National Atmospheric Emissions Inventory

Report

Air Quality Pollutant Inventories for England, Scotland, Wales and Northern Ireland: 1990 – 2007

A report of the National Atmospheric Emissions Inventory, AEA Group

October 2009

Air Quality Pollutant Inventories for England, Scotland, Wales and Northern Ireland: 1990 – 2007

Main authors
J Jackson, Y Li, TP Murrells, S Okamura, N Passant, S Sneddon, J Thomas & G Thistlethwaite (AEA)

T Misselbrook (North Wyke Research)

October 2009

Title	Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2007
Customer	Department for Environment, Food and Rural Affairs, The Scottish Government, The Welsh Assembly Government, The Northern Ireland Department of Environment.
Confidentiality, copyright and reproduction	Crown Copyright
NAEI reference	48954/2007/CD6421/GT
Report number	AEAT/ENV/R/2857
Issue number	Issue 1

AEA Group
The Gemini Building
Fermi Avenue
Didcot
Oxfordshire
OX11 0QR

Telephone 0870 190 6584

AEA is a business name of AEA Technology plc
AEA is certified to ISO9001 and ISO14001

Main Authors		J Jackson, Y Li, TP Murrells, S Okamura, N Passant, S Sneddon, J Thomas & G Thistlethwaite (AEA) T Misselbrook (North Wyke Research)
Approved by	Name	Geoff Dollard
	Signature	
	Date	13th October 2009

Executive Summary

This is the Air Quality Pollutant Inventory Report for England, Scotland, Wales and Northern Ireland. The report presents emission inventories for the constituent countries of the UK for the period 1990 to 2007, for the following priority Air Quality (AQ) pollutants:

- Ammonia (NH_3)
- Carbon monoxide (CO)
- Nitrogen oxides (NO_X as NO_2)
- Non-methane volatile organic compounds (NMVOCs)
- Sub-10 micron particulate matter (PM_{10})
- Sulphur dioxide (SO_2)
- Lead (Pb)

These inventories are compiled on behalf of the UK Department for Environment, Food & Rural Affairs, the Scottish Government, the Welsh Assembly Government and the Department of Environment for Northern Ireland, by the UK emission inventory teams at AEA and North Wyke Research.

Data Sources and Inventory Methodology

The constituent country inventories are compiled by disaggregating the UK emission totals presented within "UK Emissions of Air Pollutants 1970 to 2007" (Murrells *et al.*, 2009), derived from the National Atmospheric Emissions Inventory (NAEI) database. The emission estimates for each pollutant are presented in NFR format, to be consistent with the UK inventory submissions to the United Nations Economic Commission for Europe (UNECE), which follow international inventory reporting guidelines.

The study method for disaggregating UK emission totals across the constituent countries draws on a combination of point source data (e.g. Pollution Inventory[1] data for industrial emissions) and regional and local datasets such as:

- Regional statistics on energy use (e.g. the DECC regional energy statistics) or other raw material consumption
- Major road traffic counts
- Domestic and international flight data for all major UK airports
- Rail company fuel use data
- Regional housing, population and consumption data
- Agricultural surveys (livestock numbers, crop production, fertiliser application)
- Land use survey data

Emissions from the offshore oil & gas exploration and production sector are not attributed to a specific country inventory, but are reported within an "unallocated" category. Note, however, that emissions from onshore oil & gas terminals are assigned to the appropriate country inventories.

The disaggregation of air quality (AQ) pollutant emissions across the four constituent countries of the UK has been conducted three times previously, using the 1990-2003, 1990-2005 and 1990-2006 NAEI dataset; this report presents the ongoing development of methodologies to provide AQ emission estimates for the Devolved Administrations (DAs), and for the first time includes lead emission inventories that have been compiled for the DAs.

[1] The term "Pollution Inventory" is used here to represent the industrial emissions databases of the UK environmental regulators (The Environment Agency of England & Wales, the Scottish Environment Protection Agency and the Northern Ireland Department of Environment), which comprise annual emission estimates from all IPC/IPPC-regulated processes under their authority.

For many sources of AQ pollutants, the data available for constituent country emissions are less detailed than for the UK as a whole, and for some sources, country-level data are not available at all. In particular, complete sets of fuel consumption data are not available for England, Scotland, Wales and Northern Ireland.

Regional energy statistics are published annually by the Department for Energy and Climate Change (DECC) within the quarterly Energy Trends[2] publication. These regional statistics are limited in their detail when compared to UK-level energy statistics, but do provide estimated fuel use data for England, Scotland, Wales and Northern Ireland for the following source sectors:

- Industry & Commercial
- Agriculture
- Residential

The DECC regional energy statistics have been developed in recent years to provide estimates of fuel use and CO_2 emissions data at Local Authority (LA) level across the UK. The latest available data include LA solid and liquid fuel use estimates for 2003 to 2006, with gas and electricity data also being available up to 2007.

The DECC data at local and regional level are derived from analysis of gas and electricity meter point data, supplemented by additional research to estimate the distribution of solid fuels and petroleum-based fuels across the UK. Since the initial study and presentation of experimental data for 2003 and 2004, each annual revision to the local and regional data has included data improvements through targeted sector research. These DECC Regional Energy Statistics continue to evolve and improve, reducing data inaccuracies, but nevertheless are subject to greater uncertainty and less detail than the UK energy statistics presented within DUKES (and used to underpin the UK air quality pollutant inventories). However, they are regarded as the best dataset available to inform the patterns of fuel use across the Devolved Administrations and are therefore used to underpin the pollutant emission estimates from fuel combustion sources within the inventories presented here, in conjunction with other data sources such as EU ETS fuel use data for large industrial sites and other DA-specific energy data.

For other significant emission sources there are more reliable and complete country-level datasets available, although some of these are less detailed than data used for the UK Inventory:

- Industrial process emissions are based on plant operator estimates reported to environmental agencies under regulatory systems such as Integrated Pollution Prevention and Control (IPPC). Major sources include power stations, cement and lime kilns, iron & steelworks, aluminium and other non ferrous metal plant, chemical industries;

- Agricultural emissions are based on UK emission factors and annual survey data across each of the Devolved Administrations, including estimates of arable production and livestock numbers;

- Land Use, Land Use Change and Forestry estimates are based on emission factors and regional survey data of land use;

- Emissions from waste disposal activities are estimated based on modelled emissions from the UK air quality inventories, split out across the DAs based on local authority waste disposal activity reporting which provides an insight into the local shares of UK activity for recycling, landfilling, incineration and other treatment and disposal options.

- For some sources where regional data are not available, current local mapping grids have been used; these mapping grids are commonly based on census and other survey data that are periodically updated and used within UK emissions mapping and modelling work.

[2] The latest available data are taken from the December 2008 Energy Trends, http://www.berr.gov.uk/files/file49202.pdf

In many source sectors, there is insufficient local data available back to 1990 or earlier, and assumptions and extrapolations of available datasets have frequently been used to present a time-series of air quality pollution emissions.

As a result of the more limited DA-specific activity and emission factor data, the emission estimates for the England, Scotland, Wales and Northern Ireland inventories are subject to greater uncertainty than the equivalent UK estimates.

Air Quality Emission Inventories: Key Findings

The main findings of this report are summarised below:

Carbon monoxide (CO)
UK emissions in 2007 (2.1 Mt) represent a 76% reduction on the emissions in 1990. UK emissions of CO are dominated by those from road transport (38% of UK emissions in 2007). The change in emissions between 1990 and 2007 is dominated by the reduction in emissions from the road transport sector, caused by the increased use of catalytic converters in cars; this trend is evident for all DAs. For Scotland and Northern Ireland, decreased emissions from the commercial and domestic sectors also make a significant contribution to the time trend (due to a decrease in the use of solid fuels). In Wales, emissions arising from industrial combustion and processes make a larger relative contribution, but whilst these emissions have decreased, they have declined at a lower rate than emissions from road transport.

Non-methane volatile organic compounds (NMVOCs)
UK emissions of NMVOC are estimated as 2.6 Mt for 1990 and 0.94 Mt for 2007, a decrease of 64%. The observed decrease arises primarily from the road transport and industrial sectors, but is evident generally across all sources. England, Wales and Northern Ireland show generally similar trends with time. In Scotland the emissions from Oil and Gas Processes and Industrial Processes make a considerably higher contribution to the total, although data reported by oil terminals appears to be incomplete and / or inconsistent over the time-series. The percentage reduction from these sources are less than those observed for road transport, and as a result the trend with time indicates that emissions in Scotland do not fall to the same extent as other DAs.

Nitrogen oxides reported as nitrogen dioxide (NO_X as NO_2)
UK emissions of NO_X were 2.7 Mt in 1990. Emissions have fallen significantly to 1.5 Mt in 2007, representing a 46% reduction on the 1990 emissions estimate. This is primarily a consequence of abatement measures in road transport and at coal-fired power stations, and the increased use of other fuels for power generation. Road transport and coal combustion combine to account for 54% of UK emissions in 2007.

Emissions from all of the DAs show broadly similar trends since 1990, with a few notable differences. For example, emissions from the Energy Industry sector in Wales initially reduced significantly, but in recent years emissions have increased due to an increase in the use of coal in power generation. Over recent years, the fluctuating trends in electricity generation have had a marked impact on the DA inventories; in both Wales and Scotland, an increase in coal-fired power generation in 2006 (only) has led to an increase in NO_X emissions, with a subsequent decline in the 2007 emissions. In Scotland, coal-fired generation increased by over 40% between 2005 and 2006 (12,092 GWh to 17,488 GWh), and then reduced by over 20% between 2006 and 2007 (down to 13,802 GWh). In Wales, meanwhile, coal-fired generation increased by over 30% between 2005 and 2006 (6,772 GWh to 8,859 GWh), and then reduced by over 40% between 2006 and 2007 (down to 5,121 GWh), partly as a result of a plant shut-down at Aberthaw to retro-fit 2 units with Flue Gas Desulphurisation abatement. In Northern Ireland, power station NO_X emissions have decreased by 29% from 2006 to 2007, which is primarily due to a 32% reduction in coal-fired generation from 2,701 GWh in 2006 to 1,833 GWh in 2007. This decline in power sector emissions represents nearly half of the overall decline in NO_X emissions in Northern Ireland between 2006 and 2007, with other significant reductions evident from road transport and off-road mobile machinery sources.

Sulphur dioxide (SO_2)
UK emissions of sulphur dioxide have fallen from 3.7 Mt in 1990 to 0.6 Mt in 2007, representing a decrease of 84%. This is a result of reduced emissions from the industrial and public power sectors arising from the decreasing use of coal and increasing use of abatement equipment. The trends with time for the DAs are generally similar; emissions from the power generation sector dominate the inventories, with emissions falling across the time series. In both Scotland and Wales there is an increase in SO_2 from the power sector in 2006 followed by a decline in 2007, due to the fluctuations in coal-fired generation outlined above. Significant differences between the DAs include: the varying importance of industrial combustion (which ranges from a 10% to 17% contribution), and the relatively high emissions from the domestic sector in Northern Ireland (19% of the 2007 total, compared to a UK average of 4%, primarily due to the greater use of oil and solid fuels). Note, however, that reductions in emissions are evident in Northern Ireland, as the gas infrastructure has developed since 1999, and more houses and businesses have access to mains gas to replace oil-fired and solid-fuel boilers.

Ammonia (NH_3)
The total UK emission of ammonia for 2007 is estimated at 0.29 Mt, compared to the 1990 estimate of 0.36 Mt, representing a 21% reduction. The agricultural sector dominates ammonia emissions, with over 91% of UK emissions coming from agricultural sources. Agricultural emissions have declined by 19% since 1999, most notably in England, due primarily to reductions in livestock numbers, especially cattle and pigs. Emissions from road transport have increased since 1990 due to the increased use of catalytic converter technology, although emissions are now declining due to the introduction of second generation catalysts which emit less NH_3. These increases are more than offset by the impacts of reducing livestock numbers.

Agricultural emissions dominate all of the DA inventories in 2007, contributing 89% of the total in England, 95% in Scotland and Wales, and almost 98% in Northern Ireland. Agricultural emission reductions since 1990 have been greatest in England (down 26%), then Wales (down 19%) and Scotland (down 18%), whilst reductions in Northern Ireland are estimated at around 4%.

Sub-10 micron Particulate Matter (PM_{10})
The UK emissions of PM_{10} declined by 52% from 0.28 Mt in 1990 to 0.14 Mt in 2007. This reflects a trend away from coal use particularly by domestic users. However, coal combustion still contributed 10% of UK emissions of PM_{10} in 2007, whilst road transport sources contributed a further 18%.

The relative emissions across the DAs reflect characteristics already highlighted in other pollutants. Emissions from England show proportionally higher emissions from the road transport sector (20.2% compared to 18.3% UK-wide in 2007) and emissions from Northern Ireland show proportionally higher emissions from the domestic sector (46% compared to 14% UK-wide in 2007) due to the more extensive use of solid fuels.

Lead (Pb)
The UK emissions of lead is estimated at 70 t in 2007, compared to the 1990 estimate of 2890 t, representing a 98% reduction. The major sources of lead in 2007 are from sinter plant and other processes involved in metal production. There has been some reduction in emissions from iron and steel production processes due to improved abatement measures. The largest source of lead until 1999 was from anti-knock lead additives in petrol. The lead content of leaded petrol was reduced from 0.34 g/l to 0.143 g/l in 1986. From 1987 sales of unleaded petrol increased, particularly as a result of the increased use of cars fitted with three-way catalysts, and leaded petrol was phased out from general sale at the end of 1999. Consequently a decline in emissions from the road transport sector is seen.

Emissions from Wales show proportionally higher emissions from the industrial combustion (66% compared to 48% UK-wide in 2007), mainly from the Port Talbot steelworks, whilst emissions from Northern Ireland show proportionally higher emissions from the domestic sector (41% compared to 5% UK-wide in 2007) due to the more extensive use of solid fuels.

Contacts

This work forms part of the Atmospheric Quality and Industrial Pollution (AQIP) Programme of the Department for Environment, Food and Rural Affairs. AEA compiles emission estimates for the energy, industrial process, solvents and waste sectors. The Centre for Ecology and Hydrology (Edinburgh) provides emission estimates for land use, land use change and forestry sources. North Wyke Research provides the estimates of agricultural emissions.

Science policy enquiries should be directed to Sarah Honour, Air Quality and Industrial Pollution Programme, Department for Environment, Food and Rural Affairs, Ergon House, 17 Smith Square, London, SW1P 3JR, UK.
Tel: +44 (0) 20 7238 1705, Fax: +44 (0) 20 7238 3341.
E-mail: sarah.honour@defra.gsi.gov.uk

Technical enquiries should be directed to Glen Thistlethwaite, AEA, The Gemini Building, Fermi Avenue, Didcot, Oxfordshire, OX11 0QR, UK.
Tel: +44 (0) 870 190 6584, Fax: +44 (0) 870 190 6318.
E-mail: glen.thistlethwaite@aeat.co.uk

Technical enquiries on land use, land use change and forestry should be addressed to Kirstie Dyson at the Centre for Ecology and Hydrology, Bush Estate, Penicuik, EH26 OQB, UK.
Tel: +44 (0) 131 445 8575, Fax +44 (0) 131 445 3943.
E-mail: kiso@ceh.ac.uk

Technical enquiries on agriculture should be addressed to Tom Misselbrook, North Wyke (NWRes), Devon, EX20 2SB, UK.
Tel: +44 (0) 1837 883500, Fax: + 44 (0) 1837 82139.
E-mail: tom.misselbrook@bbsrc.ac.uk

A copy of this report and related data may be found on the website maintained by AEA for Defra: http://www.naei.org.uk

Contents

Appendices

Appendix A: Definition of NFR Codes
Appendix B: Methods for Calculating Emission Distributions
Appendix C: Devolved Administration PM_{10} Inventories, 1990-2007
Appendix D: Devolved Administration CO Inventories, 1990-2007
Appendix E: Devolved Administration NO_X Inventories, 1990-2007
Appendix F: Devolved Administration SO_2 Inventories, 1990-2007
Appendix G: Devolved Administration NMVOC Inventories, 1990-2007
Appendix H: Devolved Administration NH_3 Inventories, 1990-2007
Appendix I: Devolved Administration Lead Inventories, 1990-2007

List of Figures

List of Tables

1 Introduction

1.1 BACKGROUND TO INVENTORY DEVELOPMENT FOR THE DEVOLVED ADMINISTRATIONS

This study to develop DA-level AQ pollutant datasets has been commissioned by Defra in order to better inform energy and environmental policy-makers within the Devolved Administrations in their pursuit of objectives set by the Air Quality Strategy for England, Scotland, Wales and Northern Ireland (AQS for ESWNI). These objectives also contribute to the UK's targets as a whole in terms of meeting both national and international targets on both local and transboundary air pollution.

The provision of DA-level datasets and subsequent identification of key sources at more regional and local levels is a key step to enable prioritisation of local action and to highlight the potential impacts of specific policies and measures. The time-series of AQ pollutant emissions provides an insight into the effects of environmental policies introduced since 1990, and may help to identify where win-win policies could be pursued to achieve both AQ and GHG policy goals.

1.1.1 Air quality emission reduction drivers

Overall air quality in the UK 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 (AQS, 2007). A number of policies are currently in place in the UK, which aim to improve air quality. This includes the national air quality strategy for England, Scotland, Wales and Northern Ireland.

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 (SO_2, PM_{10}, 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.

The NAQS identified air quality standards for 8 priority pollutants based on the recommendations of the Expert Panel on Air Quality Standards (EPAQS) or World Health Organisation (WHO) guidance where no EPAQS recommendation existed. The NAQS has been subject to periodic review, with consultation documents being published in 1998 and 2001 (DETR 1998a, Defra 2001), and has subsequently evolved into the Air Quality Strategy for England, Scotland, Wales and Northern Ireland (AQS for ESWNI), with the same goals. A second edition of the strategy was published in 2000 (DETR 2000), identifying further revisions and focused on the incorporation of air quality limit values in European Directives, and the impacts of devolution. On 17 July 2007 a new Air Quality Strategy was published by Defra and the Devolved Administrations. The details of this AQS can be found on the Defra website at: http://www.defra.gov.uk/environment/airquality/strategy/index.htm

The new Air Quality Strategy supersedes previous versions and covers the whole of the UK, therefore including DA-specific objective values that were previously detailed in addenda to the previous AQS.

EU Air Quality Framework Directive

The EU air quality framework directive (96/62/EC) established 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 through a series of four Daughter Directives. In 2008, the Framework Directive and first three Daughter Directives were consolidated in a new EU air quality Directive (2008/50/EC), with the 4th Daughter Directive to be brought in. However, a new EU **air quality directive (2008/50/EC)** came into force in June 2008, consolidates

the Framework Directive and the first three Daughter Directives and introduced a new regulatory framework for $PM_{2.5}$. The 4th Daughter Directive, which will be brought within the new Directive at a later date.

At present, under 2008/50/EC and the 4th Daughter Directive, limit values are set for twelve pollutants, including NO_x, SO_2, PM and CO, and member states are required to submit annual reports to the European Commission on whether the limits have been achieved within their respective areas.

UN/ECE'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.

Under the Second Sulphur Protocol, the UK must reduce its total SO_2 emissions by 50% by 2000, 70% by 2005 and 80% by 2010 (all from a 1980 baseline).

The NMVOC Protocol requires the UK to achieve a 30% reduction of anthropogenic NMVOC emissions by 1999 from a 1988 baseline. The emission estimates given in the 1999 version of the emissions inventory indicated that this was achieved.

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 were 11% lower in 1994 than in 1987 and have fallen substantially since 1994.

In 1996, the UNECE started negotiating a new multi-effect, multi-pollutant protocol on nitrogen oxides and related substances. This was aimed at addressing photochemical pollution, acidification and eutrophication. The Protocol to Abate Acidification, Eutrophication and Ground-level Ozone was adopted in Gothenburg in December 2000, where it was signed by the UK. The multi-pollutant protocol incorporates several measures to facilitate the reduction of emissions:

- Emission ceilings are specified for sulphur, nitrogen oxides, NH_3 and NMVOCs;
- Emission limits are specified for sulphur, nitrogen oxides and NMVOCs from stationary sources;
- Emission limits are indicated for CO, hydrocarbons, nitrogen oxides and particulates from new mobile sources;
- Environmental specifications for petrol and diesel fuels are given;
- Several measures to reduce NH_3 emissions from the agriculture sector are required.

The Gothenburg Protocol forms a part of the Convention on Long-range Transboundary Air Pollution. More detailed information on both of the Gothenburg protocol and the Convention may be found at the UNECE web site: www.unece.org/env/lrtap/

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 (including the UK for SO_2 and NO_x) reduced their ceilings somewhat below the levels included in the Protocol.

Large Combustion Plants 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 NOx, SO2 and dust from power plants and industrial sources.

UN/ECE Heavy Metals Protocol

The Convention on Long-range Transboundary Air Pollution was signed in 1979 and came 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 UN/ECE web site, located at: http://www.unece.org/env/lrtap/
The UK has signed this protocol.

The UN/ECE Protocol on Heavy Metals targets three particularly harmful substances: 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 the use of Best Available Technology (BAT)) to minimise emissions from these sources, through the application of special 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, cadmium and mercury, depending on the development of the scientific basis for action.

1.2 INVENTORY METHOLODOGY & DATA AVAILABILITY

This report presents emission inventories for the constituent countries of the UK for the period 1990 to 2007, for the following priority Air Quality (AQ) pollutants:

- Ammonia (NH_3)
- Carbon monoxide (CO)
- Nitrogen oxides (reported as nitrogen dioxide) (NO_X as NO_2)
- Non-methane volatile organic compounds (NMVOC)
- Sub-10 micron particulate matter (PM_{10})
- Sulphur dioxide (SO_2)
- Lead (Pb)

The estimates have been compiled by disaggregating the UK emission totals presented within “UK Emissions of Air Pollutants 1970 to 2007” (Murrells *et al.*, 2009), derived from the National Atmospheric Emissions Inventory database. The UK data is compiled annually in accordance with the requirements of United Nations Economic Commission for Europe (UNECE) reporting guidelines using the NFR reporting format and submitted to the Convention on Long-Range Transboundary Air Pollution (CLRTAP).

1.2.1 Background: Data Availability and Inventory Uncertainty

The method for disaggregating UK emission totals across the constituent countries draws on a combination of point source data (e.g. Pollution Inventory[3] data for industrial emissions) and regional and local datasets such as:

- Regional statistics on energy use (e.g. the DECC regional energy statistics) or other raw material consumption
- Major road traffic counts
- Domestic and international flight data for all major UK airports
- Rail company fuel use data

[3] The term “Pollution Inventory” is used here to represent the industrial emissions databases of the UK environmental regulators (The Environment Agency of England & Wales, the Scottish Environment Protection Agency and the Northern Ireland Department of Environment) which comprise annual emission estimates from all IPC/IPPC-regulated processes under their authority.

- Regional housing, population and consumption data
- Agricultural surveys (livestock numbers, crop production, fertiliser application)
- Land use survey data

Emissions from the offshore oil & gas exploration and production sector are not attributed to a specific country inventory, but are reported within an "unallocated" category. All onshore emissions are accounted and reported.

The disaggregation of air quality (AQ) pollutant emissions across the four constituent countries of the UK has been conducted three times previously, using the 1990-2003, 1990-2005 and 1990-2006 NAEI dataset; this report presents the ongoing development of methodologies to provide AQ emission estimates for the Devolved Administrations (DAs), and for the first time includes lead emission inventories that have been compiled for the DAs.

For many emission sources of AQ pollutants, the data available for constituent country emissions are less detailed than for the UK as a whole, and for some sources country-level data are not available at all. For this reason, a "top-down" approach using UK inventory data as the core dataset has been adopted, and percentage splits of the UK total have been derived for each of the constituent countries using available regional data.

In particular, energy balance data (i.e. fuel production, transformation and sector-specific consumption data) are not available for England, Wales and Scotland. Regional energy statistics are published annually by the Department for Energy and Climate Change (DECC) within the quarterly Energy Trends[4] publication. These regional statistics are limited in their detail when compared to UK-level energy statistics, but do provide estimated fuel use data for England, Scotland, Wales and Northern Ireland for the following source sectors:

- Industry & Commercial
- Agriculture
- Residential

The DECC regional energy statistics have been developed in recent years to provide estimates of fuel use and CO_2 emissions data at Local Authority (LA) level across the UK. The latest available data include LA solid and liquid fuel use estimates for 2003 to 2006, with gas and electricity data also being available up to 2007.

The DECC data at local and regional level are derived from analysis of gas and electricity meter point data, supplemented by additional research to estimate the distribution of solid fuels and petroleum-based fuels across the UK. Since the initial study and presentation of experimental data for 2003 and 2004, each annual revision to the local and regional data has included data improvements through targeted sector research. These DECC Regional Energy Statistics continue to evolve and improve, reducing data inaccuracies, but nevertheless are subject to greater uncertainty and less detail than the UK energy statistics presented within DUKES (and used to underpin the UK air quality pollutant inventories). However, they are regarded as the best dataset available to inform the patterns of fuel use across the Devolved Administrations and are therefore used to underpin the pollutant emission estimates from fuel combustion sources within the inventories presented here, in conjunction with other data sources such as EU ETS fuel use data for large industrial sites and other DA-specific energy data.

For other significant emission sources there are more reliable and complete country-level datasets available, although some of these are less detailed than data used for the UK Inventory:

- Industrial process emissions are based on plant operator estimates reported to environmental agencies under regulatory systems such as Integrated Pollution Prevention and

[4] The latest available data are taken from the December 2008 Energy Trends, http://www.berr.gov.uk/files/file49202.pdf

Control (IPPC). Major sources include power stations, cement and lime kilns, iron & steelworks, aluminium and other non ferrous metal plant, chemical industries;

- Agricultural emissions are based on UK emission factors and annual survey data across each of the Devolved Administrations, including estimates of arable production and livestock numbers;

- Land Use, Land Use Change and Forestry estimates are based on emission factors and regional survey data of land use;

- Emissions from waste disposal activities are estimated based on modelled emissions from the UK air quality inventory, split out across the DAs based on local authority waste disposal activity reporting which provides an insight into the local shares of UK activity for recycling, landfilling, incineration and other treatment and disposal options.

- For some sources where regional data are not available, current local mapping grids have been used; these mapping grids are commonly based on census and other survey data that are periodically updated and used within UK emissions mapping and modelling work.

In many source sectors, there is insufficient local data available back to 1990 or earlier, and assumptions and extrapolations of available datasets have frequently been used to present a time-series of air quality pollution emissions.

As a result of the more limited DA-specific activity and emission factor data, the emission estimates for the England, Scotland, Wales and Northern Ireland inventories are subject to greater uncertainty than the equivalent UK estimates. The uncertainties in the DA air quality inventories are discussed in more detail in Chapter 3.

1.2.2 Inventory Compilation Method

A comprehensive list of all sources and UK emissions for the target pollutants (CO, NO_X, SO_2, VOC, NH_3, PM_{10}, Pb) during the study period of 1990-2007 is available from the NAEI database. From these data, the key sources for each of the AQ pollutants can be determined. The DA share of the UK emissions from each source category are then determined using the best available regional data, which may range from good quality emissions or activity data, to the use of proxy data (e.g. production or employment indices, population data) to provide a “best estimate” of the DA share of the UK emissions from a given source.

There are a number of resources that have been used analyse the DA share of UK emissions for each emission source, including:

- NAEI point source database;
- Emissions mapping grid data;
- Regional data derived from analysis of activity data trends, taken from research to develop DA Greenhouse Gas (GHG) Inventories;
- Generic parameters and proxy data such as population or regional GDP data.

The development of more consistent reports and datasets between different scales (national-regional-local) derived from the NAEI database is a key improvement that this study has enabled. The main resources used within the DA air quality pollutant inventory analysis are outlined below.

1.2.2.1 NAEI Point Source Database

Operators of all IPC/IPPC-regulated industrial plant are required to submit annual emission estimates of a range of pollutants (including all of those pertinent to this study) to their local UK environmental regulatory agency, and these emission estimates are subject to established procedures of Quality Assurance and Quality Checking prior to publication. These industrial point-source pollution inventories (held by the Environment Agency, the Scottish Environment Protection Agency and the Northern Ireland Department of the Environment) are emission datasets that have been developing

and improving since their inception in the mid-1990s. Robust and reliable data for installations in England and Wales have been widely available since around 1998, whilst the equivalent datasets in Scotland and Northern Ireland became available from the early 2000s.

NAEI point source data have been improved over recent years through the increasing quality and availability of these IPC/IPPC-regulated industrial pollution emission datasets, as well as through the availability of site-specific fuel use data for sites that operate within the EU Emissions Trading Scheme (EUETS), which has been running since 2005. Annual data requests are also made directly to plant operators in key sectors such as power stations, refineries, cement & lime manufacture, iron & steel manufacture, chemical industry and waste treatment and disposal, in order to procure more detailed emissions data and other parameters (e.g. production data).

Through analysis of the time-series of data and review of the latest emission estimates, the point source data is amended as appropriate to fill in gaps and rectify any errors. These finalised data are then used as the basis for the NAEI industrial emissions estimates. The location of each site is known and therefore the point-source database can be queried to extract all emissions information relevant to a given geographical area, and hence the DA-level inventories can partly be populated in this way.

Although the use of this dataset can only provide a limited time-series of emissions from a given source sector, it is nevertheless a useful tool for deriving recent regional emissions data for a broad range of pollutants, including CO, NO_X, SO_2, VOC, Pb, NH_3 and PM_{10}. The NAEI point-source database is most useful for industries that are dominated by large IPC/IPPC-authorised plant, such as power stations, refineries, iron & steel manufacturing, cement and lime kilns and so on. In these sectors, the point source database covers nearly 100% of emissions, and the DA emissions data available from this database is regarded to be of good quality for such sources.

1.2.2.2 NAEI Emission Mapping Grids

Emission maps for the whole of the UK are routinely produced as part of the NAEI for 25 pollutants, including all of the pollutants considered in this study. The maps are compiled at a 1km resolution and are produced annually for the most recent NAEI database (2007 in this case). The mapped emissions data are made freely available on the NAEI web site at:

http://www.naei.org.uk/mapping/mapping_2007.php

The emission maps are used by AEA and other organisations for a variety of Government policy support work at the national scale. In particular, the maps are used as input into a programme of air pollution modelling studies.

The geographical distribution of emissions across the UK is built up from distributions of emissions in each source sector. These source sector distributions are developed using a set of statistics appropriate to that sector. For large industrial 'point' sources, emissions are compiled from a variety of official UK sources (Environment Agency, Scottish Environment Protection Agency, Local Authority data). For sources that are distributed widely across the UK (known as 'area' sources), a distribution map is generated using appropriate surrogate statistics for that sector. The method used for each source varies according to the data available, but is commonly based on either local activity statistics such as raw material use, energy use, industrial production and employment data, housing and population data, road vehicle and fuel sales data, periodic census or socio-economic survey data.

Periodic surveys and censuses of industrial, commercial, domestic, and other economic sectors provide indicators regarding the location and scale of a wide variety of activity data that can be used to disaggregate emissions totals, and these are commonly utilised within the NAEI mapping grids. For a more detailed description of the integration of point source data analysis and the development of UK emission maps, see Chapter 3 of *UK Emission Mapping Methodology 2007* (Bush et al., 2009). Appendix B of this report provides a summary table of the mapping grid data availability for each UNECE sector.

The key limitation to the use of mapping grids within inventory development is the difficulty in obtaining an accurate time-series of emissions from a given sector, as the mapping grids are typically only updated every few years as more survey data becomes available. The data availability limitations inevitably impact upon the reliability of emission inventory estimates. In this study we have endeavoured to focus resources on ensuring that the most significant sources are assessed most accurately across the time-series, whilst less significant source sectors may be subject to a single mapping-grid-based disaggregation across all years.

1.2.2.3 Other Regional Data

In recent years, the NAEI team has aimed to develop a consistent time-series of detailed datasets to inform regional GHG inventories (back to 1990) and pollutant mapping campaigns. Examples of such datasets that have been used in this study include:

- Regional fuel use data for natural gas, solid fuel and petroleum-based fuels, from UK Transco, other gas network operators, the Coal Authority and the Department of Energy and Climate Change (DECC). The AEA energy mapping team has been involved in the ongoing development of the DECC Regional Energy Statistics which provide limited data from 2004 to 2007. These data are used to underpin many of the AQ pollutant emission estimates from small-scale (non-regulated) combustion sources such as domestic, commercial, public administration and small-scale industrial sectors. Back-casting the fuel use trends to 1990 has drawn upon available UK-level data and trends supplemented by analysis of additional data, such as Housing Condition Survey data, to ensure that significant changes are represented in the inventories (e.g. to reflect the development of the gas supply infrastructure in Northern Ireland since 1999).

- The Road Transport emissions database uses local traffic count data from the Department for Transport (DfT), the Northern Ireland Department of Regional Development (DRDNI), fuel use datasets (DECC), vehicle fleet data (DfT, DRDNI) and emission factors from European research sources (COPERT III, IV) to derive detailed emission estimates for a wide range of pollutants across the UK.

- Aircraft emissions are derived from the Civil Aviation Authority's (CAA) database of flight movements, fuel use data (DECC), aircraft fleet information (CAA) and emission factors from international guidance and research (Intergovernmental Panel on Climate Change, IPCC) to derive emission estimates for aircraft cruise, take-off and landing cycles.

- Regional quarry production data and quarry location information (British Geological Survey, BGS).

- Regional iron & steel production data, and regional fuel use data in the iron & steel industry (Corus, Iron & Steel Statistics Bureau).

- Site-specific emissions data split by combustion and process sources for all UK refineries, and refinery production capacities (UKPIA),

- Site-specific cement production capacities, and UK-wide cement industry fuel use data (British Cement Association).

- Regional railway diesel consumption data (local train operating companies, including freight, intercity and local passenger services).

- Regional housing & population data (Department of Communities and Local Government)

- Regional economic activity & industrial production indices (Office of National Statistics)

1.3 REPORT STRUCTURE

This report is structured as follows:

Main body of the report: This part of the report presents and discusses the inventories for England, Scotland, Wales and Northern Ireland, providing AQ pollutant emissions data for the years 1990, 1995, and 1998 to 2007. Emission inventories for PM_{10}, CO, VOCs, NH_3, NO_X, SO_2 and Pb are included in Chapter 2. Where appropriate, the reasons for any significant trends in emissions, issues regarding data availability and uncertainty estimates are provided for each inventory. A qualitative assessment of the uncertainty in the DA air quality inventories is presented in Chapter 3.

Appendix A: This appendix provides National Reporting Format sector code descriptions.

Appendix B: This appendix provides a summary of the disaggregation methods and mapping grids used in this study, for each UNECE sector.

Appendix C: Devolved Administration Emission Inventories for PM_{10}, 1990-2007 in NFR format.

Appendix D: Devolved Administration Emission Inventories for CO, 1990-2007 in NFR format.

Appendix E: Devolved Administration Emission Inventories for NO_X, 1990-2007 in NFR format.

Appendix F: Devolved Administration Emission Inventories for SO_2, 1990-2007 in NFR format.

Appendix G: Devolved Administration Emission Inventories for NMVOC, 1990-2007 in NFR format.

Appendix H: Devolved Administration Emission Inventories for NH_3, 1990-2007 in NFR format.

Appendix I: Devolved Administration Emission Inventories for Pb, 1990-2007 in NFR format.

2 Air Quality Pollutants

Inventories for England, Scotland, Wales and Northern Ireland for NH_3, CO, NO_X, NMVOC, PM_{10}, SO_2 are discussed in the following sections. These data have been derived by disaggregation of the UK figures using point source, mapping and regional datasets as appropriate (see Appendix B for details).

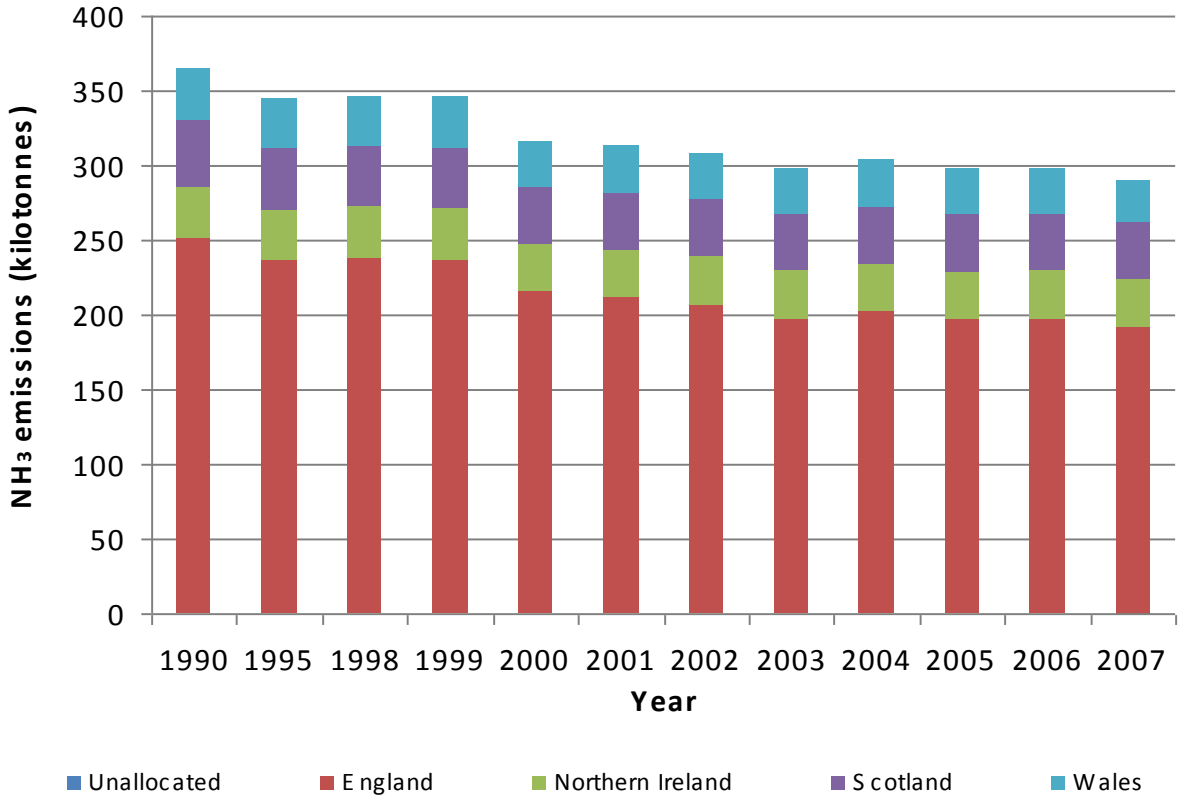
For information on the main sources & emission trends of Air Quality Pollutants in the UK National Atmospheric Emissions Inventory (NAEI) as well as supplementary information on particulate size & composition, monitoring and epidemiological evidence regarding effects on human health, please see Chapter 2 of *"UK Emissions of Air Pollutants 1970 to 2007"* (Murrells *et al*., 2009).]

2.1 AMMONIA EMISSION ESTIMATES

NH_3 emissions play an important role in a number of different environmental issues including acidification, nitrification and eutrophication. The atmospheric chemistry of NH_3 and NH_4^+ is such that transport of the pollutants can vary greatly, and that as a result, NH_3 emissions can exert impacts on a highly localised level, as well as contributing to the effects of long-range pollutant transport.

UK emission estimates for NH_3 are only available from 1990 onwards, because earlier data from the most significant industrial sources are not available (or are not considered to be reliable) for use in emission inventory estimates. UK ammonia emissions in 2007 represent a decrease of 21% on the 1990 emissions (Figure 2.1).

Figure 2-1 – Total UK NH_3 emissions



The main source of NH_3 emissions in the UK is livestock manure management, and in particular cattle manure management. These emissions derive mainly from the decomposition of urea in animal wastes and uric acid in poultry wastes. Emissions are affected by a large number of factors, including animal species, age, weight, diet, housing systems, waste-management and storage techniques. As such, the interpretation and extrapolation of experimental data is problematic, making emission estimates uncertain. Estimates are based on official livestock datasets and a number of emission factors from recent literature sources.

As well as emissions from livestock, the ammonia inventory includes emissions from fertiliser use, crops and decomposition of agricultural vegetation. It should be noted that these estimates are particularly uncertain due to the complexity of the processes involved and a greater uncertainty associated with literature emission factors.

Decreasing cattle numbers in the UK during the 1990s have led to reductions in UK ammonia emissions, and it is this trend in agricultural sources at the regional level that influences the DA-level inventories most significantly.

Non-agricultural sources of ammonia comprise a number of diverse sources. Emission estimates for these sources are often highly uncertain due to a lack of activity and emission factor data. Emissions from road transport (although relatively insignificant compared to agricultural emissions) increased in the 1990's as a result of the increasing number of three way catalysts in the vehicle fleet. However, emissions are now falling as the second generation of catalysts (which emit less NH_3 than first generation catalysts) penetrate the vehicle fleet.

Emissions of ammonia for England, Wales, Scotland and Northern Ireland are summarised in the tables and graphs below, with more detailed inventory tables in Appendix H. Table 2.1 shows how the estimated total UK NH_3 emissions are split between the 4 constituent countries.

Table 2-1 - Proportion of total NH_3 emissions from UK constituent countries

Year	England	Scotland	Wales	N Ireland	Unallocated
1990	69%	12%	9%	9%	0%
2007	66%	13%	10%	11%	0%

2.1.1 England Ammonia Inventory by NFR Sector, 1990-2007

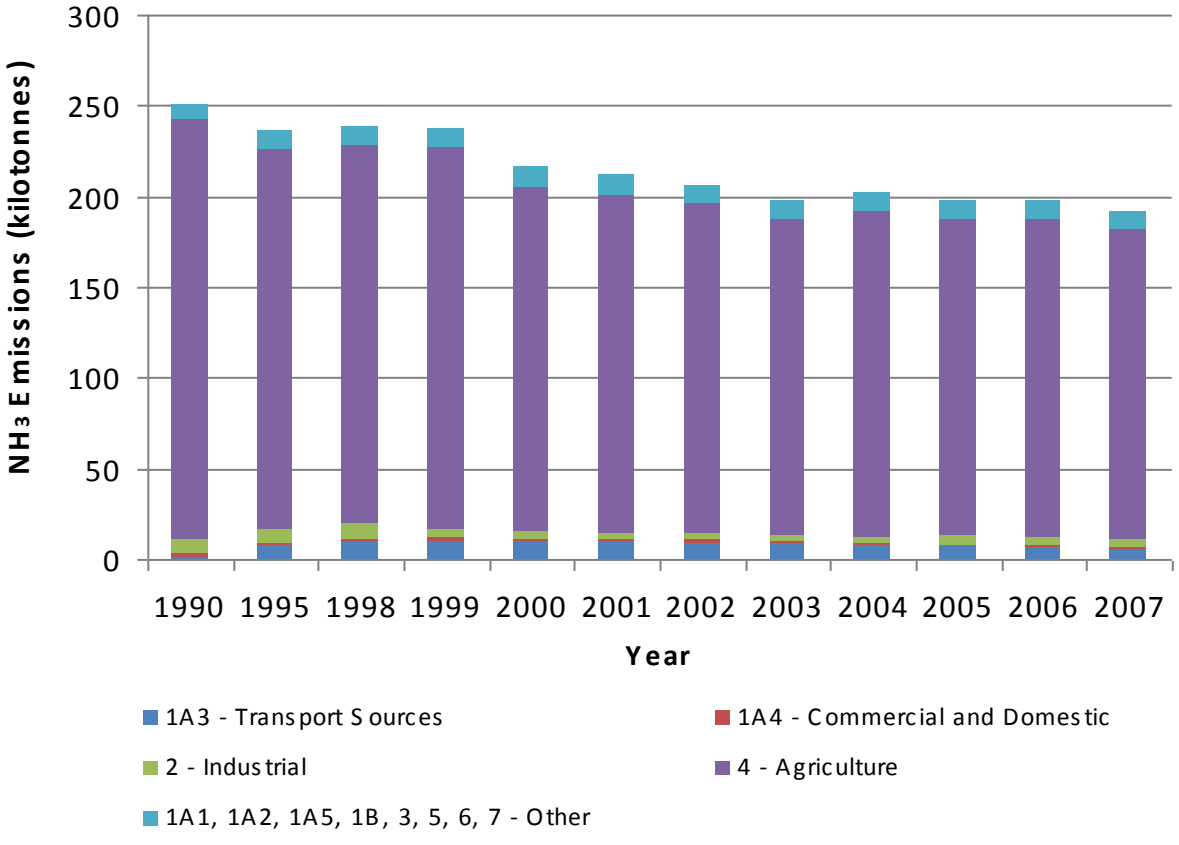
The table and graph below give a summary of the ammonia emissions in England by broad NFR sector categories. The detailed data are available in Appendix H.

Table 2-2 - England emissions of NH_3 by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007%
1A3 - Transport Sources	0.7	7.2	9.6	9.7	9.8	9.6	9.3	8.7	8.0	7.2	6.4	5.4	2.8%
1A4 - Commercial and Domestic	2.8	2.1	1.9	2.0	1.6	1.6	1.3	1.1	1.1	1.0	1.0	1.1	0.6%
2 - Industrial	7.1	7.2	8.8	4.8	3.5	3.6	3.5	3.2	3.1	5.3	5.1	4.9	3%
4 - Agriculture	231	210	208	211	191	186	182	175	180	174	175	171	89%
1A1,1A2,1B,3,6,7 - Other	8.6	9.9	9.8	10.1	10.2	10.2	10.3	10.1	10.0	9.8	9.7	9.4	5%
Total	251	236	238	237	216	211	206	198	202	197	198	192	100%

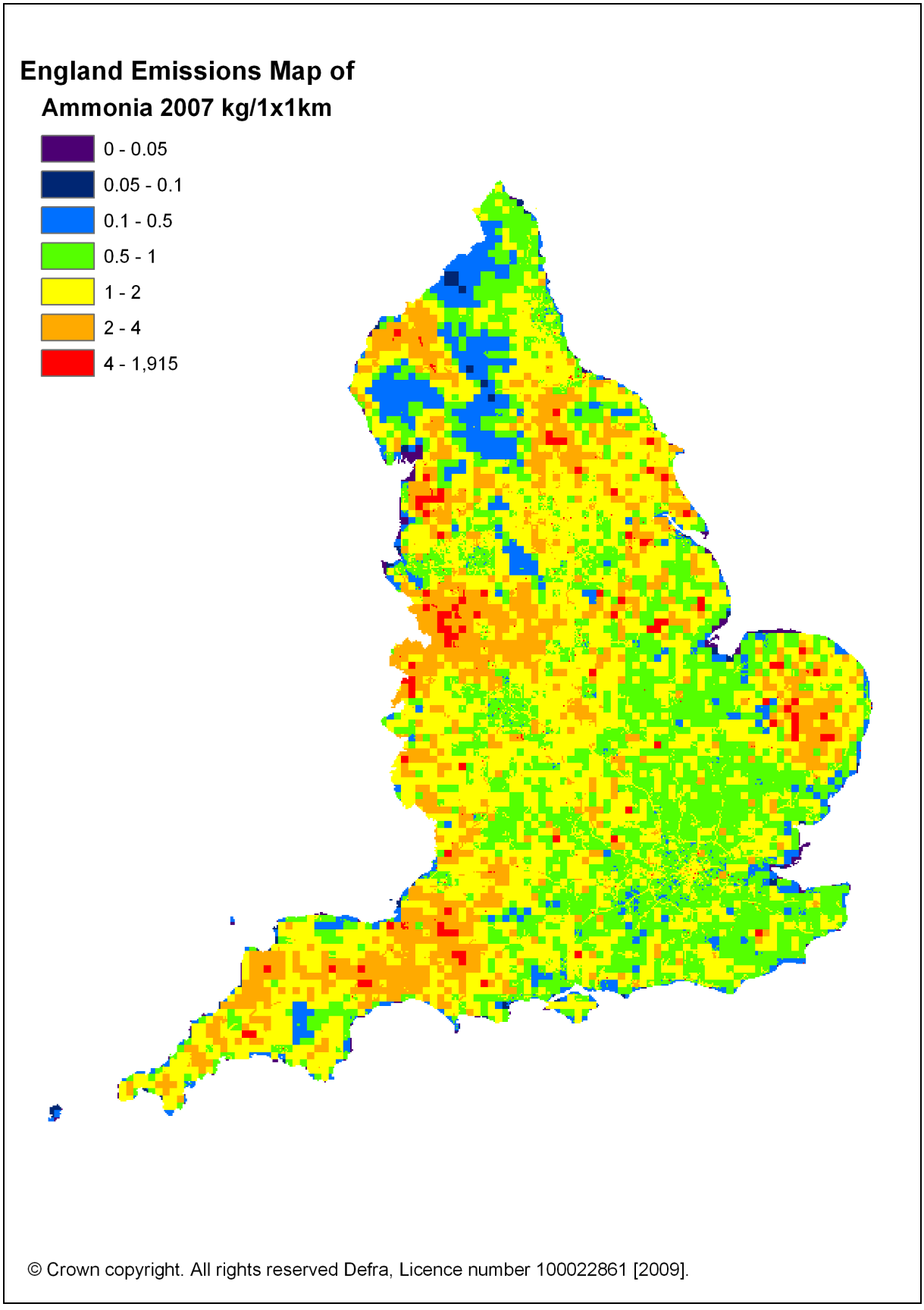
Units: kilotonnes

Figure 2-2 - Time series of England NH_3 emissions 1990-2007



England's NH_3 emissions have declined by 23% since 1990 and currently account for 66% of the UK total. The inventory is dominated by emissions from agricultural sources with 74% of the total in 2007 coming from manure management (4B: down 24% since 1990). 41% of the English total is from cattle manure management alone (4B1: down 20% since 1990). Other sources of note include transport emissions (1A3: 2.8 % of the England total in 2007) and waste treatment and disposal (6: 3.7 % of the England total in 2007).

Figure 2-3 Map of Ammonia Emissions in England, 2007



© Crown copyright. All rights reserved Defra, Licence number 100022861 [2009].

2.1.2 Scotland Ammonia Inventory by NFR Sector, 1990-2007

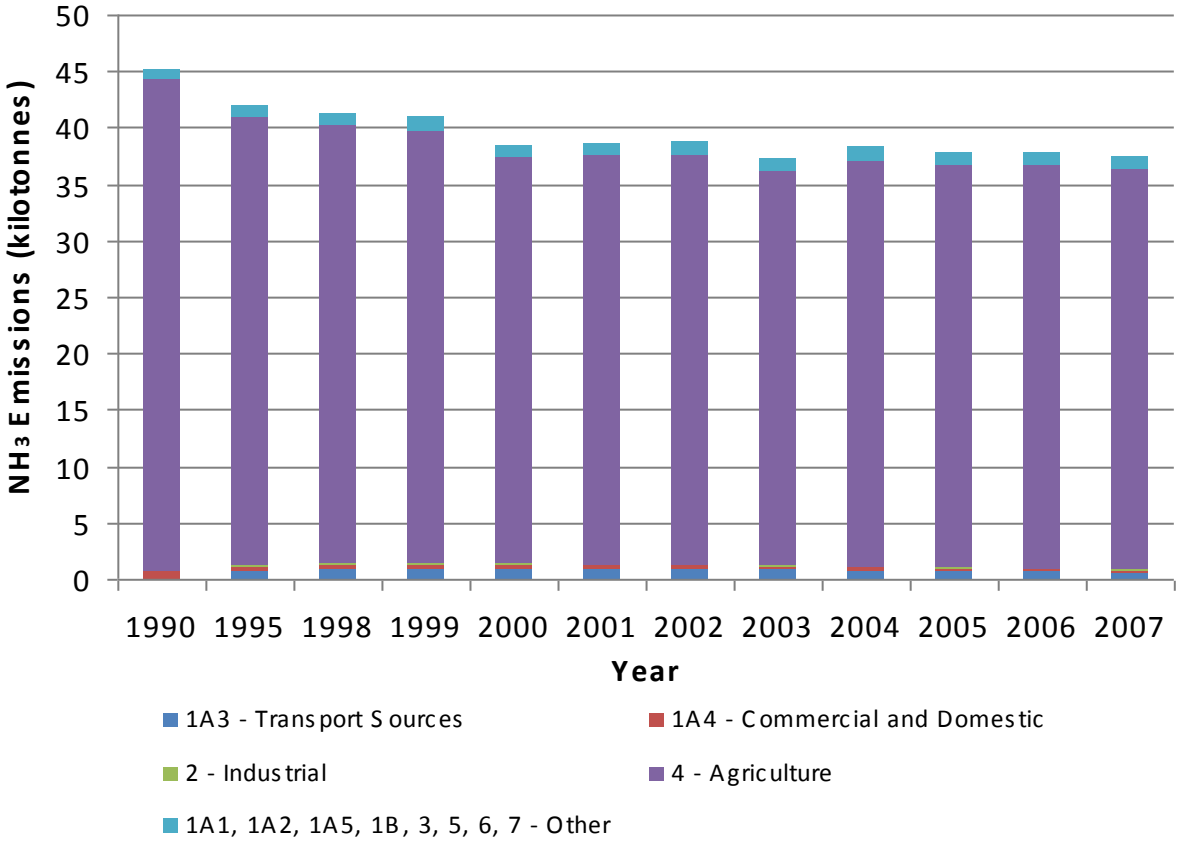
The table and graph below give a summary of the ammonia emissions in Scotland by broad NFR sector categories. The detailed data are available in Appendix H.

Table 2-3 - Scotland emissions of NH_3 by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A3 - Transport Sources	0.1	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.7	0.6	0.5	1.4%
1A4 - Commercial and Domestic	0.6	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.7%
2 - Industrial	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0%
4 - Agriculture	43.5	39.7	38.8	38.4	36.0	36.2	36.3	35.0	36.0	35.7	35.7	35.5	95%
1A1,1A2,1B,3,6,7 - Other	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	3%
Total	45	42	41	41	39	39	39	37	38	38	38	37	100%

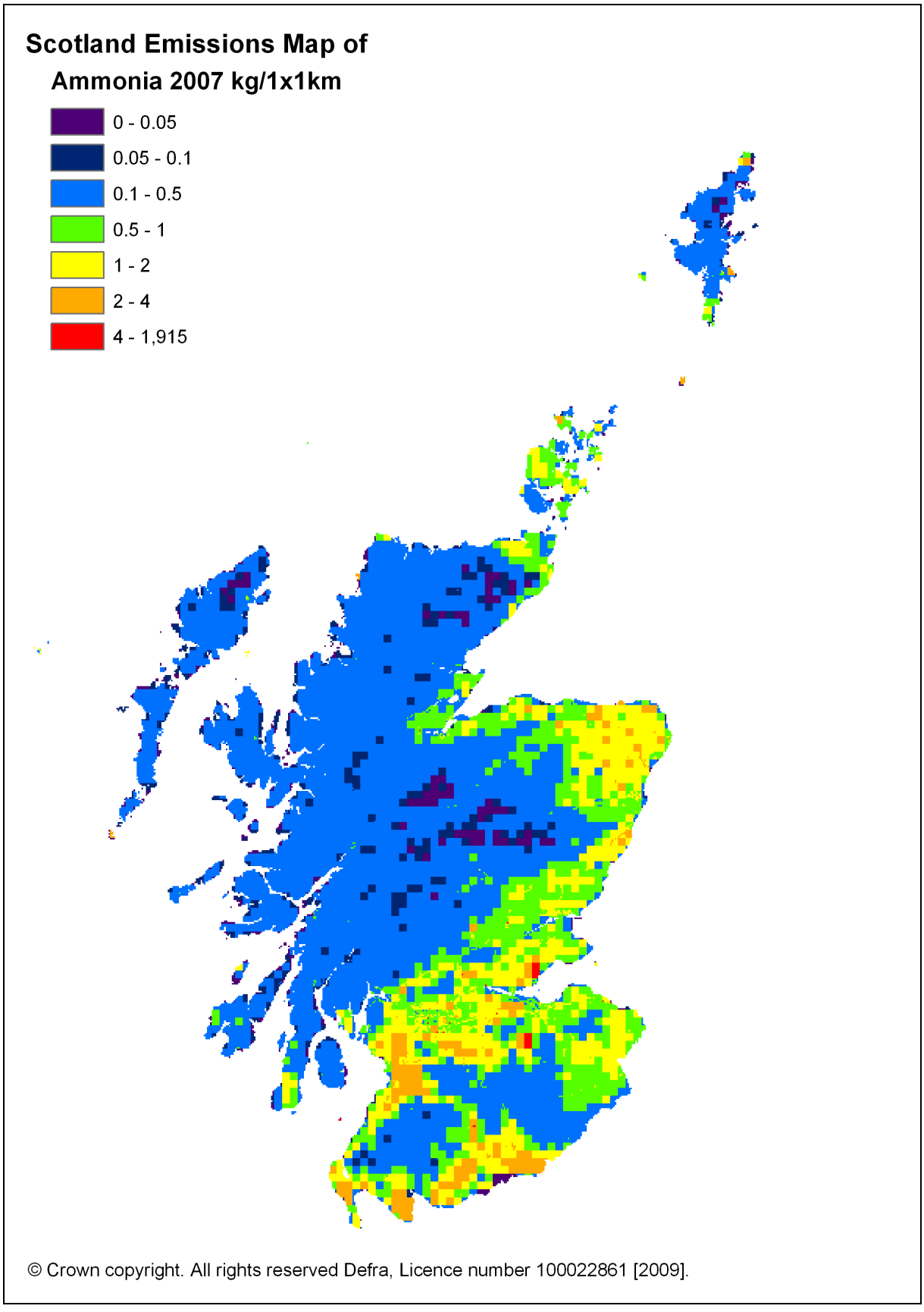
Units: kilotonnes

Figure 2-4 - Time series of Scotland NH_3 emissions 1990-2007



Scotland's NH_3 emissions have declined by 17% since 1990 and accounted for 13% of the UK total in 2007. The inventory is dominated by emissions from agricultural sources, with 76% of the total in 2007 estimated to originate from manure management (4B: down 11% since 1990). Other sources of note include transport emissions (1A3: 1.4% of the Scotland total in 2007) and waste treatment and disposal (6: 1.3 % of the Scotland total in 2007).

Figure 2-5 Map of Ammonia Emissions in Scotland, 2007



© Crown copyright. All rights reserved Defra, Licence number 100022861 [2009].

2.1.3 Wales Ammonia Inventory by NFR Sector, 1990-2007

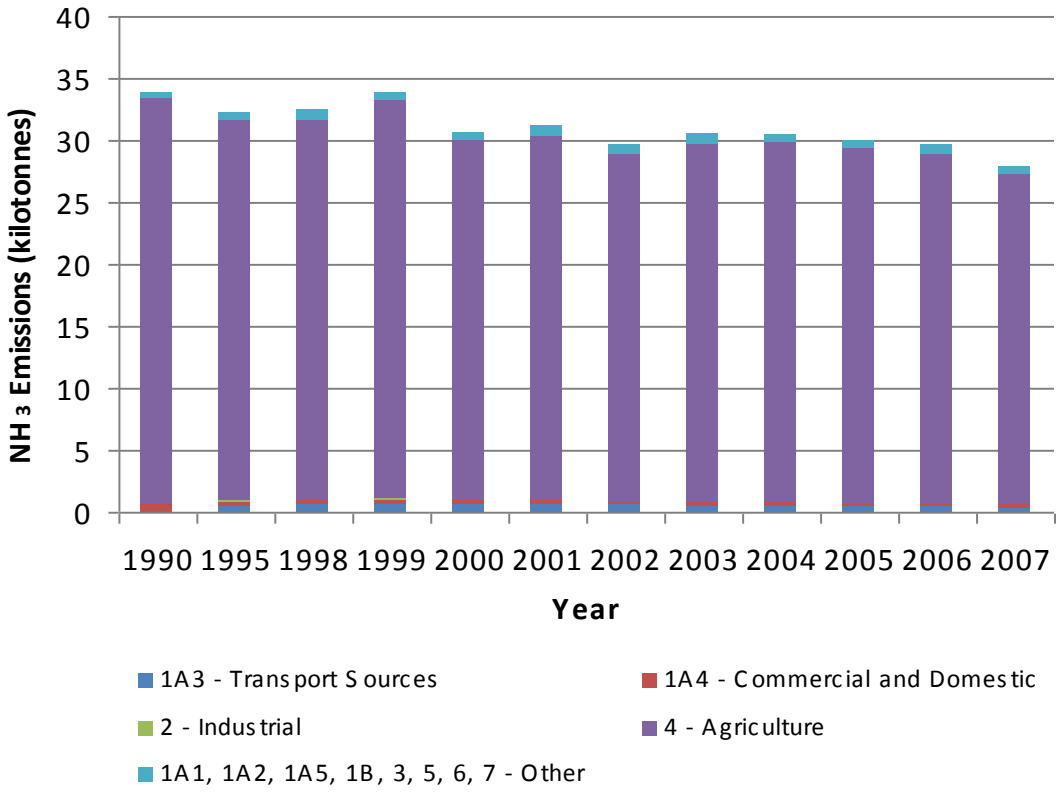
The table and graph below give a summary of the ammonia emissions in Wales by broad NFR sector categories. The detailed data are available in Appendix H.

Table 2-4 - Wales emissions of NH_3 by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A3 - Transport Sources	0.0	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.4	0.4	1.3%
1A4 - Commercial and Domestic	0.6	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.8%
2 – Industrial	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0%
4 – Agriculture	33	31	31	32	29	29	28	29	29	29	28	27	95%
1A1,1A2,1B,3 ,6, 7 - Other	0.6	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.7	0.7	0.7	0.6	2%
Total	34	32	32	34	31	31	30	31	31	30	30	28	100%

Units: kilotonnes

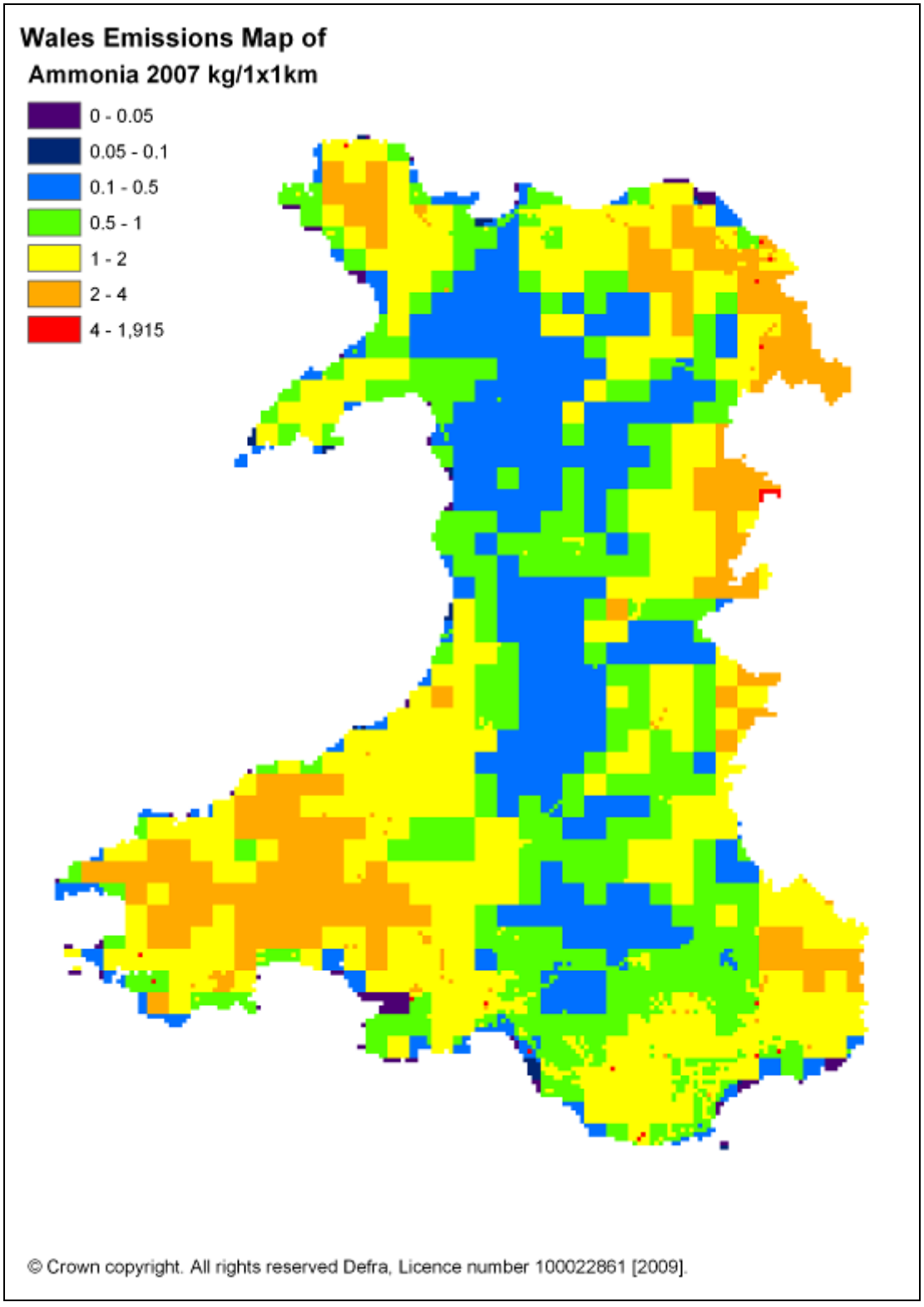
Figure 2-6 - Time series of Wales NH_3 emissions 1990-2007



NH_3 emissions in Wales have declined by 18% since 1990 and accounted for 10% of the UK total in 2007. The inventory is dominated by emissions from agricultural sources with 80% of the total in 2007 coming from manure management (4B: down 14% since 1990). 55% of emissions from Wales is estimated to originate from cattle manure management alone (4B1: down 11% since 1990). Other

sources of note include transport emissions (1A3: 1.3% of the Wales total in 2007) and waste treatment and disposal (6: 1.7 % of the Wales total in 2007)..

Figure 2-7 Map of Ammonia Emissions in Wales, 2007



2.1.4 Northern Ireland Ammonia Inventory by NFR Sector, 1990-2007

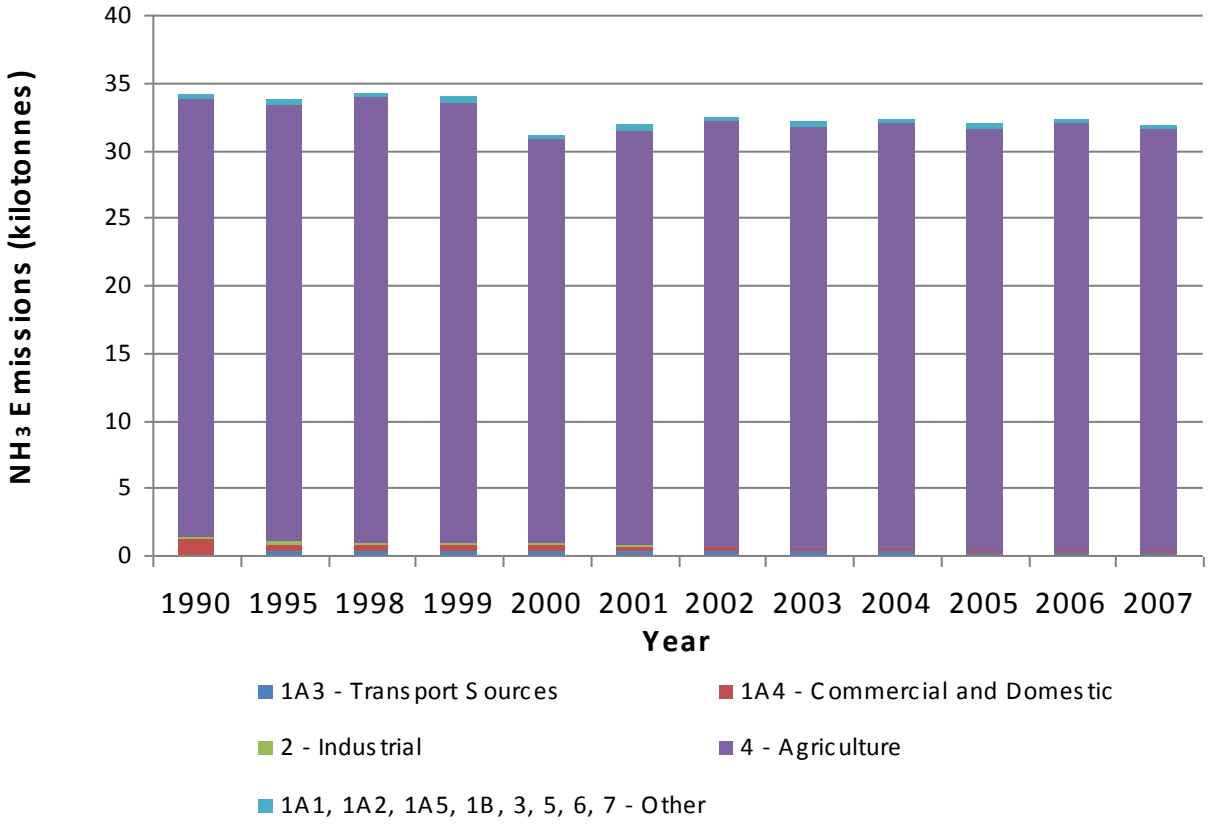
The table and graph below give a summary of the ammonia emissions in Northern Ireland by broad NFR sector categories. The detailed data are available in Appendix H.

Table 2-5 - Northern Ireland emissions of NH_3 by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A3 - Transport Sources	0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.5%
1A4 - Commercial and Domestic	1.1	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.2	0.5%
2 - Industrial	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0%
4 - Agriculture	33	32	33	33	30	31	32	31	32	31	32	31	98%
1A1,1A2,1B,3,6,7 - Other	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1%
Total	34	34	34	34	31	32	32	32	32	32	32	32	100%

Units: kilotonnes

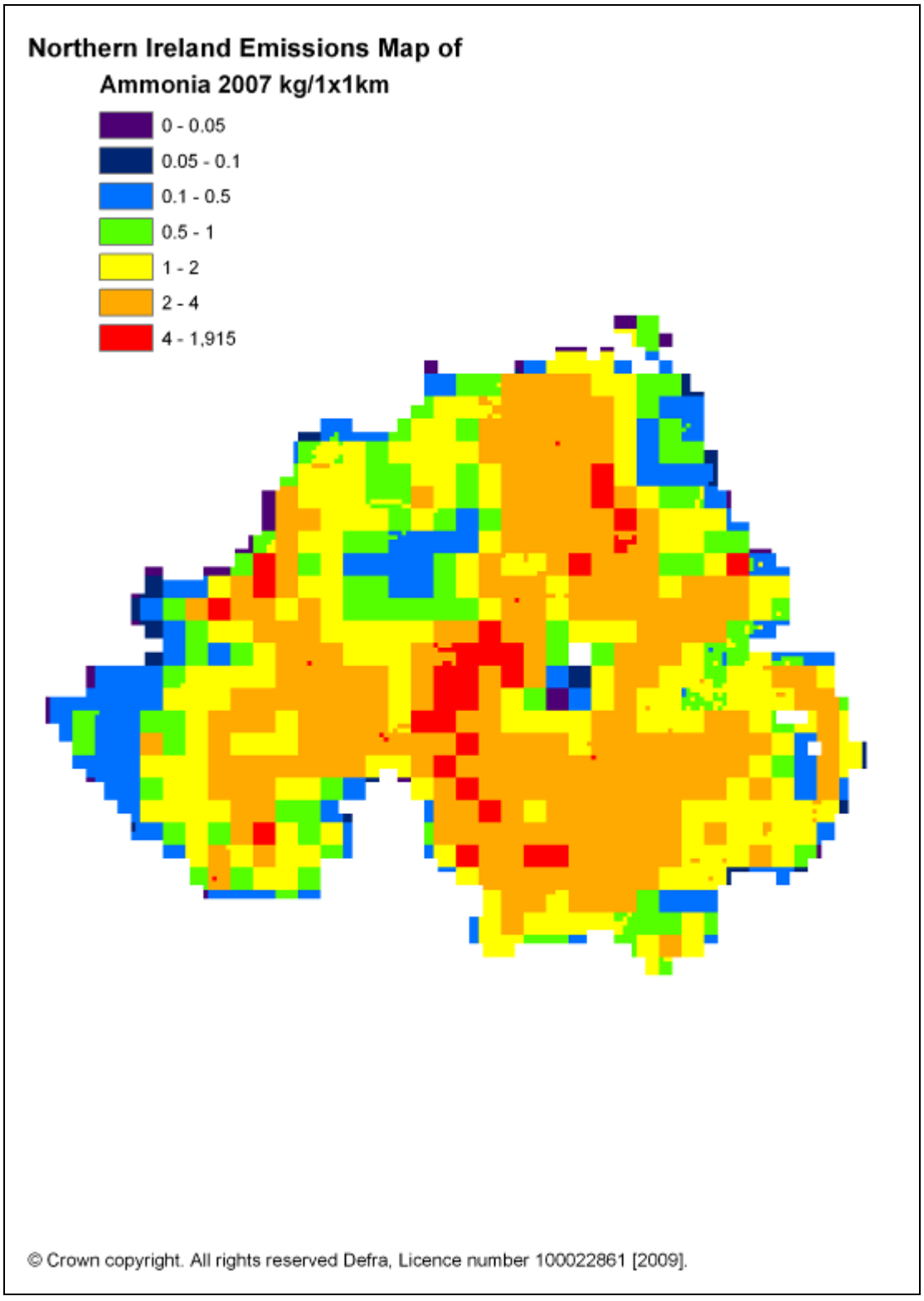
Figure 2-8 - Time series of Northern Ireland NH_3 emissions 1990-2007



Northern Ireland's NH_3 emissions have declined by 7% since 1990 and currently account for 11% of the UK total. The inventory is dominated by emissions from agricultural sources with 86% of the total in 2007 coming from manure management (4B: up 0.7% since 1990). 65% of the Northern Ireland total is from cattle manure management alone (4B1: up 14% since 1990). Other sources of note

include transport emissions (1A3: 0.5% of the Northern Ireland total in 2007) and commercial and domestic combustion (1A4: 0.5 % of the Northern Ireland total in 2007).

Figure 2-9 Map of Ammonia Emissions in Northern Ireland, 2007

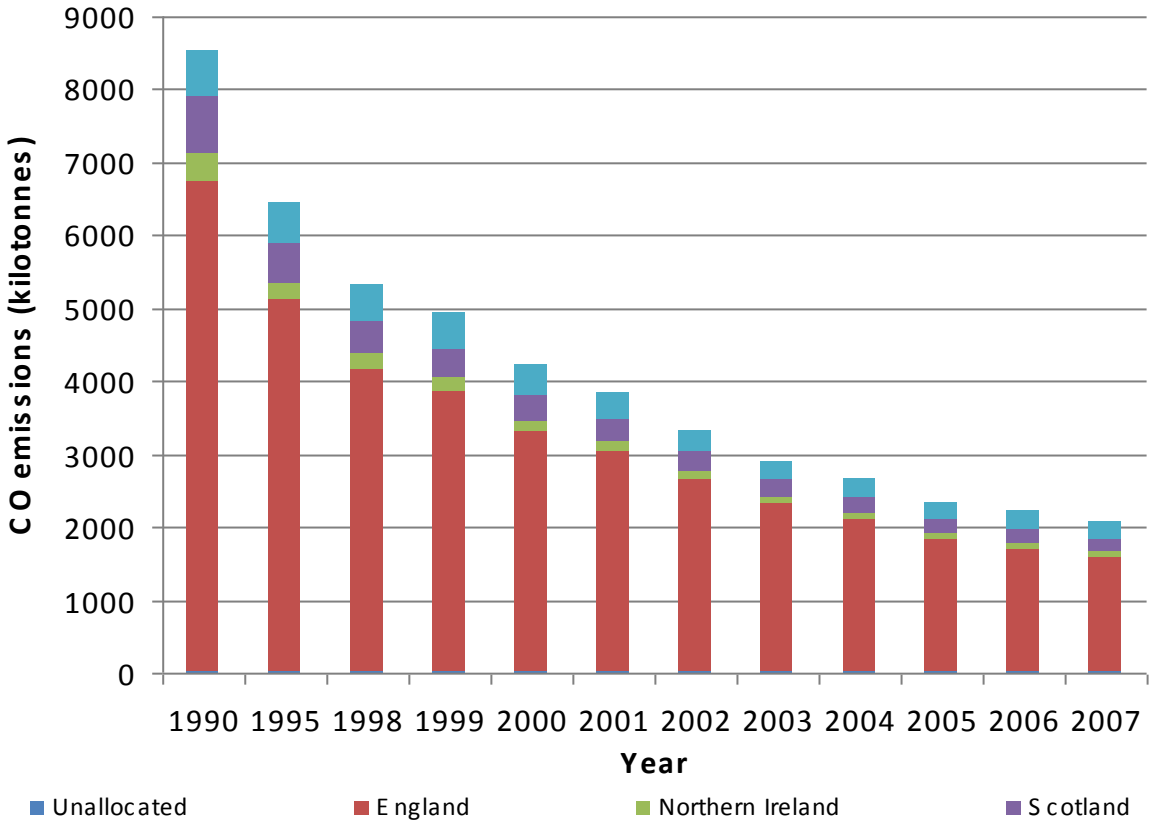


2.2 CARBON MONOXIDE EMISSION ESTIMATES

Carbon monoxide arises from incomplete fuel-combustion and is of concern mainly due to its toxicity and its role in tropospheric ozone formation. In terms of human health, CO combines with haemoglobin in blood, decreasing the uptake of oxygen by the lungs, with symptoms varying from nausea to asphyxiation depending upon the level of exposure.

Across the UK, over the period 1970-2007 emissions decreased by 83% reflecting significant reduction in emissions from road transport, agricultural field burning and the domestic sector.

Figure 2-10 - Total UK emissions of CO



The main sources of CO are outlined below:

- **Road Transport.** Petrol engines are the main source of CO emissions, especially from cold start engine cycles. Since 1990, emissions from road transport sources have reduced by around 86% due to improvements to the development of more efficient engine combustion technology, the increased use of catalytic converters and the growth in diesel engine use.

- **Off-road transport and machinery.** In the UK, just over 10% of CO emissions arise from off-road mobile machinery such as portable generators, forklift trucks, lawnmowers and cement mixers. Recent studies have been aimed at improving these estimates, but the quality of CO emission estimates from such machinery remains uncertain due to the lack of activity data and the resultant use of survey data and assumptions regarding equipment numbers and utilisation.

- **Domestic combustion**. Over 13% of CO emissions in 2007 arise from residential combustion sources. Reductions in emissions have been significant, due to the switch from solid fuels to the use of gas and electricity, with a 73% reduction in UK emissions since 1990.

Other sources of CO emissions are small compared with transport, domestic and off-road sources. Industrial combustion emissions have decreased by 57% since 1970, reflecting fuel switching from solid fuels to gas, similar to the domestic sector. The sudden decline in emissions from the agricultural sector reflects the banning of stubble burning in 1993 in England and Wales. Currently power generation accounts for only 4% of UK emissions.

Emissions of CO for England, Wales, Scotland and Northern Ireland are summarised in the tables and graphs below, with more detailed inventory tables in Appendix D. Table 2.6 shows how total UK CO emissions are split between the 4 constituent countries.

Table 2-6 - Proportion of total CO emissions from UK constituent countries

Year	England	Scotland	Wales	N Ireland	Unallocated
1990	79%	9%	7%	4%	0%
2007	75%	8%	11%	4%	1%

2.2.1 England CO Inventory by NFR Sector, 1990-2007

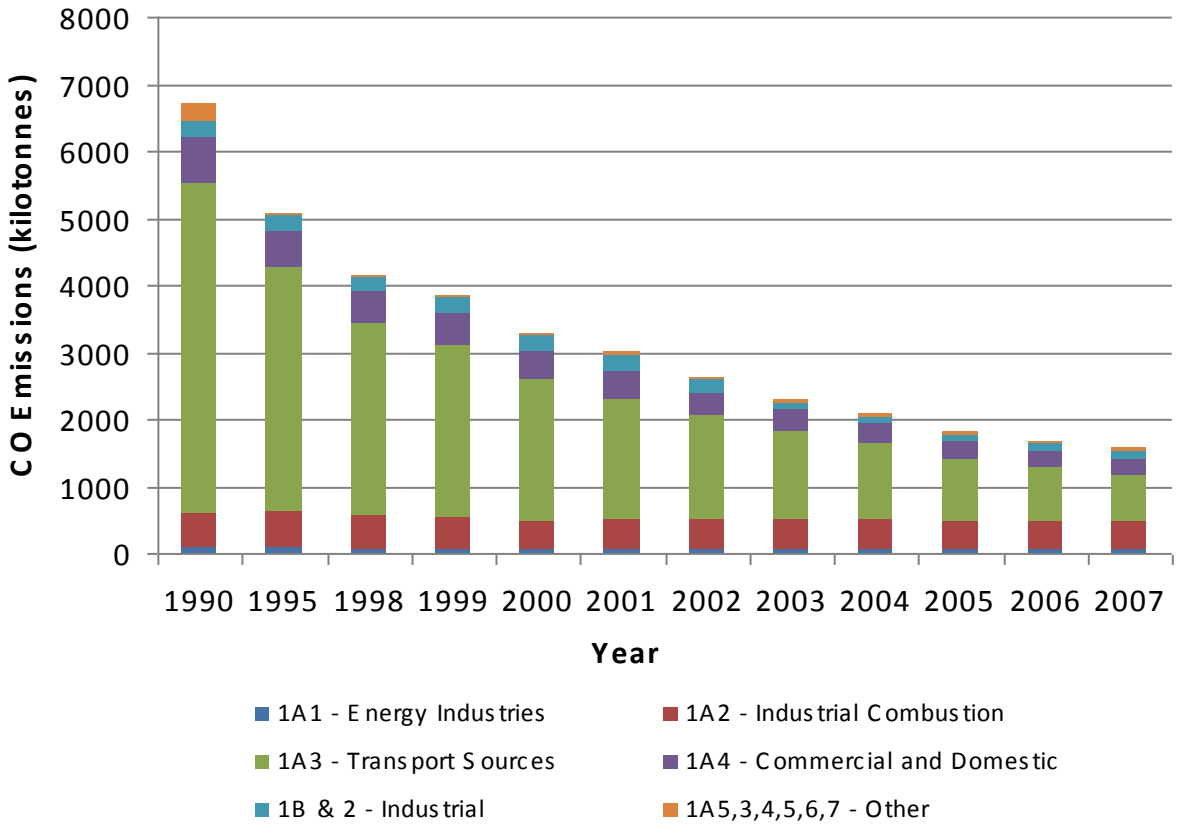
The table and graph below give a summary of the CO emissions in England by broad NFR sector categories. The detailed data are available in Appendix D.

Table 2-7 - England emissions of CO by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	99	93	56	50	59	58	56	64	62	67	67	70	4%
1A2 - Industrial Combustion	488	530	501	488	412	451	445	433	435	422	398	395	25%
1A3 - Transport Sources	4936	3655	2864	2567	2124	1796	1551	1328	1132	925	807	689	44%
1A4 - Commercial and Domestic	673	532	478	477	414	414	344	310	302	261	249	257	16%
1B & 2 - Industrial	240	231	209	228	231	232	192	114	106	98	124	122	8%
1A5,4,5,6,7 - Other	291	41	40	42	43	60	44	44	42	41	41	42	3%
Total	6727	5082	4148	3853	3282	3012	2631	2294	2079	1815	1686	1576	100%

Units: kilotonnes

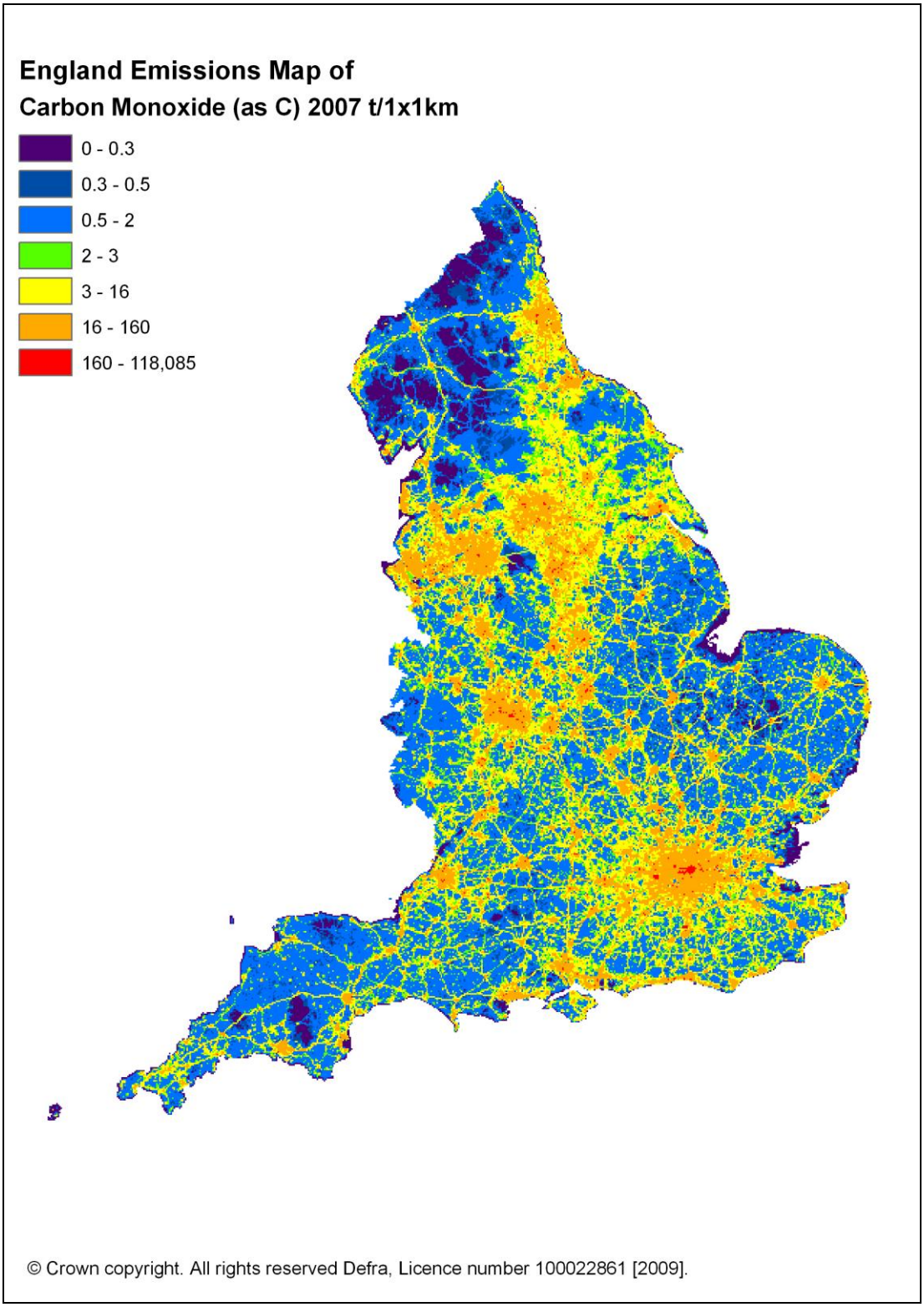
Figure 2-11 - Time series of England CO emissions 1990-2007



England's CO emissions have declined by 77% since 1990 and account for 75% of the UK total. 42% of CO emissions in England stem from road transport combustion sources (1A3bi-iv: down by 87% since 1990), whilst 25% stem from industrial combustion (1A2: down 19% since 1990) and 16% from commercial and residential combustion (1A4: down 62% since 1990). Notable increasing trends in emissions arise from the non-road transport sources, such as railways (1A3dii: up by 32% since 1990) and other mobile sources and machinery (1A3eii: up by 75% since 1990). However, the levels

of emissions from these sources are small relative to emissions that arise from road transport sources.

Figure 2-12 Map of Carbon Monoxide Emissions in England, 2007



2.2.2 Scotland CO Inventory by NFR Sector, 1990-2007

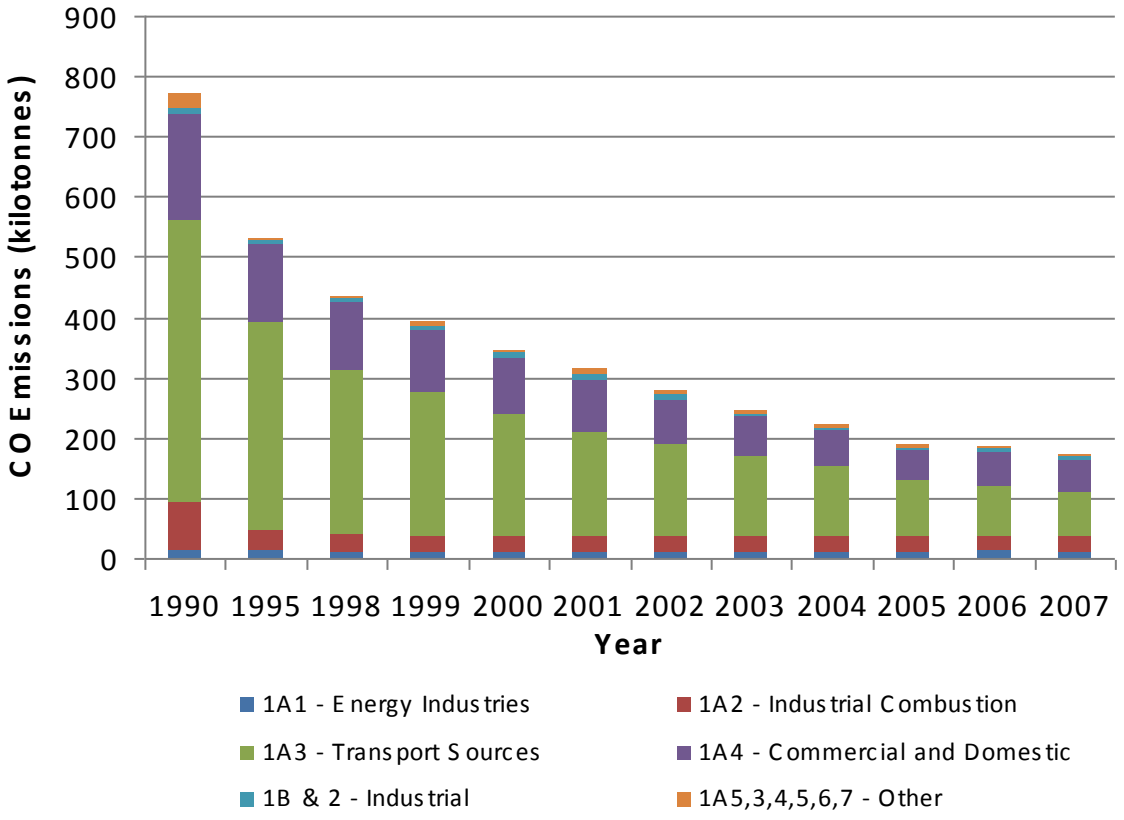
The table and graph below give a summary of the CO emissions in Scotland by broad NFR sector categories. The detailed data are available in Appendix D.

Table 2-8 - Scotland emissions of CO by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	14.6	14.6	9.9	9.1	10.8	10.5	10.0	9.5	10.0	9.9	11.9	10.8	6%
1A2 - Industrial Combustion	78.4	30.9	29.2	28.0	25.7	25.4	27.5	27.2	28.2	26.5	25.6	25.5	15%
1A3 - Transport Sources	467	346	272	237	204	174	152	132	113	93	83	72	41%
1A4 - Commercial and Domestic	177	129	113	103	93	87	74	65	60	49	56	55	32%
1B & 2 - Industrial	11.1	6.3	6.4	7.7	7.8	8.6	8.2	4.4	4.4	4.4	5.6	5.3	3%
1A5,4,5,6,7 - Other	24.0	5.0	5.0	5.5	5.8	10.3	5.9	5.9	5.6	5.5	5.3	5.3	3%
Total	771	532	436	391	347	316	278	245	221	188	187	174	100%

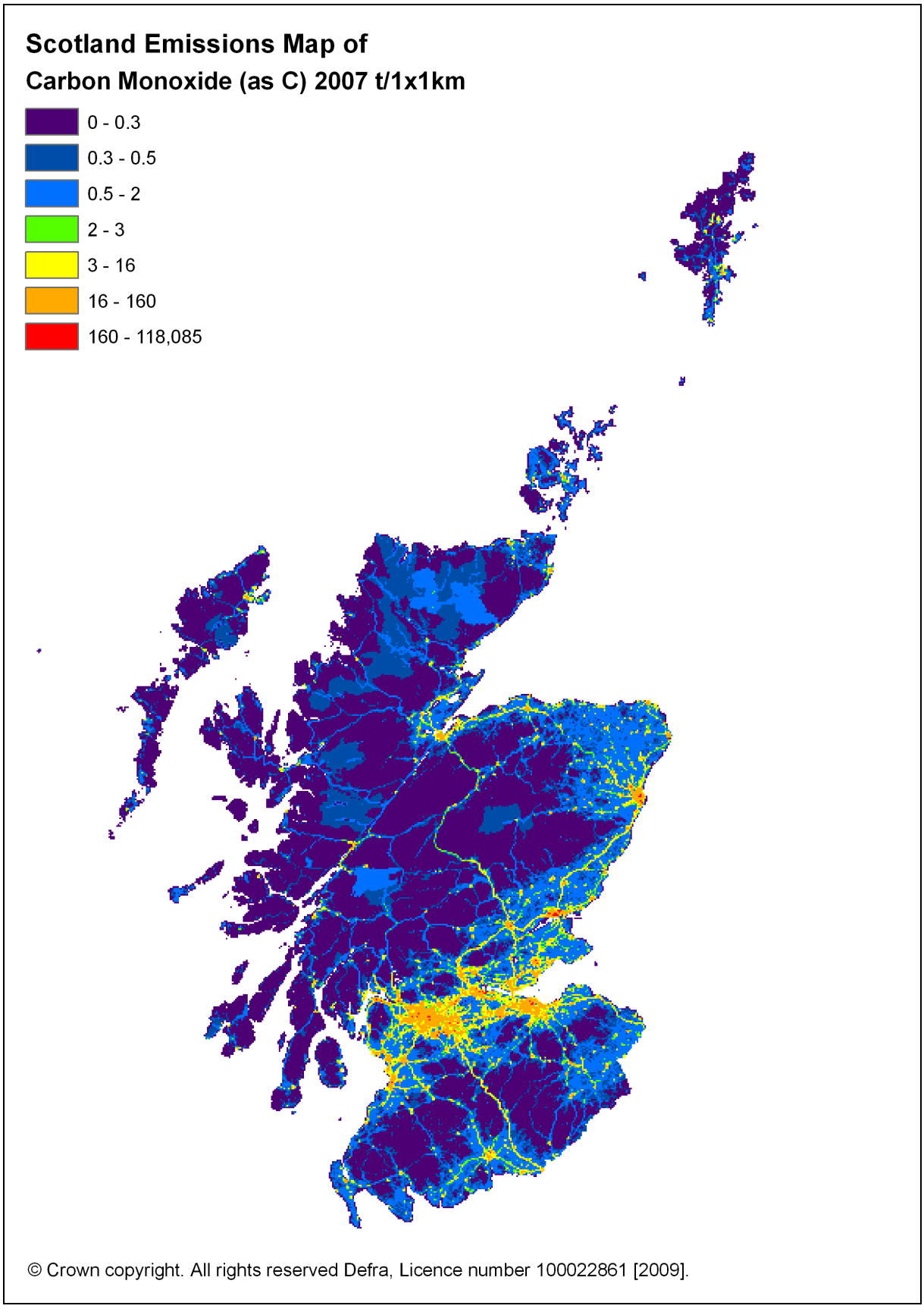
Units: kilotonnes

Figure 2-13 - Time series of Scotland CO emissions 1990-2007



Scotland's CO emissions have declined by 77% since 1990 and account for 8% of the UK total. 36% of CO emissions in Scotland stem from road transport combustion sources (1A3bi-iv: down by 86% since 1990), whilst 15% stem from industrial combustion (1A2: down 67% since 1990) and 32% from commercial and residential combustion (1A4: down 69% since 1990).

Figure 2-14 Map of Carbon Monoxide Emissions in Scotland, 2007



2.2.3 Wales CO Inventory by NFR Sector, 1990-2007

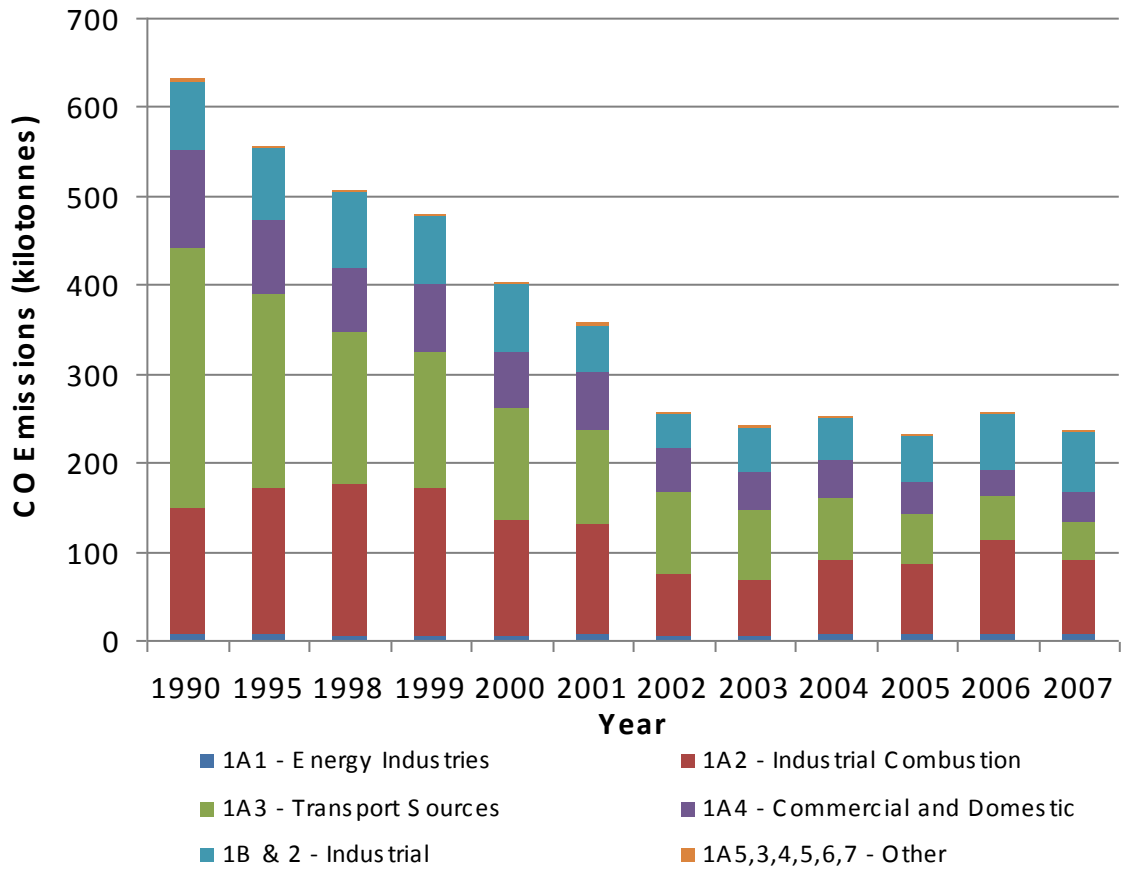
The table and graph below give a summary of the CO emissions in Wales by broad NFR sector categories. The detailed data are available in Appendix D.

Table 2-9 - Wales emissions of CO by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	6.3	6.2	4.4	3.9	5.2	5.9	4.8	5.2	6.9	6.2	6.8	5.7	2%
1A2 - Industrial Combustion	142	165	171	168	131	124	69	61	84	80	106	85	36%
1A3 - Transport Sources	293	218	170	152	126	107	93	80	69	56	50	43	18%
1A4 - Commercial and Domestic	109	83	74	76	63	64	49	43	42	35	30	32	14%
1B & 2 - Industrial	77	81	85	76	75	54	37	49	46	52	63	68	29%
1A5,4,5,6,7 - Other	4.5	2.3	2.3	2.4	2.5	3.7	2.5	2.5	2.4	2.4	2.3	2.3	1%
Total	632	556	507	479	402	358	256	241	251	231	257	236	100%

Units: kilotonnes

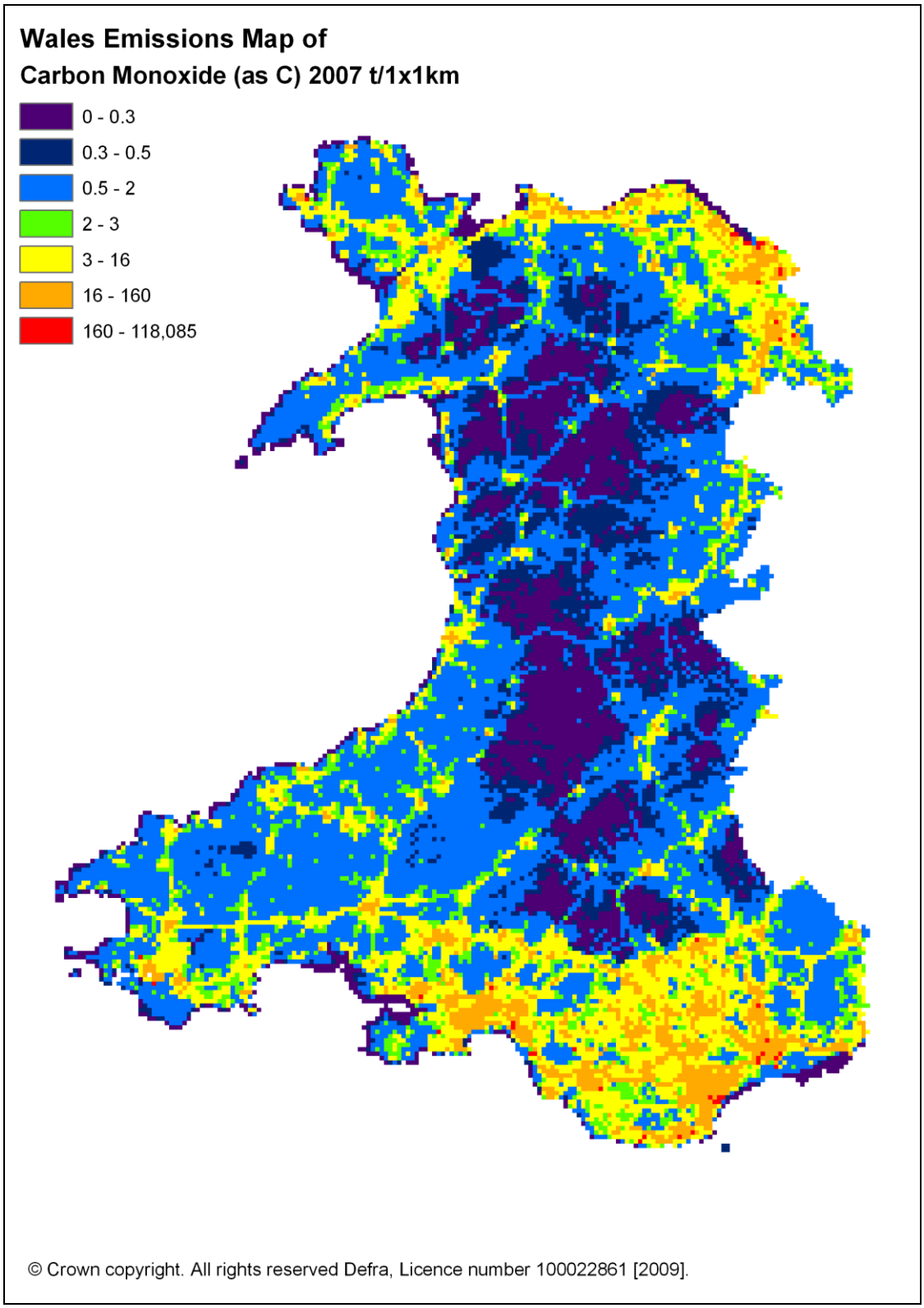
Figure 2-15 - Time series of Wales CO emissions 1990-2007



Wales's CO emissions have declined by 63% since 1990 and account for 11% of the UK total. The iron & steel industry contributes a very significant emission to the Welsh total, with a total of 36% of CO from industrial combustion (1A2: down 40% since 1990). 17% of CO emissions in Wales stem from road transport combustion sources (1A3bi-iv: down by 86% since 1990), whilst 14% stem from commercial and residential combustion (1A4: down 70% since 1990). Total CO emissions have gone

up between 2005 and 2006, with increased emissions from the iron & steel industry (1A2), solid fuel transformation (1B1b) and metal production (2C). This is due to increased industrial output that is notable in Wales and the above average concentration of heavy industry within the country. However, this subsequently declined again between 2006-2007.

Figure 2-16 Map of Carbon Monoxide Emissions in Wales, 2007



2.2.4 Northern Ireland CO Inventory by NFR Sector, 1990-2007

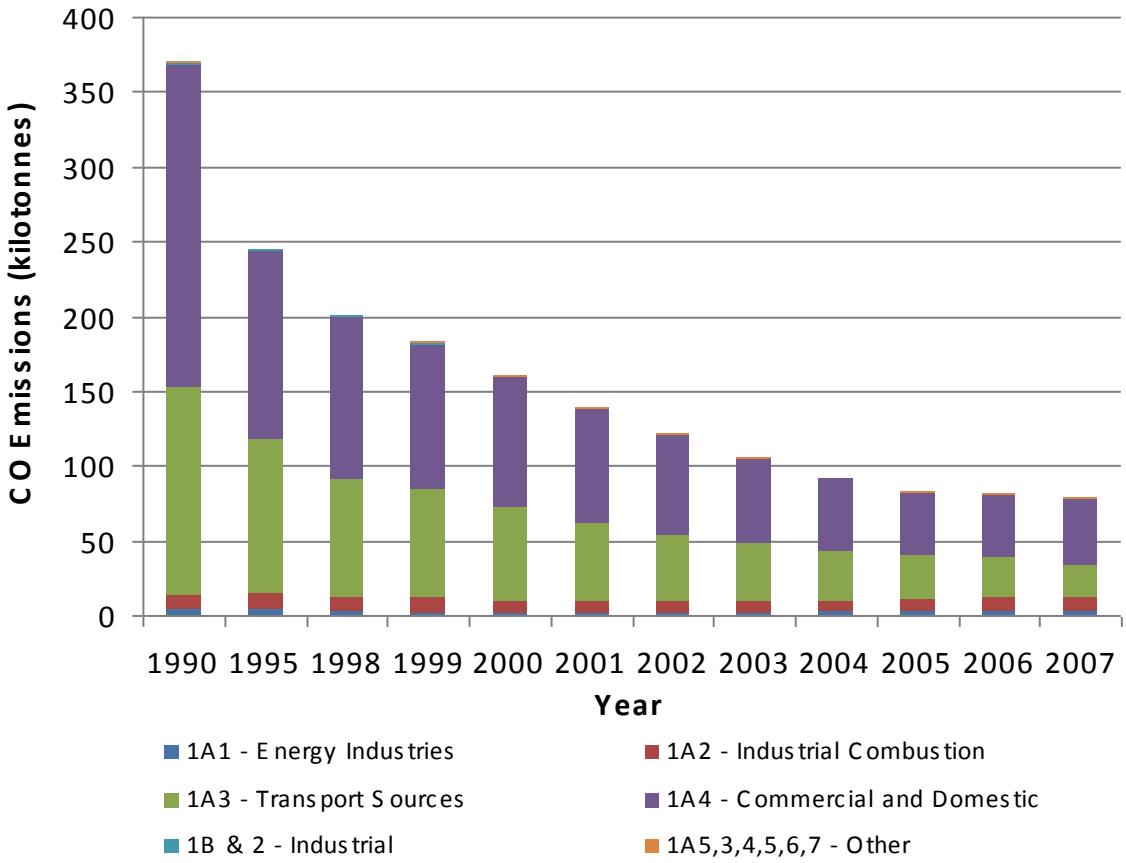
The table and graph below give a summary of the CO emissions in Northern Ireland by broad NFR sector categories. The detailed data are available in Appendix D.

Table 2-10 - Northern Ireland emissions of CO by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	4.1	3.8	2.2	1.4	1.3	1.5	1.1	1.1	2.1	3.1	2.9	2.7	3%
1A2 - Industrial Combustion	9.8	10.8	10.3	10.1	8.4	7.8	7.8	7.7	7.8	7.9	8.8	9.1	12%
1A3 - Transport Sources	138	103	79	73	62	52	44	39	34	29	27	21	27%
1A4 - Commercial and Domestic	216	127	108	96	87	76	67	57	47	41	42	44	56%
1B & 2 - Industrial	0.2	0.2	0.2	0.4	0.4	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0%
1A5,3,4,5,6,7 - Other	2.5	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.2	2%
Total	371	245	201	183	160	139	122	106	92	83	82	79	100%

Units: kilotonnes

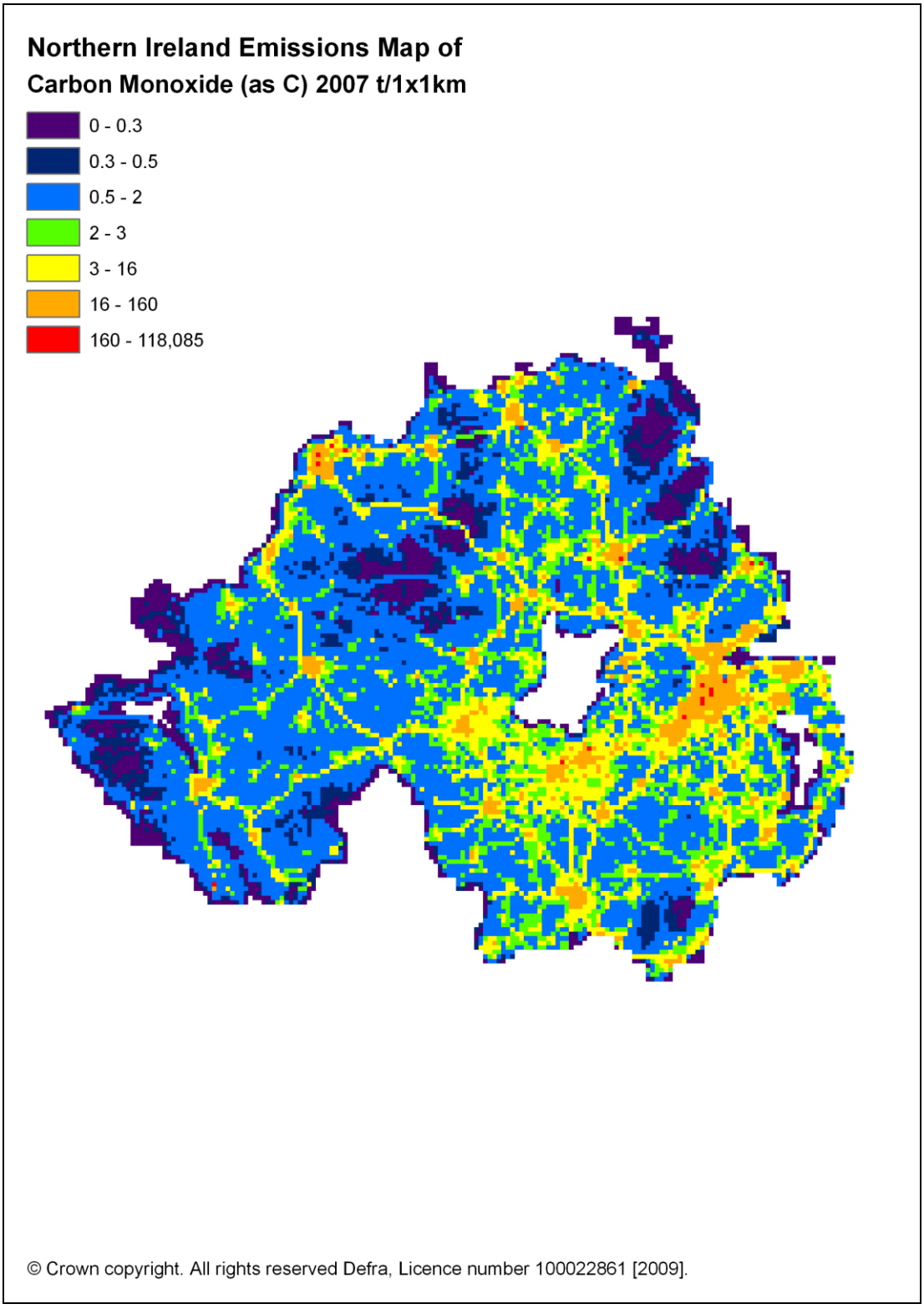
Figure 2-17 - Time series of Northern Ireland CO emissions 1990-2007



Northern Ireland's CO emissions have declined by 79% since 1990 and accounted for 4% of the UK total in 2007. 26% of CO emissions in Northern Ireland stem from road transport combustion sources (1A3bi-iv: down by 85% since 1990), whilst only 12% come from industrial combustion sources (1A2: down 7% since 1990). 56% of the Northern Ireland total emission comes from commercial and residential combustion (1A4: down 80% since 1990). This contribution is much greater than in other DAs (commercial and residential emissions contribute 16%, 32% and 14% within England, Scotland

and Wales respectively) due to the greater use of solid fuels in domestic heating combined and the significantly lower industrial emissions in the region.

Figure 2-18 Map of Carbon Monoxide Emissions in Northern Ireland, 2007



2.3 NITROGEN OXIDES EMISSION ESTIMATES

Across the UK, NO_X emissions arise primarily from combustion sources. The estimation of these emissions is complex since the nitrogen can be derived from either the fuel or atmospheric nitrogen. The emission is 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. The main three combustion sources of NO_x are:

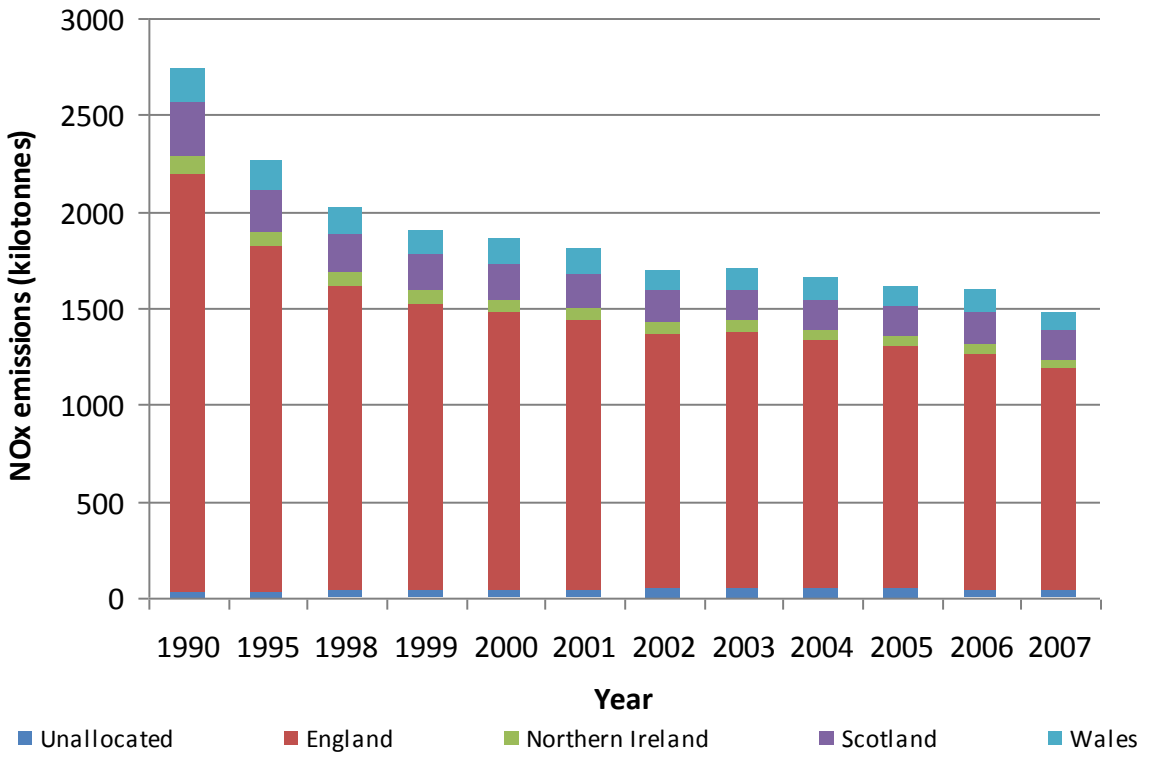
- **Transport.** In 2007 road vehicles contributed 30% of total UK NO_X emissions. Since 1990 there has been a steady decline in emissions due to the introduction of catalytic converters on cars and stricter regulations on truck emissions. Research indicates that conurbations and city centres show high localised emissions due to the combination of road transport, residential and commercial combustion sources. Similarly, around ports and major terminals, significant localised emissions arise from shipping, railway locomotives and road vehicles.

- **Power Generation.** 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. More recently the increased use of nuclear generation and the introduction of CCGT (Combined Cycle Gas Turbine) plant burning natural gas have further reduced NO_X emissions. The emissions from the low-NO_X turbines used are much lower than those of pulverised coal fired plant even when low-NO_X burners are fitted. Assuming that these trends continue, power station emissions are expected to fall further. The emissions from electricity generators have declined by 56% since 1970.

- **Industrial Combustion.** The emissions from industrial combustion have declined by 61% since 1970 and they currently contribute 16% to total UK emissions. This is primarily due to the decline in coal use in favour of gas and electricity.

As can be seen in figure 2.19, total UK emissions of NO_x have decreased by 46% since 1990.

Figure 2-19 - Total UK emissions of NO_x



Emissions of NO_X for England, Wales, Scotland and Northern Ireland are summarised in the tables and graphs below, with more detailed inventory tables in Appendix E. Table 2.11 shows how total UK NO_x emissions are split between the 4 constituent countries.

Table 2-11 - Proportion of total NO_x emissions from UK constituent countries

Year	England	Scotland	Wales	N Ireland	Unallocated
1990	79%	10%	6%	3%	1%
2007	77%	10%	7%	3%	3%

2.3.1 England NOX Inventory by NFR Sector, 1990-2007

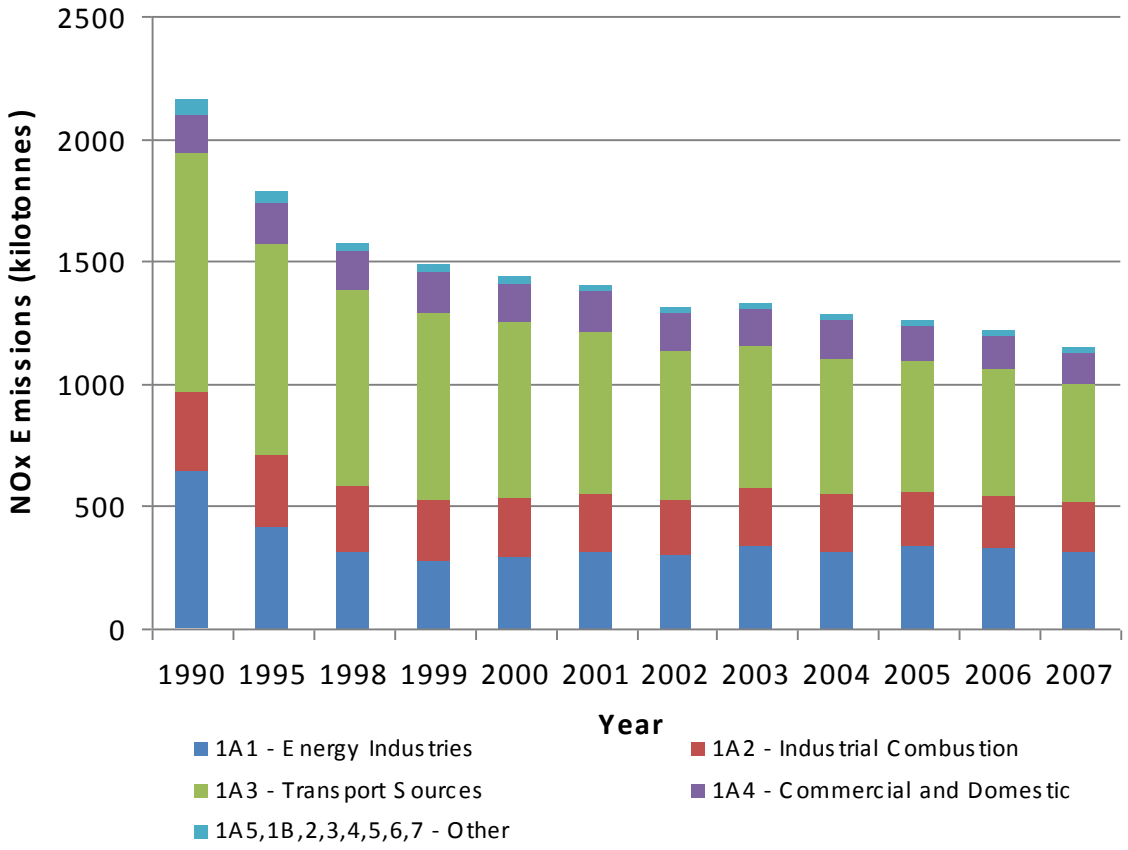
The table and graph below give a summary of the NO_X emissions in England by broad NFR sector categories. The detailed data are available in Appendix E.

Table 2-12 - England emissions of NO_x by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	648	414	312	275	291	314	300	336	316	336	326	314	27%
1A2 - Industrial Combustion	317	295	268	255	247	239	231	237	234	225	216	203	18%
1A3 - Transport Sources	980	865	801	759	711	660	606	584	554	530	520	481	42%
1A4 - Commercial and Domestic	156	160	164	163	160	161	153	152	152	144	134	125	11%
1A5,1B,2,4,5,6 - Other	62	48	29	31	29	28	25	20	25	23	23	24	2%
Total	2163	1782	1574	1482	1438	1402	1313	1329	1281	1258	1219	1147	100%

Units: kilotonnes

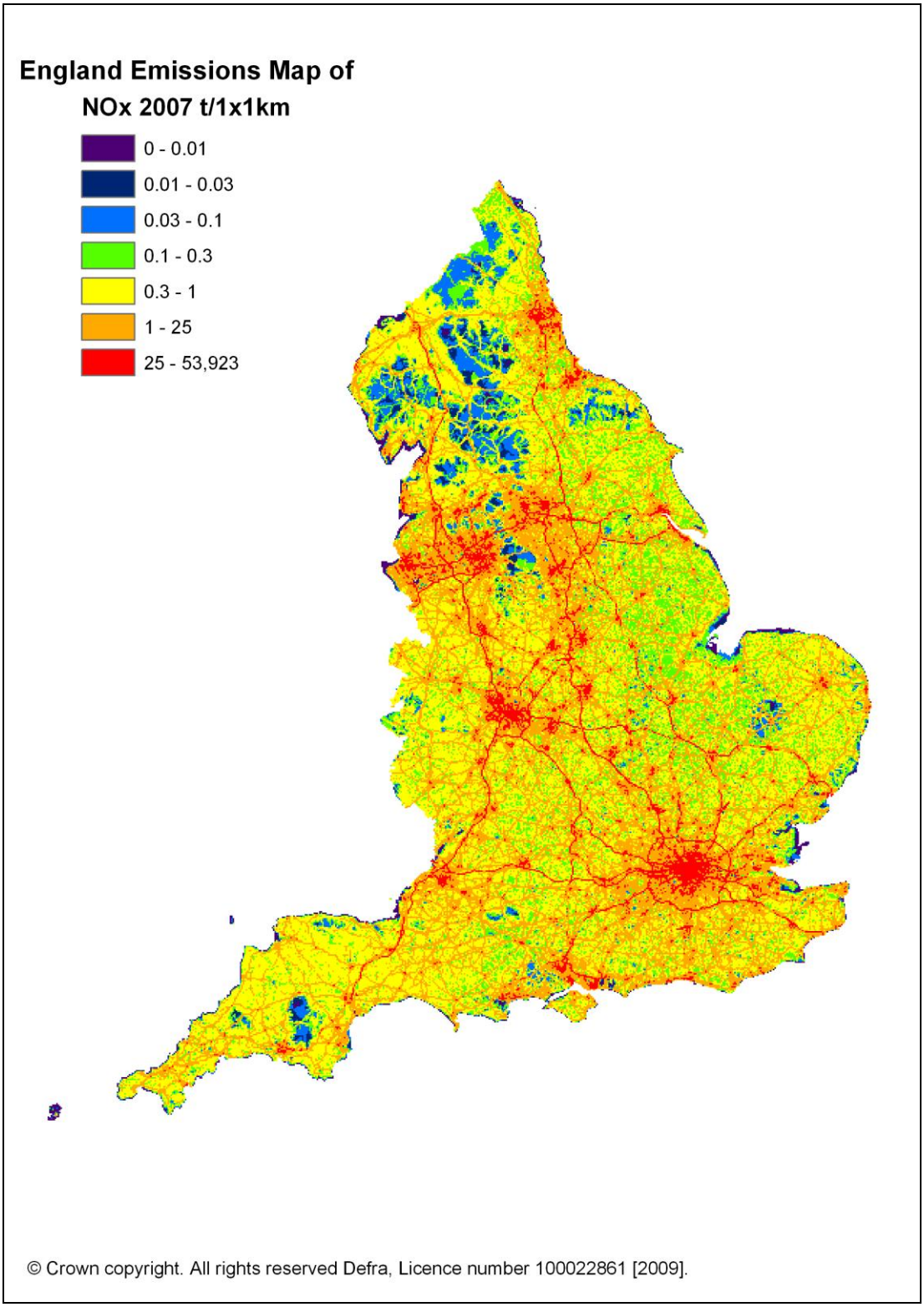
Figure 2-20 - Time series of England NO_x emissions 1990-2007



England's NO_X emissions have declined by 47% since 1990 and account for 77% of the UK total. Power generation is a very significant source, accounting for 25% of the England total in 2007, although emissions from this source have reduced by 53% since 1990. 31% of NO_X emissions in England stem from road transport combustion sources (1A3bi-iv: down by 60% since 1990), whilst 18% stem from industrial combustion (1A2: down 36% since 1990). Notable increases in emissions arise from railways (1A3c: up by 98% since 1990 accounting for 3% of the 2007 England total

emission) and from national navigation (1A3dii: up 32% since 1990 accounting for 7% of the 2007 England total emission).

Figure 2-21 Map of NOx Emissions in England, 2007



© Crown copyright. All rights reserved Defra, Licence number 100022861 [2009].

2.3.2 Scotland NO_X Inventory by NFR Sector, 1990-2007

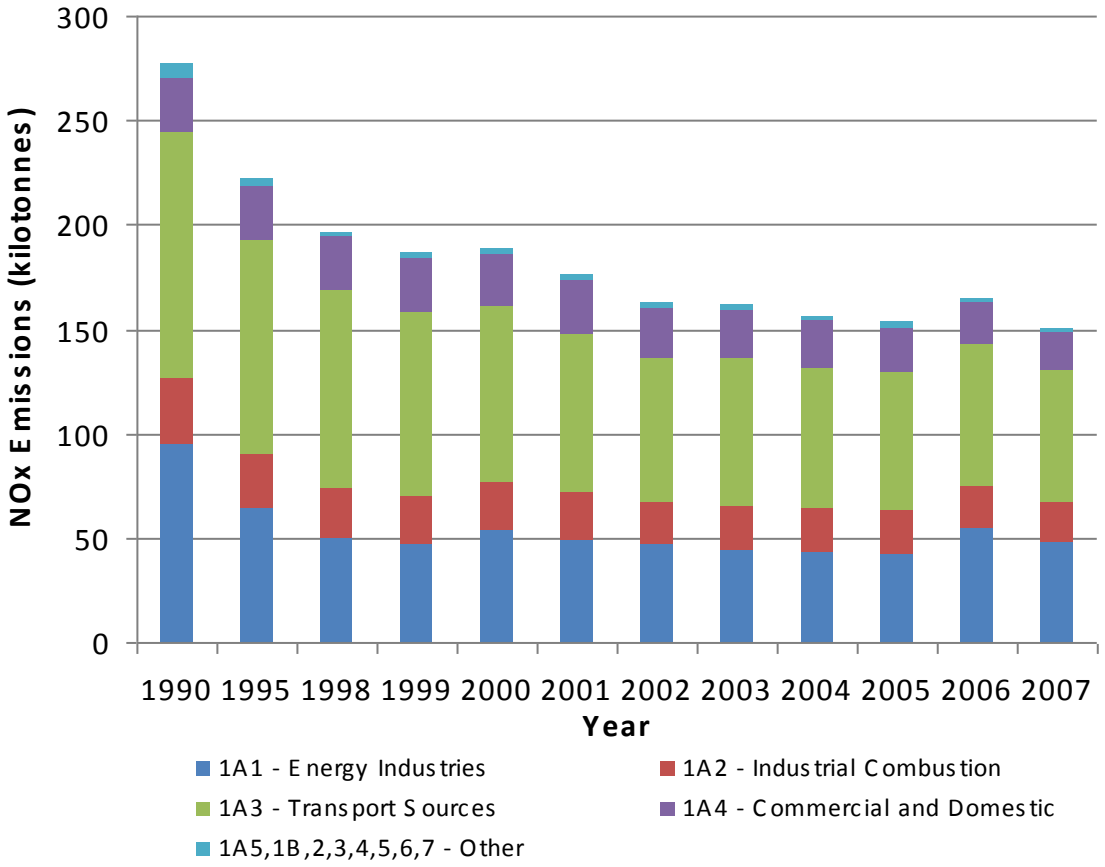
The table and graph below give a summary of the NO_X emissions in Scotland by broad NFR sector categories. The detailed data are available in Appendix E.

Table 2-13 - Scotland emissions of NO_x by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	95	64	50	47	54	49	47	44	43	43	55	48	32%
1A2 - Industrial Combustion	31	26	24	23	23	23	21	21	21	21	20	19	13%
1A3 - Transport Sources	119	103	94	88	84	76	69	71	68	66	68	63	42%
1A4 - Commercial and Domestic	26	26	26	26	25	25	24	23	22	21	20	18	12%
1A5,1B,2,4,5,6 - Other	6	4	3	3	3	3	3	2	3	3	3	2	2%
Total	277	222	197	187	189	177	163	162	157	154	165	151	100%

Units: kilotonnes

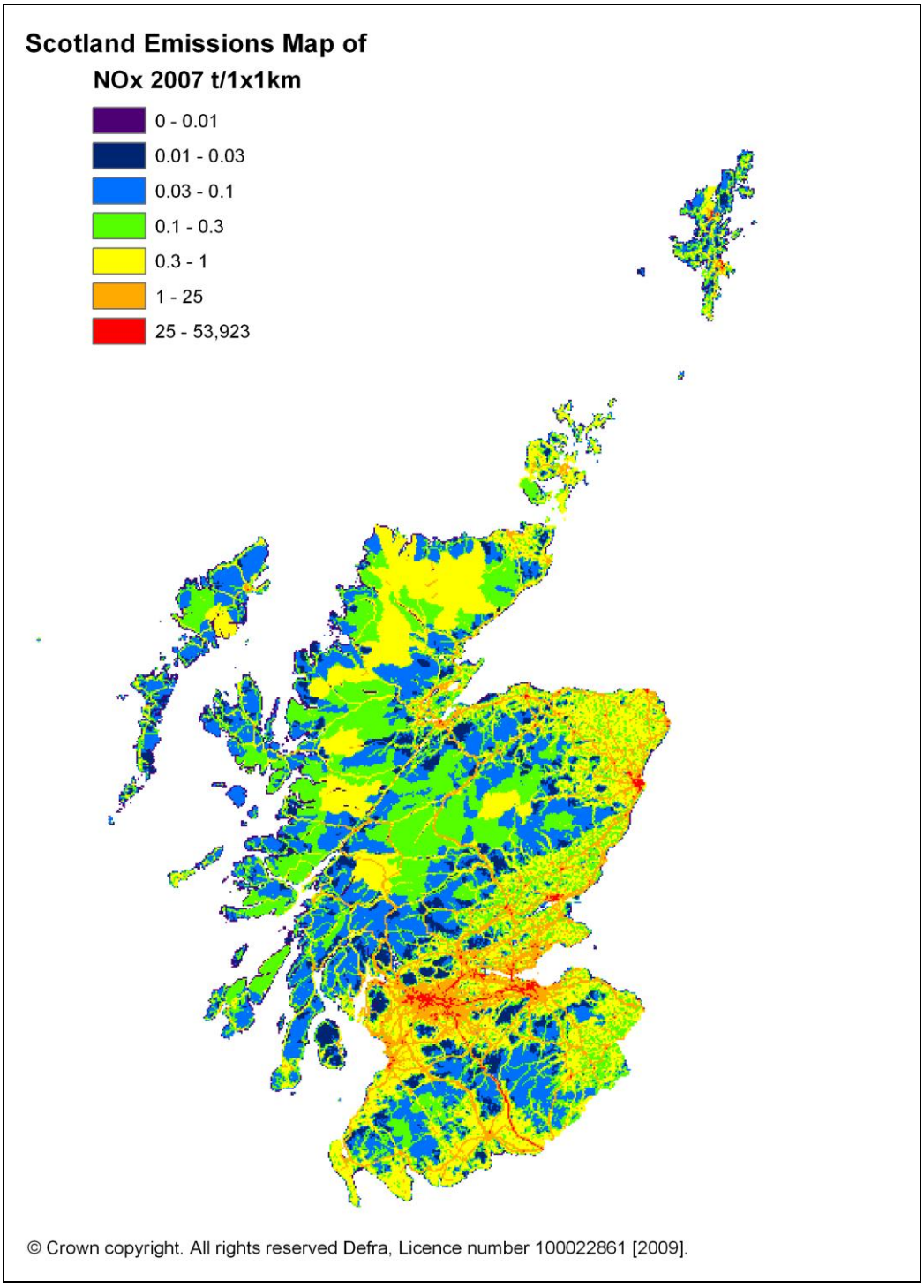
Figure 2-22 - Time series of Scotland NO_x emissions 1990-2007



Scotland's NO_X emissions have declined by 45% since 1990 and currently account for 10% of the UK total. Power generation is a very significant source, accounting for 28% of the Scotland total in 2007; emissions from this source have reduced by 51% since 1990. Recent trends in electricity generation have had a noticeable impact on the inventory; In Scotland, coal-fired generation increased by over 40% between 2005 and 2006 (12,092 GWh to 17,488 GWh), and then reduced by over 20% between 2006 and 2007 (to 13,802 GWh). The impact of the changes in contributions from coal-powered generation is reflected in the increased emissions of NO_X from Scotland in 2006 with a subsequent

decline in emissions in 2007 (Figure 2-22). A further 26% of NO_X emissions in Scotland arise from road transport combustion sources (1A3bi-iv: down by 59% since 1990), 13% stem from industrial combustion (1A2: down 39% since 1990) and 6% is from residential combustion sources (1A4bi: down 3% since 1990). Increases in emissions are only apparent in relatively minor source sectors such as domestic and international aviation landing and take off (LTO) (1A3ai(i): up by 210% since 1990 and 1A3aii(i): up by 74% since 1990 in 2007). Combined, these sources account for less than 1% of the emissions in Scotland in 2007.

Figure 2-23 Map of NOx Emissions in Scotland, 2007



2.3.3 Wales NO_X Inventory by NFR Sector, 1990-2007

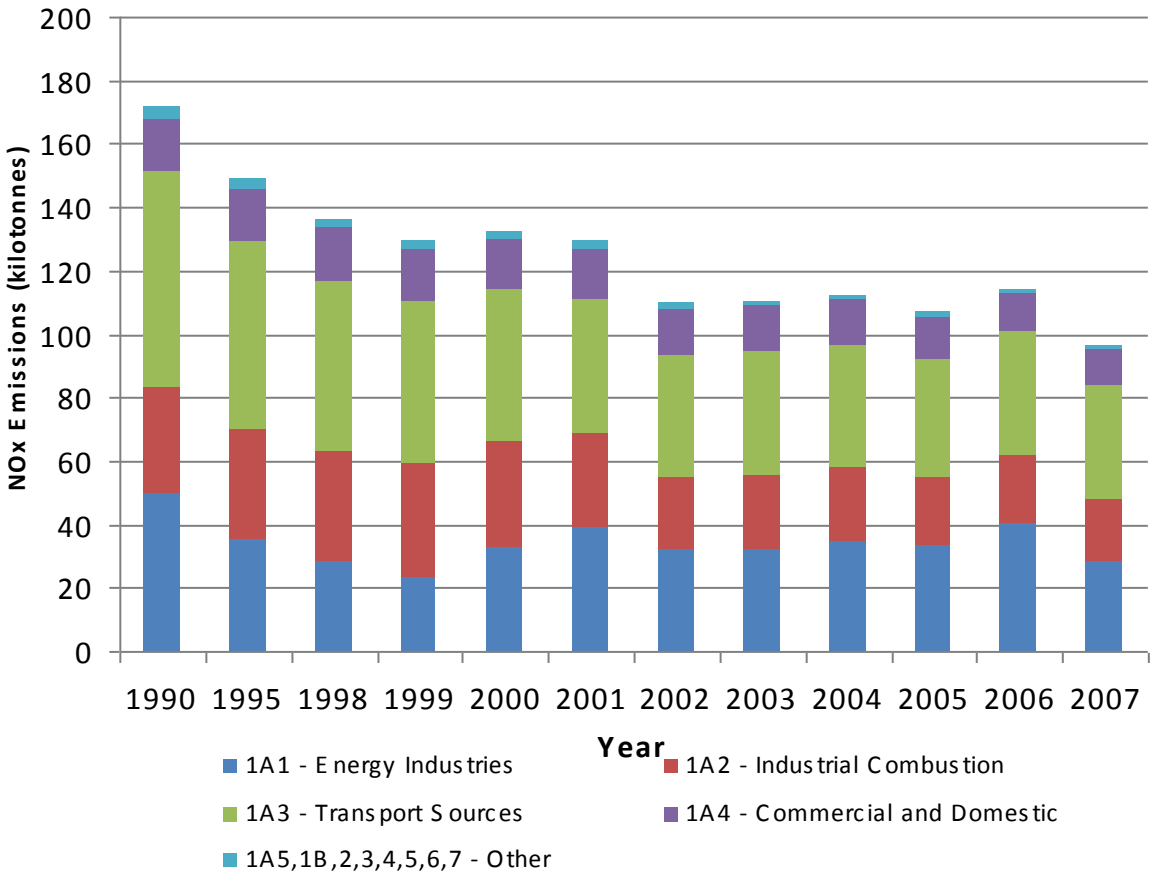
The table and graph below give a summary of the NO_X emissions in Wales by broad NFR sector categories. The detailed data are available in Appendix E.

Table 2-14 - Wales emissions of NO_x by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	50	35	29	23	33	39	32	32	35	33	41	28	29%
1A2 - Industrial Combustion	33	35	34	36	34	30	23	23	23	22	21	20	20%
1A3 - Transport Sources	68	59	54	51	48	42	38	39	38	37	39	36	38%
1A4 - Commercial and Domestic	17	17	17	16	16	16	15	15	14	13	12	11	11%
1A5,1B,2,4,5,6 - Other	4	3	3	3	3	2	2	1	2	1	1	2	2%
Total	172	149	136	130	133	129	110	110	113	107	114	97	100%

Units: kilotonnes

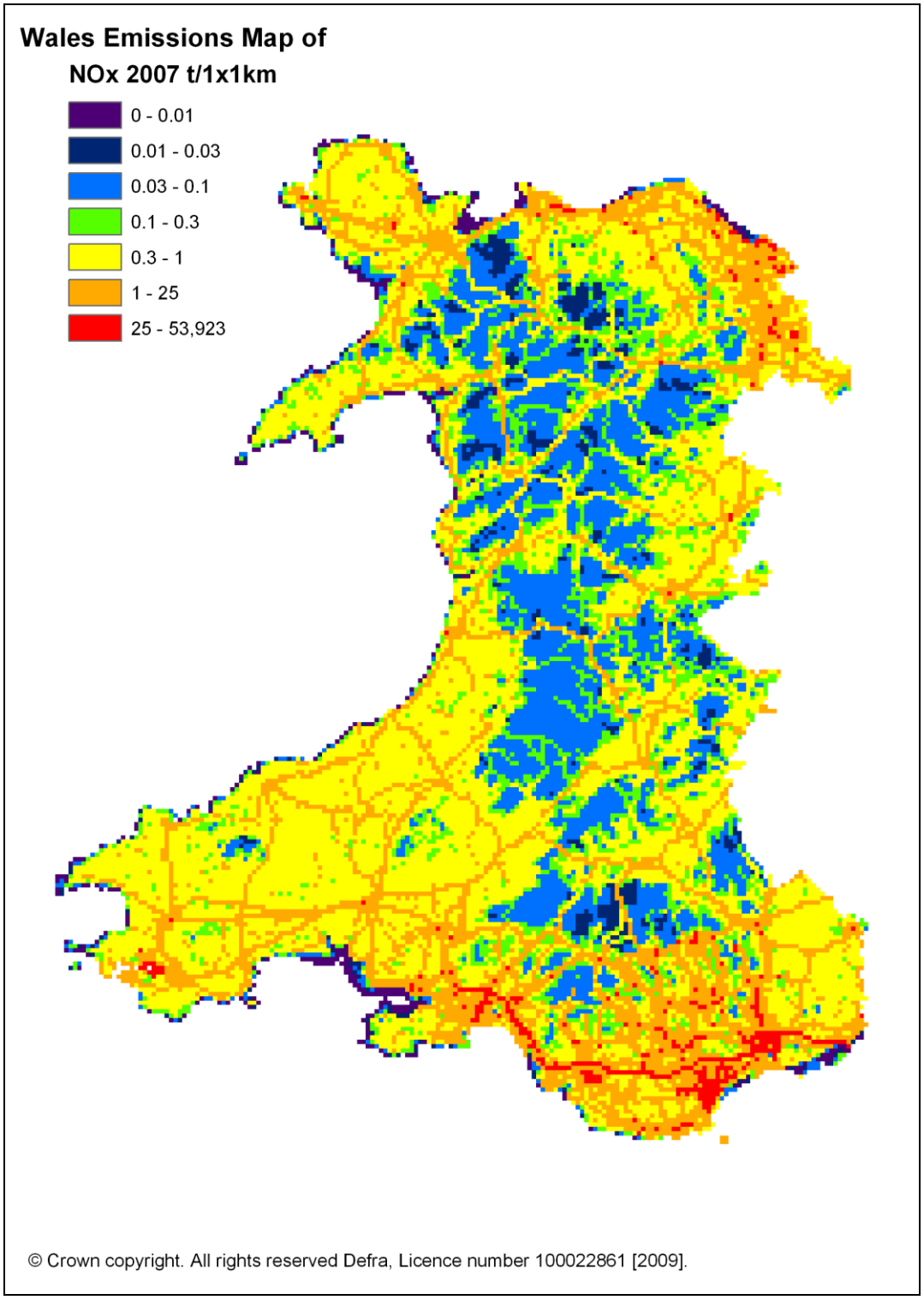
Figure 2-24 - Time series of Wales NO_x emissions 1990-2007



Wales' NO_X emissions have declined by 44% since 1990 and accounted for 7% of the UK total in 2007. Power generation is a very significant source, accounting for 21% of the Wales total in 2007; emissions from this source have reduced by 51% since 1990. Recent trends in electricity generation have had a noticeable impact on the inventory. In Wales, coal-fired generation increased by over 30% between 2005 and 2006 (6,772 GWh to 8,859 GWh), and then reduced by over 40% between 2006 and 2007 (to 5,121 GWh), partly as a result of a plant shut-down at Aberthaw to retro-fit 2 units with Flue Gas Desulphurisation abatement. The impact of these temporal changes in power

generation is reflected in the noted increase in emissions of NO_X from Wales in 2006 and subsequent decline in 2007 (Figure 2-24). A further 23% of NO_X emissions in Wales stem from road transport combustion sources (1A3bi-iv: down by 61% since 1990), 20% stem from industrial combustion (1A2: down 41% since 1990) and 5% of emissions are from residential combustion sources (1A4bi: down 5% since 1990). Notable increases in significant emissions arise from railways (1A3c: up by 71% since 1990 to 4% of the 2007 Wales total) and from national navigation (1A3dii: up 12% since 1990 to 11% of the 2007 Wales total).

Figure 2-25 Map of NOx Emissions in Wales, 2007



© Crown copyright. All rights reserved Defra, Licence number 100022861 [2009].

2.3.4 Northern Ireland NO_X Inventory by NFR Sector, 1990-2007

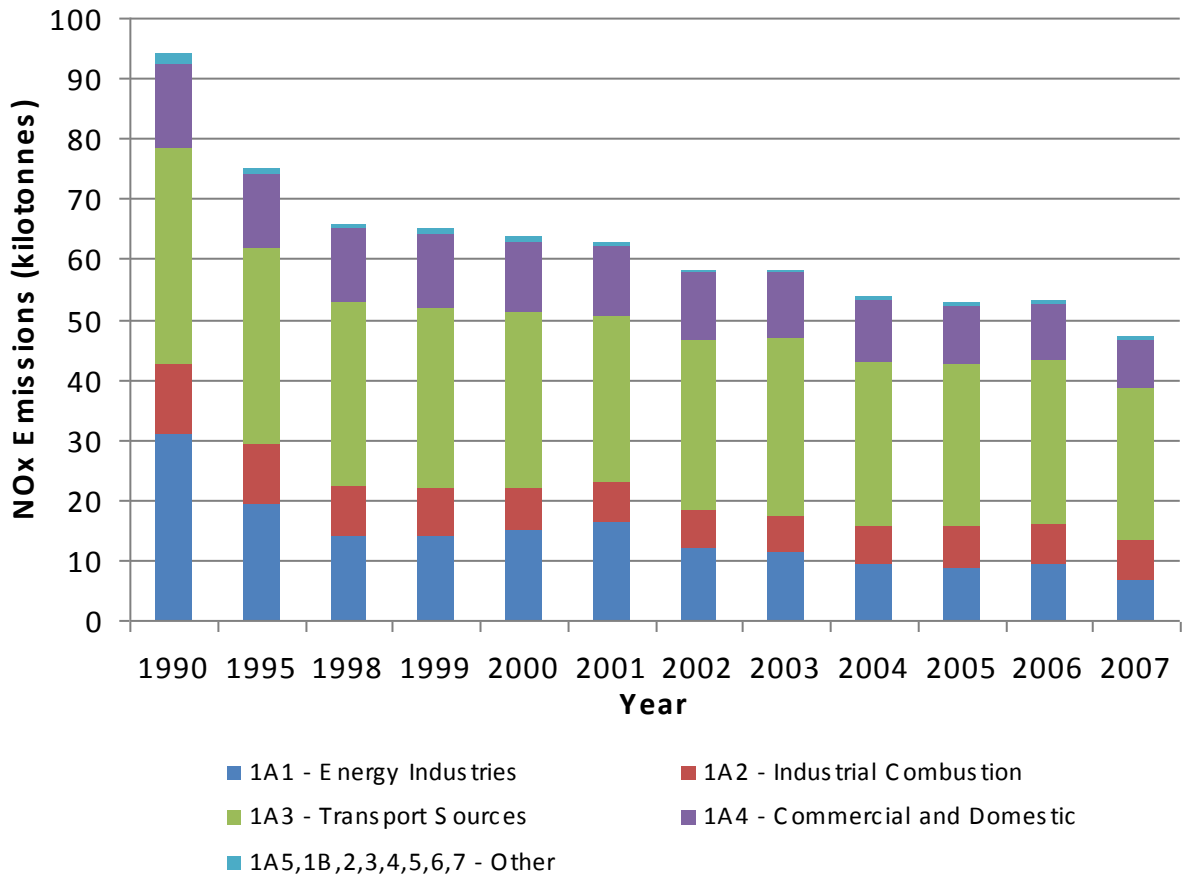
The table and graph below give a summary of the NO_X emissions in Northern Ireland by broad NFR sector categories. The detailed data are available in Appendix E.

Table 2-15 - Northern Ireland emissions of NO_x by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	31	19	14	14	15	16	12	11	9	9	9	7	14%
1A2 - Industrial Combustion	12	10	9	8	7	7	6	6	6	7	7	7	14%
1A3 - Transport Sources	36	33	30	30	29	28	28	30	27	27	27	25	53%
1A4 - Commercial and Domestic	14	12	12	12	12	12	11	11	10	10	9	8	17%
1A5,1B,2,4,5, 6 - Other	2	1	1	1	1	1	1	0	1	1	1	1	1%
Total	94	75	66	65	64	63	58	58	54	53	53	47	100 %

Units: kilotonnes

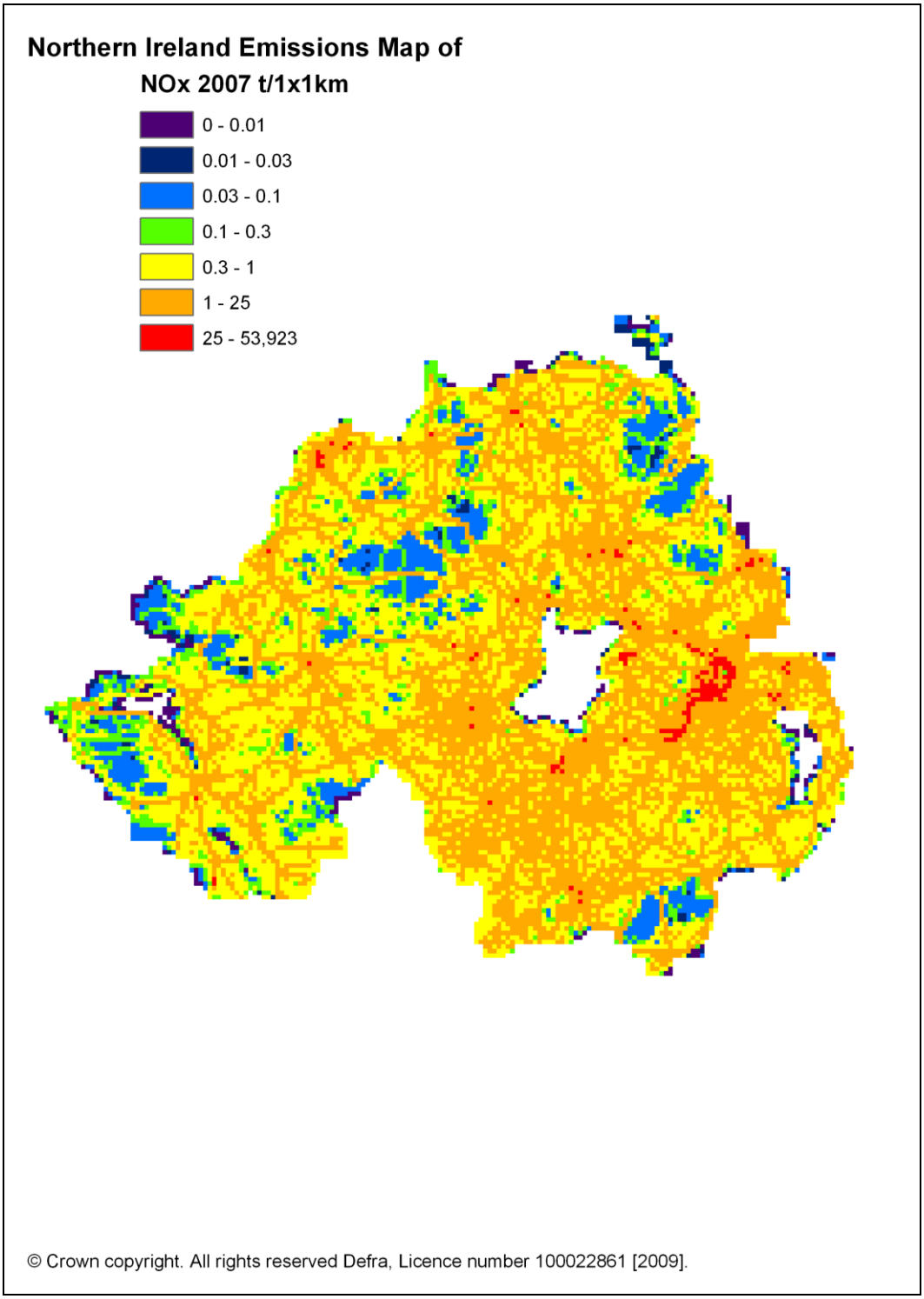
Figure 2-26 - Time series of Northern Ireland NO_x emissions 1990-2007



Northern Ireland's NO_X emissions have declined by 50% since 1990 and account for only 3% of the UK total. Power generation is a significant source, accounting for 14% of the Northern Irish total in 2007, although emissions from this source have reduced by 79% since 1990. 41% of NO_X emissions in Northern Ireland stem from road transport combustion sources (1A3bi-iv: down by 39% since

1990), whilst 14% stem from industrial combustion (1A2: down 42% since 1990) and 7% are from residential combustion sources (1A4bi: down 23% since 1990). Notable increases in emissions arise from national navigation (1A3dii: up 33% since 1990 to 10% of the 2007 Northern Irish total) and from very minor sources sector such as domestic and international aviation LTO (1A3ai(i): up by 370% since 1990 and 1A3aii(i): up by 128% since 1990). However, combined these two sources account for less than 1 % of the Northern Ireland total emission in 2007.

Figure 2-27 Map of NOx Emissions in Northern Ireland, 2007



2.4 NON-METHANE VOLATILE ORGANIC COMPOUNDS EMISSION ESTIMATES

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. The diversity of processes which emit NMVOCs is huge, covering not only many branches of industry, but also transport, agriculture and domestic sources.

UK emissions inventory data indicate that only 20% of the NMVOC emissions arise from combustion sources (unlike SO_2 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. 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.

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 cleaners and small bakeries.

- **Solvent and other product use.** This sector comprises industrial and domestic solvent applications (cleaning, degreasing), as well as the manufacturing and processing of chemical products. It represents 43% of the UK total NMVOC emission in 2007. During the 1990s, industrial NMVOC emissions have fallen as a result of emission controls, technological changes, and reduced manufacturing output in some sectors. Emissions from the chemical industry have reduced during the 1990s as tighter emission controls have been introduced. Domestic solvent emissions have also fallen due to a trend towards formulating products such as paints and aerosols with lower solvent contents.

- **Stationary Combustion.** This sector includes emissions from public electricity and heat production as well as those from petroleum refining and the manufacture of iron and steel. Emissions from the petroleum-refineries have fallen significantly due to a reduction in refinery capacity and tighter emission regulations during the 1990s.

- **Production processes**. This sector includes emissions from metal production, road construction, and non-fuel mining. These processes are estimated to comprise 4% of the UK total emission in 2007.

- **Processes in wood, paper pulp and food & drink.** Emissions from the food and drink industry comprised 8% of the total NMVOC emission in 2007. The largest source is whisky maturation although bread baking, animal feed manufacture, fat and oil processing and barley malting are also important sources.

- **Transport.** Emissions from transport sources are currently responsible for 13% of NMVOC emissions of which 9.3% are a result of road transport. During the 1990s, these emissions have declined significantly due to the increased use of catalytic converters and fuel switching from petrol to diesel cars.

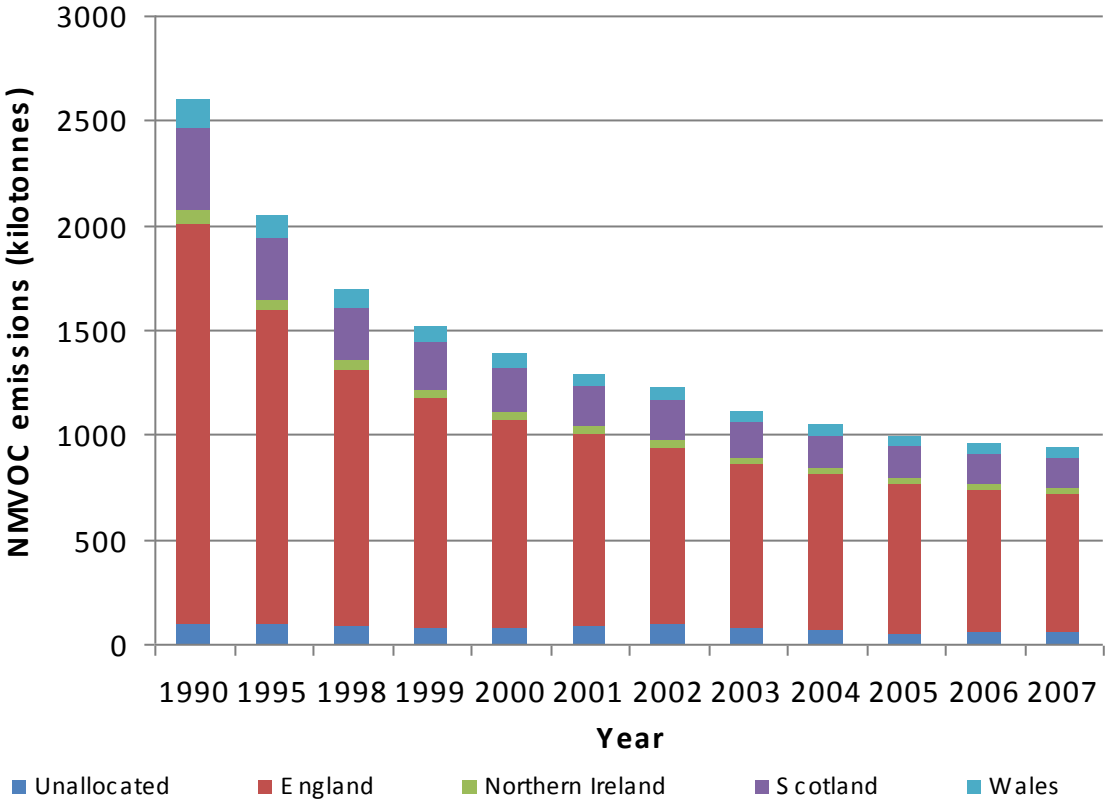
- **Offshore oil and gas.** Emissions from this sector have increased substantially with the growth of the UK's offshore activities, and stem primarily from tanker loading / unloading.

Other sources of NMVOCs include:

- Gas leakage from the national gas distribution networks.
- Evaporative losses from the distribution and marketing of petrol.
- Waste treatment and disposal contribute.
- Natural and agricultural sources.

UK emissions of NMVOC fell by 64% between 1990 and 2007, primarily due to reductions in road transport sources through the use of catalytic converters and fuel switching to diesel technology.

Figure 2-28 – Total UK NMVOC emissions



Emissions of NMVOCs for England, Wales, Scotland and Northern Ireland are summarised in the tables and graphs below, with more detailed inventory tables in Appendix G. Table 2.16 shows how total UK NMVOC emissions are split between the 4 constituent countries.

Table 2-16 - Proportion of total NMVOC emissions from UK constituent countries

Year	England	Scotland	Wales	N Ireland	Unallocated
1990	74%	15%	5%	3%	4%
2007	70%	16%	5%	3%	6%

2.4.1 England NMVOC Inventory by NFR Sector, 1990-2007

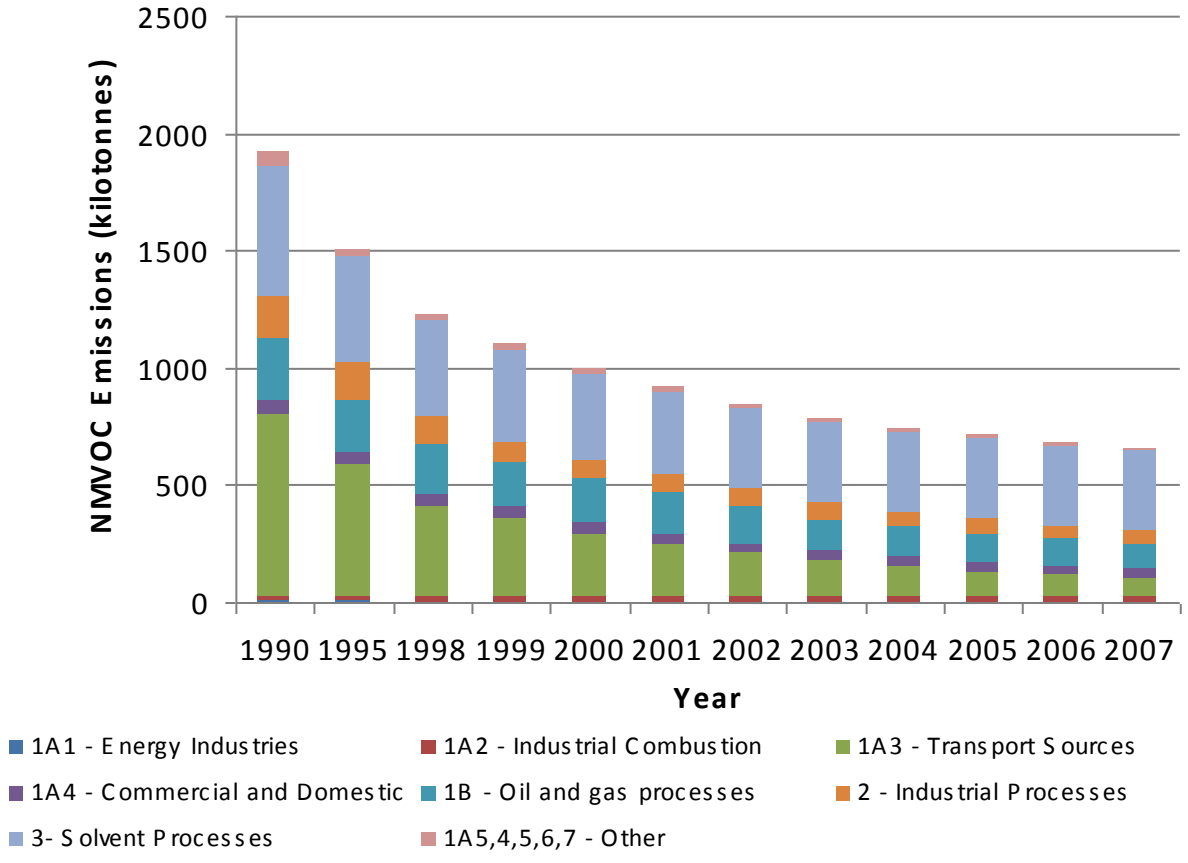
The table and graph below give a summary of the NMVOC emissions in England by broad NFR sector categories. The detailed data are available in Appendix G.

Table 2-17 - England emissions of NMVOC by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	5.6	5.9	2.9	3.1	3.9	3.5	4.1	3.3	3.7	3.4	4.1	4.0	1%
1A2 - Industrial Combustion	23.0	23.8	23.9	23.4	22.8	22.9	22.1	21.8	22.1	21.9	21.1	20.5	3%
1A3 - Transport Sources	773	557	383	331	266	219	184	154	128	107	93	82	12%
1A4 - Commercial and Domestic	61	49	50	51	44	42	39	38	39	38	38	39	6%
1B - Oil and gas processes	264	224	210	187	187	181	161	136	129	124	113	106	16%
2 - Industrial Processes	179	162	120	89	82	75	72	70	64	61	53	53	8%
3- Solvent Processes	557	450	416	391	368	354	345	343	345	342	341	340	51%
1A5,4,6 - Other	53	26	22	21	20	19	18	17	16	16	16	16	2%
Total	1916	1499	1229	1097	995	918	845	783	745	713	680	660	100%

Units: kilotonnes

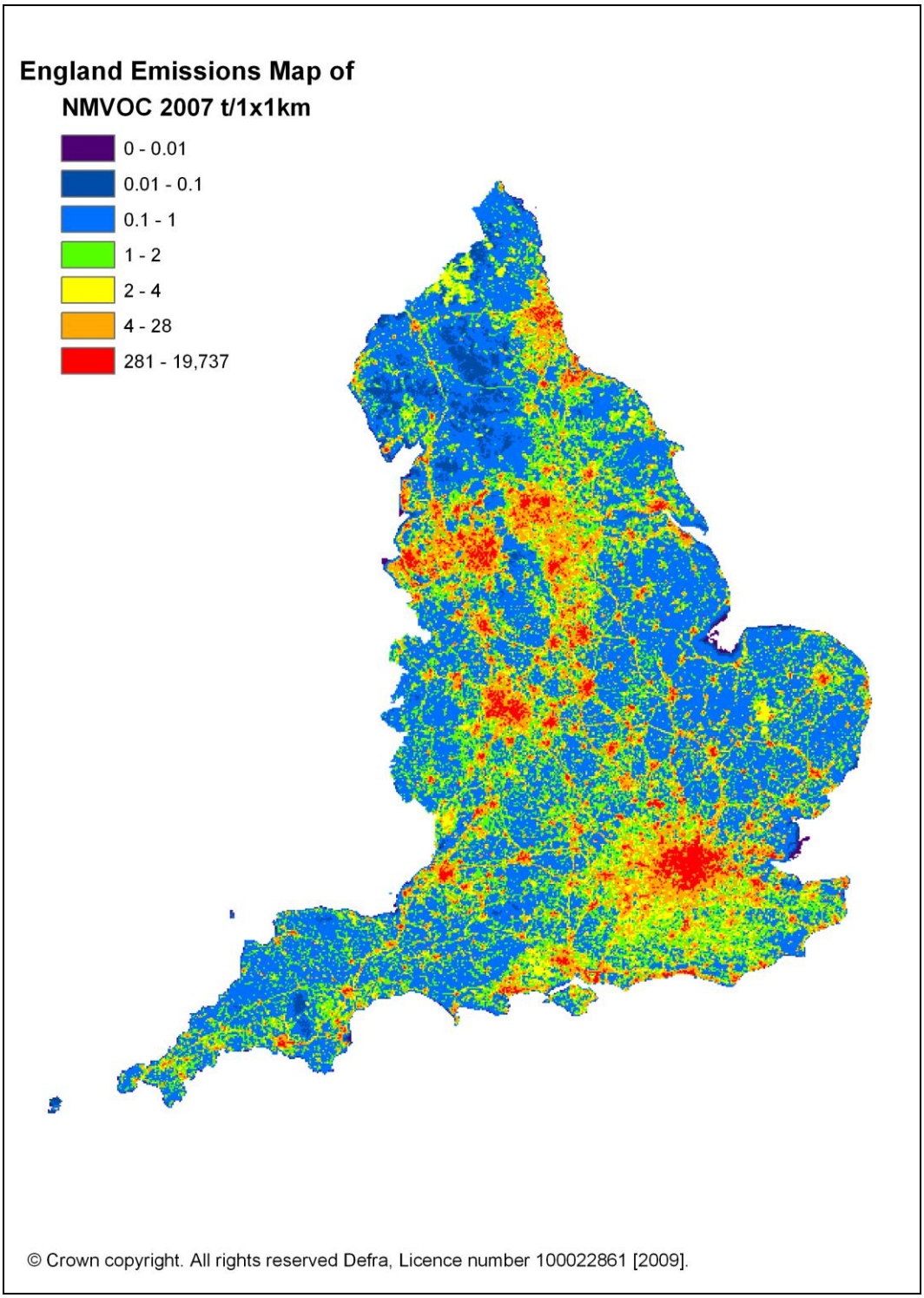
Figure 2-29 - Time series of England NMVOC emissions 1990-2007



England's NMVOC emissions have declined by 66% since 1990 and account for 70% of the UK total. Significant sources include:

- Road transport sources, including evaporative losses (1A3bi-v: 11% of the total in 2007, down 90% since 1990)
- Oil & gas processes (1B: 16% of the total in 2007, down 60% since 1990)
- Industrial processes (2: 8% of the total in 2007, down 71% since 1990)
- Solvent processes (3: 51% of the total in 2007, down 39% since 1990)

Figure 2-30 Map of NMVOC Emissions in England, 2007



2.4.2 Scotland NMVOC Inventory by NFR Sector, 1990-2007

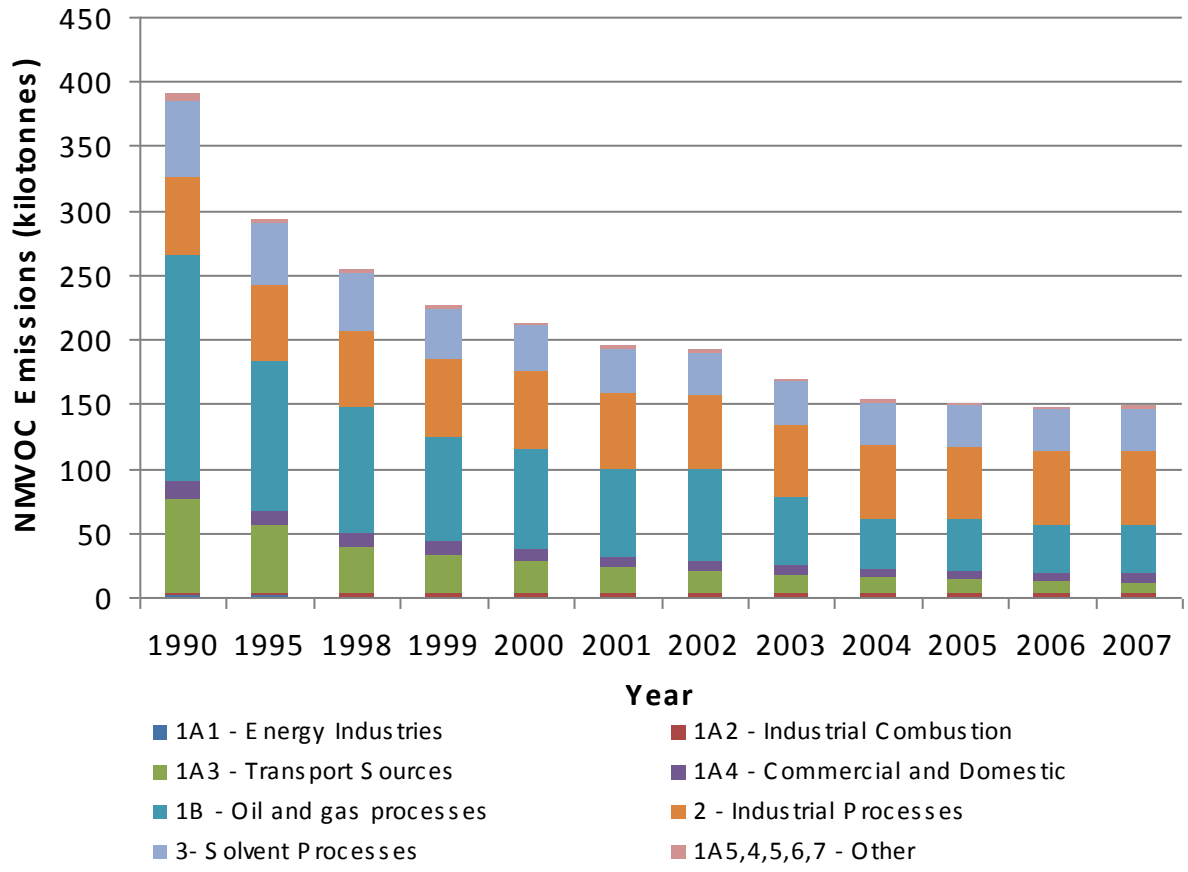
The table and graph below give a summary of the NMVOC emissions in Scotland by broad NFR sector categories. The detailed data are available in Appendix G.

Table 2-18 - Scotland emissions of NMVOC by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	0.8	0.9	0.5	0.3	0.5	0.4	0.5	0.4	0.5	0.5	0.6	0.5	0%
1A2 - Industrial Combustion	2.2	2.2	2.2	2.2	2.1	2.2	2.1	2.0	2.0	1.9	1.9	1.9	1%
1A3 - Transport Sources	73.4	53.0	36.7	30.6	25.5	20.9	17.7	15.2	12.7	10.8	9.8	8.7	6%
1A4 - Commercial and Domestic	13.3	9.9	9.8	9.7	8.5	7.8	7.1	7.0	6.9	6.7	6.9	7.1	5%
1B - Oil and gas processes	176	116	98	81	79	68	71	52	39	40	37	37	25%
2 - Industrial Processes	59.7	59.5	59.5	60.8	59.4	59.1	58.0	57.3	56.6	55.6	56.0	58.3	39%
3- Solvent Processes	59.0	48.1	44.7	38.3	35.9	34.5	33.4	33.2	33.2	33.0	32.9	32.9	22%
1A5,4,6 - Other	5.6	3.4	2.9	2.7	2.6	2.3	2.2	2.1	2.0	2.0	2.0	2.1	1%
Total	390	293	254	226	213	195	192	169	153	151	147	149	100 %

Units: kilotonnes

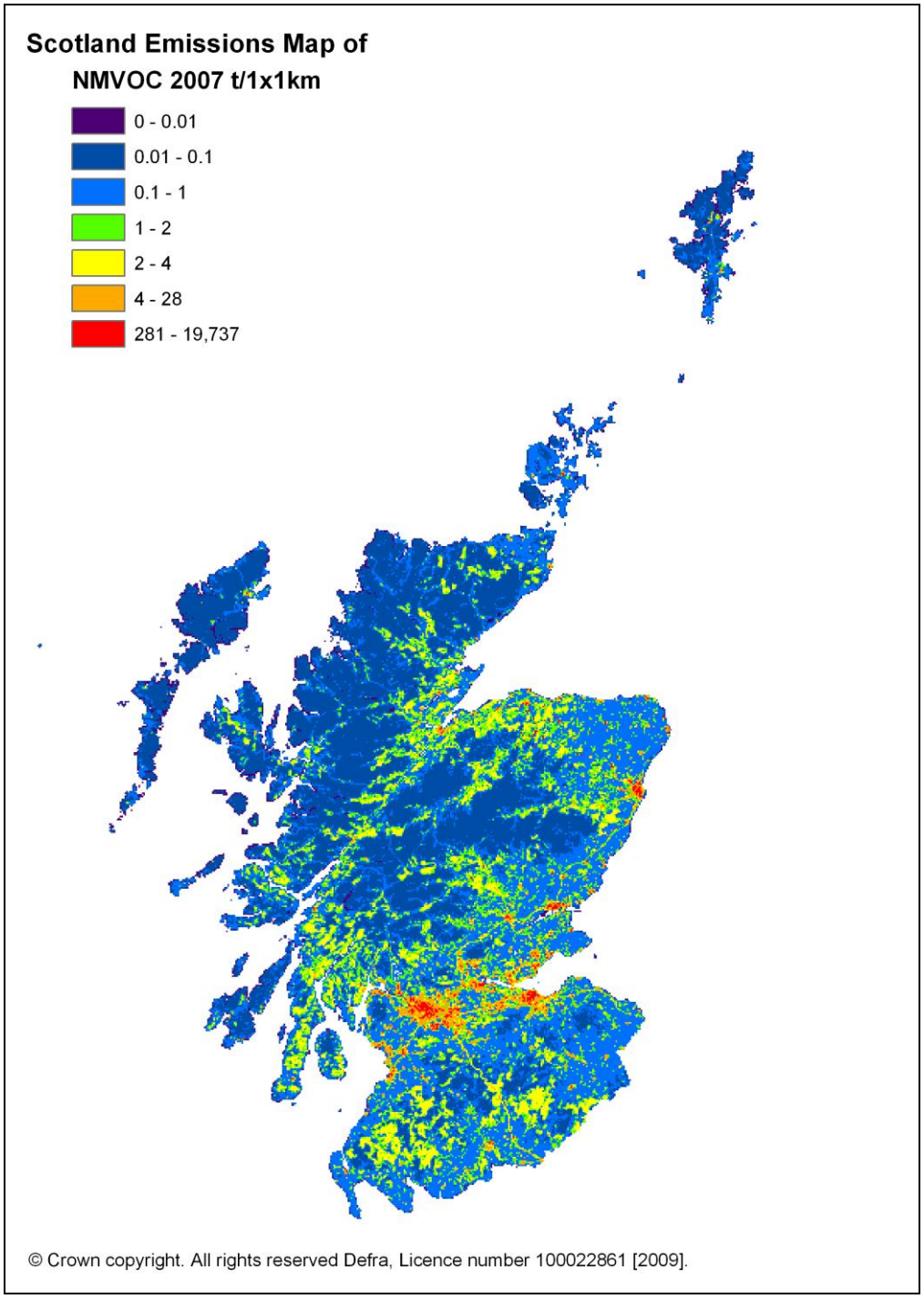
Figure 2-31 - Time series of Scotland NMVOC emissions 1990-2007



Scotland's NMVOC emissions have declined by 62% since 1990 and account for 16% of the UK total. Significant sources include:

- Road transport sources, including evaporative losses (1A3bi-v: 5% of the total in 2007, down 90% since 1990)
- Oil & gas processes (1B: 25% of the total in 2007, down 79% since 1990)
- Industrial processes (2: 39% of the total in 2007, down 2% since 1990), including food & drink emissions (2D2: dominated by brewers and distilleries, 33% of the Scottish total in 2007, up 17% since 1990)
- Solvent processes (3: 22% of the total in 2007, down 44% since 1990)

Figure 2-32 Map of NMVOC Emissions in Scotland, 2007



2.4.3 Wales NMVOC Inventory by NFR Sector, 1990-2007

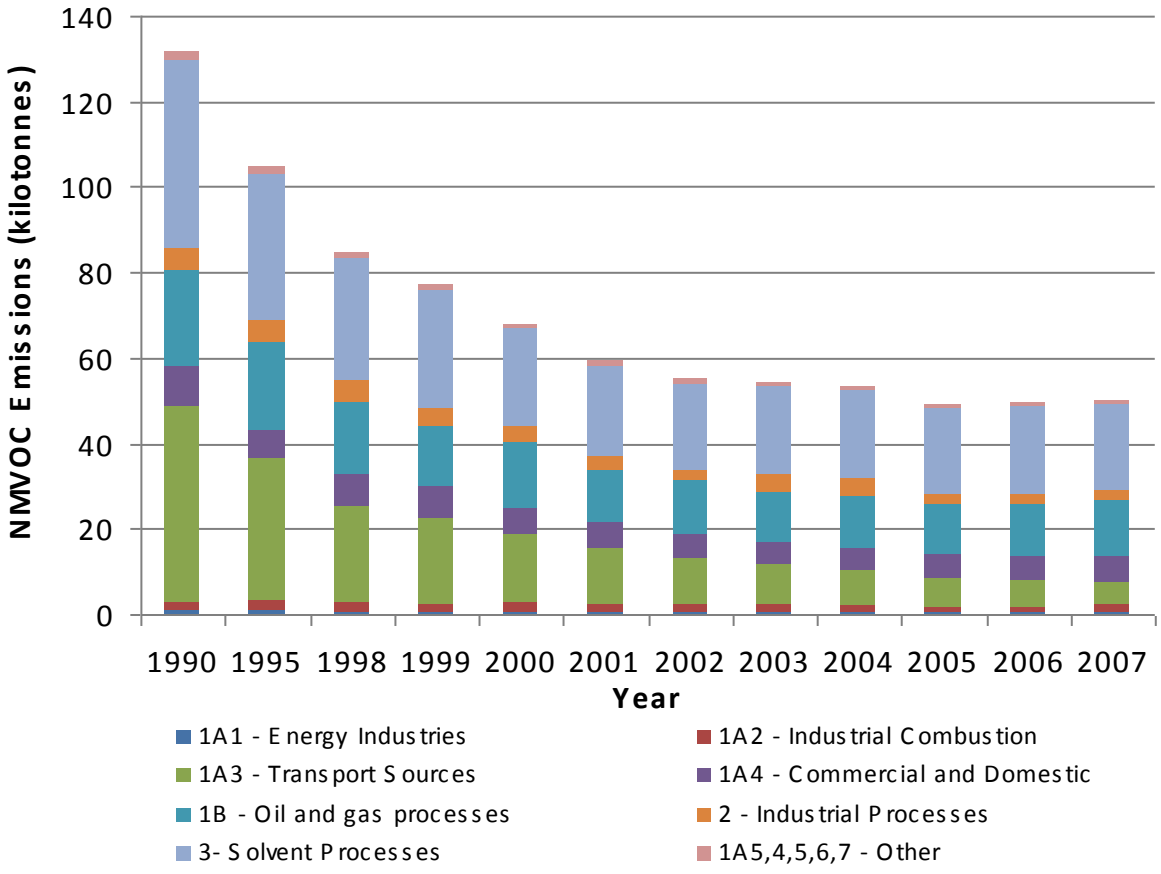
The table and graph below give a summary of the NMVOC emissions in Wales by broad NFR sector categories. The detailed data are available in Appendix G.

Table 2-19 - Wales emissions of NMVOC by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	1.0	1.0	0.5	0.5	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.5	1%
1A2 - Industrial Combustion	1.9	2.0	2.1	2.1	2.2	2.0	1.9	2.0	1.8	1.7	1.7	1.6	3%
1A3 - Transport Sources	45.9	33.2	22.9	19.7	15.9	13.0	10.9	9.3	7.9	6.6	5.9	5.2	10%
1A4 - Commercial and Domestic	9.4	7.0	7.2	7.6	6.2	5.9	5.2	5.1	5.4	5.4	5.6	6.0	12%
1B - Oil and gas processes	22.3	20.6	17.1	14.2	15.2	12.5	12.8	11.6	12.3	11.7	12.4	13.2	26%
2 - Industrial Processes	5.3	5.0	4.8	4.5	3.8	3.2	2.2	4.6	4.1	2.2	2.3	2.3	5%
3- Solvent Processes	43.7	34.2	28.8	27.3	22.8	21.2	20.5	20.4	20.4	20.1	20.4	20.2	40%
1A5,4,6 - Other	2.0	1.6	1.4	1.3	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0	2%
Total	132	105	85	77	68	59	55	54	53	49	50	50	100%

Units: kilotonnes

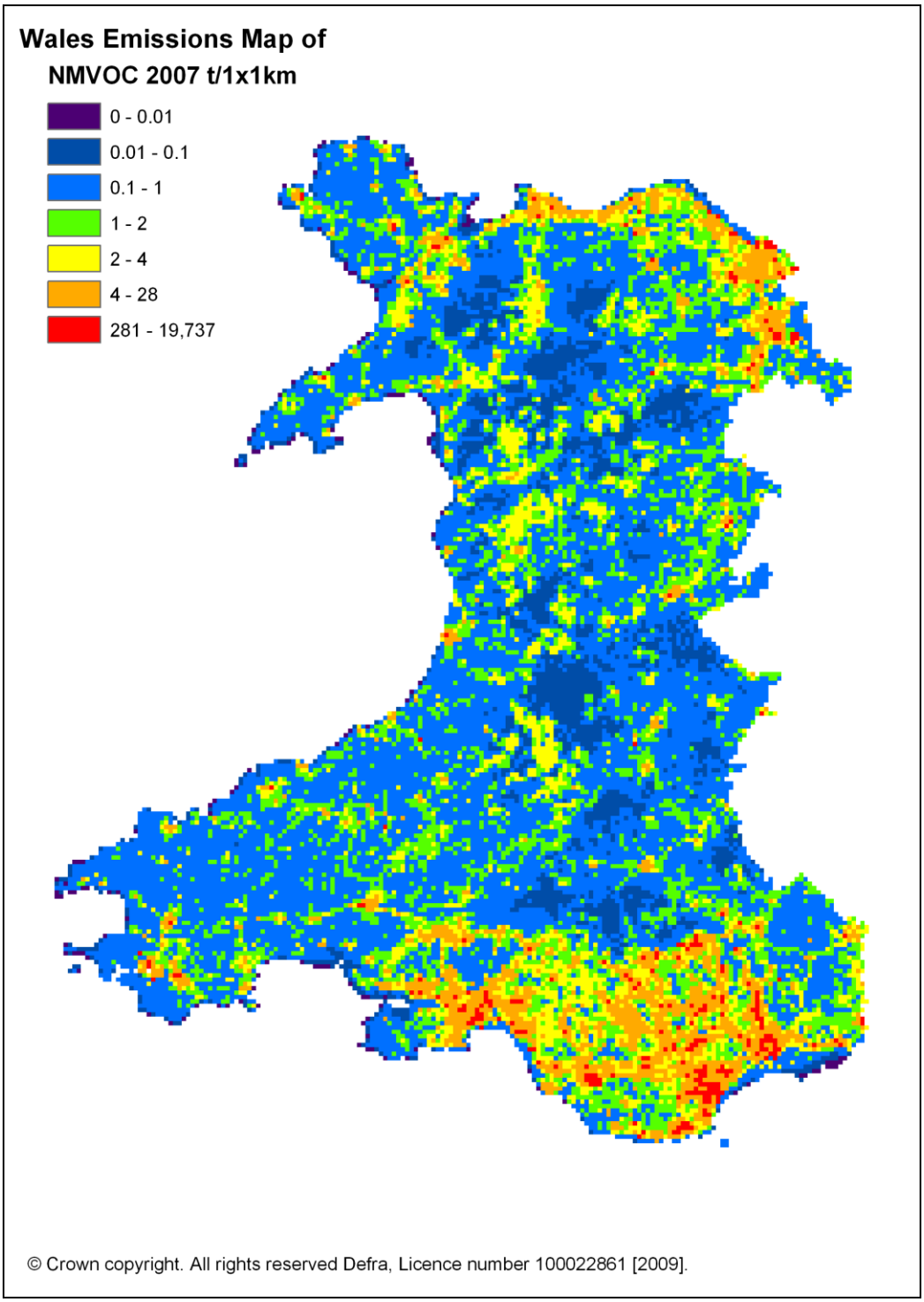
Figure 2-33 - Time series of Wales NMVOC emissions 1990-2007



Wales' NMVOC emissions have declined by 62% since 1990 and account for 5% of the UK total. Significant sources include:

- Road transport sources, including evaporative losses (1A3bi-v: 9% of the total in 2007, down 90% since 1990)
- Oil & gas processes (1B: 26% of the total in 2007, down 41% since 1990)
- Industrial processes (2: 5% of the total in 2007, down 58% since 1990)
- Solvent processes (3: 40% of the total in 2007, down 54% since 1990)

Figure 2-34 Map of NMVOC Emissions in Wales, 2007



2.4.4 Northern Ireland NMVOC Inventory by NFR Sector, 1990-2007

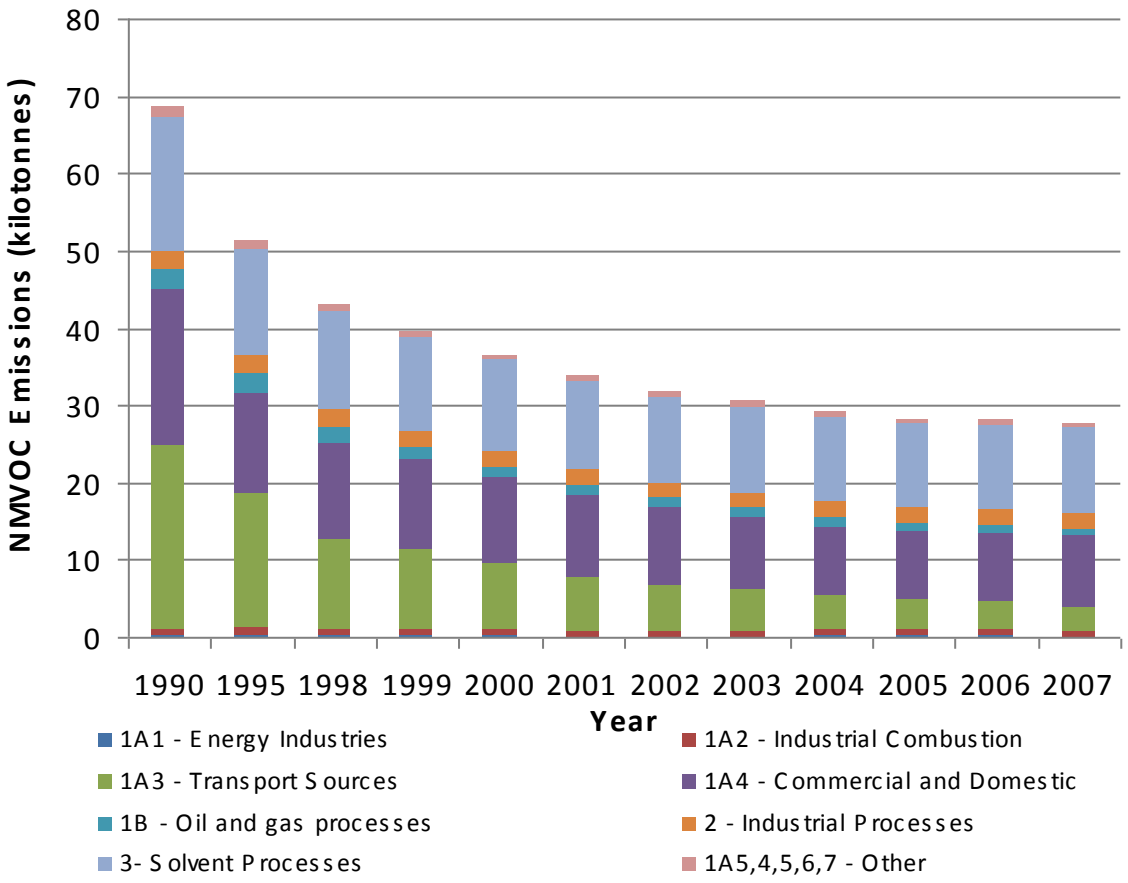
The table and graph below give a summary of the NMVOC emissions in Northern Ireland by broad NFR sector categories. See Appendix G for more detailed data.

Table 2-20 - Northern Ireland emissions of NMVOC by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	0.3	0.4	0.2	0.2	0.2	0.0	0.0	0.0	0.2	0.3	0.4	0.1	0%
1A2 - Industrial Combustion	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	3%
1A3 - Transport Sources	23.6	17.4	11.7	10.3	8.6	7.1	6.0	5.4	4.5	3.9	3.5	3.1	11%
1A4 - Commercial and Domestic	20.2	13.1	12.3	11.7	11.1	10.5	10.0	9.4	8.9	8.7	8.9	9.2	33%
1B - Oil and gas processes	2.7	2.5	2.2	1.6	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.9	3%
2 - Industrial Processes	2.4	2.4	2.2	2.1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.1	7%
3- Solvent Processes	17.4	13.8	12.8	12.2	11.8	11.4	11.2	11.1	11.1	11.0	11.0	11.0	40%
1A5,4,6 - Other	1.2	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	2%
Total	69	51	43	40	37	34	32	30	29	28	28	28	100%

Units: kilotonnes

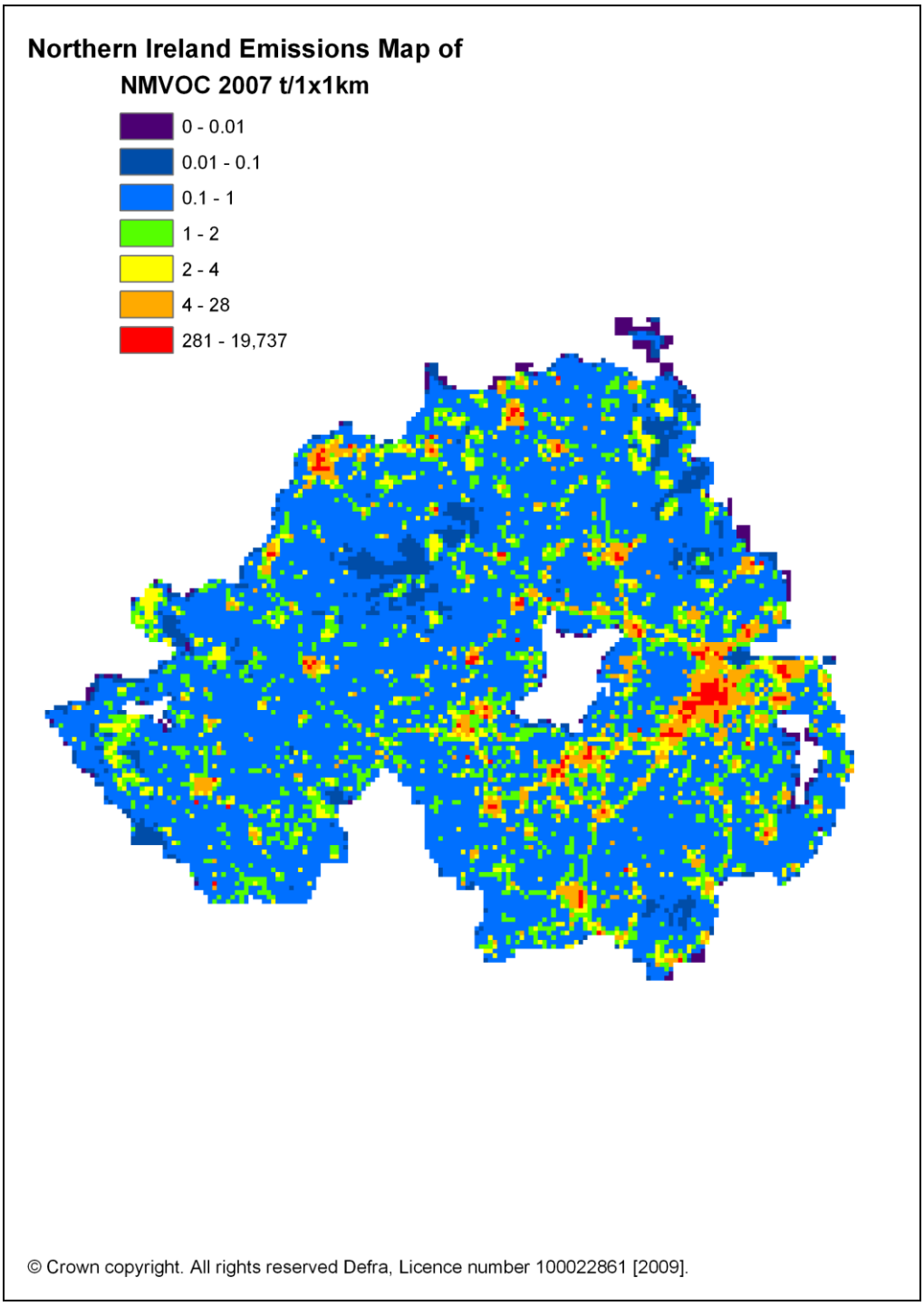
Figure 2-35 - Time series of Northern Ireland NMVOC emissions 1990-2007



Northern Ireland's NMVOC emissions have declined by 59% since 1990 and account for 3% of the UK total. Significant sources include:

- Road transport sources, including evaporative losses (1A3bi-v: 10% of the total in 2007, down 88% since 1990)
- Oil & gas processes (1B: 3% of the total in 2007, down 67% since 1990)
- Commercial & domestic combustion (1A4: 33% of the total in 2007, down 54% since 1990)
- Solvent processes (3: 40% of the total in 2007, down 37% since 1990)
- Food & drink sector (2D2: 7% of the total in 2007, up 7% since 1990).

Figure 2-36 Map of NMVOC Emissions in Northern Ireland, 2007



2.5 PARTICULATE MATTER AS PM_{10}

PM_{10} is a measure of the size distribution of the particles emitted to air and represents the proportion material with an aerodynamic diameter less than 10 micro meters. PM_{10} in the atmosphere arises from primary and secondary sources:

Primary Sources
Direct emissions of particulate matter into the atmosphere arise from a wide range of sources such as fuel combustion, surface erosion and wind blown dusts and mechanical break-up in, for example, quarrying and construction sites.

Secondary Sources
Particulate matter may be formed in the atmosphere through 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.

These inventories only consider primary sources. For further information on secondary particulates see the Air Quality Expert Group's Report on particulate matter in the United Kingdom (AQEG, 2005) http://www.defra.gov.uk/environment/airquality/publications/particulate-matter/index.htm

The main sources of primary PM_{10} are briefly described below:

- **Road Transport.** Diesel engines typically emit a greater mass of particulates per vehicle kilometre than petrol engines. Particulate emissions also arise from all vehicles through brake and tyre wear as well as from the re-entrainment of dust from road surfaces caused by vehicle movements.

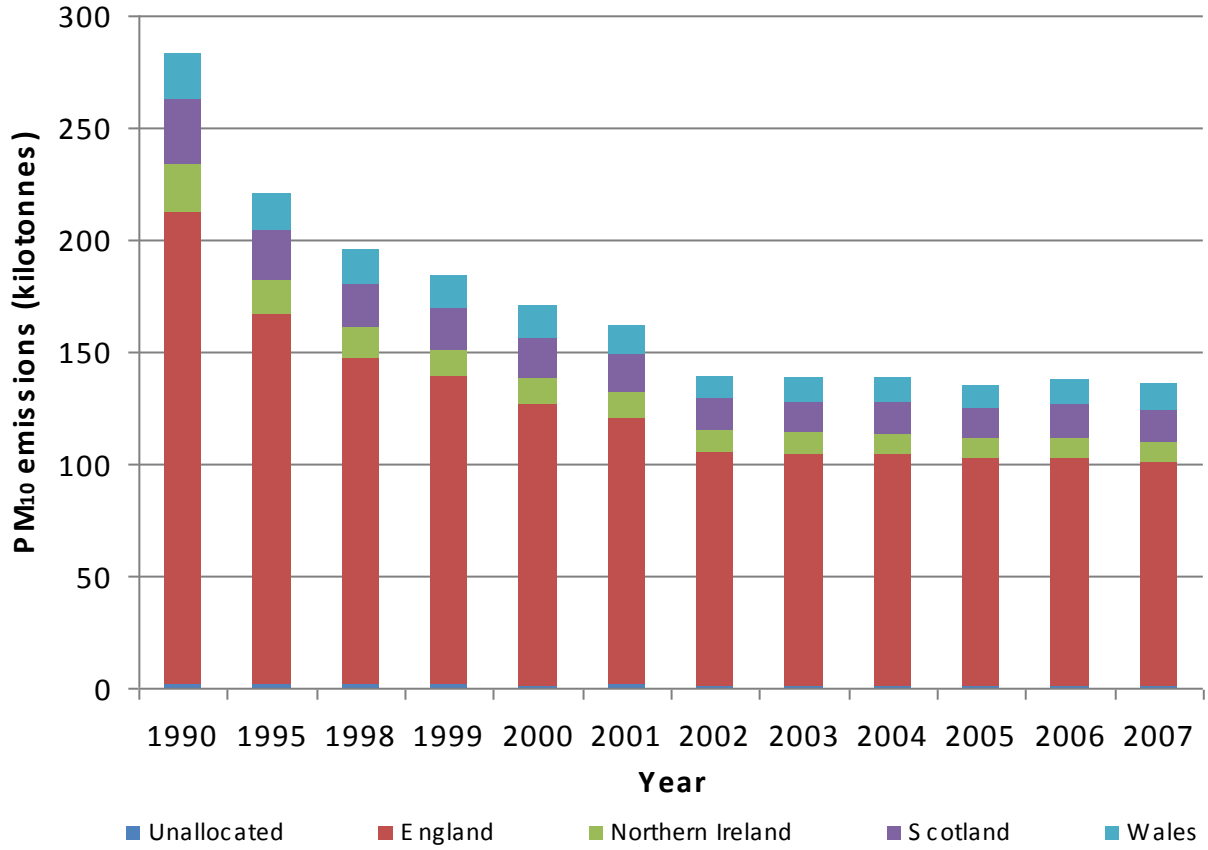
- **Stationary Combustion.** Domestic coal combustion has historically been the main source of particulate emissions in the UK, but restrictions in the use of coal for domestic combustion through the Clean Air Acts has lead to other sources becoming more important nationally. Domestic coal is still a significant source in Northern Ireland, some smaller towns and villages, and in areas associated with the coal industry. Other fossil fuels emit PM_{10}, with combustion of wood, gas oil and fuel oil all contributing significantly to UK emissions. In general, particles emitted from fuel combustion are of a smaller size than from other sources.

- **Industrial Processes.** Particulates are emitted from a wide range of industrial processes including: the production of metals, cement, lime, coke & chemicals, bulk handling of dusty materials, construction, mining and quarrying. Whilst emission monitoring results are now widely available for stack and other point-source emissions of particulates from regulated industrial processes, the quantification of diffuse & fugitive emissions from industrial sources is more difficult. Few UK measurements are available for these fugitive releases but there have been substantial improvements in the estimation of PM_{10} emissions from industrial processes in recent years.

2.5.1 UK Trends in PM_{10} Emissions

Emissions of PM_{10} from across the UK have declined significantly since 1970, mainly due to improved abatement of industrial and power generation emission sources and a general reduction in coal use as an energy source across many economic sectors. For example, emissions in the domestic and commercial sector have fallen from 245 ktonnes (50% of the total emission) in 1970 to 18 ktonnes (14%) in 2007.

Figure 2-37 Total UK emissions of PM_{10}



It is notable that emissions from power stations have declined despite a significant growth in electricity generation capacity, due to fuel switching from coal to both natural gas and nuclear power and also due to abatement being fitted at some coal-fired power stations. For example, the installation of flue gas desulphurisation (FGD) at a number of plants has reduced particulate matter emissions substantially. Emissions from road transport have varied across the time-series as a number of factors have combined. The main source of road transport emissions is exhaust gases from diesel engines. 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 have been decreasing due to the penetration of new vehicles meeting tighter PM_{10} emission regulations ("Euro standards" for diesel vehicles were first introduced in 1992).

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. 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.

Emissions of PM_{10} for England, Wales, Scotland and Northern Ireland are summarised in the tables and graphs below, with more detailed inventory tables in Appendix C. Table 2.21 shows how total UK PM_{10} emissions are split between the 4 constituent countries.

Table 2-21 - Proportion of total PM_{10} emissions from UK constituent countries

Year	England	Scotland	Wales	N Ireland	Unallocated
1990	74%	10%	7%	8%	1%
2007	74%	10%	8%	7%	1%

2.5.2 England PM_{10} Inventory by NFR Sector, 1990-2007

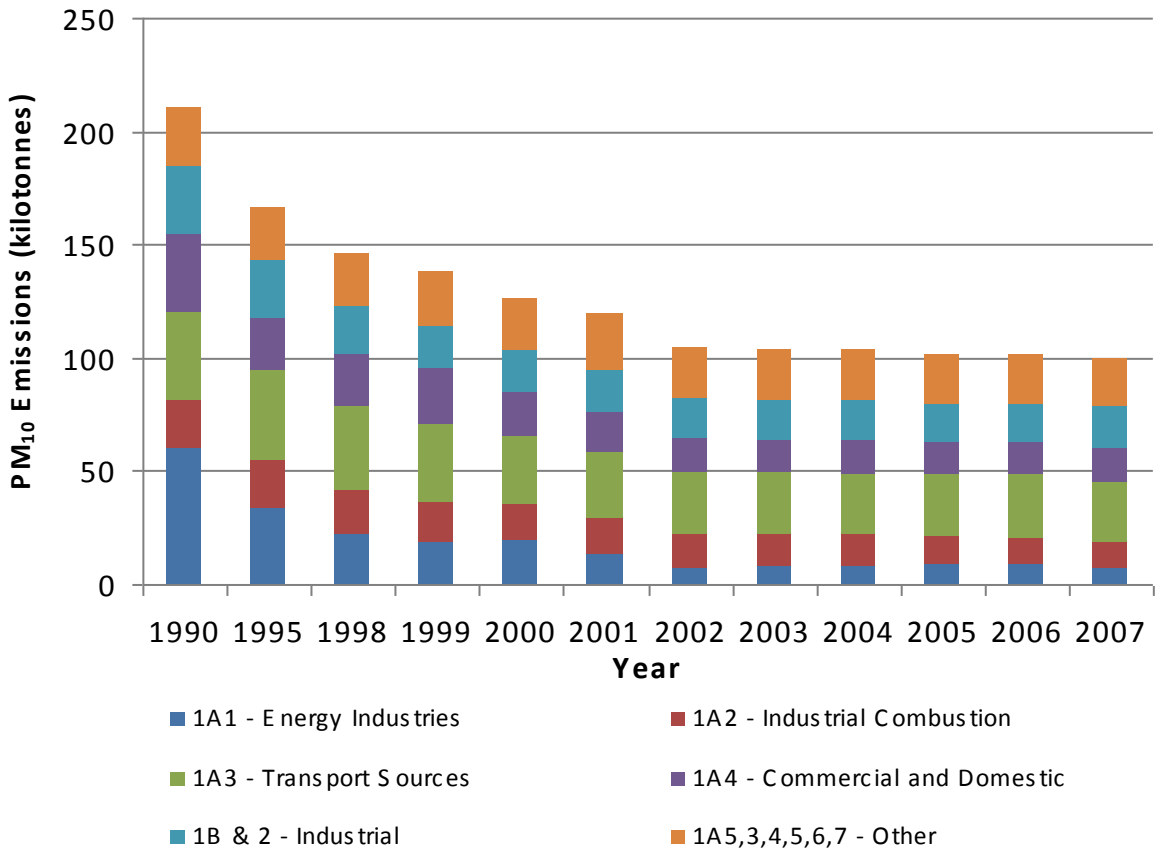
The table and graph below give a summary of the PM_{10} emissions in England by broad NFR sector categories. The detailed data are available in Appendix C.

Table 2-22 - England emissions of PM_{10} by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	59.8	33.9	22.4	18.2	19.0	13.4	7.4	7.6	7.9	8.8	9.0	7.4	7%
1A2 - Industrial Combustion	21.3	20.7	19.4	17.7	16.3	16.0	14.9	14.5	14.1	12.7	11.6	11.3	11%
1A3 - Transport Sources	38.9	40.2	36.6	34.7	30.1	28.5	26.9	27.0	26.9	26.7	27.5	26.6	27%
1A4 - Commercial and Domestic	34.7	22.9	23.6	24.9	19.6	18.3	15.5	14.7	14.6	14.0	14.3	15.0	15%
1B & 2 - Industrial	29.7	25.3	20.6	18.9	18.0	17.9	17.6	17.7	17.6	17.5	17.3	18.3	18%
1A5,3,4,5,6,7 - Other	25.9	22.7	23.2	23.3	22.8	25.5	21.9	22.2	22.2	21.8	22.0	21.4	21%
Total	210	166	146	138	126	120	104	104	103	102	102	100	100%

Units: kilotonnes

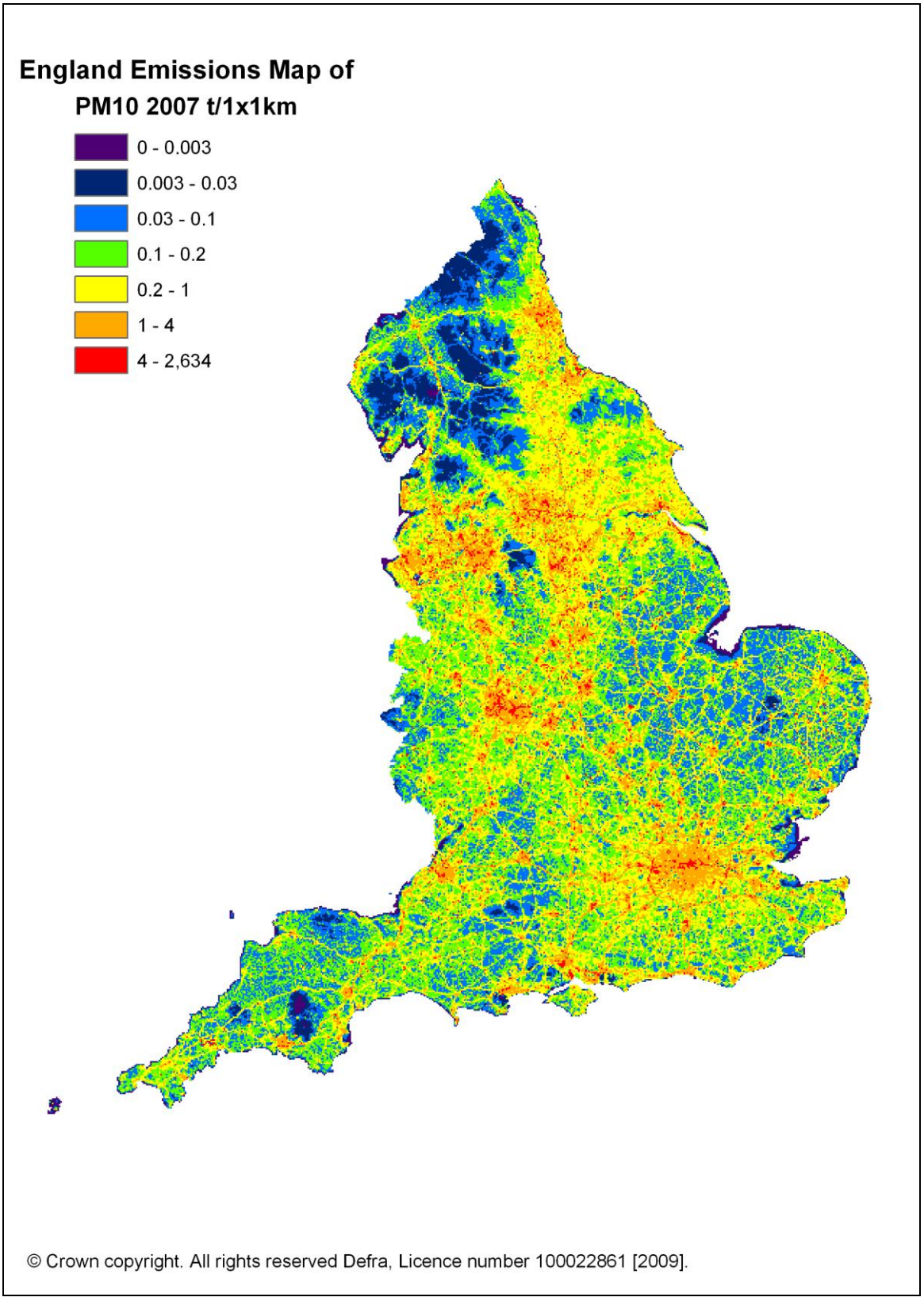
Figure 2-38 - Time series of England PM_{10} emissions 1990-2007



England's PM_{10} emissions have declined by 52% since 1990 and account for 74% of the UK total. 27% of PM_{10} emissions in England come from transport sources (down by 32% since 1990), whilst

15% stem from commercial and residential combustion (mainly of coal and solid fuels, down by 57% since 1990). Emissions from power generation (1A1a) were 27% of the England total emission in 1990, but have been significantly reduced to 6% of the England total in 2007.

Figure 2-39 Map of PM_{10} Emissions in England, 2007



2.5.3 Scotland PM_{10} Inventory by NFR Sector, 1990-2007

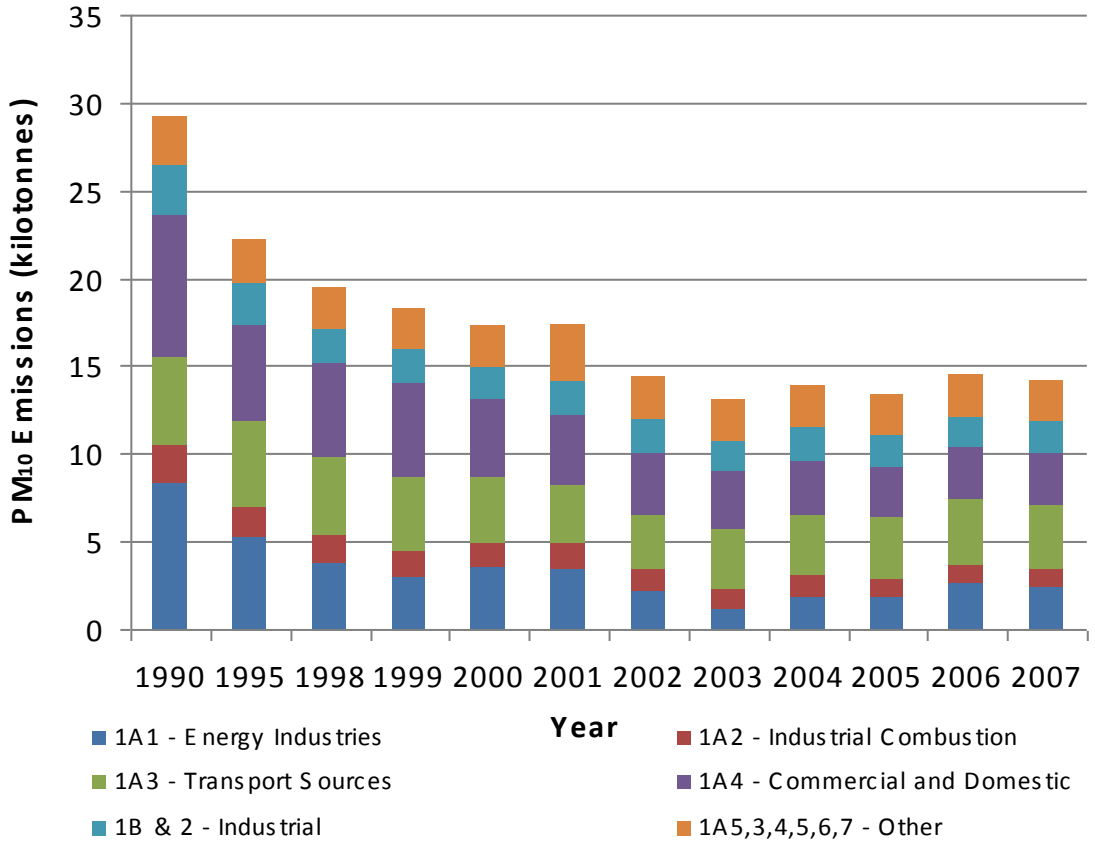
The table and graph below give a summary of the PM10 emissions in Scotland by broad NFR sector categories. The detailed data are available in Appendix C.

Table 2-23 - Scotland emissions of PM_{10} by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	8.3	5.2	3.8	3.0	3.6	3.5	2.2	1.1	1.8	1.8	2.6	2.4	17%
1A2 - Industrial Combustion	2.2	1.7	1.5	1.4	1.4	1.4	1.2	1.2	1.2	1.1	1.1	1.1	8%
1A3 - Transport Sources	5.0	5.0	4.4	4.2	3.7	3.4	3.1	3.4	3.4	3.5	3.7	3.6	26%
1A4 - Commercial and Domestic	8.2	5.4	5.4	5.4	4.5	4.0	3.5	3.3	3.1	2.9	2.9	3.0	21%
1B & 2 - Industrial	2.8	2.4	1.9	1.9	1.8	1.9	1.9	1.8	1.9	1.8	1.8	1.7	12%
1A5,3,4,6,7 - Other	2.7	2.5	2.4	2.3	2.5	3.2	2.4	2.4	2.5	2.4	2.3	2.3	16%
Total	29	22	20	18	17	17	14	13	14	13	14	14	100 %

Units: kilotonnes

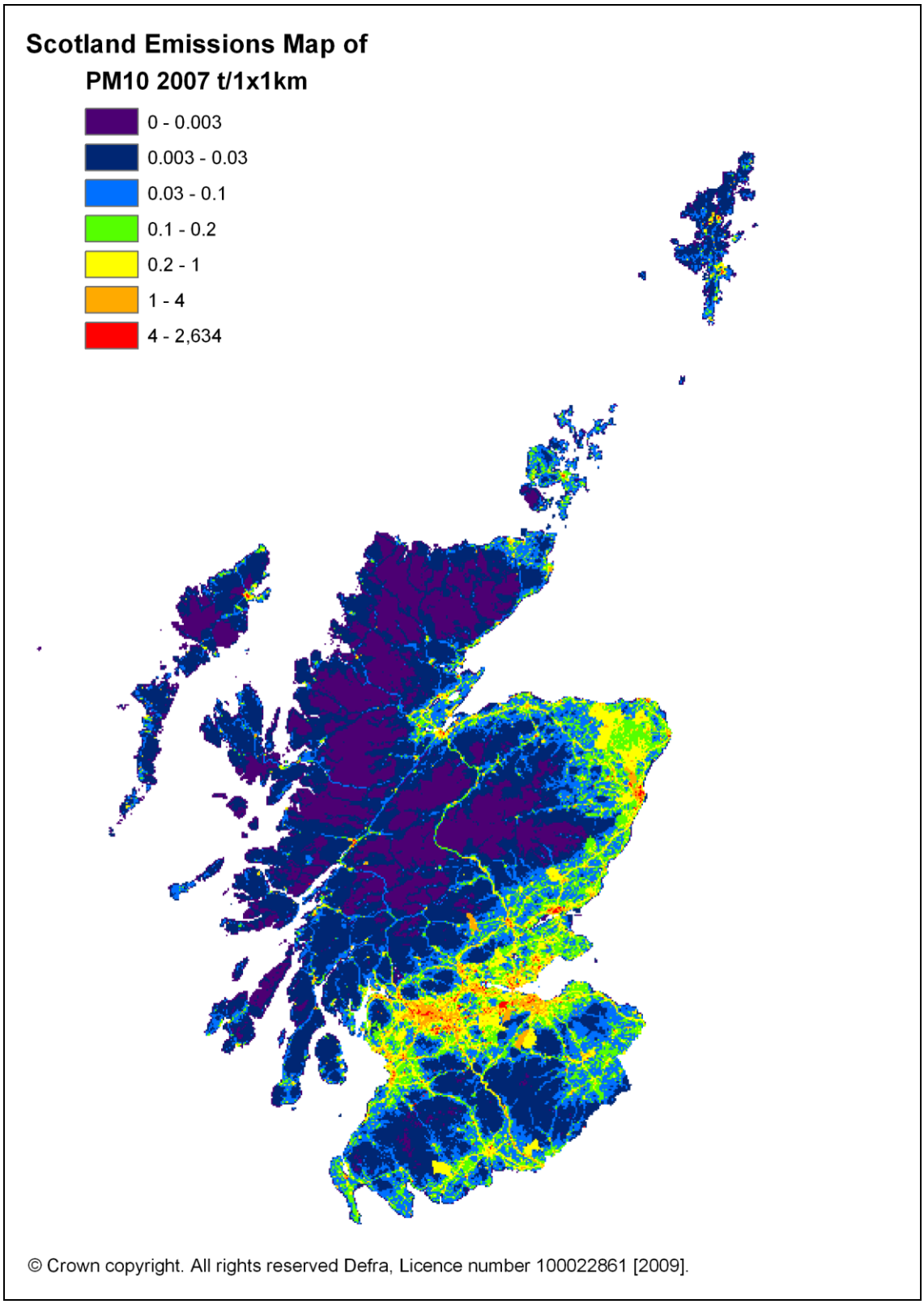
Figure 2-40 - Time series of Scotland PM_{10} emissions 1990-2007



Scotland's PM_{10} emissions have declined by 52% since 1990 and account for 10% of the UK total. 26% of PM_{10} emissions in Scotland come from transport sources (down by 27% since 1990), whilst 21% stem from commercial and residential combustion (mainly of coal and solid fuels, down by 63%

since 1990). Emissions from power generation (1A1a) were 25% of the Scotland total emission in 1990, but have been reduced to 15% of the Scotland total in 2007. Reduction in emissions from the iron & steel combustion sector (1A2a) of 99.8% over 1990-2005 are primarily due to the closure of the Ravenscraig steelworks in 1992.

Figure 2-41 Map of PM_{10} Emissions in Scotland, 2007



© Crown copyright. All rights reserved Defra, Licence number 100022861 [2009].

2.5.4 Wales PM_{10} Inventory by NFR Sector, 1990-2007

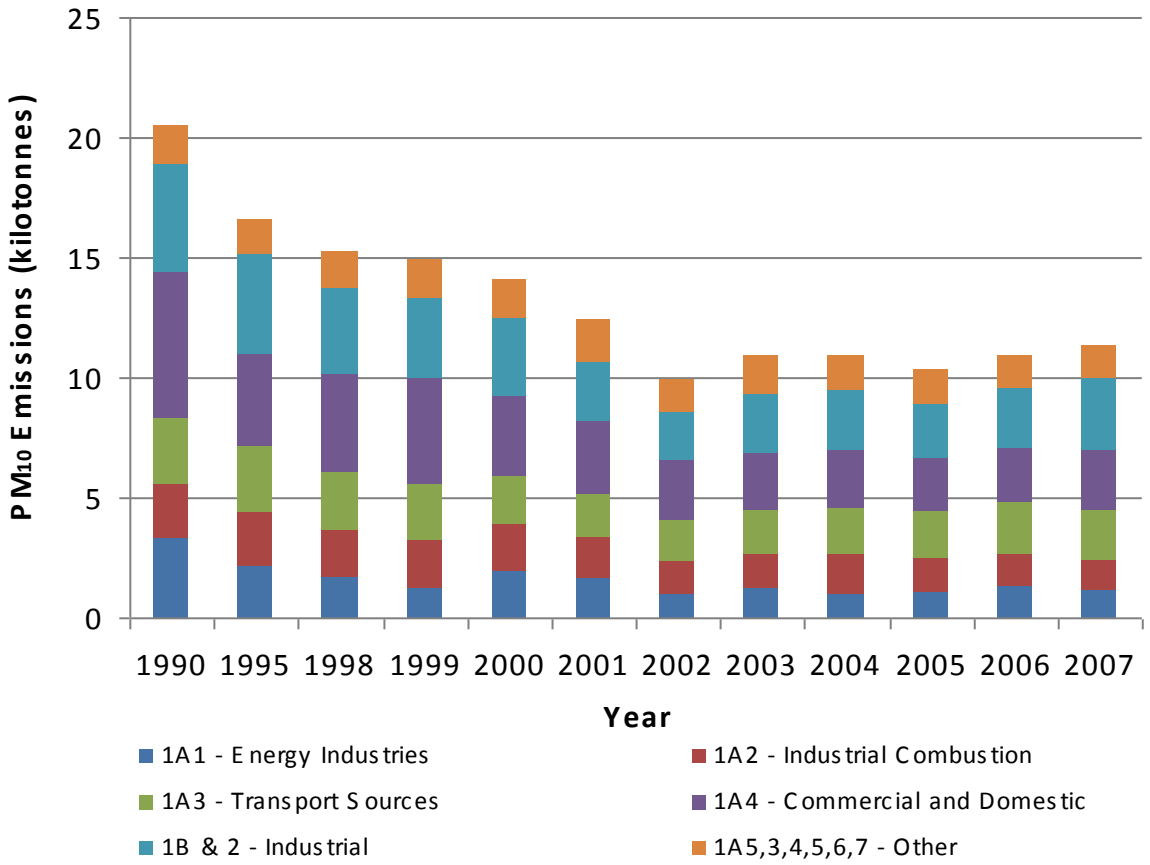
The table and graph below give a summary of the PM_{10} emissions in Wales by broad NFR sector categories. The detailed data are available in Appendix C.

Table 2-24 - Wales emissions of PM_{10} by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	3.3	2.2	1.6	1.2	1.9	1.6	1.0	1.2	1.0	1.1	1.3	1.2	10%
1A2 - Industrial Combustion	2.3	2.3	2.0	2.0	2.0	1.7	1.3	1.4	1.7	1.4	1.3	1.3	11%
1A3 - Transport Sources	2.7	2.7	2.5	2.3	2.0	1.8	1.7	1.8	1.9	2.0	2.1	2.1	18%
1A4 - Commercial and Domestic	6.1	3.9	4.1	4.4	3.3	3.0	2.5	2.4	2.4	2.3	2.3	2.5	22%
1B & 2 - Industrial	4.5	4.1	3.6	3.3	3.2	2.5	2.0	2.5	2.5	2.3	2.4	3.0	26%
1A5,3,4,6,7 - Other	1.6	1.4	1.5	1.6	1.6	1.7	1.3	1.6	1.5	1.4	1.3	1.4	12%
Total	20	17	15	15	14	12	10	11	11	10	11	11	100%

Units: kilotonnes

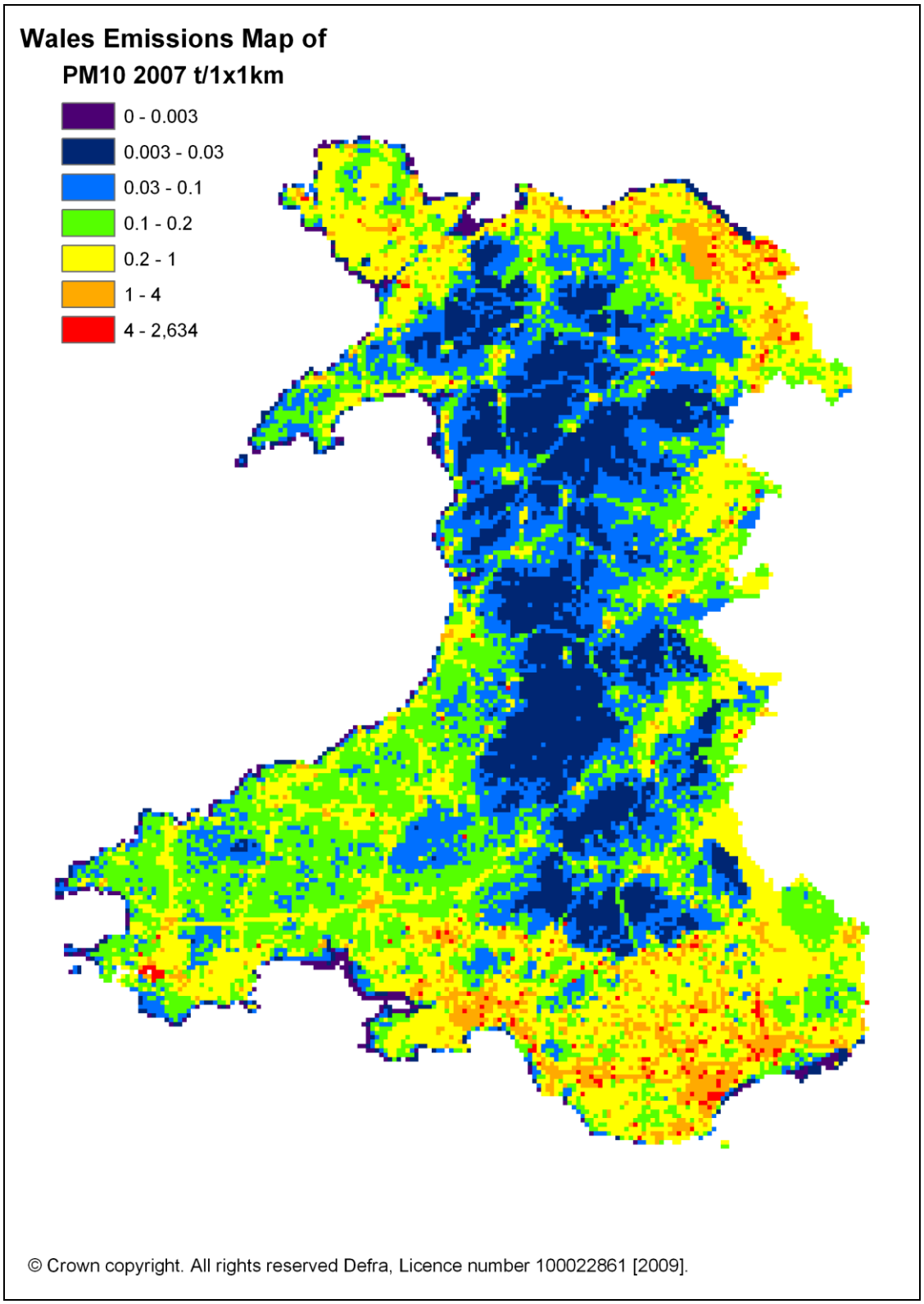
Figure 2-42 - Time series of Wales PM_{10} emissions 1990-2007



Wales's PM_{10} emissions have declined by 45% since 1990 and accounted for 8% of the UK total in 2007. 18% of PM_{10} emissions in Wales come from transport sources (down by 24% since 1990), whilst 22% stem from commercial and residential combustion (mainly of coal and solid fuels, down by 59% since 1990). Emissions from power generation (1A1a) were 13% of the Wales total emission in

1990, but have been reduced by 73% to below 7% of the Wales total in 2007. It is notable that heavy industry plays a more significant role in the Wales PM_{10} inventory than in other parts of the UK, with key contributions from refining (4%), iron & steel combustion (6%), other manufacturing combustion (6%) and 26% from Industrial Process sectors included in the 2007 Welsh total.

Figure 2-43 Map of PM_{10} Emissions in Wales, 2007



2.5.5 Northern Ireland PM_{10} Inventory by NFR Sector, 1990-2007

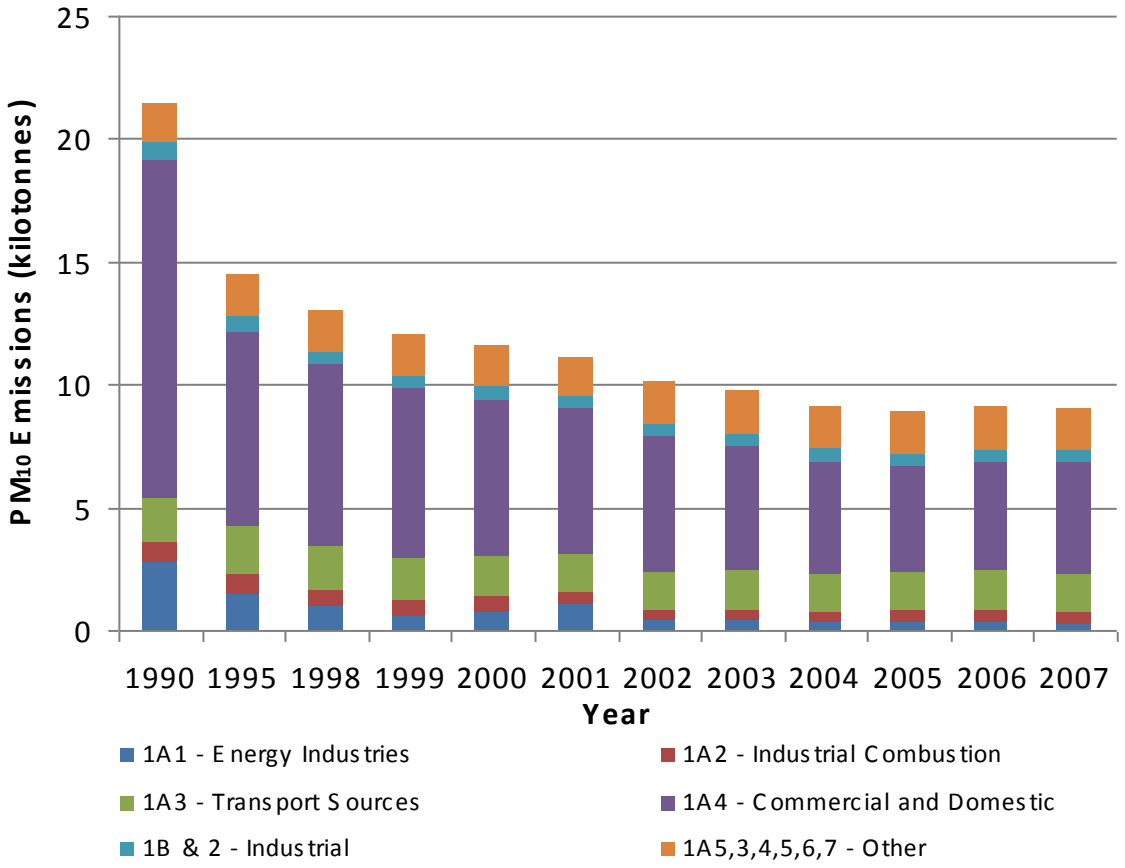
The table and graph below give a summary of the PM_{10} emissions in Northern Ireland by broad NFR sector categories. The detailed data are available in Appendix C.

Table 2-25 - Northern Ireland emissions of PM_{10} by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	2.7	1.5	1.0	0.6	0.8	1.0	0.4	0.4	0.3	0.3	0.3	0.3	3%
1A2 - Industrial Combustion	0.9	0.8	0.7	0.6	0.6	0.5	0.4	0.4	0.4	0.5	0.5	0.5	5%
1A3 - Transport Sources	1.8	1.9	1.8	1.8	1.6	1.5	1.5	1.6	1.6	1.5	1.6	1.5	17%
1A4 - Commercial and Domestic	13.8	8.0	7.4	6.9	6.4	6.0	5.5	5.0	4.6	4.4	4.4	4.6	51%
1B & 2 - Industrial	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5%
1A5,3,4,6,7 - Other	1.5	1.7	1.7	1.7	1.7	1.6	1.7	1.8	1.8	1.7	1.8	1.7	19%
Total	21	15	13	12	12	11	10	10	9	9	9	9	100%

Units: kilotonnes

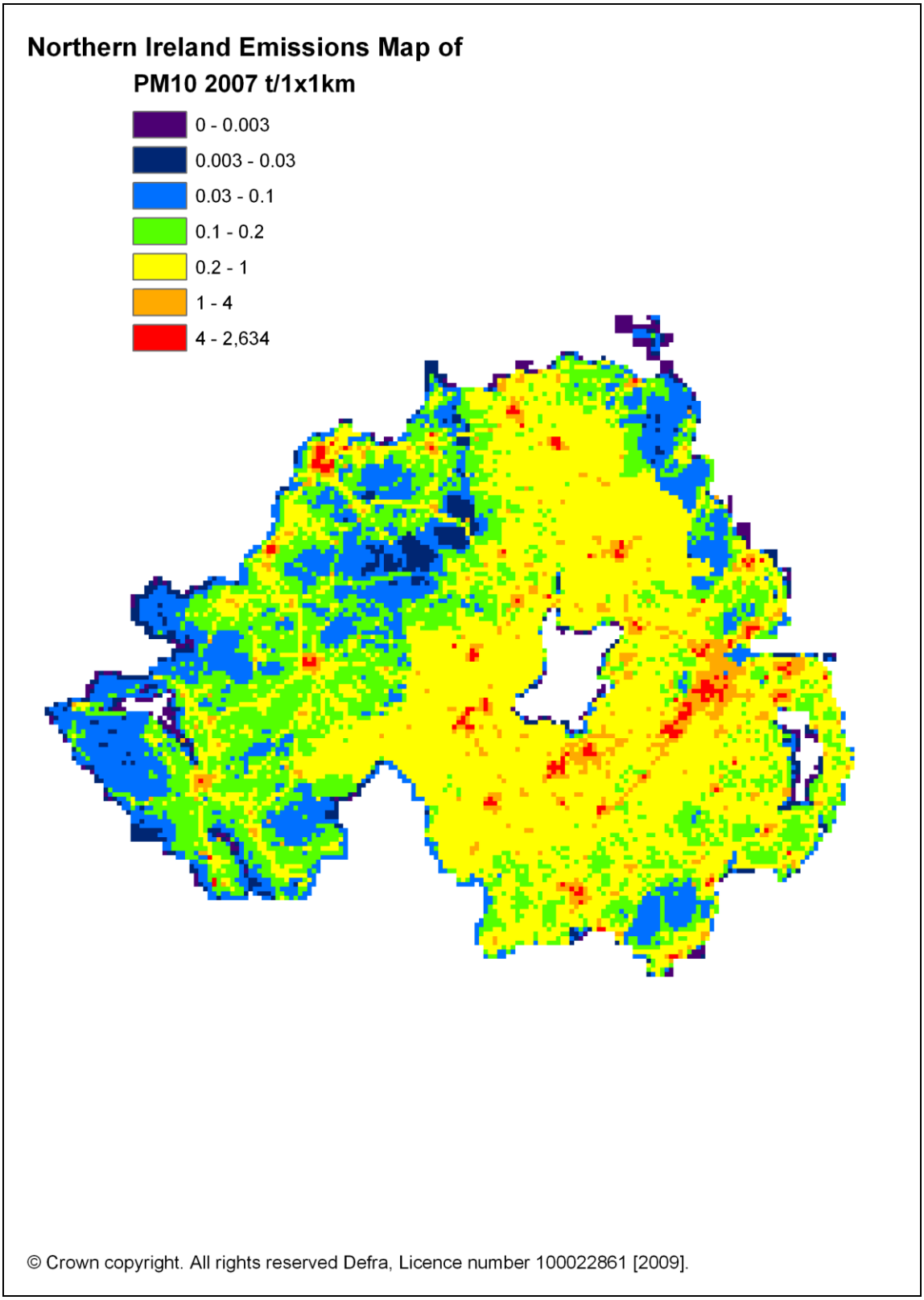
Figure 2-44 - Time series of Northern Ireland PM_{10} emissions 1990-2007



Northern Ireland's PM_{10} emissions have declined by 58% since 1990 and accounted for 7% of the UK total in 2007. 17% of PM_{10} emissions in Northern Ireland come from transport sources (down by 14% since 1990), whilst 51% stem from commercial and residential combustion (mainly of coal and solid

fuels), down by 67% since 1990. Emissions from power generation (1A1a) were 13% of the total emissions in 1990, but have been reduced to 3% of the Northern Ireland total in 2007.

Figure 2-45 Map of PM_{10} Emissions in Northern Ireland, 2007

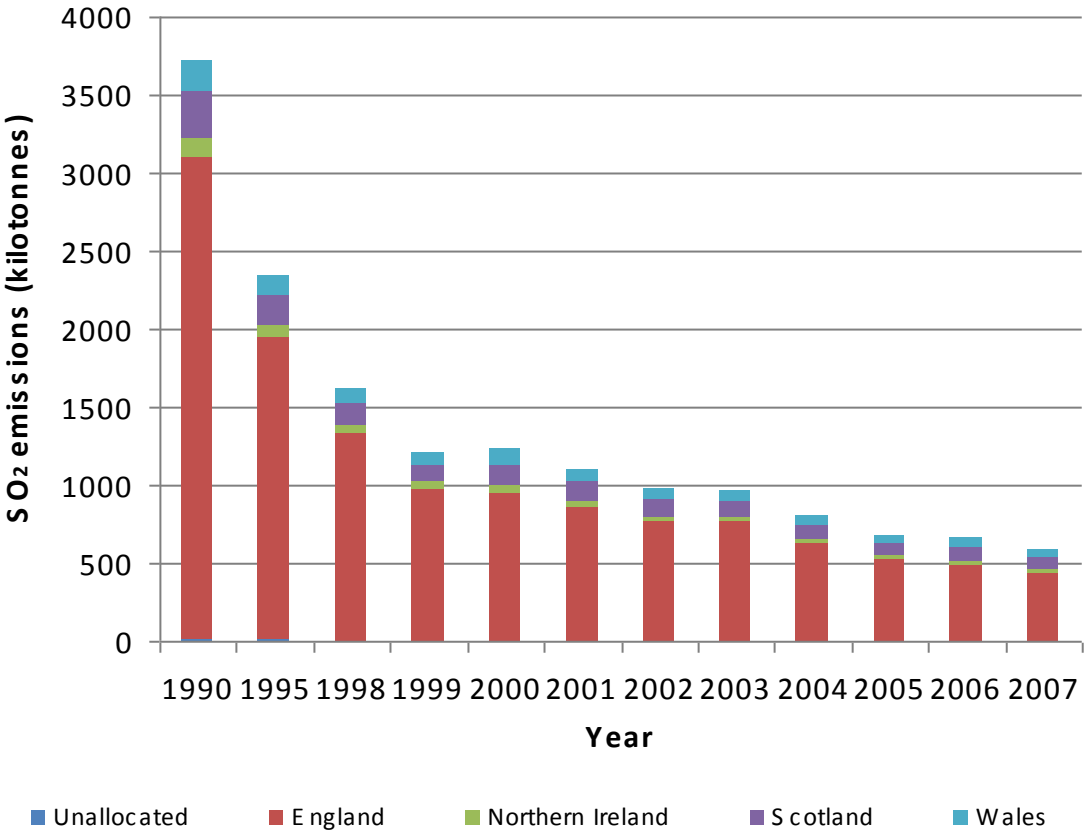


© Crown copyright. All rights reserved Defra, Licence number 100022861 [2009].

2.6 SULPHUR DIOXIDE EMISSION ESTIMATES

Since 1970 there has been a substantial overall reduction of more than 90% in SO_2 emissions from across the UK, mainly due to a decline in emissions from combustion of sulphur-containing solid fuels and petroleum products.

Figure 2-46 - Total UK emissions of SO_2



Emissions from combustion of petroleum products have fallen significantly due to 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 reduced 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.

Fuel combustion accounts for more than 93% of total UK SO_2 emissions with the sulphur arising from the fuel itself. The SO_2 emission 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, 2008), sulphur contents of liquid fuels (Watson, 2008) and data from coal producers regarding sulphur contents of coals enable reliable estimates to be produced. The main combustion sources are:

- **Power generation.** Power stations account for 48% of UK SO_2 emissions in 2007. Historically coal-fired stations have been the most important source, but the gradual change in fuel mix of UK power stations (to more nuclear and gas-fired plant) and improvements in generation efficiency and these reductions will continue in the near future as more CCGT stations are built and FGD is fitted to more coal fired power plant.

- **Industrial Combustion.** Emissions of SO_2 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 2007 emissions from combustion sources have fallen by 95%, primarily due to the decline in energy-intensive heavy industries such as iron & steel manufacturing. In addition, UK industry has gradually switched from coal and oil-based fuels in favour of natural gas, as it provides a cleaner, cheaper energy source.

In 2007, road transport emissions account for less than 1% of the total SO_2 emissions. Previously this source was more significant, but a tightening of fuel standards during the 1990s has lead to a significant decline in emissions due to the reduction in the sulphur content of DERV. The reduction in the sulphur content of gas oil has also reduced emissions from off-road vehicles. Emissions from domestic, commercial & institutional sectors have also declined since 1970, reflecting the major changes in fuel mix from oil and coal to gas. Emissions from waste incinerators have reduced significantly during the 1990s due to the introduction of stricter emission standards forcing the closure of old-design incinerators and their replacement with more modern plant with improved abatement.

Emissions of SO_2 for England, Wales, Scotland and Northern Ireland are summarised in the tables and graphs below, with more detailed inventory tables in Appendix F. Table 2.26 shows how total UK SO_2 emissions are split between the 4 constituent countries.

Table 2-26 - Proportion of total SO_2 emissions from UK constituent countries

Year	England	Scotland	Wales	N Ireland	Unallocated
1990	83%	8%	5%	3%	0%
2007	75%	13%	9%	3%	0%

2.6.1 England SO_2 Inventory by NFR Sector, 1990-2007

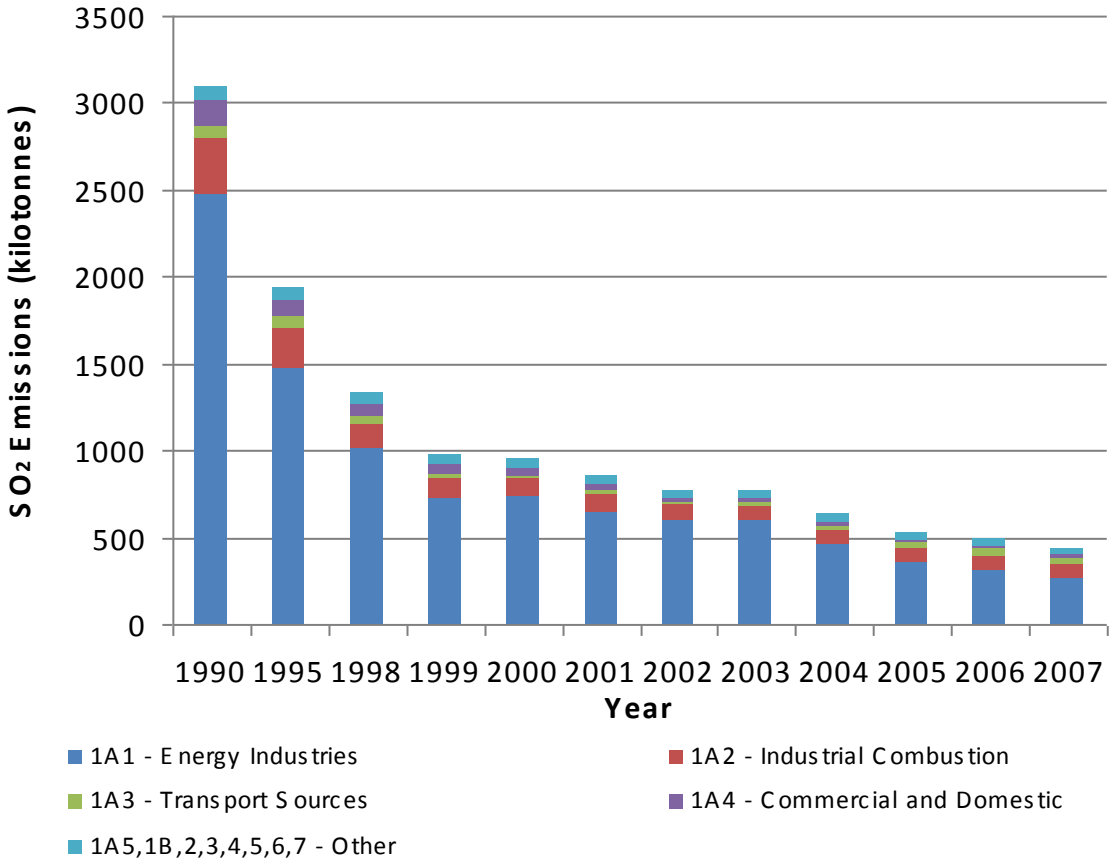
The table and graph below give a summary of the SO_2 emissions in England by broad NFR sector categories. The detailed data are available in Appendix F.

Table 2-27 - England emissions of SO_2 by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	2478	1472	1011	722	733	642	593	597	456	355	314	270	61%
1A2 - Industrial Combustion	317	233	144	114	102	107	92	82	85	84	78	74	17%
1A3 - Transport Sources	72	63	38	28	20	16	15	22	26	30	40	38	9%
1A4 - Commercial and Domestic	144	100	73	53	45	41	28	24	22	18	18	18	4%
1A5,1B,2,6 - Other	80	72	68	58	50	43	39	42	43	42	41	41	9%
Total	3092	1940	1334	975	950	850	767	766	632	529	491	441	100%

Units: kilotonnes

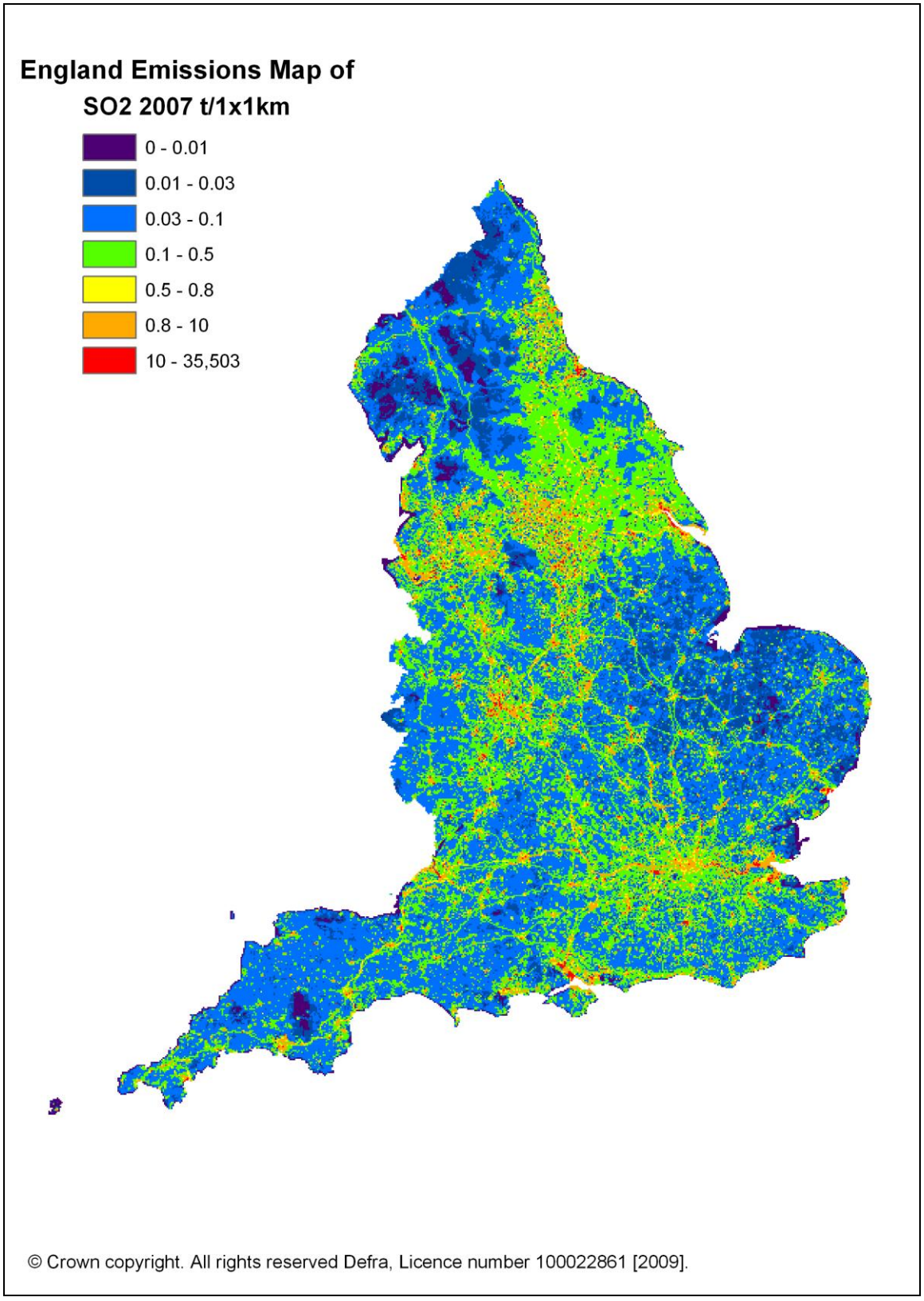
Figure 2-47 - Time series of England SO_2 emissions 1990-2007



England's SO_2 emissions have declined by 86% since 1990 and accounted for 75% of the UK total in 2007. Power generation is by far the most significant source, accounting for 47% of the England total in 2007 (mainly from the sulphur in coal and fuel oil), but due to the growth in gas & nuclear fuel use and the installation of FGD plant at a number of coal-fired power stations, emissions from this source have reduced by 91% since 1990. 17% of SO_2 emissions in England are from industrial combustion (1A2: down by 77% since 1990), 13% from refineries (1A1b: down 38% since 1990) whilst national

navigation and residential combustion contribute 8 and 3% of the total respectively. Reductions in SO_2 emissions across all sectors are also due to the progress towards production of low-sulphur petroleum-based fuels such as gas oil (diesel) and burning oil.

Figure 2-48 Map of SO_2 Emissions in England, 2007



© Crown copyright. All rights reserved Defra, Licence number 100022861 [2009].

2.6.2 Scotland SO_2 Inventory by NFR Sector, 1990-2007

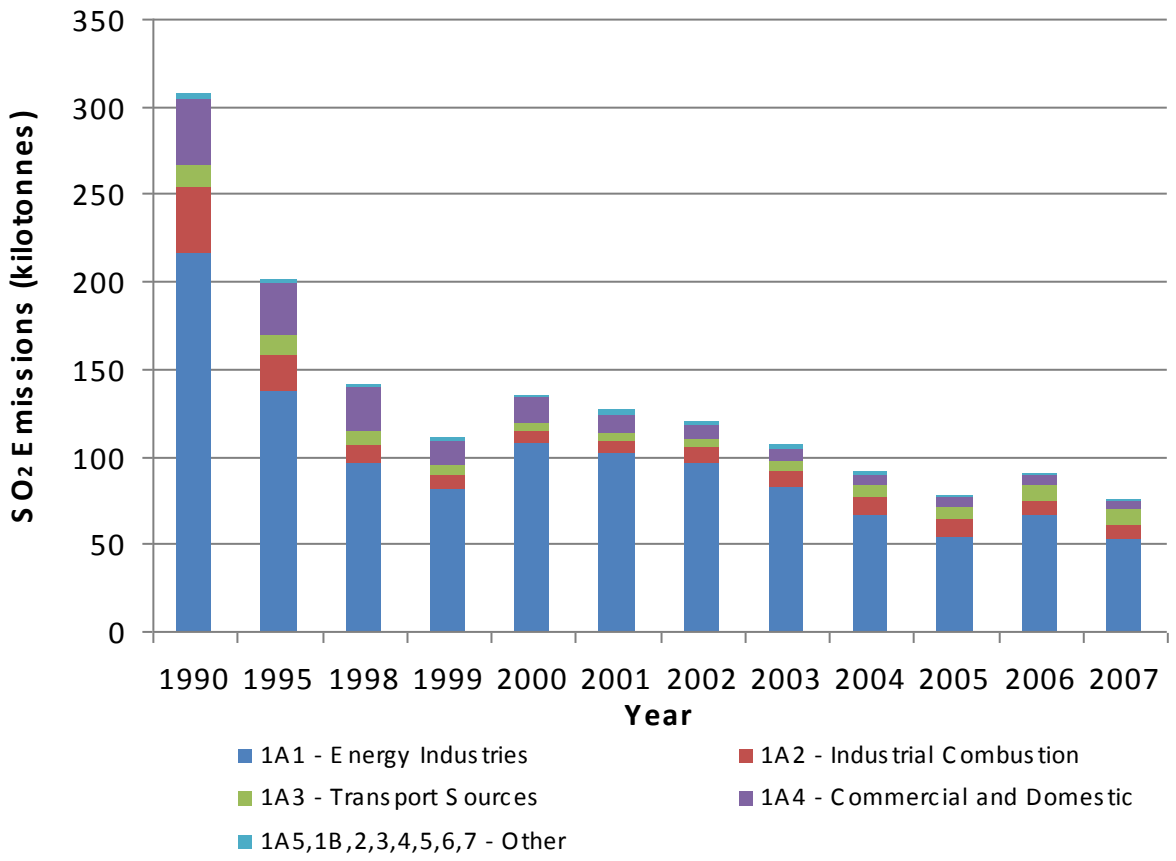
The table and graph below give a summary of the SO_2 emissions in Scotland by broad NFR sector categories. The detailed data are available in Appendix F.

Table 2-28 - Scotland emissions of SO_2 by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	217	137	96	81	107	101	96	82	67	54	66	53	69%
1A2 - Industrial Combustion	37.2	21.1	10.4	7.5	6.9	7.1	9.7	9.2	9.8	10.4	8.6	7.8	10%
1A3 - Transport Sources	12.2	11.3	7.7	6.5	5.4	4.3	3.7	5.5	6.6	7.5	9.3	9.1	12%
1A4 - Commercial and Domestic	38.4	29.5	24.7	13.2	13.9	10.9	8.4	7.2	6.3	4.9	5.5	5.0	7%
1A5,1B,2,6 - Other	2.9	1.9	1.9	2.0	1.8	2.9	2.1	1.8	1.8	1.7	1.5	1.4	2%
Total	307	201	141	110	135	127	120	106	91	78	91	76	100%

Units: kilotonnes

Figure 2-49 - Time series of Scotland SO_2 emissions 1990-2007

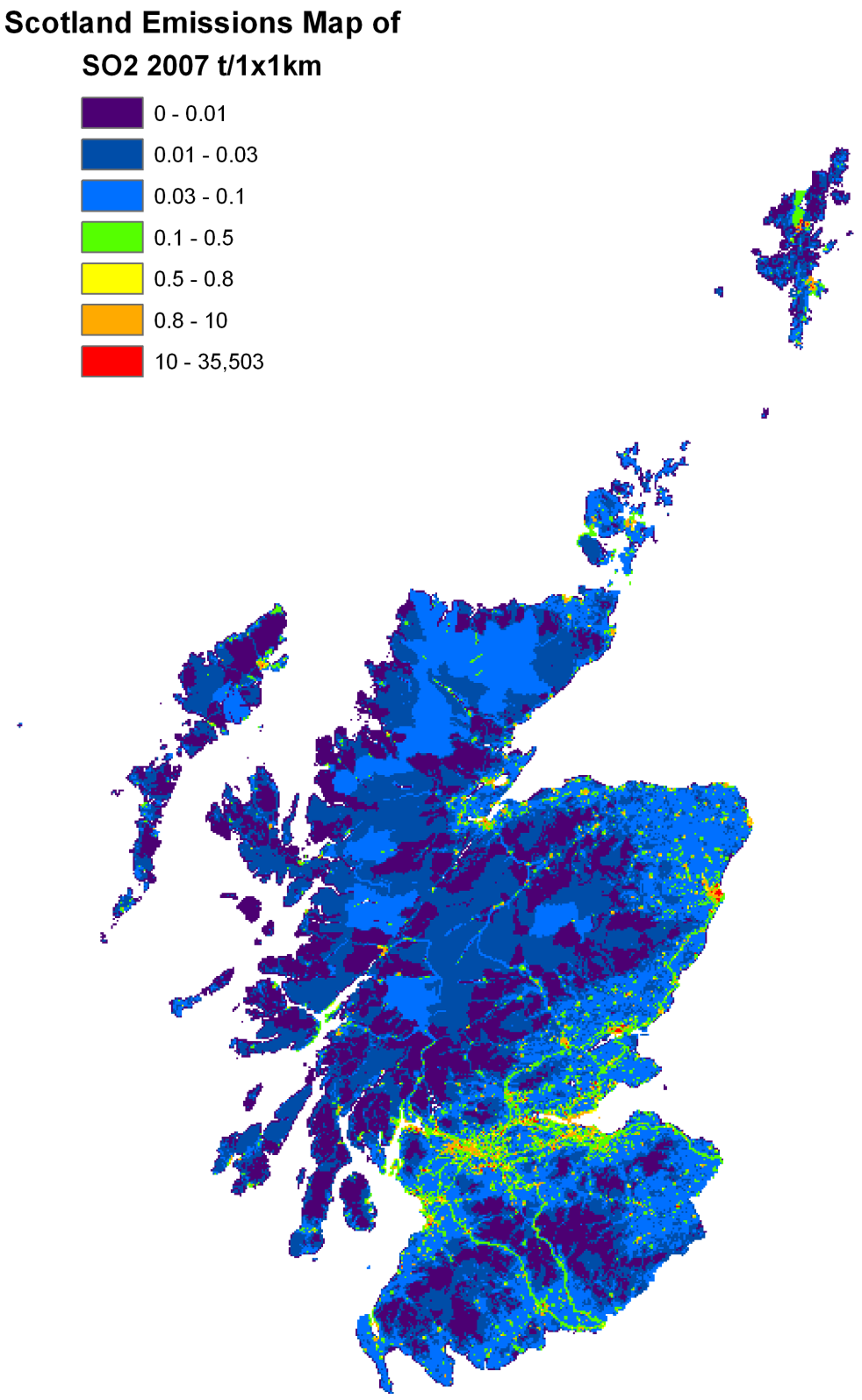


Scotland's SO_2 emissions have declined by 75% since 1990 and account for 13% of the UK total. Power generation is by far the most significant source, accounting for 62% of the Scotland total in 2007 (mainly from the sulphur in coal and fuel oil), but due to the growth in gas & nuclear fuel use, emissions from this source have reduced by 76% since 1990. However, in recent years, fluctuating trends in electricity generation have had a noticeable impact on emissions of SO_2 from power

generation in Scotland. In 2006, coal-fired generation in Scotland increased by over 40% from 2005 (12,092 GWh to 17,488 GWh), and then declined by over 20% in 2007 (down to 13,802 GWh). As for emissions of NOx, the impact of the changes in contributions from coal-powered generation are reflected in the emissions of SO_2 from the Energy Industries in Scotland, which showed a temporary increase in 2006 in comparison to preceding and following years (Figure 2-49).

In 2007, 10% of SO_2 emissions in Scotland are from industrial combustion (1A2: down by 79% since 1990), 8% from refineries (1A1b: down 71% since 1990) whilst national navigation and residential combustion contribute 11 and 5% of the total respectively. The overall downward trend in SO_2 emissions across all sectors is also due to the progressive introduction of low-sulphur petroleum-based fuels such as gas oil (diesel) and burning oil.

Figure 2-50 Map of SO_2 Emissions in Scotland, 2007



© Crown copyright. All rights reserved Defra, Licence number 100022861 [2009].

2.6.3 Wales SO_2 Inventory by NFR Sector, 1990-2007

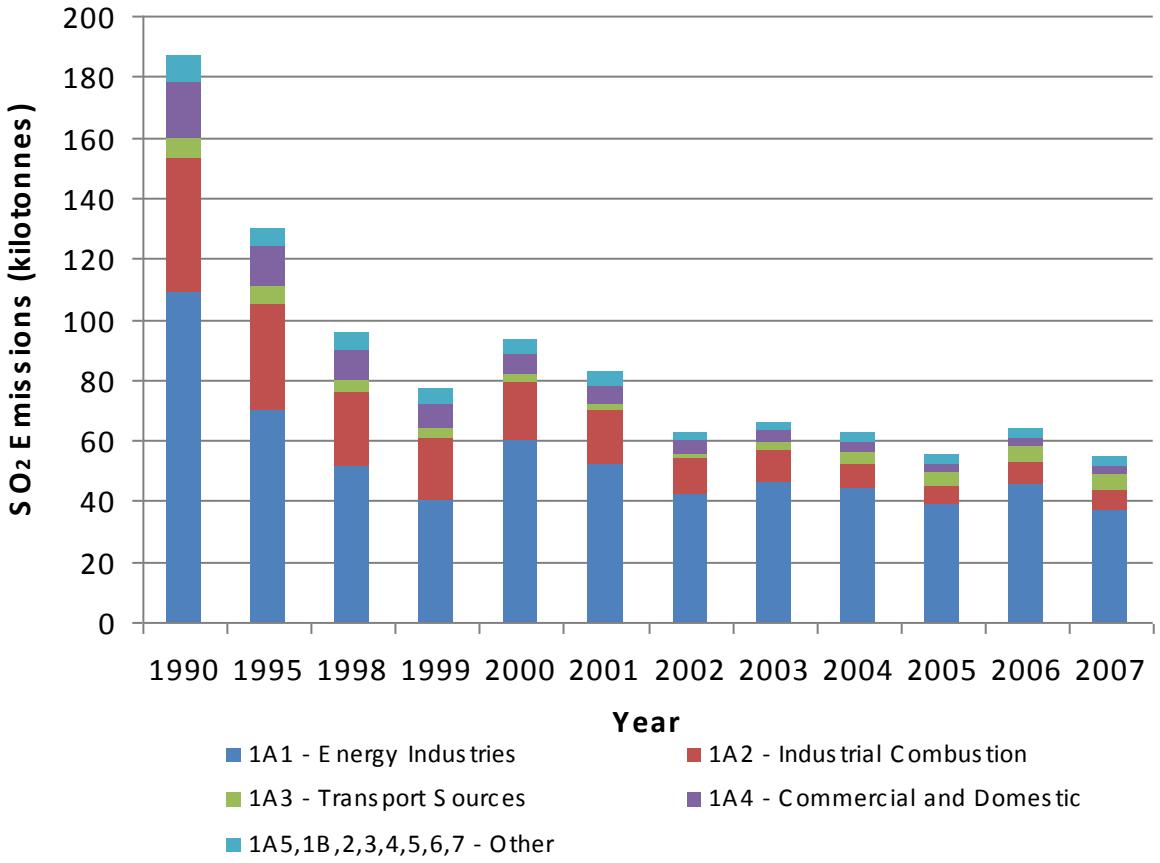
The table and graph below give a summary of the SO_2 emissions in Wales by broad NFR sector categories. The detailed data are available in Appendix F.

Table 2-29 - Wales emissions of SO_2 by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	109	70	52	40	60	52	42	46	44	39	46	37	68%
1A2 - Industrial Combustion	44.6	35.4	24.3	20.7	19.3	18.0	11.7	10.8	8.4	6.0	7.0	6.7	12%
1A3 - Transport Sources	6.3	5.7	3.8	3.1	2.6	1.9	1.7	2.7	3.6	4.1	5.2	5.1	9%
1A4 - Commercial and Domestic	18.9	13.0	9.9	8.1	6.7	6.1	4.2	3.7	3.5	2.8	2.6	2.7	5%
1A5,1B,2,6 - Other	8.7	5.9	5.9	5.0	4.3	4.8	3.2	2.8	3.1	3.4	3.2	3.3	6%
Total	187	130	96	77	93	83	63	66	63	55	64	55	100%

Units: kilotonnes

Figure 2-51 - Time series of Wales SO_2 emissions 1990-2007

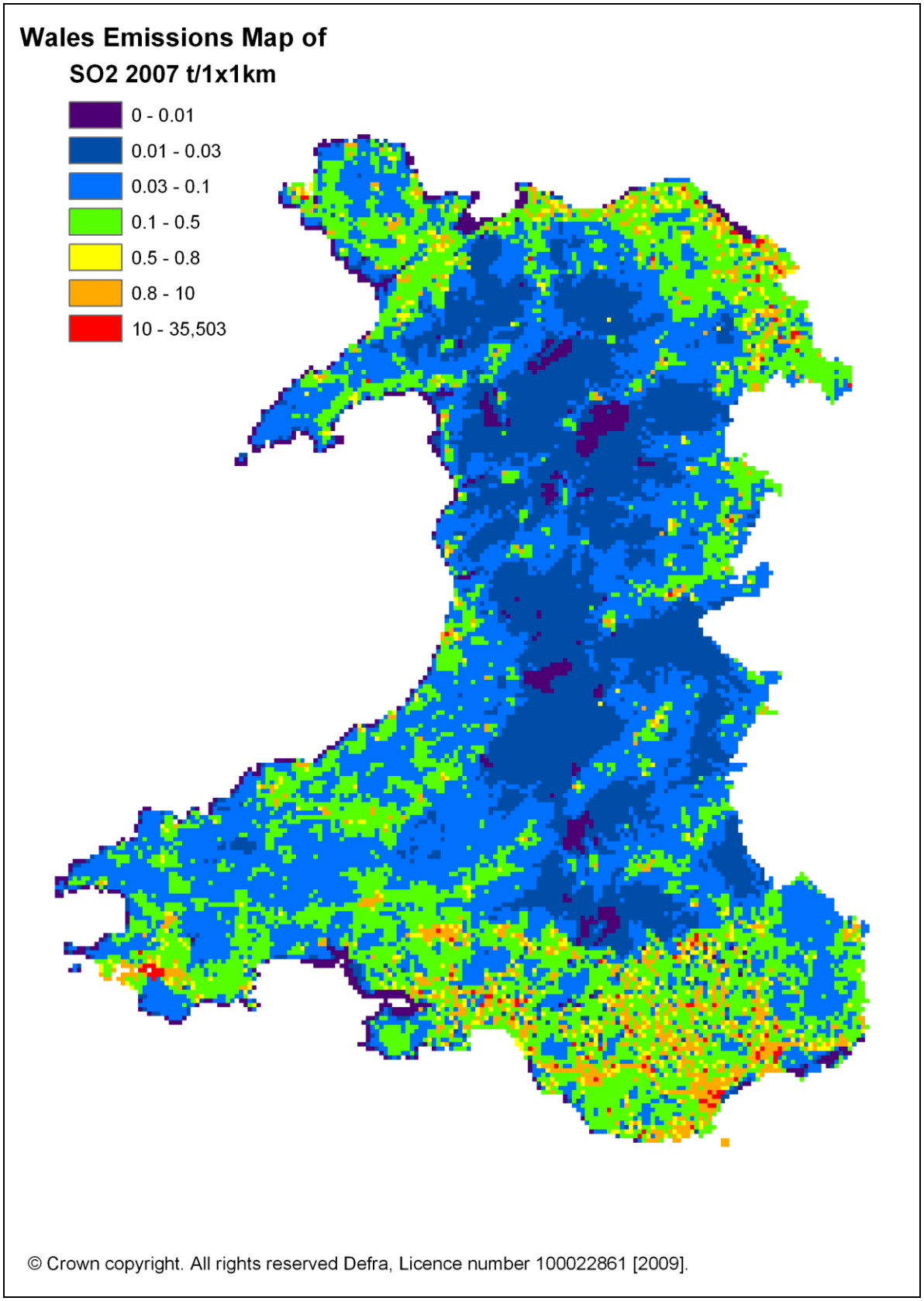


Wales' SO_2 emissions have declined by 71% since 1990 and accounted for 9% of the UK total in 2007. Power generation is by far the most significant source, accounting for 40% of the Wales total in 2007 (mainly from the sulphur in coal and fuel oil), but due to the growth in gas & nuclear fuel use, emissions from this source have reduced by 74% since 1990. However, this downward trend has shown variations as a result of fluctuations in sources of electricity generation, most notably in 2006, where emissions of SO_2 showed a significant increase from preceding and following years (Figure 2-

51) as a result of a 30% increase in coal fired generation between 2005 and 2006 (6,772 GWh to 8,859 GWh).

12% of SO_2 emissions in Wales are from industrial combustion (1A2: down by 85% since 1990, but it increased slightly between 2005 and 2006 due to increased industrial output), 27% from refineries (1A1b: down 35% since 1990), 4% from residential combustion and 9% from national navigation (1A3dii: up 66% since 1990 due to increased port movements). Reductions in SO_2 emissions across all sectors are also due to the progress towards production of low-sulphur petroleum-based fuels such as gas oil (diesel) and burning oil.

Figure 2-52 Map of SO_2 Emissions in Wales, 2007



© Crown copyright. All rights reserved Defra, Licence number 100022861 [2009].

2.6.4 Northern Ireland SO_2 Inventory by NFR Sector, 1990-2007

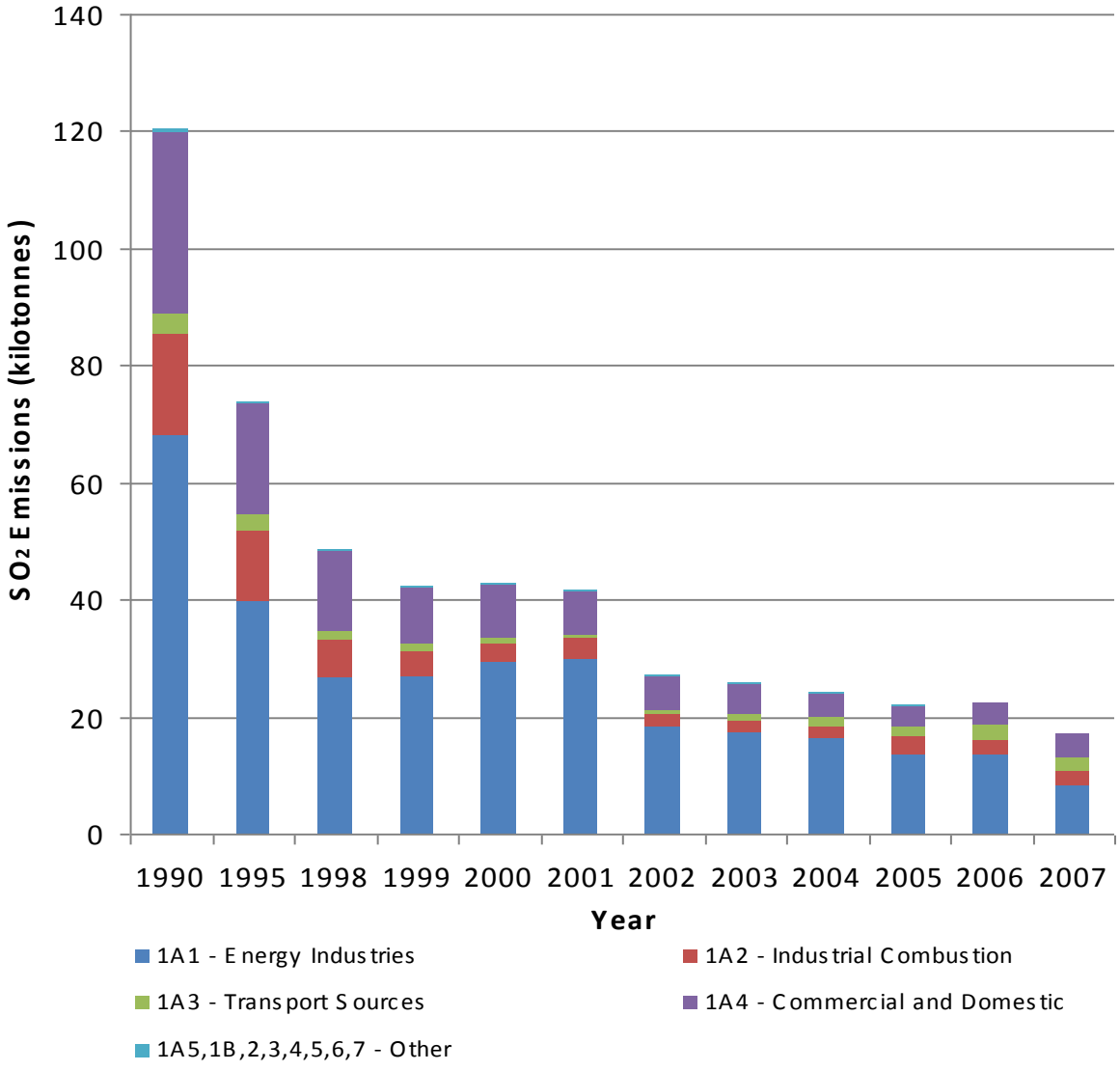
The table and graph below give a summary of the SO_2 emissions in Northern Ireland by broad NFR sector categories. The detailed data are available in Appendix F.

Table 2-30 - Northern Ireland emissions of SO_2 by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	68.1	39.8	26.8	26.8	29.2	30.1	18.3	17.4	16.4	13.7	13.4	8.3	49%
1A2 - Industrial Combustion	17.5	11.8	6.3	4.4	3.3	3.2	2.1	1.9	2.0	3.1	2.8	2.4	14%
1A3 - Transport Sources	3.3	3.0	1.8	1.3	1.0	0.8	0.7	1.1	1.4	1.7	2.3	2.1	13%
1A4 - Commercial and Domestic	31.1	18.7	13.4	9.4	9.1	7.3	5.8	5.2	4.1	3.4	3.8	4.0	24%
1A5,1B,2,6 - Other	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	1%
Total	120	74	48	42	43	42	27	26	24	22	22	17	100%

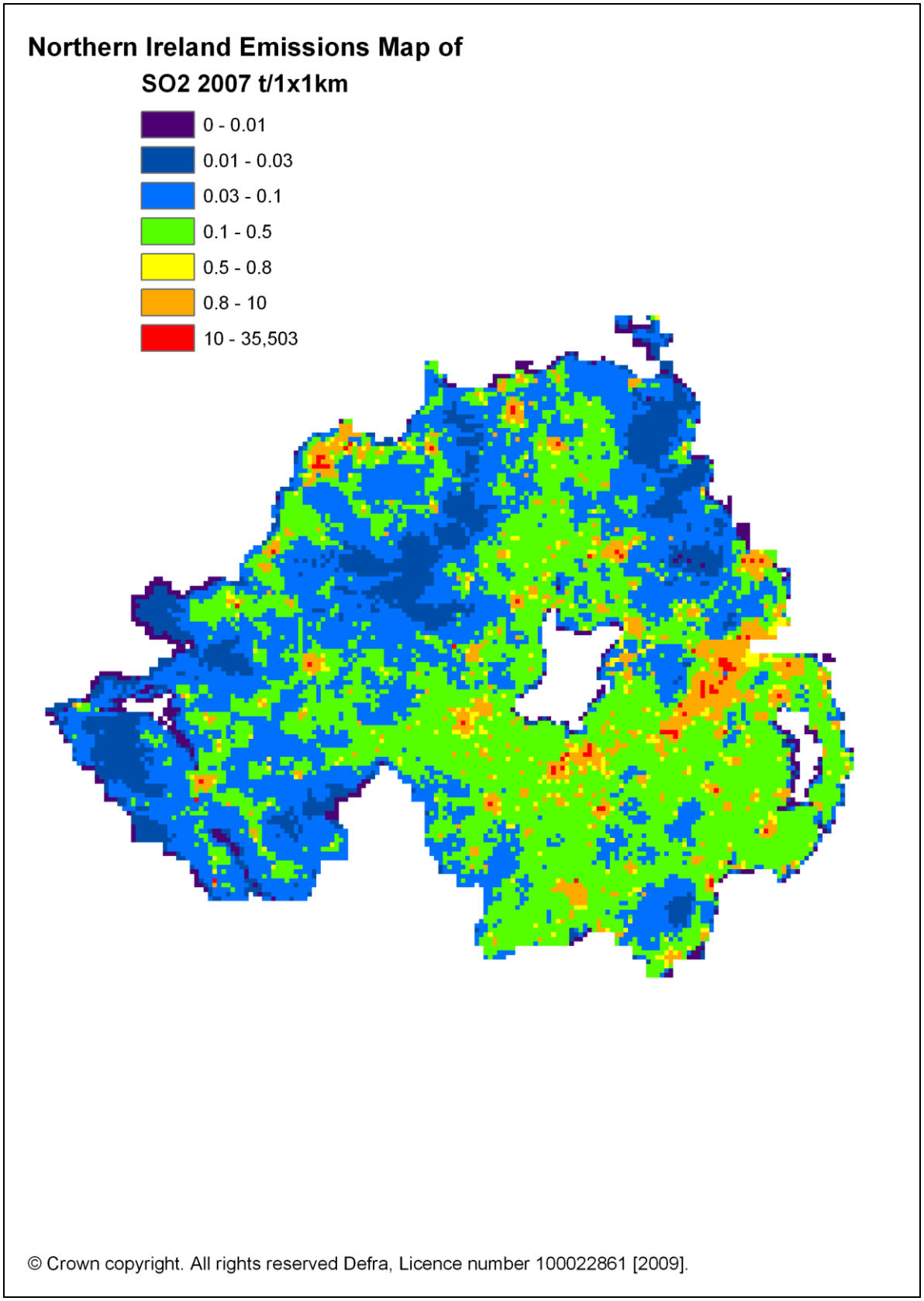
Units: kilotonnes

Figure 2-53 - Time series of Northern Ireland SO_2 emissions 1990-2007



Northern Ireland's SO_2 emissions have declined by 86% since 1990 and they accounted for 3% of the UK total in 2007. Power generation is by far the most significant source, accounting for 49% of the Northern Irish total in 2007 (mainly from the sulphur in coal and fuel oil), but due to the growth in gas use, emissions from this source have reduced by 88% since 1990. 14% of SO_2 emissions in Northern Ireland are from industrial combustion (1A2: down by 86% since 1990), whilst 19% stems from residential combustion (1A4bi: down 87% since 1990) which is much higher than the rest of the UK, reflecting the higher use of coal and solid fuels in the domestic sector in this region. These emissions are expected to decline in the future as the gas supply network develops further and solid fuel use is reduced. Reductions in SO_2 emissions across all sectors are due to the use of low-sulphur petroleum-based fuels such as gas oil (diesel) and burning oil.

Figure 2-54 Map of SO_2 Emissions in Northern Ireland, 2007

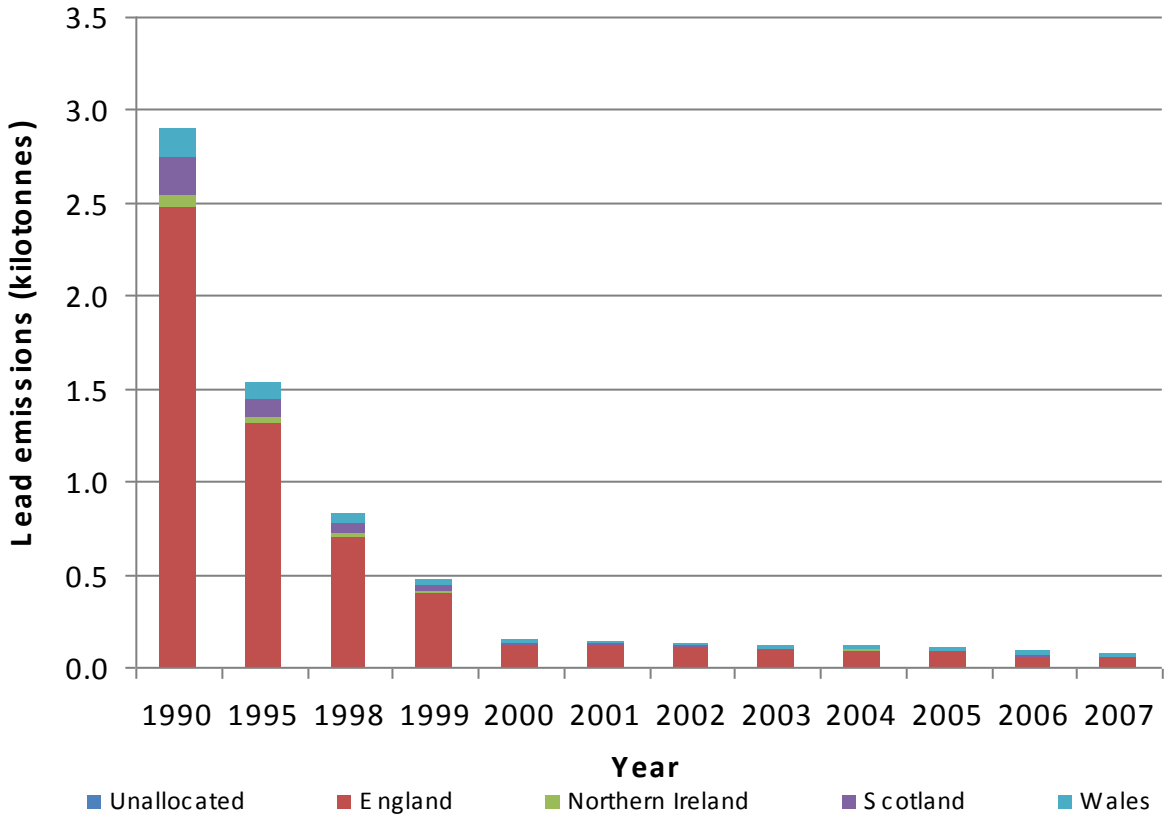


© Crown copyright. All rights reserved Defra, Licence number 100022861 [2009].

2.7 LEAD EMISSION ESTIMATES

Since 1970, emissions of lead to air in the UK have declined by 99%, with reductions in emissions occurring in most sectors. However, the decline has been mainly driven by the progressive phasing out of leaded petrol in the UK. The lead content of leaded petrol was reduced from around 0.34 g/l to 0.143 g/l in 1986. From 1987, sales of unleaded petrol increased, particularly as a result of the increased use of cars fitted with three-way catalyst and leaded petrol was then phased out from general sale at the end of 1999. The largest source of lead until 1999 was the road transport sector.

Figure 2-55 - Total UK emissions of Lead



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

- **Iron and Steel Sector Combustion.** This sector is responsible for 40% of the lead emissions in the UK in 2007, of which sinter production process account for 99.7%. Emissions have remained fairly constant between 1990-2007. However the proportion of the lead emissions it accounts for has consequently increased due to the decline in emissions from the transport sector.

- **Industrial Processes.** Emissions of lead from industry arise only from a few industries, dominated by metal production. Other sources include the chemical industry and solid fuel transformation. Between 1970 and 2007 emissions from metal production and the chemical industry have fallen by 93% and 97% respectively.

- **Waste Incineration.** In 1990, lead emissions from waste incineration accounted for 8% (238 t) of the overall emissions in the UK. Municipal Solid Waste (MSW) incinerators not meeting the new standards closed in the period leading up to December 1996. Also, improved combustion and flue gas controls, and developments in abatement technology in modern MSW incinerator design has resulted in emissions from waste incineration declining down to zero. MSW incineration used to generate electricity is accounted in source category 1A1a, this has also declined significantly since 1990.

In 2007, transport emissions accounted for 4% of the total lead emissions. Previously this source was the most significant, accounting for 86% of emissions in 1970. Emissions of lead for England, Wales, Scotland and Northern Ireland are summarised in the tables and graphs below, with more detailed inventory tables in Appendix F. Table 2.26 shows how total UK lead emissions are split between the 4 constituent countries.

Table 2-31 - Proportion of total Lead emissions from UK constituent countries

Year	England	Scotland	Wales	N Ireland	Unallocated
1990	86%	7%	5%	2%	0%
2007	72%	4%	22%	2%	0%

2.7.1 England Lead Inventory by NFR Sector, 1990-2007

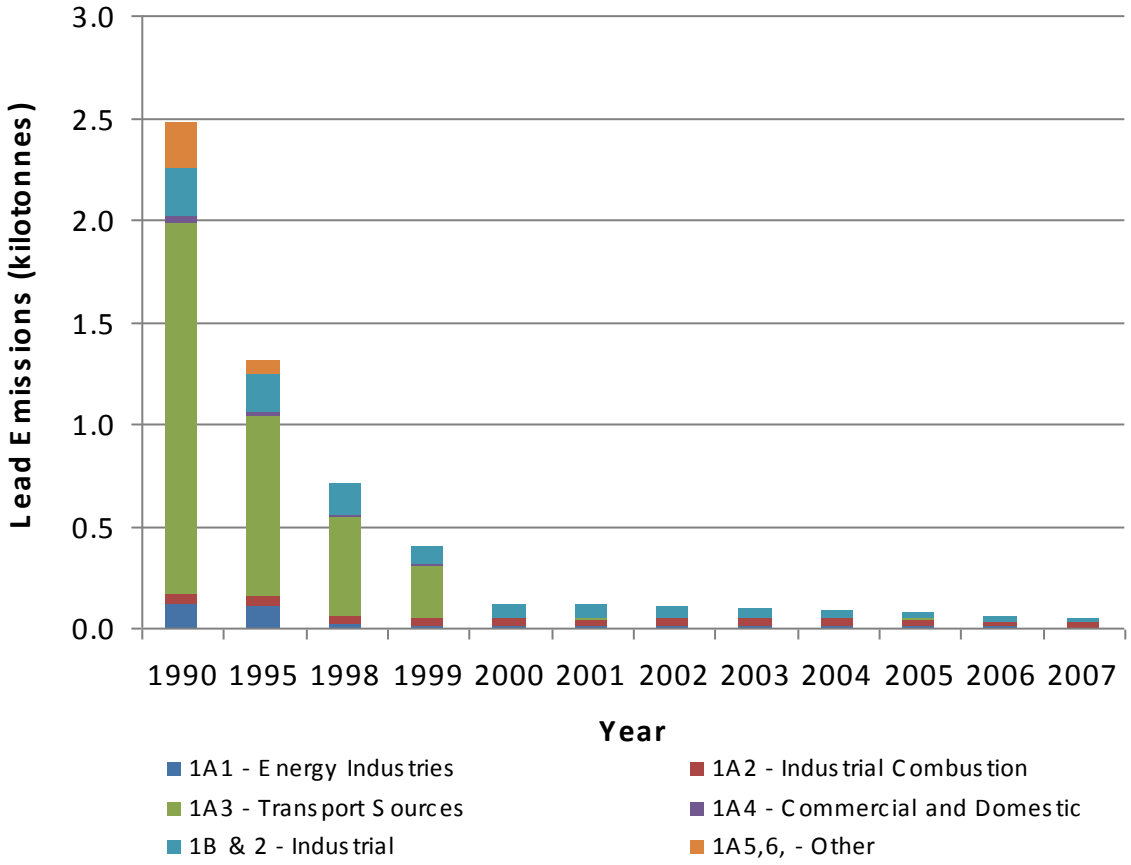
The table and graph below give a summary of the lead emissions in England by broad NFR sector categories. The detailed data are available in Appendix I.

Table 2-32 - England emissions of Lead by NFR source sector (tonnes)

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	117	107	18	14	14	11	9	10	10	10	8	3	5%
1A2 - Industrial Combustion	49	45	39	36	30	33	36	35	36	34	18	23	45%
1A3 - Transport Sources	1813	884	483	255	2	2	2	2	2	2	2	2	4%
1A4 - Commercial and Domestic	44	24	10	9	6	6	5	4	4	3	3	3	6%
1B & 2 - Industrial	224	185	154	85	63	63	59	44	39	33	23	20	39%
1A5,6, - Other	230	67	0.7	1.1	1.1	0.3	0.3	0.3	0.3	0.2	0.1	0.1	0%
Total	2478	1312	705	400	116	115	110	95	91	82	55	51	100%

Units: tonnes

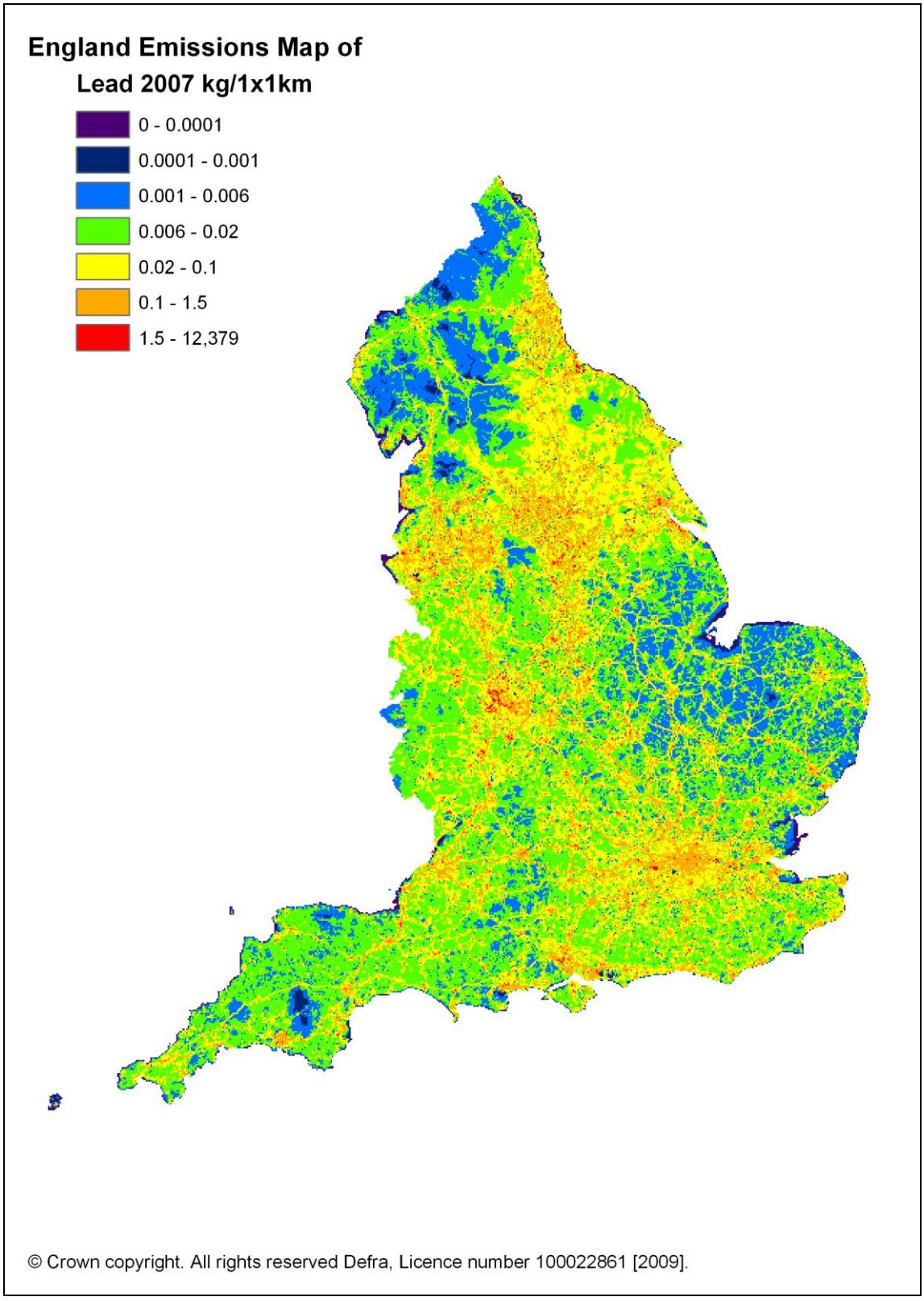
Figure 2-56 - Time series of England Lead emissions 1990-2007



England's lead emissions have declined by 98% since 1990 and accounted for 72% of the UK total in 2007. The emissions that arise due to the combustion in the iron and steel industries is the most significant source, accounting for 36% of the England total in 2007. As a result, 45% of the overall emissions are from industrial combustion (1A2a: up 9.7% since 1990 and 1A2: down 53% since

1990). Transport sources used to dominate the emission of lead in England in 1990, accounting for 73%. However, as mentioned previously, due to the phase out of leaded petrol, transport sources now only account for 4.1% of lead emissions in England.

Figure 2-57 Map of Lead Emissions in England, 2007



© Crown copyright. All rights reserved Defra, Licence number 100022861 [2009].

2.7.2 Scotland Lead Inventory by NFR Sector, 1990-2007

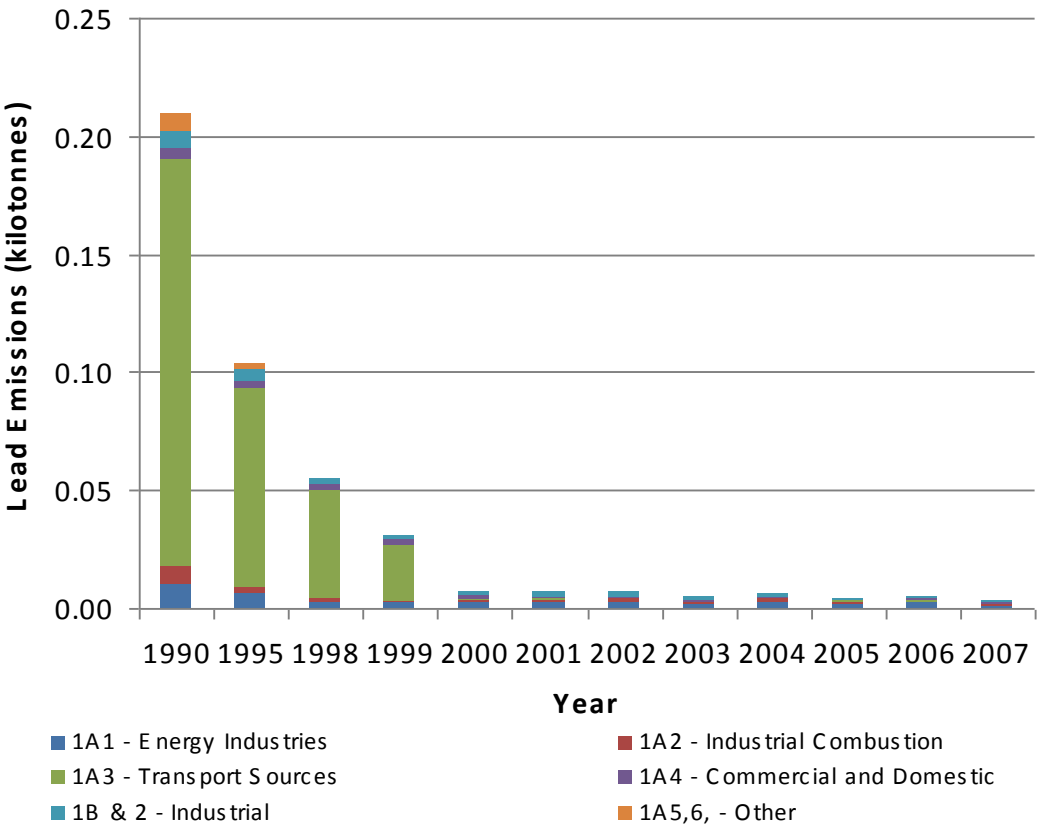
The table and graph below give a summary of the lead emissions in Scotland by broad NFR sector categories. The detailed data are available in Appendix I.

Table 2-33 - Scotland emissions of Lead by NFR source sector (tonnes)

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	10.2	6.7	2.5	2.0	2.6	2.7	2.7	1.3	2.5	1.9	2.3	0.7	23%
1A2 - Industrial Combustion	7.3	2.0	1.5	1.2	1.0	0.7	1.0	0.9	1.5	0.7	0.4	0.6	20%
1A3 - Transport Sources	172	84.2	46.1	23.6	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.3	10%
1A4 - Commercial and Domestic	5.0	3.0	2.1	2.0	1.6	1.4	1.2	1.1	0.9	0.7	0.8	0.8	27%
1B & 2 - Industrial	7.4	5.1	2.9	2.2	1.8	1.8	2.0	1.1	0.9	0.8	0.7	0.6	21%
1A5,6, - Other	7.3	2.4	0.1	0.1	0.1	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0%
Total	210	103	55.2	31.1	7.2	7.0	7.2	4.7	6.1	4.4	4.7	3.0	100%

Units: tonnes

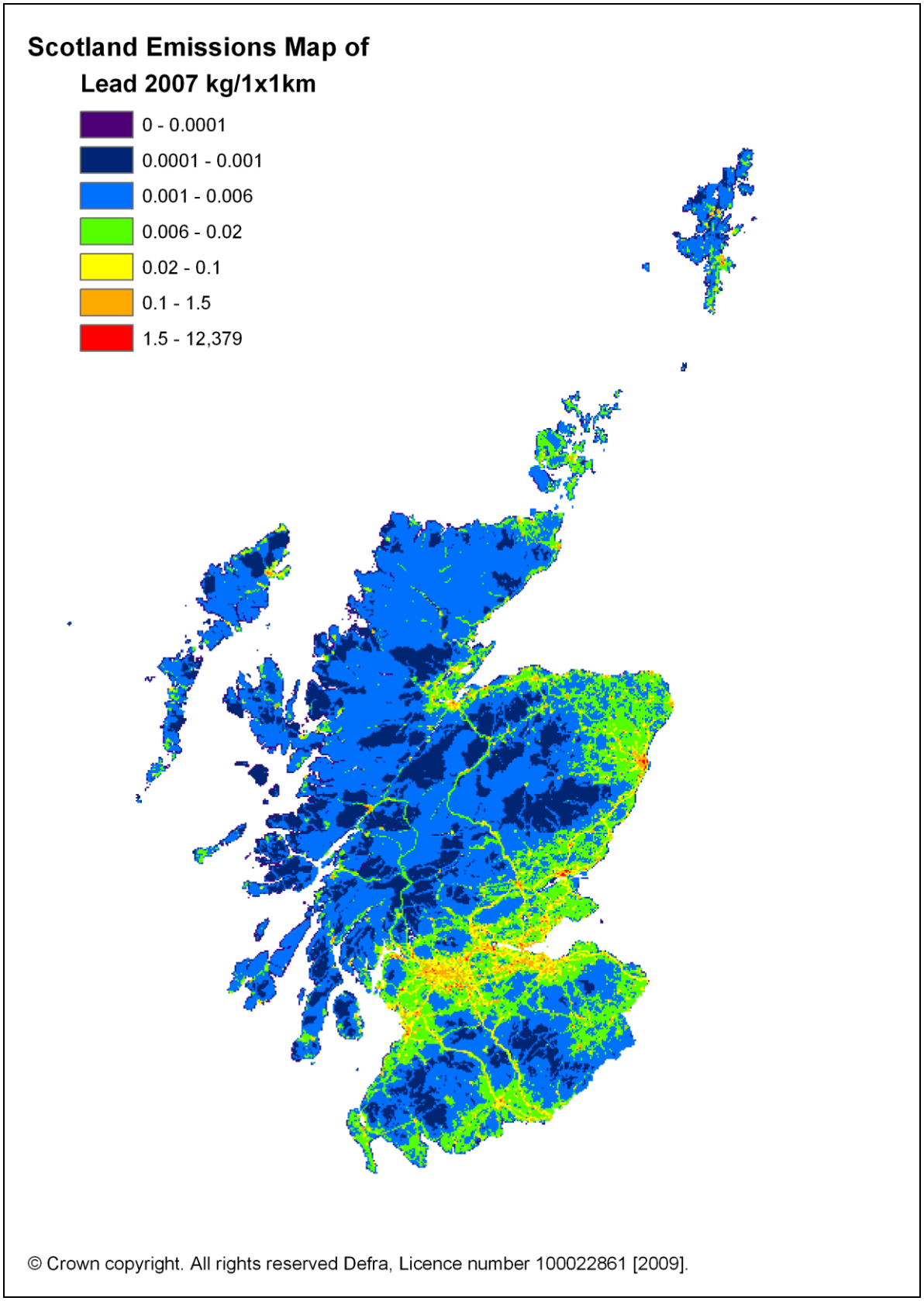
Figure 2-58 - Time series of Scotland Lead emissions 1990-2007



Scotland's lead emissions have declined by 99% since 1990 and accounted for 4% of the UK total in 2007. In Scotland, emission from domestic combustion is the most significant source, accounting for 23% of the Scotland total in 2007 (1A4bi: down 77% since 1990). 23% of lead emissions in Scotland come from energy industries (1A1: down 93% since 1990). Emissions from power generation (1A1a) accounted for 17% of the Scotland total emissions in 2007, but this is an increase in proportion of the

overall emission relative to 1990 when it was only responsible for 4.8% of overall emissions. This is due to the decreased emissions from transport sources (1A3: down 99.8% since 1990).

Figure 2-59 Map of Lead Emissions in Scotland, 2007



2.7.3 Wales Lead Inventory by NFR Sector, 1990-2007

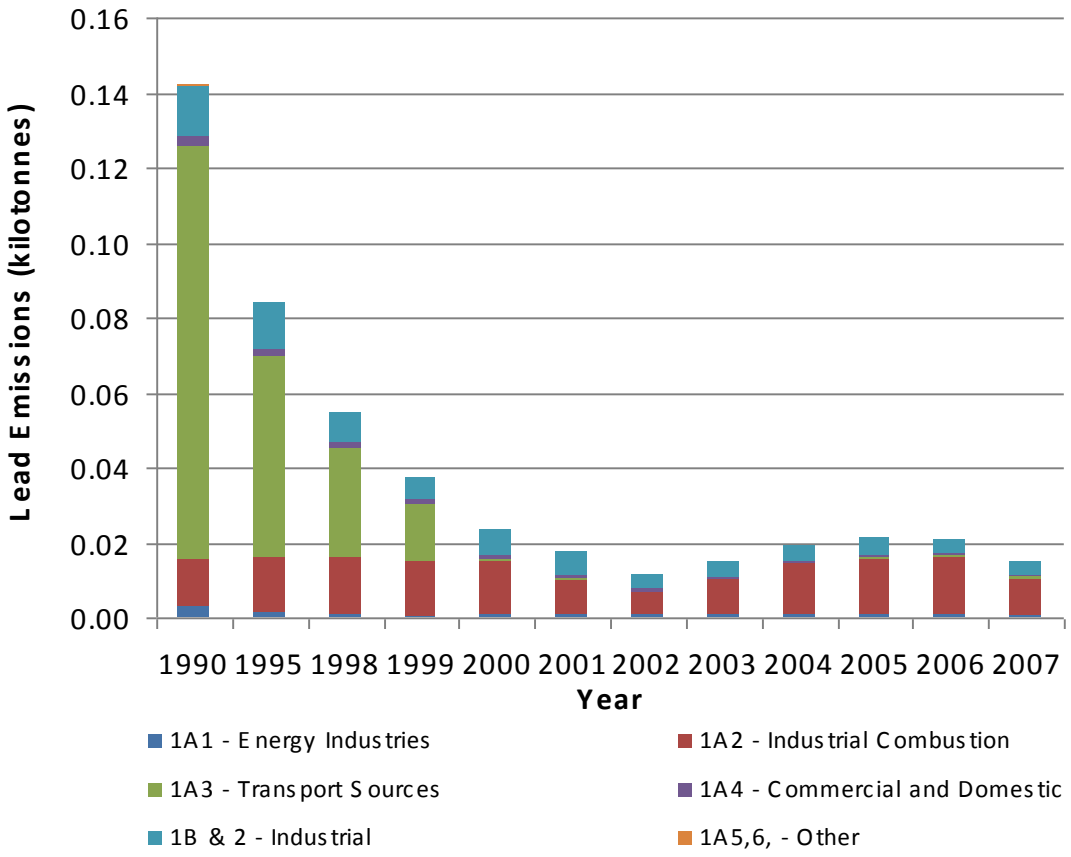
The table and graph below give a summary of the SO_2 emissions in Wales by broad NFR sector categories. The detailed data are available in Appendix I.

Table 2-34 - Wales emissions of Lead by NFR source sector (tonnes)

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	3.3	1.6	0.9	0.7	1.2	1.1	1.0	1.3	1.2	1.1	1.1	0.5	3%
1A2 - Industrial Combustion	12.1	14.4	15.0	14.2	14.0	8.9	5.8	9.0	13.3	14.6	15.2	10.1	66%
1A3 - Transport Sources	110	53.8	29.3	15.5	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	1%
1A4 - Commercial and Domestic	2.7	1.7	1.4	1.4	1.0	1.0	0.8	0.7	0.6	0.5	0.5	0.5	3%
1B & 2 - Industrial	13.2	12.7	7.8	5.5	6.8	6.5	3.9	3.8	4.2	4.9	3.8	4.0	26%
1A5,6, - Other	0.4	0.3	0.0	0.1	0.1	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0%
Total	142	84.4	54.6	37.3	23.3	17.8	11.5	14.9	19.5	21.3	20.8	15.3	100 %

Units: tonnes

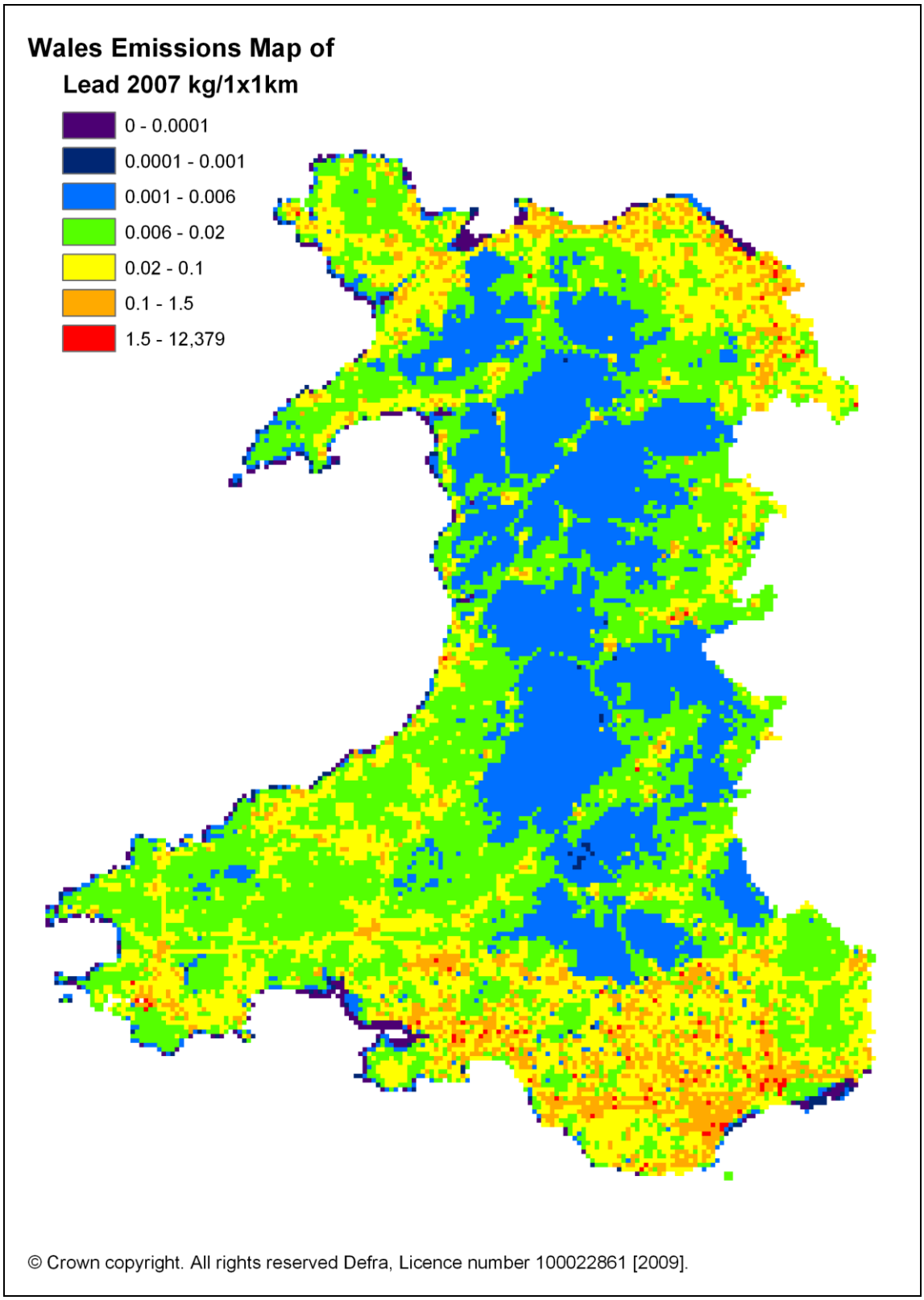
Figure 2-60 - Time series of Wales Lead emissions 1990-2007



Wales' lead emissions have declined by 89% since 1990 and accounted for 22% of the UK total in 2007. The emissions that arise due to the combustion in the iron and steel industries is by far the most significant source, accounting for 65% of the Wales total in 2007. 66% of lead emissions in Wales are from industrial combustion (1A2a: up 1.5% since 1990 and 1A2: down 17% since 1990), 26% from industrial processes and fugitive emissions from fuels (1A2 & 1B: down 70% since 1990), and 3% arise from energy industries (1A1: down by 85% since 1990) and transport sources (1A3:

down 99.8% since 1990). The proportion of emissions from the industrial combustion sector is explained by the above average concentration of heavy industry within the country. This is part of the reason the emission decline in Wales is lower than the England, Scotland, and Northern Ireland emission decline.

Figure 2-61 Map of Lead Emissions in Wales, 2007



2.7.4 Northern Ireland Lead Inventory by NFR Sector, 1990-2007

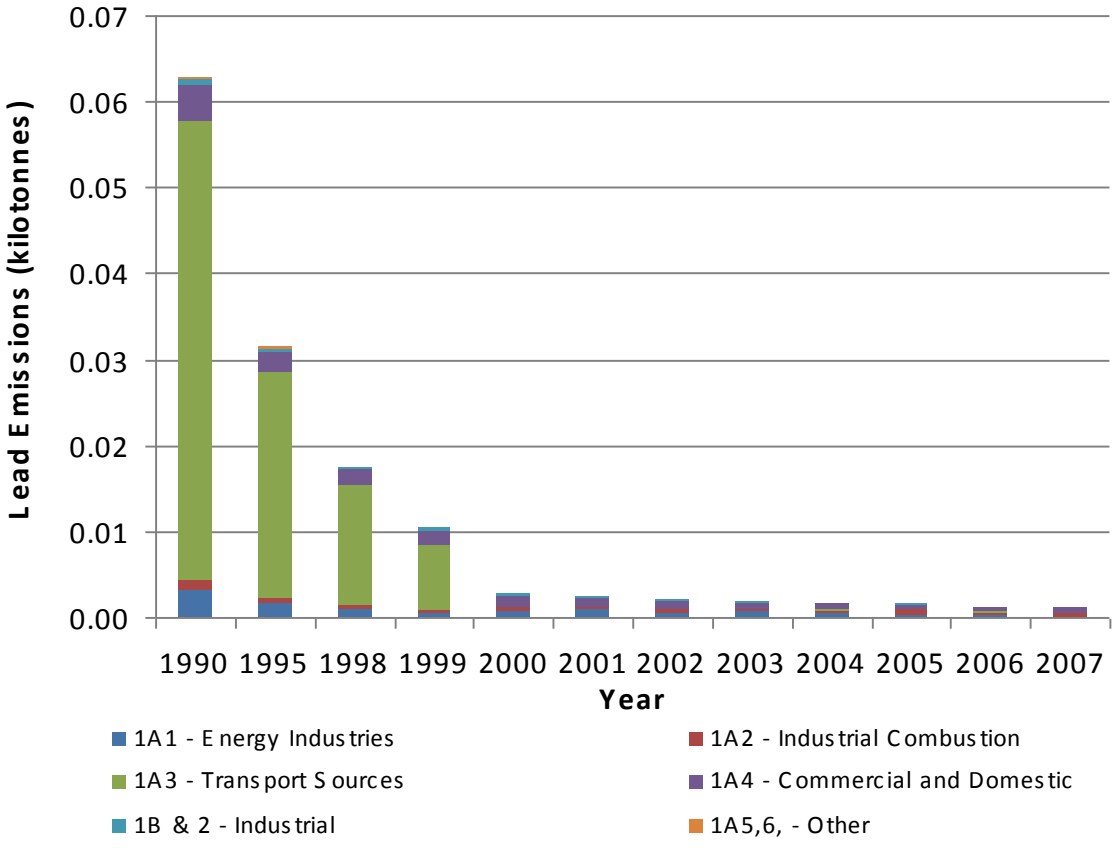
The table and graph below give a summary of the lead emissions in Northern Ireland by broad NFR sector categories. The detailed data are available in Appendix I.

Table 2-35 - Northern Ireland emissions of Lead by NFR source sector (tonnes)

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	3.2	1.5	0.8	0.5	0.6	0.9	0.6	0.6	0.5	0.3	0.3	0.1	5%
1A2 - Industrial Combustion	1.2	0.8	0.6	0.5	0.4	0.2	0.2	0.2	0.3	0.5	0.2	0.3	27%
1A3 - Transport Sources	53.3	26.2	14.0	7.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	9%
1A4 - Commercial and Domestic	4.2	2.2	1.8	1.6	1.3	1.1	1.0	0.8	0.6	0.5	0.5	0.6	50%
1B & 2 - Industrial	0.6	0.5	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	8%
1A5,6, - Other	0.2	0.2	0.02	0.03	0.03	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0%
Total	62.7	31.4	17.4	10.3	2.8	2.6	2.1	1.8	1.6	1.5	1.2	1.1	100%

Units: tonnes

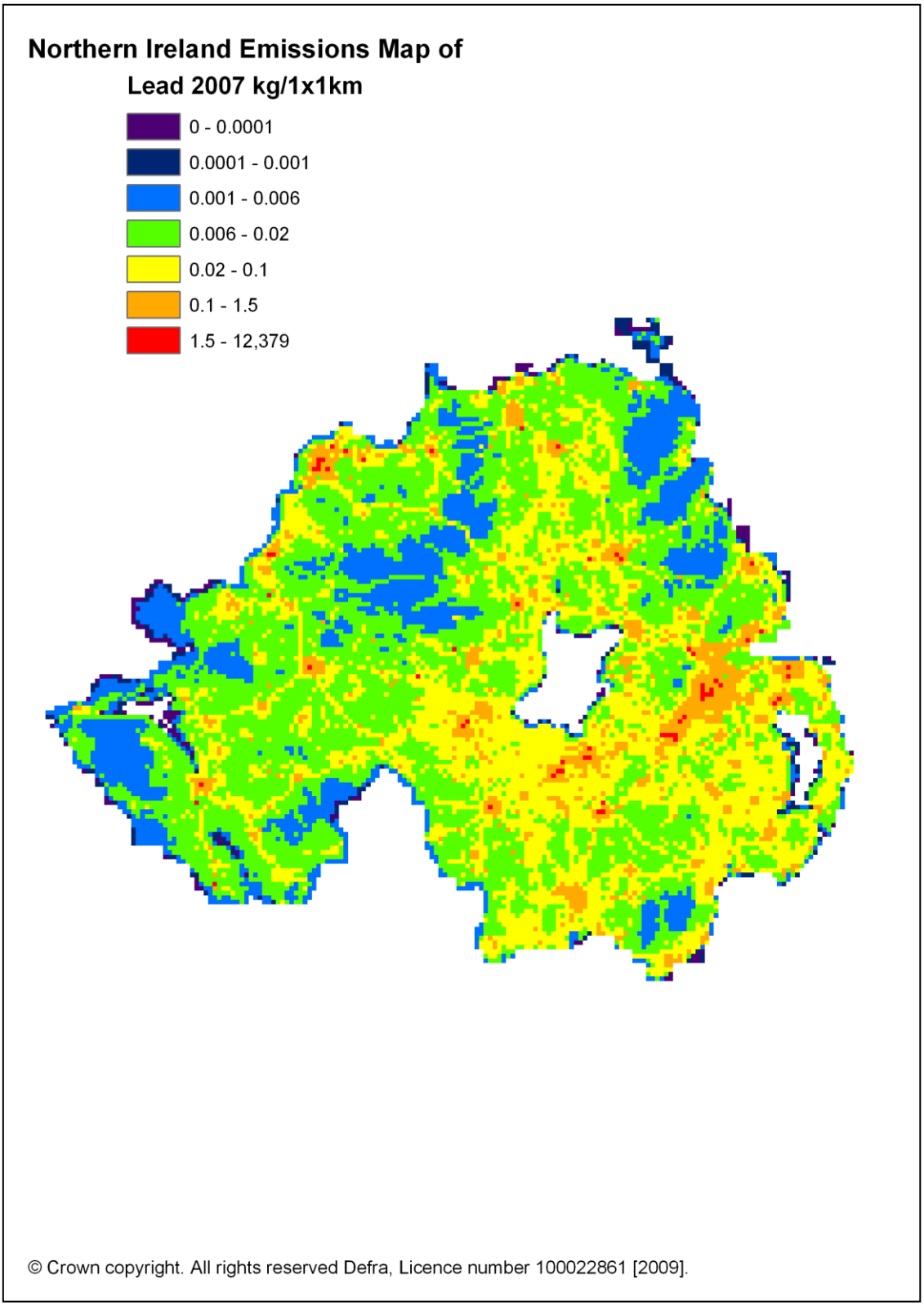
Figure 2-62 Time series of Northern Ireland Lead emissions 1990-2007



Northern Ireland's lead emissions have declined by 98% since 1990 and accounted for 2% of the UK total in 2007. In Northern Ireland, emissions that arise from domestic combustion is the most significant source, accounting for 41% of the Northern Ireland total in 2007 (1A4bi: down 86% since 1990). 27% of lead emissions in Northern Ireland come from industrial combustion (1A2: down 73%

since 1990), 9% from transport sources (1A3: down 99.8% since 1990), 8% from industrial processes and fugitive emissions from fuels (1A2 & 1B: down 84% since 1990), and 5% arise from energy industries (1A1: down by 98% since 1990).

Figure 2-63 Map of Lead Emissions in Northern Ireland, 2007



3 Uncertainties

As discussed in Section 1.2, the air quality pollutant inventories for England, Scotland, Wales and Northern Ireland are derived using a "top-down" approach whereby the UK inventory totals are disaggregated across the four countries. For most sources there is insufficient regional data to enable a comprehensive "bottom-up" calculation to be made, and hence available proxy data are used to estimate the country-specific share of UK activity for each emission source.

The calculated uncertainties of the UK inventories for AQ pollutants are shown in the table below:

Table 3.1 Uncertainty calculated for the UK Emission Inventories of AQ Pollutants

Pollutant	Estimated Uncertainty %
PM_{10}	- 20 to + 30
Carbon Monoxide	- 20 to + 30
Oxides of Nitrogen	+/- 10
Sulphur Dioxide	+/- 4
Non-Methane Volatile Organic Compounds	+/- 10
Ammonia	+/- 20
Lead	-30 to +50

(Source: *"UK Emissions of Air Pollutants 1970 to 2007"*, Murrells *et al*., 2009)

Further to these uncertainties in the UK datasets, there is an additional uncertainty inherent in the methodologies of disaggregating the UK emissions across the four countries. Further to this, there is greater uncertainty for emission estimates in the early years of the timeseries, as these estimates are frequently based on very limited historic data; in more recent years the development of environmental regulation and reporting has increased (e.g. through the development of annual reporting of emissions by operators of major industrial plant, now under IPPC).

The air quality pollutant inventories for England, Scotland, Wales and Northern Ireland are therefore subject to greater uncertainty than the equivalent UK estimates. The level of uncertainty is anticipated to reduce as further research is conducted and more data reporting at local and regional level is developed; one example of this is the ongoing DECC Regional Energy Statistics work programme, which includes annual research tasks targeted to improve local and regional energy data in specific source sectors.

The key characteristics of each inventory are discussed below, by pollutant, with an indicative "Uncertainty Rating" provided in each case.

3.1 AMMONIA

Ammonia emission estimates are more uncertain than SO_2, NO_X and NMVOC inventories due largely to the nature of the major agricultural sources. 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 that make the interpretation of experimental data difficult and emission estimates uncertain (DOE, 1994). Emission estimates for non-agricultural sources such as wild animals are also highly uncertain. Unlike the case of NO_X and NMVOC, a few sources dominate the inventory and there is limited potential for error compensation.

Uncertainty Rating: **HIGH**

3.2 CARBON MONOXIDE

In 2007, 88% of UK carbon monoxide emissions were derived from the combustion of fuels, with 37% of the UK total from road transport sources alone. Emission estimates for road transport are highly uncertain, as the available dataset of emission measurements is small and shows significant variability. Emissions from stationary combustion processes are also variable and depend on the technology employed and the specific combustion conditions. Emission estimates from small and medium-sized installations are derived from emission factors based on relatively few measurements of emissions from different types of boiler. As a result of the high uncertainty in major sources, emission estimates for CO are much more uncertain than other pollutants such as NO_X, CO_2 and SO_2 which are also emitted mainly from combustion processes. Unlike the case of NO_x and NMVOC, a few sources dominate the inventory and there is limited potential for error compensation.

Uncertainty Rating: **HIGH**

3.3 NITROGEN OXIDES

NO_X emission estimates are less accurate than SO_2 because they are calculated using measured emission factors, which can vary widely with combustion conditions. Hence, emission factors given in the literature for combustion sources show large variations. In the case of road transport emissions, while the inventory methodology takes into account variations in the amount of NO_X emitted as a function of speed and vehicle type, significant variations in measured emission factors have been found even when keeping these parameters constant.

From the above, one might expect the NO_X inventory to be very uncertain, however the overall uncertainty is in fact lower than any pollutant other than SO_2 for a number of reasons:

While NO_X emission factors may be somewhat uncertain, activity data used in the NO_X inventory is very much more certain. This contrasts with inventories for pollutants such as volatile organic compounds and PM_{10}, which contain a higher degree of uncertainty.

The NO_X inventory is made up of a large number of emission sources with many of similar size and with none dominating. This leads to a large potential for error compensation, where an underestimate in emissions in one sector is very likely to be compensated by an overestimate in emissions in another sector.

Many of the larger point-source emission sources make up the bulk of the regional estimates, and these are commonly derived from extrapolation of on-line measurement data and hence are regarded to be good quality.

Uncertainty Rating: **LOW**

3.4 NON-METHANE VOLATILE ORGANIC COMPOUNDS

The NMVOC inventory is more uncertain than SO_2 and NO_X inventories. This is due in part to the difficulty in obtaining good emission factors or emission estimates for some sectors (e.g. fugitive sources of NMVOC emissions from industrial processes, and natural sources) and partly due to the absence of good activity data for some sources. As with NO_X, there is a high potential for error compensation, and this is responsible for the relatively low level of uncertainty compared with most other pollutants in the NAEI.

Uncertainty Rating: **MODERATE**

3.5 PM_{10}

The UK emission inventory for PM_{10} has undergone considerable revision over recent years through specific research into key source sectors to improve the veracity of emission factors and improve the "bottom-up" activity data such as fuel use. Nonetheless, the uncertainties in the PM_{10} emission estimates must still be considered high, due to persisting uncertainties in some sectors regarding emission factors, activity data and particulate size distribution profiles.

Emission factors are generally based on a few measurements on an emitting source that is assumed to be representative of all similar sources. Emission estimates for PM_{10} are based whenever possible on source-specific measurements of PM_{10}, but frequently the available data is emission measurement of total particulate matter and hence conversion to PM_{10} is required based either on the size distribution of the sample collected or (more usually) on literature data on typical size distributions.

Many sources of particulate matter are diffuse or fugitive in nature, such as emissions from coke ovens, metal processing, raw material stockpiles, loading and unloading activities, construction or quarrying sites. These emissions are difficult to measure and are often dependent on conditions that vary over time and between localities such as meteorology and topography and hence are also difficult to model accurately. In many such cases it is likely that no satisfactory estimates or measurements have ever been made.

Emission estimates for combustion of fuels are generally considered more reliable than those for industrial processes, quarrying and construction. All parts of the inventory would need to be improved before the overall uncertainty could be reduced to the levels seen in the inventories for CO_2, SO_2, NO_X, or NMVOC.

***Uncertainty Rating*: HIGH**

3.6 SULPHUR DIOXIDE

Sulphur dioxide emissions can be estimated with most confidence as they depend largely on the level of sulphur in fuels. Hence the DA inventories, being based upon comprehensive analysis of coals and fuel oils consumed by power stations and the agriculture, industry and domestic sectors, contain accurate emission estimates for the most important sources.

***Uncertainty Rating:* LOW**

3.7 LEAD

The lead inventory is more uncertain than SO_2 and NO_X inventories, and the certainty of the emissions varies over the time-series as different source sectors dominate at different times due to the very significant reductions in emissions from the key sources in 1990, notably road transport. From the key sources in 1990, the lead emission estimates were based on measured concentrations of lead in the fuels, which were tightly regulated prior to being phased out in the late 1990s. This gives a high confidence in the estimates for those sources of fuel combustion, which dominated in the early 1990s but are now much reduced. In the more recent years, the level of emissions is estimated to be very much lower, and derived from a smaller number of sources. The metal processing industries are mainly regulated under IPPC and hence the estimates provided by plant operators are based on emission measurements or emission factors that have been researched for the specific process type, and hence are likely to be quite certain. The emissions from other smaller-scale combustion and process sources from industrial and commercial activities are less well documented and the estimates are based on emission factors that are less certain.

***Uncertainty Rating:* MODERATE**

4 References

APEG (1999), Source Apportionment of Airborne. Particulate Matter in the United Kingdom. Report of the Airborne Particles Expert Group. ISBN 0-7058-1771-7

Air Quality Expert Group (AQEG, 2005). Particulate Matter in the United Kingdom. http://www.defra.gov.uk/environment/airquality/aqeg/particulate-matter/index.htm

Alcan (2004, 2008), Personal Communication.

Agricultural Industries Confederation (2006). Fertiliser Statistics 2006 Report www.agindustries.org.uk

ATOC (2008), Fuel use by train operating companies, 2007, personal communication.

Bell, DM (2008), ISR and Power Station Fuel Consumption, Personal Communication, Northern Ireland Department of Environment.

British Cement Association (2008), Cement industry fuel use data and plant capacity data, Personal Communication, Richard Leese.

BGS (2008), United Kingdom Minerals Yearbook 1990-2007. British Geological Survey.

British Glass (2008), Production Statistics for UK Glass Industry, Personal Communication.

Bush *et al.* (2009) NAEI UK Emission Mapping Methodology 2007. AEA.

Centre of Ecology and Hydrology (2009). Regional emissions of air quality pollutants from biomass burning, including domestic peat combustion estimates, personal communication (Kirstie Dyson).

Choudrie SL, Jackson J, Watterson JD, Murrells T, Passant N, Thomson A, Cardenas L, Leech A, Thistlethwaite G (2009), UK Greenhouse Gas Inventory, 1990 to 2007. AEA Energy & Environment. ISBN 0-9554823-8-0.

Civil Aviation Authority (2008), database of UK flight information.

Coal Authority (2008), Regional Coal Production, Personal Communication.

Corus (2008). Site-specific breakdown of pollutant emissions by sub-source, for all UK integrated steelworks, personal communication (Peter Quinn).

DECC (2008a), “Digest of UK Energy Statistics” Department of Energy & Climate Change, HMSO.

DECC (2008b), Energy Trends December 2008, articles on DA electricity generation and consumption patterns and the regional energy statistics for 2003 to 2006. http://www.berr.gov.uk/files/file49202.pdf

DECC (2008c), Local gas use data by LDZ, personal communication.

DECC (2008d), Oil & Gas flaring and venting volume data by installation and gas landings information, personal communication (Clive Evans).

DECC Oil & Gas (2008), Environmental Database for annual Emissions and Discharges from Offshore Installations, from the EEMS reporting inventory.

DETR (1998a), Review of the United Kingdom National Air Quality Strategy - A Consultation Document. 98EP0541/A. The Stationary Office, Norwich.

DETR (2000), The Air Quality Strategy for England, Scotland, Wales and Northern Ireland- Working Together for Clean Air. The Stationary Office, Norwich.

Defra (2001), The Air Quality Strategy for England, Scotland, Wales and Northern Ireland - A Consultation Document on Proposals for Air Quality Objectives for Particles, Benzene, Carbon Monoxide and PAHs. HMSO.

Defra (2005), The Air Quality Strategy for England, Scotland, Wales and Northern Ireland: Addendum. HMSO.

Defra (2007), The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (Volume 1). HMSO.

DfT (2008), Road Freight Statistics 2007, Transport Statistics Bulletin SB(08) 21, August 2008.

DfT (2008a) Vehicle Licensing Statistics: 2007, Transport Statistics Bulletin SB(08)15, 2008.

DfT (2008b) “Transport Statistics Great Britain: 2008 edition”, The Stationary Office

DfT (2008c) “Road Statistics 2007: Traffic, Speeds and Congestion” Transport Statistics Bulletin (SB (08) 20), 2008

DfT (2008d) Transport Statistics Great Britain, Table 2.2. Air Transport Movements

DfT (2008e), English Regional Traffic Growth and Speed Forecasts, Rev 1.1 April 2008, personal communication with Malcolm Jay, ITEA Division, DfT, April 2008

DOE (1994), Impacts of Nitrogen Deposition on Terrestrial Ecosystems, Report of The UK Review Group on Impacts of Atmospheric Nitrogen. ISBN 1-870393-22-8.

DoE NI (2008a), spreadsheet of emissions to atmosphere from authorised processes in Northern Ireland, as reported to the Inventory of Statutory Releases (data for 2005-2007).

DoE NI (2008b), spreadsheet of EUETS operator data including fuel use, process details and emissions totals, personal communication.

DoRDNI (2007a) “Northern Ireland Transport Statistics 2006-2007”, Central Statistics and Research Branch, Department of Regional Development in Northern Ireland. (Available at http://www.drdni.gov.uk/index/statistics/stats-catagories/ni_transport_statistics.htm)

DoRDNI (2008b), “Traffic and Travel Information Report, 2007, Incorporating Annual Traffic Census and Vehicle Kilometres of Travel” Traffic Information and Control, Department for Regional Development, Northern Ireland, August 2008.

DoRDNI (2009), personal communication with Stephanie Harcourt, Central Statistics and Research Branch, Department for Regional Development Northern Ireland, June 2009.

Environment Agency (2008a), database of emissions to atmosphere from authorised processes in England & Wales, as reported to the Pollution Inventory (data for 1998-2007).

Environment Agency (2008b), database of EUETS operator data including fuel use, process details and emissions totals, personal communication.

EEA (2007), EMEP/CORINAIR Emission Inventory Guidebook – 2007. Technical report No 16/2007. Group 7 – Road Transport, European Environment Agency August 2007. http://www.eea.europa.eu/publications/EMEPCORINAIR5/B710vs6.0.pdf

EPAQS (1995), Expert Panel on Air Quality Standards – Particles. HMSO. London.

Firmus Energy (2008). Gas sales in Northern Ireland: domestic and non-domestic data. Personal Communication.

ISSB, (2009) Iron & Steel Industry Annual Statistics for the UK, including regional fuel use data. Personal Communication, Donna Leach.

Joanna Jackson, Yvonne Li, Neil Passant, Jenny Thomas, Glen Thistlethwaite, Kirstie Dyson & Laura Cardenas (2009), Greenhouse Gas Inventories, for England, Scotland, Wales and Northern Ireland: 1990 - 2007.

Murrells *et al.* (2009), UK Emissions of Air Pollutants 1970-2007. AEA, Harwell, Oxfordshire.

National Grid (2008), natural gas leakage from high pressure, low pressure distribution systems and from Above Ground Installations, personal communication.

NIDoE (2008). Inventory of Statutory Releases 2005-2007. Northern Ireland Department of Environment, Personal Communication from David Bell.

Northern Gas Networks (2008). Natural Gas leakage from LDZ and AGIs, personal communication

North Wyke Research (2008). Ammonia emissions from agricultural sources by region, personal communication (Tom Misselbrook).

ONS (2008), Datasets available pertaining to a wide range of industrial and population-related activities via the publications “Annual Abstract of Statistics” and “Regional Trends”, including regional GDP data, Office for National Statistics.

Phoenix Natural Gas (2007), Gas consumption detailed by end-user sectors for 2005 and gas leakage data, Personal Communication

Phoenix Natural Gas (2008), Gas consumption and gas leakage data for 2007, Personal Communication

QUARG (1996), Airborne Particulate Matter in the United Kingdom, Third report of the Quality of Urban Air Review Group. Department of the Environment. ISBN 0-9520771-3-2.

Scotia Gas Networks (2008) Natural Gas leakage from LDZ and AGIs, personal communication

SEPA (2008a), Annual atmospheric emissions data for authorised processes in Scotland, from SEPA’s Pollution Release Inventory, Personal Communication.

SEPA (2008b), spreadsheet of EUETS operator data including fuel use, process details and emissions totals, personal communication.

Transco / National Grid Transco (2008) Historic Gas Demands by Load Category, Personal Communication.

Translink (2008), Annual fuel consumption, Personal Communication.

UKPIA (2008), Pollutant emissions for UK refineries, from combustion and process sources. Personal Communication, Malcolm Watson, United Kingdom Petroleum Industry Association Ltd

Wales & West Utilities (2008) Natural Gas leakage from LDZ and AGIs, personal communication

www.wastedataflow.org, website providing regional waste disposal fate data, to inform regional estimates of landfill waste activities.

Watson M (2008), Personal communication regarding sulphur content of liquid fuels, UKPIA.

White Young Green (2005), Methane Emissions from Abandoned Coal Mines, research report: Defra.