

UK Emissions of Air Pollutants 1970 to 2009

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Executive Summary

- 1 This is the annual report of the National Atmospheric Emission Inventory (NAEI), which forms part of the UK emissions inventory programme funded by the Department for Environment Food and Rural Affairs (Defra) and the devolved administrations. This report is produced by AEA Technology plc, the UK inventory agency for air quality emission inventories, under contract to Defra.
- 2 **UK air pollutants** - This report presents the latest estimates of emissions to the atmosphere from the UK for the period 1970 to 2009. Details are provided of the economic sectors that contribute to the emissions, the time trend in emissions and the factors that have affected the trend and the spatial distribution of the emissions. The 2009 annual inventory contains estimates of emissions of 44 pollutant species, including 10 groups of related pollutant compounds, which include non-methane volatile organic compounds (NMVOCs), hydrofluorocarbons (HFC) perfluorocarbons (PFC) and a number of groups of persistent organic pollutants (POPs). Size fractionation is available for particulate matter, speciation is available for 500 NMVOCs and the oxidation states of Hg, Ni and Cr are given. The pollutants considered in this report are:

Air Quality Pollutants

- particulate matter, (PM₁₀)*
- black smoke
- carbon monoxide, (CO)
- benzene, (C₆H₆)
- 1,3-butadiene, (C₄H₆)
- nitrogen oxides, (NO_x)
- sulphur dioxide, (SO₂)
- non-methane volatile organic compounds, (NMVOC)*
- ammonia, (NH₃)
- hydrogen chloride, (HCl)
- hydrogen fluoride, (HF)

Persistent Organic Pollutants

- polycyclic aromatic hydrocarbons, (PAHs)*[†]
- dioxins and furans, (PCDD/Fs)
- polychlorinated biphenyls, (PCBs)
- pesticides:
 - lindane, hexachlorobenzene (HCB), pentachlorophenol, (PCP)
- short-chain chlorinated paraffins, (SCCPs)
- polychlorinated naphthalenes, (PCNs)
- polybrominated diphenyl ethers, (PBDEs)

Base Cations

- calcium, (Ca)
- magnesium, (Mg)
- sodium, (Na)
- potassium, (K)

Greenhouse Gases

- carbon dioxide, (CO₂)
- methane, (CH₄)
- nitrous oxide, (N₂O)
- hydrofluorocarbons, (HFCs)
- perfluorocarbons, (PFCs)
- sulphur hexafluoride, (SF₆)

Heavy Metals

- arsenic, (As)
- beryllium, (Be)
- cadmium, (Cd)
- chromium, (Cr)*
- copper, (Cu)
- lead, (Pb)
- manganese, (Mn)
- mercury, (Hg)*
- nickel, (Ni)*
- tin, (Sn)
- selenium, (Se)
- vanadium, (V)
- zinc, (Zn)

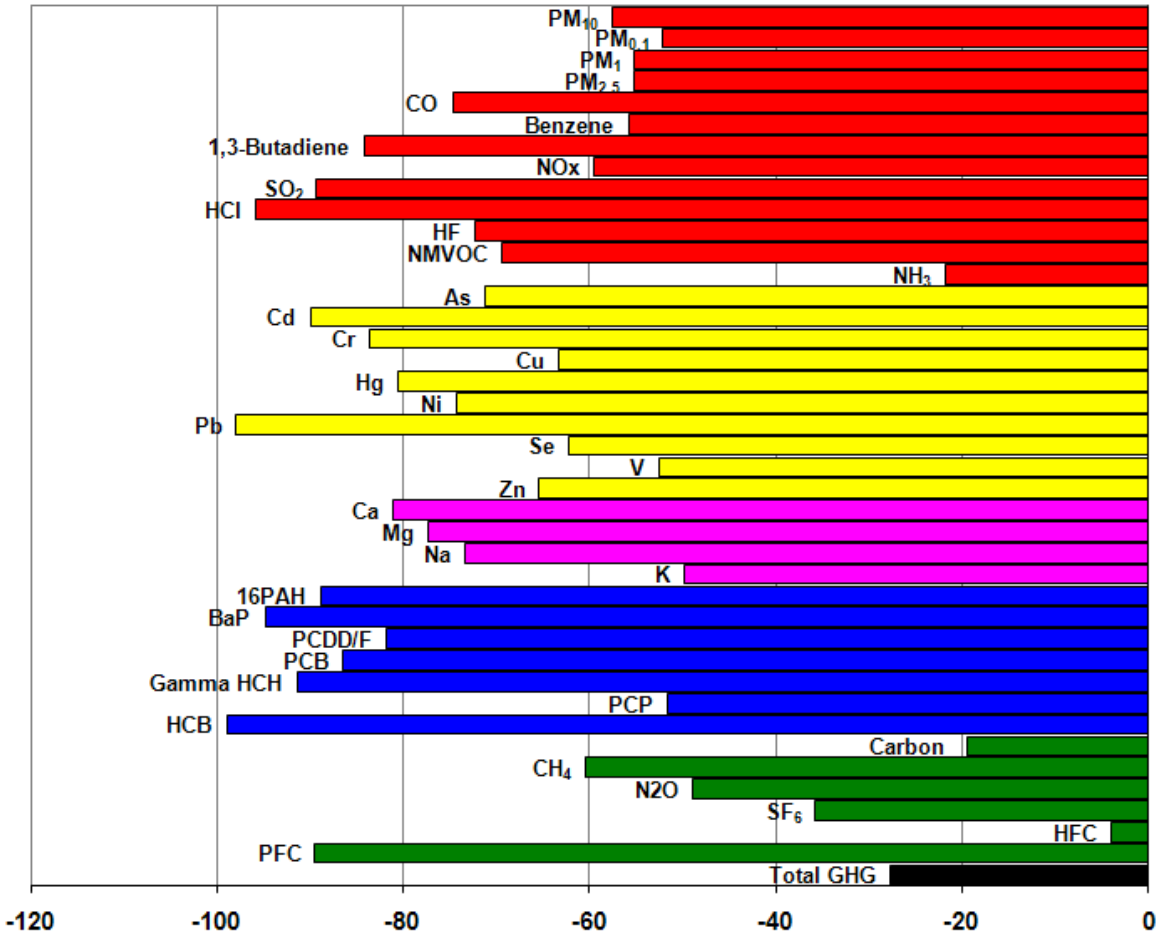
*Pollutant emissions are given as a total emission and speciated emissions. Particulate matter emissions are given as PM₁₀, PM_{2.5}, PM_{1.0} and PM_{0.1}.

[†] Benzo[a]pyrene is included in the Air Quality Strategy, but appears in this report in the chapter on Persistent Organic Pollutants, as it is a PAH.

In the 2009 inventory, emission levels of pollutants one year prior to the ceilings set under the National Emission Ceilings Directive (NECD) were estimated. There is considerable interest as we approach the target year of 2010. The 2009 emissions are below the NECD levels required in 2010 for all four pollutants covered by the NECD, which regulates non-methane volatile organic compounds, sulphur dioxide, nitrogen oxides and ammonia. The emissions of nitrogen oxides are below target levels in the 2009 inventory. Emission reductions between 2008 and 2009 are partly a result of the economic downturn, therefore, the UK needs to achieve further emission reductions to ensure that emission levels remain at the 2009 level to ensure the 2010 ceiling will be met. This is considered further in Section 1.3.1 in this report.

The changes in emissions between 1990 and 2009 are summarised in the following chart, expressed as a percentage changes from the 1990 values. Emissions of all pollutants have decreased during this period. In the 2008 inventory, the impact of the economic downturn resulted in emissions for the majority of pollutants to decrease. A similar trend can be observed in the 2009 inventory.

**Summary of Changes in Emissions 1990-2009
(expressed as a % of 1990)**



3 **Particulate Matter (PM)** – The UK emissions of PM₁₀ declined by 58% between 1990 and 2009, giving an emission of 0.12 Mt in 2009. This reflects a trend away

from coal use particularly by domestic users. Emissions from residential plants accounted for 14% of UK emissions of PM₁₀ in 2009, whilst road transport sources contributed a further 23%. PM₁₀ emissions from road transport have shown a steady decline across recent years. Other PM size fractions are also included in this report. PM_{2.5} emissions have also fallen, but by a slightly smaller amount. The largest source of PM_{2.5} is combustion in industrial, commercial and residential sectors. Road transport and other transport sectors also make large contributions accounting for 29% and 7.5%, respectively, of the 2009 total emissions.

4 **Black Smoke** - Black smoke emissions (not shown on the chart) in the UK have declined significantly (by some 67% between 1990 and 2009). Emissions in 2009 were estimated to be 151 kt. These estimates are based on old measurement data and are hence very uncertain. The largest source sector of black smoke is road transport, accounting for 42% of the 2009 total emission.

5 **Carbon Monoxide (CO)** - Emissions in 2009 (2.3 Mt) represent a 75% reduction on the emissions in 1990. UK emissions of CO are dominated by those from road transport (47% of UK emissions in 2009). The change in emissions between 1990 and 2009 is dominated by the reduction in emissions from the road transport sector, caused by the increased use of three-way catalytic converters in cars.

6 **Benzene** –Emissions have decreased by 56% between 1990 and 2009, giving an emission of 17.6 kt in 2009. Fuel combustion in the residential sector is the most significant source of benzene, accounting for some 48% of UK emissions in 2009. The next most significant source is emissions from petrol fuelled passenger cars (18%). The decline in emissions over time is primarily due to a marked reduction in benzene emissions from road transport as a result of tighter European vehicle emission standards and European Directives on fuel quality being introduced.

7 **1,3-Butadiene** – Emissions in 2009 were estimated to be 2.3 kt, representing a decrease of 84% between 1990 and 2009. Emissions of 1,3-butadiene are dominated by fuel combustion in the road transport sector, which account for some 52% of the 2009 UK emissions. There have been significant reductions in the emissions from this sector due to the increase in the number of cars equipped with three-way catalytic converters.

8 **Nitrogen Oxides (NO_x)** - UK emissions of NO_x were approximately 2.7 Mt in 1990. Emissions have fallen to around 1.09 Mt in 2009, representing a 60% reduction on the 1990 emissions estimate. This is primarily a consequence of abatement measures in road transport and coal fired power stations and the increased use of gas for power generation. Road transport accounts for 33% of total UK NO_x emissions in 2009, whilst power stations contribute a further 23%.

9 **Sulphur dioxide (SO₂)** - UK emissions of sulphur dioxide has fallen from 3.7 Mt in 1990 to 0.4 Mt in 2009, a decrease of 89%. This is a result of reduced emissions from the industrial and public power sectors due to lower use of high sulphur coal and increasing use of abatement equipment. Combustion of fuels in the power station, refining and manufacture of solid fuels sectors accounted for 56% of the 2009 UK SO₂ emissions.

10 **Hydrogen Chloride (HCl)** - UK emissions of hydrogen chloride have decreased by 96% between 1990 and 2009, giving an emission of 11 kt in 2009. This reduction is largely a result of declining coal use across the energy sector.

11 **Hydrogen Fluoride (HF)** – The total hydrogen fluoride emissions for 2009 are estimated to be 2.8 kt, representing a 72% reduction on the 1990 emission estimates.

- As with hydrogen chloride, the dominant source is coal combustion for public power contributing 52% of emissions in 2009.
- 12 **Non-methane volatile organic compounds (NMVOC)** - UK emissions of NMVOC are estimated as 2.7Mt for 1990 and 0.83 Mt for 2009, thereby showing a decrease of 69%. The observed decrease arises primarily from tighter European vehicle emission standards and fuel quality directives being introduced and the impact of the Solvent Emissions Directive. In 2009, solvents use sector accounted for 44% of the overall emissions.
- 13 **Ammonia (NH₃)** - Total UK emissions of ammonia were estimated to be 0.29 Mt in 2009, compared to the 1990 estimate of 0.37 Mt, a 22% reduction. The agricultural sector accounted for 89% of ammonia emissions in 2009. There were increases in emissions from the road transport sector between 1990 and 2000, caused by the increased use of three-way catalytic converters. Improvements in these mean that emissions from the road transport sector are now declining. There have been decreases in emissions from the agricultural sector between 1990 and 2009 due to decreased agricultural livestock numbers. Emissions from the waste sector have increased between 2004 and 2009 due to increased emissions from composting.
- 14 **Lead (Pb)** - UK emissions of lead has declined sharply following the switch from leaded to unleaded and lead replacement petrol. Emissions in 2009 are estimated to be 60 t, a decrease of 98% on the 1990 estimates. Road transport contributed only 2.6% of total UK emissions in 2009, compared to 74% in 1990.
- 15 **Persistent Organic Pollutants (POPs)** – The 2009 UK emissions of persistent organic compounds may be summarised as follows: 616 t **PAH** (USEPA 16), 193g I-TEQ **PCDD/F** (grams of International toxic equivalent¹ of dioxins & furans) and 0.9 t **PCB**. Emissions from all three of these pollutant groups have greatly decreased. Emissions in 2009 equate to decreases of 89%, 82% and 86% on the 1990 emissions, for PAHs, PCDD/Fs and PCBs respectively. The reason for the change in emissions is mostly related to improvements made to the methodologies for emission estimates. In the case of PAH significant work has been done during the current compilation cycle to improve the estimates of PAH emissions from transport.
- 16 **Carbon Dioxide² (CO₂)** – Emission estimates for CO₂ (on the chart expressed as carbon) from the UK show a decrease of 20% between 1990 and 2009, giving an emission of 130 Mt of carbon in 2009. The most significant reductions arise from the public power and industrial combustion sectors. In 2009, power generation accounted for 32% of UK emissions, whilst road transport emissions accounted for 24% of the total emissions.
- 17 **Methane (CH₄)** - Estimates of methane emissions show a decrease of 60% from 1990 to 2009, giving emissions of 2.1 Mt (or 44 Mt CO₂equivalent) in 2009. The largest sources are landfills, agriculture, natural gas distribution and coal mining. The reduction in emissions is largely due to the decline in the coal mining industry and increased levels of methane recovery on landfill sites.
- 18 **Nitrous Oxide (N₂O)** - UK emissions of nitrous oxide were 0.11 Mt (or 35 Mt CO₂equivalent) in 2009, corresponding to a decrease of 49% between 1990 and 2009. Emissions of nitrous oxide are dominated by those arising from direct soil emissions

¹ Toxic equivalents are used for PCDD/F to provide an estimate of the toxicity of the mixture of the 209 PCDD/Fs emitted from sources in terms of a mass of the most toxic PCDD/F

²Figures for GHG emissions in this report is consistent with the submission of the UK to the UNFCCC

and production processes. Emission estimates of N₂O are highly uncertain (see Section 7.4).

- 19 **Fluorocarbons HFC, PFC and SF₆**- The UK emissions in 2009 were HFCs: 3.0 Mt of carbon equivalent³, PFCs: 0.04 Mt of carbon equivalent and sulphur hexafluoride: 0.2 Mt of carbon equivalent. These correspond to reductions of 4.0%, 90% and 36% since 1990 for HFC, PFC and SF₆ respectively. Halocarbon use is the biggest contributor to HFC and SF₆ emissions, accounting for 99% and 88% of the emissions in 2009 respectively. The largest contributor of emissions for PFC emissions in 2009 is from the use of PFC in electronics (49%) and the aluminium production sector (41%).
- 20 The 2009 emission inventory indicates that the dominant source of many air pollutants is fossil fuel combustion in road transport and the use of coal for power and heating (see table below).

Table ES1: Road Transport and Coal Combustion Contribution to Total UK Atmospheric Emissions of Selected Pollutants in 2009

Pollutant	Coal Combustion (% share of UK total)	Road Transport (% share of UK total)	Total Contribution to UK emissions (%)
Hydrogen Chloride	83%	n/a	83%
Hydrogen Fluoride	81%	n/a	81%
Tin	9%	19%	28%
16 Polycyclic Aromatic Hydrocarbons	18%	17%	35%
Sulphur Dioxide	53%	0%	54%
Beryllium	19%	54%	72%
1,3-Butadiene	n/a	52%	52%
Carbon Monoxide	5%	47%	52%
Selenium	21%	16%	38%
Nitrogen Oxides	19%	33%	52%
Copper	6%	47%	53%
Magnesium	33%	n/a	33%
PM ₁₀	9%	23%	32%
Carbon	20%	24%	44%
Sodium	30%	n/a	30%
Benzo[a]pyrene	23%	4%	28%
Manganese	21%	2%	24%
Benzene	2%	22%	23%
Potassium	11%	0.01%	11%

³ The UK Greenhouse Gas Inventory estimates speciated emissions of HFCs and PFCs. However due to the nature of the industry that produce and use these gases they are considered to be commercially confidential. Therefore in this report they have been aggregated and reported as carbon equivalent values. This is the Global Warming Potential of the greenhouse gas. SF₆ is reported in the same way for consistency.

Pollutant	Coal Combustion (% share of UK total)	Road Transport (% share of UK total)	Total Contribution to UK emissions (%)
Arsenic	12%	n/a	12%

These data indicate the significance to UK air quality pollutant emissions from these two key emission sources.

21 A copy of this report may be found at the NAEI web site (www.naei.org.uk) along with a facility for interrogation of the underlying data and links to data on emissions in other countries.

GLOSSARY

Emission Units

Pollutant emissions are presented using a number of different mass and / or toxicity units, as appropriate, with specific reporting protocols including:

- NO_x emissions are quoted in terms of NO_x as NO₂
- SO_x emissions are quoted in terms of SO_x as SO₂
- Dioxins and Furans are quoted in terms of mass, but accounting for toxicity. This is the I-TEQ and is explained further in the relevant section.
- Pollutant emissions are quoted as mass of the full pollutant unless otherwise stated, e.g. ammonia emissions are the mass of ammonia emitted and not the mass of the nitrogen content of the NH₃.

Acronyms and Definitions

ABI	Annual Business Inquiry
ACTRAFF	actual rail traffic database
AQD	Air Quality Directive
AQS	Air Quality Strategy
AS	Aviation Spirit
ATF	Aviation Turbine Fuel
ATM	Air Traffic Movement
ATOC	Association of Train Operating Companies
AUP	Auxiliary Power Unit
BAU	Business as usual
BCA	British Cement Association
BCF	British Coatings Federation
BERR	Department for Business, Enterprise & Regulatory Reform
BGS	British Geological Survey
BMW	Biodegradable Municipal Waste
CAA	Civil Aviation Authority
CCA	Climate Change Agreement
CCGT	Combined Cycle Gas Turbine
CD	Crown Dependency
CEH	Centre for Ecology and Hydrology
CHP	Combined heat and power
DA	Devolved Administrations
DECC	Department of Energy & Climate Change
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DERV	Diesel Fuel
DoENI	Department of Environment Northern Ireland
DRDNI	Department for Regional Development Northern Ireland
DPF	Diesel Particulate Filters
DUKES	Digest of UK Energy Statistics
EMEP	European Monitoring and Evaluation Program
EE	Energy Efficiency
EEMS	Environmental Emissions Monitoring System
EPR	Environmental Permitting Regulations
EU ETS	European Union Emissions Trading Scheme
ESWNI	England, Scotland, Wales, Northern Ireland
FGD	Flue gas desulphurisation
GDP	Gross Domestic Product
GCV	Gross Calorific Value
GHG	Greenhouse gases
GHGI	Greenhouse gas inventory
GCA	Gross Value Added
GWh	Giga Watt Hour (unit of energy)
GWP	Global Warming Potential
HGV	Heavy Goods Vehicle
HM	Heavy Metals
ICAO	International Civil Aviation Organisation
IEF	Implied Emission Factor
IPC	Industrial Pollution Control
IPPC	Integrated Pollution Prevention and Control
ISR	Inventory of Statutory Releases (DoENI)
ISSB	Iron and Steel Statistics Bureau
KtC	Kilo tonne of Carbon
KtC-e	Kilo tonne of Carbon-equivalent (taking account of GWP)
LAEI	London Atmospheric Emissions Inventory
LA-IPPC	Local Authority Integrated Pollution Prevention and Control
LGV	Larger Goods Vehicles
LPG	Liquefied petroleum gas
LRTAP	Convention on Long-Range Transboundary Air Pollution
LTO	Landing & Take Off
MPP	Major Power Producers (i.e. most power station operators)
MSW	Municipal Solid Waste
NFR	Nomenclature for Reporting

NAEI	National Atmospheric Emissions Inventory
NEC	National Emission Ceilings Directive
OCGT	Open Cycle Gas Turbine
ONS	Office for National Statistics
OT	Overseas Territories
PAH	Polycyclic Aromatic Hydrocarbons
PAMs	Policies and Measures
PI	Pollution Inventory (of the Environment Agency of England & Wales)
POC	Port of call
POPs	Persistent Organic Pollutants
PPC	Pollution Prevention and Control
PRODCOM	PRODUCTION COMMUNAUTAIRE
PSDH	Project for the Sustainable Development of Heathrow
QA/QC	Quality Control/Quality Assurance
RASCO	Regional Air Services Co-ordination
RDF	Refuse Derived Fuel
RESTATs	Renewable Energy Statistics (published by DECC)
RTFO	Renewable Transport Fuels Obligation
SCCP	Short Chain Chlorinated Paraffins
SEPA	Scottish Environmental Protection Agency
SPRI	Scottish Pollutant Release Inventory
SWA	Scotch Whiskey Association
THC	Total Hydrocarbons
TSP	Total Suspended Particulate
TRL	Transport Research Laboratory
TFEIP	Task Force on Emission Inventories and Projections
UEP	Updated Energy Projection (UK energy forecasts produced by DECC)
UKCCP	UK Climate Change Programme
UKMY	UK Minerals Yearbook
UKPIA	UK Petroleum Industries Association
UNECE	United Nations Economic Commissions for Europe
US EPA	United States Environment Protection Agency
ULSP	Ultra-low Sulphur Petrol
WML	Waste Management Licensing
WID	Waste Incineration Directive

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ANNEX 1 DEFINITIONS OF UNECE SOURCE SECTORS		

1 Introduction

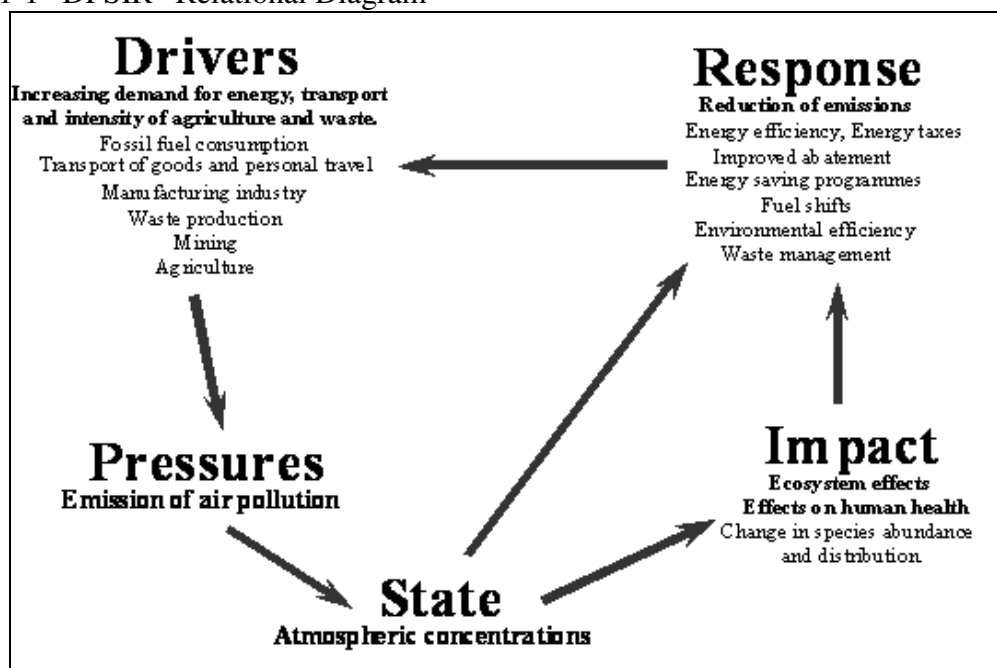
1.1 INTRODUCTION TO EMISSION INVENTORIES

Emission inventories play an important role in assessing the effects of human activity on atmospheric pollution. The principal demands for energy, transportation, materials and food may be regarded as the “*drivers*” for the production of air pollutants. In order for an economy to continue to develop in a sustainable way these sources of pollution must be managed. To do this we must understand the “*impacts*”, i.e. what types of pollution affect which parts of the environment or human health, and to what extent. To decide whether action is necessary we also need to know the “*state*” of the environment, i.e. to evaluate whether the levels in the environment exceed those which will cause environmental harm.

In taking appropriate action we must be able to respond in a focused way to control and reduce pollution while avoiding larger-scale damage to economic development. Emission inventories provide policy makers and the public with an understanding of the key polluting sources or the “*pressures*”, how these sources have developed with economic growth and how they are likely to contribute to pollution in the future. This understanding is essential for a focused “*response*” to the problems associated with air pollution and to meet the demands of sustainable development.

Figure 1.1 shows how our understanding of the *pressures* (through emission inventories) interacts with other areas of environmental knowledge such as *impact* assessment and monitoring (*state*). Figure 1.1 also outlines the relationship between: emission inventories, economic activity and effective environmental policy.

Figure 1-1 “DPSIR” Relational Diagram



1.1.1 Nomenclature of the inventory

The economic sectors that emit pollutants are presented in the UK National Atmospheric Emission Inventory in the nomenclature for reporting (NFR) format (EMEP/CORINAIR (2009)) which gives a code to each sector. The exception to this is the processing of data to form maps of emissions, which are expressed in Selected Nomenclature for Air Pollution (SNAP) code (EMEP/CORINAIR (1997)). SNAP codes were originally developed by the European Topic Centre (ETC) at the European Environment Agency (EEA) for reporting under the National Emissions Ceilings Directive. The use of SNAP codes is, however, now declining as Member States move towards using the Convention on Long-Range Transboundary Air Pollution (LRTAP) templates for NECD reporting. These templates use NFR codes⁴.

1.2 THE UK NATIONAL ATMOSPHERIC EMISSIONS INVENTORY

The UK emissions inventory is compiled by the UK Emissions Inventory Team, at AEA. The inventory and the related programme of work is conducted on behalf of the Department for Environment, Food and Rural Affairs (Defra), Department of Energy and Climate Change (DECC) and the Devolved Administrations. More specifically, within Defra, work on air quality pollutants is lead by the Science and Evidence Team (Atmosphere and Local Environment Programme, ALE), under the heading of the National Atmospheric Emissions Inventory (NAEI). Work on greenhouse gases (GHGs) is conducted for the Climate & Energy, Science & Analysis, division of DECC and is delivered as the Greenhouse Gas Emissions Inventory (GHGI). However, the UK programme is a single internally consistent programme. The notional split into two components (an air quality inventory and a GHG inventory), allows more focussed delivery on the relevant environmental issues and Government commitments.

The NAEI and GHGI are the standard reference air emissions inventories for the UK and include emission estimates for a wide range of pollutants, including: GHGs, regional pollutants leading to acid deposition and photochemical pollution, persistent organic pollutants (POPs) and other toxic pollutants such as heavy metals. The full range of pollutants for which emissions are estimated is summarised in Table 1.2. Where possible, estimates are presented for 1970-2009. However, for some pollutants, for example ammonia (NH₃) and POPs, there is insufficient information to produce a 1970-2009 time series and estimates are presented from 1980, 1990 or 2000 to 2009. The summary of the time series available for each pollutant is summarised in Table 1.2.

Emission inventories serve several important functions, including:

1. **Provision of Public Information-** The data from the NAEI and GHGI is made available to the public in various forms. The aim is to make information available in an easily understandable format, informing the public of emissions in their area as well as making national emissions data available. The NAEI/GHGI is paid for by tax payer's money, through the national and devolved administration governments, and consequently it is important to maintain a high public profile and accessibility to the work. A copy of this

⁴ For details regarding the NECD and LRTAP Convention, please see Annex 1.

report is available on the internet at www.naei.org.uk. Further information can be found in Section 1.2.3.

2. **Development of policy-** The data from the NAEI/GHGI is used to inform development of policies to tackle emissions of air quality pollutants and GHGs.
 - **Identification of Primary Sources-** The NAEI/GHGI compiles emissions from all possible anthropogenic and natural sources (where information allows). Consequently it is simple to determine which source sectors are the major emitters of individual pollutants.
 - **Temporal and Spatial Trend Assessment-** The NAEI/GHGI provides information to allow temporal trend analysis as it is compiled annually (from 1970 for most pollutants). This information feeds directly into policy associated with reducing future emissions. UK maps are also generated for more than 20 pollutants, allowing spatial trends to be assessed.
 - **Inventory Comparisons-** Mapped emission inventories exist for a number of cities across the UK. In some cases the techniques used to compile these emission inventories differ from the NAEI/GHGI. As a result comparison with the NAEI/GHGI highlights the potential strengths and weaknesses of the different techniques.
 - **National Modelling Studies-** The NAEI/GHGI is used in a variety of modelling studies investigating spatial and temporal trends in deposition and concentration of pollutants. Furthermore, it is possible to use the NAEI/GHGI alone to investigate the impact on emissions of particular future policy scenarios.
 - **Local Support-** Data from the NAEI/GHGI is frequently used by Local Authorities to support air quality assessments, and aid the generation of local policy.
3. **National and International Reporting-** The NAEI/GHGI provides the official air emissions estimates for the UK. National and International reporting requirements are given in more detail in the following Sections.
4. **Progress on Complying with National and International Commitments-** The annual inventory provides an important assessment tool for policy makers. The inventory is used to monitor progress towards emission ceilings and reductions at both the national and international level. It is, therefore, an important tool in assessing the effectiveness of existing policy measures.
5. **Provision of Information to the Private Sector-** Data that goes towards compiling the NAEI/GHGI emissions inventory is often used by industry. This allows emission reductions to be planned by introducing abatement equipment, altering processes or improving efficiencies.

1.2.1 International Commitments

The NAEI provides the UK air emission data for submission to United Nations Economic Commission for Europe (UNECE). The GHGI provides data for submission to the United Nations Framework Convention on Climate Change (UNFCCC) (Table 1.1). Under the UNFCCC, the UK is committed to developing, publishing and regularly updating national emission inventories of GHGs using reporting guidelines from the Intergovernmental Panel on Climate Change (IPCC). The inventories for both direct GHGs (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) and indirect GHGs (nitrogen oxides, carbon monoxide and non-methane volatile organic compounds) are drawn from the UK NAEI/GHGI emissions data included in this report. Similarly, NAEI estimates of emissions of nitrogen oxides, carbon monoxide, ammonia, sulphur dioxide, NMVOC, POPs and heavy metals are submitted to UNECE under the Convention on Long-Range Transboundary Air Pollution (CLRTAP). Member States are also required to submit emissions data for four pollutants under the National Emissions Ceilings Directive (NECD). As part of the commitments to the CLRTAP, countries are also required to submit emission projections for selected pollutants (under the Gothenburg Protocol). These emission projections are compiled and reported as part of the NAEI programme. NAEI data are provided to international emission inventory activities such as the EC's CORINAIR and EUROSTAT inventories.

Table 1.1 Reporting requirements for the 2009 inventory

Legal Obligation	Reporting requirement		Reporting deadline
	Pollutants	Time period	
LRTAP Convention (1979 Convention on long range transboundary air pollution)	Emissions of SO ₂ , NO _x , NH ₃ , NMVOCs, CO, Heavy Metals, Persistent Organic pollutants (POPs), particulate matter (PM)	1980-2009	15 February 2011
EU NECD (Directive 2001/81/EC)	Emissions of SO ₂ , NO _x , NMVOCs, NH ₃	2008-2009, 2010	31 December 2010
UNFCCC EU Monitoring Mechanism (Council Decision 280/2004/EC)	Emissions of CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆ , NO _x , CO, NMVOC, SO ₂	GHG 1990-2009, Indirect GHG in the UK (NO _x , CO, NMVOC, SO ₂)	15 January 2011 to European Commission 15 April 2011 to UNFCCC

Members of the UK inventory team have a strong international profile, and play an important role in the development of international guidelines by the European Environment Agency, the UNECE, and the IPCC. The aim of these organisations is to achieve a consistent set of good quality inventories for all European countries, and UK inventory experts contribute to this process in a number of ways. More information may be found respectively at the EEA, EMEP, IPCC and UNFCCC websites at:

<http://www.eea.europa.eu> and www.emep.int and www.unfccc.int and www.ipcc.ch

In addition to the national emission inventories derived from the NAEI, other emissions data and inventories covering specific industrial production and combustion activities are also

submitted to international agencies as part of the UK's commitments to environmental regulatory and trading mechanisms:

- **The European Pollutant Release and Transfer Register (E-PRTR).** This multi-media inventory of environmental releases is submitted to the EU by Defra, using data derived from the Environment Agency's Pollution Inventory, the Scottish Pollutant Release Inventory from the Scottish Environmental Protection Agency, the Inventory of Statutory Releases from the Northern Ireland Environment Agency and an inventory of Local Authority-regulated installation compiled by Defra.
- **The European Union Emissions Trading Scheme (EU ETS).** Emissions of carbon dioxide from installations operating within the EU ETS are submitted annually to the Community Independent Transaction Log (CITL), as part of the trading system established across Europe to promote reductions of GHG emissions from the largest emitting sites in the EU area.

1.2.1.1 International Review

In 2010, the UK NAEI was reviewed by a team of UNECE experts. The review team focused on the official 2010 UK LRTAP submission and IIR that were submitted to the UNECE in February 2010, assessing the inventory data, methods and report quality, completeness and consistency against UNECE requirements. The results of the review are available on the CEIP website at <http://www.ceip.at/review-process/review-2010/>.

1.2.2 National Information

The NAEI/GHGI database provides atmospheric emissions data from all anthropogenic sources to the public, UK Government, the devolved administrations, local authorities and private sector organisations. Many of the specific policy uses have been outlined above, but there are a number of other ways in which the data is used, including:

- The NAEI emissions inventory underpins a range of detailed studies into geographically- or sector-referenced analysis, providing key data inputs into local / regional / national policy scenario analysis, to support other information available to Defra, the DA governments and Local Authorities. This information is required for a wide variety of uses; from long-term policy support to specific short-term issues. For example the emissions data underpinned air quality modelling carried out as an integral part of the development of the 2007 Air Quality Strategy (see http://uk-air.defra.gov.uk/library/reports?section_id=17) for details of the modelling carried out and the resulting policies developed).
- The NAEI dataset is made available to other organisations working on related research projects for Defra, the DAs, Local Authorities, within academia or to organisations involved in international projects and programmes. This ensures a high level of consistency and efficiency in providing UK-specific information, such as source-specific emission factors, for a wide range of research applications.
- Mapped emission inventories for the UK are generated on a 1x1km scale. These data may be applied to develop local emission inventories, and to provide key data inputs into the Local Authority Review and Assessment process, which assesses current and future air

quality issues that impact on human health at a local level. The UK Pollution Climate Mapping model (PCM) (see Grice et al (2010), Kent et al (2010) and Yap et al (2009)) for the most recent modelling method and results, the Ozone Source Receptor model (OSRM) (Murrells et al, 2010) and many other UK air quality modelling community ranging from urban dispersion models to regional scale chemistry transport models use the NAEI 1x1km mapped emissions data to calculate spatially disaggregated maps of ambient concentrations of air quality pollutants. These models are used both in reporting air quality exceedences to the European Commission under the three European Daughter Directives on air quality, now merged under the Air Quality Directive (AQD) and the 4th Daughter Directive, and extensively for scenario modelling to inform policy developments by the UK Government.

- Emission estimates for point sources and emissions arising from the surrounding area are used in modelling studies as part of Environmental Impact Assessments by developers and their consultants, within the planning process for new developments.
- The NAEI team works closely with industrial and commercial Trade Associations to exchange emissions, activity and production data whilst managing issues of commercially confidentiality. This ensures that the NAEI/GHGI and the Trade Associations can arrive at emission estimates that are truly representative for specific economic sectors, but do not disclose specific company / farm scale activities.
- Emission factor data is provided for use by Local Authorities, academics and other consultants through the UK's Emission Factor Database on the NAEI website.

Table 1.2 Pollutants Covered by the Inventories

Pollutant		Range of Estimates ¹	Type of Pollutant ²
Carbon Dioxide	CO ₂	1970-2009	G
Methane	CH ₄	1970-2009	G
Nitrous Oxide	N ₂ O	1990-2009	G
Hydrofluorocarbons	HFC	1990-2009	G
Perfluorocarbons	PFC	1990-2009	G
Sulphur Hexafluoride	SF ₆	1990-2009	G
Nitrogen Oxides	NO _x (NO ₂ + NO)	1970-2009	NAQS, AC, EU, IG, O
Sulphur Dioxide	SO ₂	1970-2009	NAQS, AC, IG
Carbon Monoxide	CO	1970-2009	NAQS, O, IG
Non-Methane Volatile Organic Compounds	NMVOG	1970-2009	NAQS, O, IG
Black Smoke	BS	1970-2009	NAQS
Particulates < 10 µm	PM ₁₀	1970-2009	NAQS
Ammonia	NH ₃	1980-2009	AC, EU
Hydrogen Chloride	HCl	1970-2009	AC
Hydrogen Fluoride	HF	1970-2009	AC
Lead	Pb	1970-2009	NAQS, HM
Cadmium	Cd	1970-2009	HM
Mercury	Hg	1970-2009	HM
Copper	Cu	1970-2009	HM
Zinc	Zn	1970-2009	HM
Nickel	Ni	1970-2009	HM
Chromium	Cr	1970-2009	HM
Arsenic	As	1970-2009	HM
Selenium	Se	1970-2009	HM
Vanadium	V	1970-2009	HM
Beryllium	Be	2000-2009	HM
Manganese	Mn	2000-2009	HM
Tin	Sn	2000-2009	HM
Polycyclic Aromatic Hydrocarbons	PAH	1990-2009	POP
Dioxins and Furans	PCDD/F	1990-2009	POP
Polychlorinated Biphenyls	PCB	1990-2009	POP
Lindane (gamma-HCH)	HCH	1990-2009	POP
Pentachlorophenol	PCP	1990-2009	POP
Hexachlorobenzene	HCB	1990-2009	POP
Short-chain chlorinated paraffins	SCCP	1990-2009	POP
Polychlorinated Naphthalenes	PCN	NE	POP
Polybrominated diphenyl ethers	PBDE	SE	POP
Sodium	Na	1990-2009	BC
Potassium	K	1990-2009	BC
Calcium	Ca	1990-2009	BC
Magnesium	Mg	1990-2009	BC

¹ An explanation of the codes used for time series:

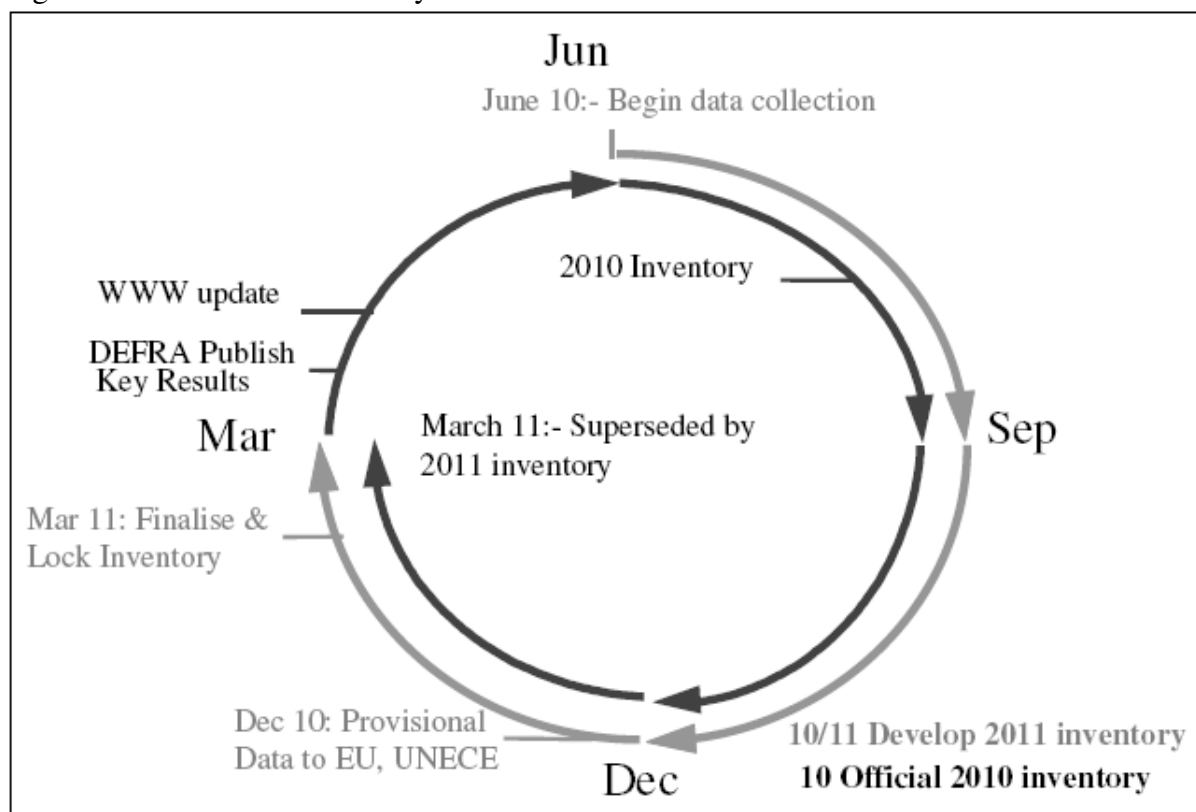
SE A "Single Emission" estimate not attributed to a specific year
NE "Not Estimated" due to lack of information currently available

² An explanation of the codes used for pollutant types:

G Greenhouse gas **IG** Indirect greenhouse gas
O Ozone precursor **AC** pollutant associated with acidification
EU pollutant associated with terrestrial and aquatic eutrophication
NAQS National Air Quality Standard/Local Air Quality Management pollutant
HM Heavy Metal
POP Persistent Organic Pollutant
BC Base cation

The NAEI/GHGI is compiled on an annual basis; each year the latest set of data are added to the inventory and the full time series is updated to take account of improved data and any advances in the methodology used to estimate the emissions. Updating the full time series is an important process as it ensures that the entire dataset is consistent and uses the methodology that is the most current, and hence considered to give the most accurate results and the most accurate indication of temporal trends. The new data are then reported to UNECE, UNFCCC and other international and national organisations. This annual cycle of activity is represented schematically in Figure 1-2.

Figure 1-2 The Annual NAEI Cycle



1.2.3 Information Dissemination

Data from the NAEI/GHGI is made available to national and international bodies in a number of different formats as explained in Sections 1.2.1 and 1.2.2. This annual report outlines the definitive latest emission estimates by source and provides a short introduction to the NAEI and summary of the trend analysis for all main pollutants, primarily focusing on the non-GHG pollutants. The report is the latest in a series of annual reports published by the UK emissions inventory team (Eggleston, 1988; Eggleston and Munday, 1989; Munday, 1990; Leech, 1991; Gillham et al 1992; Gillham et al 1994; Salway et al 1996, 1996a, 1997, Salway 2000, Salway et al 1999, Goodwin et al 2000, Goodwin et al 2001, Goodwin et al 2002, Dore et al 2003, Dore et al 2004, Dore et al 2005, Dore et al 2006, Dore et al 2007, Dore et al 2008, Murrells et al 2009, Murrells et al 2010b).

Chapters 2 to 7 present the NAEI/GHGI emission estimates for the UK. They have been divided into five groups, reflecting the national and international activity relating to atmospheric pollution, namely air quality pollutants, heavy metals, base cations, POPs, stratospheric ozone depleting substances and GHGs. Each of these chapters include a discussion of the importance of the pollutants concerned, present time series emission data, and discuss the data trends and spatial disaggregation within the UK.

The contents of this report complement other publications by the NAEI throughout the year. The following reports should be consulted to find out further information on these specific areas of the inventory:

- **GHG emission trends and methodology used to compile the GHG inventory**
UK Greenhouse Gas Inventory, 1990 to 2009 (MacCarthy et al, 2011)

The GHG inventory team of the NAEI prepares an annual report for Submission under the Framework Convention on Climate Change required under the EU Monitoring Mechanism (Decision 280/2004/EC). The report and its annexes provide key trend analysis of the GHG inventory and the methodologies used.

- **Methodology used to compile the air emissions inventory**
UK's 2009 Informative Inventory Report (Passant et al 2011)

The Informative Inventory Report is compiled annually to accompany the UK's 2011 data submission under the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP) and contains detailed information on the UK inventory, methodologies used and a summary of the annual emission estimates of air quality pollutants by source in the UK since 1980.

- **Mapping methodology**
UK Emission Mapping Methodology (Bush et al, 2011)

An annual report containing the detailed methodology used to compile the 1km x 1km maps for the main pollutants covered by the NAEI. The report also provides recommendations for future improvements for the compilation of the maps.

- **Projections results and methodology**
UK Emission Projections of Air Quality Pollutants to 2020 (Wagner et al, 2009)

The projections report presents the projections of air quality pollutants based on DECC's UEP37 energy projections. In addition, detailed information on the methodology used and uncertainty of the projections is included in this report. The latest projections based on the UEP38 energy projections follows the methodology in this report and the key differences between the results have been summarised in the 2010 Emission Projections Reasons for Change Paper (Wagner et al, 2010).

- **Devolved Administration Inventory**
Air Quality Pollutant Inventories for England, Scotland, Wales and Northern Ireland: 1990-2008 (MacCarthy et al, 2010)⁵

An annual report which disaggregates the UK emissions totals presented in this report to the constituent countries. The results and the methodology used are presented in this report.

⁵ This report will be superseded by the Air Quality Pollutant Inventories for England, Scotland, Wales and Northern Ireland: 1990-2009 report containing emissions data consistent with this report in September 2011.

All the above reports can be found under the reports section of the NAEI website (<http://naei.defra.gov.uk/reports.php>).

In addition there is a continuous drive to make information available and accessible to the public. A large amount of information is made available on the internet. The NAEI web pages may be found at www.naei.org.uk

These web pages are arranged to allow easy access to the detailed emissions data, as well as providing other background information on atmospheric emissions and their impacts at local to global scales. The NAEI web pages include the following information resources:

- **Data Warehouse**-Emissions data is made available in numerous formats through a database that can be queried online. This allows extraction of overview summary tables, source-specific emission factors and detailed source-specific emissions data.
- **Emissions Maps** - Emissions of pollutants are given in the form of UK maps. These maps give emissions of various pollutants on a 1 x 1 km resolution. The maps are available as images, but in addition the data behind the maps can also be accessed directly from the website.
- **Reports** - The most recent NAEI/GHGI annual report is made available in electronic format, along with a host of other reports compiled by the inventory team, and reports on related subjects.
- **Methodology** - An overview of the methods used for the compilation of the NAEI/GHGI is included on the website.

The NAEI website also provides numerous links to locations explaining technical terms and why there is an interest in particular pollutants. In particular there are links to the various Defra pages containing comprehensive measurement data on ambient concentrations of various pollutants. The Defra sites can be found at:

<http://www.defra.gov.uk/environment/quality/air/airquality/index.htm> and

<http://www.defra.gov.uk/environment/climate/index.htm>

1.2.4 Methodology

Emission estimates for pollutant releases from all anthropogenic sources in the UK are estimated by combining an activity statistic with an emission factor:

$$\text{Emission} = \text{Emission Factor} \times \text{Activity}$$

For example:

$$\begin{array}{l} \text{Carbon Emission from coal use} \\ \text{in the domestic sector} \\ \text{(in 2009)} \end{array} = \begin{array}{l} \text{Carbon content} \\ \text{of domestic coal} \\ \text{(in 2009)} \end{array} \times \begin{array}{l} \text{Coal consumption} \\ \text{in the domestic sector} \\ \text{(in 2009)} \end{array}$$

The source data used to derive estimates in the NAEI are taken from many hundreds of different data sources, ranging from National Statistics (such as the UK energy balance data within the annual DECC publication *The Digest of UK Energy Statistics*), to emissions data from UK environmental regulators, source-specific emissions research and international resources of emission factors.

The same activity data is commonly used to calculate emissions of all pollutants (i.e. all air quality and GHG pollutants) for a specific emission source. In the example above, “coal consumption in the domestic sector” is the activity data which can be taken from the DECC UK energy statistics; estimates of different pollutants from domestic coal use can be estimated by applying emission factors that are cited as “emissions per unit coal use”, e.g. “sulphur dioxide per kilogramme of coal”.

Emission factors are typically derived from source measurements across a range of emission sources that are representative of a particular source sector. In the domestic sector example, this may cover source measurements taken from emissions tests from fireplaces, closed stoves, coal-fired boilers and so on; alternatively, emission factors may be derived from analysis of fuel content for specific chemicals such as carbon or sulphur. The resulting emission factor may then be applied to all emission sources within the sector.

For industrial installations (e.g. power stations, refineries, iron and steel plant, cement kilns etc.) that are regulated under environmental legislation such as EPR and IPPC, annual emission estimates are reported by plant operators to the UK environmental regulatory agencies: the Environment Agency of England and Wales, the Scottish Environment Protection Agency and the Northern Ireland Environment Agency. For the most significant sources these emission estimates are typically based on continuous or periodic stack emission monitoring using agreed sampling, analysis and reporting methods and protocols. Due to the well-established regulatory systems of emissions monitoring and data quality control systems used to manage the IPPC system, these point source data are regarded as high quality estimates; for most pollutants, these data are used directly within the NAEI estimates for these high-emitting sectors.

The NAEI estimates are generated using a combination of reported point source emissions, and emissions calculated using emission factors.

Where point source emission data are unavailable, emissions are estimated from other activity data such as fuel consumption, distance travelled, production or other statistical data that are related to the emissions. Emission estimates are calculated by applying an emission factor to an appropriate activity statistic.

Fossil fuel combustion is a major source of emissions in the UK for many air quality pollutants, and therefore the Digest of UK Energy Statistics (DUKES) published annually by DECC is a key activity dataset that underpins many emission estimates across the NAEI. It is important to consider the difference between consumption and deliveries when making use of fuel statistics. Most readily available statistics refer to deliveries, which for many source categories relate closely to actual consumption of fuel. However, where fuel can be stockpiled, deliveries and consumption may differ significantly. This is just one example of having to ensure that the available data is correctly interpreted, and used in the most

appropriate way to arrive at representative emission estimates. The NAEI/GHGI uses DUKES as the primary source of fuel use data.

Emissions from sources such as industrial processes, farm animals and motor fuel evaporation require different statistics; in these cases data on process output, livestock numbers and motor fuel sales are appropriate.

In other cases, where emissions are more complex, further refinements or an alternative methodology is required. For example, in the estimation of emissions from road transport activity, the distance travelled by UK vehicles is a key data input; however, emissions per unit distance travelled are influenced by: vehicle type, vehicle age, engine size, fuel type, average speed and other parameters such as abatement technologies (e.g. catalytic converters, by type and according to abatement penetration rates across the fleet). To determine accurate emission estimates across the UK fleet, a complex calculation methodology is required in order to accommodate the wide range of parameters that influence pollutant emissions; to accommodate this, a separate road transport model is used for calculating the emissions given in the NAEI/GHGI.

1.2.5 Mapping Emissions

In developing mapped emissions of UK pollutants, the sources contributing to the UK emissions can be represented as one of three categories: points, lines or areas. Sectors such as power stations, refineries and large industrial plant can be represented by points. Their locations are known and data to estimate emission contributions are available. Major roads and railways are sectors that can be represented by lines if data are available. Other dispersed and numerous source sectors such as agriculture, domestic heating and commercial boiler emissions are represented by areas.

The method used to map emissions in the UK is dependent upon the data that are available. The technique employs a combination of reported emissions (for emission sources at regulated facilities) and surrogate geographical statistics to distribute emissions from line and area sources.

A detailed description of the emission mapping methodology can be found in the reports section of the NAEI website:

www.naei.org.uk/reports.php

The emission maps combine the information from different sources represented by the point, line and area sources. In order to map this combination, the UK is divided into a grid of 1km squares. Emissions are then represented in terms of the mass of emission per 1km grid squares. Maps of emissions for the majority of the pollutants covered under the NAEI/GHGI have been included in this report. These maps show emissions from all sources including some offshore sources. The offshore component is made up of shipping and fishing related emissions within a 12km coastal zone and also offshore oil and gas extraction further afield. The onshore and offshore components of the maps are both shown for NO_x below in Figure 1-3. The onshore emissions are contained within the black boarder of the map of the UK.

It is difficult to identify an offshore total for many of the pollutants as the emissions occur from a number of different sectors. For example, CH₄ emissions from offshore platforms will

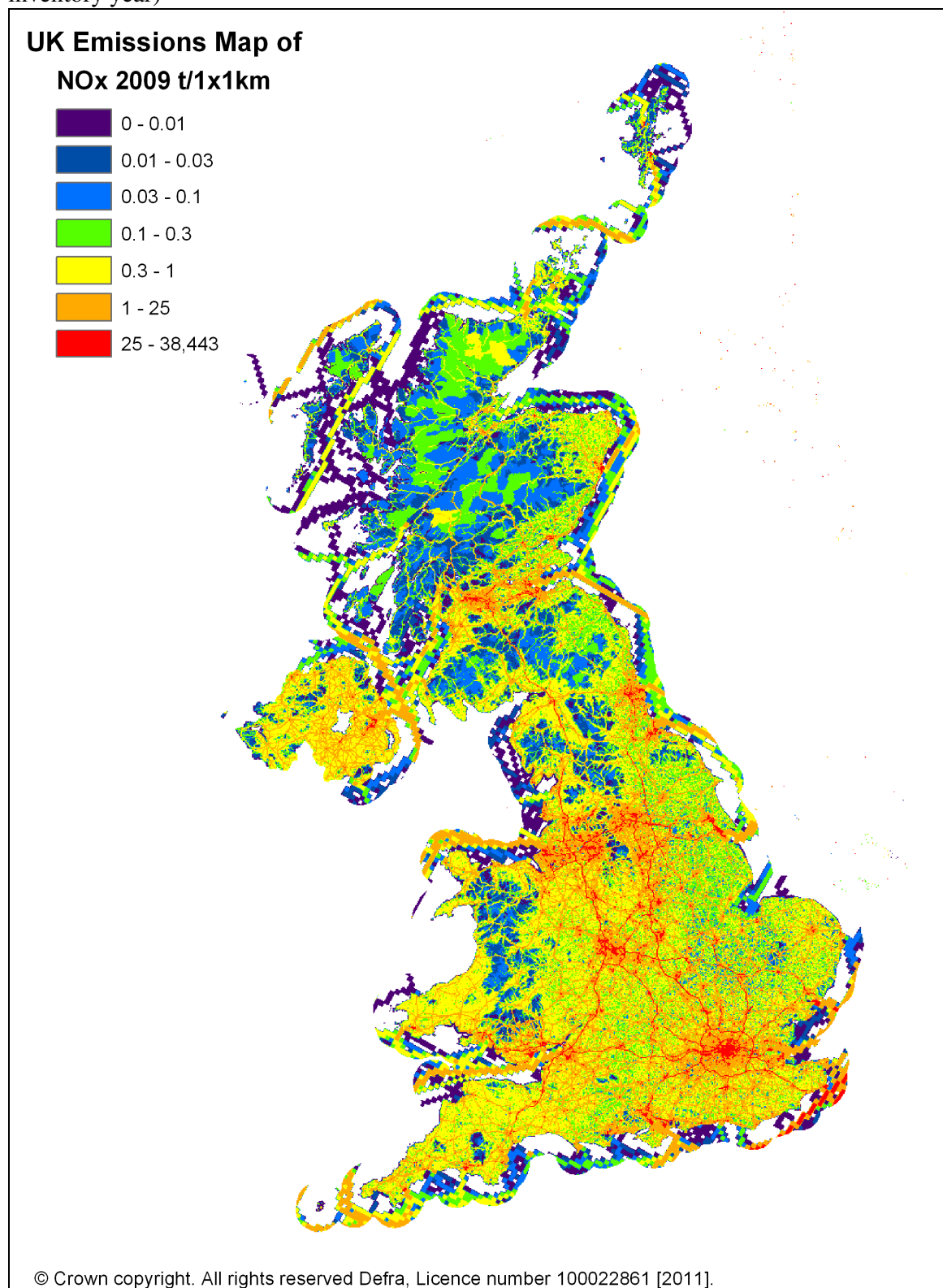
arise from a number of activities. Emissions may be included under “Extraction and Distribution of Fossil Fuels”, however other emissions may fall within the “Waste Treatment and Disposal” category (e.g. venting of CH₄). Emissions from fuel combustion in shipping fall into the “Other Mobile Sources and Machinery” sector. Annex 1 gives an explanation of the UNECE reporting framework and indicates which source category the emissions are reported under.

These maps meet the needs of a wide range of users. For example, they are used to provide input into air quality modelling, which allows Local Authorities to generate action plans as part of their air quality management role. The maps are also used in research projects investigating pollutant transport and atmospheric chemistry, and by the general public who are interested in understanding the air quality climate in their area.

1.3 ACCURACY OF EMISSION ESTIMATES

The uncertainty evaluation of emission estimates carried out by a Monte-Carlo uncertainty assessment and is detailed in the UK’s Informative Inventory Report 1980-2009 (Passant et al, 2011). The uncertainties of some pollutants have not been covered in the IIR and short explanations of the accuracy of those emissions can be found under the pollutant specific texts in this report.

Figure 1-3 NO_x Emissions Maps⁶- Onshore, Offshore and Total Emissions in 2009 (most recent inventory year)



⁶ This map is reproduced from Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office
(c) Crown copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings. Defra, Licence number 100022861, [2009]

1.3.1 Projections

Projected emissions for the four National Emission Ceilings Directive (NECD) pollutants are compiled by the NAEI team in AEA to enable comparisons with international commitments to be made. A summary of the latest forecasts was submitted in December 2010 under the NECD reporting requirements. Emission projections are also submitted under the Long-range Transboundary Air Pollution (LRTAP) convention every 5 years, with the latest dataset being provided with the 2009 inventory in February 2011.

The UK is required under the Gothenburg Protocol and the more stringent National Emission Ceilings Directive (NECD) to reduce emissions of NO_x, SO₂, NMVOCs and NH₃ by 2010 and thereafter. The target emissions are provided in Table 1.3 below, together with the UK's estimated emissions for 2009, the latest year available. UK emissions of NMVOC, SO₂ and NH₃ were below the 2010 ceiling at the time of the 2010 inventory. NO_x emissions based on the 2011 inventory are also below the 2010 ceiling. Emissions of NH₃ and NO_x in 2009 remain very close to the NECD target in 2010. Thus the UK needs to ensure emission levels continue to decline, or at least remain at levels observed in 2009, in order to meet their NECD targets.

Table 1.3 The UK's emissions in 2009 (as reported to the NECD⁷) and targets for 2010 that the UK is committed to.

Pollutant	Emissions in 2009 (ktonnes)	Gothenburg Protocol target in 2010 (ktonnes)	NECD Emissions ceiling target in 2010 (ktonnes)	Emissions in 2009 compared to 2010 Emissions ceiling target
NO _x	1,086	1,181	1,167	-7.4%
SO ₂	397	625	585	-32%
NMVOCs	826	1,200	1,200	-31%
NH ₃	288	297	297	-3.1%

Projections of UK emissions are compiled when significant new energy forecasts, road traffic projections or a new version of the inventory becomes available. The NAEI projections methodology can be found in detail in the UK Emission Projections of Air Quality Pollutants to 2020 report (Wagner et al, 2009). The key changes in the projections submit under NECD have been summarised in the 2010 Emission Projections Reasons for Changes Report (Wagner et al, 2010).

1.3.1.1 Progress towards NECD Targets

The (UEP38, 2010) emission projections show that the UK is likely to meet the NECD targets in 2010 for SO₂, NMVOCs and NH₃ (see Table 1.3). Emission estimates for NO_x were forecast to be lower than the ceiling in 2010 (by 35 ktonnes). The projections in Table 1.4 below are based on the finalised 2010 inventory because the 2011 inventory was not yet finalised for the December submissions under the NECD.

⁷ Covering the United Kingdom and Gibraltar

Table 1.4. Predicted emissions for those sectors covered under the NECD using DECC's UEP38 energy projections (ktonnes).

Projected Year	2010
NO _x	1,132
SO ₂	372
NMVOG	774
NH ₃	291

1.3.1.2 Uncertainty Analysis

The methodology and the results used to estimate the uncertainty of the projections submitted in 2010 can be found in the UK Emission Projections of Air Quality Pollutants to 2020 report (Wagner et al, 2009).

1.3.1.3 Consistency with greenhouse gas emission projections

The UK is required to submit greenhouse gas emission projections to the EU Monitoring Mechanism bi-annually. The projections data submitted in 2011 are still being processed. The 2009 submission data is included in the Greenhouse gas emission trends and projections in Europe 2009 report (EEA, 2009)⁸.

1.3.2 Continuous Improvement

The NAEI/GHGI operates a policy of continuous improvement, and reviews methodologies each year. The 2009 version of the NAEI/GHGI has seen a number of revisions and improvements. The details can be found in the UK Informative Inventory Report, 1980 to 2009 (Passant et al, 2011).

1.3.3 Summary changes in emissions trend between the 2008 and 2009 of the key pollutants

Emission levels fell for the majority of the pollutants between 2008 and 2009, excluding HFCs, Mercury, Acenaphthylene and Benzo[b]fluoranthene. The reductions are partly due to the economic downturn, policies and measures put into place to control emissions and a shift away from the use of coal. The increase in emission levels observed for these pollutants were relatively small (1-2%) apart from Mercury, where an increase in emissions of 15% was observed. This was primarily a result of a 100% increase in emissions from electric arc furnaces (NFR Code 2C1) reported under the Pollution Inventory (Environment Agency, 2010). Emission reductions were greatest for HCBs, PFCs and Nickel (44%, 29% and 27%, respectively). HCB emissions from chemical industries fell from 23kg in 2008 to zero in 2009. This reduction in HCB emissions reflects the closure of the chlorine process plant at Ineos (Runcorn) in early 2009; which would have been used to manufacture tetrachloroethenes.

Emissions from all NECD pollutants fell between 2008 and 2009, with the largest % reductions being observed for NO_x and SO₂. This is because a large proportion of NO_x and SO₂ emissions arise as a result of fuel combustion (power supply sector accounts for a

⁸ Report available under http://www.eea.europa.eu/publications/eea_report_2009_9

significant proportion of the total emissions) and coal consumption in the power supply sector fell considerably between 2008 and 2009.

In addition emissions levels of key pollutants fell for the following reasons:

NO_x - Emissions reductions were observed from passenger cars (47 ktonnes) and heavy duty vehicles (29 ktonnes) as a result of cleaner vehicles penetrating in the fleet combined with reductions in traffic activity for heavy duty vehicles (and to a lesser extent for passenger cars) between 2008 and 2009.

SO₂ - Emission from petroleum refining fell by 13 ktonnes due to a fall in the use of fuel oil and decreased emissions from catalyst regeneration between 2008 and 2009.

NH₃ - Emissions increased from the use of synthetic N-fertilisers (4 ktonnes), because of an increase in total N fertiliser use (from 958 to 971 kt) and, more importantly, an increase in urea-based fertiliser use (from 17 to 21% of total fertiliser N use) which are associated with a much greater emission factor than other fertiliser types. Emissions fell from manure management of poultry and swine by 1.48 ktonnes and 1 ktonne respectively as a result of a reduction in overall livestock numbers (poultry) and industry changes in livestock housing and manure management systems (pigs and poultry). These changes and other small reductions observed from other sources led to emission levels of NH₃ to remain relatively static between 2008 and 2009.

VOC - VOC emissions fell 103 ktonnes (11%) between 2008 and 2009. Emissions from passenger cars were the main reason for the observed reduction (43 ktonnes) due to newer and thus cleaner vehicles penetrating the fleet followed by emission reductions in oil production (14 ktonnes).

CO - The largest contributions to the overall emission reduction of 604 ktonnes between 2008 and 2009 were from passenger cars and iron and steel production. Emissions fell by 451 ktonnes from passenger cars as a result of cleaner vehicles penetrating the fleet and 51 ktonnes from iron and steel production because sharp decreases in steel production led to lower emissions from sintering, blast furnaces and basic oxygen steelmaking.

PM₁₀ - The largest emission reductions of PM₁₀ (2 ktonnes) occurred as a result of a decline in the use of coal in electricity generation. Emissions fell by 1 ktonne from industrial off-road mobile machinery as a result of a fall in the use of gas oil.

The above changes in emissions occur as a result of changes in the emission factor or activity data from 2008 to 2009 in the latest inventory. Any reasons for changes in emission trends between the 2009 NAEI and the latest inventory are explained in more detail in the UK Informative Inventory Report 1980 to 2009 (Passant et al, 2011)⁹.

⁹ Report available under <http://cdr.eionet.europa.eu/gb/un/cols3f2jg/envtx4p0w>

2 Air Quality Pollutants

2.1 INTRODUCTION

This section provides a discussion of the UK emissions affecting local and transboundary air pollution. These are targeted by both international and national policies. Table 2.1 summarises the policies and the pollutants covered.

Table 2.1 Pollutants covered by international and legislative directives

Directive	Pollutant Covered
Air Quality Strategy	PM – PM ₁₀ , PM _{2.5} , NO _x , O ₃ , SO ₂ , PAHs, Benzene, 1,3-butadiene, CO, Pb
NECD (National Emissions Ceilings Directive)	SO ₂ , NH ₃ , NO _x , NMVOC
CLRTAP (Convention on Long Range Transboundary Air Pollutants)	SO ₂ , NH ₃ , NO _x , NMVOC, PM ₁₀ , PM _{2.5} , TSP, Heavy Metals, POPs
E-PRTR	91 compounds, including: CH ₄ , CO, CO ₂ , HFCs, N ₂ O, SF ₆ , NH ₃ , NMVOC, NO _x , PFCs, SO ₂ , CFCs, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, PFC, PM ₁₀ , Benzene, HCl, HF, PAHs, PCB, PCDD, PCDF, Gamma HCH, PCP, HCB
IPPC (Integrated Pollution Prevention Control) and EPR (Environmental Permitting Regulations)	SO ₂ , NO _x , CO, VOC, metals, dust, asbestos, chlorine and its compounds
LCPD (Large Combustion Plants Directive)	SO ₂ , NO _x , PM
WID (Waste Incineration Directive)	Dust (PM), HCl, HF, SO ₂ , NO _x , Heavy metals, dioxins and furans, CO
Solvent Emissions Directive	VOC
Paints Directive	VOC
The Sulphur Content of Liquid Fuels Directive	SO ₂
Petrol vapour recovery	VOC
EU Air Quality Directives	SO ₂ , NO _x , PM, lead, benzene, CO, ozone, PAH, Cadmium, Arsenic, Nickel, Mercury

More detailed information on the methodologies used to compile the following inventories, and more detailed data are available from the NAEI website (www.naei.org.uk).

2.1.1 Transboundary air pollution

A number of international policies are currently in place to target transboundary air pollution. A specific target of these policies is acidifying pollutants and tropospheric ozone precursors, of which the total 2009 UK estimated emissions are summarised in Table 2.7.

Table 2.2 Estimated total UK Emissions of Acidifying Pollutants and Ozone Precursors in 2009

Pollutant	Total 2009 emission (ktonnes)
Nitrogen oxides (as NO ₂)	1,086
Sulphur dioxide	397
Hydrogen chloride	11
Non-methane volatile organic compounds (NMVOC)	826
Ammonia	288
Hydrogen fluoride	2.8

Concerns about acidifying pollutants arise as the deposition of acidifying species can have adverse effects on buildings and vegetation, as well as acidifying streams and lakes and damaging the aquatic environment. Sulphur dioxide and nitrogen oxides from fuel combustion are major contributors to acidification (Review Group on Acid Rain-RGAR, 1997). Ammonia (NH₃) plays an important part in the long range transport of the acidifying pollutants by the formation of relatively stable particles of ammonium sulphate and ammonium nitrate. Although NH₃ is a basic gas it deposits to soil surfaces and has an indirect effect on acidification. The biological transformation of NH₄⁺ to NO₃⁻ in soils (nitrification) and plant uptake both release acidity into the soil contributing to acidification. NH₃ deposition can also give rise to terrestrial eutrophication- where nutrient enrichment gives rise to changes in ecosystems.

Tropospheric ozone precursors include pollutants such as carbon monoxide, nitrogen oxides and volatile organic compounds. Tropospheric or ground level ozone occurs naturally, however atmospheric levels can be increased *in-situ* by the photochemical reaction of these ozone precursors. Specific non-methane volatile organic compounds (NMVOC) and groups of compounds play a key role in ozone formation. Ozone episodes in which concentrations rise substantially above background levels occur in summer months when there are long periods of bright sunshine, temperatures above 20°C and light winds. Ozone can affect human health and can damage plants and crops. There are no significant ozone emissions directly from anthropogenic activities.

UNECE's Convention on Long-Range Transboundary Air Pollution

The UK is committed to reducing acidifying gas and ozone precursor emissions and is a party to several protocols under the UNECE's Convention on Long-Range Transboundary Air Pollution (LRTAP).

Under the Second Sulphur Protocol, the UK had to reduce its total SO₂ emissions by 50% by 2000, 70% by 2005 and must reduce it 80% by 2010 (all from a 1980 baseline). The UK has now met the 2000, 2005 and 2010 target. In 2009, emissions were 92% lower than in 1980.

The NMVOC Protocol required the UK to achieve a 30% reduction of anthropogenic NMVOC emissions by 1999 from a 1988 baseline. Emissions (excluding those from forests) fell from 2,559 ktonnes in 1988 to 1,701 ktonnes in 1999 - a reduction of 34%, indicating that this was achieved. This reduction was achieved largely as a result of emission controls for road vehicles and industrial processes, introduced by European Directives and the Environmental Protection Act 1990 respectively.

Other factors also had an impact:

- Prohibition of the burning of crop residues in England and Wales since 1993, except in limited cases of exemption.
- A decline in the use of coal as a fuel by electricity generators, industry and domestic users in favour of gas;
- A decline in the use of petrol as a fuel for cars in favour of diesel;
- Improvements in technology introduced for economic reasons, or in response to health & safety legislation (e.g. the introduction of more efficient dry cleaning machines with lower emission levels);
- Measures introduced either voluntarily, or in response to pressure from end-users for improved environmental or health and safety performance (e.g. the formulations of many consumer products have been changed, resulting in lower levels of solvent in those products and therefore lower emissions of NMVOC during their use).

The NO_x Protocol required that the total emissions of NO_x in 1994 should be no higher than they were in 1987; UK emissions in 1994 were lower than in 1987 and have fallen substantially since 1994.

The UNECE Protocol to Abate Acidification, Eutrophication and Ground-level Ozone was adopted in Gothenburg in December 2000, where it was signed by the UK. Subsequently, the UK ratified the protocol in May 2005. The multi-pollutant protocol incorporates several measures to facilitate the reduction of emissions:

- Emission ceilings are specified for sulphur, nitrogen oxides, NH₃ and NMVOCs. These are summarised in Table 2.3.
- The protocol gives emission limits for sulphur, nitrogen oxides and NMVOCs from stationary sources.
- The protocol indicates limits for CO, hydrocarbons, nitrogen oxides and particulates from new mobile sources
- Environmental specifications for petrol and diesel fuels are given.
- Several measures to reduce NH₃ emissions from the agriculture sector are required.

Negotiations are currently underway for a revision to the Gothenburg Protocol with an agreement timetabled for December 2011.

Details of the UK's commitments under the UNECE Protocol on Heavy Metals can be found in section 3.1.1, whilst UK commitments under the UNECE Protocol on Persistent Organic Pollutants can be found in section 5.1.1. More detailed information on the Convention on LRTAP may be found at the UNECE web site: www.unece.org/env/lrtap/

Table 2.3 Emissions Ceilings for 2010 (ktonnes) in the Gothenburg Protocol

Country	Sulphur (as kt SO ₂)	NO _x (as kt NO ₂)	NH ₃ (kt)	NMVOC (kt)
Armenia	73	46	25	81
Austria	39	107	66	159
Belarus	480	255	158	309
Belgium	106	181	74	144
Bulgaria	856	266	108	185
Croatia	70	87	30	90
Czech Rep.	283	286	101	220
Denmark	55	127	69	85
Finland	116	170	31	130
France	400	860	780	1100
Germany	550	1081	550	995
Greece	546	344	73	261
Hungary	550	198	90	137
Ireland	42	65	116	55
Italy	500	1000	419	1159
Latvia	107	84	44	136
Liechtenstein	0.11	0.37	0.15	0.86
Lithuania	145	110	84	92
Luxembourg	4	11	7	9
Netherlands	50	266	128	191
Norway	22	156	23	195
Poland	1397	879	468	800
Portugal	170	260	108	202
Rep. of Moldova	135	90	42	100
Romania	918	437	210	523
Slovakia	110	130	39	140
Slovenia	27	45	20	40
Spain	774	847	353	669
Sweden	67	148	57	241
Switzerland	26	79	63	144
Ukraine	1457	1222	592	797
United Kingdom¹⁰	625	1181	297	1200

National Emissions Ceilings Directive

Within the EU, the National Emission Ceilings Directive was agreed in 2001. It sets emission ceilings to be achieved from 2010 onwards for each Member State for the same 4 pollutants as in the Gothenburg Protocol. A number of Member States reduced their ceilings somewhat below the levels included in the Gothenburg Protocol. The UK reduced its SO₂ ceiling to 585 ktonnes and its NO_x ceiling to 1,167 ktonnes in the NECD. Ceilings for NH₃ and NMVOCs were the same as in the Gothenburg Protocol. The European Commission is currently preparing for a revision of the NECD containing ceiling for 2020 as part of the implementation of the European Commission's Thematic Strategy on Air Pollution¹¹.

¹⁰ The territory under the NECD includes England, Scotland, Wales, Northern Ireland, Gibraltar

¹¹ http://ec.europa.eu/environment/air/pollutants/rev_nec_dir.htm

Large Combustion Plant Directive

Within the UK, the implementation of the EC's Large Combustion Plant Directive and other associated policy measures has led to substantial reductions in acidifying pollutants, specifically NO_x, SO₂ and dust, from power plants and industrial sources.

2.1.2 Local Air Quality

Overall air quality is currently estimated to be better than at any time since the industrial revolution. However air pollution is still estimated to reduce the life expectancy of every person in the UK by an average of 7-8 months (Defra, 2007). A number of policies are currently in place in an attempt to improve air quality; these are described in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland.

Air Quality Directive

The new air quality framework directive (AQD) is an EU directive that provides a framework for setting limit values, assessing concentrations and managing air quality to avoid exceeding the limits for air pollutants known to be harmful to human health and the environment. The new Directive merged together most of the previously existing legislation¹² in to a single directive with no change to existing air quality directives. This new directive entered into force on 11th June 2008.

Currently limit values are set for twelve pollutants under the AQD. These include NO_x, SO₂, Pb, PM, benzene, CO and ozone. For the first four of these pollutants the directives require that member states report annually to the European Commission on whether limits have been achieved.

The Air Quality Standards Regulations in England and Wales transposed the new Air Quality Directive (2008/50/EC) on ambient air quality and cleaner air for Europe in 2010.

Air Quality Strategy for England, Scotland, Wales and Northern Ireland

The original National Air Quality Strategy (NAQS) published in 1997 (DOE 1997) set out a framework of standards and objectives for the air pollutants of most concern (SO₂, PM₁₀, NO_x, CO, lead, benzene, 1,3-butadiene and tropospheric ozone). The aim of the strategy was to reduce the air pollutant impact on human health by reducing airborne concentrations. Different pollutants have differing timescales associated with human health impacts. Therefore concentrations during episodes (both winter and summer) are important for some pollutants, but less so for others.

The NAQS identified air quality standards for 8 priority pollutants based on the recommendations of the Expert Panel on Air Quality Standards (EPAQS) or WHO guidance where no EPAQS recommendation existed. EPAQS was set up by the Secretary of State for the Environment in 1991, and was a panel created to "*advise, as required, on the establishment and application of air quality standards in the UK... taking account of the best available evidence of the effects of air pollution on human health...*". The NAQS has been subject to periodic review, with consultation documents being published in 1998 and 2001 (DETR 1998a, Defra 2001).

¹² Framework Directive 96/62/EC, 1-3 daughter Directives 1999/30/EC, 2000/69/EC, 2002/3/EC, and Decision on Exchange of Information 97/101/EC

The NAQS then evolved into the Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland (AQS for ESWNI), with the same goals. The most recent strategy was published in 2007 (Defra 2007). In 2010, a report was published by Defra and the devolved administrations which bring together the air quality and climate change policies in the future (Defra 2010). The Air Pollution: Action on Changing Climate report does not replace the current air AQS (Defra 2007) but accounts for the rapid development of climate change policy since the strategy was published in 2007.

In addition to the above, Local Authorities in the UK have a statutory duty, under the 1995 Environment Act: Part IV, to review and assess air quality in their areas. Where a local authority considers that one or more of the air quality objectives, as prescribed in regulations, is unlikely to be met by the required date, it must declare an air quality management area (AQMA) covering the area where the problem is expected. It must then draw up an action plan setting out the measures it intends to take in pursuit of the air quality objectives in the area

Defra and the Devolved Administrations commission evaluations of the review and assessment appraisal process and the support services (including the help desk and website) provided to Local Authorities in England, Northern Ireland, Scotland and Wales. The evaluations led to recommendations to which Defra and the devolved administrations respond after careful consideration on how the review and assessment process can reasonably be improved.

The NAEI is being used as a potential source of data for the compilation of appropriate local inventories for review and assessments.

Table 2.4 summarises the total 2009 emissions of the 9 priority pollutants covered by the AQS for ESWNI.

Table 2.4 Total UK Emissions of AQS Pollutants

Pollutant	Total 2009 emission (ktonnes)
PM ₁₀	119
Carbon Monoxide	2,277
Benzene	17.6
1,3 Butadiene	2.31
Nitrogen oxides	1,086
Sulphur dioxide	397
Tropospheric Ozone	NS ¹
Lead	0.06
PAH ²	0.6

¹ No significant ozone emissions from anthropogenic sources

² Benzo[a]pyrene is used as an indicator for PAH, but the emission total given here corresponds to the USEPA 16 (see Section 5.2).

Lead and PAH emissions can be found in Section 3.7 and 5.2 respectively.

2.2 AMMONIA

2.2.1 Major Sources

Ammonia (NH₃) emissions play an important role in a number of different environmental issues including acidification; nitrification and eutrophication (see Section 2.1.1). It also acts as a precursor to secondary particulate matter, therefore contributing to the related health impacts. The atmospheric chemistry of NH₃ means that transport of the pollutants can vary greatly. As a result NH₃ emissions can impact on a highly localised level, as well as contributing to effects from long-range pollutant transport. NH₃ emissions are dominated by agricultural sources.

2.2.2 Total NH₃ Emissions

Emission estimates for NH₃ are available from 1980 onwards. This is because earlier data from the most significant industrial sources are not available, or not considered reliable enough to use.

Emissions in 2009 represent a decrease of 22% on the 1990 emissions. The primary source of NH₃ emissions in the UK is manure management from livestock, and in particular cattle. The most significant cause of reductions in recent years has been decreasing cattle numbers in the UK.

Table 2.5 gives a sectoral breakdown of the emissions of NH₃ in the UK. There are several sources of NH₃ that are not included in the official UNECE NH₃ totals. These are included as memo items.

Table 2.5 UK Emissions of NH₃ by aggregated UNECE¹ Source Category and Fuel (ktonnes)

	NFR Codes	1980	1990	2000	2005	2006	2007	2008	2009	2010 ²	2009 %
BY UNECE											
Stationary Combustion	1A1\1A2\1A4	10.5	5.5	3.6	2.5	2.8	2.9	3.1	3.0		1%
Passenger cars	1A3bi	0.4	0.7	22.9	15.4	14.3	13.1	11.9	11.0		4%
Other Transport	1A3bii-iv\A3aii(i)- 1A3aii(ii)\1A3c- 1A3eii\1A4bii\1A4cii\1A5b	0.2	0.2	0.5	0.5	0.5	0.5	0.4	0.4		0.1%
Production Processes	1B\2\3	8.7	8.8	5.2	6.8	6.5	6.3	5.7	5.4		2%
Cattle	4B1	145.8	136.8	127.2	122.7	122.4	120.1	118.2	117.0		41%
Poultry	4B9	40.0	39.5	38.8	34.1	34.0	30.9	29.9	28.6		10%
Direct Soil Emissions	4D1\4D2c	84.1	95.7	65.9	69.0	67.8	70.6	62.0	66.0		23%
Other Livestock	4B2-4B8\4B13	60.6	67.3	55.8	46.7	49.8	45.3	44.4	43.3		15%
Waste/Field Burning of Agricultural Wastes	6\7\4F	13.7	13.7	13.1	13.2	13.1	12.0	12.6	13.5		5%
BY FUEL											
Solid		10.1	5.1	2.6	1.5	1.5	1.7	1.8	1.8		1%
Petroleum		0.7	1.0	23.5	16.0	14.9	13.6	12.4	11.4		4%
Gas		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
Non-Fuel		353.2	362.1	306.9	293.5	294.8	286.3	274.1	274.8		95%
Total		364.0	368.2	333.0	310.9	311.1	301.6	288.3	288.1	297	100%
MEMO Items											
Humans & Wild Animals		7.9	7.9	8.0	8.0	8.1	8.1	8.1	8.2		

¹ See Annex 1 for definition of UNECE Categories.

²Total emissions value shown for 2010 is the ceiling set under the NECD

There have been a number of significant improvements to the NH₃ inventory in recent years. In particular efforts have been made to unify estimates being made by different organisations to arrive at a definitive emissions inventory for the UK.

2.2.3 Agricultural Sources

Ammonia emissions in 2009 were dominated by agricultural sources with emissions from livestock production and their wastes comprising 66% of the total emission. These emissions derive mainly from the decomposition of urea in animal wastes (in particular cattle) and uric acid in poultry wastes. Emissions depend on animal species, age, weight, diet, housing systems, waste management and storage techniques. Hence emissions are affected by a large number of factors, which make the interpretation of experimental data difficult and emission estimates uncertain.

Emissions from the agricultural sector are taken directly from the 'Inventory of Ammonia (NH₃) Emissions from UK Agriculture' compiled for Defra each year by a consortium of organisations. This inventory considers each source in detail, drawing on official livestock datasets and using combinations of emission factors from the literature considered to be the most appropriate. As part of this work, the agricultural NH₃ emissions inventory is reviewed each year to capture the most up to date livestock numbers, emission factors and views on methodologies (Misselbrook *et al* 2010).

As well as emissions from livestock, the agriculture inventory includes emissions from fertiliser use, crops and decomposition of agricultural vegetation. These estimates from crops and vegetation are particularly uncertain owing to the complexity of the processes involved and less data being available from the literature.

NH₃ emissions from agricultural livestock are decreasing with time. This is driven by decreasing numbers of cattle, sheep and pigs. In addition, there has been a decline in fertiliser use, which also leads to decreasing emissions. However, between 2008 and 2009, an increase in urea-based fertiliser use has been observed (from 17 to 21% of total fertiliser N use) which is associated with a much greater emission factor than other fertiliser types, led to an increase in emissions from synthetic N-fertiliser by 4 ktonnes.

2.2.4 Other Sources

The non-livestock sources comprise a number of diverse sources (including direct soil, waste and road transport emissions) that make up the remaining 34% of the total. However, emission estimates for these sources are high in uncertainty. Estimates are derived from a number of sources including the UK road transport inventory model, data from the waste and water sector contacts, and land use estimates from CEH Edinburgh (Dragosits and Sutton 2011).

Emissions of NH₃ from road transport, increased considerably between 1990 and 2000 as a result of the increasing number of three way catalytic converters in the vehicle fleet. However, emissions are now falling as the second generation of catalysts (which emit less NH₃ than first generation catalysts) penetrate the vehicle fleet.

Figure 2-1 shows estimated UK emissions of NH₃ from 1990 to 2009. The 2010 emission ceiling (under the NECD) is also shown.

Figure 2-1 Time Series of NH₃ Emissions (ktonnes)

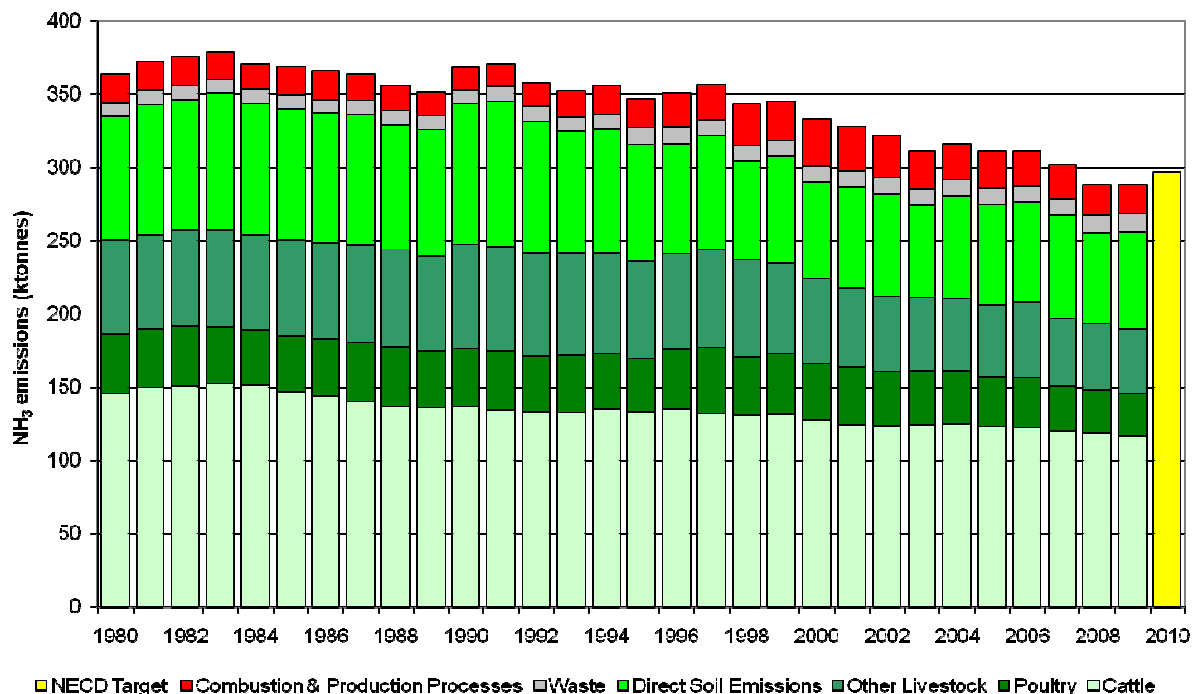
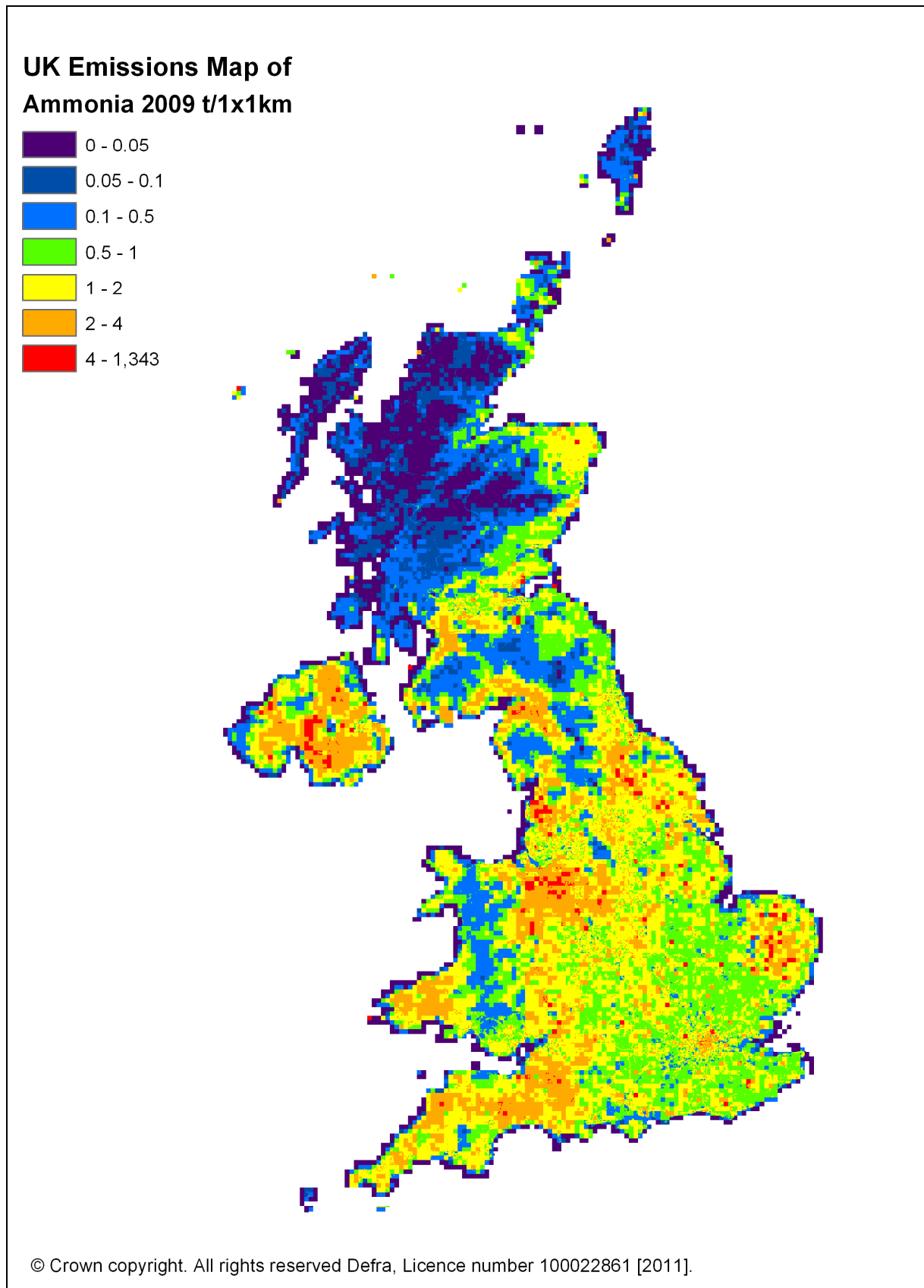


Figure 2.2 shows mapped NH₃ emissions. High emission densities are observed in agricultural areas, for example East Anglia, the South West and the North of England and Northern Ireland. Non-agricultural emissions are also noted to give rise to high emission densities in major urban areas such as London. The NH₃ emissions map is constructed at a lower resolution than other maps due to the associated uncertainties, and the restricted nature of the spatial distributions.

Figure 2-2 Spatially Disaggregated UK Emissions of NH₃



2.3 BENZENE

2.3.1 Major Sources

Studies have shown that exposure to benzene gives rise to an increase in the risk of developing leukaemia, and that benzene exerts its effect by damaging the genetic make-up of cells, i.e. it is a genotoxic carcinogen¹³. Consequently it is important to understand sources of benzene and their relative contribution to UK environmental levels, and ensure that emissions do not give rise to unacceptably high concentrations of benzene.

Benzene emissions arise predominantly from the evaporation and combustion of petroleum products. Fuel combustion in the residential sector is the most significant source of benzene, accounting for 48% of UK emissions in 2009, whilst a further 22% of the 2009 UK emission estimate comes from the road transport sector. As benzene is a constituent of petrol, emissions arise from both evaporation and combustion of petrol. Benzene emissions for 1990 to 2009 are given in Table 2.6 and Figure 2-3 below.

Benzene emissions also arise as stack emissions and, more importantly, fugitive emissions from its manufacture and use in the chemical industry. Benzene is a major chemical intermediate, being used in the manufacture of many important chemicals including those used for the production of foams, fibres, coatings, detergents, solvents and pesticides.

2.3.2 Total Benzene Emissions

Benzene emissions have been steadily decreasing since 1990. The most noticeable decrease between 1999 and 2009 arises from the road transport sector. This is because the benzene content of petrol was substantially decreased between 1999 and 2009, resulting in a corresponding decrease in emissions due to the introduction of cars equipped with three-way catalytic converters since 1991.

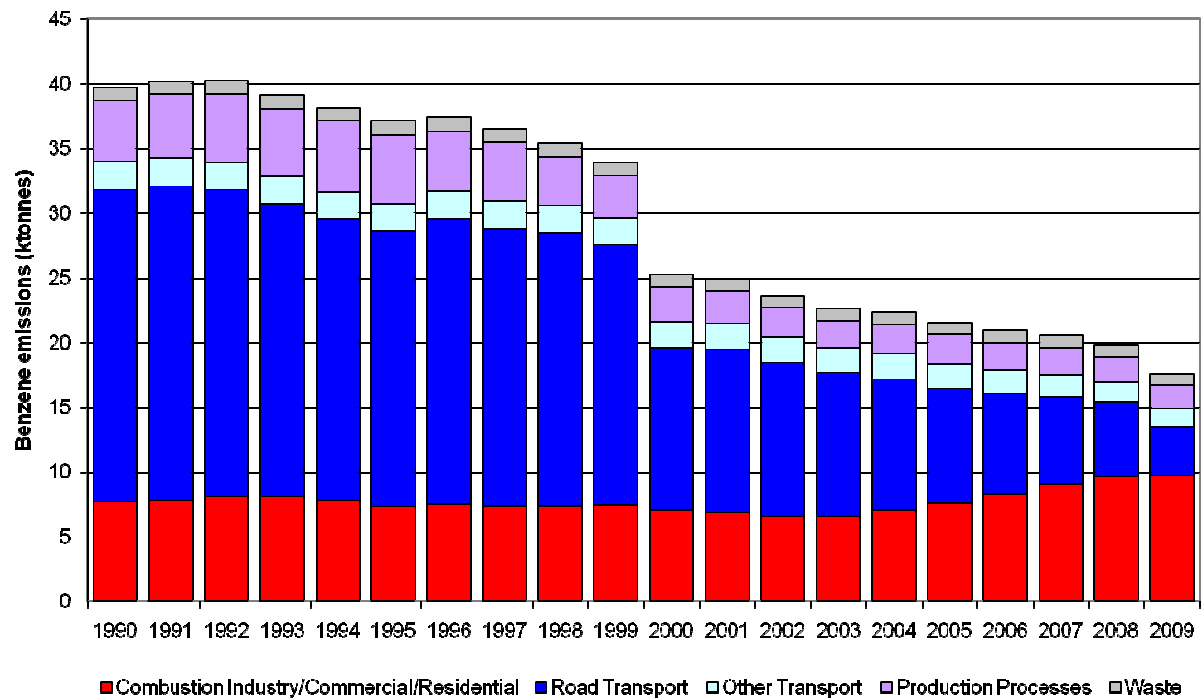
Table 2.6 UK emissions of Benzene by aggregated UNECE Source Category and Fuel (ktonnes)

	NFR Codes	1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹									
Combustion									
Industry/Commercial/Residential	1A1, 1A2a, 1A4	6.5	5.7	6.5	7.2	7.9	8.5	8.8	50%
Other Industrial Combustion	1A2f	1.1	1.3	1.0	1.1	1.1	1.1	1.0	5%
Road Transport: Passenger cars	1A3bi	17.4	11.4	8.1	7.1	6.2	5.3	3.3	19%
Other Road Transport	1A3bii-v	6.7	1.2	0.8	0.7	0.6	0.5	0.5	3%
Waste	6	1.1	1.0	0.9	1.0	0.9	0.9	0.9	5%
Production Processes	1B1, 1B2, 2	4.7	2.7	2.3	2.2	2.1	1.9	1.8	10%
Other off Road Transport (Rail, Aviation, Navigation)	1A3ai(i)-1A3aii(i), 1A3c-1A3e, 1A4ci, 1A5b	2.2	2.0	1.9	1.8	1.6	1.5	1.3	8%
BY FUEL TYPE									
Solid		7.6	7.0	7.5	8.2	9.0	9.6	9.7	55%
Petroleum		24.1	12.5	8.9	7.8	6.8	5.8	3.8	22%
Gas		2.2	2.0	1.9	1.8	1.6	1.5	1.3	8%
Non-Fuel		1.1	1.0	0.9	1.0	0.9	0.9	0.9	5%
Total		39.7	25.3	21.5	20.9	20.5	19.7	17.6	100%

¹ See Annex 1 for definition of UNECE Categories

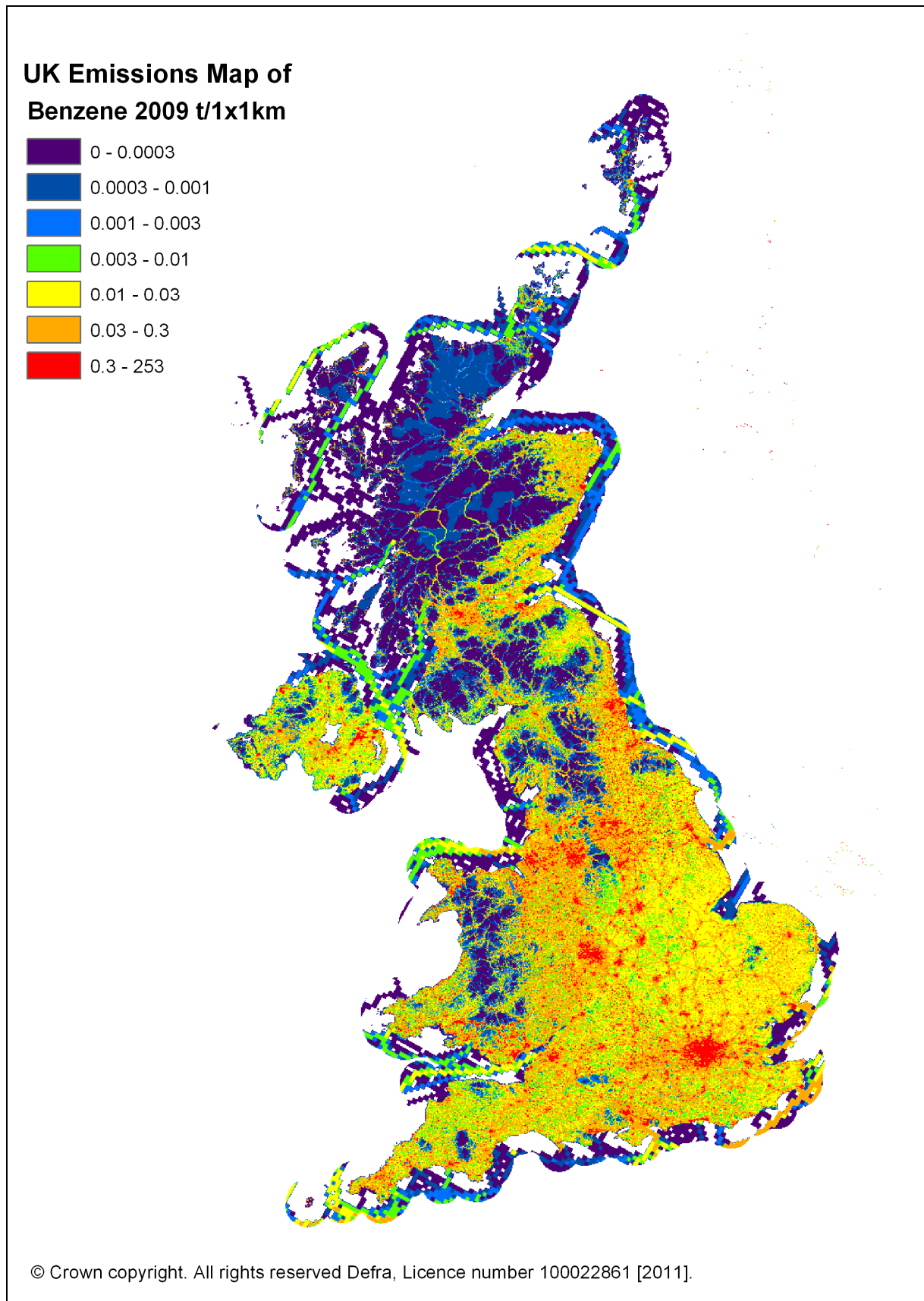
¹³ See <http://ec.europa.eu/environment/air/pdf/ppbenzene.pdf>

Figure 2-3 Time Series of Benzene Emissions (ktonnes)



Spatially disaggregated emissions of benzene are shown in Figure 2-4. It is not easy to identify the point sources contributing to the UK map. Of the area sources, road transport dominates and it is this source sector, which is apparent. Road transport emissions of benzene are higher at low speeds and decrease as speed increases. However at higher speeds emissions start to rise again. This results in relatively high emissions per kilometre in urban areas.

Figure 2-4 Spatially Disaggregated UK Emissions of Benzene



2.4 1,3-BUTADIENE

2.4.1 Major Sources

Studies have indicated that elevated concentrations of 1,3-butadiene give rise to a variety of cancers, and damages the genetic structures of cells, i.e. 1,3-butadiene is a genotoxic carcinogen¹⁴. Atmospheric concentrations have been determined at which the risk of adverse impacts is considered acceptably small, and it is therefore important to be able to understand the major sources of 1,3-butadiene which contribute to ambient concentrations.

Emissions of 1,3-butadiene arises from the combustion of petroleum products and its manufacture and use in the chemical industry. 1,3-butadiene is not present in petrol but is formed as a by-product of combustion, hence it is not present in road transport evaporative emissions.

1,3-butadiene emissions also arise as stack and, more importantly, fugitive emissions from its manufacture and extensive use in the chemical industry. 1,3-butadiene is used in the production of various forms of synthetic rubber. Reported emission estimates for the chemical industry sectors (Environment Agency, 2010) have been incorporated into the NAEI.

2.4.2 Total 1,3-Butadiene Emissions

The road transport sector dominates the UK emissions in 2009, contributing 52% of the total. Emissions of 1,3-butadiene for 1990 to 2009 are given in Table 2.7 and Figure 2-5 below.

As with benzene, the introduction of three-way catalytic converters in 1991 has played a significant role on the emission reductions observed from the road transport sector (91% reduction between 1990 and 2009). This decline has contributed significantly to the emission reduction observed for total emissions (84% between 1990 and 2009). Emissions from other significant combustion sources, such as other transportation and machinery, have not significantly decreased.

Spatially disaggregated emissions of 1,3-butadiene is shown in Figure 2.6. As discussed above, emissions of 1,3-butadiene arise predominantly from road transport activities, and an interesting comparison may be drawn with the UK emissions map for benzene (Figure 2-4), where other sources make a significant contribution to the total emissions. As with benzene, emissions of 1,3-butadiene per kilometre from road transport decrease with increasing speed (but then increase at higher speeds). Consequently the emissions density is high in urban areas, and less so on the major roads (such as motorways).

Benzene and 1,3-butadiene emission maps (Figure 2-4 and Figure 2-6) may be contrasted with mapped NO_x emissions provided in Figure 2.13, as the emissions of NO_x at higher speeds are more significant than those for benzene or 1,3-butadiene.

The level of uncertainty in the benzene and 1,3-butadiene emission inventories has been reduced in recent years. Information gained in speciating the emissions of NMVOC (see

¹⁴ See <http://monographs.iarc.fr/ENG/Monographs/vol97/mono97.pdf>

Section 2.9) has helped the generation of more robust emission inventories for both benzene and 1,3-butadiene. However, due in particular to the uncertainty in the levels of both pollutants in NMVOC emissions from road transport and other combustion processes, the uncertainty in these inventories remains higher than the uncertainty in the NMVOC inventory (Passant et al, 2011).

Table 2.7 UK Emissions of 1,3-butadiene by aggregated UNECE Category and Fuel (ktonnes)

	NFR Codes	1990	2000	2005	2006	2007	2008	2009	2009%
BY UNECE CATEGORY¹									
Combustion in Industry	1A1ac	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Road Transport / Passenger cars	1A3bi	10.6	4.9	2.3	2.0	1.8	1.6	0.9	37%
Road Transport / Others	1A3bii\iv	1.3	0.6	0.2	0.2	0.2	0.2	0.1	6%
Road Transport / Heavy Duty Vehicle	1A3biii	0.9	0.6	0.4	0.4	0.3	0.2	0.2	9%
Industrial off-road mobile machinery	1A2f	0.3	0.3	0.3	0.3	0.3	0.3	0.2	10%
Other Transport	1A3aii(i)- 1A3aii(ii)\ 1A3c- 1A5b	0.6	0.5	0.5	0.5	0.4	0.4	0.4	16%
Production Processes	1B2aiiv\1B 2av	0.8	0.5	0.4	0.4	0.4	0.4	0.5	22%
Waste Treatment and Disposal	6A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1%
BY FUEL CATEGORY									
Solid		0	0	0	0	0	0	0	0%
Petroleum		13.7	6.9	3.6	3.3	3.0	2.7	1.8	77%
Gas		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Non-Fuel		0.8	0.5	0.4	0.4	0.4	0.4	0.5	23%
Total		14.5	7.4	4.0	3.7	3.4	3.1	2.3	100%

¹ See Annex 1 for definition of UNECE Categories

Figure 2-5 Time Series of 1,3-butadiene Emissions (ktonnes)

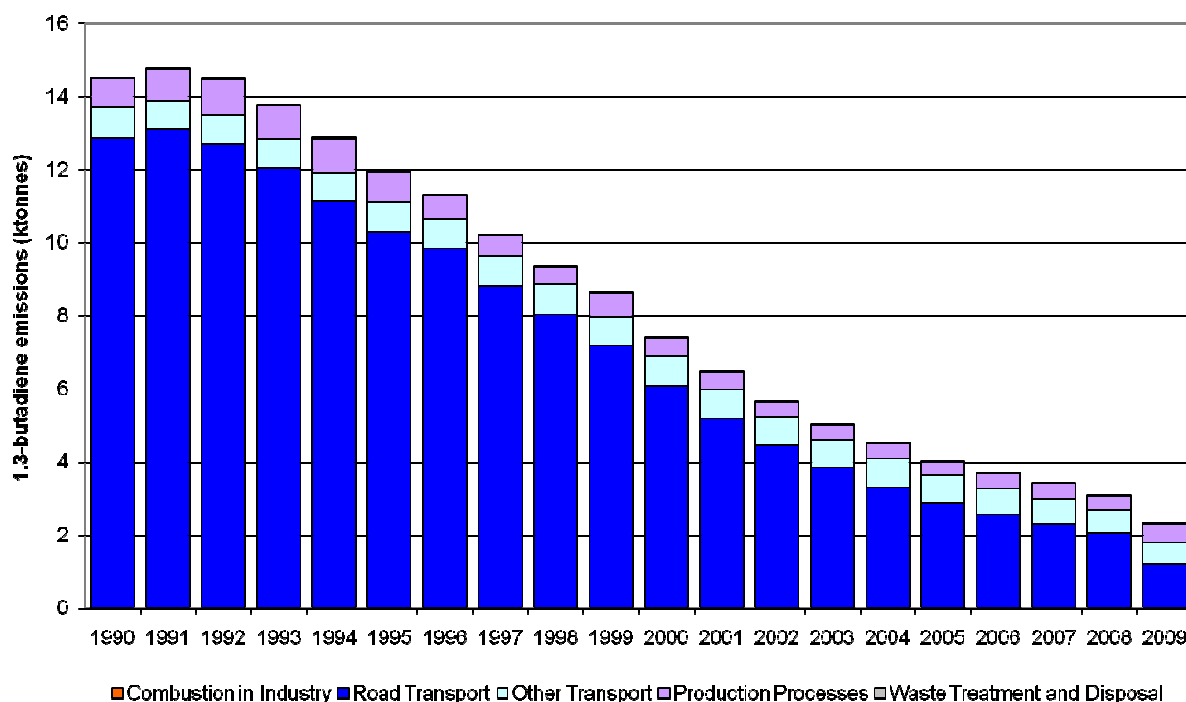
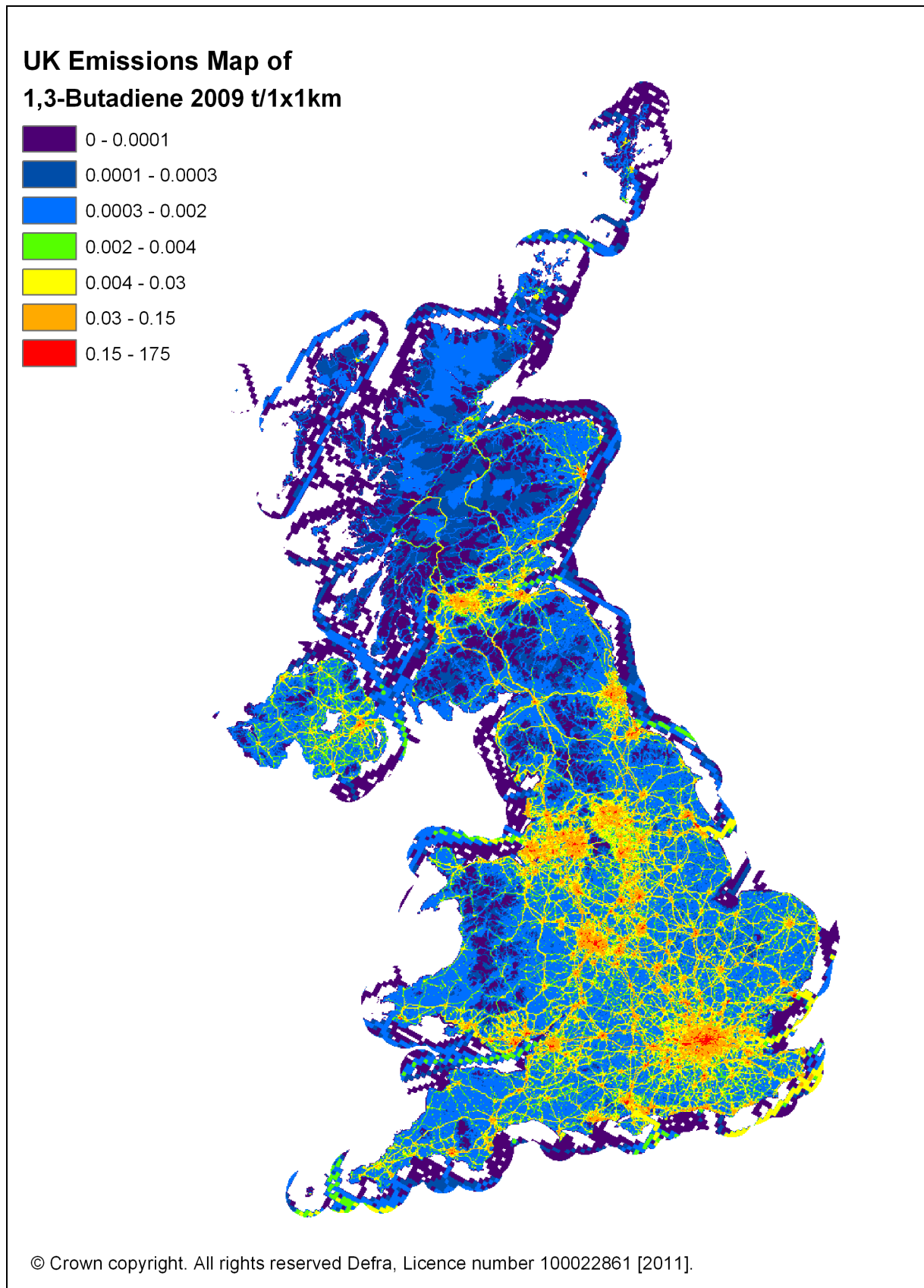


Figure 2-6 Spatially Disaggregated UK Emissions of 1,3-butadiene



2.5 CARBON MONOXIDE

2.5.1 Major Sources

Carbon monoxide arises from incomplete fuel-combustion and is of concern mainly because of its effect on human health and its role in tropospheric ozone formation. It leads to a decreased uptake of oxygen by the lungs and leads to a range of further symptoms as the concentration increases.

2.5.2 Total Carbon Monoxide Emissions

The UK emissions of carbon monoxide are shown in Figure 2-7 and Table 2.8 disaggregated by source and fuel. Over the period 1970-2009, emissions decreased by 77% reflecting significant reductions in emissions from road transport, agricultural field burning and the domestic sector.

Table 2.8 UK Emissions of CO by aggregated UNECE¹ Source Category and Fuel (ktonnes)

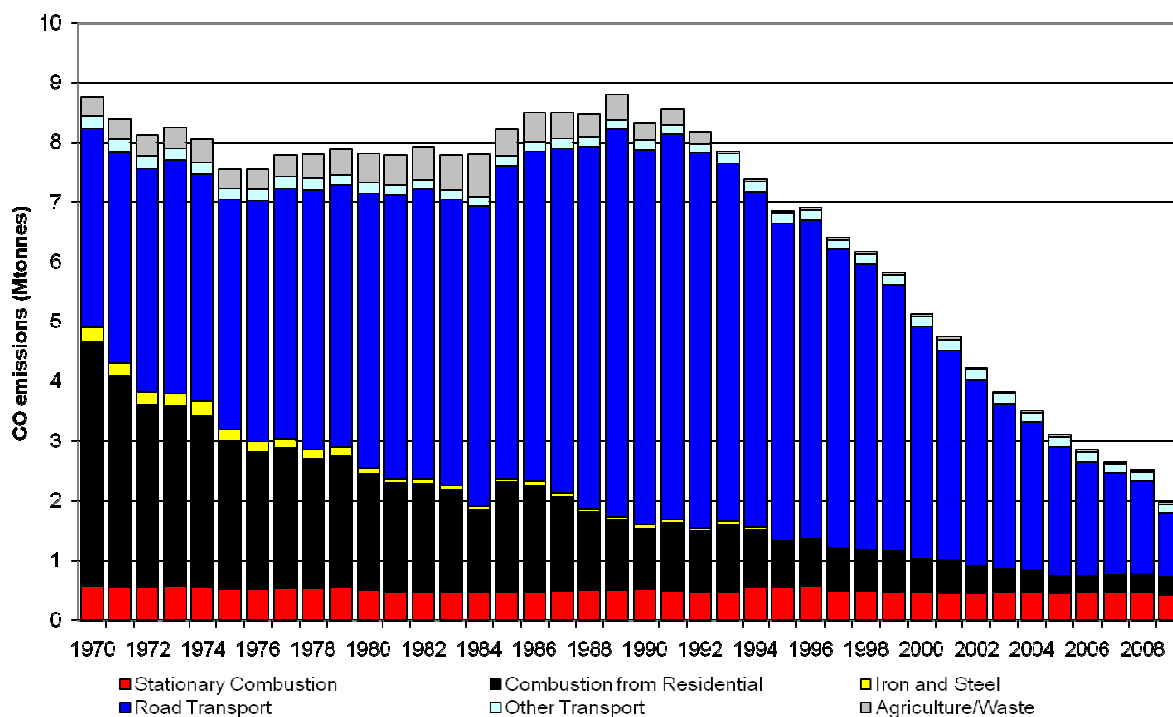
	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY²											
Public Electricity and Heat Production	1A1a	142	121	113	67	73	80	80	81	71	3%
Combustion in Industry/Commercial	1A1b&c\1A4c i(ii)\1A4a	82	52	45	47	51	46	45	54	55	2%
Iron and Steel	1A2a	245	99	68	15	13	14	13	10	7	0%
Other industrial combustion	1A2f	343	320	346	342	318	323	331	331	291	13%
Passenger cars	1A3bi	2721	3829	5369	3438	1903	1685	1504	1366	915	40%
Other Road Transport	1A3bii-iv	606	774	906	448	250	230	211	181	161	7%
Other Transport	1A3aai(i)- 1A3aai(ii)\1A3 c- 1A3eii\1A4bii \1A4cii\1A5b	215	169	158	177	177	170	153	150	143	6%
Combustion from Residential plants	1A4bi	4089	1950	1027	559	280	268	278	298	296	13%
Production Processes	1B1\1B2\2A& B	172	168	153	127	52	56	59	52	38	2%
Metal Production	2C	886	324	512	437	340	373	350	323	267	12%
Agriculture/Waste	4\5\6\7	324	485	304	36	35	35	35	34	34	3%
BY FUEL TYPE											
Solid		5299	2402	1552	880	559	555	544	563	533	23%
Petroleum		3766	4979	6668	4288	2567	2329	2118	1941	1430	63%
Gas		34	76	89	131	134	127	127	127	121	5%
Non-Fuel		726	834	691	392	232	271	272	250	194	9%
Total		9824	8291	9000	5692	3492	3281	3061	2881	2277	100%

¹ UK emissions reported in IPCC format (MacCarthy et al, 2011) differ slightly due to the different source categories used.

² See Annex 1 for definition of UNECE Categories

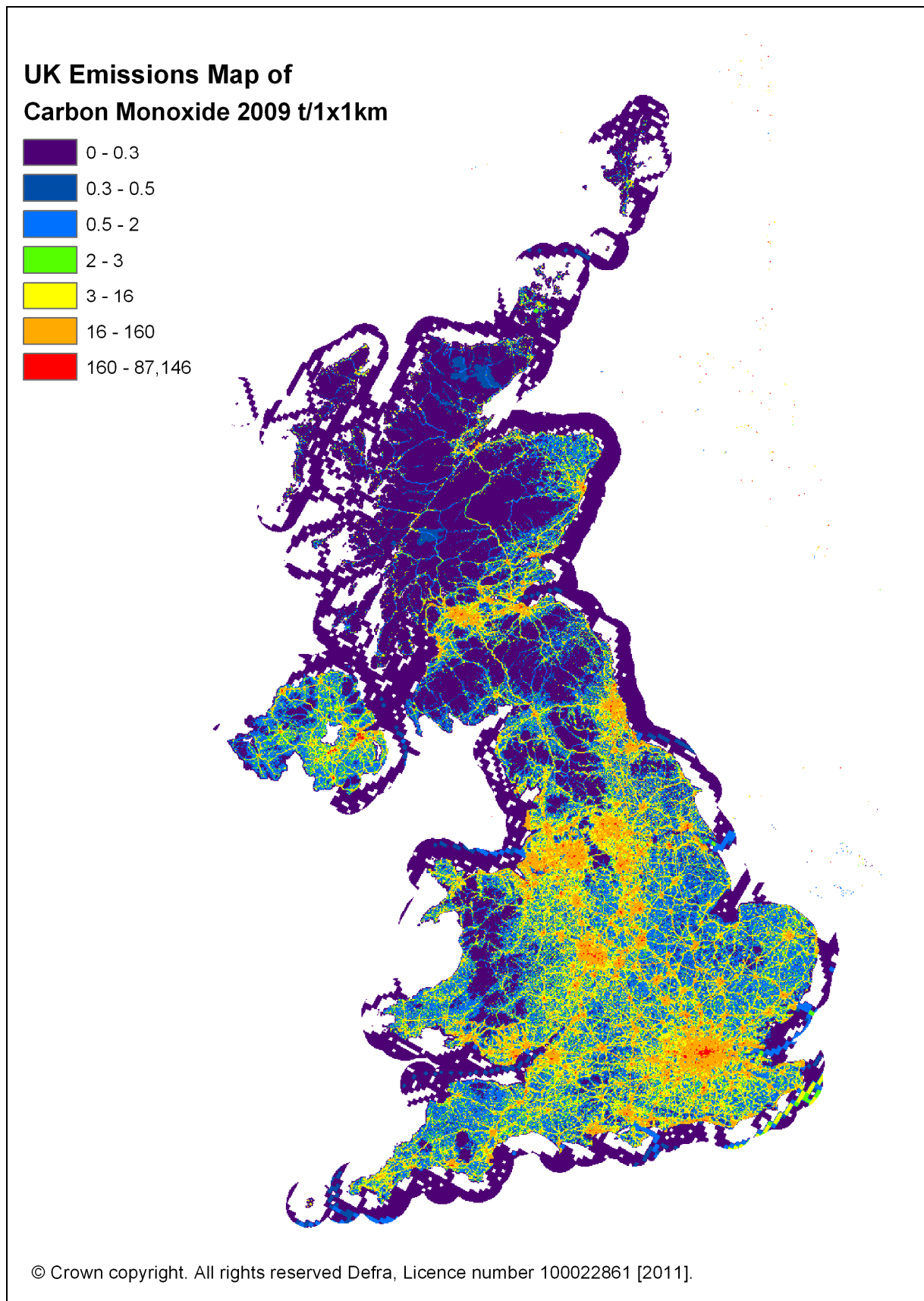
³ Field Burning of agriculture waste, forest and grassland conversion, waste incineration and other waste

Figure 2-7 Time Series CO Emissions (Mtonnes)



The spatial disaggregation of CO emissions is shown in Figure 2-8. The observed pattern of emissions is clearly dominated by road transport emissions. A large proportion of road transport emissions are from vehicles travelling at slow speeds on urban or minor roads, hence the map shows high emissions in urban conurbations.

Figure 2-8 Spatially Disaggregated UK Emissions of CO



2.5.3 Transport

The most important source of CO is road transport and in particular petrol driven vehicles. Emissions from road transport remained consistent between 1970 and 1990 but since then have declined significantly. This is due primarily to the increased use of three-way catalytic converters and to a lesser extent to fuel switching from petrol cars to diesel cars.

A significant fraction of emissions are from petrol driven off-road sources which include lawnmowers and small industrial machinery and portable generators. These emission estimates are uncertain because of uncertainties in the population and usage time of the machinery.

2.5.4 Other Sources

Other emission sources of CO are small compared with transport and off-road sources. Combustion-related emissions from the domestic and industrial sectors have decreased by 93% and 49% respectively since 1970 due to the decline in the use of solid fuels in favour of gas and electricity. The sudden decline in emissions from the agricultural sector reflects the banning of stubble burning in 1993 in England and Wales. In 2009, power generation accounted for only 3.1% of UK emissions.

2.6 HYDROGEN CHLORIDE

2.6.1 Major Sources

Hydrogen chloride (HCl) is an acidic gas primarily released to air from combustion of fuels, which contain trace amounts of chlorine; the UK emission inventory for hydrogen chloride is dominated by the combustion of solid fuel.

2.6.2 Total Hydrogen Chloride Emissions

Table 2.9 and Figure 2-9 summarises the UK emissions of hydrogen chloride. Emissions have fallen by 97% since 1970. The main source of these emissions is coal combustion and the observed decrease is a result of the decline in coal use. The installation of flue gas desulphurisation (FGD) at Drax, Ratcliffe-on-Soar, and other power stations since 1993, and a general trend towards the use of coal with lower chlorine contents at non-FGD plants has had an impact. The dip in emissions as a result of the miners' strike of 1984 is clearly visible. The other significant source of hydrogen chloride is waste incineration. Here the commissioning of new incinerators with tighter emission controls and the closure or upgrading of old plant has resulted in a large decrease for all years since 1996.

The hydrogen chloride inventory is equally as uncertain as the ammonia inventory (Passant et al, 2011). As with ammonia, a few sources dominate the inventory and the levels of uncertainty in these sources is generally quite high.

Table 2.9 UK Emissions of HCl by aggregated UNECE¹ Source Category and Fuel (ktonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009%
BY UNECE CATEGORY²											
Public Electricity and Heat Production	1A1a	222.3	257.8	238.8	72.8	12.6	11.6	8.7	5.9	4.7	42%
Stationary Combustion	1A1b-c\1A4ci	52.2	22.7	10.2	4.5	1.5	1.3	1.5	1.6	1.6	14%
Iron and Steel	1A2a	1.8	0.4	0.0	0.0	0.0	0.0	0.2	0.2	0.1	1%
Other Industrial Combustion	1A2f	38.2	12.7	10.8	3.7	3.6	3.5	3.3	3.6	3.6	32%
Production Processes	2	1.4	0.7	1.1	1.0	0.7	0.6	0.6	0.5	0.6	5%
Commercial\Institutional Combustion	1A4a	9.6	4.2	3.3	0.7	0.4	0.4	0.4	0.4	0.5	4%
Road & Other Transport	1A3b\1A3dii\1A4bii	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0%
Waste	6	6.9	6.9	5.3	0.1	0.2	0.1	0.1	0.2	0.2	1%
BY FUEL TYPE											
Solid		323.5	297.3	261.1	80.6	17.3	16.2	13.4	11.2	9.9	88%
Petroleum		0.7	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0%
Gases		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Non Fuel		8.7	7.9	8.3	2.1	1.7	1.3	1.3	1.3	1.3	12%
Total		332.9	305.8	269.6	82.71	18.95	17.5	14.8	12.483	11.2	100%

¹ UK emissions reported in IPCC format (MacCarthy et al, 2011) differ slightly due to the different source categories used.

² See Annex 1 for definition of UNECE Categories

Figure 2-9 Time Series of HCl Emissions (ktonnes)

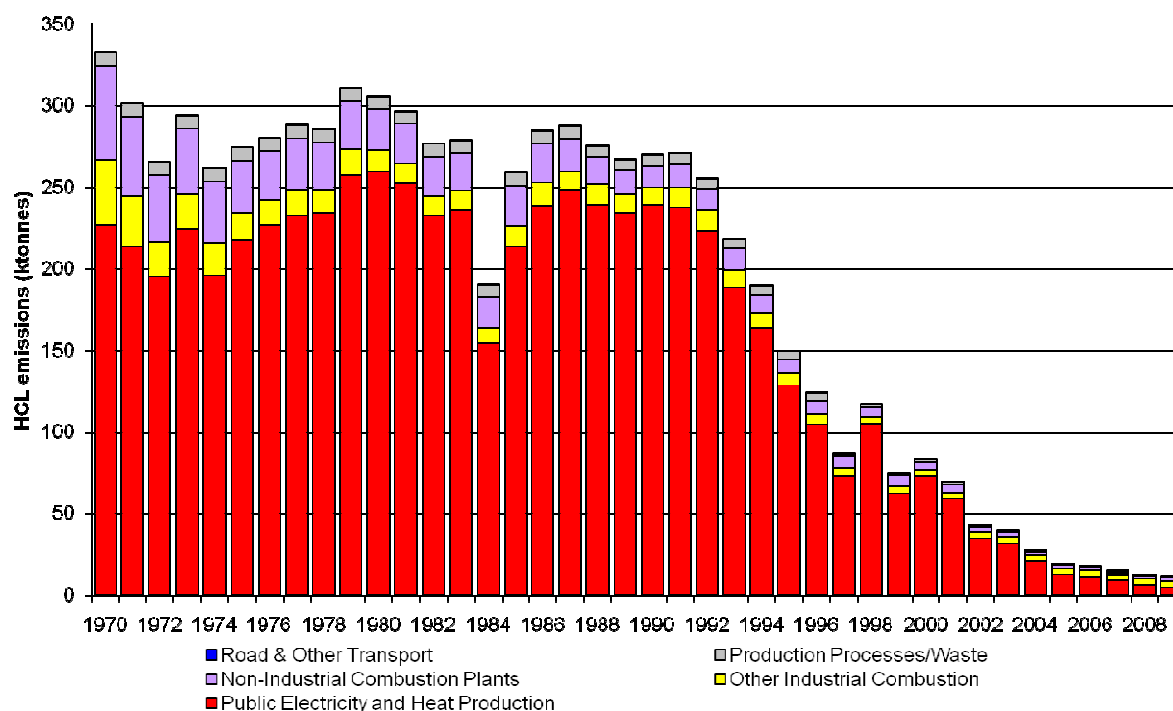
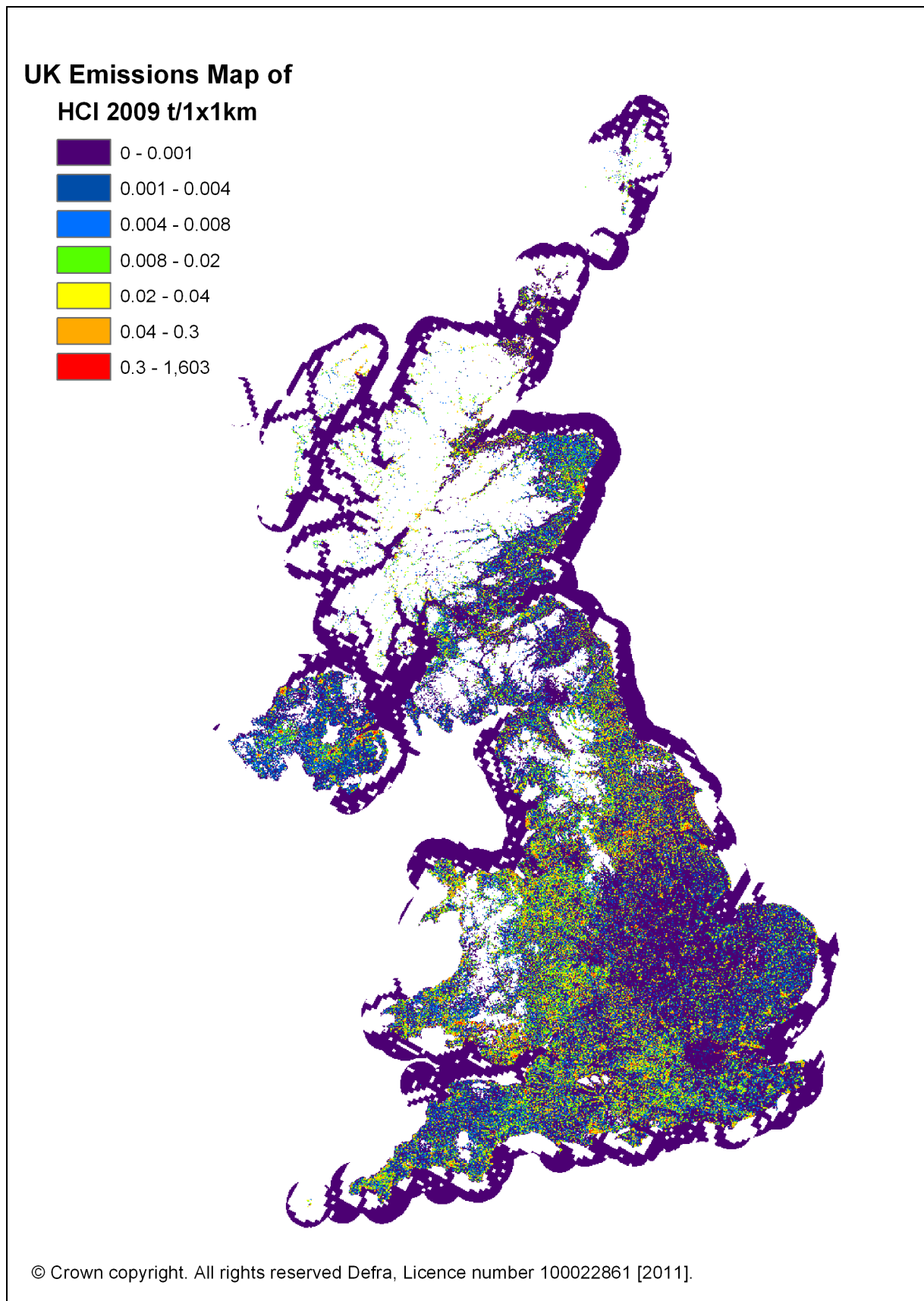


Figure 2-10 Spatially Disaggregated UK Emissions of Hydrogen Chloride



2.7 HYDROGEN FLUORIDE

2.7.1 Major Sources

Hydrogen fluoride (HF) is an acidic gas released to air from combustion of fuels that contain trace amounts of fluoride. Some industrial processes use HF as an acidic reagent (or to produce HF), giving rise to emissions.

2.7.2 Total Hydrogen Fluoride Emissions

The emissions of HF display a similar source pattern to hydrogen chloride (see Section 2.6). Like hydrogen chloride, power generation is the most significant source; contributing 52% of total hydrogen fluoride emissions in 2009 (see Table 2.10). The reduction of the emissions from this sector with time is an indication of the increased use of emission abatement equipment in power stations. Emissions of HF from the residential sector have also decreased with time. This is due to the decreasing use of coal in domestic heating. These trends with time are highlighted in Figure 2-11. The impact of the miners' strike in 1984 is again apparent.

Between 2000 and 2006, UK emissions of HF increased, primarily driven by emissions from coal-fired power generation. Between 2006 and 2009, a decline in coal-fired power generation has reduced the emissions by 59% in the power generation sector due to the economic downturn (with coal-fired power emissions almost dropping to 2000 level). Interestingly this trend is not noted for hydrogen chloride. This is because the hydrogen chloride emission per unit of coal consumed decreased between 1999 and 2006, whereas that for HF remained reasonably constant.

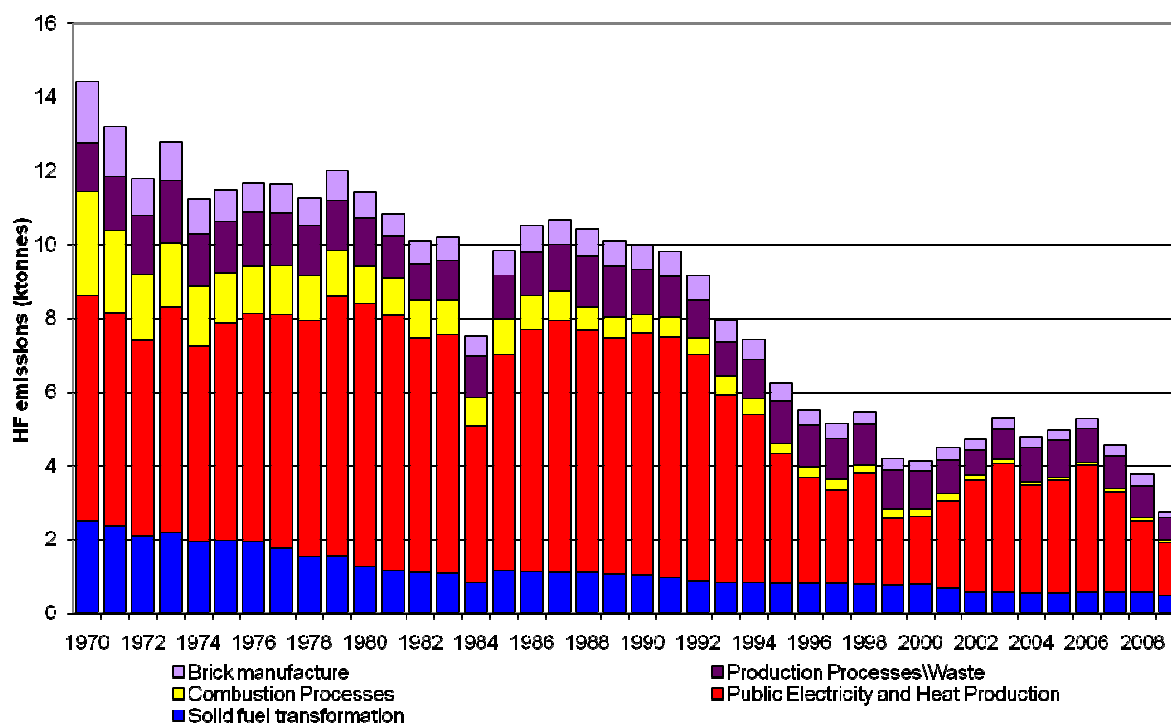
Uncertainty analysis has not been performed on the HF inventory. However, the sources of HF are very similar to those for hydrogen chloride and the level of uncertainty in emission estimates are expected to be similar. As a result it seems reasonable to assume the same level of overall uncertainty as for hydrogen chloride.

Table 2.10 UK Emissions of HF by aggregated UNECE¹ Source Category and Fuel (ktonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009%
BY UNECE CATEGORY											
Public Electricity and Heat Production	1A1a	6.1	7.1	6.6	1.8	3.1	3.5	2.8	1.9	1.4	52%
Stationary Combustion Processes	1A1c-1A2a1A4	2.8	1.0	0.5	0.2	0.1	0.1	0.1	0.1	0.1	3%
Brick manufacture	1A2f	1.7	0.7	0.7	0.3	0.3	0.3	0.3	0.3	0.2	7%
Solid fuel transformation	1B1b	2.5	1.3	1.0	0.8	0.5	0.6	0.6	0.6	0.5	17%
Production Processes	2	1.3	1.3	1.2	1.0	1.0	0.9	0.9	0.9	0.6	21%
Waste	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
BY FUEL TYPE											
Solid		13.3	10.2	8.8	3.2	4.0	4.5	3.8	3.0	2.3	81%
Petroleum		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Gas		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Non-Fuel		1.1	1.3	1.2	1.0	0.9	0.8	0.8	0.8	0.5	19%
TOTAL		14.4	11.4	10.0	4.1	5.0	5.3	4.6	3.8	2.8	100%

¹See Annex 1 for definition of UNECE Categories

Figure 2-11 Time Series of Hydrogen Fluoride Emissions (ktonnes)



2.8 OXIDES OF NITROGEN

2.8.1 Major Sources

Studies have shown that oxides of nitrogen (NO_x) can cause lung irritation as well as lowering people's resistance to pneumonia and bronchitis and other respiratory infections. People already suffering lung problems, such as asthma, as well as young children and those that work outside are particularly vulnerable. In the presence of sunlight NO_x can react to produce a photochemical smog. If hydrocarbons are also present ozone can be produced, which has a similar health effect to NO_x . Although higher concentrations of NO_x are found in city areas, resulting ozone concentrations tend to be higher in rural areas, where crop yields can be reduced as a result.

Road transport is the largest source of NO_x in the UK with stationary combustion and power generation also forming significant sources. Approximately one third of the UK NO_x emissions arise from road transport, with vehicles travelling at high speeds contributing most. The estimation of these emissions is complex since the nitrogen can be derived from either the fuel or atmospheric nitrogen. The emissions are dependent on the conditions of combustion, in particular temperature and excess air ratio, which can vary considerably. Thus combustion conditions, load and even state of maintenance are important.

2.8.2 Total Oxides of Nitrogen Emissions

Since 1970 there has been a reduction in total NO_x emissions of 58%, however this decrease in emissions has not been constant (Figure 2-12). Up to 1984 the NO_x emission profile was relatively flat with small peaks in 1973 and 1979, also seen for CO_2 , which were due largely to the cold winters in those years. However, from 1984, emissions rose markedly as a result of the growth in road traffic reaching a peak in 1989 (see Figure 2-12). Since then, total

emissions have declined by 60% mainly as a result of a 67% reduction from power stations and 66% decrease from road transport. The National Emissions Ceilings Directive target for 2010 is also shown.

The spatially disaggregated UK emission inventory of NO_x emissions, based on a 1x1 km grid, is shown in Figure 2-13. Data files are also available from the NAEI internet site (www.naei.org.uk). A large fraction (the order of 30%) of the total NO_x emission is concentrated in approximately 50 grid squares, which contain point sources. Conurbations and city centres show high emissions resulting from large volumes of road transport, residential and commercial combustion. Major route-ways (e.g. motorways and primary routes) are also clearly defined on the map. A combination of high national shipping emissions and relatively few large ports results in significant localised emissions from shipping in port areas.

Table 2.11 UK Emissions of Nitrogen Oxides (as NO_x) by aggregated UNECE¹ Category & Fuel (ktonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2010 ³	2009%
BY UNECE CATEGORY²												
Public Electricity and Heat Production	1A1a	813	862	776	346	375	391	360	278	251		23%
Stationary Combustion	1A1b-c\1A2a\1A4ci(ii)	235	156	133	130	131	116	114	108	97		9%
Other industrial combustion	1A2f	566	437	369	285	253	241	238	222	189		17%
Passenger cars	1A3bi	282	402	641	360	227	206	188	173	125		12%
Heavy duty vehicles	1A3biii	245	285	337	297	258	252	240	214	185		17%
Other Road transport	1A3bii\iv	46	58	91	90	80	70	64	56	50		5%
Non road -other Transport	1A3a(iii)\1A3a(ii)\1A3c-1A3eii\1A4bii\1A4cii\1A5b	219	169	184	192	169	160	154	145	136		13%
Residential plants	1A4bi	100	101	96	66	45	44	41	42	40		4%
Production Processes, Agriculture, Waste	1B-6	64	54	56	23	16	16	15	14	12		1%
BY FUEL TYPE												
Solid		960	899	790	325	346	367	331	242	217		20%
Petroleum		1386	1290	1548	1112	889	836	790	725	618		57%
Gas		98	207	226	296	272	252	255	256	231		21%
Non-Fuel		127	127	119	56	46	40	38	28	20		2%
Total		2570	2523	2683	1789	1553	1495	1414	1252	1086	1167	100%

¹ UK emissions reported in IPCC format (MacCarthy et al, 2011) differ slightly due to the different source categories used.

² See Annex 1 for definition of UNECE Categories

³Total emissions value shown for 2010 is the ceiling set under the NECD

Figure 2-12 Time Series of NO_x Emissions (Mtonnes)

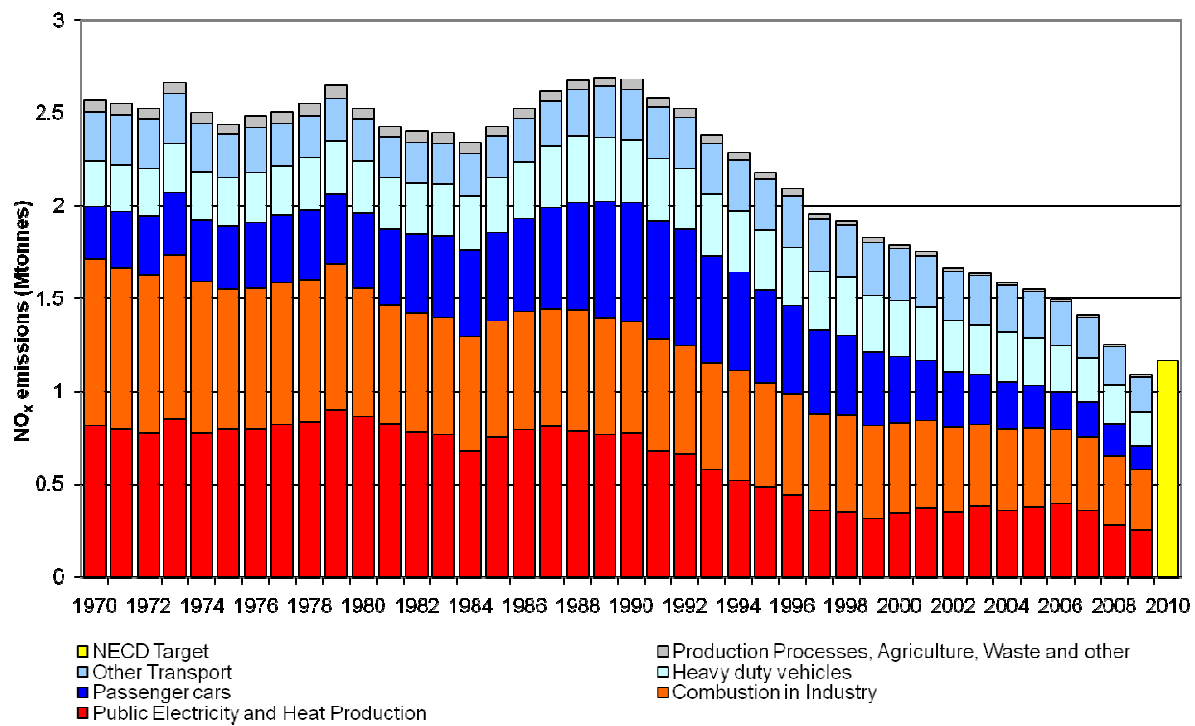
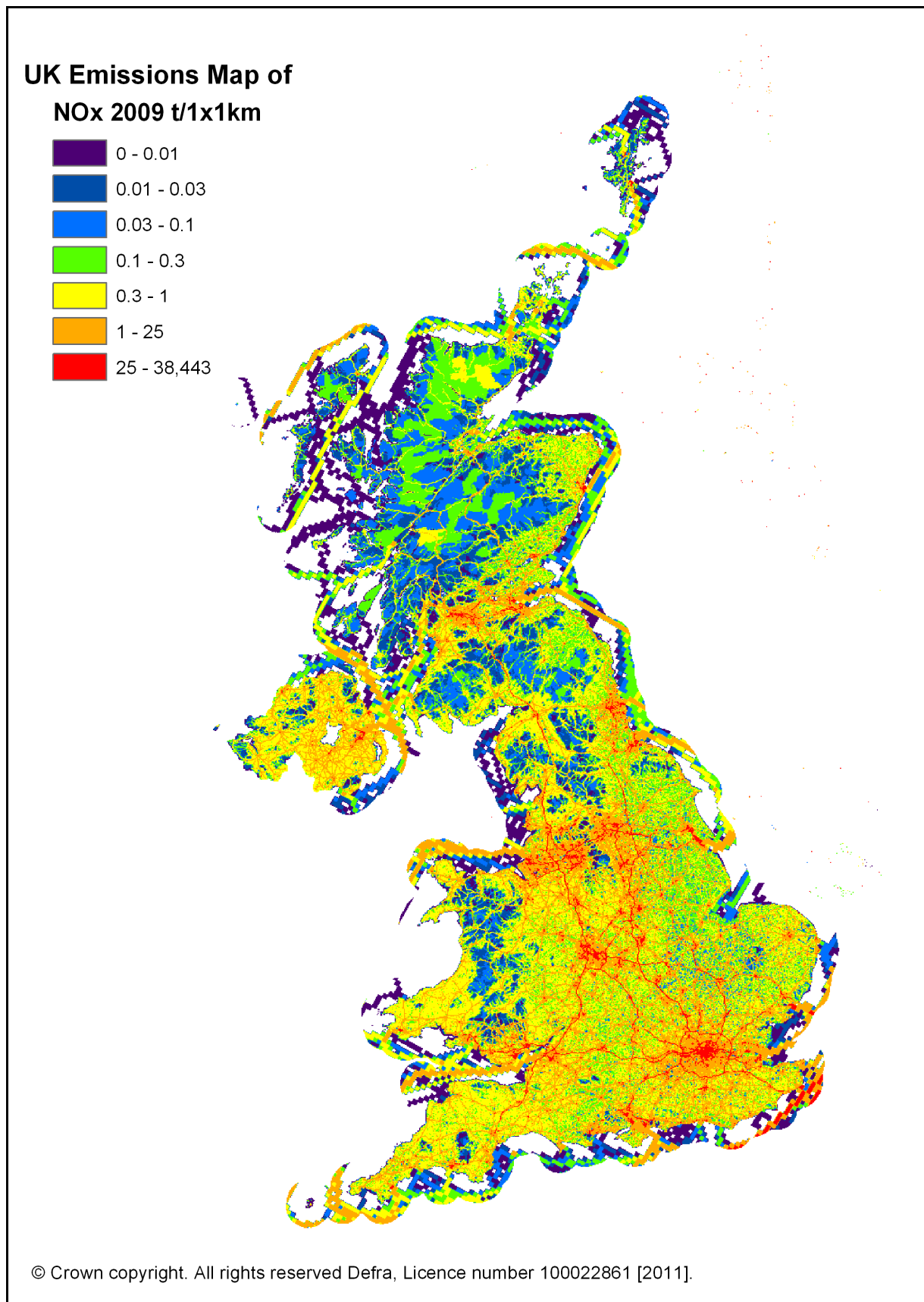


Figure 2-13 Spatially Disaggregated UK Emissions of Oxides of Nitrogen



2.8.3 Transport

In 2009 the largest source of NO_x emissions in the UK is the transport sector with road vehicles and other non-road transport modes (including off-road mobile machinery) contributing 33% and 13%, respectively, to total emissions. Road vehicle emissions rose steadily between 1970 and 1989 reflecting the overall growth in road traffic in the UK. During this period emissions from total petrol consumption, predominantly by cars, rose by 117% compared to the 1970 level and emissions from diesel consumption rose by 49%.

Figure 2-14 clearly shows the growth in the vehicle fleet and vehicle mileage during this period. Since 1989 there has been a steady decline in emissions due to the introduction of three-way catalytic converters on petrol cars and stricter regulations on truck emissions.

Figure 2-14 Emissions of NO_x from Road Transport by Vehicle Type (ktonnes), 1970 to 2009

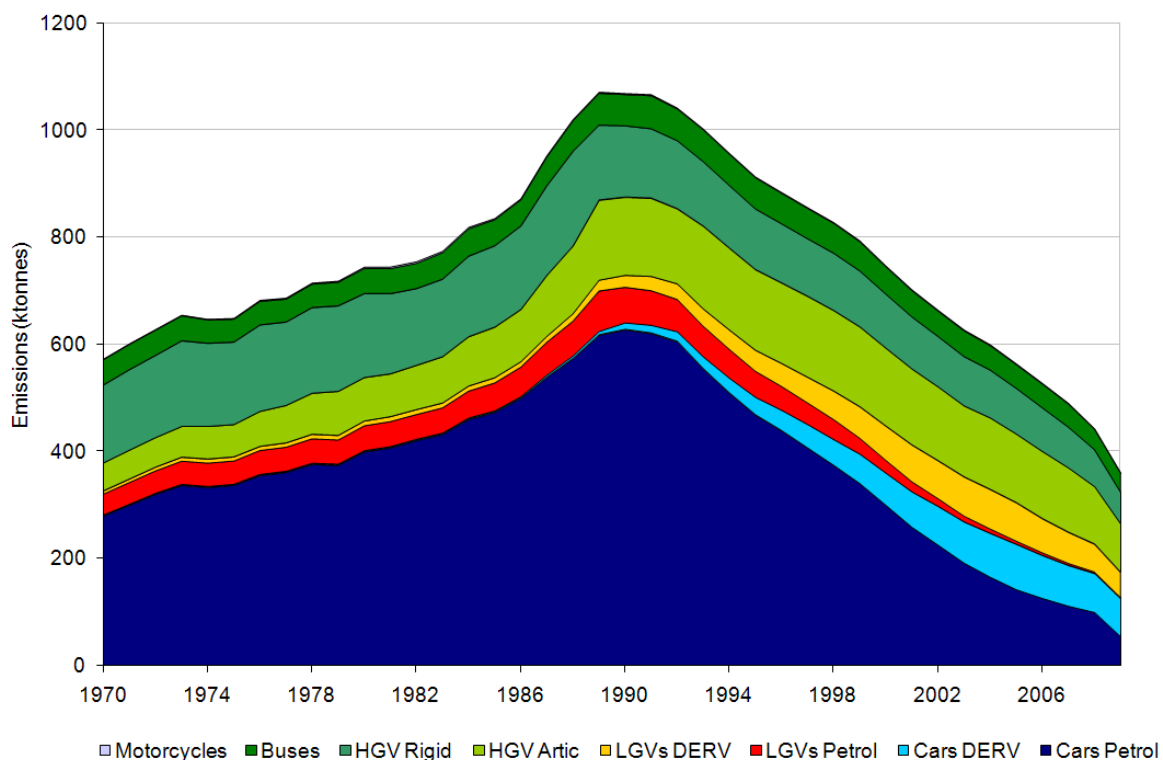


Figure 2-15 shows the average NO_x emissions per vehicle kilometre for different vehicle types between 1970 and 2009. Various emission regulations on new petrol cars, which have come into effect in stages since 1976, have led to the gradual reduction in NO_x emissions from petrol cars. The more rapid decline in emissions from 1992 is due to the penetration of cars fitted with three-way catalysts. Limits on emissions from diesel cars and light goods vehicles (LGVs) did not come into effect until 1993/94. Overall emissions per kilometre from heavy goods vehicles (HGVs) showed a small rise from 1970-1987 due to the increasing usage of larger HGVs for freight movement. Limits on emissions from HGVs first came into effect in 1988 leading to a gradual reduction in emission rates as new HGVs penetrated the fleet, accelerated by tighter limits on emissions from new HGVs in 1993/94. Emissions on a per vehicle kilometre basis are expected to continue to decline until and beyond 2010.

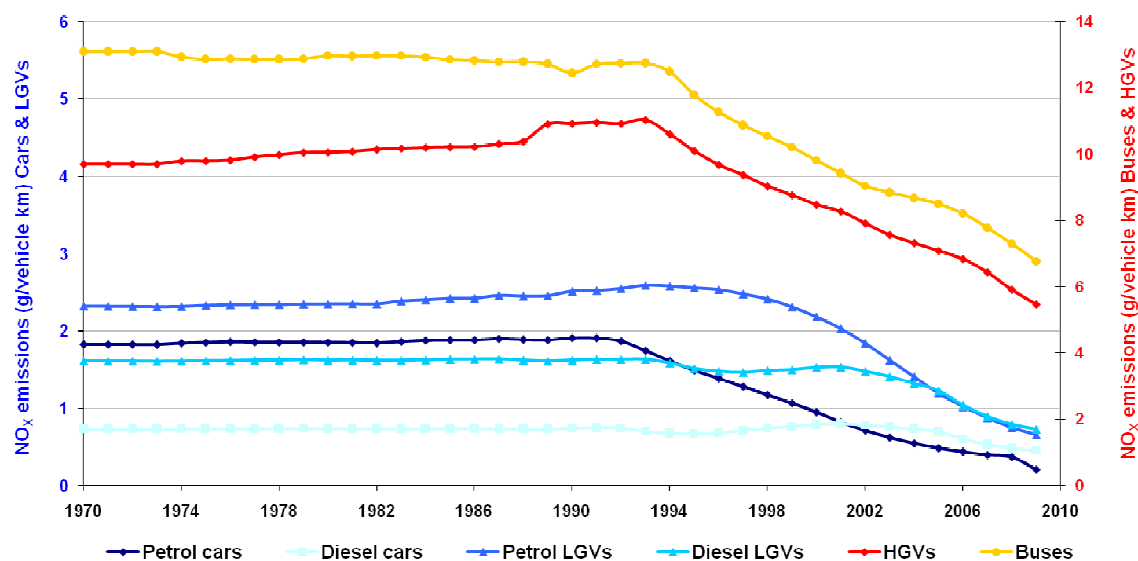
Figure 2-15 NO_x Emissions per Vehicle km by Vehicle Type (1970-2009)

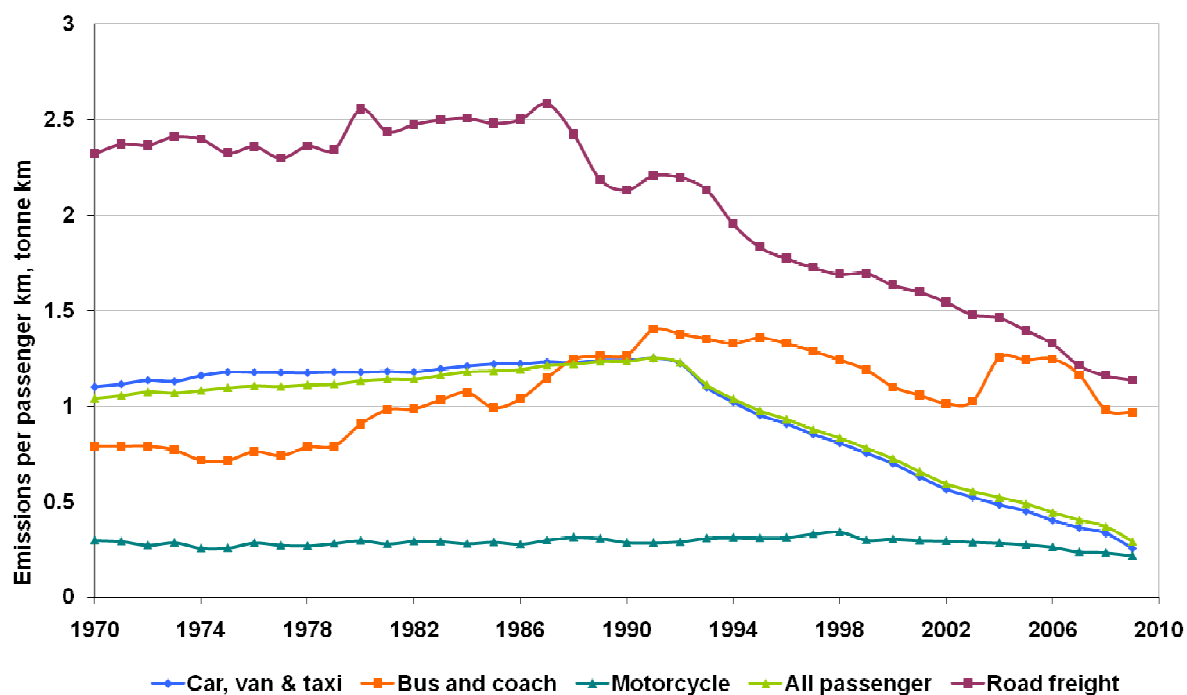
Figure 2.16 shows emissions per passenger km and by tonne km of freight. Technological improvements to HGVs have led to emissions per tonne of freight has halved in 2009 compared with 1970. Emissions per passenger km from cars, vans and taxis have significantly decreased since 1970 due mainly to the introduction of three-way catalytic converters in 1992 penetrating the car fleet. The reduction in NO_x emissions between 2008 and 2009 was driven by improvement in catalyst repair rates for petrol vehicles¹. This was due to an introduction of the Regulations Controlling Sale and Installation of Replacement Catalytic Converters and Particle Filters for Light Vehicles for Euro 3 (or above) LDVs after June 2009¹⁵.

Per passenger km emissions from buses and coaches increased between 1970 and 1991. This was due to the gradual decrease in occupancy rate of buses and their under utilisation over this period. Since 1991, this rise in per passenger km emissions has been halted by the higher fleet penetration of buses meeting tighter emission standards.

In this year's inventory, the passenger km data for buses has been revised downward in the Transport Statistic Great Britain (2010) for 2004 and 2008. This has led to the upward trend in emission per passenger-km compared to the 2008 NAEI.

¹⁵ A sensitive parameter in the emission calculations for petrol cars is the assumption made about the proportion of the fleet with catalyst systems that have failed, for example due to mechanical damage or failure of the lambda sensor. Following discussions with DfT, it is assumed that the failure rate is 5% per annum for all Euro standards and that up to 2008, only 20% of failed catalysts were rectified properly, but those that were rectified were done so within a year of failing. The revisions are based on evidence on fitting of replacement catalysts. According to DfT there is evidence that a high proportion of replacement catalysts were not Type Approved and do not restore the emission performance of the vehicle to its original level (DfT 2009). This is being addressed through the Regulations Controlling Sale and Installation of Replacement Catalytic Converters and Particle Filters for Light Vehicles for Euro 3 (or above) LDVs after June 2009. Therefore a change in the repair rate is taken into account for Euro 3 and above petrol LDVs from mid-2009, assuming all failed vehicles are rectified properly.

Figure 2-16 Emissions of NO_x (grams) by Passenger Kilometre or Freight Tonne Kilometre (1970-2009)



In 2009 other transport and machinery contributed a further 13% to total UK NO_x emissions (domestic and international take-off and landing cycles up to an altitude of 1,000 m are considered here in accordance with UNECE guidelines. Emissions arising from domestic and international cruise are not included).

2.8.4 Power Generation

Emissions from power stations have declined over the period 1970-2009 by 69%. Emissions in the seventies were fairly constant from year to year, with peaks in severe winters. Since 1979 emissions have declined with a significant decrease at the time of the miners' strike in 1984. Prior to 1989 this decline was due to the increased use of nuclear power and an increase in the average efficiency of thermal power stations.

Since 1988 the electricity generators have adopted a programme of progressively fitting low NO_x burners to their 500 MWe (megawatt electric) or larger coal fired units. The increased use of nuclear generation and the introduction of Combined Cycle Gas Turbine (CCGT) plant burning natural gas over the past two decades have further reduced NO_x emissions. The emissions from the low NO_x turbines used in CCGT plants are much lower than those of pulverised coal fired plant even when fitted with low NO_x burners, so changes in the mix of fuels used to generate electricity have a significant impact on NO_x emissions. For example, the use of coal increased between 2004 and 2006, while gas use decreased. This trend was reversed for the next three years and these year-on-year changes in the fuel mix are reflected in the NO_x emissions for this sector.

An additional factor has been the recent retrofitting of Boosted Over Fire Air (BOFA) systems to reduce NO_x formation and ensure compliance with the Large Combustion Plant Directive. Between 2007 and 2008, there was a 30% decrease in the emissions from coal burning power stations due to the use of BOFA, as well as the decreased consumption of coal.

A further 10% reduction in NO_x emissions were observed in 2009, partially as a result of additional BOFA systems coming on stream, but more as a result of the reduction in the use of coal in power stations.

2.8.5 Industry

The emissions from industrial combustion (NFR code 1A2) have declined by 69% since 1970 and they currently contribute 18% of the total UK emissions. This is due to the decline in coal use in favour of gas and electricity.

2.9 NON-METHANE VOLATILE ORGANIC COMPOUNDS

2.9.1 Major Sources

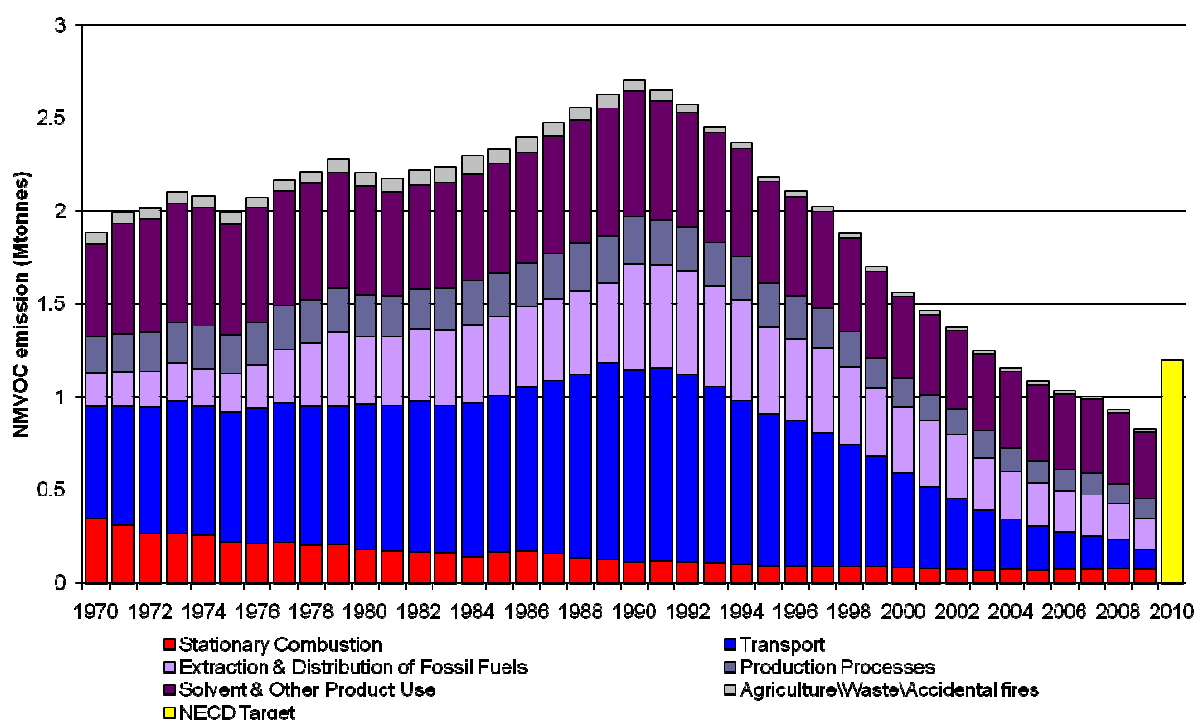
Non-Methane Volatile Organic Compounds (NMVOCs) are organic compounds which may differ widely in their chemical composition. These organic compounds are often grouped together as NMVOCs within environmental regulations and reports, as the majority display similar behaviour in the atmosphere. NMVOCs are emitted to air as combustion products, as vapour arising from handling or use of petroleum distillates, solvents or chemicals, and from numerous other sources.

Interest in NMVOC emissions has grown as their role in the photochemical production of ozone has been appreciated. The diversity of processes which emit NMVOCs is huge, covering not only many branches of industry, but also transport, agriculture and domestic sources.

2.9.2 Total NMVOC Emissions

The NMVOC inventory is summarised in Table 2.12. Only 21% of the NMVOC emissions arise from combustion sources (unlike SO₂ and NO_x where the contribution from combustion sources is much higher). Of these emissions from combustion sources, it is the transport sector that dominates. Other major sources of NMVOC emissions are the use of solvents and industrial processes. Natural emissions of NMVOCs are also reported, but are not included in the UK total (in accordance with UNECE guidelines). These natural sources are primarily emissions from forests. The NMVOC emission profile, presented in Figure 2-17, shows an increase in emissions between 1970 and 1990 with minor peaks in 1973 and 1979, followed by a steady reduction in emissions during the 1990s. The latter is largely a reflection of the increasingly stringent emission limits across a range of sectors. The data shows that NMVOC emissions in 2009 were well below the 2010 ceiling.

Figure 2-17 Time Series of NMVOC Emissions (Mtonnes) and the NECD ceiling for 2010.

Table 2.12 UK Emissions of NMVOCs by aggregated UNECE¹ Source Category and Fuel (ktonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2010 ³	2009%
BY UNECE CATEGORY²												
Stationary Combustion	1A1\1A2\1A4a\1A4bi\1A4ci(ii)	345	177	114	79	66	69	70	74	70		8%
Road Transport	1A3b	570	751	997	476	206	177	155	136	87		11%
Other Transport	1A3a(ii)\1A3a(iii)\1A3c\1A3eii\1A4bi\1A4cii\1A5b	35	34	37	35	30	27	25	23	21		2%
Extraction & Distribution of Fossil Fuels	1B	178	364	566	354	233	222	222	190	170		21%
Production Processes (excluding 2D)	2A-2C	120	138	177	75	43	37	36	29	22		3%
Processes in wood, paper pulp, food, drink industries	2D	77	85	77	79	78	78	79	81	81		10%
Solvent & Other Product Use	3	499	585	676	443	408	407	401	380	360		44%
Agriculture\Waste\Accidental fires	4\6\7	56	75	62	22	16	16	16	15	15		2%
BY FUEL TYPE												
Solid		317	149	82	42	32	34	37	41	42		5%
Petroleum		628	807	1059	535	260	229	204	182	127		19%
Gases		3	6	6	12	10	10	8	9	8		1%
Non Fuel		933	1248	1559	975	779	761	754	697	649		75%
Total		1881	2210	2706	1563	1080	1034	1004	929	826	1200	100%
MEMO Items												
Natural Emissions ⁴		91	91	92	92	92	92	92	92	92		
Other Transport ⁵		14	8	9	10	12	13	15	16	15		

¹ UK emissions reported in IPCC format (MacCarthy et al, 2011) differ slightly due to the different source categories used.

² See Annex 1 for definition of UNECE Categories

³ Total emissions value shown for 2010 is the ceiling set under the NECD

⁴ Primarily emissions from forests, but also includes accidental biomass fires

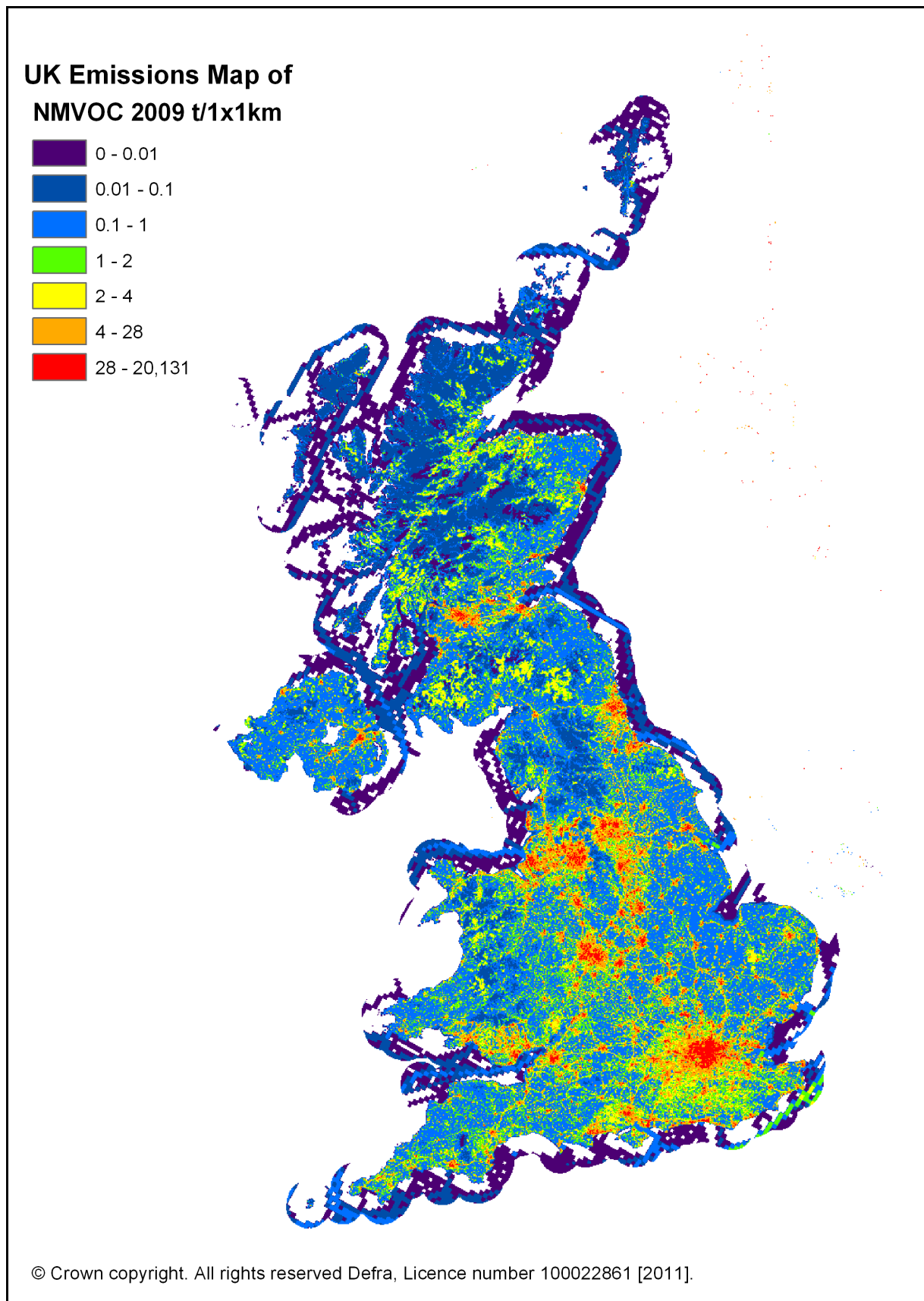
⁵ Includes Domestic/International Aviation (Cruise) and International Navigation

The spatial disaggregation of NMVOC emissions in the UK is shown in Figure 2.18. A large proportion of emissions are caused either as a result of the activities of people in and around their homes (e.g. domestic solvent use or domestic combustion), or by widespread industrial activities such as small-scale industrial coating processes, dry cleaning shops, and small bakeries, which are present in towns and cities throughout the UK. Consequently the resulting emissions map is well correlated with population density.

The NMVOC map includes a large number of point sources, including oil refineries, crude oil terminals, large combustion plant, chemicals manufacture, iron and steel processes, whisky manufacture, large bread bakeries, and industrial solvent using processes. The domestic sources are distributed using population density statistics, and the sources arising from other industrial processes are mapped using information on the size and locations of industrial installations.

Unlike the map presented previously for NO_x , the NMVOC map has little major road definition except where the major roads go through rural areas. This reflects the fact that NMVOC emissions are dependent on vehicle speed and are higher on minor and urban major roads than on the high-speed motorways and major roads.

Figure 2-18 Spatially Disaggregated UK Emissions of NMVOC



2.9.3 Solvent Use and Production Processes

Solvent & other product use and production processes are responsible for 44% and 12%, respectively, of the 2009 emission total. The estimates are derived either based on plant specific data provided by process operators or regulators or by use of appropriate emission factors combined with solvent consumption data or industrial production data. The NMVOC inventory has been subject to a continuous programme of review and improvement over the past decade, and these estimates can be considered reasonably reliable.

The solvent use sector comprises both industrial and domestic applications, both being significant sources. Emissions from industrial solvent use reached their peak in 1973, and then dipped to a low in 1981, before increasing again until 1989. Since 1989 emissions have fallen as a result of emission controls, technological changes, and reduced manufacturing output in some sectors. In comparison, domestic solvent emissions showed little temporal variation until the mid 1980s when they increased sharply. Since 1990 however, solvent use emissions (NFR code 3) have decreased by 47% due to a trend towards formulating products such as paints and aerosols with lower solvent contents.

The production processes sector includes emissions from the chemical industry, petroleum refining, and food and drink manufacture as well as minor sources such as iron and steel production and road construction. Emissions from the chemical industry grew steadily until 1990, since when tightening emission controls have led to a reduction in emissions. The emissions from the petroleum refining sector show little trend over the period from 1970 until 1994, but since then emission controls and refinery closures have led to falling emission levels.

Emissions from the food and drink industry comprised 10% (81 ktonnes) of the total NMVOC emission in 2009. The largest source is whisky maturation although bread baking, animal feed manufacture, fat and oil processing and barley malting are also important. Emissions from the sector peaked in 1980 before falling again. The trends with time are primarily driven by production in these sectors.

2.9.4 Transport

Total transport emissions (including mobile machinery) are currently responsible for 13% of NMVOC emissions of which 11% are a result of road transport. With increasing car numbers, emissions rose from 1970, to a peak in 1989. Since then emissions have declined by 90% owing to the increased use of three-way catalytic converters and fuel switching from petrol to diesel cars.

2.9.5 Other Sectors

Offshore oil and gas emissions have increased substantially since 1970 with the growth of the UK's offshore activities. The most important source of NMVOC emissions is tanker loading.

Emissions from gas leakage currently comprise around 4.5% of the total NMVOC emission. The mass of mains gas being released accidentally has decreased due to pipe replacement in recent years. There is a slight countering temporal trend of increasing NMVOC content in mains gas, but the impact of this is small compared to the impact of pipeline replacement.

The evaporative losses from the distribution and marketing of petrol rose between 1970 and the early 1990s reflecting the growth in road transport. Since then emissions have decreased, partly as a result of fuel switching to diesel, and partly as a result of increasing usage of petrol vapour recovery systems to prevent emissions from petrol terminals and service stations. This source currently accounts for 4.2% of national NMVOC emissions.

The contribution from domestic heating has fallen by 87% between 1970 and 2009 as the use of coal for domestic and commercial heating has declined. It now accounts for just 4.7% of the UK emissions.

NMVOC emissions from waste treatment and disposal contribute 1.7% to national emissions. Data from the Environment Agency (2010) shows emissions from municipal waste incinerators to be very small.

NMVOCs, in particular isoprene and mono-terpenes, are emitted from several natural and agricultural sources- such as forests. These are included under natural sources and are not included in the UK total. Entries under Agriculture in Table 2.12 represent emissions from agricultural field burning.

2.9.6 Speciation of NMVOCs

As mentioned previously, the term NMVOC covers a wide range of compounds and although a total NMVOC inventory is sufficient for most purposes, in some cases greater detail is required concerning the nature and concentration of individual compounds. For example, when assessing the photochemical production of ozone, individual species have different ozone creation potentials hence information is required on the concentration of individual species (QUARG, 1993). The speciation data contained in Table 2.13 and Table 2.14 are generated from the UK emission estimates for NMVOC. Table 2.13 shows the emissions of the 50 most important NMVOC species disaggregated as far as possible by source. "Unspeciated" emissions are those where no suitable speciation profile is available. In some cases the speciation profile that is available includes groups of compounds (e.g. C6's- representing all hydrocarbons with six carbon atoms). These are reported in the table as "other grouped species".

Table 2.13 Top 50 NMVOC Mass Emissions in 2009 (tonnes)

	Stationary combustion			Production Processes	Extraction and distribution of fossil fuels	Solvent Use	Road transport	Other transport	Waste treatment and disposal	Other Sources	Total (Tonnes)
	Energy production	Commercial/residential	Industrial								
ethanol		6,861	111	57,482		39,796			493		104,743
butane	235	1,281	271	1,895	28,674	18,914	4,874	216	42		56,401
ethane	4,735	3,919	98	880	27,676	0	1,832	178	783		40,101
methanol				1,110	0	28,973			128		30,211
propane	4,600	1,552	132	1,161	15,583	3,715	490	113	488		27,835
toluene	60	726	80	2,565	129	9,604	7,074	1,201	285		21,723
ethylene	48	7,513	157	2,208	75		6,061	2,762	951		19,775
acetone	22	5	14	1,216		17,578	623	35	2		19,495
benzene	82	8,562	354	1,263	551	0	3,796	2,031	912		17,551
pentane	78	680	300	1,197	9,876	427,923	2,698	127	36		15,420
2-methylbutane	36	1,222	105	732	6,089	48	6,378	305	27		14,942
m-xylene	279	104	35	1,446	47	9,413	2,035	412	131		13,902
hexane	82	103	45	2,289	5,326	2,464	2,366	81	188		12,943
trichloroethene				384		12,278			104		12,765
dichloromethane				1,293		9,943			116		11,352
formaldehyde	4,478	634	491	202	208	24	2,702	2,200	325		11,263
2-butanone				495		10,524	155	7	23		11,204
2-	35	456	10	166	7,274	985	1,899	113	13		10,951
decane	0.115	16		589	19	6,662	330	704			8,319
butyl acetate				155		7,832			37		8,024
2-propanol		4		396		7,466			28		7,894
1,2,4-	0.115	0.004		371	4	4,569	2,509	377			7,831
heptane	11	315	1	220	4,767	1,457	638	92			7,501
propylene	126	1,368	30	2,229	11	0	2,869	801	55		7,488
ethyl acetate				1,028		6,255			39		7,322
ethylbenzene	83	36	21	1,194	13	3,634	1,478	312	211		6,982
tetrachloroethene				71		5,795			213		6,080
4-methyl-2-				529		5,405					5,935
octane	0	28		148	4,165	1,202	352	36			5,930
p-xylene	4	81	14	630	11	2,601	1,573	318	102		5,335
o-xylene	63	59	11	507	23	2,375	1,660	398	74		5,170
nonane	0.115	24		366	49	4,055	154	111			4,759
undecane	0.115	0.004		306		3,468		206			3,980
acetylene	17	7	46	435	9	0.051	2,278	743			3,535
1-propanol				56		3,384			67		3,506
2-butoxyethanol				80		3,278					3,358
1-butanol				155		3,168			12		3,335
2-	0	64		449	137		1,759	856	8		3,273
2-	2	4	7	695	1,191	1,174		4	89		3,165
acetaldehyde	0	0		622			1,320	1,131			3,074
1,3,5-	0	0		133		1,554	892	194			2,774
methylethylbenz				172		2,320					2,491
1,2,3-	0	0		126		1,576	540	138			2,380
1-methoxy-2-				74		2,263					2,337
1,3-butadiene	1			506	4		1,203	580	12		2,306
dipentene				10		2,235					2,245
4-methyldecane				178		2,020					2,198
3-	2	3	5	475	661	910			60		2,115
2-methylhexane				112	88	791	915	195			2,101
methyl acetate				2,020							2,020
Total Top 50	15,080	35,626	2,337	93,019	112,65	252,137	63,45	16,977	6,054		597,339
Other VOCs	150	2,395	89	14,902	2,370	77,009	7,348	3,787	2,711		110,762
Other grouped	4	275	2	15,766	5,125	6,614	14,80	17,342	2,236		62,167
unspeciated	1,478	5,037	9	25,012	7,937	7,491	1,210	1,966	4,291	1,26	55,699
Total VOC	16,712	43,334	2,437	148,699	128,08	343,251	86,81	40,071	15,292	1,26	825,967

2.9.7 Photochemical Ozone Creation Potential

Table 2.13 is a useful reference for finding the emission of a particular NMVOC compound. However, species specific emissions do not reflect the fact that NMVOC compounds have different efficiencies in generating ozone through photochemical reactions. To resolve this, the concept of a photochemical ozone creation potential (POCP) was created. This POCP identifies, on a relative basis, the ozone creation potential for each NMVOC compound through modelling studies. The creation potentials are then normalised by defining ethene as a creation potential of 1.

It is therefore possible to determine which NMVOCs are the most important for the photochemical formation of ozone in the atmosphere. This is achieved by scaling the emissions of each NMVOC by the corresponding POCP to determine a weighted total based on values proposed by Jenkin et al 2000 (Table 2.14).

Table 2.14 Top 50 POCP-Weighted NMVOC Emissions in 2009

	POC P	code	Stati onar y comb ustio n	Product ion process es	Extracti on and distribut ion of fossil fuels	Solve nt use	Road transp ort	Other transp ort ³	Waste treatm ent and dispos al	Other Sourc es	Total (Mass Emissio ns)
ethanol	39.9	a	6.97	57,482		39.79			493		104,743
butane	35.2	a	1.78	1,895	28,674	18.91	4,874	216	42		56,401
ethane	12.3	a	8.75	880	27,676	0	1,832	178	783		40,101
methanol	14.0	a	-	1,110	0	28.97			128		30,211
propane	17.6	a	6.28	1,161	15,583	3,715	490	113	488		27,835
toluene	63.7	a	865	2,565	129	9,604	7,074	1,201	285		21,723
ethylene	100.	a	7.71	2,208	75		6,061	2,762	951		19,775
acetone	9.40	a	41	1,216		17.57	623	35	2		19,495
benzene	21.8	a	8.99	1,263	551	0	3,796	2,031	912		17,551
pentane	39.5	a	1.05	1,197	9,876	428	2,698	127	36		15,420
2-methylbutane	40.5	a	1.36	732	6,089	48	6,378	305	27		14,942
m-xylene	110.	a	419	1,446	47	9,413	2,035	412	131		13,902
hexane	48.2	a	230	2,289	5,326	2,464	2,366	81	188		12,943
trichloroethene	32.5	a	-	384		12,27			104		12,765
dichloromethane	6.80	a	-	1,293		9,943			116		11,352
formaldehyde	51.9	a	5.60	202	208	24	2,702	2,200	325		11,263
2-butanone	37.3	a	-	495		10.52	155	7	23		11,204
2-methylpropane	30.7	a	501	166	7,274	985	1,899	113	13		10,951
decane	38.4	a	16	589	19	6,662	330	704			8,319
butyl acetate	26.9	a	-	155		7,832			37		8,024
2-propanol	18.8	a	4	396		7,466			28		7,894
1,2,4-	127.	a	0	371	4	4,569	2,509	377			7,831
heptane	49.4	a	326	220	4,767	1,457	638	92			7,501
propylene	112.	a	1.52	2,229	11	0	2,869	801	55		7,488
ethyl acetate	20.9	a	-	1,028		6,255			39		7,322
ethylbenzene	73.0	a	140	1,194	13	3,634	1,478	312	211		6,982
tetrachloroethen	2.90	a	-	71		5,795			213		6,080
4-methyl-2-	49.0	a	-	529		5,405					5,935
octane	45.3	a	28	148	4,165	1,202	352	36			5,930
p-xylene	101.	a	99	630	11	2,601	1,573	318	102		5,335
o-xylene	105.	a	133	507	23	2,375	1,660	398	74		5,170
nonane	41.4	a	24	366	49	4,055	154	111			4,759
undecane	38.4	a	0	306		3,468		206			3,980
acetylene	8.50	a	70	435	9	0	2,278	743			3,535
1-propanol	56.1	a	-	56		3,384			67		3,506
2-butoxyethanol	48.3	a	-	80		3,278					3,358
1-butanol	62.0	a	-	155		3,168			12		3,335
2-methylpropene	62.7	a	64	449	137		1,759	856	8		3,273
2-methylpentane	42.0	a	13	695	1,191	1,174		4	89		3,165
acetaldehyde	64.1	a	0	622			1,320	1,131			3,074
1,3,5-	138.	a	0	133		1,554	892	194			2,774
methylethylbenz	94.1	c	-	172		2,320					2,491
1,2,3-	126.	a	0	126		1,576	540	138			2,380
1-methoxy-2-	35.5	a	-	74		2,263					2,337
1,3-butadiene	85.1	a	1	506	4		1,203	580	12		2,306
dipentene	74.5	b	-	10		2,235					2,245
4-methyldecane	37.6	b	-	178		2,020					2,198
3-methylpentane	47.9	a	9	475	661	910			60		2,115
2-methylhexane	41.1	a	-	112	88	791	915	195			2,101
methyl acetate	5.90	a	-	2,020							2,020
Total Top 50			53.0	93,019	112.65	252.1	63.45	16,977	6,054		597,339
Other VOC	0.38		2.63	14,902	2,370	77.00	7,348	3,787	2,711		110,762
Other grouped	0.63		281	15,766	5,125	6,614	14,80	17,342	2,236		62,167
unspecified	51.3	c	6.52	25,012	7,937	7,491	1,210	1,966	4,291	1,268	55,699
Total VOC			62.4	148,69	128.08	343.2	86.81	40,071	15,292	1,268	825,967

2.10 PARTICULATE MATTER

2.10.1 Major Sources

Historically, interest in particulate matter focused mainly on smoke, which can cause health problems especially in combination with other pollutants. A notable example was emissions of smoke and sulphur dioxide leading to the London smog in the 1950s and early 1960s when several thousand excess deaths were recorded. Smoke emissions have fallen significantly as a result of the Clean Air Act eliminating domestic coal combustion in many urban areas. However, there is increasing interest in the measurement of fine particles, such as those arising from the combustion of diesel fuel in the transport sector, and aerosol concentrations in the atmosphere from other sources, which may have harmful effects. Recent epidemiological evidence is linking concentrations of particles in the atmosphere with human health effects. Indeed, current ambient mass concentrations are thought to be sufficient to lead to increased mortality and morbidity (COMEAP, 2011).

Particles can vary widely in size and composition. Particles larger than about 30 μm (a μm is a "micrometre", or one thousandth of a millimetre) fall rapidly under gravity and those larger than about 100 μm fall out of the atmosphere so rapidly they are not usually considered. At the other end of the size scale, particles less than a tenth of a μm are so small they do not fall under gravity appreciably, but coagulate to form larger particles that are then removed from the atmosphere.

The US PM_{10} standard was a monitoring standard designed to measure the mass of particles less than 10 μm in size (more strictly, particles that pass through a size selective inlet with a 50% efficiency cut-off at 10 μm aerodynamic diameter). This corresponds to the International Standards Organisation thoracic convention for classifying those particles likely to be inhaled into the thoracic region of the respiratory tract. The epidemiological evidence of the effects of particulates shows good correlation in the UK between PM_{10} concentrations and mortality or morbidity (EPAQS 1995, 2001). Therefore PM_{10} has become the generally accepted measure of particulate material in the atmosphere in the UK and in Europe. There is also an increasing interest in the correlation between $\text{PM}_{2.5}$ and health indicators, and it may be that $\text{PM}_{2.5}$ is used as a primary metric in the future. PM_{10} measurements have been made in the UK for a number of years (see www.airquality.co.uk/archive/index.php).

For many years the monitoring of particulate levels in the UK was based on the measurement of "black smoke". Levels were estimated using a simple non-gravimetric reflectance method in which air is sampled through a filter and the resulting blackening measured. The method was originally calibrated against Total Suspended Particulate (TSP) mass concentrations for domestic coal smoke and more recently to include the 1980s contribution of vehicle exhaust to the metric. With the original calibration when most of the emissions come from coal combustion the blackening should be approximately proportional to the mass concentrations. In the 50s and 60s, domestic coal combustion was the dominant source of black smoke and hence this method gave an indication of the concentration. The NAEI estimates of black smoke emissions were extended in 1988 to include emissions from all fuel combustion. Prior to 1988 only emissions from coal combustion had been estimated and published in the Digest of Environmental Statistics.

Smoke from different sources has a different blackening effect and so there is no simple relationship between black smoke and the mass of particulate emissions. For example, typically diesel emissions have a blackening effect three times greater, on a mass for mass basis, compared with coal emissions, while petrol emissions are effectively an order of magnitude less. So, black smoke is a poor indicator of the mass concentrations of particulates in the atmosphere. Furthermore, the measurements used for deriving emission factors of black smoke were conducted several decades ago when the relative importance of sources were very different. The AQS is focused on PM₁₀ (particulate matter less than 10µm i.e. 10 millionths of a metre) and smaller size fractions (EPAQS, 1995). However, black smoke has been shown to have relationships with health effects and is still used as an indicator.

For completeness the following sections present emission estimates and discussion for PM₁₀, PM_{2.5}, PM_{1.0}, PM_{0.1}. Black Smoke is included in a summarised format.

2.10.2 PM₁₀

2.10.2.1 Sources of emissions

PM₁₀ in the atmosphere arises from primary and secondary sources. Primary particulates arise from direct emissions of particulate matter into the atmosphere from a wide range of sources such as fuel combustion, surface erosion and windblown dusts and mechanical break-up in, for example, quarrying and construction sites. Secondary particulates arise from the formation of particulate matter in the atmosphere through the reactions of other pollutants such as sulphur dioxide, nitrogen oxides and ammonia to form solid sulphates and nitrates, as well as organic aerosols formed from the oxidation of NMVOCs. This inventory only considers primary sources. For further information on secondary particulate see the report from the Air Quality Expert Group Report on particulate matter in the UK (AQEG, 2005), which can be found on

www.airquality.co.uk/archive/index.php

The main sources of primary PM₁₀ are briefly described below:

- Road Transport. All road transport sources emit PM₁₀. However diesel vehicles emit a greater mass of particulates per vehicle kilometre than petrol engine vehicles. Emissions also arise from brake and tyre wear and from the re-entrainment of dust on the road surface. Emission estimates for the resuspension (or "re-entrainment") of dust have been made. However this emission does not fall within the UNECE reporting format and consequently has been included here for information only.
- Stationary Combustion. Domestic coal combustion has traditionally been the major source of particulate emissions in the UK. However, the use of coal for domestic combustion has been restricted in the UK by the Clean Air Acts, and as a result other sources are now more important nationally. Domestic coal is still a significant source in Northern Ireland, some smaller towns and villages, and in areas associated with the coal industry. Combustion of wood, gas oil and natural gas also all contributing significantly to UK emissions of PM₁₀. In general, particles emitted from fuel combustion are of a smaller size than from other sources.

- **Industrial Processes.** These include the production of metals, cement, lime, coke, and chemicals, bulk handling of dusty materials, construction, mining and quarrying. Emissions from these sources are difficult to quantify due to the contribution of fugitive emissions (i.e. those diffuse emissions which are released directly into the atmosphere from a process rather than being collected in a controlled manner and then vented to atmosphere). Few UK measurements are available for these fugitive releases. Nonetheless, there have been substantial improvements in the estimation of PM₁₀ emissions from industrial processes in recent years. Usually a substantial fraction of the particles from these sources is larger than 10 µm but the large quantities emitted ensure that the fraction less than 10 µm is still a substantial source.

2.10.2.2 PM₁₀ Emission Estimates

Emissions of PM₁₀ are shown in Table 2.15 and Figure 2-19. Emissions of PM₁₀ from the UK have declined since 1970. This is due mainly to the reduction in coal use. Emissions in the domestic and commercial sector have fallen from 246 ktonnes (49% of the total emission) in 1970 to 18 ktonnes (15%) in 2009.

Emission estimates for the resuspension of dust from roads is not included in the standard UNECE reporting format (and hence not included in Table 2.15). However for completeness it is given in Table 2.16 below. Estimates for resuspension are based on the deposition of primary particles from all UK sources (including vehicle tailpipes and from brake and tyre wear) that are returned to the air from the turbulence of passing vehicles. As such, resuspension represents a “double count” in the emissions, but is important in reconciling roadside concentration measurements, and therefore input into modelling studies.

Table 2.15 UK Emissions of PM₁₀ by aggregated UNECE Source Category and Fuel (ktonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009%
BY UNECE CATEGORY¹											
Combustion in Energy and Transformation Industry	1A1	83	83	74	26	12	14	11	10	8	7%
Combustion in Manufacturing Industry/Commercial	1A2/1A4a/1A4ci(i)	21	9	6	4	3	4	4	5	5	4%
Industrial off-road mobile machinery	1A2f	43	28	25	18	15	14	13	12	11	9%
Residential plants	1A4bi	231	100	48	22	13	14	16	17	17	14%
Passenger cars	1A3bi	3	4	9	8	7	7	7	6	6	5%
Light duty vehicles	1A3bii	2	3	6	7	6	5	5	4	4	3%
Heavy duty vehicles	1A3biii	13	15	16	9	5	5	4	4	3	2%
	1A3biv&vi(i)\1A3aii(i)-										
Other Transport	1A3aii(ii)\1A3c-1A3cii\1A4bii\1A4cii\1A5b	27	23	26	26	24	24	22	21	21	17%
Production Processes	1B1-3	55	43	48	32	29	29	31	28	24	20%
Agriculture	4	11	12	13	14	13	13	13	13	13	11%
Waste	6\7	10	10	9	8	8	8	7	7	7	6%
By FUEL TYPE											
Solid		333	185	125	46	24	27	26	28	27	22%
Petroleum		77	62	66	54	42	39	35	32	29	25%
Gas		1	2	2	3	4	4	4	4	4	3%
Non-Fuel		87	78	87	71	67	66	68	64	59	50%
TOTAL		498	328	280	174	137	136	133	129	119	100%

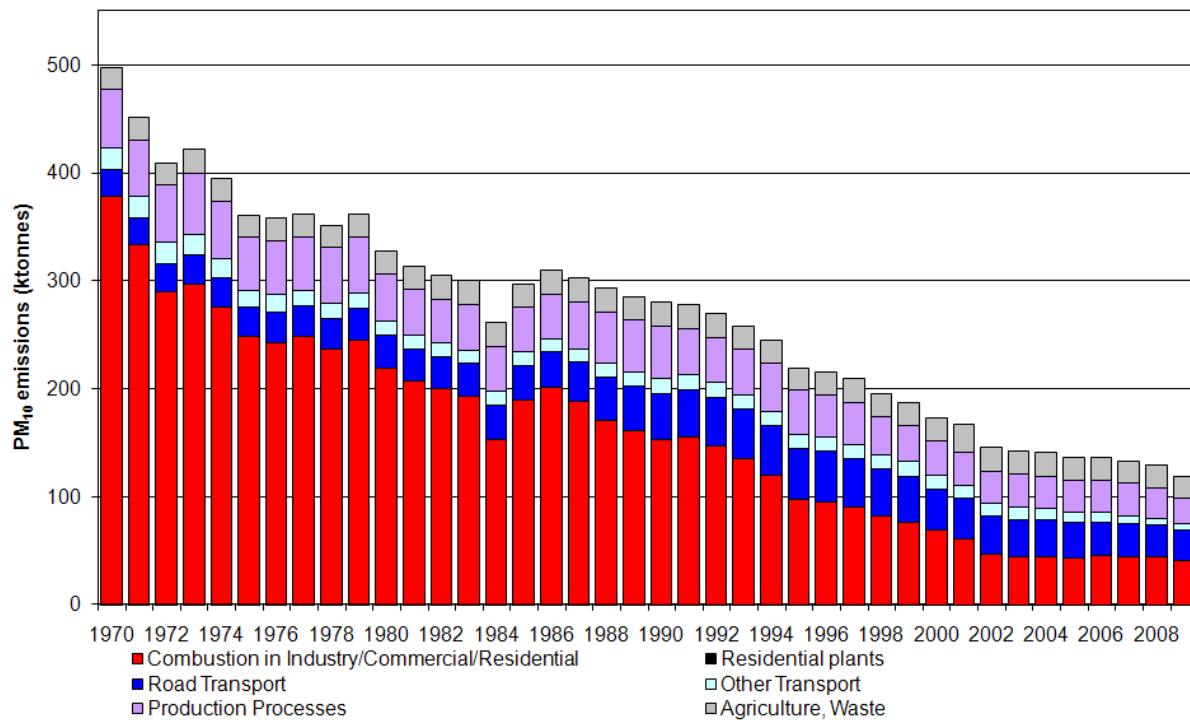
¹ See Annex 1 for definition of UNECE Categories

Table 2.16 PM₁₀ Emission Estimates from Resuspension (ktonnes)

	1970	1980	1990	2000	2005	2006	2007	2008	2009
Resuspension from Road Transport	8.2	11.2	16.9	19.4	20.7	21.1	21.3	21.2	21.0

The geographical disaggregation of emissions is shown in Figure 2-20. There is a clear distinction between the important sources in rural and urban areas. The sources of PM emissions are diverse and many of the sources do not occur inside towns and cities. However, road transport is a major source in urban areas and while contributing to only 23% of national emissions of PM₁₀, it can account for a much higher proportion (as much as 50%) in urban areas such as London (AQEG, 2005).

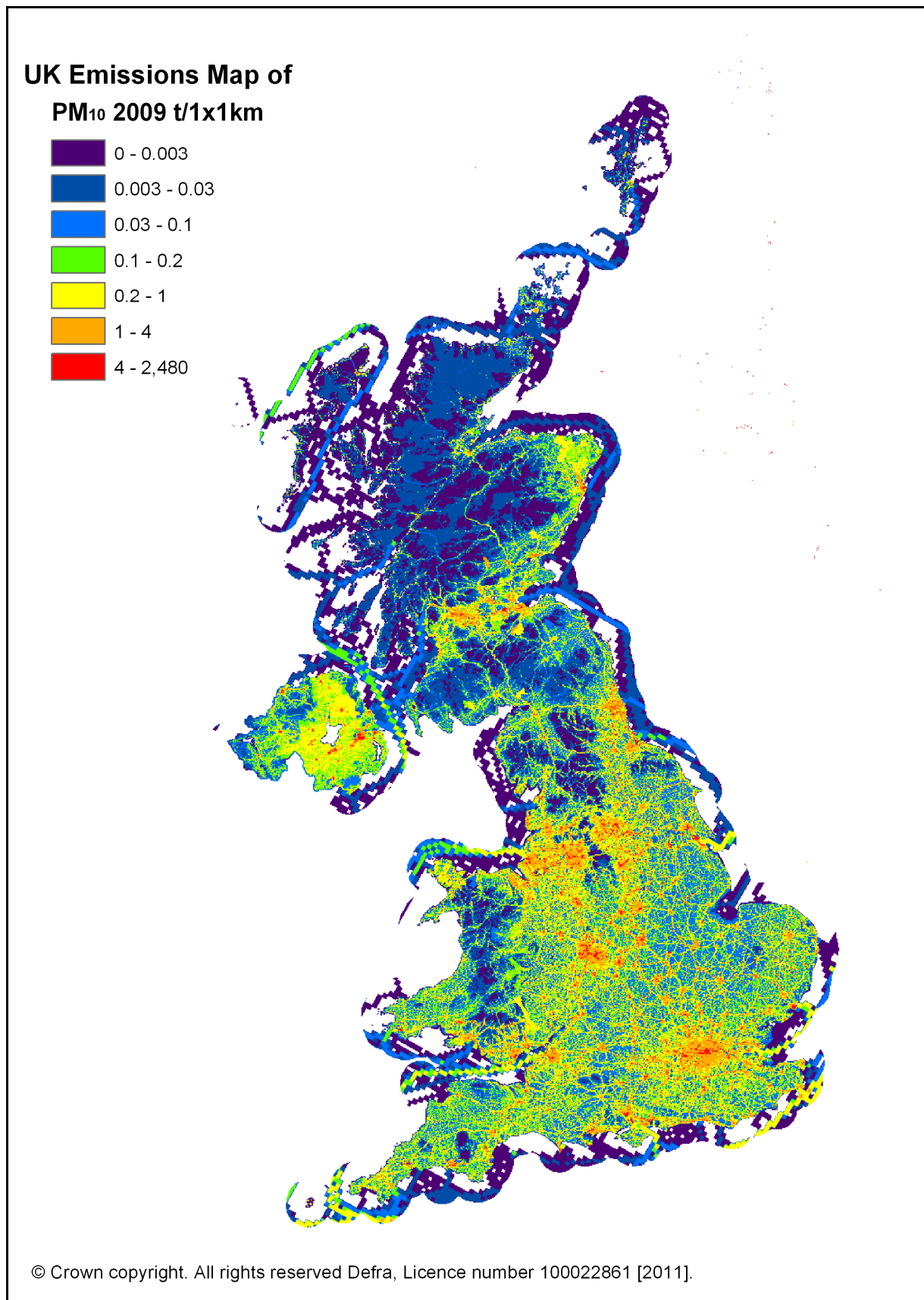
Emissions from electricity generation have also recently been declining (since 1990) despite a significant growth in the electricity generated between 1970 and 2009. This is due to the move away from coal to natural gas and nuclear power for electricity generation and to improvements in the performance of particulate abatement plant at coal-fired power stations. Also the installation of flue gas desulphurisation at some power stations has reduced particulate emissions further.

Figure 2-19 Time Series of PM₁₀ Emissions (ktonnes)

Emissions from road transport have not increased, but the contribution to the total emission has increased with time due to other sectors decreasing. The contribution to the total UK emission has risen from 4.9% in 1970 to 23% in 2009. The main source of road transport emissions is exhaust from diesel engine vehicles. Emissions from diesel vehicles have been growing due to the growth in heavy-duty vehicle traffic and the move towards more diesel cars. Since around 1992, however, emissions from diesel vehicles on a per vehicle kilometre travelled basis have been decreasing due to the penetration of new vehicles meeting tighter PM₁₀ emission regulations.

Among the non-combustion and non-transport sources, the major emissions are from industrial processes, the most important of which is quarrying whose emission rates have remained fairly constant although recently it has been declining slowly since 1994. Other industrial processes, including the manufacture of steel, cement, lime, coke, and primary and secondary non-ferrous metals, are collectively important sources of particulate matter, although emissions from individual sectors are relatively insignificant.

Figure 2-20 Spatially Disaggregated UK Emissions of PM₁₀



2.10.3 Finer Particulates: PM_{2.5}, PM_{1.0} and PM_{0.1}

Inventories for PM_{2.5}, PM_{1.0} and PM_{0.1} have been estimated from the PM₁₀ inventory and the mass fractions in these size ranges available for different emission sources and fuel types. A total of 33 different size distributions covering PM_{2.5} and PM_{1.0} emissions from different source sectors were taken from the United States Environmental Protection Agency (US EPA) (1995) as being applicable to sources in the UK. A smaller number of sectors with size fractions in the PM_{0.1} range were available from the study by the TNO Institute of Environmental Sciences in the Netherlands for the Dutch National Institute of Public Health and Environment (RIVM) (TNO, 1997). This study produced a particulate emissions inventory for Europe. In general, combustion processes emit a higher proportion of fine particles (<2.5 µm) than mechanical sources such as quarrying and construction. Gaseous fuels also tend to emit finer particles than petroleum and solid fuels.

Each of the detailed source sectors for which a PM₁₀ emission is estimated (a total of 353 individual sectors and sub-sectors) were allocated an appropriate size distribution and used to calculate emission inventories for PM_{2.5}, PM_{1.0} and PM_{0.1}. The results are shown in Table 2.17, Table 2.18 and Table 2.19.

Figure 2-21 –Figure 2-24 show trends in emissions of each particle size by source sector. The results show a comparable decline in emissions of each particle size. Between 1990 and 2009, UK emissions of PM₁₀ fell by 58%, whereas emissions of PM_{2.5} fell by 55%, PM_{1.0} by 55% and PM_{0.1} by 52%. There is a gradual change in the relative source contribution with particle size. Road transport becomes an increasingly important sector as the particle size decreases. In 2009, it accounted for 23% of PM₁₀ emissions, but 41% of PM_{0.1} emissions.

2.10.3.1 PM_{2.5} Emission estimates

Emissions of PM_{2.5} are shown in Table 2.17. Emissions of PM_{2.5} from the UK have declined since 1990. This is due mainly to the reduction in coal use. Emissions in the domestic, commercial and Institutional sector have fallen from 21 ktonnes in 1990 to 10 ktonnes in 2009.

In general the PM_{2.5} emission profile follows the PM₁₀ trends and the reductions in PM₁₀ emissions have also caused reductions in PM_{2.5}.

Table 2.17 UK emissions of PM_{2.5} by sector (ktonnes) Estimated for the Mass Fraction of Particles below 2.5 µm in each Sector in the PM₁₀ inventory

PM _{2.5}	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009%
Combustion in Energy and Transformation Industry	1A1	38	38	34	12	7	7	6	6	5	7%
Combustion in Manufacturing Industry/Commercial	1A2/1A4a\1A4ci(ii)	9	4	3	2	2	2	2	3	3	4%
Industrial off-road mobile machinery	1A2f	29	19	18	13	11	10	10	9	8	12%
Residential plants	1A4bi	87	38	19	10	7	8	9	10	10	14%
Passenger cars	1A3bi	3	4	8	8	7	6	6	6	6	8%
Light duty vehicles	1A3bii	2	2	6	7	5	5	5	4	4	5%
Heavy duty vehicles	1A3biii	12	14	15	8	5	5	4	3	3	4%
Other Transport	1A3biv&vi(i)\1A3aii(i)-1A3aii(ii)\1A3c-1A3eii\1A4bii\1A4cii\1A5b	21	16	18	18	16	16	14	14	13	19%
Production Processes	1B1-3	33	26	27	16	15	14	15	14	11	16%
Agriculture	4	2	3	2	2	2	2	2	2	2	3%
Waste	6\7	8	8	8	6	6	6	6	6	6	8%
Total		244	172	158	103	84	82	80	76	70	100%

Figure 2-21 Time Series of PM_{2.5} Emissions (ktonnes)

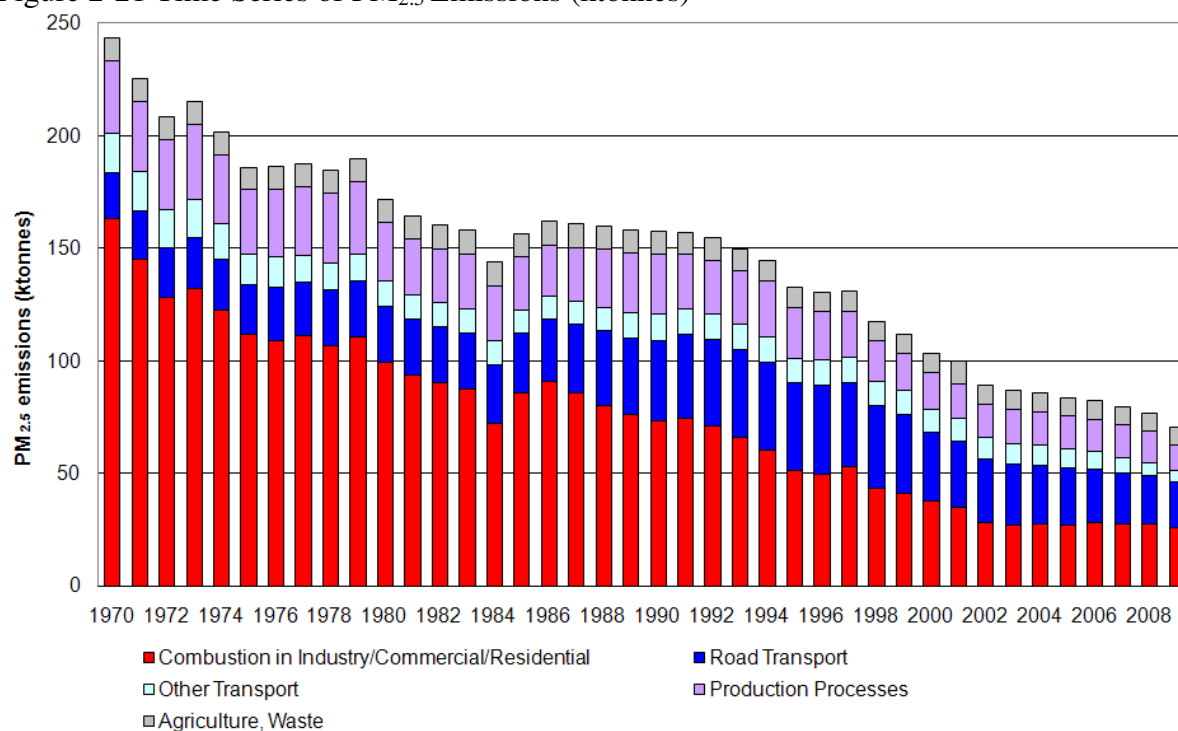
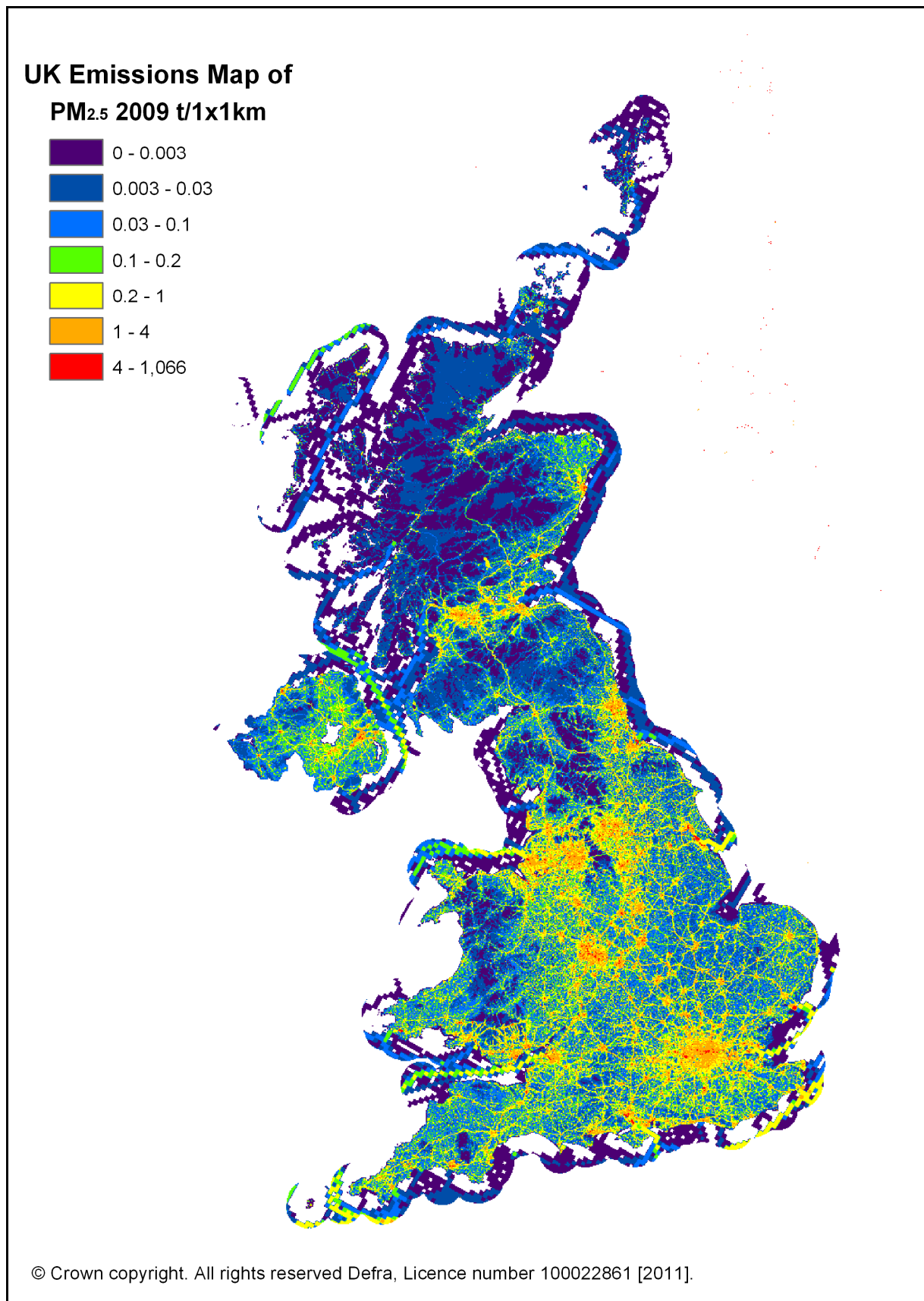


Figure 2-22 Spatially Disaggregated UK Emissions of PM_{2.5}



2.10.3.2 Emission estimates of PM_{1.0} and PM_{0.1}

Table 2.18 UK Emissions of PM_{1.0} by Sector (ktonnes) Estimated for the Mass Fraction of Particles below 1 µm in each Sector in the PM₁₀ Inventory

PM _{1.0}	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009%
Combustion in Energy and Transformation Industry	1A1	19	18	15	6	4	4	4	4	3	7%
Combustion in Manufacturing Industry/Commercial	1A2/1A4a/1A4ci(ii)	6	3	2	1	1	1	1	2	2	4%
Industrial off-road mobile machinery	1A2f	18	13	12	11	9	8	8	7	7	14%
Residential plants	1A4bi	69	29	14	7	4	5	5	6	5	11%
Passenger cars	1A3bi	2	3	7	7	6	6	6	5	5	11%
Light duty vehicles	1A3bii	1	2	5	6	5	4	4	4	3	7%
Heavy duty vehicles	1A3biii	11	12	14	8	5	4	4	3	3	5%
Other Transport	1A3biv&vi(i)\1A3aii(i)-1A3aii(ii)\1A3c-1A3cii\1A4bii\1A4cii\1A5b	16	11	12	11	9	8	7	7	6	13%
Production Processes	1B1-3	23	18	18	10	9	9	9	8	7	15%
Agriculture	4	2	3	2	2	2	2	2	2	2	4%
Waste	67	7	7	6	5	5	5	5	5	5	10%
Total		174	119	107	73	59	58	55	53	48	100%

Table 2.19 UK Emissions of PM_{0.1} by Sector (ktonnes) Estimated for the Mass Fraction of Particles below 0.1 µm in each Sector in the PM₁₀ Inventory

PM _{0.1}	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009%
Combustion in Energy and Transformation Industry	1A1	7.2	7.0	6.2	2.6	1.9	2.0	1.8	1.7	1.5	8%
Combustion in Manufacturing Industry/Commercial/Residential	1A2/1A4ci(ii)/1A4bi	7.0	3.4	2.1	1.5	1.4	1.5	1.5	1.8	1.8	10%
Industrial off-road mobile machinery	1A2f	5.4	4.0	3.5	2.9	2.4	2.2	2.2	2.0	1.7	9%
Passenger cars	1A3bi	0.9	1.2	3.4	3.9	3.5	3.4	3.2	3.1	3.0	16%
Light duty vehicles	1A3bii	0.8	1.2	2.8	3.6	2.9	2.6	2.5	2.2	2.0	11%
Heavy duty vehicles	1A3biii	6.5	7.3	8.0	4.5	2.7	2.5	2.2	1.8	1.5	8%
Other Transport	1A3biv&vi(i)\1A3aii(i)-1A3aii(ii)\1A3c-1A3cii\1A4bii\1A4cii\1A5b	3.6	2.8	3.1	3.0	2.7	2.5	2.3	2.2	2.1	11%
Production Processes	1B1-3	10.6	7.3	7.5	3.8	3.6	3.4	3.5	3.2	2.6	14%
Agriculture	4	1.7	1.8	1.8	2.1	2.0	2.0	1.9	1.9	1.9	10%
Waste	67	1.1	1.1	1.1	0.9	0.8	0.8	0.8	0.8	0.8	4%
Total		45	37	40	29	24	23	22	21	19	100%

Figure 2-23 Time Series of PM_{1.0} Emissions (ktonnes)

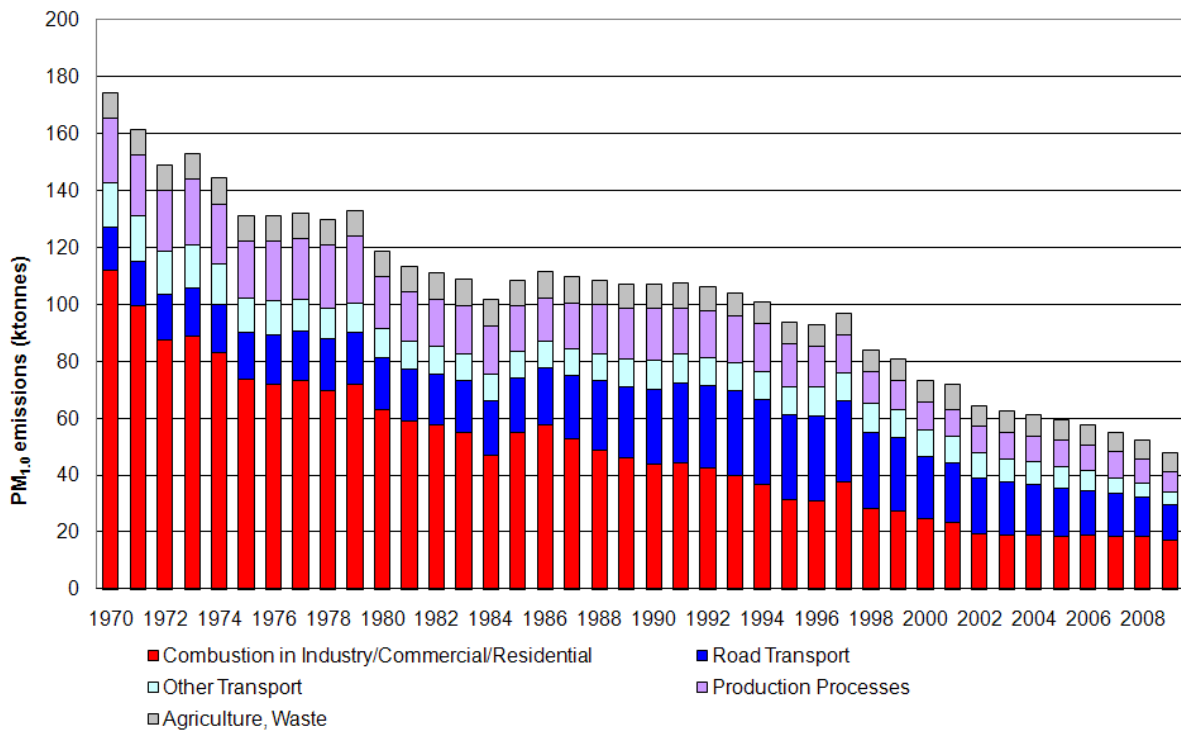
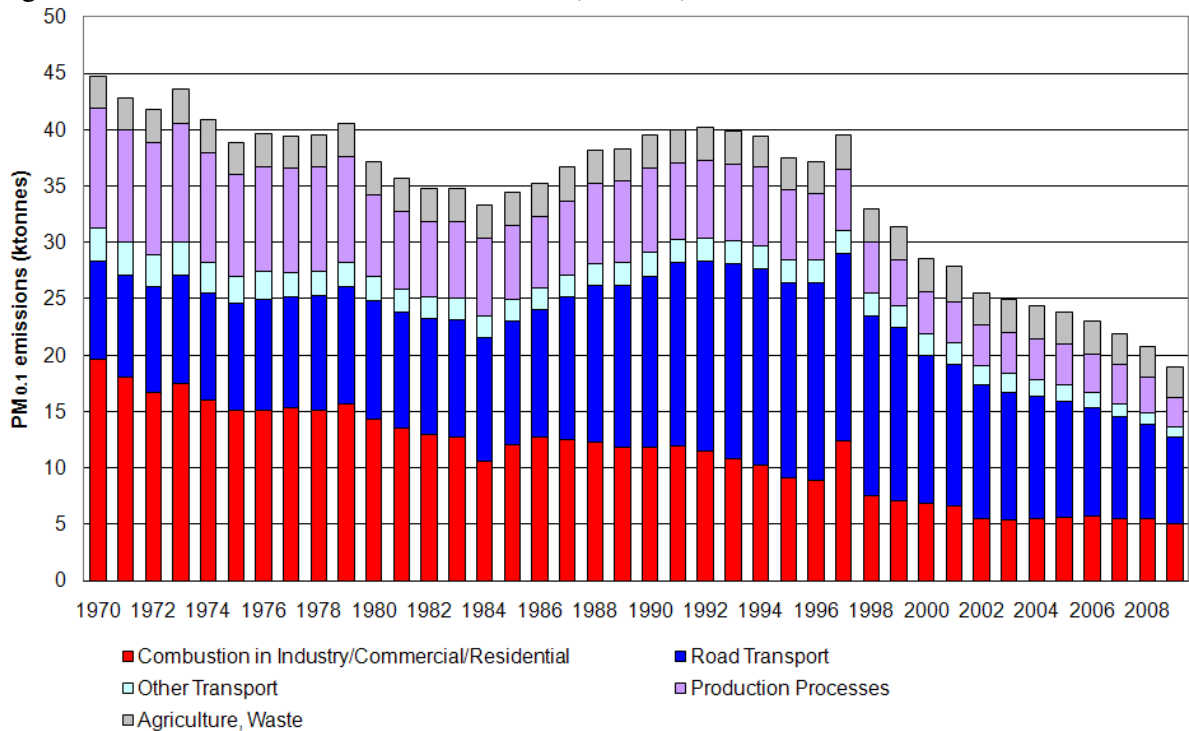


Figure 2-24 Time Series of PM_{0.1} Emissions (ktonnes)



2.10.4 Black Smoke

There has been less interest in the emissions of black smoke in recent years. This is because PM₁₀ has superseded black smoke as an indicator of particulate material in the air. In addition, the measurements, which are used to derive emission factors for black smoke, were

conducted several decades ago. It is expected that the blackening effect of some key sources (e.g. road transport) has changed across this time period, and therefore the emission estimates are considered to be very high in uncertainty. The black smoke emission estimates are presented only as a total (Table 2.20), reflecting the associated uncertainties. Black smoke emissions are less accurate than those for PM₁₀ due to the fact that, since its importance as a policy tool has declined, the black smoke inventory methodology has not been revised for many years and the relevance of the emission factors used in the inventory to current sources such as road transport and industrial technology is in doubt.

2.10.5 Key Source Description

Table 2.20 UK Emissions of Black Smoke by UNECE Source Category (ktonnes)

	1970	1980	1990	2000	2005	2006	2007	2008	2009
TOTAL	1095	625	453	252	190	183	180	169	151

2.11 SULPHUR DIOXIDE

Sulphur dioxide (SO₂) has long been recognised as a pollutant because of its role, along with particulate matter, in forming winter-time smog. Studies indicate that SO₂ causes nerve stimulation in the lining of the nose and throat. This can cause irritation, coughing and a feeling of chest tightness, which may cause the airways to narrow. People suffering from asthma are considered to be particularly sensitive to SO₂ concentrations.

Fuel combustion accounted for more than 92% of UK SO₂ emissions in 2009 with the two main sources being the combustion of solid fuel and petroleum products. SO₂ emissions can be calculated from knowledge of the sulphur content of the fuel and from information on the amount of sulphur retained in the ash. Published fuel consumption data (DECC, 2010), published sulphur contents of liquid fuels (Tucker, 2010) and data from coal producers regarding sulphur contents of coals enable reliable estimates to be produced.

2.11.1 Total Sulphur Dioxide Emissions

Since 1970 there has been a substantial overall reduction of 94% in SO₂ emissions. The emission profile exhibits a steady decline between 1970 and 2009 with the exception of small peaks in 1973 and 1979 corresponding to the harsh winters in those years, and a short period at the end of the 1980s when emissions were relatively constant from year to year. It is also evident that there is little decrease between total SO₂ emissions in 1997 and 1998. This occurs because the large reductions in emissions from the power generation sector are not as substantial between 1997 and 1998. However the downward trend resumes between 1998 and 2009. Thus emissions in 2009 were already 32% below the ceiling figure in 2010 set under NECD.

Table 2.21 shows emissions broken down by fuel categories. The two main contributors are solid fuel and petroleum products. Emissions from solid fuel use have declined by 93% since 1970 and those from petroleum by 95%. The most important factors associated with the fall in emissions from petroleum use are the decline in fuel oil use and the reduction in the sulphur content of gas oil and DERV (diesel fuel specifically used for road vehicles). The reduction in the sulphur content of gas oil is particularly significant in sectors such as domestic heating,

commercial heating and off-road sources where gas oil is used extensively. The sulphur content of DERV has steadily reduced across recent years, giving rise to a significant reduction in SO₂ emissions. SO₂ emissions from DERV in the early 1990's were relatively constant, however decreased significantly between 1994 and 2009.

Figure 2-25 Time Series of SO₂ Emissions (Mtonnes) and the ceiling to be achieved in 2010.

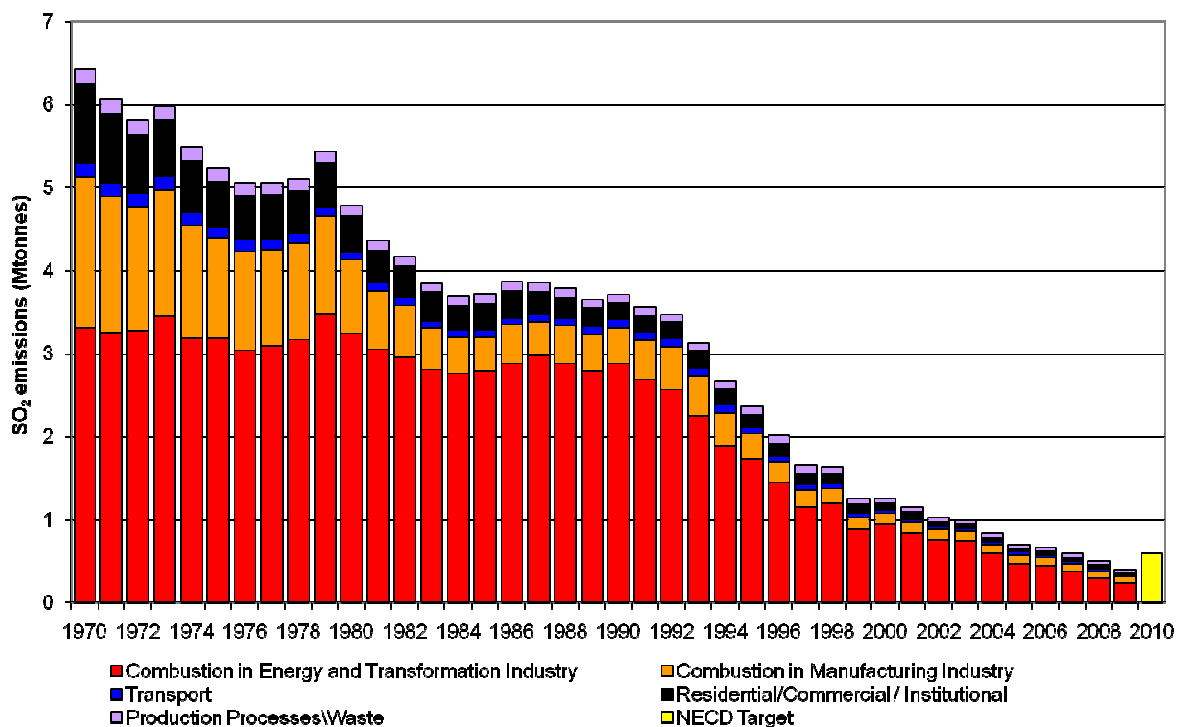


Table 2.21 UK Emissions of SO₂ by aggregated UNECE¹ Source Category and Fuel (ktonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2010 ³	2009%
BY UNECE CATEGORY²												
Public Electricity and Heat Production	1A1a	2921	3014	2731	852	386	361	285	213	160		40%
Petroleum refining	1A1b	199	197	138	73	73	75	79	72	59		15%
Stationary Combustion Other industrial combustion (Autogenerators, Brick Manufacture)	1A1c\1A2a\1A2b\1A4a\1A4ci(ii) 1A2f	928	311	106	35	15	16	19	19	18		4%
Transport	1A3aii(i)\1A3aii(ii)\ 1A3b\1A3c\1A3cii\1A4bii\ 1A4cii\1A5b	78	66	79	16	13	13	16	13	12		3%
National Navigation	1A3dii	82	30	25	20	21	20	14	13	13		3%
Residential plants	1A4bi	521	226	111	73	37	37	37	39	36		9%
Production Processes\Waste	1B1\2\6	179	129	105	61	51	51	51	51	31		8%
BY FUEL CATEGORY												
Solid		3732	3158	2748	970	473	447	372	301	246		62%
Petroleum		2516	1475	833	192	153	151	148	137	115		29%
Gas		19	10	9	15	9	10	13	11	10		3%
Non-Fuel		156	139	120	76	62	55	53	49	27		7%
Total		6423	4782	3711	1253	697	663	586	498	397	585	100%

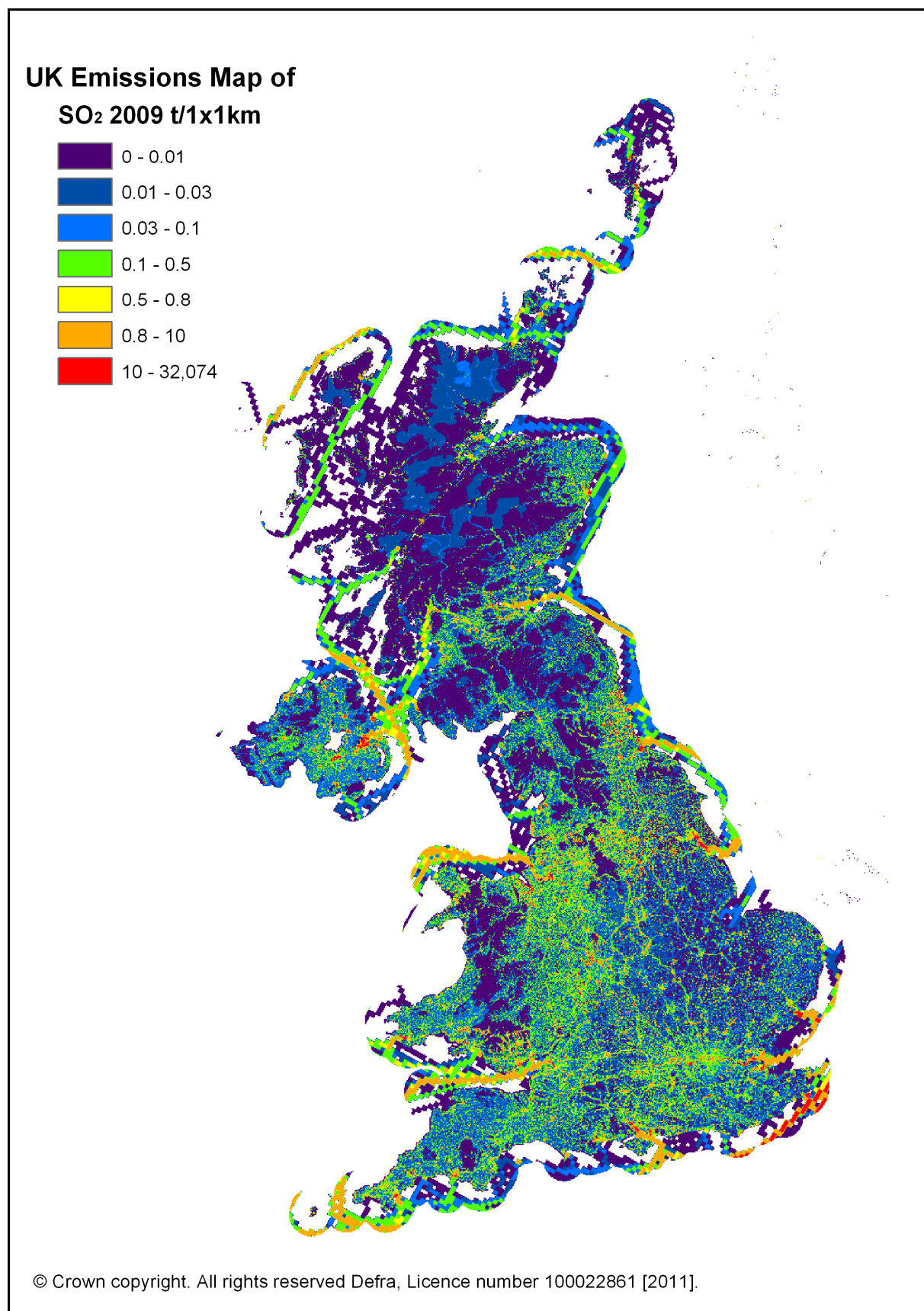
¹ UK emissions reported in IPCC format (MacCarthy et al, 2011) differ slightly due to the different source categories used.

² See Annex 1 for definition of UNECE Categories

³ Total emissions value shown for 2010 is the ceiling set under the NECD

The geographical distribution of SO₂ emissions is shown in Figure 2-26. A large fraction (around 80%) of the SO₂ emissions are concentrated into relatively few 1x1 km grid squares containing the major point sources such as refineries and power stations and large industrial plant. These are difficult to see and therefore the resulting map highlights the main conurbations. High emissions in Plymouth and Newport result from a combination of shipping and industry. London and Birmingham, which are covered by Smoke Control Areas, show relatively low SO₂ emission levels. High emission densities are noted in Belfast where there is substantial consumption of solid fuels in the domestic sector for heating.

Figure 2-26 Spatially Disaggregated UK Emissions of Sulphur Dioxide



2.11.2 Power Generation

The largest contribution to SO₂ emissions is from power stations, which accounts for 40% of the total in 2009. Historically coal combustion has been the most important source; the sulphur content of the coal being directly proportional to the emission estimate. Since 1970 there has been a gradual decline in power station emission. This reflects the changes in fuel mix and in the types of power plant, which have taken place during the period. From 1970 to 1990 the reduction was due to a gradual increase in the use of nuclear plant and improvements in efficiency. Since 1990, this decline has accelerated because of the increase in the proportion of electricity generated in nuclear plants and the use of Combined Cycle Gas Turbine (CCGT) stations and other gas fired plants. CCGTs are more efficient than conventional coal and oil stations and have negligible SO₂ emissions. It is expected that these reductions will continue in the near future as more CCGT stations are built. The use of flue gas desulphurisation plants at coal-fired plants has also reduced emissions from this sector.

2.11.3 Industry

Emissions of SO₂ from industry result from the combustion of coal and oil, some refinery processes and the production of sulphuric acid and other chemicals. Between 1970 and 2009 emissions from industrial combustion sources have fallen by 96% though most of the fall took place between 1970-1985 reflecting the decline in the energy intensive iron and steel industry and other heavy industries. There has been also been a decline in the use of coal and oil in favour of natural gas.

2.11.4 Transport

Road transport emissions account for less than 1% of the total SO₂ emissions. Between 1970 and the early 1990s, road transport emissions grew with the increase in road vehicles. However more recently emissions have declined with the reduction in the sulphur content of DERV. Similarly the reduction in sulphur content of gas oil is reflected in the emissions from off-road vehicles.

2.11.5 Other

Emissions from the remaining categories are low compared with those discussed above. Emissions from domestic and other commercial/institutional sectors have declined substantially during the period 1970-2009, reflecting the major changes in fuel mix from oil and coal to gas. The decrease in emissions from waste reflects the closure of a number of old incinerators due to the introduction of new emission standards and their replacement with modern equipment.

3 Heavy Metals

3.1 INTRODUCTION

This section includes pollutants that are controlled under the Heavy Metals Protocol of the UNECE under the Convention on Long-range Transboundary Air Pollution- Heavy Metals.

3.1.1 UNECE Heavy Metals Protocol

The Convention on Long-range Transboundary Air Pollution was signed in 1979 and entered into force in 1983. Since its entry into force, the Convention has been extended by a number of protocols, including the 1998 Protocol on Heavy Metals. This Protocol is given in outline below; more information may be found at the UNECE web site, located at: www.unece.org/env/lrtap/. The UK has signed this protocol.

The UNECE Protocol on Heavy Metals targets three particularly harmful elements: lead, cadmium and mercury. Countries are obliged to reduce their emissions of these three metals below their levels in 1990 (or an alternative year between 1985 and 1995). The protocol aims to cut emissions from, industrial sources (iron and steel industry, non-ferrous metal industry), combustion processes (power generation, road transport) and waste incineration.

The protocol specifies limit values for emissions from stationary sources and requires best available technique (BAT) for obtaining emission reductions from these sources, such as filters or scrubbers for combustion sources or mercury-free processes. The protocol also required countries to phase out leaded petrol.

Under the protocol, measures are introduced to lower heavy metal emissions from other products e.g. mercury in batteries, and examples are given of management measures for other mercury-containing products, such as electrical components (thermostats, switches), measuring devices (thermometers, manometers, barometers), fluorescent lamps, dental amalgam, pesticides and paint.

Further metals may be added to the protocol, and further measures may be introduced for lead (Pb), cadmium (Cd) and mercury (Hg), depending on the development of the scientific basis for action.

Effects of heavy metals are evident on humans and animals. Of these, the most important effects are deterioration of the immune system, the metabolic system and the nervous system. They can lead to disturbances in behaviour and some heavy metals are suspected to be or have been proven to be carcinogenic.

The impact of heavy metals on the environment due to long-range transport can be summarised as:

1. Impact on aquatic ecosystems. Atmospheric deposition of metals may influence the quality of surface waters and ground water. In addition to the effects on the uses of

- water (e.g. restricted use of water for human consumption, livestock, recreation etc) accumulation in aquatic organisms may have adverse effects on the food web.
2. Impact on terrestrial systems. Metal uptake by plants is a key route for the entry of metals into the food chain. Contaminants may be toxic to plants and can alter the structure or diversity of a habitat. When plants accumulate metals, these can be ingested by animals, creating the potential for toxic effects at higher trophic levels.
 3. Mesofauna and macrofauna. The accumulation of cadmium and lead in birds and mammals in remote areas is attributable to long range atmospheric transport.
 4. Agricultural products. Airborne heavy metals account for significant fractions of the total heavy metal input to arable soils.

Major environmental problems due to long range transport have been reported, relating to:

- Accumulation of Pb, Cd and Hg in forest top soils, implying disturbed nutrient recirculation in forest ecosystems and increased stress on tree vitality in central Europe, reinforced by the acidification of soils
- Highly increased content of Hg in fish from lakes, especially in Scandinavia.

The NAEI reports emissions of thirteen metals. The estimated emissions of these in 2009 are shown in Table 3.1 below.

Table 3.1 Total UK Emissions of Heavy Metals in 2009

Pollutant (Heavy metals)	Total 2009 UK emission (tonnes)
Arsenic	13
Beryllium	5
Cadmium	2
Chromium	26
Copper	52
Lead	60
Manganese	33
Mercury	7
Nickel	83
Selenium	31
Tin	33
Vanadium	477
Zinc	339

Emissions inventories for all of the above except beryllium, manganese, selenium, tin, and vanadium were reported by Leech (1993), Gillham *et al* (1994) and Couling *et al* (1994) and every year since the 1996 NAEI. Emission estimates for beryllium, manganese, and tin were reported for the first time in the 2000 version of the NAEI (Goodwin *et al* 2002).

Heavy metal emissions arise from a number of different sources, but in general fuel combustion and certain industrial processes that produce dust are the main contributors. The emissions arise from trace concentrations in the fuels or in the case of industrial processes, the raw materials. In the case of combustion, metals are emitted either as vapour or particulate matter or both. Volatile metals such as mercury and selenium are mostly emitted as vapour. Metals such as cadmium and lead are emitted as both with some of the vapour condensing

onto the ash particles. Other metals such as chromium do not vaporise and may be emitted in the ash particles.

Emission estimates for combustion sources are generally based on emission factors developed from fuel composition data, applied to fuel consumption statistics (DECC 2010). Emission estimates for industrial processes are generally based on data taken from the pollution inventories of UK environmental regulators or they are based on the use of emission factors and activity data taken from the literature. The methodology for industrial process emissions was last reviewed in 2002 (Passant *et al*, 2002a) and numerous changes were made.

UK data is used for the metal contents of coal and fuel oils where available. Emissions from the combustion of liquid fuels are based on data reported by Wood (1996) and other sources in the literature (Sullivan, 1991; Lloyds 1995). The emissions from coal and oil fired power stations are based on estimates reported in the environmental regulator pollution inventories (Environment Agency 2010; SEPA 2010; NIEA 2010) or within operator annual reports. Emissions from other coal combustion sources follow the PARCOM methodology (van der Most, 1992) but use data based on UK coal (Smith, 1987). Many of the emission factors for industrial processes such as iron & steel, primary lead/zinc manufacture, secondary copper and cement manufacture are based on data given in the Pollution Inventory, although literature-based emission factors are also used (sources include Clayton *et al*, (1991), EMEP/CORINAIR(1996), van der Most (1992), Jockel and Hartje (1991), and Smyllie (1996). Details of the methodology are given in Passant *et al*, (2002a). Emissions from the chloralkali industry are based on manufacturers estimates (Ratcliffe, 1999).

Heavy metal emissions can be reduced using gas cleaning equipment, which removes particulates from waste gases. This abatement equipment can be fitted to large coal-fired industrial boilers and power station boilers and also industrial processes which produce large amounts of dust. Hence, when estimating emission factors it is often necessary to assume some efficiency of abatement.

The majority of the emission factors used in generating emission estimates is based on the mass of metal emitted per unit mass of fuel burnt, or mass of metal emitted per unit mass of product for processes. These emission factors are assumed not to vary with time for many of the sources considered. This is assumed as there is usually insufficient information to estimate any temporal variation of the emission factor. However, for sources such as road transport, chlorine production, waste incineration and public power generation, there is sufficient information to allow time dependent emission factors to be estimated.

At the end of 1996 all municipal solid waste and clinical incinerators had to comply with new emission standards (see also Section 5.2.1.3). As a result, a number of old incinerators have closed, whilst some have been renovated and some new ones opened. Hence there have been significant reductions in emissions from waste incineration. Data is available for most metals from new plants (Environment Agency, 2010).

In 1984 the UK miners' strike led to a significant decrease in the use of coal for combustion in electricity generation, industry and the domestic sector. During this period there was an increased use of petroleum products. This fuel switching had a significant impact on the emissions of numerous pollutants, which can be seen in the following time series plots.

3.2 ARSENIC

Acute exposure to high levels of arsenic via the inhalation of dust or fumes leads to gastrointestinal effects such as nausea, diarrhoea and abdominal pain. Chronic inhalation exposure to inorganic arsenic is associated with irritation of the mucous membranes as well as being strongly associated with lung cancer.

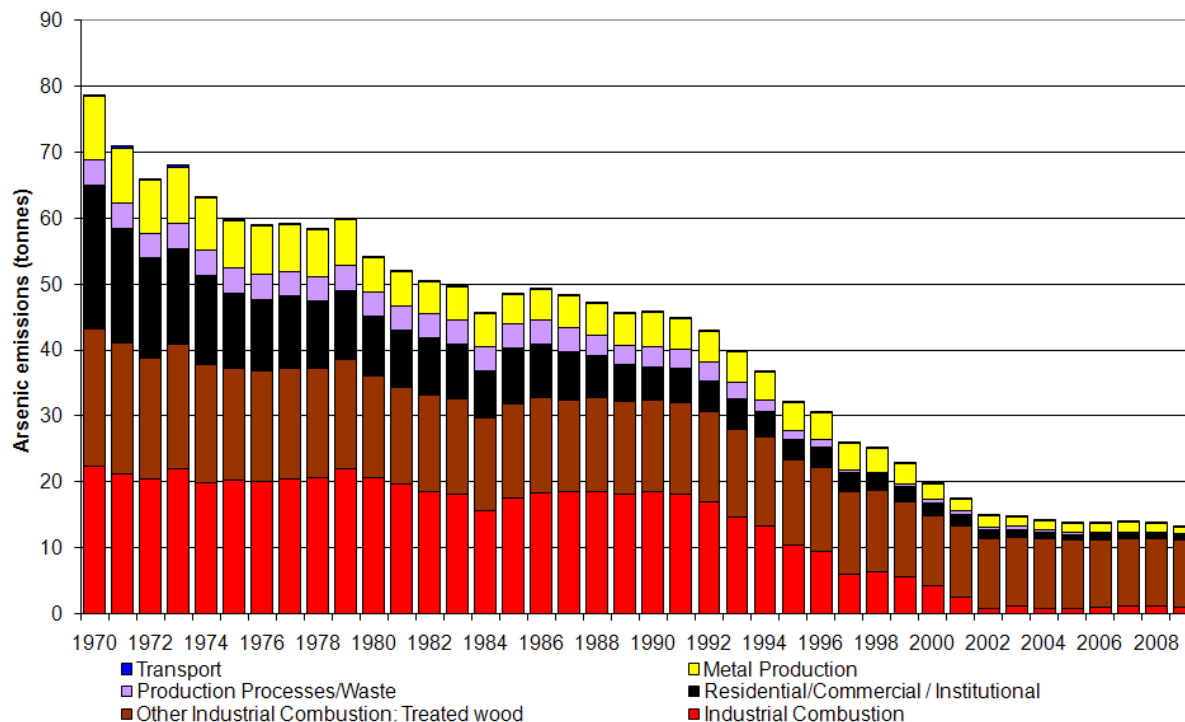
Table 3.2 and Figure 3-1 summarise the UK emissions of arsenic. Emissions have declined by 71% since 1990. Historically the largest source of emissions was coal combustion with other sources being very small by comparison. However, coal use has declined over time, in favour of natural gas use and emissions from the industrial sector are typically now greater than emissions from public power generation. As coal combustion has declined, the use of “CCA” treated wood (the preservative contains copper, chromium and arsenic) as fuel in the industrial sector has become increasingly important- to the extent that it is now the most significant component of arsenic emissions. The emissions from this source are particularly uncertain because the amount of treated wood used as a fuel source is not well characterised.

Table 3.2 UK Emissions of Arsenic by aggregated UNECE Category and Fuel (tonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹											
Public Electricity and Heat Production	1A1a	18.2	19.2	18.2	4.1	0.6	0.9	1.0	0.9	0.8	6%
Other Stationary Industrial Combustion	1A1b-c	2.8	1.2	0.3	0.1	0.1	0.1	0.2	0.1	0.1	1%
Iron and Steel	1A2a	1.3	0.3	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0%
Other Industrial Combustion: Treated wood	1A2f	20.9	15.3	13.9	10.7	10.4	10.3	10.2	10.2	10.2	77%
Transport	1A3ai(i)-1A3aii(i)\1A3b\1A3c\1A3dii\1A4bii\1A5b	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0%
Residential / Commercial / Institutional	1A4ai\1A4bi\1A4c	21.9	9.1	5.1	1.9	0.9	0.8	0.8	0.9	0.9	7%
Production Processes/Waste	1B1-2B\6	3.8	3.7	3.0	0.5	0.3	0.2	0.1	0.1	0.1	1%
Metal Production	2C	9.7	5.3	5.3	2.3	1.3	1.4	1.5	1.4	1.0	8%
BY FUEL											
Solid		54.3	38.3	31.7	15.3	10.8	11.0	11.0	11.2	11.1	84%
Petroleum		7.9	4.3	2.8	0.7	0.6	0.6	0.6	0.5	0.5	3%
Gases		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Non Fuel		16.5	11.5	11.4	3.8	2.3	2.2	2.3	2.1	1.7	13%
Total		78.8	54.2	45.9	19.7	13.8	13.8	13.9	13.8	13.2	

¹ See Annex 1 for definition of UNECE Categories

Figure 3-1 Time Series of Arsenic Emissions (tonnes)



3.3 BERYLLIUM

Acute inhalation exposure to high levels of beryllium can lead to inflammation of the lungs. Long-term exposure can cause chronic beryllium disease where non-cancerous lesions form in the lungs. Studies also suggest that inhalation can lead to an increased risk of lung cancer.

Table 3.3 summarises the UK emissions of beryllium. Estimates have only been included since the 2000 NAEI report, as a result of the figures being very uncertain. Since 2000, emissions of beryllium have declined by 23%. Emission factors have been calculated for the combustion of coal and heavy liquid fuels, but emission factors are not available for many industrial processes, with the exception of iron & steel manufacture and a few other processes, where emission estimates have been based on data given in the Pollution Inventory.

Table 3.3 UK Emissions of Beryllium by aggregated UNECE Category and Fuel (tonnes)

	NFR Codes	2000	2005	2006	2007	2008	2009	2009%
BY UNECE CATEGORY¹								
Combustion in Energy and Transformation Industry	1A1	0.7	0.6	0.5	0.5	0.5	0.4	8%
Combustion in Manufacturing Industry	1A2	0.6	0.6	0.6	0.6	0.6	0.5	9%
Passenger cars	1A3bi	0.6	0.9	0.9	1.0	1.0	1.1	20%
Light duty vehicles	1A3bii	0.5	0.6	0.6	0.7	0.7	0.6	12%
Heavy duty vehicles	1A3biii	1.2	1.3	1.3	1.3	1.3	1.2	22%
Other Transport	1A3c-eii, 1A4bii, 1A4cii, 1A5b	0.4	0.4	0.4	0.4	0.4	0.4	7%
Residential/Commercial/Institutional/ Agriculture Combustion	1A4a, bi, ci, ciii	2.8	1.0	0.9	1.0	1.1	1.1	20%
Production Processes/Waste	1B1b, 2, 6	0.2	0.2	0.1	0.1	0.2	0.1	2%
By FUEL TYPE								
Solid		3.2	1.3	1.2	1.3	1.3	1.3	25%
Petroleum		3.7	4.3	4.2	4.3	4.2	4.0	74%
Gas		0.0	0.0	0.0	0.0	0.0	0.0	0%
Non-Fuel		0.0	0.1	0.1	0.1	0.1	0.1	1%
TOTAL		7.0	5.7	5.5	5.7	5.6	5.4	100%

¹ See Annex 1 for definition of UNECE Categories

3.4 CADMIUM

Effects of acute inhalation exposure to cadmium consist mainly of effects on the lung, such as pulmonary irritation. Chronic effects via inhalation can cause a build-up of cadmium in the kidneys that can lead to kidney disease.

Table 3.4 and Figure 3-2 summarise the UK emissions of cadmium. Emissions have declined by 90% since 1990. The main sources are energy production, non-ferrous metal production and iron and steel manufacture (as well as other forms of industrial combustion). The emissions from energy production include a significant proportion from waste combustion and fuel oil combustion for electricity generation. Emissions from non-ferrous metal activities have declined across the time-series, primarily due to the closure of a lead-zinc smelting plant in 2003 and a secondary copper processing facility in 1999. In 2009, emissions of cadmium are evident from three lead battery recycling plants.

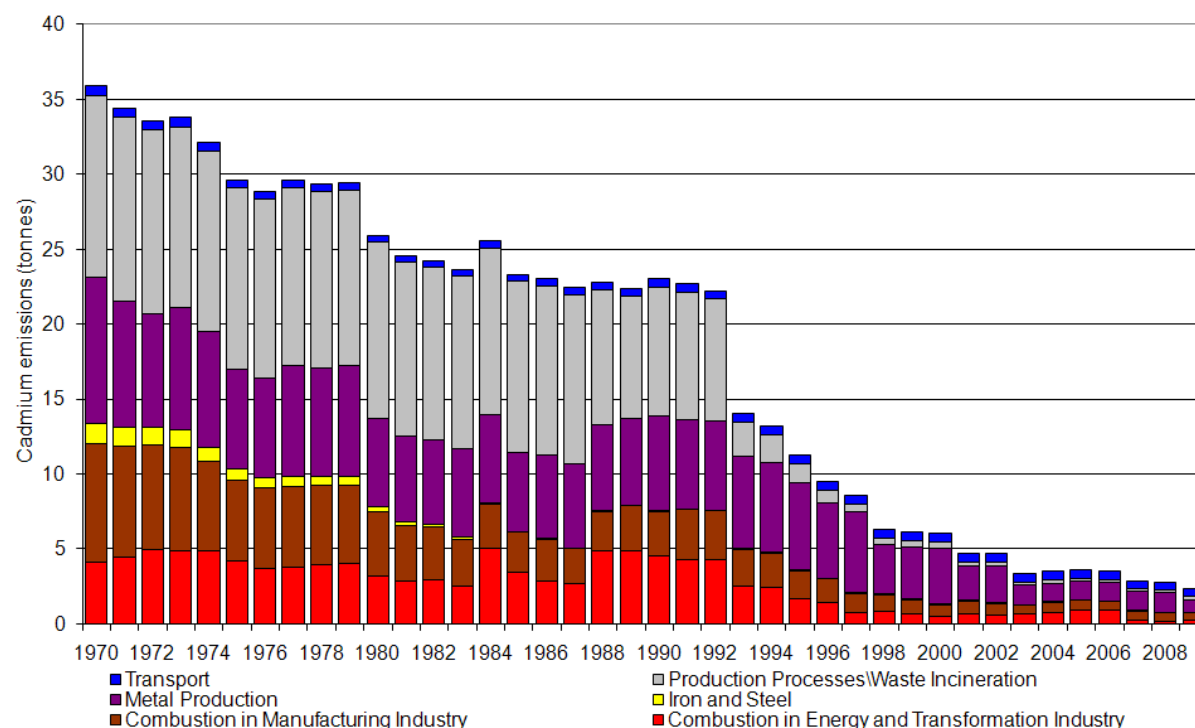
The overall decline in UK cadmium emissions is a result of the general fall in coal combustion and the decline in fuel oil combustion in power generation. The large reduction observed from waste emissions is due to improved controls on Municipal Solid Waste (MSW) incinerators from 1993 onwards and their re-classification upon conversion to power generating plants.

Table 3.4 UK Emissions of Cadmium by aggregated UNECE Category and Fuel (tonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹											
Public Electricity and Heat Production	1A1a	4.0	3.1	4.5	0.5	0.9	0.9	0.2	0.1	0.2	8%
Other Stationary Combustion	1A1b-c, 1A4a, 1A4bi, 1A4ci(iii)	2.7	1.3	1.4	0.3	0.2	0.2	0.3	0.3	0.3	11%
Iron and Steel	1A2a	1.4	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.0	2%
Other industrial combustion	1A2f	5.5	3.2	1.6	0.5	0.5	0.4	0.4	0.3	0.3	13%
Road Transport	1A3b	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	17%
Other Transport	1A3ai(i), 1A3aii(i), 1A3c, 1A3dii, 1A3eii, 1A4bii, 1A4cii, 1A5b	0.4	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	5%
Production Processes/Waste	1B1b, 2A7, 2B5, 6C	12.1	11.8	8.6	0.4	0.2	0.2	0.2	0.2	0.2	9%
Metal Production	2C	9.8	5.9	6.3	3.8	1.2	1.2	1.2	1.3	0.8	36%
By FUEL TYPE											
Solid		3.1	2.5	2.1	0.6	0.8	0.8	0.3	0.3	0.3	13%
Petroleum		10.8	5.6	3.4	1.2	1.2	1.1	1.0	0.9	0.8	36%
Gas		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Non-Fuel		22.2	17.9	17.5	4.3	1.6	1.6	1.6	1.6	1.2	52%
Total		36.0	26.0	23.1	6.0	3.6	3.5	2.8	2.8	2.3	100%

¹ See Annex 1 for definition of UNECE Categories

Figure 3-2 Time Series of Cadmium Emissions (tonnes)



3.5 CHROMIUM

Inhaled chromium is a carcinogen, leading to an increased risk of lung cancer. Acute exposure effects can result in shortness of breath, coughing and wheezing, whilst chronic exposure effects lead to perforation and ulceration of the septum, bronchitis, pneumonia, and decreased pulmonary function.

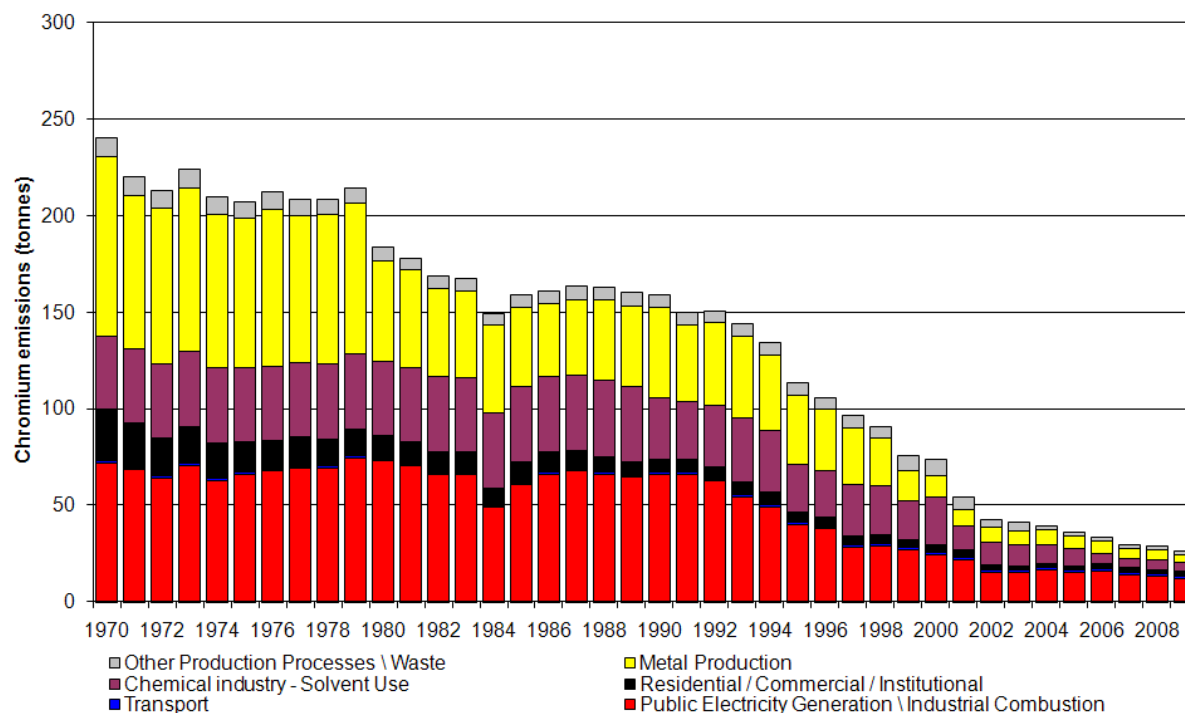
Table 3.5a and Figure 3-3 summarise the UK emissions of chromium. Emissions have fallen by 84% since 1990. The largest sources are various forms of coal combustion, iron and steel production in integrated works and in electric arc furnaces and the production of chromium-based chemicals. More recently as other process emissions have decreased, the emissions from burning “CCA” treated wood in industry as a fuel have become a relatively more important source.

Table 3.5a UK Emissions of Chromium by aggregated UNECE Category and Fuel (tonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009%
BY UNECE CATEGORY¹											
Public Electricity and Heat Production	1A1a	50.3	57.5	53.0	13.7	4.6	4.8	2.9	2.3	1.7	6%
Industrial Combustion	1A1b-c	0.9	0.7	0.3	0.2	0.2	0.2	0.3	0.3	0.2	1%
Iron and Steel	1A2a	2.0	0.5	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0%
Other Industrial Combustion: Treated wood	1A2f	18.6	14.3	12.5	10.5	10.2	10.9	10.9	10.5	10.1	39%
Transport	1A3ai(i),1A3aii(i),1A3b,1A3c,1A3dii,1A4bii,1A4cii,1A5b	1.0	0.9	1.1	1.2	1.3	1.3	1.2	1.2	1.1	4%
Residential/Commercial/Institutional/Agriculture Combustion	1A4ai,1A4bi,1A4ci(iii)	26.7	12.3	6.4	3.7	2.1	2.1	2.2	2.4	2.3	9%
Gas Mains Leakage	2B5	38.2	38.6	32.4	24.6	8.9	5.3	4.7	4.8	4.8	18%
Metal Production	2C	92.7	51.9	46.4	11.4	6.7	6.4	5.0	5.2	3.6	14%
Other Production Processes/Waste	1B1b, 2A7, 6C	9.9	6.9	6.8	8.6	2.2	2.2	2.2	2.4	2.1	8%
By FUEL TYPE											
Solid		85.2	77.8	67.8	25.3	14.6	15.1	12.9	12.7	12.2	47%
Petroleum		12.8	6.8	4.0	2.7	1.9	1.7	1.6	1.6	1.4	5%
Gas		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Non-Fuel		142.4	98.8	87.2	46.0	19.7	16.4	15.0	14.8	12.4	48%
Total		240.3	183.5	159.1	74.0	36.2	33.3	29.5	29.1	26.1	100%

¹ See Annex 1 for definition of UNECE Categories

Figure 3-3 Time Series of Chromium Emissions (tonnes)



3.5.1 Speciation of Chromium

Chromium may be emitted to air in two oxidised forms - hexavalent (Cr^{6+}) and trivalent (Cr^{3+}). The proportion of each form emitted by each source has been estimated and the overall split between the two forms is shown in Table 3.5b.

Table 3.5b Speciated Emissions of Chromium (tonnes)

BY aggregated UNECE CATEGORY ¹	NFR Codes	Cr3+	Cr6+	Total (2009)
Combustion in Energy and Transformation Industry	1A1	1.7	0.2	1.9
Combustion in Manufacturing Industry	1A2, 1A4ci(iii)	9.2	1.0	10.2
Combustion in Residential/Institutional/Commercial/Agriculture	1A4a, 1A4bi	2.1	0.2	2.3
Production Processes	1B1b, 2	8.5	1.9	10.3
Road Transport	1A3b	0.8	0.2	1.0
Off-road Vehicles and Other Machinery	1A3ai(i)-1A3aii(i), 1A3c-1A3cii, 1A4bii, 1A4cii, 1A5b	0.1	0.0	0.1
Waste Incineration	6	0.1	0.0	0.1
TOTAL		22.5	3.6	26.1

¹ See Annex 1 for definition of UNECE Categories

The profiles used for the speciation are based on the recommendations given in Passant *et al* (2002a). In general, these profiles are subject to great uncertainty and further measurement data are required, particularly for major sources such as coal combustion, glass production, electric arc furnaces and chemical processes (other than chromium chemicals for which good data are available).

3.6 COPPER

Acute effects of copper fumes can lead to irritation of the eyes, nose and throat, resulting in coughing, wheezing and nosebleeds. It may also cause 'metal fume fever', which is a flu-like illness that has symptoms of a metallic taste, fever, chill, aches and chest tightness. Chronic exposure may lead to decreased fertility in both men and women. Severe irritation and ulcers in the nose may also occur.

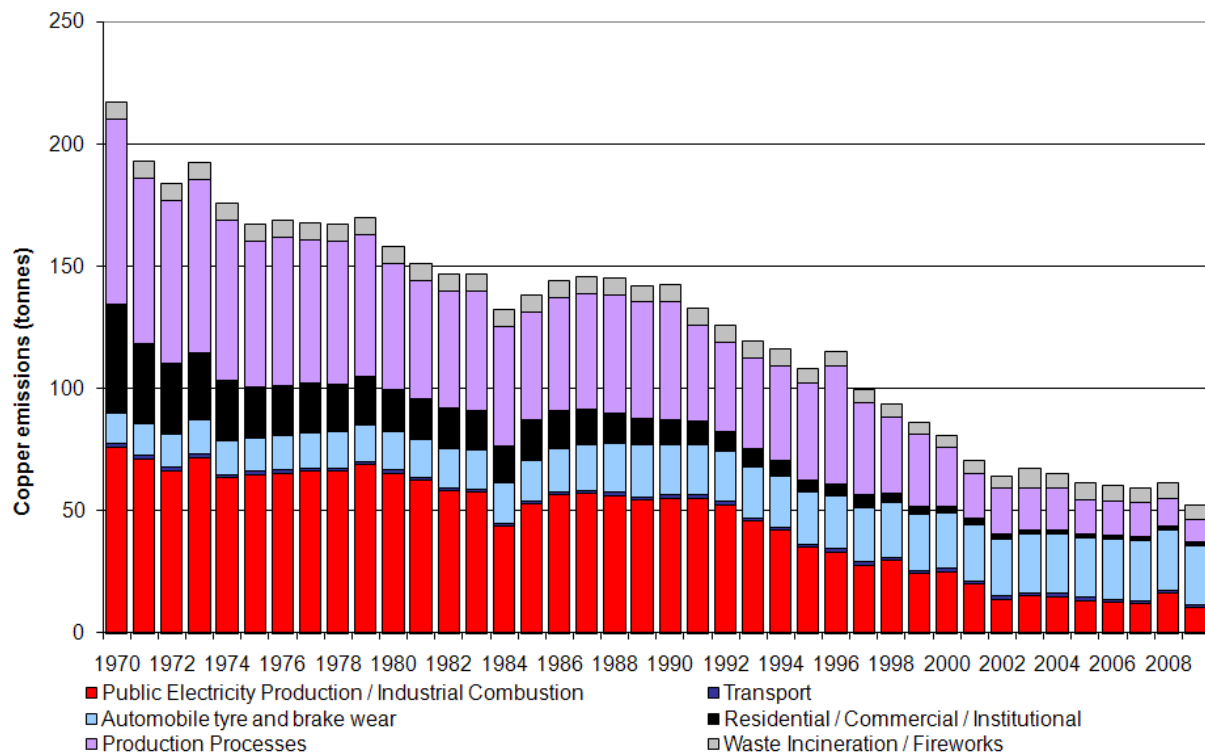
Table 3.6 and Figure 3-4 summarise the UK emissions of copper. Emissions have declined by 63% since 1990. The main sources are from tyre and brake wear, metal production, combustion of lubricants in industry and coal combustion. Emissions have declined over the period due to the decline in metal production, for example steel production and production of castings, and declines in coal combustion and to a lesser extent the combustion of heavy fuel oil in public electricity and heat production.

Table 3.6 UK Emissions of Copper by aggregated UNECE Category and Fuel (tonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009%
BY UNECE CATEGORY¹											
Public Electricity and Heat Production	1A1a	39.3	44.5	41.2	13.9	3.4	3.4	2.1	2.1	1.9	4%
Industrial Combustion	1A1b-c	11.6	4.5	1.1	0.5	0.7	0.6	0.8	0.5	0.4	1%
Iron and Steel	1A2a	2.5	0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0%
Other industrial combustion: Lubricants	1A2f	22.5	15.7	12.7	10.4	8.9	8.4	8.6	13.6	8.0	15%
Transport	1A3ai(i),1A3aii(i),1A3bi-iv),1A3c,1A3dii,1A4bii,1A4cii,1A5b	1.4	1.2	1.4	1.3	1.3	1.3	1.2	1.2	1.1	2%
Automobile tyre and brake wear	1A3bvi	12.4	15.7	20.6	22.8	24.2	24.5	24.8	24.4	24.0	46%
Other Production Processes	1B1b,2A7d,2B5a	3.0	2.8	3.6	4.9	3.0	2.7	2.7	1.8	1.2	2%
Metal Production	2C	72.7	49.1	44.9	18.9	11.3	11.6	11.3	9.6	7.8	15%
Waste Incineration/Fireworks	6, 7	7.0	7.0	6.8	5.2	6.6	6.3	5.9	6.5	6.0	12%
Residential / Commercial / Institutional/Agriculture Combustion	1A4ai,1A4bi,1A4ci(ii)	44.9	17.1	9.8	2.8	1.7	1.5	1.5	1.6	1.7	3%
By FUEL TYPE											
Solid		99.3	68.9	56.0	20.7	9.5	9.6	8.3	13.8	8.4	16%
Petroleum		17.5	10.4	6.2	4.0	3.6	3.3	3.3	2.9	2.6	5%
Gases		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Non Fuel		100.3	78.7	80.0	56.0	48.0	47.4	47.3	44.5	41.3	79%
Total		217.1	158.1	142.2	80.8	61.1	60.3	59.0	61.2	52.3	100%

¹ See Annex 1 for definition of UNECE Categories

Figure 3-4 Time Series of Copper Emissions (tonnes)



3.7 LEAD

Lead is a very toxic element and can cause a variety of symptoms at low dose levels. Lead dust or fumes can irritate the eyes on contact, as well as causing irritation to the nose and throat on inhalation. Acute exposure can lead to loss of appetite, weight loss, stomach upsets, nausea and muscle cramps. High levels of acute exposure may also cause brain and kidney damage. Chronic exposure can lead to effects on the blood, kidneys, central nervous system and vitamin D metabolism.

Table 3.7 and Figure 3-5 summarises the UK emissions of lead from 1990 to 2009. Emissions have declined by 98% since 1990. The largest source of lead until 1999 was from anti-knock lead additives in petrol. From just before 1990 sales of unleaded petrol increased, particularly as a result of the increased use of cars fitted with three-way catalysts and leaded petrol was then phased out from general sale at the end of 1999. Consequently a decline in emissions from the road transport sector is seen.

Currently major sources of lead are metal production and combustion of lubricants in industry. There has been a significant reduction in emissions from metal production due to declining production, and public electricity and heat production due to improved abatement measures. Emissions have also declined as a result of the decreasing use of coal.

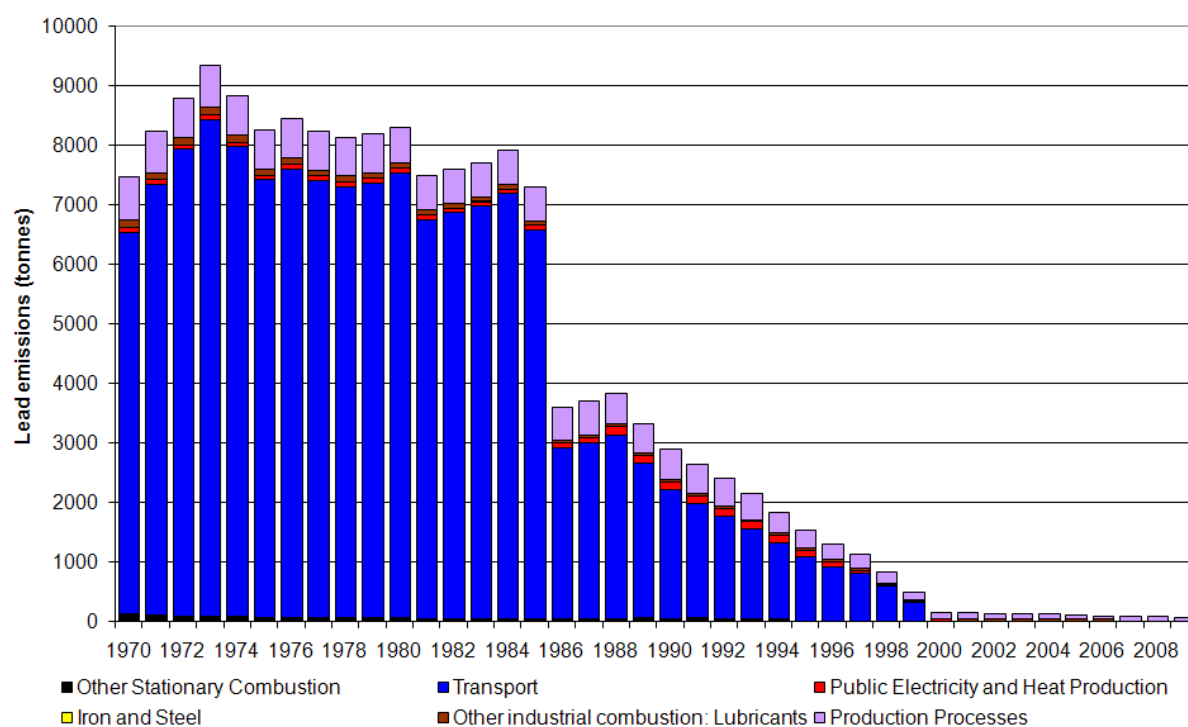
Table 3.7 UK Emissions of Lead by aggregated UNECE Category and Fuel (tonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹											
Public Electricity and Heat Production	1A1a	81.7	88.5	132.4	18.1	12.3	11.1	2.6	2.0	2.2	4%
Other Combustion in Industry	1A1b-c	10.7	4.3	1.2	0.7	1.2	1.2	1.2	1.5	1.3	2%
Iron and Steel	1A2a	4.6	1.3	0.4	0.2	0.1	0.1	0.2	0.2	0.2	0%
Other industrial combustion: Lubricants	1A2f	117.8	82.4	39.1	18.4	17.3	12.3	13.0	12.0	11.7	19%
Residential /Commercial / Institutional/Agriculture Combustion	1A4ai,1A4bi,1A4ci(iii)	109.2	47.2	47.3	9.8	4.7	4.5	4.6	5.1	5.2	9%
Transport	1A3,1A4bii,1A4biii,1A4cii,1A5b	6421.3	7486.1	2155.8	3.3	3.1	3.1	2.7	2.6	2.5	4%
Other Production Processes	1B1b, 2A7, 6C	327.5	321.5	245.4	5.9	3.9	3.6	3.5	3.4	3.1	5%
Chemical industry	2B5	92.2	92.5	93.1	10.6	13.6	3.7	2.8	3.4	3.8	6%
Metal Production	2C	314.2	174.2	175.4	82.5	53.3	49.2	48.9	43.1	30.5	50%
By FUEL TYPE											
Solid ²		216.1	141	108.5	28.8	15.5	15.4	7.9	8.5	8.4	14%
Petroleum		6509	7552	2179	6.5	8.3	6.8	5.7	5.7	5.3	9%
Gas		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Non-Fuel		754.5	604.3	602.4	114.2	85.8	66.6	65.9	59.0	46.8	77%
TOTAL		7479	8298	2890	149.5	109.5	88.7	79.4	73.2	60.4	100%

¹ See Annex 1 for definition of UNECE Categories

² All emissions from MSW combustion are included under solid fuel.

Figure 3-5 Time Series of Lead Emissions (tonnes)



3.8 MANGANESE

Long-term exposure to high levels of manganese can result in effects on the central nervous system such as visual reaction time, hand-eye coordination and hand steadiness. Exposure to higher levels over a long period of time can result in a syndrome known as manganism. This leads to feelings of weakness and lethargy, tremors and psychological disturbances.

Table 3.8 summarises the UK emissions of manganese. Estimates have only been included since the 2000 NAEI report, as the figures remain very uncertain. Emission factors have been calculated for the combustion of coal and heavy liquid fuels, but emission factors are not available for many industrial processes, with the exception of iron & steel manufacture and a few other processes, where emission estimates have been based on data given in the Pollution Inventory.

Table 3.8 UK Emissions of Manganese by aggregated UNECE Category and Fuel (tonnes)

	NFR Codes	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹								
Public Electricity and Heat Production	1A1a	24.2	7.2	6.8	8.3	9.1	7.2	22%
Industrial combustion: Wood	1A2f	10.9	5.2	5.2	5.1	6.9	6.3	19%
Other Combustion	1A1b(c), 1A2a	0.5	0.3	0.5	0.7	0.4	0.3	1%
Road Transport	1A3b	0.6	0.8	0.8	0.8	0.8	0.8	2%
Residential/Commercial/Institutional	1A4ai,bi,ci(iii)	4.4	2.6	2.4	2.4	2.5	2.5	7%
Metal Production	2C	29.8	14.7	14.4	16.1	15.7	13.9	42%
Solid fuel transformation	1B1b	3.1	2.0	2.2	2.2	2.2	1.8	6%
Other Transport	1A3c-dii,1A4bii,1A4cii,1A5b	0.2	0.2	0.2	0.1	0.1	0.1	0%
Waste Incineration	6C	1.1	0.4	0.3	0.3	0.3	0.3	1%
By FUEL TYPE								
Solid		35.4	13.1	14.1	15.5	18.2	15.7	47%
Petroleum		5.7	3.4	2.4	2.7	2.6	2.2	7%
Gas		0.0	0.0	0.0	0.0	0.0	0.0	0%
Non-Fuel		33.7	16.9	16.2	17.7	17.3	15.2	46%
TOTAL		74.8	33.4	32.8	35.9	38.1	33.2	100%

3.9 MERCURY

Acute exposure to high levels of elemental mercury vapour can lead to irritation of the lungs as well as causing coughing, chest pain and shortness of breath. High levels can also result in central nervous system (CNS) effects such as tremors and mood changes. Chronic exposure also leads to CNS disorders, with effects such as increased excitability, excessive shyness and irritability.

Table 3.9a and Figure 3-6 summarises the UK emissions of mercury. Emissions have declined by 81% since 1990. The main sources are from iron and steel production processes, public electricity and heat production, waste incineration, the manufacture of chlorine in mercury cells, coal and other forms of industrial combustion. Emissions have declined as a result of improved controls on mercury cells and their replacement by diaphragm or membrane cells and the decline of coal use. The large reduction in waste emissions is due to improved controls on MSW incinerators from 1997 onwards and their re-classification following their conversion to power generating plant. The 50% increase in emissions of

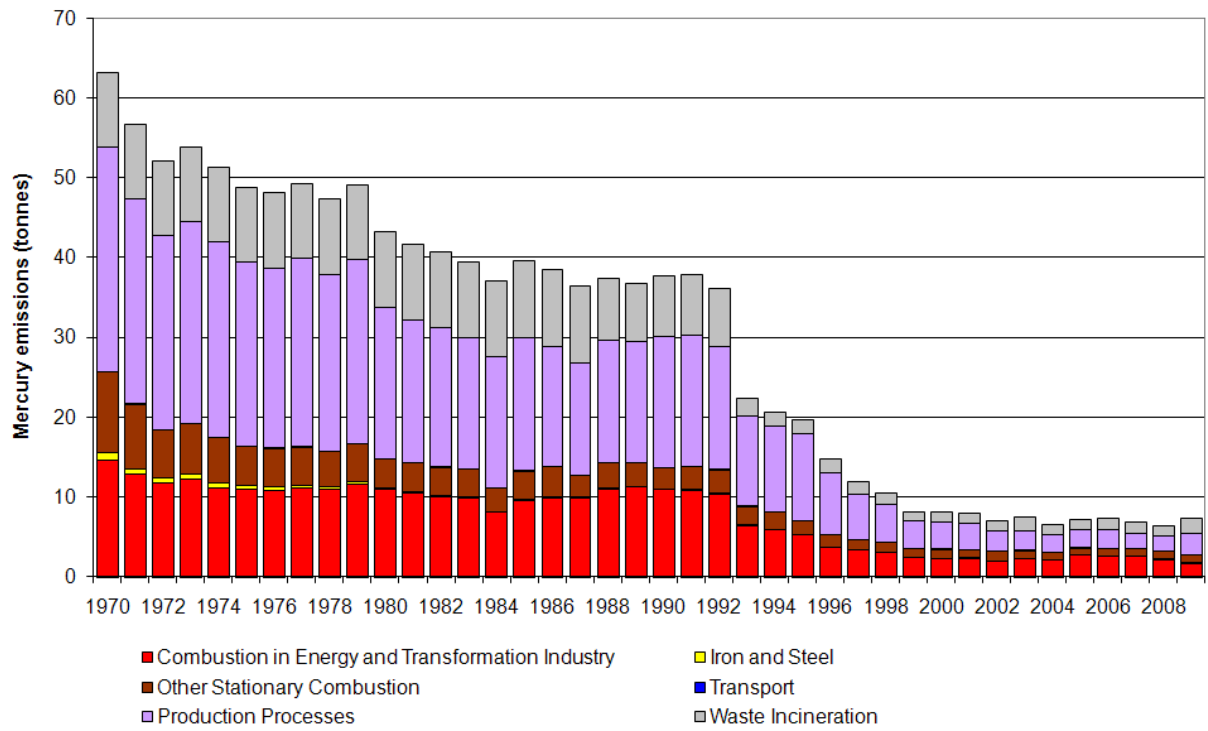
mercury from waste incineration between 2008 and 2009 was caused by a large increase in emissions reported by one incinerator. In 2009, emissions of mercury from electric arc furnaces (NFR Code 2C1) reported to the Pollution Inventory (Environment Agency 2010) increased by over 100%, this is reflected in the observed trend for production processes in Figure 3-6.

Table 3.9a UK Emissions of Mercury by aggregated UNECE Category and Fuel (tonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹											
Public Electricity and Heat Production	1A1a	7.7	8.1	8.8	1.7	2.3	2.3	2.2	1.8	1.3	18%
Stationary Combustion	1A1b-c, 1A4ai, 1A4bi, 1A4ci(iii)	6.9	2.8	2.0	0.5	0.3	0.3	0.3	0.3	0.4	5%
Iron and Steel and other metal production processes	1A2a, 2C	17.7	9.0	8.3	2.0	1.0	1.1	1.1	0.9	1.9	26%
Other Industrial Combustion	1A2f	10.2	3.6	2.7	1.2	0.9	0.9	0.9	1.0	1.0	13%
Transport	1A3b, 1A3ai(i), 1A3aii(i), 1A3c, 1A3dii, 1A3eii, 1A4bii, 1A4cii, 1A5b	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1%
Other Production Processes	1B1b, 2A7d	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0%
Chemical industry	2B5a	11.1	10.1	8.0	1.4	1.1	1.3	0.9	1.0	0.8	11%
Solid Waste Disposal on Land	6A	0.6	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.4	5%
Waste Incineration	6C	8.7	8.8	7.1	0.9	0.9	0.9	0.9	1.0	1.5	21%
By FUEL TYPE											
Solid		24.0	13.7	10.9	2.8	2.9	2.9	2.9	2.7	2.2	30%
Petroleum		1.4	0.8	0.7	0.2	0.2	0.2	0.2	0.2	0.2	3%
Gas		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1%
Non-Fuel		37.6	28.6	26.2	5.1	3.9	4.1	3.6	3.5	4.9	67%
Total		63.1	43.2	37.7	8.1	7.1	7.2	6.7	6.4	7.3	100%

¹ See Annex 1 for definition of UNECE Categories

Figure 3-6 Time Series of Mercury Emissions (tonnes)



3.9.1 Speciation of Mercury Emissions

When mercury is emitted to air it occurs in one of several different forms, and the emissions of each of these forms has been estimated individually.

Three species of mercury have been considered:

- **Hg⁰** unreactive gaseous elemental Hg
- **Hg-p** mercury attached to particulate material
- **RGM** reactive gaseous mercury (includes inorganic and organic forms normally in Hg²⁺ oxidised form)

The methodology for estimating the emissions of each of these three species are similar to that used for speciating the NMVOC emissions. Each source of mercury emission is considered individually. A speciation profile identifying the fractional contribution from each species to the mercury emission from that source is then applied. Summing across the individual sources then allows a total for each of the three species to be evaluated.

Table 3.9b Speciated Emissions of Mercury (tonnes)

BY aggregated UNECE CATEGORY ²	NFR Codes	Hg ⁰	Hg-p	RGM ¹	Total (2009)
Combustion in Energy and Transformation Industry	1A1	0.7	0.1	0.6	1.4
Combustion in Manufacturing Industry	1A2, 1A4ci(iii)	0.6	0.1	0.4	1.0
Combustion in Dom/Inst/Com	1A4a, 1A4bi	0.1	0.0	0.1	0.3
Production Processes	1B1b, 2	2.1	0.1	0.5	2.7
Road Transport	1A3b	0.0	0.0	0.0	0.0
Off-road Vehicles and Other Machinery	1A3ai(i)-1A3aii(i), 1A3c-1A3eii, 1A4bii, 1A4cii, 1A5b	0.0	0.0	0.0	0.0
Waste Incineration	6	0.4	0.0	1.5	1.9
TOTAL		3.9	0.4	3.1	7.3

¹ in table shown as Hg²⁺

² See Annex 1 for definition of UNECE Categories

The profiles used for the speciation are based on the recommendations given in Passant *et al* (2002a). In general, these profiles are subject to great uncertainty and further measurement data are required if this uncertainty is to be reduced, particularly for major sources such as coal combustion, crematoria, clinical waste incinerators, sinter plant, chloralkali processes, and primary lead/zinc production.

3.10 NICKEL

Inhalation of nickel can cause irritation to the nose and sinuses and can also lead to the loss of the sense of smell. Long-term exposure may lead to asthma or other respiratory diseases. Cancer of the lungs, nose and sinuses as well as the larynx and stomach has been attributed to exposure to nickel.

Table 3.10a and Figure 3.7 summarise the UK emissions of nickel. Emissions have declined by 74% since 1990. Currently the main source of nickel emissions is the combustion of heavy fuel oil, however in the past coal combustion was a major source. Emissions from both sources have declined since 1970 in favour of natural gas and are largely responsible for the reduction in total emissions. Between 1989 and 1997, heavy fuel oil was replaced by Orimulsion® (an emulsion of bitumen in water) in some power stations. The nickel content

of Orimulsion® was higher than that of heavy fuel oil and resulted in higher emissions in spite of the flue gas cleaning equipment required on these power stations. Emissions from refineries are important because of the large amount of refinery fuel oil and residues burnt.

Relative to the 2008 NAEI, emissions from national navigation has fallen significantly. This is as a result of the incorporation of new factors for detailed vessel types and shipping movements (Entec, 2010). Emissions from domestic combustion have increased due to a revision in the estimated consumption of petroleum coke in households based on a new data set.

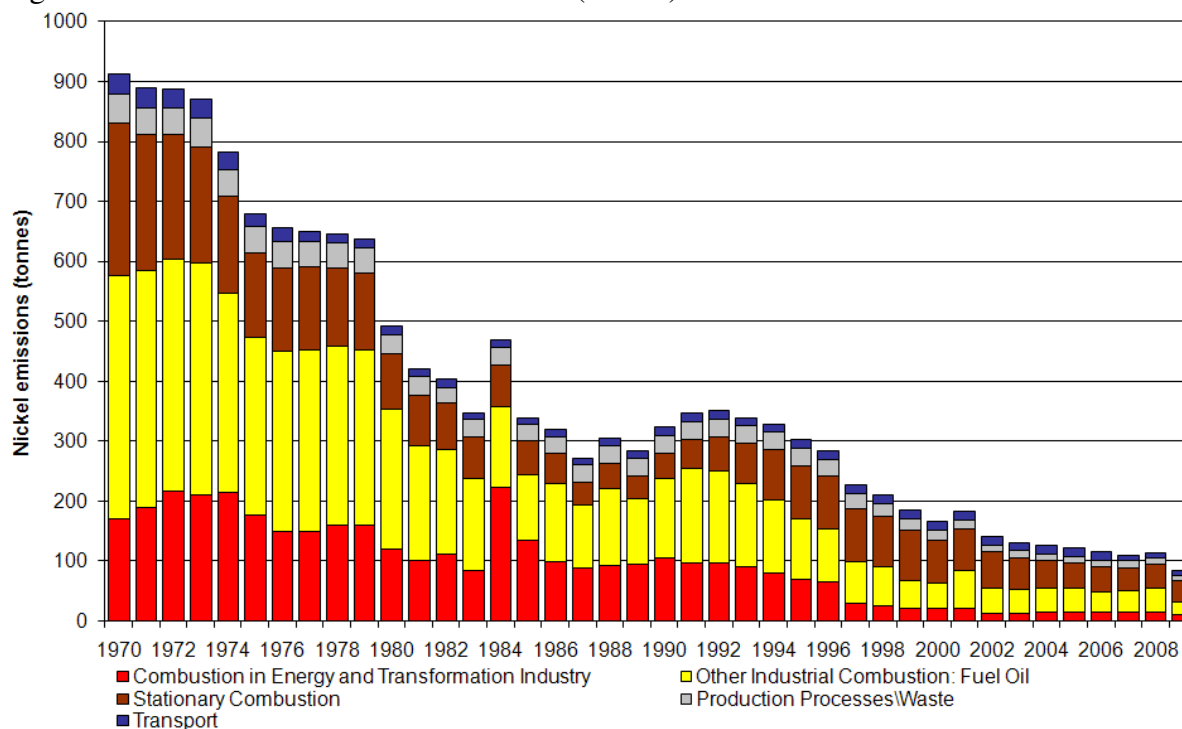
Fuel oil contains high levels of nickel (and vanadium) and so the inventory is sensitive to the consumption of this fuel. For this reason, petroleum refining is a more significant contributor to UK nickel emissions than for most other metals.

Table 3.10a UK Emissions of Nickel by aggregated UNECE Category and Fuel (tonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹											
Public Electricity and Heat Production	1A1a	144.8	96.6	92.5	12.4	5.7	5.8	4.3	4.9	3.0	4%
Petroleum refining	1A1b	22.7	21.7	11.8	7.8	9.2	8.8	11.1	9.8	8.0	10%
Other Stationary Combustion	1A1c	2.1	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0%
Iron and Steel	1A2a	112.7	26.3	3.1	6.9	3.2	2.9	4.0	3.0	3.7	4%
Other Industrial Combustion: Fuel Oil	1A2f	405.9	234.2	133.0	43.4	38.8	33.6	33.7	38.9	20.2	24%
Transport	1A3ai(i), 1A3aii(i),1A3b, 1A3c,1A4bii,1A4cii, 1A5b	4.4	4.9	5.5	5.5	5.6	5.5	5.5	5.3	5.3	6%
National Navigation	1A3dii	29.5	10.4	8.8	8.8	9.1	8.5	3.2	3.1	2.9	3%
Residential /Commercial / Institutional/Agriculture Combustion	1A4ai,1A4bi,1A4ci(iii)	142.7	65.6	38.1	62.9	40.5	38.1	35.3	38.7	33.1	40%
Production Processes/Waste	1B1b, 2, 6	48.0	31.4	30.8	18.5	10.5	12.1	12.1	9.5	7.0	8%
By FUEL TYPE											
Solid		60.2	47.4	46.2	62.6	40.2	38.3	35.5	49.5	31.8	38%
Petroleum		802.1	410.7	244.3	83.3	70.2	62.7	59.7	52.0	42.7	51%
Gas		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Non-Fuel		50.6	33.7	33.2	20.4	12.0	14.3	14.1	11.7	8.6	10%
TOTAL		912.9	491.8	323.8	166.2	122.5	115.3	109.3	113.2	83.1	100%

¹ See Annex 1 for definition of UNECE Categories

Figure 3-7 Time Series of Nickel Emissions (tonnes)



3.10.1 Speciation of Nickel Emissions

Nickel is emitted to air in many different forms, which have been grouped into five 'species' for the NAEI:

- **MN** metallic nickel
- **ON** oxidic nickel compounds such as NiO and Ni₂O₃
- **SolN** soluble nickel salts such as nickel sulphates and nickel chlorides
- **NC** nickel carbonyl, Ni(CO)₄
- **SU** sulphidic nickel compounds e.g. nickel sulphide (NiS) & nickel subsulphide (Ni₃S₂)

The proportion of each form emitted by each source has been estimated and the overall split between the two forms is shown in Table 3.10b

Table 3.10b Speciated Emissions of Nickel 2009 (tonnes)

BY aggregated UNECE CATEGORY ¹	NFR Code	MN	ON	SolN	NC	SU	Total (2009)
Combustion in Energy and Transformation Industry	1A1	0.0	4.3	6.3	0.1	0.3	11.0
Combustion in Manufacturing Industry	1A2, 1A4ci(iii)	0.0	9.5	13.9	0.1	0.7	24.2
Combustion in Dom/Inst/Com	1A4a, 1A4bi	0.0	12.8	18.9	0.2	1.0	32.8
Production Processes	1B1b, 2	1.7	5.1	0.1	0.0	0.0	6.9
Road Transport	1A3b	0.7	0.5	0.7	0.0	0.0	1.9
Off-road Vehicles and Other Machinery	1A3ai(i)-1A3aii(i), 1A3c-1A3eii, 1A4bii, 1A4cii, 1A5b	0.0	2.4	3.6	0.0	0.2	6.2
Waste Incineration	6	0.0	0.0	0.1	0.0	0.0	0.1
TOTAL		2.3	34.6	43.6	0.4	2.3	83.1

¹ See Annex 1 for definition of UNECE Categories

The profiles used for the speciation are based on the recommendations given in Passant *et al* (2002a). In general, these profiles are subject to great uncertainty and better data are desirable, particularly for major sources such as combustion of coal, fuel oil, anthracite, and petroleum coke, and electric arc furnaces. However current measurement techniques are not able to provide much useful data and so significant improvements are not likely in the short term.

3.11 SELENIUM

Acute exposure to selenium by inhalation results in respiratory effects such as irritation to the mucous membranes, severe bronchitis and bronchial pneumonia.

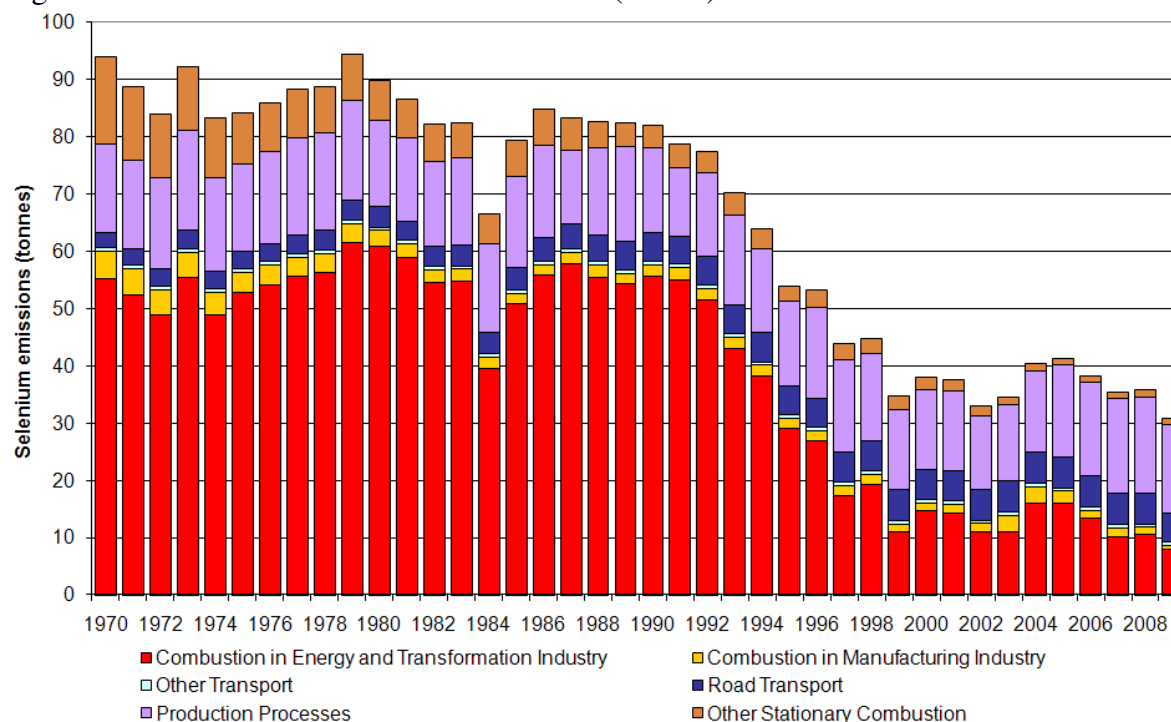
Table 3.11 and Figure 3-8 summarise the UK emissions of selenium. Emissions have declined by 62% since 1990. The main source of selenium emissions in earlier years was coal combustion. Only trace amounts are emitted by the combustion of petroleum based fuels. Glass production and combustion for public electricity and heat production are currently the most significant sources. The estimates for the manufacture of the various types of glass products (flat glass, container glass etc.) are uncertain.

Table 3.11 UK Emissions of Selenium by aggregated UNECE Category and Fuel (tonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009%
BY UNECE CATEGORY¹											
Public Electricity and Heat Production	1A1a	53.0	59.9	55.3	14.3	15.8	13.0	9.6	10.1	7.4	24%
Other Stationary Combustion	1A1b-c, 1A2f, 1A4a, 1A4bi, 1A4ci(iii)	21.4	10.5	6.1	3.7	3.4	2.9	3.2	2.8	2.4	8%
Iron and Steel	1A2a	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Passenger cars	1A3bi	1.8	2.4	3.3	3.5	3.4	3.4	3.4	3.3	3.2	10%
Heavy duty vehicles	1A3biii	0.7	0.8	1.2	1.2	1.3	1.3	1.3	1.3	1.2	4%
Other Transport	1A3ai(i), 1A3aii(ii), 1A3bii(iv), 1A3c, 1A3dii, 1A4bii, 1A4cii, 1A5b	0.9	0.9	1.1	1.2	1.3	1.3	1.4	1.3	1.3	4%
Production of Glass	2A7	11.6	13.7	12.4	11.9	13.8	14.3	14.6	14.9	13.2	43%
Other Production Processes	2B5a, 2C	3.8	1.4	2.5	2.2	2.2	2.1	2.0	2.0	2.2	7%
By FUEL TYPE											
Solid		66.4	65.3	57.7	15.4	16.5	13.1	9.5	9.5	7.1	23%
Petroleum		11.7	9.2	9.0	8.4	8.7	8.7	9.0	9.1	8.2	27%
Gas		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Non-Fuel		15.8	15.5	15.2	14.2	16.1	16.5	17.0	17.2	15.6	50%
Total		93.9	90.0	81.9	38.0	41.3	38.3	35.5	35.8	30.9	100%

¹ See Annex 1 for definition of UNECE Categories

Figure 3-8 Time Series of Selenium Emissions (tonnes)



3.12 TIN

Heavy or prolonged exposure to tin oxide may cause a disease of the lungs called stannosis. Table 3.12 summarises the UK emissions of tin. Estimates have only been included since the 2000 NAEI report and the figures remain very uncertain. Emission factors have been calculated for the combustion of coal and heavy liquid fuels, but no data are available for other potential sources such as industrial processes.

Table 3.12 UK Emissions of Tin by aggregated UNECE Category and Fuel (tonnes)

	NFR Codes	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹								
Public Electricity and Heat Production	1A1a	3.2	3.5	3.9	3.5	3.3	2.7	8%
Other Combustion	1A1b, c-1A2a	17.7	19.6	20.3	20.5	19.4	19.0	59%
Industrial Combustion: Lubricants	1A2f	2.9	2.6	2.3	2.2	1.9	1.6	5%
Road Transport	1A3b	4.7	5.9	6.1	6.4	6.3	6.1	19%
Other Transport	1A3c, 1A3dii, 1A4bii, 1A4cii	0.8	0.8	0.7	0.7	0.7	0.7	2%
Residential/Commercial/Institutional/Agriculture Combustion	1A4a, 1A4b(ii), 1A4ci(iii), 1A5b,1B1b	4.2	2.8	2.7	2.5	2.6	2.3	7%
Metal Production/Waste Incineration	2C, 6Cb	1.2	0.2	0.1	0.1	0.1	0.1	0%
By FUEL TYPE								
Solid	7.7	7.0	6.0	6.2	5.8	5.6	4.8	15%
Petroleum	25.9	26.3	29.0	29.6	29.8	28.4	27.4	84%
Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Non-Fuel	3.8	1.5	0.4	0.3	0.3	0.3	0.3	1%
TOTAL	34.7	34.7	35.3	36.1	35.9	34.3	32.5	100%

¹ See Annex 1 for definition of UNECE Categories

3.13 VANADIUM

Acute exposure to vanadium by inhalation can cause irritation to the respiratory tract. Chronic exposure may lead to pneumonia.

Table 3.13 and Figure 3-9 summarise the UK emissions of vanadium. Emission data are rather scarce so the estimates are very uncertain. Estimates of emissions have declined by 53% since 1990. The major source of emissions is the road transport sector accounting for 53%. Fuel oils accounted for some 45% of the estimated emission in 2009 and the total contribution from petroleum based fuels is 83% of the total vanadium emission. The reduction in emissions with time reflects the decline in the use of fuel oils by the electricity supply industry, industry in general and the domestic sector. Between just before 1990 and 1997, heavy fuel oil was partly replaced by Orimulsion® (an emulsion of bitumen in water) in some power stations (1A1). Emissions from refineries are very important because of the high consumption of heavy fuel oil and residues. The vanadium content of Orimulsion® was higher than that of heavy fuel oil and resulted in higher emissions in spite of the flue gas cleaning equipment required on these power stations. Of the other sources, estimates for the process emissions from the iron and steel industry, which accounted for 0.7% of 2009 emissions, are very uncertain since emissions will depend on the type of steel or alloy produced and its vanadium content. The available emissions data apply only to a generalised steel production process.

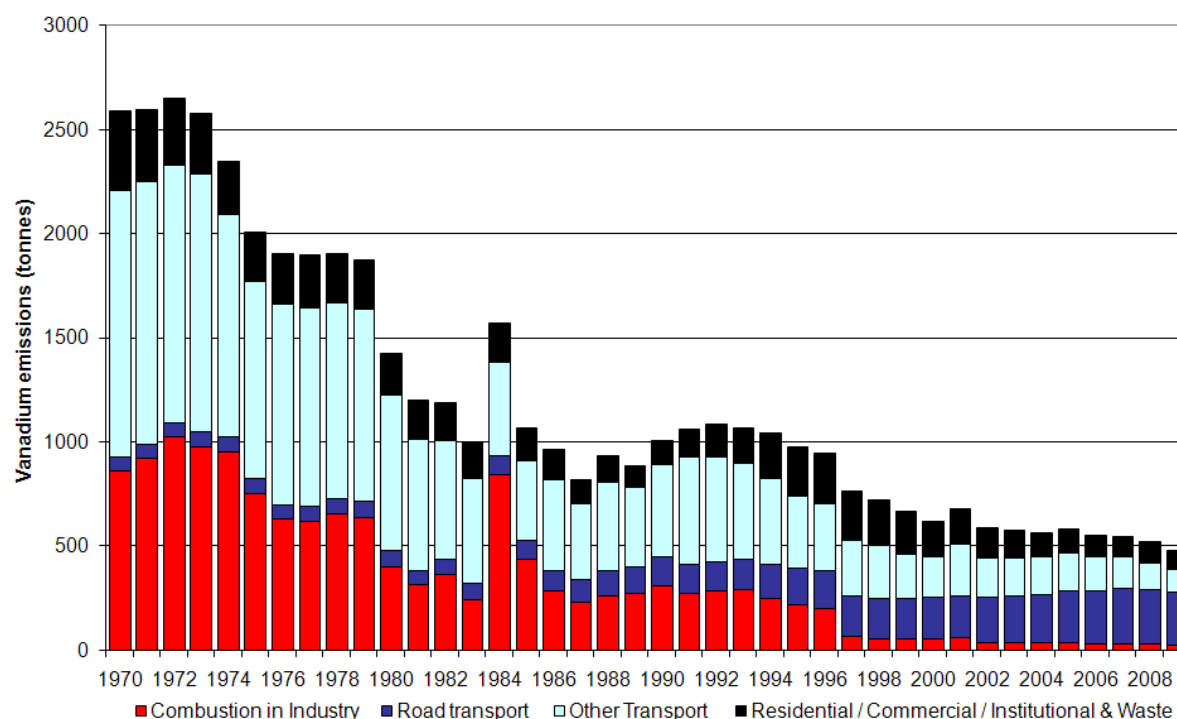
The same reasons as Nickel explain changes in the trend observed for other transport' and 'residential/ commercial/institutional/ agriculture combustion' sectors observed for Vanadium.

Table 3.13 UK Emissions of Vanadium by aggregated UNECE Category and Fuel (tonnes)

BY UNECE CATEGORY ¹	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009 %
Combustion in Industry	1A1, 1A2a	861.0	401.2	310.1	52.9	35.6	29.0	30.2	26.4	25.6	5%
Industrial off-road mobile machinery	1A2f	1170.8	691.1	388.9	140.4	129.9	111.4	111.8	89.0	70.9	15%
Passenger cars	1A3bi	1.6	2.3	12.7	53.2	78.9	84.2	88.8	90.4	93.6	20%
Light duty vehicles	1A3bii	3.2	4.8	12.5	40.7	55.0	57.1	59.8	58.8	57.1	12%
Heavy duty vehicles	1A3biii	59.2	67.4	110.2	104.7	113.0	114.6	118.9	112.6	104.1	22%
Other Transport	1A3c, 1A3di, 1A4bii, 1A4cii, 1A5b	111.6	59.6	56.5	55.1	55.6	53.1	39.6	38.6	38.1	8%
Residential/Commercial/Institutional/Agriculture Combustion	1A4ai, 1A4bi, 1A4ci(iii)	375.4	191.7	107.2	166.0	106.6	99.3	91.4	100.2	84.3	18%
Production processes	2	9.4	4.2	6.9	6.2	4.5	4.7	4.8	4.5	3.4	1%
BY FUEL TYPE											
Solid		861.0	401.2	55.7	149.3	98.0	91.6	83.9	87.2	76.5	16%
Petroleum		64.1	74.5	939.3	461.9	475.8	456.4	455.9	428.3	396.6	83%
Gas		1282.4	750.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Non-Fuel		384.8	195.9	9.9	7.9	5.4	5.4	5.5	5.0	3.9	1%
TOTAL		2592.3	1422.3	1004.9	619.1	579.1	553.4	545.3	520.5	477.0	100%

¹ See Annex 1 for definition of UNECE Categories

Figure 3-9 Time series of Vanadium Emissions (tonnes)



3.14 ZINC

Although zinc metal poses no documented health risks, if its physical state is altered during use then health risks can be created. Inhalation of metallic oxide fumes can lead to metal fume fever.

Table 3.14 and Figure 3-10 summarise the UK emissions of zinc. Emissions of zinc have declined by 77% since 1970. The main sources are metal production and combustion in industry. Emissions arising from road transport are also significant. 26% of total zinc emissions arise due to tyre wear. This arises from the zinc content of the tyre rubber - around 2% ZnO by weight. The reduction in emissions over this period is largely due to the decline in coal combustion and improvements in abatement measures in the iron and steel industry. The large reduction in emissions from MSW incinerators is due to improved emission controls applied from 1997 onwards.

Emissions from stationary combustion in manufacturing industries and construction increased significantly in the 2009 NAEI compared to the 2008 NAEI as a result of a better understanding of the use of lubricants as fuel in recent years.

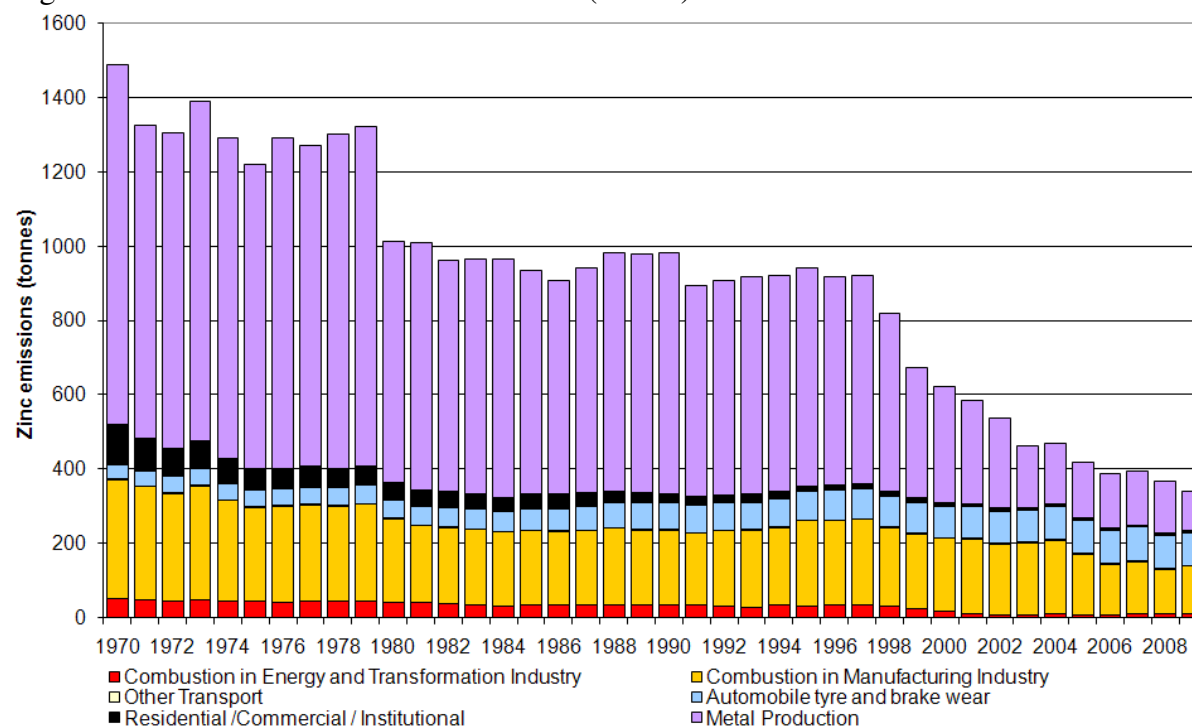
Table 3.14 UK Emissions of Zinc by aggregated UNECE Category and Fuel (tonnes)

	NFR Codes	1970	1980	1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹											
Combustion in Energy and Transformation Industry	1A1	49.2	42.0	33.8	16.7	8.0	7.6	10.0	8.4	8.4	2%
Combustion in Manufacturing Industry	1A2	321.8	223.1	201.6	196.9	163.2	135.6	140.2	121.1	129.0	38%
Residential /Commercial / Institutional/Agriculture	1A4a, 1A4bi, 1A4ci (iii)	108.7	46.1	24.6	10.2	5.3	5.1	5.2	5.7	5.8	2%
Combustion Other Transport ²	1A3ai(i), 1A3aii(ii), 1A3c-1A3dii, 1A4bii, 1A4cii, 1A5b	1.8	1.0	1.0	0.9	1.0	0.9	0.7	0.7	0.7	0%
Road Transport	1A3bi-iv	0.4	0.6	0.8	0.7	0.7	0.7	0.7	0.7	0.6	0%
Automobile tyre and brake wear	1A3bvi	38.8	50.9	72.7	83.2	89.0	90.4	91.6	90.6	88.9	26%
Metal Production	2C	917.3	601.3	617.1	295.7	145.3	141.9	140.5	134.3	100.3	30%
Other Production Processes / Waste	1B1b,2A7,2B5, 6C	50.1	48.0	30.8	18.3	7.2	6.6	7.0	6.2	5.4	2%
By FUEL TYPE											
Solid		182.4	91.0	62.4	23.1	11.4	14.6	14.7	15.0	13.8	4%
Petroleum		42.3	25.4	14.8	9.2	8.7	7.5	7.4	6.8	5.5	2%
Gas		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Non-Fuel		1263	896.6	905.1	590.4	399.6	366.6	373.8	345.9	319.9	94%
TOTAL		1488	1013	982.3	622.8	419.7	388.7	395.9	367.7	339.1	100%

¹ See Annex 1 for definition of UNECE Categories

² Including railways, shipping, naval vessels, military aircraft and off-road sources

Figure 3-10 Times Series of Zinc Emissions (tonnes)



3.15 SPATIAL DISAGGREGATION OF HEAVY METALS

All of the heavy metal emission estimates presented here have been spatially disaggregated with the exception of beryllium, manganese and tin, and UK maps are presented in Figures 3.11-3.20. The key features that are evident from the maps are briefly considered here:

Arsenic

Significant emissions arise from coal combustion, and consequently emissions in Northern Ireland are noted to be relatively high. Individual point sources are also evident.

Cadmium

The major source in 2009 arises from public power generation and industries, but the emissions from this source are not readily visible in a map, so road transport emissions appear the dominant source.

Chromium and copper

The dominant sources of chromium are coal combustion, iron and steel production processes, and chromium-based chemicals manufacture. In the case of copper, the main sources are coal combustion, transport (road transport and off road machinery) and non-ferrous metals production. From the UK emission maps it can be seen that there are a number of point sources, and elevated emissions in Northern Ireland for both of these pollutants.

Lead

A significant contribution of the lead emissions comes from the iron and steel combustion but these point sources are not readily visible on the UK emissions map. Selected motorways are clearly visible from the UK emission map.

Mercury

The major sources of mercury in 2009 were waste incineration, public electricity and heat production and specific industrial activities. As a result the UK emission map highlights a number of point sources. Other emissions are generally located in urban areas.

Nickel

Emissions of nickel are dominated by the combustion of heavy fuel oil. Consequently areas of the country with refinery activities are highlighted. It is also interesting to note that urban areas are not particularly elevated. This is due to the higher use of gas in the domestic sector in areas of higher population density.

Selenium

Emissions of selenium arise from power generation and selected industrial processes as well as road transport. Consequently the UK emissions map displays major point sources, which can be rather difficult to see, as well as highlighting the road network.

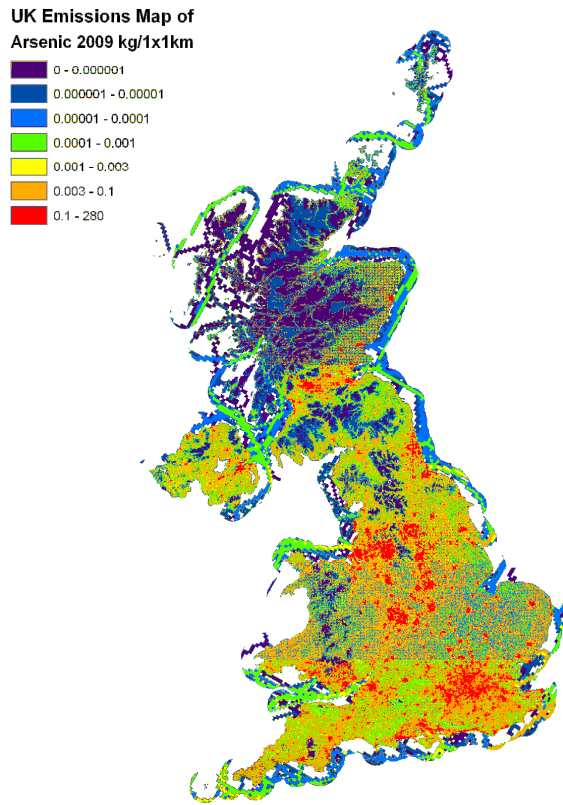
Vanadium

Vanadium emissions primarily arise from road transport, shipping, refineries and the combustion of heavy fuel oil. As a result a large number of point sources may be identified from the emissions map, and the major road network is highlighted. Areas with low population density and domestic coal use are particularly highlighted as having low emissions.

Zinc

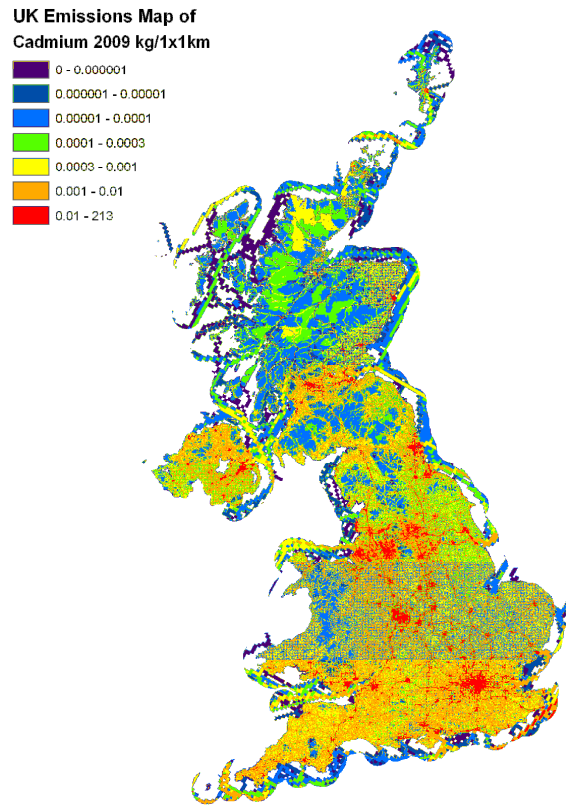
Zinc emissions primarily arise from iron and steel production processes, combustion in industry and road transport (brake and tyre wear). As a result the UK emissions map highlights the road network and a number of point sources. However, the point sources are difficult to see due to the large number of grid cells where emissions are governed by the road transport sector.

Figure 3.11 UK Emissions Map of Arsenic 2009



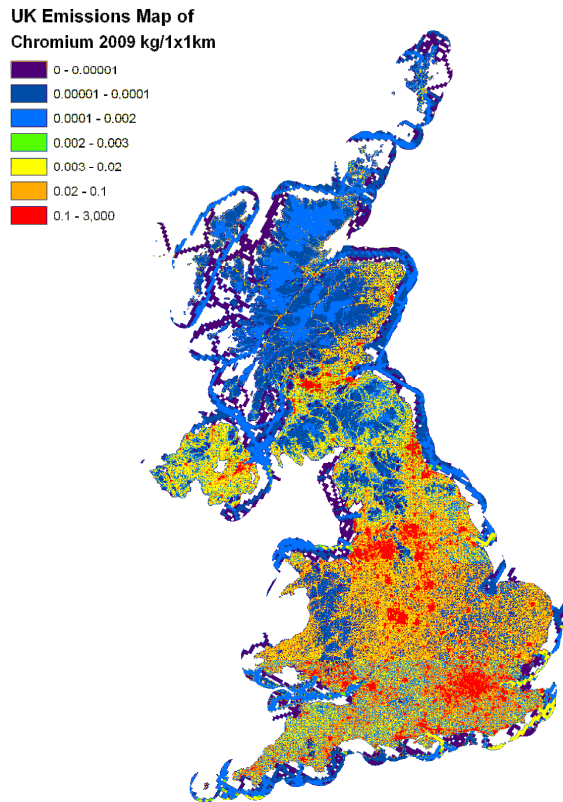
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Figure 3.12 UK Emissions Map of Cadmium 2009



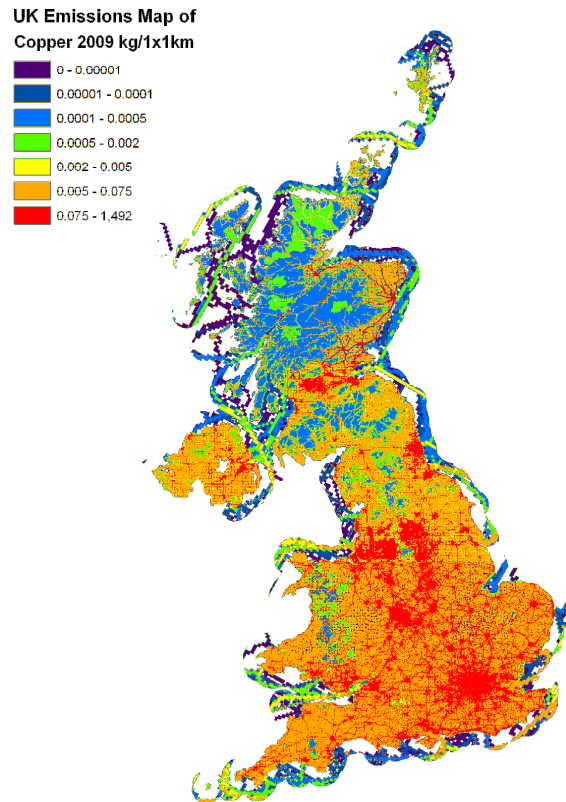
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Figure 3.13 UK Emissions Map of Chromium 2009



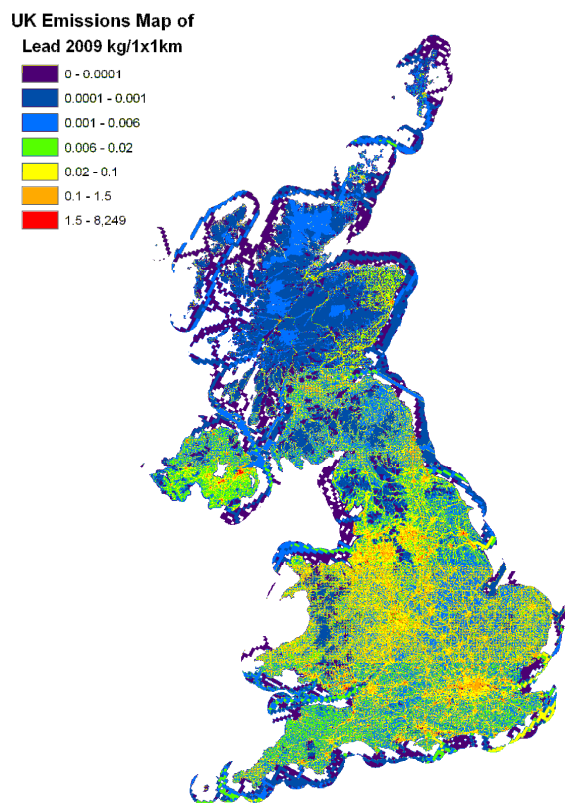
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Figure 3.14 UK Emissions Map of Copper 2009



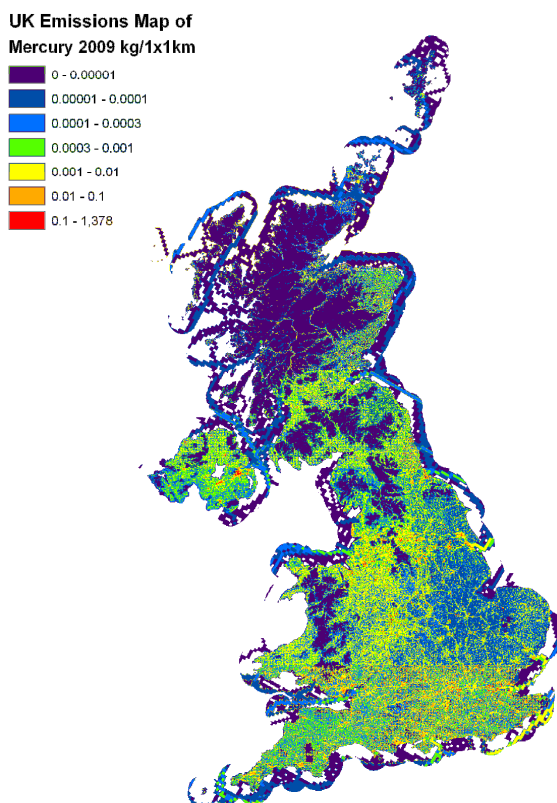
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Figure 3.15 UK Emissions Map of Lead 2009



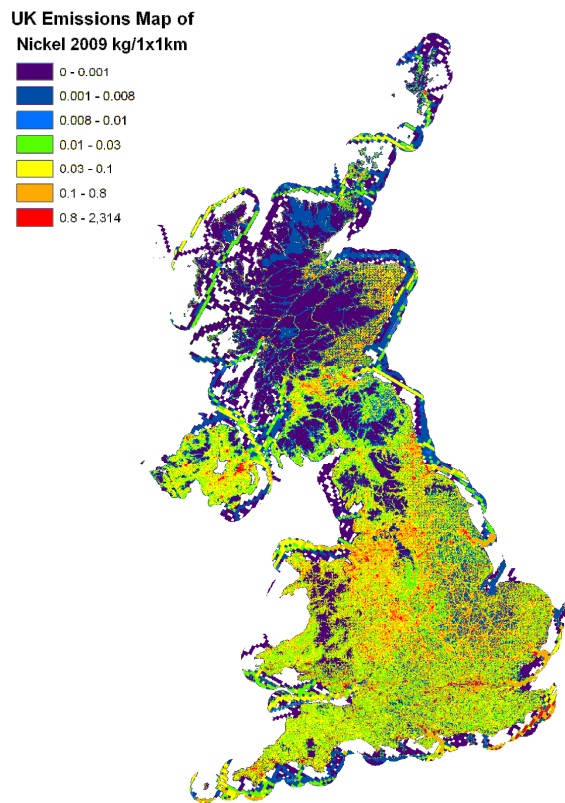
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Figure 3.16 UK Emissions Map of Mercury 2009



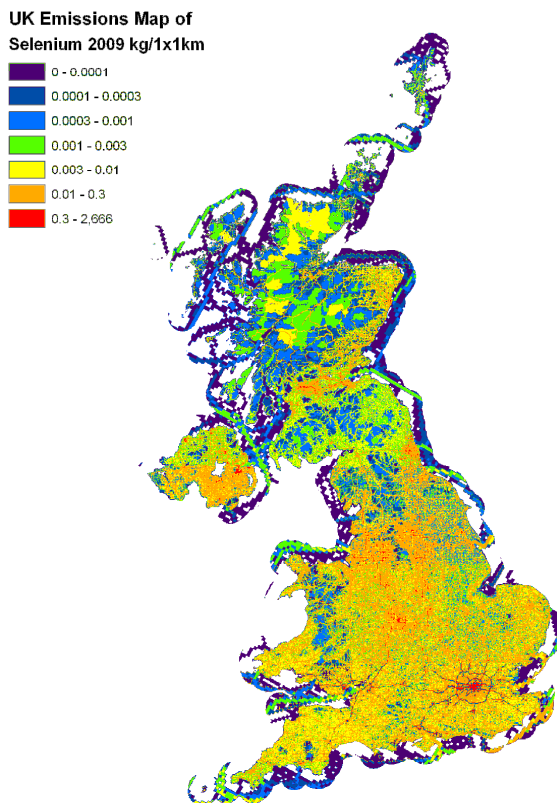
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Figure 3.17 UK Emissions Map of Nickel 2009



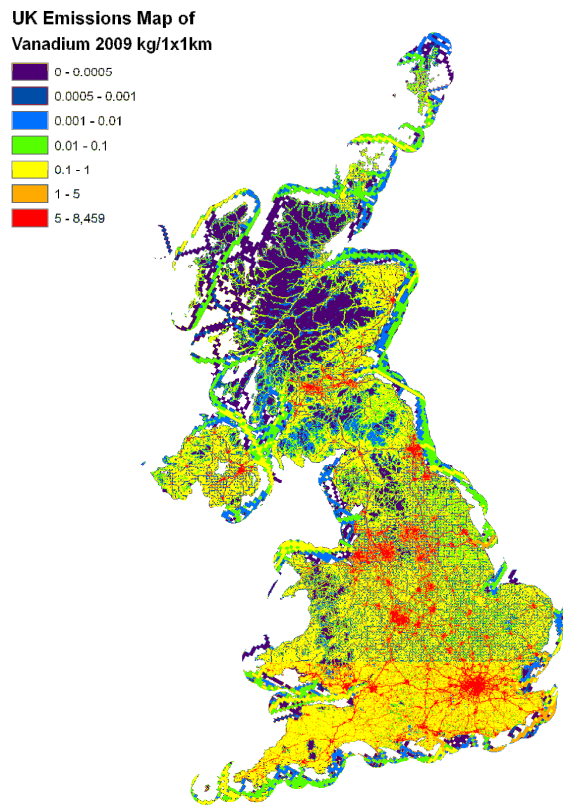
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Figure 3.18 UK Emissions Map of Selenium 2009



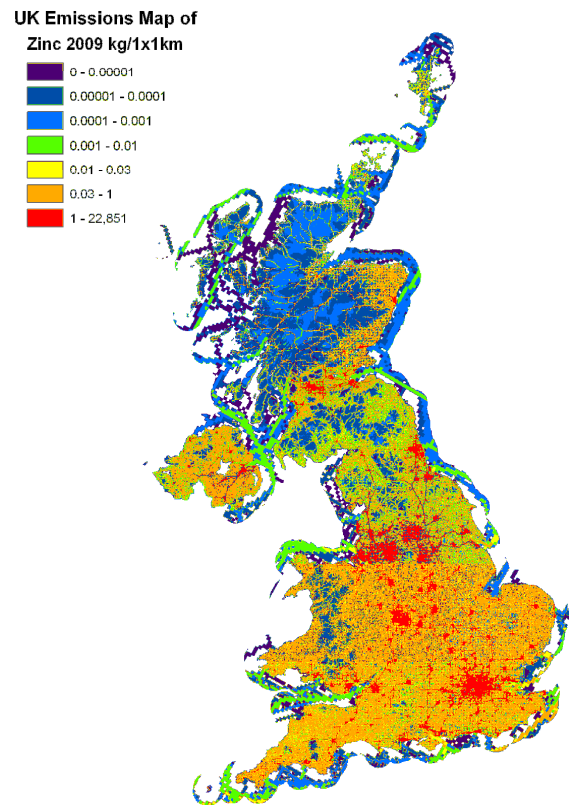
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Figure 3.19 UK Emissions Map of Vanadium 2009



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Figure 3.20 UK Emissions Map of Zinc 2009



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4 Base Cations

4.1 INTRODUCTION

Base cation emission estimates for the UK are presented in this chapter. The emission estimates cover the period 1990-2009 for Calcium (Ca), Magnesium (Mg), Sodium (Na) and Potassium (K). These estimates are highly uncertain.

A base cation is essentially a positively charged ion from group 1 or 2 of the periodic table (the alkali metals or alkaline earth metals). The most environmentally abundant of these are Na, K, Ca and Mg. Base cations are important in the environment for two reasons.

- First, their deposition has an impact on surface soil pH. The deposition of base cations increases the alkalinity of the surface; the effect in the environment is to buffer or neutralise the effects of the acidity generated by S and N deposition (which in their mobile anionic form, SO_4^{2-} and NO_3^- , leach Ca and Mg from the soil). Therefore one of the primary uses of these emission estimates is to use them to generate spatially resolved emission maps, which enable deposition maps to be calculated.
- Secondly, their emissions to air have an impact on atmospheric chemistry. It is important to understand the spatial distribution of emissions so that any impact on atmospheric chemistry, and resulting changes to pollutant transport can be accounted for in atmospheric chemistry and transport models.

4.1.1 Background

A “critical load” approach is often taken to predict the maximum levels of acidity or alkalinity that an ecosystem can tolerate. The base cations (Na^+ , K^+ , Ca^{2+} , Mg^{2+}) are known to be present in ambient air and in precipitation. The deposition of these base cations to ecosystems will offset to some extent the acidification resulting from the deposition of oxides of sulphur, oxides of nitrogen and NH_3 .

The Review Group on Acid Rain (1997) reported on the decline in base cation deposition that has been observed in Europe and North America since the early 1970's and how such a decline may offset some of the benefits of reductions in SO_2 emissions. Interest in the deposition and acid neutralising effects of base cations is mainly confined to Ca, K and Mg. It has long been assumed that the major source of these base cations in air is dust from soil erosion, but patterns of concentrations in air and precipitation also suggest significant emissions from urban and industrial sources. The concentrations of Ca, K and Mg in air and in precipitation measured at three rural sites in the UK declined dramatically between 1970 and 1991 (Lee and Pacyna, 1999). It has been suggested that the decrease in base cation deposition, which has been observed is due to the reduction in emissions from urban and industrial sources. Concentrations of Na in air and rain have shown much smaller decreases over this period, consistent with its mainly marine origin as sea-salt.

The NAEI has estimated emissions from the following sources:

- **Stationary combustion of fossil fuels:** mainly in the fly ash from solid fuel combustion
- **Mineral extraction processes:** e.g. limestone quarrying
- **Processes in the mineral products industry:** e.g. cement manufacture and concrete batching
- **Industrial processes using limestone, dolomite and soda lime:**
 - iron and steel manufacture
 - glass manufacture
- **Agricultural use:** e.g. liming of soils and dust due to cultivation.
- **Construction and demolition activities**
- **Mobile sources:** mostly in the form of dust resuspension by traffic and exhaust emissions of potassium from lead replacement petrol (LRP).

There are likely to be base cation emissions from other sources, for example incineration. Currently, these are not included in the estimates as such sources are likely to be much smaller than the sources listed above, and the levels of uncertainty in estimating the above sources do not yet warrant investigation of other sources. More information on the methodology used to estimate the emissions from the above sources can be found in Murrells et al (2010b).

4.2 CALCIUM

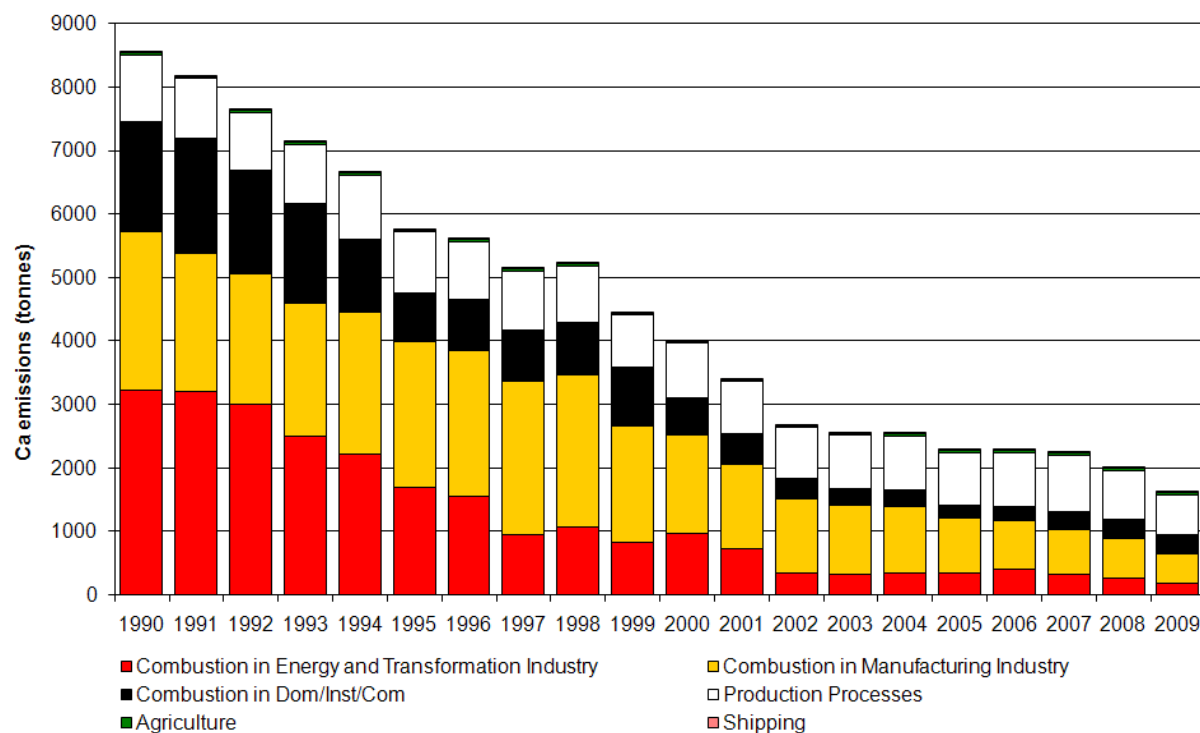
Combustion in industry and production processes contributes the most emissions of calcium. Within the latter sector, quarrying, glass production cement production and lime production are the most significant contributors. However, more recently the introduction of abatement measures has ensured reductions in the emissions.

Table 4.1 UK Emissions of Calcium by aggregated UNECE Source Category (ktonnes)

	NFR Codes	1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹									
Combustion in Energy and Transformation Industry	1A1	3.2	1.0	0.3	0.4	0.3	0.3	0.2	11%
Combustion in Manufacturing Industry	1A2	2.5	1.5	0.9	0.8	0.7	0.6	0.5	29%
Combustion in Dom/Inst/Com	1A4	1.7	0.6	0.2	0.2	0.3	0.3	0.3	18%
Other Production Industry	2A1\2C\2G	0.2	0.2	0.2	0.2	0.2	0.2	0.1	8%
Glass Production	2A7	0.8	0.6	0.7	0.7	0.7	0.6	0.5	31%
Agriculture	4G	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2%
Shipping	1A3dii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
TOTAL		8.5	4.0	2.3	2.3	2.2	2.0	1.6	100%

¹See Annex 1 for definition of UNECE Categories

Figure 4-1 Time Series of Calcium Emissions (tonnes)



4.3 MAGNESIUM

The largest single source of magnesium emissions is from fireworks (29% of total emissions). Emissions from slag cement production are another significant source (12% of total emissions). This emission falls within the production processes sector. Domestic coal burning was responsible for 79 tonnes, and coal burning power stations released 56 tonnes in 2009. These sources account for 15% and 11% of the total emissions respectively.

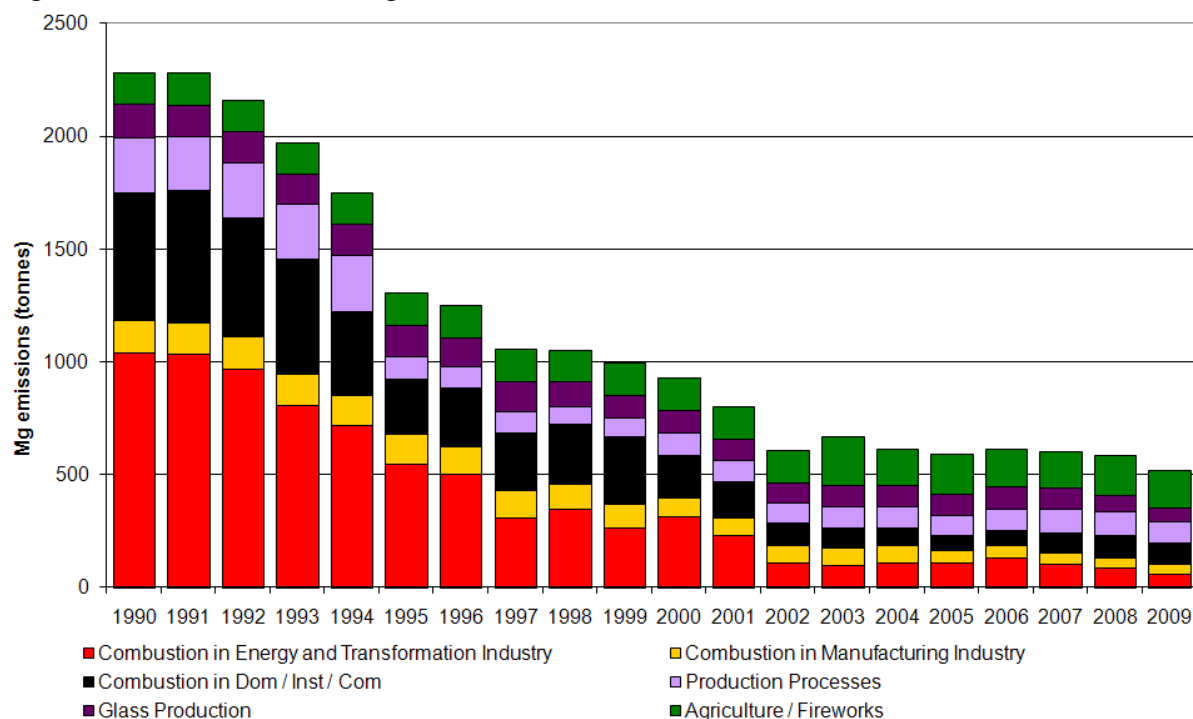
Estimates for slag cement grinding, fireworks and burning of waste lubricants have all been included in the emission estimates.

Table 4.2 UK Emissions of Magnesium by aggregated UNECE Source Category (ktonnes)

	NFR Codes	1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹									
Combustion in Energy and Transformation Industry	1A1	1.0	0.3	0.1	0.1	0.1	0.1	0.1	11%
Combustion in Manufacturing Industry	1A2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	9%
Combustion in Dom/Inst/Com	1A4	0.6	0.2	0.1	0.1	0.1	0.1	0.1	18%
Production Processes	2A1\2C\2G	0.2	0.1	0.1	0.1	0.1	0.1	0.1	18%
Glass Production	2A7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	12%
Agriculture	4G	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2%
Fireworks	7	0.1	0.1	0.2	0.2	0.1	0.2	0.2	29%
TOTAL		2.3	0.9	0.6	0.6	0.6	0.6	0.5	100%

¹ See Annex 1 for definition of UNECE Categories

Figure 4-2 Time Series of Magnesium Emissions (tonnes)



4.4 SODIUM

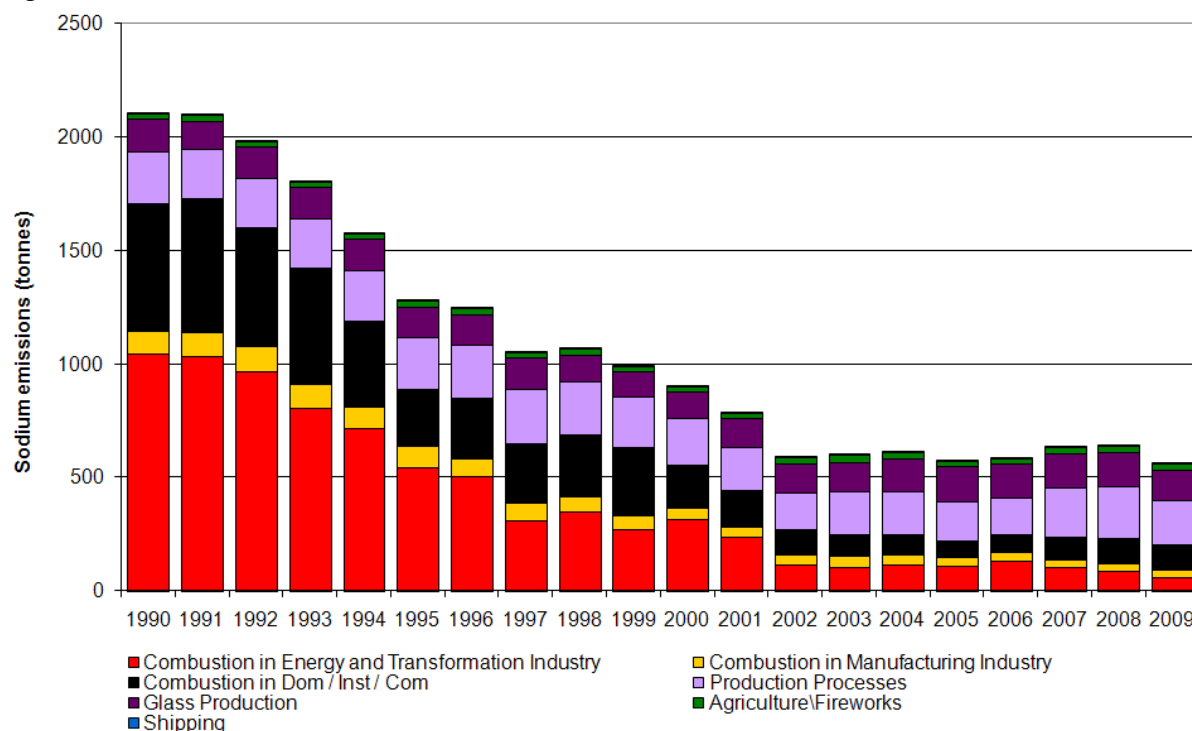
Iron and steel production from sinter plants is responsible for the greatest single emission of sodium with 154 tonnes emitted in 2009 (28% of total emissions). Domestic coal burning emissions contributed 78 tonnes and coal burning power stations 55 tonnes. Other sources include glass manufacture and residential combustion.

Table 4.3 UK Emissions of Sodium by aggregated UNECE Source Category (ktonnes)

	NFR Codes	1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹									
Combustion in Energy and Transformation Industry	1A1	1.0	0.3	0.1	0.1	0.1	0.1	0.1	10%
Combustion in Manufacturing Industry	1A2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	6%
Shipping	1A3dii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Combustion in Dom/Inst/Com	1A4	0.6	0.2	0.1	0.1	0.1	0.1	0.1	19%
Production Processes	2A1\2B5\2C\2G	0.2	0.2	0.2	0.2	0.2	0.2	0.2	36%
Glass Production	2A7	0.1	0.1	0.2	0.1	0.2	0.1	0.1	24%
Agriculture\Fireworks	4G\7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5%
TOTAL		2.1	0.9	0.6	0.6	0.6	0.6	0.6	100%

¹See Annex 1 for definition of UNECE Categories

Figure 4-3 Time Series of Sodium Emissions (tonnes)



4.5 POTASSIUM

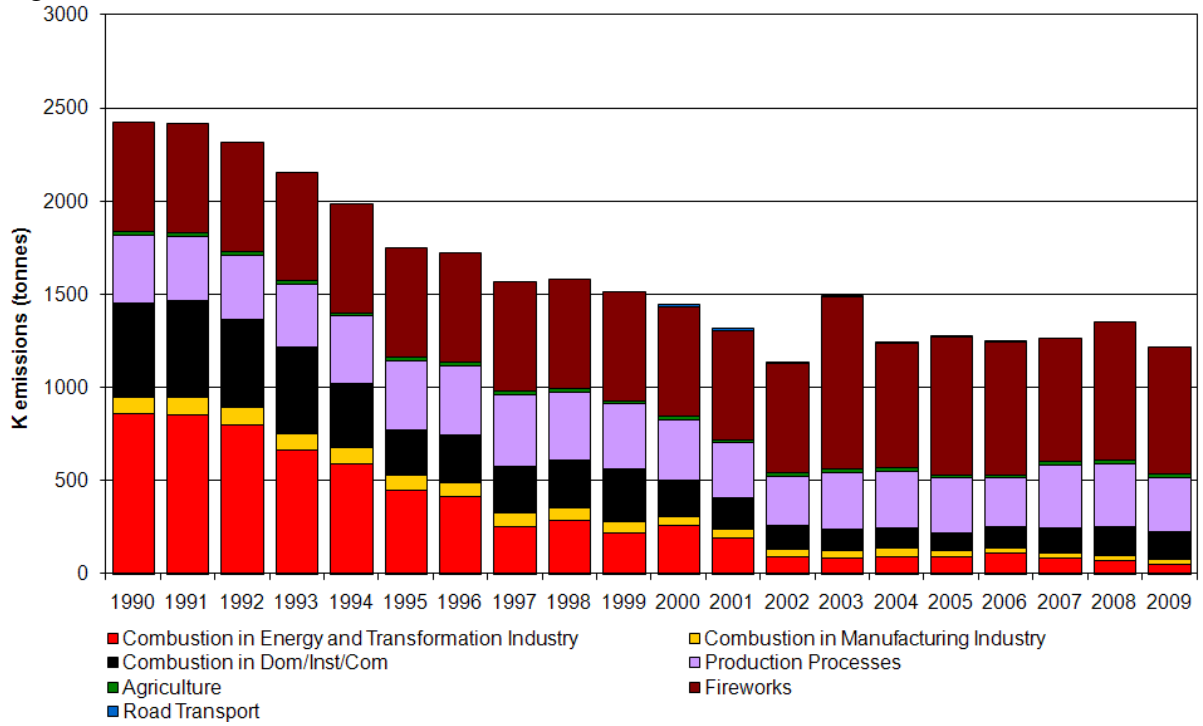
Fireworks are the largest source of potassium emissions, accounting for 681 tonnes in 2009 (56% of the national total). The peak in emissions in 2003 is due to an increase in the use of fireworks. Process emissions from iron and steel production were the second largest source, with emissions of 210 tonnes in 2009. Coal burning in the domestic sector was the third main contributor, causing the emissions of 66 tonnes of potassium.

Table 4.4 UK Emissions of Potassium by aggregated UNECE Source Category (ktonnes)

BY UNECE CATEGORY ¹	NFR Codes	1990	2000	2005	2006	2007	2008	2009	2009 %
Combustion in Energy and Transformation Industry	1A1	0.9	0.3	0.1	0.1	0.1	0.1	0.0	4%
Combustion in Manufacturing Industry	1A2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3%
Road Transport	1A3bi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Combustion in Dom/Inst/Com	1A4	0.5	0.2	0.1	0.1	0.1	0.2	0.1	12%
Production Processes	2	0.4	0.3	0.3	0.3	0.3	0.3	0.3	24%
Agriculture	4G	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2%
Fireworks	7	0.6	0.6	0.7	0.7	0.7	0.7	0.7	56%
TOTAL		2.4	1.4	1.3	1.2	1.3	1.3	1.2	100%

¹ See Annex 1 for definition of UNECE Categories

Figure 4-4 Time Series of Potassium Emissions (tonnes)



5 Persistent Organic Pollutants

5.1 INTRODUCTION

This section includes pollutants controlled under international agreements on Persistent Organic Pollutants (POPs) of the UNECE under the Convention on Long-Range Transboundary Air Pollution (LRTAP) and the UNEP Stockholm Convention on POPs.

5.1.1 International Agreements controlling POPs Releases

The Convention on LRTAP was extended by the Aarhus Protocol on POPs in 1998 which entered into force in 2003. More detail is given below and further information can be found at the UNECE web site, located at: www.unece.org/env/lrtap. The UK ratified this protocol in 2005. Annexes IV and V to the Protocol on POPs are currently under review.

The Aarhus Protocol contains annexes which contain different levels of control for substances deemed to be considered as a POP. Annex I bans substances, Annex II restricts their use, and Annex III limits unintentional releases.

Similarly the Stockholm Convention of 2004 also has annexes (a- banned, b- restricted and c- limit unintentional release). The two conventions are independent of one another but address similar lists of pollutants.

The EU POPs Regulation came into effect when the EU ratified the Stockholm Convention. This requires EU member states to report information to the European Commission. As of May 2009, nine additional POPs were added to the annexes of Stockholm, of which five are already covered by the UNECE Protocol and the EU POPs regulation (Chlordecone, Hexabromobiphenyl, alpha HCH, beta HCH and Lindane). This is likely to require changes to be made to the EU POPs regulation to allow the EU to ratify the amendment to the Stockholm Convention. Pentachlorobenzene, an unintentional POP with similar sources to dioxins and furans was added to annex c of the Stockholm Convention and will require a multi-media release inventory to be developed.

5.1.1.1 Persistent Organic Pollutants (POPs)

POPs are organic compounds that do not readily break down in the environment. Their long lifetime means that they can be transported over long distances, resulting in widespread distribution across the earth, including remote regions. They accumulate in the food chain, and their toxicity poses a threat to humans and the environment.

Over recent years there has been a growing interest in these pollutants and in particular their potential chronic toxicity and impacts on human and ecosystem health. This is reflected by the recent international agreement to reduce releases of these chemicals under the UNECE Persistent Organic Pollutants Protocol (detailed in Section 5.1.1) and their consideration for air quality standards by the Expert Panel on Air Quality Standards (EPAQS).

The UNECE Protocol on Persistent Organic Pollutants aims to control human and environmental exposure to substances that are persistent, bioaccumulative and harmful. It currently addresses a list of 16 substances (or groups of substances), that have been identified according to certain risk criteria. In brief, these 16 pollutants may be classified in three source sectors as follows:

1. **Pesticides:** aldrin, chlordane, chlordecone, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex, toxaphene, hexachlorocyclohexane (HCH, which includes “lindane”);
2. **Industrial Chemicals:** hexabromobiphenyl, polychlorinated biphenyls (PCBs);
3. **By-products or Contaminants:** dioxins, furans, polycyclic aromatic hydrocarbons (PAHs).

The ultimate objective of the protocol is to eliminate any losses, discharges and emissions of POPs to the environment. This is achieved through several different legislative mechanisms. First, the production and use of several compounds is banned (aldrin, chlordane, chlordecone, dieldrin, endrin, hexabromobiphenyl, mirex and toxaphene). Second, several compounds are scheduled for elimination at a later date (DDT, heptachlor, hexachlorobenzene, PCBs). Finally, the protocol severely restricts the use of selected compounds (DDT, HCH- including lindane and PCBs). Limited uses which are thought to be essential and for which there are no adequate substitutes can be exempted. For instance, the use of substances like DDT would be allowed under the protocol for public health emergencies. The protocol includes provisions for dealing with the surplus of products that will be banned.

Under the protocol, countries are also required to reduce their emissions of dioxins, furans, PAHs and HCB below their levels in 1990 (or an alternative year between 1985 and 1995). The protocol requires the best available techniques (BAT) to be applied to cut emissions of these POPs. For the incineration of municipal, hazardous and medical waste, it lays down specific limit values. The protocol allows for the addition of further compounds into control, depending on the development of the scientific basis for such an action.

In 1999, EPAQS (Expert Panel on Air Quality Standards) published a report on PAHs which recommended an Air Quality Standard of 0.25 ng m^{-3} benzo[*a*]pyrene as an annual average. As a result, further work assessing the concentrations of PAHs in the atmosphere has been commissioned by Defra and the results compared with the spatially disaggregated emissions inventory.

In August 2002, PAHs were added to the list of pollutants covered by the Air Quality Strategy for England, Scotland, Wales and Northern Ireland (see Section 2.1.2), and an objective was set relating to attaining an annual average air concentration of 0.25 ng m^{-3} benzo[*a*]pyrene by 2010. This national objective was reiterated in the 2007 revision of the Air Quality Strategy however although further emission reductions are expected projections indicate that there will continue to be exceedences of the objective for PAHs well after 2010 in some urban areas, industrial locations and alongside some busy roads. The fourth Air Quality Daughter Directive (2004/107/EC) sets a target value for benzo[*a*]pyrene concentrations to be achieved by 2012 of 1 ng/m^3 . As a consequence of the national objective and the target value there is a continued drive to decrease PAH emissions from the major sources.

Table 5.1 lists POPs included in the current inventory together with their total UK emissions in 2009. Each of the pollutant classes are considered in more detail in the following sections.

The UK NAEI does not include emission estimates for a number of POPs that have been banned in the UK for several years. Table 5.2 below indicates the years in which the use of particular POPs was banned or their use severely restricted, and whether the listed POPs are included in the NAEI.

Table 5.1 Total UK Emissions of POPs

Pollutant	Total 2009 UK emission	
Persistent organic compounds (POPs)		
• Polycyclic aromatic hydrocarbons (PAHs)	616	tonnes (USEPA16) ¹
• Dioxins and Furans (PCDD/F)	193	grams I-TEQ ²
• Polychlorinated biphenyls (PCBs)	0.906	tonnes
• Pesticides		
- lindane (>99% γ -HCH)	8.67	tonnes
- pentachlorophenol (PCP)	363	tonnes
- hexachlorobenzene (HCB)	0.033	tonnes
• Short Chain Chlorinated Paraffins (SCCPs)	1.3	kg
• Polychlorinated Naphthalenes (PCNs)	NE ³	
• Polybrominated Diphenyl Ethers (PBDEs)	5.4	tonnes

¹ See Table 5.3 for different PAHs included under different groupings.

² TEQ- "Toxic Equivalents" is a way of weighting emissions according to their toxicity. See Table 5.5

³ NE - Not Estimated. It has not been possible to make an emission estimate

Table 5.2 POPs Included/Not Included in the NAEI and Corresponding Year of Ban on Use

Compound or Compound Group	Banned in UK	Included in NAEI
Polycyclic aromatic hydrocarbons (PAHs)	-	Yes
Dioxins and Furans (PCDD/Fs)	-	Yes
Polychlorinated biphenyls (PCBs)	-	Yes
Hexabromobiphenyl	Never Used	No
Pesticides		
γ -Hexachlorocyclohexane (Lindane)	-	Yes
Pentachlorophenol ¹	1995 ²	Yes
Hexachlorobenzene ¹	1975	Yes
Aldrin	1989	No
Chlordane	1992	No
Dichlorodiphenyl-trichloroethane (DDT)	1984	No
Chlordecone	1977	No
Dieldrin	1989	No
Endrin	1984	No
Heptachlor	1981	No
Mirex	Never Used	No
Toxaphene	Never Used	No

¹ Hexachlorobenzene and pentachlorophenol are also emitted from other sources as well as being or having been active ingredients in pesticides.

² Use of pentachlorophenol is severely restricted rather than banned absolutely.

5.2 POLYCYCLIC AROMATIC HYDROCARBONS (PAH)

Polycyclic aromatic hydrocarbons (PAHs) are a large group of chemical compounds with a similar structure comprising two or more joined aromatic carbon rings. Different PAHs vary both in their chemical characteristics and in their environmental sources and they are found in the environment both as gases and associated with particulate material. They may be altered

after absorption into the body into substances that are able to damage the genetic material in cells and initiate the development of cancer, although individual PAHs differ widely in their capacity to damage cells in this way.

The speciated PAH inventory was first compiled for the 1996 emissions inventory (Wenborn *et al*, 1999) and has allowed a more detailed understanding of the PAH emissions in the UK. There have been several pollutant classifications relating to PAHs. Although there are a vast number of PAHs, the NAEI inventory focuses on sixteen. These 16 PAHs have been designated by the USEPA as compounds of interest using a suggested procedure for reporting test measurement results (USEPA, 1988). A subset of this includes six of the PAHs identified by the International Agency for Research on Cancer (IARC) as probable or possible human carcinogens (IARC 1987). In addition, the Borneff 6 PAHs (another subset focussing on the health impacts of the PAHs) have been used in some EC emission inventory compilations. A further subset of PAHs is those to be used as indicators for the purposes of emissions inventories under the UNECE's Persistent Organic Pollutants Protocol. These classifications are given in the following table.

Table 5.3 The USEPA 16 PAH Primary Pollutants, and other PAH Subsets

	Included in the NAEI	USEPA Priority pollutants (16 PAH)	IARC Probable or possible Human carcinogens (6 PAH)	Borneff (6 PAH)	UNECE POPs Protocol Indicators for purpose of emission inventories
Naphthalene	✓	✓			
Acenaphthene	✓	✓			
Acenaphthylene	✓	✓			
Fluorene	✓	✓			
Anthracene	✓	✓			
Phenanthrene	✓	✓			
Fluoranthene	✓	✓		✓	
Pyrene	✓	✓			
Benz[a]anthracene	✓	✓	✓		
Chrysene	✓	✓			
Benzo[b]fluoranthene	✓	✓	✓	✓	✓
Benzo[k]fluoranthene	✓	✓	✓	✓	✓
Benzo[a]pyrene	✓	✓	✓	✓	✓
Dibenz[ah]anthracene	✓	✓	✓		
Indeno[1,2,3-cd]pyrene	✓	✓	✓	✓	✓
Benzo[ghi]perylene	✓	✓		✓	

The main environmental impact of PAHs relates to their health effects, focusing on their carcinogenic properties. The most potent carcinogens of the EPA 16 have been shown to be benzo[a]anthracene, benzo[a]pyrene and dibenz[ah]anthracene (APARG 1996). The semi-volatile property of PAHs makes them highly mobile throughout the environment via deposition and re-volatilisation between air, soil and water bodies. It is possible that a proportion of PAHs released in the UK are deposited in the oceans and/or subject to long-range transport making them a widespread environmental problem.

Emissions of the total amount of the 16 PAHs and benzo[a]pyrene (BaP) are summarised in Table 5.4a and 5.4b. Whilst BaP emissions are included in the 16 PAHs, it is also considered here individually due to its importance.

Aluminium production and anode baking (carried out for the aluminium industry) was the largest source of PAH emissions in the UK until 1995 (contributing nearly half of the total PAH emission). Emissions since then have declined and in 2009 these sources accounted for less than 1% of the total PAH emissions. This is a consequence of the closure of the plant at Kinlochleven and investment in abatement equipment by the aluminium smelter operators following from the authorisation regime implementing the Environmental Protection Act 1990.

Stationary combustion in the residential/ commercial and institutional sectors is currently the largest source of PAH emissions contributing 59% of the emissions in 2009. There have been a number of significant revisions to these emission estimates across the last several years. This is due to the limited availability of data on emission factors and hence the very high uncertainty in the results. The next largest source of emissions in 2009 was from the transport sector (17% of the total emissions).

Overall, emissions of BaP increased slightly between 2007 and 2008 due to increases in throughput at coke works and the amount of domestic coal burned. Emissions declined back down in 2009 but still remain higher than 2007 emission levels.

The most notable trends in the BaP inventory include significantly reduced emissions from some industrial sources and road transport emissions. Further details can be found in Coleman *et al* (2001). Increased measurement of PAHs by both industry and regulators, particularly in the aluminium sector, has allowed improvements in the precision of the emission estimates. However uncertainties associated with the emissions estimates of PAHs are still very high.

The reason for the change in emissions between the 2008NAEI and 2009 NAEI in the case of PAH is the significant work that was carried out during the current compilation cycle to look at PAH emissions from transport.

Table 5.4a UK Emissions of 16 PAHs¹ by aggregated UNECE Source Category (tonnes)

	NFR Codes	1990	2000	2005	2006	2007	2008	2009	2009%
BY UNECE CATEGORY²									
Public Electricity and Heat Production	1A1a	67	35	39	43	39	37	31	5%
Other Industrial Combustion	1A1b-c\1A2	23	18	17	16	16	15	14	2%
Passenger cars	1A3bi	58	92	77	74	71	67	65	11%
Light duty vehicles	1A3bii	21	34	32	31	31	29	27	4%
Heavy duty vehicles - buses and coaches	1A3biii	20	11	8	7	7	6	5	1%
Other Transport	1A3biv\1A3c-1A4cii\1A5b	8	7	7	7	7	7	7	1%
Residential/Commercial / Institutional	1A4a\1A4bi\1A4ci(ii)\1A5b	705	338	254	286	329	361	363	59%
METAL PRODUCTION	2C	3499	40	8	10	6	10	7	1%
Other (Production Processes/Agriculture/Waste)	1B1\2A6\2B5\3\4\6	1118	144	114	109	107	104	96	16%
Total		5520	718	555	584	614	637	616	100%

¹ The PAHs selected are listed above in Table 5.3

² See Annex 1 for definition of UNECE Categories

Figure 5-1 Time Series of 16 PAHs Emissions (tonnes)

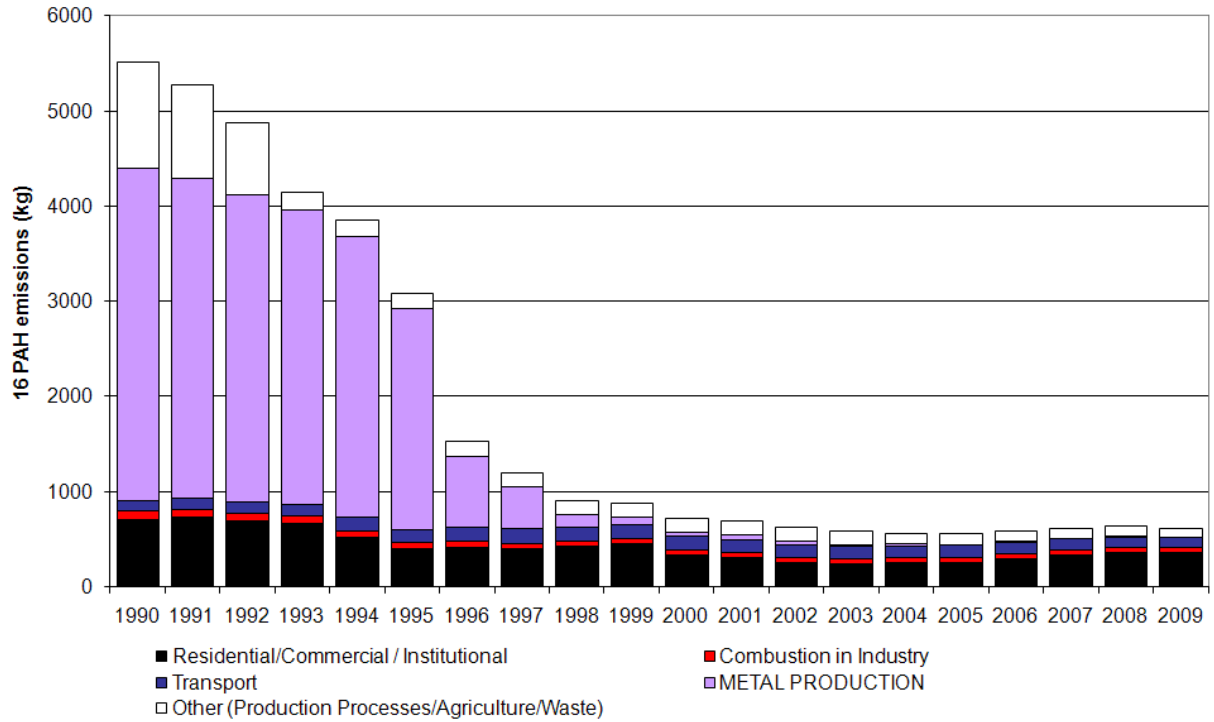


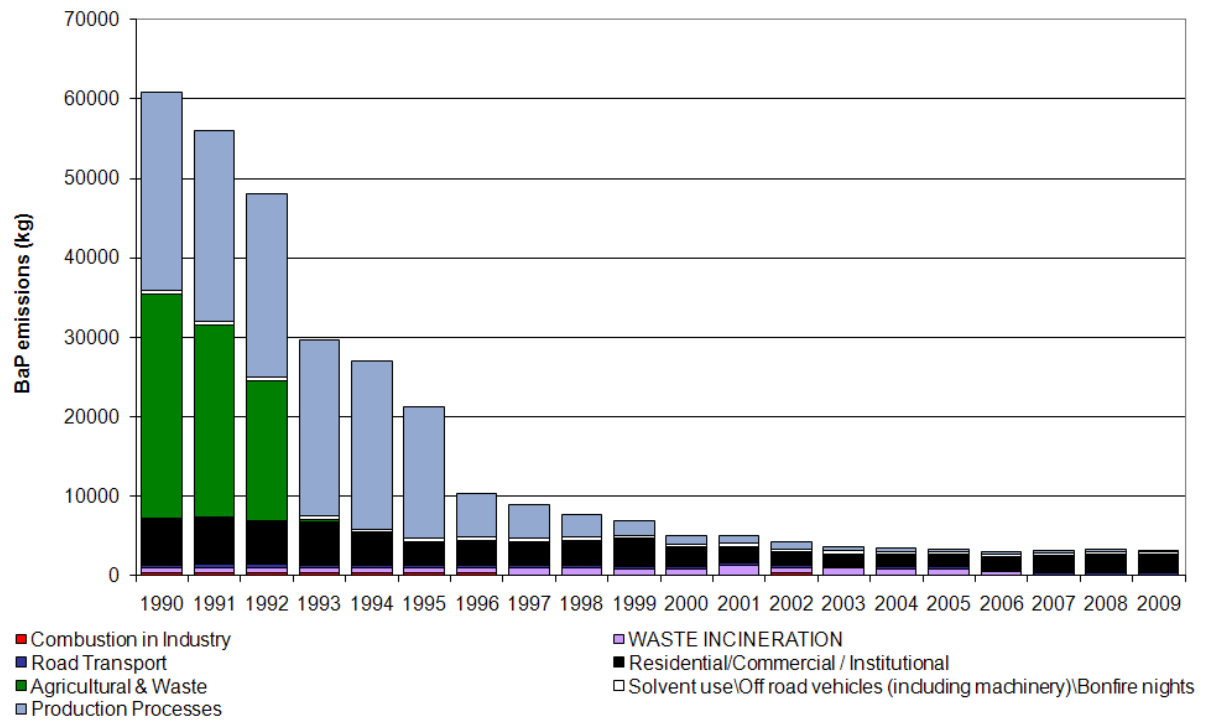
Table 5.4b UK Emissions of BaP¹ by aggregated UNECE Source Category (kg)

	NFR Codes	1990	2000	2005	2006	2007	2008	2009	2009%
BY UNECE CATEGORY²									
Combustion in Industry	1A1\1A2	299	150	163	121	120	115	102	3%
Passenger cars	1A3bi	207	158	104	97	91	85	80	3%
Light&Heavy Duty Vehicles	1A3bii\iii	123	98	62	56	52	46	41	1%
Other Transport	1A3biv\1A3c-1A4cii\1A5b	87	39	41	39	40	38	39	1%
Residential/Commercial / Institutional	1A4a\1A4bi\1A4ci(ii)	5791	2482	1595	1799	2099	2312	2294	72%
Production Processes	1B1b-3A\2A6	25058	1031	290	322	304	376	294	9%
Waste Incineration	6C	663	662	662	255	48	46	46	1%
Other (Agricultural & Waste)	4\6D\7	28681	308	293	295	286	271	270	9%
Total		60909	4928	3210	2983	3039	3290	3167	100%

¹ Benzo[a]pyrene

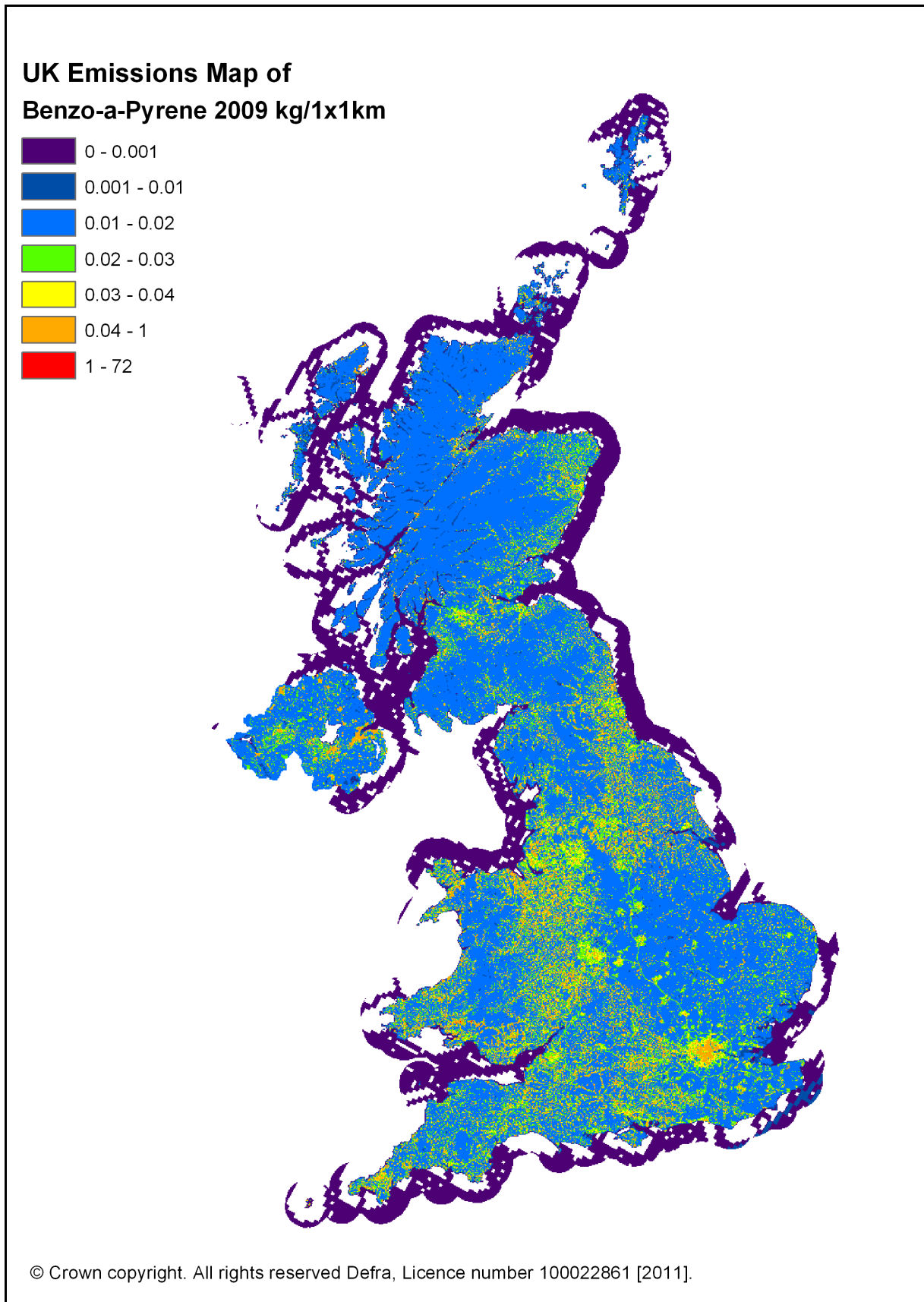
² See Annex 1 for definition of UNECE Categories

Figure 5-2 Time Series of Benzo[a]Pyrene Emissions (kg)¹⁶



¹⁶ In Murrells et al 2010b, the same figure showing the trend for Benzo[a]Pyrene was missing the source sector 'production processes'.

Figure 5-3 Spatially Disaggregated UK Emissions of Benzo[a]pyrene



5.2.1 Dioxins and Furans (PCDD/F)

5.2.1.1 Introduction

The term “dioxin” is used to refer to the polychlorinated dibenzo-*p*-dioxins (PCDD) and “furan” is used for polychlorinated dibenzofurans (PCDF). There are 210 PCDD/F congeners i.e. different compounds within a family or group having a similar structure. Of these 210 congeners the emissions of importance are those of the 7 PCDDs and 10 PCDFs which as a result of their common 2,3,7,8 chlorine substitution are thought to lead to dioxin-like toxicity. The emissions of these substances are weighted by factors called toxic equivalence factors (TEF) to estimate the quantity of the most toxic congener, 2,3,7,8-TetraChloroDibenzo-*p*-Dioxin, 17 which would have the same effect as the mixture emitted this is the known as a toxic equivalent (TEQ). The NATO/CCMS (Committee on the Challenges of Modern Society 1988) scheme known as the International toxic equivalent (I-TEQ) scheme widely used in UK and European legislation is used in the NAEI. However, the World Health Organisation (WHO) published a modification to the values used to calculate the toxic equivalents for some of the PCDDs and PCDFs in 1997, which was revised using updated information in 2006. They have also published TEFs for certain PCBs which have dioxin-like toxicity which allows PCDD/F and PCB TEQs to be combined together. The International and the two sets of WHO toxic equivalence factors (TEFs) for PCDD/Fs are shown in Table 5.5.

Table 5.5 The International and the WHO Toxic Equivalence Factors for PCDD/Fs for human exposure (the differences are highlighted)

Dioxins	International TEFs ¹	WHO 1997 TEFs ²	WHO 2006 TEFs ²
2,3,7,8 tetrachlorodibenzo- <i>p</i> -dioxin	1	1	1
1,2,3,7,8 pentachlorodibenzo- <i>p</i> -dioxin	0.5	1	1
1,2,3,4,7,8 hexachlorodibenzo- <i>p</i> -dioxin	0.1	0.1	0.1
1,2,3,6,7,8 hexachlorodibenzo- <i>p</i> -dioxin	0.1	0.1	0.1
1,2,3,7,8,9 hexachlorodibenzo- <i>p</i> -dioxin	0.1	0.1	0.1
1,2,3,4,6,7,8 heptachlorodibenzo- <i>p</i> -dioxin	0.01	0.01	0.01
Octachlorodibenzo- <i>p</i> -dioxin	0.001	0.0001	0.0003
Furans			
2,3,7,8 tetrachlorodibenzofuran	0.1	0.1	0.1
1,2,3,7,8 pentachlorodibenzofuran	0.05	0.05	0.03
2,3,4,7,8 pentachlorodibenzofuran	0.5	0.5	0.3
1,2,3,4,7,8 hexachlorodibenzofuran	0.1	0.1	0.1
1,2,3,6,7,8 hexachlorodibenzofuran	0.1	0.1	0.1
1,2,3,7,8,9 hexachlorodibenzofuran	0.1	0.1	0.1
2,3,4,6,7,8 hexachlorodibenzofuran	0.1	0.1	0.1
1,2,3,4,6,7,8 heptachlorodibenzofuran	0.01	0.01	0.01
1,2,3,4,7,8,9 heptachlorodibenzofuran	0.01	0.01	0.01
Octachlorodibenzofuran	0.001	0.0001	0.0003

¹ NATO/CCMS (1988)

² WHO (1998)

³ WHO (2006)

PCDD/Fs have been shown to possess a number of toxicological properties. The major concern is centred on their possible role in immunological developmental and reproductive effects.

5.2.1.2 Dioxin and Furan Production and Emissions to Air

The main sources of PCDD/Fs are thermal processes, but they can also be released to the environment from some chemical processes.

PCDD/Fs can arise from thermal processes where chlorine is present. For example, coal and other solid fuels contain trace amounts of chlorine compounds which can under certain combustion conditions result in PCDD/F formation. In addition, PCDD/Fs can be present in the feedstock material, or chlorinated impurities may be introduced into the feedstock of some thermal processes. The amount of chlorine required for PCDD/F formation may be small and consequently many processes have the potential to emit these pollutants. PCDD/Fs can also be emitted from the chemical production and following use of chlorinated pesticides and herbicides, many of which are now controlled. However, some chlorinated organic chemicals such as the wood preservative pentachlorophenol are still present in the UK in reservoirs such as pentachlorophenol treated wood which upon disposal have the potential to be sources of PCDD/Fs e.g. from the combustion of the treated wood. In addition, the pentachlorophenol in the treated wood can lead to dioxin emission.

5.2.1.3 Dioxin and Furan Emission Estimates

Estimated PCDD/F emissions for 1990-2009 are summarised in Table 5.6 below.

Table 5.6 UK emissions of PCDD/Fs by aggregated UNECE Source Category (grams I-TEQ/year)

	NFR Codes	1990	2000	2005	2006	2007	2008	2009	2009%
BY UNECE CATEGORY¹									
Combustion in Industry	1A1	109.1	11.8	13.2	11.9	11.2	10.8	10.7	6%
Iron and Steel (combustion)	1A2a	0.8	0.4	0.2	0.2	0.4	0.3	0.3	0%
Other industrial combustion: Wood&Coal	1A2f	40.9	26.5	15.1	14.7	14.8	17.1	17.3	9%
Transport	1A3b\1A3c- 1A4cii 1A5b	32.6	6.5	6.1	5.8	4.7	4.6	4.5	2%
Residential/Commercial / Institutional	1A4a\1A4bi\1A4ci	71.9	16.1	12.6	13.4	13.4	18.5	18.7	10%
Production Processes	1B1b\2A&B&D	5.9	2.0	1.7	1.8	1.8	1.7	1.6	1%
Metal Production (processes)	2C	113.1	59.2	47.9	48.2	39.9	42.6	35.7	18%
Agriculture\Bonfire nights	4\7	122.0	49.4	46.3	47.2	45.1	40.6	40.6	21%
Waste Incineration& Other Waste	6	563.0	93.2	90.7	75.1	66.0	64.8	63.5	33%
Total		1059.3	265.1	233.6	218.4	197.3	201.1	192.9	100%

¹ See Annex 1 for definition of UNECE Categories

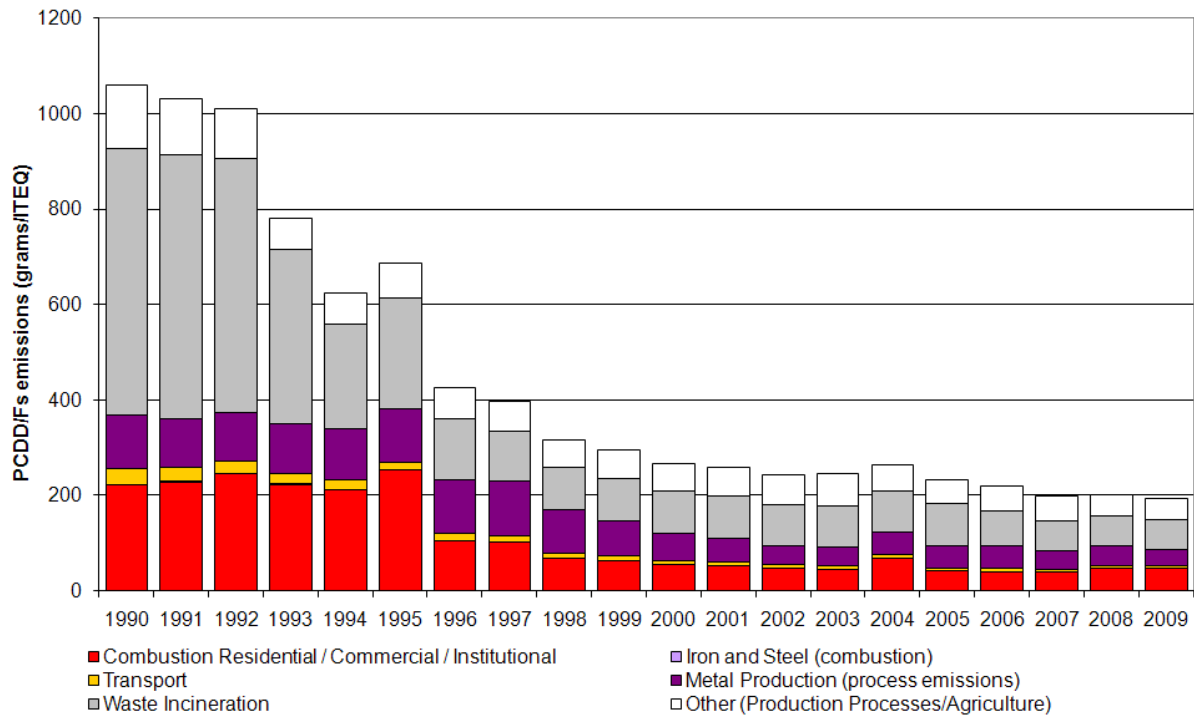
² Including railways, shipping, naval vessels, military aircraft, off-road sources and road transport

The largest sources of PCDD/F emission is thought to be the burning of waste materials in sources other than well controlled modern waste incinerators. However emissions from waste incineration have fallen between 1993 and 2009, driven by the introduction of control measures. Municipal Solid Waste (MSW) incinerators not meeting the new standards closed in the period leading up to December 1996. All remaining MSW incinerators are now classified as public power plant burning MSW as they all generate electricity. Improved combustion and flue gas controls, and developments in abatement technology in modern MSW incinerator design, has resulted in significantly lower levels of PCDD/F emissions.

The relatively low emissions from chemical incinerators reflects the use of rotary kilns and the incorporation of a secondary combustion chamber in the process to destroy organic

contaminants together with the relatively low waste throughput and advanced pollution abatement equipment.

Figure 5-4 Time Series of PCDD/Fs Emissions (grams I-TEQ)

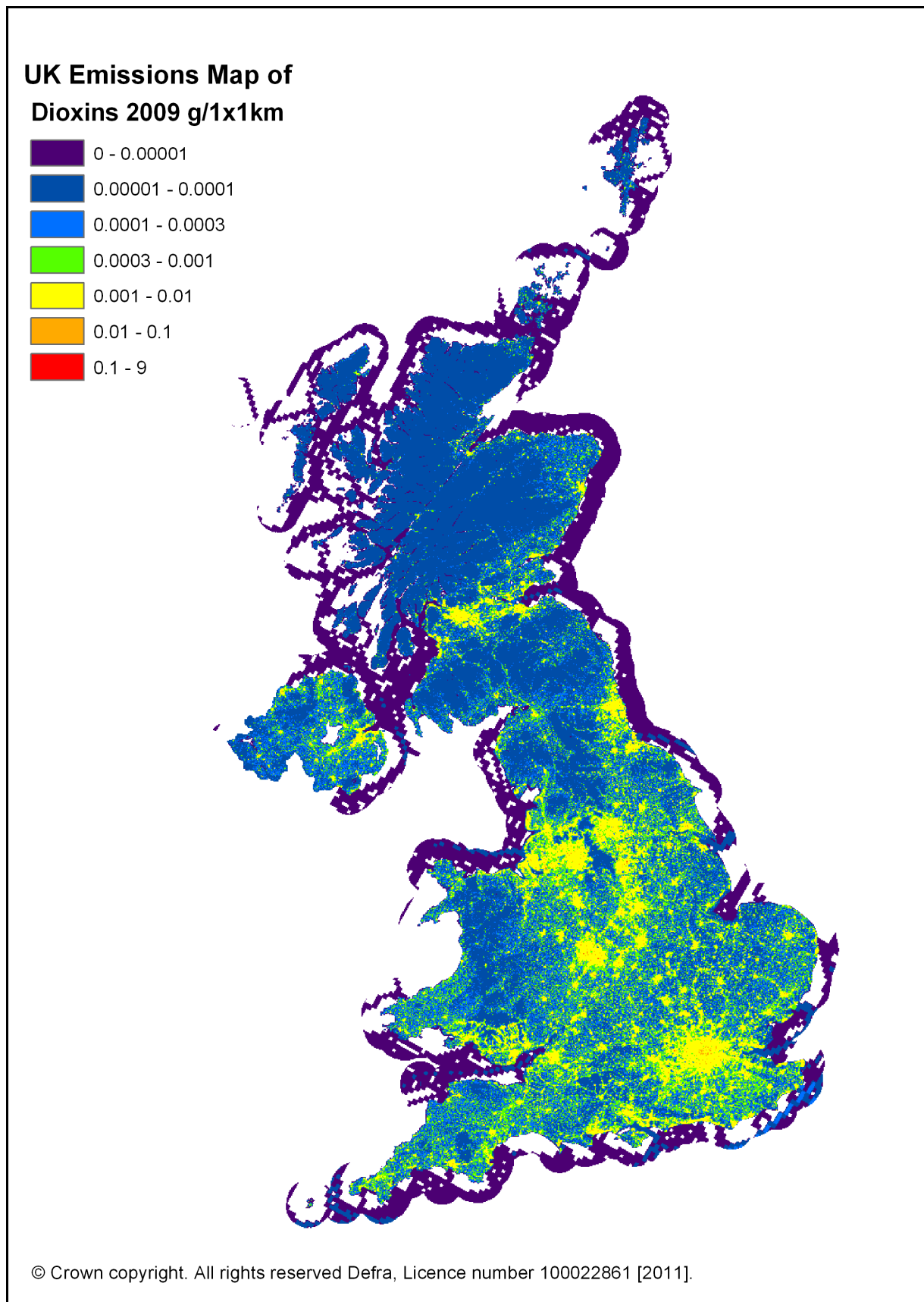


Emissions from power stations are low because the combustion is efficient and the post-combustion fly ash temperatures are rapidly reduced to increase energy efficiency. The emission factors associated with industrial and domestic coal combustion are significantly higher. Therefore even though the coal consumption in this sector is much smaller the emissions are estimated to be larger. However, emissions from all three sectors have decreased with the reduction in the quantity of coal burned.

Emission from open agricultural burning is included in the agricultural and nature sectors. This has declined to near zero since the cessation of stubble burning. There are significant emissions from sinter plants at integrated iron and steel works (included in process emissions from metal production in Figure 5-4).

It is thought that the major source of PCDD/F emissions from road transport are the 1,2-dichloroethane scavengers previously added to leaded petrol to remove lead from the cylinder. Consequently the emissions of PCDD/F from this sector are thought to have decreased following the decline in use then the removal from sale of leaded petrol. Unleaded petrol and diesel is likely to contain only trace quantities of chlorinated impurities. For 2009, the contribution to the PCDD/F emission total from road transport fuel was just over 1%.

Figure 5-5 Spatially Disaggregated UK Emissions of PCDD/F



5.2.2 Polychlorinated biphenyls (PCBs)

5.2.2.1 Introduction

PCBs are synthetic organic compounds that have had a wide range of uses as a result of their stability. Most recently they were mainly been used in electrical equipment as dielectric insulating media.

PCBs have been linked with effects such as reduced male fertility and long-term behavioural and learning impairment. They are classified as probably carcinogenic to humans. Certain PCBs have been assessed as having dioxin-like effects. PCBs are extremely persistent in the environment and possess the ability to concentrate up the food chain. These compounds are highly insoluble in water but accumulate in body fat. Present human exposure is probably dominated by the accumulation through the food chain of the PCBs present in environmental reservoirs such as soils and sediments as a result of previous releases to the environment.

5.2.2.2 Production and Emissions to Air

The sale of products containing PCBs has not been legal since 1986 and so they have not been manufactured and used in the UK for many years, but old equipment containing dielectric fluids (which in turn may contain PCBs) still exist. The emissions to air are from equipment still in use, leaking or from destruction of such equipment by using fragmentisers. It is estimated that in 2009, 55% of primary PCB emissions to the atmosphere are associated with such appliances- primarily capacitors and transformers. These emissions primarily arise from in-service appliances; however emissions during disposal are also considered to be significant. Large quantities of PCBs are thought to have been disposed of to landfill in the past, mainly in the form of electrical components or fragmentiser residues, but now such equipment containing PCBs are disposed of by chemical incineration. This process ensures significant reduction in the amount of PCBs being released into the environment. PCBs are also emitted from the soil having previously been deposited there from the air.

5.2.2.3 Emission Estimates

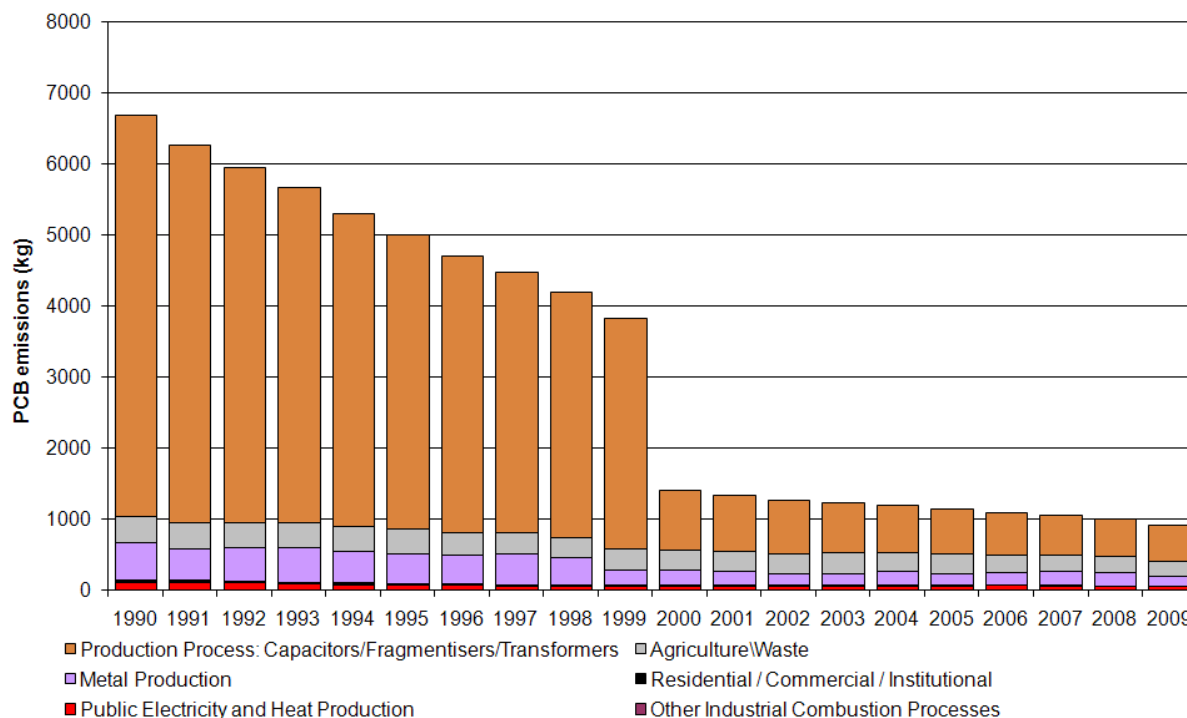
PCB speciation has been incorporated into the emission estimates since the 1998 inventory report. A summary of the total PCB emission estimates for 1990 to 2009 is given below in Table 5.7.

Table 5.7 UK Emissions of PCB Emissions by aggregated UNECE Source Category (kg)

	NFR Codes	1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹									
Public Electricity and Heat Production	1A1a	91	43	46	50	46	42	34	4%
Residential/Commercial / Institutional	1A4a\1A4bi\1A4ci	24	11	5	5	6	6	6	1%
Metal Production	2C	525	214	173	176	192	189	135	15%
Agriculture/Waste/Other	4\6\7	367	277	277	252	233	225	222	24%
Other Industrial Combustion Processes	1A1b-c\1A2\1A4ci\1B1b	21	14	10	11	11	11	10	1%
Production Process: Capacitors/Fragmentisers/Transformers	2F	5670	847	626	591	558	528	500	55%
Total		6698	1406	1137	1085	1046	1001	906	100%

¹ See Annex 1 for definition of UNECE Categories

Figure 5-6 Time Series of PCBs Emissions (kg)



Sales of PCBs in the UK were stopped in 1986. It is thought that they are still manufactured in some countries. In 1997 an Action Plan was published by DETR (now Defra) which laid out the commitments made by the UK at the Third International North Sea Conference at the Hague in 1991 in accordance with the requirements of Directive 96/59/EC. These regulations require all PCB holders in the UK to report their stocks to the relevant regulatory bodies. These stocks (except for certain exemptions) were destroyed before the end of December 2000. However, not all electrical equipment containing PCBs is readily identifiable. Emissions from electrical equipment will probably continue, and will fall as the relevant electrical equipment reaches the end of its working life and is destroyed.

PCBs occur in sewage sludge due to their persistent nature, and may occur in significant quantities. Not all the PCBs spread on land will volatilise but the potential for emissions to air is greater than that of landfill. The emission estimate comprises only 2.5% of the total and is highly uncertain. Emissions arise from waste incineration and refuse-derived fuel production resulting from the PCB content of the waste. Contributions from small scale waste account for 17% of total PCB emissions.

PCBs can be formed in trace amounts from chlorinated precursors in thermal processes such as scrap metal recycling. As a result, there are significant emissions from the iron and steel processes, as with PCDD/Fs.

5.2.3 Pesticide Emissions

5.2.3.1 Introduction

Although there is little available information to enable accurate estimates of pesticide emissions to air, the emission estimates presented here follow from significant improvements to the earlier emission estimates first made in 1996.

Despite these improvements, the confidence in the accuracy of these estimates is low. Relevant data is currently scarce with the majority of emission factors coming from the US or Europe. The emission factors used here have been derived for a particular method of pesticide application (during specific atmospheric conditions), which may not be representative of the situation in the UK. Until further data become available it is difficult to reduce the uncertainty associated with these estimates. At present no relevant measurement programmes are known of, and therefore the possibility of acquiring additional data is considered to be poor.

5.2.3.2 Pesticide Production and Emissions to Air

Pesticide emissions to the air occur predominately through three pathways: during manufacture, during application and volatilisation after application. Table 5.8a, Table 5.9 and Table 5.10 show the estimated emissions of lindane (>99% γ -HCH), pentachlorophenol (PCP) and hexachlorobenzene (HCB) respectively.

5.2.3.3 Lindane (γ -HCH)

Acute (short-term) effects caused by the inhalation of lindane consist of irritation of the nose and throat, as well as effects on the blood. Chronic (long-term) effects through inhalation have been associated with effects on the liver, blood, immune and cardiovascular systems.

Lindane has been used as an insecticide, fungicide and used as a wood preservation treatment. Lindane is used in the agriculture, domestic and veterinary sectors. Until 1990 lindane was also used as a remedial wood treatment i.e. in a curative role rather than a preservative/preventative. However, data on quantities used for a remedial wood treatment prior to 1990 are not available. Approvals for the use of lindane containing pesticides in the UK have now been withdrawn and use has not been allowed since 2002.

Hexachlorocyclohexane (HCH) exists in several isomers, however as a result of regulation in 1981, use of products containing less than 99% γ -HCH has not been allowed. Consequently only the γ isomer has been considered in any detail here. The emission estimates presented in

Table 5.8a was made assuming that emissions arise from the application of lindane to treated wood and agricultural and domestic use. In 2009 lindane emissions were solely due to emissions from previously treated wood. Emissions from wood preserving have fallen since 1990.

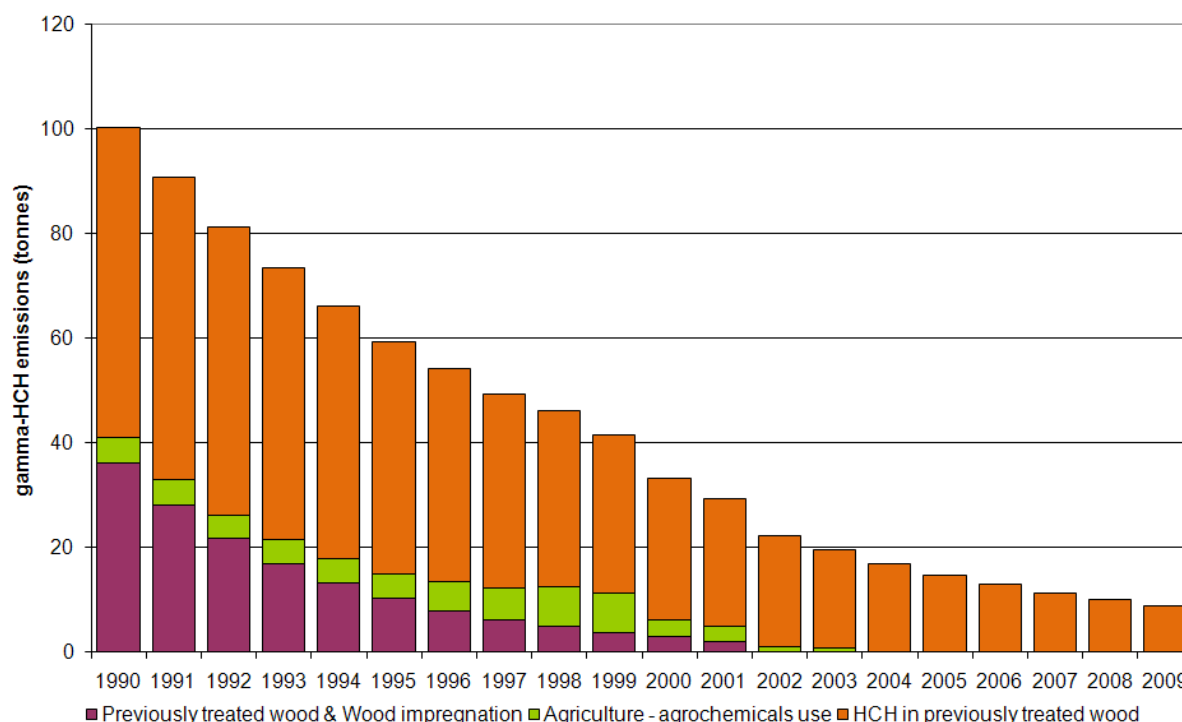
Emissions from agricultural pesticide activities contributed to total lindane emissions until 2006. However, since 2006 there has been no emission from this sector. These emissions are based on statistics on the use of pesticides containing lindane, obtained from personal communication with the Central Science Laboratory's (now the Food and Environment Research Agency's) Pesticide Usage Survey Team. The emission factors used are taken from van der Most *et al* (1989).

Table 5.8a UK Emissions of Lindane by aggregated UNECE Source Category (tonnes).

		1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹									
Previously treated wood & Wood impregnation	3D	36.1	2.9	0.0	0.0	0.0	0.0	0.0	0%
HCH in previously treated wood	2F	59.4	27.3	14.6	12.9	11.3	10.0	8.8	100%
Agriculture - agrochemicals use	4G	4.9	3.1	0.01	0.0	0.0	0.0	0.0	0%
Total		100.4	33.2	14.6	12.9	11.3	10.0	8.8	100%

¹ See Annex 1 for definition of UNECE Categories

Figure 5-7 Times Series of Lindane Emissions (tonnes)



For completeness, the total emissions of HCH are also included here (see Table 5.8b below), although the differences are obscured due to rounding. These total HCH emissions estimates assume the worst case scenario of 1% contribution from non γ isomers to the HCH total.

Table 5.8 b UK Emissions of HCH by aggregated UNECE Source Category (tonnes).

		1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY¹									
Previously treated wood & Wood impregnation	3D	36.4	2.9	0.0	0.0	0.0	0.0	0.0	0%
HCH in previously treated wood	2F	60.0	27.5	14.8	13.0	11.4	10.1	8.8	100%
Agriculture - agrochemicals use	4G	5.0	3.1	0.0	0.0	0.0	0.0	0.0	0%
Total		100.4	33.2	14.6	12.9	11.3	10.0	8.8	11.2

¹ See Annex 1 for definition of UNECE Categories

5.2.3.4 Pentachlorophenol (PCP)

PCP is associated with both acute and chronic effects on humans through inhalation. Acute effects can lead to eye irritation as well as liver, blood and neurological effects. Chronic

exposure can result in effects on the respiratory tract, immune system, liver, kidneys, blood as well as the eyes and nose.

PCP is used as a biocide, and is effective in destroying insect eggs. It is used in the timber and textile industries. The emission estimates given here also include emissions from the use of sodium pentachlorophenoxide (NaPCP) and pentachlorophenyl laureate (PCPL) as well as PCP since these were also included in the proprietary formulations.

The estimated PCP emissions for 1990 to 2009 are given in Table 5.9. The largest percentage contribution to the total PCP emission arises from wood that has been treated within the last 16 years. This accounts for some 99.99% of the 2009 total PCP emission.

Once again it is very difficult to be certain of these estimates due to the lack of research into emission rates and limited knowledge of quantities used both in the year of the estimate and in previous years. An emission factor of 3% of the wood content per year has been used.

PCP emissions from the textile industry primarily arise from volatilisation during application as a cotton preservative. Emission factors used were based on a study of PCP emissions in the UK (Wild, 1992) reporting that approximately 30% of the applied PCP is lost through volatilisation. Emissions from this sector are comparatively small.

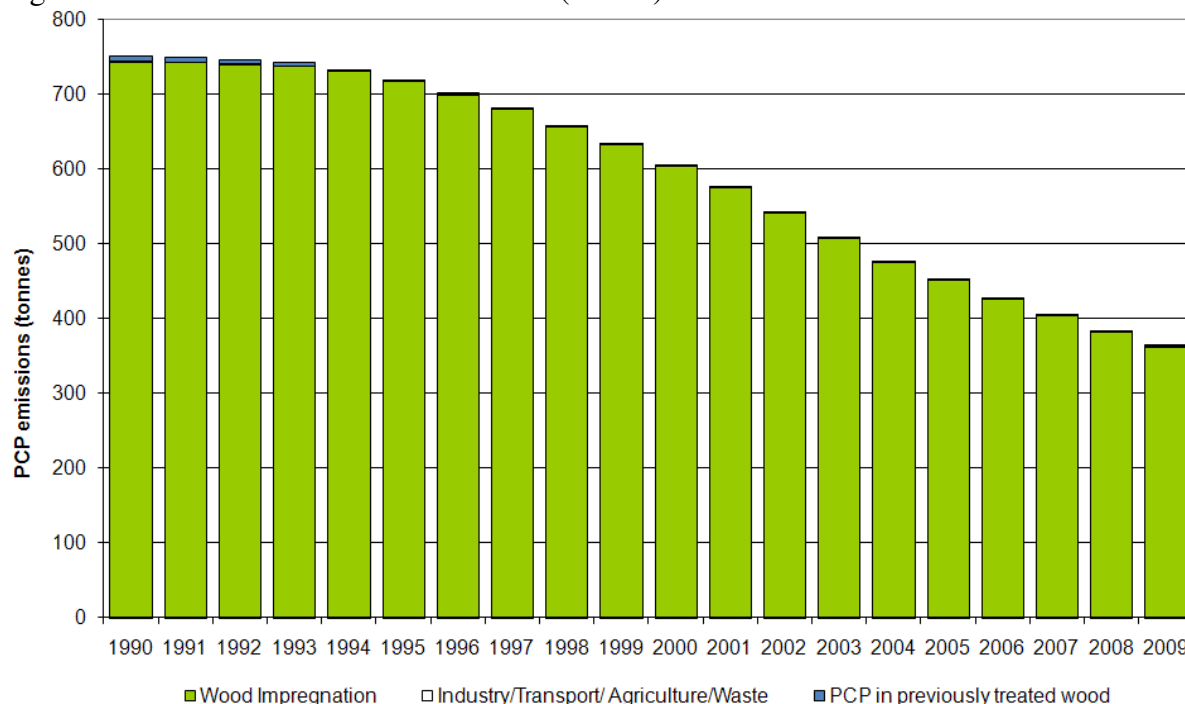
In the early 1990's, PCP was used in the agricultural sector as the active ingredient in disinfecting wooden trays used in mushroom farming (classified as solvent use). Usage statistics were reliable and came from the Pesticide Usage Survey Group at MAFF (MAFF, 1991a,b,c; 1992a,b,c,d). The emission factor assumed 30% loss due to volatilisation (Wild, 1992). In recent years emissions from this source (mushroom farming) are thought to be insignificant due to PCP no longer being used for this purpose.

Table 5.9 UK Emissions of PCP by aggregated UNECE¹ Source Category (tonnes)

	NFR Codes	1990	2000	2005	2006	2007	2008	2009	2009 %
Wood Impregnation	3D	744	605	451	427	404	383	363	99.99%
Industry/Transport/ Agriculture/Waste	1A\2B5a\3C\4G\6	0	0	0	0	0	0	0	0.01%
PCP in previously treated wood	2F	7	0	0	0	0	0	0	0.00%
Total		751	605	451	427	404	383	363	100%

¹ See Annex 1 for definition of UNECE Categories

Figure 5-8 Times Series of PCP Emissions (tonnes)



The emission inventory for PCP is very uncertain as only limited emission factors are available on the release of PCP during agricultural activities and statistics are not actively collected on the extent of its usage. There is some data on release of PCP from combustion processes, but the available studies are not consistent with each other suggesting that the uncertainty may be considerable. Without new data becoming available, significant improvements are not expected in the near future.

5.2.3.5 Hexachlorobenzene (HCB)

Very little information is available on the health effects of HCB via ingestion. However, the lungs may be affected by repeated or prolonged exposure. It is also considered to be a possible carcinogen.

Studies in the USA have identified two main industrial sources of HCB (Mumma *et al*, 1975) (Jacoff *et al*, 1986). These are the manufacture of chlorinated solvents (e.g. trichloroethylene, tetrachloroethylene and carbon tetrachloride) and the manufacture of specific pesticides where HCB remains as an impurity. HCB emissions may also arise from combustion sources, but other than waste incineration these could not be estimated. These emissions are believed to be small.

Statistics for chlorinated solvent production in the UK are commercially confidential; hence estimates were made based on UK solvent usage data from the Solvent Industries Association and import and export statistics.

Although there is no UK manufacture of pesticides that results in the production of HCB, pesticides with HCB as an impurity are still imported and used in the UK for agricultural pest control. Statistics for the use of these pesticides is provided by the Pesticide Usage Survey Group (personal communication). The use of chlorothalonil increased significantly in 2004

but since then emissions have declined and since 2008 emission levels have fallen below pre-2004 levels. This is reflected in the emission estimates (see Table 5.10).

HCB emissions from secondary aluminium production result from the use of hexachloroethane (HCE) tablets as a degassing agent (van der Most *et al*, 1992). Regulations now control the use of HCE and so since 1999 emissions from secondary aluminium production is zero. Data on the quantity of degassing agent supplied and the quantity of HCE used per tonne of aluminium melted were obtained from industrial experts and van der Most *et al* (1989).

Emissions from pesticide application and chlorinated solvent production now account for virtually all of the UK HCB emissions until 2008 (Table 5.10). In 2009, emissions from chlorinated solvent production fell to zero, because of a closure of a chlorine plant. Thus emissions from pesticide application account for a higher share (71%) of total HCB emissions compared to 2008. In 1990, the same sector contributed 4.2% to the total emissions. This change is a result of the reduced emissions from the production of chlorinated solvents and the control on the use of HCE in secondary aluminium smelting. In 1990, 77% of the HCB emissions were attributed to aluminium production.

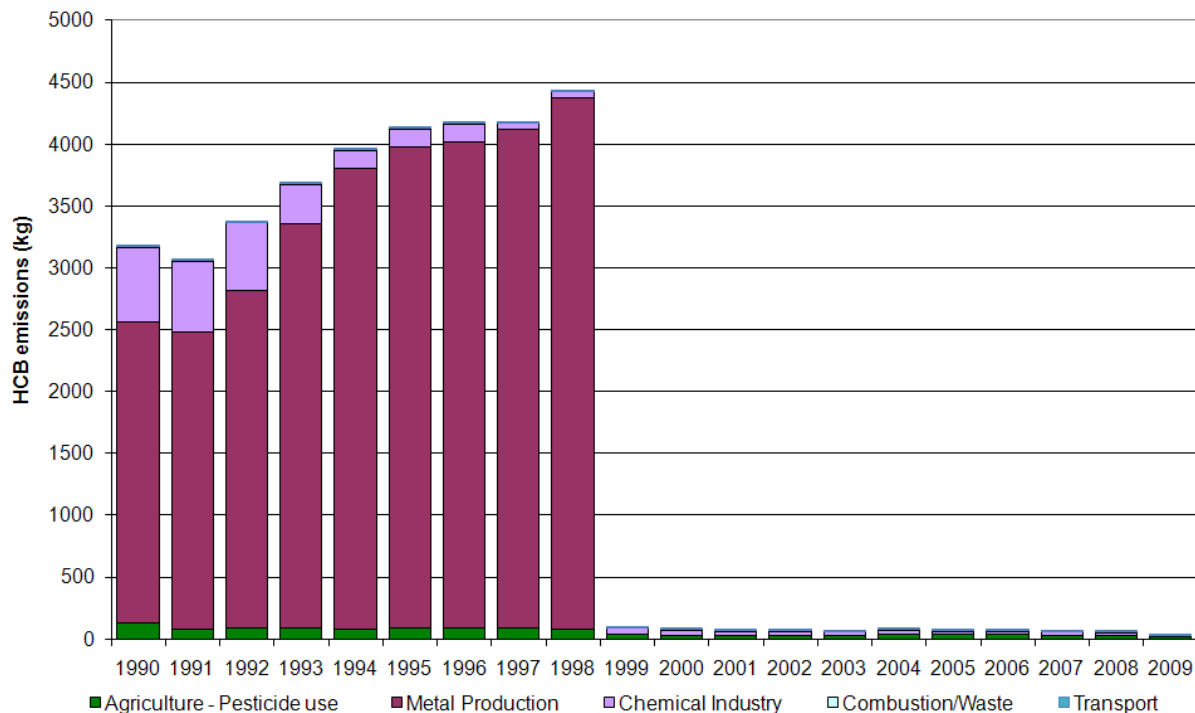
Table 5.10 UK Emissions of HCB by aggregated UNECE¹ Source Category (kg)

	NFR Codes	1990	2000	2005	2006	2007	2008	2009	2009 %
BY UNECE CATEGORY									
Chemical Industry	2B5	596.2	43.5	24.7	23.4	23.4	23.4	0.0	0%
Metal Production	2C	2435.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Agriculture - Pesticide use	4G	132.0	30.2	39.2	35.4	31.4	26.9	23.3	71%
Combustion Processes/Waste ²	1A1a\1A4a\6c\1A2fi	6.3	5.9	6.7	7.4	7.5	7.7	9.2	28%
Transport	1A3dii	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0%
Total		3169.6	79.7	70.6	66.3	62.4	58.2	32.6	100%

¹ See Annex 1 for definition of UNECE Categories

² Public Electricity and Heat Production, Commercial / Agriculture fuel combustion and waste incineration

Figure 5-9 Time Series of HCB Emissions (kg)



5.2.4 Short Chain Chlorinated Paraffins (SCCP)

5.2.4.1 Introduction

SCCPs are a range of commercially available chlorinated paraffins with 10-13 carbon atoms. The commercial products are usually mixtures of different carbon chain length paraffins with a range of different degrees of chlorination. SCCPs are considered to be persistent organic pollutants. Due to their stability potential to bioaccumulate and toxicological properties they are of concern to the environment and human health.

5.2.4.2 SCCP Production and Emissions to Air

SCCPs were manufactured in the EU and marketed under a variety of trade names. The chlorine content of SCCPs generally ranges from 30 to 70% by weight. Consumption in the UK in 2009 is estimated to be approximately 234 tonnes down from 286 tonnes in 2007.

The main use of SCCPs used to be in metal working fluids; however these are no longer sold. The remaining market is thought to be as a flame retardant in certain rubbers and textiles. It has been reported that there are negligible emissions to air of SCCP from production sources, and releases from the majority of industrial consumption results in emissions primarily to water (with very low emissions to air). Emissions from waste water to the atmosphere are unlikely to be large as a result of the physical properties of SCCPs.

5.2.4.3 SCCP Emission Estimates

Current estimates are based on information provided in the European Union Risk Assessment Report (1999) and other data. Emissions of SCCPs have declined considerably since 1990 due to the decrease in consumption caused by a general switch to alternatives.

Table 5.11 UK Emissions of SCCPs (tonnes)

	1990	2000	2005	2006	2007	2008	2009	2009 %
TOTAL	47.2	3.15	0.0007	0.0007	0.001	0.001	0.001	100%

5.2.5 Polychlorinated Naphthalenes (PCN)

5.2.5.1 Introduction

PCNs are a group of 75 theoretically possible chlorinated naphthalenes containing between one and eight chlorine atoms. Their chemical structure is similar to that of PCBs. PCNs are widely considered to be associated with cancer and chronic liver disease.

PCNs have been used in a variety of industries. The most important uses are cable insulation, wood preservation, engine oil additives, electroplating masking compounds, feedstock for dye production, dye carriers, capacitors and refractive testing oils.

PCNs have been produced in a number of countries including the UK, USA and France. Their synonyms and trade names include Halowax, Nibren waxes, Seekay Waxes, Cerifal Materials and N-Oil. The majority of production generates a standard mixture of the different PCN congeners.

5.2.5.2 PCN Production and Consumption

A number of assumptions give an estimate of the world-wide PCN production over all years, as 150,000 tonnes. Similar assumptions can be made to derive UK production, which is estimated to have been 6,650 tonnes over the period of production.

5.2.5.3 PCN Emission Estimates

There is very little information concerning the production of PCNs for commercial purposes. Commercially produced PCNs are thought to be the most important source of PCNs in the atmosphere, with the other source sectors being thermal sources, other industrial processes and contamination in PCB industrially produced mixtures.

PCNs have not been produced in the UK for over 30 years and therefore the major releases that were present during their extensive use have decreased. The potential sources are expected to be dominated by the disposal routes of capacitors and engine oil (this is where the majority of the PCNs produced are thought to have been used). Another potential source of PCNs may be the incineration industry. PCNs have been found in fly ash and flue gas in waste incinerators. Landfills are also expected to be a source of PCN emissions.

PCNs have been found in emissions from incinerators and are thought to be produced from the combustion of PAHs. Therefore PCNs could in theory be produced from other high temperature combustion processes. A full review of emission measurements from such processes would be required prior to ascertaining the scale of the emissions of PCNs from such a potentially large array of sources. As the information regarding the emission of PCNs in the UK is relatively sparse, it is not currently realistic to quote an emission estimate for PCNs. It is hoped that data will become available to resolve this in the future.

5.2.6 Polybrominated Diphenyl Ethers (PBDEs)

5.2.6.1 Introduction

There are 209 possible congeners of PBDEs. Concern about potential risks to human health and the environment has centred on their potential toxicity, persistence and the tendency for bioaccumulation.

Since the 1960s, PBDEs have been added to foams and plastics as flame-retardants. They are sold as mixtures containing a certain typical level of bromination; hence pentabromo, octabromo and decabromo diphenyl ethers. They have been used in a variety of materials (Strandman et al. 2000), including thermoplastics (e.g. high-impact polystyrene) that are used in electrical equipment, computer circuit boards, casings, upholstery, furnishings; interiors in cars, buses, trucks and aeroplanes, rugs, drapery and building materials.

5.2.6.2 PBDE Production and Releases to Air

The annual EU production of polybrominated diphenyl ethers has been estimated to be 11,000 tonnes per year. It has been reported (EU 2000) that the UK used up to 2,000 tonnes of polybrominated biphenyl in 1994. However this is thought to have declined rapidly over the last decade. Production of the three commercial mixtures (penta-, octa- and deca-dibrominated diphenyl) has virtually ceased in the EU.

The possible routes of release of PBDEs vary from production to the disposal of the materials for which they are used. There is limited information concerning the releases and it is difficult to attempt to estimate an emission inventory without any measurements of releases from sources or potential sources. Attempts have been made to gather UK usage information. However, information is not easily accessible, particularly as PBDEs are a material used in such a wide variety of industries.

5.2.6.3 PBDE Emission Estimates

It has not been possible to obtain UK specific emission data for PBDEs, but an estimate of the UK emission has been made using the total EU estimate. This is done by scaling with population. Without further assessment of the potential emissions from materials such as plastic and upholstery, during production use and disposal, it is not possible to make a more accurate estimate. The resulting UK emission estimate for PBDE's is 5.4 tonnes (Penta-BDE: 0.3t, Octa-BDE: 0.1t, Deca-BDE: 5.0t) per year.

There are a number of improvements that could be made to the UK emission estimate for PBDEs. The current approach concentrates on the releases from foam materials during their use. Resources could be focused on:

- Emission from manufacturing sites
- Release from materials during and following disposal
- Release from other materials that contain PBDEs

6 Stratospheric Ozone Depleting Substances

Ozone, ozone depleting substances and ozone forming compounds (ozone precursors) are all important atmospheric pollutants for differing reasons. Ozone itself is a gas, which has an irritant effect on the surface tissues of the body, such as the eyes, nose and lungs (as well as damaging crops and buildings). Consequently at tropospheric levels (i.e. near the surface) ozone and ozone precursors are important pollutants. Ozone emissions are not estimated by the NAEI as the direct emissions are not significant compared with photochemical formation of ozone from ozone precursors. Estimating ozone concentrations in the troposphere requires modelling, and the input of information on ozone precursors. Consequently there is a need for emission estimates of ozone precursors, and these are given in this report (for location see Table 6.1 below).

Ozone naturally occurs in the stratosphere (higher layers of the earth's atmosphere) formed by the action of ultraviolet light from the sun on oxygen molecules. At this level, ozone is beneficial to health, filtering out harmful ultraviolet rays that can cause skin cancers. Chemicals, which cause stratospheric ozone depletion, must therefore be estimated.

Table 6.1 Location of Ozone Depleting substances and Precursors in this Report

Nitrous Oxide (N ₂ O)	Ozone Precursor	Section 7.4: Nitrous Oxide
NMVOCs	Ozone Precursor	Section 2.9: non-methane volatile organic compounds
NO _x	Ozone Precursor	Section 2.8: NO _x emissions
HFCs	Stratospheric Ozone Depleting Substances	Section 7.5.1 : Hydrofluorocarbons
PFCs	Stratospheric Ozone Depleting Substances	Section 7.5.2 : Perfluorocarbons

Evidence suggests that stratospheric ozone depletion is being caused by anthropogenic emissions of chlorine and bromine-containing substances (halocarbons) such as: CFCs, halons, and HCFCs. HCFCs are similar to CFCs but have a lower potential for depleting ozone and in some cases are being used as transitional replacements (for example in refrigeration equipment). Emissions of methyl chloroform, carbon tetrachloride and methyl bromide also contribute to the effect.

International agreement to limit the production and consumption (and hence emission) of ozone depleting substances and phase out use of these substances was reached in 1987 through the Montreal Protocol on Substances that Deplete the Ozone Layer. This has subsequently been strengthened by a number of Amendments. In addition, the EU introduced EC Regulation 3093/94, which in some cases adopted a faster timescale for the reductions. Overall this has led to substantial reductions in the production and consumption of these substances over the last 15 years.

The NAEI does not contain emissions inventories for all of these substances individually, although some of them, such as HCFCs, are included within the emissions for non-methane volatile organic compounds (VOCs) (see Section 2.9).

7 Greenhouse Gas Emissions

7.1 INTRODUCTION

Increasing atmospheric concentrations of GHGs originating from anthropogenic activities are leading to enhanced warming of the atmosphere and global climate change. The major GHGs are carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) all of which have both natural and anthropogenic sources. In contrast, the three industrial gases: hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulphur hexafluoride (SF₆), are potent greenhouse gases but only originate from anthropogenic sources (no natural sources have been verified).

These six GHGs comprise the ‘basket of emissions’ against which reduction targets were agreed at the Third Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC) in Kyoto, Japan in December 1997. The target for the UK, which is part of the ‘burden sharing’ of the EU-15’s target under the Kyoto Protocol, is to achieve a reduction of the global warming potential (GWP) of the six GHGs of 12.5% by 2008-2012 compared to the base year (1990 emissions estimates for CO₂, CH₄ and N₂O and 1995 emission estimates for HFCs, PFCs and SF₆ based on the 2004 inventory). Consequently the UK is required to compile annual emission inventories of these GHGs and report the emissions to international bodies, such as the UNFCCC to demonstrate progress against its target under the Kyoto Protocol. The EU is also a signatory to the Protocol, and as a member, the UK has to also submit GHG emissions data to the European Union Monitoring Mechanism (EUMM).

To ensure GHG emission reductions continue following the Kyoto period, in June 2009, the ‘climate and energy package’ became a law to implement the 20-20-20 targets in the EU. One branch of the 20-20-20 target sets a target for the EU to reduce their GHG emissions to at least 20% below 1990 levels by 2020.

Greenhouse Gas Inventories are submitted to UNFCCC and the EUMM in the Common Reporting Format (CRF). The CRF is a detailed and complex reporting framework, and gives net carbon emissions (that is emissions minus removals). The overseas territories and crown dependencies covered in the UNFCCC, EUMM and UNECE reporting differ. Consequently emission “totals” will vary between the reporting formats. A summary of the GHG emissions including emissions covered by all overseas territories and crown dependencies are presented in this report. This is consistent with the UK reporting to the UNFCCC and is thus not based on the UNECE reporting which is used for the reporting other pollutants in this report. More detailed information on the emission trend and the methodology used may be found in the annual report on UK GHG emissions produced by AEA (MacCarthy et al, 2011).

The 2009 emissions for each of these six GHGs are summarised in

Table 7.1 and their inventories are discussed in the following sections. Inventories for the three indirect GHGs (carbon monoxide, nitrogen oxides and NMVOCs) are included in chapter 2¹⁷.

The total global warming potential of UK GHG emissions has been calculated using their GWPs, which measures their effectiveness in global warming relative to CO₂, agreed by IPCC for a 100 year time horizon (IPCC, 1996).

Table 7.1 GWP for UK Emissions of Greenhouse Gases in 2009

Direct GHG	Emissions (ktonnes) in 2009	GWP (100 years)	Global Warming Equivalence (equivalent kt of CO ₂)
CO ₂ (as Carbon)	129,765.6	3.7	475,807
CH ₄	2087.48	21	43,837
N ₂ O	111.64	310	34,607
HFCs ¹	2980.15 ²	140 - 11,700	10,927
PFCs ¹	40.12 ²	6,500 - 9,200	147
SF ₆	180.49 ²	23,900	662

¹ A number of GWPs are used as this refers to a group of compounds.

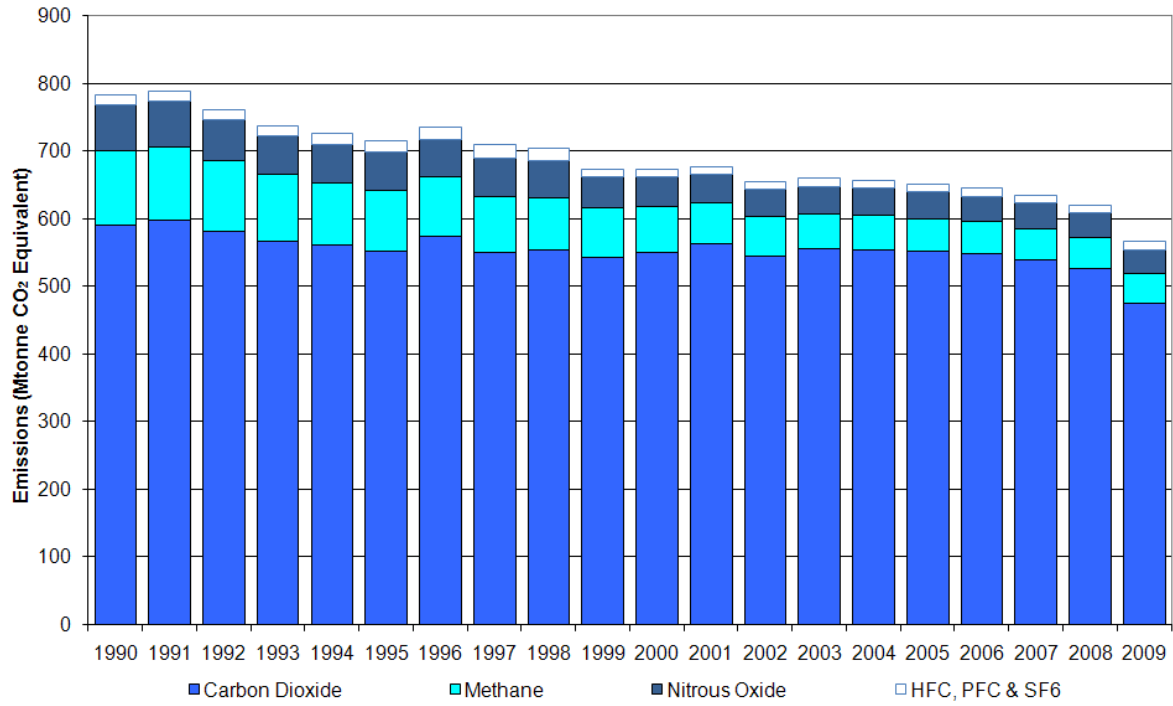
² Included in this table as Carbon

During the period 1990-2009, there has been a 28% reduction in UK emissions of total GHGs (CO₂, CH₄, N₂O, HFC, PFC and SF₆).

Figure 7-1 shows GHG emissions (comprising CO₂, CH₄, N₂O, HFCs, PFCs and SF₆) as CO₂ equivalent¹⁸ for 1990 to 2009. Reliable emission estimates of HFCs, PFCs, SF₆ and N₂O (from adipic acid production) are not available prior to 1990.

¹⁷ The emissions of indirect GHGs are included in this report using the UNECE reporting format, thus is inconsistent with the figures reported in MacCarthy et al (2011). Emissions values for the six direct GHGs are consistent with the UK's submission to the UNFCCC.

¹⁸ Different pollutants can be expressed as a carbon equivalent emission by taking their global warming potential relative to CO₂ into account. This then allows comparisons across different pollutant species on a like for like basis.

Figure 7-1 Total UK GHG Emissions 1990-2009 (CO₂ equivalent)

7.2 CARBON DIOXIDE

7.2.1 Key Source Description

UK CO₂ emissions have declined by 20% between 1970 and 2009, as shown in Figure 7.2. The level of emissions depends on the fuel mix and the fuel consumption data. Thus, the fuel combustion sectors such as electricity supply, road transport and industrial and domestic combustion dominate the proportion of total emissions. Details of UK fuel consumption are given annually in the DECC Digest of United Kingdom Energy Statistics (DUKES) (DECC, 2010). The fuel consumption data used to calculate the pollutant emission totals in the NAEI are given in Table 7.3; fuels that are used as feedstock 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).

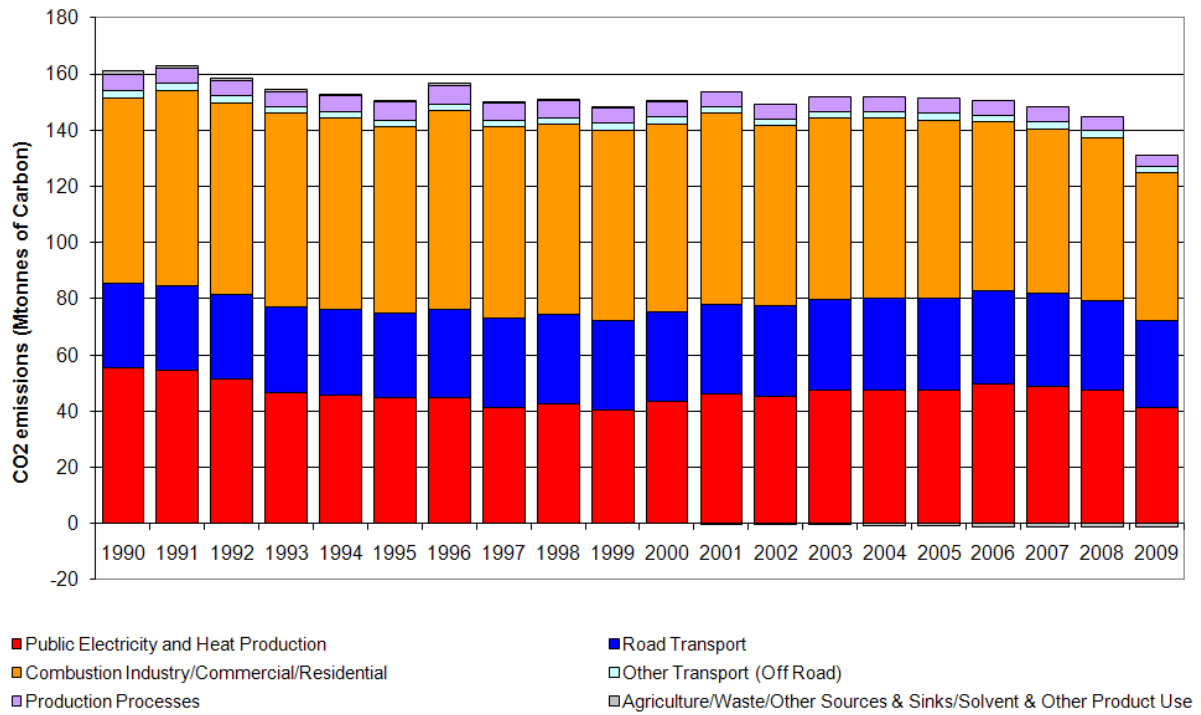
7.2.2 Total Carbon Emissions

Table 7.2 UK Emissions of Carbon by aggregated CRF Source Category (Mtonnes)

	IPCC Codes	1990	2000	2005	2006	2007	2008	2009	2009 %
BY IPCC CATEGORY¹									
Public Electricity and Heat Production	1A1a	55.7	43.5	47.3	49.8	48.7	47.3	41.3	32%
Combustion Industry/Commercial/Residential	1A1b&c\1A2a\1A4a\1A4b\1A4c	44.9	47.5	45.3	43.0	41.6	41.7	38.2	29%
Other Industrial Combustion	1A2f	20.7	19.6	17.9	17.2	16.7	16.4	14.5	11%
Road Transport	1A3b	30.0	31.7	32.8	33.0	33.3	32.1	30.8	24%
LULUCF	5	0.8	-0.1	-1.0	-1.1	-1.2	-1.3	-1.3	-1%
Other Transport (off Road)	1A3a\1A3c-1A3e\1A5b	2.8	2.4	2.6	2.6	2.6	2.5	2.3	2%
Production Processes	1B1\1B2\2	6.0	5.5	5.4	5.0	5.4	5.0	3.9	3%
Agriculture	45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Waste & Non-aerosol household products\ Solvent & Other Product Use	6\7\3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0%
Total		161.2	150.3	150.4	149.5	147.3	143.8	129.8	100%

¹ See MacCarthy et al, 2011 for definitions of IPCC categories

Figure 7-2 Time Series of Carbon Emissions (Mtonnes)



Fuel combustion sources are clearly dominant and occur in urban centres and across the road network (Figure 7-3).

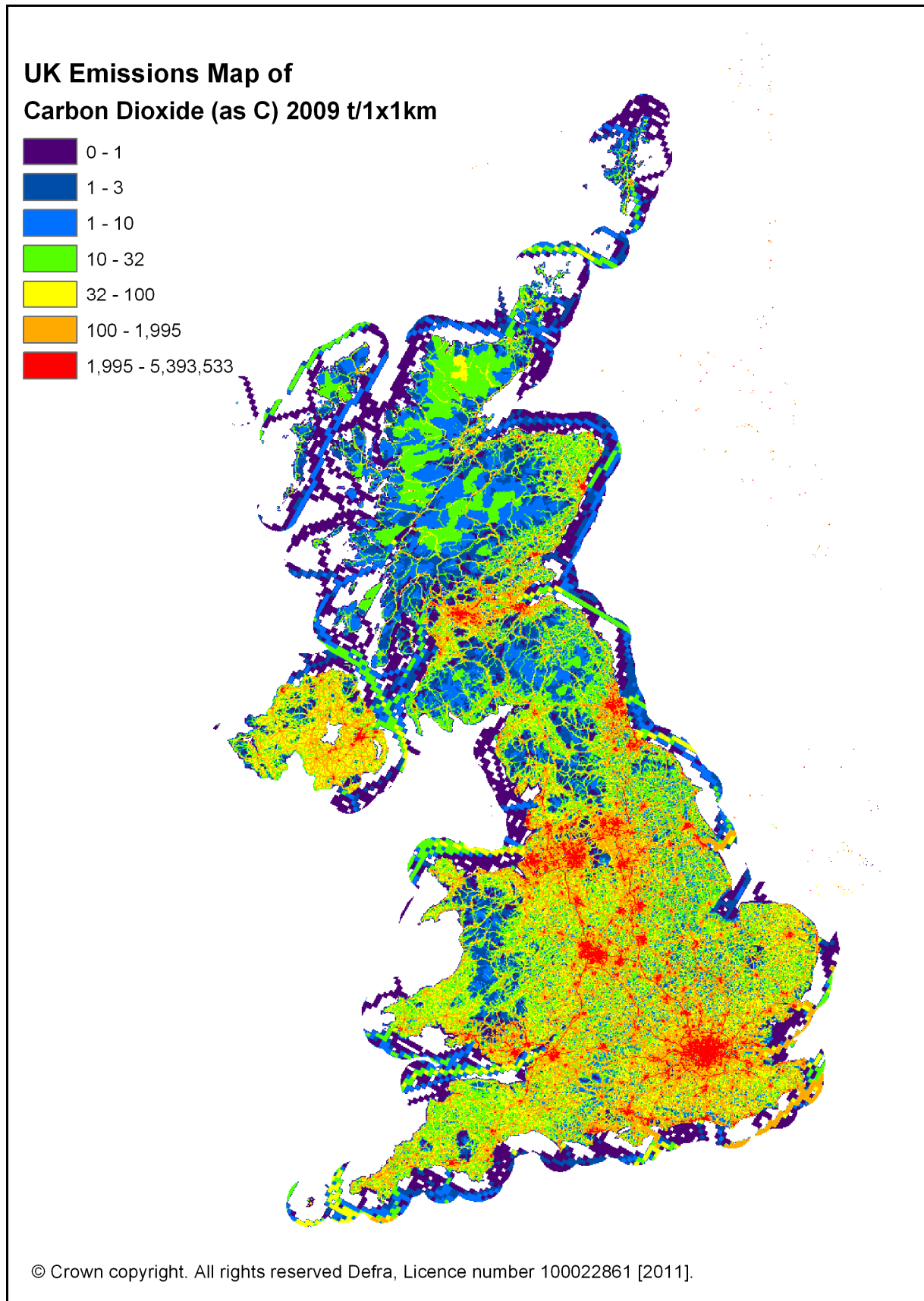
Figure 7-3 Spatially Disaggregated UK Emissions of CO₂ (as Carbon)

Table 7.3 UK Fuel Consumption, 1970-2009

Fuel	Consumer	Units	1970	1980	1990	2000	2005	2006	2007	2008	2009
Coal	Domestic	Mt	20.1	8.9	4.2	1.9	0.6	0.6	0.6	0.7	0.7
Coal	Industry	Mt	21.5	8.5	7.9	3.8	3.6	3.6	3.8	3.9	3.5
	Major Power										
Coal	Producers	Mt	77.2	89.6	82.6	44.8	50.6	55.9	51.0	46.3	38.3
Coal	Others	Mt	12.7	4.8	2.8	0.8	0.5	0.4	0.4	0.5	0.6
Other Solid Fuels	All Consumers	Mt	16.7	5.7	3.7	1.7	1.1	1.0	1.0	1.0	0.7
Motor Spirit	Road Transport	Mt	14.2	19.1	24.2	21.3	18.7	18.1	17.5	16.6	15.7
Gas Oil	Industry	Mt	5.8	5.1	3.2	3.2	3.2	2.9	2.9	2.7	2.2
Gas Oil	Others	Mt	6.1	6.1	4.2	3.2	3.1	2.7	2.7	2.7	2.6
DERV	Road Transport	Mt	5.0	5.8	10.6	15.6	19.4	20.1	21.0	20.6	20.0
Fuel Oil	Industry	Mt	20.3	10.1	4.1	0.8	0.7	0.6	0.7	0.5	0.5
	Major Power										
Fuel Oil	Producers	Mt			0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Major Power										
Fuel Oil	Producers	Mt	12.1	6.4	6.0	0.8	0.7	0.7	0.5	0.9	0.6
Fuel Oil	Others	Mt	6.0	2.5	1.3	0.6	0.4	0.4	0.2	0.3	0.2
Fuel Oil	Refineries	Mt	4.0	3.8	2.1	1.2	1.6	1.0	1.0	0.9	0.7
	Major Power										
Orimulsion	Producers	Mt	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Burning Oil	Domestic	Mt	1.2	1.3	1.5	2.4	2.3	2.4	2.1	2.2	2.2
Burning Oil	Others	Mt	4.0	0.5	0.5	1.3	1.5	1.5	1.4	1.4	1.4
Aviation											
Turbine Fuel	Air Transport	Mt	1.1	1.1	1.4	0.8	0.8	0.8	0.8	0.8	0.7
Other Petroleum Products	All Consumers	Mt	0.5	0.6	1.2	1.6	1.9	2.1	1.9	1.8	1.9
Petroleum Gases	Others	Mth	690	711	664	677	744	767	718	642	624
Petroleum Gases	Refineries	Mth	1011	987	1303	1308	1305	1254	1172	1342	1282
Natural Gas	Domestic	Mth	627	8420	10257	12628	13037	12526	12046	12275	11430
Natural Gas	Industry	Mth	800	6686	7015	10756	9630	9140	8815	8803	7840
	Major Power										
Natural Gas	Producers	Mth	60	55	3	9683	10088	9491	10913	11753	11116
Natural Gas	Others	Mth	2206	2188	3019	4646	4534	4152	3927	3928	3426

7.3 METHANE

7.3.1 Key Source Description

The largest source of methane (CH₄) emissions in the UK arises from landfills, accounting for 37% of total emissions. The agricultural sector where the emissions arise primarily from enteric fermentation in the guts of ruminant animals and from animal wastes accounts for the second largest source.

7.3.2 Total Methane Emissions

Since 1990, the total methane emission in the UK has declined by 60%. There is a wide variety of emissions contributing significant amounts to the methane total. These include landfill sites, livestock in the agricultural sector, leakage during the transmission and distribution of natural gas and coal mines.

Table 7.4 UK Emissions of Methane by UNECE¹ Source Category and Fuel (ktonnes)

	IPCC Codes	1990	2000	2005	2006	2007	2008	2009	2009 %
BY IPCC CATEGORY¹									
Combustion Industry/Commercial/Residential	1A1\1A2\1A4a,b,c	99	64	49	48	49	51	48	2%
Road Transport	1A3b	30	15	8	8	7	6	4	0%
Other Transport (Rail, Aviation, Navigation)	1A3a, 1A3c, 1A3d	0	0	0	0	0	0	0	0%
Coal Mining and Handling	1B1a	870	333	194	180	126	133	136	7%
Production Processes	1B1b-2C	97	65	47	44	55	48	51	2%
Natural gas	1B2b	405	320	234	221	222	208	204	10%
Enteric Fermentation: Cattle	4A1	652	596	592	575	578	565	558	27%
Enteric Fermentation: Sheep	4A10	214	207	170	171	165	160	154	7%
Other Livestock & Agriculture	4A3-9\4B\4F	200	170	158	157	154	151	149	7%
Waste/LULUCF	6\5	2698	1419	873	854	832	807	783	37%
TOTAL		5267	3189	2326	2258	2188	2129	2087	100%

¹ See MacCarthy et al, 2011 for definitions of IPCC categories

Figure 7-4 Time Series of Methane Emissions (Mtonnes)

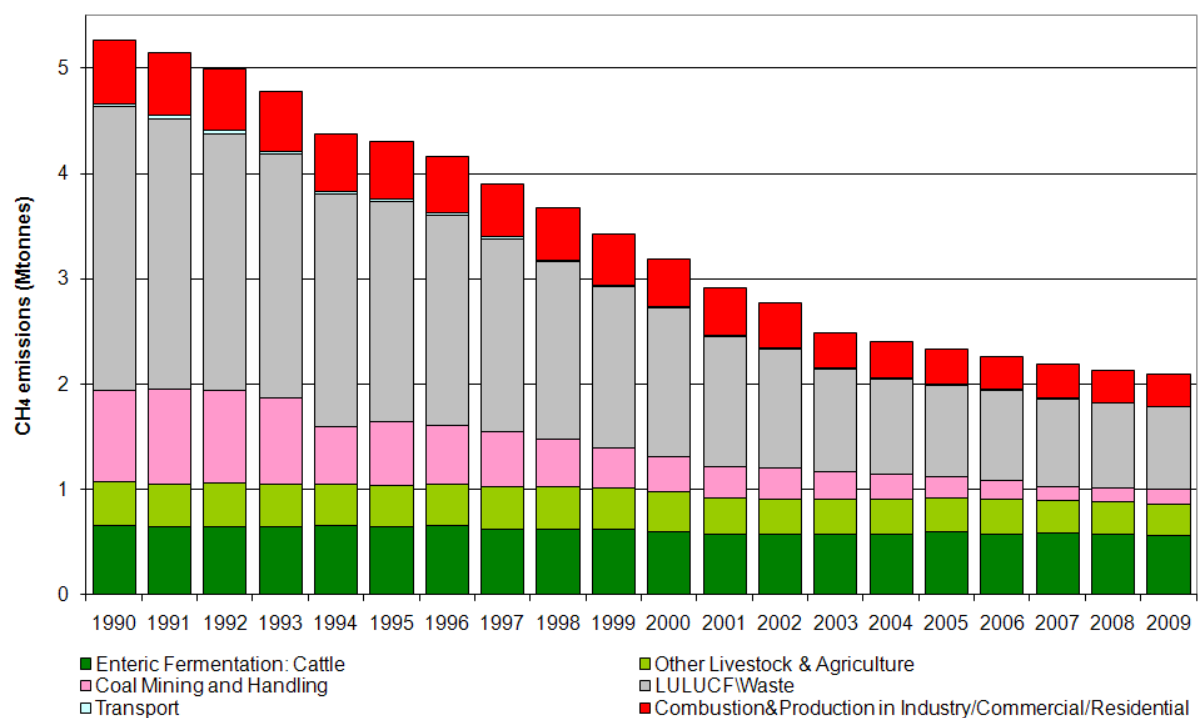
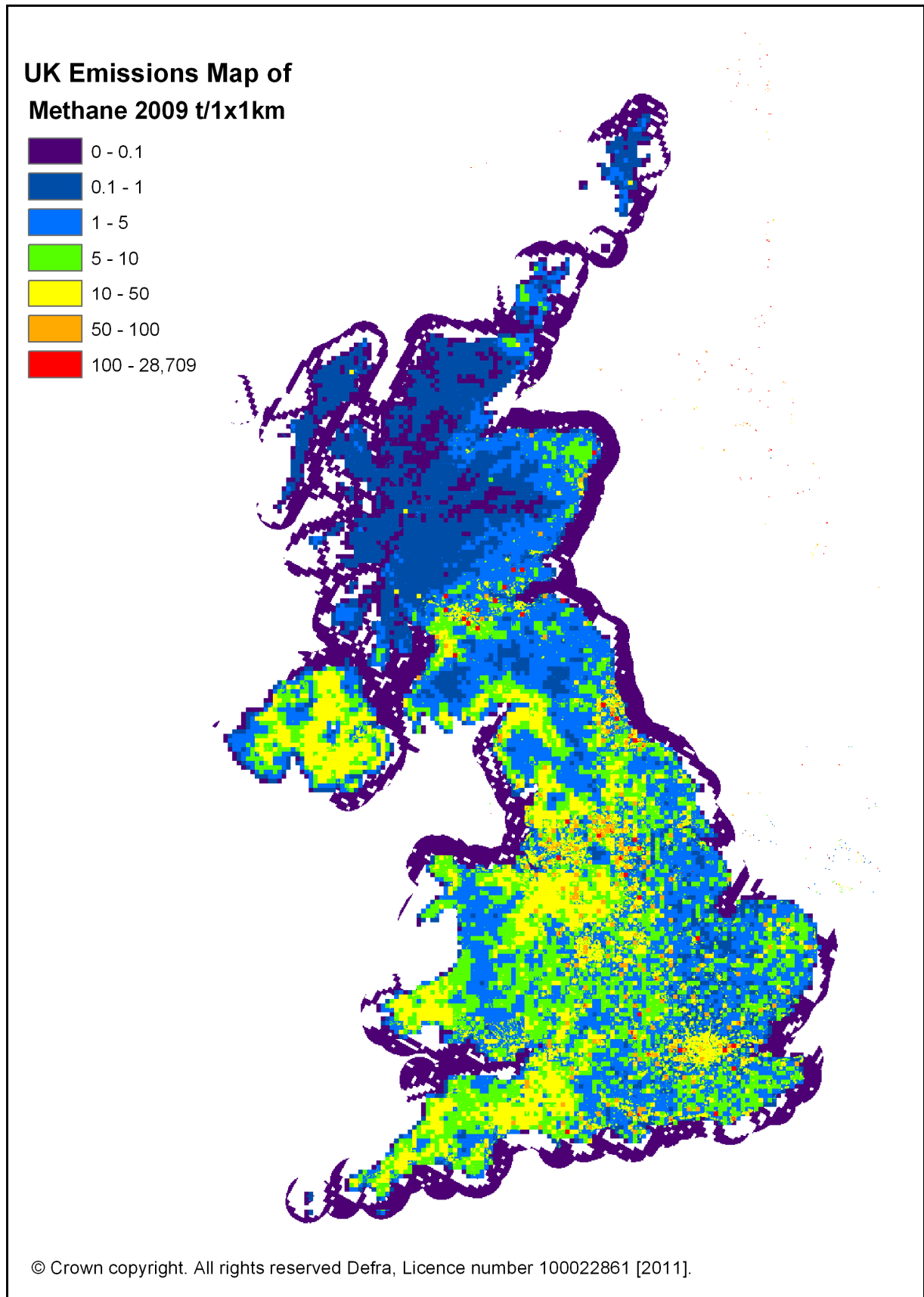


Figure 7-5 Spatially Disaggregated UK Emissions of Methane



7.4 NITROUS OXIDE

7.4.1 Key Source Description

The major source of nitrous oxide emissions in the UK is from agricultural activities. The emissions from agricultural soils currently account for around 72% of total UK emissions. The most significant sources are fertiliser application and emissions indirectly from leaching. Less significant sources include industrial processes (emissions from adipic acid manufacture and nitric acid manufacture) where emissions have declined significantly since 1998 as a result of an abatement unit being commissioned (Table 7.4 and Figure 7-6).

Emissions from the road transport sector have increased significantly since 1992. This is a direct result of the introduction of three-way catalytic converters, which produce significantly more nitrous oxide than cars not equipped with abatement technology. Between 1990 and 2009 the proportion of vehicle kilometres travelled by cars equipped with catalytic converters has increased from <1% to 100% of petrol cars and therefore emissions of N₂O from road transport have increased substantially. The contribution of road transport to the total N₂O emission is small, but is one of the few sources that has been increasing across the time series. More recent catalysts have addressed this problem and give lower N₂O emissions.

7.4.2 Total Nitrous Oxide Emissions

Table 7.4 UK Emissions of Nitrous Oxide by aggregated UNECE¹ Category and Fuel (ktonnes)

	IPCC Codes	1990	2000	2005	2006	2007	2008	2009	2009%
BY CATEGORY²	IPCC								
Public Electricity and Heat Production	1A1a	5.4	3.1	3.5	3.9	3.6	3.3	2.9	3%
Stationary Combustion	1A1\1A2\1A4a\1a4b\1A4c	4.7	4.7	4.2	4.0	3.8	3.7	3.6	3%
Industrial off-road mobile machinery	1A2f	4.8	4.0	4.0	4.0	4.0	3.9	3.4	3%
		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0%
Road Transport	1A3b	3.8	5.0	4.2	4.1	4.0	3.4	3.2	3%
Other Transport	1A3a\1A3c-1A3e\1A5b	0.9	0.9	1.1	1.1	1.1	1.1	1.1	1%
Production Processes	1B2	79.7	18.1	9.7	7.8	9.0	7.9	3.9	4%
Direct Soil Emission	4D1	103.5	93.8	86.8	82.9	80.7	80.8	80.3	72%
Other Agriculture	4B\4F\4G	9.2	8.2	7.2	7.1	7.0	6.8	6.6	6%
Forestry\Waste	5\6	6.7	7.1	6.9	6.9	6.8	6.7	6.6	6%
TOTAL		218.7	145.0	127.6	121.7	120.1	117.6	111.6	100%

¹ See MacCarthy et al, 2011 for definitions of IPCC categories

Figure 7-6 Time Series of Nitrous Oxide Emissions (ktonnes)

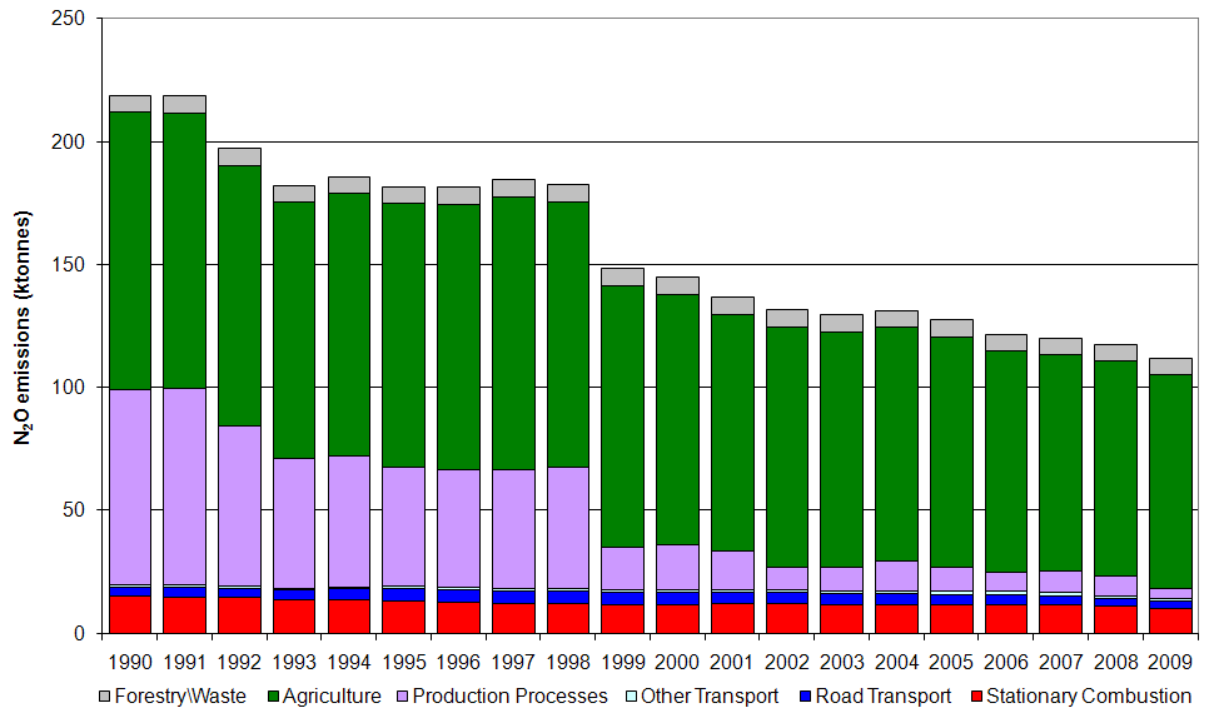
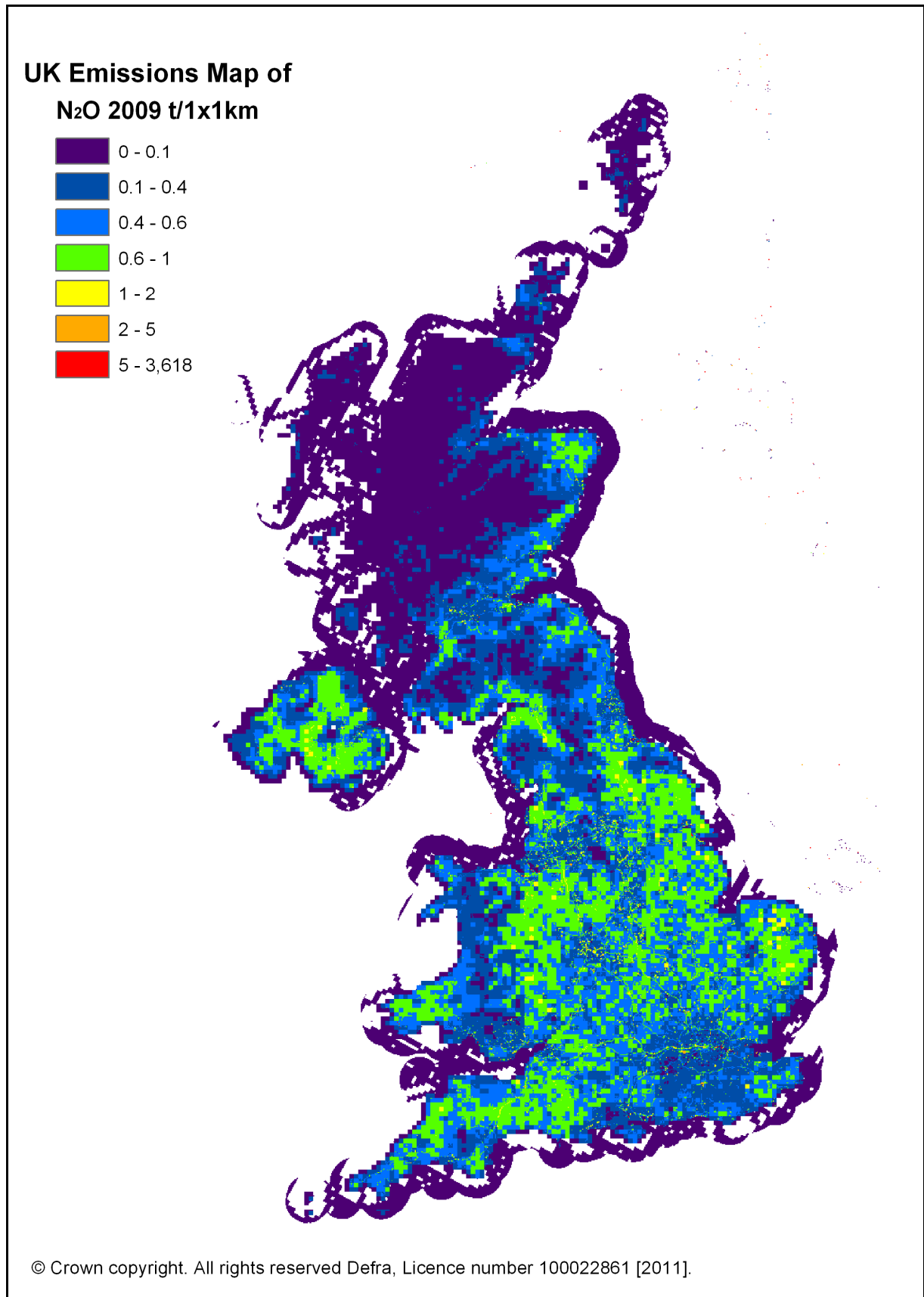


Figure 7-7 Spatially Disaggregated UK Emissions of Nitrous Oxide



7.5 THE FLUORINATED GREENHOUSE GASES: HFC, PFC AND SF₆

7.5.1 Hydrofluorocarbons (HFCs)

The UK emissions of HFCs are shown in Table 7.5. The emissions are reported in terms of kilotonnes of carbon equivalent to account for their global warming potential (GWP). The HFC emissions comprise many species each with its own GWP, hence it is more helpful to express emissions in terms of GWP. It is not currently possible to give emission estimates for individual HFCs because some of these are considered commercially sensitive data within the industries involved.

HFCs had limited usage primarily as refrigerants blended with chlorofluorocarbons (CFCs). However, CFCs and HCFCs are being phased out under the Montreal protocol, and hence HFCs are now being used increasingly as:

- Substitutes for CFCs and HCFCs in domestic, commercial and industrial refrigeration and air conditioning
- Substitutes for CFCs in plastic foam blowing
- Substitutes for CFCs for some medical aerosols
- Substitutes for CFCs for industrial and specialist aerosols
- Fire fighting fluids

The NAEI's annual GHG Inventory Report (MacCarthy et al, 2011) reports the emissions, estimation methodology and ongoing improvements in more detail. The UK reports both actual and potential emissions of HFCs, although here only the actual emissions are presented.

Refrigeration is the largest source and contributed 68% of the total HFC emissions in 2009. Emissions arise due to leakage from refrigeration and air conditioning equipment during its lifetime, from losses during manufacture, and from the recovery of the refrigerants on decommissioning.

There has been a large decrease in emissions from "Halocarbon production" from 1998 to 2009, due to the installation of abatement systems fitted to a plant producing HCFCs and the active move away from the use of HCFCs under the Montreal Protocol in 1987.

In the case of closed foams (where the fluid is retained within the foam) there will be some leakage of HFC from the foam during its lifetime and on disposal but with open foams all losses occur during manufacture. Since 1990, the use of HFCs in aerosols has greatly increased, and this source sector now accounts for 25% of the total emission.

The total UK emission of HFC (in C equivalent) has decreased by 4.0% over 1990-2009 and is characterised by the increasing use of HFCs but offset by the large reduction in emissions from halocarbon production between 1998 and 2009.

Table 7.5 UK Emissions of Hydrofluorocarbons (ktonnes C equivalent)

	IPCC Codes	1990	2000	2005	2006	2007	2008	2009	2009 %
Production Processes	2C & 2E1	3102	714	121	106	49	41	32	1%
Halocarbons use	2F	3	1669	2678	2787	2835	2919	2948	99%
Total		3105.2	2383.5	2799.6	2893.6	2883.3	2960.1	2980.1	100%

¹ Includes metered dose inhalers.

7.5.2 Perfluorocarbons (PFCs)

Table 7.6 shows the UK emissions of PFCs reported as kilotonnes of carbon equivalent. It is not currently possible to give emission estimates for individual PFCs because some of these are considered commercially sensitive data within the industries involved. PFCs had limited usage prior to the phase out of CFCs in the electronics and electrical industry. PFCs are now used in:

- Etching processes in the semiconductor industry
- Chemical vapour deposition in the electronics industry
- Soldering processes
- Leak testing of electrical components
- Cooling electrical components, for example in supercomputers and radar systems.

Other uses include

- Refrigerant blended with HFC
- Fire fighting in specialist applications
- Cushioning in the soles of training shoes

Other minor uses of CFCs, which now use PFCs, include cosmetics and tracer gas.

The largest source of PFCs until 2009 was from the aluminium production sector. The emissions are caused by the anode effect, which occurs when alumina concentrations become too low in the smelter. This can cause very high electrical current and decomposition of the salt - fluorine bath. The fluorine released reacts with the carbon anode, creating PFC compounds CF_4 and C_2F_6 . Emissions from this sector declined by 49% between 2008 and 2009 and therefore now the second largest emitting sector after the use of PFCs in the electronics sector where emissions arise from the manufacture of semiconductors. The aluminium sector and electronics sector account for 41% and 49% of the total emissions respectively.

Table 7.6 UK Emissions of Perfluorocarbons (ktonnes C equivalent)

	IPCC Codes	1990	2000	2005	2006	2007	2008	2009	2009 %
ALUMINIUM PRODUCTION	2C	363	70	16	35	23	32	17	41%
Halocarbons production (by-product)	2E2	3	6	30	25	15	3	3	8%
Halocarbons use	2F	16	51	25	24	23	22	20	51%
Total		382	127	71	83	60	57	40	100%

7.5.3 Sulphur Hexafluoride (SF₆)

SF₆ is used in the following applications:

- insulation medium in high voltage applications such as switchgear and circuit breakers
- cover gas in magnesium foundries to protect the molten magnesium from re-oxidising when it is cast
- degasser in aluminium casting applications, though its use in the UK is rather limited
- insulating gas in double glazing applications, replacing vacuum as an insulation technique
- plasma etching of polysilicon and nitrite surfaces
- atmospheric tracer for scientific studies
- cushioning in soles of training shoes (until 2003)

Table 7.7 shows the UK emissions of SF₆. The largest source is from electrical insulation (included under 2F), where SF₆ is used directly. Emissions from this sector accounted for 77% of the UK total in 2009.

The other main sources are from uses as a cover gas from manufacture of trainers and the magnesium sector. The use of SF₆ as a cushioning agent in trainers will be phased out in the near future. In the magnesium sector, producers have begun using HFCs as an alternative cover gas in 2004 to replace SF₆ and hence the SF₆ emissions from this sector are also decreasing. Emissions from electrical insulation arise during the manufacture and filling of electrical switchgear and from leakage and maintenance during the equipment's lifetime. This application has only been in use for the last 20 to 30 years and little of the equipment has been decommissioned to date. It is expected that users will take great care over future fluid recovery, so that emissions will be minimised. SF₆ emissions have decreased by 36% since 1990.

Table 7.7 UK Emissions of Sulphur Hexafluoride (ktonnes C equivalent)

	IPPC Codes	1990	2000	2005	2006	2007	2008	2009	2009 %
METAL PRODUCTION	2C	116	298	69	49	40	24	21	12%
Halocarbons use	2F	165	192	234	190	176	170	159	88%
Total		281	490	303	239	216	194	180	100%

8 Crown Dependencies and Overseas Territories

8.1 INTRODUCTION

The geographical coverage of the UK emission inventories submitted to the UNECE only includes the emissions from the UK and Gibraltar. In addition to these locations, the NAEI also includes emission inventories for other UK Crown Dependencies (CDs) and Overseas Territories (OTs), for 1990 to 2009 inclusive.

Difficulty in obtaining suitable input data limits the application of consistent, robust methodologies to the determination of the CD and OT inventories, and hence these inventories are subject to higher uncertainty than the UK estimates. The differing economic status and climates of these areas has also had to be taken into account.

Under the National Emission Ceilings Directive the “UK” is defined as the United Kingdom (England, Scotland, Wales, Northern Ireland) and Gibraltar. The 1979 Geneva Convention on LRTAP and the 1988 Sofia Protocol (concerning Nitrogen Oxides) define the "UK" as including Bailiwicks of Jersey and Guernsey, the Isle of Man, Gibraltar, and the United Kingdom Sovereign Base Areas of Akrotiri and Dhekhelia on the Island of Cyprus.

Where data are available, emission estimates of NO_x, CO, SO₂ and NMVOC have been compiled for these locations. Tables of emission estimates are presented below for:

- Jersey;
- Guernsey;
- Isle of Man; and
- Gibraltar

[No data are available for the bases on Cyprus.]

8.2 CROWN DEPENDENCY EMISSIONS

8.1.1 THE BAILIWICK OF JERSEY

Table 8.2.1.1 Jersey NO_x emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	0.94	0.95	1.32	1.13	1.18	1.22	1.18	0.99	1.07	0.97	0.63	0.55	0.49	0.33	0.41	0.32	0.31	0.46	0.29	0.27
	Energy - other mobile sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
	Energy - road transport	0.87	0.87	0.86	0.83	0.85	0.81	0.72	0.68	0.68	0.58	0.58	0.55	0.50	0.46	0.42	0.38	0.38	0.34	0.34	0.28
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	1.81	1.82	2.18	1.96	2.03	2.03	1.90	1.67	1.75	1.55	1.22	1.10	1.00	0.79	0.84	0.70	0.69	0.80	0.63	0.56

Table 8.2.1.2 Jersey CO emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	1.10	1.10	0.67	0.94	0.78	0.76	0.80	0.64	0.63	0.56	0.51	0.48	0.38	0.34	0.36	0.33	0.28	0.26	0.24	0.24
	Energy - other mobile sources	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
	Energy - road transport	7.31	7.39	7.32	7.08	6.96	6.66	6.10	5.29	5.03	4.10	3.77	3.21	2.76	2.50	2.14	1.90	1.71	1.51	1.43	0.95
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	8.43	8.51	8.00	8.03	7.74	7.44	6.91	5.94	5.68	4.68	4.30	3.70	3.16	2.85	2.51	2.24	1.99	1.76	1.67	1.19

Table 8.2.1.3 Jersey SO₂ emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	3.59	3.47	5.01	4.30	4.29	4.05	4.20	2.79	3.16	2.71	1.44	1.37	1.00	0.34	0.50	0.29	0.34	0.62	0.26	0.24
	Energy - other mobile sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Energy - road transport	0.05	0.04	0.05	0.04	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	3.64	3.51	5.06	4.34	4.34	4.09	4.23	2.82	3.19	2.73	1.44	1.38	1.00	0.35	0.50	0.29	0.34	0.62	0.26	0.24

Table 8.2.1.4 Jersey NMVOC emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	0.09	0.09	0.06	0.08	0.07	0.07	0.07	0.06	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02
	Energy - other mobile sources	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Energy - road transport	0.94	0.95	0.93	0.89	0.88	0.84	0.76	0.65	0.61	0.50	0.46	0.40	0.34	0.29	0.24	0.22	0.19	0.17	0.16	0.10
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	1.06	0.97	0.88	0.79	0.74	0.68	0.65	0.62	0.57	0.55	0.54	0.54	0.52	0.51	0.50	0.49	0.48	0.48	0.46	0.45
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	2.10	2.02	1.87	1.76	1.70	1.59	1.48	1.32	1.24	1.10	1.05	0.98	0.90	0.83	0.77	0.73	0.70	0.67	0.64	0.57

8.1.2 THE BAILIWICK OF GUERNSEYTable 8.2.2.1 Guernsey NO_x emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	0.64	0.77	0.66	0.69	0.69	0.72	0.75	0.75	0.75	0.75	0.71	0.25	0.25	0.27	0.24	0.32	0.48	0.43	0.48	0.50
	Energy - other mobile sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Energy - road transport	0.89	1.02	0.90	0.90	0.87	0.85	0.84	0.85	0.76	0.69	0.73	0.55	0.51	0.49	0.42	0.38	0.33	0.34	0.23	0.20
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	1.53	1.79	1.57	1.59	1.56	1.58	1.59	1.60	1.51	1.44	1.44	0.79	0.76	0.76	0.65	0.70	0.81	0.77	0.72	0.70

Table 8.2.2.2 Guernsey CO emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	0.09	0.10	0.09	0.09	0.09	0.10	0.10	0.09	0.11	0.12	0.12	0.05	0.05	0.05	0.04	0.05	0.08	0.05	0.06	0.07
	Energy - other mobile sources	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01
	Energy - road transport	4.80	4.56	4.36	4.09	4.00	3.88	3.56	3.65	3.20	3.13	2.65	2.34	1.82	1.68	1.56	1.47	1.32	1.19	1.03	0.70
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	4.89	4.68	4.47	4.21	4.11	4.00	3.68	3.76	3.32	3.26	2.78	2.40	1.88	1.74	1.62	1.54	1.41	1.25	1.10	0.77

Table 8.2.2.3 Guernsey SO₂ emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	2.55	2.94	2.51	2.69	2.54	2.42	2.67	2.27	2.44	2.25	1.94	0.39	0.33	0.33	0.23	0.31	0.57	0.38	0.54	0.42
	Energy - other mobile sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Energy - road transport	0.07	0.08	0.07	0.07	0.07	0.06	0.04	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	2.63	3.02	2.58	2.76	2.60	2.47	2.72	2.30	2.46	2.26	1.95	0.39	0.33	0.34	0.23	0.32	0.57	0.39	0.54	0.43

Table 8.2.2.4 Guernsey NMVOC emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Energy - other mobile sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Energy - road transport	0.85	0.70	0.62	0.56	0.54	0.52	0.48	0.48	0.42	0.40	0.35	0.30	0.23	0.20	0.18	0.17	0.15	0.14	0.12	0.08
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0.39	0.40	0.39	0.39	0.37	0.37	0.36	0.35	0.34	0.33	0.33	0.33	0.32	0.31	0.31	0.31	0.35	0.35	0.35	0.35
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0.03	0.03	0.04	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Total	1.28	1.15	1.06	0.99	0.95	0.93	0.88	0.88	0.80	0.78	0.71	0.66	0.57	0.53	0.52	0.51	0.53	0.51	0.49	0.45

8.1.3 THE ISLE OF MAN

Table 8.2.3.1 The Isle of Man NO_x emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	0.74	0.76	0.77	0.79	0.79	0.85	0.88	0.98	0.99	1.03	0.85	0.44	0.45	0.31	0.39	0.45	0.41	0.42	0.43	0.41
	Energy - other mobile sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Energy - road transport	0.66	0.66	0.65	0.60	0.56	0.57	0.84	0.77	0.80	0.75	0.64	0.71	0.71	0.76	0.76	0.77	0.77	0.75	0.76	0.76
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	1.40	1.43	1.43	1.39	1.35	1.41	1.72	1.75	1.80	1.78	1.48	1.15	1.15	1.06	1.15	1.22	1.18	1.18	1.20	1.17

Table 8.2.3.2 The Isle of Man CO emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	4.46	4.46	4.46	4.47	4.47	4.48	4.48	3.74	3.04	2.33	1.57	1.27	1.12	0.61	0.61	0.63	0.62	0.63	0.62	0.63
	Energy - other mobile sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Energy - road transport	4.91	4.95	4.91	4.42	4.09	3.94	5.61	4.56	4.40	3.89	2.22	2.65	2.25	2.23	1.83	1.72	1.58	1.47	1.33	0.90
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	9.37	9.41	9.38	8.89	8.56	8.42	10.10	8.30	7.45	6.22	3.79	3.93	3.38	2.85	2.45	2.35	2.20	2.10	1.95	1.52

Table 8.2.3.3 The Isle of Man SO₂ emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	3.46	3.44	3.41	3.57	3.42	3.41	3.73	3.20	3.27	3.09	2.23	0.67	0.55	0.20	0.19	0.19	0.18	0.17	0.16	0.15
	Energy - other mobile sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Energy - road transport	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	3.50	3.48	3.45	3.61	3.46	3.45	3.77	3.23	3.30	3.11	2.24	0.67	0.55	0.21	0.19	0.19	0.18	0.18	0.16	0.15

Table 8.2.3.4 The Isle of Man NMVOC emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.33	0.26	0.20	0.13	0.11	0.10	0.06	0.06	0.06	0.06	0.05	0.05	0.05
	Energy - other mobile sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Energy - road transport	0.62	0.62	0.61	0.55	0.50	0.49	0.69	0.56	0.54	0.48	0.28	0.34	0.28	0.27	0.22	0.21	0.19	0.17	0.16	0.11
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0.44	0.43	0.40	0.38	0.36	0.35	0.35	0.35	0.35	0.35	0.37	0.38	0.38	0.41	0.42	0.41	0.42	0.43	0.42	0.42
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Total	1.48	1.46	1.43	1.34	1.28	1.25	1.45	1.26	1.17	1.05	0.80	0.84	0.78	0.75	0.69	0.68	0.66	0.65	0.63	0.58

8.1.4 GIBRALTARTable 8.2.4.1 Gibraltar NO_x emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	0.35	0.37	0.36	0.33	0.34	0.33	0.31	0.33	0.32	0.34	0.33	0.31	0.29	0.29	0.30	0.33	0.31	0.33	0.32	0.33
	Energy - other mobile sources	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Energy - road transport	0.17	0.16	0.19	0.13	0.12	0.12	0.11	0.11	0.11	0.11	0.13	0.13	0.14	0.17	0.21	0.18	0.18	0.12	0.12	0.13
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	0.56	0.57	0.59	0.50	0.51	0.49	0.47	0.48	0.47	0.49	0.51	0.45	0.44	0.47	0.52	0.51	0.49	0.45	0.46	0.48

Table 8.2.4.2 Gibraltar CO emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	0.08	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.11
	Energy - other mobile sources	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Energy - road transport	1.61	1.50	1.88	1.31	1.28	1.14	1.14	1.10	1.02	1.01	0.93	0.83	0.85	0.77	0.71	0.65	0.57	0.50	0.42	0.34
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	1.71	1.60	1.98	1.41	1.38	1.23	1.24	1.19	1.11	1.10	1.03	0.93	0.94	0.87	0.81	0.75	0.67	0.60	0.53	0.45

Table 8.2.4.3 Gibraltar SO₂ emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Energy - Power stations and small combustion sources	1.01	1.02	0.98	0.99	0.93	0.84	0.79	0.76	0.75	0.72	0.71	0.56	0.47	0.43	0.40	0.42	0.41	0.40	0.43	0.41
	Energy - other mobile sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Energy - road transport	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0.03	0.03	0.03	0.02	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	1.05	1.06	1.02	1.01	0.95	0.86	0.81	0.77	0.76	0.73	0.72	0.56	0.47	0.43	0.40	0.42	0.41	0.40	0.43	0.41

Table 8.2.4.4 Gibraltar NMVOC emissions (ktonnes)

NFR Codes	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
1	Energy - Power stations and small combustion sources	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Energy - other mobile sources	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Energy - road transport	0.21	0.20	0.24	0.17	0.17	0.15	0.16	0.16	0.14	0.14	0.13	0.11	0.13	0.10	0.09	0.08	0.07	0.06	0.05	0.04	0.04
2	Industrial processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Solvent use	0.18	0.18	0.17	0.15	0.15	0.14	0.13	0.13	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.14
4	Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Land use change and forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	0.40	0.39	0.42	0.33	0.33	0.30	0.31	0.31	0.28	0.27	0.27	0.25	0.27	0.25	0.24	0.23	0.23	0.22	0.21	0.21	0.21

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Annex 1

Definitions of UNECE Source Sectors

CONTENTS

- 1. UNECE Classification of Emission Sources
- Table A1 Mapping of NAEI Base Categories to NFR

1. UNECE Classification of Emission Sources

For this report, the NAEI emission estimates have been reported according to the UNECE/CORINAIR Nomenclature for Reporting (NFR) Categories. These categories replaced the commonly used SNAP categories for official reporting of non-GHGs in 2000. The reason that the reporting structure was changed was to promote harmonisation with the CRF reporting structure used in the official reporting of GHG emissions.

The change from using SNAP codes to NFR codes in this report has only now been made because the SNAP reporting format was considered generally preferable for several reasons. One of these is that the SNAP structure is considered more intuitive, and therefore more user-friendly for those not in day-to-day contact with emission inventories. In addition, it is a reporting structure, which is generally preferred by emission inventory compilers themselves. Table A1 below summarises the NFR reporting structure.

The NFR reporting structure, and the way in which it relates to UK Inventory categories is listed in detail as Table A2 below. In many cases the NAEI categories shown here are aggregates of more detailed emission sectors. The sectors are presented in this way in Table A2 to allow an in depth understanding of the source sector content without presenting an excessive amount of information. In addition, the names of several NAEI categories have been changed to enable a fuller understanding by those not familiar with some of the nomenclature.

There are currently on-going discussions at the international level regarding amendments to the NFR reporting structure, but changes are likely to be small.

The NAEI reports emissions from the combustion of fuels and non-combustion emissions from a range of sectors. The fuels data are taken from the Digest of UK Energy Statistics (DUKES), (BERR, 2008). Hence the fuel definitions and the choice of base sector categories used in the NAEI often reflect those in the DUKES publications. The choice of non-combustion sources generally reflects the availability of data on the emissions from specific activities.

The allocation of a particular source to one of these sectors is well defined and given in more detail in Table A2. The majority of allocations are easy to understand. For example, emissions arising from fuel combustion in the manufacture of glass will come under “1A2 Manufacturing Industries and Construction”. Emission arising from the manufacture/handling of the glass material itself and the raw materials will come under “2A Mineral Products”.

Table A1- A Summary of the NFR Reporting Structure

1A	FUEL COMBUSTION
1A1a	1 A 1 a Public Electricity and Heat Production
1A1b	1 A 1 b Petroleum refining
1A1c	1 A 1 c Manufacture of Solid Fuels and Other Energy Industries
1A2	1 A 2 Manufacturing Industries and Construction
1A3ai(i)	1 A 3 a i Civil Aviation (International, LTO)
1A3aii(i)	1 A 3 a ii Civil Aviation (Domestic, LTO)
1A3b	1 A 3 b Road Transportation
1A3c	1 A 3 c Railways
1A3dii	1 A 3 d ii National Navigation
1A3e	1 A 3 e Other (Please specify in a covering note)
1A4a	1 A 4 a Commercial / Institutional Combustion
1A4b	1 A 4 b Residential
1A4c	1 A 4 c Agriculture / Forestry / Fishing
1A5a	1 A 5 a Other, Stationary (including Military)
1A5b	1 A 5 b Other, Mobile (Including military)
1B	FUGITIVE EMISSIONS FROM FUELS
1B1	1B1 Fugitive Emissions from Solid Fuels
1B2	1 B 2 Oil and natural gas
2	PROCESSES
2A	2 A MINERAL PRODUCTS (b)
2B	2 B CHEMICAL INDUSTRY
2C	2 C METAL PRODUCTION
2D	2 D OTHER PRODUCTION (b)
2G	2 G OTHER
3	SOLVENT USE
3A	3 A PAINT APPLICATION
3B	3 B DEGREASING AND DRY CLEANING
3C	3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING
3D	3 D OTHER including products containing HMs and POPs
4	AGRICULTURE
4B	4 B MANURE MANAGEMENT (c)
4C	4 C RICE CULTIVATION
4D1	4 D 1 Direct Soil Emission
4F	4 F FIELD BURNING OF AGRICULTURAL WASTES
4G	4 G OTHER (d)
5B	5 B FOREST AND GRASSLAND CONVERSION
6	WASTE
6A	6 A SOLID WASTE DISPOSAL ON LAND
6B	6 B WASTE-WATER HANDLING
6C	6 C WASTE INCINERATION (e)
6D	6 D OTHER WASTE (f)
7	7 OTHER
	MEMO ITEMS
1A3ai(ii)	International Aviation (Cruise)
1A3aii(ii)	Domestic Aviation (Cruise)
1A3di(i)	International maritime Navigation
1A3di(ii)	International inland waterways (Included in NEC totals only)
5E	5 E Other
X	X (11 08 Volcanoes)

A2 Mapping of NAEI Base Categories to NFR

NFRCode	NFRName	SourceName
0	Not used for NFR	Cropland - Biomass Burning
0	Not used for NFR	Cropland remaining Cropland
0	Not used for NFR	Direct N2O emission from N fertilisation of forest land
0	Not used for NFR	Exports
0	Not used for NFR	Forest Land - Biomass burning
0	Not used for NFR	Forest Land - Drainage of Organic Soils
0	Not used for NFR	Forest Land remaining Forest Land
0	Not used for NFR	Grassland - Biomass Burning
0	Not used for NFR	Grassland Conversion
0	Not used for NFR	Grassland remaining Grassland
0	Not used for NFR	Harvested Wood Products
0	Not used for NFR	Land converted to Cropland
0	Not used for NFR	Land converted to Forest Land
0	Not used for NFR	Land converted to Grassland
0	Not used for NFR	Land converted to Other Land
0	Not used for NFR	Land converted to Settlements
0	Not used for NFR	Land converted to Wetland
0	Not used for NFR	N2O emissions from disturbance associated with land-use conversion to cropland
0	Not used for NFR	Non-CO2 emissions from drainage of soils and wetlands
0	Not used for NFR	Other Land - Biomass Burning
0	Not used for NFR	Other Land remaining Other Land
0	Not used for NFR	OvTerr LULUCF - Cayman, Falklands, Montserrat, Bermuda and Gibraltar
0	Not used for NFR	OvTerr LULUCF - Jersey, Guernsey and IOM
0	Not used for NFR	Settlements - Biomass Burning
0	Not used for NFR	Settlements remaining Settlements
0	Not used for NFR	Shipping - UK international
0	Not used for NFR	Wetlands - Biomass Burning
0	Not used for NFR	Wetlands remaining Wetland
1A1a	1 A 1 a Public Electricity and Heat Production	Other industrial combustion
1A1a	1 A 1 a Public Electricity and Heat Production	Power stations
1A1b	1 A 1 b Petroleum refining	Refineries - combustion
1A1c	1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	Coke production
1A1c	1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	Collieries - combustion
1A1c	1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	Gas production
1A1c	1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	Gas Production - combustion at gas separation plant
1A1c	1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	Gas Production - gas combustion
1A1c	1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	Nuclear fuel production
1A1c	1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	Oil Production - gas combustion
1A1c	1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	Solid smokeless fuel production
1A1c	1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	Town gas manufacture
1A2a	1 A 2 a Iron and Steel	Blast furnaces
1A2a	1 A 2 a Iron and Steel	Iron and steel - combustion plant
1A2fi	1 A 2 f i Stationary combustion in manufacturing industries and construction: Other (Please specify in your IIR)	Ammonia production - combustion
1A2fi	1 A 2 f i Stationary combustion in manufacturing	Autogenerators

	industries and construction: Other (Please specify in your IIR)	
1A2fi	1 A 2 f i Stationary combustion in manufacturing industries and construction: Other (Please specify in your IIR)	Cement - non-decarbonising
1A2fi	1 A 2 f i Stationary combustion in manufacturing industries and construction: Other (Please specify in your IIR)	Cement production - combustion
1A2fi	1 A 2 f i Stationary combustion in manufacturing industries and construction: Other (Please specify in your IIR)	Industrial engines
1A2fi	1 A 2 f i Stationary combustion in manufacturing industries and construction: Other (Please specify in your IIR)	Lime production - non decarbonising
1A2fi	1 A 2 f i Stationary combustion in manufacturing industries and construction: Other (Please specify in your IIR)	Other industrial combustion
1A2fii	1 A 2 f ii Mobile Combustion in manufacturing industries and construction: (Please specify in your IIR)	Industrial off-road mobile machinery
1A3ai(i)	International Aviation- LTO	Aircraft - international take off and landing
1A3ai(i)	International Aviation- LTO	Aircraft engines
1A3ai(i)	International Aviation- LTO	OvTerr Aviation (all)- Cayman, Falkland, Montserrat, Bermuda and Gibraltar
1A3aii(i)	1 A 3 a ii Civil Aviation (Domestic, LTO)	Aircraft - domestic take off and landing
1A3aii(i)	1 A 3 a ii Civil Aviation (Domestic, LTO)	Aircraft between UK and Gibraltar - TOL
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - all vehicles LPG use
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - all vehicles LRP use
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - cars - cold start
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - cars - motorway driving
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - cars - rural driving
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - cars - urban driving
1A3bi	1 A 3 b i R.T., Passenger cars	Road Transport - cars Dioxins/PCP
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - cars non catalyst - cold start
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - cars non catalyst - motorway driving
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - cars non catalyst - rural driving
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - cars non catalyst - urban driving
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - cars with catalysts - cold start
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - cars with catalysts - motorway driving
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - cars with catalysts - rural driving
1A3bi	1 A 3 b i R.T., Passenger cars	Road transport - cars with catalysts - urban driving
1A3bi	1 A 3 b i R.T., Passenger cars	Road vehicle engines
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road transport - all vehicles biofuels use
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road transport - LGVs - cold start
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road transport - LGVs - motorway driving
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road transport - LGVs - rural driving
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road transport - LGVs - urban driving
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road Transport - LGVs Dioxins
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road transport - LGVs non catalyst - cold start
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road transport - LGVs non catalyst - motorway driving
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road transport - LGVs non catalyst - rural driving
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road transport - LGVs non catalyst - urban driving
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road transport - LGVs with catalysts - cold start
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road transport - LGVs with catalysts - motorway driving
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road transport - LGVs with catalysts - rural driving
1A3bii	1 A 3 b ii R.T., Light duty vehicles	Road transport - LGVs with catalysts - urban driving
1A3biii	1 A 3 b iii R.T., Heavy duty vehicles	Road transport - buses and coaches - motorway

		driving
1A3biii	1 A 3 b iii R.T., Heavy duty vehicles	Road transport - buses and coaches - rural driving
1A3biii	1 A 3 b iii R.T., Heavy duty vehicles	Road transport - buses and coaches - urban driving
1A3biii	1 A 3 b iii R.T., Heavy duty vehicles	Road transport - HGV articulated - motorway driving
1A3biii	1 A 3 b iii R.T., Heavy duty vehicles	Road transport - HGV articulated - rural driving
1A3biii	1 A 3 b iii R.T., Heavy duty vehicles	Road transport - HGV articulated - urban driving
1A3biii	1 A 3 b iii R.T., Heavy duty vehicles	Road transport - HGV rigid - motorway driving
1A3biii	1 A 3 b iii R.T., Heavy duty vehicles	Road transport - HGV rigid - rural driving
1A3biii	1 A 3 b iii R.T., Heavy duty vehicles	Road transport - HGV rigid - urban driving
1A3biii	1 A 3 b iii R.T., Heavy duty vehicles	Road Transport - HGVs/buses Dioxins
1A3biv	1 A 3 b iv R.T., Mopeds & Motorcycles	Road Transport - Mopeds & Motorcycles Dioxins
1A3biv	1 A 3 b iv R.T., Mopeds & Motorcycles	Road transport - mopeds (<50cc 2st) - urban driving
1A3biv	1 A 3 b iv R.T., Mopeds & Motorcycles	Road transport - motorcycle (>50cc 2st) - rural driving
1A3biv	1 A 3 b iv R.T., Mopeds & Motorcycles	Road transport - motorcycle (>50cc 2st) - urban driving
1A3biv	1 A 3 b iv R.T., Mopeds & Motorcycles	Road transport - motorcycle (>50cc 4st) - motorway driving
1A3biv	1 A 3 b iv R.T., Mopeds & Motorcycles	Road transport - motorcycle (>50cc 4st) - rural driving
1A3biv	1 A 3 b iv R.T., Mopeds & Motorcycles	Road transport - motorcycle (>50cc 4st) - urban driving
1A3bv	1 A 3 b v R.T., Gasoline evaporation	Road transport - cars - evaporative
1A3bv	1 A 3 b v R.T., Gasoline evaporation	Road transport - LGVs - evaporative
1A3bv	1 A 3 b v R.T., Gasoline evaporation	Road transport - mopeds (<50cc 2st) - evaporative
1A3bv	1 A 3 b v R.T., Gasoline evaporation	Road transport - motorcycle (>50cc 2st) - evaporative
1A3bv	1 A 3 b v R.T., Gasoline evaporation	Road transport - motorcycle (>50cc 4st) - evaporative
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - buses and coaches - motorway driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - buses and coaches - rural driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - buses and coaches - urban driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - cars - motorway driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - cars - rural driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - cars - urban driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - HGV articulated - motorway driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - HGV articulated - rural driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - HGV articulated - urban driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - HGV rigid - motorway driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - HGV rigid - rural driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - HGV rigid - urban driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - LGVs - motorway driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - LGVs - rural driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - LGVs - urban driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - mopeds (<50cc 2st) - urban driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - motorcycle (>50cc 2st) - rural driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - motorcycle (>50cc 2st) - urban driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - motorcycle (>50cc 4st) - motorway driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - motorcycle (>50cc 4st) - rural driving
1A3bvi	1 A 3 b vi R.T., Automobile tyre and brake wear	Road transport - motorcycle (>50cc 4st) - urban driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - buses and coaches - motorway driving

1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - buses and coaches - rural driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - buses and coaches - urban driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - cars - motorway driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - cars - rural driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - cars - urban driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - HGV articulated - motorway driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - HGV articulated - rural driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - HGV articulated - urban driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - HGV rigid - motorway driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - HGV rigid - rural driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - HGV rigid - urban driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - LGVs - motorway driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - LGVs - rural driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - LGVs - urban driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - mopeds (<50cc 2st) - urban driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - motorcycle (>50cc 2st) - rural driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - motorcycle (>50cc 2st) - urban driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - motorcycle (>50cc 4st) - motorway driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - motorcycle (>50cc 4st) - rural driving
1A3bvii	1 A 3 b vii R.T., Automobile road abrasion	Road transport - motorcycle (>50cc 4st) - urban driving
1A3c	1 A 3 c Railways	Rail - coal
1A3c	1 A 3 c Railways	Railways - freight
1A3c	1 A 3 c Railways	Railways - intercity
1A3c	1 A 3 c Railways	Railways - regional
1A3dii	1 A 3 d ii National Navigation	Marine engines
1A3dii	1 A 3 d ii National Navigation	Shipping - coastal
1A4ai	1 A 4 a i Commercial / institutional: Stationary	Miscellaneous industrial/commercial combustion
1A4ai	1 A 4 a i Commercial / institutional: Stationary	Public sector combustion
1A4ai	1 A 4 a i Commercial / institutional: Stationary	Railways - stationary combustion
1A4bi	1 A 4 b i Residential plants	Domestic combustion
1A4bii	1 A 4 b ii Household and gardening (mobile)	House and garden machinery
1A4ci	1 A 4 c i Stationary	Agriculture - stationary combustion
1A4cii	1 A 4 c ii Off-road Vehicles and Other Machinery	Agricultural engines
1A4cii	1 A 4 c ii Off-road Vehicles and Other Machinery	Agriculture - mobile machinery
1A4cii	1 A 4 c ii Off-road Vehicles and Other Machinery	OvTerr Other Mobile (all)- Cayman, Falkland, Montserrat, Bermuda and Gibraltar
1A4ciii	1A 4 c iii National Fishing	Fishing vessels
1A5b	1 A 5 b Other, Mobile (Including military)	Aircraft - military
1A5b	1 A 5 b Other, Mobile (Including military)	Aircraft - support vehicles
1A5b	1 A 5 b Other, Mobile (Including military)	Shipping - naval
1B1a	1 B 1 a Coal Mining and Handling	Closed Coal Mines
1B1a	1 B 1 a Coal Mining and Handling	Coal storage and transport
1B1a	1 B 1 a Coal Mining and Handling	Deep-mined coal
1B1a	1 B 1 a Coal Mining and Handling	Open-cast coal
1B1b	1 B 1 b Solid fuel transformation	Coke production
1B1b	1 B 1 b Solid fuel transformation	Iron and steel - flaring
1B1b	1 B 1 b Solid fuel transformation	Solid smokeless fuel production
1B2ai	1 B 2 a i Exploration Production, Transport	Gas Production - Gas terminal storage
1B2ai	1 B 2 a i Exploration Production, Transport	Gas Production - Offshore Well Testing
1B2ai	1 B 2 a i Exploration Production, Transport	Gas Production - process emissions
1B2ai	1 B 2 a i Exploration Production, Transport	Gasification processes
1B2ai	1 B 2 a i Exploration Production, Transport	Oil Production - Offshore Oil Loading
1B2ai	1 B 2 a i Exploration Production, Transport	Oil Production - Offshore Well Testing
1B2ai	1 B 2 a i Exploration Production, Transport	Oil Production - Oil terminal storage
1B2ai	1 B 2 a i Exploration Production, Transport	Oil Production - Onshore Oil Loading
1B2ai	1 B 2 a i Exploration Production, Transport	Oil Production - process emissions

1B2ai	1 B 2 a i Exploration Production, Transport	Petroleum processes
1B2aiv	1 B 2 a iv Refining / Storage	Refineries - drainage
1B2aiv	1 B 2 a iv Refining / Storage	Refineries - general
1B2aiv	1 B 2 a iv Refining / Storage	Refineries - process
1B2aiv	1 B 2 a iv Refining / Storage	Refineries - tankage
1B2av	1 B 2 a v Distribution of oil products	Petrol stations - petrol delivery
1B2av	1 B 2 a v Distribution of oil products	Petrol stations - spillages
1B2av	1 B 2 a v Distribution of oil products	Petrol stations - storage tanks
1B2av	1 B 2 a v Distribution of oil products	Petrol stations - vehicle refuelling
1B2av	1 B 2 a v Distribution of oil products	Petrol terminals - storage
1B2av	1 B 2 a v Distribution of oil products	Petrol terminals - tanker loading
1B2av	1 B 2 a v Distribution of oil products	Refineries - road/rail loading
1B2av	1 B 2 a v Distribution of oil products	Sea going vessel loading
1B2av	1 B 2 a v Distribution of oil products	Ship purging
1B2b	1 B 2 b Natural gas	Gas leakage
1B2c	1 B 2 c Venting and flaring	Gas Production - gas flaring
1B2c	1 B 2 c Venting and flaring	Gas Production - gas venting
1B2c	1 B 2 c Venting and flaring	Oil Production - gas flaring
1B2c	1 B 2 c Venting and flaring	Oil Production - gas venting
1B2c	1 B 2 c Venting and flaring	Refineries - flares
2A1	2 A 1 Cement Production	Cement - decarbonising
2A1	2 A 1 Cement Production	Slag cement production
2A2	2 A 2 Lime Production	Lime production - decarbonising
2A3	2 A 3 Limestone and Dolomite Use	Basic oxygen furnaces
2A3	2 A 3 Limestone and Dolomite Use	Glass - general
2A3	2 A 3 Limestone and Dolomite Use	Power stations - FGD
2A3	2 A 3 Limestone and Dolomite Use	Sinter production
2A4	2 A 4 Soda Ash Production and use	Chemical industry - soda ash
2A4	2 A 4 Soda Ash Production and use	Glass - general
2A6	2 A 6 Road Paving with Asphalt	Bitumen use
2A6	2 A 6 Road Paving with Asphalt	Other industry - asphalt manufacture
2A7a	2 A 7 a Quarrying and mining of minerals other than coal	Dewatering of lead concentrates
2A7a	2 A 7 a Quarrying and mining of minerals other than coal	Quarrying
2A7b	2 A 7 b Construction and demolition	Construction
2A7c	2A 7 c Storage, handling and transport of mineral products	Cement and concrete batching
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Brick manufacture - Fletton
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Brick manufacture - non Fletton
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Coal tar and bitumen processes
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Glass - container
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Glass - continuous filament glass fibre
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Glass - domestic
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Glass - flat
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Glass - frits
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Glass - glass wool

2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Glass - lead crystal
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Glass - special
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Glazed ceramics
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Refractories - chromite based
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Refractories - non chromite based
2A7d	2 A 7 d Other Mineral products (Please specify the sources included/excluded in the notes column to the right)	Unglazed ceramics
2B1	2 B 1 Ammonia Production	Ammonia production - feedstock use of gas
2B2	2 B 2 Nitric Acid Production	Nitric acid production
2B3	2 B 3 Adipic Acid Production	Adipic acid production
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - alkyl lead
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - ammonia based fertilizer
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - ammonia use
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - cadmium pigments and stabilizers
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - carbon black
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - carbon tetrachloride
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - chloralkali process
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - chromium chemicals
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - ethylene
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - general
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - halogenated chemicals
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - hydrochloric acid use
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - magnesia
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - methanol
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - nitric acid use

2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - pesticide production
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - phosphate based fertilizers
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - picloram production
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - pigment manufacture
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - reforming
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - sodium pentachlorophenoxide
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - sulphuric acid use
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - tetrachloroethylene
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - titanium dioxide
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Chemical industry - trichloroethylene
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Coal tar distillation
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Solvent and oil recovery
2B5a	2 B 5 a Other chemical industry (Please specify the sources included/excluded in the notes column to the right)	Sulphuric acid production
2C1	2 C 1 Iron and steel production	Basic oxygen furnaces
2C1	2 C 1 Iron and steel production	Blast furnaces
2C1	2 C 1 Iron and steel production	Cold rolling of steel
2C1	2 C 1 Iron and steel production	Electric arc furnaces
2C1	2 C 1 Iron and steel production	Hot rolling of steel
2C1	2 C 1 Iron and steel production	Integrated steelworks - other processes
2C1	2 C 1 Iron and steel production	Integrated steelworks - stockpiles
2C1	2 C 1 Iron and steel production	Iron and steel - flaring
2C1	2 C 1 Iron and steel production	Iron and steel - steel pickling
2C1	2 C 1 Iron and steel production	Ladle arc furnaces
2C1	2 C 1 Iron and steel production	Sinter production
2C3	2 C 3 Aluminum production	Alumina production
2C3	2 C 3 Aluminum production	Primary aluminium production - anode baking
2C3	2 C 3 Aluminum production	Primary aluminium production - general
2C3	2 C 3 Aluminum production	Primary aluminium production - PFC emissions
2C3	2 C 3 Aluminum production	Primary aluminium production - pre-baked anode process
2C3	2 C 3 Aluminum production	Primary aluminium production - vertical stud Soderberg process
2C3	2 C 3 Aluminum production	Secondary aluminium production
2C5a	2 C 5 a Copper production	Copper alloy and semis production
2C5a	2 C 5 a Copper production	Secondary copper production
2C5b	2 C 5 b Lead production	Lead battery manufacture
2C5b	2 C 5 b Lead production	Secondary lead production
2C5c	2 C 5 c Nickel production	Nickel production
2C5d	2 C 5 d Zinc production	Primary lead/zinc production

2C5d	2 C 5 d Zinc production	Zinc alloy and semis production
2C5d	2 C 5 d Zinc production	Zinc oxide production
2C5e	2 C 5 e Other metal production (Please specify the sources included/excluded in the notes column to the right)	Foundries
2C5e	2 C 5 e Other metal production (Please specify the sources included/excluded in the notes column to the right)	Magnesium alloying
2C5e	2 C 5 e Other metal production (Please specify the sources included/excluded in the notes column to the right)	Magnesium cover gas
2C5e	2 C 5 e Other metal production (Please specify the sources included/excluded in the notes column to the right)	Other non-ferrous metal processes
2C5e	2 C 5 e Other metal production (Please specify the sources included/excluded in the notes column to the right)	Tin production
2D1	2 D 1 Pulp and Paper	Paper production
2D2	2 D 2 Food and Drink	Bread baking
2D2	2 D 2 Food and Drink	Brewing - fermentation
2D2	2 D 2 Food and Drink	Brewing - wort boiling
2D2	2 D 2 Food and Drink	Cider manufacture
2D2	2 D 2 Food and Drink	Malting - brewers' malts
2D2	2 D 2 Food and Drink	Malting - distillers' malts
2D2	2 D 2 Food and Drink	Malting - exported malt
2D2	2 D 2 Food and Drink	Other food - animal feed manufacture
2D2	2 D 2 Food and Drink	Other food - cakes biscuits and cereals
2D2	2 D 2 Food and Drink	Other food - coffee roasting
2D2	2 D 2 Food and Drink	Other food - margarine and other solid fats
2D2	2 D 2 Food and Drink	Other food - meat fish and poultry
2D2	2 D 2 Food and Drink	Other food - sugar production
2D2	2 D 2 Food and Drink	Spirit manufacture - casking
2D2	2 D 2 Food and Drink	Spirit manufacture - distillation
2D2	2 D 2 Food and Drink	Spirit manufacture - fermentation
2D2	2 D 2 Food and Drink	Spirit manufacture - other maturation
2D2	2 D 2 Food and Drink	Spirit manufacture - Scotch whisky maturation
2D2	2 D 2 Food and Drink	Spirit manufacture - spent grain drying
2D2	2 D 2 Food and Drink	Sugar beet processing
2D2	2 D 2 Food and Drink	Wine manufacture
2D3	2 D 3 Wood processing	Wood products manufacture
2E	2E_Production_of_Halocarbons_and_Sulphur_Hexafluoride	Halocarbons production - by-product
2E	2E_Production_of_Halocarbons_and_Sulphur_Hexafluoride	Halocarbons production - fugitive
2F	2 F Halocarbons use	Aerosols - halocarbons
2F	2 F Halocarbons use	Capacitors
2F	2 F Halocarbons use	Commercial Refrigeration
2F	2 F Halocarbons use	Domestic Refrigeration
2F	2 F Halocarbons use	Electrical insulation
2F	2 F Halocarbons use	Electronics - PFC
2F	2 F Halocarbons use	Electronics - SF6
2F	2 F Halocarbons use	Firefighting
2F	2 F Halocarbons use	Foams
2F	2 F Halocarbons use	Fragmentisers
2F	2 F Halocarbons use	Industrial Refrigeration
2F	2 F Halocarbons use	Metered dose inhalers
2F	2 F Halocarbons use	Mobile Air Conditioning
2F	2 F Halocarbons use	One Component Foams
2F	2 F Halocarbons use	Other PFC use
2F	2 F Halocarbons use	OvTerr F-gas emissions (all)- Cayman, Falkland, Montserrat, Bermuda and Gibraltar
2F	2 F Halocarbons use	OvTerr F-gas emissions (all)- Guernsey, Jersey, IOM
2F	2 F Halocarbons use	PDBE use

2F	2 F Halocarbons use	Precision cleaning - HFC
2F	2 F Halocarbons use	Previously treated wood
2F	2 F Halocarbons use	Refrigerated Transport
2F	2 F Halocarbons use	SCCP use
2F	2 F Halocarbons use	Sporting goods
2F	2 F Halocarbons use	Stationary Air Conditioning
2F	2 F Halocarbons use	Textile coating
2F	2 F Halocarbons use	Transformers
2G	2 G OTHER (Please specify in a covering note)	Other industry - part B processes
3A1	3 A 1 Decorative coating application	Decorative paint - retail decorative
3A1	3 A 1 Decorative coating application	Decorative paint - trade decorative
3A2	3 A 2 Industrial coating application	Industrial coatings - agricultural and construction
3A2	3 A 2 Industrial coating application	Industrial coatings - aircraft
3A2	3 A 2 Industrial coating application	Industrial coatings - automotive
3A2	3 A 2 Industrial coating application	Industrial coatings - coil coating
3A2	3 A 2 Industrial coating application	Industrial coatings - commercial vehicles
3A2	3 A 2 Industrial coating application	Industrial coatings - drum
3A2	3 A 2 Industrial coating application	Industrial coatings - marine
3A2	3 A 2 Industrial coating application	Industrial coatings - metal and plastic
3A2	3 A 2 Industrial coating application	Industrial coatings - metal packaging
3A2	3 A 2 Industrial coating application	Industrial coatings - vehicle refinishing
3A2	3 A 2 Industrial coating application	Industrial coatings - wood
3A3	3 A 3 Other coating application (Please specify the sources included/excluded in the notes column to the right)	Industrial coatings - high performance
3B1	3 B 1 Degreasing	Leather degreasing
3B1	3 B 1 Degreasing	Surface cleaning - 111-trichloroethane
3B1	3 B 1 Degreasing	Surface cleaning - dichloromethane
3B1	3 B 1 Degreasing	Surface cleaning - hydrocarbons
3B1	3 B 1 Degreasing	Surface cleaning - oxygenated solvents
3B1	3 B 1 Degreasing	Surface cleaning - tetrachloroethylene
3B1	3 B 1 Degreasing	Surface cleaning - trichloroethylene
3B2	3 B 2 Dry cleaning	Dry cleaning
3C	3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Coating manufacture - adhesives
3C	3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Coating manufacture - inks
3C	3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Coating manufacture - other coatings
3C	3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Film coating
3C	3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Leather coating
3C	3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Other rubber products
3C	3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Paper coating
3C	3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Textile coating
3C	3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	Tyre manufacture
3D1	3 D 1 Printing	Printing - flexible packaging
3D1	3 D 1 Printing	Printing - heatset web offset
3D1	3 D 1 Printing	Printing - metal decorating
3D1	3 D 1 Printing	Printing - newspapers
3D1	3 D 1 Printing	Printing - other flexography
3D1	3 D 1 Printing	Printing - other inks
3D1	3 D 1 Printing	Printing - other offset
3D1	3 D 1 Printing	Printing - overprint varnishes
3D1	3 D 1 Printing	Printing - print chemicals
3D1	3 D 1 Printing	Printing - publication gravure
3D1	3 D 1 Printing	Printing - screen printing
3D2	3 D 2 Domestic solvent use including fungicides	Aerosols - carcare products
3D2	3 D 2 Domestic solvent use including fungicides	Aerosols - cosmetics and toiletries

3D2	3 D 2 Domestic solvent use including fungicides	Aerosols - household products
3D2	3 D 2 Domestic solvent use including fungicides	Agriculture - agrochemicals use
3D2	3 D 2 Domestic solvent use including fungicides	Non-aerosol products - automotive products
3D2	3 D 2 Domestic solvent use including fungicides	Non-aerosol products - cosmetics and toiletries
3D2	3 D 2 Domestic solvent use including fungicides	Non-aerosol products - domestic adhesives
3D2	3 D 2 Domestic solvent use including fungicides	Non-aerosol products - household products
3D2	3 D 2 Domestic solvent use including fungicides	Non-aerosol products - paint thinner
3D2	3 D 2 Domestic solvent use including fungicides	OvTerr Solvent Use (all)- Cayman, Falkland, Montserrat, Bermuda and Gibraltar
3D2	3 D 2 Domestic solvent use including fungicides	OvTerr Solvent Use (all)- Guernsey, Jersey, IOM
3D3	3 D 3 Other product use	Creosote use
3D3	3 D 3 Other product use	Industrial adhesives - other
3D3	3 D 3 Other product use	Industrial adhesives - pressure sensitive tapes
3D3	3 D 3 Other product use	Other solvent use
3D3	3 D 3 Other product use	Road dressings
3D3	3 D 3 Other product use	Seed oil extraction
3D3	3 D 3 Other product use	Wood impregnation - creosote
3D3	3 D 3 Other product use	Wood impregnation - general
3D3	3 D 3 Other product use	Wood impregnation - LOSP
4A1	4 A 1 Enteric_Fermentation_Cows	Agriculture livestock - dairy cattle enteric
4A1	4 A 1 Enteric_Fermentation_Cows	Agriculture livestock - other cattle enteric
4A10	4 A 10 Enteric_Fermentation_Deer	Agriculture livestock - deer enteric
4A3	4 A 3 Enteric_Fermentation_Sheep	Agriculture livestock - sheep enteric
4A4	4 A 4 Enteric_Fermentation_Goats	Agriculture livestock - goats enteric
4A6	4 A 6 Enteric_Fermentation_Horses	Agriculture livestock - horses enteric
4A8	4 A 8 Enteric_Fermentation_Swine	Agriculture livestock - pigs enteric
4B12	4 B 12 Solid_Storage_and_Drylot	Agriculture livestock - manure liquid systems
4B13	4 B 13 Other	Agriculture livestock - deer wastes
4B13	4 B 13 Other	Agriculture livestock - manure other
4B13	4 B 13 Other	Agriculture livestock - manure solid storage and dry lot
4B13	4 B 13 Other	Domestic pets
4B13	4 B 13 Other	Non-agriculture livestock - horses wastes
4B1a	4 B 1 a Dairy	Agriculture livestock - dairy cattle
4B1a	4 B 1 a Dairy	Agriculture livestock - dairy cattle wastes
4B1b	4 B 1 b Non-Dairy	Agriculture livestock - other cattle
4B1b	4 B 1 b Non-Dairy	Agriculture livestock - other cattle wastes
4B3	4 B 3 Sheep	Agriculture livestock - sheep goats and deer wastes
4B4	4 B 4 Goats	Agriculture livestock - goats wastes
4B6	4 B 6 Horses	Agriculture livestock - horses wastes
4B8	4 B 8 Swine	Agriculture livestock - pigs
4B8	4 B 8 Swine	Agriculture livestock - pigs wastes
4B9a	4 B 9 a Laying hens	Agriculture livestock - laying hens
4B9a	4 B 9 a Laying hens	Agriculture livestock - laying hens wastes
4B9b	4 B 9 b Broilers	Agriculture livestock - broilers
4B9b	4 B 9 b Broilers	Agriculture livestock - broilers wastes
4B9d	4 B 9 d Other poultry	Agriculture livestock - other poultry
4B9d	4 B 9 d Other poultry	Agriculture livestock - other poultry wastes
4D1a	4 D 1 a Synthetic N-fertilizers	Agricultural soils
4D1a	4 D 1 a Synthetic N-fertilizers	House and garden machinery
4D2c	N-excretion on pasture range and paddock unspecified (Please specify the sources included/excluded in the notes column to the right)	N-excretion on pasture range and paddock unspecified
4F	4 F FIELD BURNING OF AGRICULTURAL WASTES	Field burning
4G	4 G OTHER (d)	Agricultural pesticide use - chlorothalonil use
4G	4 G OTHER (d)	Agricultural pesticide use - chlorthal-dimethyl use
4G	4 G OTHER (d)	Agricultural pesticide use - quintozone
4G	4 G OTHER (d)	Agriculture - agrochemicals use
4G	4 G OTHER (d)	Agriculture - stationary combustion
4G	4 G OTHER (d)	Cropland - Liming
4G	4 G OTHER (d)	Grassland - Liming

6A	6 A SOLID WASTE DISPOSAL ON LAND	Application to land
6A	6 A SOLID WASTE DISPOSAL ON LAND	Landfill
6A	6 A SOLID WASTE DISPOSAL ON LAND	Waste disposal - batteries
6A	6 A SOLID WASTE DISPOSAL ON LAND	Waste disposal - electrical equipment
6A	6 A SOLID WASTE DISPOSAL ON LAND	Waste disposal - lighting fluorescent tubes
6A	6 A SOLID WASTE DISPOSAL ON LAND	Waste disposal - measurement and control equipment
6B	6 B WASTE-WATER HANDLING	Sewage sludge decomposition
6Ca	6 C a Clinical waste incineration (d)	Incineration - clinical waste
6Cb	6 C b Industrial waste incineration (d)	Incineration - chemical waste
6Cb	6 C b Industrial waste incineration (d)	Incineration - sewage sludge
6Cb	6 C b Industrial waste incineration (d)	Other industrial combustion
6Cb	6 C b Industrial waste incineration (d)	Regeneration of activated carbon
6Cc	6 C c Municipal waste incineration (d)	Incineration
6Cd	6 C d Cremation	Crematoria
6Cd	6 C d Cremation	Foot and mouth pyres
6Cd	6 C d Cremation	Incineration - animal carcasses
6Ce	6 C e Small scale waste burning	Agricultural waste burning
6Ce	6 C e Small scale waste burning	Small-scale waste burning
6D	6 D OTHER WASTE (f)	Accidental fires - vehicles
6D	6 D OTHER WASTE (f)	Composting - NH ₃
6D	6 D OTHER WASTE (f)	RDF manufacture
7A	7 A Other (included in national total for entire territory)	Accidental fires - dwellings
7A	7 A Other (included in national total for entire territory)	Accidental fires - other buildings
7A	7 A Other (included in national total for entire territory)	Accidental fires - vehicles
7A	7 A Other (included in national total for entire territory)	Agriculture - agrochemicals use
7A	7 A Other (included in national total for entire territory)	Bonfire night
7A	7 A Other (included in national total for entire territory)	Cigarette smoking
7A	7 A Other (included in national total for entire territory)	Fireworks
7A	7 A Other (included in national total for entire territory)	Infant emissions from nappies
7A	7 A Other (included in national total for entire territory)	Non-aerosol products - household products
z_11B	Forest Fires	Accidental fires - forests
z_11C	Other natural emissions (Please specify in notes and your IIR)	Accidental fires - straw
z_11C	Other natural emissions (Please specify in notes and your IIR)	Accidental fires - vegetation
z_11C	Other natural emissions (Please specify in notes and your IIR)	Adult breath and sweat
z_11C	Other natural emissions (Please specify in notes and your IIR)	Deforestation (non IPCC)
z_11C	Other natural emissions (Please specify in notes and your IIR)	Natural fires
z_11C	Other natural emissions (Please specify in notes and your IIR)	Natural sources
z_11C	Other natural emissions (Please specify in notes and your IIR)	Road transport - resuspension
z_11C	Other natural emissions (Please specify in notes and your IIR)	Wild birds wastes
z_11C	Other natural emissions (Please specify in notes and your IIR)	Wild other animal wastes
z_1A3ai(ii)	International Aviation- Cruise (Memo)	Aircraft - international cruise
z_1A3ai(i)	Civil Aviation (Domestic, Cruise)	Aircraft - domestic cruise
z_1A3ai(i)	Civil Aviation (Domestic, Cruise)	Aircraft between UK and Gibraltar - Cruise
z_1A3di(i)	International Navigation (Memo)	Shipping - international IPCC definition