Local and Regional CO_2 Emissions Estimates for 2003

A report produced for Defra

Justin Goodwin
Katie King
Neil Passant
James Sturman
Yvonne Li

August 2005

Netcen/ED48209Ext9/Issue1

Local and Regional CO_2 Emissions Estimates for 2003

A report produced for Defra

Justin Goodwin
Katie King
Neil Passant
James Sturman
Yvonne Li

August 2005

Netcen/ED48209Ext9/Issue1

Title	Local and Regional CO_2 Emissions Estimates for 2003
Customer	ESI, Defra
Customer reference	
Confidentiality, copyright and reproduction	This document has been prepared by AEA Technology plc in connection with a contract to supply goods and/or services and is submitted only on the basis of strict confidentiality. The contents must not be disclosed to third parties other than in accordance with the terms of the contract.
File reference	**ED 48209901**
Report number	**AEAT/ENV/R/2036**
Report status	Unrestricted

Netcen
AEA Technology Environment
Building 551
Harwell Business Centre
Didcot
Oxon.
OX11 0QJ
Telephone 0870 1906511
Facsimile 0870 1906607

	Name	Signature	Date
Authors	Katie King Neil Passant		
Reviewed by	Chris Dore		
Approved by	Geoff Dollard		

Contents

1 Introduction

This report describes work undertaken by Netcen to provide Defra with Local Authority (NUTS4) and Government Office Regions (NUTS1) level carbon dioxide emissions estimates for 2003. 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.

1.1 Aim

The aim of this project is to provide nationally consistent carbon dioxide emission estimates at local authority and regional level. The data represent the primary emissions from the consumption of fuel or other process activities that emit CO_2 plus the emissions relevant to the production of consumed electricity. The data are intended to provide a starting point for further thought on quantifying emissions at a local and regional level. The estimates presented stretch the bounds of what is reasonable to assume in an attempt to provide a number for each Local Authority and Region and sector and 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 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 data can be used as a starting point for regional and local authority climate change indicators in the Government's Sustainable Development indicator set and the Audit Commission's updated set of Quality of Life indicators respectively. It is hoped that these data as they are presented can stimulate discussion and interest in Local Carbon accounting as a step towards reducing emissions of carbon. Where better local data is available from local governments these data can be used to improve the estimates over time.

1.2 Methodology

This work has been made possible following the publication of new local gas, electricity and road transport fuel consumption estimates by DTI (DTI 2004a, DTI 2005b). Together these 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 DTI electricity consumption data has enabled Netcen to map for the first time carbon dioxide emissions from electricity generation to the point of consumption. This is a key difference to the data previously published by the NAEI where emissions have traditionally been 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 2003.

The local CO_2 estimates presented in this report are split into three categories: domestic (including electricity use), industrial and commercial (not including power stations) and road transport. Within each sector there is then further disaggregation by fuel and/or source type which requires further assumptions about the fuel mix and demand. Natural (e.g. soils) and land use change emissions are also included in the LA data. 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, fishing and coastal shipping, are reported as unallocated because these could not be spatially disaggregated to LA level.

This reporting structure 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). The simplified structure has been adopted because of the aggregated nature of the data available from the DTI.

1.3 Structure of this report

Official estimates of total UK emissions of CO_2 for 2003 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. The results are summarised in **Section 4** and provided in detail in a spreadsheet which accompanies this report (LocalRegionalCO2_2003V4.xls). **Section 5** of this report provides recommendations for improvements to this analysis.

2 Summary of CO_2 inventory for the UK

An overview of the UK inventory for CO_2 in 2003 is presented here (NAEI UK Emissions Inventory 2003). This provides a context for the data presented in this report.

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, 2004). 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)

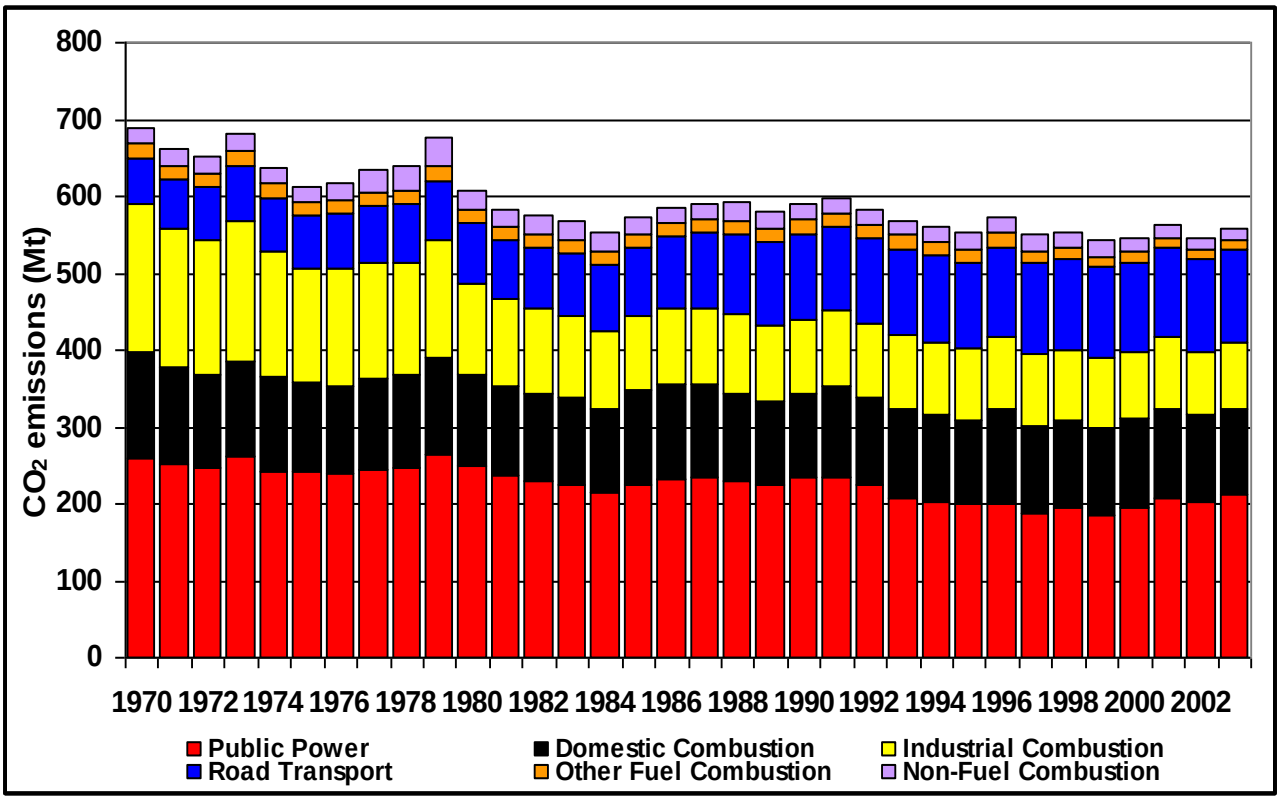


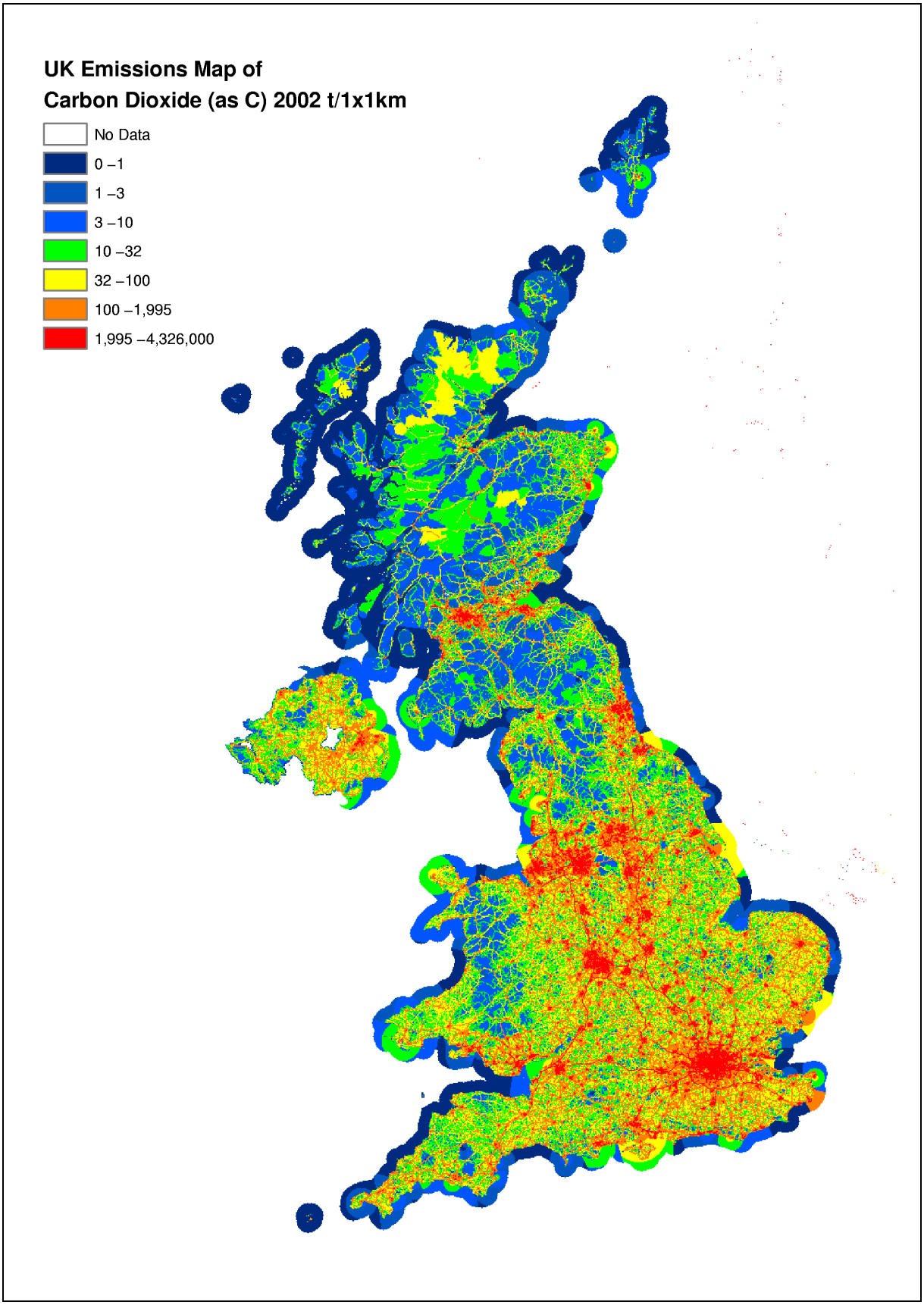
Table 1 **UK Fuel Consumption, 2003**

Fuel	Consumer		2003
Coal	Major Power Prod	Mtonnes	52
Coal	Industry	Mtonnes	3
Coal	Domestic	Mtonnes	1
Coal	Others	Mtonnes	1
Other Solid Fuels	All Consumers	Mtonnes	2
Motor Spirit	Road Transport	Mtonnes	20
Gas Oil	Road Transport	Mtonnes	18
Gas Oil	Industry	Mtonnes	4
Gas Oil	Others	Mtonnes	3
Fuel Oil	Major Power Prod	Mtonnes	1
Fuel Oil	Refineries	Mtonnes	2
Fuel Oil	Industry	Mtonnes	1
Fuel Oil	Others	Mtonnes	0
Orimulsion	Major Power Prod	Mtonnes	0
Burning Oil	Domestic	Mtonnes	3
Burning Oil	Others	Mtonnes	1
Aviation Turb. Fuel	Air Transport	Mtonnes	11
Other Pet. Products	All Consumers	Mtonnes	1
Petroleum Gases	Refineries	Mtherms	1136
Petroleum Gases	Others	Mtherms	813
Natural Gas	Major Power Prod	Mtherms	9713
Natural Gas	Industry	Mtherms	10518
Natural Gas	Domestic	Mtherms	13171
Natural Gas	Others	Mtherms	4238
Other Gases	All Consumers	Mtherms	901

Source: *Netcen, using the Digest of United Kingdom Energy Statistics published by the DTI*

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 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 new 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 2 below.

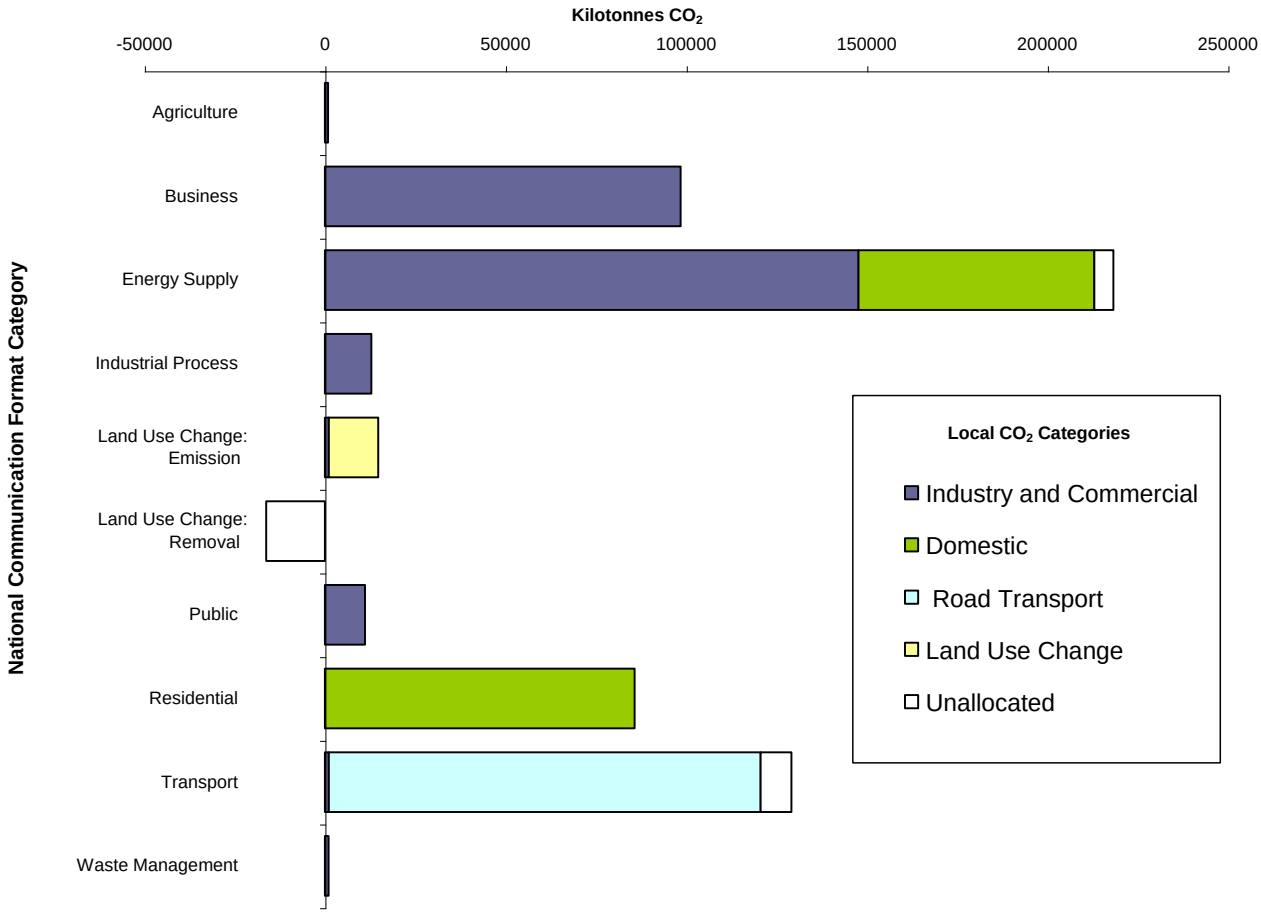
Table 2 NAEI emissions sectors in Local CO_2 reporting categories

Local CO_2 category	**Detailed emission sources included in each category**
Industrial and commercial	Industry, commercial, agriculture and public sector fuel combustion Industry, commercial, agriculture and public sector electricity use Industrial process emissions Management of airports and ports (support vehicles, stationary heating and power) Industrial and agricultural off-road machinery Industry autogeneration of electricity Electricity use and stationary combustion in the rail sector Diesel rail transport Waste incineration Emissions from Agricultural soils Deforestation
Domestic	Domestic fuel combustion Domestic electricity use Domestic house and garden machinery
Road Transport	Road transport fuel use and burning of lubricants
Land Use Change	Natural CO_2 emissions from soils Other land use change emissions (peat extraction)
Unallocated outside LA boundary emissions	Domestic Aviation Offshore gas and oil Shipping (including coastal shipping and fishing) (n.b. International aviation and shipping are outside scope of the UK inventory)
Unallocated inside LA boundary emissions	Some gas and electricity consumers which cannot be allocated for confidentiality reasons or because of problems with geo-referencing

The unallocated emissions are for sectors that cannot be disaggregated to LA level because the emission occur outside the Local Authority area i.e. aviation, shipping and offshore oil and gas or can not be allocated for confidentiality reasons (e.g. Large users of gas and electricity) or errors (e.g. old or non existent postcode references that can not be geo-referenced) in the data sets.

The emission totals in the NAEI CO_2 inventory in the National Communication Format can be compared with the emissions totals in the Local CO_2 reporting categories. This comparison is shown in Figure 3.

Figure 3 Summary of UK CO_2 inventory for 2003



Further comment is provided on this comparison in section 4.1 after the methodology for this work has been explained.

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 3 and descriptions of the data and methods are provided in the following sections.

Table 3 Summary of data sources and methods

LA CO_2 category	Fuel type / sector details	Data sources and method
Domestic	Electricity	DTI electricity consumption data; Surrogate population data to model NI consumption distribution
	Gas	DTI gas consumption data; Further data for Northern Ireland from Phoenix Gas.
	Solid and liquid fuels	NAEI modelling of fuel use distributions using population distributions and household fuel use (Experian survey)
Commercial and industrial	Electricity	DTI electricity consumption data; Surrogate employment data to model NI consumption distribution
	Gas	DTI gas consumption data; Further data for Northern Ireland from Phoenix Gas and individual point sources. Additional NAEI point source data to fill gaps.
	Solid and liquid fuels	NAEI modelling of fuel use based in employment distributions and fuel intensity by sector.
	Industrial process emissions Industry autogeneration of electricity Stationary combustion and electricity use in the rail sector Waste incineration	Large emission points from NAEI point source database. The remaining emissions in each sector distributed using NAEI modelling of employment and fuel intensity.
	Industrial and agricultural off-road machinery	Industrial off-road is allocated using a distribution of employment within heavy industries. Agricultural off-road is allocated according to land use weighted by estimates of machinery usage on different land use types.
	Management of airports (support vehicles, stationary heating and power)	Airport support activities are allocated to airport locations weighted by numbers of aircraft movements at each
	Agricultural soils Deforestation	Application of limestone and dolomite to agricultural soils distributed in proportion to arable land use Emissions from deforestation assumed to be in proportion to forest land cover.
	Rail	Diesel emissions estimated based on train movements (only for GB)
Road Transport	Petrol, diesel and others road transport	Emissions from fuel combustion in the road transport sector based on detailed DfT traffic census data and NAEI emissions factors.
Land Use Change	CO_2 emissions from soils Other land use change emissions (peat extraction)	Natural emissions from soil distributed in proportion to amounts of arable land use Emissions from land following peat extraction distributed in proportion to amounts of bogs (deep peat) land cover

3.1 Electricity consumption

The DTI electricity consumption data used in this work is an experimental dataset published for the first time (DTI, 2004a). It has been compiled using data from the administrative systems of the electricity companies' data aggregators. It has been noted by DTI that the quality of this data is variable across the country and that there is still significant further work to do to improve it. However it provides a very useful first attempt to distribute electricity consumption across the UK.

The CO_2 emission for electricity consumption from the NAEI in 2003 (174,467 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 25 million electricity meters across Great Britain. The location of these meters were determined from the Gemserve database of meters MPAS (Meter Point Administration System). DTI have identified some errors in the data files used to allocate meter point postcodes to local authorities and have published a list (Energy Trends, Sept 2005) of those authorities which they think were most seriously affected. These have been flagged in the spreadsheet accompanying this report.

Data for the industrial and commercial sector was also obtained from meters but there were problems with the geographical referencing of a significant proportion of the meters. Therefore 10% of the industry and commercial electricity consumption has not been allocated to Local Authorities. The carbon emissions associated with this electricity is therefore reported as unallocated in the results presented in this report.

Reconciliation with data in DUKES by DTI found the result to be an over estimate of nearly 5% of the GB total domestic electricity consumption (DTI, 2005a Table 1 p33). This is possibly because of the inclusion of some non-domestic users within this dataset as a result of the requirement for an arbitrary cut-off of 100,000 KWh above which the user is assumed to be industrial or commercial . DTI are still working to improve this. The statistical difference overall for all users is +0.3% and is therefore a good match with DUKES totals.

The DTI data also includes 9210 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 15%.

The DTI dataset does not provide a distribution of electricity consumption in Northern Ireland. The Energy Trends article published in March 2005 (DTI 2005a) does however provide total electricity consumption for the domestic sector (2589 Gwh) and industrial and commercial sectors (4121 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.

3.2 Gas consumption

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 (DTI 2004a). The estimates have been compiled by DTI using data provided by National Grid Transco (NGT) at postcode sector level. DTI have allocated each postcode sector in the NGT dataset to one or more Local Authority (LA) area. Issues exist for future gas data collection with the expected break up of NGT. DTI are working to secure future data supply from future gas distributors.

Data quality issues

There are a number of issues with the NGT data that reduce the overall quality of the dataset and results in some misallocation of gas use between LAs but 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. DTI have listed (Energy Trends, March 2005) those authorities where they think these problems seem to be most evident in terms of estimated domestic customer numbers, and these have been flagged in the spreadsheet accompanying this report.

Firstly for reasons of confidentiality some postcode sectors in the NGT 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 – an equal split based on land area. Where local information was received from LAs to provide a better split then this was used.

Thirdly some postcode sectors specified in the NGT 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 NGT to locate gas meter points. DTI made simple assumptions to allocate these postcode sectors to LAs which had postcode sectors with similar numbers.

For this project Netcen 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. If NGT is able to provide higher resolution data using up to date postcode sector boundaries in future then these problems could be reduced.

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 31 power stations and 16 large industrial users. However the local authority areas in which these 47 users are located are known as is the total gas usage by the excluded users (by Government Office Region) and users in Northern Ireland. Netcen has used site specific emissions data from the Environment Agency's Pollution Inventory to deduce the locations of these exclusions and to provide estimates of CO_2 associated with them. The method for identifying site specific fuel usage is described in Annex 1 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 800 GWh and for Commercial and Industry the total is 1910 GWh (Moynihan, 2004). This 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.)

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 were calculated using the data from the Netcen point source database which uses public domain emissions data to estimate energy use (see annex 1). The gas consumption at the excluded sites were estimated as follows.

Netcen's site specific fuel usage estimates for gas (derived using the method described in Annex 1 of this report) were compared with the data on the location of the 47 gas consumers excluded from the DTI data in order to deduce which sites in Netcen's point source database might correspond to the exclusions from the DTI data. In the case of the power stations, this was a relatively easy task due to the limited number of power stations in the UK. In most cases, identification of the excluded power station was not in doubt but some uncertainty remained regarding the following:

- The DTI data excluded one power station in Fife but the Netcen data included two power stations which use gas (in one case as a secondary fuel);
- The DTI data excluded three power stations in North Lincolnshire while the NETCEN data included four power stations in this area;
- The DTI data excluded one power station each in Stockton-on-Tees, Kingston upon Hull, and Huntingdonshire, but no power stations could be identified in these areas in the Netcen data. Instead, it was assumed that they referred to power stations in Redcar and Cleveland, East Riding of Yorkshire and Bedford instead.

Some of the problems listed above might arise due to errors in the allocation of sites to local authority areas in one or both sets of data. Local authority boundaries have also changed from time to time and so differences could also be due to the use of data from different periods in the two data sets.

The 16 large industrial users could not be identified with much certainty. In most cases, the Netcen data contained more plant for a given area than were excluded from the DTI data. It was also not clear whether 'plant' given in the Netcen data were equivalent to 'sites' given in the DTI data, or whether multiple plant on a single industrial site might constitute a single 'site' in the DTI data. For reasons of simplicity it was decided that plant in the Netcen data would be assumed to be equivalent to sites in the DTI data and that the largest user of gas in a given area would be assumed to be that excluded by DTI. In the case of Middlesborough,

the DTI data excluded one large user but no users were found in the Netcen data. Instead, it was assumed that the DTI referred to a very large user in the neighbouring Redcar and Cleveland area.

Overall agreement between the gas consumption for the excluded sites and gas consumption as estimated by Netcen was very good, despite the problems with identification. Northern Ireland is included with power stations in the table below because this is how the numbers were reported by DTI (DTI 2004a Table 1 p20).

Table 4 Comparison of DTI excluded gas consumption and Netcen calculated gas consumption at large point source and Northern Ireland

	Gas consumption reported by DTI (GWh)	Netcen (GWh)
Power stations + Northern Ireland	278367	274878
Large industrial users	35835	38831
All excluded users	314202	313708

These site specific gas use estimates i.e. the Netcen 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 7281 kilotonnes of CO_2. The residual UK industry and commercial emission was then calculated and distributed using the Dti LA level gas consumption estimates for the Commercial and Industry sector. This residual was calculated as shown in Table 5. It is assumed that emission factors for this industrial and commercial gas use are constant throughout the country.

Table 5 Calculation of remaining CO_2 emission from Commercial and Industry sector after exclusions

	Kt CO_2	
NAEI emission for Industry and commercial (not including power stations)		80049
Agriculture	+	277
Processes	+	1164
Total Local CO_2 Industry and Commercial gas use emission		81491
Large users (not including power stations) excluded from this dataset	-	7281
Total emission to distribute using the DTI gas data		74209*

*Please note that not all of this NAEI emission was able to allocate across the LAs (see results in Table 8) as some of the DTI Industrial and commercial consumption are included in the domestic gas.

3.3 Other Domestic fuel use

The methodology used for mapping emissions from domestic combustion uses detailed data on fuel use by postcode areas. The maps of domestic fuel use were developed for the NAEI 2000 inventory with further work on the Northern Ireland distribution undertaken for the 2002 inventory. These distributions will be updated for 2004. They are not updated every year because of resource issues.

For England, Scotland and Wales, domestic emissions are based on Experian consumer survey data (Business Geographics, 2001) that gives the number of households within a postcode sector using a particular fuel for heating. These households are distributed within each postcode sector on the basis of the 1km population density map assuming constant fuel usage per household. These calculations generated initial distribution maps for the following fuels: coal, wood, solid smokeless fuel, coke, gas oil, burning oil and bottled gas.

However it is important to be consistent with the NAEI Devolved Administrations Emission Inventory. Therefore the distributions were then re-normalised to be consistent with domestic fuel consumption totals for the UK Devolved Administrations. These are calculated using country specific statistics and factors which indicate the typical domestic energy consumption per capita in each region.

The domestic coal and Smokeless Solid Fuels grids have also been further enhanced to limit coal burning to outside Smoke Control Areas (SCAs) and to limit SSF burning to within SCAs. However the maps available of SCAs were of limited quality and rather old. This work therefore needs updating for the 2004 NAEI mapped inventory.

The Experian data did not cover Northern Ireland, therefore a different methodology was used. 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).

Domestic House and Garden Machinery

The NAEI source called Domestic house and garden machinery is also included in the domestic sector for the LA CO_2 estimates. These emissions are distributed across the UK Local Authorities according to the population distribution in the 2001 Census but excluding highly urban areas using land cover map definitions.

3.4 Road transport

Road transport fuel use estimates at Local Authority level were compiled this year by Netcen for DTI. The method used is described in detail in Goodwin et al (2005) which assessed a number of different methods for allocating road transport emissions. This project has adopted the approach taken by Goodwin et al (2005) for the allocation of emissions to road transport.

In summary, emissions on major roads are estimated using detailed vehicle specific traffic census data (annual average daily flows) for 2003 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.

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.

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 2003 emission from petrol and diesel used (based on DTI fuel sales data) in road transport is 117865kt. The additional emission resulting from the bottom up method based on vehicle kilometres and vehicle fuel consumption assumptions is 9057kt an addition of about 7%.

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

The UK total rail emissions are compiled from three journey types: freight, intercity and regional. Emissions are calculated based on fuel use reported in DUKES. Because it is not possible to separate rail use of electricity from commercial and industrial from the DTI dataset both diesel and electric emissions from the rail sector are allocated to commercial and industrial sector.

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 rail network used for this mapping does not currently included Northern Ireland. However this is not a significant omission as it only represents 1.3% of fuel consumption in this sector (NAEI Devolved Administrations Emission Inventory 2003). The total CO_2 emission for diesel trains in the UK is 964kt.

Electricity used by railways is included in the Industrial and Commercial dataset from DTI. DUKES 2004 Table 5.3 states that National Rail used 2700 GWh in 2003 (DTI 2004b). Electricity provides about 50% of the energy used by railways (calculated by AEA Technology as part of work on behalf of the Strategic Rail Authority)**.** However in any particular Local Authority it is likely that this split will not be 50% because of the uneven distribution and electric and diesel trains across the UK - with more electrification in the south east of England than in the rest of the UK. Also the DTI LA level dataset does not include all actual locations of the electricity consumption because they are not known so some electricity use by railways is unallocated (Janes *pers comm*.).

3.6 Other Industrial and Commercial fuel use

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;
- 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 Netcen'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;
- Combustion processes not subject to regulation as combustion processes under IPC but included in the UK's National Allocation Plan (NAP) for the purposes of the EU carbon emission trading scheme (EU ETS).

In all cases, however, the estimates are consistent with national emission estimates compiled for the UK Greenhouse Gas Inventory (GHGI) which, in turn, is consistent with energy statistics published in the Digest of UK Energy Statistics (DUKES). Full details of the method used to derive the fuel use estimates are provided in Annex 1 in this report.

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 6 Fuel categories for reporting emissions

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

Employment based distributions for area source

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 7 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 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 2003. 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.

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.

Other distribution grids used to map area source emissions

Natural emissions are distributed using 1km resolution land cover maps derived from the Land Cover Map 2000 data from the Centre for Ecology and Hydrology (CEH).

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 Netcen for improving the UK inventory in this sector.

3.7 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 calculations of emissions for all other sectors has been done by using the NAEI 1km resolution maps. A map of Local Authorities boundaries has been used to assign each 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 8 on the following page 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.

Use 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 domestic. 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.

Figure 4 below shows total CO_2 emissions per capita by Local Authority (excluding natural emissions). 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 8.

Figure 4 CO_2 emissions by Local Authority per capita in 2003 (in Kt CO_2)

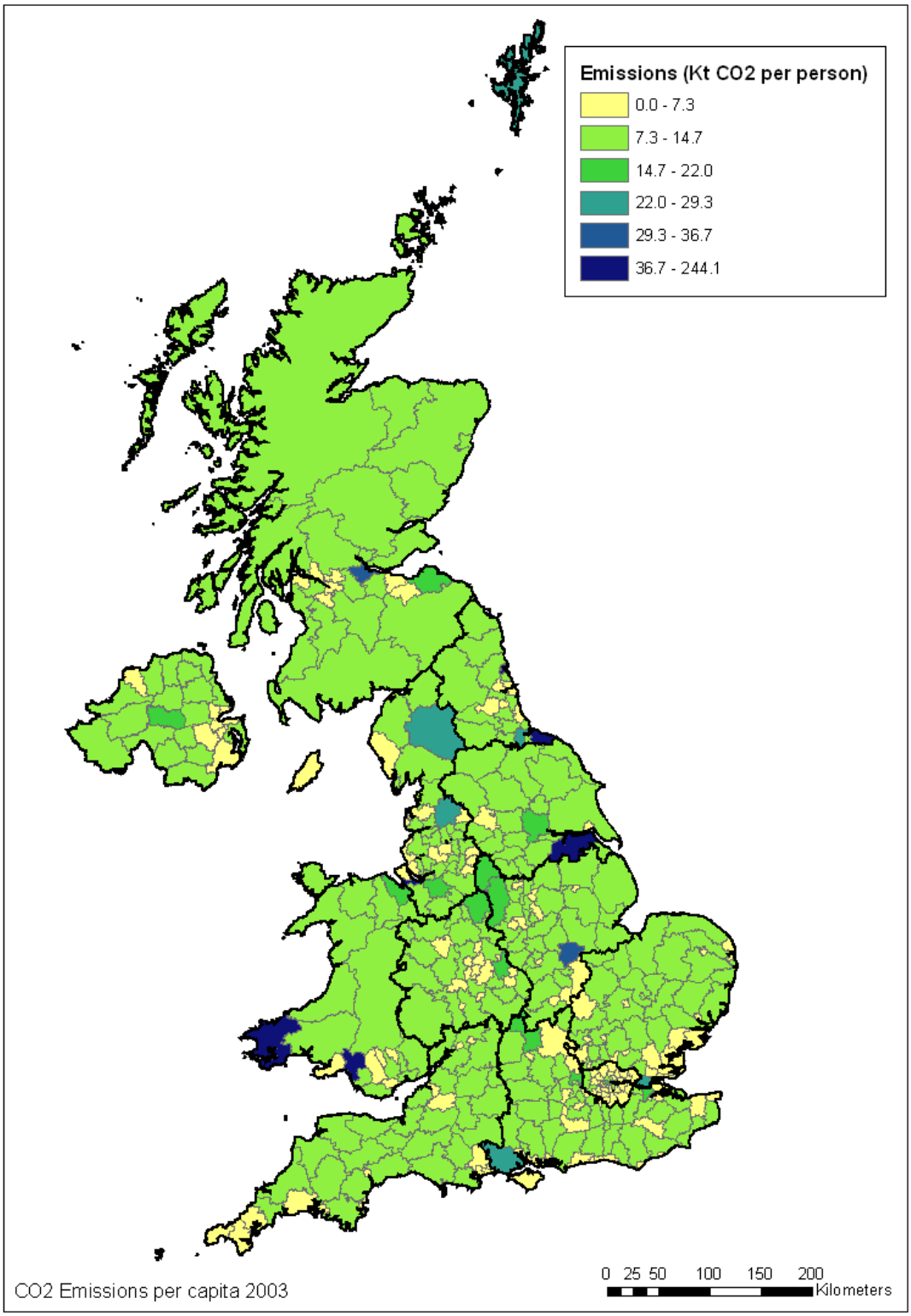


Table 8 Detailed results for Government Office Regions (kt CO_2)

NUTS4 Area and Government Office Region	WALES	SCOTLAND	NORTH EAST	NORTH WEST	YORKSHIRE AND THE HUMBER	EAST MIDLANDS	WEST MIDLANDS	EAST OF ENGLAND	GREATER LONDON	SOUTH EAST	SOUTH WEST	NORTHERN IRELAND	Unallocated consumption	Large elec users (high voltage lines) unknown location	UK TOTAL
Industrial and Commercial Electricity	5361	8830	4135	11161	7256	7565	5953	7996	13804	12322	7095	2218	10515	4956	109166
Industrial and Commercial Gas	4244	5848	2860	8583	7416	4619	5987	4897	6946	7053	3722	386			62559
Industrial Gas (Exclusions)	469	1150	1629	2263	387						257	89			6245
Industry Commercial Oil	4591	4041	2437	4485	6216	1673	1673	3580	463	4885	2238	1210			37494
Industry Commercial Solid Fuel	1777	908	4534	902	2244	882	370	793	17	1535	377	320			14658
Industry Commercial Wastes And Biomass	75	148	162	318	198	182	394	88	334	254	105	33			2291
Industry Process Gases	3947	21	5431	32	6280	110	140	17	6	14	30	3			16030
Industry Non Fuel	1018	493	844	1063	1029	1363	402	282	7	1400	353	177			8431
Industry Off-Road Machinery	151	207	124	334	266	270	339	232	115	275	221	78	1		2613
Agriculture Oil	61	92	17	43	36	40	42	40	1	51	85	55	5		566
Agriculture Solid	1	2	0	1	1	1	1	1	0	1	2	1			12
Agriculture And Deforestation	31	170	40	34	98	138	73	202	2	118	129	18	5		1058
Railways	56	84	36	64	89	107	94	65	41	141	181		5		963
Total Industry and Commercial	**21782**	**21993**	**22250**	**29283**	**31516**	**16949**	**15467**	**18193**	**21737**	**28049**	**14793**	**4588**	**10530**	**4956**	**262087**
Domestic Electricity	2796	6855	2442	6867	5081	4581	5709	6478	7419	9266	6142	1393	271		65301
Domestic Gas	4096	6908	4183	10964	7753	6302	7782	7339	11327	11748	5617	162			84181
Domestic Oil	494	568	168	522	487	618	696	1645	86	1235	1402	1756			9676
Domestic Solid Fuel	641	453	182	248	522	485	294	230	73	206	260	733			4327
Domestic Home And Garden	12	22	11	29	21	18	23	23	31	34	21	7			252
Total Domestic	**8040**	**14806**	**6985**	**18630**	**13864**	**12005**	**14504**	**15715**	**18935**	**22489**	**13442**	**4051**	**271**		**163737**
Road Transport Petrol	3331	5453	2556	7442	5454	5183	6132	6857	5811	10751	6076	2624			67670
Road Transport Diesel	2703	4997	2080	6822	5572	5520	5968	6341	4207	8294	5033	1717			59253
Road Transport Other	83	135	63	182	137	132	158	175	130	272	152	62	2		1683
Total Road Transport	**6116**	**10586**	**4699**	**14446**	**11164**	**10834**	**12258**	**13373**	**10147**	**19317**	**11262**	**4403**	**2**		**128606**
Land Use Change	225	2979	540	467	1278	1700	833	2455	22	1288	1475	350	64		13676
Total	**36163**	**50363**	**34473**	**62826**	**57822**	**41488**	**43061**	**49735**	**50842**	**71144**	**40972**	**13392**	**10867**	**4956**	**568105**
Power Station Emissions:	13753	17978	4030	10333	47920	28340	6293	11854	3316	22928	2704	5020			174467
Electricity consumption emissions	8157	15684	6577	18028	12337	12146	11662	14474	21223	21589	13237	3611	10786	4956	174467
Regional Totals without electricity consumption allocation	41759	52657	31926	55131	93405	57682	37692	47115	32935	72483	30439	14801	81		568105

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 2003

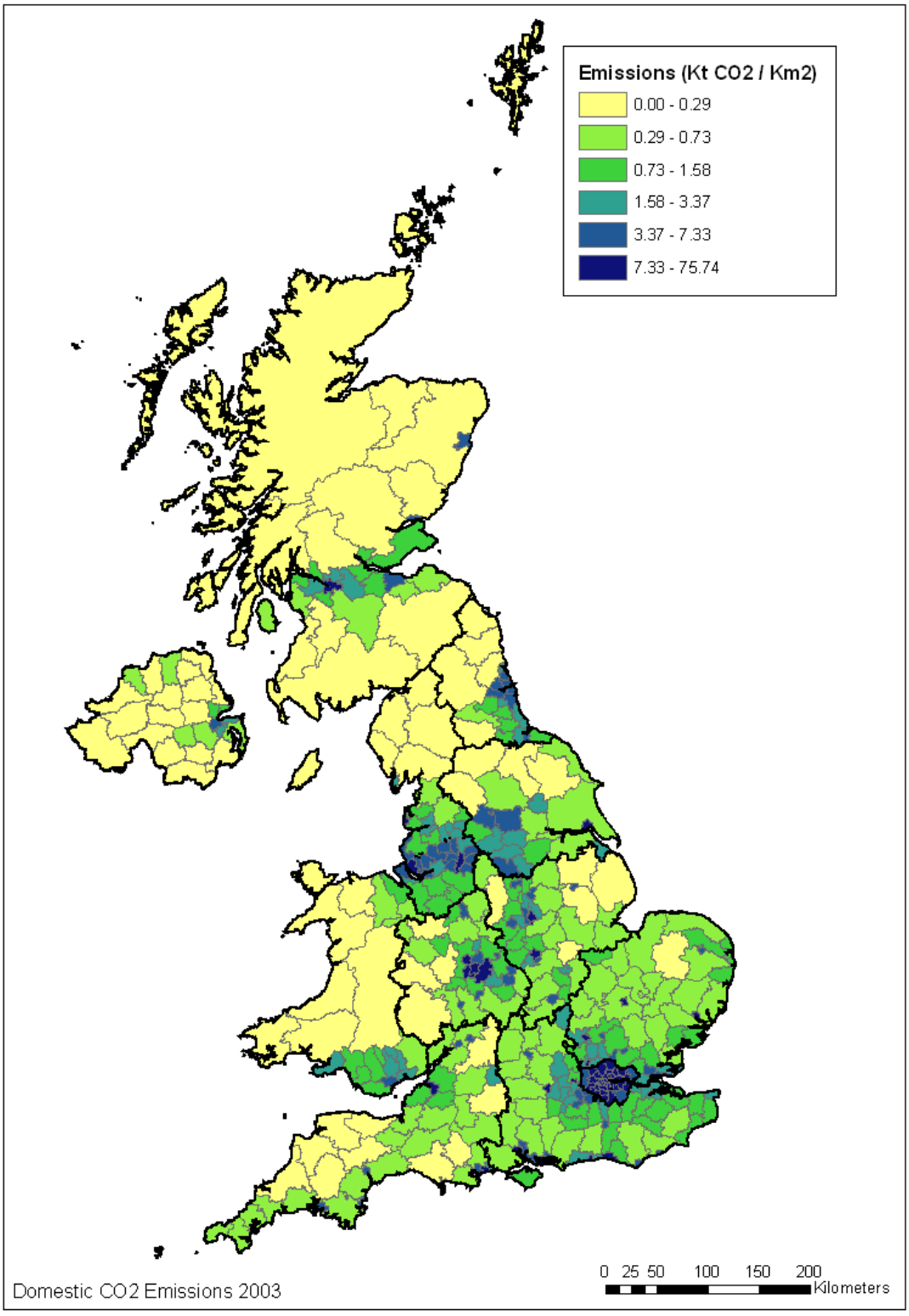


Figure 6 Industry CO_2 emissions by Local Authority for 2003

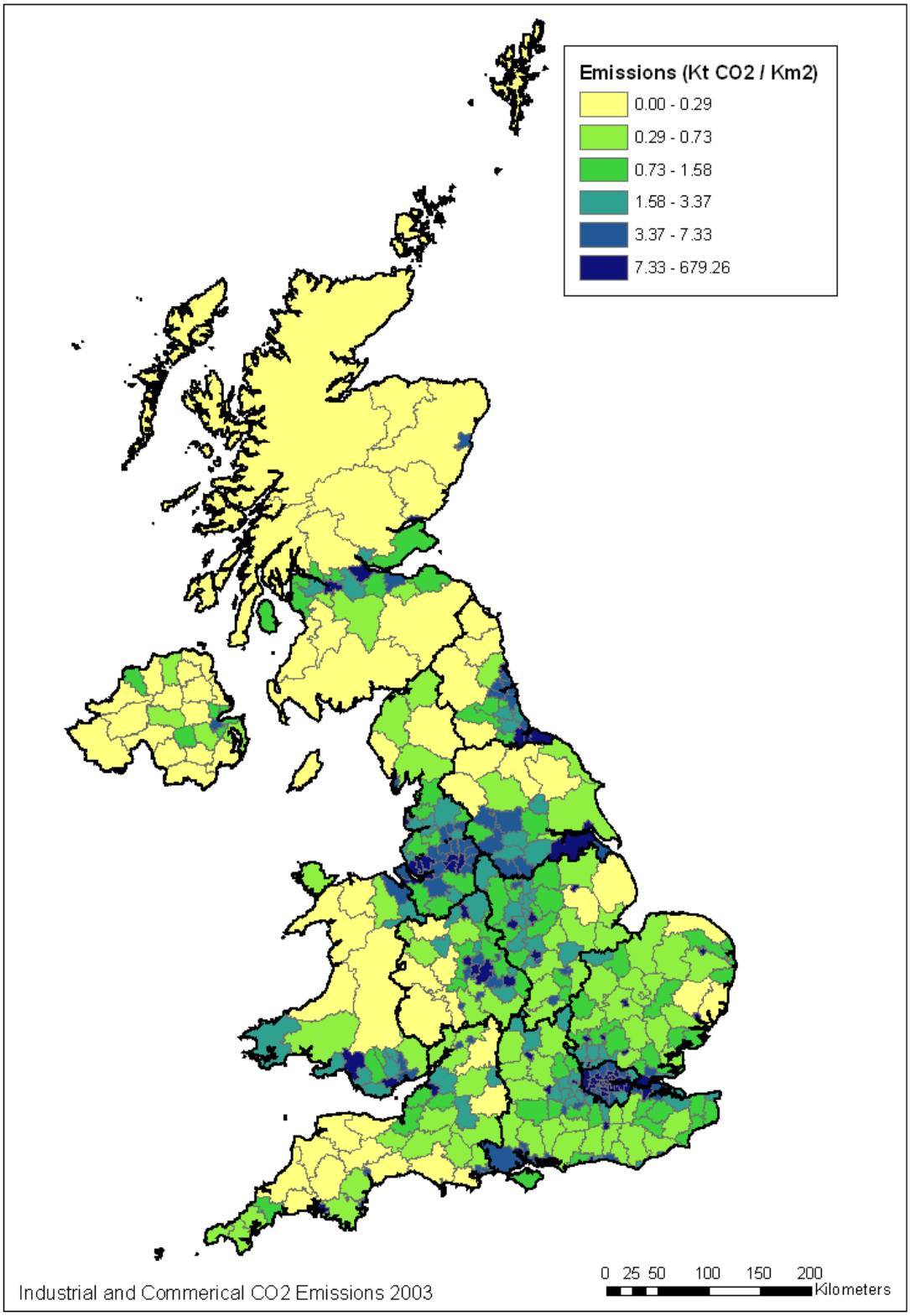


Figure 7 Transport CO_2 emissions by Local Authority for 2003

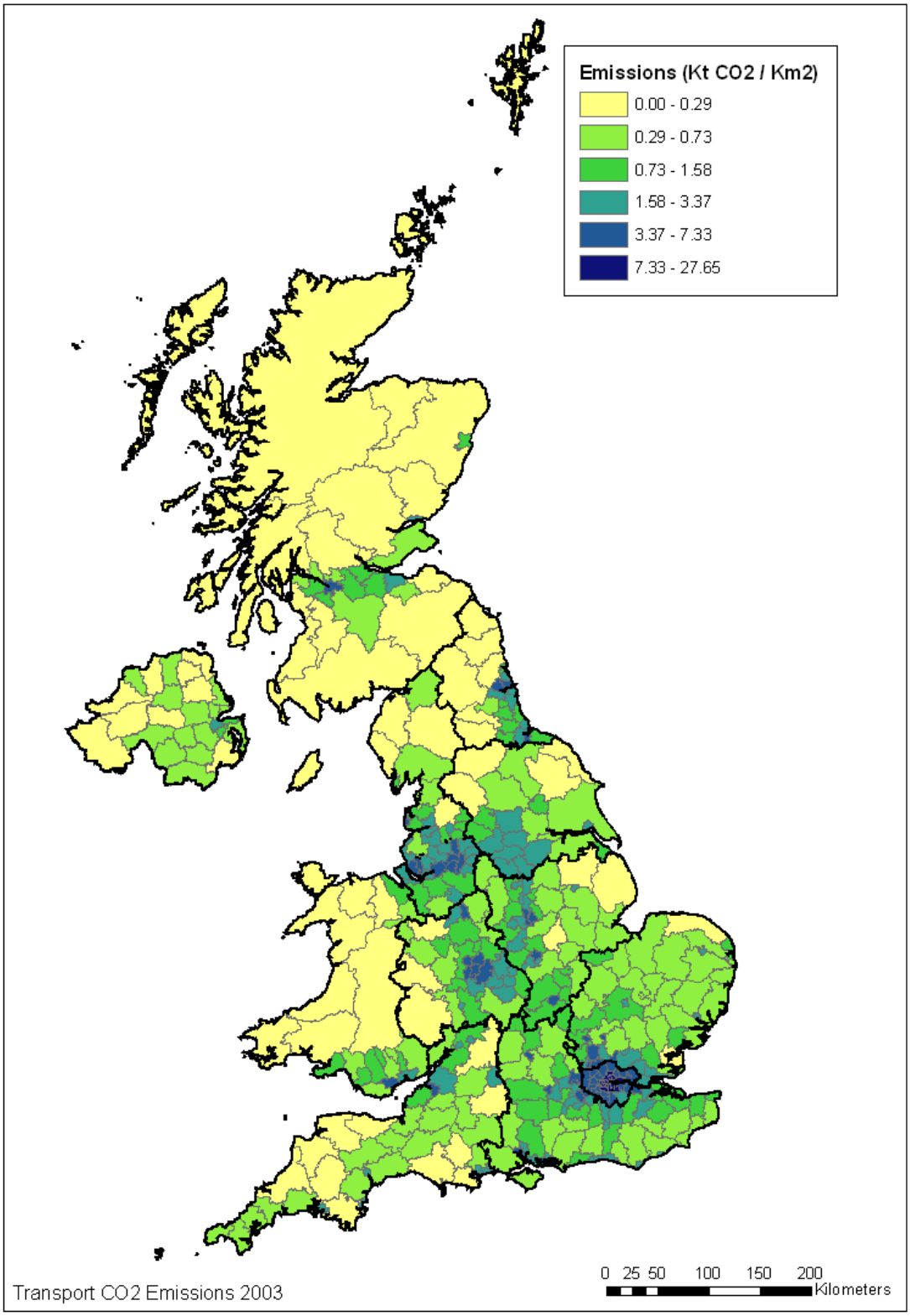
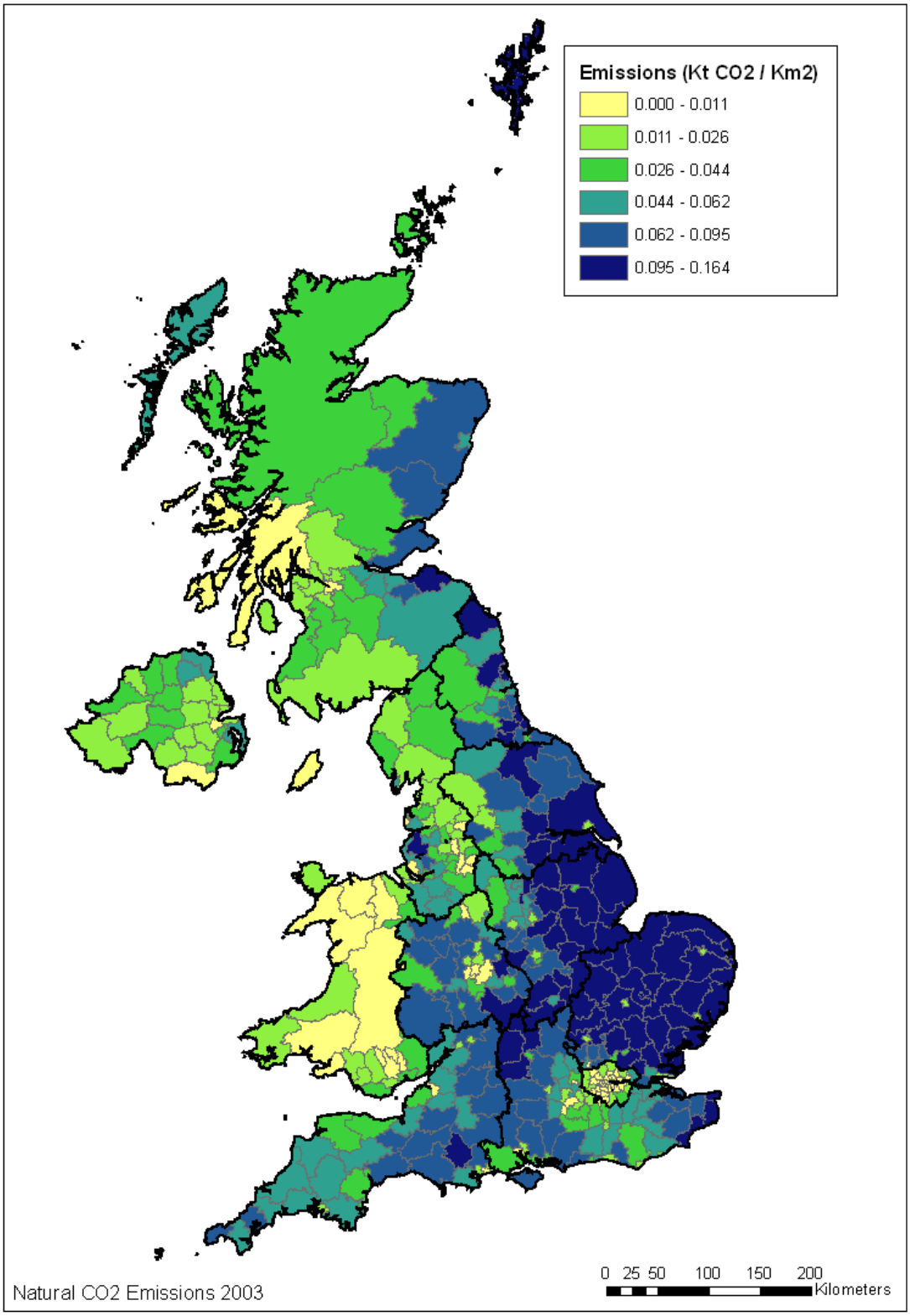


Figure 8 Natural CO_2 emissions by Local Authority for 2003



4.1 Reconciliation with NAEI totals and DA inventory

Table 9 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:

i. Energy supply emissions have been redistributed across domestic and industrial and commercial users of electricity. There is also an unallocated portion of this emission that is Offshore Oil and Gas.
ii. Domestic gas emissions are slightly higher in the Local CO_2 estimates (84 kt CO_2) which may due to different allocation method used by DTI.
iii. Land Use Change emissions in the Industry and Commercial sector are application of limestone and dolomite to agricultural soils and deforestation.
iv. The road transport emissions in this table show separately the 9057 kt CO_2 the difference between emissions calculated from DTI fuel sales data and those estimated from vehicle kilometre data (it is thought that some of this difference is from imported fuels in vehicle tanks).
v. The unallocated transport emissions are aviation and shipping emissions.
vi. The transport emissions that are shown in the Industry and Commercial column relate to airport support vehicles and the rail sector.
vii. The industry totals include a slight point sources over estimate (528 kt CO_2) show separately under "Excluded" which are not included in the reported NAEI totals.
viii. Emissions sinks have not been included in the Local CO_2 estimates.
ix. Lastly, there are some slight differences in the numbers in this table and those in Table 10 because of rounding.

Table 9 Summary of UK CO2 inventory for 2003 (kt CO_2) quoted on an IPCC basis.

Emissions in kt CO2	Local CO2 Category					National Communications	
National Communication Format Category	Domestic	Industry and Commercial	Road Transport	Land Use Change	LA CO2 Total	Unallocated (1)	UK Total
Agriculture		855			855		855
Business		98480			98480		98480
Energy Supply	65301	147748			213048	5226	218274
Industrial Process		12845			12845		12845
Land Use Change: Emission		1058		13676	14734		14734
Land Use Change: Removal						-16270	-16270
Public		11095			11095		11095
Residential	85750				85750		85750
Road Transport			119548		119548		119548
Other Transport		1069			1069	8535	9604
Waste Management		1013			1013		1013
Re-allocation (2)	12008	-12008				-	-
Excluded (3)	84	528	9057		9669	-	-
Total	163142	262683	128604	13676	568105	-2509	555928

(1) Emissions not allocated to LA CO2 See points (ii), (iv) and (vii) above
(2) Re-allocation due to DTI miss allocation of electricity data between domestic and commercial and industry
(3) Excluded from the UK total because of different calculation methodology

Comparisons at Devolved Administration level

The totals for the Devolved Administrations presented in this report have also been compared with those presented in the NAEI Devolved Administration Inventory for 2003. The results are very similar once the redistribution of power station emissions have been taken into account.

There are also slight differences in the emissions from fuel use in the domestic and industry sectors, especially for oil. These are the result of updated methods used to derive these local estimates that will be applied to future devolved Administration inventories.

Table 10 shows a comparison between Devolved Administrations (DA) estimates and those done for this project (LA CO2). Due to rounding errors the final totals are slightly different. Overall there is a 4% difference between the DA and LA CO2 totals resulting from slight differences in the methodology for LA CO2 emissions allocations and in the allocations of shipping and Land Use Change emissions. Electricity consumption emissions have not been calculated for the DA inventory and therefore the DA emissions are from Electricity production only.

Table 10 Emissions reconciled with the UK and Devolved Administrations inventories for 2003.

Emissions kt CO2	England			Wales			Scotland			NI			Allocated Totals			Reconciliation to UK totals		
Sector	DA	LACO2	LACO2 as % of regional	DA	LACO2	LACO2 as % of regional	DA	LACO2	LACO2 as % of regional	DA	LACO2	LACO2 as % of regional	DA	LACO2	LACO2 as % of regional	Unallocated DA	Unallocated and over estimated LACO2	
Domestic (1)	70,991	82,068	116%	4,588	5,214	114%	7,017	7,902	113%	3,154	2,657	84%	**85,750**	**97,841**	**114%**			
Industry and Commercial (1)	118,724	121,620	102%	16,842	16,391	97%	13,125	13,122	100%	2,467	2,367	96%	**151,157**	**153,501**	**102%**	13,839	-612	(5)
Road Transport (2)	99,420	107,499	108%	5,967	6,116	103%	9,804	10,586	108%	4,356	4,403	101%	**119,548**	**128,604**	**108%**		-9,057	(2)
Land Use Change (LUC)	6,831	10,058	147%	1,112	225	20%	4,778	2,979	62%	954	350	37%	**13,676**	**13,612**	**100%**		64	(6)
Electricity Generation (3)	137,683			13,732			18,031			5,021			**174,467**					
Domestic electricity consumption		53,986			2,796			6,855			1,393			**65,030**			271	(6)
Industry & commercial electricity consumption		77,286			5,361			8,830			2,218			**93,694**			15,487	(7)
Unallocated to LA CO2 estimates (4)	2,490			297			1,588			124			**4,500**			9,261	13761	(4)
LUC removals	-4,030			-1,345			-10,082			-813			**-16,270**				-16,270	
Total	432,111	452,517	105%	41,193	36,104	88%	44,260	50,273	114%	15,262	13,388	88%	**532,826**	**552,282**	**104%**	23,100	3,643	
Reconcilliation Totals													**23,100**	**3,643**				
UK Total Net Emissions													**555,927**	**555,925**				

(1) Excluding Electricity Use emissions see below

(2) Includes emssions from VEHKM based estimates (+9057) for the LACO2

(3) Emissions from Power Plant

(4) Includes coastal Shipping, off shore industry and aviation that can be partly allocated to Devolved Administrations but not LACO2

(5) LA CO2 overestimate in Ind other fuel (528kt) and gas (84kt)

(6) Unallocated emissions to LA CO2

(7) Electricity consumption that is not allocated to LAs in DTI dataset + large user

5 Limitations of the existing data and recommendations for improvements

There are a number of improvements that could be made to the emission estimates presented in this report. Many of these depend on acquiring more detailed datasets.

The following recommendations offer ideas for future improvements to the data. These ideas are grouped into one of two categories. Those that would bring "significant improvement" and usability to the data and those that will have a minor impact on the data quality classed as "Other Improvements".

5.1 Significant Improvements

Annual updates and Development of Historic (1990 or 2000) base year estimates for progress monitoring.

As there is likely to be continued interest on progress emissions reductions there will be a continued demand for local and regional emissions estimated that are comparable. It is therefore recommended that an annual update programme be established to derive updates on an annual basis. If estimates are updated annually it will be important to make sure that previous years estimates remain consistent so that a meaningful time series can be presented. This will require "back" revisions to early years data to accommodate improved methodologies and ensure that time trend fluctuations reflect "real" changes rather than changes in methodology.

Climate Change Levy Agreement data

Access to this data would provide additional fuel consumption information for smaller industrial plant not reporting under the EUETS and enable a more accurate picture of the consumption of different fuels for a number of small to medium sized installations. This data is currently compiled by a number of agencies representing industrial trading groups and trade associations and provided to Defra on an annual basis. It is currently help as commercially sensitive data and therefore not available to the UK inventory. Use of this data would greatly improve the distribution of all fuel based emissions from industry, commercial and agricultural sources. Significant effort may be required to collate and reconcile the data with the UK inventory and geo-reference the site specific datasets. Issues of confidentiality may require some aggregation of the data for some Local Authorities. If available this data would also enhance other UK inventory outputs for air quality modelling and policy support.

Gas Consumption Data

Higher spatial resolution data on gas consumption from National Grid Transco would significantly improve the domestic and industrial and commercial gas distribution and allocations to Local and Regional areas. It could also be used to improve assumptions made about where other fuels (e.g. Coal, Oil and LPG) are used.

Further details on the excluded large gas users, such as the names of the operators, would also be useful to improve the Netcen assumptions about which

sites these represent. Improvements to this dataset rely on DTI and the gas distribution companies willingness to collect and provide good quality data. The mechanisms for data collection are there (billing information) but the collation and checking responsibilities still need to be arranged. Incorporation of more detailed gas consumption into the inventory will be relatively simple and as the data will be re-aggregated to Local Authority levels again there will be no confidentiality issues.

Electricity Consumption Data

DTI are still working to improve their electricity consumption data, to reduce the amount that is currently unallocated to LAs. A revised dataset could be included in an update of this work.

Estimates of Electricity use in by LA in NI would improve the estimates there, instead of using population and employment distributions. In addition a revised 2003 as well as a new 2004 dataset would help the time series consistency of any future datasets. Any improved datasets could easily be incorporated into the existing methodology.

EU-ETS emissions trading scheme.

Currently Defra and the Environment Agency compile a detailed dataset of industry fuel consumption as part of the EU-ETS (emissions trading scheme). Unfortunately, we are unable to obtain access to this dataset, which would greatly enhance the accuracy and reliability of our regional fuel consumption data. Having access to this dataset would allow us to far more accurately predict what fuel types are being burnt at precise locations together with the volume of fuel being consumed. Currently this data is not held in a centralised dataset although it is reported by companies in their monitoring and reporting submissions to the Environment Agency. Collation and incorporation in the NAEI would require significant resources initially to set up a suitable data flow and DUKES reconciliation system. However, the national greenhouse inventory would benefit from this inclusion in future inventories.

Pollution Inventory Reporting of fuel use and activities

The reporting of fuel use by fuel type by installation to the Environment Agencies Pollution Inventory would improve our understanding of fuels burned in large installations. This data would overlap with some of the EUETS data but would provide a valuable cross check and fill gaps for installations not included in the EUETS. It is not clear if the Environment Agency have the authority to demand this data under IPPC or EPER. However, it is acknowledged that there is a need for this data within the EA for benchmarking and assessing reporting compliance. It is unlikely that reported activity data would be in the public domain so its use would need to be monitored carefully. As with the EU-ETS data a significant resource effort would initially be required to incorporate this data in the UK inventory. However the benefits for Air Quality modelling and UK total emission estimates would be significant as it would enable improved calculation of large and small process emissions.

Domestic mapping improvements (Non Gas Fuels)

The mapping of domestic fuel use in Great Britain needs to be updated for the 2004 inventory. This should include an update of the Experian data and/or investigation into improved data sources such as the EST Home Energy Efficiency Database, new gas consumption data from DTI and improvements to the

locations of Smoke Control Areas. The important and difficult areas include liquid and solid fuel use as there is very little data on where these fuels are consumed. Further surveys similar to those done in Northern Ireland, reporting by distributors or additions of questions in future Census activities (on the type and quantity of fuels burned) would provide useful insight into the locations of solid and liquid fuel consumption in the UK. Targeted surveys or research into likely fuel types and quantities burned where gas supply is limited might provide improved spatial estimates. Improved spatial detail of gas supply data itself would also help to identify specific locations burning solid and liquid fuels where gas supply is absent. Improvements in this area are likely to be relatively costly requiring surveys or the development of additional reporting requirements for suppliers of solid and liquid fuels. DTI will have a leading role in future developments of Local Authority solid and liquid consumption data. Rural and semi areas are most likely to see improvements in data quality from this work.

Small industrial commercial and public service improvements (Non Gas Fuels)

As with domestic fuel use mapping the areas of highest uncertainty are solid and liquid fuel use. It is unlikely that this data will be captured by either the CCA or the EUETS and is currently derived from employment data and inverse gas use modelling. Improved gas use spatial detail would enable the identification of areas where gas is not burned and other fuel consumption should be allocated. Further research into fuel preferences for different commercial and industrial sectors where gas is unavailable should be undertaken through DTI DUKES data collection channels. It is likely that these choices will often depend on the age of the installation and the most viable fuel at the time of construction. While this dataset would offer significant improvements to rural and urban area estimates, It is difficult to see exactly how the data could be collected and reconciled with the Larger reporting installations. User fuel use reporting for non gas users or improved distributor reporting would help to pinpoint areas of solid and liquid fuel use and improve the allocations to NUTS 4 areas. Collation and interpretation of data will be difficult and time consuming.

5.2 Other Improvements

Calculation of a historic base year.
It may be worth considering calculation of a historic base year (either 1990 or 2000) to enable emission reduction achievements to be assessed. Although 1990 is the base year for the UK and an obvious choice for Regional and Local Authority estimates there is limited spatial data available for a consistent comparison with later years. It may therefore be more sensible to consider 2000 as a base year for Local and Regional estimates. Even for 2000 the availability of core datasets such as electricity and gas consumption is limited and will need to be derived. This will require resources and time to deliver and may not provide a comparable base year.

Extending the Scope of the Estimates:

It may be attractive to extend the scope of this work in the future to include the additional GHG pollutants so that the basket of 6 GHG's can be calculated. This is possible using the same methodology as for CO_2. However, the estimates will be more uncertain as many important sectors for the non CO_2 gases do not have as robust spatial distributions or emission factors (e.g. the use of refrigerants, agricultural fertilizer use and emission factors for N_2O from vehicles). Extending

the scope of pollutants will require additional resources in order to distribute the emission sources for agriculture and land use for CH_4 and N_2O. Additional effort will also be required to allocate F-gas emissions from refrigeration and air conditioning units.

Extensions to include other end user allocations or the "footprint" approach (e.g. from the emissions from refineries and cement plant to the consumers of their products to the total carbon cost of consumables use in different Local Authorities and Regions) should be explored as this can give a more complete picture of global emission reduction impacts of Locally taken actions. This work could start with a scoping study to investigate current footprint methodologies and how they could incorporate better emissions data.

Incorporation of renewable use and efficiency actions

Future work to include data on existing efficiency improvements and domestic level renewable use (e.g. CHP, solar, wind and geothermal) would improve the usefulness of the data to Local and Regional Governments. Some improvements to the distribution of emissions could be made through incorporation of any spatial Clear Skies, the Home Energy Efficiency Database and HECA data. In addition the incorporation of the effects of the UK's CHP programme should be investigated and incorporated. As scoping study to look at the available data sources would provide a starting point to assess the technicalities of incorporating and disseminating Local Energy efficiency data.

Road Transport improvements

A number of improvements could be made to the road transport estimates including:

- Improve assumptions on mileage of petrol and diesel vehicles using available DfT data. This would be a relatively minor activity for netcen and DfT to assess the available data and agree new assumptions.

- Improved availability of minor road traffic counts from the DfT census. This could be achieved through the incorporation of more local traffic survey data collected from county councils traffic departments and incorporated in the DfT AADF dataset.

- Estimation of emissions relevant to residents travel allocated to Regions and Local Authorities. This could be done using National Travel Survey data. This would require some research into data sources and methods and consultation with stakeholders. A small scoping study could assess available data and views and propose a method to be followed.

Rail mapping improvements

The inclusion of the diesel rail network for Northern Ireland would provide a complete estimate for this sector. In addition the kilometres travelled on the railway network in Great Britain are in need of updating as is a means of providing a split between electric and diesel vehicle km. This information is likely to be available from Network Rail. The development of a national rail map including vehicle km, passenger km and diesel/electric splits would be extremely

useful for energy use assessments, emissions assessments and modal transport studies. Some data is available from rail maintenance databases held by rail industry contractors. Rail timetables could also provide data on rail traffic density. London have been investigating several data sources and improved methods recently. This approach could be built on relatively easily for the UK as a whole assuming that the data is available at a reasonable price.

Further improvements could be achieved through analysis of Sustainable Travel Development Towns programme pilots data.

Finally, the inclusion of diesel rail network for NI would provide a complete estimate for this sector.

Off road spatial distributions of fuel use

Further work is required to improve the fuel consumption allocation for the off road sector. This sector includes house and garden machinery, Agricultural and forestry machinery, air support vehicles, road maintenance vehicles and construction vehicles. All are assumed to consume non road fuels (i.e. red diesel for agriculture). Supply/Distribution information for these data are not available and current methods use assumptions linked to employment data. This leads to some significant miss allocations as many of these activities take place well away from registered employment locations (e.g. construction). Improved distribution/supply information from suppliers or consumers would help to provide a more spatially accurate estimate.

Land use Change and Forestry

The NAEI has recently received (since the drafting of this report) spatially disaggregated emissions data from CEH on emissions from Agricultural soils, Deforestation, Natural CO_2 emissions from soils and other land use change emissions. This data is currently only on a 20x20km grid and therefore is difficult to assign to Local Authorities. This will be included in the 2004 inventory maps.

References

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

DTI (2004a) Energy Trends December 2004 www.dti.gov.uk/energy/inform/energy_trends/dec_04.pdf

DTI (2004b) Digest of UK Energy Statistics

DTI (not dated) Energy Consumption in the UK, www.dti.gov.uk/energy/inform/energy_consumption/ecuk.pdf

DTI, 2005a Energy Trends March 2005 www.dti.gov.uk/energy/inform/energy_trends/mar_04.pdf

DTI 2005b Energy Trends June 2005 www.dti.gov.uk/energy/inform/energy_trends/jun_04.pdf

Goodwin, J., Hobson, M., King, K, Murrells, T. And Sturman, J. (2005) Development of regional estimates of fuel consumption by the road transport sector – Stage 2. Netcen report number AEAT / ENV / R / 1880.

Janes *pers comm*. Email communication regarding allocation of railway electricity use within the DTI Local Authority Electricity Consumption dataset, July 2005.

Moynihan, S. (2004) Personal Communication to Glen Thistlethwaite in Netcen: Sean Moynihan, Phoenix Gas, September 2004.

NAEI Devolved Administrations Emission Inventory 2003, Compiled by Netcen, 2005.

NAEI UK Emissions Inventory 2003, Compiled by Netcen, 2005.

Pye, S. and Vincent, K. (2003) Determining the impact of domestic solid fuel burning on concentrations of PAHs and sulphur dioxide in Northern Ireland, A report produced for the Department for Environment, Food and Rural Affairs; the Scottish Executive; the National Assembly for Wales and the Department of the Environment in Northern Ireland, AEAT/ENV/R/1498.

Annex 1 Site Specific Fuel Use Estimates

Site specific fuel consumption estimates have been made many of the large energy users in the UK. The approach used varies according to sector.

Power stations

Fuel usage estimates have previously been made for the GHGI and the UK's National Atmospheric Emissions Inventory (NAEI). These estimates are based on public fuel consumption data provided by process operators in their environmental reports, although some gaps in the data must be filled by extrapolation from other data sets (such as earlier fuel use, electricity generating capacity data or emissions data). The overall fuel consumption for each fuel type is consistent with data given by DUKES for major power producers with the exception of consumption of fuel oil. In the case of this fuel, data available from process operators suggests that the consumption figure given in DUKES for major power producers is too low. The GHGI/NAEI and the fuel usage estimates are based on the higher fuel consumption available from process operators. Consistency with overall fuel oil consumption given by DUKES is maintained by assuming that DUKES' data for industrial fuel oil consumption is overestimated by an amount equal to the underestimation of fuel oil use by major power producers.

Other combustion processes regulated under IPC

Plant burning fuels in boilers, furnaces or gas turbines with an aggregate net rated thermal input of 50 MW or more are regulated under IPC. Some of these plant are power stations and a description of the method used to estimate fuel usage has already been given. The remaining plant are either industrial plant (including autogenerators) or commercial/public sector boiler plant. Fuel usage at these plant have been estimated based on CO_2 emissions data reported to regulators (e.g. in the Pollution Inventory in the case of plant in England or Wales). The CO_2 emissions have been converted into fuel usage estimates using CO_2 emission factors for fuel combustion taken from the GHGI, i.e.

Fuel consumption = CO_2 emission / carbon emission per unit of fuel burnt

In order to perform this calculation, it is necessary to make assumptions about the fuel or fuels burnt at each site. This has been done based on Netcen knowledge of fuels burnt by specific processes or, where this is not available, on information on fuel types for specific sites given in IPC authorisation documents (which date mainly from the early 1990s).

In a small number of cases, authorisation documents are not available and, in some other cases, the fuel types given in authorisation documents are not consistent with recent emissions data reported in the Pollution Inventory. For example, some authorisation documents state that coal or fuel oil is burnt by a combustion plant, yet the Pollution Inventory does not report for that plant any recent emissions of pollutants such as sulphur dioxide or metals which would be characteristic of these fuels. In all of these cases, Netcen has made an estimate of the fuel types burnt at these plant based on factors such as the presence or absence of emissions of characteristic pollutants, or the nature of the process being carried out. For example, no authorisation document is available for one site operated by Transco, but it is assumed that the fuel will be natural gas. In some cases, such as the example just given, the fuel types can be deduced with

some confidence, while in other cases the allocation of fuels is much more uncertain.

Refineries

Refinery fuel usage is based on fuel consumption data given in DUKES, with fuel allocated to each refinery on the basis of capacity data. This is consistent with current NAEI/GHGI practice, although it should be noted that this may not be very accurate. Capacity gives a broad indication of the scale of operations at each refinery, whereas fuel consumption will depend upon factors such as the feedstock, products made, the types of unit operation carried out, and the design of those units.

Integrated steelworks

Using a consistent methodology to that in the NAEI fuel usage estimates for sintering and blast furnaces are based on fuel consumption data given in DUKES, with fuel allocated to each site on the basis of total CO_2 emissions reported for that site by Corus UK Ltd (operator of all three sites).

Coke ovens
Fuel usage estimates for coke ovens are based on fuel consumption data given in DUKES, with fuel allocated to each site on the basis of total CO_2 emissions reported for that site in the Pollution Inventory.

Cement clinker production

Fuel usage estimates for cement kilns are based on GHGI/NAEI estimates of sector fuel usage and are allocated to each site on the basis of clinker capacity. This is consistent with current NAEI/GHGI practice, although a number of issues should be highlighted:

- Recent DUKES coal consumption data for the 'mineral products' industry sector (which includes clinker production) are much lower than expected by Netcen. Therefore, the NAEI/GHGI estimates include some combustion of natural gas in order to maintain consistency with both Netcen estimates of energy required by the cement industry and overall fuel usage data from DUKES. In reality, cement kilns do not burn natural gas.
- Ratios of fuel consumption to clinker production will vary from site to site largely depending upon whether the process is 'dry' (generally least energy-intensive), 'semi-dry', 'semi-wet', or 'wet' (generally most energy-intensive). So fuel consumption will tend to be overestimated for sites using the dry process and underestimated for sites using the wet process.

Lime production

Fuel usage estimates for lime kilns are based on GHGI/NAEI estimates of sector fuel usage. Coal, coke, and natural gas are burnt, with each lime kiln using only one of these fuels. The fuels are therefore allocated to each site burning the appropriate fuel based on site capacity.

Other plant regulated under IPC

A number of processes are regulated under IPC as either metal industry processes or chemical industry processes but which involve in part the use of fossil fuels. Estimates of fuel consumption are made in a manner similar to that used for combustion processes regulated under IPC (see above).

As with combustion processes, the allocation of fuels to some sites is subject to more uncertainty than in other cases.

Combustion processes included in the UK NAP

The UK NAP includes details of combustion processes which are participating in the EU ETS, including annual allocations of CO_2. Some of these processes are also covered by one of the other categories dealt with above, and these processes have been ignored. The CO_2 allocations for the remaining processes have been used as the basis of fuel use estimates. The procedure was as follows:

1. The total quantity of fuel usage estimated for IPC combustion processes, cement kilns, lime kilns, and other IPC processes was calculated.
2. The difference between total fuel usage for the industrial/commercial/public sectors given by DUKES and that calculated as 1) above was calculated.
3. The fuel calculated as 2) above was then allocated to individual industrial sectors and to the commercial/public sector proportionately to that sectors' share of the total consumption of fuel. This yielded a fuel usage profile for each sector i.e. the proportion of energy for the sector supplied by each of coal, fuel oil, gas oil and natural gas.
4. The CO_2 allocations for each NAP site were converted into fuel usage estimates using the fuel usage profile for the appropriate sectors and CO_2 emission factors taken from the GHGI.

This approach was slightly modified for glass furnaces, where the sector fuel usage profile was considered likely to give less accurate results than if a 50/50 split of gas oil to natural gas use was assumed instead.