National Atmospheric Emissions Inventory

Air Pollutant Inventories for England, Scotland, Wales, and Northern Ireland: 1990-2016

Prepared by Ricardo Energy & Environment for the Department for Environment, Food & Rural Affairs, The Scottish Government, The Welsh Government and The Northern Ireland Department for Agriculture, Environment and Rural Affairs.

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16th October 2018

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Glossary

API	Air pollutant inventory
AQ	Air quality
AQEG	Air Quality Expert Group
AQS for ESWNI	Air Quality Strategy for England, Scotland, Wales and Northern Ireland
NH_3	Ammonia
BAT	Best Available Techniques
BEIS	Department for Business, Energy & Industrial Strategy
BOFA	Boosted Over Fire Air
CO	Carbon monoxide
CCGT	Combined Cycle Gas Turbine
CLRTAP	Convention on Long-Range Transboundary Air Pollution
COMEAP	Committee on the Medical Effects of Air Pollutants
Defra	Department for Environment, Food & Rural Affairs
DA	Devolved Administration
DERV	Diesel engine road vehicle
DfT	Department for Transport
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
GHG	Greenhouse Gas
GDP	Gross Domestic Product
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
HFO	Heavy Fuel Oil
IED	Industrial Emissions Directive
IIR	Informative Inventory Report
IPPC	Integrated Pollution Prevention and Control
LCPD	Large Combustion Plant Directive
LDV	Light duty vehicles
LPG	Liquefied Petroleum Gas
LA	Local Authority
MDO	Marine Diesel Oil
MSW	Municipal solid waste
NAQS	National Air Quality Strategy
NAEI	National Atmospheric Emissions Inventory
NECD	National Emissions Ceiling Directive
NO_X	Nitrogen oxides
NFR	Nomenclature for Reporting
NMVOC	Non-methane volatile organic compounds

OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
PCP	Pentachlorophenol
PI	Pollution Inventory
$PM_{2.5}$	Particulate matter less than 2.5 micrometres
PM_{10}	Particulate matter less than 10 micrometres
Pb	Lead
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 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 2016, for the following priority 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})
- Particulate matter less than 2.5 micrometres ($PM_{2.5}$)
- 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 pollutant inventories (API) for each of the Devolved Administrations (DAs) has been commissioned by Defra 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 in terms of meeting both national and international targets on both local and transboundary air pollution. Defra's Clean Air Strategy 2018 sets out how the UK intends to reduce emission of pollutants, making our air healthier to breathe, protecting nature and boosting the economy. The draft strategy is available on Defra's website: https://consult.defra.gov.uk/environmental-quality/clean-air-strategy-consultation/user_uploads/clean-air-strategy-2018-consultation.pdf

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 Pollutants

Each of the priority AQ pollutants for which DA inventories are calculated are briefly described below. 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 several 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 an important source of NH_3 within the UK, with the vast majority of emissions arising from this sector. Non-agricultural sources of NH_3 are diverse. Emission estimates for these sources are often highly uncertain since ammonia tends to originate from diffuse sources, leading 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, engine load and even state of maintenance are important. Studies into the effects of exposure on human health 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 from across many industrial sectors, transport, agriculture and the residential 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} and $PM_{2.5}$ is a measure of the size distribution of the particles emitted to air and represents the material with an aerodynamic diameter less than 10 and less than 2.5 micrometres respectively. Particulate matter 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 (AQEG) 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 residential 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 2016)" (Wakeling, et al., 2018) 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 (EMEP/EEA Guidebook, 2016). These are known as "bottom-up" and "top-down" approaches respectively.

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 sub-national statistics on energy use;
- 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.

Disaggregated emission estimates are only published when they can be directly attributed to the constituent countries, therefore emissions from offshore oil and gas installations and the vessels servicing them are excluded from the reported totals and accompanying dataset. In 2016, this 'unallocated' proportion of the UK inventory total was between 4 and 6% of the UK total for NO_X and NMVOCs, between 1 and 3% for CO and SO_2 and zero or negligible for the other pollutants. For this reason, the sum of the DA total emissions for these pollutants will not match the published UK national totals. Further information on the data sources and inventory methodology can be found in Appendix B.

1.4 Uncertainties

The air 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 NAEI 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 2016)" (Wakeling, et al., 2018). 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 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 notably different to the ranking at UK level given in Table 1.

In general, the NAEI 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.

[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.

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

(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 (PM_{10} and $PM_{2.5}$)	High
Sulphur dioxide	Low
Lead	High

2 Devolved Administrations' Air 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 pollutants.

These sections include the following:

Figures graphically presenting the inventory data, showing the annual trend from 1990 to 2016 for each pollutant. These graphs are also disaggregated by sector, and further information on these sectors can be found in **Appendix G**.

Summary information on trends is provided for each pollutant, highlighting the key reasons for the observed trend since 1990 and other notable 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 substantive 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.

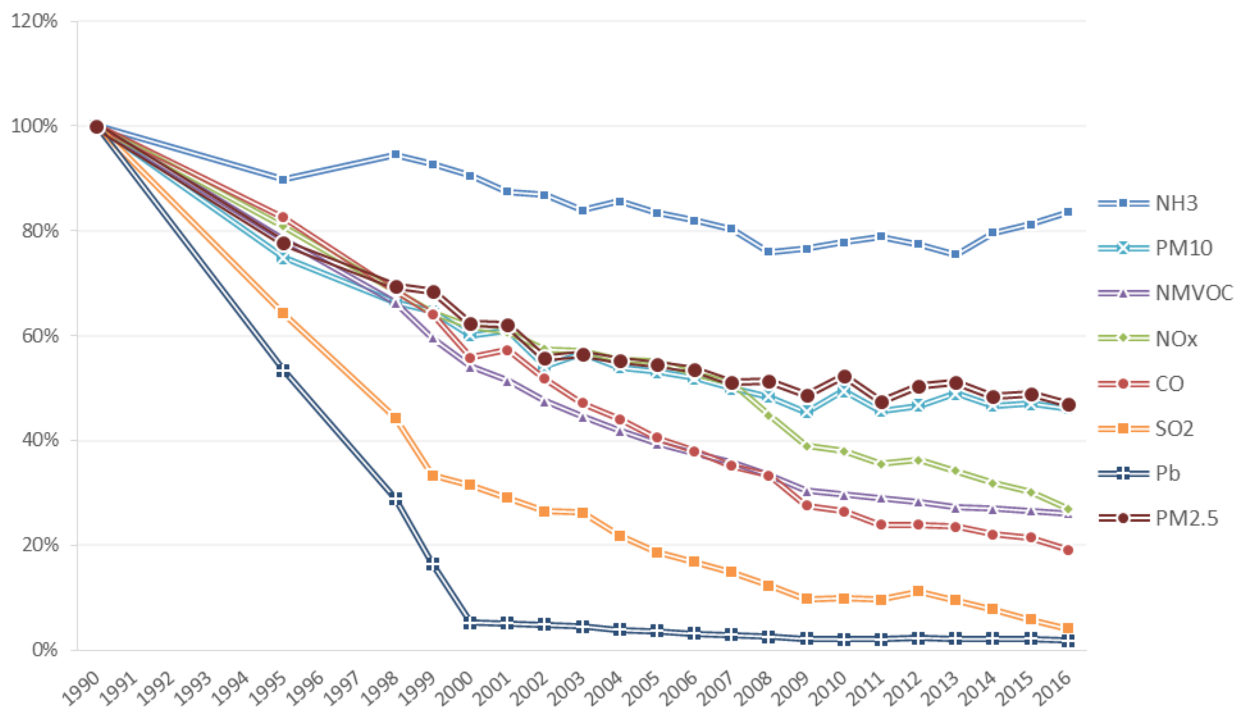
2.1 England

The following section provides a summary of emissions in England for the eight air 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}), particulate matter less than 2.5 micrometres ($PM_{2.5}$), sulphur dioxide (SO_2) and lead (Pb).

Figure 1 shows emissions of all eight air pollutants normalised to provide the relative rate of decline since 1990. This graph shows that all pollutant emission levels are lower in 2016 than they were in 1990. The rate at which they have declined is similar for PM_{10}, $PM_{2.5}$, 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.

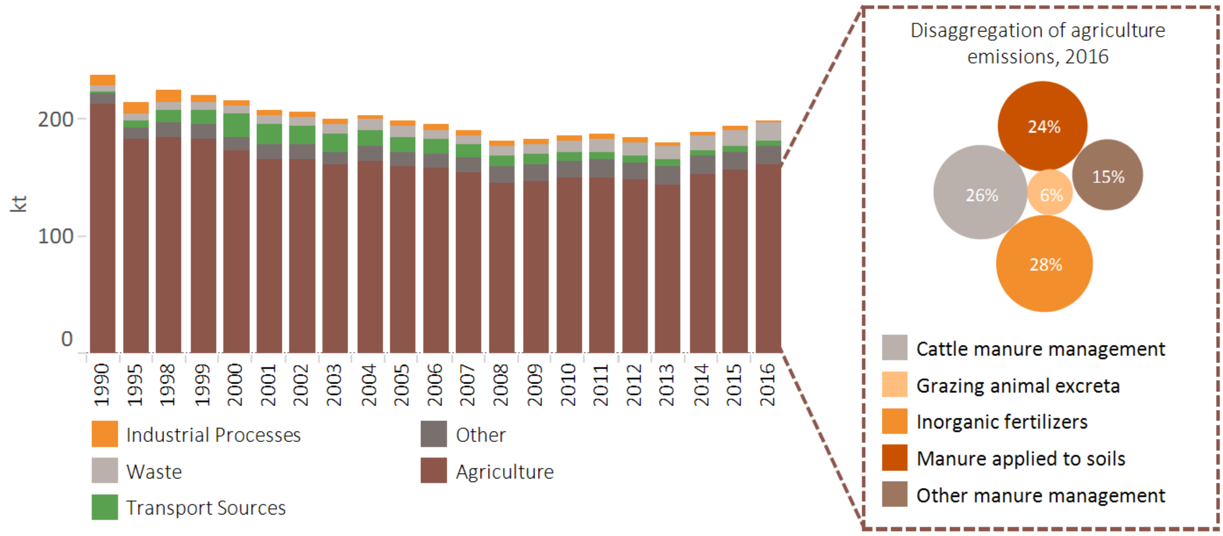
By contrast, NH_3 emissions have declined at a slower rate than other pollutants and have even risen in recent years due to increases in emissions from fertiliser application, livestock manure management and application to soils, and composting. SO_2 emissions declined rapidly between 1990 and 1999 due 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



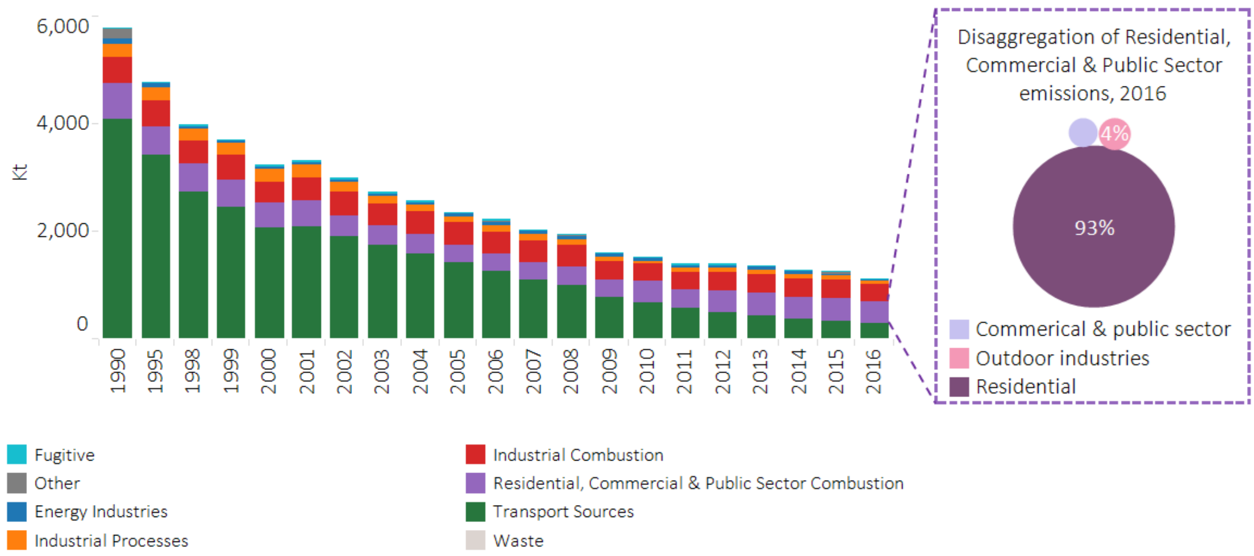
The following sections provide an overview of emissions from each of the eight pollutants giving explanations for the trends and characteristics of the graphs. Data summary tables for these emission estimates can be found in **Appendix F.** Mapping of the categories used in the graphs can be found in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

Figure 2 – Ammonia Emissions in England



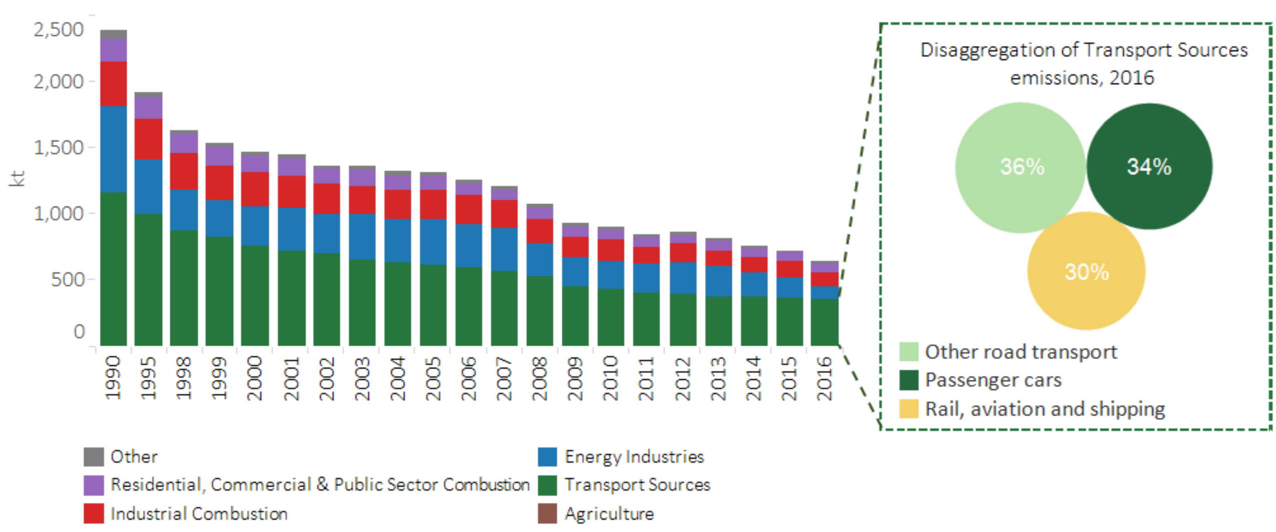
Emissions of **ammonia** were estimated to be 199kt in 2016 and have declined overall by 16% since 1990. Emissions in England account for 69% of the UK total in 2016. Agricultural sources make up by far the largest component in the inventory throughout the time series, with cattle manure management, manure applied to soils and inorganic fertilizers each accounting for around a quarter 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 2016.

Figure 3 – Carbon Monoxide Emissions in England



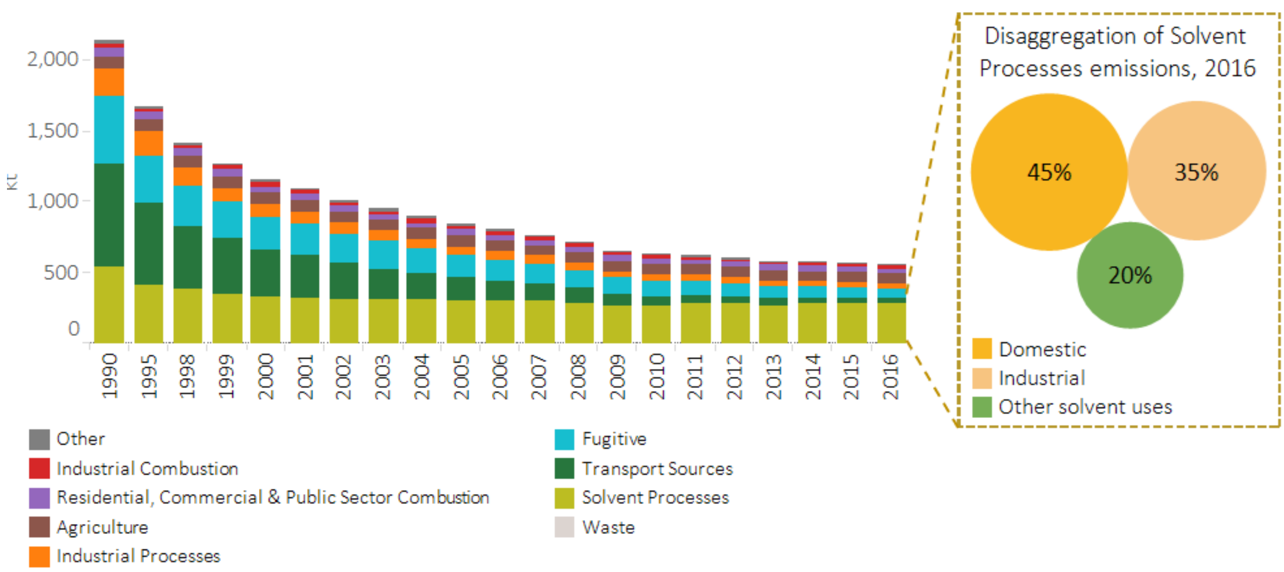
Emissions of **carbon monoxide** were estimated to be 1,111kt in 2016 and have declined by 81% since 1990. Emissions in England account for 73% of the UK total in 2016. This decline in emissions stems from changes in transport sources, particularly in road transport. The decline is driven by the introduction 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 improvements in catalyst repair rates resulting from the introduction of regulations controlling the sale and installation of replacement catalytic converters and particle filters for 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 residential sector (BEIS, 2017a).

Figure 4 – Nitrogen Oxides Emissions in England



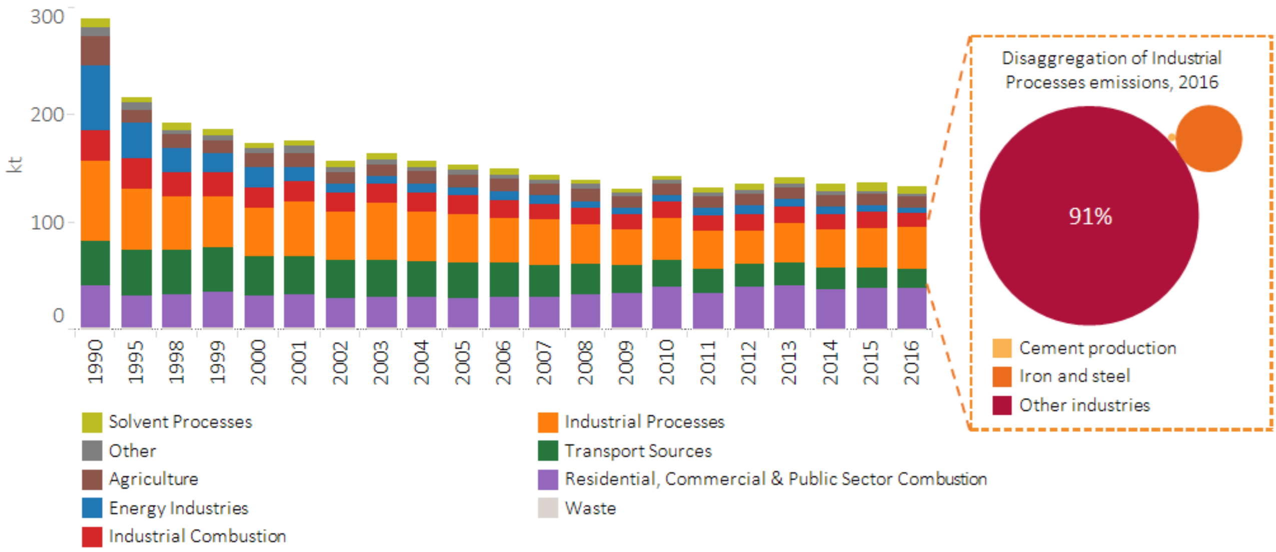
Emissions of **nitrogen oxides** were estimated to be 643kt in 2016, representing 72% of the UK total. Emissions have declined by 73% since 1990, mainly due to changes in transport sources, particularly in road transport (passenger cars and other road transport). This decline is driven by the successive 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 improvements in catalyst repair rates after the introduction of regulations controlling the sale and installation of replacement catalytic converters and particle filters for 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 energy industries are primarily due to shifts in the electricity generation fuel mix in the early 1990s from coal to natural gas (BEIS, 2017) along with the installation of NO_X abatement at coal-fired power stations such as the installation of Boosted Over Fire Air (BOFA) systems since 2008. More recently, the accelerated phase-out of coal-firing at power stations in favour of natural gas, and an increasing share of renewable energy generation (BEIS, 2017b) has contributed to an 11% decline in emissions since 2015.

Figure 5 – NMVOC Emissions in England



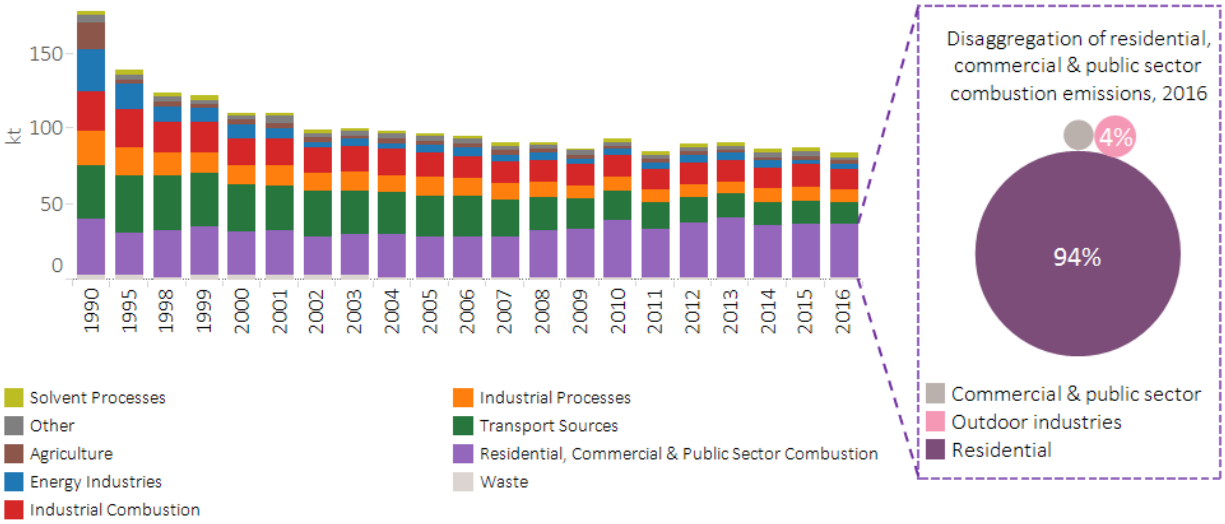
Emissions of **non-methane volatile organic compounds** were estimated to be 556kt in 2016, representing 68% of the UK total in 2016. Emissions have declined by 74% since 1990. Emissions from solvent processes reduced during the 1990s, but across the time series the trend is dominated by reductions in emissions from transport sources and fugitive 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 important source of NMVOC emissions, with significant emissions in 2016 arising from both domestic and industrial solvent applications.

Figure 6 – PM_{10} Emissions in England



Emissions of **PM_{10}** were estimated to be 133kt in 2016 and have declined by 54% since 1990. They account for 78% of the UK total in 2016. Unlike most other pollutants, the emissions profile of PM_{10} is diverse: Transport sources, residential, commercial and public sector combustion, industrial combustion and industrial processes each accounted for over 10% of total emissions in 2016. Emissions from energy industries have had the most notable impact on the trend since 1990. 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 (BEIS, 2017a). Additionally, PM_{10} exhaust emissions from diesel vehicles have been decreasing due to the successive introduction of tighter emission standards over time. However, since 2007 emissions from the residential sector and combustion from unclassified industries have increased, coincident with an increase in use of wood as a fuel, predominantly in the residential sector (BEIS, 2017a).

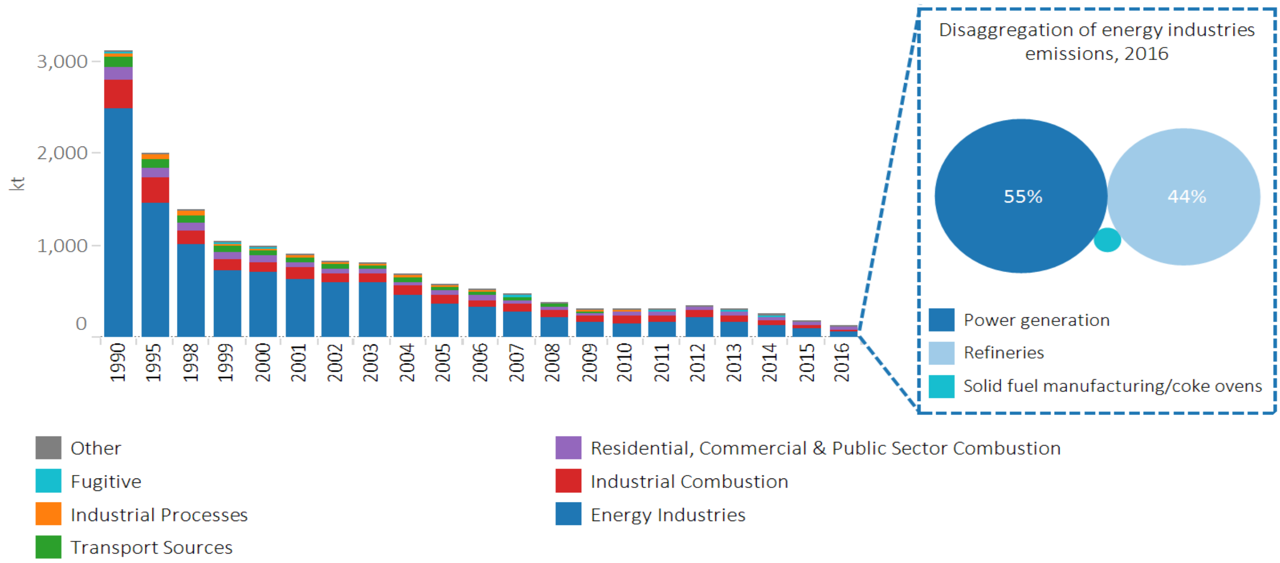
Figure 7 – $PM_{2.5}$ Emissions in England[2]



Emissions of **$PM_{2.5}$** were estimated to be 84kt in 2016 and have declined by 53% since 1990. Emissions in England account for 78% of the UK total in 2016. As with PM_{10}, $PM_{2.5}$ emissions have a large number of significant sources. Since combustion tends to produce finer particles, emissions from these sources (e.g. energy industries, industrial combustion) are of greater importance for this size fraction compared to PM_{10}. For $PM_{2.5}$, residential, commercial and public sector combustion accounts for 43% of 2016 emissions. The primary drivers for the decline in emissions since 1990 are the switch in the fuel mix used in electricity generation away from coal and towards natural gas, particularly in the early time-series, and later reductions in emissions from the transport sector due to the introduction of progressively more stringent emissions standards through time. Since 2005, declines in emissions have been offset by increases in emissions from the residential sector, and in particular, the combustion of wood.

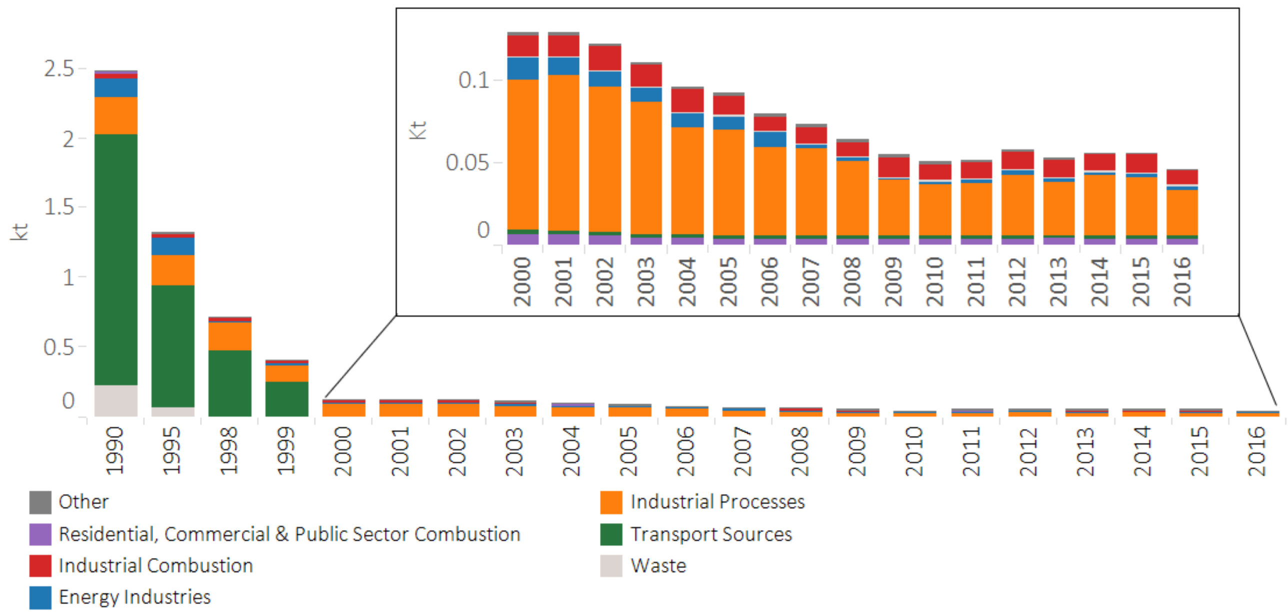
[2] 'Outdoor industries' presented in the bubble graph relate to combustion emissions from machinery in the agriculture, forestry and fishing industries.

Figure 8 - Sulphur Dioxide Emissions in England



Emissions of **sulphur dioxide** were estimated to be 128kt in 2016, representing 72% of the UK total. Emissions have declined by 96% since 1990, which has been dominated by the reduction in energy industries emissions, coincident with large changes in the power generation sector. 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) plants, 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 (BEIS, 2017b). The increase in emissions in 2012 was due to an increase in the use of coal in power generation relative to previous years (BEIS, 2017b). Transport sources emissions have declined, coincident with the reduced sulphur content of road fuels, both petrol and diesel. Emissions from industrial combustion, declined substantially during the 1990s, mainly due to a reduction in coal and fuel oil use in the chemicals sector and unclassified industry.

Figure 9 – Lead Emissions in England



Emissions of **lead** were estimated to be 46 tonnes in 2016, representing 72% of the UK total. Emissions have declined by 98% since 1990 almost entirely due to changes in transport sources. 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 predominant sources of emissions are linked to industry (industrial processes and industrial combustion) with the dominant 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 2016. The table is shaded according to the overall contribution of that sector to the pollutant total. The table below indicates that the Residential, Commercial & Public Sector Combustion category is important for CO, SO_2, PM_{10} and $PM_{2.5}$ accounting for over 25% of emissions for each pollutant. Fuel combustion is a major source of emissions, whilst Industrial Processes are also important, 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 2016

Sector	NH_3	CO	NOx	VOC	PM_{10}	$PM_{2.5}$	SO_2	Pb
Agriculture	81.0%	IE	0.3%	12.8%	8.4%	3.0%	IE	IE
Energy Industries	IE	3.6%	15.8%	IE	2.5%	3.1%	35.8%	5.7%
Fugitive	IE	0.2%	IE	12.2%	IE	IE	1.0%	IE
Industrial Combustion	IE	28.5%	16.8%	2.8%	10.7%	16.4%	21.4%	19.1%
Industrial Processes	1.3%	4.5%	IE	6.9%	28.1%	10.4%	5.7%	60.7%
Residential, Commercial & Public Sector Combustion	IE	36.0%	9.9%	6.9%	27.4%	42.7%	27.2%	9.3%
Solvent Processes	IE	IE	IE	49.9%	5.3%	3.3%	IE	IE
Transport Sources	1.8%	25.5%	54.7%	6.6%	14.4%	16.4%	7.5%	3.8%
Waste	8.0%	0.7%	IE	0.1%	1.3%	1.9%	IE	0.2%
Other	7.9%	1.1%	2.5%	1.8%	1.9%	2.7%	1.4%	1.2%

* The sector: “other” will include all “other” categories in the inventory and also a number of categories that are insignificant for a specific pollutant. These have been marked in the table as “IE“ (used in inventory reporting for “Included Elsewhere”). A breakdown of what is included within this category in respect to each pollutant can be found in **Table 20**.

Figure 10 – Ammonia Emissions in England, 2016

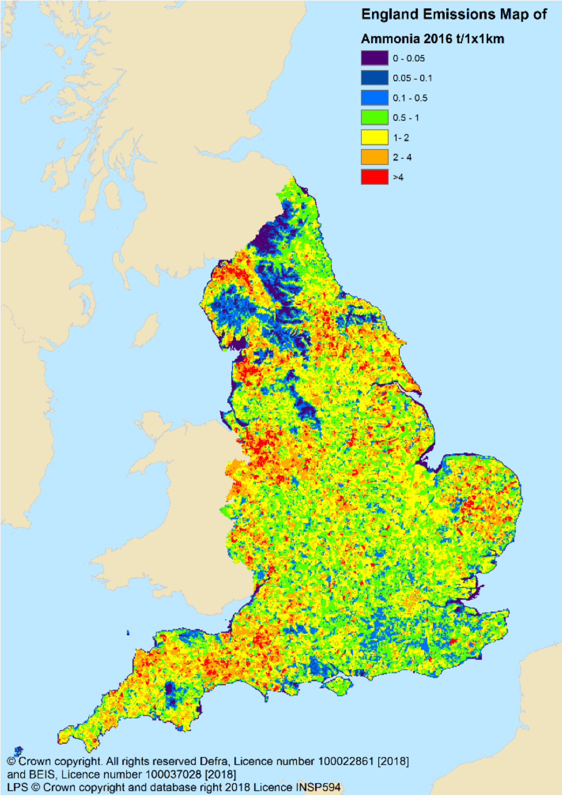


Figure 11 – Carbon Monoxide Emissions in England, 2016

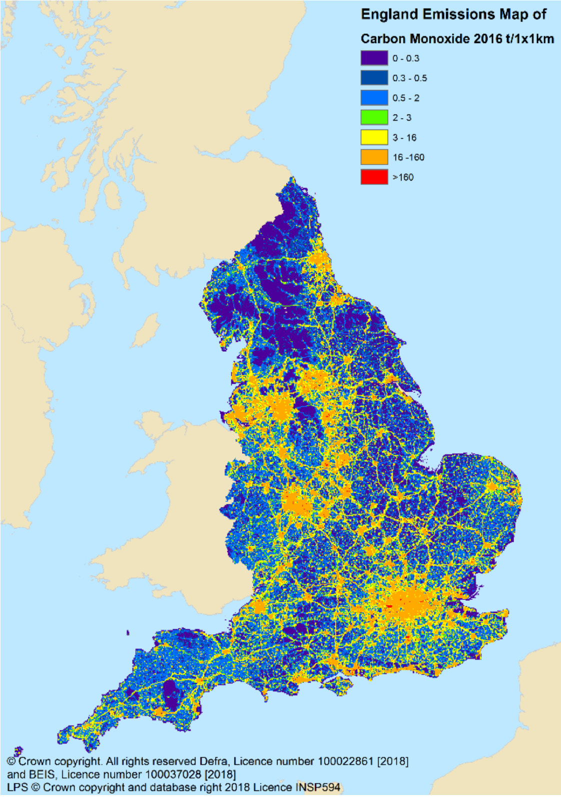


Figure 12 – Nitrogen Oxides Emissions in England, 2016

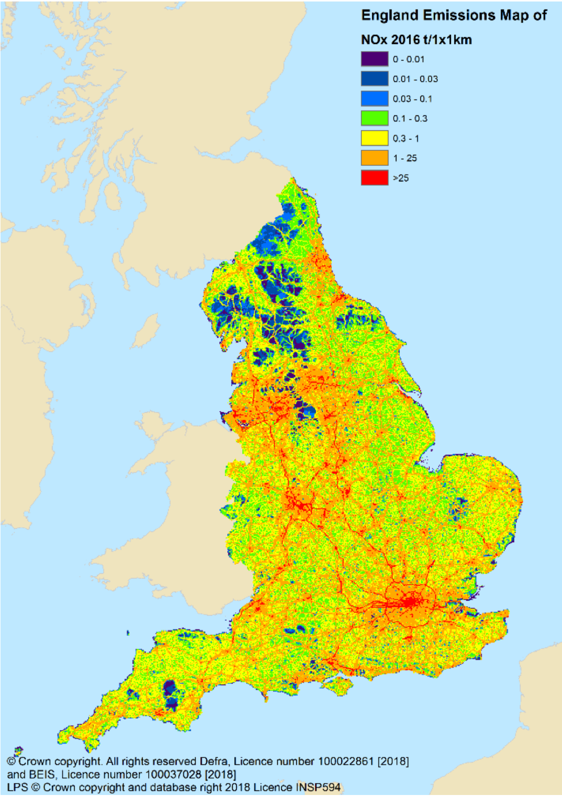


Figure 13 – NMVOC Emissions in England, 2016

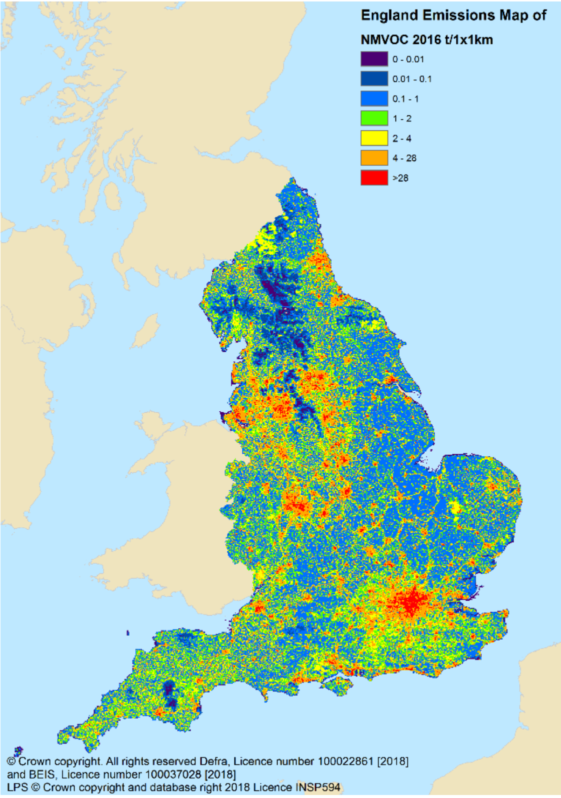


Figure 14 - PM_{10} Emissions in England, 2016

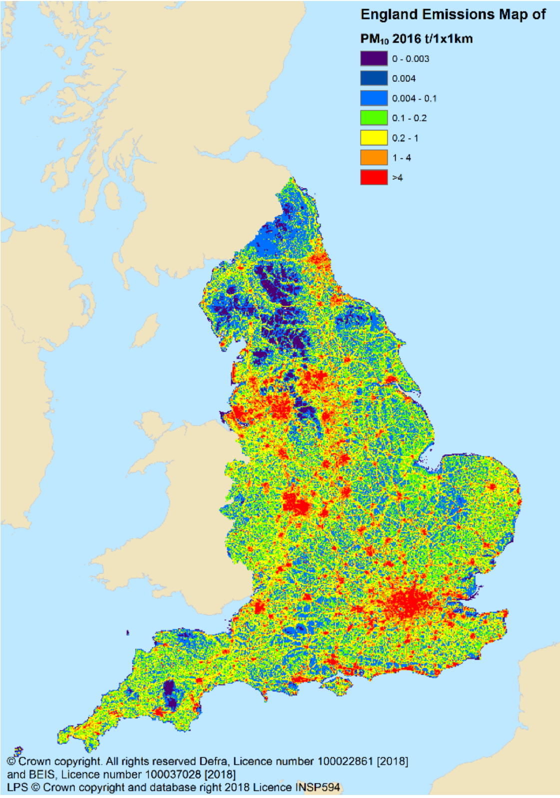


Figure 15 – $PM_{2.5}$ Emissions in England, 2016

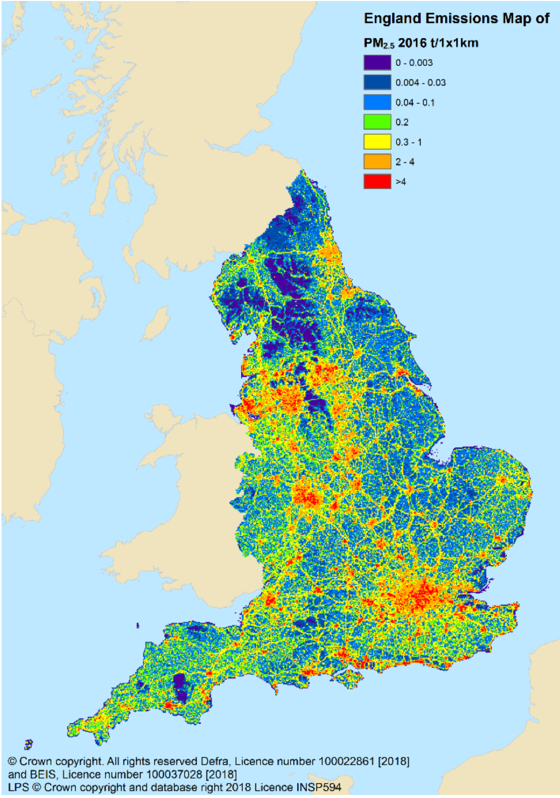


Figure 16 – Lead Emissions in England, 2016

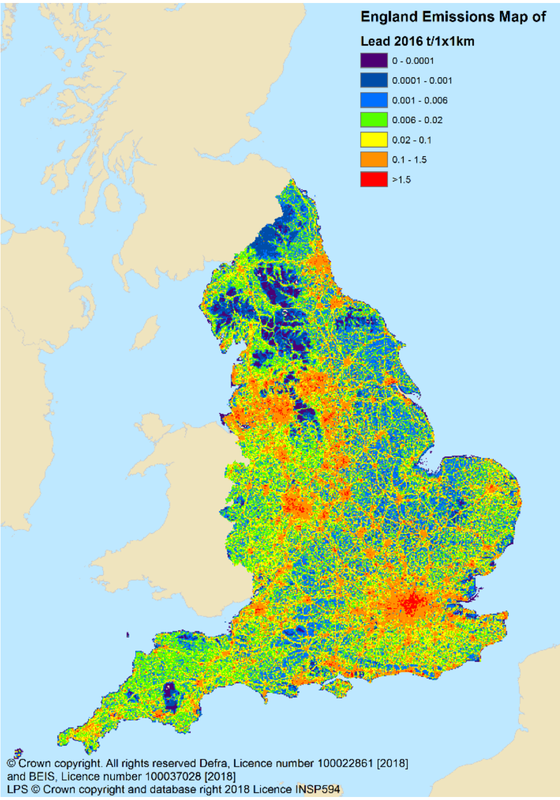
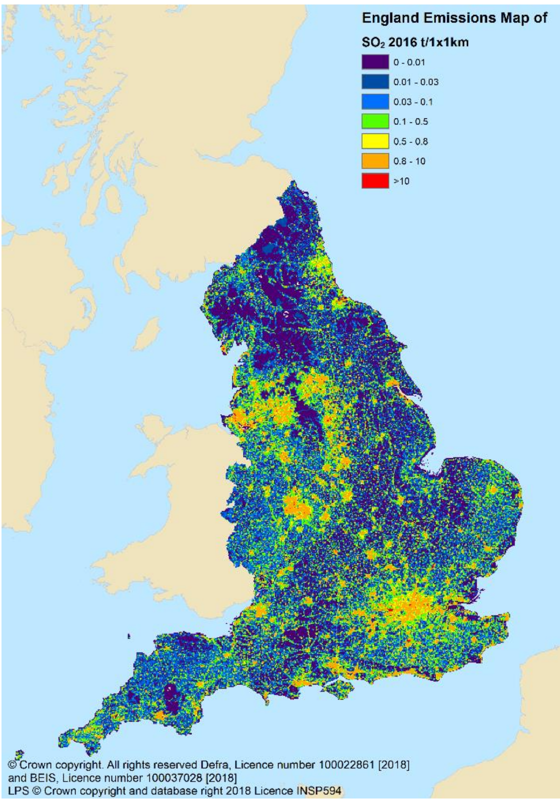


Figure 17 – Sulphur Dioxide Emissions in England, 2016



2.2 Scotland

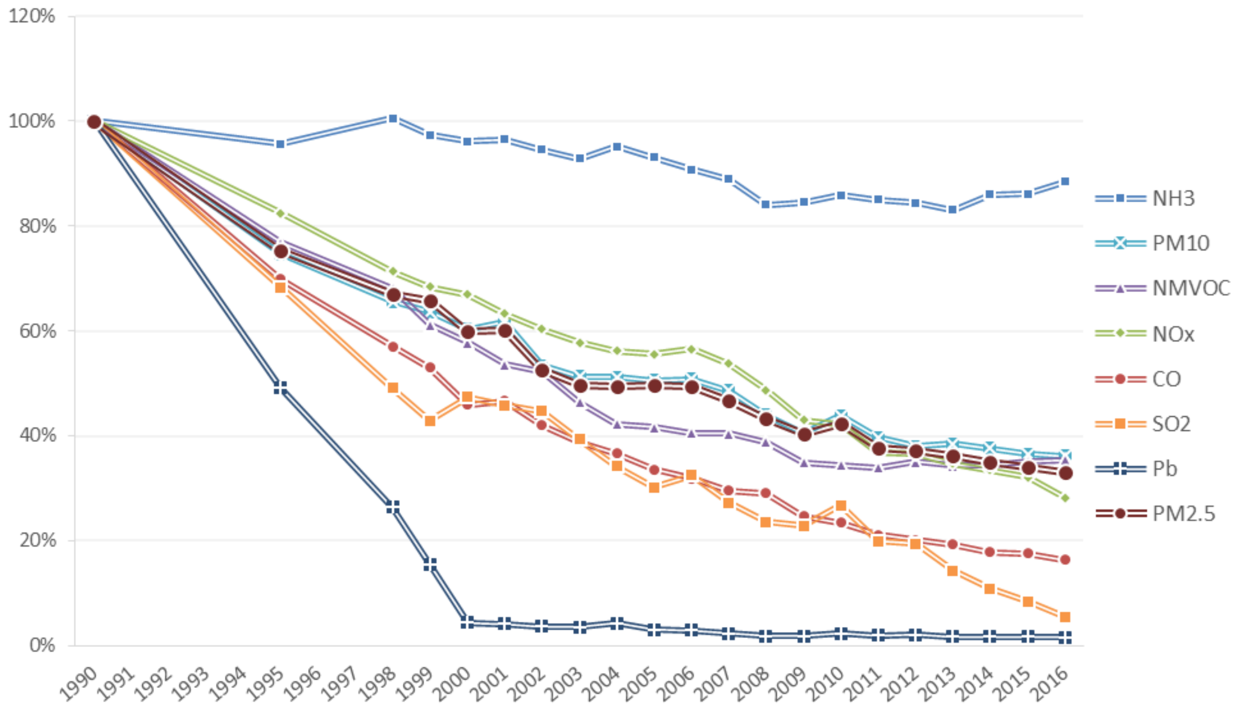
The following section provides a summary of emissions in Scotland for the eight air pollutants: ammonia (NH_3), carbon monoxide (CO), nitrogen oxides (NO_X as NO_2), non-methane volatile organic compounds (NMVOCs), particulate matter less than 10 micrometres (PM_{10}), particulate matter less than 2.5 micrometres ($PM_{2.5}$), sulphur dioxide (SO_2) and lead (Pb).

Figure 18 shows emissions of all eight air pollutants normalised to provide the relative rate of decline since 1990. This graph shows that all pollutant emission levels are lower in 2016 than they were in 1990. The decline is relatively similar for PM_{10}, $PM_{2.5}$, 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.

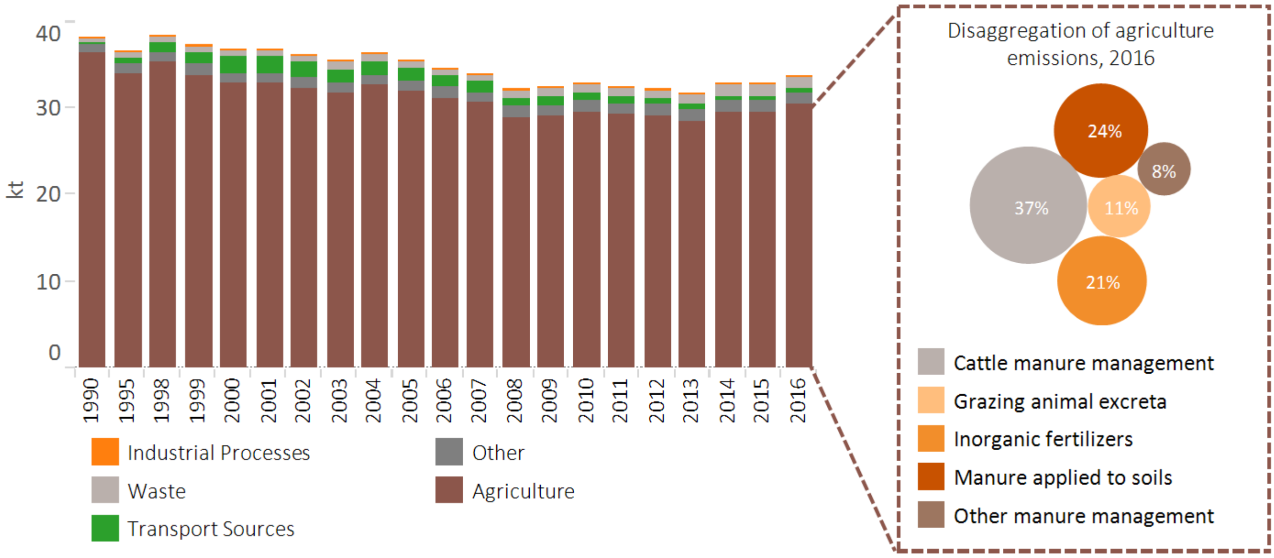
Emissions of NO_X have declined notably since 2007 primarily due to reductions in road transport emissions and the power generation sector. These are most likely linked to the installation of de-NO_X abatement systems (Boosted Over-Fire Air) on all four units at Longannet coal-fired power station (Scottish Power, Longannet Power Station, 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, and Longannet power station closed in March 2016.

Figure 18 – Scotland normalised trends for all pollutants



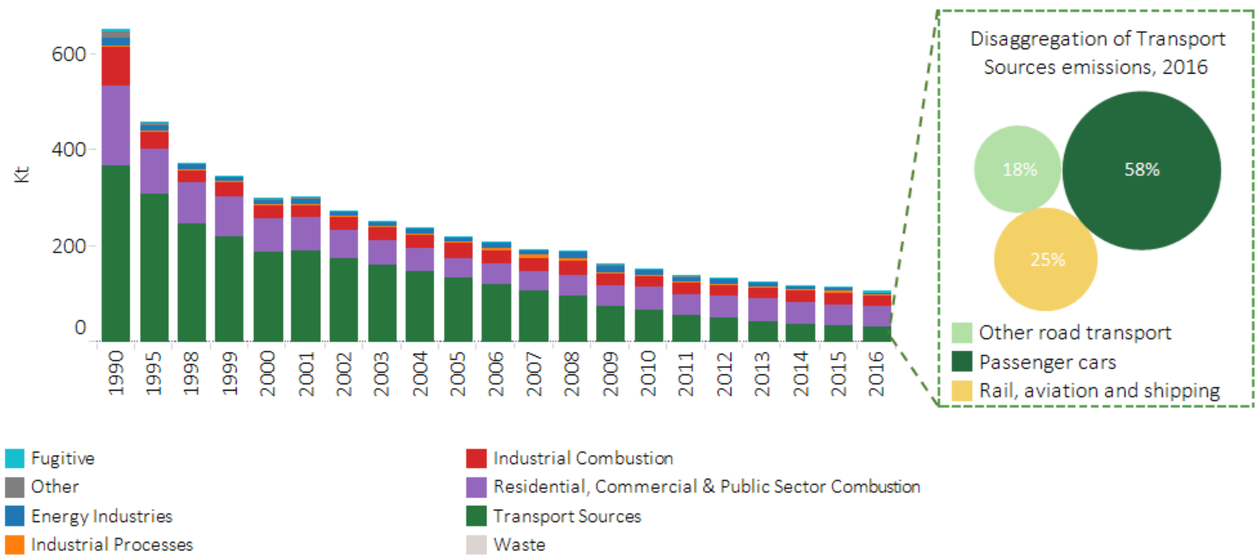
The following sections provide an overview of emissions of each of the eight pollutants giving explanations for the trends and characteristics of the graphs. Data summary tables for these emission estimates can be found in **Appendix F**. Mapping of the categories used in the graphs can be found in **Appendix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

Figure 19 – Ammonia Emissions in Scotland



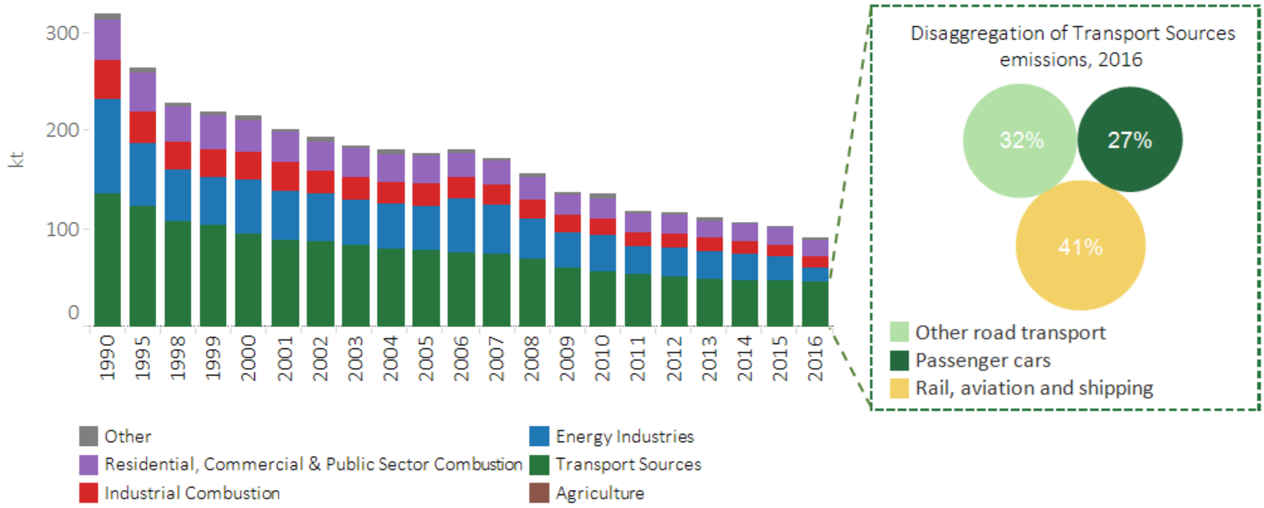
Emissions of **ammonia** were estimated to be 34kt in 2016. These emissions have declined by 12% since 1990 and accounted for 12% of the UK total in 2016. Agriculture sources have dominated the inventory throughout the time series, with cattle manure management accounting for 37% of the emissions from 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 2016. Over the time-series, there has been a long-term increase in emissions from the waste sector. In the early part of the time-series this is due to an increase in the waste composted. More recently, however, this has been driven by increased anaerobic digestion activity, in particular, from the spreading of non-manure digestates on agricultural land. Transport emissions are dominated by exhaust emissions from passenger cars. Initial increases in the 1990s are linked to the introduction of three-ways catalysts, although subsequent technological advancements mean that emissions have been declining since 2000.

Figure 20 – Carbon Monoxide Emissions in Scotland



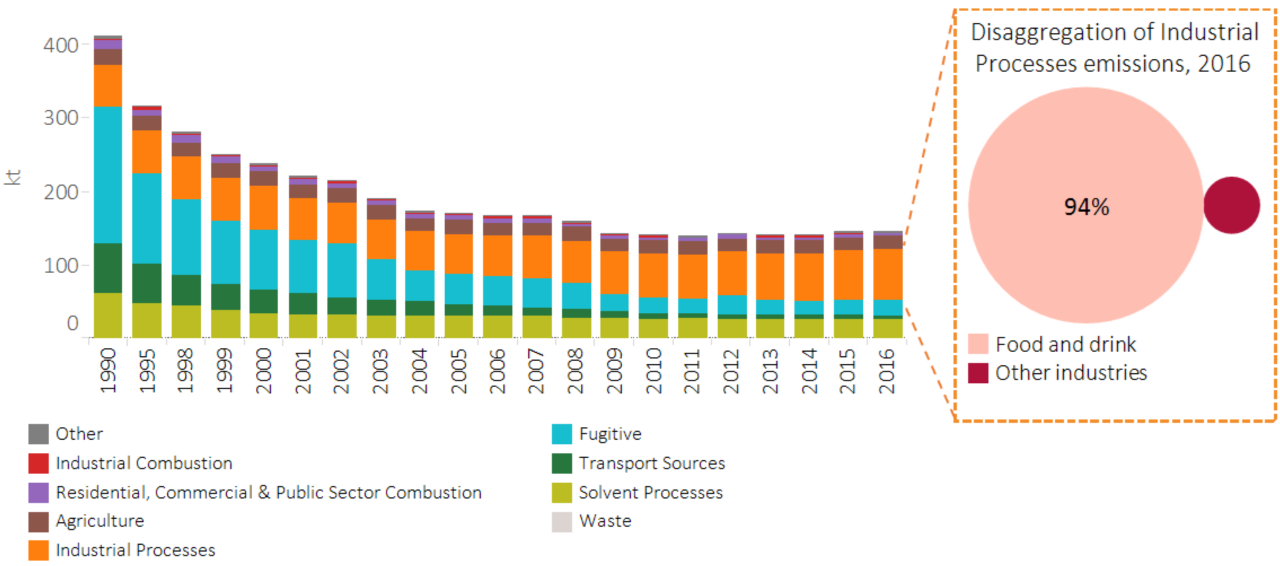
Emissions of **carbon monoxide** were estimated to be 107kt in 2016 and have declined by 84% since 1990. Emissions in Scotland accounted for 7% of the UK total in 2016. This decline in emissions stems from changes in transport sources, particularly in road transport (passenger cars and other road transport). The decline is driven by the introduction of Euro standards after 1992 which required 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 improvements in catalyst repair rates resulting from the introduction of regulations controlling the sale and installation of replacement catalytic converters and particle filters for light duty vehicles. In recent years, emissions from the residential, commercial and public sector combustion have increased, which corresponds with an increasing use of wood fuel in the domestic sector (BEIS, 2017a).

Figure 21 – Nitrogen Oxides Emissions in Scotland



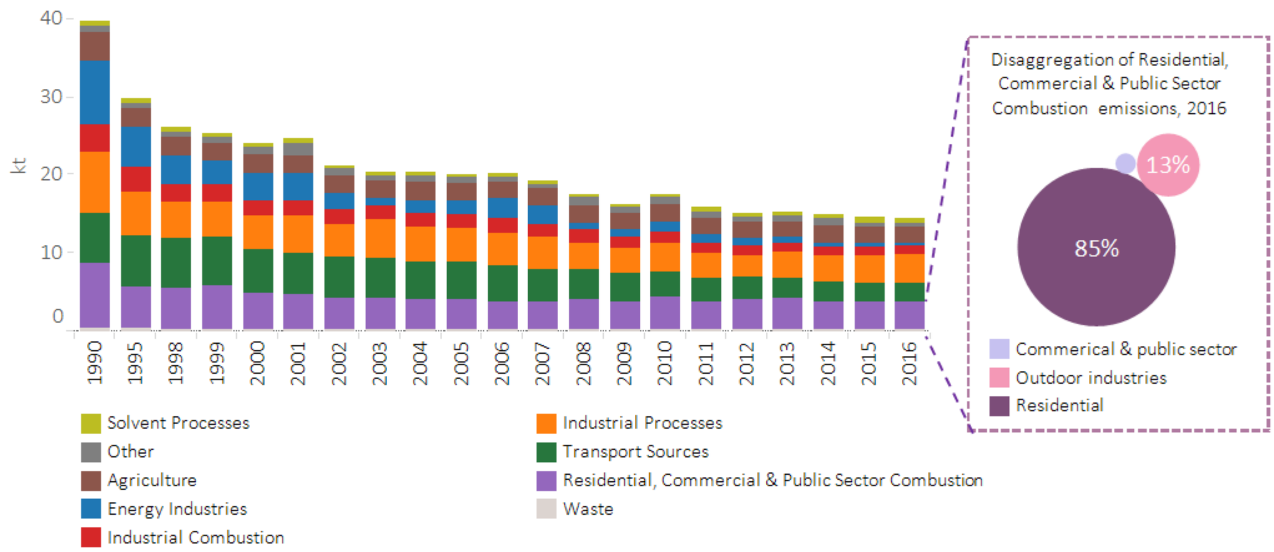
Emissions of **nitrogen oxides** were estimated to be 90kt in 2016, representing 10% of the UK total. Emissions have declined by 72% since 1990, mainly due to changes in transport sources, particularly in road transport (passenger cars and other road transport). This decline is driven by the successive 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 improvements in catalyst repair rates resulting from the introduction of regulations controlling the sale and installation of replacement catalytic converters and particle filters for light duty vehicles. However, the increasing number of diesel cars partly offsets these emissions reductions, because diesel cars emit higher NO_X relative to their petrol counterparts (84% of 2016 passenger car emissions is due to diesel cars). The peak in NO_X emissions in 2006 is due to an increase in emissions linked to the increased use of coal at power stations that year. There was also a small increase in coal-fired generation in 2012 due to a UK-wide shift in power generation fuel mix from gas to coal in that year (BEIS, 2017a). 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, Longannet Power Station, 2012). BOFA systems were also fitted on all four units at Cockenzie power station which then closed in 2013 (Scottish Power, 2011). Longannet power station closed in March 2016.

Figure 22 – NMVOC Emissions in Scotland



Emissions of **non-methane volatile organic compounds** were estimated to be 146kt in 2016, representing 18% of the UK total. Emissions have declined by 65% since 1990. This reduction has been dominated by the 89% 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 94% of industrial processes emissions in 2016) have consistently increased since 2008 due to the increased production and storage of whisky, now contributing approximately 45% 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 23 – PM_{10} Emissions in Scotland[3]

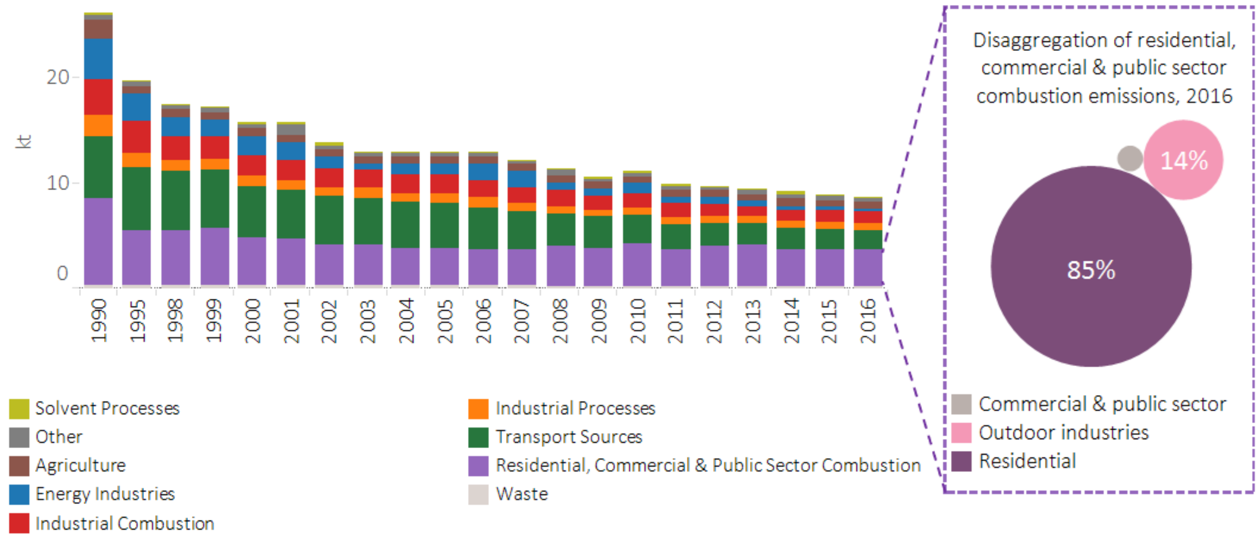


Emissions of **PM_{10}** were estimated to be 14kt in 2016, declining by 64% since 1990. These emissions account for 8% of the UK total. Unlike most other pollutants, the emissions profile of PM_{10} is diverse:

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

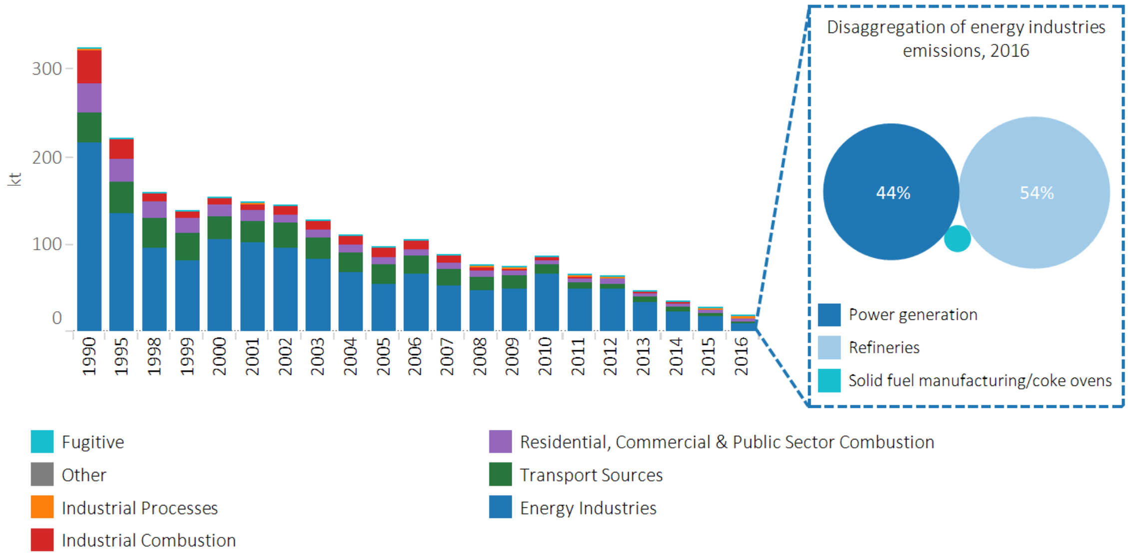
transport sources, residential, commercial and public sector combustion, industrial combustion and industrial processes each accounted for over 10% of total emissions in 2016. Emissions from energy industries and transport sources have had the most notable impact on the trend. This reduction is primarily 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 (BEIS, 2017a). PM_{10} exhaust emissions from diesel fuelled vehicles have been decreasing due to the successive introduction of tighter emission standards over time. Increasingly non-exhaust sources of PM_{10} (for example tyre wear) have become more important to consider as exhaust PM_{10} has been reduced. In fact, in 2016, 72% of emissions from the road transport sector were related to non-exhaust sources. In recent years, emissions from the residential and other combustion sector have slightly increased, and this is due to an increasing quantity of wood fuel use, primarily in the residential sector (BEIS, 2017a).

Figure 24 – $PM_{2.5}$ Emissions in Scotland[3]



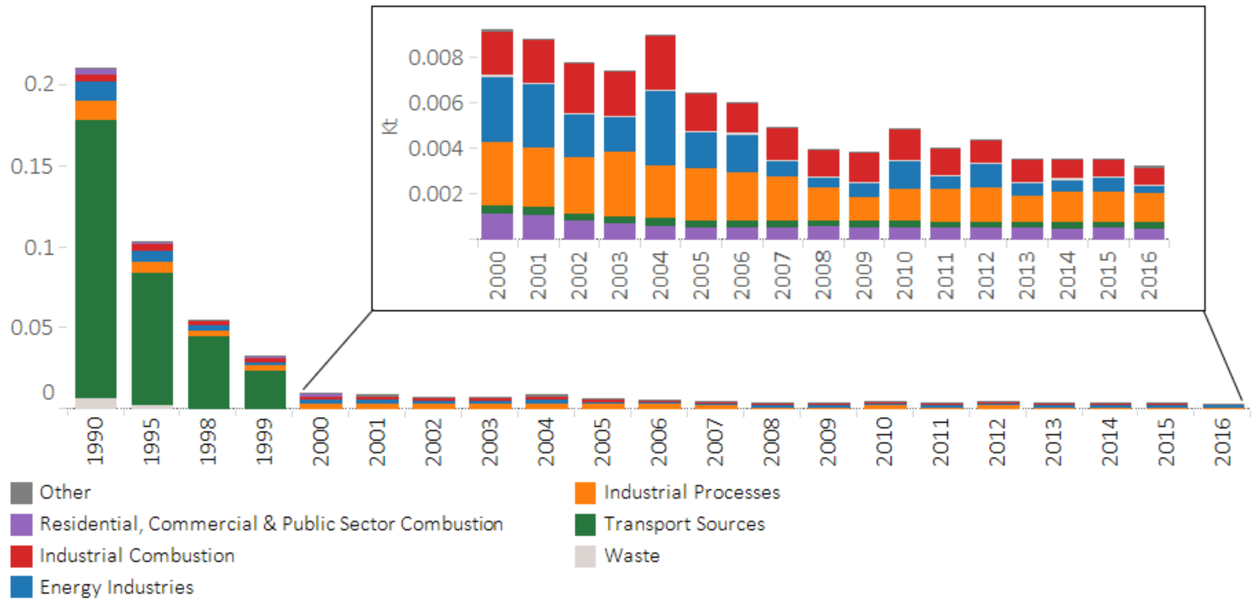
Emissions of $\mathbf{PM_{2.5}}$ were estimated to be 9kt in 2016, declining by 67% since 1990. These emissions account for 8% of the UK total in 2016. As with PM_{10}, $PM_{2.5}$ emissions have a large number of significant sources. However, process emissions tend to produce coarser PM fractions and as such, combustion emissions are of greater importance for $PM_{2.5}$ compared to PM_{10}. For $PM_{2.5}$, residential, commercial and public sector combustion accounts for 40% of 2016 emissions. The primary drivers for the decline in emissions since 1990 are the switch in the fuel mix used in electricity generation away from coal and towards natural gas, particularly in the early time-series, and later reductions in emissions from the transport sector due to the introduction of progressively more stringent emissions standards through time. Since 2005, declines in emissions have been offset by increases in emissions from the residential sector, and in particular, the combustion of wood.

Figure 25 – Sulphur Dioxide Emissions in Scotland



Emissions of **sulphur dioxide** were estimated to be 18kt in 2016, representing 10% of the UK total in 2016. Emissions have declined by 94% since 1990, which has been dominated by the 96% reduction in energy industries emissions, coincident with large changes in the power generation sector. These include the reduction in coal fired power relative to other sources; improved emission controls on some large coal fired plants 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 (BEIS, 2017a). The closure of Longannet in 2016 causes a large reduction in the emissions in the latest reported year. Transport sources emissions have declined, coincident with the reduced sulphur content of road fuels, both petrol and diesel.

Figure 26 – Lead Emissions in Scotland



Emissions of **lead** were estimated to be 3.3 tonnes in 2016, representing 5% of the UK total. Emissions have declined by 98% since 1990 almost entirely due to changes in transport sources. 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 predominant 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 2016. The table is shaded according to the overall contribution of that sector to the pollutant total. The table below indicates that the Residential and Other Combustion sector is an important sector when considering emissions of CO, SO_2, PM_{10} and $PM_{2.5}$.

The top five sectors mainly relate to fuel combustion. Industrial Processes is also notable, especially for NMVOC, which is due to the importance 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 importance when considering emissions of NH_3.

Table 3 – Source Emission Contributions Ranked by Sector, Scotland 2016

Sector	NH_3	CO	NOx	VOC	PM_{10}	$PM_{2.5}$	SO_2	Pb
Agriculture	90.1%	IE	0.1%	12.2%	14.5%	7.2%	IE	IE
Energy Industries	IE	4.7%	15.9%	IE	2.5%	3.1%	47.5%	10.9%
Fugitive	IE	0.7%	IE	14.3%	IE	IE	0.4%	IE
Industrial Combustion	IE	23.8%	13.1%	1.0%	7.6%	12.2%	8.8%	26.3%
Industrial Processes	0.2%	0.2%	IE	47.7%	25.1%	8.4%	3.8%	39.6%
Residential, Commercial & Public Sector Combustion	IE	41.6%	18.2%	3.0%	24.8%	40.2%	20.7%	15.7%
Solvent Processes	IE	IE	IE	18.2%	4.1%	2.3%	IE	IE
Transport Sources	1.1%	27.1%	50.4%	2.8%	16.9%	21.1%	17.7%	7.3%
Waste	4.7%	0.7%	IE	0.0%	1.2%	1.8%	IE	0.2%
Other	3.9%	1.3%	2.3%	0.8%	3.3%	3.6%	1.0%	0.1%

* The sector: “other” includes all “other” categories in the inventory and also a number of categories that are insignificant for a specific pollutant. These have been marked in the table as “IE“ (used in inventory reporting for “Included Elsewhere”). A breakdown of what is included within this category in respect to each pollutant can be found in **Table 20**.

Figure 27 – Ammonia Emissions in Scotland, 2016

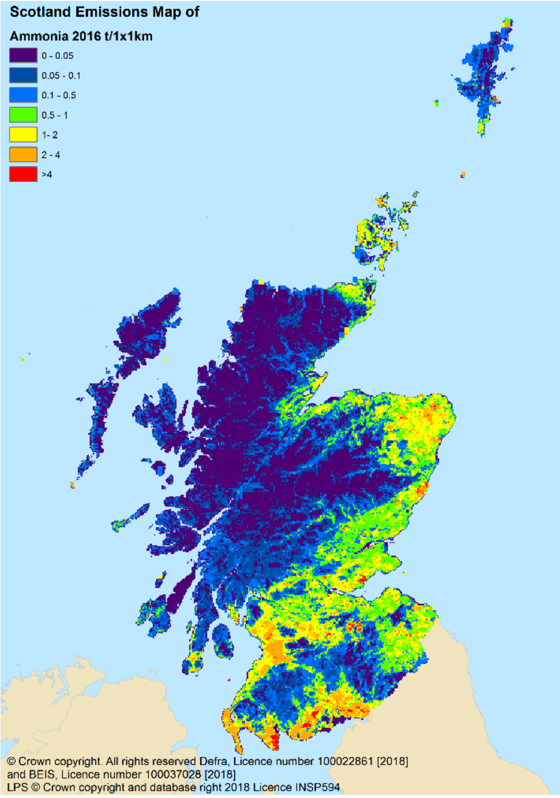


Figure 28 – Carbon Monoxide Emissions in Scotland, 2016

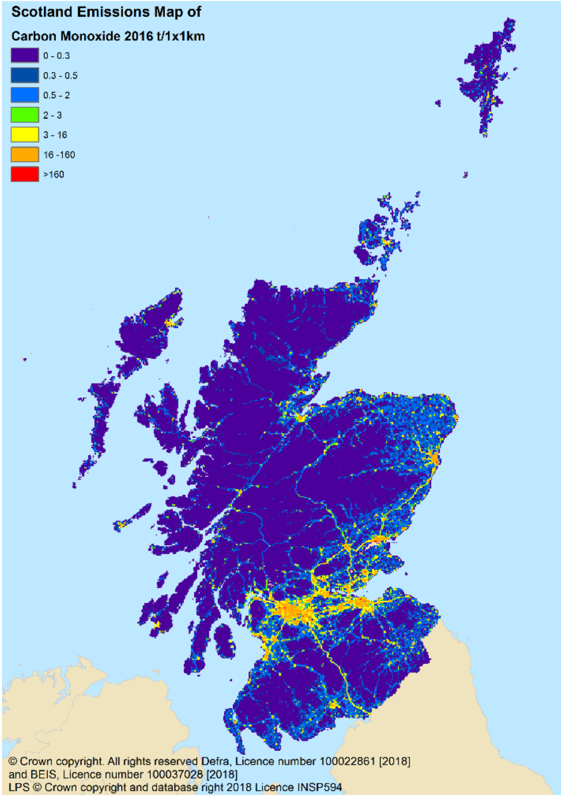


Figure 29 – Nitrogen Oxides Emissions in Scotland, 2016

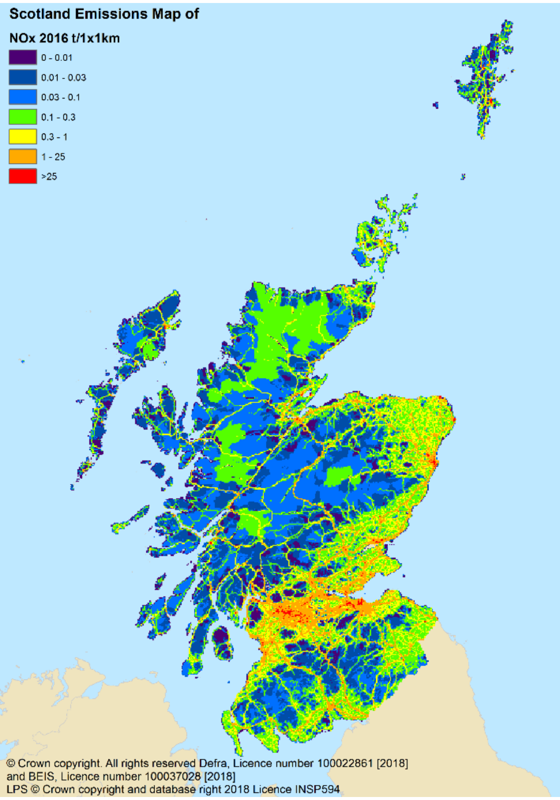


Figure 30 – NMVOC Emissions in Scotland, 2016

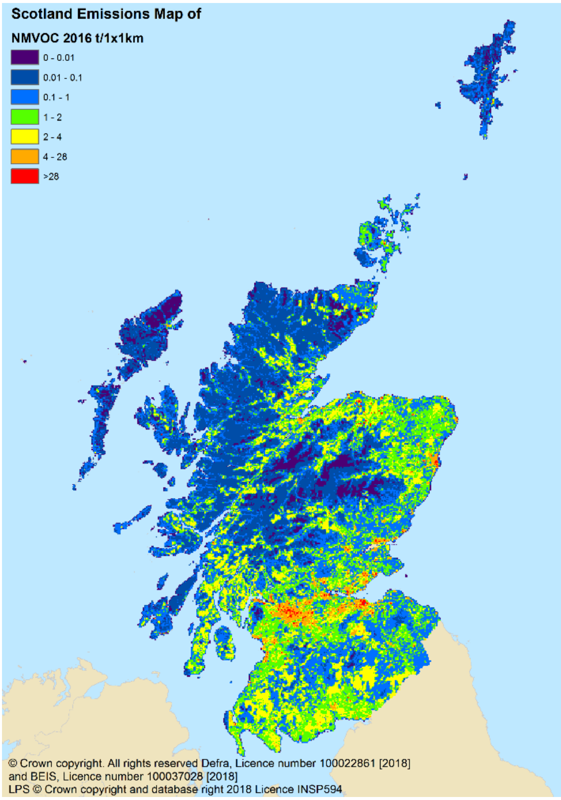


Figure 31 – PM_{10} Emissions in Scotland, 2016

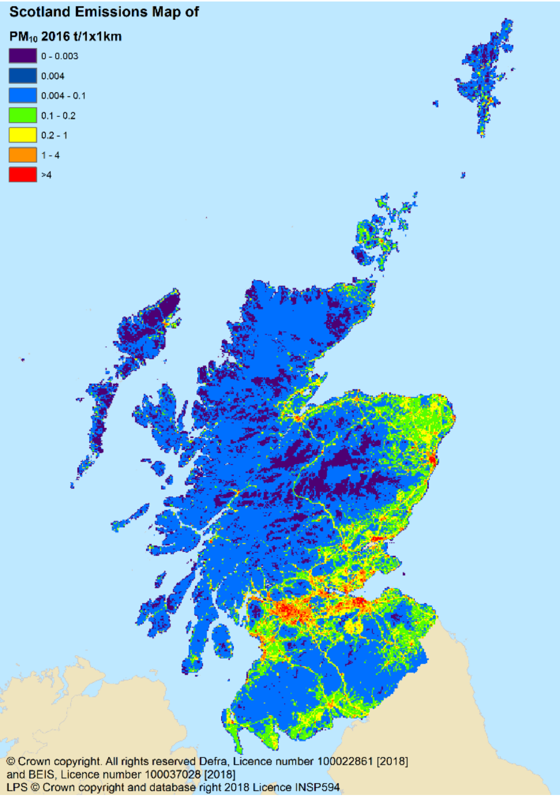


Figure 32 – $PM_{2.5}$ Emissions in Scotland, 2016

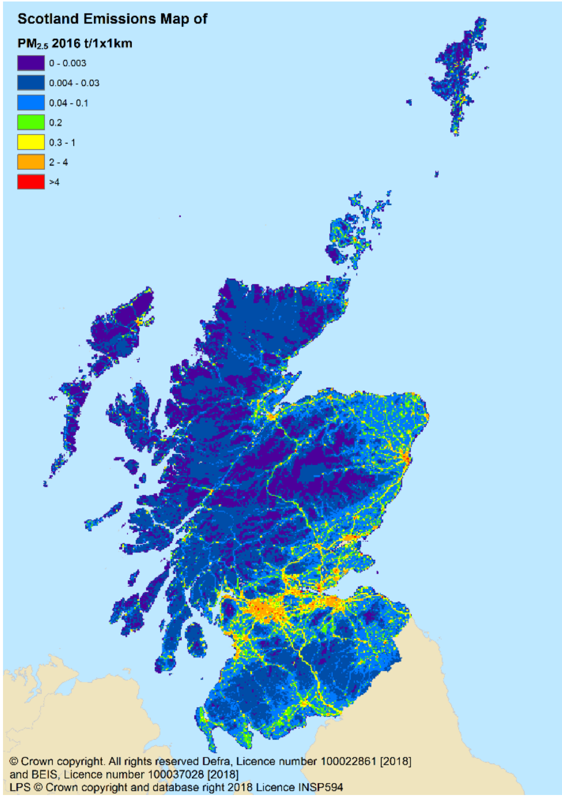


Figure 33 – Lead Emissions in Scotland, 2016

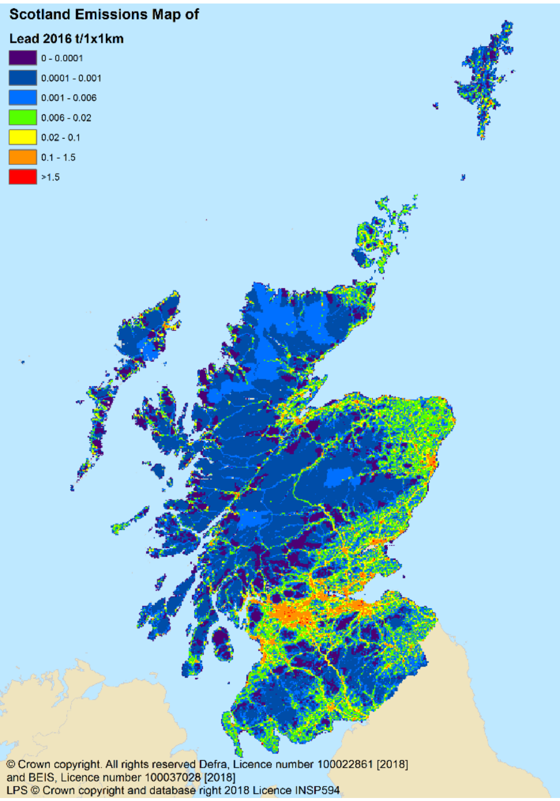
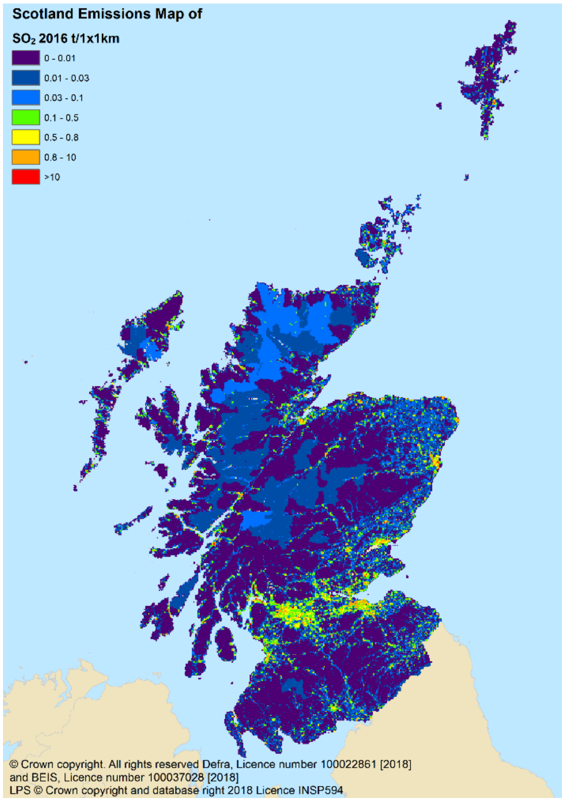


Figure 34 – Sulphur Dioxide Emissions in Scotland, 2016



2.3 Wales

The following section provides a summary of emissions in Wales for eight air 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}), particulate matter less than 2.5 micrometres ($PM_{2.5}$), sulphur dioxide (SO_2) and lead (Pb).

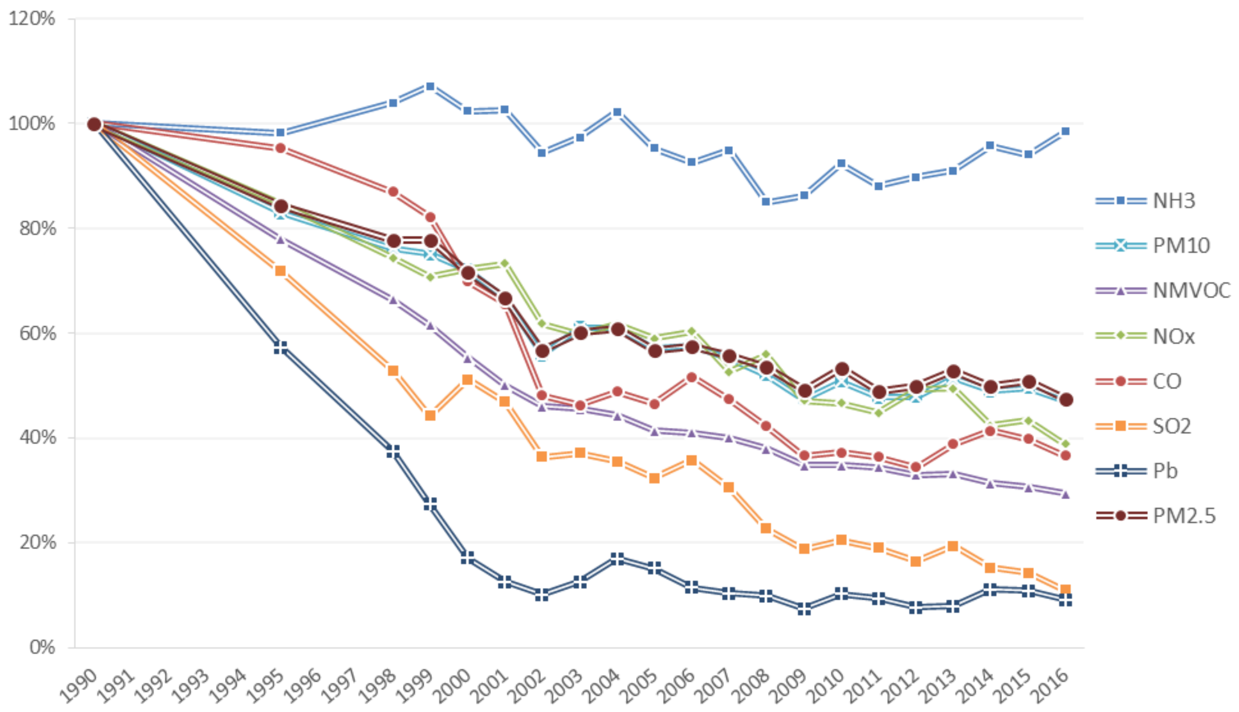
Figure 35 shows emissions of all eight air pollutants normalised to provide the relative rate of decline since 1990. This graph shows that all pollutant emission levels are lower in 2016 than they were in 1990. The decline is relatively similar for PM_{10}, $PM_{2.5}$, NO_X, NMVOC and CO.

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, even showing a slight increase in emissions 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.

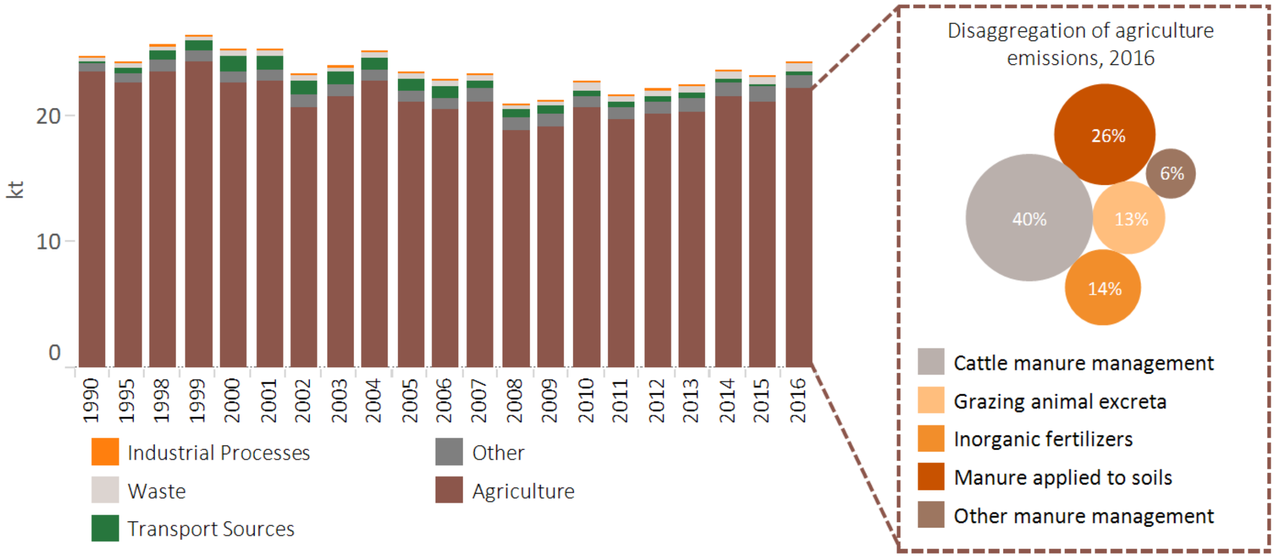
Many pollutant trends in Wales are also influenced substantially by the combustion and process emission sources linked to the iron and steel industry, and in particular changes in activity at Port Talbot steelworks. For example, between 2012 and 2013 an upturn in production at the plant led to increases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

Figure 35 – Wales normalised trends for all pollutants



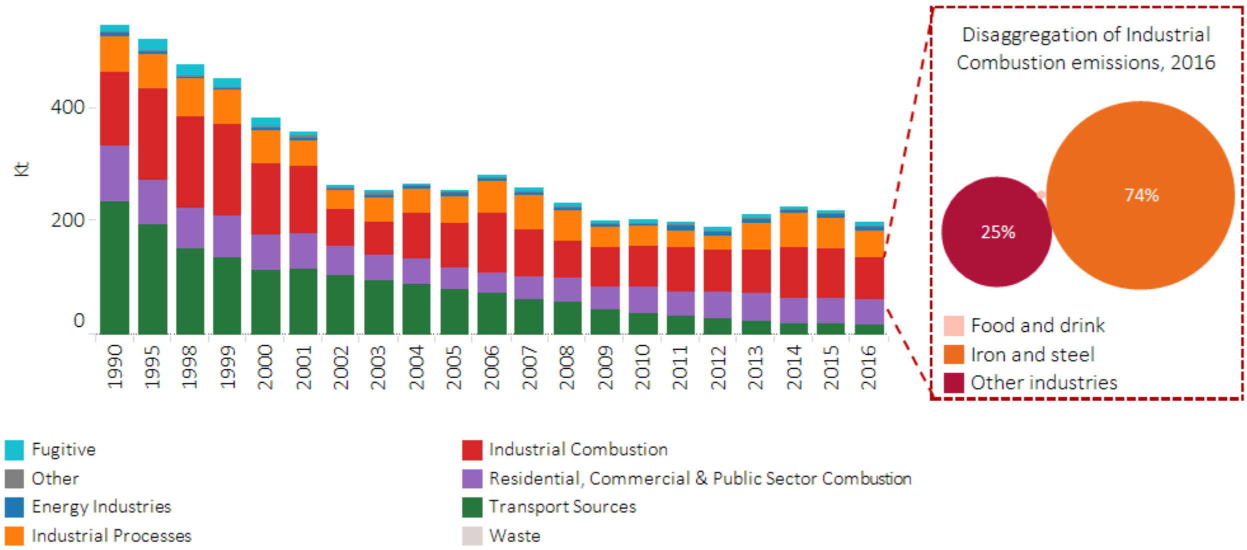
The following sections provide an overview of emissions from each of the eight pollutants giving explanations for the trends and characteristics of the graphs. Data summary tables for these emission estimates can be found in **Appendix F**. Mapping of the categories used in the graphs can be found in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

Figure 36 – Ammonia Emissions in Wales



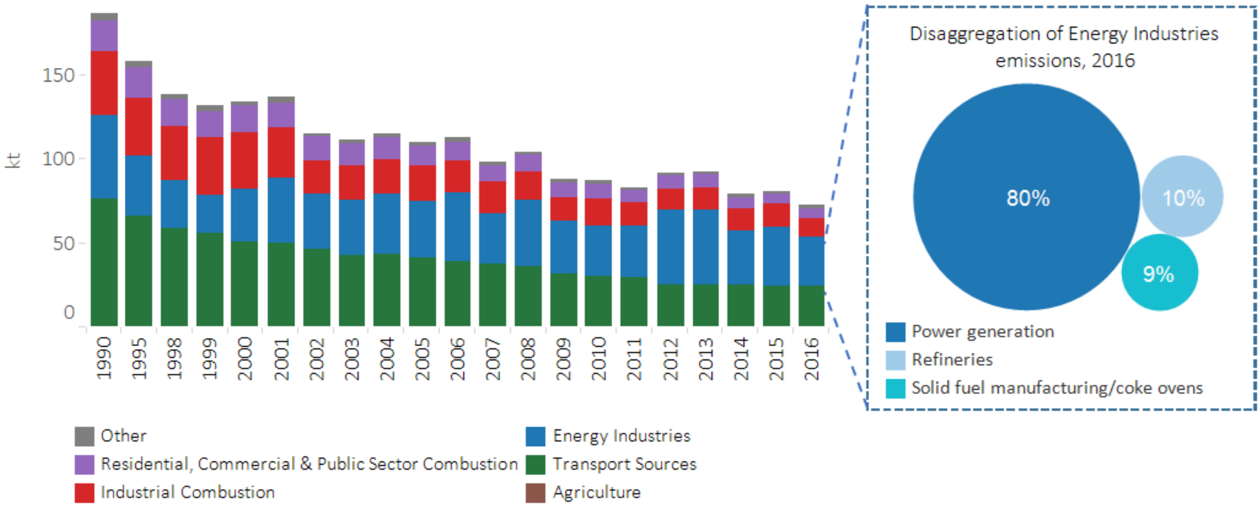
Emissions of **ammonia** were estimated to be 24kt in 2016. These emissions have declined overall by 2% since 1990 and account for 8% of the UK total in 2016. Agriculture sources have dominated the inventory throughout the time series, with cattle manure management accounting for 40% of the emissions from this sector in 2016. 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 2016.

Figure 37 – Carbon Monoxide Emissions in Wales



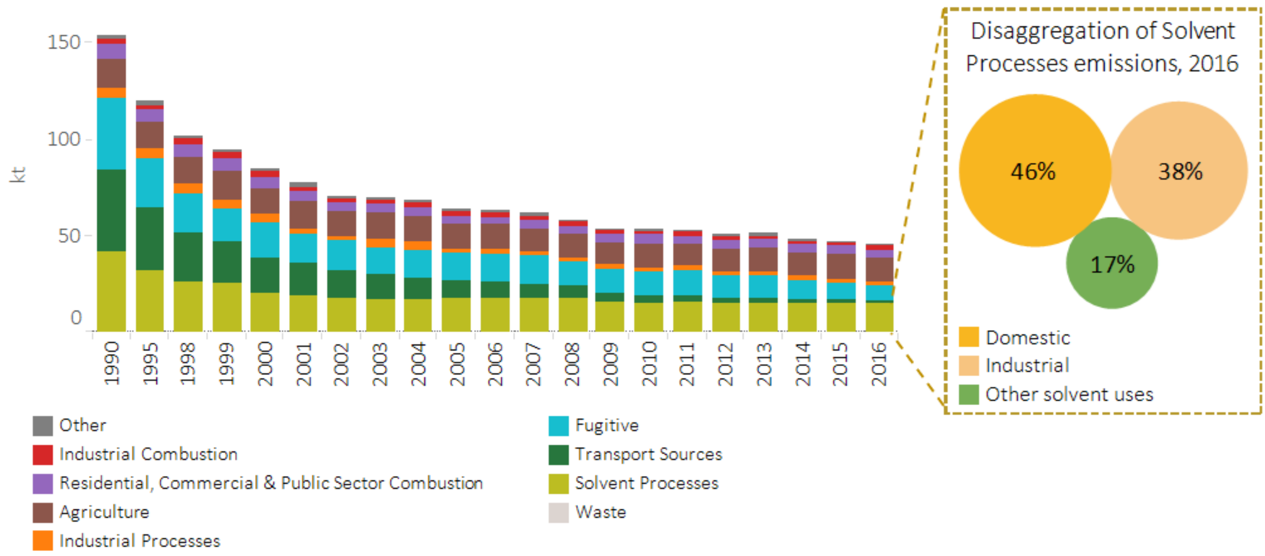
Emissions of **carbon monoxide** were estimated to be 200kt in 2016 and have declined by 63% since 1990. Emissions in Wales accounted for 13% of the UK total in 2016. This decline in emissions stems from changes in transport sources, particularly road transport (passenger cars and other road transport). 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 improvements in catalyst repair rates resulting from the introduction of regulations controlling the sale and installation of replacement catalytic converters and particle filters for light duty vehicles. In more recent years, the most important sector has been industrial combustion and, more specifically, the iron and steel industry.

Figure 38 – Nitrogen Oxides Emissions in Wales



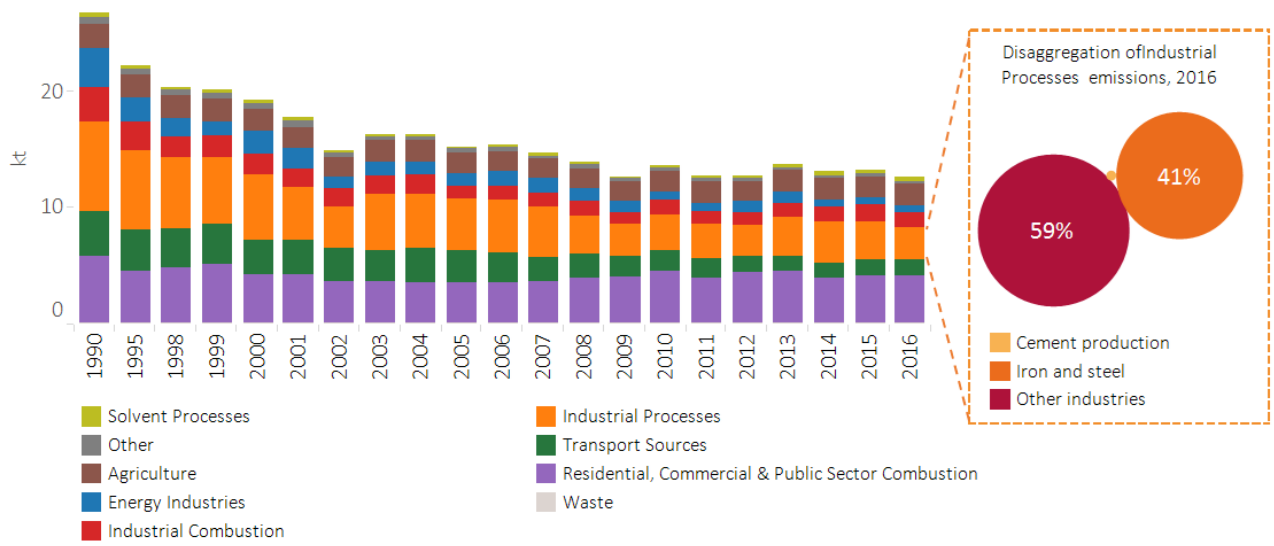
Emissions of **nitrogen oxides** were estimated to be 73kt in 2016, representing 8% of the UK total. Emissions have declined by 61% since 1990, mainly due to changes in transport sources, particularly in road transport (passenger cars and other road transport). This decline is driven by the successive 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 improvements in catalyst repair rates resulting from the introduction of regulations controlling the sale and installation of replacement catalytic converters and particle filters for 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 reduction in emissions more recently corresponds to the reduction in coal use at Aberthaw power station since 2013.

Figure 39 – NMVOC Emissions in Wales



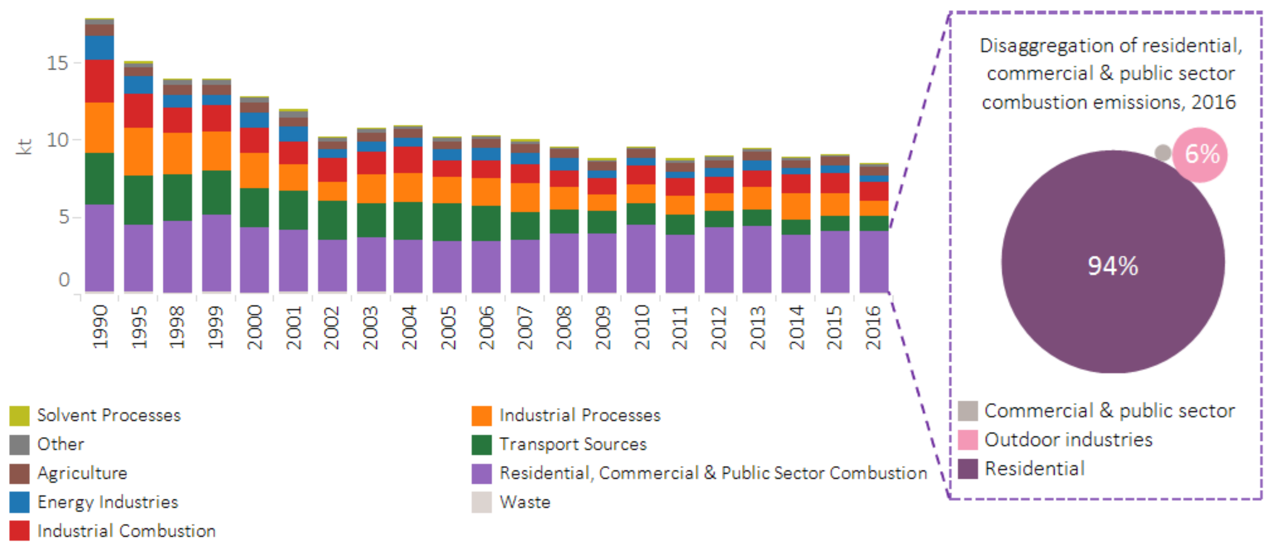
Emissions of **non-methane volatile organic compounds** were estimated to be 45kt in 2016, representing 6% of the UK total. Emissions have declined by 71% since 1990. This reduction is mainly due to the decrease in emissions from transport and fugitive sources, including evaporative losses of fuel vapour 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 important source of NMVOC emissions, with the largest amount of emissions arising from domestic solvent applications.

Figure 40 – PM_{10} Emissions in Wales[4]



Emissions of **PM_{10}** were estimated to be 13kt in 2016 and have declined by 53% since 1990. These emissions account for 7% of the UK total in 2016. Unlike most other pollutants, the emissions profile of PM_{10} is diverse: transport sources, residential, commercial and public sector combustion, industrial combustion and industrial processes each account for significant fractions of the total. In 2016 the most important sources were residential combustion, and iron and steel process sources such as sinter plants, basic oxygen furnaces and blast furnaces. As a result, recent trends are influenced by the use of solid fuels in the residential sector as well as iron and steel production trends, but there is no strong trend in overall emissions evident in the last 8 years. In recent years, emissions from residential, commercial and public sector combustion have increased, and this is primarily due to increasing wood fuel use in the residential sector (BEIS, 2017a).

Figure 41 – $PM_{2.5}$ Emissions in Wales[4]

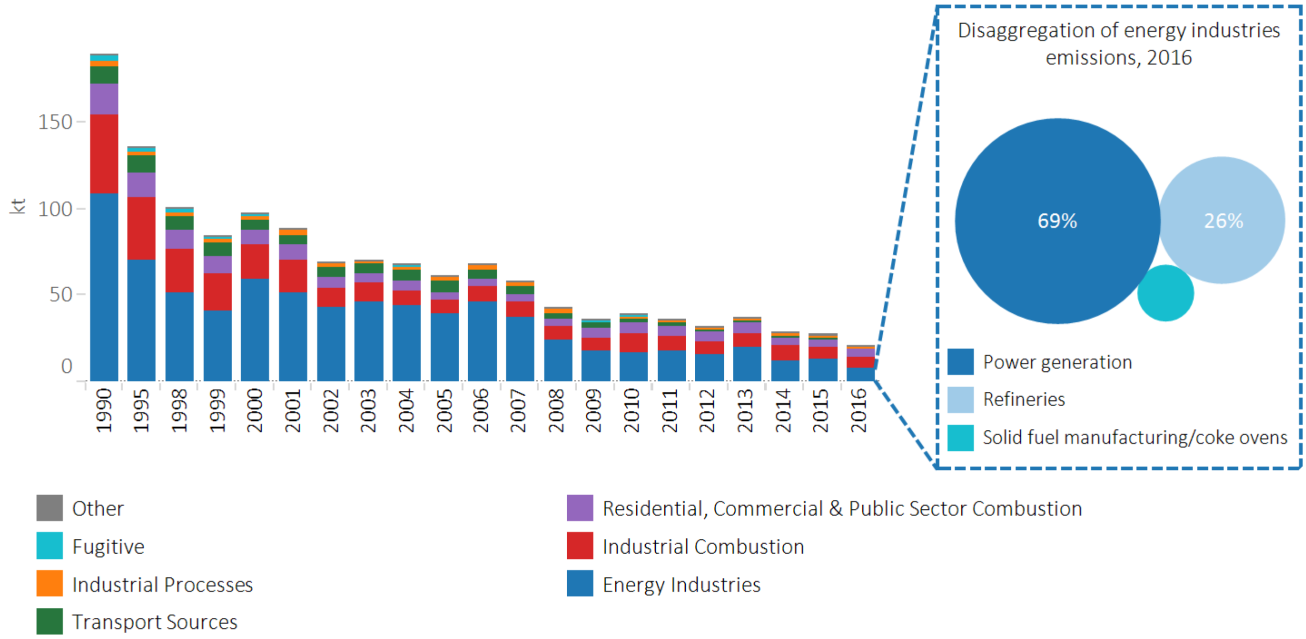


Emissions of **$PM_{2.5}$** were estimated to be 9kt in 2016 and have declined by 53% since 1990. These emissions account for 8% of the UK total in 2016. As with PM_{10}, $PM_{2.5}$ emissions have a large number of significant sources. However, process emissions tend to produce coarser PM fractions and as such, combustion emissions are of greater importance for $PM_{2.5}$ compared to PM_{10}. For $PM_{2.5}$, residential, commercial and public sector combustion accounts for 47% of 2016 emissions. The primary drivers for the decline in

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

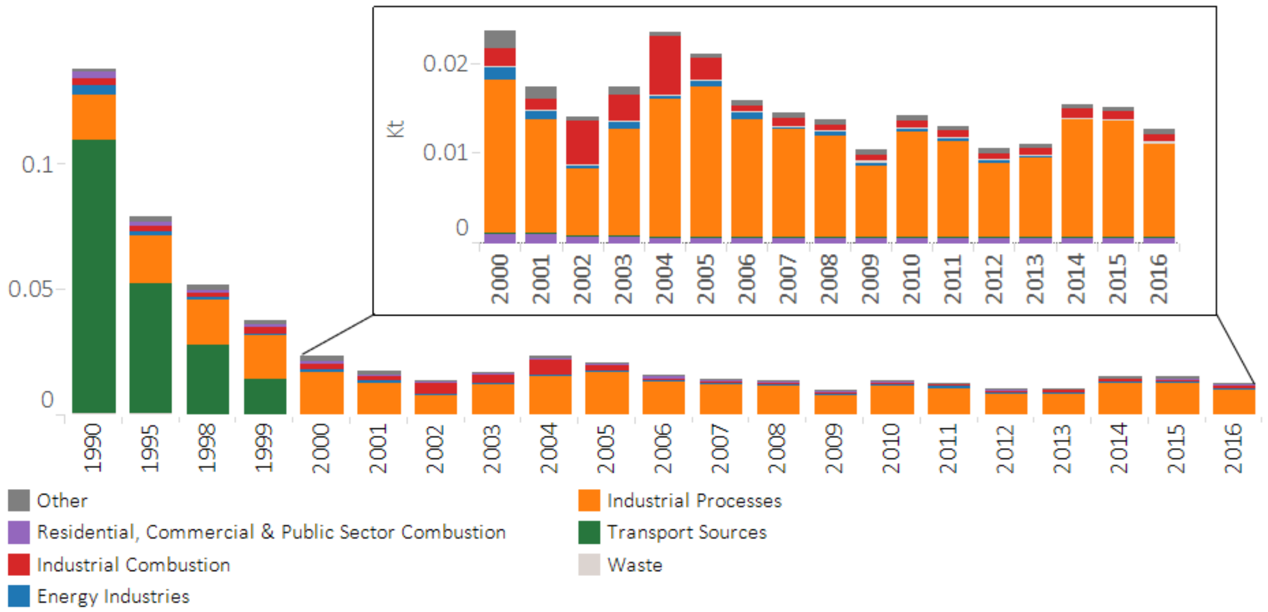
emissions since 1990 are the switch in the fuel mix used in electricity generation away from coal and towards natural gas, particularly in the early time-series, and later reductions in emissions from the transport sector due to the introduction of progressively more stringent emissions standards through time. Since 2005, declines in emissions have been offset by increases in emissions from the residential sector, and in particular, the combustion of wood.

Figure 42 – Sulphur Dioxide Emissions in Wales



Emissions of **sulphur dioxide** were estimated to be 21kt in 2016, representing 12% of the UK total. Emissions have declined by 89% since 1990, which has been dominated by the 93% 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 residential sector and production trends (and related coal use) in the iron and steel industry.

Figure 43 – Lead Emissions in Wales



Emissions of **lead** were estimated to be 13 tonnes in 2016, representing 20% of the UK total. Emissions have declined by 91% since 1990 almost entirely due to changes in transport sources. 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 substantive 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 2016. The table is shaded according to the overall contribution of that sector to the pollutant total. 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 important 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 2016

Sector	NH_3	CO	NOx	VOC	PM_{10}	$PM_{2.5}$	SO_2	Pb
Agriculture	91.4%	IE	0.2%	27.3%	14.4%	6.6%	IE	IE
Energy Industries	IE	3.0%	40.7%	IE	4.4%	4.7%	35.4%	1.5%
Fugitive	IE	4.8%	IE	15.4%	IE	IE	4.1%	IE
Industrial Combustion	IE	36.5%	15.4%	3.5%	9.7%	13.8%	31.1%	6.1%
Industrial Processes	0.2%	24.3%	IE	5.1%	23.1%	12.6%	2.4%	82.9%
Residential, Commercial & Public Sector Combustion	IE	22.7%	8.6%	9.8%	32.7%	47.2%	21.9%	4.5%
Solvent Processes	IE	IE	IE	32.0%	2.6%	1.3%	IE	IE
Transport Sources	0.9%	8.1%	32.9%	4.7%	10.1%	10.8%	4.7%	0.9%
Waste	3.1%	0.2%	IE	0.1%	0.8%	1.1%	IE	0.0%
Other	4.4%	0.3%	2.1%	2.2%	2.3%	1.8%	0.4%	4.1%

* The sector: “other” will include all “other” categories in the inventory and also a number of categories that are insignificant for a specific pollutant. These have been marked in the table as “IE“ (used in inventory reporting for “Included Elsewhere”). A breakdown of what is included within this category in respect to each pollutant can be found in **Table 20**

Figure 44 – Ammonia Emissions in Wales, 2016

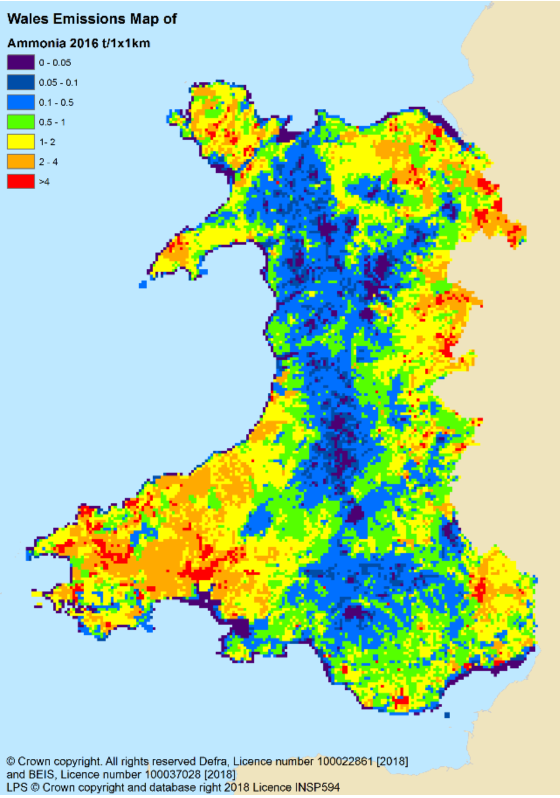


Figure 45 – Carbon Monoxide Emissions in Wales, 2016

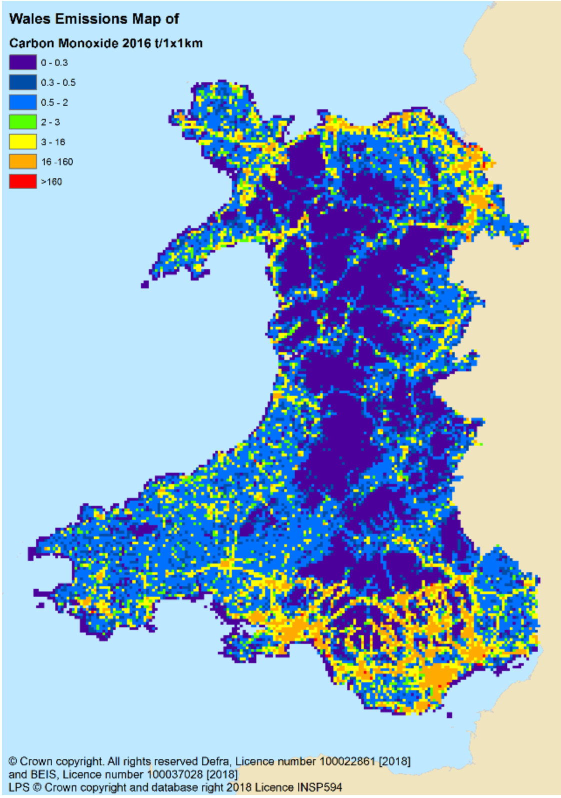


Figure 46 – Nitrogen Oxides Emissions in Wales, 2016

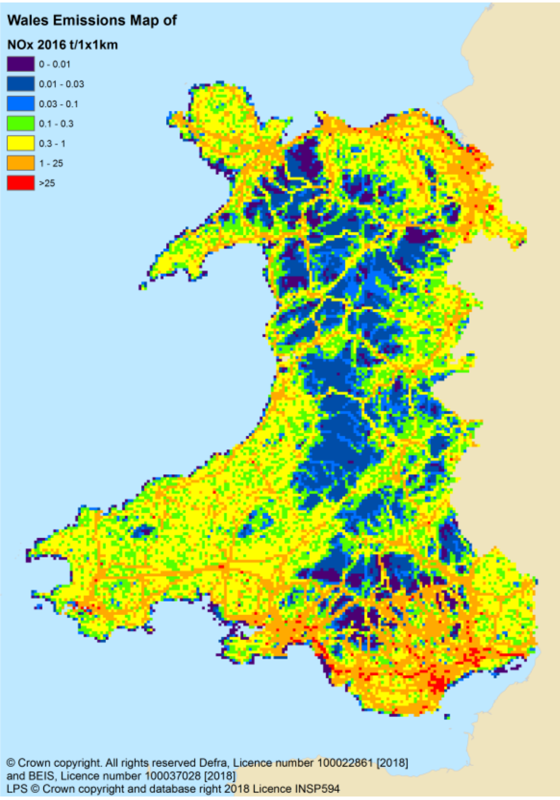


Figure 47 – NMVOC Emissions in Wales, 2016

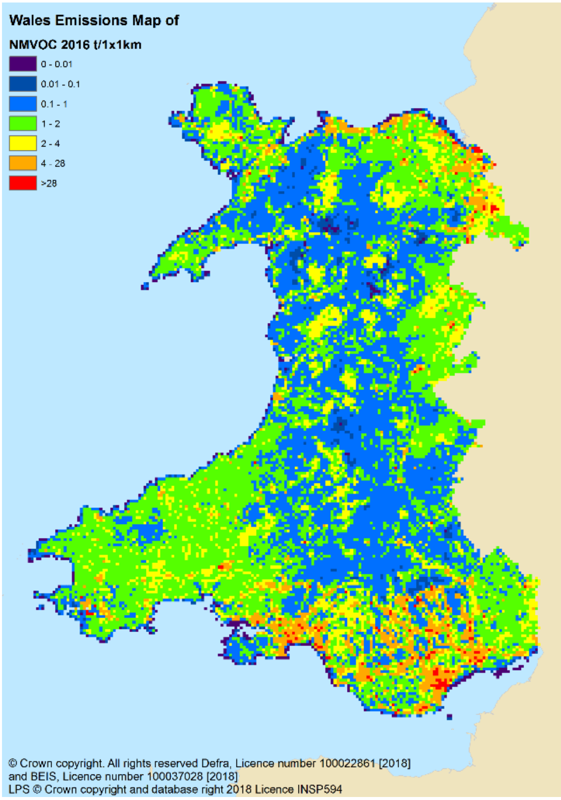


Figure 48 – PM_{10} Emissions in Wales, 2016

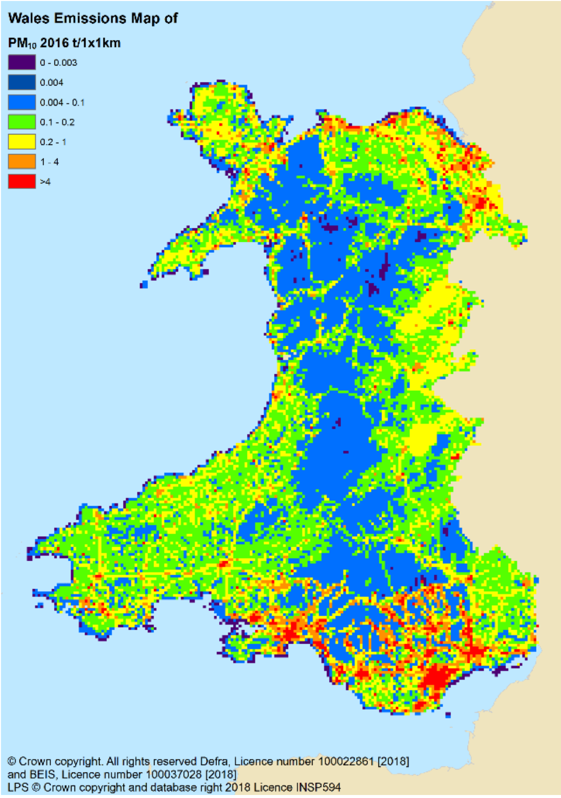


Figure 49 – $PM_{2.5}$ Emissions in Wales, 2016

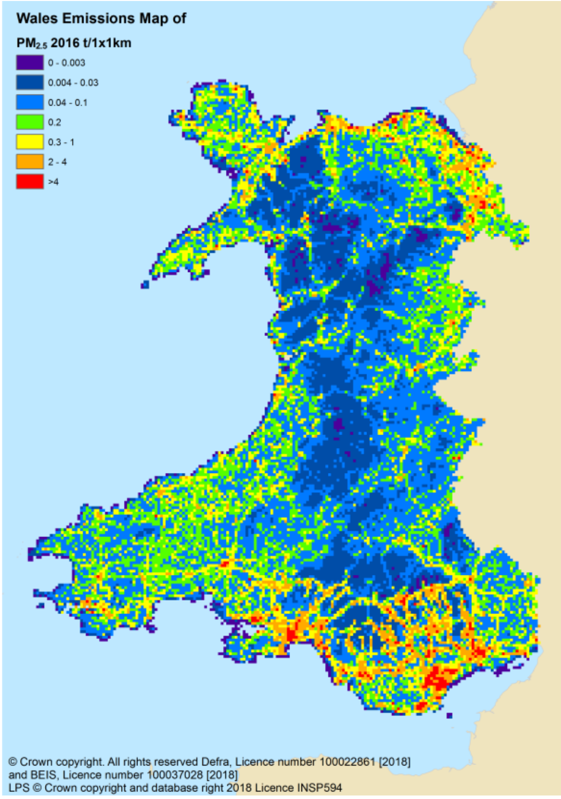


Figure 50 – Lead Emissions in Wales, 2016

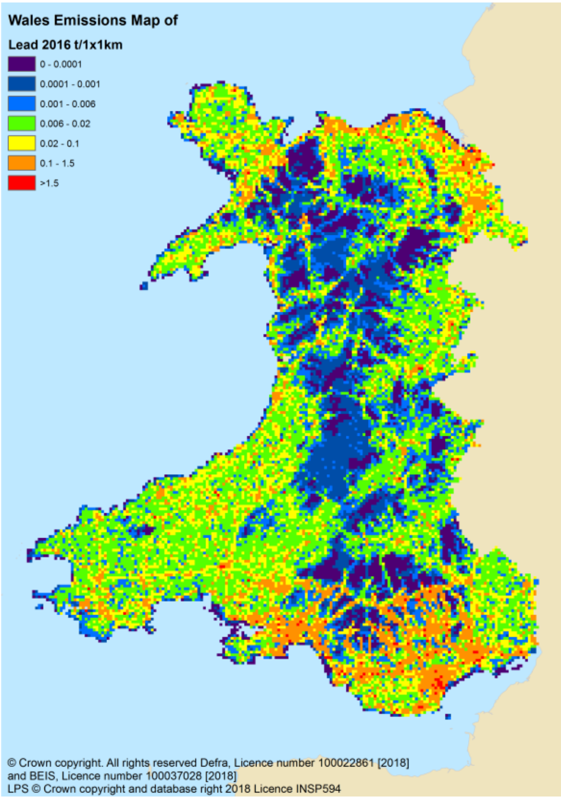
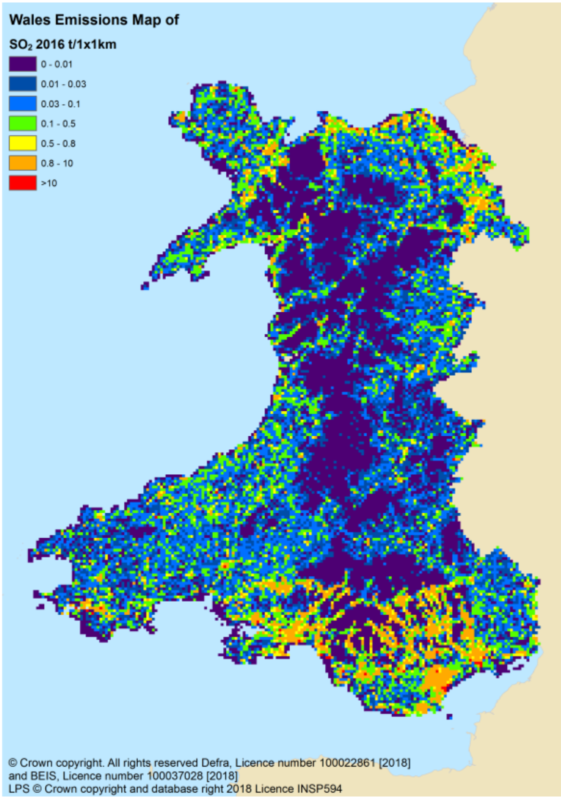


Figure 51 – Sulphur Dioxide Emissions in Wales, 2016



2.4 Northern Ireland

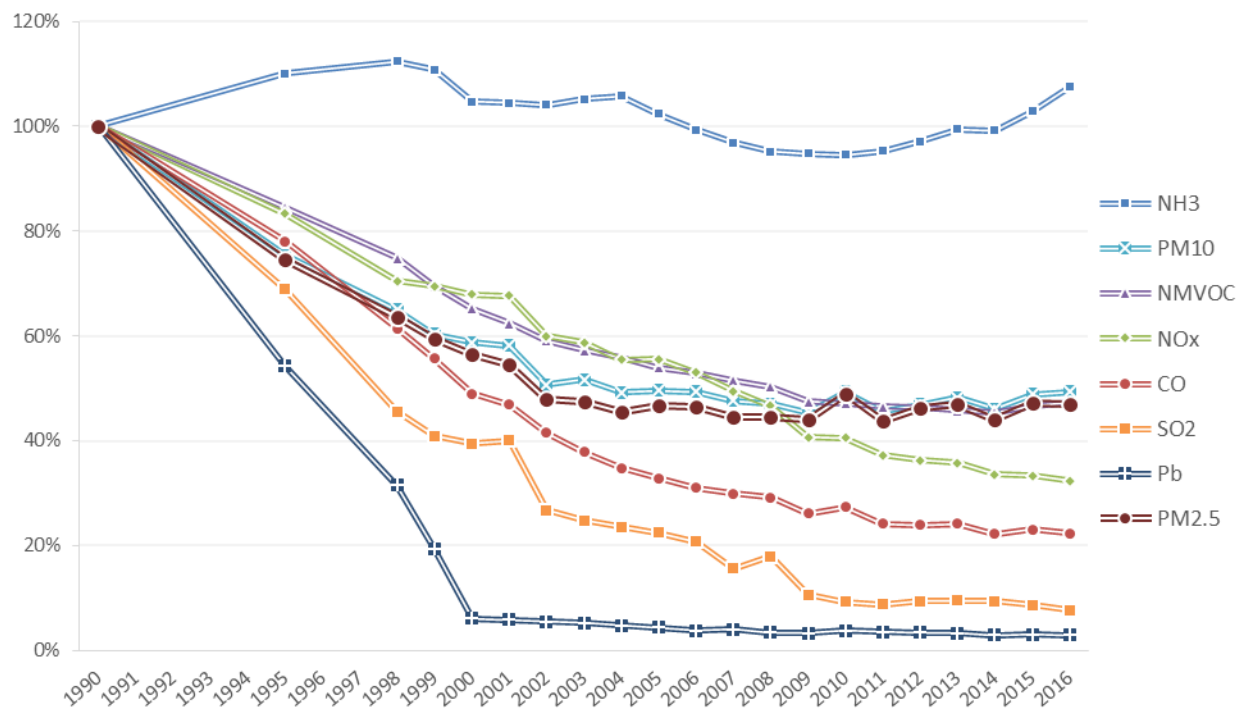
The following section provides a summary of emissions in Northern Ireland for the eight air pollutants: ammonia (NH_3), carbon monoxide (CO), nitrogen oxides (NO_X as NO_2), non-methane volatile organic compounds (NMVOCs), particulate matter less than 10 micrometres (PM_{10}), particulate matter of less than 2.5 micrometres ($PM_{2.5}$), sulphur dioxide (SO_2) and lead (Pb).

Figure 52 shows emissions of all eight air pollutants normalised to provide the relative rate of decline since 1990. This graph shows that all pollutant emission levels except ammonia are lower in 2016 than they were in 1990. The decline is relatively similar for PM_{10}, $PM_{2.5}$, NO_X and NMVOC.

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 but has increased again since 2010.

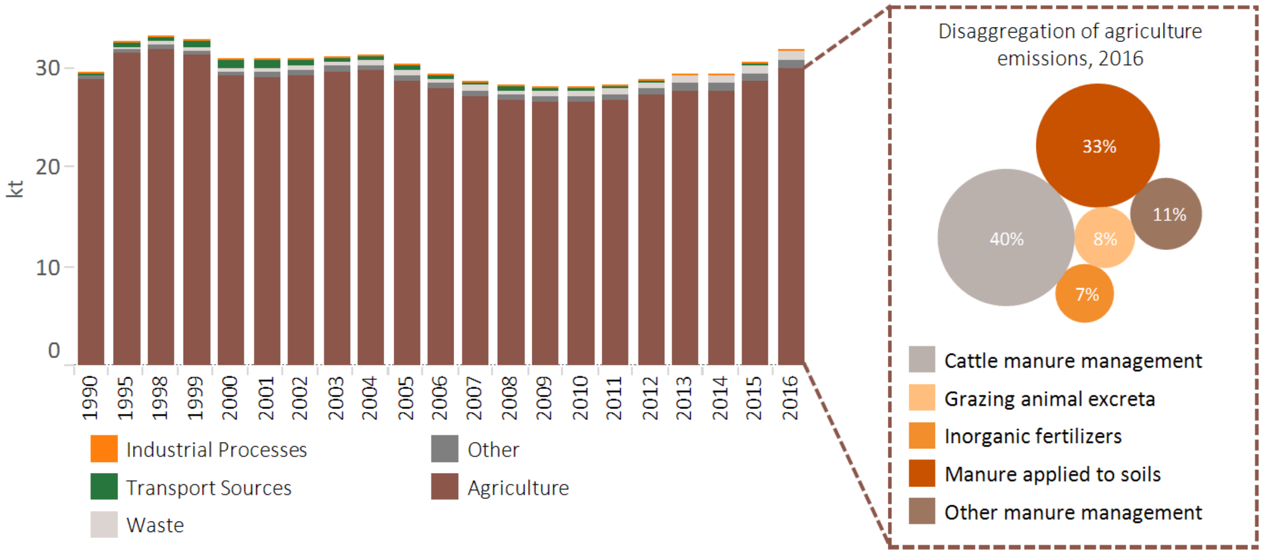
The reductions in SO_2 after 2001 are due to a reduction in use of coal in several industries but predominantly in power generation, linked to the development of the natural gas pipeline to Northern Ireland which enabled fuel-switching away from coal and oil-fired generation (BEIS, 2017b).

Figure 52 – Northern Ireland normalised trends for all pollutants



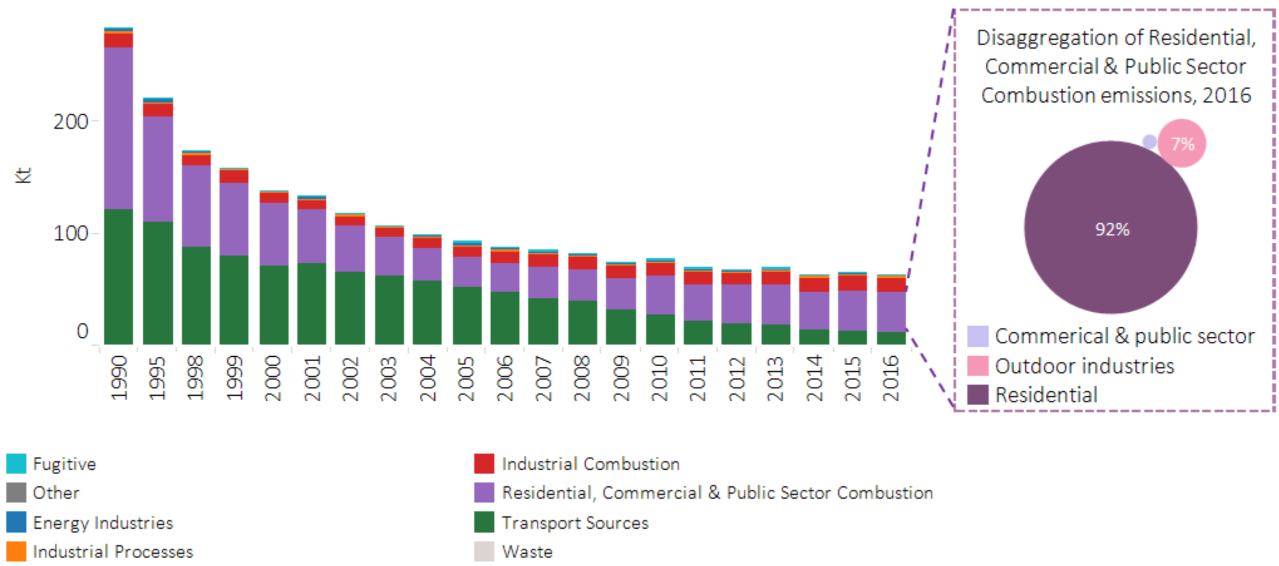
The following sections provide an overview of emissions from each of the eight pollutants giving explanations for the trends and characteristics of the graphs. Data summary tables for these emission estimates can be found in **Appendix F**. Mapping of the categories used in the graphs can be found in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

Figure 53 – Ammonia Emissions in Northern Ireland



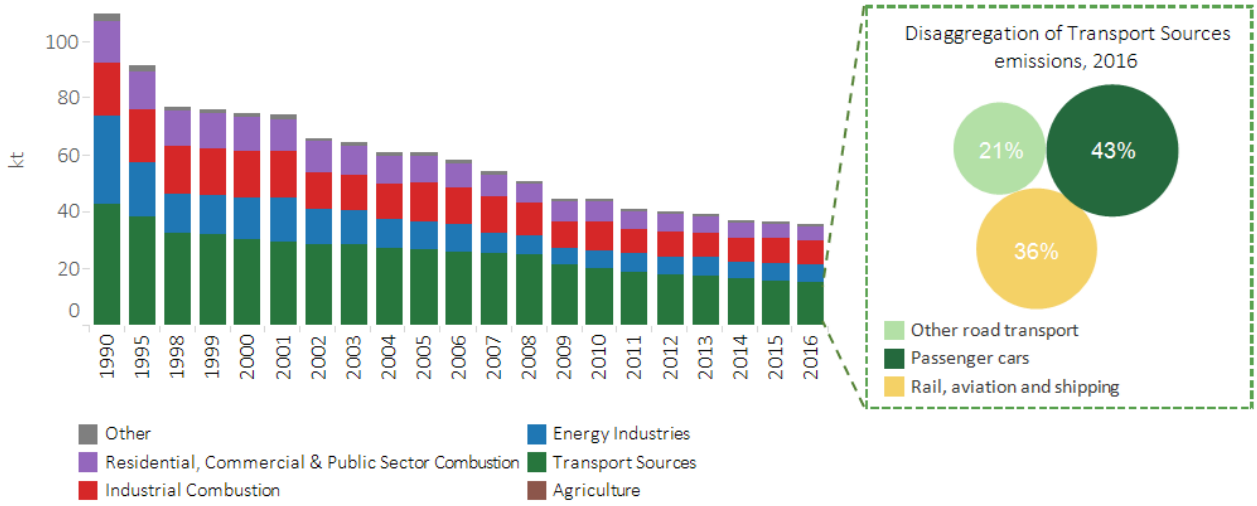
Emissions of **ammonia** were estimated to be 32kt in 2016. Emissions have increased overall by 7% since 1990 and account for 11% of the UK total in 2016. Agriculture sources have dominated the inventory throughout the time series, with cattle manure management accounting for 40% of the emissions from this sector. NH_3 emissions have increased in recent years and this is due largely to emissions increasing from waste management, and application of waste to soils from dairy cattle.

Figure 54 – Carbon Monoxide Emissions in Northern Ireland



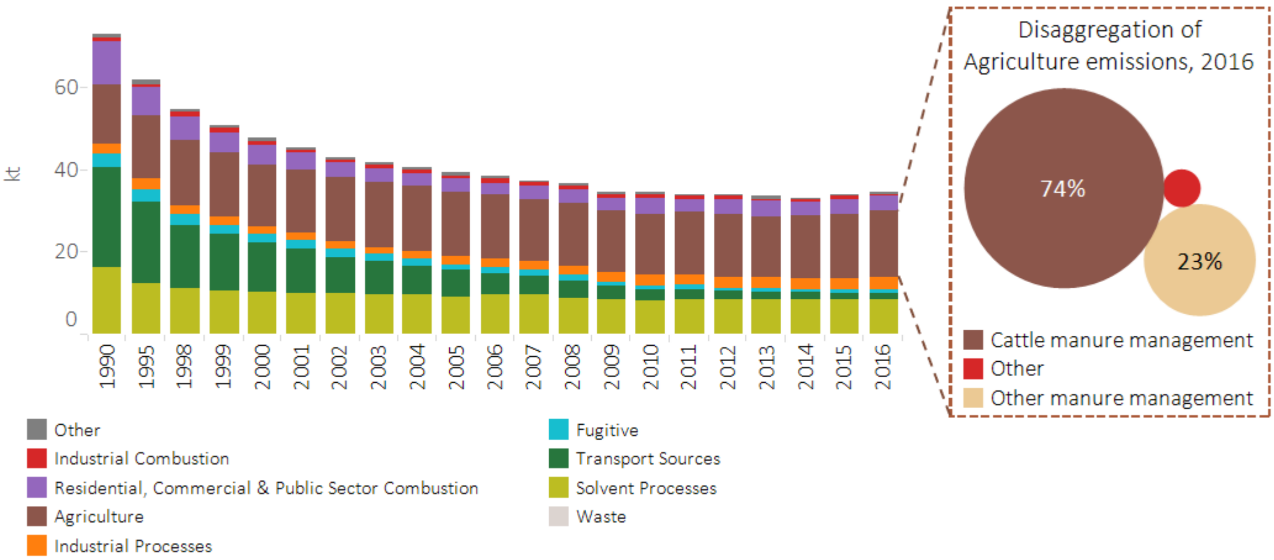
Emissions of **carbon monoxide** were estimated to be 63kt in 2016 and have declined by 78% since 1990. Emissions in Northern Ireland accounted for 4% of the UK total in 2016. The decline in emissions stems largely from residential, commercial and public sector combustion and transport sources, particularly 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 improvements in catalyst repair rates resulting from the introduction of regulations controlling the sale and installation of replacement catalytic converters and particle filters for light duty vehicles. The decrease in residential, commercial and public sector 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 burned in the residential sector (BEIS, 2017a).

Figure 55 – Nitrogen Oxides Emissions in Northern Ireland



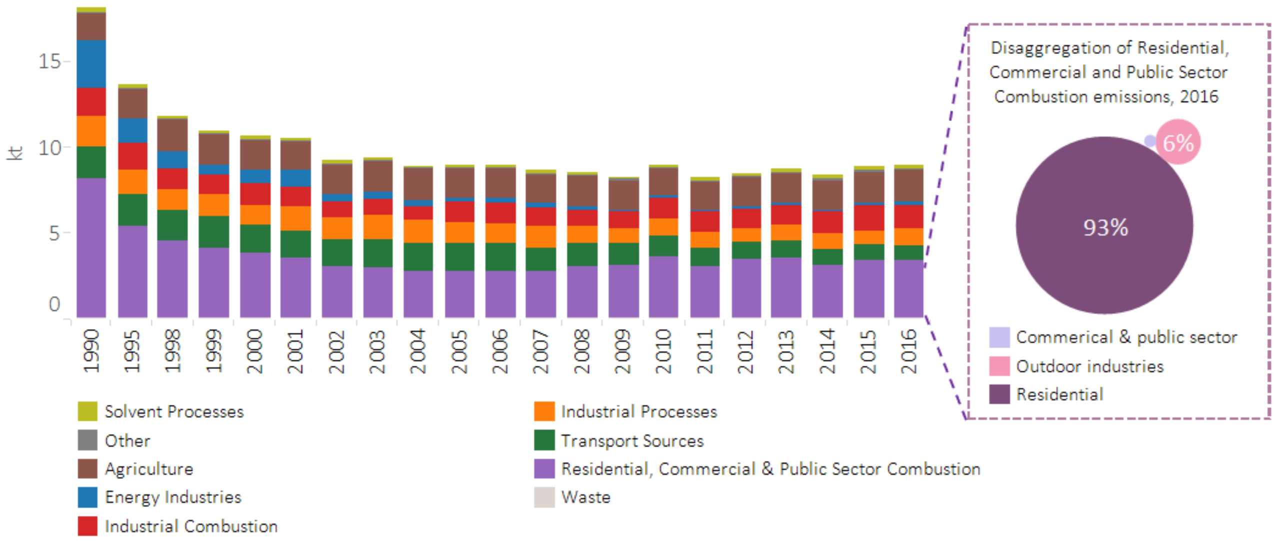
Emissions of **nitrogen oxides** were estimated to be 36kt in 2016, representing 4% of the UK total. Emissions have declined by 68% since 1990, partly due to changes in transport sources, particularly in road transport (passenger cars and other road transport). This decline is driven by the successive 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 improvements in catalyst repair rates resulting from the introduction of regulations controlling the sale and installation of replacement catalytic converters and particle filters for light duty vehicles. However, the increasing number of diesel cars offsets these emissions reductions, because diesel cars have higher NO_X emissions relative to their petrol counterparts. Energy industries have also had a notable impact on the trend with implementation of abatement technology and reductions in the amount of coal used.

Figure 56 – NMVOC Emissions in Northern Ireland



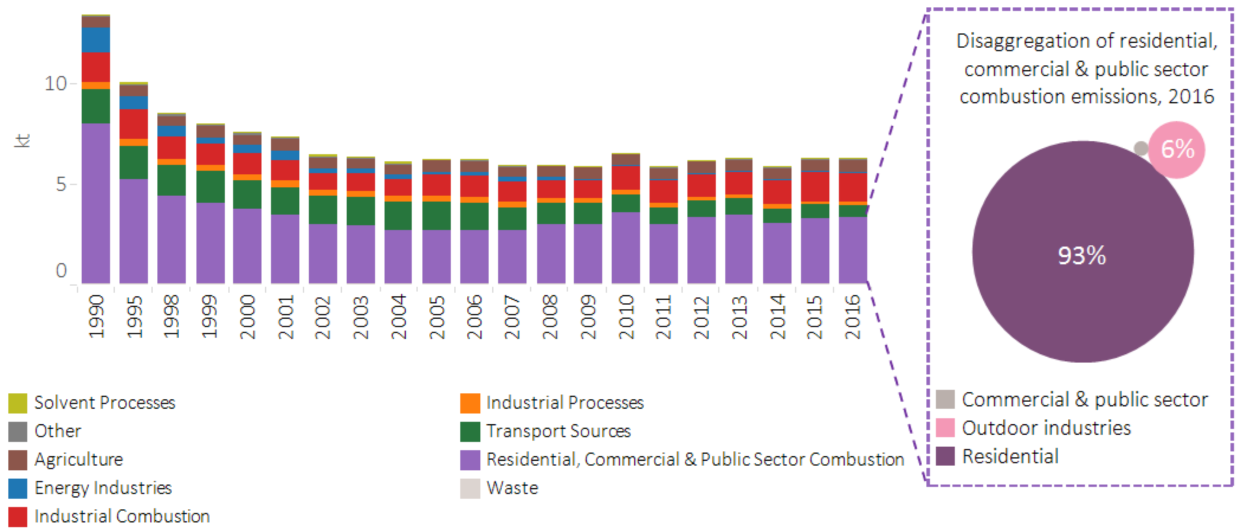
Emissions of **non-methane volatile organic compounds** were estimated to be 34kt in 2016, representing 4% of the UK total. Emissions have declined by 53% since 1990 mainly due to the decrease in transport sources, including evaporative losses. This decline is coincident with emission control technologies 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 emissions from transport sources, agriculture is now the most important source of NMVOC emissions, more specifically emissions from cattle manure management.

Figure 57 – PM_{10} Emissions in Northern Ireland[5]



Emissions of **PM_{10}** were estimated to be 9kt in 2016 and accounted for 5% of the UK total. Emissions have declined by 51% since 1990, with the major decrease observed between 1990 and 2004. The decreasing trend was defined by emissions from residential, commercial and public sector combustion, with a reduction in the use of peat and coal and 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 residential, commercial and public sector combustion have primarily increased coincident with increasing wood fuel use in the residential sector (BEIS, 2017a).

Figure 58 - $PM_{2.5}$ Emissions in Northern Ireland[5]

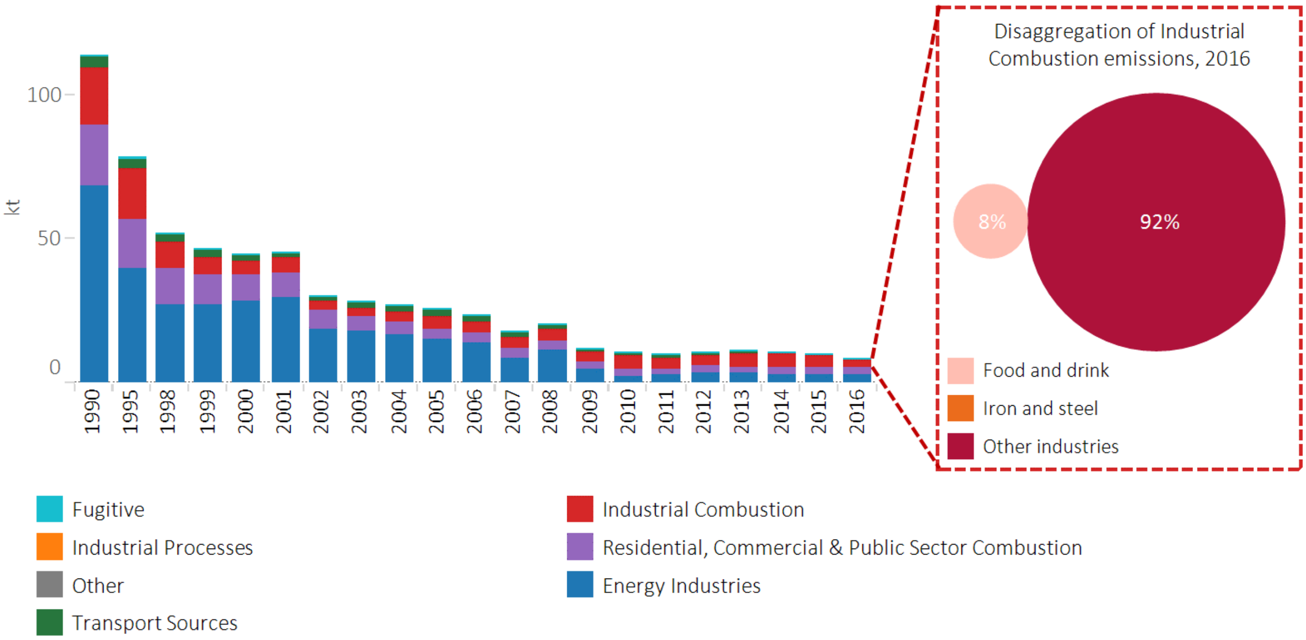


Emissions of **$PM_{2.5}$** were estimated to be 6kt in 2016 and accounted for 6% of the UK total. Emissions have declined by 53% since 1990, with the major decrease observed between 1990 and 2004. As with PM_{10}, $PM_{2.5}$ emissions have a large number of significant sources. However, process emissions tend to produce coarser PM fractions and as such, combustion emissions are of greater importance for $PM_{2.5}$ compared to PM_{10}. For $PM_{2.5}$, residential, commercial and public sector combustion accounts for 52% of 2016 emissions. The primary drivers for the decline in emissions since 1990 are the switch in the fuel mix used in electricity generation away from coal and towards natural gas, particularly in the early time-series, and later reductions

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

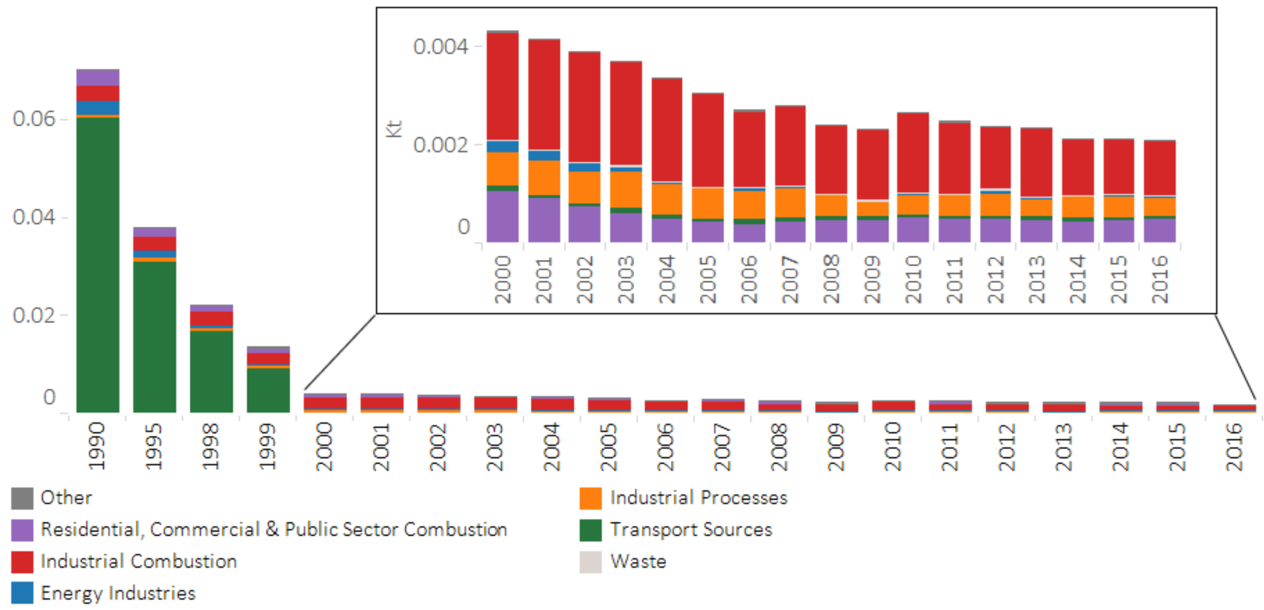
in emissions from the transport sector due to the introduction of progressively more stringent emissions standards through time. Since 2005, declines in emissions have been offset by increases in emissions from the residential sector, and in particular, the combustion of wood.

Figure 59 – Sulphur Dioxide Emissions in Northern Ireland



Emissions of **sulphur dioxide** were estimated to be 9kt in 2016, representing 5% of the UK total. Emissions have declined by 92% since 1990, which has been dominated by the 96% reduction in energy industries emissions due to the introduction of CCGT (Combined Cycle Gas Turbine) plants, 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 and oil has been made possible. Road transport emissions have declined, coincident with the reduced sulphur content of road fuels, both petrol and diesel.

Figure 60 – Lead Emissions in Northern Ireland



Emissions of **lead** were estimated to be 2.1 tonnes in 2016, representing 3% of the UK total. Emissions have declined by 97% since 1990 almost entirely due to changes in transport sources. 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 substantive 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 in 2016. The table is shaded according to the overall contribution of that sector to the pollutant total. The table below indicates that the Residential and Other Combustion sector is a significant sector when considering emissions for CO, Pb, PM_{10}, $PM_{2.5}$ and SO_2, accounting for at least 20% of emissions for each pollutant.

The majority of the top five sectors are related to the combustion of fuel, except for agriculture, which is an important sector in Northern Ireland when considering 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 2016

Sector	NH_3	CO	NOx	VOC	PM_{10}	$PM_{2.5}$	SO_2	Pb
Agriculture	94.0%	IE	0.0%	47.2%	21.0%	8.6%	IE	IE
Energy Industries	IE	3.0%	16.5%	IE	1.3%	1.6%	27.1%	3.7%
Fugitive	IE	0.0%	IE	2.4%	IE	IE	0.0%	IE
Industrial Combustion	IE	22.3%	23.0%	1.9%	16.0%	21.9%	35.5%	53.6%
Industrial Processes	0.0%	0.1%	IE	8.2%	10.6%	3.1%	0.0%	16.5%
Residential, Commercial & Public Sector Combustion	IE	55.7%	14.6%	10.1%	37.5%	51.9%	29.5%	22.4%
Solvent Processes	IE	IE	IE	24.7%	2.5%	1.2%	IE	IE
Transport Sources	0.5%	18.0%	43.6%	4.2%	9.7%	9.9%	7.4%	3.6%
Waste	3.1%	0.4%	IE	0.1%	0.7%	0.9%	IE	0.1%
Other	2.3%	0.6%	2.3%	1.3%	0.8%	1.0%	0.5%	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. These have been marked in the table as “IE“ (used in inventory reporting for “Included Elsewhere”). A breakdown of what is included within this category in respect to each pollutant can be found in **Table 20**.

Figure 61 – Ammonia Emissions in Northern Ireland, 2016

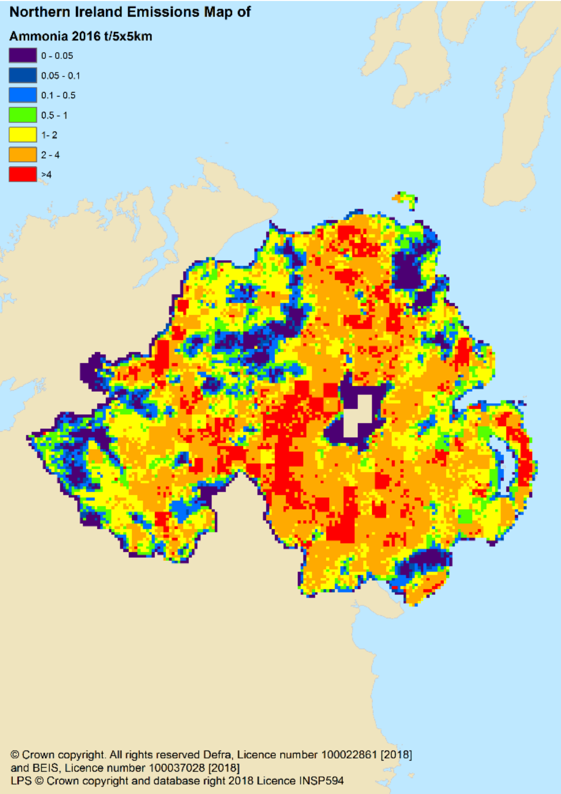


Figure 62 – Carbon Monoxide Emissions in Northern Ireland, 2016

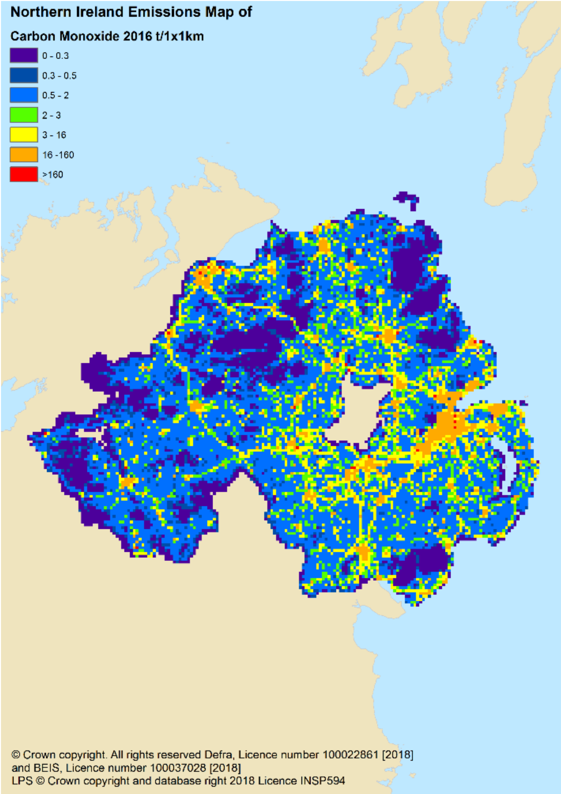


Figure 63 – Nitrogen Oxides Emissions in Northern Ireland, 2016

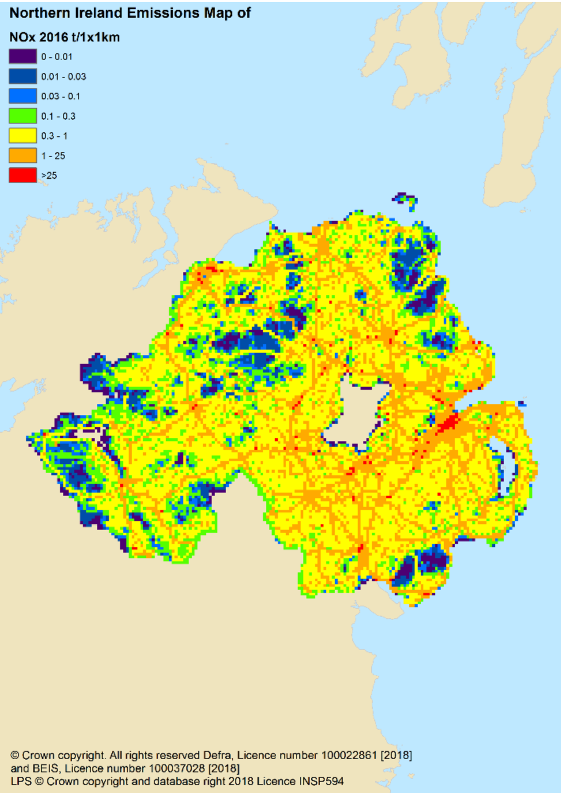


Figure 64 – NMVOC Emissions in Northern Ireland, 2016

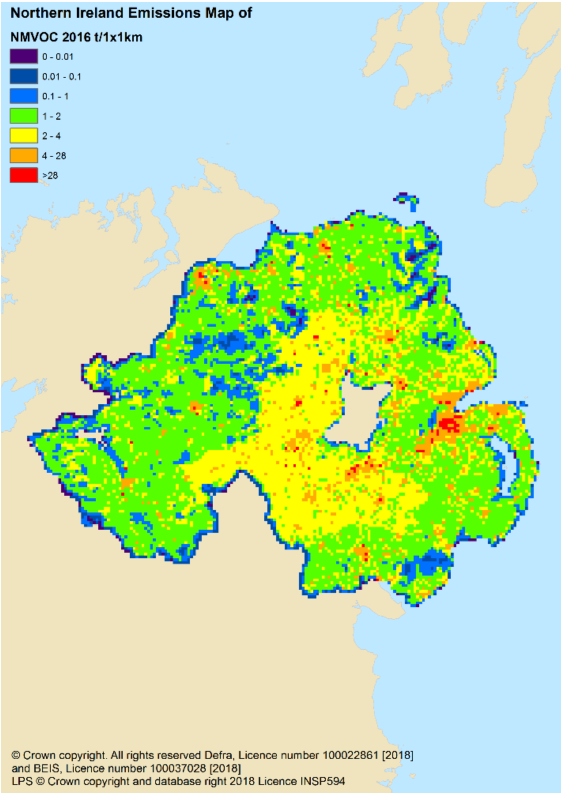


Figure 65 – PM_{10} Emissions in Northern Ireland, 2016

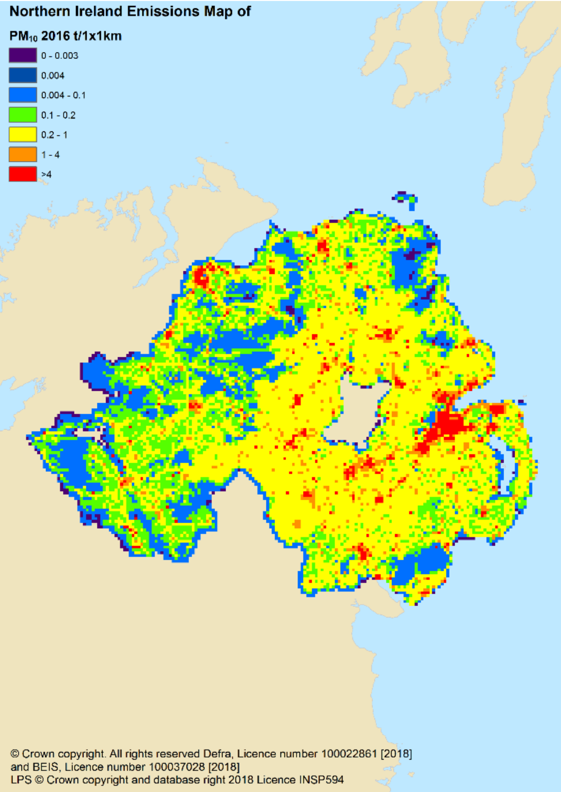


Figure 66 – $PM_{2.5}$ Emissions in Northern Ireland, 2016

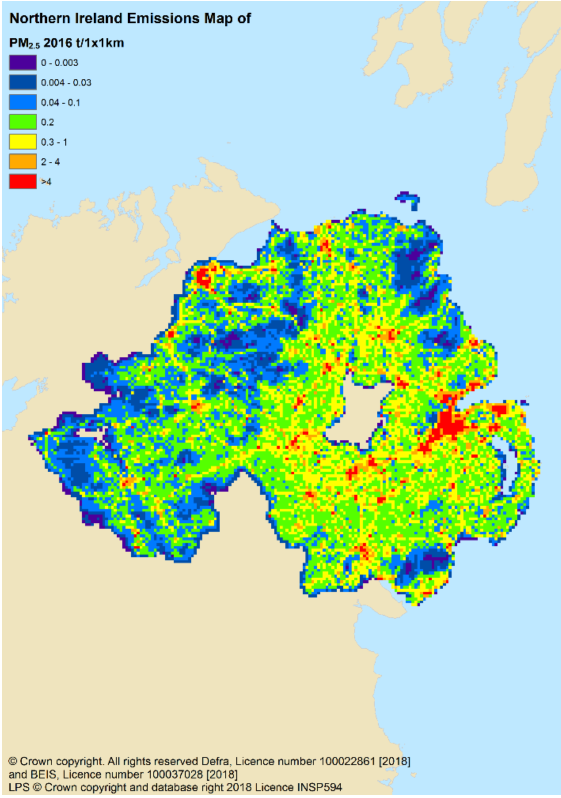


Figure 67 – Lead Emissions in Northern Ireland, 2016

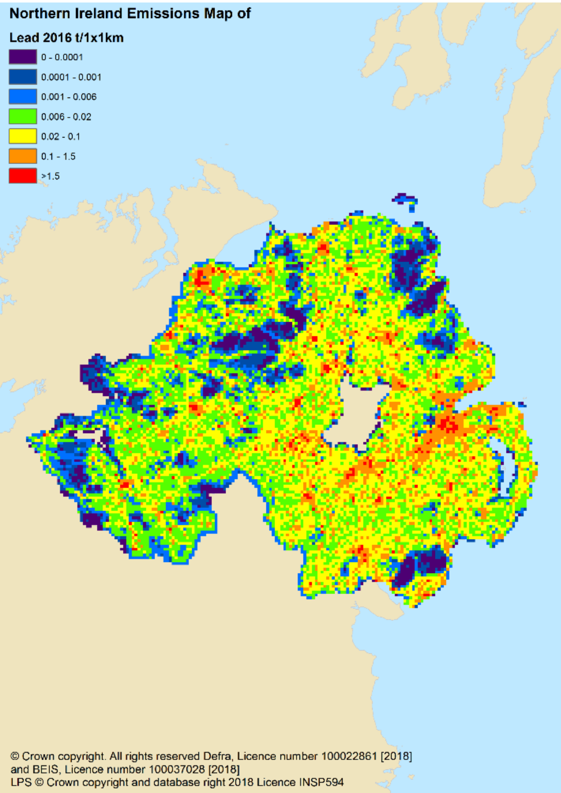
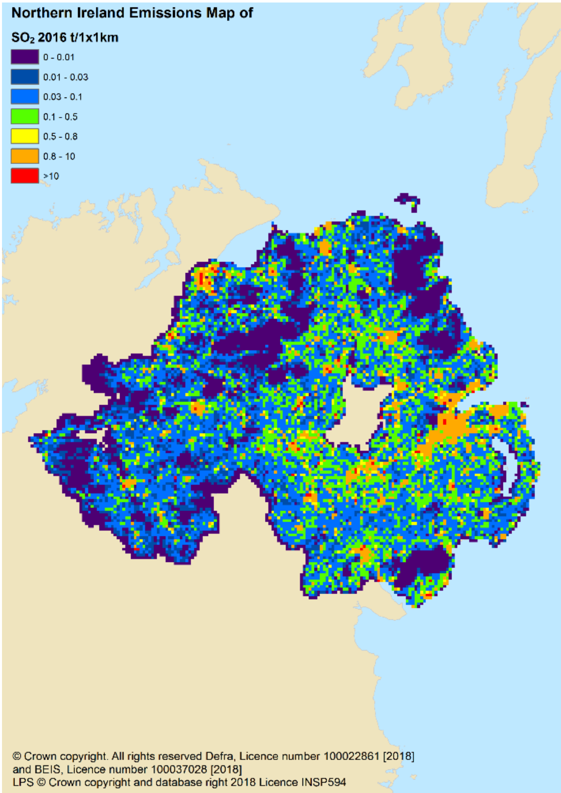


Figure 68 – Sulphur Dioxide Emissions in Northern Ireland, 2016



Appendix A Background to Inventory Development

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

In addition to the existing regulations and mechanisms outlined below, Defra has committed to implementing a new Clean Air Strategy, a draft of which was recently out for consultation during summer 2018. This draft strategy sets out proposed actions to reduce air pollutant emissions from transportation, combustion at home, farming, and industrial processes. The strategy also outlines Defra's intention to support further investment in Clean Air Innovation and minimise air quality impacts from the Renewable Heat Incentive Scheme. The final Clean Air Strategy is due for release later this year. In addition, Defra will publish a detailed National Air Pollution Control Programme in 2019.

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, 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 since revised the NECD, repealing the original Directive and replacing it with a new legislative instrument (Directive 2016/2284/EU) which ensures the emissions ceilings originally set continue till 2020. In addition, new national emission reduction commitments will be applicable from 2020 and 2030 onwards for SO_2, NO_X, NMVOC, NH_3, and $PM_{2.5}$ so as to cut the health impact attributed to air pollution by approximately half when compared to 2005.

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

CLRTAP 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 substantially between 2007 and 2008 from road transport (NFR 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 37 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, 2017).

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 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 pollutant 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 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 (BEIS, 2017b). 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 residential.

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 areas and the patterns of gas and electricity consumption. The latest available data include Local Authority fuel use estimates available for solid, liquid, gas, and electricity use are available from 2005 for Great Britain, and since 2008 for Northern Ireland.

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 important 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 (BEIS OPRED, 2017) 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 pollutant emissions inventory (Defra, 2018) 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.
- Emissions from **shipping activities** are based on a bottom-up inventory introduced into the inventory estimates for the first time this year. High resolution terrestrial Automatic Identification System (AIS) vessel movement data supplied by the UK Maritime and Coastguard Agency for 2014 is used to calculate emissions specific to each vessel at each point of the vessel’s voyage around the UK’s coastline. This method captures a number of smaller vessels and voyages that were not captured by the previous approach, such as movement to and from offshore oil and gas installations. Country-specific proxies based predominantly on port movement statistics (DfT Maritime Statistics, 2017) are used to estimate fuel use and emissions back to 1990, and to forecast to 2016. Emissions from shipping was split between the DAs using the methodology described in Appendix C.

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., 2017).

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 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 pollutants which are used within inventory compilation, such that more recent data are likely to be more accurate. The uncertainties in the Devolved Administrations’ 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 Gross Value Added data.

These main resources used within the DA air 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 Pollutant Inventory. The maps are compiled at a 1km resolution and are produced annually. 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., 2017).

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, residential, 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 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 (2017a,b), SEPA (2017a,b), Natural Resources Wales (2017a,b) NIEA (2017a,b). Exceptions are minor fuels: sewage gas use is estimated based on UK-wide estimates disaggregated using DA share of UK population (ONS, 2017); landfill gas use is based on the elution of methane from landfills from the MELMod model (Ricardo, 2017).
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 (2017).
1A1c	Coke & SSF production (all fuels)	Point source data provided by plant operators (see 1A1a). Regional iron & steel production and fuel use data (ISSB, 2017). UK fuel use data from BEIS (2017a).
	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 (2017).
	Gas production, downstream network (all fuels)	EU ETS installation data for natural gas use from 2005-2016. All other years estimated based on the DA share from the 2005 EU ETS data. Environment Agency (2017b), SEPA (2017b), Natural Resources Wales (2017b), NIEA (2017b) Colliery methane use based on deep mined coal production, data from the Coal Authority (2017).
	Upstream oil & gas, including gas separation plant (all fuels)	BEIS Offshore Inspectorate (2017) 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 by source from Tata Steel (2017).

NFR Sector	Source	Disaggregation Method
	Iron & steel combustion plant (all fuels)	Regional iron & steel production and fuel use data (ISSB, 2017) used to inform estimates to 2004. Data to disaggregate emissions from 2005 onwards is proved by the operators of integrated steelworks themselves.
1A2b	Combustion in non-ferrous metals manufacturing industry	Pollution Inventory (EA 2017a, SEPA 2017a, NRW 2017a, NIEA 2017a), EU ETS (EA 2017b, SEPA 2017b, NRW 2017b, NIEA 2017b) IDBR and employment data (ONS, 2017). 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 2008-2016; 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. Coal use in autogeneration derived from Energy Trends publications (BEIS, 2017b) Exceptions: All NH_3 production and methanol production (both 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	
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, 2017).
	Other industrial combustion (oils)	Sub-national energy statistics, BEIS (2017b), and analysis of point source data derived from EU ETS and IED data. Environment Agency (2017a,b), SEPA (2017a,b), NRW (2017a, b) NIEA (2017a,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 (2017), Northern Gas Networks (2017), Scotia Gas Networks (2017), Wales & West Utilities (2017), Airtricity (2017), Firmus Energy (2017), Vayu (2017). Sub-national energy statistics, BEIS (2017b), and analysis of point source data derived from EU ETS and IED data. Environment Agency (2017a,b), SEPA (2017a,b), NRW (2017a,b), NIEA (2017a,b).
	Industrial off-road machinery (all fuels)	Disaggregated by mapping grids from 2007-2010
1A3ai (i)	Aircraft – international take-off and landing (all fuels)	CAA (2017), UK airport statistics. All take-off and landing cycle emissions for each flight assigned to DA of origin and destination 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 (2017) Composition of fleet: GB - Vehicle Licensing Statistics Report, DfT (2017) NI - Dept. of Regional Development (2017) Traffic data: National Traffic Census, DfT (England, Scotland, Wales: 1990-2016) 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- 2016) Fuel consumption: Digest of UK Energy Statistics (1990-2016) (BEIS, 2017a)
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.

NFR Sector	Source	Disaggregation Method
		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 (1990-2016)
1A3dii	Coastal shipping (all fuels)	UK Maritime and Coastguard Agency, DfT Maritime Statistics (2017). MMO Fishing statistics (MMO, 2016). Scarbrough et al., (2017), IMO (2015) Estimates for all inland waterways are based on population (ONS, 2017).
1A3eii	Aircraft support vehicles (gas oil)	Regional aircraft movements, DfT (2017d)
1A4a	Railways – stationary combustion	Sub-national energy statistics, BEIS (2017b). Natural gas use all in England.
	Industrial & commercial combustion	Sub-national energy statistics, BEIS (2017b), 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, BEIS (2017b) and Housing Condition Survey data. Domestic peat combustion data from CEH (Personal communication, 2017). Northern Ireland gas use in the residential sector is based on estimates from all energy suppliers in Northern Ireland (Airtricity, Firmus Energy, Vayu; all 2017). Domestic wood combustion mapping grids based on a BEIS domestic wood survey (BEIS, 2016)
1A4bii	Household and gardening mobile machinery (all fuels)	Population data (ONS, 2017)
1A4ci	Agriculture – Stationary combustion	Agricultural employment data, Defra (2017a) used for allocation of solid and gaseous fuels. Regional energy statistics, BEIS (2017b) 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 BEIS sub-national energy data (BEIS, 2017b)
1A4ciii	Fishing vessels	UK Maritime and Coastguard Agency, DfT Maritime Statistics (2017). MMO Fishing statistics (MMO, 2016). Scarbrough et al., (2017), IMO (2015)
1A5b	Military aircraft and naval shipping	Regional GDP data (ONS, 2017).
1B1a	Deep-mined coal	Regional deep mine production, Coal Authority (2017). 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, 2017). Coal feed to coke ovens, ISSB, WS, BEIS and (1999-2004) PI. 2005 onwards: EU ETS (EA 2017b, SEPA 2017b, NRW 2017b, NIEA 2017b)
	Iron & steel flaring	Coal feed to coke ovens, ISSB, WS, BEIS and (1999-2004) PI. Data to disaggregate emissions from 2005 onwards is proved by the operators of integrated steelworks themselves.
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 BEIS Offshore Inspectorate (2017) 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 (2017) and analysed using the NAEI point source database.

NFR Sector	Source	Disaggregation Method
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 (2017).
	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, 2017)
	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 (BEIS Offshore Inspectorate, 2017) and PI/SPRI (Environment Agency 2017a; SEPA 2017a; NRW 2017a)
	Gas leakage from supply infrastructure	Leakage data provided by gas network operators: National Grid (2017), Northern Gas Networks (2017), Scotia Gas Networks (2017), Wales & West Utilities (2017), Airtricity (2017).
1B2c	Upstream oil & gas: flaring & venting	Emissions derived from the EEMS dataset (BEIS Offshore Inspectorate, 2017), 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, 2017)
2A1	Slag cement production	Point source data provided by plant operators (see 1A1a).
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. Glass ballotini emissions are not reported by operators, and so emissions are assumed equal across all known operating plants in England and Scotland (it is believed that there is no production in Wales and Northern Ireland).
2A5	Construction, asphalt manufacture	Regional GDP data (ONS, 2017).
	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, 2017).
2B2	Nitric acid production	Point source data provided by plant operators (see 1A1a). Now 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	Mapping grids for chromium, magnesia, nitric acid use, phosphate based fertilizers, pigment manufacture, and reforming. Coal tar and bitumen processes, and ammonia use in the chemical industry based on point source data provided by plant operators (see 1A1a).

NFR Sector	Source	Disaggregation Method
		Other chemical industry sources (i.e. alkyl lead, ammonia based fertilizer, carbon black, sulphuric acid use, solvent and oil recovery, and sulphuric acid production) are based on population statistics (ONS, 2017)
2C1	Industrial process emissions from SMEs, hot & cold steel rolling emissions, lead battery manufacture, zinc alloy and semis production, and zinc oxide production	Regional GDP data (ONS, 2017).
	Alumina production	All emissions in Scotland.
	Process emissions from: blast furnaces, EAFs, BOFs, primary aluminium production & anode baking, non-ferrous metal processes	Point source data provided by plant operators (see 1A1a), plus supplementary data provided by Tata Steel (2017), SSI (2014) and the ISSB (2017)
	Flaring & stockpile emissions at iron & steelworks	Regional iron & steel production and fuel use data (ISSB, 2017).
	Non-ferrous metal processes	All emissions in England
	Foundries	Foundries mapping grid
2D3a	Aerosol and non-aerosol products (cosmetics & toiletries, household products, paint thinners),	Population data, ONS (2017).
	Agrochemical use	Arable mapping distribution grid
2D3b	Road dressings and bitumen use	Road dressing mapping grid.
	Asphalt manufacture	Regional GDP data (ONS, 2017).
2D3d	Trade & retail decorative paints,	Population data, ONS (2017).
	Industrial coatings: Aircraft, agricultural and construction vehicles, coil coating, leather coating	Regional GDP data (ONS, 2017).
	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: film, metal packaging, automotive, drum, textile, paper	Point source data provided by plant operators (see 1A1a).
2D3e	Domestic surface cleaning.	Population data, ONS (2017).
	Industrial surface cleaning	Industrial employment mapping distribution grid.
	Leather coating and degreasing	Regional GDP data (ONS, 2017).
2D3f	Dry cleaning (solvent use)	Dry cleaning mapping grid
2D3g	Rubber & plastic products	Population data, ONS (2017).
	Industrial coating manufacture: adhesives, inks, solvents and pigments, tyre manufacture	Various industry-specific coatings mapping distribution grids

NFR Sector	Source	Disaggregation Method
2D3h	Printing – flexible packaging, publication gravure	Point source data provided by plant operators (see 1A1a).
	Other printing sources	Population data, ONS (2017).
2D3i	Seed oil extraction	All emissions in England
	Wood impregnation – creosote, LOSP	Wood impregnation mapping grid
	Solvent Use	Population data, ONS (2017).
2G	Cigarette smoking and fireworks	Population data, ONS (2017).
2H1	Paper production	GDP data, ONS (2017)
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 and point source database.
	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, 2017).
2I	Wood product process emissions	Wood coating mapping grid.
3A	Manure management	DA splits for manure management based on regional pollutant-specific emissions data provided by Rothamsted Research (2017)
3B	Inorganic N fertilizers	DA splits for manure management based on regional pollutant-specific emissions data provided by Rothamsted Research (2017)
3D1	Agricultural soil emissions	DA splits for manure management based on regional pollutant-specific emissions data provided by Rothamsted Research (2017)
3F	Field burning of agricultural wastes	Field burning estimates from Rothamsted Research (2017)
5A	Landfills	DA-specific models based on country-specific waste consignment landfilling data published by the Environment Agency, Scottish Environmental Protection Agency, Natural Resources Wales, and the Northern Ireland Environment Agency (all 2017)
5B	Composting	Population data, ONS (2017).
5C1	Incineration: MSW, crematoria, chemical waste	Point source data provided by plant operators (see 1A1a).
5C1 5C2	Incineration: Clinical waste, sewage sludge	Population data, ONS (2017).
	Incineration: animal carcases	Agriculture mapping grid.
	Foot & mouth pyres	Data on livestock disposal, NAO (2002).

NFR Sector	Source	Disaggregation Method
	Open-burning of waste	Population data, ONS (2017).
5D1	Small scale waste burning	Population data, ONS (2017)
6A	Sewage sludge decomposition	Population data, ONS (2017).
6A	Other sources: accidental fires, bonfires, cigarettes, fireworks, infant emissions from nappies, domestic pets	Population data, ONS (2017).
	Non-agricultural horses, professional horses	Driver for non-agricultural horses based on activity data time series from Rothamsted Research and CEH (2017)
	Parks, gardens and golf courses	Data on non-fuel fertiliser use, Rothamsted (2017)

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 National Grid (National Grid, 2017), other gas network operators, the Coal Authority (Coal Authority, 2017) and the Department for Business, Energy & Industrial Strategy (BEIS, 2017a). 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 2016. These data are used to underpin many of the AQ pollutant emission estimates from small-scale (non-regulated) combustion sources such as residential, 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, 2017) database of flight movements, fuel use data (BEIS, 2017a), aircraft fleet information (CAA, 2017) 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, 2017).
- **Regional iron and steel production data**, and regional fuel use data in the iron and steel industry (Tata Steel, 2017), (ISSB, 2017).
- Site-specific emissions data split by combustion and process sources for all **UK refineries**, and refinery production capacities (UKPIA, 2017).
- Site-specific cement production capacities and UK-wide **cement industry** fuel use data (Mineral Products Association, 2017).
- 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, 2017).

Appendix C Shipping Inventory Improvements

The UK inventory estimates have been revised following a major shipping study published in 2017 (Ricardo, 2017)[6] which was used to revise the UK air pollutant inventories in the UK Informative Inventory Report 2018 (Wakeling et al., 2018). The estimates for domestic and international shipping activity and emissions for England, Scotland, Wales and Northern Ireland have been derived as far as practicable on the methods used to generate the UK inventory estimates. The overall method utilises a highly detailed, spatially disaggregated dataset of shipping movement data which is available for the year 2014 only, to determine the fuel consumption of gas oil and fuel oil by 16 vessel types, with EFs applied to assess the emissions of individual pollutants according to information on engines and auxiliary engines/boilers by vessel.

The movements of individual shipping vessels have been allocated to the DAs according to the origin port of each vessel movement and for every vessel type. Where vessel movements originate at offshore locations (mainly oil and gas rigs) then the activity and emissions are reported as “Unallocated”.

For international shipping estimates, the analysis of ship movements is limited by the range of the Automatic Identification System (AIS) dataset used to track individual ships within the UK inventory method. Even though the range of the dataset reaches out beyond the UK waters, the AIS position messages should reliably cover up to ~40/50 nautical miles from the UK coast and with partial coverage beyond this. Therefore, the analysis of the international shipping movements (at UK and DA level) is subject to higher uncertainty, as assumptions have to be applied to the activity that it is partially covered.

For each individual vessel type, the 2014 estimates of fuel use and emissions are then extrapolated back to 1990 and forward to 2016 using a series of parameters and assumptions. One notable assumption applied is a fuel switching from heavy fuel oil to marine distillate oil as a result of the tightening in 2015 of the Sulphur Emission Control Area (SECA) fuel sulphur limit from 0.5% to 0.1%. This affects the analysis of the time series for 2015 and 2016 and is described in further detail in section 3.1.2.1 of the original shipping study (Ricardo, 2017).

Magnitude of recalculations by DA

Across all sources, years and DAs, the new shipping method leads to higher estimates of fuel use and emissions from shipping for all pollutants presented in this report. The overall impacts on the estimates of emissions from the shipping sector as a result of these improvements are summarised in **Figure 69** to **Figure 75** below. In 2015, SO_2 emissions have been significantly recalculated where this improvement work has also informed revisions to the relative usage of high and low sulphur fuels in areas outside Sulphur Emission Control Areas (SECAs). A comparison for $PM_{2.5}$ is not provided because emissions were not estimated for this pollutant last year.

Table 7 demonstrates the methods and data sources used to extrapolate the time-series for each vessel type. The same approach was used for each pollutant.

[6] http://naei.beis.gov.uk/reports/reports?report_id=950

Figure 69 - Emissions of ammonia from domestic navigation (1A3dii) and fishing vessels (1A4ciii) in this year's submission and the previous year.

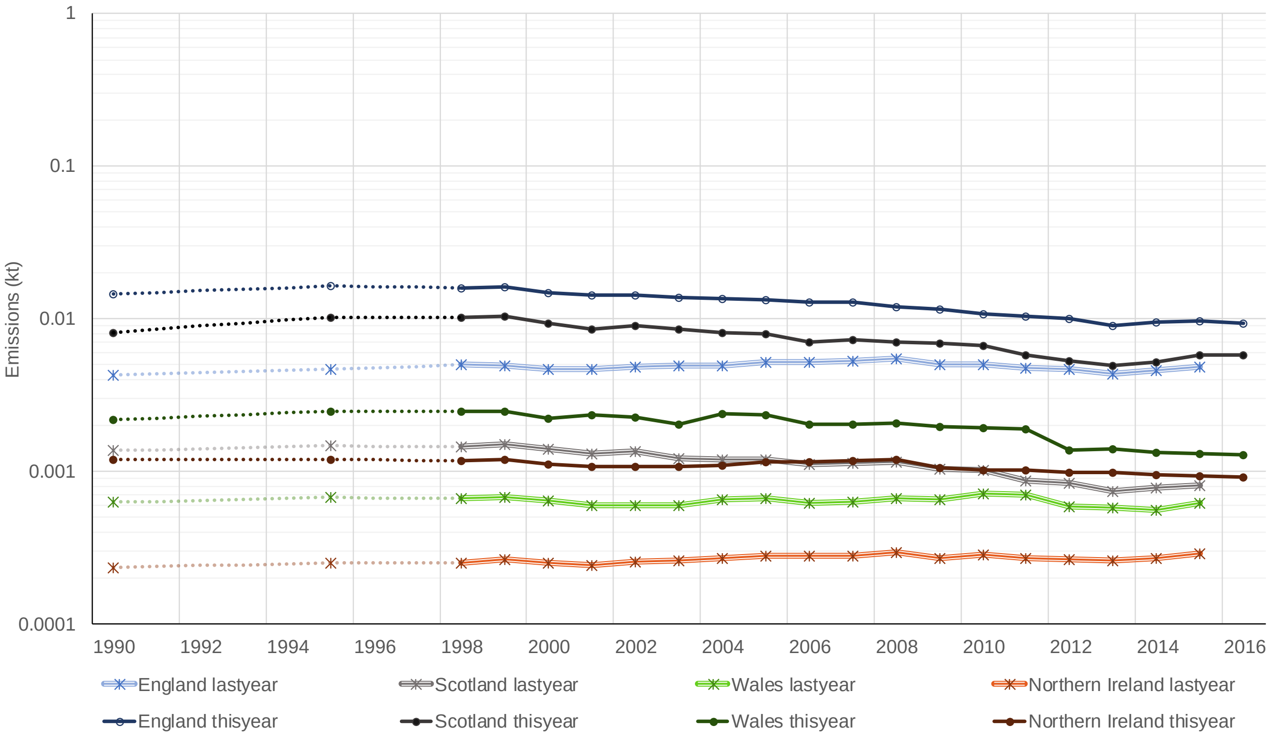


Figure 70 – Emissions of carbon monoxide reported domestic navigation (1A3dii) and fishing vessels (1A4ciii) in this year's submission and the previous year

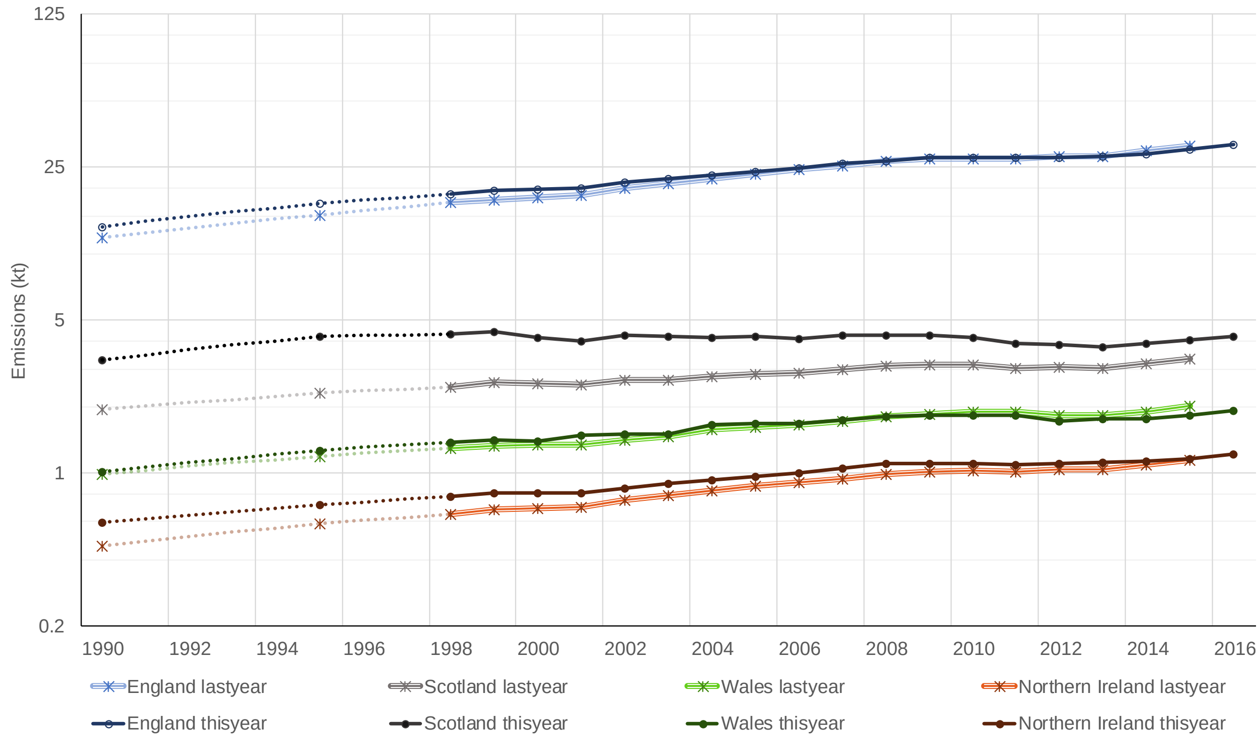


Figure 71 - Emissions of nitrous oxides from domestic navigation (1A3dii) and fishing vessels (1A4ciii) in this year's submission and the previous year

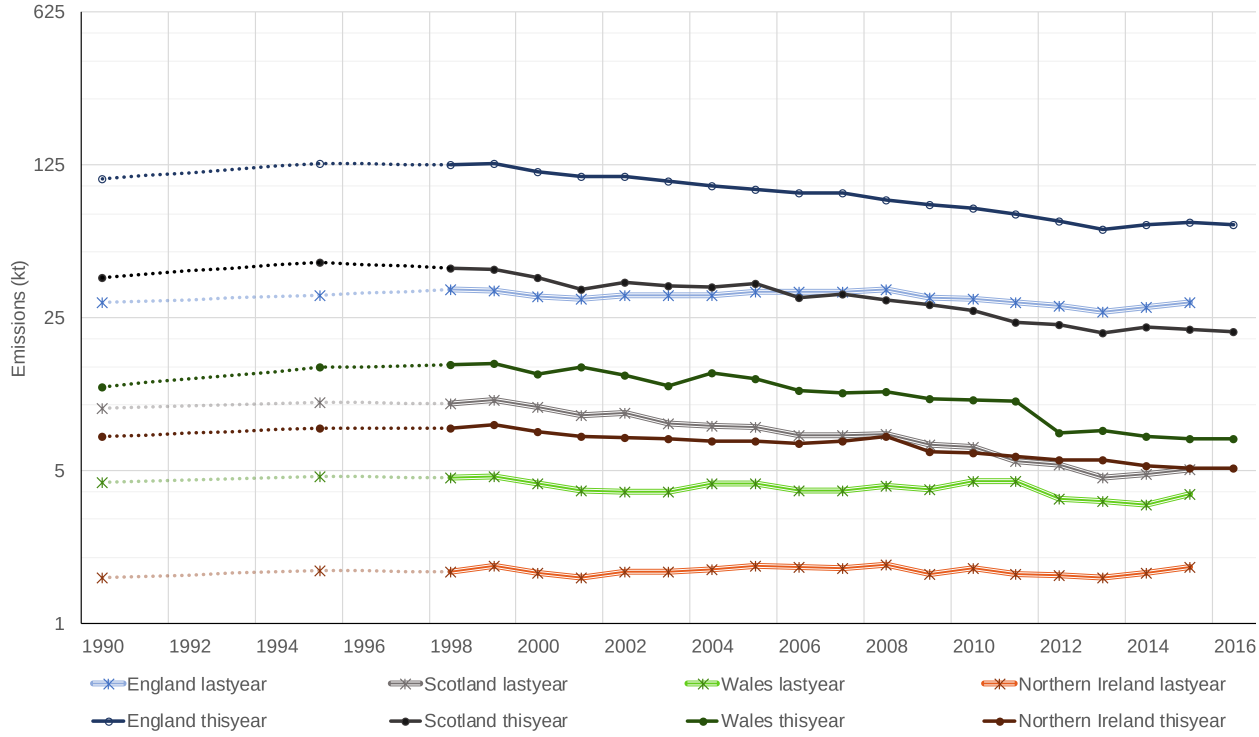


Figure 72 - Emissions of lead from domestic navigation (1A3dii) and fishing vessels (1A4ciii) in this year's submission and the previous year

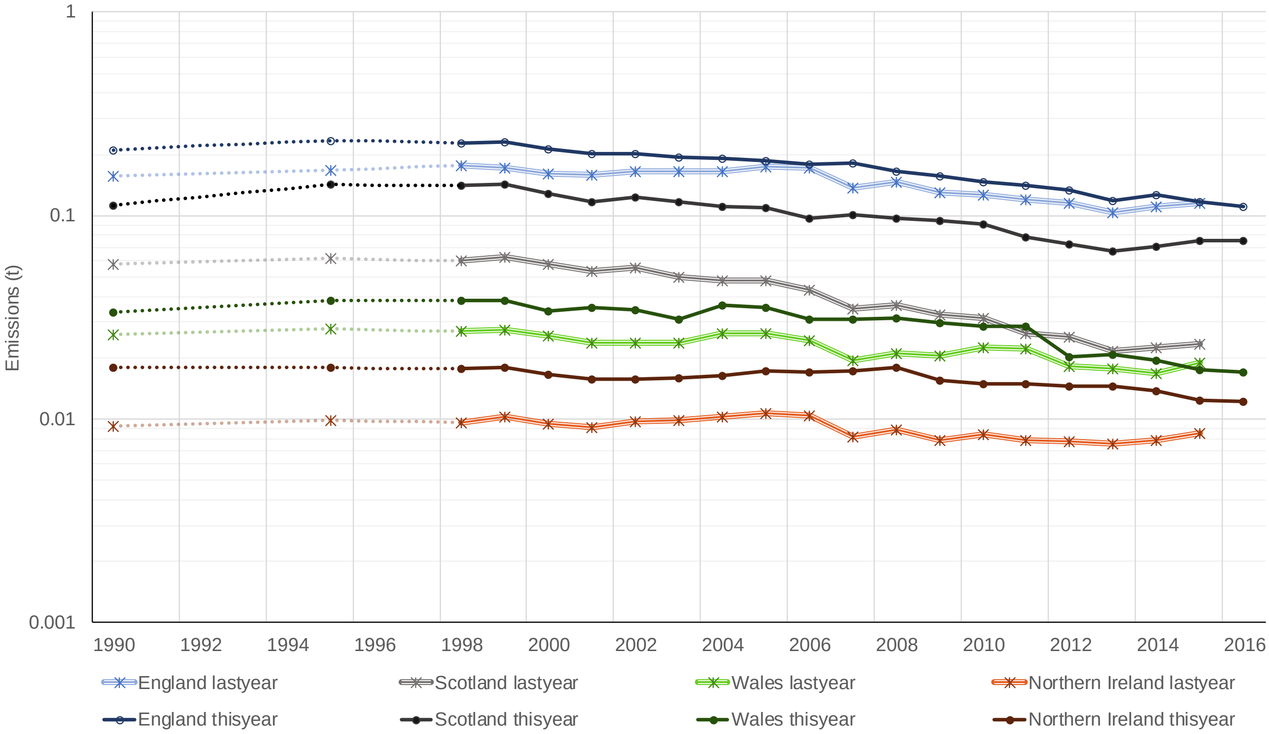


Figure 73 - Emissions of PM_{10} from domestic navigation (1A3dii) and fishing vessels (1A4ciii) in this year's submission and the previous year

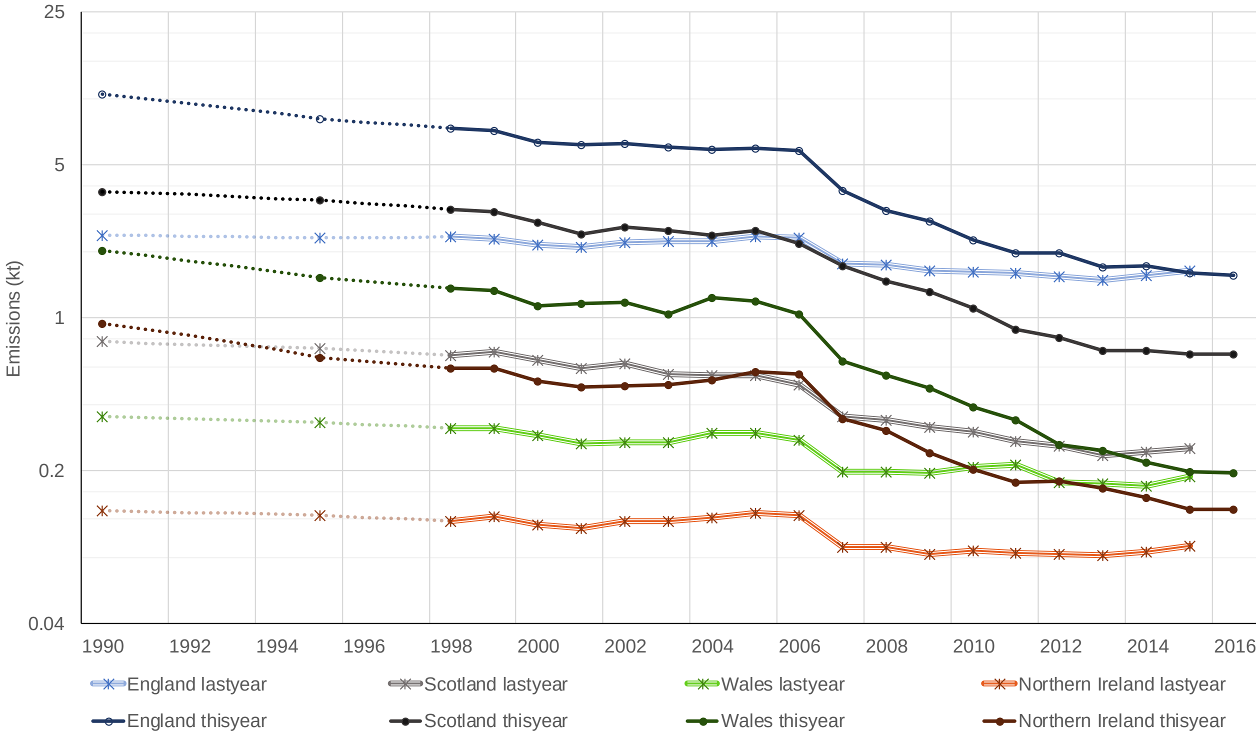


Figure 74 - Emissions of sulphur dioxide from domestic navigation (1A3dii) and fishing vessels (1A4ciii) in this year's submission and the previous year

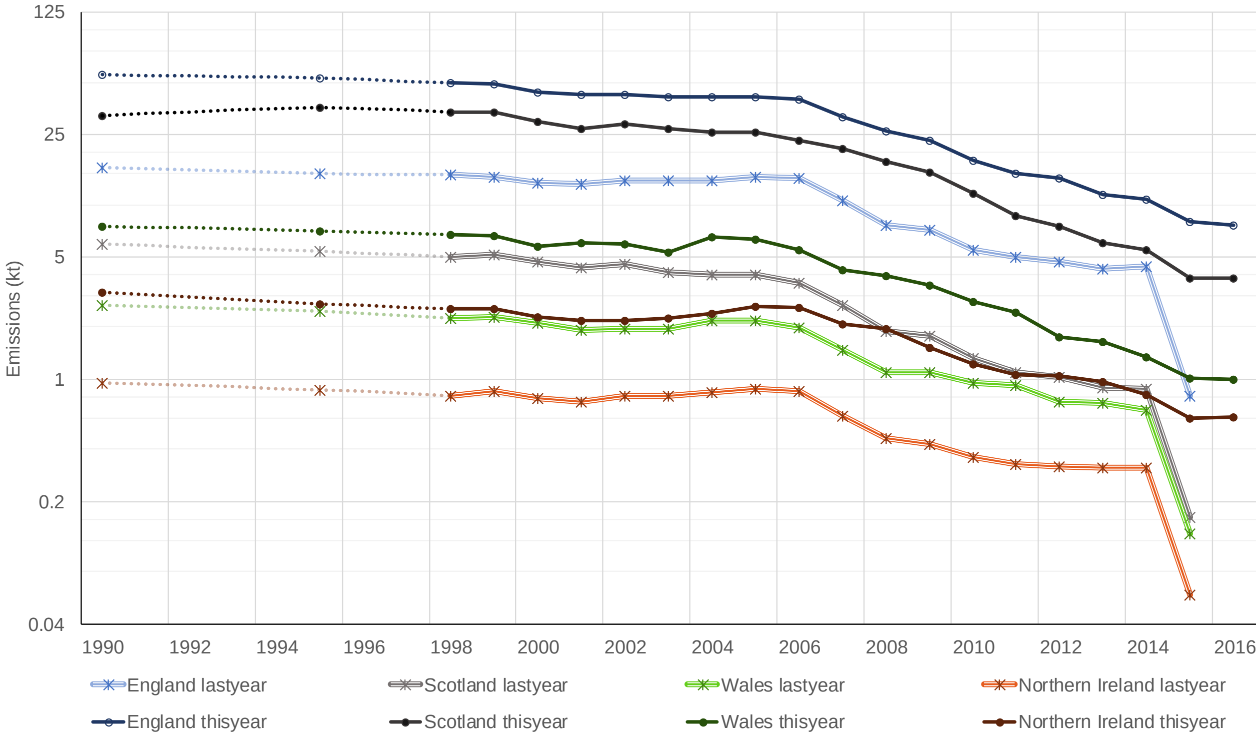


Figure 75 - Emissions of NMVOCs from domestic navigation (1A3dii) and fishing vessels (1A4ciii) in this year's submission and the previous year

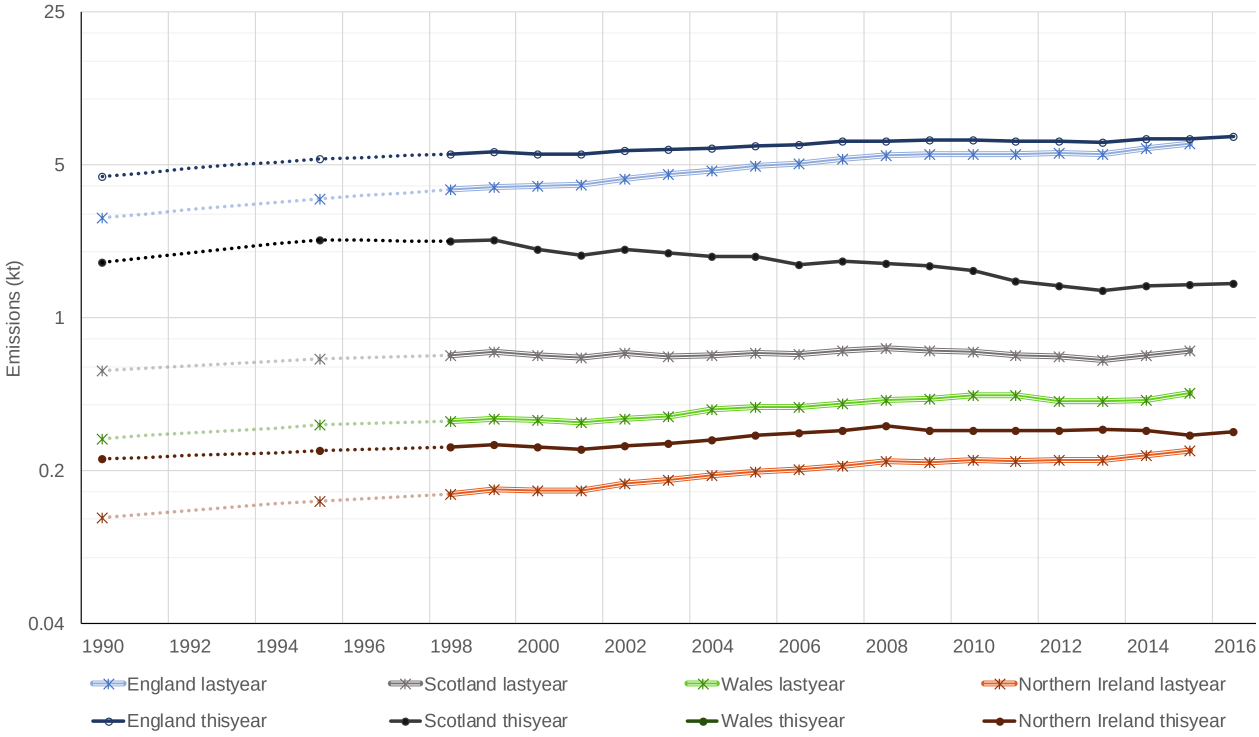


Table 7 - Methods and data sources for the new DA shipping inventory

Vessel Type	UK method	DA method	Comment
Fishing (1A4c)	**1990-2016** UK Sea Fisheries Annual Statistics Landings into the UK by UK and foreign vessels (thousand tonnes) All species, weight landed.	**1990-2016** UK Sea Fisheries Annual Statistics. Landings into each country, Tables 3.2a-d. Scottish Fisheries Statistics Northern Ireland Fisheries Statistics	A full time series of DA data are available for landings by UK vessels, and for Scotland there are data that enable analysis of the additional landings by foreign vessels. Allocations of landings by foreign vessels to England, Wales and Northern Ireland are estimated for earlier years, extrapolating the England, Wales and Northern Ireland share once the Scotland data are accounted for from the documented UK total. There is greater uncertainty for the allocations to England, Wales and Northern Ireland in earlier years than for Scotland. This vessel type accounts for less than 1% of all international shipping fuel use in the UK, but does account for ~4% of domestic HFO use and ~12% of domestic MDO use.
Bulk Carrier ([7]1A3d, memo)	**2000-2016** DfT Maritime Statistics PORT0107 (domestic), PORT0109 (int'l). Type: "all dry bulk" **1994-1999** PORT0104 (domestic and int'l) **1990-1993** Extrapolation of 1994- trends	**2000-2016** DfT Maritime Statistics PORT0499 (domestic and int'l). **1990-1999** Extrapolate back 3-yr average of UK share from 2000-2002	Limited data for earlier years in the time series. DA data from port movement statistics pre-2000 are aggregated (domestic + int'l). Domestic vessel movements: DA share is stable in early 2000s. International: variable DA share of UK total evident in 2000s. This vessel type accounts for typically around 15% of all HFO use (dom. and int'l) and 2-3% of all MDO use (dom. and int'l).
Chemical tankers (1A3d, memo)	**2000-2016** DfT Maritime Statistics PORT0107 (domestic), PORT0109 (int'l). Type: "other liq. bulk products" **1994-1999**	**2000-2016** DfT Maritime Statistics PORT0499 (domestic and int'l). **1990-1999** Extrapolate back 3-yr average of UK share from 2000-2002	Limited data for earlier years in the time series. DA data from port movement statistics pre-2000 are aggregated (domestic + int'l). The DA share of vessel movements across both domestic and international shows a lot of variation in the 2000s, so the extrapolation of the DA share back to 1990 is associated with high uncertainty. This vessel type accounts for typically around 3-4% of

[7] For all non-fishing vessel types the domestic shipping estimates are allocated to IPCC source 1A3d, within the national inventory total, whilst international shipping estimates are reported as a memo item, outside of the national inventory total. This is in accordance with IPCC reporting guidance.

Vessel Type	UK method	DA method	Comment
	PORT0104 (domestic and int'l) **1990-1993** Extrapolation of 1994- trends		all domestic MDO and HFO use, and 4-6% of all int'l MDO and HFO use.
Containers (1A3d, memo)	**2000-2016** DfT Maritime Statistics PORT0107 (domestic), PORT0109 (int'l). Type: "container traffic" **1995-1999** PORT0104 (domestic and int'l) **1990-1994** Extrapolation of 1995- trends	**2000-2016** DfT Maritime Statistics PORT0499 (domestic and int'l). **1992-1999** PORT0205 (domestic and int'l) **1990-1991** Assume 1992 DA split	DA data from port movement statistics pre-2000 are aggregated (domestic + int'l), and aggregated across all Roll-on Roll-off (Ro-Ro) and Lift-on Lift-off (Lo-Lo) vessels, but are regarded as a good proxy for DA shipping movements. The DA share of UK activity 1992- is quite stable, so the assumption for 1990 and 1991 is associated with low uncertainty. This vessel type accounts for ~5% of UK domestic HFO use, and accounts for almost 50% of international HFO use.
Passenger ferries and cruise ships (1A3d, memo)	**1990-2016** DfT Maritime Statistics SPAS0101 (int'l). **2003-2016** DfT Maritime Statistics SPAS0201 (domestic). **1994-2002** DfT T3.3, UK domestic passenger movements by route type **1990-1993** Extrapolation of 1994- trends	**1990-2016** DfT Maritime Statistics SPAS0101 (int'l). **2003-2016** DfT Maritime Statistics SPAS0201 (domestic). **1990-2002** Extrapolation of 2003 DA split	International data are available at DA level across the time series. The domestic ferry data are available broken down by route and then for specific inter-island ferries, with a 50-50 split of passenger numbers allocated to each DA for a shared route (e.g. Stranraer-Belfast route: 50% S, 50% NI). These vessel types account for ~7% of domestic MDO use and ~5% of international MDO use. [No notable HFO use.]
General Cargo (1A3d, memo)	**2000-2016** DfT Maritime Statistics PORT0107 (domestic), PORT0109 (int'l). Type: "all other general cargo traffic"	**2000-2016** DfT Maritime Statistics PORT0499 (domestic and int'l). **1992-1999**	DA data from port movement statistics pre-2000 are aggregated (domestic + int'l), and aggregated across all Ro-Ro and Lo-Lo vessels, but are regarded as a good proxy for DA General Cargo movements.

Vessel Type	UK method	DA method	Comment
	1994-1999 PORT0104 (domestic and int'l) **1990-1993** Extrapolation of 1994- trends	PORT0205 (domestic and int'l) **1990-1991** Assume 1992 DA split	The DA share of UK activity 1992- is quite stable, so the assumption for 1990 and 1991 is associated with low uncertainty. This vessel type accounts for a high % of UK activity across all fuels, int'l and domestic: ~5% domestic HFO, ~2% domestic MDO, ~10% int'l HFO, ~15% int'l MDO.
Liquefied Gas tankers (1A3d, memo)	**2000-2016** DfT Maritime Statistics PORT0107 (domestic), PORT0109 (int'l). Type: "liquefied gas" **1990-1999** Extrapolation of 2000- trends	**2000-2016** DfT Maritime Statistics PORT0499 (domestic and int'l). **1990-1999** Extrapolate back 3-yr average of UK share from 2000-2002. *Expert assumptions applied to reflect the opening of Liquefied Natural Gas (LNG) terminals in Wales (2009) and England (2005).*	LNG terminals opened in England in 2005 and Wales in 2009, and the DA trend reflects this, noting that other liquefied gas movements will be evident for direct distribution to chemical and petrochemical industry sites. This vessel type accounts for around 3% of MDO and HFO use in domestic shipping and is a small component of international shipping.
Offshore oil & gas (1A3d)	**1990-2016** UK production of oil, gas, NGLs. DUKES T3.1.1 (BEIS, 2017)	**1998-2016** Scottish oil & gas production statistics for Scotland's share of UK production of oil and gas. England and Wales share of remainder from 2014 analysis. **1990-1997** Extrapolate back 5-yr average of Scotland share from 1998-2002. Extrapolate back the England/Wales split.	There is no "international" component of this activity. The Scotland share of UK production is very stable across the late 1990s, 2000s. The 3-yr, 5-yr or 7-yr averages from 1998 onwards are all 74% of the UK total (within 0.4%). Therefore, the extrapolation back to 1990 is regarded as a reasonably good estimate, although there is some uncertainty due to the growth of the industry in that period. Movements from oil & gas rigs to the UK are accounted as "unallocated" in line with the protocol that emissions are accounted to the origin location. Northern Ireland allocation is zero. Wales allocation is less than 1.5% across the time series.
Oil tankers (1A3d, memo)	**2000-2016** DfT Maritime Statistics PORT0107 (domestic), PORT0109 (int'l). Type: "crude oil"	**2000-2016** DfT Maritime Statistics PORT0499 (domestic and int'l). **1990-1999**	Limited data for earlier years in the time series. DA data from port movement statistics pre-2000 are aggregated (domestic + int'l). The DA share of UK activity for both domestic and international oil tankers is quite stable in the early 2000s.

Vessel Type	UK method	DA method	Comment
	1994-1999 PORT0104 (domestic and int'l) **1990-1993** Extrapolation of 1994- trends	Extrapolate back 3-yr average of UK share from 2000-2002	This vessel type accounts for a high % of UK shipping activity for domestic and international HFO and MDO use: ~30% domestic HFO, ~10% domestic MDO, ~10% int'l HFO, ~15% int'l MDO.
Refrigerated Bulk (1A3d, memo)	**2000-2016** DfT Maritime Statistics PORT0107 (domestic), PORT0109 (int'l). Type: "other dry bulk" **1994-1999** PORT0104 (domestic and int'l) **1990-1993** Extrapolation of 1994- trends	**2000-2016** DfT Maritime Statistics PORT0499 (domestic and int'l). **1990-1999** Extrapolate back 3-yr average of UK share from 2000-2002	Limited data for earlier years in the time series. DA data from port movement statistics pre-2000 are aggregated (domestic + int'l). The DA share of UK activity for both domestic and international refrigerated bulk is moderately stable in the early 2000s. This vessel type accounts for a low % of UK shipping activity for domestic HFO and MDO use (<2%), and around a 3% share of int'l HFO and MDO.
Roll-on Roll-off (1A3d, memo)	**2000-2016** DfT Maritime Statistics PORT0107 (domestic), PORT0109 (int'l). Type: "roll-on roll-off traffic" **1995-1999** PORT0104 (domestic and int'l) **1990-1994** Extrapolation of 1995- trends	**2000-2016** DfT Maritime Statistics PORT0499 (domestic and int'l). **1992-1999** PORT0205 (domestic and int'l) **1990-1991** Assume 1992 DA split	DA data from port movement statistics pre-2000 are aggregated (domestic + int'l), and aggregated across all Ro-Ro and Lo-Lo vessels, but are regarded as a good proxy for DA shipping movements. The DA share of UK activity 1992- is quite stable, so the assumption for 1990 and 1991 is associated with low uncertainty. This vessel type accounts for a high % of UK shipping activity for domestic and international HFO and MDO use: ~17% domestic HFO, ~6% domestic MDO, ~5% int'l HFO, ~40% int'l MDO.
Service – Tug, Service - Other (1A3d, memo)	**2000-2016** DfT Maritime Statistics PORT0107 (domestic), PORT0109 (int'l). Type: "all dom./int'l traffic" **1994-1999** PORT0104 (domestic and int'l) **1990-1993** Extrapolation of 1994- trends	**2000-2016** DfT Maritime Statistics PORT0499 (domestic and int'l). **1992-1999** PORT0205 (domestic and int'l) **1990-1991** Assume 1992 DA split	DA data from port movement statistics pre-2000 are aggregated (domestic + int'l), and aggregated across all Ro-Ro and Lo-Lo vessels, but are applied as a proxy for service boat movements. No DA-specific data on service boats has been identified. These vessel types combined account for around 4% of domestic HFO use and around 8% of domestic MDO use, but very little (<1%) of all international shipping fuel use.

Appendix D 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., 2018). The most significant changes for each pollutant in the most recent inventory for 2015 are given in the tables below (note the shading within columns indicates magnitude of absolute emission recalculations). Recalculations to the $PM_{2.5}$ inventory are not included in this section as emissions from this pollutant group are included for the first time this compilation cycle.

Table 8 - Recalculations to 2015 estimates for ammonia between previous and current inventory submissions

Category	Reason for the change in NH_3 emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)
Overall change		**-0.42**	**-0.2%**	**-3.52**	**-9.7%**	**-3.40**	**-12.9%**	**-4.32**	**-12.5%**
Agriculture	Significant changes to the inventory model for calculating emissions from the agricultural sector were introduced for the 1990-2016 inventory. In particular, this has implemented a combined NH_3 and GHG model with greatly improved spatial, temporal and sectoral resolution. Whilst most NH_3 factors have remained unchanged, those for nitrogen fertiliser application, which are spatially and temporally sensitive, have changed as a result of finer model resolution, and the introduction of dynamic modelling on N excretion by ruminant livestock. Derivation of this finer resolution has come from more detailed data that relates diet and production characteristics. England emissions estimates are increased as the spatial resolution of fertiliser use suggests much greater urea-based fertiliser application in England compared to DAs.	12.26	8.1%	-1.69	-5.3%	-1.57	-6.8%	-2.64	-8.3%
Energy Industries	Minor recalculations	-0.01	-7.1%	0.00	-25.9%	0.00	662.4%	0.00	50.4%
Fugitive	Recalculations to activity data from in the iron and steel sector since 2013 for Wales and England due to updated data provided by steelworks operators.	0.10	91.1%	0.00	-63.3%	0.01	65.4%	0.00	-63.3%
Industrial Combustion	Minor recalculations.	0.19	11.8%	0.00	0.2%	0.03	21.7%	0.05	47.8%
Industrial Processes	Minor recalculations.	-0.11	-4.7%	-0.01	-13.8%	-0.02	-28.7%	0.00	-23.8%
Other	Recalculations predominantly due to improvement in the understanding of biomass fuel combustion by sector within the DUKES tables.	-2.62	-22.3%	-0.85	-51.2%	-1.22	-69.1%	-0.21	-39.6%
Solvent Processes	-	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
Transport Sources	Minor recalculations.	-0.16	-3.8%	-0.03	-6.1%	-0.02	-6.5%	-0.01	-4.8%

Category	Reason for the change in NH_3 emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)
Waste	Downward revision of sewage sludge decomposition emissions as emissions from sewage sludge applied to agricultural soils are reallocated to agriculture. In addition, land spreading of non-manure digestates are included in the agriculture inventory.	-10.09	-55.7%	-0.94	-46.5%	-0.63	-55.3%	-1.51	-78.5%
Residential, Commercial & Public Sector Combustion	Minor recalculations.	0.00	0.1%	0.00	0.1%	0.00	0.1%	0.00	0.1%

“Change in 2015 (kt)” refers to the change in emission estimate for 2015 between the previous inventory and the current inventory.

Table 9 - Recalculations to 2015 estimates for carbon monoxide between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)
Overall change		**17.62**	**1.4%**	**2.55**	**2.3%**	**1.85**	**0.9%**	**1.28**	**2.0%**
Agriculture	-	0.00		0.00		0.00		0.00	
Energy Industries	Minor recalculations.	1.65	3.0%	0.27	4.2%	0.80	12.7%	0.41	18.5%
Fugitive	Major recalculations in activity data from 2013-15 due to new data being received from Tata Steel for the Port Talbot steelworks. This is largely a reallocation from 1A2 to 2C1. Also, some refinement to the disaggregation of overall iron and steel sector activity is possible as a result of the new data and so there are recalculations in England also.	-0.44	-13.6%	0.00	0.0%	-4.20	-47.6%	0.00	0.0%
Industrial Combustion	Major recalculations in activity data from 2013-15 due to new data being received from Tata Steel for the Port Talbot steelworks. This is largely a reallocation from 1A2 to 2C1. Also, some refinement to the disaggregation of overall iron and steel sector activity is possible as a result of the new data and so there are recalculations in England also.	2.53	0.7%	0.07	0.3%	-16.22	-16.1%	0.57	4.1%
Industrial Processes	Major recalculations in activity data from 2013-15 due to new data being received from Tata Steel for the Port Talbot steelworks. This is largely a reallocation from 1A2 to 2C1. Also, some refinement to the disaggregation of overall iron and steel sector activity is possible as a	2.24	3.6%	0.14	255.0%	21.10	61.3%	0.05	3478.3%

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)
	result of the new data and so there are recalculations in England also.								
Other	Primarily due to the reallocation of accidental fires to the Waste category, but to a lesser extent, revisions to the naval shipping and military aircraft later time-series also contribute.	-8.62	-73.3%	-0.83	-74.9%	-0.47	-79.2%	-0.28	-78.7%
Transport Sources	Recalculations for some small aircraft due to moving emission factors from local inventories to 2016 EMEP/EEA guidebook values. Earlier in the time-series, the introduction of a bottom-up shipping inventory which causes major increases in the estimates of fuel and gas oil consumed dominates the reason for change.	-0.39	-0.1%	1.07	3.4%	-0.78	-4.0%	-1.28	-8.9%
Waste	Reallocation of accidental bonfires and emissions from bonfire night to Waste category from Other.	7.19	70.6%	0.71	61.4%	0.41	84.6%	0.24	80.3%
Residential, Commercial & Public Sector Combustion	A major recalculation in the time-series for residential petroleum coke consumption. The inventory now uses a tier 2, technology-specific approach, using default emission factors for solid fuels rather than the previous tier 1 approach which necessitated the use of liquid fuel emission factors.	13.45	3.4%	1.12	2.6%	1.20	2.7%	1.57	4.7%

Table 10 - Recalculations to 2015 estimates for nitrogen oxides between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)
Overall change		**44.44**	**6.7%**	**18.93**	**22.7%**	**5.36**	**7.1%**	**4.55**	**14.2%**
Agriculture	NOx emissions not previously estimated for the agriculture sector.	5.03		0.95		0.62		0.52	
Energy Industries	Minor recalculations.	2.93	1.9%	0.47	2.0%	0.74	2.1%	0.83	16.7%
Fugitive	Minor recalculations.	0.00	3.0%	0.00	0.0%	-0.01	-3.3%	0.00	0.0%
Industrial Combustion	Reallocations of natural gas within the UK energy statistics from commercial to industrial sectors has caused a shift in the dynamics of points contributions and the significance of IDBR maps in the derivation of drivers to disaggregate overall fuel use. Recalculations in DUKES in 2015 cause absolute changes.	3.37	2.9%	0.52	4.3%	0.91	7.3%	-0.37	-4.0%
Industrial Processes	Minor recalculations.	-0.10	-8.5%	0.00	-7.8%	-0.02	-3.5%	0.00	33.7%
Other	Revision of emissions from naval shipping and military aircraft.	-2.59	-18.5%	-0.23	-18.7%	-0.10	-18.3%	-0.06	-18.4%
Transport Sources	Inclusion of a newly-developed bottom-up inventory for the shipping sector causes major recalculations for NOx. Estimates of fuel oil and gas oil use are much greater than previously thought, and recalculations are largely a result of this increased fuel use along the UK coastline. Recalculations are more significant early in the time-series.	35.74	11.3%	10.80	30.1%	2.75	12.8%	2.98	23.1%
Waste	Minor recalculations.	0.12	11.1%	0.01	11.3%	0.01	12.8%	0.00	19.3%
Residential, Commercial & Public Sector Combustion	Recalculations more significant for Scotland as they now are considered to hold a much greater proportion of overall emissions from the fishing sector as a result of the newly-introduced bottom-up inventory.	-0.06	-0.1%	6.41	63.6%	0.45	7.7%	0.63	13.6%

Table 11 - Recalculations to 2015 estimates for NMVOCs between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)
Overall change		**-6.22**	**-1.1%**	**4.23**	**3.0%**	**-0.43**	**-0.9%**	**0.90**	**2.7%**
Agriculture	Introduction of new agriculture inventory models means that NMVOC emissions are calculated using a Tier 1 methodology (rather than a Tier 2 approach used in previous years). This regression is necessitated as some parameters aren't available in the new model run by Rothamsted. The new model also includes emissions from cultivated crops in response to NECD review recommendations.	8.94	14.6%	2.11	13.6%	1.58	15.0%	1.02	6.9%
Energy Industries	Minor recalculations.	-0.09	-3.9%	-0.01	-1.8%	0.12	24.0%	0.01	8.1%
Fugitive	Minor recalculations.	0.65	0.8%	0.02	0.1%	-0.49	-5.4%	0.01	1.8%
Industrial Combustion	Minor recalculations in absolute terms.	1.49	9.4%	0.15	9.7%	0.14	8.8%	0.09	15.0%
Industrial Processes	Revision in the methodology used to disaggregated emissions for Scotch Whisky maturation to now be based on reporting point sources.	-2.24	-5.5%	2.67	4.1%	-0.23	-9.0%	0.28	11.5%
Other	Minor recalculations in absolute terms.	1.64	101.5%	0.08	26.5%	0.08	66.4%	0.06	124.4%
Solvent Processes	Updated paint sales figures and a revision of emissions from aerosols as methodology considers revised assumption for share of UK fillings used in UK.	-24.62	-8.2%	-2.18	-7.6%	-2.20	-13.1%	-1.10	-11.5%
Transport Sources	Methodology for gasoline evaporation updated to meet the 2016 EMEP/EEA Guidebook, updating emission factors.	7.56	24.9%	1.14	37.0%	0.41	21.9%	0.36	30.8%
Waste	Minor recalculations in absolute terms.	1.39	36.1%	0.18	39.2%	0.13	77.2%	0.09	82.4%
Residential, Commercial & Public Sector Combustion	Minor recalculations.	-0.94	-2.4%	0.09	2.2%	0.04	0.9%	0.06	1.7%

Table 12 - Recalculations to 2015 estimates for PM_{10} between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)
Overall change		**23.11**	**20.5%**	**2.77**	**23.7%**	**1.52**	**13.0%**	**1.02**	**13.0%**
Agriculture	Harmonisation of PM emission factors to the 2016 EMEP/EEA Guidebook.	1.06	10.7%	0.20	11.0%	0.35	24.1%	0.04	2.3%
Energy Industries	Minor recalculations in absolute terms.	0.23	5.0%	0.02	5.5%	0.07	12.8%	0.04	73.3%
Fugitive	Minor recalculations in absolute terms.	0.01	0.8%	0.06	17.2%	0.07	70.8%	0.00	-17.7%
Industrial Combustion	Other industrial combustion emissions recalculated in the later time-series, particularly in 2015. Revisions to biomass activity data (mainly straw) through improved resolution of sector fuel demand in DUKES.	1.13	7.6%	0.04	3.0%	0.19	16.4%	0.27	22.0%
Industrial Processes	A major methodological change to emissions calculations for the construction sector causes a large increase in estimates of PM emissions. This new methodology is now aligned with the 2016 EMEP/EEA Guidebook and emissions split by type of construction are presented in the inventory for the first time. In addition, a change to the emission factor from quarrying contributes significantly to increases in all DAs.	18.18	101.3%	1.80	116.0%	0.64	23.6%	0.49	120.4%
Other	Reallocation of accidental fires and bonfire night emissions to waste.	-1.73	-84.7%	-0.17	-87.5%	-0.09	-85.8%	-0.06	-86.1%
Solvent Processes	Minor recalculations in absolute terms.	2.86	69.5%	0.26	80.8%	0.16	94.6%	0.11	94.8%
Transport Sources	Minor recalculations in absolute terms. Early parts of the time-series are more significantly affected by the integration of the newly-developed bottom-up shipping inventory which estimates significant fuel use (both fuel oil and gas oil) over the entire time-series.	-0.05	-0.3%	0.33	15.1%	0.00	0.2%	0.03	3.9%
Waste	Minor recalculations in absolute terms.	1.69	104.6%	0.17	96.2%	0.10	115.6%	0.06	113.5%
Residential, Commercial & Public Sector Combustion	Minor recalculations in absolute terms.	-0.27	-0.7%	0.07	2.1%	0.04	1%	0.05	1.6%

Table 13 - Recalculations to 2015 estimates for sulphur dioxide between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)
Overall change		**10.89**	**6.3%**	**4.15**	**17.8%**	**1.28**	**4.9%**	**0.81**	**8.9%**

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)	Change in 2015 (kt)	Change in 2015 (%)
Energy Industries	Minor recalculations.	0.96	1.1%	-0.05	-0.3%	0.02	0.2%	0.10	3.9%
Fugitive	Minor recalculations.	-0.41	-11.0%	0.00	0.0%	-0.30	-24.7%	0.00	
Industrial Combustion	Minor recalculations.	1.33	3.6%	0.10	5.1%	0.09	1.2%	-0.10	-2.4%
Industrial Processes	Minor recalculations.	-0.52	-7.7%	0.00	0.4%	0.11	23.2%	0.00	
Other	Minor recalculations.	0.42	45.0%	0.04	45.0%	0.02	45.0%	0.01	45.0%
Transport Sources	Inclusion of a newly-developed bottom-up inventory for the shipping sector causes major recalculations for SO_2. Estimates of fuel oil and gas oil use are much greater than previously thought, and recalculations are largely a result of this increased fuel use along the UK coastline. Recalculations are more significant early in the time-series.	6.69	330.7%	2.84	860.4%	0.80	403.6%	0.50	380.8%
Waste	Minor recalculations.	-0.04	-5.6%	0.00	-5.0%	0.00	-5.8%	0.00	-6.5%
Residential, Commercial & Public Sector Combustion	Recalculations more significant for Scotland as they now are considered to hold a much greater proportion of overall emissions from the fishing sector as a result of the newly-introduced bottom-up inventory.	2.45	7.7%	1.22	48.7%	0.55	13.3%	0.30	14.1%

Table 14 - Recalculations to 2015 estimates for lead between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2015 (t)	Change in 2015 (%)	Change in 2015 (t)	Change in 2015 (%)	Change in 2015 (t)	Change in 2015 (%)	Change in 2015 (t)	Change in 2015 (%)
Overall change		**0.01**	**19.6%**	**0.00**	**30.8%**	**0.00**	**9.8%**	**0.00**	**27.9%**
Energy Industries	Minor recalculations.	0.00	-0.2%	0.00	-2.5%	0.00	17.3%	0.00	-1.4%
Fugitive	Minor recalculations.	0.00	-16.0%	0.00		0.00	-24.9%	0.00	
Industrial Combustion	Minor recalculations.	0.00	4.8%	0.00	2.6%	0.00	5.5%	0.00	14.1%
Industrial Processes	Emissions from fireworks included in the Pb industrial processes sector after recommendation by NECD review.	0.01	33.5%	0.00	140.6%	0.00	12.7%	0.00	270.8%
Other	Minor recalculations.	0.00	-51.3%	0.00	-51.3%	0.00	-51.3%	0.00	-51.3%
Transport Sources	Minor recalculations.	0.00	0.8%	0.00	22.4%	0.00	-0.8%	0.00	4.6%
Waste	Minor recalculations.	0.00	-3.9%	0.00	-4.6%	0.00	-0.6%	0.00	-5.1%
Residential, Commercial & Public Sector Combustion	Minor recalculations.	0.00	0.3%	0.00	2.9%	0.00	0.5%	0.00	2.4%

Appendix E Uncertainties

The following sections provide information on the key characteristics of each pollutant based on the uncertainty assessments carried out for the UK NAEI, 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 2016" (Wakeling, et al., 2018).

An indicative "Uncertainty Rating" is provided for each pollutant that reflects the relative magnitude in uncertainty estimates made for each pollutant at UK level across the full timeseries. 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 2016" (Wakeling, et al., 2018). 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 2015 NAEI mapping report (Tsagatakis et al.,2017). 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.

E.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, which are more diffuse and therefore difficult to spatially model. 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[8].

<u>Uncertainty Rating</u>: **MODERATE**

E.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. Because 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**

[8] 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.

E.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**

E.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 robust 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 accurate activity data for some sources, such as for the use of cleaning products and domestic use of fuels for each specific Devolved Administration. 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**

E.5 Particulate Matter

The emission inventory for PM_{10} and $PM_{2.5}$ 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} / $PM_{2.5}$ 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**

E.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 residential sectors, contains accurate emission estimates for the most important sources.

***Uncertainty Rating*: LOW**

E.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 about 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 F Summary Tables

In these tables, 'Other' is inclusive of categories which are considered to contribute negligible emissions for a given pollutant. For example, in the case of carbon monoxide, the 'Other' sector includes emissions from the agriculture, solvent processes, and other categories. The allocations of categories to the "Other" sector is presented in **Table 20**, Appendix F.

F.1 Summary Air Pollutant Emission Estimates for England

Table 15 - Summary of air pollutant emission estimates for England (1990-2016)*

	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Ammonia (kt)	Agriculture	212	182	173	159	149	151	148	145	154	157	161
	Transport Sources	0.7	5.8	19.2	13.1	8.4	7.2	6.2	5.3	4.7	4.1	3.7
	Industrial Processes	9.8	8.6	4.9	5.4	4.4	5.1	4.7	3.5	3.0	2.2	2.5
	Waste	5.2	6.4	6.8	8.6	9.2	10.5	10.6	11.2	13.3	14.8	15.9
	Other	10.2	10.6	11.6	12.4	14.1	14.4	14.8	15.4	14.9	15.7	15.7
	Total	**238**	**214**	**216**	**199**	**185**	**188**	**184**	**180**	**190**	**193**	**199**
Carbon monoxide (kt)	Energy Industries	100.0	91.5	59.2	67.6	58.9	61.4	72.1	70.3	62.7	56.5	39.9
	Industrial Combustion	488	497	388	431	316	315	331	349	366	369	316
	Transport Sources	4,052	3,383	2,050	1,392	652	545	482	415	359	321	283
	Fugitive	22.5	13.1	10.8	4.7	4.5	3.6	4.2	4.3	3.9	2.8	1.7
	Industrial Processes	229	227	227	97.6	76.6	75.8	76.7	81.1	74.2	65.0	49.6
	Waste	11.4	11.3	10.2	9.8	7.8	7.8	7.6	7.4	7.4	7.4	7.4
	Other	200	18.3	16.8	15.9	16.2	15.8	15.2	14.7	13.9	13.1	12.6
	Residential, Commercial & Public Sector Combustion	675	533	465	327	398	360	394	423	392	405	400
	Total	**5,778**	**4,774**	**3,228**	**2,346**	**1,529**	**1,384**	**1,384**	**1,365**	**1,279**	**1,240**	**1,111**
Nitrogen oxides (kt)	Agriculture	0.7	0.7	0.8	1.6	1.6	1.7	1.6	1.7	1.7	1.8	1.8
	Energy Industries	651	416	292	346	212	206	238	224	188	154	101
	Industrial Combustion	340	312	256	231	157	136	137	121	115	121	108
	Transport Sources	1,160	993	760	606	430	411	392	376	372	363	352
	Industrial Processes	0.5	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Waste	0.4	0.4	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Other	62.5	50.8	31.8	26.3	27.5	25.7	23.7	22.1	19.9	17.0	16.2

	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
	Residential, Commercial & Public Sector Combustion	169	153	130	102	78.7	67.8	71.3	71.1	63.0	63.9	63.9
	Total	**2,384**	**1,927**	**1,471**	**1,313**	**907**	**848**	**864**	**815**	**760**	**721**	**643**
NMVOC (kt)	Agriculture	91.5	85.1	82.0	76.6	71.3	69.8	69.0	69.7	70.3	70.3	71.0
	Industrial Combustion	25.5	26.1	25.4	25.7	19.7	17.3	18.0	15.1	15.6	17.4	15.7
	Transport Sources	734	574	333	164	67.7	58.0	51.1	45.1	41.4	38.8	36.6
	Fugitive	474	330	227	160	109	107	98.0	84.3	83.5	78.0	67.8
	Industrial Processes	190	172	90.0	62.4	44.0	40.1	40.2	40.1	39.6	38.5	38.2
	Solvent Processes	534	415	329	297	264	277	276	272	274	276	278
	Waste	2.1	2.0	1.6	1.5	0.8	0.8	0.8	0.7	0.7	0.7	0.7
	Other	20.7	20.6	19.2	16.2	13.1	12.5	12.1	11.5	10.9	10.5	10.3
	Residential, Commercial & Public Sector Combustion	59.7	46.7	45.7	38.1	42.7	36.6	40.2	42.6	39.5	38.5	38.1
	Total	**2,131**	**1,671**	**1,153**	**841**	**632**	**619**	**605**	**581**	**576**	**569**	**556**
PM10 (kt)	Agriculture	27.5	12.1	12.4	11.5	11.0	11.0	10.9	10.8	11.2	11.0	11.2
	Energy Industries	59.8	33.8	18.8	8.5	5.5	5.9	8.2	7.5	6.2	4.8	3.3
	Industrial Combustion	28.8	27.4	19.3	16.8	15.4	14.5	14.9	14.2	14.9	15.9	14.2
	Transport Sources	40.6	42.6	36.6	32.8	24.7	23.1	22.2	21.1	20.4	19.8	19.2
	Industrial Processes	74.9	56.9	44.3	45.3	38.3	34.3	30.5	36.9	35.1	36.1	37.5
	Solvent Processes	7.8	6.2	5.8	5.2	4.1	5.4	5.7	6.0	6.6	7.0	7.1
	Waste	2.7	2.7	2.5	2.4	1.8	1.8	1.7	1.7	1.7	1.7	1.7
	Other	8.6	5.9	4.2	3.9	3.6	3.5	3.4	3.3	3.2	2.9	2.6
	Residential, Commercial & Public Sector Combustion	38.4	29.0	29.8	27.4	38.5	32.5	37.4	40.1	35.8	36.8	36.6
	Total	**289**	**216**	**174**	**154**	**143**	**132**	**135**	**142**	**135**	**136**	**133**
Sulphur dioxide (kt)	Energy Industries	2,481	1,470	712	358	150	165	216	168	120	92.0	46.0
	Industrial Combustion	316	253	106	100.0	79.6	65.8	71.0	67.9	61.6	38.0	27.5
	Transport Sources	107	93.7	49.9	44.8	19.6	16.3	15.5	12.7	12.3	9.8	9.6
	Fugitive	16.1	16.1	6.1	6.2	7.1	5.6	5.6	5.8	5.7	3.4	1.2
	Industrial Processes	51.1	54.2	38.3	29.0	10.6	10.6	5.7	6.8	7.0	6.2	7.4
	Other	17.5	11.0	6.5	6.0	5.3	4.8	4.4	3.8	3.3	2.0	1.9
	Residential, Commercial & Public Sector Combustion	138	109	65.7	39.3	37.5	33.5	33.5	34.4	34.7	34.1	34.9

	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
	Total	**3,126**	**2,007**	**985**	**583**	**309**	**301**	**351**	**300**	**244**	**185**	**128**
Lead (t)	Energy Industries	138	117	13.9	9.2	2.4	2.9	4.1	3.3	2.6	2.7	2.6
	Industrial Combustion	30.3	25.2	12.8	11.1	9.9	10.1	10.2	10.0	9.9	10.7	8.8
	Transport Sources	1,804	879	2.3	2.1	1.7	1.7	1.7	1.7	1.7	1.7	1.8
	Industrial Processes	262	224	91.3	64.3	30.9	31.5	36.5	32.2	36.2	35.4	28.0
	Waste	227	66.1	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Other	2.9	2.0	1.7	2.0	1.7	1.7	1.6	1.7	1.6	1.1	0.5
	Residential, Commercial & Public Sector Combustion	23.4	13.7	7.1	3.7	4.2	4.0	4.0	4.4	4.2	4.3	4.3
	Total	**2,487**	**1,327**	**130**	**92.6**	**51.0**	**52.0**	**58.3**	**53.4**	**56.4**	**55.9**	**46.2**
PM2.5 (kt)	Agriculture	17.4	3.1	2.9	2.7	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Energy Industries	27.5	16.4	9.3	5.3	3.6	3.8	5.0	4.5	3.8	3.2	2.6
	Industrial Combustion	26.4	25.3	18.2	16.1	14.8	13.9	14.2	13.5	14.2	15.3	13.7
	Transport Sources	35.5	37.5	31.2	27.2	19.5	17.9	17.1	15.9	15.1	14.4	13.7
	Industrial Processes	23.0	18.8	12.5	11.8	8.9	8.2	8.0	8.9	9.0	9.0	8.7
	Solvent Processes	3.0	2.5	2.4	2.2	1.7	2.2	2.3	2.4	2.6	2.8	2.8
	Waste	2.5	2.5	2.4	2.2	1.7	1.7	1.6	1.6	1.6	1.6	1.6
	Other	5.1	4.0	3.0	3.0	2.8	2.8	2.7	2.7	2.6	2.4	2.3
	Residential, Commercial & Public Sector Combustion	37.5	28.4	29.2	26.8	37.6	31.8	36.5	39.1	34.9	36.0	35.8
	Total	**178**	**138**	**111**	**97.1**	**93.1**	**84.7**	**89.9**	**91.0**	**86.3**	**87.1**	**83.8**

* 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.

F.2 Summary Air Pollutant Emission Estimates for Scotland

Table 16 - Summary of air pollutant emission estimates for England (1990-2016)*

	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Ammonia (kt)	Agriculture	36.5	34.1	32.8	32.0	29.6	29.3	29.2	28.6	29.6	29.6	30.5
	Transport Sources	0.1	0.6	2.0	1.4	0.9	0.7	0.6	0.6	0.5	0.4	0.4
	Industrial Processes	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Waste	0.6	0.7	0.8	1.0	1.1	1.2	1.2	1.3	1.5	1.5	1.6
	Other	1.1	1.1	1.2	1.2	1.3	1.2	1.3	1.3	1.3	1.3	1.3
	Total	**38.3**	**36.6**	**36.8**	**35.6**	**32.9**	**32.5**	**32.3**	**31.8**	**32.9**	**32.9**	**33.9**
Carbon monoxide (kt)	Energy Industries	14.9	14.8	11.3	10.0	11.2	9.4	9.9	8.7	7.2	6.8	5.0
	Industrial Combustion	79.7	31.9	25.4	29.3	25.8	26.3	23.8	23.8	25.3	26.9	25.4
	Transport Sources	367	305	185	132	64.7	54.4	49.0	42.3	36.9	32.6	28.9
	Fugitive	5.2	1.1	1.1	1.0	0.9	1.0	0.7	0.9	1.0	1.2	0.8
	Industrial Processes	4.0	3.2	3.4	3.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
	Waste	1.2	1.2	1.1	1.0	0.8	0.8	0.8	0.7	0.7	0.7	0.7
	Other	16.0	2.0	1.8	1.7	1.7	1.7	1.6	1.6	1.5	1.4	1.4
	Residential, Commercial & Public Sector Combustion	165	97.2	70.7	41.4	47.6	44.0	46.0	47.8	44.2	44.8	44.4
	Total	**653**	**457**	**300**	**220**	**153**	**138**	**132**	**126**	**117**	**115**	**107**
Nitrogen oxides (kt)	Agriculture	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Energy Industries	96.6	64.9	54.8	44.5	37.1	29.0	30.2	28.1	26.2	24.2	14.4
	Industrial Combustion	39.9	32.8	28.5	22.6	16.6	14.6	14.0	13.3	12.8	12.6	11.8
	Transport Sources	136	122	94.7	78.3	56.4	53.0	51.1	48.7	47.4	47.2	45.5
	Industrial Processes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other	6.4	4.4	4.0	3.6	3.2	3.3	2.9	3.1	2.5	2.3	2.1
	Residential, Commercial & Public Sector Combustion	41.2	39.4	32.0	28.6	21.5	18.2	18.5	17.7	18.0	16.5	16.5
	Total	**320**	**264**	**214**	**178**	**135**	**118**	**117**	**111**	**107**	**103**	**90.3**
NMVOC (kt)	Agriculture	21.6	20.6	20.0	19.4	18.3	18.1	18.0	17.7	17.8	17.6	17.8
	Industrial Combustion	2.6	2.3	2.3	2.2	1.9	1.7	1.8	1.4	1.5	1.7	1.5
	Transport Sources	67.5	52.9	31.0	16.2	7.3	6.2	5.5	4.9	4.5	4.3	4.1
	Fugitive	185	123	82.5	42.6	22.1	20.7	24.8	20.9	19.0	21.1	20.9

	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
	Industrial Processes	58.1	58.2	58.7	53.7	59.3	59.6	61.1	63.8	66.0	67.8	69.4
	Solvent Processes	61.4	48.0	34.0	29.6	25.8	27.1	26.7	26.2	26.6	26.5	26.5
	Waste	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Other	2.5	2.5	2.3	1.8	1.5	1.4	1.4	1.2	1.2	1.2	1.1
	Residential, Commercial & Public Sector Combustion	12.7	8.1	7.0	5.4	5.5	4.8	5.0	5.0	4.8	4.4	4.4
	Total	**411**	**316**	**238**	**171**	**142**	**140**	**144**	**141**	**141**	**145**	**146**
PM10 (kt)	Agriculture	3.5	2.3	2.4	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.1
PM10 (kt)	Energy Industries	8.2	5.1	3.6	1.7	1.3	1.1	1.0	0.8	0.6	0.5	0.4
PM10 (kt)	Industrial Combustion	3.6	3.1	2.1	1.8	1.5	1.3	1.2	1.1	1.1	1.2	1.1
PM10 (kt)	Transport Sources	6.4	6.6	5.6	4.9	3.3	3.0	2.8	2.7	2.6	2.5	2.4
PM10 (kt)	Industrial Processes	7.7	5.6	4.2	4.4	3.6	3.3	2.8	3.3	3.3	3.4	3.6
PM10 (kt)	Solvent Processes	0.8	0.6	0.5	0.4	0.3	0.5	0.5	0.5	0.6	0.6	0.6
PM10 (kt)	Waste	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
PM10 (kt)	Other	0.8	0.7	0.8	0.8	0.9	0.9	0.6	0.7	1.0	0.6	0.5
PM10 (kt)	Residential, Commercial & Public Sector Combustion	8.5	5.3	4.7	3.7	4.2	3.6	3.9	4.0	3.7	3.6	3.6
PM10 (kt)	**Total**	**39.8**	**29.7**	**24.0**	**20.1**	**17.4**	**15.8**	**15.1**	**15.3**	**15.0**	**14.5**	**14.4**
Sulphur dioxide (kt)	Energy Industries	217	135	104	53.9	66.2	48.0	48.5	33.7	23.0	17.4	8.6
Sulphur dioxide (kt)	Industrial Combustion	39.7	24.0	7.1	11.2	4.4	3.8	2.6	2.9	2.6	2.1	1.6
Sulphur dioxide (kt)	Transport Sources	33.8	36.5	27.9	23.2	10.0	7.5	6.3	5.1	4.5	3.2	3.2
Sulphur dioxide (kt)	Fugitive	0.6	0.1	0.4	0.4	0.2	0.2	0.1	0.2	0.3	0.1	0.1
Sulphur dioxide (kt)	Industrial Processes	0.8	0.7	0.7	0.8	0.6	0.7	0.8	0.6	0.6	0.7	0.7
Sulphur dioxide (kt)	Other	1.3	0.9	0.6	0.6	0.5	0.4	0.4	0.4	0.3	0.2	0.2
Sulphur dioxide (kt)	Residential, Commercial & Public Sector Combustion	32.7	25.1	13.4	8.4	5.2	4.5	4.4	3.9	4.1	3.7	3.7
Sulphur dioxide (kt)	**Total**	**326**	**222**	**154**	**98.4**	**87.0**	**65.1**	**63.1**	**46.8**	**35.4**	**27.5**	**18.1**
Lead (t)	Energy Industries	11.8	7.6	3.0	1.6	1.3	0.6	1.1	0.6	0.6	0.6	0.4
Lead (t)	Industrial Combustion	3.7	3.2	2.0	1.8	1.4	1.2	1.0	1.1	0.9	0.9	0.9
Lead (t)	Transport Sources	171	82.2	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Lead (t)	Industrial Processes	12.9	6.3	2.8	2.3	1.4	1.4	1.5	1.2	1.4	1.4	1.3
Lead (t)	Waste	7.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lead (t)	Other	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
	Residential, Commercial & Public Sector Combustion	4.5	2.3	1.2	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5
	Total	**211**	**104**	**9.3**	**6.5**	**4.9**	**4.1**	**4.4**	**3.6**	**3.6**	**3.6**	**3.3**
PM2.5 (kt)	Agriculture	1.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Energy Industries	3.9	2.6	1.8	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.3
	Industrial Combustion	3.4	3.0	2.0	1.7	1.4	1.3	1.2	1.1	1.0	1.2	1.1
	Transport Sources	5.8	6.0	4.9	4.3	2.7	2.4	2.3	2.1	2.0	1.9	1.8
	Industrial Processes	2.1	1.5	0.9	0.9	0.7	0.7	0.6	0.7	0.7	0.7	0.7
	Solvent Processes	0.3	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2
	Waste	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Other	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.5	0.4	0.3
	Residential, Commercial & Public Sector Combustion	8.3	5.2	4.6	3.6	4.1	3.5	3.8	3.9	3.6	3.5	3.5
	Total	**26.2**	**19.8**	**15.7**	**13.0**	**11.1**	**9.9**	**9.8**	**9.5**	**9.2**	**8.9**	**8.7**

* 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.

F.3 Summary Air Pollutant Emission Estimates for Wales

Table 17 - Summary of air pollutant emission estimates for Wales (1990-2016) *

	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Ammonia (kt)	Agriculture	23.5	22.6	22.6	21.1	20.6	19.6	20.1	20.4	21.5	21.1	22.2
	Transport Sources	0.1	0.4	1.2	0.8	0.5	0.5	0.4	0.3	0.3	0.3	0.2
	Industrial Processes	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	0.4	0.6	0.7	0.6	0.6	0.7	0.7	0.7	0.8
	Other	0.8	0.7	0.9	0.9	1.0	1.0	1.0	1.1	1.0	1.1	1.1
	Total	**24.7**	**24.2**	**25.2**	**23.5**	**22.8**	**21.7**	**22.1**	**22.4**	**23.6**	**23.2**	**24.3**
Carbon monoxide (kt)	Energy Industries	6.2	5.9	4.9	6.1	6.5	7.1	8.6	9.3	6.4	7.1	6.1
	Industrial Combustion	131	161	126	77.6	69.2	76.2	73.0	75.2	87.8	84.6	72.9
	Transport Sources	233	193	113	79.4	38.2	31.9	28.3	24.1	20.9	18.5	16.2
	Fugitive	12.4	19.2	15.3	3.1	6.4	6.0	6.0	6.0	5.6	4.6	9.6
	Industrial Processes	63.3	61.5	59.0	48.0	34.8	32.5	24.4	47.2	59.8	55.5	48.6
	Waste	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4
	Other	2.1	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6
	Residential, Commercial & Public Sector Combustion	97.1	78.1	62.2	38.6	47.3	43.7	46.8	49.0	44.3	46.1	45.4
	Total	**546**	**520**	**382**	**254**	**204**	**198**	**188**	**212**	**226**	**217**	**200**
Nitrogen oxides (kt)	Agriculture	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Energy Industries	49.9	35.2	32.2	33.6	30.4	30.9	44.4	44.9	32.5	35.3	29.6
	Industrial Combustion	37.2	35.2	34.0	20.5	16.1	14.1	12.8	13.0	13.5	13.4	11.2
	Transport Sources	76.7	66.3	50.2	41.4	30.4	29.4	25.3	25.2	24.8	24.3	23.9
	Industrial Processes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other	4.0	3.5	3.0	2.2	2.0	2.0	1.7	1.9	2.0	1.6	1.5
	Residential, Commercial & Public Sector Combustion	19.0	18.1	15.5	12.3	8.4	7.3	7.7	7.4	6.4	6.3	6.3
	Total	**187**	**158**	**135**	**110**	**87.3**	**83.8**	**92.0**	**92.6**	**79.3**	**81.1**	**72.6**
NMVOC (kt)	Agriculture	14.4	14.0	13.8	12.8	11.8	11.8	11.9	12.0	12.2	12.1	12.4
	Industrial Combustion	2.5	2.7	3.0	2.2	1.9	1.8	1.6	1.6	1.7	1.7	1.6
	Transport Sources	42.2	32.7	18.3	9.4	4.0	3.4	3.0	2.6	2.4	2.3	2.1
	Fugitive	37.2	25.0	18.1	13.8	12.8	12.8	11.2	11.7	9.4	8.6	7.0

	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
	Industrial Processes	5.6	5.2	4.1	2.4	2.2	2.2	2.0	2.4	2.4	2.4	2.3
	Solvent Processes	41.7	31.9	20.2	17.6	14.7	15.5	15.1	14.9	14.7	14.6	14.5
	Waste	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	Other	2.1	2.1	1.9	1.2	1.1	1.1	1.1	1.1	1.0	1.0	1.0
	Residential, Commercial & Public Sector Combustion	8.1	6.1	5.6	4.3	5.0	4.4	4.8	4.8	4.3	4.5	4.4
	Total	**154**	**120**	**85.1**	**63.7**	**53.5**	**53.0**	**50.7**	**51.0**	**48.2**	**47.1**	**45.4**
PM10 (kt)	Agriculture	2.0	1.9	2.0	1.8	1.7	1.7	1.8	1.8	1.9	1.8	1.8
	Energy Industries	3.3	2.1	1.9	1.0	0.8	0.8	0.9	1.1	0.6	0.6	0.6
	Industrial Combustion	3.0	2.4	1.7	1.2	1.3	1.1	1.1	1.1	1.2	1.4	1.2
	Transport Sources	3.8	3.5	2.9	2.8	1.8	1.6	1.5	1.4	1.4	1.3	1.3
	Industrial Processes	7.7	6.8	5.6	4.4	3.1	3.0	2.6	3.3	3.5	3.4	2.9
	Solvent Processes	0.4	0.3	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3
	Waste	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Other	0.6	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Residential, Commercial & Public Sector Combustion	5.7	4.4	4.2	3.4	4.5	3.9	4.3	4.4	3.9	4.1	4.1
	Total	**26.7**	**22.2**	**19.2**	**15.2**	**13.6**	**12.8**	**12.8**	**13.7**	**13.1**	**13.3**	**12.6**
Sulphur dioxide (kt)	Energy Industries	109	69.6	58.7	39.5	16.9	17.3	15.5	19.4	11.8	12.7	7.4
	Industrial Combustion	45.4	37.0	20.1	7.1	10.0	8.6	7.5	8.3	8.7	7.3	6.5
	Transport Sources	10.3	9.2	5.9	6.1	2.7	2.4	1.6	1.5	1.3	1.0	1.0
	Fugitive	4.1	3.1	1.4	1.0	1.6	1.1	0.9	0.9	1.2	0.9	0.9
	Industrial Processes	2.9	2.7	2.2	2.3	0.4	0.5	0.5	0.7	0.6	0.6	0.5
	Other	0.8	0.7	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1
	Residential, Commercial & Public Sector Combustion	17.7	14.0	8.4	5.2	7.2	6.1	5.3	5.9	5.2	4.6	4.6
	Total	**190**	**136**	**97.1**	**61.5**	**39.0**	**36.1**	**31.4**	**36.9**	**28.9**	**27.2**	**20.8**
Lead (t)	Energy Industries	3.7	1.8	1.5	0.7	0.5	0.4	0.4	0.3	0.2	0.2	0.2
	Industrial Combustion	2.5	2.0	2.0	2.4	0.8	0.7	0.7	0.7	0.9	0.9	0.8
	Transport Sources	109	52.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Industrial Processes	18.2	19.0	17.0	16.8	11.6	10.6	8.3	8.8	13.1	12.8	10.5
	Waste	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other	1.5	1.8	2.0	0.4	0.6	0.6	0.6	0.6	0.6	0.5	0.5

	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
	Residential, Commercial & Public Sector Combustion	2.7	1.8	1.1	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Total	**138**	**79.3**	**23.7**	**21.0**	**14.2**	**13.0**	**10.6**	**11.1**	**15.5**	**15.1**	**12.7**
PM2.5 (kt)	Agriculture	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.6	0.6	0.6	0.6
	Energy Industries	1.6	1.1	1.0	0.6	0.5	0.5	0.6	0.7	0.4	0.4	0.4
	Industrial Combustion	2.8	2.3	1.6	1.2	1.2	1.1	1.1	1.1	1.2	1.3	1.2
	Transport Sources	3.4	3.2	2.6	2.4	1.4	1.3	1.1	1.1	1.0	1.0	0.9
	Industrial Processes	3.3	3.1	2.4	1.7	1.2	1.3	1.1	1.5	1.7	1.5	1.1
	Solvent Processes	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Waste	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Other	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.2
	Residential, Commercial & Public Sector Combustion	5.6	4.3	4.1	3.4	4.4	3.8	4.2	4.3	3.8	4.0	4.0
	Total	**17.9**	**15.1**	**12.8**	**10.2**	**9.6**	**8.8**	**8.9**	**9.5**	**8.9**	**9.1**	**8.5**

* 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.

F.4 Summary Air Pollutant Emission Estimates for Northern Ireland

Table 18 - Summary of air pollutant emission estimates for Northern Ireland (1990-2016) *

	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Ammonia (kt)	Agriculture	28.8	31.5	29.1	28.7	26.4	26.6	27.2	27.7	27.7	28.6	29.9
	Transport Sources	0.0	0.3	0.9	0.6	0.4	0.3	0.3	0.3	0.2	0.2	0.2
	Industrial Processes	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Waste	0.2	0.2	0.3	0.5	0.5	0.6	0.6	0.8	0.8	0.9	1.0
	Other	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.7
	Total	**29.6**	**32.6**	**31.0**	**30.3**	**28.0**	**28.2**	**28.7**	**29.4**	**29.4**	**30.4**	**31.8**
Carbon monoxide (kt)	Energy Industries	4.1	3.7	1.3	3.4	3.0	2.3	1.7	1.5	1.5	2.6	1.9
	Industrial Combustion	14.3	13.3	9.9	11.1	12.6	12.5	12.0	12.5	13.6	14.5	14.1
	Transport Sources	122	109	69.9	52.2	27.1	22.2	19.9	17.9	14.6	13.1	11.4
	Fugitive	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Industrial Processes	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Waste	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Other	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4
	Residential, Commercial & Public Sector Combustion	143	94.4	57.1	25.8	34.2	31.1	33.6	36.0	32.9	34.6	35.3
	Total	**284**	**222**	**139**	**93.4**	**77.7**	**68.9**	**68.0**	**68.7**	**63.2**	**65.5**	**63.4**
Nitrogen oxides (kt)	Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Energy Industries	31.1	19.3	14.8	9.9	6.1	6.2	6.4	6.9	5.8	5.8	5.9
	Industrial Combustion	18.7	18.9	16.3	14.0	10.2	8.8	8.6	8.2	8.5	8.8	8.2
	Transport Sources	42.7	38.0	30.1	26.9	20.2	18.9	18.0	17.5	16.5	15.9	15.5
	Industrial Processes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other	2.2	1.8	1.5	1.1	1.1	1.0	1.0	1.0	0.9	0.8	0.8
	Residential, Commercial & Public Sector Combustion	15.1	13.5	11.9	9.3	7.0	6.1	5.9	5.7	5.3	5.3	5.2
	Total	**110**	**91.5**	**74.7**	**61.1**	**44.6**	**41.0**	**39.9**	**39.3**	**36.9**	**36.7**	**35.6**
NMVOC (kt)	Agriculture	14.6	15.7	15.3	15.6	14.7	15.1	15.3	15.1	15.2	15.8	16.3
	Industrial Combustion	0.9	0.9	0.8	0.9	0.7	0.7	0.7	0.5	0.6	0.7	0.7
	Transport Sources	24.2	19.8	11.9	6.1	2.7	2.3	2.1	1.9	1.6	1.5	1.4
	Fugitive	3.3	3.2	2.1	1.6	0.9	0.9	0.9	0.9	0.9	0.8	0.8

	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
	Industrial Processes	2.3	2.3	1.9	1.9	2.8	2.5	2.5	2.4	2.5	2.8	2.8
	Solvent Processes	16.1	12.2	10.2	9.3	8.1	8.6	8.5	8.4	8.5	8.4	8.5
	Waste	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Other	0.8	0.8	0.8	0.9	0.6	0.6	0.5	0.5	0.5	0.5	0.4
	Residential, Commercial & Public Sector Combustion	10.5	6.7	4.6	3.1	3.7	3.3	3.5	3.7	3.3	3.5	3.5
	Total	**72.9**	**61.7**	**47.6**	**39.4**	**34.4**	**34.0**	**33.9**	**33.4**	**33.1**	**34.0**	**34.5**
PM10 (kt)	Agriculture	1.7	1.7	1.8	1.7	1.6	1.7	1.7	1.7	1.8	1.8	1.9
	Energy Industries	2.7	1.5	0.8	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Industrial Combustion	1.6	1.6	1.2	1.1	1.3	1.2	1.2	1.2	1.3	1.5	1.4
	Transport Sources	1.9	1.8	1.6	1.7	1.2	1.1	1.0	1.0	0.9	0.9	0.9
	Industrial Processes	1.8	1.5	1.2	1.3	1.0	0.9	0.8	0.9	0.9	0.9	1.0
	Solvent Processes	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
	Waste	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Other	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Residential, Commercial & Public Sector Combustion	8.1	5.3	3.8	2.7	3.6	3.1	3.4	3.6	3.1	3.4	3.4
	Total	**18.2**	**13.7**	**10.7**	**9.0**	**9.0**	**8.3**	**8.5**	**8.8**	**8.4**	**8.9**	**9.0**
Sulphur dioxide (kt)	Energy Industries	68.2	39.7	28.3	14.9	2.1	2.3	3.0	3.1	2.7	2.6	2.4
	Industrial Combustion	19.7	17.4	5.0	4.2	4.5	4.0	3.8	4.4	4.8	4.2	3.1
	Transport Sources	4.6	4.0	2.4	2.7	1.2	1.1	1.1	1.0	0.8	0.6	0.7
	Fugitive	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
	Other	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Residential, Commercial & Public Sector Combustion	21.2	17.2	9.2	3.7	2.6	2.5	2.7	2.4	2.3	2.4	2.6
	Total	**114**	**78.5**	**45.0**	**25.7**	**10.5**	**10.0**	**10.7**	**10.9**	**10.7**	**9.9**	**8.9**
Lead (t)	Energy Industries	2.8	1.3	0.2	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.1
	Industrial Combustion	2.9	3.0	2.2	1.9	1.6	1.5	1.3	1.4	1.1	1.1	1.1
	Transport Sources	60.3	31.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Industrial Processes	0.8	0.8	0.7	0.6	0.4	0.4	0.4	0.3	0.4	0.4	0.3
	Waste	0.1	0.1	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

	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
	Residential, Commercial & Public Sector Combustion	3.7	2.0	1.1	0.4	0.5	0.5	0.5	0.5	0.4	0.4	0.5
	Total	**70.5**	**38.2**	**4.3**	**3.1**	**2.7**	**2.5**	**2.4**	**2.4**	**2.1**	**2.1**	**2.1**
PM2.5 (kt)	Agriculture	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Energy Industries	1.2	0.7	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Industrial Combustion	1.5	1.4	1.1	1.1	1.2	1.1	1.1	1.1	1.2	1.4	1.4
	Transport Sources	1.7	1.6	1.4	1.4	0.9	0.8	0.8	0.7	0.7	0.7	0.6
	Industrial Processes	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Solvent Processes	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1
	Waste	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Other	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Residential, Commercial & Public Sector Combustion	7.9	5.2	3.7	2.6	3.5	3.0	3.4	3.5	3.1	3.3	3.3
	Total	**13.5**	**10.0**	**7.6**	**6.3**	**6.6**	**5.9**	**6.2**	**6.3**	**5.9**	**6.3**	**6.3**

* 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 G Definition of NFR Codes and Sector categories

Table 19 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 19 - Definition of NFR Codes and Sector Categories

NFR Code	NFR Source Description	Sector Category	Sub-sector Category
1A1a	Public electricity and heat production	Energy Industries	Power generation
1A1b	Petroleum refining	Energy Industries	Refineries
1A1c	Manufacture of solid fuels and other energy industries	Energy Industries	Solid fuel manufacturing/coke ovens
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 industries
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	Industrial Combustion	Other industries
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	Industrial Combustion	Other industries
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 industries
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	Industrial Combustion	Other industries
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	Industrial Combustion	Other industries
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
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

NFR Code	NFR Source Description	Sector Category	Sub-sector Category
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, Commercial & Public Sector Combustion	Commercial & public sector
1A4bi	Residential: Stationary	Residential, Commercial & Public Sector Combustion	Residential
1A4bii	Residential: Household and gardening (mobile)	Residential, Commercial & Public Sector Combustion	Residential
1A4ci	Agriculture/Forestry/Fishing: Stationary	Residential, Commercial & Public Sector Combustion	Outdoor industries
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	Residential, Commercial & Public Sector Combustion	Outdoor industries
1A4ciii	Agriculture/Forestry/Fishing: National fishing	Residential, Commercial & Public Sector Combustion	Outdoor industries
1A5b	Other, Mobile (including military, land based and recreational boats)	Other	Other
1B1a	Fugitive emission from solid fuels: Coal mining and handling	Fugitive	Fugitive
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 industries
2A5a	Quarrying and mining of minerals other than coal	Industrial Processes	Other industries
2A5b	Construction and demolition	Industrial Processes	Other industries
2A6	Other mineral products (please specify in the IIR)	Industrial Processes	Other industries
2B10a	Chemical industry: Other (please specify in the IIR)	Industrial Processes	Other industries

NFR Code	NFR Source Description	Sector Category	Sub-sector Category
2B10b	Storage, handling and transport of chemical products (please specify in the IIR)	Industrial Processes	Other industries
2B2	Nitric acid production	Industrial Processes	Other industries
2B3	Adipic acid production	Industrial Processes	Other industries
2B6	Titanium dioxide production	Industrial Processes	Other industries
2B7	Soda ash production	Industrial Processes	Other industries
2C1	Iron and steel production	Industrial Processes	Iron and steel
2C3	Aluminium production	Industrial Processes	Other industries
2C5	Lead production	Industrial Processes	Other industries
2C6	Zinc production	Industrial Processes	Other industries
2C7a	Copper production	Industrial Processes	Other industries
2C7c	Other metal production (please specify in the IIR)	Industrial Processes	Other industries
2D3a	Domestic solvent use including fungicides	Solvent Processes	Domestic
2D3b	Road paving with asphalt	Solvent Processes	Industrial
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 solvent uses
2G	Other product use (specified in the IIR)	Industrial Processes	Other industries
2H1	Pulp and paper industry	Industrial Processes	Other industries
2H2	Food and beverages industry	Industrial Processes	Food and drink
2H3	Other industrial processes (please specify in the IIR)	Industrial Processes	Other industries
2I	Wood processing	Industrial Processes	Other industries
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

NFR Code	NFR Source Description	Sector Category	Sub-sector Category
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
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
3Da2b	Sewage sludge applied to soils	Agriculture	Manure applied to soils
3Da2c	Other organic fertilizers applied to soils (including compost)	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 agricultural practices
3De	Cultivated crops	Agriculture	Other agricultural practices
3F	Field burning of agricultural residues	Agriculture	Other agricultural practices
5A	Biological treatment of waste - Solid waste disposal on land	Waste	Waste
5B1	Biological treatment of waste - Composting	Waste	Waste
5B2	Anaerobic Digestion	Waste	Other waste practices
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
5D2	Industrial wastewater handling	Waste	Waste
5E	Anaerobic Digestion - emissions from land spreading of non-manure digestates	Waste	Other waste practices
6A	Other (included in national total for entire territory) (please specify in IIR)	Other	Other

Table 20 - Summary of the sector categories included in “Other” for each pollutant

Sector Category	NH_3	CO	NO_X	NMVOC	PM	SO_2	Pb
Agriculture	□	✓	□	□	□	✓	✓
Energy Industries	✓	□	□	✓	□	□	□
Fugitive	✓	□	✓	□	✓	□	✓
Industrial Combustion	✓	□	□	□	□	□	□
Industrial Processes	□	□	✓	□	□	□	□
Residential, Commercial & Public Sector Combustion	✓	□	□	□	□	□	□
Solvent Processes	✓	✓	✓	□	□	✓	✓
Waste	□	□	✓	□	□	✓	□
Other	□	□	□	□	□	□	□

Appendix H Additional data tables

Appendix G contains an array of additional data tables regarding road transport, specifying the split in emissions of all pollutants according to both vehicle class and fuel type. Different sources of non-exhaust vehicle emissions (emissions not relating to the combustion of fuel in the vehicle's engine) are also displayed according to vehicles class[9].

Table 21- Emissions for England, road transport, split by vehicle class and fuel type.

Pollutant	Vehicle Classification	Fuel type	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
Carbon monoxide (t)	Light duty vehicles	DERV	15,799	25,186	25,016	25,797	23,765	18,771	16,094	14,167	12,348	10,361
	Light duty vehicles	Petrol	571,334	406,479	190,544	55,257	17,767	11,557	9,538	7,691	6,491	5,276
	Passenger cars	DERV	8,042	17,432	17,406	12,660	10,644	9,556	9,128	8,750	9,126	9,666
	Passenger cars	Petrol	3,260,711	2,765,909	1,623,028	1,115,611	476,254	330,227	273,797	224,543	198,225	164,820
Ammonia (t)	Light duty vehicles	DERV	11.4	21.7	35.0	48.2	52.9	61.8	69.5	79.8	89.4	99.2
	Light duty vehicles	Petrol	45.2	69.5	242	196	137	102	87.5	75.8	64.4	54.9
	Passenger cars	DERV	11.9	34.7	54.1	89.9	129	177	201	225	248	273
	Passenger cars	Petrol	551	5,590	18,769	12,678	7,903	5,670	4,741	4,071	3,474	2,996
Nitrogen oxides (t)	Light duty vehicles	DERV	18,902	32,963	46,449	54,393	50,124	56,754	63,048	69,699	76,552	81,784
	Light duty vehicles	Petrol	71,939	51,071	24,572	6,397	1,486	840	645	508	394	311
	Passenger cars	DERV	8,198	24,591	39,813	70,091	83,792	92,373	96,193	99,022	100,734	103,228
	Passenger cars	Petrol	700,179	519,270	292,203	153,027	50,809	33,463	26,467	22,285	18,899	15,979
Lead (t)	Light duty vehicles	DERV	0.06	0.11	0.16	0.20	0.21	0.21	0.22	0.23	0.24	0.25
	Light duty vehicles	Petrol	176	66.3	0.06	0.02	0.01	0.01	0.01	0.01	0.01	0.01
	Passenger cars	DERV	0.04	0.12	0.17	0.27	0.35	0.40	0.41	0.42	0.44	0.47
	Passenger cars	Petrol	1,608	805	1.1	0.86	0.44	0.40	0.37	0.37	0.36	0.36

[9] Please note that estimates of diesel and petrol use in road transport are not considered official statistics. Country-specific energy balances are not available to reconcile against.

Pollutant	Vehicle Classification	Fuel type	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
PM_{10} (t)	Light duty vehicles	DERV	4,755	7,235	5,940	4,845	3,335	2,574	2,186	1,880	1,656	1,374
	Light duty vehicles	Petrol	92.6	59.5	22.7	8.7	4.2	3.5	3.4	3.5	3.6	3.7
	Passenger cars	DERV	3,167	5,862	5,076	4,575	4,095	3,316	2,991	2,597	2,399	2,118
	Passenger cars	Petrol	1,587	1,131	643	423	266	236	224	224	224	226
$PM_{2.5}$ (t)	Light duty vehicles	DERV	4,755	7,235	5,940	4,845	3,335	2,574	2,186	1,880	1,656	1,374
	Light duty vehicles	Petrol	92.6	59.5	22.7	8.7	4.2	3.5	3.4	3.5	3.6	3.7
	Passenger cars	DERV	3,167	5,862	5,076	4,575	4,095	3,316	2,991	2,597	2,399	2,118
	Passenger cars	Petrol	1,587	1,131	643	423	266	236	224	224	224	226
Sulphur dioxide (t)	Light duty vehicles	DERV	4,330	5,399	239	236	58.9	59.8	58.2	60.3	66.2	73.9
	Light duty vehicles	Petrol	1,834	1,002	182	25.6	3.1	2.5	1.9	1.8	1.9	2.0
	Passenger cars	DERV	3,080	5,805	261	323	100	111	110	112	122	136
	Passenger cars	Petrol	16,755	12,168	3,676	952	138	118	89.8	89.6	95.8	106
NMVOC (t)	Light duty vehicles	DERV	1,712	3,183	4,737	5,075	3,397	2,817	2,619	2,482	2,453	2,320
	Light duty vehicles	Petrol	41,097	28,111	12,675	3,163	665	342	255	193	150	118
	Passenger cars	DERV	1,654	2,972	3,065	2,936	2,347	2,188	2,131	2,001	2,004	1,992
	Passenger cars	Petrol	428,832	339,871	183,457	96,372	30,160	18,385	14,153	11,203	9,414	7,726

Table 22 - Emissions for Scotland, road transport, split by vehicle class and fuel type.

Pollutant	Vehicle Classification	Fuel type	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
Carbon monoxide (t)	Light duty vehicles	DERV	1,557	2,479	2,502	2,585	2,520	2,002	1,724	1,519	1,331	1,125

Pollutant	Vehicle Classification	Fuel type	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
	Light duty vehicles	Petrol	52,171	37,045	17,719	5,142	1,709	1,115	920	745	635	524
	Passenger cars	DERV	872	1,864	1,726	1,185	1,020	906	872	844	889	951
	Passenger cars	Petrol	294,406	246,604	144,748	104,345	45,767	32,163	26,687	21,714	19,007	15,788
Ammonia (t)	Light duty vehicles	DERV	1.2	2.3	3.7	5.1	5.9	6.9	7.8	8.9	10.0	11.2
	Light duty vehicles	Petrol	4.7	7.6	27.3	21.5	15.7	11.5	9.9	8.6	7.3	6.1
	Passenger cars	DERV	1.4	4.1	6.1	9.6	14.2	19.2	21.9	24.7	27.1	29.8
	Passenger cars	Petrol	55.4	590	1,916	1,306	805	580	482	408	342	294
Nitrogen oxides (t)	Light duty vehicles	DERV	1,734	3,071	4,572	5,472	5,331	6,028	6,706	7,435	8,208	8,832
	Light duty vehicles	Petrol	7,373	5,227	2,564	667	162	90.9	69.8	54.8	42.7	33.9
	Passenger cars	DERV	871	2,661	4,112	7,081	8,677	9,531	9,969	10,311	10,481	10,750
	Passenger cars	Petrol	69,647	50,714	28,120	15,080	5,003	3,299	2,597	2,159	1,812	1,525
Lead (t)	Light duty vehicles	DERV	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
	Light duty vehicles	Petrol	16.8	6.3	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Passenger cars	DERV	0.00	0.01	0.02	0.03	0.04	0.04	0.04	0.04	0.05	0.05
	Passenger cars	Petrol	153	75.2	0.10	0.08	0.04	0.04	0.04	0.04	0.03	0.03
PM_{10} (t)	Light duty vehicles	DERV	479	728	605	492	359	278	238	204	181	151
	Light duty vehicles	Petrol	8.7	5.6	2.2	0.85	0.43	0.36	0.36	0.37	0.39	0.41
	Passenger cars	DERV	344	645	528	460	427	343	311	272	251	222
	Passenger cars	Petrol	146	102	57.8	39.3	25.0	22.5	21.4	21.3	21.2	21.3
$PM_{2.5}$ (t)	Light duty vehicles	DERV	479	728	605	492	359	278	238	204	181	151
	Light duty vehicles	Petrol	8.7	5.6	2.2	0.85	0.43	0.36	0.36	0.37	0.39	0.41
	Passenger cars	DERV	344	645	528	460	427	343	311	272	251	222

Pollutant	Vehicle Classification	Fuel type	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
	Passenger cars	Petrol	146	102	57.8	39.3	25.0	22.5	21.4	21.3	21.2	21.3
Sulphur dioxide (t)	Light duty vehicles	DERV	424	529	23.9	23.7	6.3	6.4	6.2	6.4	7.1	8.0
	Light duty vehicles	Petrol	175	95.9	17.9	2.5	0.33	0.26	0.19	0.19	0.19	0.21
	Passenger cars	DERV	335	645	27.5	32.8	10.5	11.6	11.4	11.8	12.8	14.2
	Passenger cars	Petrol	1,591	1,137	340	90.9	13.3	11.5	8.7	8.6	9.1	10.0
NMVOC (t)	Light duty vehicles	DERV	165	308	472	512	360	298	278	264	263	252
	Light duty vehicles	Petrol	3,543	2,423	1,128	288	63.0	32.4	24.1	18.3	14.3	11.5
	Passenger cars	DERV	177	315	304	279	233	216	212	201	202	201
	Passenger cars	Petrol	38,985	30,426	16,322	8,873	2,831	1,739	1,338	1,052	878	719

Table 23 - Emissions for Wales, road transport, split by vehicle class and fuel type.

Pollutant	Vehicle Classification	Fuel type	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
Carbon monoxide (t)	Light duty vehicles	DERV	1,008	1,612	1,599	1,657	1,569	1,237	1,070	942	829	695
	Light duty vehicles	Petrol	33,106	23,602	11,143	3,216	1,037	670	552	445	381	313
	Passenger cars	DERV	535	1,170	1,266	850	684	607	581	563	595	635
	Passenger cars	Petrol	188,524	157,724	89,269	64,046	27,919	19,314	16,129	13,311	11,731	9,700
Ammonia (t)	Light duty vehicles	DERV	0.78	1.5	2.4	3.3	3.8	4.4	4.9	5.6	6.3	7.0
	Light duty vehicles	Petrol	3.1	5.0	17.8	14.2	10.0	7.2	6.2	5.3	4.5	3.8
	Passenger cars	DERV	0.87	2.6	4.4	6.9	9.6	12.8	14.6	16.6	18.3	20.1
	Passenger cars	Petrol	35.4	381	1,201	811	495	347	290	249	209	178
Nitrogen oxides (t)	Light duty vehicles	DERV	1,103	1,970	2,907	3,509	3,342	3,732	4,146	4,579	5,073	5,422
	Light duty vehicles	Petrol	4,818	3,428	1,651	433	102	56.8	43.6	34.1	26.6	21.0
	Passenger cars	DERV	530	1,658	2,993	5,062	5,822	6,298	6,570	6,849	6,996	7,164
	Passenger cars	Petrol	44,365	32,286	17,337	9,302	3,078	2,003	1,586	1,336	1,128	948
Lead (t)	Light duty vehicles	DERV	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
	Light duty vehicles	Petrol	10.8	4.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Passenger cars	DERV	0.00	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.03
	Passenger cars	Petrol	97.6	48.0	0.06	0.05	0.03	0.02	0.02	0.02	0.02	0.02
PM_{10} (t)	Light duty vehicles	DERV	312	476	388	317	224	172	148	127	113	93.5
	Light duty vehicles	Petrol	5.5	3.6	1.4	0.54	0.27	0.22	0.22	0.23	0.24	0.25
	Passenger cars	DERV	209	400	384	328	287	228	207	182	169	150
	Passenger cars	Petrol	93.3	65.4	35.6	24.1	15.2	13.5	12.9	13.0	13.1	13.2
$PM_{2.5}$ (t)	Light duty vehicles	DERV	312	476	388	317	224	172	148	127	113	93.5

Pollutant	Vehicle Classification	Fuel type	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
	Light duty vehicles	Petrol	5.5	3.6	1.4	0.54	0.27	0.22	0.22	0.23	0.24	0.25
	Passenger cars	DERV	209	400	384	328	287	228	207	182	169	150
	Passenger cars	Petrol	93.3	65.4	35.6	24.1	15.2	13.5	12.9	13.0	13.1	13.2
Sulphur dioxide (t)	Light duty vehicles	DERV	274	343	15.2	15.2	3.9	3.9	3.9	4.0	4.4	4.9
	Light duty vehicles	Petrol	113	62.0	11.3	1.6	0.20	0.16	0.12	0.12	0.12	0.13
	Passenger cars	DERV	204	402	20.0	23.5	7.1	7.7	7.6	7.8	8.5	9.5
	Passenger cars	Petrol	1,016	726	210	56.0	8.2	6.9	5.3	5.3	5.7	6.2
NMVOC (t)	Light duty vehicles	DERV	107	200	300	328	227	187	175	166	165	157
	Light duty vehicles	Petrol	2,220	1,527	696	178	38.6	19.8	14.8	11.2	8.7	6.9
	Passenger cars	DERV	109	198	223	200	157	144	141	134	136	136
	Passenger cars	Petrol	24,980	19,486	10,091	5,460	1,731	1,054	815	648	545	446

Table 24 - Emissions for Northern Ireland, road transport, split by vehicle class and fuel type.

Pollutant	Vehicle Classification	Fuel type	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
Carbon monoxide (t)	Light duty vehicles	DERV	641	601	432	454	461	354	319	269	237	199
	Light duty vehicles	Petrol	456	510	492	281	129	84.7	78.1	46.4	38.2	32.0
	Passenger cars	DERV	309	967	1,240	843	654	546	510	491	514	541
	Passenger cars	Petrol	116,602	103,016	62,887	45,204	21,744	15,368	13,705	10,683	9,498	7,910
Ammonia (t)	Light duty vehicles	DERV	0.49	0.54	0.64	0.93	1.1	1.3	1.5	1.6	1.8	2.0
	Light duty vehicles	Petrol	0.04	0.10	0.74	1.2	1.2	0.89	0.82	0.52	0.42	0.36
	Passenger cars	DERV	0.52	2.2	4.5	7.1	9.4	11.7	13.0	14.4	15.7	17.1
	Passenger cars	Petrol	23.1	262	875	576	374	268	240	196	168	145
Nitrogen oxides (t)	Light duty vehicles	DERV	696	736	791	970	982	1,052	1,207	1,271	1,400	1,498
	Light duty vehicles	Petrol	62.6	68.7	67.4	35.7	12.5	7.2	6.0	3.5	2.6	2.1
	Passenger cars	DERV	304	1,376	2,940	5,036	5,526	5,569	5,658	5,796	5,868	5,960
	Passenger cars	Petrol	28,400	21,707	12,331	6,477	2,283	1,505	1,265	1,006	851	719
Lead (t)	Light duty vehicles	DERV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Light duty vehicles	Petrol	0.14	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Passenger cars	DERV	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03
	Passenger cars	Petrol	59.8	30.8	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.02
PM_{10} (t)	Light duty vehicles	DERV	200	178	105	86.9	66.2	49.5	44.1	36.1	32.1	26.6
	Light duty vehicles	Petrol	0.07	0.08	0.06	0.05	0.03	0.03	0.03	0.02	0.02	0.02
	Passenger cars	DERV	122	341	388	336	285	211	186	161	149	130
	Passenger cars	Petrol	55.7	40.7	23.6	15.6	10.6	9.7	9.9	9.5	9.6	9.8
$PM_{2.5}$ (t)	Light duty vehicles	DERV	200	178	105	86.9	66.2	49.5	44.1	36.1	32.1	26.6

Pollutant	Vehicle Classification	Fuel type	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
	Light duty vehicles	Petrol	0.07	0.08	0.06	0.05	0.03	0.03	0.03	0.02	0.02	0.02
	Passenger cars	DERV	122	341	388	336	285	211	186	161	149	130
	Passenger cars	Petrol	55.7	40.7	23.6	15.6	10.6	9.7	9.9	9.5	9.6	9.8
Sulphur dioxide (t)	Light duty vehicles	DERV	170	125	4.1	4.1	1.1	1.1	1.1	1.1	1.2	1.4
	Light duty vehicles	Petrol	1.5	1.3	0.48	0.14	0.02	0.02	0.02	0.01	0.01	0.01
	Passenger cars	DERV	115	330	19.5	23.3	6.7	6.8	6.5	6.6	7.1	7.9
	Passenger cars	Petrol	624	465	142	37.1	5.8	5.0	4.1	3.9	4.2	4.6
NMVOC (t)	Light duty vehicles	DERV	69.7	77.2	86.0	95.8	70.1	55.7	54.7	49.2	49.0	46.7
	Light duty vehicles	Petrol	31.6	35.0	33.3	16.5	5.0	2.6	2.2	1.2	0.92	0.74
	Passenger cars	DERV	62.6	164	223	204	154	133	127	119	120	119
	Passenger cars	Petrol	15,332	12,573	6,979	3,722	1,289	799	658	492	414	340

Table 25 – Non-exhaust $PM_{2.5}$ emissions for England from road vehicles (tonnes)

Emission Source	Vehicle classification	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
Brake Wear	Cars	879	916	961	978	945	945	939	957	963	983
	LGVs	161	174	199	233	246	245	251	265	274	285
	HGV	223	212	227	230	200	190	190	195	200	197
	Buses and coaches	59.1	67.2	70.1	71.3	69.6	60.6	62.1	62.1	59.2	54.6
	Motorcycles/moped	9.1	5.7	6.8	8.2	7.0	6.8	6.3	6.5	6.6	6.8
Road abrasion	Cars	1,186	1,240	1,330	1,383	1,356	1,359	1,356	1,384	1,400	1,427
	LGVs	140	157	183	217	230	232	239	252	263	275
	HGV	440	450	502	513	464	440	444	458	476	475
	Buses and coaches	78.3	83.4	87.5	86.6	84.4	73.0	74.9	74.9	71.4	65.9
	Motorcycles/moped	8.1	5.4	6.6	7.7	6.5	6.5	6.1	6.3	6.3	6.4
Tyre wear	Cars	1,541	1,611	1,717	1,775	1,732	1,735	1,729	1,764	1,782	1,817
	LGVs	287	317	369	435	461	463	476	504	524	547
	HGV	373	393	445	461	419	405	410	422	439	440
	Buses and coaches	51.5	56.2	58.7	58.4	56.9	49.4	50.6	50.6	48.3	44.5
	Motorcycles/moped	12.3	8.0	9.6	11.4	9.7	9.5	9.0	9.3	9.3	9.5

Table 26 – Non-exhaust $PM_{2.5}$ emissions for Scotland from road vehicles (tonnes)

Emission Source	Vehicle classification	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
Brake Wear	Cars	82.1	85.8	89.7	94.1	93.4	93.2	92.9	94.5	95.0	96.6
	LGVs	15.2	16.5	19.5	23.2	25.4	25.2	25.7	27.1	28.3	29.9
	HGV	24.8	23.8	24.8	26.7	25.3	23.6	23.7	23.6	23.9	23.8
	Buses and coaches	8.2	8.9	9.4	9.4	10.0	8.8	9.1	9.2	8.9	8.3
	Motorcycles/moped	0.4	0.3	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4
Road abrasion	Cars	116	122	129	138	138	139	139	141	142	145
	LGVs	14.1	15.7	18.8	22.4	25.0	25.1	25.9	27.4	28.6	30.2
	HGV	45.8	46.1	49.9	54.1	52.3	50.6	51.0	50.7	51.3	51.6
	Buses and coaches	11.3	11.6	12.3	12.0	13.3	12.0	12.4	12.5	12.1	11.2
	Motorcycles/moped	0.5	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Tyre wear	Cars	149	155	164	174	174	175	175	178	179	183
	LGVs	28.2	31.2	37.3	44.4	49.3	49.3	50.8	53.6	56.0	59.1
	HGV	39.7	40.8	44.1	47.1	45.8	44.4	44.8	44.7	45.5	45.8
	Buses and coaches	7.3	7.7	8.1	8.0	8.7	7.8	8.0	8.1	7.8	7.3
	Motorcycles/moped	0.6	0.5	0.6	0.7	0.6	0.6	0.6	0.7	0.6	0.6

Table 27 – Non-exhaust $PM_{2.5}$ emissions for Wales from road vehicles (tonnes)

Emission Source	Vehicle classification	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
Brake Wear	Cars	82.1	85.8	89.7	94.1	93.4	93.2	92.9	94.5	95.0	96.6
	LGVs	15.2	16.5	19.5	23.2	25.4	25.2	25.7	27.1	28.3	29.9
	HGV	24.8	23.8	24.8	26.7	25.3	23.6	23.7	23.6	23.9	23.8
	Buses and coaches	8.2	8.9	9.4	9.4	10.0	8.8	9.1	9.2	8.9	8.3
	Motorcycles/moped	0.4	0.3	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4
Road abrasion	Cars	116	122	129	138	138	139	139	141	142	145
	LGVs	14.1	15.7	18.8	22.4	25.0	25.1	25.9	27.4	28.6	30.2
	HGV	45.8	46.1	49.9	54.1	52.3	50.6	51.0	50.7	51.3	51.6
	Buses and coaches	11.3	11.6	12.3	12.0	13.3	12.0	12.4	12.5	12.1	11.2
	Motorcycles/moped	0.5	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Tyre wear	Cars	149	155	164	174	174	175	175	178	179	183
	LGVs	28.2	31.2	37.3	44.4	49.3	49.3	50.8	53.6	56.0	59.1
	HGV	39.7	40.8	44.1	47.1	45.8	44.4	44.8	44.7	45.5	45.8
	Buses and coaches	7.3	7.7	8.1	8.0	8.7	7.8	8.0	8.1	7.8	7.3
	Motorcycles/moped	0.6	0.5	0.6	0.7	0.6	0.6	0.6	0.7	0.6	0.6

Table 28 - Non-exhaust $PM_{2.5}$ emissions for Northern Ireland from road vehicles (tonnes)

Emission Source	Vehicle classification	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016
Brake Wear	Cars	31.2	35.4	42.0	46.0	48.0	47.5	48.6	48.3	48.8	49.8
	LGVs	2.2	2.5	3.0	4.1	4.8	4.6	5.0	5.0	5.2	5.5
	HGV	6.9	7.7	9.4	13.0	11.8	10.6	10.2	10.1	10.4	10.3
	Buses and coaches	1.1	1.3	1.6	1.3	1.4	1.7	1.5	1.5	1.4	1.3
	Motorcycles/moped	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Road abrasion	Cars	46.2	52.4	62.2	69.0	72.3	71.0	72.9	72.7	73.6	75.2
	LGVs	2.0	2.2	2.7	3.8	4.5	4.4	4.7	4.8	5.0	5.2
	HGV	11.3	12.6	15.4	21.2	20.3	18.4	17.8	17.7	18.2	18.2
	Buses and coaches	1.4	1.6	2.0	1.8	2.0	2.4	2.3	2.3	2.2	2.0
	Motorcycles/moped	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Tyre wear	Cars	58.2	65.9	78.3	86.5	90.6	89.1	91.4	91.1	92.2	94.1
	LGVs	4.0	4.5	5.4	7.6	9.0	8.7	9.4	9.4	9.9	10.3
	HGV	9.9	11.1	13.7	19.7	18.0	16.2	15.6	15.5	16.0	16.1
	Buses and coaches	0.9	1.1	1.3	1.2	1.3	1.5	1.4	1.4	1.3	1.2
	Motorcycles/moped	0.1	0.1	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.2