National Atmospheric Emissions Inventory

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Air Quality Pollutant Inventories for England, Scotland, Wales and Northern Ireland: 1990-2014

A report of the National Atmospheric Emissions Inventory

September 2016

Aether

RICARDO

Ricardo Energy & Environment

Air Quality Pollutant Inventories for England, Scotland, Wales and Northern Ireland: 1990-2014

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A copy of this report and related data may be found on the Defra NAEI website: http://naei.defra.gov.uk/

Contents

Glossary

AQ	Air quality
AQPI	Air quality pollutant inventory
AQS for ESWNI	Air Quality Strategy for England, Scotland, Wales and Northern Ireland
NH_3	Ammonia
BAT	Best Available Techniques
BOFA	Boosted Over Fire Air
CO	Carbon monoxide
CCGT	Combined Cycle Gas Turbine
Defra	Department for Environment, Food & Rural Affairs
DECC	Department of Energy and Climate Change
DA	Devolved Administration
DERV	Diesel engine road vehicle
DUKES	Digest of UK Energy Statistics
DVLA	Driver and Vehicle Licensing Agency
EEA	European Environment Agency
EEMS	Environmental and Emissions Monitoring System
EMEP	European Monitoring and Evaluation Programme
EPR	Environmental Permitting Regulations
EU ETS	EU Emissions Trading System
EC	European Commission
EEA	European Environment Agency
EU	European Union
EPAQS	Expert Panel on Air Quality Standards
FGD	Flue-gas desulphurization
GHG	Greenhouse Gas
GDP	Gross Domestic Product
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
IED	Industrial Emissions Directive
IIR	Informative Inventory Report
IPPC	Integrated Pollution Prevention and Control
LCPD	Large Combustion Plant Directive
LDV	Light duty vehicles
Pb	Lead
LPG	Liquefied Petroleum Gas
LA	Local Authority
MSW	Municipal solid waste
NAQS	National Air Quality Strategy
NAEI	National Atmospheric Emissions Inventory
NECD	National Emissions Ceiling Direction
NO_X	Nitrogen oxides
NFR	Nomenclature for Reporting
NMVOC	Non-methane volatile organic compounds
PM_{10}	Particulate matter less than 10 micrometres
PCP	Pentachlorophenol
PI	Pollution Inventory
SED	Solvent Emissions Directive
SI	Statutory instrument

SO_2	Sulphur dioxide
UK	United Kingdom
UKPIA	United Kingdom Petroleum Industry Association
UNECE	United Nations Economic Commission for Europe
WID	Waste Incineration Directive
WHO	World Health Organization

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1. Introduction

This is the Air Quality Pollutant Inventory Report for England, Scotland, Wales and Northern Ireland. The report presents emission inventories for the Devolved Administrations of the UK for the period 1990 to 2014, 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)
- Particulate matter less than 10 micrometres (PM_{10})
- Sulphur dioxide (SO_2)
- Lead (Pb)

These inventories are compiled on behalf of the UK Department for Environment, Food & Rural Affairs (Defra), the Scottish Government, the Welsh Government and the Department of Agriculture, Environment and Rural Affairs for Northern Ireland, by the UK emission inventory teams at Ricardo Energy & Environment, Aether and Rothamsted Research.

1.1. Background to Inventory Development

The development of Air Quality pollutant inventories (AQPI) for each of the Devolved Administrations (DAs) has been commissioned by Defra in order to better inform 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, and may help to identify where policies could be pursued to achieve both Air Quality and Greenhouse Gas policy goals.

Further information on the background of the inventory development can be found in Appendix A.

1.2. About the Air Quality Pollutants

This report includes information on the seven pollutants in the Devolved Administrations' air quality pollutant inventory. Below is a brief description of the main aspects of each pollutant. Further information can be found on the NAEI website: http://naei.defra.gov.uk/overview/ap-overview, which includes an overview of the health impacts of these pollutants.

Ammonia (NH_3) emissions play an important role in a number of different environmental issues including acidification, eutrophication and changes in biodiversity. The atmospheric chemistry of NH_3 and ammonium (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. Agriculture is a significant source of NH_3 within the UK, with the vast majority of emissions arising from this sector. Non-agricultural sources of NH_3 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.

Carbon monoxide (CO) arises primarily from incomplete fuel-combustion and industrial processes, 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.

Nitrogen oxides (NO_X) 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 in air-fuel ratio (this is the extent by which oxygen in the air is in excess of the minimum amount required for complete combustion of the fuel), which can vary considerably. Thus combustion conditions, load and even state of maintenance are important. In regards to human health, studies suggest NO_X has an exacerbating effect on respiratory illnesses and cardiovascular disease; however, due to NO_X often being co-emitted with several other pollutants, the quantification of health impacts from NO_X alone is complex (COMEAP, 2015).

Non-Methane Volatile Organic Compounds (NMVOCs) are emitted to air from a large, diverse range of sources arising from across many industrial sectors, transport, agriculture and the domestic sector. They are emitted primarily as combustion by-products, as vapour arising from the transfer, storage and handling or use of petroleum distillates, or from the use of solvents or chemicals. The *Solvent and Other Product Use* sector comprises industrial and domestic solvent applications (such as cleaning, degreasing), as well as the manufacturing and processing of chemical products.

Particulate matter as PM_{10} is a measure of the size distribution of the particles emitted to air and represents the material with an aerodynamic diameter less than 10 micrometres. PM_{10} in the atmosphere arises from primary and secondary sources. Primary sources are direct emissions of particulate matter into the atmosphere and 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.

Particulate matter may be formed in the atmosphere through reactions of other pollutants such as SO_2, NO_X and NH_3 to form solid sulphates and nitrates, as well as organic aerosols formed from the oxidation of NMVOCs. These are known as secondary sources. 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) and on fine particulate matter ($PM_{2.5}$) in the United Kingdom (AQEG, 2012).

Sulphur dioxide (SO_2) emissions commonly arise from combustion, and can be calculated from the sulphur content of the fuel and from information on the amount of sulphur retained in the ash. Inventory estimates are produced using UK energy statistics, together with information on the sulphur content of liquid fuels (UKPIA, 2015) and data on sulphur content of coal from coal suppliers.

Lead (Pb) emissions, prior to 1999 arose primarily from the combustion of leaded petrol. The lead content of 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 catalysts. Leaded petrol was then phased out from general sale at the end of 1999. These changes have caused a significant decline in total Pb emissions across the UK between 1990 and 2000. The UK-wide emissions of Pb are now dominated by combustion sources (mainly of solid fuels, biomass and lubricants in industrial and domestic sectors), and from metal production processes at foundries and iron and steel works.

1.3. Data Sources and Inventory Methodology

The Devolved Administrations' inventories are compiled by disaggregating the UK emission totals presented within "UK Informative Inventory Report 1990 to 2014" (Wakeling, et al., 2016) derived from the National Atmospheric Emissions Inventory (NAEI) database. The emission estimates for each pollutant are presented in Nomenclature for Reporting (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. Emission estimates at the national level are made using direct emission measurements (e.g. for industrial point sources) or by combining activity data with a mixture of country-specific and default emission factors (EEA, 2013).

The method for disaggregating UK emission totals across the Devolved Administrations (DAs) draws on a combination of point source data (e.g. Pollution Inventory[1] data for industrial emissions) and sub-national and local datasets such as:

- BEIS (formerly DECC) sub-national statistics on energy use;

[1] The term "Pollution Inventory" is used here to represent the industrial emissions databases of the UK environmental regulators: the Environment Agency, the Scottish Environment Protection Agency, Natural Resources Wales and the Northern Ireland Environment Agency, which comprise annual emission estimates from all EPR/IED-regulated processes under their authority.

- Other regional energy use data for specific industries or regional data on raw material consumption or sector-specific production;
- Major road traffic count data;
- Domestic and international flight data for all major UK airports;
- Regional housing, employment, population and consumption data;
- Agricultural surveys (livestock numbers, crop production, fertiliser application);
- Land use survey data.

Further information on the data sources and inventory methodology can be found in Appendix B.

1.4. Uncertainties

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 UK AQ inventory is subject to uncertainty assessments using both the Tier 1 uncertainty aggregation method and a Tier 2 method using a statistical Monte-Carlo technique. The Tier 1 methodology investigates the impact of the assumed uncertainty of individual parameters (such as emission factors and activity statistics) upon the uncertainty in the total emission of each pollutant. Results from both the Tier 1 methodology and the Monte-Carlo analysis are presented in Chapter 1.7 of the "UK Informative Inventory Report 1990 to 2014" (Wakeling, et al., 2016). Table 1 below provides an indication of the relative magnitude in uncertainty estimates made for each pollutant at UK level. A 'low' rating implies a lower level of uncertainty in the emission estimates for the pollutant relative to the uncertainty in the estimates for a pollutant with a 'high' rating. Further information on the uncertainties for each pollutant can be found in Appendix D.

Uncertainties in the UK inventory are associated with the availability and quality of the activity data, emission factors and methodologies used in emissions calculations throughout the time series. As well as the uncertainties in the UK inventory, there is an additional uncertainty inherent in the methodologies of disaggregating the UK emissions across the four countries. The air quality pollutant inventories for England, Scotland, Wales and Northern Ireland are therefore subject to greater uncertainty than the equivalent UK estimates. The uncertainties in emission estimates may differ for each DA according to the relative mix of emissions from different sources with different levels of uncertainties. These have not been quantified, but the overall uncertainty ranking of each pollutant at DA level is not likely to be significantly different to the ranking at UK level given in Table 1.

In general, the UK AQ inventory is regarded as an international leader in terms of quality and accuracy, e.g. through the application of higher Tier (more comprehensive) methodologies, particularly for key sources, and a continuous improvement process.

Table 1 – Indicative uncertainty rating for each pollutant present in the UK AQPI

(low refers to the uncertainty of a particular pollutant being relatively low when comparing to the other pollutants and vice versa)

Pollutant	Indicative Uncertainty Rating
Ammonia	Moderate
Carbon monoxide	Moderate
Nitrogen oxides	Low
Non-methane volatile organic compounds	Low
Particulate matter (<10um)	High
Sulphur dioxide	Low
Lead	High

2. Devolved Administrations' Air Quality Pollutant Estimates

The following sections outline the findings of the inventory for each Devolved Administration, providing information on the trends and emission estimates for each of the seven air quality pollutants.

These sections include the following:

Figures graphically presenting the inventory data, showing the annual trend from 1990 to 2014 for each pollutant. These graphs are also disaggregated by sector, and further information on these sectors can be found in Appendix F.

Summary information on trends is provided for each pollutant, highlighting the key reasons for the observed trend since 1990 and other significant aspects of the trend. This information is not guided by detailed statistical analysis, but through association of underlying trends in activity data with the visible emissions trends.

Normalised trends for all pollutants are graphically presented to enable pollutant comparison. This normalised graph provides information on the relative rate at which all pollutants have declined across the time series, with 1990 emissions as the base value (equal to 1).

Mapped emissions for all pollutants are also provided to show the geographical disaggregation of each pollutant. This helps the reader to identify the more significant areas for emissions and the patterns associated with that pollutant. For example, NO_X emissions are concentrated around the road networks of the countries.

Sector contribution matrix provides an overview of the importance of each sector for each pollutant. For example, the transport sector accounts for a considerable proportion of CO, NO_X and PM_{10} emissions in some regions. This is another way in which the pollutants can be compared.

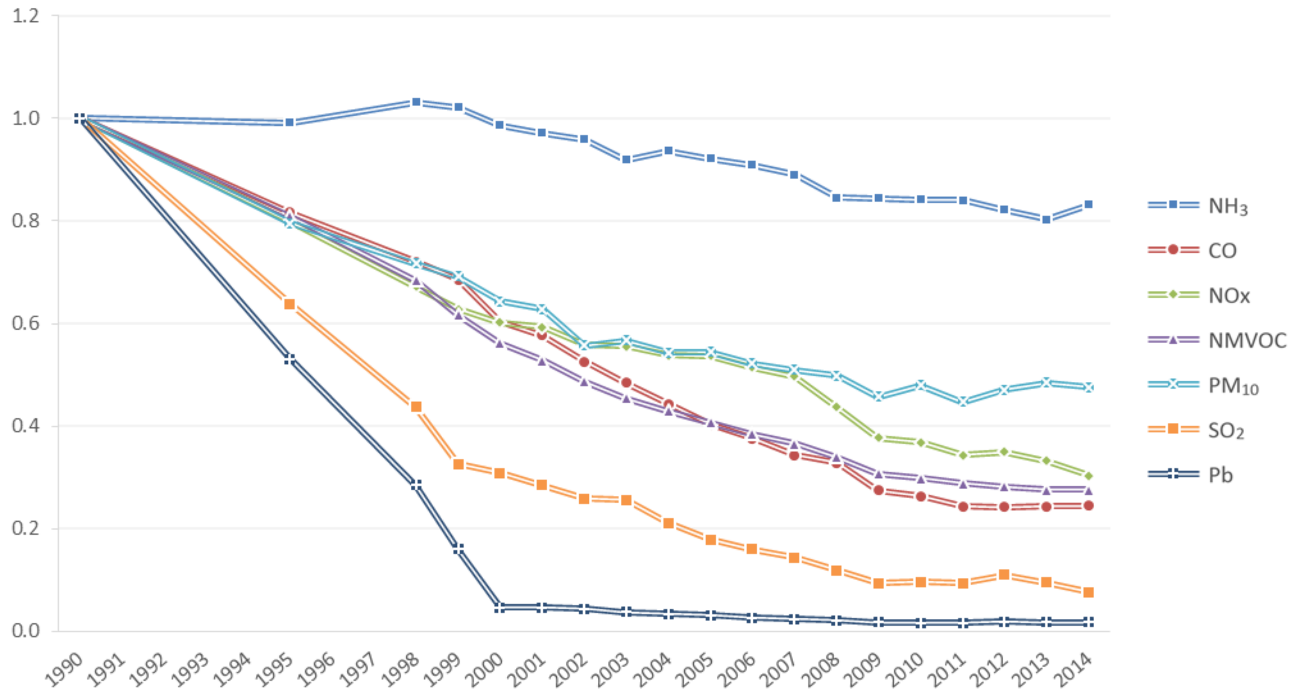
2.1. England

The following section provides a summary of emissions in England for the seven air quality pollutants: ammonia (NH_3), carbon monoxide (CO), nitrogen oxides (NO_X as NO_2), non-methane volatile organic compounds (NMVOCs), particulate matter smaller than 10 micrometres (PM_{10}), sulphur dioxide (SO_2) and lead (Pb).

Figure 1 shows emissions of all seven air quality pollutants normalised to provide the relative rate of decline since 1990. This graph shows that all pollutant emission levels are lower in 2014 than they were in 1990. The rate at which they have declined is similar for PM_{10}, NO_X, NMVOC and CO. However, Pb shows a much higher rate of reduction from 1990 to 2000 which is coincident with the phase-out of leaded petrol.

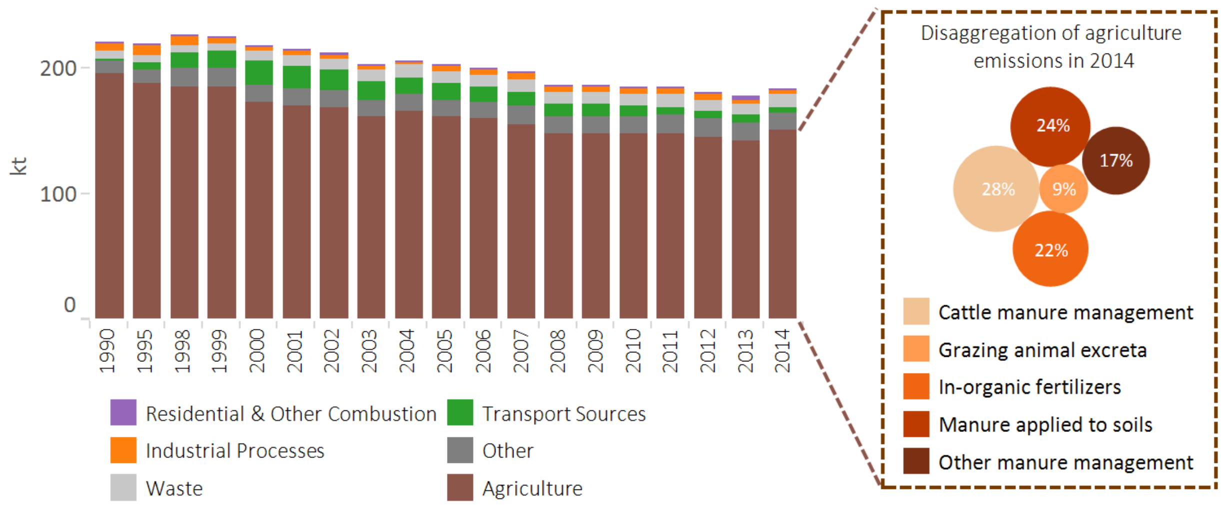
By contrast, NH_3 emissions have declined at a slower rate than other pollutants, and have even slightly risen in recent years due to increases in emissions from fertiliser application, livestock manure management and application to soils, and composting. SO_2 emissions declined rapidly between 1990 and 1999 due to reductions in the sulphur content of fuels and a shift in electricity production to use more natural gas and less coal and fuel oil. Emissions of NO_X have declined notably since 2007 primarily due to reductions in road transport emissions and the power generation sector.

Figure 1 – England normalised trends for all pollutants



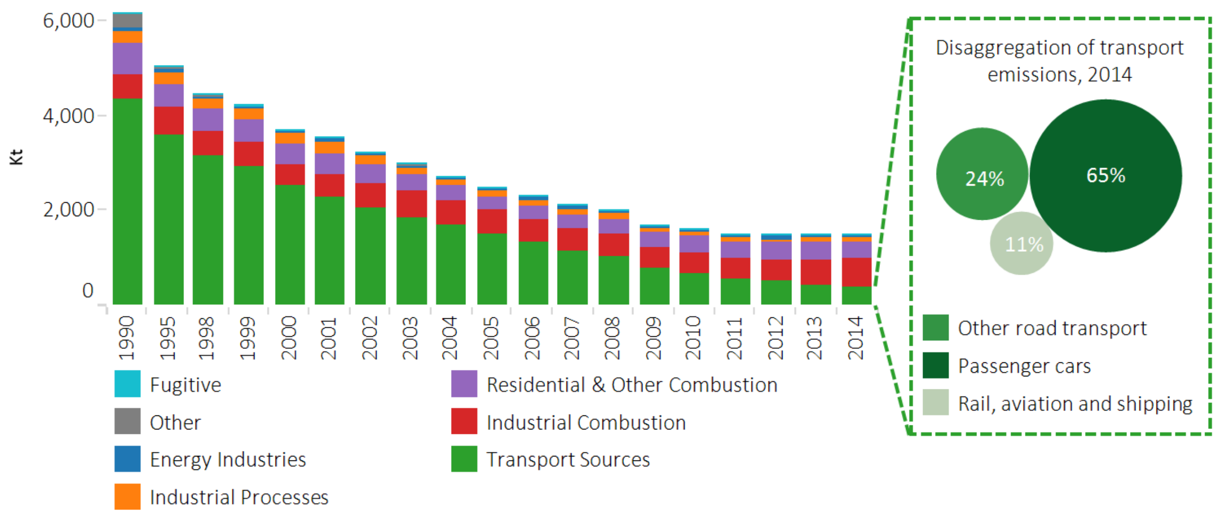
The following sections provide an overview of emissions from each of the seven pollutants giving explanations for the trends and characteristics of the graphs. Data summary tables for these emission estimates can be found in Appendix E. Mapping of the categories used in the graphs can be found in Appendix F.

Figure 2 – Ammonia Emissions in England



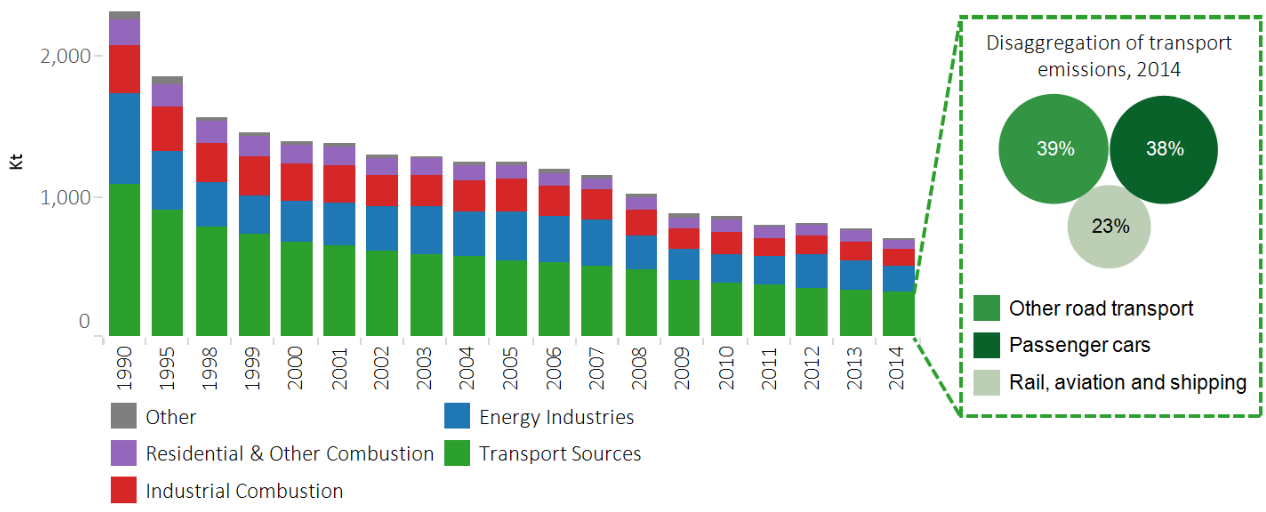
Emissions of **ammonia** were estimated to be 184kt in 2014 and have declined by 17% since 1990. Emissions in England account for 65% of the UK total in 2014. Agricultural sources make up by far the largest component in the inventory throughout the time series, with cattle manure management accounting for 28% of the emissions from this sector. The trend in NH_3 emissions has been largely driven by decreasing cattle numbers and a decline in fertiliser use, which have tended to decrease emissions across the time series. However, an increased usage of urea-based fertilisers, which are associated with higher NH_3 emission factors, has had the opposite effect in recent years. The result is a plateauing of emissions since 2008, with an observed increase between 2013 and 2014.

Figure 3 – Carbon Monoxide Emissions in England



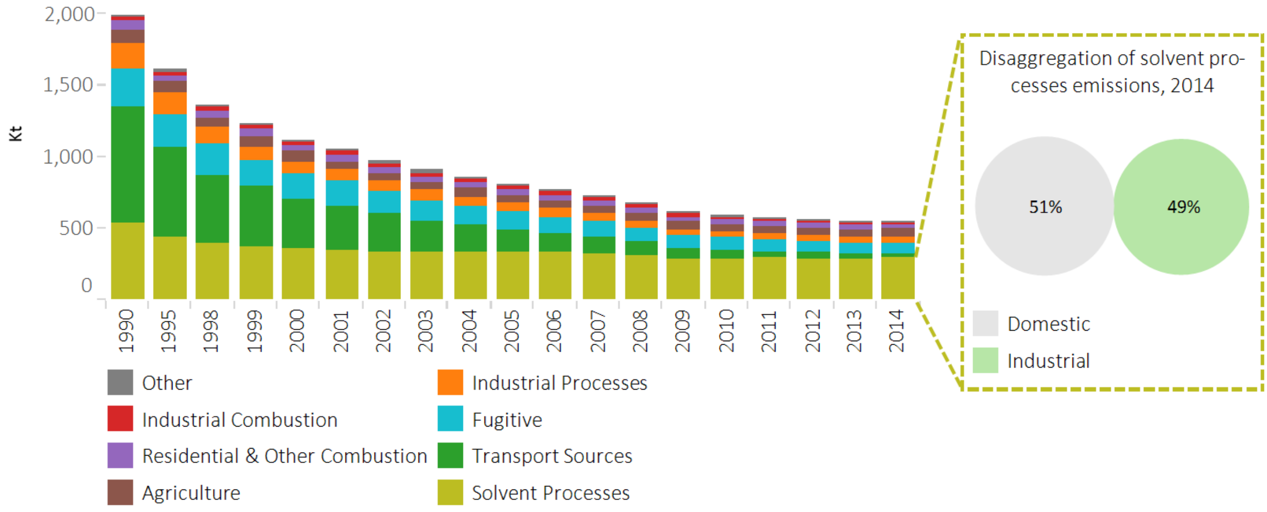
Emissions of **carbon monoxide** were estimated to be 1,515kt in 2014 and have declined by 75% since 1990. Emissions in England account for 73% of the UK total in 2014. This decline in emissions stems from changes in the transport sector, particularly in road transport. The decline is driven by the introduction of Euro standards after 1992 which requires fitting of emission control (e.g. three-ways catalyst) in new petrol vehicles and in more recent years the switch from petrol cars to diesel cars. Since 2008, emissions from passenger cars have further decreased, which is mainly driven by the assumption on improvements in catalyst repair rates made in the NAEI to take into account of the introduction of Regulations Controlling Sale and Installation of Replacement Catalytic Converters and Particle Filters for Light Vehicles for Euro 3 (or above) light duty vehicles. In recent years, emissions from the residential and other combustion sector have increased, which corresponds with an increasing use of wood fuel, predominantly in the domestic sector (Waters, 2015).

Figure 4 – Nitrogen Oxides Emissions in England



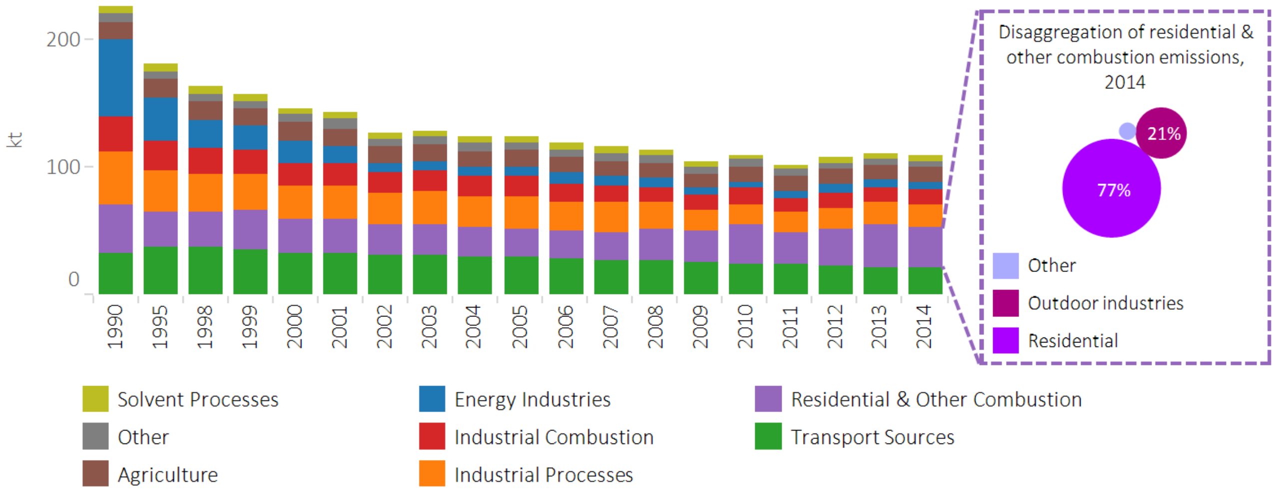
Emissions of **nitrogen oxides** were estimated to be 708kt in 2014, representing 75% of the UK total in 2014. Emissions have declined by 70% since 1990, mainly due to changes in the transport sector, particularly in road transport. This decline is driven by the successive introduction of tighter emission standards for petrol cars and all types of new diesel vehicles over the last decade. Since 2008, emissions from passenger cars have further decreased, which is mainly driven by the assumption on improvements in catalyst repair rates made in the NAEI to take into account of the introduction of Regulations Controlling Sale and Installation of Replacement Catalytic Converters and Particle Filters for Light Vehicles for Euro 3 (or above) light duty vehicles. However, the increasing number of diesel cars offsets these emissions reductions, because diesel cars emit higher NO_x relative to their petrol counterparts. Emission reductions across the time series from the Energy sector are primarily due to shifts in the electricity generation fuel mix in the early 1990s from coal to natural gas (DECC, 2015d) along with the installation of NO_x abatement at coal-fired power stations. Since 2008, the installation of Boosted Over Fire Air (BOFA) systems across coal power stations to reduce NO_x formation has led to a further decline in emissions.

Figure 5 – NMVOC Emissions in England



Emissions of **non-methane volatile organic compounds** were estimated to be 550kt in 2014, representing 67% of the UK total. Emissions have declined by 72% since 1990. Emissions from the chemical industry reduced during the 1990s), but across the time series the trend is dominated by reductions in emissions from road transport sources, including evaporative losses of fuel vapour from petrol vehicles. The decline is driven by emission control technologies introduced in new petrol vehicles since the early 1990s and in more recent years the switch from petrol cars to diesel cars. The reduction in emissions also occurs to a lesser extent due to the introduction of petrol vapour recovery systems at filling stations. With this large reduction in transport emissions, solvent processes are now the most significant source of NMVOC emissions, with emissions in 2014 arising from both domestic and industrial solvent applications.

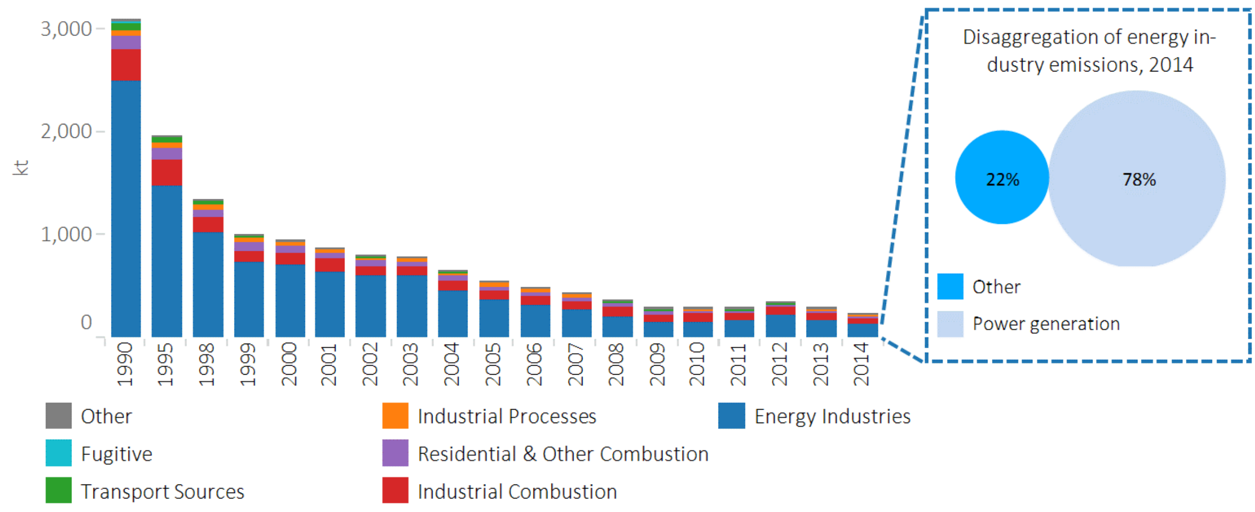
Figure 6 – PM_{10} Emissions in England[2]



Emissions of **PM_{10}** were estimated to be 108kt in 2014 and have declined by 52% since 1990. They account for 73% of the UK total in 2014. Unlike most other pollutants, PM_{10} emissions have a large number of significant sources. Transport, residential combustion, agriculture and industrial processes each accounted for over 10% of total emissions in 2014. Emissions from energy industries have had the most significant impact on the trend. The reduction in these emissions is primarily due to the reduction in coal-fired energy generation in place of natural gas, which has negligible PM_{10} emissions (DECC, 2015d). PM_{10} exhaust emissions from diesel fuelled vehicles have been decreasing due to the successive introduction of tighter emission standards over time. Since 2007, emissions from the residential and other combustion sector have increased, which is coincident with an increasing use of wood fuel, predominantly in the domestic sector (Waters, 2015).

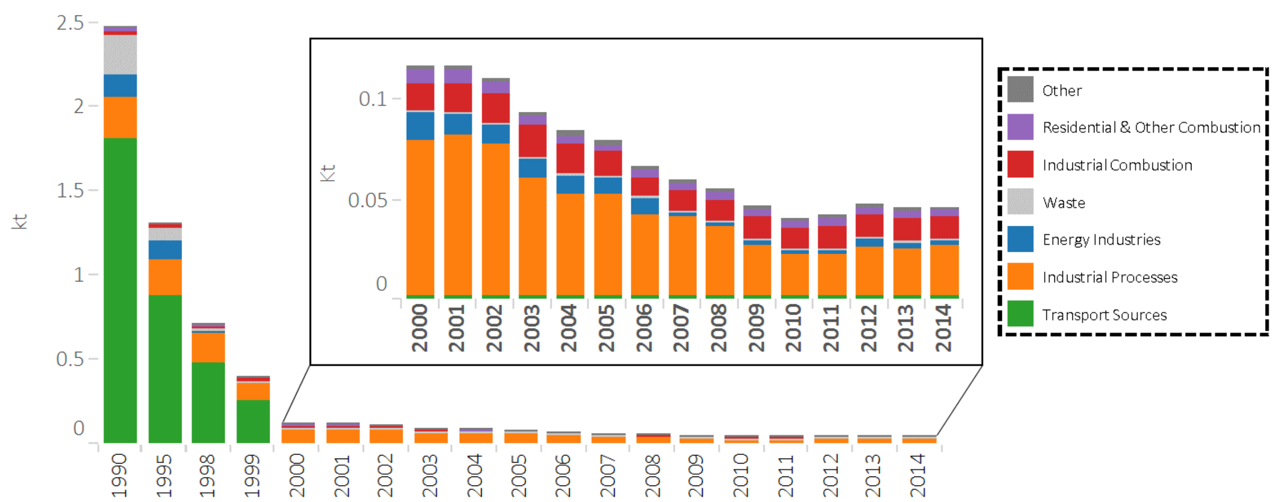
[2] 'Outdoor industries' presented in the bubble graph relate to combustion emissions from machinery in the agriculture, forestry and fishing industries.

Figure 7 – Sulphur Dioxide Emissions in England



Emissions of **sulphur dioxide** were estimated to be 237kt in 2014, representing 77% of the UK total in 2014. Emissions have declined by 92% since 1990, which has been dominated by the reduction in energy industries emissions, coincident with significant changes in the power generation section. These include the reduction in coal fired power generation since 1990; improved emission controls on large coal fired plant; co-firing of biomass in coal fired power stations; the introduction of CCGT (Combined Cycle Gas Turbine) plant, which are more efficient than conventional coal and oil stations and have negligible SO_2 emissions; and, since 2007, the rapid expansion of wind power which has no direct emissions (DECC, 2015d). The increase in emissions in 2012 was due to an increase in the use of coal in power generation relative to previous years (DECC, 2015d). Transport emissions have declined, coincident with the reduced sulphur content of road fuels, both petrol and diesel. Emissions from the industrial combustion sector, declined significantly during the 1990s, mainly due to a reduction in coal and fuel oil use in the chemicals sector and unclassified industry.

Figure 8 – Lead Emissions in England



Emissions of **lead** were estimated to be 46 tonnes in 2014, representing 70% of the UK total in 2014. Emissions have declined by 98% since 1990 almost entirely due to changes in the transport sector. Petrol with lead additives was phased out from general sale by the end of 1999, which is the reason underlying a 99.9% decrease in transport emissions between 1990 and 2000. Also during the 1990s, emissions from the waste sector declined as older waste incinerators were phased out. Since 2000, the most significant sources of emissions are linked to industry (industrial processes and industrial combustion) with the predominant subsector being the production of iron and steel.

Table 2 below provides a summary of the percentage contribution of each sector for each pollutant in 2014. Using the ranking of these percentage contributions, the sectors have been ordered to provide its indicative significance across all pollutants. As such, the table below indicates that the transport category is the most significant when considering emissions from all pollutants. This sector accounts for over 15% of emissions for three pollutants: CO, NO_x and PM_{10}. Fuel combustion is a major source of emissions, whilst Industrial Processes are also significant, especially for emissions of Pb from the iron and steel industry. This table also highlights that although emissions from the agriculture sector are not significant when considering all pollutants, it is of very high significance when considering emissions of NH_3; the same is true for NMVOC emissions from solvent processes.

Table 2 – Source Emission Contributions Ranked by Sector, England 2014

Overall Rank	Sector	NH_3	CO	NO_x	NMVOC	PM_{10}	SO_2	Pb
1	Transport Sources	2.5%	27.0%	45.1%	6.0%	18.7%	2.8%	3.7%
2	Residential & Other Combustion	1.1%	25.0%	9.1%	5.6%	30.8%	13.6%	8.2%
2	Industrial Combustion	0.0%	37.5%	17.6%	3.0%	10.8%	26.3%	23.2%
4	Industrial Processes	1.5%	4.7%	0.0%	7.0%	15.8%	3.0%	55.7%
5	Energy Industries	0.0%	4.0%	25.8%	0.0%	5.6%	50.2%	5.4%
6	Agriculture	81.7%	0.0%	0.0%	11.0%	10.4%	0.0%	0.0%
7	Other	7.9%	1.5%	2.3%	1.7%	4.7%	0.3%	3.5%
8	Fugitive	0.0%	0.3%	0.0%	13.1%	0.0%	3.9%	0.0%
9	Solvent Processes	0.0%	0.0%	0.0%	52.6%	3.4%	0.0%	0.0%
10	Waste	5.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%

* The sector: "other" will include all "other" categories in the inventory and also a number of categories that are insignificant for a specific pollutant.

Emission maps for all seven pollutants are shown below.

Figure 9 – Ammonia Emissions in England, 2014

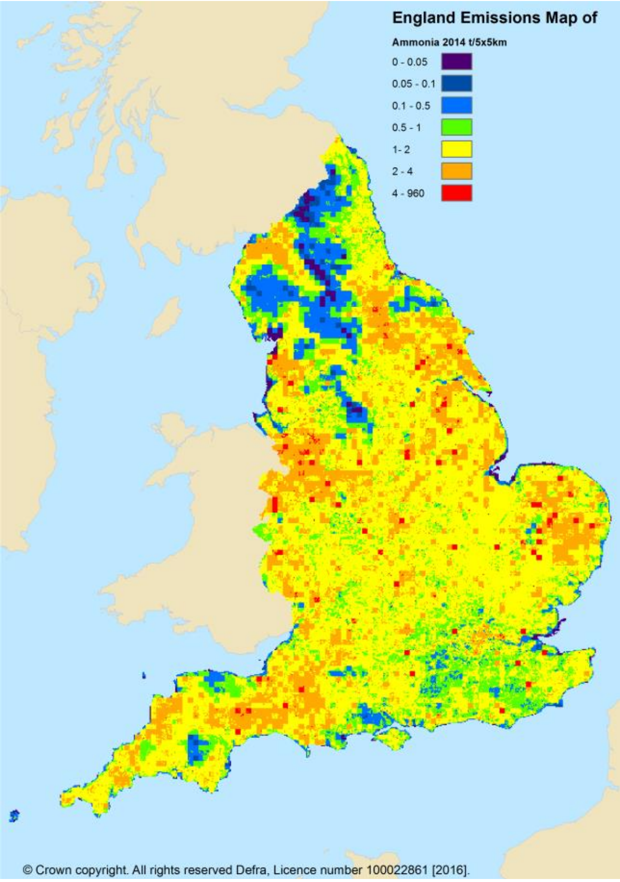


Figure 10 – Carbon Monoxide Emissions in England, 2014

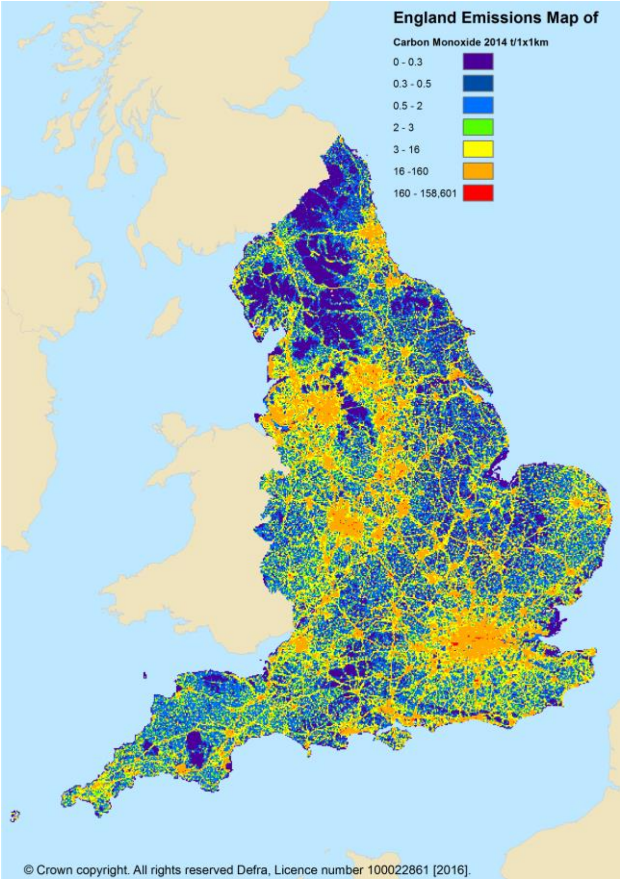


Figure 11 – Nitrogen Oxides Emissions in England, 2014

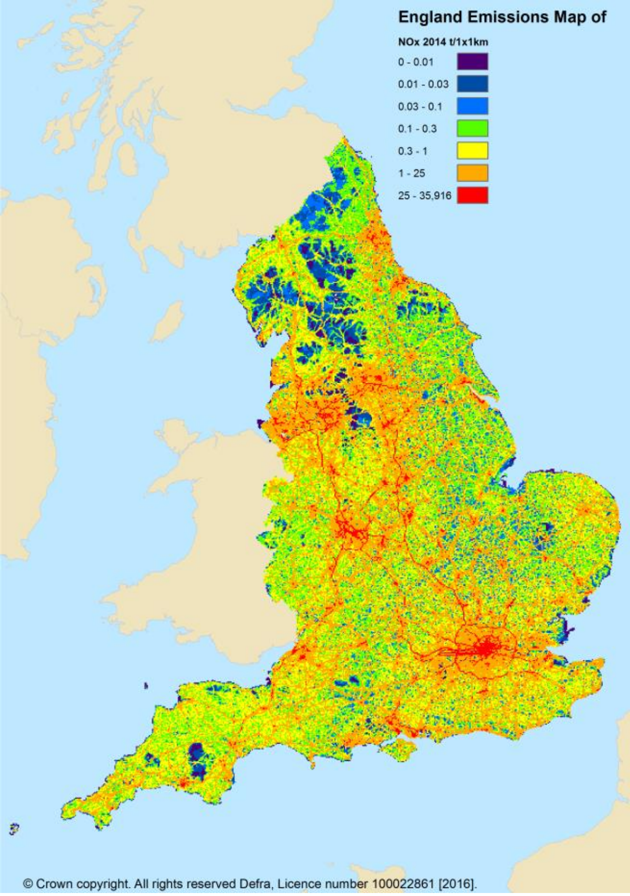


Figure 12 – NMVOC Emissions in England, 2014

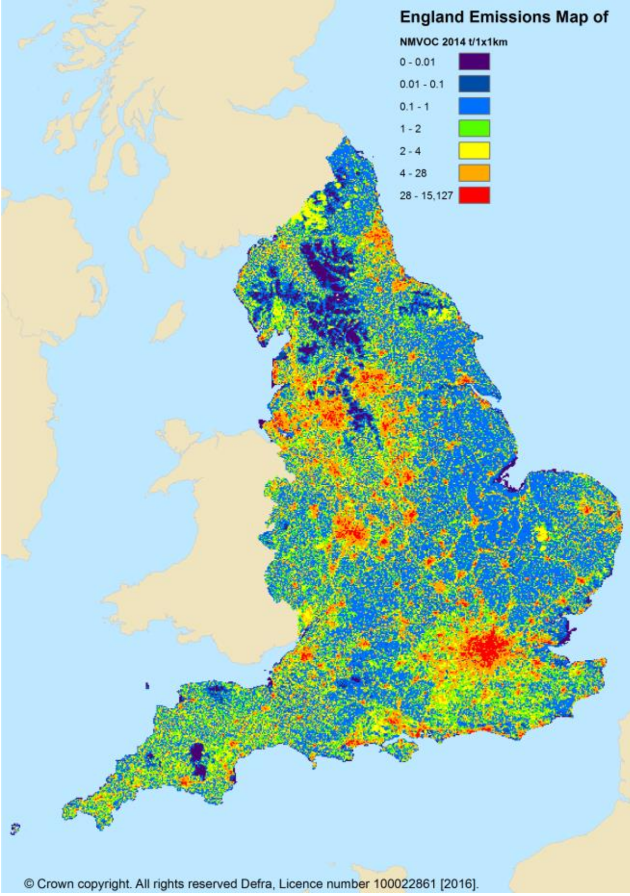


Figure 13 – PM_{10} Emissions in England, 2014

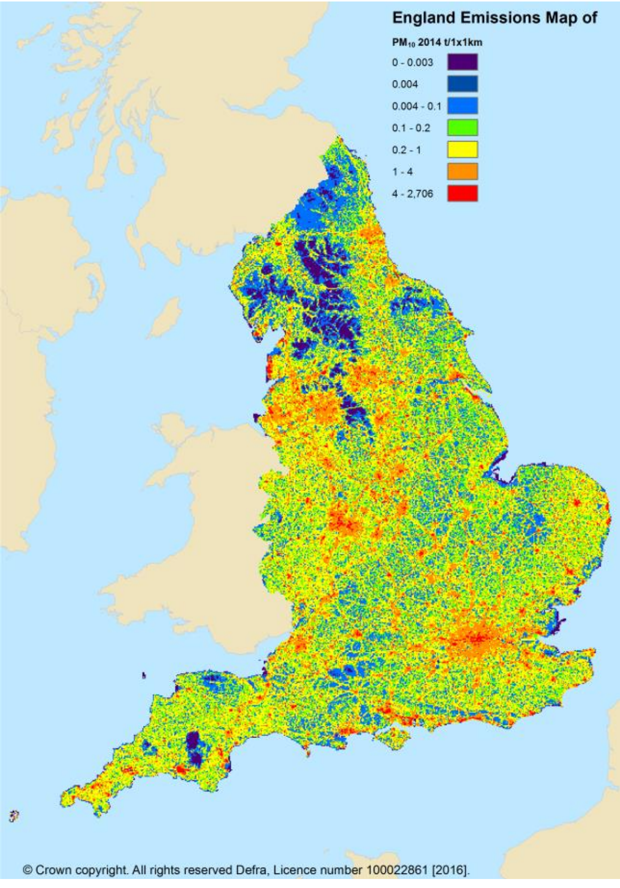


Figure 14 – Sulphur Dioxide Emissions in England, 2014

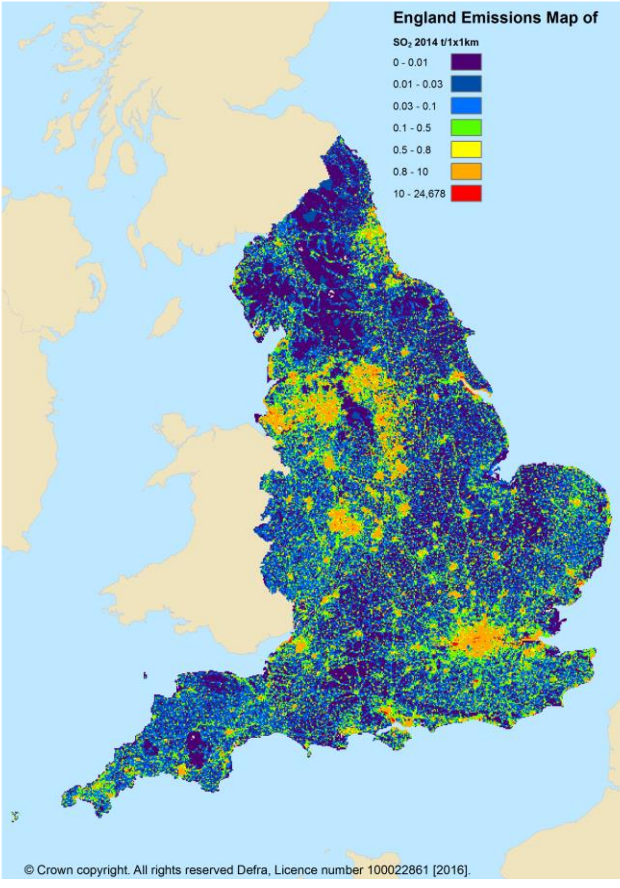
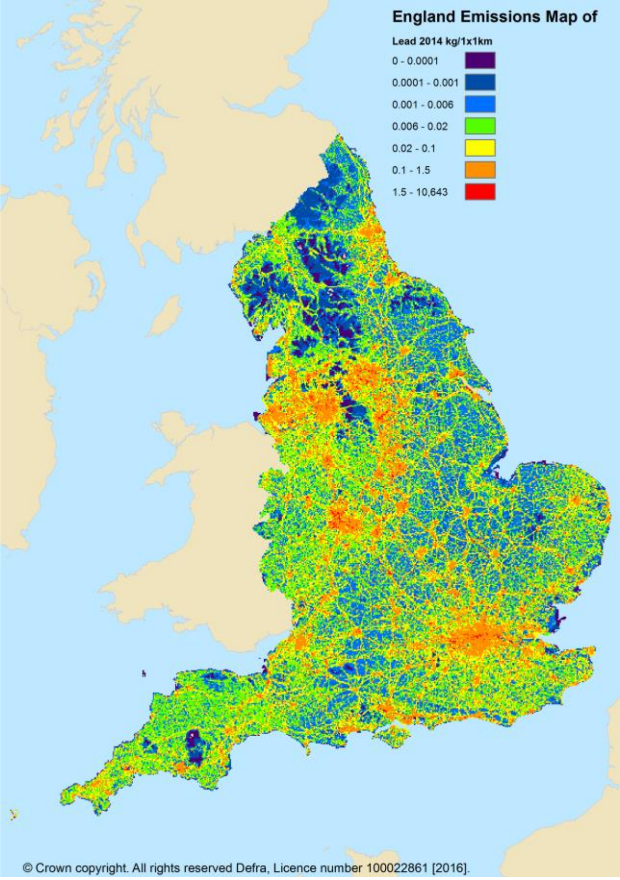


Figure 15 – Lead Emissions in England, 2014



2.2. Scotland

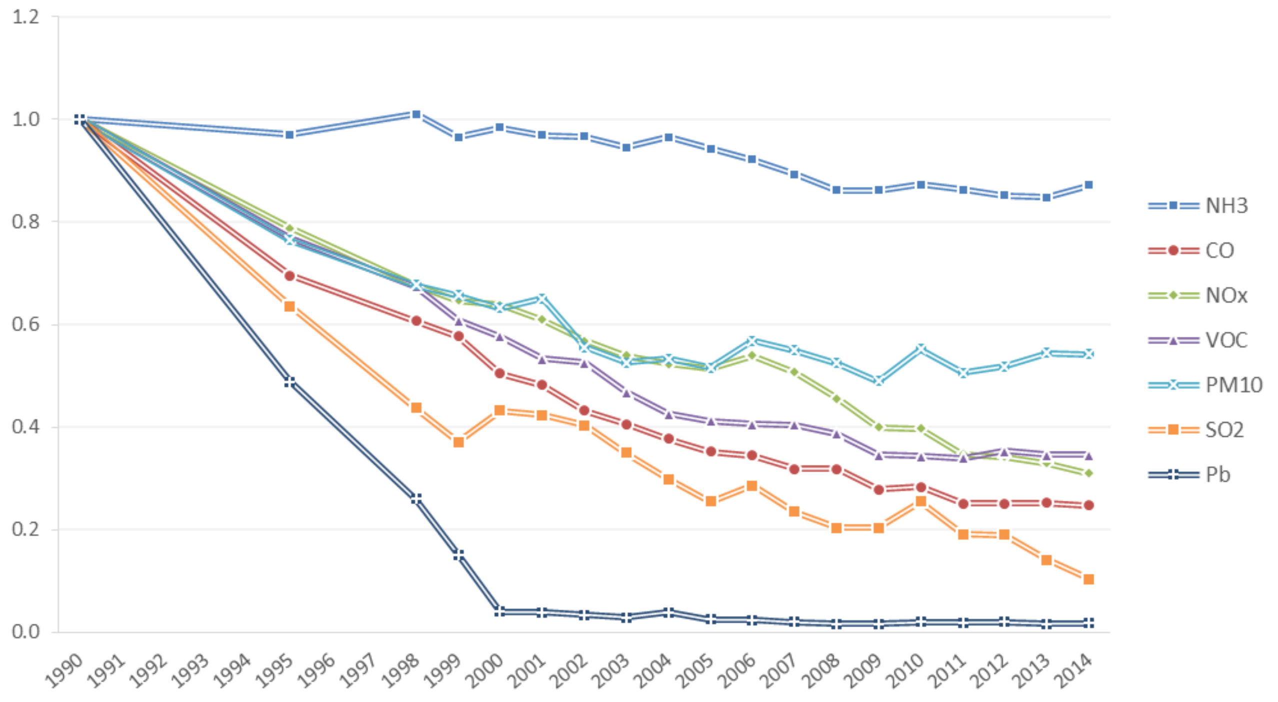
The following section provides a summary of emissions in Scotland for the seven air quality pollutants: ammonia (NH_3), carbon monoxide (CO), nitrogen oxides (NO_X as NO_2), non-methane volatile organic compounds (NMVOCs), particulate matter less than 10 micrometres (PM_{10}), sulphur dioxide (SO_2) and lead (Pb).

Figure 16 shows emissions of all seven air quality pollutants normalised to provide the relative rate of decline since 1990. This graph shows that all pollutant emission levels are lower in 2014 than they were in 1990. The decline is relatively similar for PM_{10}, NO_X, NMVOC, SO_2 and CO.

However, Pb shows a much higher rate of reduction from 1990 to 2000 which is coincident with the phase-out of leaded petrol by the end of 1999. NH_3 emissions, by contrast, have declined at a slower rate than other pollutants. The peaks in SO_2 emissions for 2006 and 2010 were due to an increase in energy emissions, linked to changes in the consumption of coal in power stations.

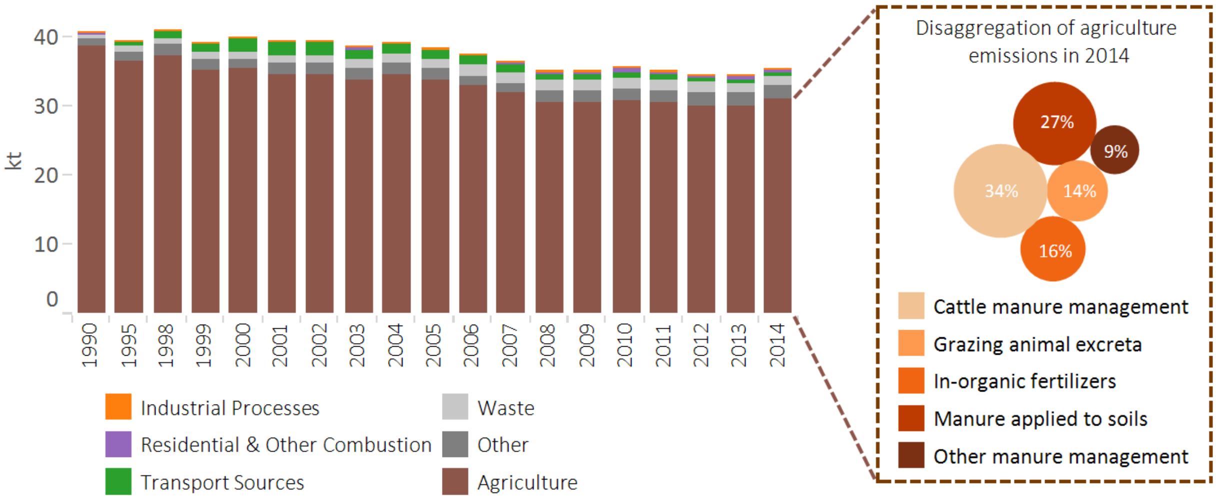
Emissions of NO_X have declined notably since 2007 primarily due to reductions in road transport emissions and the power generation sector. These are most likely linked to the installation of de-NO_X abatement systems (Boosted Over-Fire Air) on all four units at Longannet coal-fired power station (Scottish Power, 2012) and also at Cockenzie power station (Scottish Power, 2011) , which reduces NO_X emissions formed during coal combustion by up to 25%. Cockenzie power station has since ceased operation, in March 2013.

Figure 16 – Scotland normalised trends for all pollutants



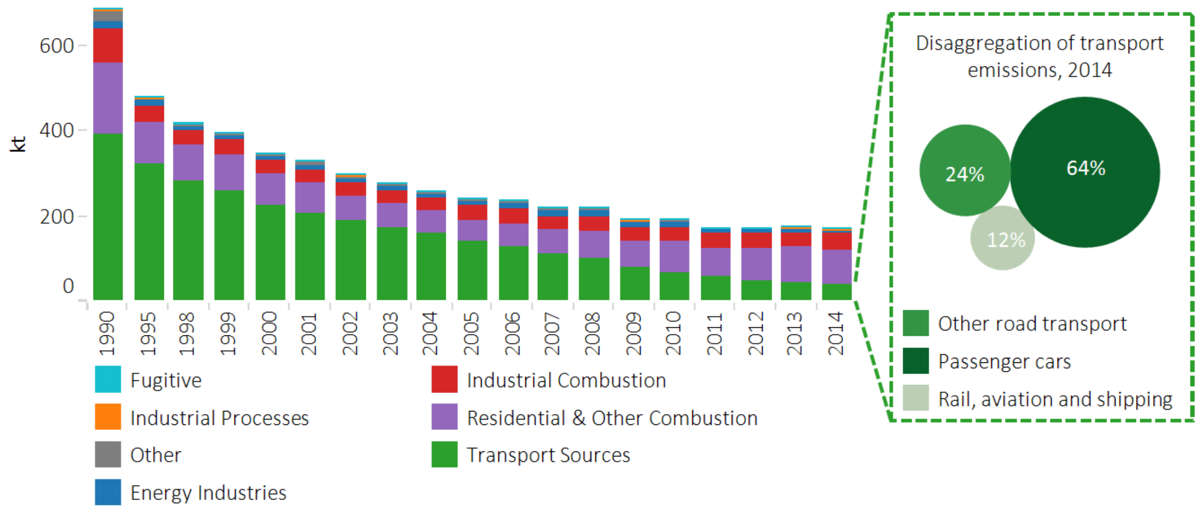
The following sections provide an overview of emissions from each of the seven pollutants giving explanations for the trends and characteristics of the graphs. Data summary tables for these emission estimates can be found in Appendix E. Mapping of the categories used in the graphs can be found in Appendix F.

Figure 17 – Ammonia Emissions in Scotland



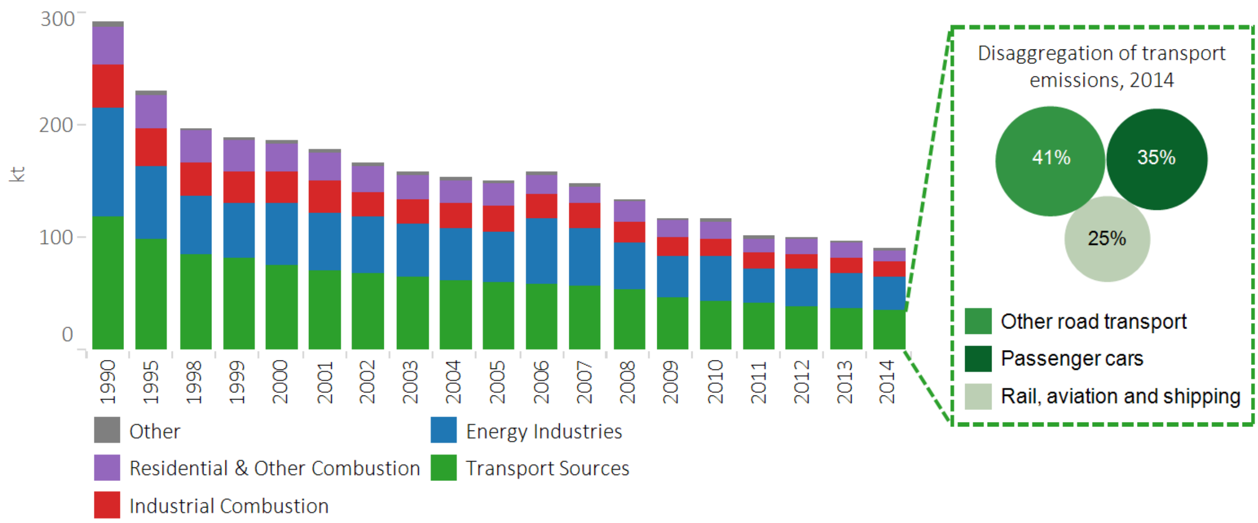
Emissions of **ammonia** were estimated to be 35kt in 2014. These emissions have declined by 13% since 1990 and accounted for 13% of the UK total in 2014. Agricultural sources have dominated the inventory throughout the time series, with cattle manure management accounting for 34% of the emissions from this sector. The trend in NH_3 emissions has been largely driven by decreasing animal numbers and a decline in fertiliser use, which have tended to decrease emissions across the time series. However, an increased usage of urea-based fertilisers, which are associated with higher NH_3 emission factors, has had the opposite effect in recent years. The result is a plateauing of emissions since 2008, with an observed increase between 2013 and 2014.

Figure 18 – Carbon Monoxide Emissions in Scotland



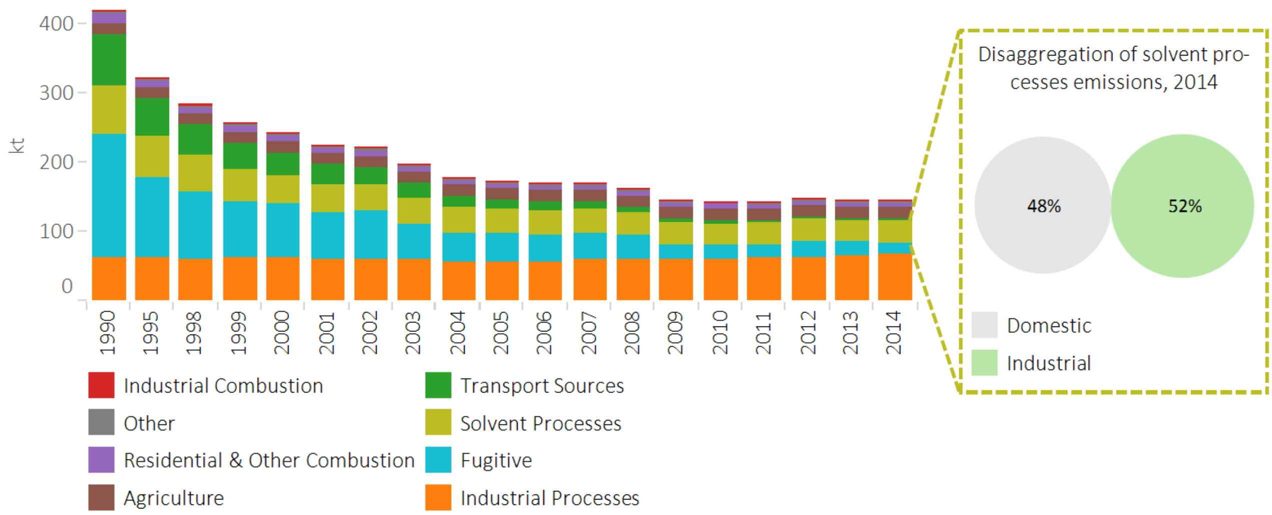
Emissions of **carbon monoxide** were estimated to be 170kt in 2014 and have declined by 75% since 1990. Emissions in Scotland accounted for 8% of the UK total in 2014. This decline in emissions stems from changes in the transport sector, particularly in road transport. The decline is driven by the introduction of Euro standards after 1992 which requires fitting of emission control (e.g. three-ways catalyst) in new petrol vehicles and in more recent years the switch from petrol cars to diesel cars. Since 2008, emissions from passenger cars have further decreased, which is mainly driven by the assumption on improvements in catalyst repair rates made in the NAEI to take into account of the introduction of Regulations Controlling Sale and Installation of Replacement Catalytic Converters and Particle Filters for Light Vehicles for Euro 3 (or above) light duty vehicles. In recent years, emissions from the residential and other combustion sector have increased, which corresponds with an increasing use of wood fuel in the domestic sector (Waters, 2015).

Figure 19 – Nitrogen Oxides Emissions in Scotland



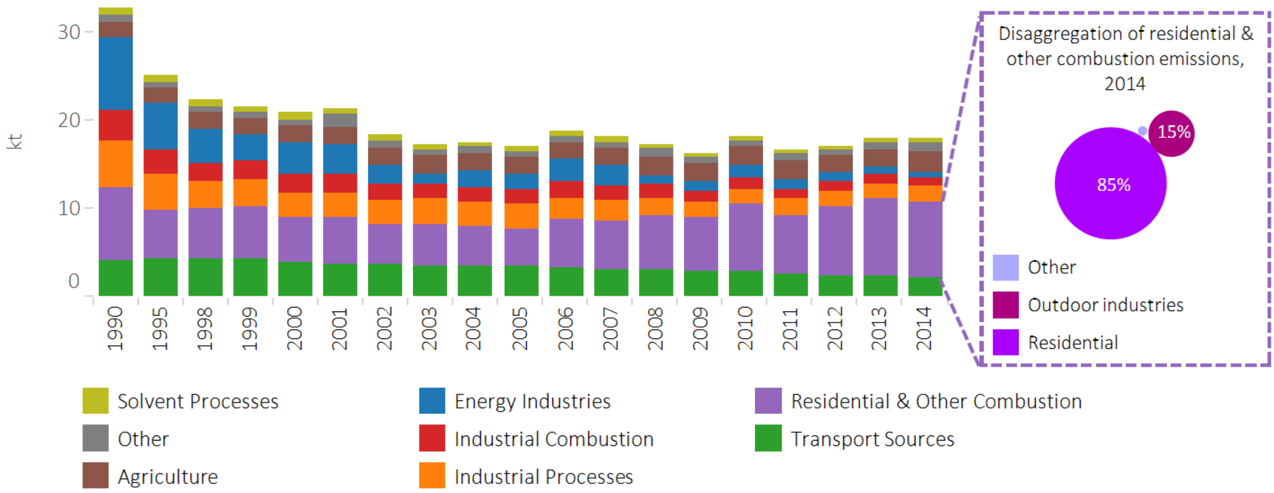
Emissions of **nitrogen oxides** were estimated to be 91kt in 2014, representing 10% of the UK total in 2014. Emissions have declined by 69% since 1990, mainly due to changes in the transport sector, particularly in road transport. This decline is driven by the successive introduction of tighter emission standards for petrol cars and all types of new diesel vehicles over the last decade. Since 2008, emissions from passenger cars have further decreased, which is mainly driven by the assumption on improvements in catalyst repair rates made in the NAEI to take into account of the introduction of Regulations Controlling Sale and Installation of Replacement Catalytic Converters and Particle Filters for Light Vehicles for Euro 3 (or above) light duty vehicles. However, the increasing number of diesel cars offsets these emissions reductions, because diesel cars emit higher NO_x relative to their petrol counterparts. The peak in NO_x emissions in 2006 is due to an increase in emissions linked to the increased use of coal at Longannet power station that year. There was a smaller peak in coal-fired generation in 2012 due to a UK-wide shift in power generation fuel mix from gas to coal in that year (DECC, 2015d). The decline in NO_x emissions since 2007 is also linked to the power sector, as Boosted Over-Fire Air (BOFA) abatement systems were fitted to all four of Longannet's units, to reduce NO_x emissions from coal-fired generation by up to 25% (Scottish Power, 2012). BOFA systems were also fitted on all four units at Cockenzie power station which then closed in 2013 (Scottish Power, 2011).

Figure 20 – NMVOC Emissions in Scotland



Emissions of **non-methane volatile organic compounds** were estimated to be 146kt in 2014, representing 18% of the UK total in 2014. Emissions have declined by 65% since 1990. This reduction has been dominated by the 90% decrease in fugitive emissions since 1990. This is primarily due to the decrease in emissions from the exploration, production and transport of oil, specifically emissions from the onshore loading of oil. The decrease between 2008 and 2009 was due to reductions in fugitive NMVOC emissions from oil loading at the Sullom Voe terminal in Shetland. Emissions from the food and drink industry (which accounts for almost 100% of industrial processes emissions in 2014) have consistently increased since 2008 due to the increased production and storage of whisky, now contributing approximately 50% of NMVOC emissions in Scotland. Emissions from road transport sources, including evaporative losses of fuel vapour from petrol vehicles have also declined over time due to emission control technologies introduced in new petrol vehicles since the early 1990s. The reduction in emissions also occurs to a lesser extent due to the introduction of petrol vapour recovery systems at filling stations.

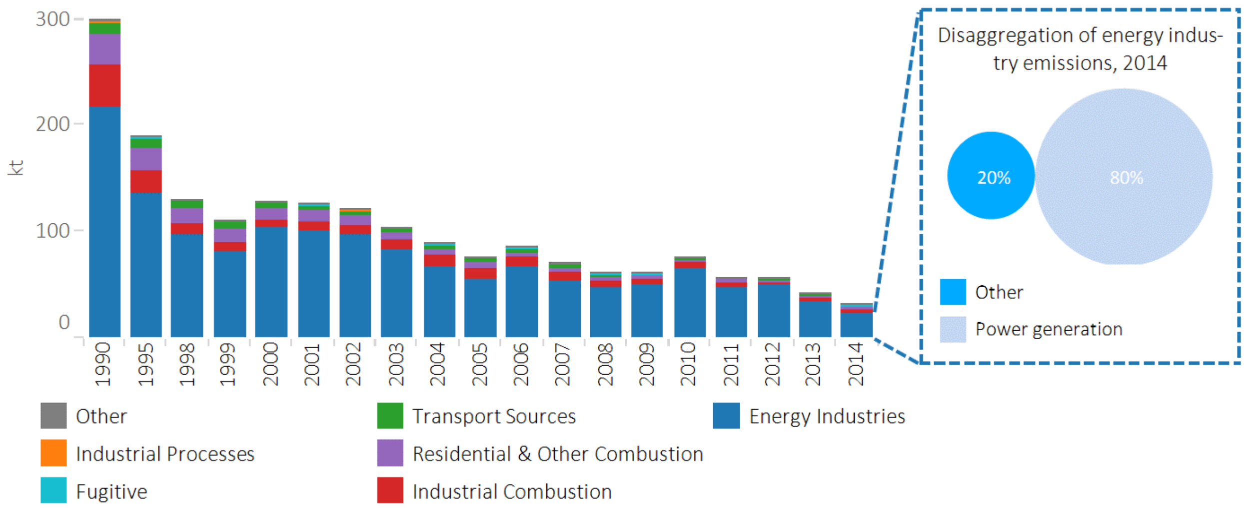
Figure 21 – PM_{10} Emissions in Scotland[3]



Emissions of **PM_{10}** were estimated to be 18kt in 2014, declining by 46% since 1990. These emissions account for 12% of the UK total. Unlike most other pollutants, PM_{10} emissions have a large number of significant sources. Transport, residential combustion and agriculture all accounted for over 10% of emissions across most of the time series. Emissions from energy industries have had the most significant impact on the trend. This reduction is primarily due to abatement at coal fired stations, the increase in nuclear and renewable energy sources and the increase in the use of gas in energy generation (which has negligible PM_{10} emissions) in place of coal(DECC, 2015d). PM_{10} exhaust emissions from diesel fuelled vehicles have been decreasing due to the successive introduction of tighter emission standards over time. In recent years, emissions from the residential and other combustion sector have increased, and this is due to an increasing quantity of wood fuel use, primarily in the domestic sector (Waters, 2015).

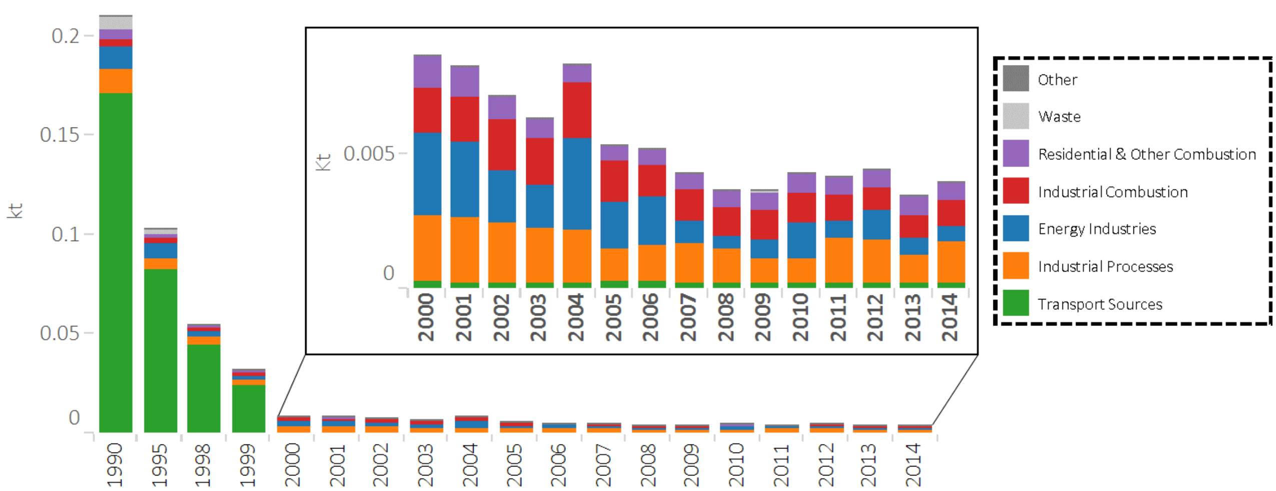
[3] 'Outdoor industries' presented in the bubble graph relate to combustion emissions from machinery in the agriculture, forestry and fishing industries.

Figure 22 – Sulphur Dioxide Emissions in Scotland



Emissions of **sulphur dioxide** were estimated to be 31kt in 2014, representing 10% of the UK total in 2014. Emissions have declined by 90% since 1990, which has been dominated by the 89% reduction in energy industries emissions, coincident with significant changes in the power generation section. These include the reduction in coal fired power relative to other sources; improved emission controls on some large coal fired plant such as the installation of a FGD (flue-gas desulphurization) plant at Longannet power station; and also the supply of lower-sulphur coal in later years to Cockenzie (Scottish Power, 2011). Emissions from power generation fell between 2012 and 2013 due to the closure of Cockenzie power station in March 2013, and a UK-wide shift in power generation fuel mix back from coal to natural gas (DECC, 2015d). Road transport emissions have declined, coincident with the reduced sulphur content of road fuels, both petrol and diesel.

Figure 23 – Lead Emissions in Scotland



Emissions of **lead** were estimated to be 3.9 tonnes in 2014, representing 6% of the UK total in 2014. Emissions have declined by 98% since 1990 almost entirely due to changes in the transport sector. Petrol with lead additives was phased out from general sale by the end of 1999, which is the reason for the 99.8% decrease in transport emissions between 1990 and 2000. The most significant sources of emissions are now combustion of coal in all sectors and the use of lubricants in transport. The peak in 2004 was due to an increase in reported emissions from coal combustion in power generation.

Table 3 below provides a summary of the percentage contribution of each sector for each pollutant in 2014. Using the ranking of these percentage contributions, the sectors have been ordered to provide its indicative significance across all pollutants. As such, the table below indicates that the residential and other combustion sector is the most significant sector when considering emissions from all pollutants. This sector accounts for approximately a half of CO and PM_{10} emissions, and over a sixth of all Pb emissions.

The top five sectors mainly relate to fuel combustion. Industrial Processes is also significant, especially for NMVOC, which is due to the significance of the food and drink industry in Scotland. This table also highlights that although emissions from the Agriculture sector are not as significant when considering all pollutants, it is of very high significance when considering emissions of NH_3.

Table 3 – Source Emission Contributions Ranked by Sector, Scotland 2014

Overall Rank	Sector	NH_3	CO	NO_X	NMVOC	PM_{10}	SO_2	Pb
1	Residential & Other Combustion	1.6%	46.2%	12.3%	5.2%	47.3%	8.5%	17.4%
2	Transport Sources	1.4%	24.1%	39.1%	2.3%	12.4%	3.6%	4.8%
3	Industrial Combustion	0.0%	23.2%	14.6%	1.1%	5.2%	8.3%	23.4%
3	Industrial Processes	0.2%	0.0%	0.0%	45.8%	10.7%	1.9%	38.7%
5	Energy Industries	0.0%	4.5%	32.2%	0.0%	3.9%	75.4%	15.4%
6	Agriculture	87.3%	0.0%	0.0%	10.7%	12.2%	0.0%	0.0%
7	Other	5.2%	1.4%	1.8%	0.9%	6.0%	0.2%	0.2%
8	Fugitive	0.0%	0.6%	0.0%	12.6%	0.0%	2.2%	0.0%
9	Solvent Processes	0.0%	0.0%	0.0%	21.5%	2.4%	0.0%	0.0%
10	Waste	4.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%

* The sector: "other" will include all "other" categories in the inventory and also a number of categories that are insignificant for a specific pollutant.

Emission maps for all seven pollutants are shown below.

Figure 24 – Ammonia Emissions in Scotland, 2014

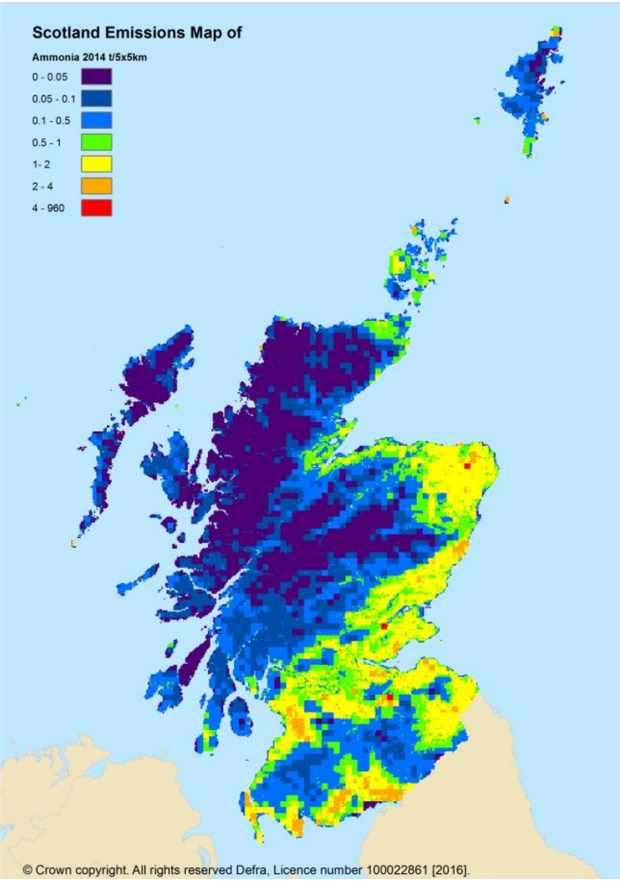


Figure 25 – Carbon Monoxide Emissions in Scotland, 2014

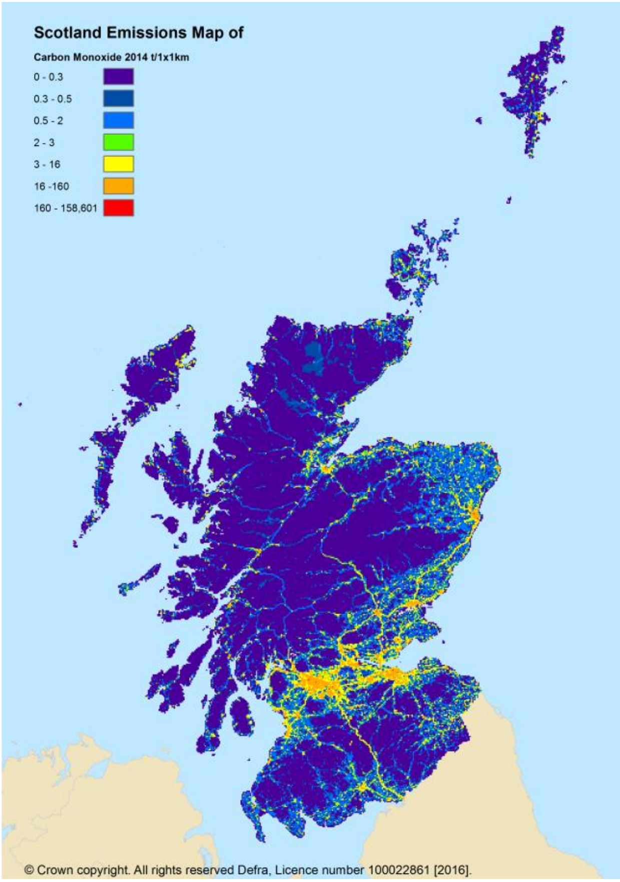


Figure 26 – Nitrogen Oxides Emissions in Scotland, 2014

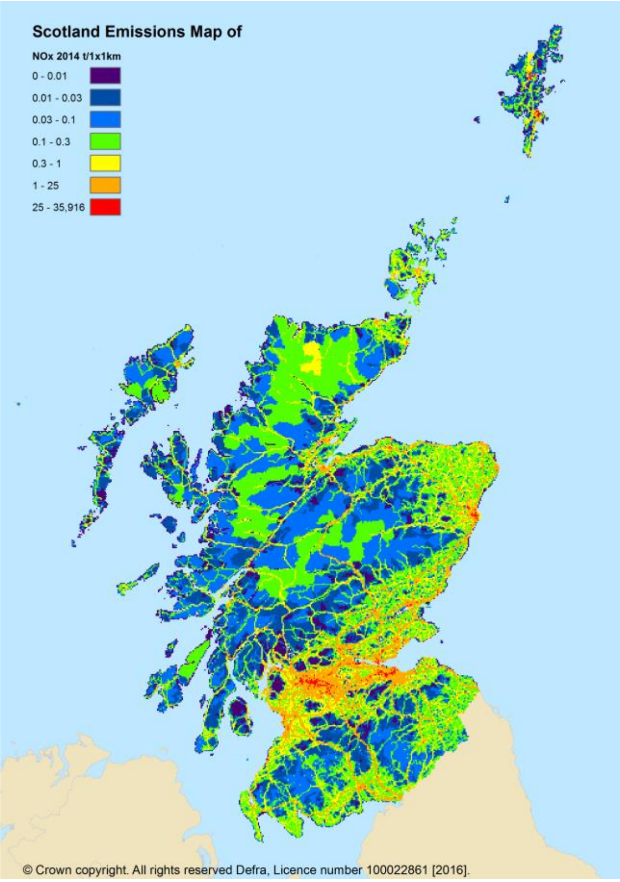


Figure 27 – NMVOC Emissions in Scotland, 2014

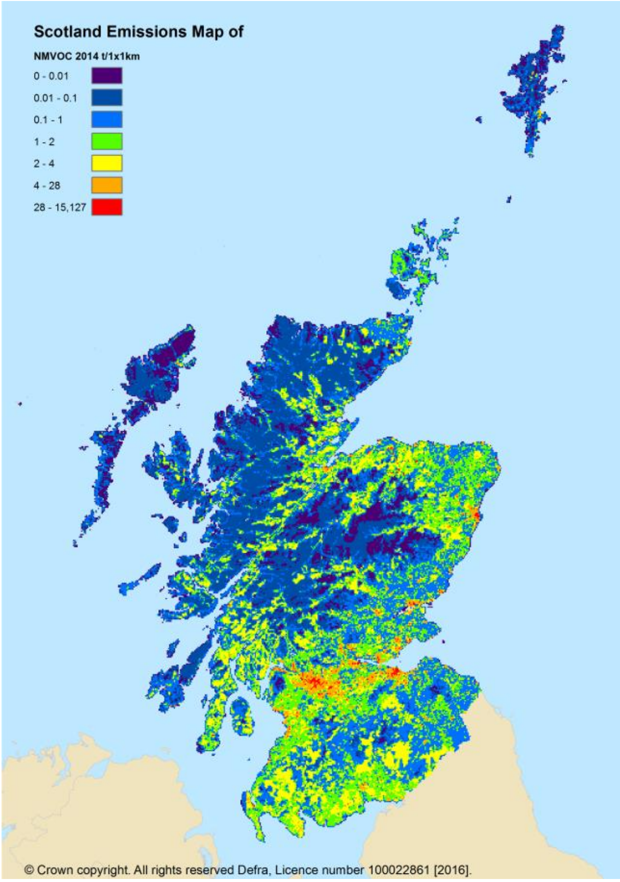


Figure 28 – PM_{10} Emissions in Scotland, 2014

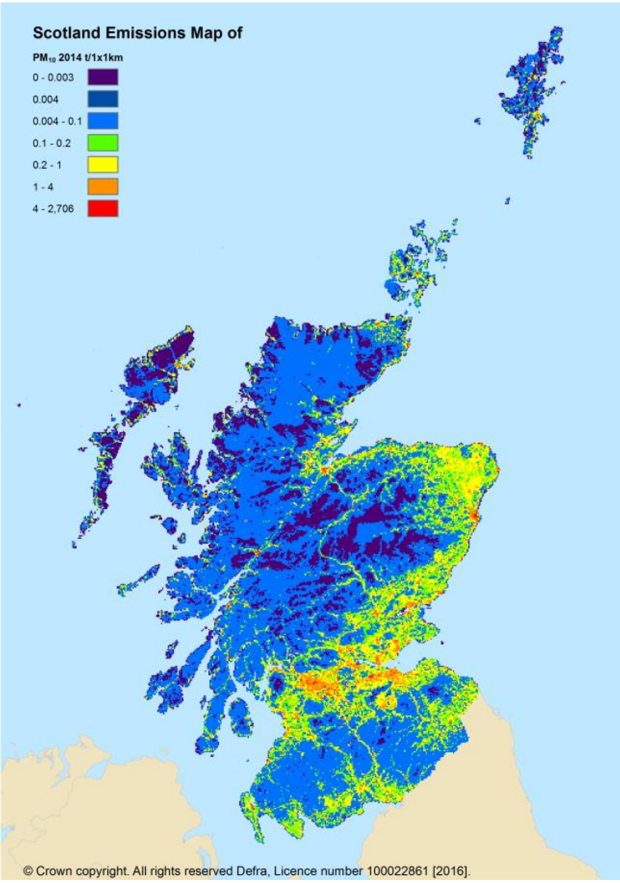


Figure 29 – Sulphur Dioxide Emissions in Scotland, 2014

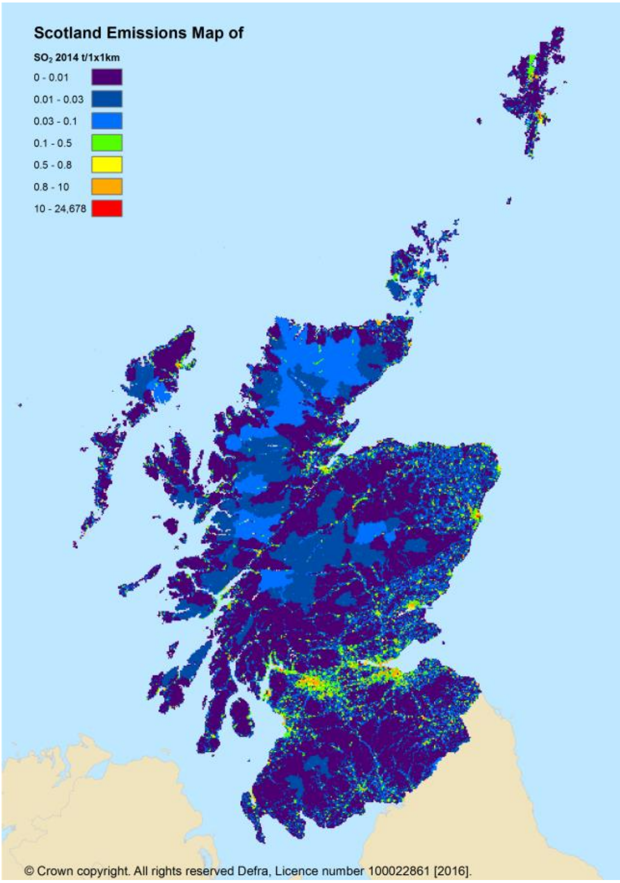
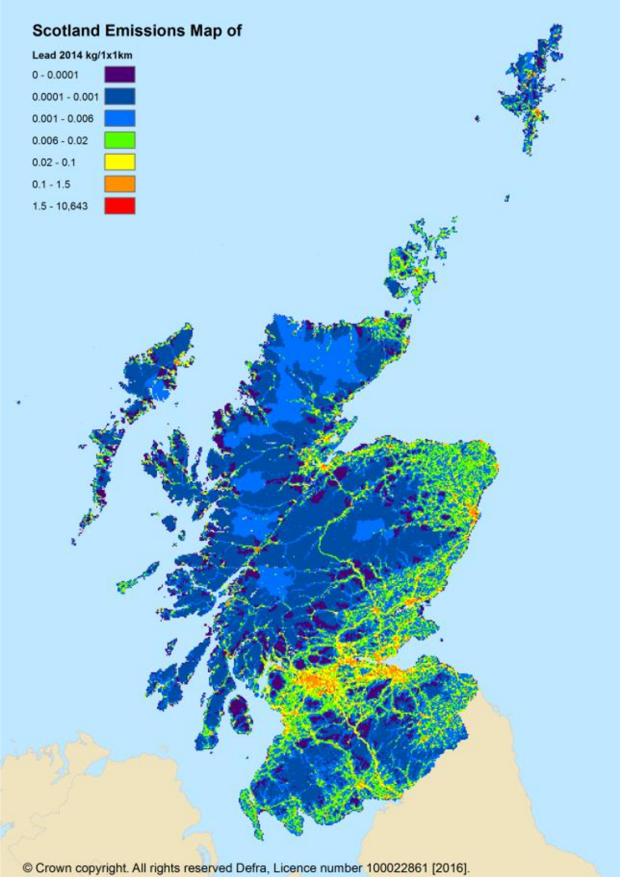


Figure 30 – Lead Emissions in Scotland, 2014



2.3. Wales

The following section provides a summary of emissions in Wales for the seven air quality pollutants: ammonia (NH_3), carbon monoxide (CO), nitrogen oxides (NO_X as NO_2), non-methane volatile organic compounds (NMVOCs), particulate matter less than 10 micrometres (PM_{10}), sulphur dioxide (SO_2) and lead (Pb).

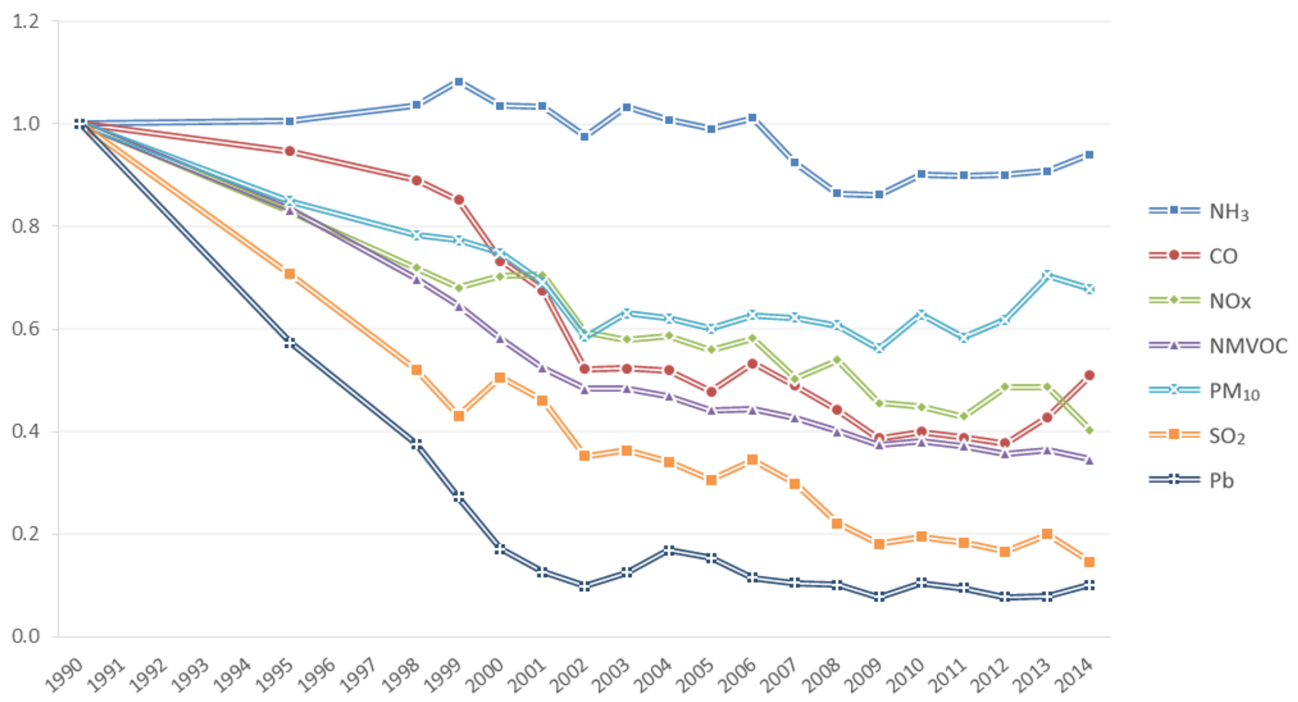
Figure 31 shows emissions of all seven air quality pollutants normalised to provide the relative rate of decline since 1990. This graph shows that all pollutant emission levels are lower in 2014 than they were in 1990. The decline is relatively similar for PM_{10}, NO_X, NMVOC and CO.

However, Pb shows a higher rate of reduction from 1990 to 2000 coincident with the phase-out of leaded petrol by the end of 1999. NH_3 emissions, by contrast, have declined at a much slower rate than other pollutants, plateauing in recent years.

Reductions in SO_2 since 2006 are due, primarily, to the retro-fitting of Flue Gas Desulphurisation and the co-firing of biomass at power stations, with the increase in 2013 due in part to increases in generation and hence the amount of fuel consumed.

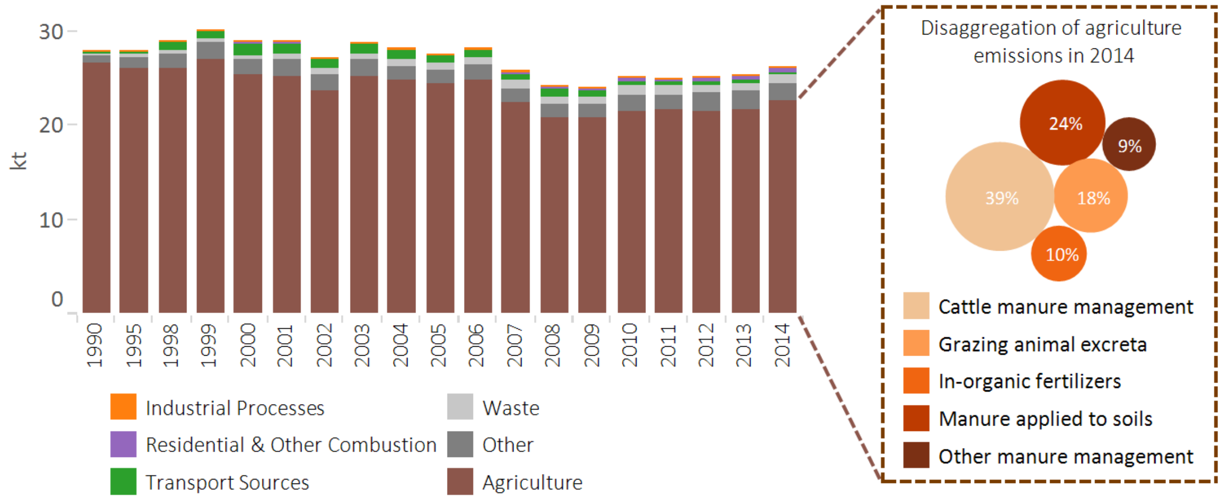
Many pollutant trends in Wales are also influenced significantly by the combustion and process emission sources linked to the iron and steel industry, and in particular changes in activity at Port Talbot steelworks. For example, between 2012 and 2013 an upturn in production at the plant led to increases in emissions from the sector across the priority air quality pollutants reported here, influencing the national trends most notably for CO, Pb and SO_2.

Figure 31 – Wales normalised trends for all pollutants



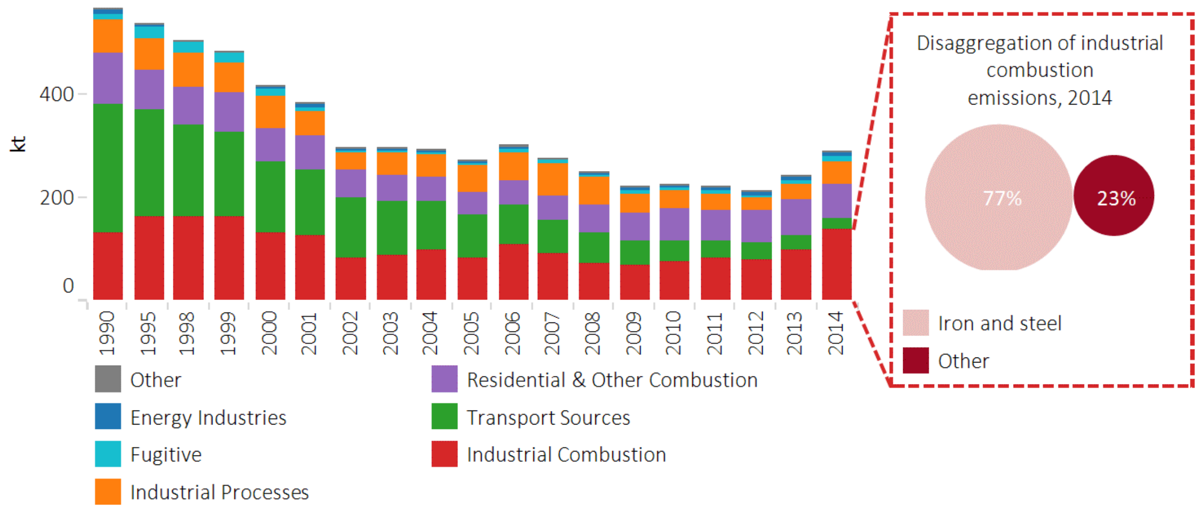
The following sections provide an overview of emissions from each of the seven pollutants giving explanations for the trends and characteristics of the graphs. Data summary tables for these emission estimates can be found in Appendix E. Mapping of the categories used in the graphs can be found in Appendix F.

Figure 32 – Ammonia Emissions in Wales



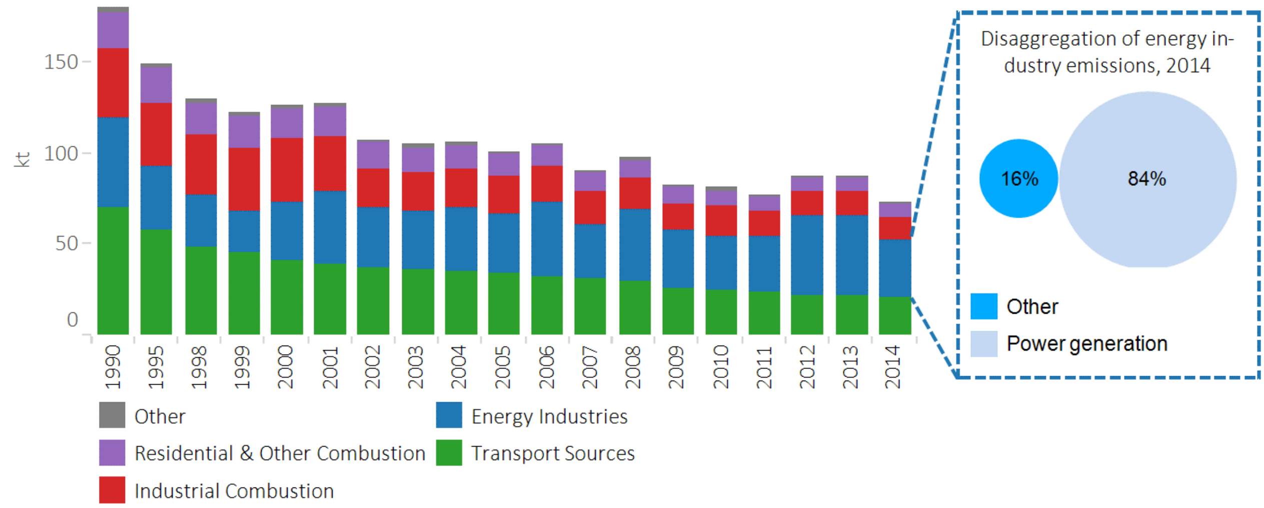
Emissions of **ammonia** were estimated to be 26kt in 2014. These emissions have declined by 6% since 1990 and account for 9% of the UK total in 2014. Agricultural sources have dominated the inventory throughout the time series, with cattle manure management accounting for 39% of the emissions from this sector in 2014. The trend in NH_3 emissions has been largely driven by decreasing animal numbers and a decline in fertiliser use, which have tended to decrease emissions across the time series. However, an increased usage of urea-based fertilisers, which are associated with higher NH_3 emission factors, has had the opposite effect in recent years. The result is a plateauing of emissions since 2008, with an observed increase between 2013 and 2014.

Figure 33 – Carbon Monoxide Emissions in Wales



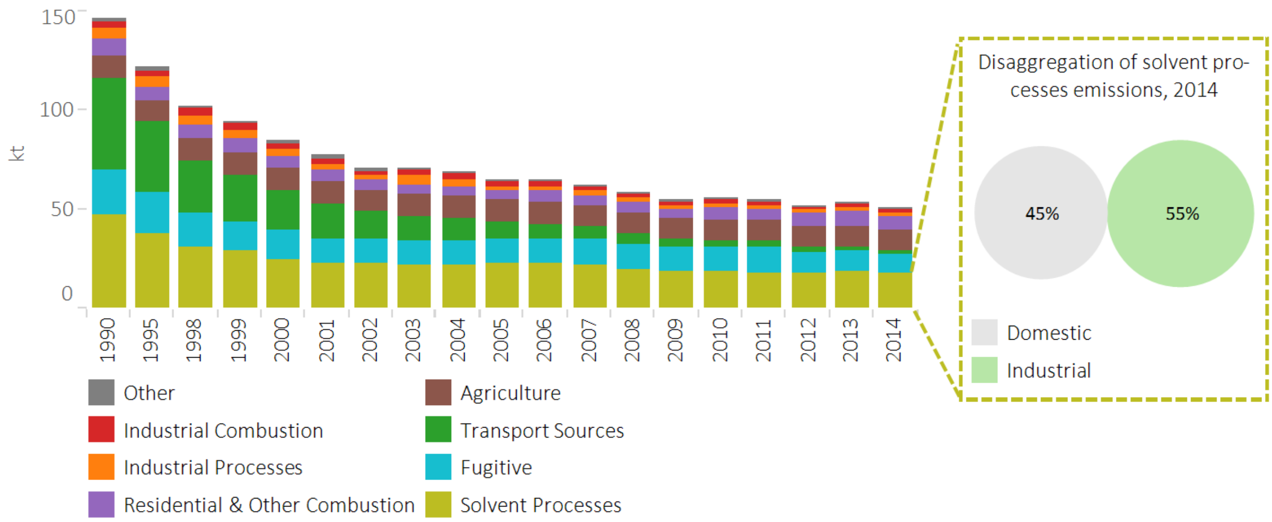
Emissions of **carbon monoxide** were estimated to be 288kt in 2014 and have declined by 49% since 1990. Emissions in Wales accounted for 14% of the UK total in 2014. This decline in emissions stems from changes in the transport sector, particularly road transport. The decline is driven by the introduction of Euro standards after 1992 which requires fitting of emission control (e.g. three-ways catalyst) in new petrol vehicles and in more recent years the switch from petrol cars to diesel cars. Since 2008, emissions from passenger cars have further decreased, which is mainly driven by the assumption on improvements in catalyst repair rates made in the NAEI to take into account of the introduction of Regulations Controlling Sale and Installation of Replacement Catalytic Converters and Particle Filters for Light Vehicles for Euro 3 (or above) light duty vehicles. In more recent years, the most significant sector has been industrial combustion and, more specifically, the iron and steel industry where the significant increase in emissions in 2013 and 2014 correspond with production changes.

Figure 34 – Nitrogen Oxides Emissions in Wales



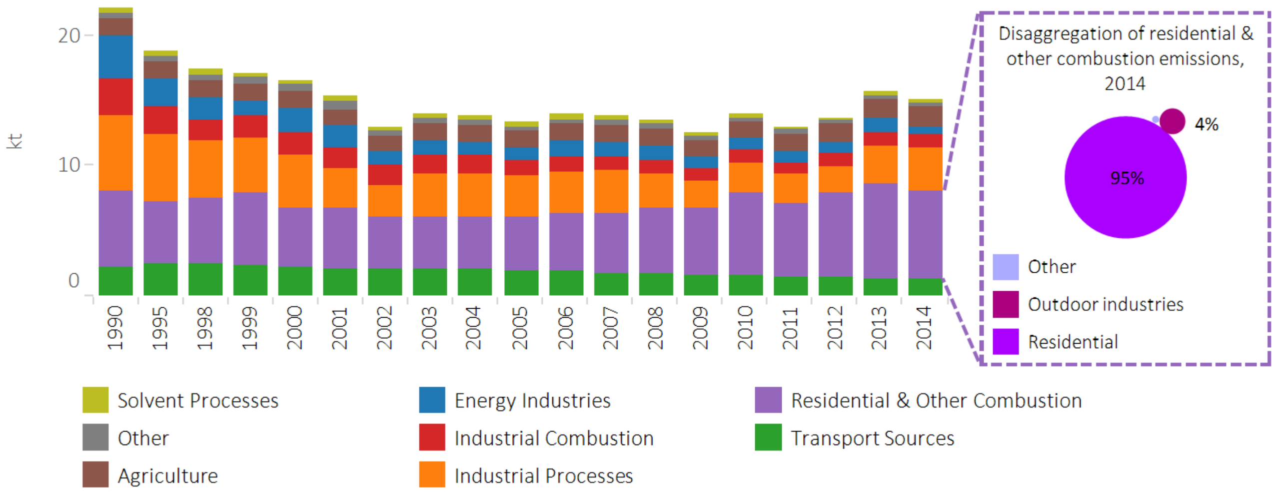
Emissions of **nitrogen oxides** were estimated to be 73kt in 2014, representing 8% of the UK total in 2014. Emissions have declined by 60% since 1990, mainly due to changes in the transport sector, particularly in road transport. This decline is driven by the successive introduction of tighter emission standards for petrol cars and all types of new diesel vehicles over the last decade. Since 2008, emissions from passenger cars have further decreased, which is mainly driven by the assumption on improvements in catalyst repair rates made in the NAEI to take into account of the introduction of Regulations Controlling Sale and Installation of Replacement Catalytic Converters and Particle Filters for Light Vehicles for Euro 3 (or above) light duty vehicles. However, the increasing number of diesel cars offsets these emissions reductions, because diesel cars emit higher NO_x relative to their petrol counterparts. The recent upturn in emissions from energy industries (2012, 2013) corresponds with the rise in coal-fired power generation.

Figure 35 – NMVOC Emissions in Wales



Emissions of **non-methane volatile organic compounds** were estimated to be 51kt in 2014, representing 6% of the UK total in 2014. Emissions have declined by 65% since 1990. This reduction is mainly due to the decrease in emissions from road transport sources, including evaporative losses of fuel vapour from petrol vehicles. This decline is coincident with emission control technologies introduced in new petrol vehicles since the early 1990s and, in more recent years, the increasing proportion of diesel fuelled vehicles in the passenger fleet. The reduction in emissions also occurs to a lesser extent due to the introduction of petrol vapour recovery systems at filling stations. Due to this large reduction in transport emissions, solvent processes are now the most significant source of NMVOC emissions, with an equal amount of emissions arising from both industrial and domestic solvent applications.

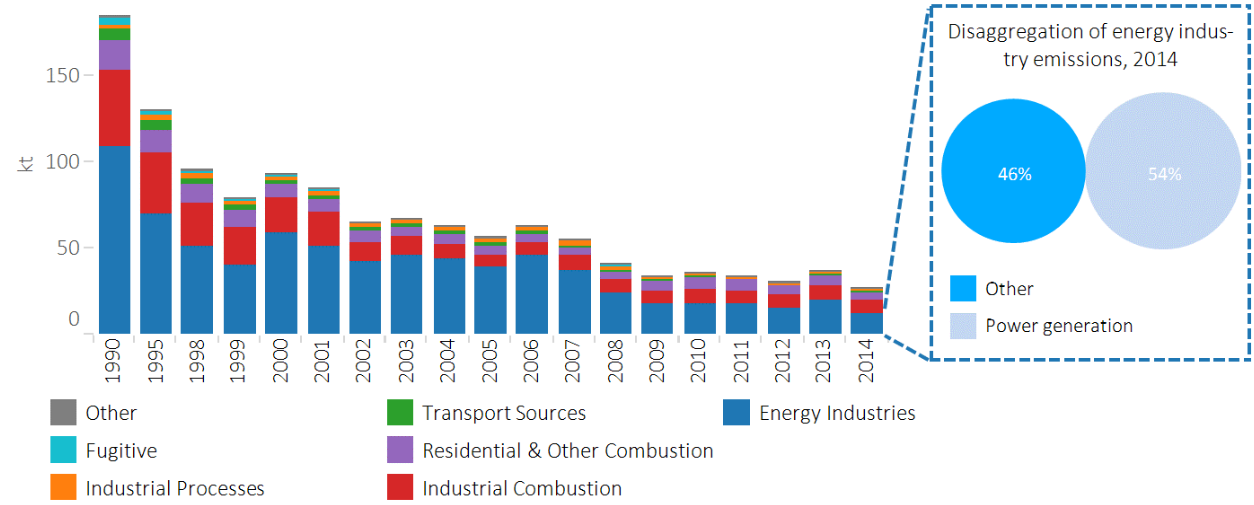
Figure 36 – PM_{10} Emissions in Wales[4]



Emissions of PM_{10} were estimated to be 15kt in 2014 and have declined by 32% since 1990. These emissions account for 10% of the UK total in 2014. Unlike most other pollutants, PM_{10} emissions have a large number of significant sources. Transport, residential combustion, industrial processes and agriculture all accounted for over 10% of emissions across most of the time series. In 2014 the most significant sources were from residential combustion, and from iron and steel process sources such as from sinter plant, basic oxygen furnaces and blast furnaces. As a result, recent trends are influenced by the use of solid fuels in the domestic sector as well as iron and steel production trends, but there is no strong trend in overall emissions evident in the last 6 years. In recent years, emissions from the residential and other combustion sector have increased, and this is primarily due to increasing wood fuel use in the domestic sector (Waters, 2015).

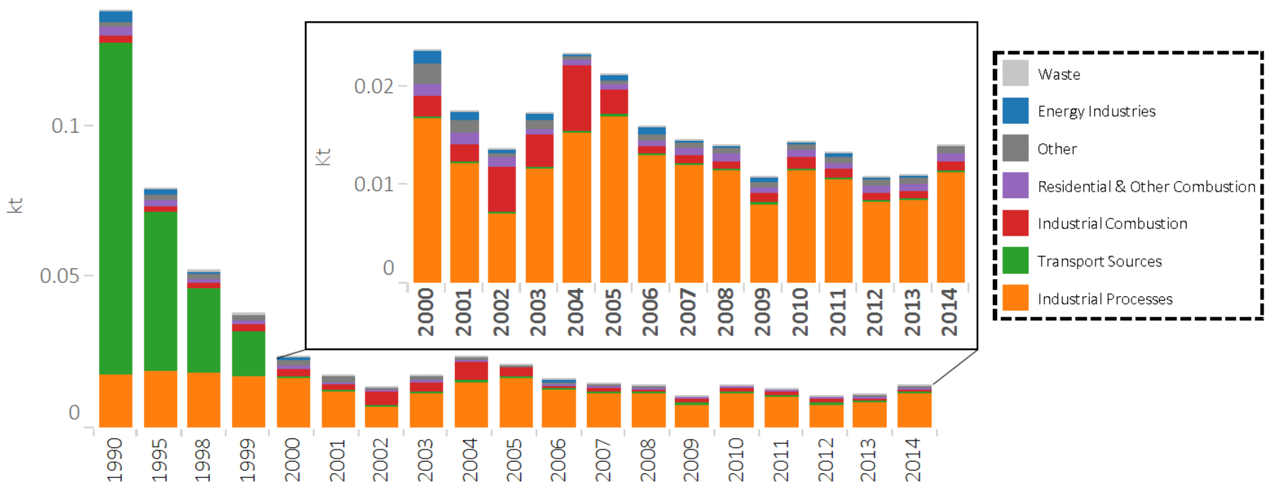
[4] 'Outdoor industries' presented in the bubble graph relate to combustion emissions from machinery in the agriculture, forestry and fishing industries.

Figure 37 – Sulphur Dioxide Emissions in Wales



Emissions of **sulphur dioxide** were estimated to be 27kt in 2014, representing 9% of the UK total in 2014. Emissions have declined by 85% since 1990, which has been dominated by the 89% reduction in energy industries emissions. This reduction is coincident with the UK-wide shift in power generation fuel mix away from coal to natural gas, nuclear and renewable sources. Trends in recent years are influenced by emissions from a range of energy industries (power generation, oil refining) as well as the use of solid fuels in the domestic sector and production trends (and related coal use) in the iron and steel industry.

Figure 38 – Lead Emissions in Wales



Emissions of **lead** were estimated to be 14 tonnes in 2014, representing 21% of the UK total in 2014. Emissions have declined by 90% since 1990 almost entirely due to changes in the transport sector. Petrol with lead additives was phased out from general sale by the end of 1999, which is the reason for the 99.9% decrease in transport emissions between 1990 and 2000. The most significant sources of emissions are now industrial processes in the iron and steel industry.

Table 4 below provides a summary of the percentage contribution of each sector for each pollutant in 2014. Using the ranking of these percentage contributions, the sectors have been ordered to provide its indicative significance across all pollutants. As such, the table below indicates that the residential and other combustion sector is the most significant sector when considering emissions from all pollutants. This sector accounts for over 15% of emissions for three pollutants: CO, PM_{10} and SO_2.

The majority of the top five sectors are related to the combustion of fuel, whilst Industrial Processes is also significant, which is due to the iron and steel industry present in Wales. This table also highlights that although emissions from the agriculture sector are not as significant when considering all pollutants, it is of very high significance when considering emissions of NH_3.

Table 4 – Source Emission Contributions Ranked by Sector, Wales 2014

Overall Rank	Sector	NH_3	CO	NO_X	NMVOC	PM_{10}	SO_2	Pb
1	Residential & Other Combustion	1.9%	22.5%	8.9%	12.7%	45.2%	19.3%	4.8%
2	Industrial Combustion	0.0%	47.2%	17.5%	3.1%	6.7%	27.5%	6.5%
3	Industrial Processes	0.2%	15.4%	0.0%	4.9%	21.6%	1.4%	80.4%
4	Transport Sources	1.1%	8.5%	28.1%	3.8%	8.7%	2.7%	0.8%
5	Energy Industries	0.0%	2.2%	43.8%	0.0%	3.9%	43.7%	1.5%
6	Agriculture	86.1%	0.0%	0.0%	20.7%	10.2%	0.0%	0.0%
7	Other	7.1%	0.4%	1.8%	1.6%	2.1%	0.1%	6.0%
8	Fugitive	0.0%	3.9%	0.0%	17.3%	0.0%	5.3%	0.0%
9	Solvent Processes	0.0%	0.0%	0.0%	35.9%	1.5%	0.0%	0.0%
10	Waste	3.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

* The sector: "other" will include all "other" categories in the inventory and also a number of categories that are insignificant for a specific pollutant.

Emission maps for all seven pollutants are shown below.

Figure 39 – Ammonia Emissions in Wales, 2014

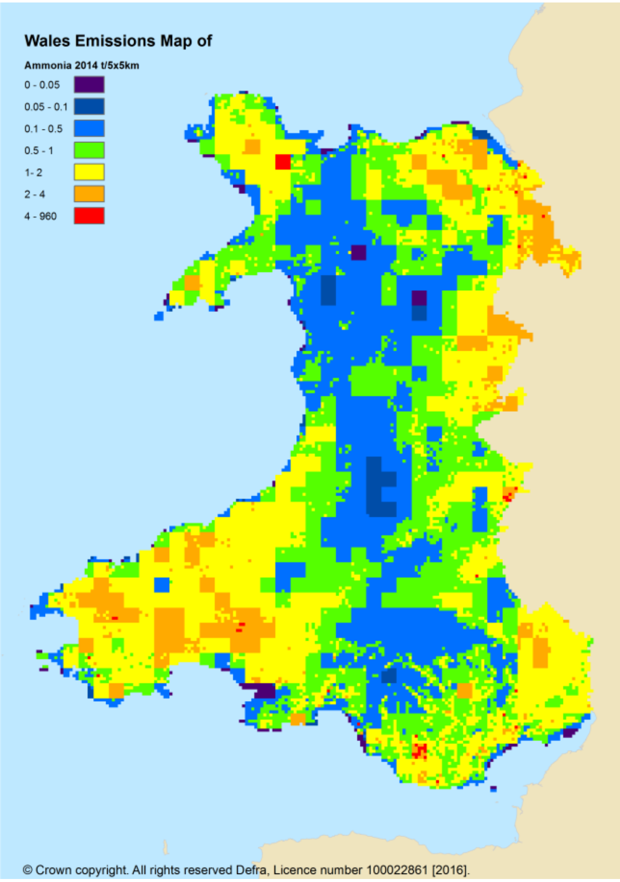


Figure 40 – Carbon Monoxide Emissions in Wales, 2014

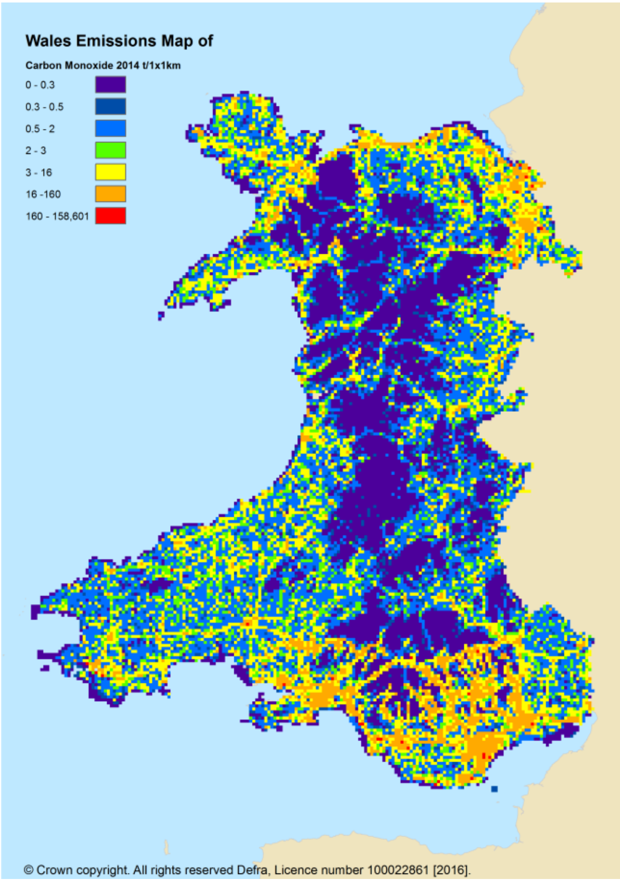


Figure 41 – Nitrogen Oxides Emissions in Wales, 2014

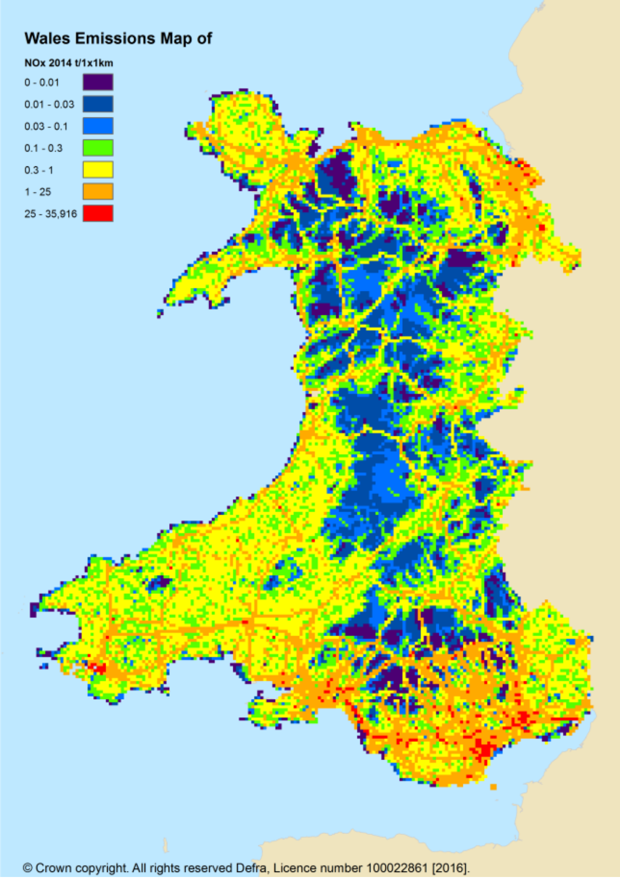


Figure 42 – NMVOC Emissions in Wales, 2014

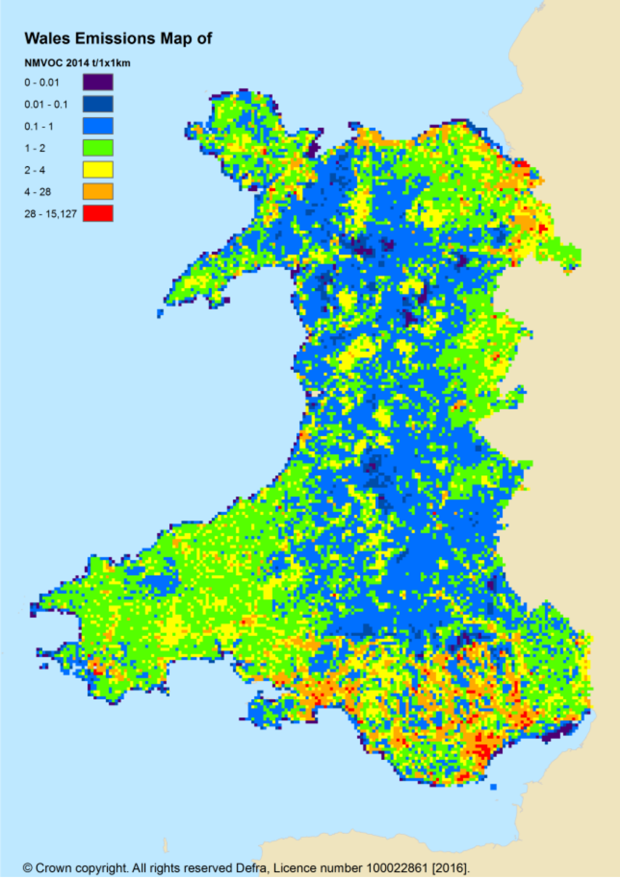


Figure 43 – PM_{10} Emissions in Wales, 2014

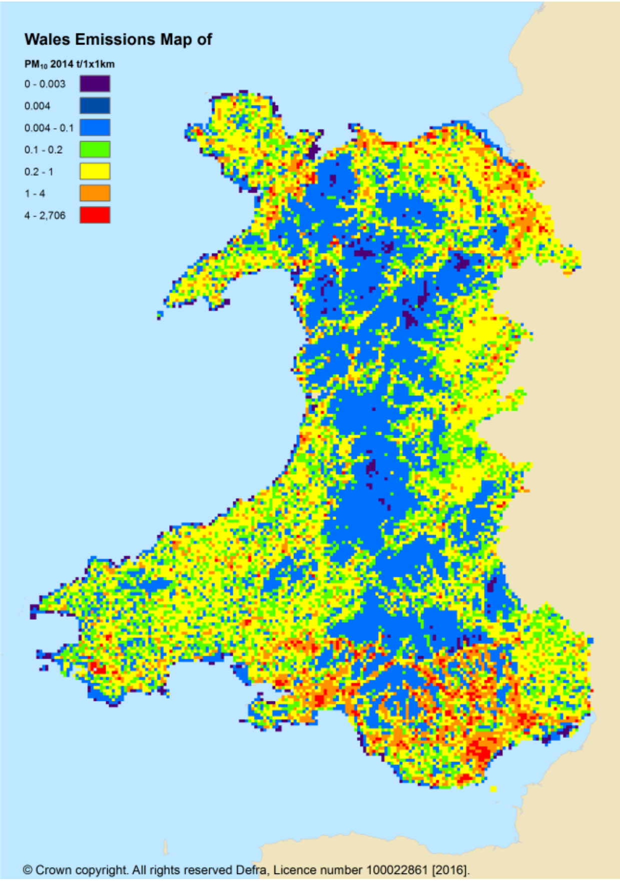


Figure 44 – Sulphur Dioxide Emissions in Wales, 2014

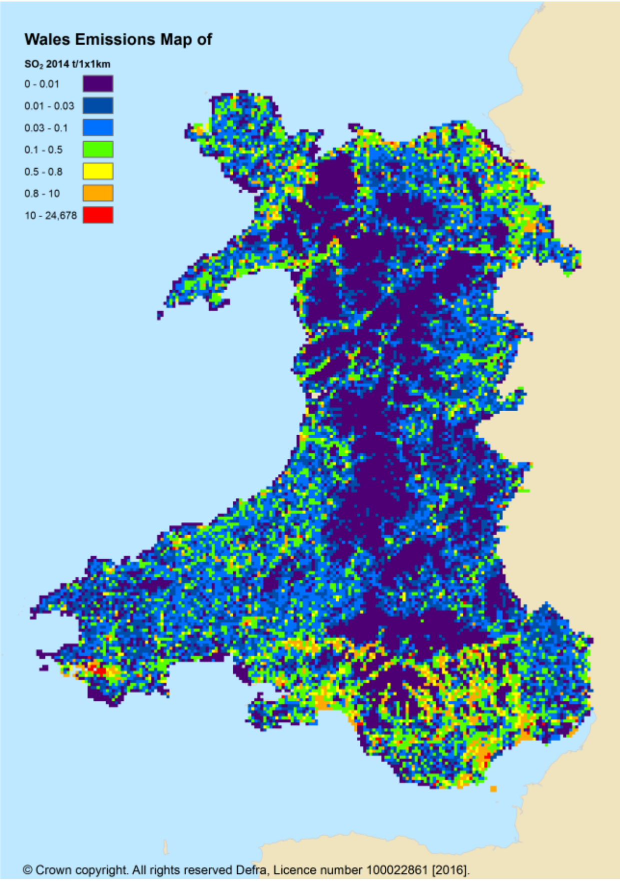
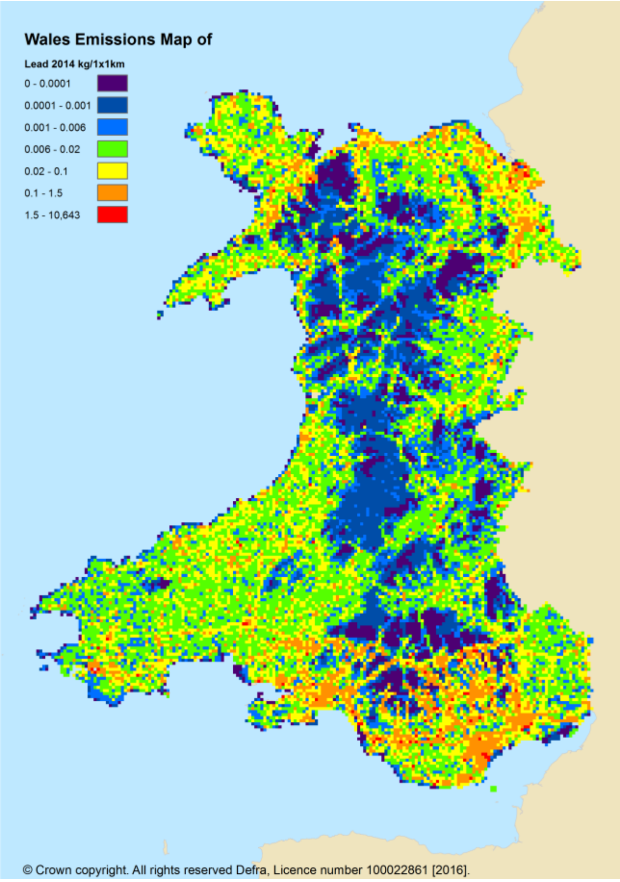


Figure 45 – Lead Emissions in Wales, 2014



2.4. Northern Ireland

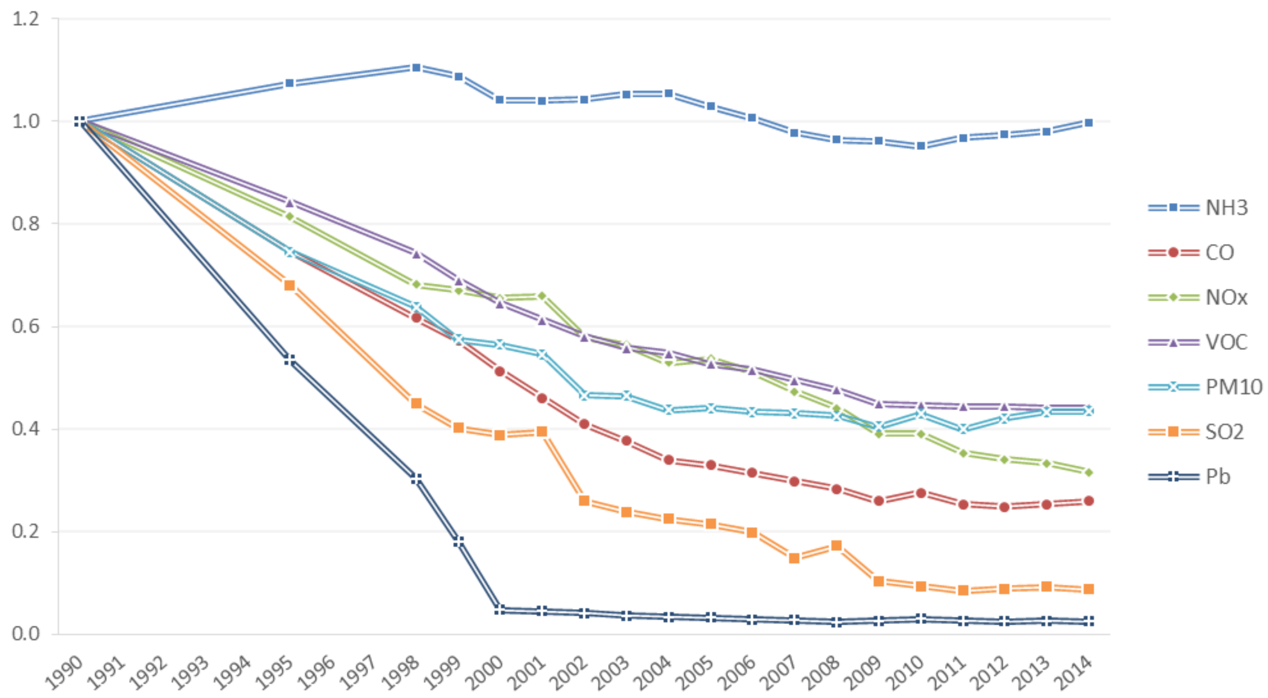
The following section provides a summary of emissions in Northern Ireland for the seven air quality pollutants: ammonia (NH_3), carbon monoxide (CO), nitrogen oxides (NO_X as NO_2), non-methane volatile organic compounds (NMVOCs), particulate matter less than 10 micrometres (PM_{10}), sulphur dioxide (SO_2) and lead (Pb).

Figure 46 shows emissions of all seven air quality pollutants normalised to provide the relative rate of decline since 1990. This graph shows that all pollutant emission levels are lower in 2014 than they were in 1990. The decline is relatively similar for PM_{10}, NO_X, NMVOC and CO.

However, Pb shows a much higher rate of reduction from 1990 to 2000 due to the phase-out of leaded petrol by the end of 1999. NH_3 emissions, by contrast, only reached levels that were lower than 1990 estimates from 2007 onwards.

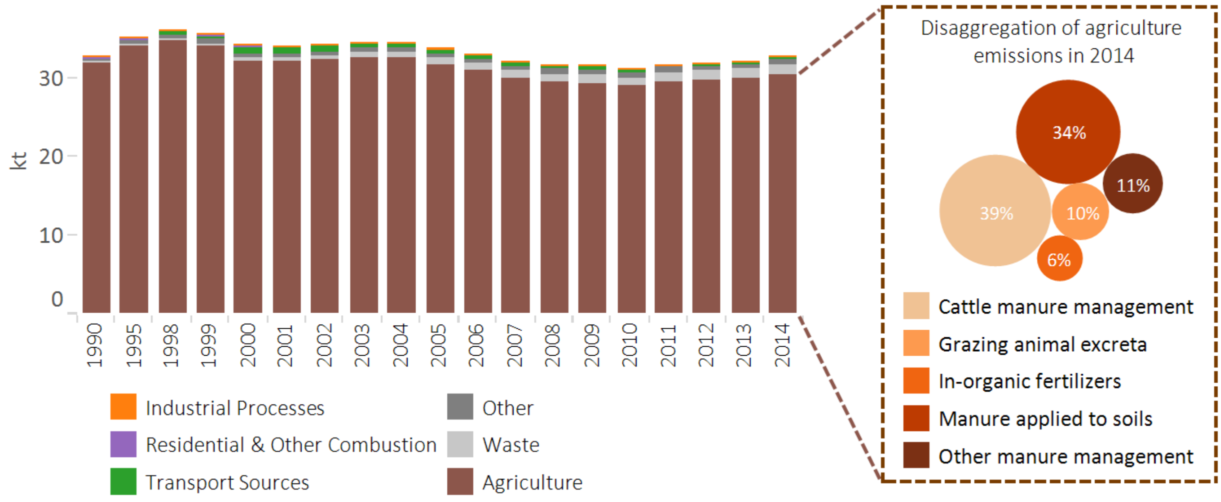
The reductions in PM_{10} and SO_2 after 2001 are due to a reduction in use of coal in several industries but predominantly in power generation, linked to the development of the natural gas pipeline to Northern Ireland which enabled fuel-switching away from coal and oil-fired generation (DECC, 2015d).

Figure 46 – Northern Ireland normalised trends for all pollutants



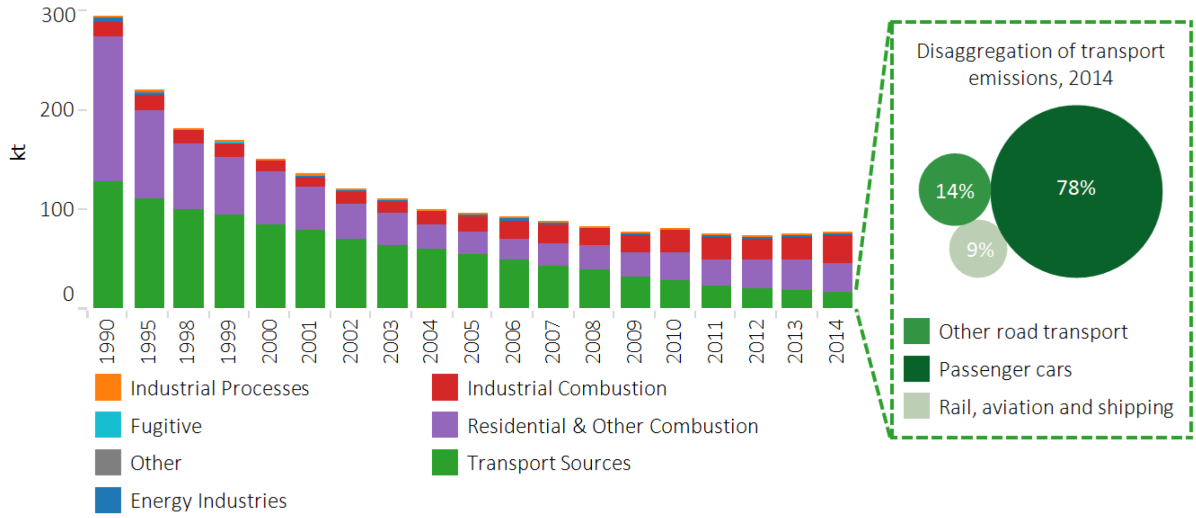
The following sections provide an overview of emissions from each of the seven pollutants giving explanations for the trends and characteristics of the graphs. Data summary tables for these emission estimates can be found in Appendix E. Mapping of the categories used in the graphs can be found in Appendix F.

Figure 47 – Ammonia Emissions in Northern Ireland



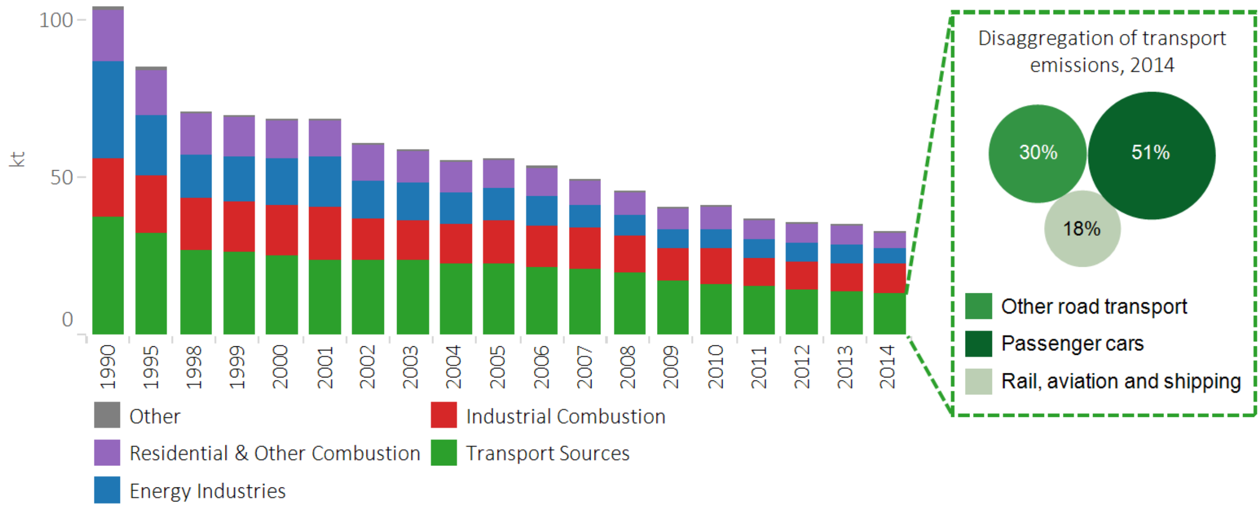
Emissions of **ammonia** were estimated to be 33kt in 2014. This total in 2014 is equal to 1990 emissions in and account for 12% of the2014 UK total. Agricultural sources have dominated the inventory throughout the time series, with cattle manure management and the application of manure to soils accounting for 73% of the emissions from this sector. NH_3 emissions have increased in recent years and this is mainly due to increased emissions from manure applied to the soil, and the manure management processes for pigs.

Figure 48 – Carbon Monoxide Emissions in Northern Ireland



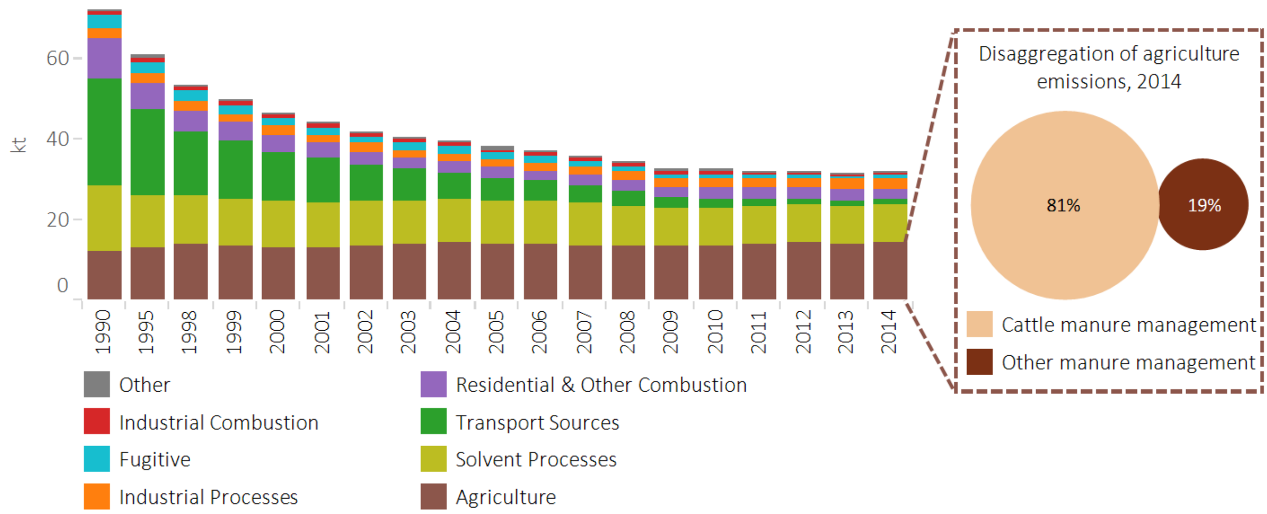
Emissions of **carbon monoxide** were estimated to be 77kt in 2014 and have declined by 74% since 1990. Emissions in Northern Ireland accounted for 4% of the UK total in 2014. This decline in emissions stems from changes in the other combustion sector, and the transport sector, particularly in road transport. The decline is driven by the introduction of Euro standards after 1992 which requires fitting of emission control (e.g. three-ways catalyst) in new petrol vehicles and in more recent years the switch from petrol cars to diesel cars. Since 2008, emissions from passenger cars have further decreased, which is mainly driven by the assumption on improvements in catalyst repair rates made in the NAEI to take into account of the introduction of Regulations Controlling Sale and Installation of Replacement Catalytic Converters and Particle Filters for Light Vehicles for Euro 3 (or above) light duty vehicles. The decrease in residential and other combustion in the earlier part of the time series is mainly due to the expansion of the gas network leading to reductions in the consumption of solid and liquid fuels; the increase in more recent years is due to an increasing quantity of wood combusted in the domestic sector (Waters, 2015).

Figure 49 – Nitrogen Oxides Emissions in Northern Ireland



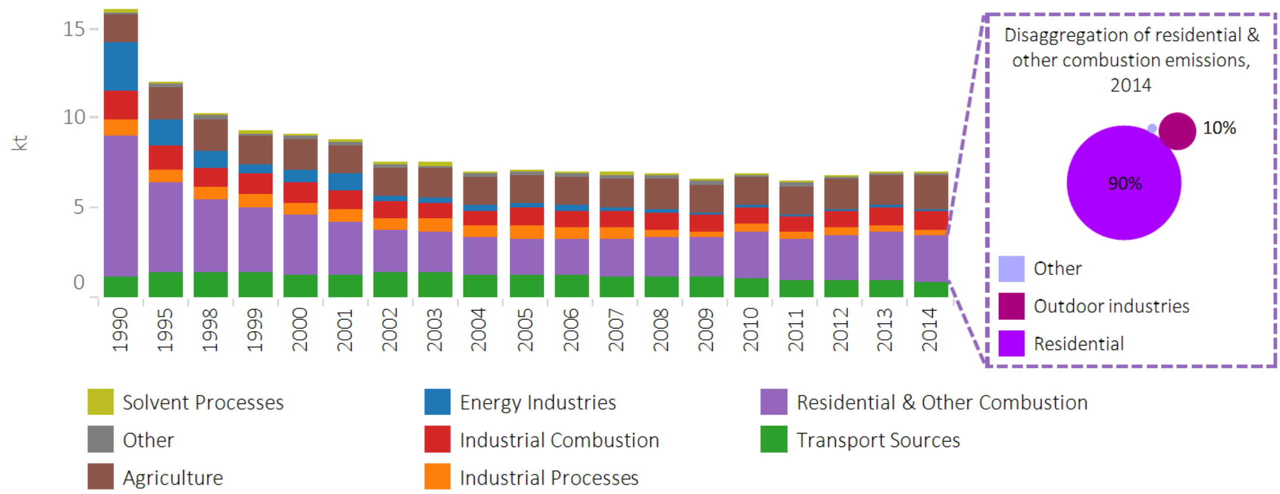
Emissions of **nitrogen oxides** were estimated to be 33kt in 2014, representing 3% of the UK total. Emissions have declined by 68% since 1990, partly due to changes in the transport sector, particularly in road transport. This decline is driven by the successive introduction of tighter emission standards for petrol cars and all types of new diesel vehicles over the last decade. Since 2008, emissions from passenger cars have further decreased, which is mainly driven by the assumption on improvements in catalyst repair rates made in the NAEI to take into account of the introduction of Regulations Controlling Sale and Installation of Replacement Catalytic Converters and Particle Filters for Light Vehicles for Euro 3 (or above) light duty vehicles. However, the increasing number of diesel cars offsets these emissions reductions, because diesel cars emit higher NO_X emissions relative to their petrol counterparts. Energy industries have also had a significant impact on the trend with implementation of abatement technology and reductions in the amount of coal used.

Figure 50 – NMVOC Emissions in Northern Ireland



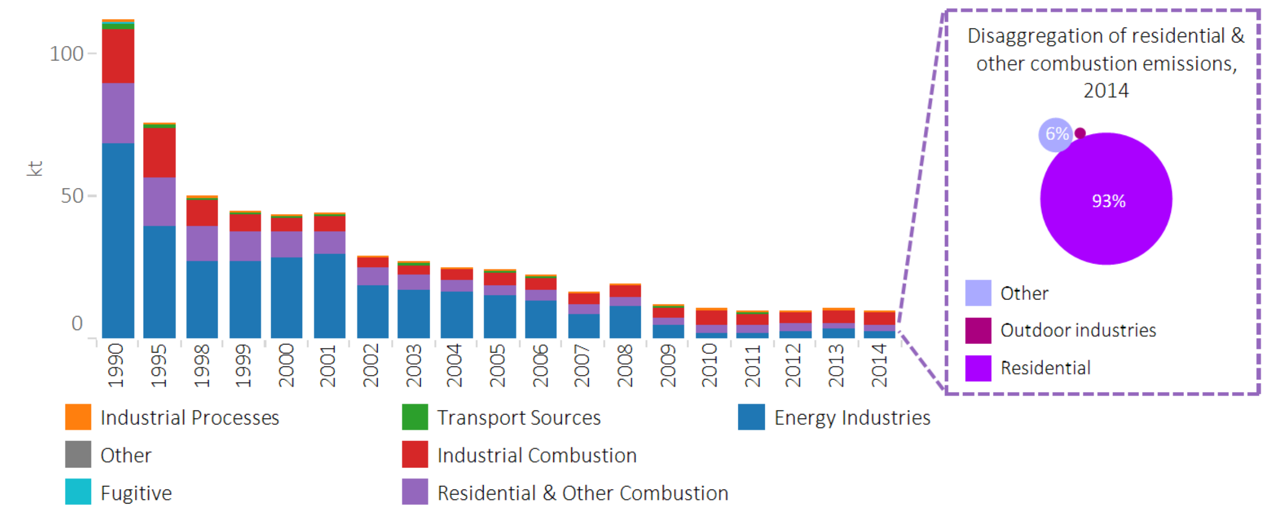
Emissions of **non-methane volatile organic compounds** were estimated to be 32kt in 2014, representing 4% of the UK total. Emissions have declined by 56% since 1990 mainly due to the decrease in road transport emission sources, including evaporative losses. This decline is coincident with emission control technologies introduced in new petrol vehicles since early 1990s and, in more recent years, the increasing proportion of diesel fuelled vehicles in the passenger fleet. The reduction in emissions also occurs to a lesser extent due to the introduction of petrol vapour recovery systems at filling stations. With this large reduction in transport emissions, agriculture is now the most significant source of NMVOC emissions, more specifically emissions from cattle manure management.

Figure 51 – PM_{10} Emissions in Northern Ireland



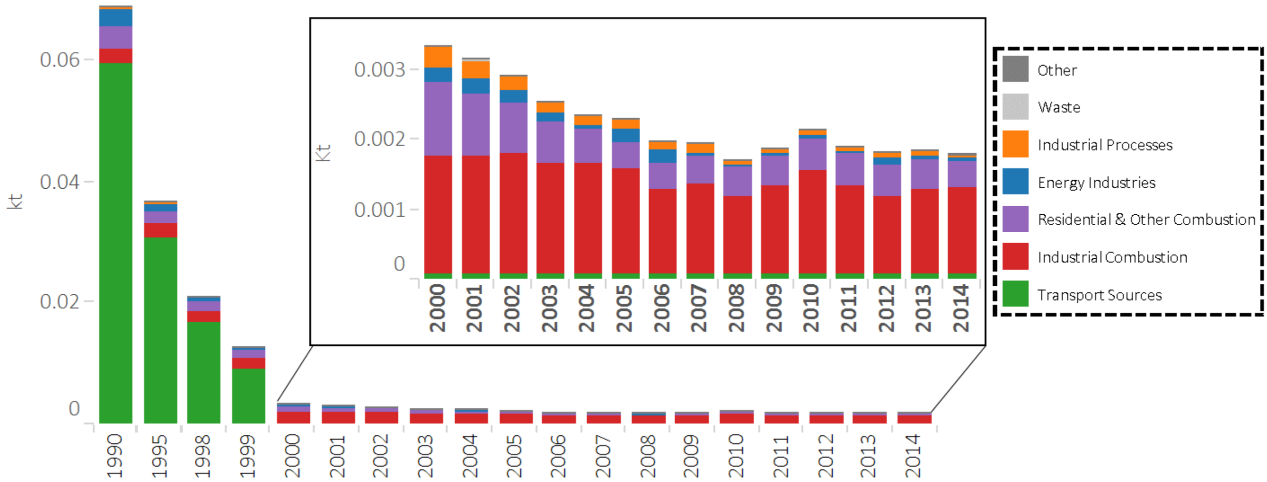
Emissions of **PM_{10}** were estimated to be 7kt in 2014 and accounted for 5% of the UK total. Emissions have declined by 57% since 1990, with the major decrease observed between 1990 and 2004. The decreasing trend was defined by emissions from residential combustion, with a reduction in the use of peat and coal and significant fuel-switching across many economic sectors from coal and oil to natural gas. PM_{10} exhaust emissions from vehicles have been decreasing due to the successive introduction of tighter emission standards over time, while non-exhaust PM_{10} emissions from vehicles have been increasing due to increasing traffic activity. In recent years, emissions from the residential and other combustion sector have primarily increased coincident with increasing wood fuel use in the domestic sector (Waters, 2015).

Figure 52 – Sulphur Dioxide Emissions in Northern Ireland



Emissions of **sulphur dioxide** were estimated to be 10kt in 2014, representing 3% of the UK total in 2014. Emissions have declined by 91% since 1990, which has been dominated by the 96% reduction in energy industries emissions due to the introduction of CCGT (Combined Cycle Gas Turbine) plant, which are more efficient than conventional coal and oil stations and have negligible SO_2 emissions. In addition, as the natural gas network has expanded to different parts of Northern Ireland, other sectors have also shown step-changes in emissions as fuel-switching away from coal has been made possible. Road transport emissions have declined, coincident with the reduced sulphur content of road fuels, both petrol and diesel.

Figure 53 – Lead Emissions in Northern Ireland



Emissions of **lead** were estimated to be 1.8 tonnes in 2014, representing 3% of the UK total in 2014. Emissions have declined by 97% since 1990 almost entirely due to changes in the transport sector. Leaded petrol was phased out from general sale by the end of 1999, which is the reason for the 99.9% decrease in transport emissions between 1990 and 2000. The most significant source of emissions is now the use of lubricants in industry.

Table 5 below provides a summary of the percentage contribution of each sector for each pollutant. Using the ranking of these percentage contributions, the sectors have been ordered to provide its indicative significance across all pollutants. As such, the table below indicates that the residential and other combustion sector is the most significant sector when considering emissions from all pollutants. This sector accounts for at least 15% of emissions for five pollutants: CO, NO_X, Pb, PM_{10} and SO_2.

The majority of the top five sectors are related to the combustion of fuel, except for agriculture, which is a significant sector in Northern Ireland for NH_3, PM_{10} and NMVOC. The table also highlights that whilst emissions from the solvent processes sector are not as significant when considering all pollutants, it is relatively significant when considering emissions of NMVOC.

Table 5 – Source Emission Contributions Ranked by Sector, Northern Ireland 2014

Overall Rank	Sector	NH_3	CO	NO_X	NMVOC	PM_{10}	SO_2	Pb
1	Residential & Other Combustion	0.5%	36.6%	15.3%	8.2%	36.0%	20.0%	20.6%
2	Industrial Combustion	0.0%	38.9%	27.5%	2.0%	14.8%	48.3%	68.8%
3	Transport Sources	0.7%	22.0%	40.4%	3.9%	12.6%	3.9%	4.0%
4	Agriculture	92.9%	0.0%	0.0%	44.9%	26.9%	0.0%	0.0%
5	Industrial Processes	0.0%	0.0%	0.0%	7.9%	5.7%	0.0%	4.1%
5	Energy Industries	0.0%	1.6%	15.7%	0.0%	0.6%	26.7%	2.3%
7	Other	2.0%	0.9%	1.1%	1.1%	2.1%	0.2%	0.1%
8	Solvent Processes	0.0%	0.0%	0.0%	29.5%	1.4%	0.0%	0.0%
9	Fugitive	0.0%	0.0%	0.0%	2.7%	0.0%	0.8%	0.0%
9	Waste	3.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%

* The sector: "other" will include all "other" categories in the inventory and also a number of categories that are insignificant for a specific pollutant.

Emission maps for all seven pollutants are shown below.

Figure 54 – Ammonia Emissions in Northern Ireland, 2014

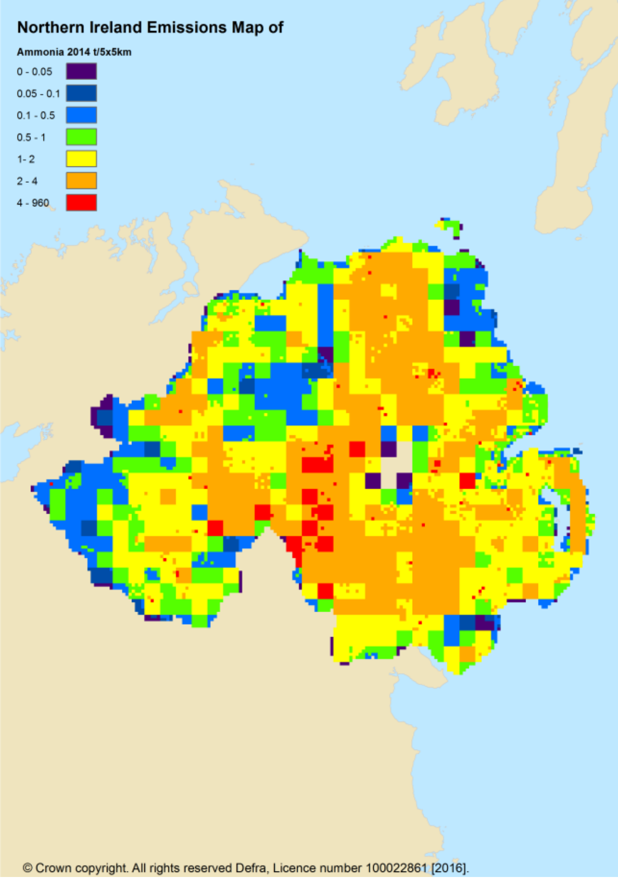


Figure 55 – Carbon Monoxide Emissions in Northern Ireland, 2014

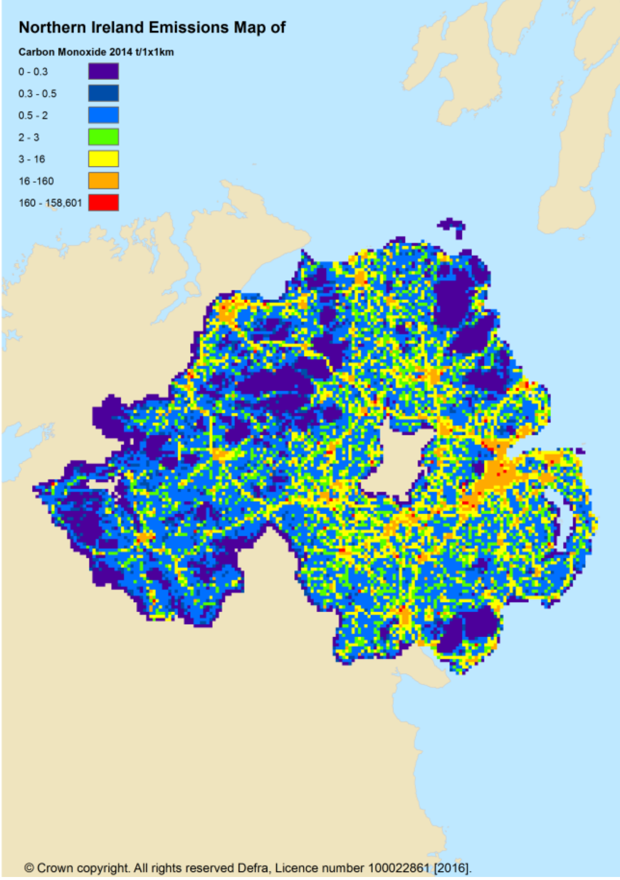


Figure 56 – Nitrogen Oxides Emissions in Northern Ireland, 2014

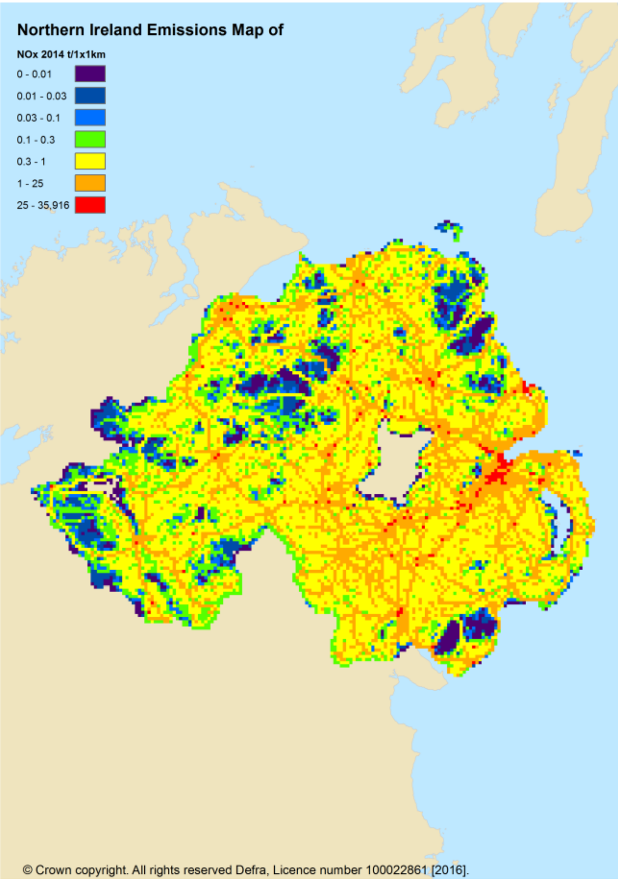


Figure 57 – NMVOC Emissions in Northern Ireland, 2014

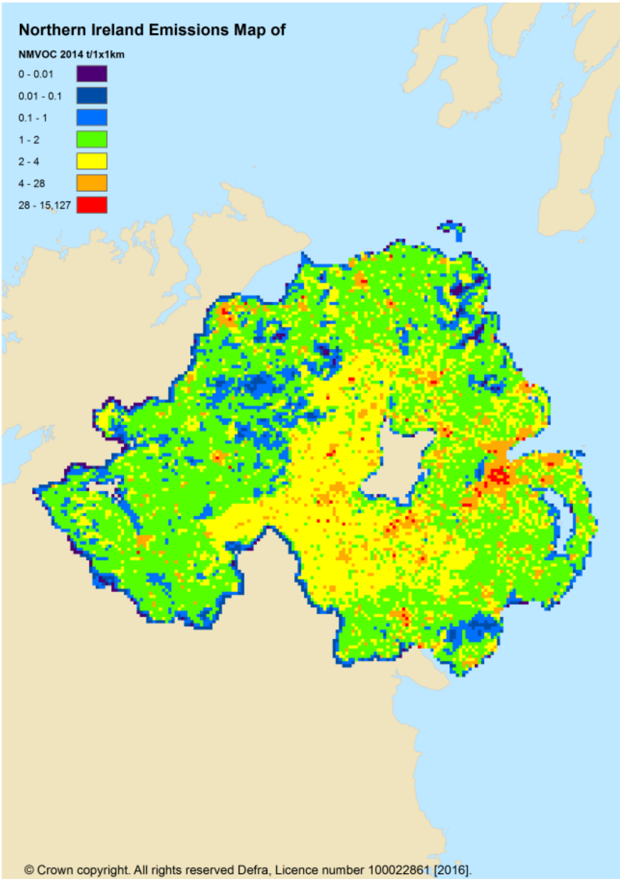


Figure 58 – PM_{10} Emissions in Northern Ireland, 2014

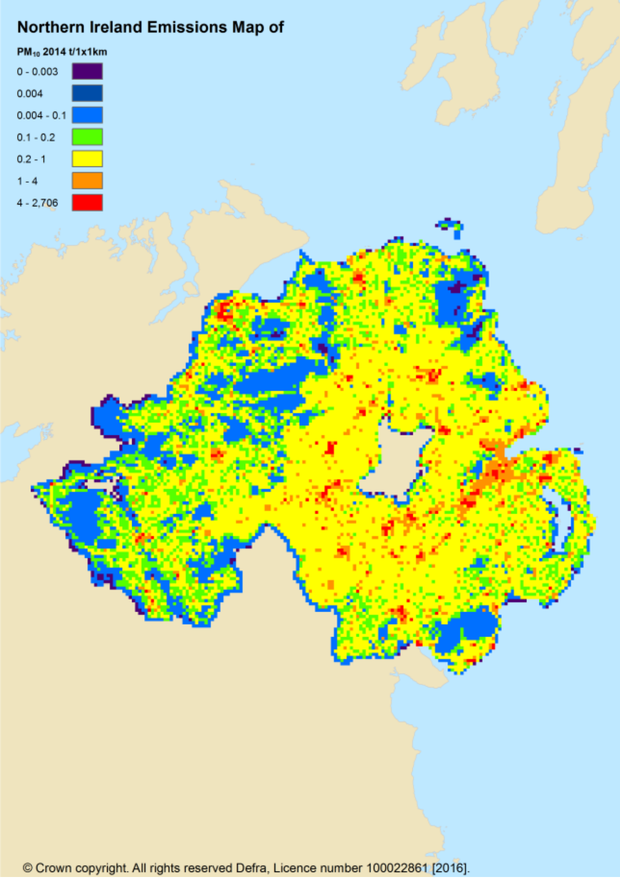


Figure 59 – Sulphur Dioxide Emissions in Northern Ireland, 2014

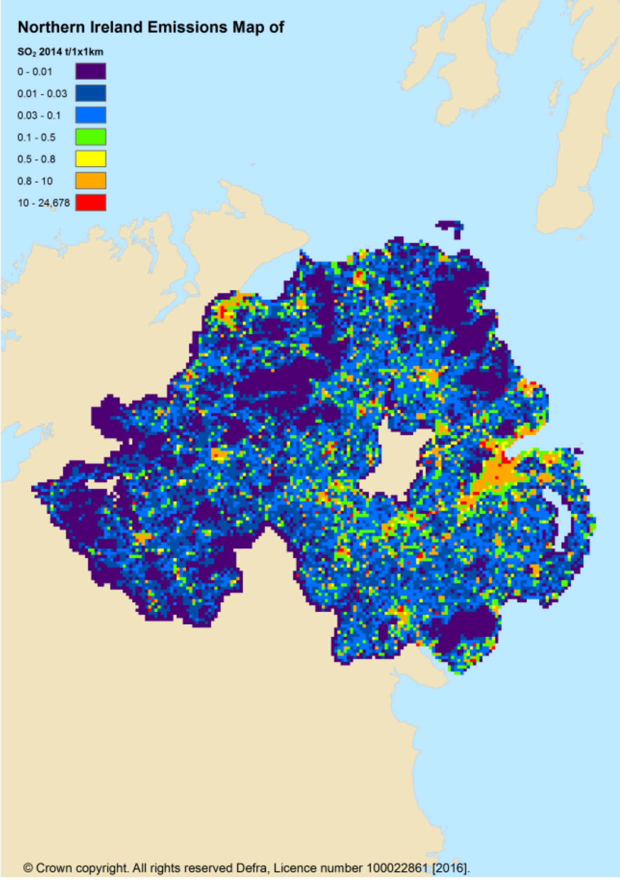
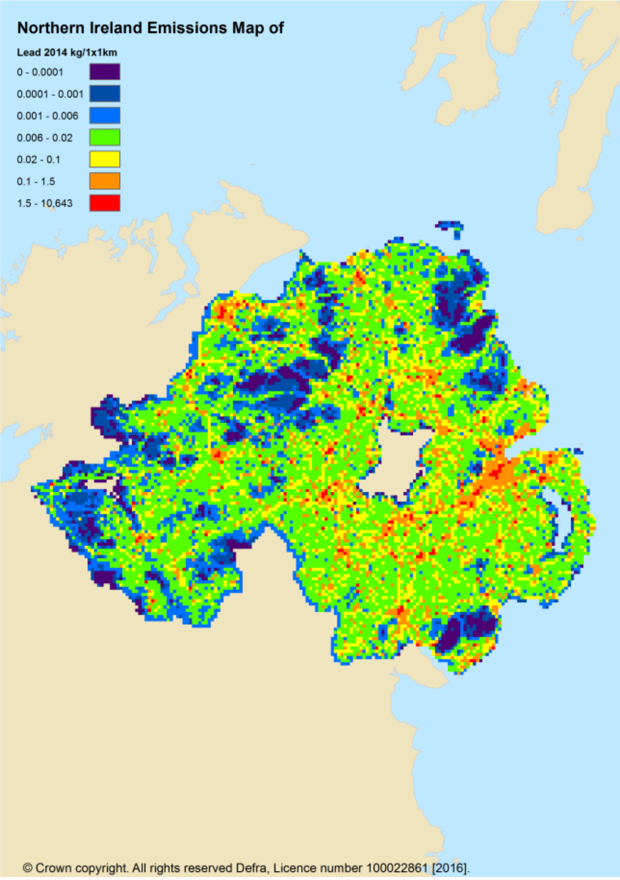


Figure 60 – Lead Emissions in Northern Ireland, 2014



Appendix A Background to Inventory Development

The following sections provide further detail on the background of the air quality pollutant inventory development for the Devolved Administrations. This is supporting information for Section 1.1 of the main report.

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. The estimated burden in the UK of anthropogenic particulate matter air pollution in 2010 as a loss of life expectancy from birth is approximately six months. The burden as an effect on mortality in 2010 was equivalent to nearly 29,000 deaths in the UK at typical ages (COMEAP, 2010) and an associated loss of total population life of 300,000 life-years (PHE, 2014). The policies described below, which aim to improve air quality, are currently in place in the UK.

A.1 National Emissions Ceilings Directive

Within the EU, the National Emission Ceilings Directive (NECD) was agreed in 2001. It sets emission ceilings to be achieved from 2010 onwards for each Member State for the same four pollutants in the original Gothenburg Protocol, which cause harm to people's health and to the natural environment: sulphur dioxide, nitrogen oxides, non-methane volatile organic compounds and ammonia. The UK met all four of its emissions ceilings by 2010, and continues to do so.

The European Commission has prepared a revision to the NECD. The Directive is not yet in force, but it will ensure that the emission ceilings set in the original directive for SO_2, NO_X, NMVOC and NH_3 shall apply until 2020. In addition, new national emission reduction commitments will be applicable from 2020 and 2030 onwards for SO_2, NO_X, NMVOC, NH_3, $PM_{2.5}$ and CH_4.

A.2 Gothenburg Protocol

The EU Member States, Central and Eastern European countries, the United States and Canada negotiated the 'multi-pollutant' protocol under the Convention on Long-Range Transboundary Air Pollution (CLRTAP) 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 (Gothenburg Protocol). It incorporates several measures to facilitate the reduction of emissions:

- Emission ceilings are specified for sulphur, nitrogen oxides, ammonia and NMVOCs, which were to be attained by 2010 and all subsequent years;
- Emission limits are specified for sulphur, nitrogen oxides and NMVOCs from stationary sources;
- Emission limits are indicated for carbon monoxide, hydrocarbons, nitrogen oxides and particulates from new mobile sources;
- Environmental specifications for petrol and diesel fuels are given;
- Several measures to reduce ammonia emissions from the agriculture sector are required.

The Gothenburg Protocol was amended in 2012 to include national emission reduction commitments (expressed as percentage reduction from emission levels in 2005) to be achieved in 2020 and beyond. Several of the Protocol's technical annexes were also revised with updated sets of emission limit values for both key stationary sources and mobile sources, as well as the addition of emission reduction commitments for $PM_{2.5}$.

A.3 Industrial Emissions Directive

The Industrial Emissions Directive (2010/75/EU) entered into force in 2011 and aims to minimise pollution from applicable industrial sources throughout the EU. This Directive integrated seven existing pieces of legislation. Operators of particular industrial installations are required to obtain an integrated permit from the Environment Agency, Scottish Environment Protection Agency, Natural Resources Wales or the Northern Ireland Environment Agency.

A.4 Heavy Metals Protocol

The LRTAP Convention has been extended by a number of protocols, including the 1998 Protocol on Heavy Metals, to which the UK is a signatory. The Heavy Metals Protocol 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 requires countries to phase out leaded petrol. Under the protocol, measures are introduced to lower heavy metal emissions from other products (such as 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.

The protocol was amended in 2012 to introduce more stringent emission limit values for emissions of particulate matter and of the specific heavy metals cadmium, lead and mercury applicable for certain combustion and other industrial emission sources releasing them into the atmosphere. The emission source categories for the three heavy metals were also extended to the production of silico- and ferromanganese alloys.

A.5 Persistent Organic Pollutants (POPs) Protocol

The UNECE adopted the Protocol on Persistent Organic Pollutants (POPs) in 1998, which focuses on a list of 16 substances that have been singled out according to agreed risk criteria. The substances comprise eleven pesticides, two industrial chemicals and three by-products/contaminants.

The objective of the Protocol is to eliminate any discharges, emissions and losses of POPs. The Protocol bans the production and use of some products, whilst others are scheduled for elimination at a later stage. The Protocol includes provisions for dealing with the wastes of products that will be banned. It also obliges Parties to reduce their emissions of dioxins, furans, polycyclic aromatic hydrocarbons (PAHs) and hexachlorobenzene (HCB) below their levels in 1990 (or an alternative year between 1985 and 1995). For the incineration of municipal, hazardous and medical waste, it lays down specific limit values.

The Protocol was amended in 2009 to include seven new substances and implement revised obligations for some substances as well as emission limit values (ELVs) for waste incineration.

A.6 Sulphur Content of Liquid Fuels Directive

The EC's Directive to limit sulphur content in gas oil and fuel oil has been transposed into UK regulations which were initially established in 2000 but were updated with Statutory Instruments brought into force across the DAs via the Sulphur Content of Liquid Fuel Regulations 2007 (England and Wales: SI79/2007; Scotland: SI 27/2007; Northern Ireland: SI 272/2007). The main impact of these regulations has been to gradually drive down the maximum sulphur content of refinery products, with the 2007 Regulations requiring that gas oil has a maximum 0.1% content Sulphur by mass from January 2008 onwards. The impacts of this change are evident within the recent emission trends of the UK and DA inventories as SO_2 emissions have declined significantly between 2007 and 2008 from road transport (1A3b) and other sources where petroleum-based fuels are dominant.

A.7 Air Quality Strategy for England, Scotland, Wales and Northern Ireland

The UK Government leads on the UK's input to International and European legislation relating to Air Quality, with input from the Scottish Government, Welsh Government and Northern Ireland Government. Linked to the requirements of the EU Directives, the Air Quality Strategy for England, Scotland, Wales and Northern Ireland (Defra, 2007) sets out a framework of standards and objectives for the air pollutants of most concern at the time (sulphur dioxide, particulate matter, nitrogen oxides, polycyclic aromatic hydrocarbons, benzene, 1, 3-butadiene, carbon monoxide, lead, ammonia and ozone).

These standards relate to the quality of air, whilst the objectives are policy targets for the restriction of levels at which particular substances are present in the air. The aim of the strategy is to reduce concentrations of air pollutants to avoid unacceptably higher impacts on human health and ecosystems.

A.8 Air quality plan for nitrogen dioxide (NO_2) in UK

The Air quality plans for nitrogen dioxide form the government's plan for reducing nitrogen dioxide emissions in the UK's towns and cities as part of its commitment for cleaner air.

The air quality plans set out targeted local, regional and national measures to ensure that UK air will be cleaner than ever before. This will build on significant improvements in air quality in recent decades and fulfil the UK's environmental responsibilities, benefiting health and making cities better places to live and work.

The documents include 38 zone plans, a UK overview document, a list of national measures and a technical report. High resolution maps showing the modelled effects of the measures by 2020 and 2025 can be found on the UK Air website (UK-AIR, 2015).

A.9 EU Air Quality Directive

The Directive on Ambient Air Quality and Cleaner Air for Europe (2008/50/EC) sets concentration limit values for seven pollutants, including NO_X, SO_2, PM_{10} and CO and an exposure reduction target for $PM_{2.5}$. The Fourth Daughter Directive (2004/107/EC), under the now repealed Air Quality Framework Directive, set target values for a further five substances (heavy metals and polycyclic aromatic hydrocarbons). Member States are required to submit annual reports to the European Commission on whether the concentration limits have been achieved within their respective areas and to develop management plans where they are not. This legislative framework was established to manage air quality and to avoid exceeding the air pollutant concentration limits known to be harmful to human health and the environment.

The 2008 Directive was transposed into UK law by the Air Quality Standards Regulations (2010) and their equivalents for Scotland, Wales and Northern Ireland.

Appendix B Inventory Methodology

This Appendix provides further detail on how the inventory is compiled, and the data sources that are used during compilation. This information supports Section 1.3 of the main report.

The disaggregation of air quality (AQ) pollutant emissions across the four Devolved Administrations (DAs) of the UK is part of a programme of on-going data and methodology improvement, to provide emission inventories for the Devolved Administrations. This programme spans both greenhouse gas and air quality emission inventories, and is driven by the developing requirements for sub-national reporting against emission targets and Devolved Administration policy development.

B.1 Data Availability

For many emission sources of air quality pollutants, the data available for Devolved Administration 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, energy balance data (i.e. fuel production, transformation and sector-specific consumption data) are not available across the time series for England, Scotland, Wales and Northern Ireland. Sub-national energy statistics are published annually by the Department for Business, Energy & Industrial Strategy (BEIS) within the quarterly Energy Trends publication (DECC 2015b). These sub-national 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 combustion source sectors: industry, commercial, agriculture (combustion sources) and domestic.

These BEIS sub-national energy statistics are based on local electricity and gas consumption patterns, as part of a project to develop Local Authority carbon dioxide emissions data. These statistics use local electricity and gas use data from the National Grid and the gas supply network operators (formerly Transco). Solid and liquid fuel use is calculated using point source consumption data for major industrial sites, and a complex modelling process to distribute remaining UK fuel allocations that uses employment and population data and takes account of smoke control zones and the patterns of gas and electricity consumption. The latest available data include Local Authority solid and liquid fuel use estimates for 2005 to 2013, with gas and electricity data also being available up to 2014.

The BEIS sub-national energy statistics are National Statistics and are revised and improved each year through targeted sector research aimed at reducing uncertainties in the modelling approach. The lack of consistent and comprehensive fuel use data from across the Devolved Administrations (especially for solid and liquid fuels) leads to significant potential errors in the distribution of UK fuel use across the regions. Expert judgement and proxy data are used to address data gaps and inconsistencies in energy use data over the time series. The Devolved Administrations' emission estimates for earlier years in the inventory time series and the reported inventory trends are associated with higher uncertainty than the data and trends reported in the UK emissions inventory.

The BEIS sub-national energy statistics are used to derive estimates for industry sector combustion of fuels such as fuel oil, gas oil and coal. These data are based predominantly on analysis of available point source data, supplemented by production and employment surveys, and in several sectors data on building Display Energy Certificates and Energy Performance Certificates are used to provide a better indicator of the Devolved Administrations' energy use than the production or employment indices.

For other significant emission sources there are 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 Industrial Emissions Directive (IED). Major sources include power stations, cement and lime kilns, iron & steel works, aluminium and other non-ferrous metal plant, chemical industries. These data are not available across the full time series from 1990, as the regulatory reporting regimes were developed in the late 1990s (in England, Wales and Northern Ireland) and early 2000s (in Scotland).
- Emissions from oil and gas terminals and offshore platforms and rigs, are based on operator estimates reported to the BEIS Offshore Inspectorate team (DECC Offshore Inspectorate, 2015) through the

Environmental Emissions Monitoring System (EEMS). 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, whilst emissions from onshore oil & gas terminals are assigned to the appropriate country inventories.

- **Agricultural emissions** are based on official livestock datasets, annual fertiliser use surveys, farm management practice surveys and detailed emission factors from recent literature sources. The methodology for compiling the inventory of NH_3 emissions from agriculture follows that of Misselbrook, T.H. et al., (2004). Emissions are affected by a large number of factors, including animal species, age, weight, diet, housing and manure management systems, and environmental conditions. As such, the interpretation and extrapolation of experimental data is problematic, making emission estimates uncertain.
- Emissions from **waste disposal activities** are estimated based on modelled emissions from the UK air quality inventory (Defra, 2012) split out across the DAs based on local authority waste disposal activity reporting (www.wastedataflow.org) which provides an insight into the local shares of UK activity for recycling, landfilling, incineration and other treatment and disposal options. Waste incineration emissions are based on point source emissions data.

For some sources where regional data are not available, current NAEI 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 (Tsagatakis *et al.*, 2016).

In many source sectors, there are insufficient local activity 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.

B.2 Key Compilation Resources

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. There are step-changes in data availability during the time series, such as installation-specific fuel use data from major industrial plant under EU ETS (from 2005 onwards) and sites regulated under Environmental Permitting Regulations / Industrial Emissions Directive (EPR/IED) (1998 onwards for England and Wales, 1999 onwards for Northern Ireland, and in 2002 and from 2004 onwards for Scotland).

These data sources are used, where possible, to inform the back-casting of emission estimates, but there remains a greater level of uncertainty in emission estimates from the earlier part of the time series compared to more recent years. Furthermore, the data quality from these environmental regulatory systems has evolved over the years as monitoring, reporting and quality checking methods and protocols have developed. This also impacts upon the accuracy of the reported emissions of air quality pollutants which are used within inventory compilation, such that more recent data are likely to be more accurate. The uncertainties in the Devolved Administrations’ air quality inventories are discussed in more detail in Appendix D.

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

- NAEI point source database;
- NAEI emission mapping grid data;
- Local and regional data derived from analysis of activity data trends;
- Generic parameters and proxy data such as population or economic indicators such as GVA data.

These main resources used within the DA air quality pollutant inventory are outlined below.

B.2.1 NAEI Point Source Database

Operators of all EPR/IED-regulated industrial plant are required to submit annual emission estimates of a range of pollutants (including all of those pertinent to this report) 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, Natural Resources Wales and the Northern Ireland Environment Agency) 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 EPR/IED-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 System (EU ETS), which has been running since 2005. Annual data requests are also made directly to plant operators or trade associations 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 (such as 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.

The NAEI point source database is most useful for industries that are dominated by large EPR/IED-authorised plant, such as power stations, refineries, iron & steel manufacturing, cement and lime kilns and so on. For these sectors, the point source database covers nearly 100% of emissions, and is regarded to be the best available dataset for such sources, as it is largely based on energy use and emissions data derived from regulatory agency sources that are subject to quality checking and (in the case of EU ETS data) independent verification.

Annual revisions to the NAEI point source database are conducted when new data become available and/or when installation-level data are revised by operators, regulators or through enquiry by the UK inventory team to resolve data discrepancies which may be evident between reporting mechanisms.

B.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 the Devolved Administrations' Air Quality Pollutant Inventory. The maps are compiled at a 1km resolution and are produced annually for the most recent NAEI database. The mapped emissions data are available on the NAEI web site at: http://naei.defra.gov.uk/data/mapping. For a more detailed description of the integration of point source data analysis and the development of UK emission maps, see Tsagatakis et al. (2016).

The emission maps are used by the UK inventory team 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, Natural Resources Wales, Northern Ireland Environment Agency, and 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.

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, the project team has focussed resources on ensuring that the most significant sources are assessed most accurately across the time series, whilst less significant source sectors may be disaggregated using a mapping grid for all years in the time series.

The table below provides a summary of the mapping grid data availability for each sector using the Nomenclature for Reporting (NFR) structure, which is the format currently required for the submission under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP).

Table 6 - Disaggregation Methodologies for the Devolved Administrations Air Quality Pollutant Inventories

NFR Sector	Source	Disaggregation Method
1A1a	Public electricity and heat production (all fuels)	All emissions from major fuels are derived from the point source database, which is based on annual emissions estimates reported to UK environmental regulators by IPC/IED-regulated industry and (since 2005) fuel use data available from the EU ETS. Environment Agency (2015a,b), SEPA (2015a,b), Natural Resources Wales (2015a,b) NIEA (2015a,b). Exceptions are minor fuels: sewage gas use is estimated based on UK-wide estimates disaggregated using DA share of UK population (ONS, 2015); landfill gas use is based on the elution of methane from landfills from the MELMOD model (Ricardo, 2015).
1A1b	Petroleum refining (all fuels)	Point source data provided by plant operators to IPC/IED pollution inventories (see 1A1a). Further detail on combustion and process emissions provided by UKPIA (2015).
1A1c	Coke & SSF production (all fuels)	Point source data provided by plant operators (see 1A1a). Regional iron & steel production and fuel use data (ISSB, 2015). UK fuel use data from DECC (2015a).
	Nuclear fuel production (all fuels)	All emissions are in England
	Colliery combustion and colliery methane production (all fuels)	Deep mined coal production, data from the Coal Authority (2015).
	Gas production, downstream network (all fuels)	EU ETS installation data for natural gas use from 2005-2014. All other years estimated based on the DA share from the 2005 EU ETS data. Environment Agency (2015b), SEPA (2015b), Natural Resources Wales (2015b), NIEA (2015b)
	Upstream oil & gas, including gas separation plant (all fuels)	DECC Offshore Inspectorate (2015) EEMS inventory. Point source data for NO_X, SO_2, VOC. (CO and PM_{10} assumed same as SO_2.)
1A2a	Blast furnaces & sinter plant	Point source data provided by plant operators (see 1A1a), supplemented by site-specific breakdown of emissions from Tata Steel (2014).
	Iron & steel combustion plant (all fuels)	Regional iron & steel production and fuel use data (ISSB, 2015) used to inform estimates to 2004. 2005 onwards derived from activity data from EU ETS.
1A2b	Combustion in non-ferrous metals manufacturing industry	Pollution Inventory (EA 2015a, SEPA 2015a, NRW 2015a, NIEA 2015a), EU ETS (EA 2015b, SEPA 2015b, NRW 2015b, NIEA 2015b) IDBR and employment data (ONS, 2015). Overall analysis of the 1A2b,c,d,e and g sectors used to constrain the DA totals to previous 1A2 DA estimates, using 1A2g Other Industry as residual. Detailed analysis conducted for 2008-2014; 1A2b,c,d,e 1990-2008 DA trends matched with UK trends due to data limitations for the detailed industry sub-sector activities at DA level. Exceptions: All NH_3 production (1A2c) is located in England.
1A2c	Combustion in chemical manufacturing industry, NH_3 production	
1A2d	Combustion in paper, pulp and print manufacturing industry	
1A2e	Combustion in food processing, beverages and tobacco manufacturing industry	

NFR Sector	Source	Disaggregation Method
1A2f	Combustion in minerals industries: cement and lime	Cement: Point source data from plant operators (see 1A1a). All lime production is in England.
1A2g	Refractory & ceramic production	Regional GDP data (ONS, 2015).
	Autogenerators (coal)	All emissions in England.
	Other industrial combustion (oils)	Sub-national energy statistics, DECC (2015b), and analysis of point source data derived from EU ETS and IED data. Environment Agency (2015a,b), SEPA (2015a,b), NRW (2015a, b) NIEA (2015a,b). Overall analysis of the 1A2b,c,d,e and g sectors used to constrain the DA totals to previous 1A2 DA estimates, using 1A2g Other Industry as residual.
	Other industrial combustion (SSF, coke)	
	Other industrial combustion (coal)	
	Other industrial combustion & auto-generators (gas)	Natural gas consumption data from gas network operators: National Grid (2015), Northern Gas Networks (2015), Scotia Gas Networks (2015), Wales & West Utilities (2015), Airtricity (2015), Firmus Energy (2015), Vayu (2015). Sub-national energy statistics, DECC (2015b), and analysis of point source data derived from EU ETS and IED data. Environment Agency (2015a,b), SEPA (2015a,b), NRW (2015a,b), NIEA (2015a,b).
	Industrial off-road machinery (all fuels)	Sub-national energy statistics (DECC, 2015b) and DA GDP data (ONS, 2015).
1A3ai (i)	Aircraft – international take-off and landing (all fuels)	CAA (2015), UK airport statistics. All take-off and landing cycle emissions for each flight assigned to DA of origin airport.
1A3aii (i)	Aircraft – domestic take-off and landing (all fuels)	
1A3bi to 1a3bvii	Road Transport	Vehicle km, DfT, NI Department for Regional Development (DRD) Emission factors: Boulter et al. (2009) COPERT 4 (EEA, 2013b) Fuel efficiency: Road Freight Statistics, DfT (2015) Composition of fleet: Vehicle Licensing Statistics Report, DfT (GB) Dept. of Regional Development (NI). Traffic data: National Traffic Census, DfT (England, Scotland, Wales: 1990-2014) Dept. of Regional Development (NI: 1990-1999), Traffic Census Report (NI: 2000), Vehicle Kilometres of Travel Survey of Northern Ireland Annual Report (NI: 2001), Traffic and Travel Information, DRDNI (NI: 2002- 2014) Fuel consumption: Digest of UK Energy Statistics (1990-2014),
1A3c	Railways: intercity, regional and freight	UK specific emission factors in g/vehicle (train) km are taken from the Department for Transport's Rail Emissions Model (REM) for different rail engine classes based on factors provided by WS Atkins Rail. Data from UKPIA on sulphur content of gas oil. Gas oil consumption data from Office of Rail Regulation for passenger and freight trains for 2005-2009 combined with trends in train km to estimate consumption for other years. Train km data from REM are used to provide the breakdown between train classes. Fuel consumption: Digest of UK Energy Statistics (1990-2014)
1A3dii	Coastal shipping (gas oil, fuel oil)	Port movement data, DfT (2015b) Maritime Statistics. Estimates for all inland waterways are based on population (ONS, 2015).
1A3eii	Aircraft support vehicles (gas oil)	Regional aircraft movements, DfT (2015d)
1A4a	Railways – stationary combustion	Sub-national energy statistics, DECC (2015b)
	Industrial & commercial combustion	Sub-national energy statistics, DECC (2015b), and analysis of point source data and public and commercial mapping grids from regional employment data by sector. Gas use data supplemented by data from gas network operators (same references as 1A2g). PSEC data (DFPNI 2015) used to inform the N Ireland estimates.
	Public sector combustion	
1A4bi	Domestic combustion	For coal, anthracite, petroleum fuels, natural gas, analysis is from sub-national energy statistics, DECC (2015b) and Housing Condition Survey data. Domestic peat combustion data from CEH (Personal communication, 2015). Northern Ireland gas use in the residential

NFR Sector	Source	Disaggregation Method
		sector is based on estimates from all energy suppliers in Northern Ireland (Airtricity, Firmus Energy, Vayu; all 2015)
1A4bii	Household and gardening mobile machinery (all fuels)	Regional dwellings data, ONS (2015).
1A4ci	Agriculture – Stationary combustion	Agricultural employment data, Defra (2015a) used for allocation of solid and gaseous fuels. Regional energy statistics, DECC (2015b) used for petroleum-based fuels. N Ireland gas use data for agriculture sector based on 2005 estimate for the sector provided by Phoenix Natural Gas (2007).
1A4cii	Agriculture – mobile machinery	Agricultural off-road mapping grid, with overall petroleum fuel allocations constrained to the DECC sub-national energy data (DECC, 2015b)
1A4ciii	Fishing vessels	Port movement data, DfT (2015b) Maritime Statistics
1A5b	Military aircraft and naval shipping	Regional GDP data (ONS, 2015).
1B1a	Deep-mined coal	Regional deep mine production, Coal Authority (2015). Emissions from closed coal mines derived from WSP report (Fernando, 2011)
1B1b	Charcoal, Coke & SSF production	Charcoal production estimates based on regional GDP data (ONS, 2015). Coal feed to coke ovens, ISSB, WS, DECC and (1999-2004) PI. 2005 onwards: EU ETS (EA 2015b, SEPA 2015b, NRW 2015b, NIEA 2015b)
	Iron & steel flaring	Coal feed to coke ovens, ISSB, WS, DECC and (1999-2004) PI. 2005 onwards: EU ETS (EA 2015b, SEPA 2015b, NRW 2015b, NIEA 2015b)
1B2ai	Upstream oil & gas: offshore oil loading, well testing.	All emissions unallocated.
	Upstream oil & gas: process emissions, onshore oil loading, oil terminal storage	Emissions derived from the DECC Offshore Inspectorate (2015) EEMS point source dataset, with extrapolations back to cover 1990, 1995 where data gaps are evident.
1B2aiv	Refinery process emissions (drainage, tankage, general)	Point source data provided by plant operators (see 1A1a), UKPIA (2015) and analysed using the NAEI point source database.
1B2av	Petrol terminal storage and loading, Refinery road and rail haulage emissions	Point source data provided by plant operators (see 1A1a), supplemented by refinery road/rail loading estimates from UKPIA (2015).
	Petrol station emissions from delivery, vehicle refuelling, storage tanks and spillages	Regional road transport distribution based on analysis of vehicle km data for different vehicle types and the resultant fuel use distributions. Hence, references as 1A3b.
1B2b	Gasification processes	Regional GDP data (ONS, 2015)
	Upstream gas production: terminal storage, well testing, process emissions	All well testing emissions offshore (therefore all Unallocated). Process and storage emissions based on operator-reported data from EEMS (DECC Offshore Inspectorate, 2015) and PI/SPRI (Environment Agency 2015a; SEPA 2015a; NRW 2015a)
	Gas leakage from supply infrastructure	Leakage data provided by gas network operators: National Grid (2015), Northern Gas Networks (2015), Scotia Gas Networks (2015), Wales & West Utilities (2015), Airtricity (2015).
1B2c	Upstream oil & gas: flaring & venting	Emissions derived from the EEMS dataset (DECC Offshore Inspectorate, 2015), with extrapolations back to cover 1990, 1995 where data gaps are evident.
	Refinery flaring	Point source data provided by plant operators (see 1A1a) supplemented by data from the trade association (UKPIA, 2015)
2A1	Cement decarbonising	Point source data provided by plant operators (see 1A1a).
	Concrete batching	Regional GDP data (ONS, 2015).
	Slag cement production	Slag cement production mapping grid

NFR Sector	Source	Disaggregation Method
2A2	Lime production decarbonising	All lime production in England.
2A3	Glass industry process emissions	Point source data provided by plant operators (see 1A1a). Exceptions are emissions from production of flat glass, frits and lead crystal, all of which only occur in England.
2A5	Construction, asphalt manufacture	Regional GDP data (ONS, 2015).
	Quarrying (aggregates)	Quarries mapping grid.
	Lead mining	All emissions in England.
2A6	Bricks and ceramics	All fletton brick production in England. Non-fletton brick estimates based on point source data provided by plant operators (see 1A1a). Process emissions from concrete batching plants and ceramics manufacture based on regional GDP statistics (ONS, 2015).
2B1	Ammonia production	All ammonia production now in England. Point source emissions data and plant capacity data used for earlier years.
2B2	Nitric acid production	Point source data provided by plant operators (see 1A1a). Now all England.
2B3	Adipic acid production	Point source data provided by plant operators (see 1A1a). All England.
2B6	Chemical industry – titanium dioxide	All emissions in England
2B7	Chemical industry – soda ash manufacture	All emissions in England
2B10	Ship purging	All emissions unallocated (i.e. offshore)
	Chemical industry process emissions	Point source data provided by plant operators (see 1A1a). Exceptions are sectors where all emissions are in England: acrylonitrile, alkyl lead, ammonia-based fertiliser, carbon black, ethylene oxide, methanol, sulphuric acid production/use, coal tar and bitumen processes.
2C	Industrial process emissions from SMEs, hot & cold steel rolling emissions, lead battery manufacture.	Regional GDP data (ONS, 2015).
	Process emissions from: blast furnaces, EAFs, BOFs, primary aluminium production & anode baking, alumina production, non-ferrous metal processes	Point source data provided by plant operators (see 1A1a), plus supplementary data provided by Tata Steel (2014), SSI (2014) and the ISSB (2015)
	Flaring & stockpile emissions at iron & steelworks	Regional iron & steel production and fuel use data (ISSB, 2015).
	Foundries	Foundries mapping grid
2D3a	Aerosol and non-aerosol products (cosmetics & toiletries, household products, paint thinners),	Population data, ONS (2015).
	Agrochemical use	Arable mapping distribution grid
2D3b	Road dressings and bitumen use	Road dressing mapping grid.
	Asphalt manufacture	Regional GDP data (ONS, 2015).
2D3d	Trade & retail decorative paints,	Population data, ONS (2015).
	Industrial coatings: commercial vehicles, aircraft, agricultural and construction vehicles.	Regional GDP data (ONS, 2015).

NFR Sector	Source	Disaggregation Method
	Industrial coatings: wood, metal, plastic, marine, vehicle refinishing.	Various coatings mapping distribution grids are used based on surveys of locations of such processes.
	Industrial coatings: coil, film, metal packaging, automotive, drum, textile, paper	Point source data provided by plant operators (see 1A1a).
2D3e	Domestic surface cleaning.	Population data, ONS (2015).
	Industrial surface cleaning	Industrial employment mapping distribution grid.
	Leather coating and degreasing	Regional GDP data (ONS, 2015).
2D3f	Dry cleaning (solvent use)	Dry cleaning mapping grid
2D3g	Rubber & plastic products	Population data, ONS (2015).
	Tyre manufacture	Point source data provided by plant operators (see 1A1a).
	Industrial coating manufacture: adhesives, inks, solvents and pigments	Various industry-specific coatings mapping distribution grids
2D3h	Printing – flexible packaging, publication gravure	Point source data provided by plant operators (see 1A1a).
	Other printing sources	Population data, ONS (2015).
2D3i	Solvent use	Population data, ONS (2015).
	Seed oil extraction	Point source data provided by plant operators (see 1A1a).
	Wood impregnation – creosote, LOSP	Wood impregnation mapping grid
2H1	Paper production process emissions	Regional GDP data (ONS, 2015).
2H2	Cider & wine manufacture, sugar beet processing and sugar manufacture	All emissions are in England.
	Spirit manufacture	Point source data provided by plant operators (see 1A1a).
	Brewery emissions	Brewing mapping grid
	Food & drink process industries: meat & fish, margarine, cakes & biscuits, animal feed, coffee roasting	Population used to disaggregate emissions.
	Other food & drink processes: bread baking, malting.	Point source data provided by plant operators (see 1A1a).
2H3	Other industry Part B process emissions	Regional GDP data (ONS, 2015).
2I	Wood product process emissions	Wood coating mapping grid.
3B	Manure management	Ammonia DA splits for manure management, based on regional emissions data for 1990, 1995, 2000-2014 provided by Rothamsted Research (2015), 2013 Mapping data from CEH (Dragosits U. et al., 2014) and population data, ONS (2015).
3D1	Inorganic N fertilizers	Ammonia DA splits for fertiliser use, based on regional emissions data for 1990, 1995, 2000-2014 provided by Rothamsted Research, population data, ONS (2015).
	Agricultural soil emissions	Ammonia DA splits for agricultural soils, based on regional emissions data for 1990, 1995, 2000-2014 provided by Rothamsted Research (2015)
3F	Field burning of agricultural wastes	Field burning estimates from Rothamsted Research (2015)
5A	Landfills	Regional landfill MSW disposal data (www.wastedataflow.org), combined with DA-specific landfill model developed by the Defra Waste team (Defra, 2012b).
5B	Composting	Population data, ONS (2015).

NFR Sector	Source	Disaggregation Method
5C1	Incineration: MSW, crematoria, chemical waste	Point source data provided by plant operators (see 1A1a).
	Incineration: Clinical waste, sewage sludge	Population data, ONS (2015).
	Incineration: animal carcases	Agriculture mapping grid.
	Foot & mouth pyres	Data on livestock disposal, NAO (2002).
5C2	Open-burning of waste	Population data, ONS (2015).
5D1	Sewage sludge decomposition	Population data, ONS (2015).
6A	Other sources: accidental fires, bonfires, cigarettes, fireworks, infant emissions from nappies, domestic pets	Population data, ONS (2015).
	Heather burning	Agriculture mapping grid
	Non-agricultural horses, professional horses	Driver for non-agricultural horses based on activity data time series from Rothamsted Research and CEH (2015)
	Parks, gardens and golf courses	Data on non-fuel fertiliser use, Rothamsted (2015)

B.2.3 Other Regional Data

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

- **Sub-national fuel use data** for natural gas, solid fuel and petroleum-based fuels, from UK Transco (Transco, 2015), other gas network operators, the Coal Authority (Coal Authority, 2015) and the Department for Business, Energy & Industrial Strategy (DECC, 2015b). The UK energy mapping team has been involved in the on-going development of the BEIS sub-national energy statistics which provide limited data from 2004 to 2014. 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 emission factors (g/km) for different types of vehicles, which depend on the fuel type (petrol or diesel) and are influenced by the drive cycle or average speeds on the different types of roads; traffic activity for each DA region, including distance and average speed travelled by each type of vehicle on each type of road; DA-specific fleet data on petrol/diesel car mix, car engine size and fleet composition (i.e. age distribution) for cars, light goods vehicles (LGVs) and rigid heavy goods vehicles (HGVs) based on data from the Driver and Vehicle Licensing Agency (DVLA); the age of the fleet determines the proportion of vehicles manufactured in conformity with different exhaust emission regulations;
- **Aircraft emissions** are derived from the Civil Aviation Authority's (CAA, 2015) database of flight movements, fuel use data (BEIS), aircraft fleet information (CAA, 2015) 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, 2015).
- **Regional iron and steel production data**, and regional fuel use data in the iron and steel industry (Tata Steel, 2014), (ISSB, 2015).
- Site-specific emissions data split by combustion and process sources for all **UK refineries**, and refinery production capacities (UKPIA, 2015).

- Site-specific cement production capacities and UK-wide **cement industry** fuel use data (Mineral Products Association, 2015).
- The **rail sector** uses information from the UK's Department for Transport Rail Emissions Model (REM).
- **Regional housing and population data** (Department for Communities and Local Government).
- **Regional economic activity and industrial production indices** (Office of National Statistics) (ONS, 2015).

Appendix C Recalculations

Throughout the UK inventory, emission estimates are updated annually across the full time series in response to new research and revisions to data sources. These changes also have an impact on the calculation of the Devolved Administrations' inventories. For further details on recalculations and method changes affecting each NFR sector, see chapter 8 'Recalculations and Methodology Changes' of the UK Informative Inventory Report (IIR) (Wakeling *et al.*, 2016). The most significant changes for each pollutant in the most recent inventory for 2013 are given in the tables below (note the shading within columns indicates magnitude of absolute emission recalculations).

Table 7 - Recalculations to 2013 estimates for ammonia between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)
Overall change		**-1.20**	**-1%**	**1.23**	**4%**	**0.44**	**2%**	**0.71**	**2%**
Agriculture	Main changes in the agriculture sector are driven by a change in livestock number and revision to the N fertiliser use and reconciliation of time series with the GHG inventory. The NH_3 emissions are now being calculated consistently with the GHG inventory.	0.44	0%	0.81	3%	-0.19	-1%	0.68	2%
Energy Industries	Revision in UK inventory to use new EMEP-EEA Guidebook emission factors for energy industry fuel combustion.	-0.65	-91%	-0.10	-98%	-0.05	-100%	-0.02	-99%
Fugitive	Minor revisions.	0.00	-1%	0.00	0%	0.00	0%	0.00	0%
Industrial Combustion	Revisions in the UK inventory to use new EMEP-EEA Guidebook emission factors for industrial combustion sources, combined with increased activity statistics for wood use in unclassified industry within UK energy statistics.	0.41	133%	0.03	552%	0.02	35%	0.01	51%
Industrial Processes	Minor revisions.	0.00	0%	0.00	0%	0.01	11%	0.00	0%
Other	The 2016 submission NH_3 inventory has had minor changes mainly due to very minor revisions to DUKES or Pollution Inventory.	-1.37	-10%	0.35	26%	0.56	46%	0.03	5%
Residential and other combustion	There were small revisions to the activity data and emission factors to various sources within small stationary combustion, the most notable being domestic wood and petcoke combustion.	0.56	37%	0.19	44%	0.14	34%	0.02	15%
Solvent Processes	No revisions.	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Transport Sources	Revisions to emission factors across the UK fleet, mainly leading to lower emission estimates for cars, with minor revisions to other vehicle groups.	-0.59	-10%	-0.06	-10%	-0.04	-10%	-0.03	-12%
Waste	Minor revisions.	0.00	0%	0.00	0%	0.01	1%	0.01	1%

Table 8 - Recalculations to 2013 estimates for carbon monoxide between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)
Overall change		**31.86**	**2%**	**23.16**	**15%**	**-16.54**	**-6%**	**9.81**	**15%**
Agriculture	No revisions.	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Energy Industries	Minor revisions.	1.03	2%	0.33	3%	0.13	1%	0.05	5%
Fugitive	Minor revisions. Correction to estimate for one oil and gas terminal in Wales for 2013 data only.	0.10	2%	0.00	0%	1.61	26%	0.00	1%
Industrial Combustion	Revisions to allocation of emissions from several fuels (including coke, natural gas) used in industries (mainly Iron and Steel, Unclassified).	17.63	4%	-0.65	-2%	-20.46	-17%	3.92	20%
Industrial Processes	Update to estimates of CO from steel production.	-0.21	0%	-0.01	-12%	-14.82	-33%	0.00	-75%
Other	Minor revisions.	-1.82	-13%	-0.18	-14%	-0.10	-15%	-0.06	
Residential and other combustion	The main change between the 2015 and 2016 submission is due to a significant revision in the consumption of wood fuel by the domestic sector in DUKES (much higher wood use now reported across the time series as well as now showing a large increasing trend in wood use). In addition, the emission factor has been revised as part of the 2014 AQPI Improvement program, the new approach involves the use of EMEP/EEA Tier 2 factors.	87.77	28%	25.28	44%	22.28	47%	6.03	24%
Transport Sources	CO emission factors for road transport have been revised (now based on COPERT 4 instead of TRL/DfT 2009).	-73.18	-14%	-1.67	-4%	-5.20	-17%	-0.15	-1%
Waste	Minor revisions.	0.52	5%	0.05	4%	0.03	5%	0.02	5%

Table 9 - Recalculations to 2013 estimates for nitrogen oxides between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)
Overall change		**11.96**	**2%**	**2.92**	**3%**	**-3.46**	**-4%**	**4.70**	**16%**
Agriculture	No revisions.	0.00		0.00		0.00		0.00	
Energy Industries	The review of refinery emission estimates, primarily through clarification of energy statistics for naphtha, led to a decrease in 2013 emission estimates for 1A1b.	-5.55	-2%	-1.37	-4%	-2.31	-5%	-0.01	0%
Fugitive	Minor revisions.	0.00	1%	0.00	0%	0.00	0%	0.00	1%
Industrial Combustion	The methodology for industrial combustion and non-residential combustion of six major fuels (coal, coke, fuel oil, gas oil, burning oil, gas) has been revised resulting in higher emission estimates across the UK in recent years.	14.83	13%	1.64	13%	-0.68	-5%	3.91	78%
Industrial Processes	Minor revisions.	0.10	9%	0.00	1%	-0.17	-32%	0.00	2%
Other	Minor revisions.	-0.01	0%	-0.01	-1%	0.00	0%	0.00	0%
Residential and other combustion	The methodology for industrial combustion and non-residential combustion of six major fuels (coal, coke, fuel oil, gas oil, burning oil, gas) has been revised resulting in higher emission estimates across the UK in recent years.	8.90	14%	1.78	16%	0.83	13%	0.09	2%
Transport Sources	The UK inventory estimates have been revised for individual vehicle types, to use new emission factors. The impacts across DAs varies according to the impacts within each vehicle sub-class. In England and Wales, lower estimates from cars and LDVs outweighs the higher estimates for HGVs and rail, whereas for Scotland and Northern Ireland the impacts of the higher emissions from HGVs and rail are dominant.	-6.25	-2%	0.88	2%	-1.13	-5%	0.71	5%
Waste	Minor revisions.	-0.05	-5%	0.00	3%	0.00	2%	0.00	5%

Table 10 - Recalculations to 2013 estimates for NMVOCs between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)
Overall change		**5.45**	**1%**	**7.45**	**5%**	**4.71**	**10%**	**1.44**	**5%**
Agriculture	Revisions to the UK estimates to improve the estimates from livestock waste management have led to slightly higher emissions. In England, Wales and Northern Ireland the revisions are most notable for poultry and sheep; for Scotland, revisions to estimates for non-dairy cattle also have a notable impact.	2.34	4%	1.84	14%	0.44	5%	0.25	2%
Energy Industries	Minor revisions, other than lower estimates from power stations in England that use straw.	-0.34	-11%	-0.01	-2%	-0.01	-1%	0.00	-4%
Fugitive	Minor revisions.	0.18	0%	0.03	0%	0.05	1%	0.02	3%
Industrial Combustion	The main impact here is due to revisions to UK energy statistics and therefore NAEI emission estimates from gas oil and petrol use in off-road machinery.	1.54	11%	0.15	11%	0.03	2%	0.06	10%
Industrial Processes	Minor revisions except in England where revised emissions data for food and drink sites and chemical industry processes have led to a minor increase.	1.27	3%	0.16	0%	0.00	0%	0.02	1%
Other	Minor revisions.	0.13	8%	0.03	22%	0.05	68%	0.01	22%
Residential and other combustion	The main recalculation is due to a significant revision in the consumption of wood fuel by the domestic sector in DUKES (much higher wood use now reported across the time series, and now showing a large increasing trend in wood use). In addition, the emission factors for many sources have been updated to use EMEP-EEA 2013 Guidebook Tier 2 factors.	8.92	37%	2.86	54%	2.81	69%	0.75	35%
Solvent Processes	In England, revised estimates for processes such as degreasing (surface cleaning) and printing lead to an overall reduction in VOCs from solvent processes. In Scotland and Wales the dominant source is coating applications where higher estimates are now made for wood coating. In Northern Ireland these two main changes cancel each other out.	-7.42	-3%	1.98	7%	1.42	8%	0.00	0%
Transport Sources	Revised VOC estimates across all DAs arise from evaporative losses and higher rail emissions. In addition, new emission factors applied to different vehicle groups and also new activity data for 2013 for Northern Ireland impact across the DAs. Higher emissions from petrol cars dominate in Scotland and Northern Ireland, whilst England and Wales both exhibit lower overall emissions from cars and other vehicle groups.	-1.14	-3%	0.41	12%	-0.08	-4%	0.35	31%
Waste	Minor revisions.	-0.03	-1%	-0.01	-1%	0.00	-1%	0.00	-1%

Table 11 - Recalculations to 2013 estimates for PM_{10} between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)
Overall change		**18.11**	**20%**	**4.29**	**32%**	**4.60**	**42%**	**0.93**	**15%**
Agriculture	Across all DAs, lower emissions are now estimated for poultry manure management. Minor revisions to other livestock manure management also apply to each DA.	-4.86	-30%	-0.78	-27%	-0.46	-24%	-0.65	-28%
Energy Industries	Minor revisions apart from a correction to allocation of emissions for coal-fired power stations in England.	0.43	7%	0.03	4%	0.03	3%	0.00	4%
Fugitive	Minor revisions.	0.00	0%	0.00	0%	0.03	35%	0.00	1%
Industrial Combustion	Higher emissions in all DAs are estimated from use of coal and gas oil in industrial combustion, partly due to revisions to UK energy statistics but also due to revisions to emission factors for solid fuel combustion to use EMEP-EEA 2013 Guidebook data.	4.49	60%	0.33	49%	0.51	102%	0.54	114%
Industrial Processes	All DAs have higher emissions, primarily due to a revision to emission factors for construction and demolition, to use EMEP-EEA 2013 Guidebook factors.	3.82	31%	0.48	40%	0.88	42%	0.06	20%
Other	Minor revisions.	-0.07	-3%	-0.01	-3%	0.00	-3%	0.00	-3%
Residential and other combustion	The main recalculation is due to a significant revision in the consumption of wood fuel by the domestic sector in DUKES (much higher wood use now reported across the time series, and now showing a large increasing trend in wood use). In addition, the emission factors for many sources have been updated to use EMEP-EEA 2013 Guidebook Tier 2 factors.	14.18	71%	4.02	84%	3.56	98%	0.92	51%
Solvent Processes	Minor revisions.	-0.21	-5%	0.14	58%	0.06	35%	0.01	12%
Transport Sources	Minor revisions.	0.25	1%	0.07	3%	-0.02	-1%	0.03	4%
Waste	Minor revisions.	0.08	4%	0.01	4%	0.00	5%	0.00	5%

Table 12 - Recalculations to 2013 estimates for sulphur dioxide between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)	Change in 2013 (kt)	Change in 2013 (%)
Overall change		**-8.72**	**-3%**	**3.06**	**8%**	**-1.69**	**-4%**	**0.21**	**2%**
Energy Industries	A correction has been made to a factor for coal-fired power stations (increase in recent years due to inclusion of one former autogenerator in the power station data).	14.09	9%	2.94	9%	0.94	5%	0.31	11%
Fugitive	Minor revisions.	-0.04	-1%	0.00	0%	0.05	5%	0.00	
Industrial Combustion	A reduction in the quantity of petroleum coke used as an industrial fuel has led to a reduction in emissions in England and Wales.	-20.03	-22%	0.02	1%	-1.64	-16%	0.01	0%
Industrial Processes	A correction to estimates for secondary lead emissions led to lower estimates in England and Wales. An assumption applied to address reporting gaps has been revised; new information indicates emissions 'below reporting threshold' for PI reporting, indicating NAEI estimates were too high.	-0.86	-11%	0.00	0%	-0.56	-50%	0.00	
Other	Minor revisions.	0.00	0%	0.00	-1%	0.00	0%	0.00	1%
Residential and other combustion	Revisions to UK energy statistics for anthracite and fuel oil have had minor impacts across the DAs.	-2.30	-6%	0.06	2%	-0.52	-8%	-0.13	-5%
Transport Sources	Minor revisions.	0.33	5%	0.04	4%	0.02	3%	0.02	4%
Waste	Minor revisions.	0.10	17%	0.01	14%	0.01	19%	0.00	19%

Table 13 - Recalculations to 2013 estimates for lead between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2013 (t)	Change in 2013 (%)	Change in 2013 (t)	Change in 2013 (%)	Change in 2013 (t)	Change in 2013 (%)	Change in 2013 (t)	Change in 2013 (%)
Overall change		**1.45**	**3%**	**0.79**	**30%**	**-2.86**	**-21%**	**0.00**	**0%**
Energy Industries	Minor revisions.	-0.02	-1%	0.06	10%	0.01	3%	0.01	23%
Fugitive	Minor revisions.	-0.04	-3%	0.00		-0.03	-4%	0.00	
Industrial Combustion	Higher emissions across DAs due to minor revisions to UK energy statistics for solid fuel use.	2.41	27%	0.04	5%	0.04	4%	0.05	4%
Industrial Processes	A new source of lead emissions from wood processing leads to increased Scottish totals, but other revisions to I&S estimates and from castings have a greater impact in England and Wales.	-0.15	-1%	0.77	277%	-2.83	-25%	0.03	60%
Other	Minor revisions.	0.00	0%	0.00	-1%	0.00	0%	0.00	1%
Residential and other combustion	Revisions to UK-wide estimates from solid fuel use in the residential and commercial sectors have a minor impact across all DAs.	-0.07	-2%	-0.01	-1%	-0.01	-1%	-0.07	-14%
Transport Sources	Minor revisions.	0.00	0%	0.00	0%	0.00	2%	0.00	5%
Waste	Revision to the UK-wide estimates of lead emissions from clinical waste incineration.	-0.68	-85%	-0.07	-87%	-0.04	-87%	-0.02	-88%

Appendix D Uncertainties

The following sections provide information on the key characteristics of each pollutant based on the uncertainty assessments carried out for the UK AQ inventory, which uses both the Tier 1 uncertainty aggregation method and a Tier 2 statistical (Monte-Carlo) analysis. This information supports Section 1.4 of the main report. Further details are described in Chapter 1.7 of the "UK Informative Inventory Report 1990 to 2014" (Wakeling, et al., 2016).

An indicative "Uncertainty Rating" is provided for each pollutant that reflects the relative magnitude in uncertainty estimates made for each pollutant at UK level. A 'low' rating implies a lower level of uncertainty in the emission estimates for the pollutant relative to the uncertainty in the estimates for a pollutant with a 'high' rating. A quantitative estimate of uncertainties in the inventories for each pollutant at UK level is given in the "UK Informative Inventory Report 1990 to 2014" (Wakeling, et al., 2016). Quantitative estimates of uncertainties for each Devolved Administration have not been made, but would be higher than the uncertainties at UK level and reflect uncertainties in the spatial distribution of emissions. These are higher for more diffuse sources than point sources. More details on the qualitative uncertainty estimates of the spatially resolved UK inventory are given in Section 5.1 of the 2014 NAEI mapping report (Tsagatakis et al.,2016). The uncertainties in emission estimates may differ for each DA according to the relative mix of emissions from point sources and more diffuse sources in the DA and how this differs from the UK mix for a given pollutant. However, the overall uncertainty ranking of each pollutant at DA level is not likely to be significantly different to the ranking at UK level given below for each pollutant and in Table 1 of the main body of the report.

The following sections refer to causes of uncertainties in emission estimates at UK level.

D.1 Ammonia

Ammonia emission estimates are more uncertain than those for SO_2, NO_X as NO_2 and NMVOC largely due to the nature of the major agricultural sources. Emissions depend on animal type, age, weight, diet, housing systems, waste management and storage techniques. This large number of impacting factors makes 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 as NO_2 and NMVOC, a few uncertain sources dominate the inventory for NH_3 and there is limited potential for error compensation[5].

<u>Uncertainty Rating</u>: MODERATE

D.2 Carbon Monoxide

Carbon monoxide emissions occur almost exclusively from combustion of fuels, particularly by road transport. Emission estimates for road transport are moderately uncertain, as measurements are quite limited on some vehicle types and emissions highly variable between vehicles and for different traffic situations.

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 emission data for major sources, emission estimates for CO are much more uncertain than other pollutants such as NO_x (as NO_2) and SO_2 which are also emitted mainly from major combustion processes. Unlike the case of NO_x (as NO_2) and NMVOC, a few sources dominate the inventory and there is limited potential for error compensation.

<u>Uncertainty Rating</u>: MODERATE

[5] Error compensation refers to the theory that as more contributing sources are identified, there will logically be an increasing chance for lower or upper errors to be cancelled out, reducing the uncertainty in the aggregate total.

D.3 Nitrogen Oxides

NO_x (as NO_2) emission estimates are less accurate than SO_2 because, although they are calculated using measured emission factors, these emission factors can vary much more with combustion conditions; emission factors given in the literature for combustion sources show large variations. In the case of road transport (1A3b) 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 between vehicles of the same type 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 for any pollutant other than SO_2 for a number of reasons:

- While NO_x emission factors are somewhat uncertain, activity data used in the NO_x inventory is very much less uncertain. This contrasts with inventories for pollutants such as volatile organic compounds, PM_{10}, metals, and persistent organic pollutants, which contain a higher degree of uncertainty in source activity estimates.
- The NO_x inventory is made up of a large number of independent 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. The other extreme is shown by the inventories for PCP, HCH and HCB where one or two sources dominate and the inventories are highly uncertain.
- Many of the larger point-source emission sources make up the bulk of the UK estimates, and these are commonly derived from continuous emission measurement data and hence are regarded to be good quality.

Uncertainty Rating: LOW

D.4 Non-Methane Volatile Organic Compounds

The NMVOC inventory is more uncertain than those for SO_2 and NO_x. 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. Given the broad range of independent sources of NMVOCs, 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: LOW

D.5 Particulate Matter

The emission inventory for PM_{10} is subject to high uncertainty. This stems from uncertainties in the emission factors themselves, and the activity data with which they are combined to quantify the emissions. For many source categories, emissions data and/or emission factors are available for total particulate matter only and emissions of PM_{10} must be estimated based on assumptions about the size distribution of particle emissions from that source. This adds a further level of uncertainty for estimates of PM_{10} and, to an even greater extent, $PM_{2.5}$ and other fine particulate matter.

Many sources of particulate matter are diffuse or fugitive in nature e.g. emissions from coke ovens, metal processing, or quarries. These emissions are difficult to measure and in some cases it is likely that no entirely satisfactory measurements have ever been made, so emission estimates for these fugitive sources are particularly uncertain.

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 in PM could be reduced to the levels seen in the inventories for SO_2, NO_x or NMVOC.

Uncertainty Rating: HIGH

D.6 Sulphur Dioxide

SO_2 emissions can be estimated with the most confidence as they depend largely on the level of sulphur in fuels. Hence, the inventory, which is based upon comprehensive analysis on the sulphur content of coals and fuel oils consumed by power stations and the agriculture, industry and domestic sectors, contains accurate emission estimates for the most important sources.

Uncertainty Rating: LOW

D.7 Lead

The Pb 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 Pb 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 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 the Industrial Emissions Directive (IED) and the estimates provided by plant operators to the regulatory agencies and used in the national inventories are based on emission measurements or emission factors that have been researched for the specific process type. There is a moderate level of uncertainty associated with these annual emission estimates due to the discrete nature of the stack emissions monitoring techniques and determination of mass emission flow rates from point sources. Furthermore, the variability of lead content of raw materials such as fuels (e.g. coal) is such that the discrete Pb emission measurements provide a snap-shot of the process and plant performance, and there is some uncertainty as regards how representative that result may be for use in scaling up to provide annual emission estimates.

These uncertainties are inherent within the inventories from environmental regulators of EPR/IED industries and are unavoidable; the emissions data from IED-regulated installations used in the compilation of these DA inventories are subject to a managed process of quality checking by the environmental regulatory agencies and are regarded as the best data available for inventory compilation.

The observed year-to-year variations in emission estimates are based on actual trends reported by plant operators and may reflect changes in lead content of raw materials. The uncertainty in emission monitoring applies to all pollutants to some degree, but more so for pollutants such as Pb for which (i) no continuous emission monitoring systems are available, and (ii) where fuel composition is known to be highly variable depending on the fuel source. This is not the case for species such as NO_X and SO_2 where many regulated sites will use Continuous Emission Monitoring Systems and the fuel elemental composition is either not a significant factor in process emissions or does not vary as much as for heavy metals and other trace contaminants.

The emission estimates of Pb 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 than those based on regulatory emissions monitoring and reporting.

Uncertainty Rating: HIGH

Appendix E Summary Tables

E.1 Summary Air Quality Pollutant Emission Estimates for England

Table 14 - Summary of air quality pollutant emission estimates for England (1990-2014) *

	Category	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Ammonia (kt)	Agriculture	196.0	188.0	186.0	186.0	173.0	170.0	168.0	161.0	165.0	161.0	159.0	156.0	147.0	148.0	148.0	148.0	145.0	142.0	150.0
	Transport Sources	0.7	5.8	11.5	13.3	19.2	17.9	16.7	15.2	14.2	13.1	12.2	11.2	9.9	9.5	8.4	7.3	6.2	5.3	4.6
	Industrial Processes	7.1	7.2	8.8	4.8	3.5	3.6	3.5	3.2	3.1	5.3	5.0	4.8	4.2	4.0	4.3	4.9	4.6	3.3	2.8
	Waste	5.2	6.3	6.5	6.8	7.0	8.2	8.6	9.0	9.5	9.7	9.9	10.0	9.6	9.9	9.7	9.8	9.4	9.4	9.6
	Other	11.2	11.6	14.4	14.3	14.1	13.9	13.7	13.8	13.8	13.7	13.6	13.6	14.4	14.1	14.3	14.6	14.7	15.0	14.6
	Residential & other combustion	0.3	0.5	0.7	0.7	0.8	0.9	0.9	1.0	1.0	1.1	1.0	1.0	1.2	1.3	1.6	1.4	1.8	2.1	2.0
	Total	**221**	**219**	**228**	**226**	**218**	**215**	**212**	**203**	**207**	**204**	**201**	**197**	**187**	**186**	**186**	**186**	**181**	**177**	**184**
Carbon monoxide (kt)	Energy Industries	101.0	92.8	56.5	50.8	59.9	58.5	58.0	64.1	62.0	67.1	66.9	68.7	64.1	57.7	58.1	60.2	70.8	68.6	60.6
	Industrial Combustion	525.0	566.0	510.0	507.0	442.0	493.0	523.0	564.0	512.0	497.0	480.0	466.0	458.0	416.0	418.0	436.0	455.0	489.0	568.0
	Transport Sources	4335.0	3609.0	3164.0	2916.0	2524.0	2291.0	2058.0	1858.0	1690.0	1505.0	1336.0	1146.0	1032.0	798.0	678.0	568.0	509.0	443.0	408.0
	Fugitive	22.5	13.1	13.1	10.7	10.7	6.5	5.0	7.2	4.8	4.7	5.1	4.9	4.7	4.0	4.0	3.6	4.2	4.4	4.1
	Industrial Processes	226.0	225.0	204.0	226.0	227.0	233.0	196.0	114.0	106.0	95.1	122.0	120.0	116.0	79.5	74.7	73.9	74.7	77.8	71.7
	Other	291.0	29.9	28.3	28.8	27.9	44.3	28.9	29.6	28.3	27.6	29.0	29.3	27.6	26.6	25.9	25.5	24.8	24.0	23.4
	Residential & other combustion	671.0	505.0	476.0	492.0	435.0	434.0	377.0	352.0	337.0	298.0	285.0	290.0	325.0	318.0	372.0	336.0	361.0	399.0	379.0
	Total	**6171**	**5041**	**4451**	**4231**	**3727**	**3562**	**3246**	**2989**	**2740**	**2495**	**2324**	**2125**	**2028**	**1699**	**1631**	**1503**	**1499**	**1506**	**1515**
Nitrogen oxides (kt)	Energy Industries	650.0	416.0	313.0	277.0	292.0	314.0	310.0	343.0	326.0	345.0	337.0	328.0	244.0	219.0	208.0	202.0	234.0	219.0	182.0
	Industrial Combustion	344.0	318.0	283.0	269.0	260.0	256.0	231.0	227.0	228.0	233.0	215.0	210.0	180.0	151.0	157.0	136.0	138.0	132.0	125.0
	Transport Sources	1088.0	906.0	784.0	736.0	678.0	648.0	617.0	585.0	565.0	546.0	527.0	506.0	476.0	402.0	383.0	366.0	346.0	329.0	319.0
	Other	58.9	46.6	28.1	29.6	27.8	25.9	23.1	24.7	25.5	23.0	23.7	27.0	25.3	23.9	24.3	22.4	20.4	18.9	16.6
	Residential & other combustion	185.0	169.0	155.0	150.0	141.0	137.0	120.0	113.0	107.0	102.0	93.4	86.0	92.2	81.4	86.0	73.8	76.1	74.3	64.7
	Total	**2326**	**1856**	**1564**	**1462**	**1399**	**1381**	**1300**	**1293**	**1251**	**1249**	**1196**	**1156**	**1018**	**877**	**857**	**799**	**813**	**773**	**708**
NMVOC (kt)	Agriculture	89.1	65.1	67.2	68.3	64.8	61.5	58.9	59.7	62.0	59.6	59.0	59.5	58.3	57.8	58.9	58.5	57.7	58.2	60.7
	Industrial Combustion	25.5	25.9	26.1	25.6	25.3	25.6	25.0	25.1	26.0	25.6	24.8	24.7	22.7	18.5	18.9	16.6	16.9	16.1	16.7
	Transport Sources	799.0	619.0	474.0	417.0	350.0	314.0	266.0	223.0	188.0	159.0	136.0	114.0	99.9	69.7	58.8	49.3	42.8	37.1	32.7
	Fugitive	272.0	231.0	210.0	185.0	175.0	175.0	153.0	142.0	134.0	130.0	118.0	112.0	100.0	94.7	85.0	82.6	78.2	71.8	72.1
	Industrial Processes	182.0	165.0	121.0	89.6	85.7	74.5	73.3	68.4	60.3	59.0	53.3	51.5	45.3	40.1	42.6	38.5	38.4	38.7	38.4
	Solvent Processes	541.0	437.0	400.0	377.0	356.0	341.0	336.0	332.0	333.0	328.0	327.0	321.0	304.0	287.0	285.0	289.0	287.0	286.0	289.0
	Other	20.5	20.5	17.5	17.1	18.1	17.2	19.0	17.3	16.3	15.5	15.7	14.4	13.6	12.5	11.5	10.9	10.4	9.7	9.2

Pollutant	Category	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Residential & other combustion	58.4	44.4	46.3	48.4	42.2	40.9	37.3	37.1	35.8	33.4	31.2	30.6	32.0	29.9	33.6	29.3	31.6	33.2	30.7
	Total	**1987**	**1608**	**1361**	**1228**	**1117**	**1050**	**969**	**904**	**855**	**810**	**765**	**727**	**676**	**611**	**595**	**575**	**563**	**551**	**550**
PM_{10} (kt)	Agriculture	13.3	13.6	14.5	13.9	13.7	13.3	12.9	12.5	12.6	12.1	12.2	11.7	11.6	11.3	11.4	11.4	11.2	11.2	11.2
	Energy Industries	59.9	33.9	22.3	18.0	18.9	13.2	7.2	7.3	7.7	8.5	8.8	7.4	7.6	5.8	5.4	5.7	7.9	6.8	6.0
	Industrial Combustion	27.5	23.6	19.9	20.0	17.8	17.5	16.3	16.2	15.4	15.1	14.0	12.9	12.6	11.4	12.3	11.0	11.5	12.0	11.6
	Transport Sources	32.9	37.1	36.3	35.9	32.6	32.0	31.0	30.4	29.9	29.3	28.5	27.1	25.9	24.7	24.1	22.8	21.8	20.8	20.1
	Industrial Processes	40.8	32.5	28.9	26.8	25.2	26.0	24.5	27.0	23.4	24.8	22.1	23.5	20.4	16.7	16.4	15.1	15.4	16.3	17.0
	Solvent Processes	6.8	5.2	5.3	5.2	4.9	4.7	4.8	4.7	4.6	4.6	4.9	4.8	4.1	3.4	3.5	3.6	3.6	3.6	3.7
	Other	7.3	6.8	6.0	6.2	6.0	9.0	6.2	6.7	6.2	6.4	6.4	6.4	5.9	5.5	5.4	5.3	5.3	5.0	5.0
	Residential & other combustion	37.9	27.3	29.0	30.6	26.7	26.5	23.4	23.5	23.1	22.6	21.4	21.6	25.0	24.7	30.3	26.3	30.0	34.1	33.2
	Total	**226**	**180**	**162**	**157**	**146**	**142**	**126**	**128**	**123**	**123**	**118**	**115**	**113**	**104**	**109**	**101**	**107**	**110**	**108**
Sulphur dioxide (kt)	Energy Industries	2481.0	1470.0	1011.0	723.0	713.0	638.0	593.0	596.0	456.0	356.0	315.0	272.0	209.0	154.0	149.0	163.0	214.0	166.0	119.0
	Industrial Combustion	315.0	254.0	150.0	121.0	106.0	117.0	97.9	89.6	96.1	99.7	87.5	82.4	77.9	71.8	79.5	65.8	70.5	71.5	62.4
	Transport Sources	70.6	58.9	36.0	28.3	20.7	18.4	18.8	19.2	19.1	19.6	19.4	15.1	11.1	9.9	8.1	7.2	6.7	6.3	6.6
	Fugitive	21.3	19.8	12.5	9.6	8.7	8.1	7.7	8.6	10.2	9.1	9.7	15.6	15.0	13.1	12.4	10.0	9.7	9.6	9.2
	Industrial Processes	51.1	54.1	55.6	45.6	38.2	30.6	28.6	31.2	29.2	28.9	28.4	26.1	17.8	11.4	10.7	10.7	5.7	6.9	7.0
	Other	6.8	3.8	1.1	1.3	1.1	1.9	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.7	0.7
	Residential & other combustion	135.0	105.0	82.2	76.9	63.3	63.4	49.8	44.0	41.9	37.2	34.5	33.2	35.1	31.0	36.0	32.3	31.8	33.4	32.2
	Total	**3080**	**1966**	**1349**	**1006**	**951**	**877**	**797**	**790**	**654**	**551**	**495**	**445**	**366**	**292**	**297**	**290**	**339**	**294**	**237**
Lead **(tonnes)**	Energy Industries	138.0	117.0	17.8	14.0	13.9	11.3	10.2	10.1	10.2	8.9	8.9	2.7	2.8	2.7	2.6	3.1	4.3	3.3	2.5
	Industrial Combustion	31.0	25.7	20.5	17.0	13.6	14.3	15.2	16.0	14.5	12.0	10.1	10.6	10.3	11.5	10.3	10.8	11.3	11.2	10.7
	Transport Sources	1804.0	879.0	481.0	253.0	2.2	2.1	2.0	2.0	2.1	2.1	2.1	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	Industrial Processes	244.0	207.0	173.0	102.0	77.6	79.9	75.4	58.3	50.5	50.4	40.0	39.1	34.5	25.3	20.4	20.7	24.7	23.7	25.6
	Waste	230.0	68.7	0.4	0.6	0.6	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Other	3.0	2.1	2.0	1.9	1.8	1.9	2.2	1.9	2.1	2.1	2.1	2.1	2.0	1.7	1.5	1.8	1.6	1.7	1.6
	Residential & other combustion	23.4	13.6	10.6	9.9	7.0	6.9	5.4	4.7	4.3	3.6	3.3	3.4	3.8	3.6	3.8	3.7	3.7	3.9	3.8
	Total	**2473**	**1314**	**706**	**398**	**117**	**117**	**111**	**93**	**84**	**79**	**67**	**60**	**55**	**47**	**41**	**42**	**47**	**46**	**46**

* The uncertainties in the data are greater than the precision indicated by the table above. This higher level of resolution has been chosen to aid transparency.

E.2 Summary Air Quality Pollutant Emission Estimates for Scotland

Table 15 - Summary of air quality pollutant emission estimates for Scotland (1990-2014) *

	Category	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Ammonia (kt)	Agriculture	38.4	36.4	37.1	34.9	35.3	34.6	34.6	33.8	34.6	33.7	32.9	31.7	30.6	30.5	30.6	30.4	30.0	29.8	31.0
	Transport Sources	0.1	0.6	1.2	1.3	2.0	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.0	1.0	0.9	0.7	0.6	0.6	0.5
	Industrial Processes	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Waste	0.8	1.0	1.0	1.0	1.1	1.2	1.3	1.3	1.4	1.5	1.5	1.6	1.5	1.6	1.6	1.6	1.5	1.5	1.5
	Other	1.2	1.3	1.6	1.7	1.5	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.5	1.5	1.8	1.8	1.8	1.9	1.8
	Residential & other combustion	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.4	0.5	0.6	0.6
	Total	**41**	**39**	**41**	**39**	**40**	**39**	**39**	**38**	**39**	**38**	**37**	**36**	**35**	**35**	**36**	**35**	**35**	**34**	**35**
Carbon monoxide (kt)	Energy Industries	15.1	15.1	10.5	9.9	11.6	11.4	11.0	10.1	10.5	10.5	12.4	11.9	15.1	14.5	14.0	11.8	12.9	10.2	7.8
	Industrial Combustion	83.3	38.4	32.2	33.8	29.4	29.8	31.4	34.5	31.7	35.1	35.6	33.9	34.9	30.1	33.0	34.3	32.1	33.6	39.5
	Transport Sources	392.0	324.0	284.0	261.0	227.0	206.0	188.0	173.0	159.0	142.0	128.0	110.0	99.6	77.7	65.9	55.4	50.3	44.0	41.0
	Fugitive	5.1	1.1	1.0	1.2	1.1	1.8	1.2	0.9	0.9	1.0	0.8	1.0	0.9	0.9	0.9	1.0	0.7	0.9	1.0
	Industrial Processes	4.1	3.4	3.9	3.7	3.6	3.5	3.5	3.5	3.5	3.5	4.2	4.3	4.3	3.7	4.1	0.1	0.1	0.1	0.1
	Other	23.4	3.2	3.0	3.0	2.9	7.1	3.0	3.1	2.9	2.9	3.0	3.0	2.9	2.8	2.7	2.6	2.6	2.5	2.4
	Residential & other combustion	166.0	94.5	83.2	84.8	72.8	72.3	59.5	55.2	52.3	48.3	53.8	56.0	62.6	62.4	75.0	67.8	74.5	83.2	78.7
	Total	**689**	**480**	**418**	**398**	**348**	**332**	**298**	**280**	**260**	**243**	**238**	**220**	**220**	**192**	**196**	**173**	**173**	**174**	**170**
Nitrogen oxides (kt)	Energy Industries	96.5	65.1	51.2	48.8	55.2	50.8	49.7	46.8	45.6	45.3	57.8	51.2	41.0	37.7	39.1	31.0	32.4	31.1	29.2
	Industrial Combustion	39.8	32.5	30.0	28.8	28.5	28.5	23.2	22.4	22.8	23.4	21.6	21.7	19.6	16.1	16.0	14.1	13.6	13.8	13.3
	Transport Sources	118.0	98.8	85.6	81.2	74.4	70.6	68.2	64.7	62.3	60.3	58.6	56.9	53.8	46.2	43.8	41.1	39.0	37.0	35.5
	Other	5.4	3.2	2.4	2.9	2.9	3.1	2.7	2.7	2.7	2.6	2.6	2.5	2.5	2.2	2.3	2.4	2.1	2.2	1.6
	Residential & other combustion	32.8	30.9	28.6	27.8	25.9	25.6	22.7	21.5	20.0	19.2	17.5	16.1	16.8	14.8	15.2	13.2	13.2	12.7	11.1
	Total	**293**	**231**	**198**	**189**	**187**	**179**	**166**	**158**	**153**	**151**	**158**	**148**	**134**	**117**	**116**	**102**	**100**	**97**	**91**
NMVOC (kt)	Agriculture	18.9	16.7	17.0	16.5	16.7	16.2	16.4	16.3	16.7	16.6	16.5	16.2	15.6	15.3	15.7	15.7	15.6	15.4	15.6
	Industrial Combustion	2.6	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.3	2.2	2.2	2.2	2.2	1.8	1.8	1.6	1.6	1.5	1.6
	Transport Sources	72.6	55.9	42.7	37.4	31.5	28.3	24.5	20.7	17.6	14.9	13.0	11.0	9.7	6.8	5.8	4.9	4.3	3.7	3.3
	Fugitive	177.0	117.0	97.4	81.0	78.4	67.5	70.5	52.7	39.4	40.5	38.3	38.1	34.8	22.7	20.5	19.5	23.8	20.1	18.4
	Industrial Processes	63.2	62.8	60.9	62.7	62.0	60.9	60.1	58.9	57.7	56.9	57.0	58.9	58.8	59.5	60.9	61.3	63.0	65.4	66.6
	Solvent Processes	70.7	57.4	52.4	45.2	41.9	40.0	38.5	37.7	37.3	34.4	35.5	35.6	33.3	31.2	30.2	31.8	31.4	30.3	31.3
	Other	3.1	3.1	2.7	2.5	2.7	2.5	2.6	2.4	2.3	2.2	2.3	2.0	1.9	1.8	1.6	1.5	1.5	1.4	1.3
	Residential & other combustion	12.6	8.1	8.2	8.5	7.3	7.0	6.2	6.2	5.9	5.7	6.4	6.4	6.9	6.6	7.8	6.8	7.6	8.1	7.6
	Total	**421**	**323**	**284**	**256**	**243**	**225**	**221**	**197**	**179**	**173**	**171**	**170**	**163**	**146**	**144**	**143**	**149**	**146**	**146**

	Category	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PM_{10} (kt)	Agriculture	1.8	1.8	2.0	1.8	2.0	2.0	2.0	2.0	2.1	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.0	2.1	2.2
	Energy Industries	8.3	5.2	3.8	3.0	3.6	3.5	2.1	1.1	1.8	1.8	2.6	2.3	1.0	1.1	1.4	1.1	1.1	0.8	0.7
	Industrial Combustion	3.5	2.8	2.1	2.1	2.0	2.0	1.8	1.7	1.7	1.7	1.7	1.6	1.5	1.3	1.3	1.1	1.1	1.0	0.9
	Transport Sources	4.0	4.4	4.2	4.2	3.7	3.6	3.6	3.4	3.4	3.3	3.2	3.0	2.9	2.8	2.7	2.5	2.4	2.3	2.2
	Industrial Processes	5.3	4.1	3.1	2.9	2.8	2.9	2.8	3.0	2.8	2.6	2.5	2.4	2.1	1.7	1.8	1.9	1.7	1.7	1.9
	Solvent Processes	0.9	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4
	Other	0.7	0.7	0.6	0.7	0.8	1.5	0.8	0.7	0.7	0.7	0.6	0.6	1.1	0.6	0.8	0.8	0.6	0.8	1.1
	Residential & other combustion	8.4	5.5	5.8	6.0	5.3	5.3	4.5	4.6	4.5	4.4	5.4	5.5	6.2	6.2	7.7	6.7	7.7	8.8	8.4
	Total	**33**	**25**	**22**	**22**	**21**	**21**	**18**	**17**	**18**	**17**	**19**	**18**	**17**	**16**	**18**	**17**	**17**	**18**	**18**
Sulphur dioxide (kt)	Energy Industries	217.0	135.0	96.5	81.4	104.0	101.0	96.2	82.3	67.0	53.8	66.2	53.1	46.9	49.9	65.6	47.8	48.5	34.1	23.5
	Industrial Combustion	39.4	22.6	10.5	7.7	7.0	7.5	9.9	9.6	10.3	11.2	9.2	8.0	5.5	4.3	4.2	3.6	2.5	3.0	2.6
	Transport Sources	11.5	9.9	7.1	6.5	5.4	4.9	5.1	4.6	4.5	4.5	4.1	3.1	2.2	2.1	1.6	1.3	1.2	1.1	1.1
	Fugitive	1.1	0.5	0.5	0.8	0.6	1.5	1.2	0.7	0.8	0.7	0.5	0.8	0.9	0.7	0.7	0.5	0.5	0.5	0.7
	Industrial Processes	0.8	0.7	0.8	0.8	0.7	0.7	0.6	0.8	0.8	0.8	0.8	0.7	0.7	0.8	0.6	0.7	0.8	0.6	0.6
	Other	0.3	0.2	0.1	0.1	0.1	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Residential & other combustion	28.4	21.1	15.4	13.8	10.8	10.4	7.6	6.3	5.7	5.0	4.8	4.6	4.7	3.4	3.2	3.1	3.1	3.0	2.6
	Total	**298**	**190**	**131**	**111**	**129**	**126**	**121**	**105**	**89**	**76**	**86**	**70**	**61**	**61**	**76**	**57**	**57**	**42**	**31**
Lead **(tonnes)**	Energy Industries	11.8	7.6	2.7	2.2	3.0	2.8	1.9	1.5	3.4	1.7	1.8	0.8	0.5	0.7	1.3	0.6	1.1	0.6	0.6
	Industrial Combustion	3.4	2.8	2.1	1.9	1.7	1.7	1.9	1.7	2.1	1.5	1.2	1.2	1.1	1.1	1.1	1.0	0.8	0.9	0.9
	Transport Sources	171.0	82.1	44.7	23.5	0.3	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Industrial Processes	12.0	5.6	3.5	2.7	2.4	2.4	2.2	2.0	1.9	1.2	1.4	1.5	1.3	0.9	0.9	1.7	1.6	1.0	1.5
	Waste	7.3	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Residential & other combustion	4.5	2.3	1.7	1.6	1.2	1.2	0.9	0.8	0.7	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	Total	**210**	**103**	**55**	**32**	**9**	**8**	**7**	**6**	**8**	**5**	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**3**	**4**

* The uncertainties in the data are greater than the precision indicated by the table above. This higher level of resolution has been chosen to aid transparency.

E.3 Summary Air Quality Pollutant Emission Estimates for Wales

Table 16 - Summary of air quality pollutant emission estimates for Wales (1990-2014) *

	Category	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Ammonia (kt)	Agriculture	26.5	26.0	26.0	27.0	25.4	25.3	23.7	25.3	24.8	24.3	24.9	22.5	20.9	20.8	21.5	21.5	21.5	21.6	22.6
	Transport Sources	0.1	0.4	0.7	0.8	1.2	1.1	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.3	0.3
	Industrial Processes	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Waste	0.3	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.8	0.9	0.9	0.9	0.9	0.9	0.9
	Other	0.9	1.1	1.6	1.7	1.5	1.6	1.7	1.7	1.4	1.4	1.4	1.4	1.4	1.4	1.8	1.8	1.9	2.0	1.9
	Residential & other combustion	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5
	Total	**28**	**28**	**29**	**30**	**29**	**29**	**27**	**29**	**28**	**28**	**28**	**26**	**24**	**24**	**25**	**25**	**25**	**25**	**26**
Carbon monoxide (kt)	Energy Industries	6.3	6.0	4.3	3.7	5.0	5.8	4.8	5.1	6.7	6.1	6.7	5.2	6.3	5.7	6.5	7.0	8.5	9.1	6.2
	Industrial Combustion	132.0	164.0	165.0	164.0	130.0	128.0	84.7	88.1	96.7	82.8	110.0	89.1	72.0	70.7	75.9	83.8	81.2	99.5	136.0
	Transport Sources	250.0	205.0	176.0	161.0	139.0	127.0	115.0	105.0	95.9	85.9	77.1	66.7	60.2	46.6	39.6	33.2	29.7	25.9	24.4
	Fugitive	12.4	19.2	19.2	14.9	15.3	8.7	3.6	5.0	3.4	3.1	6.6	7.1	5.2	4.7	6.3	6.0	6.0	7.8	11.3
	Industrial Processes	64.4	62.3	66.5	61.0	60.0	45.2	33.4	43.6	42.8	48.8	56.9	60.5	53.6	38.2	34.7	32.3	24.1	30.5	44.4
	Other	3.9	1.6	1.5	1.5	1.4	2.6	1.5	1.5	1.5	1.4	1.5	1.5	1.4	1.3	1.3	1.3	1.2	1.2	1.2
	Residential & other combustion	97.7	77.8	72.5	76.3	64.5	65.7	53.0	49.0	47.4	43.4	44.3	47.2	52.0	52.3	62.4	56.9	63.3	69.2	65.0
	Total	**567**	**536**	**505**	**482**	**416**	**383**	**296**	**297**	**294**	**271**	**303**	**277**	**251**	**220**	**227**	**220**	**214**	**243**	**288**
Nitrogen oxides (kt)	Energy Industries	49.8	35.2	28.5	23.2	32.3	39.8	32.9	32.5	35.5	33.7	41.1	29.1	39.2	32.4	30.5	30.6	44.2	44.6	31.9
	Industrial Combustion	37.7	35.6	32.8	35.0	34.9	30.7	21.1	21.8	21.5	20.6	19.6	19.3	17.2	14.2	15.6	14.1	13.1	13.7	12.8
	Transport Sources	69.7	57.1	48.5	45.2	41.3	39.1	37.5	35.6	34.9	33.6	32.4	31.2	29.7	25.5	24.5	23.7	21.9	21.2	20.5
	Other	3.2	2.7	2.2	2.2	2.2	2.0	1.3	1.3	1.5	1.4	1.4	1.6	1.6	1.4	1.4	1.5	1.1	1.1	1.3
	Residential & other combustion	20.0	18.9	17.6	17.1	16.1	15.7	14.1	13.3	12.5	11.7	10.6	9.6	9.6	8.7	8.9	7.6	7.6	7.3	6.5
	Total	**180**	**150**	**130**	**123**	**127**	**127**	**107**	**105**	**106**	**101**	**105**	**91**	**97**	**82**	**81**	**77**	**88**	**88**	**73**
NMVOC (kt)	Agriculture	11.2	10.9	11.3	11.6	11.2	11.1	10.2	11.2	11.2	10.8	11.4	10.2	10.0	9.9	10.1	10.2	10.2	10.1	10.5
	Industrial Combustion	2.5	2.8	2.9	3.0	3.1	2.7	2.3	2.6	2.5	2.2	2.3	2.3	2.2	1.7	1.8	1.7	1.6	1.7	1.6
	Transport Sources	45.9	35.2	26.3	22.9	19.2	17.2	14.8	12.5	10.6	9.0	7.8	6.5	5.8	4.0	3.4	2.9	2.5	2.2	1.9
	Fugitive	22.9	21.1	17.2	14.1	15.2	12.3	12.4	11.8	12.6	11.7	12.6	13.2	11.7	12.1	12.2	12.5	10.4	10.9	8.8
	Industrial Processes	6.3	5.9	4.8	4.5	4.0	3.2	2.2	4.7	4.1	2.3	2.4	2.3	2.2	2.0	2.3	2.3	2.1	2.4	2.5
	Solvent Processes	47.1	37.5	31.1	29.4	24.7	23.0	22.2	21.7	21.7	22.8	22.4	21.7	20.2	18.8	18.5	18.2	18.1	18.5	18.2
	Other	2.0	2.2	1.8	1.6	1.8	1.5	1.7	1.5	1.2	1.1	1.2	1.1	1.1	0.9	1.0	1.0	1.0	0.9	0.8
	Residential & other combustion	8.2	6.3	6.8	7.3	6.0	5.8	5.0	5.0	4.9	4.8	5.0	5.2	5.6	5.5	6.5	5.8	6.5	6.9	6.4
	Total	**146**	**122**	**102**	**94**	**85**	**77**	**71**	**71**	**69**	**65**	**65**	**63**	**59**	**55**	**56**	**55**	**52**	**53**	**51**

	Category	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PM_{10} (kt)	Agriculture	1.2	1.2	1.3	1.3	1.3	1.2	1.3	1.2	1.4	1.3	1.3	1.2	1.3	1.3	1.3	1.4	1.4	1.4	1.5
	Energy Industries	3.3	2.2	1.6	1.2	2.0	1.7	1.0	1.2	1.0	1.0	1.3	1.2	1.1	0.9	0.8	0.8	0.9	1.1	0.6
	Industrial Combustion	2.9	2.2	1.6	1.7	1.7	1.6	1.5	1.5	1.3	1.1	1.1	1.1	1.0	0.9	1.1	0.9	0.9	1.0	1.0
	Transport Sources	2.2	2.4	2.4	2.4	2.1	2.1	2.0	2.0	2.0	1.9	1.9	1.8	1.7	1.6	1.6	1.5	1.4	1.4	1.3
	Industrial Processes	5.7	5.2	4.5	4.2	4.0	3.1	2.4	3.3	3.4	3.2	3.2	3.3	2.6	2.0	2.3	2.3	2.1	3.0	3.3
	Solvent Processes	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
	Other	0.5	0.5	0.5	0.5	0.5	0.7	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
	Residential & other combustion	5.9	4.7	5.1	5.5	4.7	4.7	4.0	4.1	4.0	4.0	4.4	4.5	5.1	5.1	6.3	5.5	6.5	7.2	6.8
	Total	**22**	**19**	**17**	**17**	**17**	**15**	**13**	**14**	**14**	**13**	**14**	**14**	**13**	**13**	**14**	**13**	**14**	**16**	**15**
Sulphur dioxide (kt)	Energy Industries	109.0	69.6	51.7	40.1	58.8	51.7	42.2	46.2	44.1	39.0	45.8	37.2	24.3	17.8	16.9	17.3	15.3	19.4	11.8
	Industrial Combustion	45.2	36.0	24.9	22.1	20.2	18.7	11.6	10.9	8.5	7.0	8.0	8.4	7.6	7.2	8.9	8.2	7.8	8.7	7.5
	Transport Sources	5.9	5.0	3.5	3.0	2.5	2.2	2.2	2.2	2.4	2.4	2.2	1.7	1.2	1.2	1.1	1.0	0.8	0.8	0.7
	Fugitive	4.4	3.3	2.7	2.1	1.5	1.7	0.7	0.8	0.9	1.0	1.2	1.2	1.3	1.1	1.8	1.3	1.1	1.3	1.4
	Industrial Processes	2.9	2.7	2.8	2.3	2.2	2.6	2.2	1.9	2.1	2.3	2.1	2.3	2.1	0.4	0.4	0.4	0.5	0.6	0.4
	Other	0.3	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Residential & other combustion	17.3	13.6	10.6	10.0	8.2	8.2	6.1	5.3	5.1	4.8	4.4	4.4	4.4	5.7	7.0	5.8	5.4	6.2	5.2
	Total	**185**	**131**	**96**	**80**	**93**	**85**	**65**	**67**	**63**	**57**	**64**	**55**	**41**	**34**	**36**	**34**	**31**	**37**	**27**
Lead **(tonnes)**	Energy Industries	3.7	1.8	0.8	0.6	1.5	1.0	0.5	0.8	0.4	0.8	0.9	0.4	0.5	0.5	0.5	0.4	0.4	0.3	0.2
	Industrial Combustion	2.8	2.2	1.7	2.3	2.2	1.6	4.6	3.2	6.6	2.5	0.9	0.9	0.8	0.9	1.1	0.9	0.8	0.9	0.9
	Transport Sources	109.0	52.5	27.9	14.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Industrial Processes	17.6	18.6	18.2	16.9	16.7	12.3	7.2	11.6	15.3	16.9	12.9	12.0	11.5	8.1	11.6	10.6	8.2	8.4	11.4
	Waste	0.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other	1.5	1.8	1.8	1.8	2.0	1.4	0.5	0.8	0.4	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.9
	Residential & other combustion	2.7	1.8	1.5	1.5	1.1	1.1	0.8	0.7	0.7	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	Total	**138**	**79**	**52**	**38**	**24**	**18**	**14**	**17**	**24**	**21**	**16**	**15**	**14**	**11**	**15**	**13**	**11**	**11**	**14**

* The uncertainties in the data are greater than the precision indicated by the table above. This higher level of resolution has been chosen to aid transparency.

E.4 Summary Air Quality Pollutant Emission Estimates for Northern Ireland

Table 17 - Summary of air quality pollutant emission estimates for Northern Ireland (1990-2014) *

	Category	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Ammonia (kt)	Agriculture	32.0	34.1	34.7	34.0	32.2	32.1	32.3	32.7	32.7	31.8	31.0	30.0	29.6	29.4	28.9	29.5	29.7	29.9	30.5
	Transport Sources	0.0	0.3	0.5	0.6	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.2
	Industrial Processes	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Waste	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	0.9	1.1	1.1	1.2	1.2	1.2	1.3
	Other	0.4	0.5	0.6	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7
	Residential & other combustion	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
	Total	**33**	**35**	**36**	**36**	**34**	**34**	**34**	**35**	**35**	**34**	**33**	**32**	**32**	**32**	**31**	**32**	**32**	**32**	**33**
Carbon monoxide (kt)	Energy Industries	4.1	3.8	2.2	1.3	1.3	1.4	1.2	1.1	2.0	3.2	2.8	2.6	2.5	2.3	2.5	1.8	1.4	1.2	1.2
	Industrial Combustion	15.2	14.8	12.4	13.0	11.9	11.5	12.5	13.6	11.8	16.1	18.5	18.1	15.2	16.0	21.3	22.4	21.9	23.3	29.9
	Transport Sources	128.0	111.0	99.4	94.7	85.2	78.7	69.6	65.0	60.9	55.3	49.2	43.7	40.1	32.2	27.6	22.8	20.6	18.6	16.9
	Fugitive	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Industrial Processes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other	2.3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.7	0.7
	Residential & other combustion	146.0	89.2	67.3	59.1	52.0	43.4	36.6	30.7	24.8	21.7	21.6	22.8	25.1	25.3	29.5	27.1	28.8	31.2	28.2
	Total	**295**	**220**	**182**	**169**	**151**	**136**	**121**	**111**	**100**	**97**	**93**	**88**	**84**	**77**	**82**	**75**	**73**	**75**	**77**
Nitrogen oxides (kt)	Energy Industries	31.1	19.3	13.9	14.2	14.8	16.0	12.4	11.5	9.8	9.6	9.7	7.0	6.4	5.5	5.7	5.6	5.8	6.1	5.2
	Industrial Combustion	18.4	18.4	16.3	16.0	16.1	16.3	12.9	12.4	12.6	14.1	12.9	13.1	11.6	10.1	11.0	9.4	9.0	8.9	9.1
	Transport Sources	37.5	32.2	27.0	26.1	24.7	24.0	23.8	24.0	22.8	22.3	21.4	20.8	19.8	17.5	16.3	15.2	14.5	13.7	13.3
	Other	1.6	1.0	0.8	0.9	0.8	0.7	0.5	0.6	0.6	0.6	0.6	0.7	0.6	0.6	0.6	0.5	0.5	0.4	0.4
	Residential & other combustion	15.6	14.0	13.0	12.7	11.9	11.7	10.8	10.3	9.5	9.4	8.7	7.9	7.5	7.1	7.2	6.1	5.9	5.6	5.1
	Total	**104**	**85**	**71**	**70**	**68**	**69**	**60**	**59**	**55**	**56**	**53**	**49**	**46**	**41**	**41**	**37**	**36**	**35**	**33**
NMVOC (kt)	Agriculture	11.9	13.0	13.9	13.6	13.3	13.3	13.7	13.8	14.4	14.0	14.0	13.6	13.4	13.4	13.5	14.0	14.2	14.0	14.4
	Industrial Combustion	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.8	0.7	0.7	0.6	0.6	0.6	0.6
	Transport Sources	26.3	21.3	16.0	14.4	12.4	11.2	9.2	7.9	6.8	5.8	5.0	4.3	3.8	2.7	2.3	1.9	1.7	1.5	1.3
	Fugitive	3.3	3.2	2.8	2.1	2.0	1.9	1.8	1.8	1.7	1.6	1.5	1.4	1.2	1.1	0.9	0.9	0.8	0.8	0.9
	Industrial Processes	2.3	2.3	2.2	2.1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.1	2.2	2.2	2.3	2.3	2.4	2.5	2.5
	Solvent Processes	16.7	13.3	12.2	11.6	11.3	11.0	10.8	10.7	10.7	10.6	10.7	10.6	10.0	9.5	9.4	9.5	9.4	9.4	9.4
	Other	0.8	0.8	0.6	0.6	0.6	0.5	0.5	0.4	0.6	0.7	0.7	0.4	0.5	0.5	0.5	0.4	0.3	0.3	0.4
	Residential & other combustion	10.2	6.3	5.2	4.7	4.2	3.7	3.3	3.0	2.7	2.6	2.6	2.6	2.7	2.6	2.9	2.6	2.8	2.9	2.6
	Total	**72**	**61**	**54**	**50**	**47**	**44**	**42**	**40**	**40**	**38**	**37**	**36**	**35**	**33**	**32**	**32**	**32**	**32**	**32**

Pollutant	Category	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PM_{10} (kt)	Agriculture	1.5	1.7	1.8	1.5	1.7	1.5	1.5	1.6	1.6	1.5	1.5	1.6	1.7	1.6	1.5	1.6	1.7	1.7	1.9
	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	0.2	0.1	0.1	0.1	0.1	0.0	0.0
	Industrial Combustion	1.5	1.4	1.1	1.1	1.1	1.0	0.9	0.8	0.8	1.0	1.0	1.0	0.9	0.9	1.0	0.9	0.9	1.0	1.0
	Transport Sources	1.1	1.3	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.1	1.1	1.1	1.0	1.0	0.9	0.9
	Industrial Processes	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4
	Solvent Processes	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Other	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
	Residential & other combustion	7.9	5.0	4.1	3.7	3.3	2.9	2.4	2.3	2.1	2.0	2.0	2.0	2.2	2.2	2.6	2.3	2.5	2.7	2.5
	Total	**16**	**12**	**10**	**9**	**9**	**9**	**8**	**8**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**6**	**7**	**7**	**7**
Sulphur dioxide (kt)	Energy Industries	68.2	39.7	26.8	26.8	28.3	29.9	18.3	17.4	16.4	14.9	13.5	8.3	11.0	4.6	2.3	2.3	2.9	3.0	2.6
	Industrial Combustion	19.5	16.7	9.0	5.9	4.8	5.3	3.2	2.9	3.3	4.5	4.2	3.9	3.9	3.9	5.1	4.4	3.9	4.5	4.8
	Transport Sources	2.6	2.3	1.5	1.3	1.0	0.9	1.0	1.0	1.0	1.1	1.0	0.8	0.6	0.5	0.5	0.4	0.4	0.4	0.4
	Fugitive	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
	Industrial Processes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Residential & other combustion	21.1	17.1	12.7	10.7	9.0	7.9	6.5	5.3	4.2	3.6	3.5	3.5	3.6	2.5	2.5	2.4	2.6	2.3	2.0
	Total	**112**	**76**	**50**	**45**	**43**	**44**	**29**	**27**	**25**	**24**	**22**	**17**	**19**	**12**	**11**	**10**	**10**	**10**	**10**
Lead **(tonnes)**	Energy Industries	2.8	1.3	0.7	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0
	Industrial Combustion	2.4	2.4	2.0	1.9	1.7	1.7	1.7	1.6	1.6	1.5	1.2	1.3	1.1	1.3	1.5	1.3	1.1	1.2	1.2
	Transport Sources	59.6	30.6	16.6	9.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Industrial Processes	0.4	0.4	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Waste	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Residential & other combustion	3.7	2.0	1.5	1.3	1.0	0.9	0.7	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4
	Total	**69**	**37**	**21**	**13**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**

* The uncertainties in the data are greater than the precision indicated by the table above. This higher level of resolution has been chosen to aid transparency.

Appendix F Definition of NFR Codes and Sector categories

Table 18 below provides a lookup table between the NFR codes and descriptions used to provide a high degree of detail in the inventory, and the categories used in the graphs within this report.

The Sector Category "Other" is applied to 1A5b and 6A across all pollutants, as shown in the table below. Additional Sector Categories are included under "Other" for each pollutant. If a Sector Category is insignificant for a pollutant, then it is included within the "Other" category in the tables and graphs of the report. See Table 19 below for further information.

Table 18 - Definition of NFR Codes and Sector Categories

NFRCode	NFR Source Description	Sector Category	Sub-sector Category
1A1a	Public electricity and heat production	Energy Industries	Power generation
1A1b	Petroleum refining	Energy Industries	Other
1A1c	Manufacture of solid fuels and other energy industries	Energy Industries	Other
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	Industrial Combustion	Iron and steel
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	Industrial Combustion	Other
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	Industrial Combustion	Other
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	Industrial Combustion	Other
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	Industrial Combustion	Food and drink
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Industrial Combustion	Other
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	Industrial Combustion	Other
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	Industrial Combustion	Other
1A3ai(i)	International aviation LTO (civil)	Transport Sources	Rail, aviation and shipping
1A3aii(i)	Domestic aviation LTO (civil)	Transport Sources	Rail, aviation and shipping
1A3bi	Road transport: Passenger cars	Transport Sources	Passenger cars
1A3bii	Road transport: Light duty vehicles	Transport Sources	Other road transport
1A3biii	Road transport: Heavy duty vehicles and buses	Transport Sources	Other road transport

NFRCode	NFR Source Description	Sector Category	Sub-sector Category
1A3biv	Road transport: Mopeds & motorcycles	Transport Sources	Other road transport
1A3bv	Road transport: Gasoline evaporation	Transport Sources	Other road transport
1A3bvi	Road transport: Automobile tyre and brake wear	Transport Sources	Other road transport
1A3bvii	Road transport: Automobile road abrasion	Transport Sources	Other road transport
1A3c	Railways	Transport Sources	Rail, aviation and shipping
1A3dii	National navigation (shipping)	Transport Sources	Rail, aviation and shipping
1A3eii	Other (please specify in the IIR)	Transport Sources	Rail, aviation and shipping
1A4ai	Commercial/institutional: Stationary	Residential & Other Combustion	Other
1A4bi	Residential: Stationary	Residential & Other Combustion	Residential
1A4bii	Residential: Household and gardening (mobile)	Residential & Other Combustion	Residential
1A4ci	Agriculture/Forestry/Fishing: Stationary	Residential & Other Combustion	Outdoor industries
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	Residential & Other Combustion	Outdoor industries
1A4ciii	Agriculture/Forestry/Fishing: National fishing	Residential & Other Combustion	Outdoor industries
1A5b	Other, Mobile (including military, land based and recreational boats)	Other	Other
1B1b	Fugitive emission from solid fuels: Solid fuel transformation	Fugitive	Fugitive
1B2ai	Fugitive emissions oil: Exploration, production, transport	Fugitive	Fugitive
1B2aiv	Fugitive emissions oil: Refining / storage	Fugitive	Fugitive
1B2av	Distribution of oil products	Fugitive	Fugitive
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	Fugitive	Fugitive
1B2c	Venting and flaring (oil, gas, combined oil and gas)	Fugitive	Fugitive
2A1	Cement production	Industrial Processes	Cement production
2A3	Glass production	Industrial Processes	Other
2A5a	Quarrying and mining of minerals other than coal	Industrial Processes	Other
2A5b	Construction and demolition	Industrial Processes	Other
2A6	Other mineral products (please specify in the IIR)	Industrial Processes	Other
2B10a	Chemical industry: Other (please specify in the IIR)	Industrial Processes	Other

NFRCode	NFR Source Description	Sector Category	Sub-sector Category
2B10b	Storage, handling and transport of chemical products (please specify in the IIR)	Industrial Processes	Other
2B2	Nitric acid production	Industrial Processes	Other
2B6	Titanium dioxide production	Industrial Processes	Other
2B7	Soda ash production	Industrial Processes	Other
2C1	Iron and steel production	Industrial Processes	Iron and steel
2C3	Aluminium production	Industrial Processes	Other
2C5	Lead production	Industrial Processes	Other
2C6	Zinc production	Industrial Processes	Other
2C7a	Copper production	Industrial Processes	Other
2C7c	Other metal production (please specify in the IIR)	Industrial Processes	Other
2D3a	Domestic solvent use including fungicides	Solvent Processes	Domestic
2D3b	Road paving with asphalt	Solvent Processes	Other
2D3d	Coating applications	Solvent Processes	Industrial
2D3e	Degreasing	Solvent Processes	Industrial
2D3f	Dry cleaning	Solvent Processes	Industrial
2D3g	Chemical products	Solvent Processes	Industrial
2D3h	Printing	Solvent Processes	Industrial
2D3i	Other solvent use (please specify in the IIR)	Solvent Processes	Other
2H1	Pulp and paper industry	Industrial Processes	Other
2H2	Food and beverages industry	Industrial Processes	Food and drink
2H3	Other industrial processes (please specify in the IIR)	Industrial Processes	Other
2I	Wood processing	Industrial Processes	Other
3B1a	Manure management - Dairy cattle	Agriculture	Cattle manure management
3B1b	Manure management - Non-dairy cattle	Agriculture	Cattle manure management
3B2	Manure management - Sheep	Agriculture	Other manure management
3B3	Manure management - Swine	Agriculture	Other manure management
3B4d	Manure management - Goats	Agriculture	Other manure management
3B4e	Manure management - Horses	Agriculture	Other manure management
3B4gi	Manure management - Laying hens	Agriculture	Other manure management
3B4gii	Manure management - Broilers	Agriculture	Other manure management
3B4giii	Manure management - Turkeys	Agriculture	Other manure management
3B4giv	Manure management - Other poultry	Agriculture	Other manure management

NFRCode	NFR Source Description	Sector Category	Sub-sector Category
3B4h	Manure management - Other animals (please specify in IIR)	Agriculture	Other manure management
3Da1	Inorganic N-fertilizers (includes also urea application)	Agriculture	In-organic fertilizers
3Da2a	Animal manure applied to soils	Agriculture	Manure applied to soils
3Da3	Urine and dung deposited by grazing animals	Agriculture	Grazing animal excreta
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	Agriculture	Other
3F	Field burning of agricultural residues	Agriculture	Other
5A	Biological treatment of waste - Solid waste disposal on land	Waste	Waste
5B1	Biological treatment of waste - Composting	Waste	Waste
5C1a	Municipal waste incineration	Waste	Waste
5C1bii	Hazardous waste incineration	Waste	Waste
5C1biii	Clinical waste incineration	Waste	Waste
5C1biv	Sewage sludge incineration	Waste	Waste
5C1bv	Cremation	Waste	Waste
5C2	Open burning of waste	Waste	Waste
5D1	Domestic wastewater handling	Waste	Waste
6A	Other (included in national total for entire territory) (please specify in IIR)	Other	Other

Table 19 - Summary of the sector categories included in "Other" for each pollutant

Sector Category	CO	NH_3	NO_x	Pb	PM_{10}	SO_2	VOC
Agriculture	✓		✓				
Energy Industries		✓					✓
Fugitive		✓	✓	✓	✓		
Industrial Combustion		✓					
Industrial Processes			✓				
Other	✓	✓	✓	✓	✓		✓
Solvent Processes		✓					
Waste	✓		✓		✓	✓	✓

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