed using a map of arable land cover as a surrogate for this activity.

## 3.7 Land Use and Land Use Change and Forestry Emissions

| | |
|---|---|
| LULUCF Emissions: Agricultural Soils And Deforestation | 0.2% |
| LULUCF Emissions: Other | 4% |
| LULUCF Removals | -5% |

Land Use Land Use Change and Forestry (LULUCF) activities produce as well as remove atmospheric $CO_2$. Generally emissions are produced from soils and liming of soils and are removed through forest growth. Currently in the UK, LULUCF activities are a net removal of emissions from the atmosphere.

The Centre for Ecology and Hydrology (CEH) in Edinburgh annually prepares estimates of the uptake (removal from atmosphere) of carbon dioxide by afforestation and net loss or gain of carbon dioxide from soils (emissions to or removals from the atmosphere) for inclusion in the UK GHG Inventory. These emissions are classified as the LULUCF Sector for inclusion in the UK GHG Inventory (CEH 2006). The LULUCF Sector is different from other sectors in the Greenhouse Gas Inventory in that it contains both sources and sinks of greenhouse gases. The sources, or emissions to the atmosphere, are given as positive values; the sinks, or removals from the atmosphere, are given as negative values.

The estimates are reported according to the new NFR (the UNECE Nomenclature For Reporting) classification of sources and removals. Figures for 2004 are shown in Table 10. The emissions are also divided into the categories used for reporting these emissions in the dataset of Local Authority $CO_2$ estimates. For the 2003 dataset the emissions from agricultural soils and deforestation were included in the Industrial and Commercial sector and the LULUCF sector for 2003 only included the “Emissions: other” category and no removals. Emissions from agricultural soils and deforestation have been included in LULUCF this year and removals have also been distributed across Local Authorities.

The data for 2004 from CEH provides greater disaggregation of the sectors than has been reported by the NAEI for 2004, dividing each LULUCF sector into emissions and removals instead of reporting a net emission for each. This results in larger emissions and removals totals but the same net emission as reported by the NAEI.

The methodology for distributing the 2003 emissions across Local Authorities was however very different - simply using land use rather than matrices of land use change. The estimates for 2004 were made using dynamic models of change in stored carbon driven by land use change data. For forestry, the model deals primarily with plant carbon and is driven by the area of land newly afforested each year. Changes in soil carbon are driven by estimated time series of land use transitions between semi-natural, cultivated (farm), woodland and urban. The models, and those for other LULUCF activities, are run for each of the four devolved administrative regions of the UK. Until now no data has been reported in map format at a scale below the devolved administrations (England, Scotland, Wales and Northern Ireland); here we report results from preliminary methods to provide estimates of LULUCF emissions and removals at the scale of Local Authority within the UK.

**Table 10** Emissions of CO2 from Land Use Change and Forestry (kT CO2)

| | | LA $CO_2$ Categories | | |
|---|---|---|---|---|
| NFR Code | Description | LULUCF Emissions: Agricultural Soils And Deforestation | LULUCF Emissions: Other | LULUCF Removals |
| 5A1 | Forest Land remaining Forest Land | | | |
| 5A2 | Land converted to Forest Land | | | -16302 |
| 5B1 | Cropland remaining Cropland (Yield improvement) | | | -640 |
| 5B1 | Cropland remaining Cropland (lowland drainage) | | 1195 | |
| 5B | Liming of Cropland | 496 | | |
| 5B2 | Land converted to Cropland (non-forest biomass) | | 244 | |
| 5B2 | Land converted to Cropland (soil) | | 14035 | |
| 5C1 | Grassland remaining Grassland (Peat extraction) | | 355 | |
| 5C | Liming of Grassland | 319 | | |
| 5C2 | Land converted to Grassland (non-forest biomass) | | | -198 |
| 5C2 | Land converted to Grassland (deforestation to grass) | 130 | | |
| 5C2 | Land converted to Grassland (soil) | | | -8441 |
| 5D1 | Wetlands remaining Wetlands | | | |
| 5D2 | Land converted to Wetlands | | | |
| 5E1 | Settlements remaining Settlements | | | |
| 5E2 | Land converted to Settlements (non-forest biomass) | | | -51 |
| 5E | Land converted to Settlements (deforestation to settlements) | 53 | | |
| 5E2 | Land converted to Settlements (soil) | | 6245 | |
| 5F1 | Other Land remaining Other Land | | | |
| 5F2 | Land converted to Other Land | | | |
| 5G | Harvested Wood Products * | | 619 | |
| | Total | 998 | 22693 | -25632 |

* not included in the LA estimates because of insufficient data for distributing the emissions

Full details of the methodology used by CEH to estimate emissions and removals by Local Authority for 2004 is given in Annex 4.

## 3.8 Aggregation of emissions to Local Authority level

The calculations of emissions from electricity use, gas use and road transport for this report were done at the Local Authority level using data provided at this level by DTI and required no further aggregation. The LULUCF data was provided by CEH at Local Authority Level.

The calculations of emissions for all other sectors has been done by using the NAEI 1km resolution maps and point sources at known locations. A map of Local Authorities boundaries has been used to assign each point or 1km square of the NAEI maps to a Local Authority. The 1km emission maps could then be aggregated up to Local Authority level.

# 4 Results

The results of this work are presented at a variety of levels of detail. Table 12 below shows regional totals for the detailed sectors and fuels. Local Authority level detailed data are available in the spreadsheet that accompanies this report. The spreadsheet contains a detailed breakdown of emissions by sector and fuel together with population counts and per capita emissions.

## 4.1 Uses and limitations of the data

This data is compiled using national spatial data and attempts to locate emissions where they occur. The data do not estimate emissions resulting from the production or transportation of materials or consumables unless the production or transportation occurs with in the defined area boundary. Emissions for transport are for traffic activities within the Region or Local Authority and do not include residents activities outside the boundary. Only very limited local knowledge or data has been used due to the resource limitations of this project. Therefore, there are a number of sectors that have a high level of uncertainty in the data. These sectors include the combustion of coal and liquid fuels in small industry/commercial/public service and to a lesser extent in the domestic sector. This is because there is very limited knowledge of the distributions of coal and liquid fuel use. This work does not take into account localised renewable consumption or energy efficiency through the use of CHP and does not attempt to correct or fill gaps in the DTI electricity use or gas use datasets.

If used as indicators (e.g. by dividing the total or sub totals by the population or GDP) some misleading results can occur due to the over simplification of the emissions allocations and the lack of local knowledge. Useful comparisons can be made for the road transport data and the electricity and gas consumption data. However, the user should be aware that even these datasets have limitations and excluded components that may result in only partial representation of a Local Authority or Region.

In most cases emissions will include elements that are outside of a Region or Local Authorities control (e.g. traffic from outside the region). However, a Region or Local Authority can be influential in improving many sources that are not within their direct control (e.g. encouragement of energy efficiency and renewable measures in planning developments, parking/travel incentives for cleaner vehicles using the area).

These estimates can be used as indicative estimates to raise awareness about emissions and emission reduction potential, or as a starting point for a more detailed and rigorous Local Inventory. However, these estimates should not be used for detailed benchmarking or target setting with out checking against local data for the main source categories. Examples of the uses made of the 2003 dataset are given in Annex 1.

Some additional classifications of Local Authorities have been included in the results spreadsheet. The Defra Classification of Local Authority Districts and Unitary Authorities in England has been included in order to identify the level of rurality within these administrative areas. A similar classification is not available for Wales, Scotland or Northern Ireland. The NUTS 3 Area codes and names have also been included in order that the data can easily be aggregated up to these areas. NUTS3 codes and names have not been included for Scotland because the Local Authorities in Scotland do not exactly match with the NUTS classification in Scotland.

Figure 4 below shows total $CO_2$ emissions per capita by Local Authority. This highlights those LAs that have significant industrial emissions particularly where population numbers are low. Further maps are provided in on the pages following Table 12.

## 4.2 Uncertainty ratings

Ratings of the confidence that data users can have in the estimates have been assigned to each of the detailed sectors in the results spreadsheet. These are assigned on the basis of expert judgement taking account of the data sources used to make the estimates.

The following were used as definitions of the ratings:

1 High quality estimate based on real emissions or activity data at known locations
2 Good quality estimate based on mostly real emissions or activity data at known locations and some modelled emissions
3 Medium quality estimate based on mostly modelled emissions using appropriate surrogate statistics
4 Low quality estimate based on surrogate statistics which may not be fully appropriate for this sector

**Table 11** Uncertainty ratings for Local $CO_2$ sectors

| Sector | Uncertainty rating | Comment | % UK emission |
|---|---|---|---|
| Industrial, Commercial and Agriculture Electricity | 2 | The DTI dataset of electricity consumption has some unallocated consumption. NI data are distributed using employment. | 19% |
| Industrial, Commercial and Agriculture Gas | 2 | The quality of the DTI dataset of gas consumption is limited by some poor geo-referencing of meter points to local authorities. Also, the DTI definition of domestic gas consumers includes some small commercial users. | 11% |
| Industrial Gas (Large Users) | 1 | Reported emissions from EA PI, SEPA, DoE NI | 1.1% |
| Industry and Commercial Oil | 2 | A combination of known emissions from PI, SEPA, DoE NI (>60% of UK total) and modelled estimates using fuel and employment distributions | 6% |
| Industry and Commercial Solid Fuel | 2 | A combination of known emissions from PI, SEPA, DoE NI (>70% of UK total) and modelled estimates using fuel and employment distributions | 3% |
| Industry and Commercial Wastes And Biomass | 1 | Almost entirely (>90% of UK total) consisting of known emissions from PI, SEPA, DoE NI. The remaining emissions are modelled estimates using fuel and employment distributions | 0.5% |
| Industry Process Gases | 2 | A combination of known emissions from PI, SEPA, DoE NI (>60% of UK total) and modelled estimates using fuel and employment distributions | 3% |
| Industry Non Fuel | 1 | Almost entirely (>90% of UK total) consisting of known emissions from PI, SEPA, DoE NI. The remaining emissions are modelled estimates using fuel and employment distributions | 1% |
| Industry Off-Road Machinery | 4 | This sector is poorly characterised because little is known about the spatial distributions of these machines. | 1% |
| Agriculture Oil | 4 | Modelled estimates using fuel and employment distributions for stationary combustion; landuse data used to distribute machinery emissions. | 0.7% |
| Agriculture Solid Fuel | 3 | Modelled estimates using fuel and employment distributions | 0.004% |
| Agriculture Non Fuel | 4 | Land use maps are used to distrbute the application of pesticides. | 0.007% |
| Railways | 4 | old dataset of rail movements for GB. Better for NI. | 0.5% |
| Domestic Electricity | 2 | The DTI dataset of electricity consumption has some unallocated consumption. NI data are distributed using employment. | 12% |
| Domestic Gas | 2 | The quality of the DTI dataset of gas consumption is limited by some poor geo-referencing of meter points to local authorities. Also, the DTI definition of domestic gas consumers includes some small commercial users. | 15% |
| Domestic Oil | 3 | Estimates made using complex modelling of household energy demand compared with known gas usage | 2% |
| Domestic Solid Fuel | 3 | Estimates made using complex modelling of household energy demand compared with known gas usage | 1% |
| Domestic Home And Garden Machinery | 3 | Based on population distribution | 0.05% |
| Domestic Household Products | 3 | Based on population distribution | 0.3% |
| Road Transport Petrol (Major roads) | 2 | Activity data are good quality annual average traffic count points. Emissions calculated using complex modelling of fleet mix and average speeds on different roads. | 8% |
| Road Transport Petrol (Minor roads) | 3 | Activity data are calculated from regional average traffic flows and vehicle splits. Emissions calculated using complex modelling of fleet mix and average speeds on different roads. | 4% |
| Road Transport Diesel (Major roads) | 2 | Activity data are good quality annual average traffic count points. Emissions calculated using complex modelling of fleet mix and average speeds on different roads. | 8% |
| Road Transport Diesel (Minor roads) | 3 | Activity data are calculated from regional average traffic flows and vehicle splits. Emissions calculated using complex modelling of fleet mix and average speeds on different roads. | 3% |
| Road Transport Other | 4 | Locations of LPG use and burning of engine oil are not known and are therefore ditributed across all road traffic activity. | 0.1% |
| LULUCF Emissions: Agricultural Soils And Deforestation | 3 | Modelled estimates based on land use change matrices | 0.2% |
| LULUCF Emissions: Other | 3 | Modelled estimates based on land use change matrices | 4% |
| LULUCF Removals | 3 | Modelled estimates based on land use change matrices | -5% |

**Figure 4** Domestic $CO_2$ emissions by Local Authority per capita in 2004 (in kT $CO_2$)

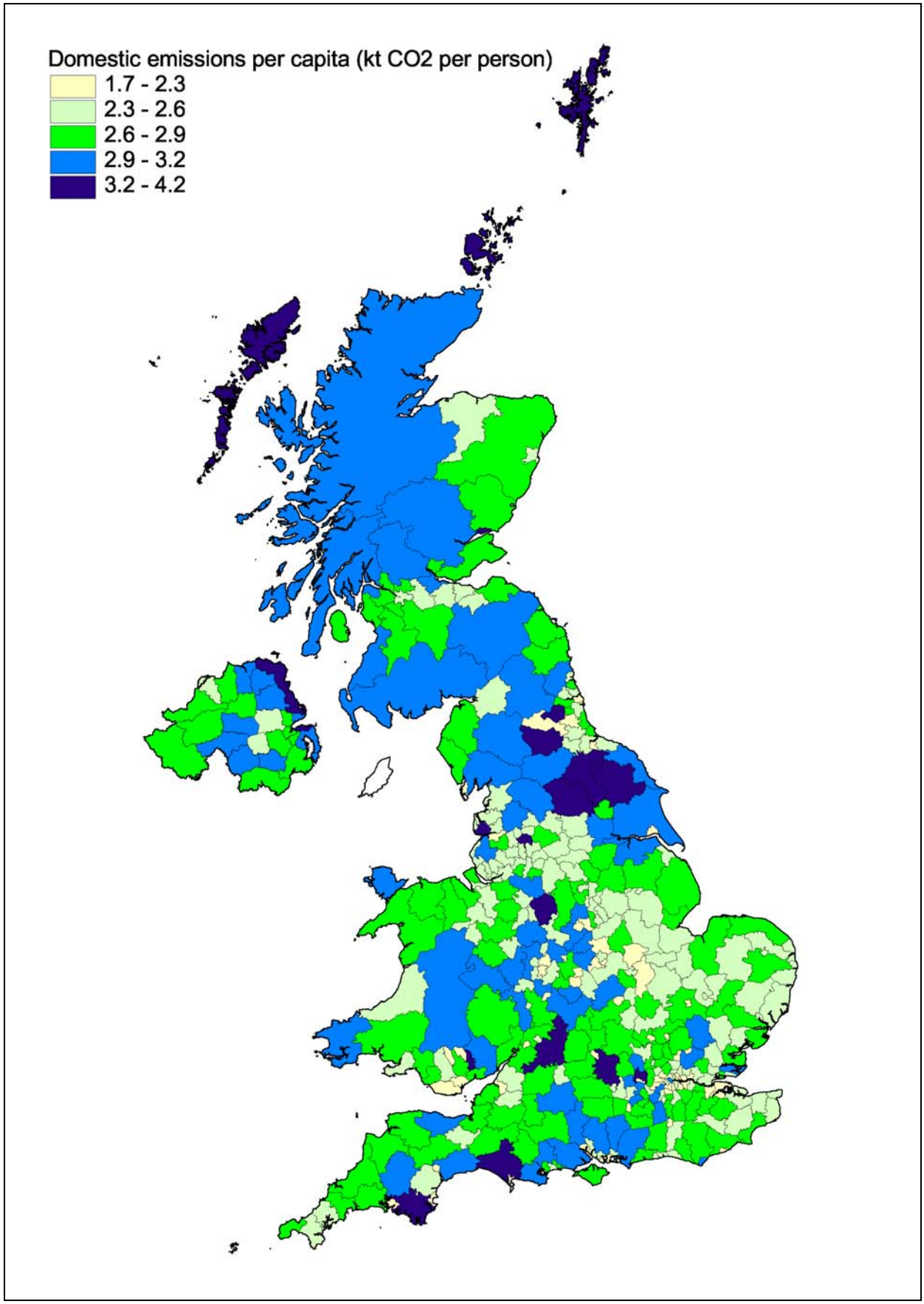


**Table 12** Detailed results for Government Office Regions (kT $CO_2$)

| NUTS4 Area and Government Office Region or Devolved Administration | Wales (1) | Scotland (1) | North East | North West | Yorkshire and the Humber | East Midlands | West Midlands | East of England | Greater London | South East | South West | Northern Ireland (1) | Unallocated Consumption | Large Elec Users (2) | UK Total (1) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Industrial Electricity | 5722 | 9381 | 4241 | 10909 | 8264 | 8183 | 8676 | 8286 | 14017 | 12365 | 7923 | 2593 | 2338 | 3860 | 106759 |
| Industrial Gas | 4152 | 5210 | 2584 | 7628 | 6627 | 4154 | 5443 | 4305 | 6417 | 6258 | 3337 | 102 | 180 | | 56397 |
| Industrial Gas (Exclusions) | | 1151 | 1279 | 2128 | 685 | | | | | | 718 | 63 | | | 6025 |
| Industry Commercial Oil | 2681 | 5088 | 2201 | 4186 | 5053 | 1146 | 1040 | 3313 | 468 | 5065 | 1343 | 760 | | | 32345 |
| Industry Commercial Solid Fuel | 1744 | 1452 | 4260 | 784 | 1521 | 1758 | 1167 | 697 | 17 | 1114 | 628 | 443 | | | 15585 |
| Industry Commercial Wastes And Biomass | 37 | 492 | 61 | 197 | 514 | 67 | 106 | 119 | 25 | 197 | 40 | 11 | | | 1865 |
| Industry Process Gases | 2026 | 169 | 5447 | 259 | 6351 | 655 | 1156 | 144 | 49 | 114 | 240 | 22 | | | 16634 |
| Industry Non Fuel | 720 | 505 | 568 | 1029 | 607 | 1409 | 380 | 273 | | 1437 | 353 | 182 | | | 7462 |
| Industry Off-Road Machinery | 456 | 625 | 376 | 1010 | 805 | 816 | 1023 | 702 | 347 | 832 | 668 | 237 | | | 7896 |
| Agriculture Oil | 504 | 737 | 142 | 323 | 232 | 250 | 298 | 202 | 9 | 329 | 645 | 457 | | | 4127 |
| Agriculture Solid | 2 | 3 | 0 | 2 | 2 | 2 | 2 | 2 | 0 | 2 | 3 | 2 | | | 21 |
| Agriculture Non fuel | 1 | 5 | 1 | 1 | 4 | 6 | 3 | 8 | 0 | 4 | 5 | 1 | | | 38 |
| Railways | 159 | 262 | 92 | 229 | 265 | 251 | 243 | 160 | 101 | 347 | 358 | 33 | | | 2500 |
| Domestic Electricity | 2922 | 6425 | 2388 | 6947 | 5091 | 4578 | 5613 | 6399 | 7040 | 9053 | 6008 | 1630 | 62 | | 64158 |
| Domestic Gas | 3554 | 6032 | 3612 | 9480 | 6784 | 5458 | 6806 | 6345 | 9782 | 10180 | 5001 | 153 | | | 73186 |
| Domestic Oil | 705 | 650 | 105 | 421 | 150 | 332 | 407 | 883 | 32 | 1320 | 1621 | 2089 | | | 8713 |
| Domestic Solid Fuel | 581 | 1001 | 252 | 339 | 1157 | 224 | 411 | 134 | 23 | 438 | 244 | 941 | | | 5745 |
| Domestic Home And Garden Machinery | 12 | 22 | 11 | 29 | 21 | 18 | 23 | 23 | 31 | 34 | 21 | 7 | | | 252 |
| Domestic Household Products | 72 | 127 | 63 | 169 | 124 | 105 | 132 | 135 | 181 | 200 | 123 | 42 | | | 1474 |
| Road Transport Petrol (Major roads) | 2364 | 3763 | 1469 | 4922 | 3399 | 3611 | 3905 | 4423 | 2994 | 7467 | 4053 | 1358 | | | 43728 |
| Road Transport Petrol (Minor roads) | 953 | 1596 | 1038 | 2401 | 1985 | 1458 | 2143 | 2310 | 2770 | 3220 | 1920 | 1066 | | | 22860 |
| Road Transport Diesel (Major roads) | 2139 | 3944 | 1369 | 5372 | 4310 | 4613 | 4645 | 5015 | 2545 | 6877 | 3905 | 1071 | | | 45802 |
| Road Transport Diesel (Minor roads) | 723 | 1289 | 765 | 1658 | 1423 | 1076 | 1498 | 1609 | 1958 | 1998 | 1336 | 802 | | | 16135 |
| Road Transport Other | 27 | 44 | 21 | 60 | 44 | 42 | 51 | 56 | 46 | 88 | 49 | 20 | | | 548 |
| LULUCF Emissions: Agricultural Soils And Deforestation | 64 | 202 | 36 | 46 | 78 | 97 | 71 | 127 | 2 | 106 | 128 | 42 | | | 998 |
| LULUCF Emissions: Other | 1731 | 8263 | 595 | 921 | 1033 | 1299 | 1096 | 1734 | 129 | 1334 | 2125 | 1816 | 619 | | 22693 |
| LULUCF Removals | -2227 | -13329 | -810 | -629 | -809 | -764 | -802 | -960 | -79 | -1611 | -1513 | -2099 | | | -25632 |
| Total | 31823 | 45107 | 32166 | 60820 | 55723 | 40841 | 45536 | 46444 | 48903 | 68768 | 41282 | 13842 | 3199 | 3860 | 538315 |

Notes: (1) The UK, Wales, Scotland and Northern Ireland totals shown here differ from the totals published in the national inventory reports because some national emissions cannot be assigned to local areas and because of the different methods used to calculate industrial emissions. See Section 5.1 of main report for details.
(2) High voltage large electricity users.

The maps on the following pages display emissions that are normalised by area in order to make comparisons between local authorities more meaningful – showing emission intensity rather than a total emission.

**Figure 5** Domestic $CO_2$ emissions by Local Authority for 2004

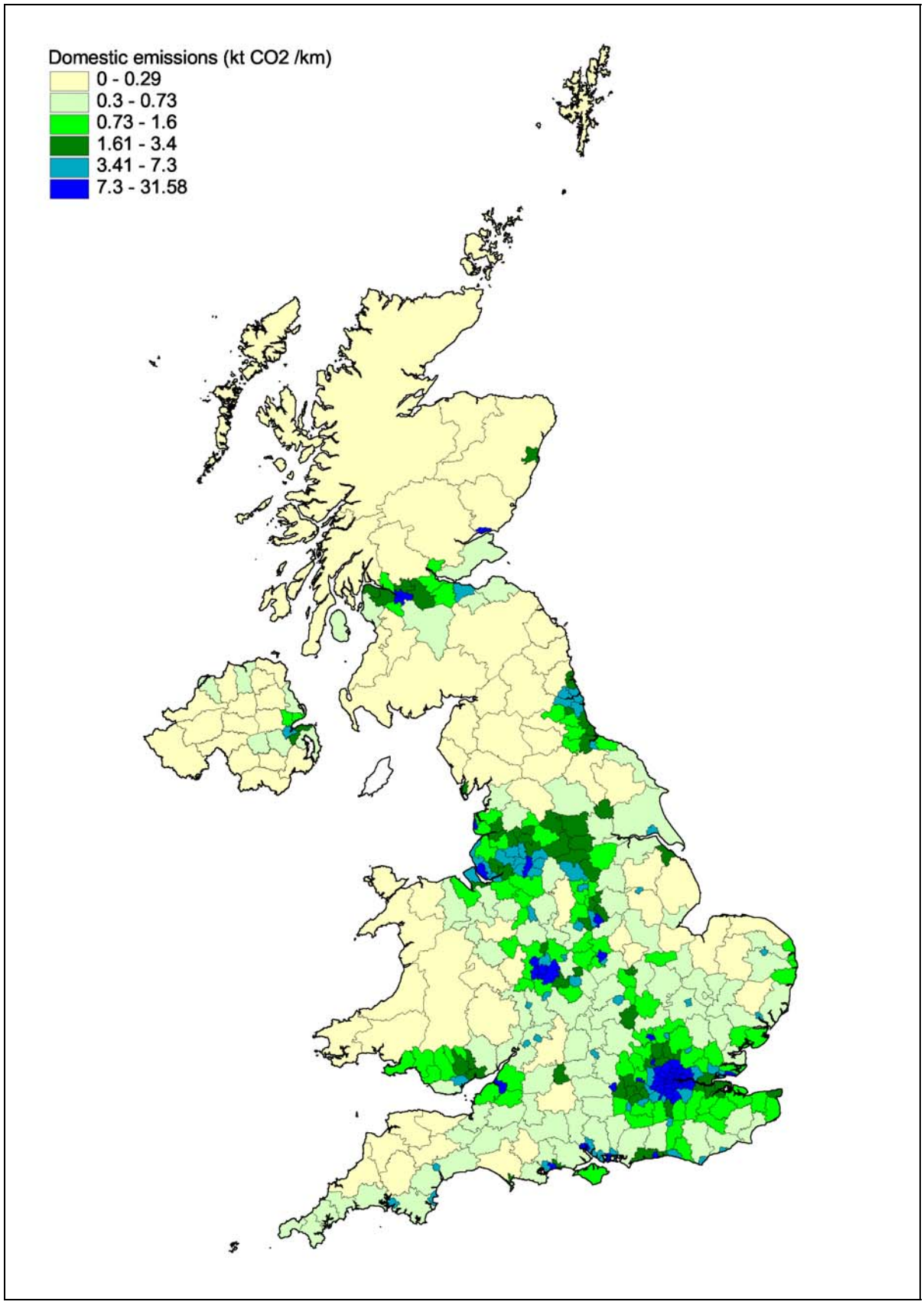


**Figure 6** Industry $CO_2$ emissions by Local Authority for 2004

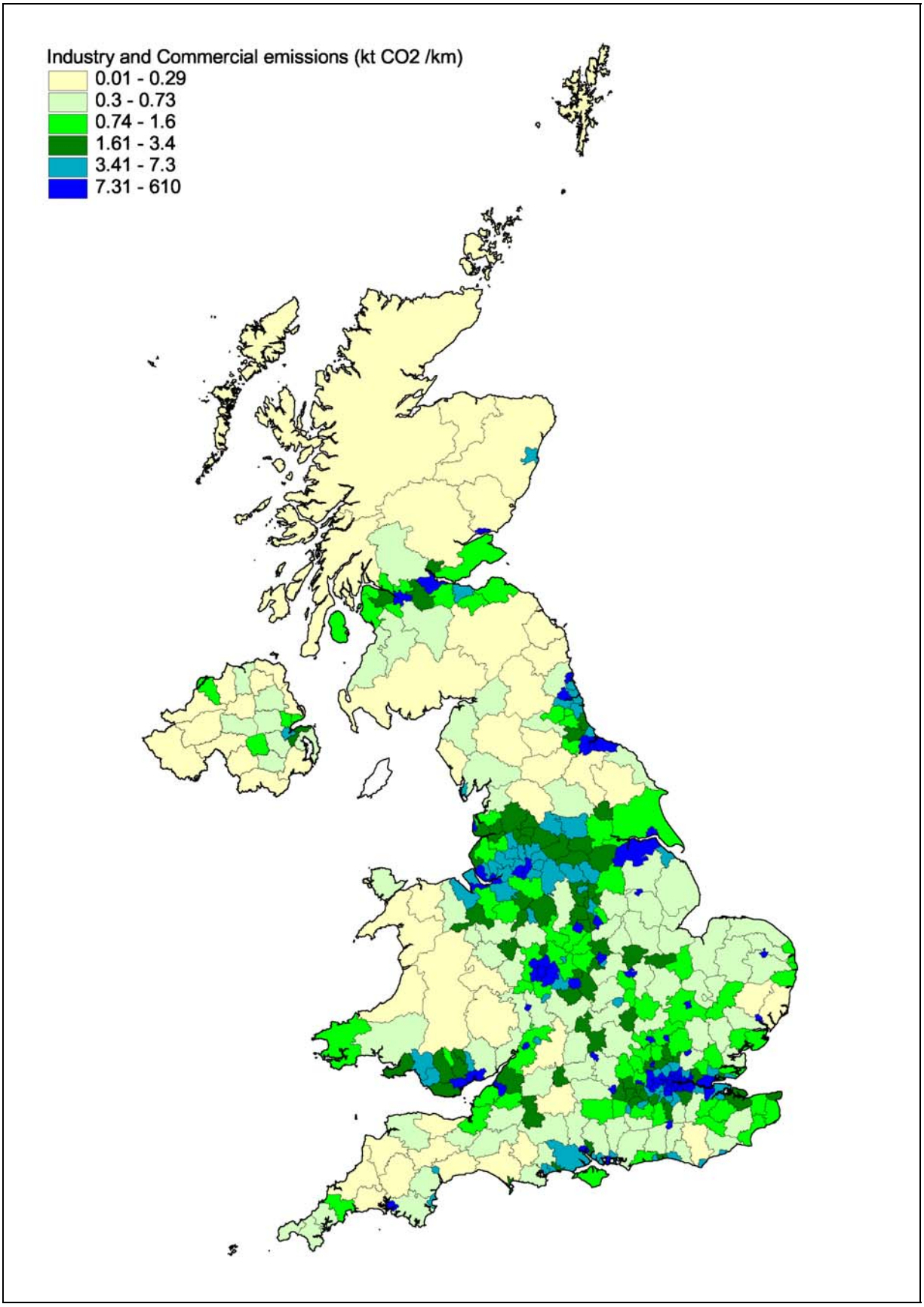


**Figure 7** Road Transport $CO_2$ emissions by Local Authority for 2004

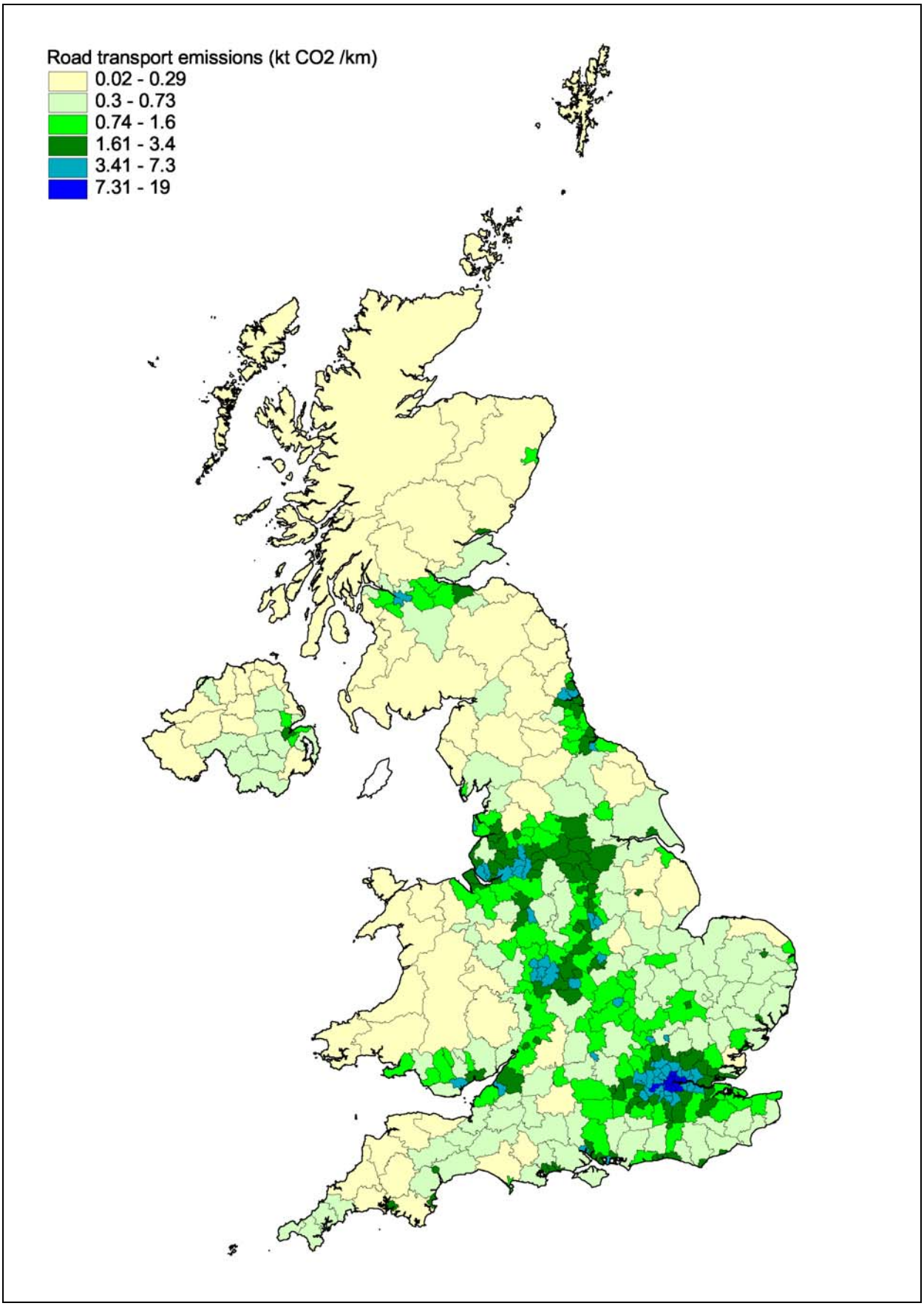
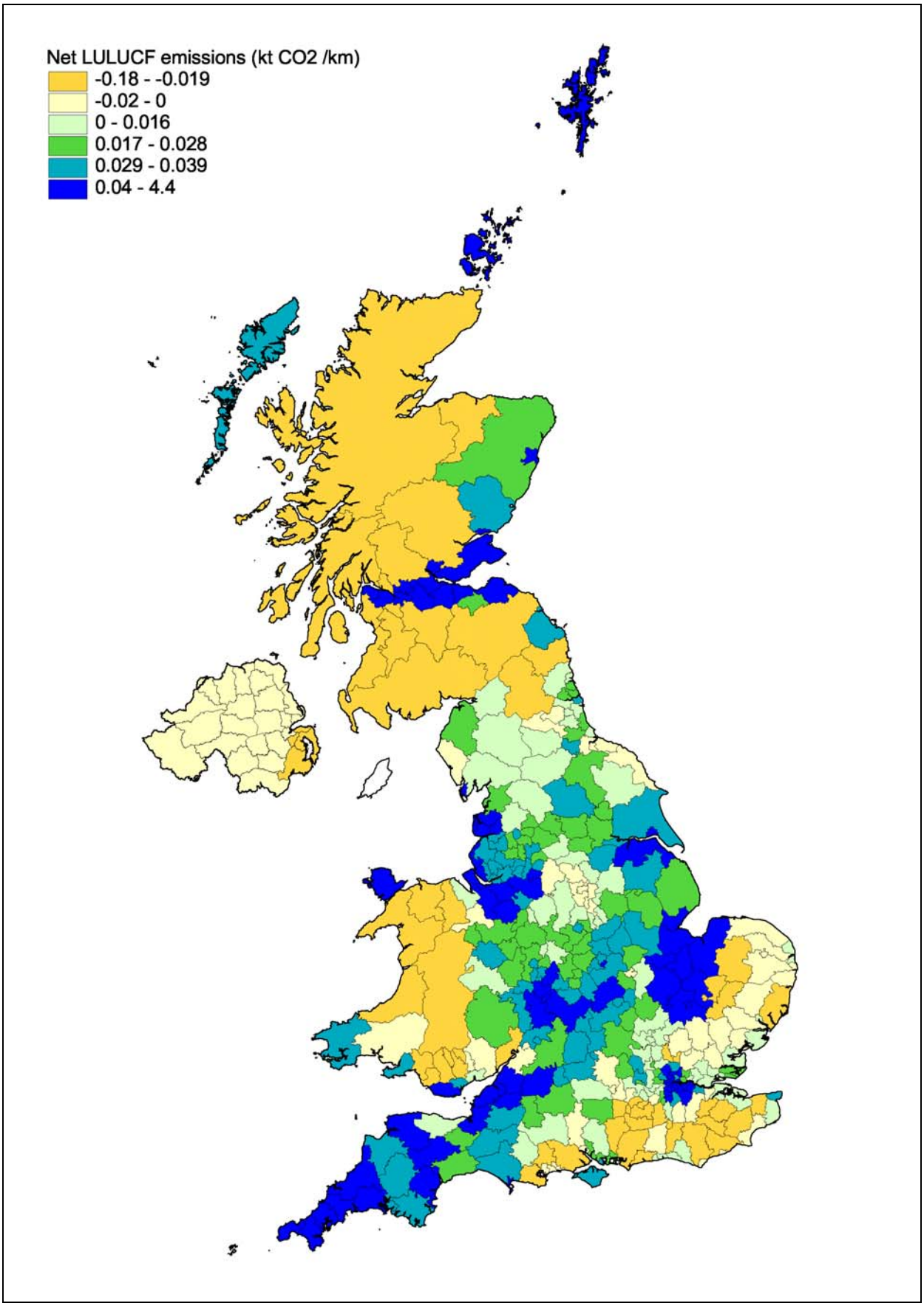


**Figure 8** Net Land use change $CO_2$ emissions by Local Authority for 2004



## 4.3 Reconciliation with NAEI totals

Table 13 provides a comparison between the total emissions provided in this report and the UK $CO_2$ inventory in National Communication Format.

The key points to note from this comparison are as follows (related to the numbered notes in the table:

1. The LA $CO_2$ industrial and commercial sector includes the points source emissions calculated using the Pollution Inventory, SEPA and DoE NI reported emissions combined with ETS data. There are significant differences between the mapped emissions for some sectors compared with the NAEI inventory for 2004. These differences are in the Business sector and industrial process rows (see Annex 2 for a full explanation). In particular the other industrial combustion sector is too high.
2. Energy supply emissions have been redistributed across domestic and industrial and commercial users of electricity. The Offshore Oil and Gas sector is not included in the Local $CO_2$ estimates.
3. Reported emissions for sinter plant and iron and steel flaring are lower than NAEI estimates.
4. There is a 1kT rounding error in the domestic emissions reported here.
5. The transport sectors not included in the Local $CO_2$ estimates are aviation and shipping emissions including military emissions in these sectors.
6. The road transport emissions in this table are 9483 kT $CO_2$ higher than the NAEI emissions calculated from DTI fuel sales data. The emissions reported in this dataset are from detailed vehicle kilometre data (it is thought that some of this difference is from imported fuels in vehicle tanks).
7. The transport emissions that are shown in the Industry and Commercial column relate to airport support vehicles and the rail sector. These are 4kT lower than reported in the NAEI because the railways stationary combustion emissions are included in "other industrial combustion" in the Business line.

**Table 13** Emissions reconciled with the UK for 2004 (kt $CO_2$)

| | | **Local CO2 Category** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **National Communication Format Category** | NAEI $CO_2$ total | Domestic | Industry and Commercial | Transport | LULUCF | Total | NAEI Sectors not included in Local $CO_2$ estimates | Other amounts to reconcile local CO2 with NAEI | Notes |
| Total NC Format | 559044 | | | | | | | | |
| Agriculture | 4622 | | 4622 | | | 4622 | | | |
| Business | 98466 | | 99586 | | | 99586 | | -1121 | 1 |
| Energy Supply | 212565 | 64158 | 127594 | | | 191752 | 20813 | | 2 |
| Industrial Process | 13430 | | 11793 | | | 11793 | | 1637 | 3 |
| Land Use Change: NET Emission | -1942 | | | | -1942 | -1942 | | | |
| Public | 10650 | | 10650 | | | 10650 | | | |
| Residential | 89370 | 89369 | | | | 89369 | | 1 | 4 |
| Transport | 131433 | | 2959 | 129074 | | 132033 | 8880 | -9479 | 5,6,7 |
| Waste Management | 452 | | 452 | | | 452 | | | |
| Local CO2 totals | | 153527 | 257656 | 129074 | -1942 | 538315 | | | |

# 5 Changes compared with the 2003 estimates

Changes in methodology in the 2004 estimates compared with 2004 can be divided into two categories: changes in the estimates of the national totals for the 2004 inventory and changes in the way the NAEI sectors have been mapped across the Local Authorities. These changes are shown in Table 14 overleaf and explained below.

Changes in estimation of the National totals for $CO_2$:

- Significant changes in the national totals can be seen for Industry-off road machinery, Agriculture oil, Agriculture solid fuels, railways and domestic solid fuel (all increases in emissions) and domestic oil and road transport other (both decreases). These changes have occurred because of a review of the methodology used to calculate off-road (industrial and agricultural) machinery emissions. Increases in these sectors were made for 2004. To ensure consistency between the NAEI and DUKES fuel use totals there were therefore consequential decreases in emissions in other sectors – domestic, industrial and commercial stationary combustion.
- There is also a large increase in domestic coal in the 2004 estimates as a result of a change in the estimates in DUKES. Emissions from peat have also been included in the inventory for the first time for 2004.
- There has been a reduction in the Road Transport Other sector – this is mainly emissions from the burning of engine oil. The UK estimate for this sector has been recalculated for 2004.
- The industrial and domestic gas columns show significant reductions compared. This is the result of a correction total emission distributed across these sectors. An additional sector was included in error in this total in 2003.

Changes in the spatial distribution of emissions:

- The industrial and domestic electricity columns show some changes in distributions. These are as a result of changes in the DTI methodologies for calculating the LA electricity and gas consumption numbers. They are more likely to reflect improvements in methodology rather than actual changes in consumption.
- 
- There are differences in the distributions of the other industrial fuels because of the different method used for estimating emissions at point sources, i.e. using ETS data in addition to the Pollution Inventory.
- The domestic non-gas fuel use distributions have changed significantly because of the new distribution grids produced for 2004.
- The land use change sector has been increased in scope for the 2004 estimates. Removals have been included for the first time and more emissions types are included. The spatial distributions have been estimated using a much more sophisticated and comprehensive method than for the 2003 estimates. This also affects the Agriculture and Deforestation column.

**Table 14** Change in regional estimates of $CO_2$ emissions of between 2003 and 2004 (2004 emissions as a percentage of 2003, (<2% change not shown)

| NUTS4 Area and Government Office Region | Industrial Electricity | Industrial Gas | Industrial Gas (Exclusions) | Industry Commercial Oil | Industry Commercial Solid Fuel | Industry Commercial Wastes And Biomass | Industry Process Gases | Industry Non Fuel | Industry Off-Road Machinery | Agriculture Oil | Agriculture Solid | Agriculture Non fuel | Railways | Domestic Electricity | Domestic Gas | Domestic Oil | Domestic Solid Fuel | Domestic Home And Garden Machinery | Domestic Household Products | Road Transport Petrol | Road Transport Diesel | Road Transport Other | LULUCF Emissions: Agricultural Soils And Deforestation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wales (1) | 107% | 98% | 0% | 58% | | 49% | 51% | 71% | 302% | 821% | 180% | | 282% | 105% | 87% | 143% | 91% | | | | 106% | 33% | 206% |
| Scotland (1) | 106% | 89% | | 126% | 160% | 333% | 822% | 102% | 302% | 804% | 180% | | 310% | 94% | 87% | 114% | 221% | | | | 105% | 32% | 119% |
| North East | 103% | 90% | 79% | 90% | 94% | 38% | | 67% | 302% | 823% | 180% | | 258% | 98% | 86% | 62% | 139% | | | | 103% | 33% | 90% |
| North West | 98% | 89% | 94% | 93% | 87% | 62% | 814% | 97% | 302% | 753% | 180% | | 356% | | 86% | 81% | 137% | | | | 103% | 33% | 139% |
| Yorkshire and the Humber | 114% | 89% | 177% | 81% | 68% | 260% | | 59% | 302% | 648% | 180% | | 297% | | 87% | 31% | 222% | | | | 103% | 33% | 79% |
| East Midlands | 108% | 90% | | 68% | 199% | 37% | 598% | 103% | 302% | 631% | 180% | | 234% | | 87% | 54% | 46% | | | 98% | 103% | 32% | 70% |
| West Midlands | 146% | 91% | | 62% | 316% | 27% | 823% | 94% | 302% | 715% | 180% | | 259% | | 87% | 59% | 140% | | | | 103% | 32% | 98% |
| East of England | 104% | 88% | | 93% | 88% | 136% | 840% | 97% | 302% | 506% | 180% | | 248% | | 86% | 54% | 58% | | | | 104% | 32% | 63% |
| Greater London | | 92% | | | | 7% | 839% | 0% | 302% | 727% | 180% | | 246% | 95% | 86% | 37% | 32% | | | | 107% | 35% | 74% |
| South East | | 89% | | 104% | 73% | 78% | 800% | 103% | 302% | 651% | 180% | | 246% | 98% | 87% | 107% | 212% | | | | 107% | 32% | 89% |
| South West | 112% | 90% | 279% | 60% | 167% | 38% | 812% | | 302% | 757% | 180% | | 198% | 98% | 89% | 116% | 94% | | | | 104% | 32% | |
| Northern Ireland (1) | 117% | 26% | 70% | 63% | 138% | 32% | 825% | 103% | 302% | 835% | 180% | | | 117% | 95% | 119% | 128% | | | 92% | 109% | 32% | 229% |
| Unallocated consumption | 22% | | | | | | | | | | | | | | | | | | | | | | 0% |
| Large elec users (high voltage lines) unknown location | 78% | | | | | | | | | | | | | | | | | | | | | | |
| UK TOTAL | 98% | 90% | 96% | 86% | 106% | 81% | 104% | 89% | 302% | 729% | 180% | | 260% | | 87% | 90% | 133% | | | | 105% | 33% | 94% |

# 6 Emissions Reallocated to End Users

The emissions estimates presented in the previous section go some way towards allocating emissions on the end users basis, as described in the introduction of this report. Further calculations have been undertaken to more fully reallocate the emissions from fuel production and distribution to end users. These are described in this section.

NAEI UK total emissions are reported in a number of different formats for different purposes each year. One of these is known as the End Users report in which emissions from fuel production and processing are reallocated to end user categories to reflect the total emissions relating to that fuel use. End users emissions are reported by Defra in the e-Digest of Environmental Statistics (http://www.defra.gov.uk/environment/statistics/globatmos/index.htm) and the Environment In Your Pocket publication (Defra 2005).

Emission sectors in the NAEI are divided into three categories: Energy Supply (the production and processing of fuels including electricity), Energy Users (such as residential, industry and road transport) and others (which emit $CO_2$ but it is not related to fuel use, such as industrial process emissions, and land use change). Emissions from energy supply industries are reallocated to each energy user sector in the NAEI in proportion to the amount of energy used by these sectors. As some fuel producers use fuel from other producers, they are allocated emissions from each other and these have then to be reallocated to end users. This circularity results in an iterative approach being used to estimate emissions from the end users. The iterations stop when all fuel producers have no more fuel to relocate to end users.

Table 15 below shows the energy supply emissions in 2004 split into the sectors producing the emissions. Table 16 then shows these emissions by end user. Finally Table 17 shows the total emissions for the end user categories including both relocated energy supply emissions and the emissions at the point of fuel use.

**Table 15** Energy Supply Emissions by Fuel Type 2004

| Energy Supply Fuel Type | Emission Source Name | Emission (kT $CO_2$) |
|---|---|---|
| Anthracite & Coal | Collieries - combustion | 157 |
| Coke | Coke production | 918 |
| Electricity | Power stations | 170607 |
| | Power stations - FGD | 311 |
| Natural Gas | Gas production | 1381 |
| | Gas separation plant - combustion | 765 |
| Oil | Offshore oil and gas - flaring | 20813 |
| | Refineries - combustion | 17560 |
| Solid Smokeless Fuel | Solid smokeless fuel production | 54 |
| Grand Total | | 212565 |

### Method for redistribution of end user emissions

The emissions related to energy supply (mostly at known point sources) have been removed from the Local Authority $CO_2$ estimates and the emissions in Table 16 redistributed to the locations of the end users. The cells in Table 16 have been colour coded according to the method used to distribute the emissions across Local Authorities. These are divided into electricity emissions, gas emissions, other emissions and sectors not allocated to Local Authorities.

**Table 16** Energy Supply Emissions Reallocated to End User by Fuel Type, 2004

| End User | Fuel Type (Emissions in kT $CO_2$) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Anthracite & Coal | Coke | Electricity | Natural Gas | Oil | Solid Smokeless Fuel | Grand Total |
| Industry Iron & Steel | 11 | 945 | 2387 | 33 | 163 | | 3540 |
| Industry Other Combustion | 42 | 15 | 49847 | 569 | 1307 | 2.6 | 51783 |
| Industry Other Processes | 14 | 0.7 | | 45 | 930 | | 989 |
| Road Transport | | | | | 21398 | | 21398 |
| Rail Transport | | | 3877 | 0.1 | 270 | | 4148 |
| Water Transport | | | | | 373 | | 373 |
| Domestic Aviation (Take off and landing) | | | | | 90 | | 90 |
| Air Transport Support | | | | | 45 | | 45 |
| Domestic | 18 | 7.2 | 61190 | 1213 | 1041 | 49 | 63518 |
| Commercial | 0.9 | | 49487 | 360 | 103 | | 49951 |
| Agriculture | 0.1 | | 2221 | 7.2 | 438 | | 2667 |
| Military Transport (Air & Water) | | | | | 315 | | 315 |
| Exports | | 20 | 1215 | | 12509 | 6.3 | 13750 |
| Grand Total | 86 | 989 | 170224 | 2227 | 38981 | 58 | 212565 |

The electricity emissions are distributed across Local Authorities in proportion to the DTI electricity consumption data as described in section 3.1. The electricity emissions shown here are emissions related to end user electricity and don't include electricity used by other energy producers. The number here is therefore slightly lower than that used in the standard set of Local $CO_2$ estimates shown in Table 12. Electricity exports have not been included in the end user results.

The emissions from gas use shown here are the additional emissions produced during the production of gas. These have been distributed across Local Authorities in proportion to the gas consumption data from DTI described in section 3.2.

The other emissions shown in Table 16 have been distributed across the Local Authorities in proportion to the emissions in these sectors in the NAEI maps. For some sectors the final Local $CO_2$ estimates have been used because these were already calculated at the correct level of aggregation – this is true for road transport, rail, agriculture and domestic. For other sectors a more specific map of emissions was required in order that the end user emissions were allocated to the correct geographic locations. This method was used for the various industry sectors, air transport support and commercial. These maps were calculated from the detailed NAEI points and area emissions datasets and the end users emissions were distributed in proportion to the primary $CO_2$ emissions in these maps.

Total end user emissions are shown in Table 17. The end user emissions by local authority are provided in the detailed results spreadsheet (LocalRegionalCO2_2004Final.xls).

**Table 17** Total end User emissions including emissions at point of fuel use (kT $CO_2$ 2004)

| End User | | Fuel Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sector | Sub sector | Anthracite & Coal | Coke | Electricity | Natural Gas | Non Fuel | Oil | Solid Smokeless Fuel | Grand Total |
| Industry | | | | | | | | | |
| | Industry Iron & Steel | 11 | 18268 | 2387 | 2033 | 1641 | 830 | | 25170 |
| | Industry Other Combustion | 7945 | 328 | 49847 | 34896 | 1528 | 13168 | 48 | 107759 |
| | Industry Other Processes | 3197 | 15 | | 2162 | 7806 | 9812 | | 22993 |
| Road transport | | | | | | 219 | 140770 | | 140988 |
| Other transport | | | | | | | | | |
| | Rail Transport | | | 3877 | 5 | | 2809 | | 6691 |
| | Water Transport: National navigation | | | | | 124 | 3923 | | 4047 |
| | Air transport: Domestic Aviation | | | | | | 6637 | | 6637 |
| Residential | | 3730 | 153 | 61190 | 74399 | 66 | 10592 | 909 | 152888 |
| Commercial and public administration | | 187 | | 49487 | 22082 | 41 | 1090 | | 72886 |
| Agriculture | | 21 | | 2221 | 442 | 829 | 4551 | | 8103 |
| Military aircraft and shipping | | | | | | | 3218 | | 3218 |
| LULUCF | | | | | | -2756 | | | -2756 |
| Exports | | | 20 | 1215 | | | 8121 | 6 | 9969 |
| Other emissions | | | | | | 452 | | | 452 |
| Grand Total | | 15091 | 18784 | 170224 | 136019 | 9949 | 205520 | 963 | 559044 |

# 7 Possible further developments of these estimates

There are a number of improvements that could be made to NAEI the emission estimates presented in this report. A number of different improvement requests were highlighted at the recent Stakeholder meeting on the 27th September 2006. These improvements can be categorised into two main areas: improvement to the accuracy of the existing datasets through the use of new data, and the improved usability of $CO_2$ data at Local Authority level through additional or alternative presentation and interaction with the data.

A number of enhancement opportunities have been identified for the distributions of emissions through better representation of emissions at a Local Authority level. Improvements will generally occur through a better understanding of the combustion of different fuels particularly coal, solid fuels and oil (Gas combustion is already well resolved). Specific improvements through improved data will include:

- **Residential:** Further improvements could be made to this sector using survey information on fuel use type for central heating and cooking by household. Some additional information can be gathered from Energy Saving Trust (EST) activities including data on energy performance of homes and EST data in their HEED system. However, some work is required to derive suitable UK wide datasets that can be used. Although existing HECA data is not useful for the UK inventory mapping, it is feasible that further harmonisation and extension of HECA reporting would provide a useful contribution to the understanding of energy efficiency and fuel types in different Local Authority areas.
- **Local Authority Industrial Regulation:** Regulated industrial process emissions from Local Authority regulated processes. Development and maintenance of a common database of processes with reported or estimates emission estimates based on a common methodology.
- **EA Pollution Inventory/SEPA/DoE NI:** Reporting of fuel use information by fuel type for regulated 'part A' processes.
- **Harmonisation of energy statistics:** There are currently significant differences between fuel usage reported in the ETS and that reported in DUKES. Harmonisation of these data sources will improve over the next few years, allowing for improved consistency between the national, regional and local inventories.
- **Boilers**: Access to information on fuel consumption in commercial and institutional installations including (schools, hospitals, public buildings) with particular focus on non gas fuelled systems. Previous 'Boiler Insurance' studies have provided distribution datasets that were of value for industrial as well as commercial and institutional sectors.
- **Road Transport:** Improving the consistency between Local and National road traffic data. Encourage more detailed collation of traffic count data by DfT and increase numbers of count points in Northern Ireland. Improve the mapping of minor road emissions through improved use of minor road traffic counts to derive area specific traffic flows. Determine with DfT how representative the minor road counts are for aggregation into area specific averages.
- **Development of road transport cold start weighting** distributions using the National Travel Survey data, car parking locations and employment and population information.

A number of improvements to the basis of the data and to the outputs and supporting material will help to engage with Local Authorities and to provide the foundation for data that can be used to develop efficient action plans and monitor progress towards targets.

- **Development of the metrics** used for reporting emissions by Local Authority. It will be important to develop a clear set of metrics to present the data in a clear and concise manner. Including the units of measure (e.g. deciding between total Green house gases, Carbon or CO2) and the indices (e.g. emissions per capita / GVA / household / employee / vehicle / etc).
- **Agree a common methodology** and approach to estimating LA emissions including differentiating between and/or integrating end-user and footprint approaches. Elements that could be developed include a 'Composite' inventory that includes:
    - Direct emissions from fuel combustion from end users (residential, transport, commercial, institutional, agriculture etc);
    - Emissions from Energy production sector within the LA (e.g. Power Stations, Refineries, Gas distribution, etc);
    - End user allocated emissions to the Local Authority from the Energy Production sector to end users based on fuel used;
    - Waste emissions according to the location of Landfills;
    - Waste emissions allocated according to waste generation;
    - Other wider carbon footprint emissions (e.g. emissions from manufacture of imported products, vehicles, goods).
- **Establishment of a Local Data methodology** for LAs to improve the estimates with their own data in a consistent way and to establish a transparent and accepted definition of boundaries to emissions (e.g. where are waste disposal, electricity generation, fuel production accounted for?)
- **Time-series**: Improving our ability to establish a consistent time-series for each Local Authority dataset that illustrates local improvements through energy efficiency. These developments link to the stabilisation and improvement of data collection for energy consumption (especially electricity and gas use). For Electricity, separation of "Green Tariff" and Fossil Fuel Electricity consumption would be important as would the separation of bio-fuel use from fossil fuels in transport.
- **Support to record and track actions:** Provision of suitable detail in the datasets to enable LAs to track the success of actions in their emissions per Capita (e.g. energy efficiency, public transport, planning action). This could be provided by enabling basic emissions datasets to be improved with LA data and through separation of emissions sectors more fully e.g. commercial into different sectors, Public Service into Schools, Local Authority buildings and so on. This could be done in collaboration with the Carbon Trusts LA $CO_2$ programme.
- **Baseline projections:** Integration of national and Local Projections to provide baseline projections based on economic and planning forecasts.

Many of the issues highlighted above depend on acquiring more detailed datasets and the development with stakeholders of a common approach to estimating and reporting emissions.

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# Annex 1 Users of the LA and Regional $CO_2$ estimates of emissions for 2003

A desk-based review of users of the 2003 dataset has been undertaken by AEA Energy & Environment. This involved a trawl of websites that have made reference to the 2003 dataset. It is therefore not a comprehensive list of data users but does provide insight into the range of applications of this data. Links to the websites found are given in Table 18.

### Local Authorities and County Councils

The data have been used by local authorities in a range of publications and for a variety of purposes. In some cases data for a county have been presented at local authority level within that area to raise awareness of the issue and compare regions, either on a website or publication. Examples include the Dorset Environmental Data Book 2005 and the website produced by Lancashire County Council.

Other councils have used the data as part of their climate change strategies and action plans. In these cases data were used to compare the current $CO_2$ emissions for that area with the national average and neighbouring regions, or as an estimate of baseline emissions. Example of these were Oxford City Council's Climate Change Action Plan, and Penwith District Council's Climate Change Strategy.

The data have also been used by other consultants working on behalf of local authorities to produce Strategic Environmental Assessment and Sustainability Scoping Reports. The carbon emissions data were used as baseline statistics for each council area.

### Regional Organisations

The data have been presented by regional observatories in the West Midlands, South West and East of England for information relevant to their region. The South West Observatory uses the data as part of the State of the Environment (SW) Report. The South East Climate Change Programme also highlights the release of these statistics in its regular newsletter.

### Government Publications

The Government's Sustainable Development website uses the data as one of its regional sustainability indicators, and the Sustainable Development in Government Annual Report mentions the statistics by comparing carbon emissions from the central government estate with those from a city the size of Liverpool.

The Audit Commission has also produced area profiles for local authority areas in the UK, and use the domestic emissions, domestic emissions per capita, and the total emissions per capita as environmental indicators.

### Environmental and Other Organisations

The WWF have presented the data in its "Counting Consumption" report. This presents the ecological footprint of each of the regions and devolved countries in the UK. Friends of the Earth have presented the data for England in their Regional Spatial Strategy policy brief, setting out policies for sustainable development in English regions.

Regional sub sectors of Friends of the Earth have also featured the data in press releases on their websites. Pembrokeshire Friends of the Earth concentrated on the revelation that carbon emissions from their county were second highest in Wales, while Friends of the Earth Scotland presented all of the data relevant to Scotland.

The Maidstone Green Party have also produced a press release highlighting the data and calling on the council to do something about climate change issues. A news story also featured on the Green Building website, highlighting the amount of carbon emissions from housing.

Web forums, such as the Bristol North-South Forum, and HillingdonChat.com have also highlighted the results of the study for their local area, and it is also mentioned on a number of sites as a source of extra information about local $CO_2$ emissions.

**Table 18** Table of Web Links to Examples of Data Users

| Data user / publication or data purpose | Web link |
|---|---|
| Audit Commission – Local Area Profiles | http://www.areaprofiles.audit-commission.gov.uk |
| Birmingham City Council (produced by Halcrow) - Sustainability Appraisal and Strategic Environmental Assessment for the Longbridge Area Action Plan | http://www.birmingham.gov.uk/Media/Longbridge%20AAP%20SA-SEA%20Baseline%5BAppD%5D.PDF?MEDIA_ID=138571&FILENAME=Longbridge%20AAP%20SA-SEA%20Baseline%5BAppD%5D.PDF |
| Bristol North-South forum - Newsletter | http://www.digitalbristol.org/members/nsf/new_actions.htm |
| Brook Lyndhurst for RICS - The City Climate Challenge for 2050 - Your City, Your Responsibility | http://www.rics.org/NR/rdonlyres/0C2E8B67-FEA0-476B-8475-FE01820431E7/0/city_climate_challenge_full180906.pdf |
| Central and Local Government Information Partnership- Summary of Regional Air Quality and GHG Emissions Data Availability | http://www.clip.gov.uk/Documents/Resources/Transport/060208-Reg%20&%20local%20level%20statistics%20on%20air%20qual%20&%20pol%20ems%20v2.pdf |
| Centre for Sustainable Energy - Carbon Dioxide Mapping for Local Authorities - Aim to help local authorities map their CO2 emissions | http://www.cse.org.uk/cgi-bin/projects.cgi?local&&1021 |
| Dacorum Council (report produced by Halcrow/TRL) - Dacorum Strategic Environmental Assessment and Sustainability Scoping Report | http://www.dacorum.gov.uk/dbcweb/pdf/Dacorum%20Consultation%20Scoping%20Report%2006-02-23b%20FINAL.PDF |
| Dorset county council - Dorset Environmental Data Book 2005 | http://download.southwestrda.org.uk/file.asp?File=/other/quarterly-economic-reports/Economics%20Review%20Feb06.pdf |
| East of England Observatory - Presents data relevant to the east of England | http://www.eastofenglandobservatory.org.uk/viewResource.asp?categoryGEOID=873&uri=http://eastofenglandobservatory.org.uk/resources/?id=13429 |
| East Riding of Yorkshire Council - The First Annual Monitoring Report, December 2005 | http://www.eastriding.gov.uk/corp-docs/forwardplanning/docs/monitoring/amr/amr2005_submission.pdf |
| Eastern Region Public Health Observatory - Provides link to report | http://www.erpho.org.uk/viewResource.aspx?id=13105 |
| Energy Saving Trust - Link to report provided under housing and building energy efficiency publications | http://www.est.org.uk/housingbuildings/localauthorities/information/nonest/index.cfm?ty=1&ext_id=1219 |
| Energy Saving Trust - The monitoring & targeting of household energy efficiency: - Development of a unified approach | http://mail.mtprog.com/CD_Layout/Day_2_22.06.06/1615-1815/ID65_Amato_final.pdf |
| Environment agency - sea environment objectives | http://www.environment-agency.gov.uk/commondata/103599/seatbl_230506_1134722.doc |
| Friends of the Earth - Press Release | http://www.foe.co.uk/resource/press_releases/local_and_regional_authori_21102005.html |

| Data user / publication or data purpose | Web link |
|---|---|
| Friends of the Earth - Regional Spatial Strategy - a Blueprint for justice and sustainable development in the English regions | http://www.foe.co.uk/resource/guides/rss_2nd_edition.pdf |
| Friends of the Earth North East - Comments on the Yorkshire and Humber Spatial Strategy and Climate Change Study | http://www.northeasteip.co.uk/downloads/documents/20060222220638.pdf |
| Friends of the Earth Scotland - Press Release - presents data for the Scottish regions | http://www.foe-scotland.org.uk/press/pr20051005.html |
| Friends of the Earth Wales - Press Release | http://www.foe.co.uk/cymru/english/press_releases/2006/cc_gas_high.html |
| Green Building - News story - a third of CO2 is from housing | http://www.newbuilder.co.uk/news/NewsFullStory.asp?ID=1013 |
| Herefordshire Partnership - State of Herefordshire report | http://www.herefordshirepartnership.com/docs/Appendix.pdf |
| Hestia services Ltd - Local energy support update | http://www.hestia-europe.com/Content/Files/LSP%20Update/NovDec%202005.pdf |
| Hillingdonchat.com - Daily news bulletin | http://hillingdon.middx.net/forum/viewtopic.php?t=3172&view=previous&sid=a30b3c3b9e5793e5fdca2f69062e15b2 |
| Kent Green Party - Press release (about Maidstone) | http://www.kentgreenparty.org/pressreleases/index.php?subaction=showcomments&id=1130675412&archive=1135795642&start_from=&ucat=3&go=archives |
| Lancashire County Council – Presents data relevant to Lancashire | http://www.lancashire.gov.uk/environment/lancashireprofile/monitors/co2emission.asp |
| Levett-Therival Sustainability consultants - Carbon Emissions from The South West, and Implications for The Regional Spatial Strategy | http://www.southwest-ra.gov.uk/media/SWRA/RSS%20Documents/Technical%20Documents/00.05_Carbon_Emissions_from_The_South_West_and_Implications_for_the_RSS.pdf |
| Maidstone Green Party - Press Release | http://maidstone.greenparty.org.uk/publications/MGP%20PR-20051029.pdf |
| Natural environmental statistics advisory committee meeting minutes - newsletter - lists recent publications | http://www.scotland.gov.uk/Resource/Doc/933/0027739.pdf |
| NSCA - News - New Local carbon emissions data | http://www.nsca.org.uk/pages/news/press_releases/pr94.cfm |
| One North East - Used as baseline statistics - link is to relevant appendix, couldn't find main report | http://www.onenortheast.co.uk/lib/liDownload/9841/060901%20Annex%20B%20Baseline%20Data.pdf?CFID=3558624&CFTOKEN=51454240 |
| Oxford City Council (Report produced by Dr Rajat Gupta, Oxford Brookes Uni) - Oxford Climate Change Action Plan | http://www.oxford.gov.uk/files/meetingdocs/32031/item%207%20part%202.pdf |
| Pell Frischmann (consulting engineers) - North Lincolnshire Local Transport Plan - SEA Statement | http://www.northlincs.gov.uk/NR/rdonlyres/4BBADE24-B523-4B6B-A910-8B3002A77310/16453/SEAStatement.pdf |
| Pembrokeshire Friends of the Earth - Press release CO2 emissions from Pembrokeshire 2nd highest in Wales | http://www.pembsfoe.org.uk/Pr/Pr-2006.php |
| Penwith District Council - A Climate Change Strategy for Penwith | http://www.penwith.gov.uk/media/adobe/8/2/climatechangestrat-finalapril2006_1.pdf |
| Prepared by Pricewaterhouse Coopers - Sustainable Development in Government - 4th annual report | http://www.sd-commission.org.uk/watchdog/4th_Annual_Report_(final)_UPDATED_30_11_05.pdf |

| Data user / publication or data purpose | Web link |
|---|---|
| Prepared by Scott Wilson - SA/SEA of Crawley Local Development Framework, Sustainability Appraisal report | http://www.crawley.gov.uk/stellent/groups/public/documents/strategypolicy/int088205.pdf |
| Scottish Executive Statistics - search result - link to report | http://www.scotland.gov.uk/Topics/Statistics/Browse/Environment/seso/sesoSubSearch/Q/SID/192 |
| South East Climate Change Partnership - Emissions Monitoring Group - Baseline Data and Emissions Inventories Guidelines | http://www.hecafora.com/downloads/root/regions/london/documents/SECCP_Toolkit_Guidelines.doc |
| South East Climate Change Programme - Newsletter | http://www.climatesoutheast.org.uk/downloads/SECCP%20e-news%20update%20181105.doc |
| South Gloucestershire Council - Tomorrow's Climate, Today's Challenge - a climate change strategy and action plan for South Gloucestershire | http://www.southglos.gov.uk/NR/rdonlyres/46BAC681-3AAC-4192-8795-8E957C3D702B/0/DraftClimateChangeStrategy.pdf |
| South West Observatory - State of the environment (SW) report | http://www.swenvo.org.uk/publications/SOE_2006.asp |
| South West of England Regional Development Agency - Economics Review - First Quarter, Feb 2006 | http://download.southwestrda.org.uk/file.asp?File=/other/quarterly-economic-reports/Economics%20Review%20Feb06.pdf |
| St Albans City and District Council (report produced by Halcrow/TRL) - St Albans Strategic Environmental Assessment and Sustainability Scoping Report | http://www.stalbans.gov.uk/pressroom/consultations/sa_sea_draft_scoping_report_1.pdf |
| Sustainable Development - Regional Sustainable Development Indicators | http://www.sustainable-development.gov.uk/regional/index.htm |
| Three Rivers District Council (report produced by Halcrow/TRL) - Three Rivers Strategic Environmental Assessment and Sustainability Scoping Report | www.threerivers.gov.uk/GetResource.aspx?file=Three%20Rivers%20LDD%20Scoping%20Report%20FINAL.PDF |
| West Midlands Regional Observatory - West Midlands Regional Energy Strategy Monitoring Report 2006 | http://www.wmro.org/resources/res.aspx/CmsResource/resourceFilename/806/Energy-strategy-monitoring_v2.0_BM.pdf |
| WWF - Counting Consumption Report - Ecological Budget UK Project | http://www.wwf.org.uk/filelibrary/pdf/countingconsumption.pdf |
| Yorkshire and Humber Assembly - Annual Monitoring Report | http://www.yhassembly.gov.uk/p_contentDocs/639_5.pdf |

# Annex 2 Site Specific Fuel Use Estimates

Fuels used by large consumers have been estimated using two types of data:

- Information on fuels burnt during 2005 which is held in the Environment Agency (EA) and DoE (Northern Ireland) databases of installations that are in the EU Emissions Trading Scheme (ETS).
- Information on emissions of carbon dioxide from combustion processes during 2004 which have been reported by operators to the EA, the Scottish Environment Protection Agency (SEPA), and the Department of the Environment in Northern Ireland (DoE(NI)).

The derivation of estimates from these two sources is described in the two following sections.

### Estimating fuel use for ETS processes

The EA have provided access to data for 516 installations in England and Wales which reported fuel consumption and CO2 emissions in 2005. Equivalent data was also received from DoE (Northern Ireland), covering 22 installations. Data for Scottish ETS Installations was not received in time for this analysis.

The data provided includes some information on the relationship between the process covered by the ETS application and processes regulated under IPC and IPPC (Authorisation numbers, Site names and locations). These data have been used to identify those ETS processes which also report to the Pollution Inventory (PI). The type and quantity of fuels burnt by the ETS processes are included in the EA data and these fuels have all been assigned to one of the standard fuel types used in the NAEI (e.g. coal, fuel oil, gas oil). Each process has also been allocated to one of the industrial sector classifications used in the NAEI – these are, in turn, based on the classification used in DUKES.

The ETS data relate to 2005 whereas we require estimates of fuel consumed in 2004. So, in those cases where processes are covered by the ETS but also report $CO_2$ emissions for 2004 in the PI, we have derived estimates of 2004 fuel consumption by calculating the percentage change between $CO_2$ emitted in 2005 (given in the ETS data) and $CO_2$ emitted in 2004 (given in the PI) and then assuming that consumption of each fuel also changes by the same percentage between 2005 and 2004. Since fuel consumption during 2005 is given in the ETS data, fuel consumption in 2004 can then be calculated.

In the case of processes which are covered by the ETS but do not report $CO_2$ emissions for 2004 in the PI, we have assumed that the same quantity of fuel was burnt in 2004 as in 2005.

### Estimating fuel use for non-ETS processes

A large number of processes are not covered by the ETS data either because they are not required to provide data at the present time, or are not covered by the scheme. In these cases, some data are available from other sources including the PI; the Scottish Pollutant Release Inventory (SPRI), compiled by SEPA; and the Inventory of Sources and Releases (ISR), compiled by DoE(NI). These sources include estimates of $CO_2$ emissions during 2004 and these have been used as the basis of estimates of fuel usage during 2004. AEAT have, as part of the previous year's work, compiled a set of assumptions regarding the mix of fuels burnt at each regulated process. These assumptions were used again to generate

estimates of fuel consumption using the $CO_2$ emissions data and $CO_2$ emission factors, taken from the UK Greenhouse Gas Inventory (GHGI).

**Results**

Results are summarised in Table 19 ($CO_2$ emissions by sector) and Table 20 (fuel consumption estimates by fuel type). In each case the data derived here are compared with data taken from the GHGI. The rows in grey are where there is an exact or almost exact match.

**Table 19** Comparison of Estimates of Point Source CO2 Emissions by Sector with GHGI data (emissions in kTonnes CO2)

| Source Name | GHGI | Points | % points |
|---|---|---|---|
| Cement - decarbonising | 5456 | 5456 | 100% |
| Coke production | 918 | 915 | 100% |
| Collieries - combustion | 137 | 19 | 14% |
| Blast furnaces | 4389 | 4389 | 100% |
| Sinter production | 2258 | 1640 | 73% |
| Iron and steel - combustion plant | 13932 | 10678 | 77% |
| Lime production - non decarbonising | 304 | 493 | 162% |
| Miscellaneous industrial/commercial combustion | 11861 | 380 | 3% |
| Other industrial combustion | 56603 | 126692 | 224% |
| Power stations | 169767 | 176290 | 104% |
| Public sector combustion | 10650 | 1350 | 13% |
| Refineries - combustion | 17560 | 17304 | 99% |
| Glass - general | 287 | 287 | 100% |
| Cement production - combustion | 4637 | 4561 | 98% |
| Primary aluminium production - general | 554 | 554 | 100% |
| Ammonia production - feedstock use of gas | 1329 | 1329 | 100% |
| Ammonia production - combustion | 577 | 577 | 100% |
| Electric arc furnaces | 23 | 23 | 100% |
| Basic oxygen furnaces | 133 | 133 | 100% |
| Lime production - decarbonising | 815 | 815 | 100% |
| Incineration - MSW | 881 | 881 | 100% |
| Incineration - chemical waste | 234 | 234 | 100% |
| Brick manufacture - Fletton | 128 | 128 | 100% |
| Power stations - FGD | 311 | 311 | 100% |
| Ladle arc furnaces | 13 | 13 | 100% |

Table 19 shows clearly that there are significant differences between the summed emissions for point sources and the national (GHGI) emission for many sectors. In most of these cases, the point source emission is lower than the national emission and this is not necessarily a problem since many smaller processes will not be included in the point source data. For example, the point source emissions for public sector combustion, collieries-combustion and miscellaneous industrial/commercial combustion are only a small fraction of GHGI emissions but many combustion plant in these sectors will be small and therefore not included in the ETS data, PI, SPRI or ISR. The point source emissions for iron & steel industry combustion are 77% of the GHGI figure. There are many small plant, including iron and steel foundries, in the UK which probably make up this difference.

Point source emissions for power stations, refinery – combustion and cement production - combustion are close to the national figure with the power stations figure being slightly high and the other two sources slightly low. Emissions from coke production are very close.

Point source emissions for other industrial combustion, and lime production – non decarbonising are significantly too high. The latter sector is small. The excess emission in 'Other industrial combustion' is perhaps reflecting an underestimate in fuel use reported in DUKES.

**Table 20** Comparison of Estimates of Fuel Consumption by Fuel with GHGI data (figures in Mtonnes for solid/liquid fuels; Mtherms for gaseous fuels)

| Fuel category | Fuel | GHGI | Points | % points |
|---|---|---|---|---|
| Natural gas | Colliery methane | 149 | 19 | 13% |
| | Natural gas | 117862 | 166475 | 141% |
| Oils | Burning oil | 4691 | 25 | 1% |
| | Fuel oil | 12960 | 9596 | 74% |
| | Gas oil | 1786 | 2110 | 118% |
| | LPG | 2709 | 2132 | 79% |
| | Naphtha | 22 | 0 | 0% |
| | OPG | 8512 | 17581 | 207% |
| Process gases | Blast furnace gas | 15288 | 13596 | 89% |
| | Sour gas | 444 | 352 | 79% |
| | Coke oven gas | 1284 | 1156 | 90% |
| Solid fuels | Petroleum coke | 4423 | 1402 | 32% |
| | Coke | 2570 | 2215 | 86% |
| | Coal | 121254 | 129607 | 107% |
| Wastes and bio fuels | Waste oils | 422 | 39 | 9% |
| | Scrap tyres | 182 | 123 | 67% |
| | MSW | 881 | 881 | 100% |
| | Waste solvent | 363 | 189 | 52% |

Table 20 also shows significant differences between the data for point sources and the national (GHGI) data for many fuels. In most cases the point source data would be expected to be considerable lower than the GHGI figure (in the case of burning oil) or at least lower (in the case of almost all other fuels). The figures for blast furnace gas, coal, and gas oil are close which is encouraging. The point source figures for coke, coke oven gas, fuel oil, waste oils, and waste solvent, although lower than the GHGI figures, may still be reasonable given that some fuel is used by small plant which are not included in either the ETS data or the PI/SPRI/ISR.

Consumption of OPG and MSW are significantly lower in the GHGI compared with the point source data. Consumption of natural gas is also lower in the GHGI.

There are a number of reasons why the point source data do not always match GHGI data:

- the GHGI data are based on national estimates of fuel consumption combined with emission factors with are largely literature-based. In comparison, point source data are based either on actual fuel use at individual sites and/or $CO_2$ emission estimates provided by individual process operators. There is therefore no guarantee that emissions will be the same when derived using these two very different approaches;
- some processes given in the ETS data may not have been assigned to the correct GHGI source categories;
- some fuels given in the ETS data may not have been assigned to the correct GHGI fuel categories – this is perhaps most likely with fuel oil / gas oil;
- some processes given in the ETS data cover more than one GHGI source category but have currently been assigned to just one of those categories;
- some of the point source estimates are based on the assumption that fuel consumption given in the ETS data for 2005 is also applicable to 2004. This assumption may introduce significant errors;

- ETS data and emissions data given in the PI, SPRI and ISR do not include all sources in the UK, whereas the GHGI does;
- some assumptions have to be made in order to generate certain of the GHGI estimates (e.g. emission estimates for lime – combustion and power stations and estimates of consumption of waste oils are all at least partially dependent upon assumptions) and these assumptions may be wrong.

# Annex 3 Mapping Domestic Fuel Consumption

Section 3.3 of this report provides an overview of the method used to calculate new distributions of domestic fuels across Great Britain. The method is described in detail here in a series of stages.

**Stage 1: Calculation of average household energy use**

The first stage was to calculate GB average heating energy demand per household for different dwelling types with and without central heating. The data obtained from BRE are summarised below. The energy consumption data have been modelled by BRE to be consistent with DUKES data. Detached houses and bungalows have been aggregated in these tables because there is no separate count for bungalows in the 2001 census (see Stage 2).

**Table 21** Fuel Consumption data for GB 2004 (PJ), and averages by household type

| | Solid fuel | Gas | Elec | Oil | Total | | Households ('000s) | Average GJ / household |
|---|---|---|---|---|---|---|---|---|
| With central heating (all types) | 29.9 | 1352.2 | 355.2 | 98.4 | 1835.8 | PJ | 22729 | 80.8 |
| With central heating: | | | | | | | | |
| detached plus bungalow | 9.8 | 396.3 | 101.5 | 64.6 | 572.2 | PJ | 5976 | 95.7 |
| Semi-detached | 9.8 | 437.1 | 103.9 | 19.1 | 570.0 | PJ | 6514 | 87.5 |
| Terrace | 8.0 | 359.8 | 88.7 | 6.8 | 463.3 | PJ | 5983 | 77.4 |
| Flat | 2.2 | 156.5 | 60.3 | 7.4 | 226.4 | PJ | 4189 | 54.0 |
| Other | 0.0 | 2.6 | 0.8 | 0.5 | 3.9 | PJ | 67 | 58.5 |
| Without central heating (all types) | 21.0 | 72.9 | 51.0 | 1.2 | 146.0 | PJ | 2096 | 69.7 |
| Without central heating: | | | | | | | | |
| detached plus bungalow | 3.6 | 3.8 | 3.6 | 0.0 | 11.1 | PJ | 131 | 84.6 |
| Semi-detached | 9.0 | 19.1 | 14.0 | 0.5 | 42.5 | PJ | 538 | 79.0 |
| Terrace | 7.7 | 36.1 | 21.5 | 0.4 | 65.6 | PJ | 893 | 73.5 |
| Flat | 0.8 | 13.9 | 11.7 | 0.3 | 26.7 | PJ | 527 | 50.6 |
| Other | 0.0 | 0.0 | 0.1 | 0.0 | 0.2 | PJ | 7 | 22.5 |

Source: BRE

**Table 22** Numbers of households using different fuels, GB 2004

| **With central heating** | **Solid fuel** | **Gas** | **Electricity** | **Oil** | **Total** |
|---|---|---|---|---|---|
| All | 374 | 19917 | 1912 | 707 | 22910 |
| Detached + bungalow | 90 | 5087 | 337 | 529 | 6043 |
| Semi-detached | 129 | 6006 | 343 | 102 | 6580 |
| Terrace | 138 | 5442 | 415 | 55 | 6050 |
| Flat | 14 | 3335 | 806 | 14 | 4169 |
| Other | 4 | 48 | 11 | 5 | 68 |

| **No central heating** | Solid fuel | Gas | Electricity | Oil | Total |
|---|---|---|---|---|---|
| All | 234 | 1222 | 450 | 6 | 1912 |
| Detached + bungalow | 41 | 39 | 30 | 4 | 114 |
| Semi-detached | 103 | 319 | 87 | 0 | 509 |
| Terrace | 79 | 637 | 117 | 0 | 833 |
| Flat | 10 | 221 | 216 | 2 | 449 |
| Other | 0 | 6 | 0 | 0 | 6 |

Source: BRE

Table 23 shows average consumption per household for different dwellings for gas, solid fuels and oil. These are calculated at GB level from the data in Table 21 and Table 22. Electricity use has not been included here because it is not comparable. Electricity use includes lighting and appliances as well as cooking and heating. A weighted average fuel usage has been for detached houses and bungalows.

**Table 23** *Calculated Average consumption per household for different fuel types (GJ per household)*

| **With central heating** | **Gas** | **Solid fuel** | **Oil** |
|---|---|---|---|
| Detached plus bungalow | 78 | 109 | 122 |
| Semi-detached | 73 | 76 | 188 |
| Terrace | 66 | 58 | 123 |
| Flat | 47 | 159* | 526* |
| Other | 55 | | 103 |
| | | | |
| **No central heating** | | | |
| Detached plus bungalow | 99 | 88 | 11 |
| Semi-detached | 60 | 87 | |
| Terrace | 57 | 97 | |
| Flat | 63 | 80 | 148 |
| Other | 2* | | |

**These figures are calculated using data for a small number of households (< 20,000)*

The gas data in Table 23 have been combined with 1km resolution 2001 population census data of numbers of households of these different types of dwelling (see Stage 2) and the solid fuel and oil data have been used later in Stage 5.

#### Stage 2: Calculation of maps of households by dwelling type (1km resolution)

Maps at 1km resolution of household counts by household type and presence of central heating have been created from Census 2001 data for England, Wales and Scotland. These maps match the categories of households shown in the tables above.
Data are available at Output area level from the 2001 census. The Output Areas cover roughly 125 households but their actual size has considerable geographical variation related to population density. Household counts for each 1km square across Great Britain have been calculated by overlaying the output area boundaries with the grid squares and calculating area weighted sums of the output area household counts.

### Stage 3: Calculation of theoretical total energy demand per grid square

The key question in this modelling is to determine the locations of non-gas fuel usage. Therefore the initial modelling stage is to compare the actual gas consumption data from the DTI with a theoretical total energy demand. The difference between these two patterns highlights grid squares where there is energy demand that is not met by gas.
The census households distributions described in Stage 2 have been multiplied by the average gas use figures calculated in Stage 1 (see Table 23). The results were summed to create a total modelled gas consumption. The difference between this distribution and the DTI gas data is the residual energy demand.

Comments on the residual energy demand:

- Some locations have negative values which were large in some locations. This is where the modelled energy demand is not high enough. It is likely that these locations are where either there are higher than average energy users or where there are more households in the gas dataset than in the 2001 census (new house building).

- Some locations have large positive values, some of which are in city centres. This is where the modelled energy demand is high and the actual gas demand is not so high. In rural areas this can be explained by a lack of the gas network and therefore represents large amounts of non-gas fuels. In cities, which all have gas networks, it may be that actual energy demand is lower than average and therefore the model is overestimating energy demand. This is especially likely in high population density areas with higher than average ambient temperatures. It is likely that in cities any real residual energy demand will be met primarily by electricity.

**Stage 4: Allocation of residual demand to non-gas fuels**

The residual energy demand map was calculated in GJ energy units. This needed to be converted back into numbers of households in order to apportion these households to different fuels based on regional data from BRE. For each grid square, a fraction of total theoretical gas consumption associated with each dwelling type was calculated. These fractions were then used to divide up the residual energy demand into the different household types and then division by the average gas usage data in Table 23 gave numbers of households of each dwelling type that don't use gas. This is equivalent to back-calculating stage 3 with just a fraction of the total energy requirement.

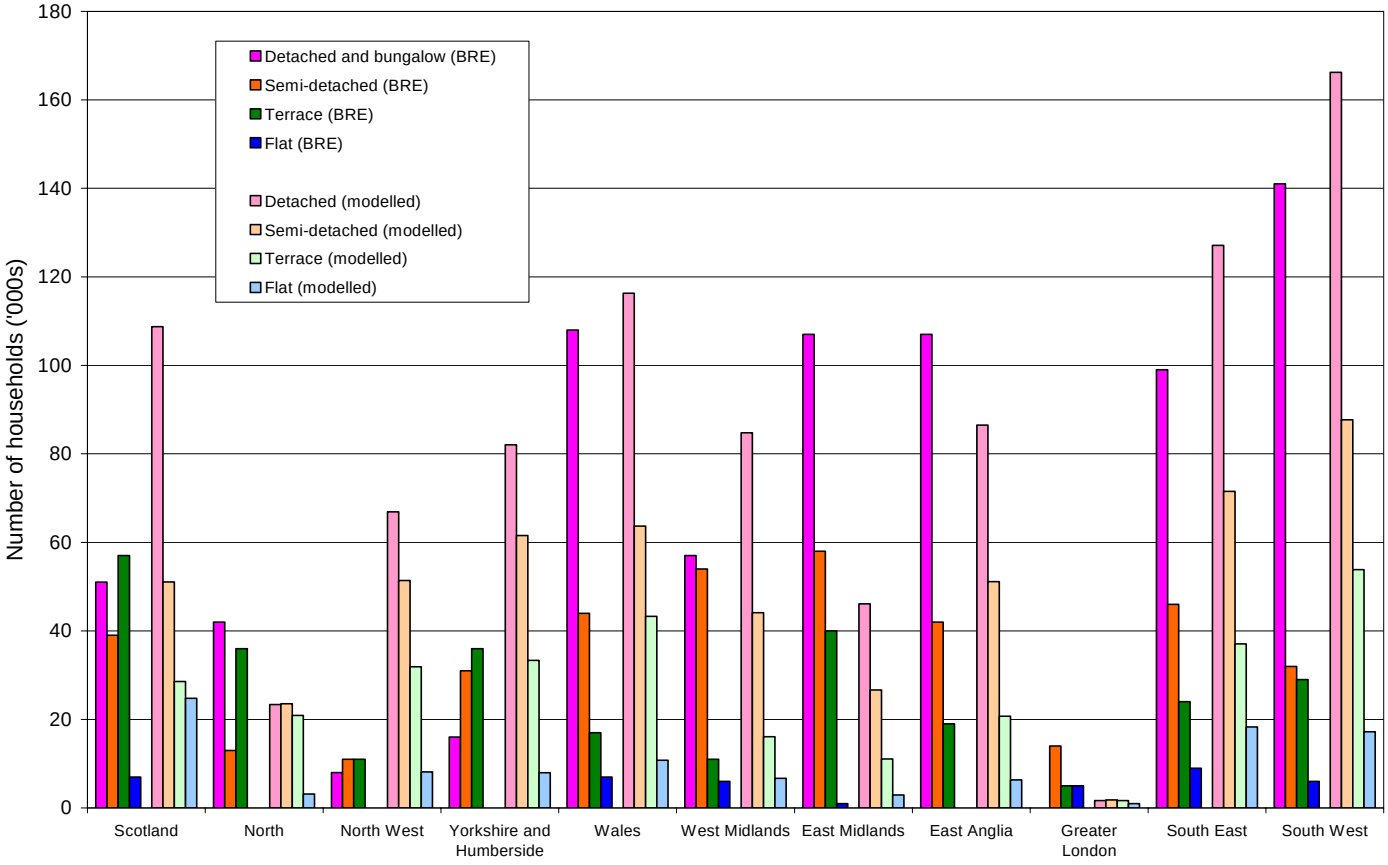
Experimental statistical data from DTI on the numbers of type-2 (Economy 7) electricity meters by Middle Layer Super Output Area has been combined with total household numbers for the same geographical areas to calculate an estimated fraction of households using electricity for heating. The DTI electricity dataset shows a significantly higher proportion of electricity use in eastern England, however checks by DTI reveal this to be correct. The DTI data were not available for Scotland because the data had not been compiled in time for this work. Therefore an alternative data source has been used for Scotland: the Experian Home Pack dataset of household information. This provides estimated counts of the type of the main heating fuel by postcode sector (Business Geographics 2001). These datasets have been combined to produce a map of estimated fraction of total households in each grid square that use electricity to heat their homes. This fraction has then been removed from the non-gas households, calculated as described above. Any remaining residual energy demand in the largest (greater than 250,000 population) conurbations has also been removed as it is assumed that this is met by electricity or is a result of over estimates of modelled energy use (see above).

The resulting distribution of households that use all solid and liquid fuels (comprising coal, smokeless solid fuels, oil, LPG, wood and peat) have been compared with regional data from BRE (BRE 2006) to verify the model results at this stage. The comparison is shown in Figure 9 and the match is fairly good. The modelled household numbers are generally higher except in the north, Greater London and East Midlands. A possible explanation for this over estimate is that the modelled energy use is too high in many areas because of the simple use of GB average energy factors.

There is a mismatch in the region boundaries between these two datasets, with BRE North being bigger than the Government Office Region called North East and BRE North West is smaller than the Government Office Region North West and Merseyside. The figures for Wales, West Midlands, South East and South West all show the same pattern in the BRE and modelled numbers, although all modelled household numbers are too high. In Greater London modelled numbers are too low, likely because of the removal of all residual energy demand in the London agglomeration. This may have been an over simplification because of the large area that this agglomeration covers, stretching out into the Home Counties. In East Anglia and East Midlands the modelled numbers are too low, as a result of the significantly higher proportion of electricity use here compared with other regions (see above), an aspect that may not be included in the BRE datasets.

Notwithstanding the differences explained here, the modelled estimates do follow the BRE numbers reasonably well and hence it is felt that the model represents reasonably well the distribution of non-gas fuels across Great Britain.

**Figure 9** Comparing modelled and BRE household types with solid and liquid fuels




## Stage 5: Solid and liquid fuels use distributions

Data from BRE provides fractions of households of different types that use solid and liquid fuels and bottled gas. These are available for each Government Office Region or Devolved Administration but do not include data for wood and peat. The fractions have been applied to the modelled distributions of households that use solid and liquid fuels calculated in stage 4 above. Average fuel use factors by household types have also been applied to the distributions (see Table 23) so that the different household types could be added together to give total fuel use maps. Along with these data a number of simple assumptions have been made about the locations of fuels burnt:

- coal is burnt exclusively outside Smoke Control Areas;
- oil is burnt outside the biggest cities (of greater than 250,000 populations) but inside the smaller cities in grid squares where there is residual demand;
- smokeless solid fuels (SSF, coke, anthracite) are burnt exclusively within smoke control areas;
- wood is assumed to have the same distribution as coal but has been excluded from Northern Ireland; and
- peat has the same distribution as coal but is only burnt in Northern Ireland.

A new map of Smoke Control Areas has been created by combination of a digital picture of Smoke Control Area available from Defra and urban area boundaries.

The GB maps were combined with existing maps of domestic fuel use for Northern Ireland. The method used to create the Northern Ireland maps is described briefly in section 3.3 of the main report. The two sets of distributions were combined by weighting each by the fraction of UK fuel used in GB and NI (derived from the NAEI regional inventory). The resulting UK distributions of the domestic fuels are shown in the following maps. The maps show the normalised distribution of fuel use, i.e. each grid cell as a fraction of the UK.

**Figure 10** Modelled domestic gas use

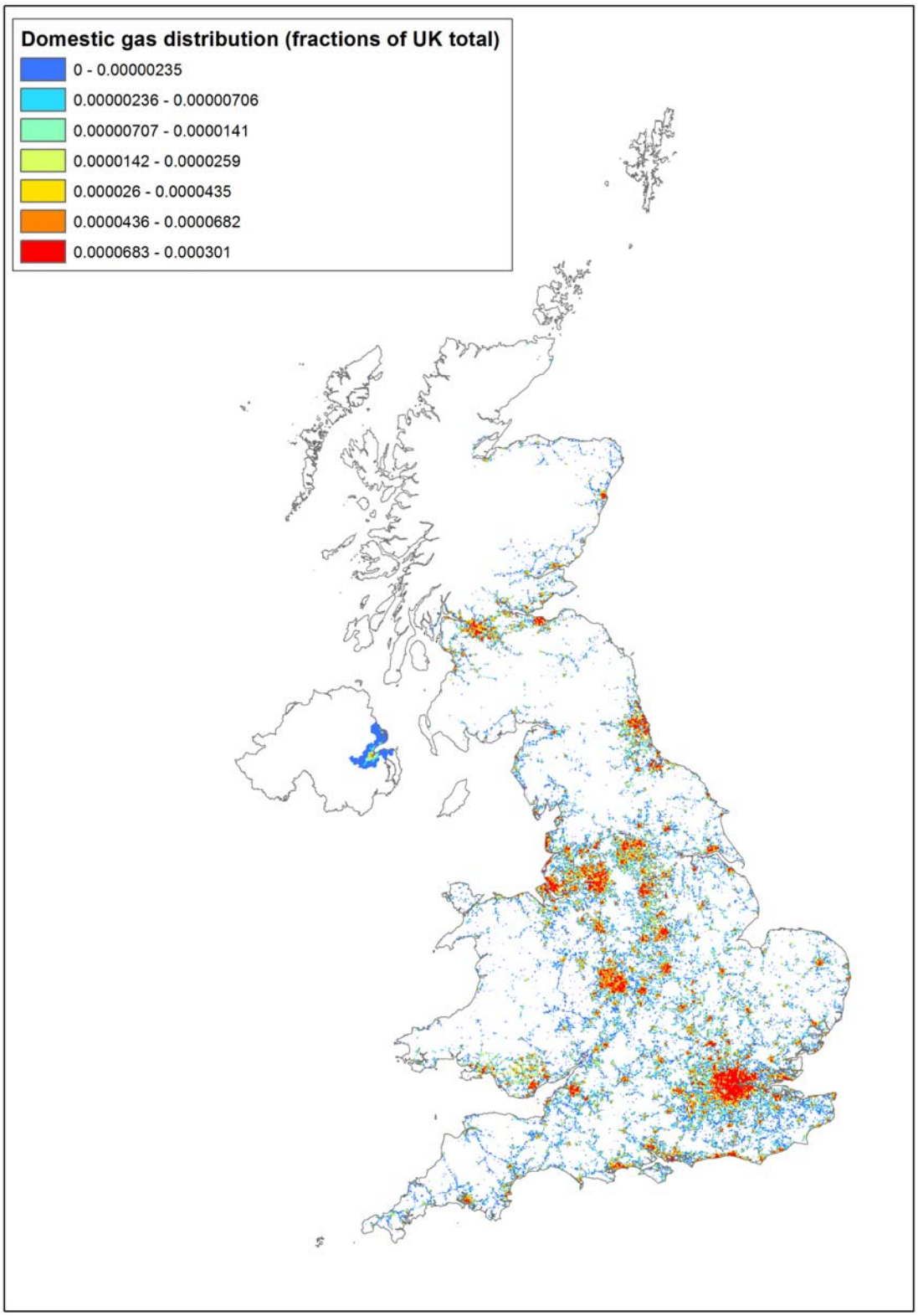


**Figure 11** Modelled domestic coal use

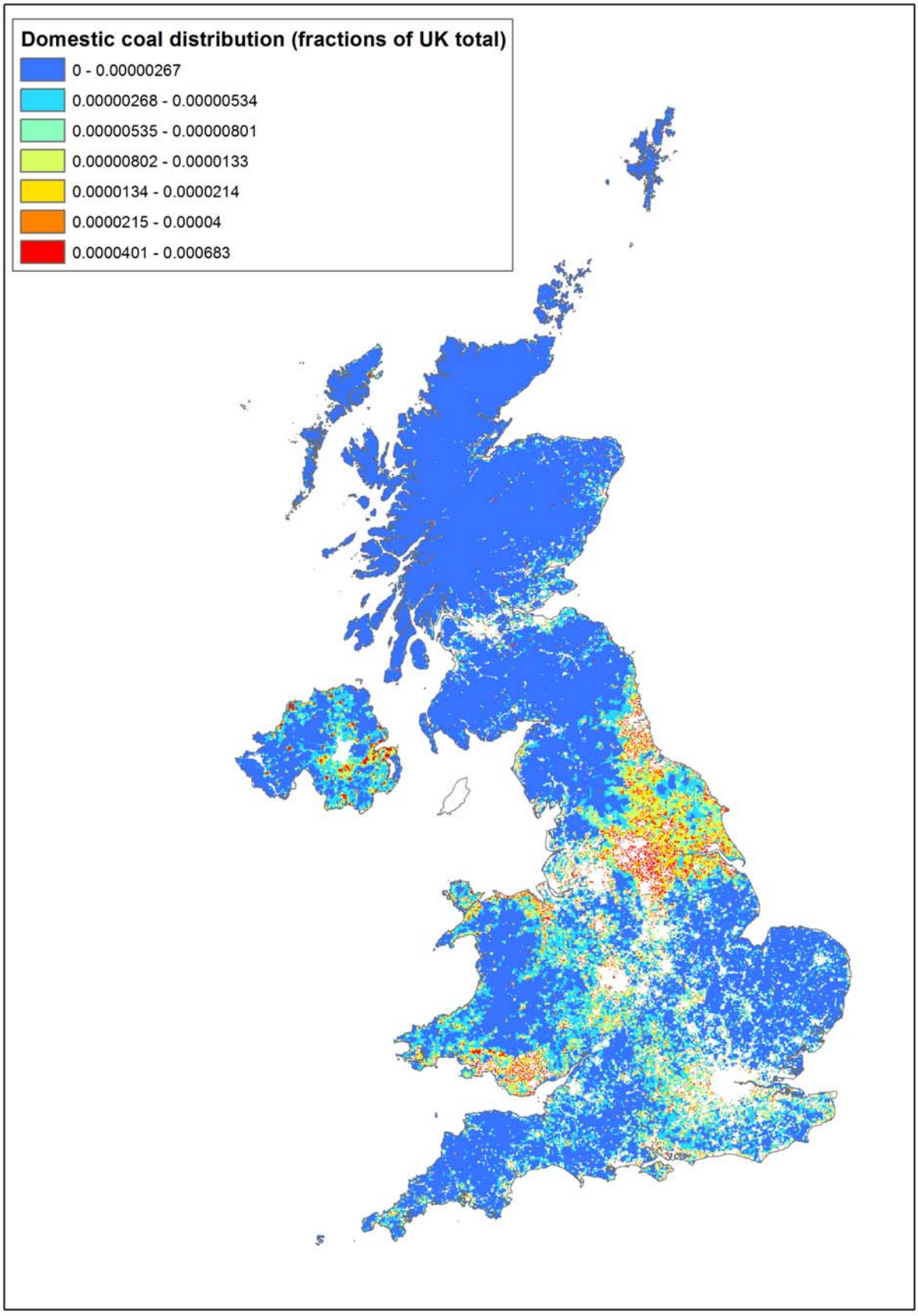
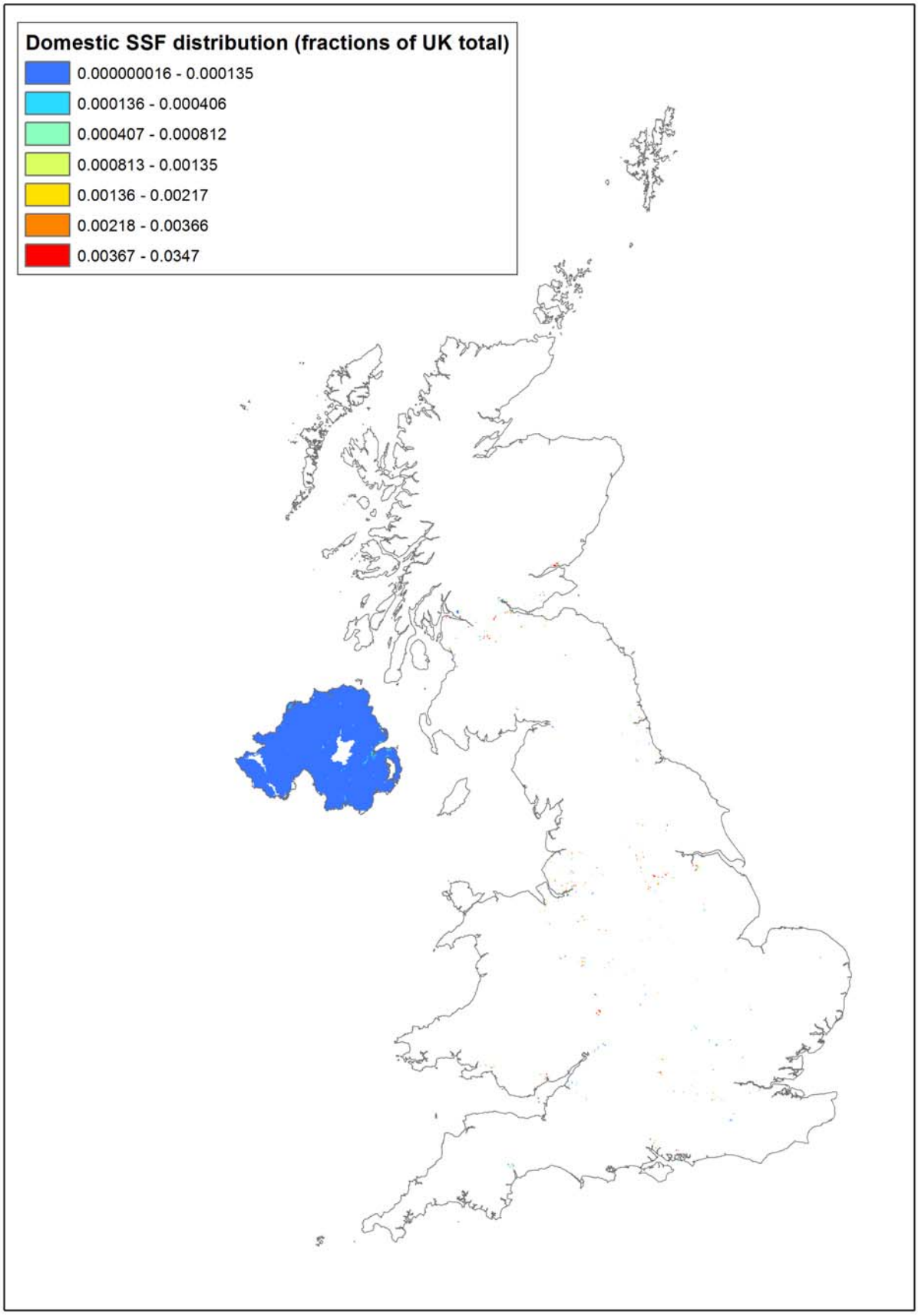
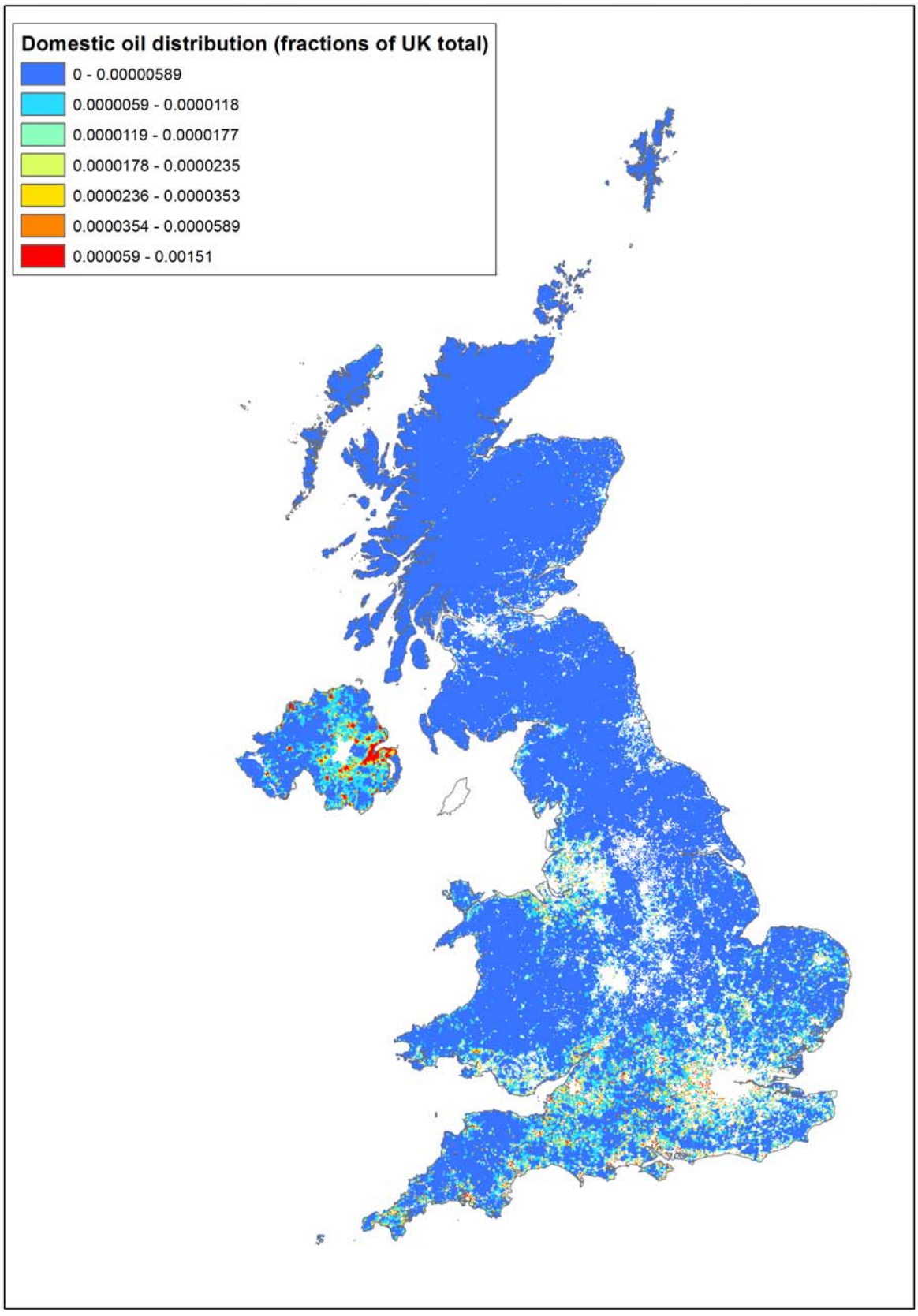


**Figure 12** Modelled domestic smokeless solid fuel use



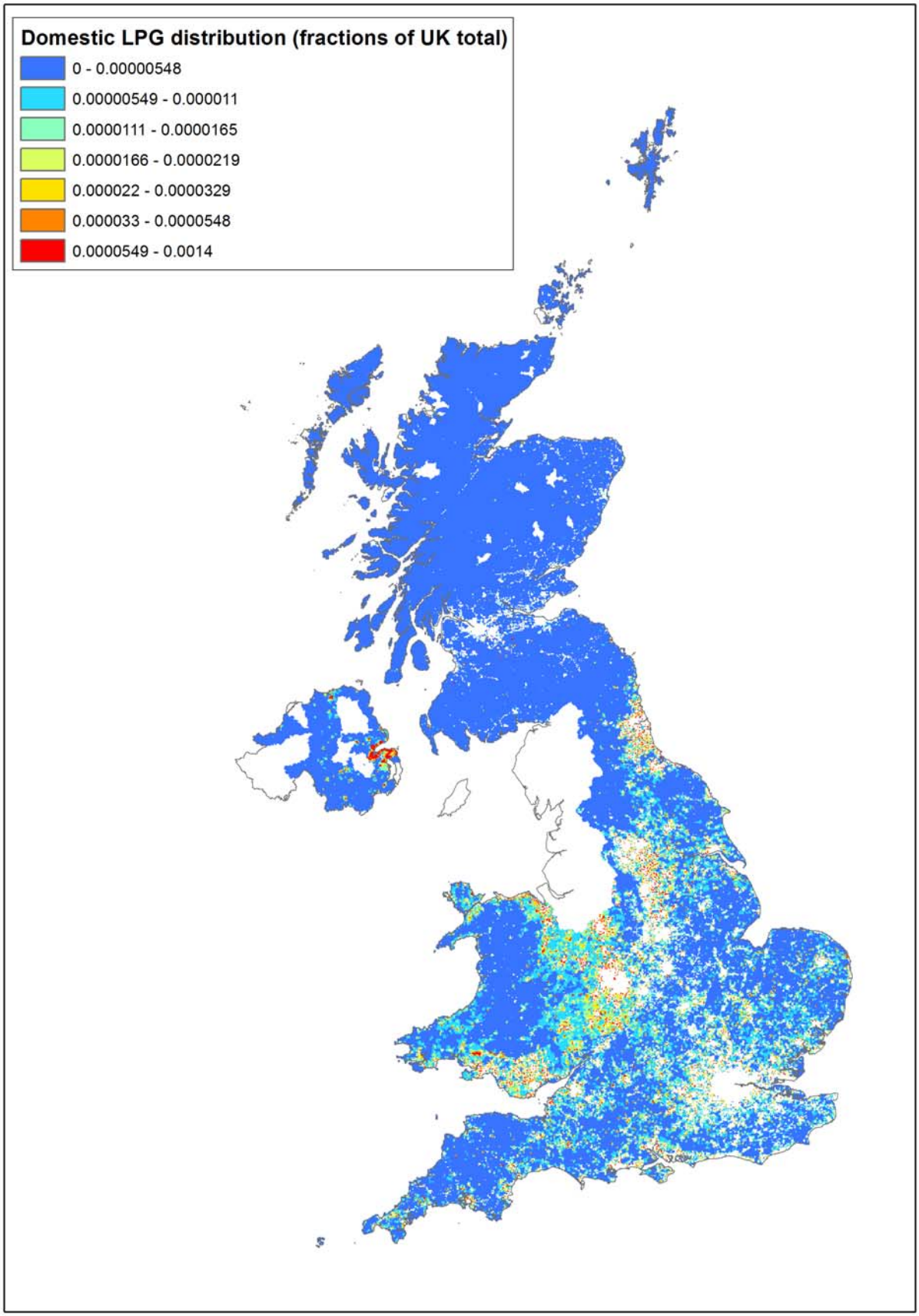

Note: the method used in Northern Ireland assumed a widespread use of smokeless fuels based on fuel survey data and population distributions whereas for GB SSF has been limited grid cells with residual fuel demand in smoke control areas.

**Figure 13** Modelled domestic oil use




Note: the NAEI regional inventory states that 26% of domestic oil is used in Northern Ireland, which results in the values in Northern Ireland looking significantly higher than in GB for equivalent sized towns. This reflects the limited availability of gas in Northern Ireland but the estimate may be reviewed in future versions of the inventory.

**Figure 14** Modelled domestic LPG (bottled gas) use




Note: the BRE data states that there is no bottled gas use in the North West region. The survey on which the BRE numbers are based found no bottled gas in this region.

**Further developments of this work: Checking against regional data and independent survey data**

The new maps represent a significant improvement on the previous domestic maps because of new data sources and new modelling techniques. Initial validation of the results show a reasonable match between the model results and the BRE regional data. There are still some quite large differences but given the uncertainties in this work this is not surprising. Further validation of these results will be done as part of the continued development of these maps for the 2005 inventory. This will compare the results with regional data such as the English House Conditions survey and the General Household Survey.

**References**

BRE (2006) a dataset compiled by BRE for AEA Energy & Environment on behalf of Defra based on modelling used to compile the Domestic Energy Fact File for 2004.

Business Geographics (2001) LIFE Sectors database at postcode sector level based on Experian Consumer Surveys.

# Annex 4 Mapping Carbon Emissions & Removals for the Land Use, Land Use Change & Forestry Sector

## Land Use, Land Use Change and Forestry in the National Inventory

The Department for Environment, Food and Rural Affairs (Defra) takes the lead in the UK in preparing the annual Inventory of Greenhouse Gas Emissions for the United Nations Framework Convention on Climate Change. The Inventory is prepared in 7 main sections, or Sectors. Defra have contracted AEA Energy & Environment to prepare the main greenhouse gas emissions inventory but contract the Centre for Ecology and Hydrology to prepare the data for the Sector 5 tables relating to Land Use, Land Use Change and Forestry in the UK.

In addition to the National Greenhouse Gas Inventory, the UK is required to provide reports to both the EU and the UNFCCC on its progress towards its Kyoto Protocol target. Article 3.3 of the Kyoto Protocol requires Parties in meeting their emissions reduction commitments to account for Afforestation, Reforestation and Deforestation (ARD) since 1990. Accounting ARD under Article 3.3 requires i) definition of forest, ii) knowledge of forest type and planting/deforestation date, iii) geographical location, and iv) a method to distinguish deforestation from areas harvested and replanted. Also, Article 3.4 of the Kyoto Protocol allows Parties flexibility to choose Forest Management, Cropland Management, Grazing Land Management and Revegetation towards meeting commitments, but this is not mandatory. The UK elects Forest Management as an activity under Article 3.4, but does not elect Cropland Management, Grazing Land Management and Revegetation (Defra 2006). The activities of afforestation, reforestation and deforestation are covered by Sector 5, the Land Use, Land Use change and Forestry Sector (LULUCF).

CEH (Edinburgh) annually prepares Sector 5 estimates for inclusion in the UK GHG Inventory. These estimates are made using dynamic models of change in stored carbon driven by land use change data. For forestry, the model deals primarily with plant carbon and is driven by the area of land newly afforested each year. Changes in soil carbon are driven by estimated time series of land use transitions between semi-natural, cultivated (farm), woodland and urban. The models, and those for other LULUCF activities, are run for each of the four devolved administrative regions of the UK. Until now no data has been reported in map format at a scale below the devolved administrations (England, Scotland, Wales and Northern Ireland); here we report results from preliminary methods to provide estimates of LULUCF emissions and removals at the scale of Local Authority within the UK.

The LULUCF Sector is different from other sectors in the Greenhouse Gas Inventory in that it contains both sources and sinks of greenhouse gases. The sources, or emissions *to* the atmosphere, are given as positive values; the sinks, or removals *from* the atmosphere, are given as negative values.

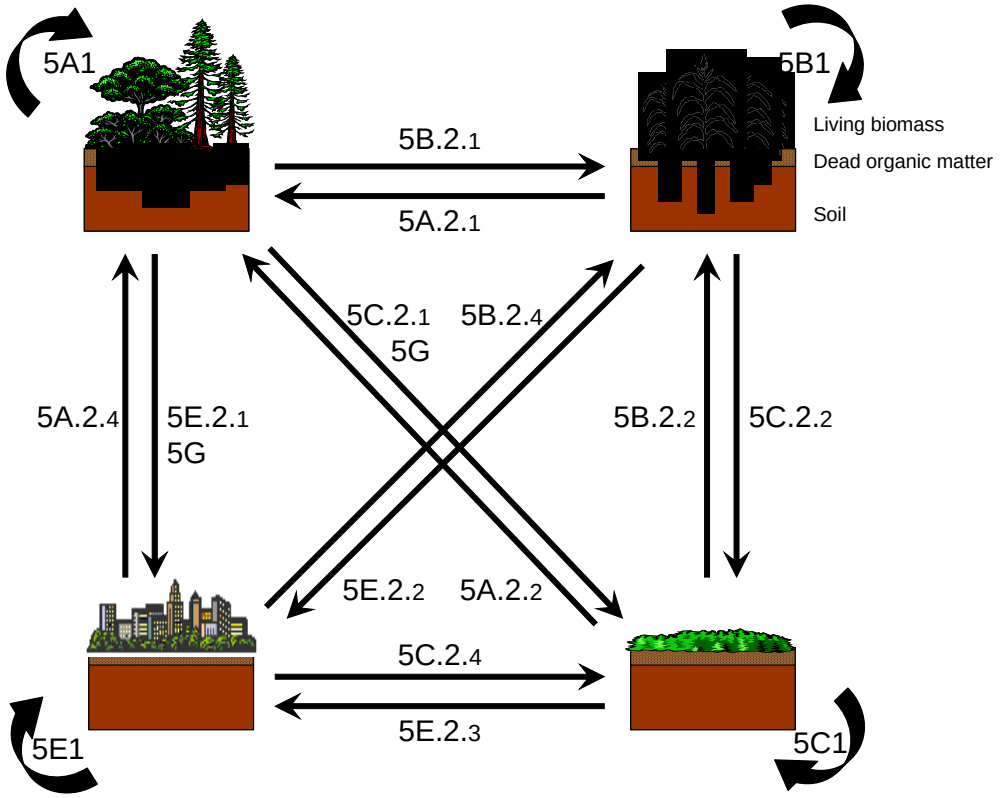
*Categories*

The IPCC Good Practice Guidance (GPG) for Land Use, Land Use Change and Forestry (IPCC 2003) describes a uniform structure for reporting emissions and removals of greenhouse gases. This format for reporting can be seen as “land based”; all land in the country must to be identified as having remained in one of six classes since a previous survey, or as having changed to a different (identified) class in that period. The six land classes are A. Forest Land, B. Cropland, C. Grassland, D. Wetlands, E. Settlements and F. Other land.

Category G. Other is used for LULUCF activities that do not fall within any of the other categories.

The GPG allows modification of the basic set of six land classes to match national databases. In the UK, areas of wetlands will either be saturated land (e.g. bogs, marshes) and, due to the classifications used in the Countryside Survey, will fall into the Grassland category or into open water, which is included in the Other Land category. The Other land category includes lakes, rivers, reservoirs and rocky coastal land etc and no emissions or removals are reported. In addition, it is assumed that there are very few, if any, transitions of land to a type that is classified as 'Other'. Thus, for practical uses, the UK land use change matrix can be simplified to that shown in Figure 15 including only Forest Land (A), Cropland (B), Grassland (C) and Settlements (E) (shown clockwise from top left). For each land use and land use transition, the change in stocks of carbon in living biomass (above and below ground), dead biomass and soil organic matter should be reported. In Figure 15, each arrow represents the possible change for an area of land between two time points showing the corresponding category designation; '1' refers to land that has not changed use (e.g. 5A1 is for Forest Land remaining Forest Land) , '2' refers to land that has undergone change (e.g. 5A2.1 is for Cropland converted to Forest Land).

**Figure 15:** UK Sector 5 land use transitions showing categories for carbon stock change. See text for details.




Different activities are associated with each land use or land use change. For example, 'afforestation' refers to all land change to Forest Land, 'peat extraction' affects Grassland remaining Grassland and 'liming' relates to all Cropland and Grassland. The change in carbon stocks of living biomass, dead biomass and soil organic matter must be reported for each activity together with other relevant non-carbon changes.

Further subdivision of the classes by ecosystem, administrative region or time of occurrence of change is also encouraged in the IPCC Good Practice Guidance. For the UK, the data is currently subdivided into England, Scotland, Wales and Northern Ireland where possible and some categories are further disaggregated into time periods relating to the effects of forest planting before or after 1990. Subdivision into smaller units, such as

20kmx20km regions, is appropriate for modelling purposes and reporting of estimates to Local Authority scale is described in this report.

*Activities*

The activities relevant to LULUCF are listed in Table 24. The main category designations are listed with the activity description and the UK total emissions/removals (kT $CO_2$) for 2004 as reported in the 2004 Inventory. The activities are sorted in order of magnitude and divided into four groups; afforestation, emissions from soils due to land use change, minor emissions and categories assumed to have zero emissions/removals for the UK. Full details are given in the report "Land Use Change and Forestry: The 2004 UK Greenhouse Gas Inventory and projections to 2020" (CEH 2006).

**Table 24:** The UK carbon emissions and removals in Sector 5 (Land Use, Land Use change and Forestry) for 2004 sorted in order of magnitude.

| Category | Activity | 2004 UK total kT $CO_2$ emission (+) or removal (-) |
|---|---|---|
| 5A2 | Land converted to Forest Land (Afforestation) | -16302 |
| 5B2 | Land converted to Cropland (Soil) | 14035 |
| 5C2 | Land converted to Grassland (Soil) | -8441 |
| 5E2 | Land converted to Settlements (Soil) | 6245 |
| 5B1 | Cropland remaining Cropland (Lowland drainage) | 1195 |
| 5B1 | Cropland remaining Cropland (Yield improvement) | -641 |
| 5G | Harvested Wood Products | 619 |
| 5B | Liming of Cropland | 496 |
| 5C1 | Grassland remaining Grassland (Peat extraction) | 355 |
| 5C | Liming of Grassland | 319 |
| 5B2 | Land converted to Cropland (Non-forest biomass) | 244 |
| 5C2 | Land converted to Grassland (Non-forest biomass) | -198 |
| 5C2 | Land converted to Grassland (Deforestation to grass) | 129 |
| 5E | Land converted to Settlements (Deforestation to settlements) | 53 |
| 5E2 | Land converted to Settlements (Non-forest biomass) | -51 |
| 5E1 | Settlements remaining Settlements | 0 |
| 5A1 | Forest Land remaining Forest Land | 0 |
| 5D1 | Wetlands remaining Wetlands | 0 |
| 5D2 | Land converted to Wetlands | 0 |
| 5F1 | Other Land remaining Other Land | 0 |
| 5F2 | Land converted to Other Land | 0 |

Each of the three (non-zero) groups of activities is described below. Emissions and removals from the LULUCF Sector are predominantly of $CO_2$. Emissions of other greenhouse gases are produced by biomass burning during the conversion of Forest Land to Grassland or to Settlements ($CH_4$, $N_2O$, $NO_x$ and CO). Estimates of $N_2O$ and $CH_4$ emissions and removals from other land use change activities will be included in the 2005 inventory but these are anticipated to be very small quantities. Emissions of these non-$CO_2$ gases from agricultural land (e.g. due to fertilization) are already reported in the Agriculture sector of the Greenhouse Gas Inventory. Only carbon (for $CO_2$) is included in this report.

Note that throughout this report the Figures 3-9 show a map of the UK using one of two colour charts; maps in yellow-red-black indicate sources of carbon, maps in blue-green indicate sinks of carbon. Each map has been scaled individually to show most effectively the pattern of carbon flux in that category – the scale is shown on the key for each map.

**Forestry – Afforestation**

For the National Inventory, the carbon uptake by forests planted since 1922 is calculated by a carbon accounting model, C-Flow, as the net change in pools of carbon in standing trees, litter and soil for conifer and broadleaf forests and in products (Dewar & Cannell 1992, Milne *et al.* 1998). Forests accumulate carbon (removing it from the atmosphere) in their biomass and soils as they grow, but timber harvesting and planting activities disturb this accumulation and result in emissions of carbon to the atmosphere. The net carbon stock change at any one time depends on the balance between these different activities. Forestry management cycles operate over long time scales (50 years+) so the rate of carbon removal *now* is driven by the rate of forest planting in previous decades. Two types of input data are required for the model; a) areas of new forest planted in each year in the past, and b) the stemwood growth rate and harvesting pattern.
For the National estimates we use the combined area of new private and state planting from 1922 to 2000 for England, Scotland, Wales and Northern Ireland sub-divided into conifers and broadleaves. For mapping at LA scale, the C-Flow model was applied to 20km x 20km grid squares across the UK by estimating the required input planting data at this scale. The planting data was also extended to 2004. The model output per grid square was then combined to provide estimates per Local Authority (LA). This is achieved by taking the grid square data and assigning appropriate values to every 1km square in the UK. These smaller units can then be combined according to the LA boundaries (see Figure 16).

**Figure 16:** Model output is generated for 852 squares across the UK. Data are combined to provide estimates for each Local Authority (data for illustration only).

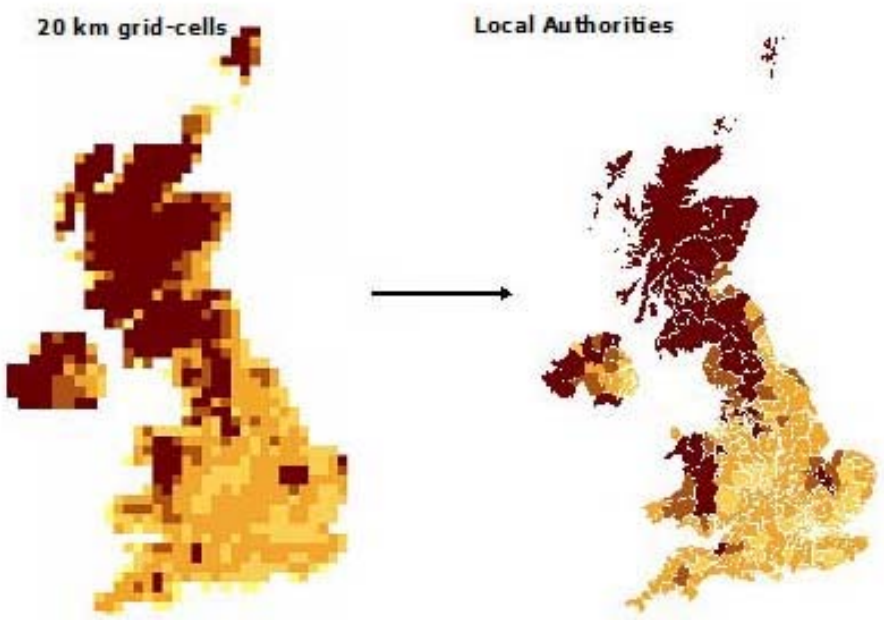
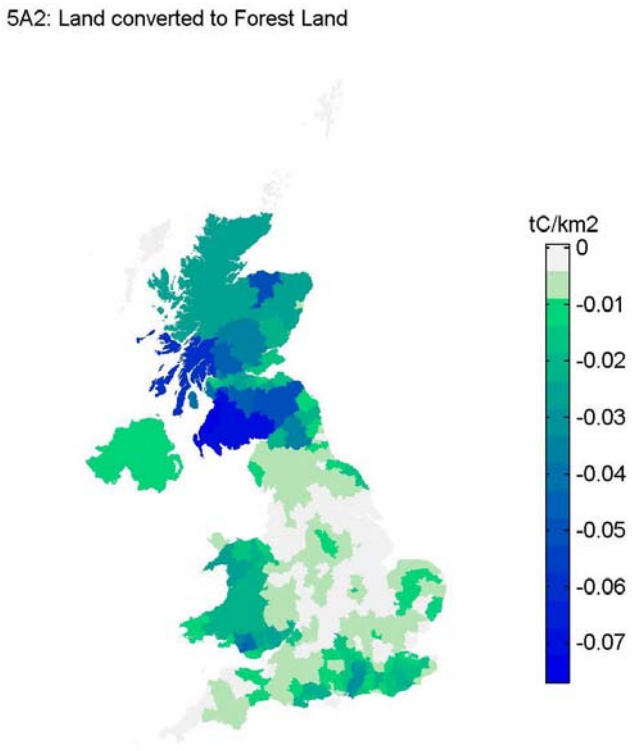



Figure 17 shows the distribution of carbon removals due to afforestation across the UK expressed as tC per $km^2$. Maps of total carbon emissions/removals per LA can be misleading due to the wide range of areas across authorities – maps tend to be dominated by the Highlands region of Scotland.

**Figure 17:** Distribution of carbon removals from the atmosphere due to afforestation across the UK expressed as tC per $km^2$.




**Cropland, Grassland, Settlements – Emissions from Soils due to land use change**

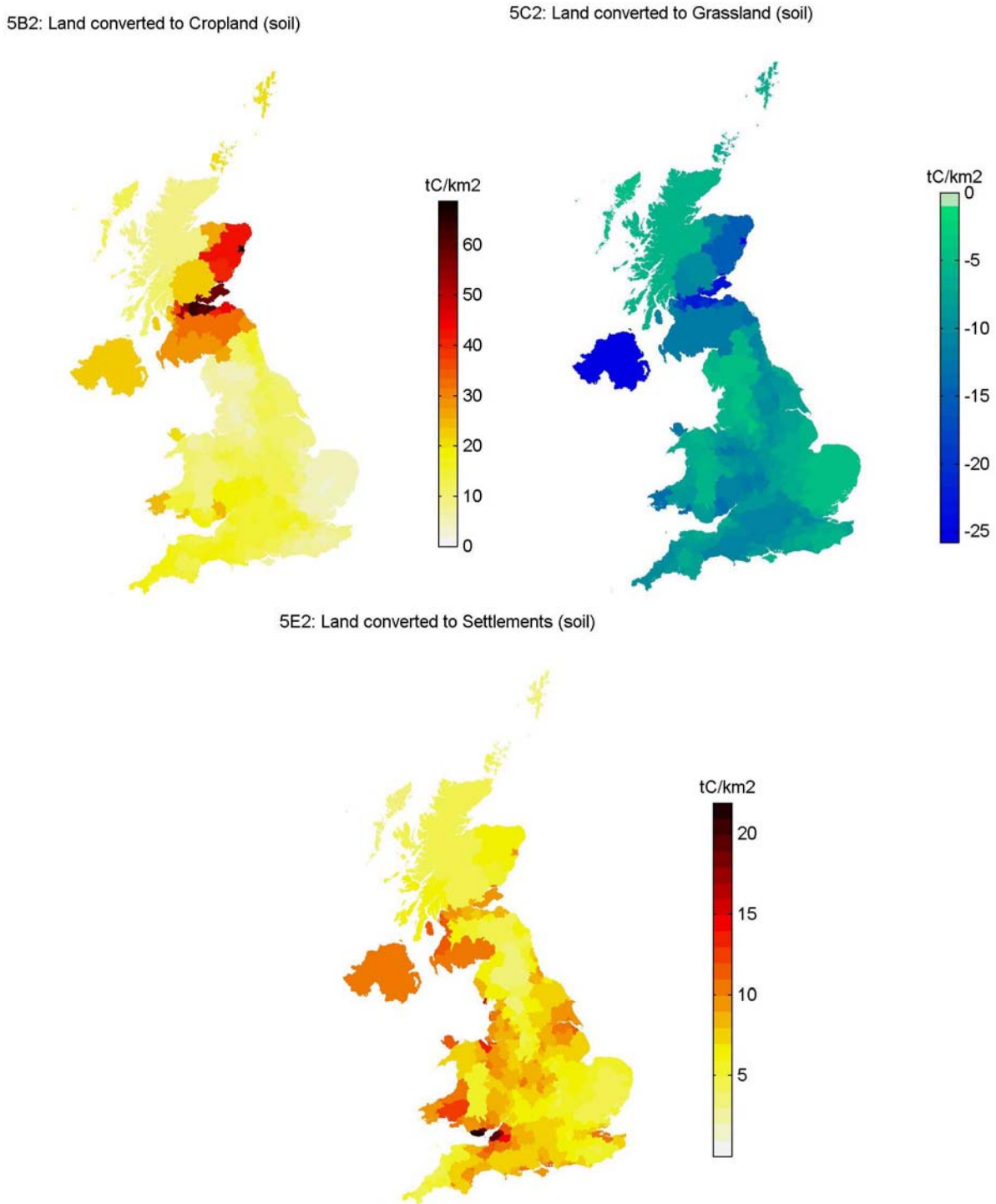
Changes from one land use type to another will result in a change in soil carbon stocks over time. The change in vegetation cover and management will affect the amount of carbon that goes into the soil from biomass decomposition. Also, the initial disturbance of the soil will release carbon to the atmosphere.

For the National Inventory, the method for assessing changes in soil carbon stock due to land use change links a matrix of change from land surveys to a dynamic model of carbon stock change. For Great Britain (England, Scotland and Wales), matrices from the Monitoring Landscape Change data from 1947 & 1980 (MLC 1986) and the Countryside Surveys (CS) of 1984, 1990 and 1998 (Haines-Young *et al.* 2000) are used. In Northern Ireland, less data are available to build matrices of land use change, but for 1990 to 1998 a matrix for the whole of Northern Ireland was available from the Northern Ireland Countryside Survey (Cooper & McCann 2002). The only data available pre-1990 for Northern Ireland are land use areas from the Agricultural Census and the Forest Service (Cruickshank & Tomlinson 2000). Matrices of land use change were then estimated for 1970-80 and 1980-90 using area data. The basis of the method devised assumed that the relationship between the matrix of land use transitions for 1990-1998 and the area data for 1990 is the same as the relationship between the matrix and area data for each of two earlier periods – 1970-79 and 1980-89. The matrices developed by this approach were used to extrapolate areas of land use transition back to 1950 to match the start year in the rest of the UK.

We have developed time series of land use change in 20 x 20 km grid-cells (to match those used for the afforestation fluxes) for the period from using the Countryside Surveys covering periods 1984 to 1990 and 1990 to 1998. The land use change matrices for the 20 x 20 km grid-cells are scaled to match those used in estimates of emissions and removals for the devolved administration areas in the United Kingdom. These matrices are then used

for each grid-cell in a model analogous to that presently used for the full devolved area. The data are then combined to give estimates per Local authority region (see Figure 18).

**Figure 18:** Emissions from soil due to land use change (tC/km$^2$) for conversion of all land type to (a) Cropland (b) Grassland and (c) Settlements.

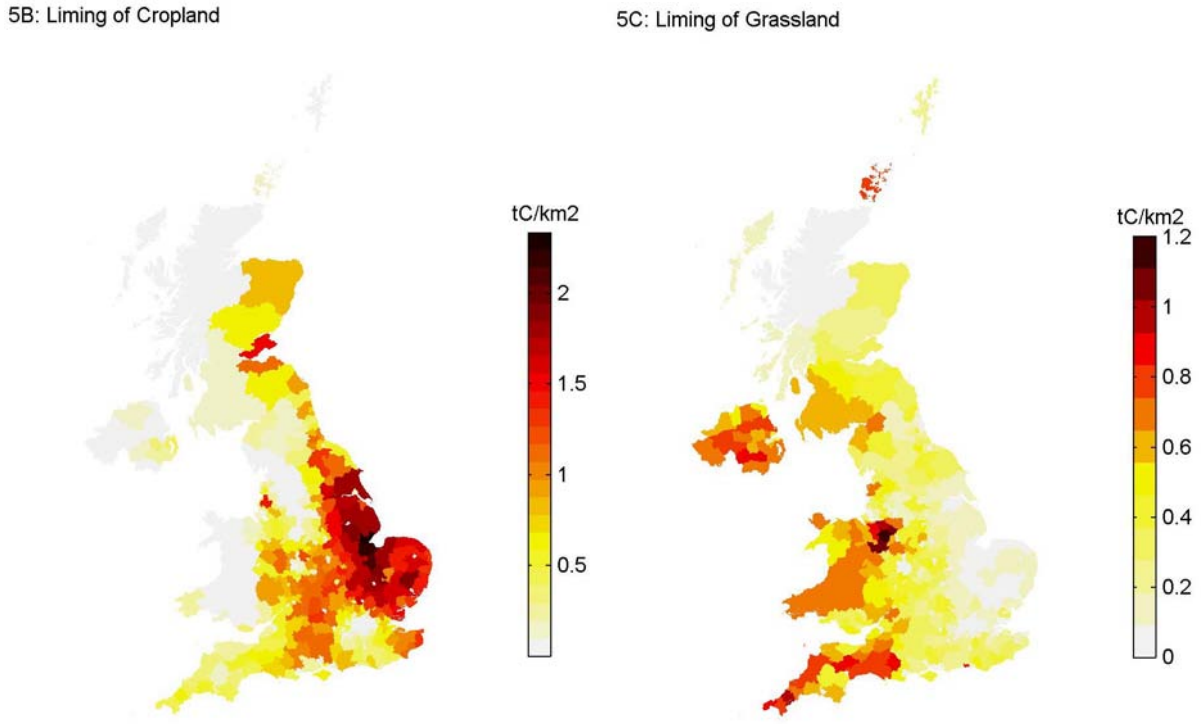


## Estimates of various minor emissions

*Liming of Cropland and Grassland*

The National Inventory estimate of carbon flux due to liming of agricultural land (Grassland and Cropland) uses land use data from the Agricultural Census for the four devolved administrations, England, Scotland, Wales and Northern Ireland. Similar land use data is also available from the Census at a smaller scale, at local authority or regional groupings, so the flux can be estimated for each LA using the same method as used nationally (see Figure 19).
Due to non-disclosure and confidentiality issues the sum of the LA land use data from the Census does not exactly equal the published national totals; the estimated carbon flux data from the LA calculations do not exactly equal that submitted in the National inventory. We have assumed that the difference in published areas applies to all LAs in proportion to their area and have adjusted the flux estimates so that the sum is equal to the submitted inventory value (5B liming and 5C liming).

**Figure 19:** Carbon emissions due to liming of agricultural land, (a) Cropland and (b) Grassland.




*Non-Forest Biomass*

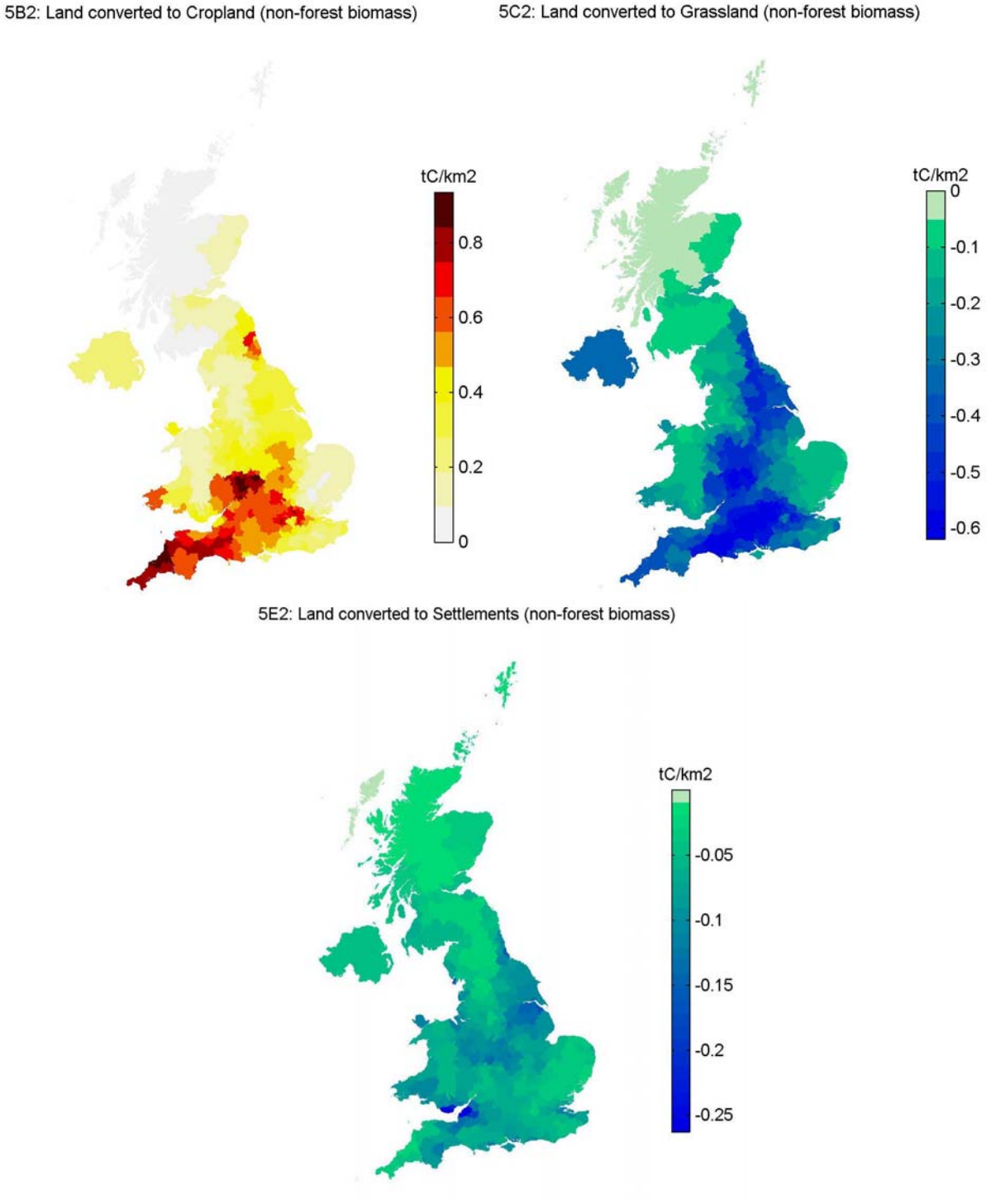
The different land use types have different biomass carbon densities at equilibrium. Change from one land use type to another can result in an increase or decrease in biomass carbon density. This category describes the annual change in the carbon stock in vegetation biomass due to all land use change to Grassland, Cropland or Settlements, excluding forests and woodland.

For the National Inventory, estimates of emissions and removals for this category are made using the Countryside Survey Land Use Change matrix approach, with biomass densities weighted by expert judgment. Changes in carbon stocks in biomass due to land use change are now based on the same area matrices used for estimating changes in carbon stocks in soils. The biomass carbon density for each land type is assigned by expert judgement based on the work of Milne & Brown (1997). Five basic land uses were assigned initial biomass carbon densities, then the relative occurrence of these land uses in the four countries of the UK were used to calculate mean biomass carbon densities for each of the

IPCC types, Cropland, Grassland and Settlements. The mean biomass carbon densities for each land type were then weighted by the relative proportions of change occurring between land types in the same way as the calculations for changes in soil carbon densities. Changes between these equilibrium biomass carbon densities were assumed to happen in a single year.

This matrix approach was extended and applied to each 20km x 20km grid square across the UK, and the results combined to give estimates for each Local Authority (see Figure 20).

**Figure 20:** Carbon emissions and removals across the UK due to changes in non-forest biomass (vegetation) following land use change to Cropland, Grassland or Settlements.

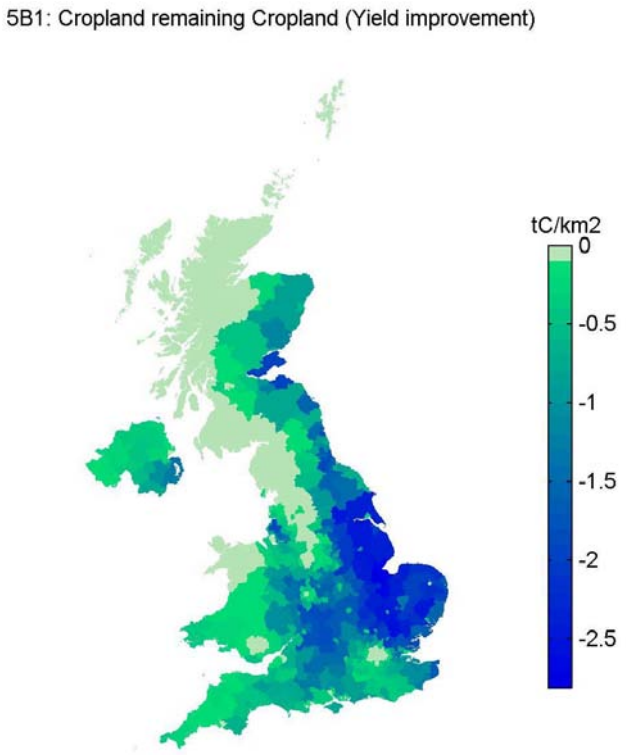


*Crop Yield Improvement*

There is an annual increase in the biomass of cropland vegetation in the UK that is due to yield improvements (from improved species strains or management, rather than fertilization or nitrogen deposition). For the 2004 national inventory there has been a complete revision of the activity data and methodology in this category. The increases in crop yield are now calculated separately from those resulting from land use change.

The method used for the national figures has been repeated separately for each Local Authority as the required cropland area data are available (see Figure 21).

**Figure 21:** Carbon removals due to increases in Crop yield. This is part of the Cropland remaining Cropland category.

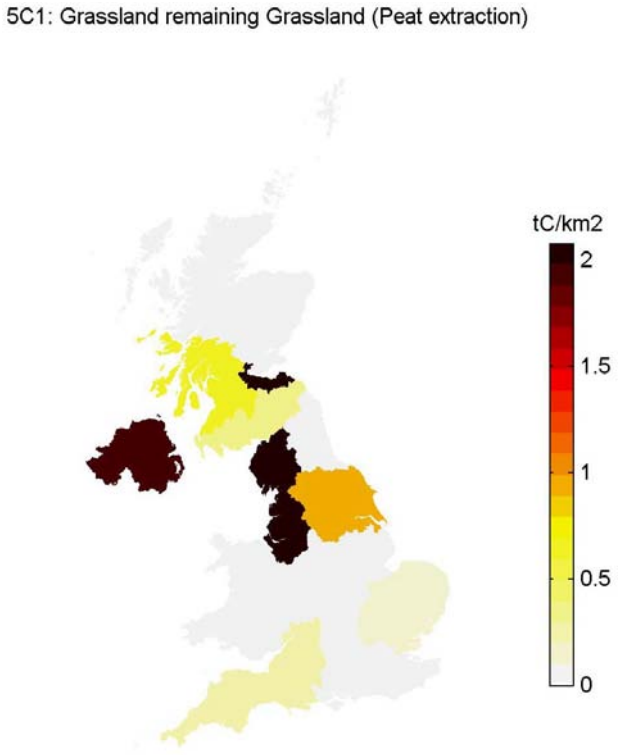



*Peat Extraction*

Carbon emission from peat extraction is calculated for the National Inventory based on data published in the *Mineral Extraction in Great Britain Business Monitor PA1007.* The data are also given for smaller regions, e.g. North East England, but not at the LA level. We have assumed that the data applies to all the LAs within the region in proportion to their area. The peat extraction data gives the area of origin of the peat and we have assumed that the carbon emission applies to this area (see Figure 22).

Due to non-disclosure and confidentiality issues for West Central Scotland and the Highlands, total figures are given but not broken down into peat for fuel or horticultural use. We have assumed that all extraction in the Highlands is for fuel (which is reported in the Energy sector) and that all extraction in West Central Scotland is for horticultural use. Also, due to rounding errors in the published figures, the sum of the extraction areas for the regions does not exactly equal the national totals. The emissions per LA have been adjusted in proportion to their area so that the total equals the submitted national emission.

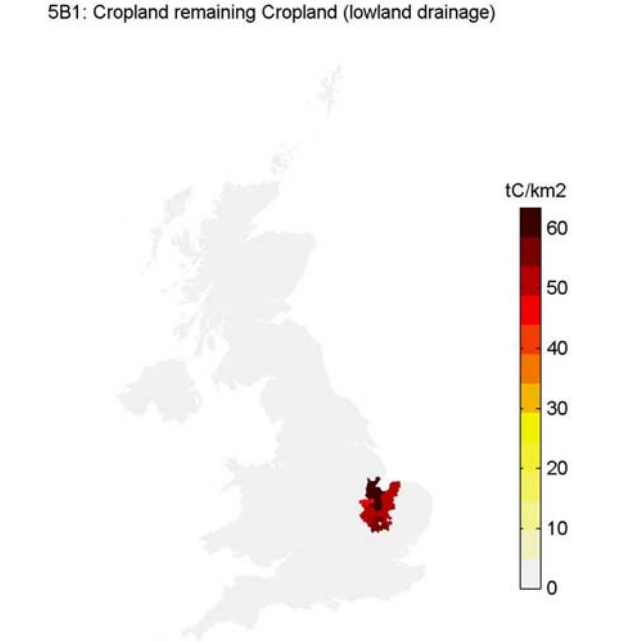
**Figure 22:** Carbon emissions, tC/km$^2$, resulting from the extraction of peat for horticultural use. This is part of the Grassland remaining Grassland category.




*Lowland Drainage*

Lowland wetlands in England were drained many years ago for agricultural purposes and continue to emit carbon from the soil. Bradley (1997) described the methods used to estimate these emissions but details of the exact locations are not given; the area is described as the East Anglian Fen and Skirtland (and limited areas in the rest of England). Using a map of peatland in England, we have allocated emissions to the Local Authorities falling within and around East Anglia with larger areas of peatland. For 2004, the total UK emission in this category is 326 GgC. Figure 23 shows the estimated distribution and emissions (tC/km$^2$).

**Figure 23:** Carbon emissions in 2004 due to lowland drainage in previous years.

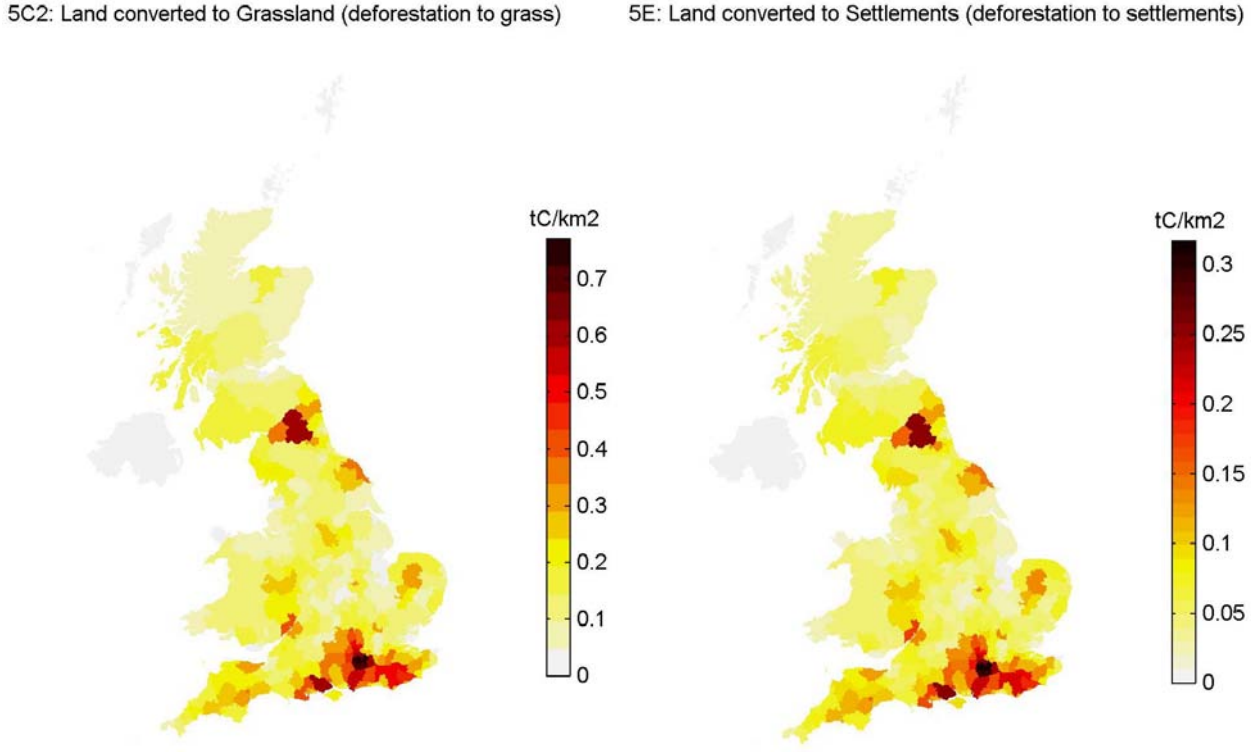


*Deforestation*

In the 2003 Inventory deforestation was assumed only to be a conversion of Forest land to Settlements. For the 2004 national inventory, a revised interpretation of the available data allows the emissions to be disaggregated into deforestation to Grassland (reported in 5C) as well as to Settlements (reported in 5E). Deforestation to Cropland is negligible and deforestation is not estimated for Northern Ireland.

Deforestation figures from the Forestry Commission were collated by Levy and Milne (2006) for England, Scotland and Wales and the resulting carbon emissions reported in the national inventory. The area of land deforested in each Local Authority is not currently available so we assume that the area deforested is proportional to the total area of forest in each LA, and that the relative conversion of forest to either Settlement or Grassland is the same for each LA (see Figure 24).

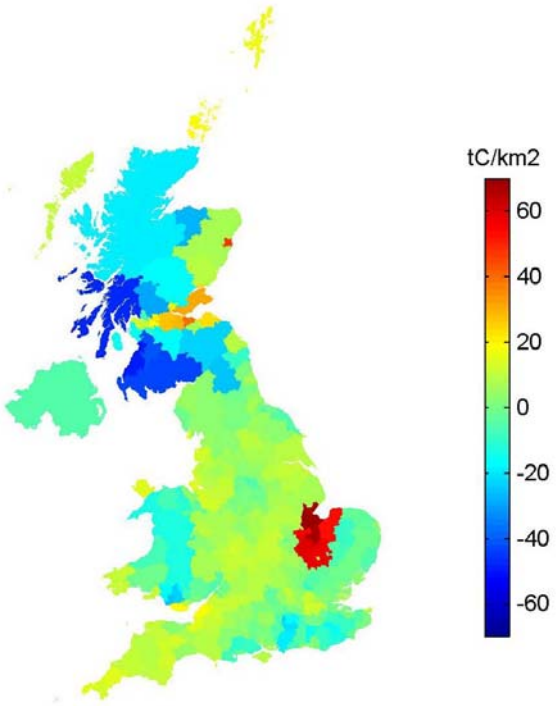
**Figure 24:** Emissions of carbon resulting from deforestation to Grassland or Settlements. Note that the scales are different for the two maps.



## Summary

The total carbon emissions for the UK land use, land use change and forestry sector (excluding harvested wood products which cannot be mapped) are shown in Figure 25.

**Figure 25:** The total carbon emissions or removals for Sector 5 across the UK.

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