National Atmospheric Emissions Inventory

Air Pollutant Inventories for England, Scotland, Wales, and Northern Ireland: 2005-2019

Prepared by Aether Ltd 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.

Department for Environment Food & Rural Affairs

Department for Business, Energy & Industrial Strategy

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Glossary

AQEG	Air Quality Expert Group
NH_3	Ammonia
B[a]p	Benzo[a]pyrene
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
Hg	Mercury
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
PAHs	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCDD/Fs	Dioxins and furans [polychlorobenzodioxins (PCDDs) and polychlorodibenzofurans (PCDFs)]
PCP	Pentachlorophenol
PI	Pollution Inventory
$PM_{2.5}$	Particulate matter less than 2.5 micrometres
PM_{10}	Particulate matter less than 10 micrometres
POPs	Persistent Organic Pollutants
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

1 Introduction

This report presents air pollutant emissions inventories for England, Scotland, Wales, and Northern Ireland (collectively England and the Devolved Administrations), for the period 2005 to 2019 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 Aether, Ricardo Energy & Environment, Rothamsted Research, and the UK Centre for Ecology & Hydrology (UKCEH).

In addition to the above suite of air pollutants, for which source data and inventory methods are well-established, experimental inventory statistics are presented in **Appendix C** for emissions of (i) dioxins and furans (PCDD/Fs), (ii) benzo[a]pyrene (B[a]p), and (iii) mercury (Hg). These are priority toxic pollutants, for which emission estimates are within the scope of UK inventory submissions under the Convention on Long-Range Transboundary Air Pollution (CLRTAP). The inventories for B[a]p and PCDD/Fs were presented for the first time in the 1990-2017 inventory. The data quality at the sub-national level is such that the PCDD/F and B[a]p inventory data continue to be regarded as experimental statistics at this stage. The inventory for Hg is presented for the first time in this inventory. Similarly, the data quality at the sub-national level means that these emissions estimates should be regarded as experimental statistics only. Further work is be needed to improve the quality of DA estimates across the time series; see **Appendix C** for further details.

1.1 Background to Inventory Development

The development of air pollutant inventories (API) for England and 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. These objectives also contribute to the UK's meeting both national and international targets on both local and transboundary air pollution. Defra's Clean Air Strategy 2019 sets out how the UK intends to reduce pollutant emissions, make our air healthier to breathe, protect nature, and boost the economy. The strategy is available here: https://www.gov.uk/government/publications/clean-air-strategy-2019.

Provision of DA-level datasets and subsequent identification of key sources at more regional and local levels is crucial for the prioritisation of local action and to highlight the potential impacts of specific policies and measures. The time series of air pollutant emissions provides an insight into the effects of environmental policies and may help 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 air pollutants for which DA inventories are calculated is 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 a key 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 the transport of the pollutants can vary greatly. As a result, NH_3 emissions can both exert impacts on a highly localised level and contribute to the effects of long-range pollutant transport. Agriculture is the most important source of NH_3 within the UK, contributing to the majority of emissions across the time series. Emission estimates for non-agricultural sources are often 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. CO 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 the 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)** emissions arise primarily from combustion sources. Estimating these emissions is complex since the nitrogen can be derived either from the nitrogen contained within fuels or through the oxidation of atmospheric nitrogen at the high temperatures associated with combustion engines. The emissions rate depends on combustion conditions, particularly temperature and the relative proportions of air-fuel in a combustion chamber, which can vary considerably. Thus, combustion conditions, engine load, and state of engine maintenance are important. Studies into the effects of exposure on human health suggest NO_X exacerbates 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, 2018).
- **Non-Methane Volatile Organic Compounds (NMVOCs)** are emitted to air from various sources 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 solvent or chemical use. The *Solvent and Other Product Use* sector comprises industrial and domestic solvent applications (such as cleaning, degreasing) and the manufacturing and processing of chemical products. NMVOCs are involved in the photochemical production of ozone and the formation of secondary aerosols in the atmosphere over a large spatial scale. However, the exact reactivity is dependent on the particular compound in question. Some NMVOCs also directly impact human health: benzenes and 1,3-butadiene are both carcinogens, for example.
- **Particulate matter** is a general term describing the size distribution of the solid and liquid particles emitted to air. Particulate matter is categorised into different size fractions: **PM_{10}** refers to particles with an aerodynamic diameter of fewer than 10 micrometres, whilst **$PM_{2.5}$** refers to particles with an aerodynamic diameter of fewer than 2.5 micrometres. In general, particulate matter in the atmosphere arises from primary and secondary sources. Primary sources are direct emissions of particulate matter into the atmosphere. They arise from a wide range of sources such as fuel combustion 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 fine particulate matter ($PM_{2.5}$) in the United Kingdom (AQEG, 2012).
- **Sulphur dioxide (SO_2)** emissions commonly arise from combustion. They can be calculated from the sulphur content of the fuel and information on the amount of sulphur retained in the ash. Inventory estimates are produced using UK energy statistics, information on the sulphur content of liquid fuels, and data on the sulphur content of coal from coal suppliers. SO_2 has long been recognised as a pollutant because of its role, along with particulate matter, in winter-time smog formation and the creation of acid rain. Studies indicate that SO_2 causes nerve stimulation in the lining of the nose and throat. This can cause irritation, coughing and a feeling of chest tightness, which may cause the airways to narrow. People who have asthma are considered to be particularly sensitive to SO_2 concentrations.
- **Lead (Pb)** is a very toxic element and can cause various symptoms at low concentrations. Lead dust or fumes can irritate the eyes on contact and irritate the nose and throat on inhalation. Acute exposure can lead to loss of appetite, weight loss, stomach upsets, nausea and muscle cramps. High levels of acute exposure may also cause brain and kidney damage. Chronic exposure can affect the blood, kidneys, central nervous system and vitamin D metabolism. 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 due to the increased use of cars fitted with three-way catalytic converters that are incompatible with leaded petrol due to catalyst poisoning. Leaded petrol was then phased out from general sale at the end of 1999. These changes have caused a significant decline in total lead emissions across the UK between 1990 and 2000. UK-wide Pb emissions now primarily originate from combustion sources (mainly of solid fuels, biomass, and lubricants in industrial and residential sectors, and metal production processes at foundries and iron and steelworks).

1.3 Data Sources and Inventory Methodology

The England and Devolved Administrations' inventories are compiled by disaggregating the UK emission totals presented within the 'UK Informative Inventory Report (1990 to 2019)' (Churchill, et al., 2021), derived from the National Atmospheric Emissions Inventory (NAEI). The emission estimates for each pollutant are presented in this report 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, 2019). These are known as 'bottom-up' and 'top-down' approaches, respectively.

The method for disaggregating UK emission totals across England and 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;
- Data on vehicle kilometres travelled;
- Domestic and international flight data from each major UK airport;
- Regional housing, employment, population, and economic 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 2019, this 'unallocated' proportion of the UK inventory total was 6% of the UK total for NMVOCs and NO_X, 2% for CO, and 1% for SO_2, PM_{10}, and $PM_{2.5}$. The 'unallocated' proportion of the UK inventory was zero or negligible for the remaining pollutants. For this reason, the sum of the DA total emissions for these pollutants do 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

Uncertainties in the UK inventory are associated with the availability and quality of activity data, emission factors, and the methodologies used in emissions calculations throughout the time series. These uncertainties are quantified using a Tier 1 uncertainty aggregation (or error propagation) method, or 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. The Tier 1 methodology and the Monte-Carlo analysis result for the UK air pollutant inventory are presented in Chapter 1.7 of the 'UK Informative Inventory Report (1990 to 2019)' (Churchill, et al., 2021).

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[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.

The air pollutant inventories for England and the Devolved Administrations are derived by disaggregating UK emissions across the four countries and the unallocated region, and so the UK-wide uncertainty is compounded by further uncertainty introduced by the methods developed to split emissions on a source-activity scale. The uncertainties associated with the DA air pollutant inventories are quantified using a Tier 1 uncertainty aggregation approach, described in **Appendix E** and summarised 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 methodologies, particularly for key sources, and a continuous improvement process.

Further commentary on the levels of uncertainty in data used to estimate the emission inventories of B[a]p, PCDD/Fs, and Hg is included in **Appendix C.3.2**.

Table 1 – Total Tier 1 uncertainty values by pollutant split by region[2]

	Emissions			Estimated uncertainty		
Pollutant	**2005 (t)**	**2019 (t)**	**Trend (%)**	**2005 (t)**	**2019 (t)**	**Trend (%)**
England						
PM_{10}	163	135	-17%	38%	51%	11%
$PM_{2.5}$	99.3	84.7	-15%	26%	61%	17%
SO_2	606	121	-80%	8.7%	30%	1.4%
NO_X	1317	615	-53%	6.8%	9.2%	2.4%
NMVOCs	851	535	-37%	13%	22%	9.5%
NH_3	183	183	0%	49%	54%	11%
Pb	0.12	0.07	-41%	50%	74%	5.6%
Scotland						
PM_{10}	20.3	14.2	-30%	34%	50%	24%
$PM_{2.5}$	12.8	8.56	-33%	25%	60%	36%
SO_2	90.4	13.8	-85%	10%	24%	2.9%
NO_X	181	84.5	-53%	12%	14%	7.7%
NMVOCs	174	148	-15%	16%	19%	16%
NH_3	33.8	31.3	-7.5%	54%	53%	25%
Pb	0.01	0.01	-37%	59%	85%	24%
Wales						
PM_{10}	14.6	11.8	-20%	35%	56%	37%
$PM_{2.5}$	9.95	8.38	-16%	35%	71%	52%
SO_2	65.4	17.3	-74%	12%	18%	3.6%
NO_X	112	52.9	-53%	14%	15%	7.7%
NMVOCs	62.8	44	-30%	26%	45%	32%
NH_3	22.3	23.1	3.7%	66%	68%	41%

[2] Note that CO emissions are not quantified in the UK air pollutant inventory, and as such, no Tier 1 approach is presented in the DA air pollutant inventories.

Pollutant	Emissions			Estimated uncertainty		
	2005 (t)	2019 (t)	Trend (%)	2005 (t)	2019 (t)	Trend (%)
Pb	0.02	0.01	-42%	75%	76%	8.4%
Northern Ireland						
PM_{10}	8.73	8.65	-0.9%	54%	81%	58%
$PM_{2.5}$	6.17	6.3	2.1%	48%	86%	79%
SO_2	28.3	8.87	-69%	18%	38%	8.6%
NO_X	63.1	35	-45%	19%	20%	12%
NMVOCs	39.3	34.9	-11%	42%	58%	42%
NH_3	30.3	32.8	8.1%	63%	62%	33%
Pb	0.004	0.003	-16%	73%	74%	44%

2 Devolved Administrations’ Air Pollutant Estimates

The following sections outline the emissions inventories for England and each Devolved Administration, providing information on the trends and emission estimates for each of the eight air pollutants.

These sections include the following:

- **Figures presenting the inventory data**, showing the annual trend from 2005 to 2019 for each pollutant. These graphs are also disaggregated by sector, and further information on the categorisation used in these summaries relative to NFR code can be found in **Appendix G**.
- **Summary information on trends** is provided for each pollutant, highlighting the key reasons for the observed trend since 2005 and other notable aspects. This information is not guided by detailed statistical analyses but through the association of underlying trends in activity data with the visible trends in emissions.
- **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 2005 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 spatial patterns associated with that pollutant. For example, NO_X emissions are concentrated around the road networks of the countries.
- **Sectoral 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.

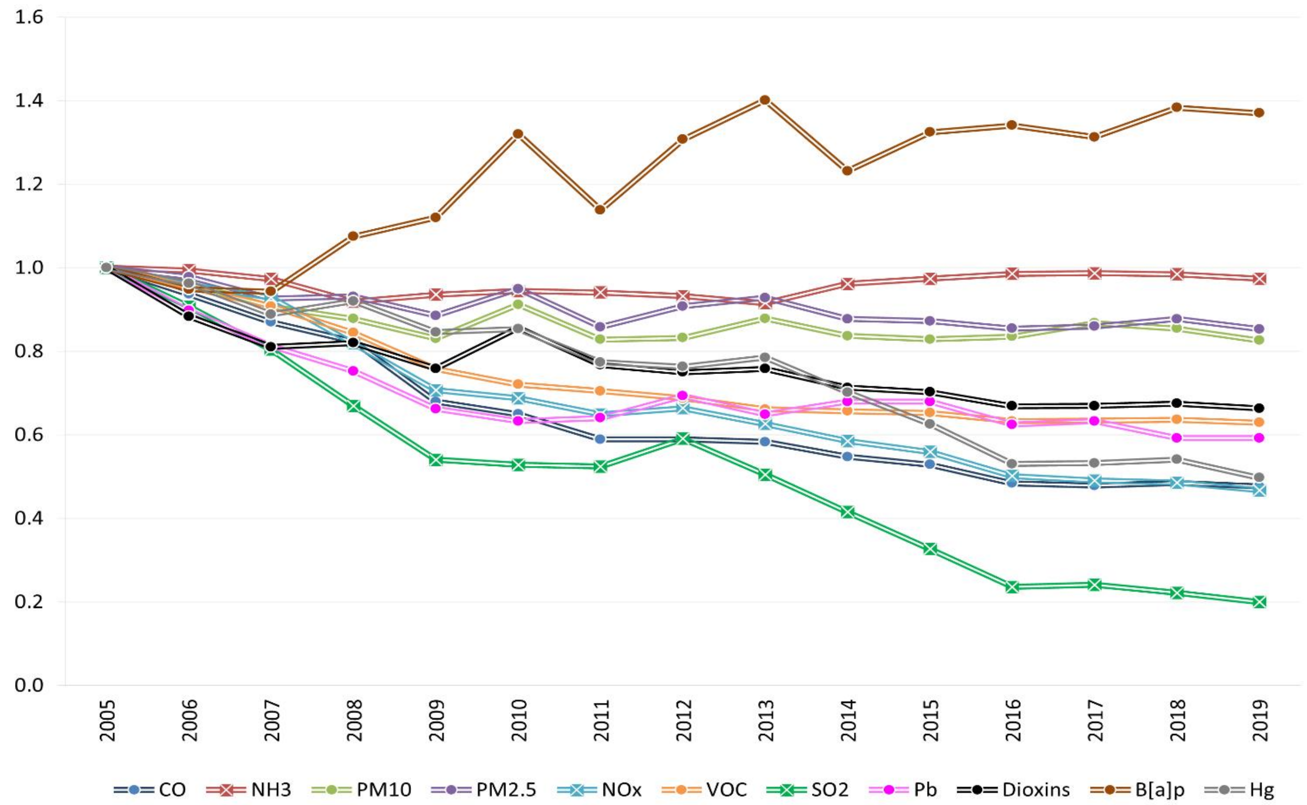
2.1 England

The following section summarises emissions in England for the eight priority air pollutants: NH_3, CO, NO_X, NMVOCs, PM_{10}, $PM_{2.5}$, SO_2, and Pb. Information is also presented for emissions of PCDD/Fs ,B[a]p, and Hg, with more detailed information for these three pollutants presented in **Appendix C.2**. Emissions of PCDD/Fs, B[a]p, and Hg should be considered as experimental statistics only[3]. **Appendix F** presents the DA inventory data summary tables, whilst **Appendix G** presents source category mapping used in the report**.**

Figure 1 shows emissions of all eleven air pollutants normalised against the 2005 baseline to illustrate the relative trends since then. This graph shows that most pollutant levels are lower in 2019 than they were in 2005. The greatest rate of decline is observed in the trend for SO_2 emissions principally due to the reduction in coal use within the economy, with more modest declines observable for CO, NO_X, Hg, Pb, VOCs, and dioxins.

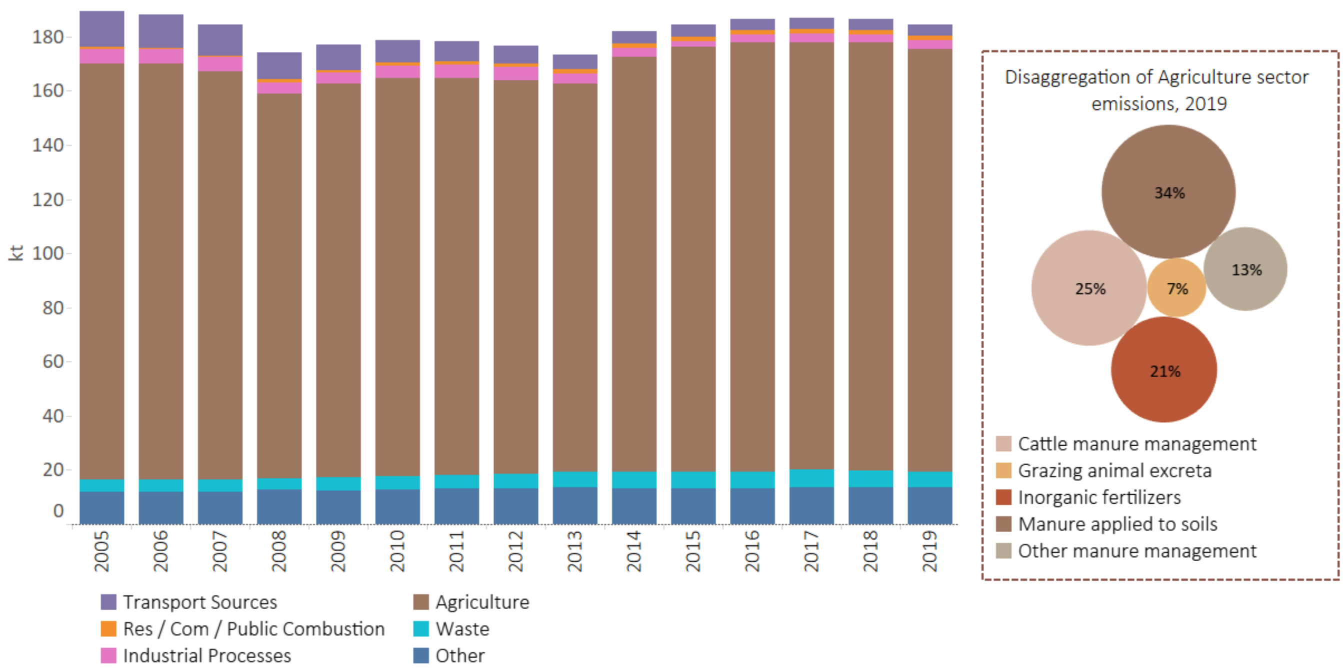
By contrast, NH_3 emissions have declined at a slower rate than other pollutants and have even risen in recent years due to increases in activity from several sources; urea-based fertiliser application; increases in housed cattle numbers and subsequent manure spreading on soils; and increases in digestate and other organic fertilisers which are applied to soils. Emissions from B[a]p have increased over the time series, a trend principally dictated by increases in wood combustion in residential settings.

Figure 1 – England normalised trends for all pollutants



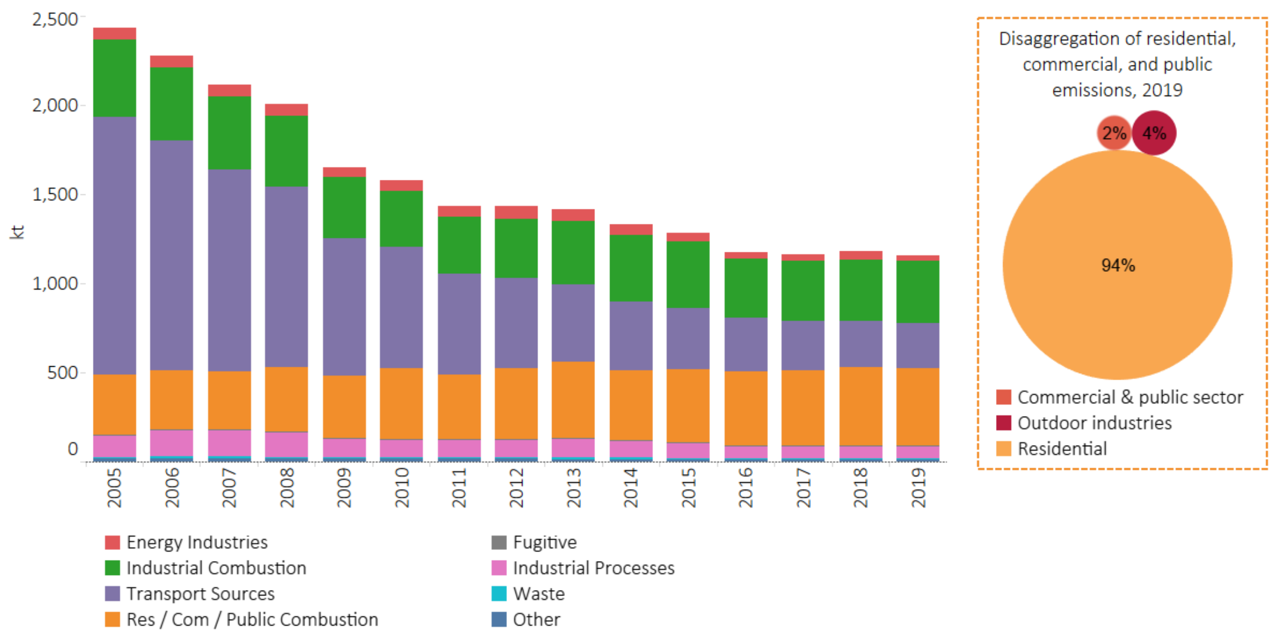
[3] The statistics are considered experimental as they have been recently developed: the benzo[a]pyrene and dioxin inventories were first developed for the 1990-2017 inventory published in 2019, whilst the mercury inventory is presented for the first time in this publication. While the inventories and trends have been interrogated and to ensure the suitability of methods for the most important sources, it is recognised that data quality on a subnational level is generally poor. As a result, these statistics are currently considered experimental only, and require further work to evaluate the methods used, to identify alternative methods that are more suitable, and to reduce the uncertainty in the early part of the time series. More information on the inventory methods used for b[a]p, dioxins, and mercury is found in **Appendix C**.

Figure 2 – Ammonia Emissions in England



Emissions of **ammonia** in England were estimated to be 184kt in 2019 and have declined by 2.7% since 2005. Emissions in England account for 68% of the UK total in 2019. Agricultural sources make up by far the largest contribution to ammonia emissions in the inventory throughout the time series. In 2019, emissions from cattle manure management (NFR 3B1a, 3B1b) and animal manure applied to soils (NFR 3Da2a) each account for 22% and 20% of total emissions in England, respectively, whilst inorganic fertilisers (NFR 3Da1) account for a further 17%. The initial trends in NH_3 emissions were primarily driven by decreases in livestock numbers (except for poultry) and declines in the use of nitrogen-based fertilisers until 2010. After this point, the declines associated with these sources levelled out and even began to increase slightly. The increase in emissions since 2013 is primarily a result of increased application of urea-based and organic fertilisers such as digestate to agricultural soils.

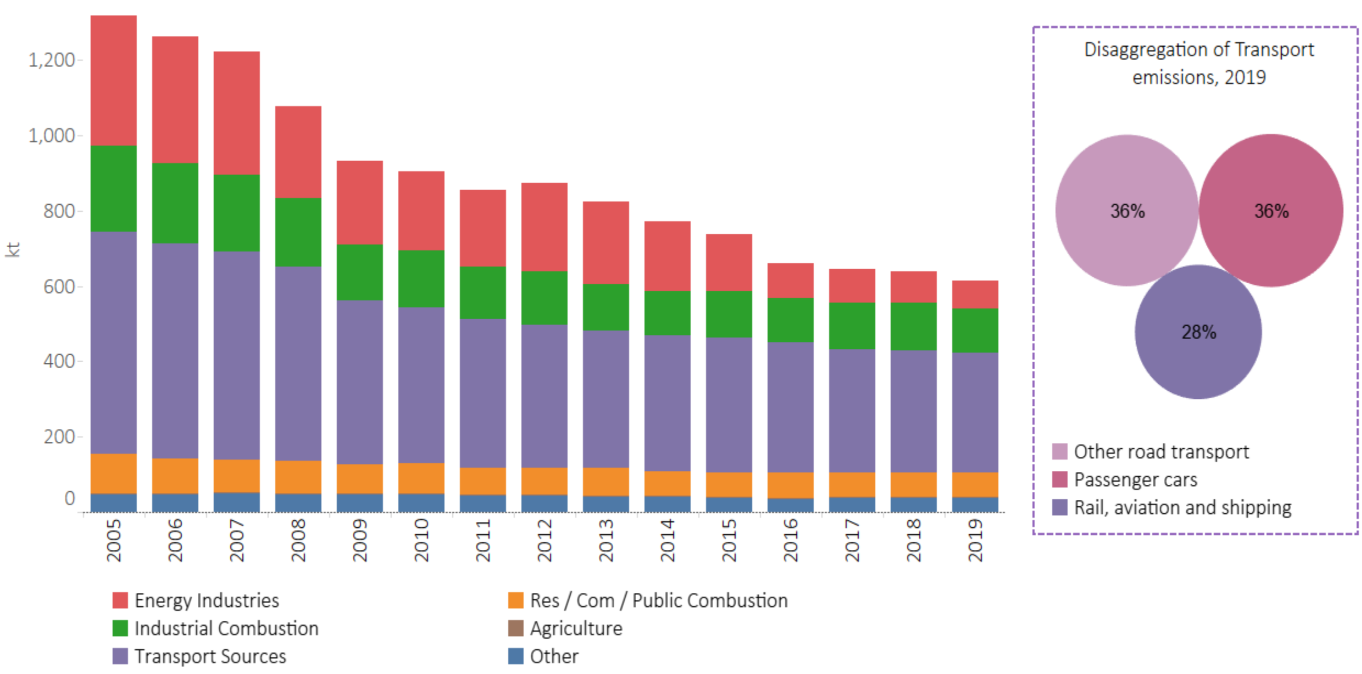
Figure 3 – Carbon Monoxide Emissions in England[4]



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

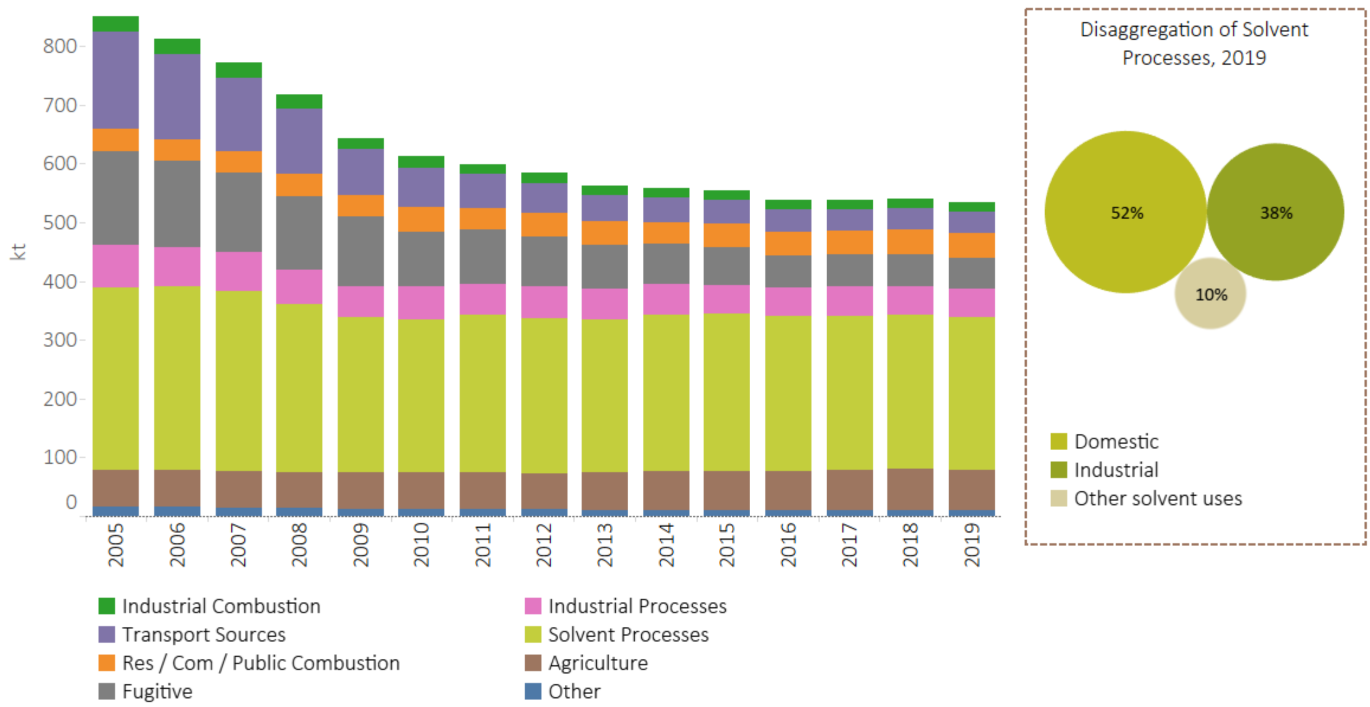
Emissions of **carbon monoxide** in England were estimated to be 1,160kt in 2019 and have declined by 52% since 2005. Emissions in England account for 74% of the UK total in 2019. The decline in emissions is driven by trends from transport sources, particularly from the road sector, where there has been an 86% decrease in emissions since 2005 (contributing 93% of the overall CO trend for England). This decline is primarily to the penetration of vehicles compliant with more recent Euro standards into the fleet, which required the fitting of emission controls (e.g. three-way catalytic converters) in new petrol vehicles. Improved catalyst repair rates resulting from regulations controlling the sale and installation of replacement catalytic converters and particle filters for light-duty vehicles in 2008 also contribute to the trend. More recently, the switch from petrol cars to diesel cars, which have lower associated CO emissions rates, has also contributed to the observed trend. In other sectors, emissions from the residential, commercial and public combustion sectors have increased more recently, corresponding with an increase in the use of wood as fuel, predominantly in the residential sector (BEIS, 2020a).

Figure 4 – Nitrogen Oxides Emissions in England



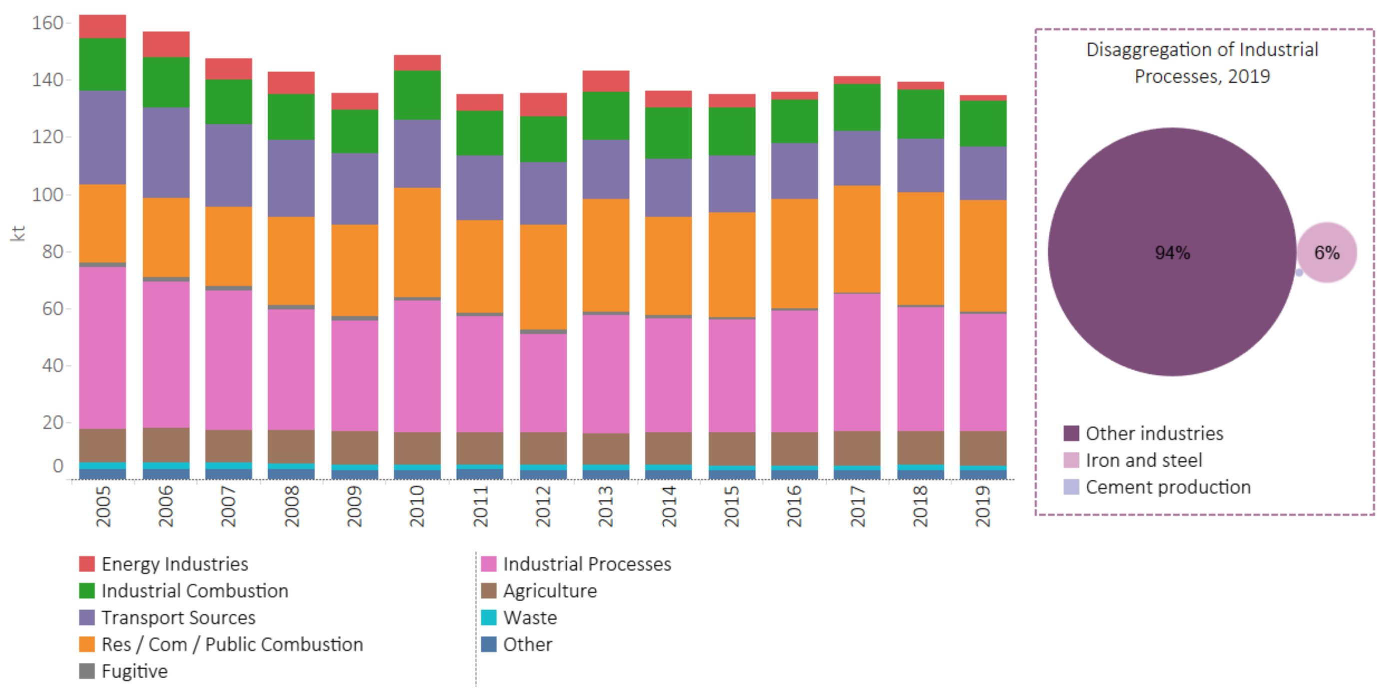
Emissions of **nitrogen oxides** in England were estimated to be 615kt in 2019, representing 73% of the UK total. Emissions have declined by 53% since 2005, mainly due to changes in transport sources, particularly in road transport. This decline is driven by the successive introduction of tighter emission standards for petrol cars and all types of new diesel vehicles over the past decade. Improved catalyst repair rates resulting from regulations controlling the sale and installation of replacement catalytic converters and particle filters for light-duty vehicles in 2008 also contribute to the trend. However, more recently, the increasing number of diesel cars has offset these emissions reductions because diesel cars emit higher NO_X relative to their petrol counterparts. Emissions reduction across the time series from energy industries is due to shifts in the electricity generation fuel mix and uptake of efficient abatement technologies. For example, Boosted Over Fire Air (BOFA) systems have been utilised in coal-fired power stations 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, 2020b) has contributed to a 16% decline in overall NO_X emissions since 2015.

Figure 5 – NMVOC Emissions in England



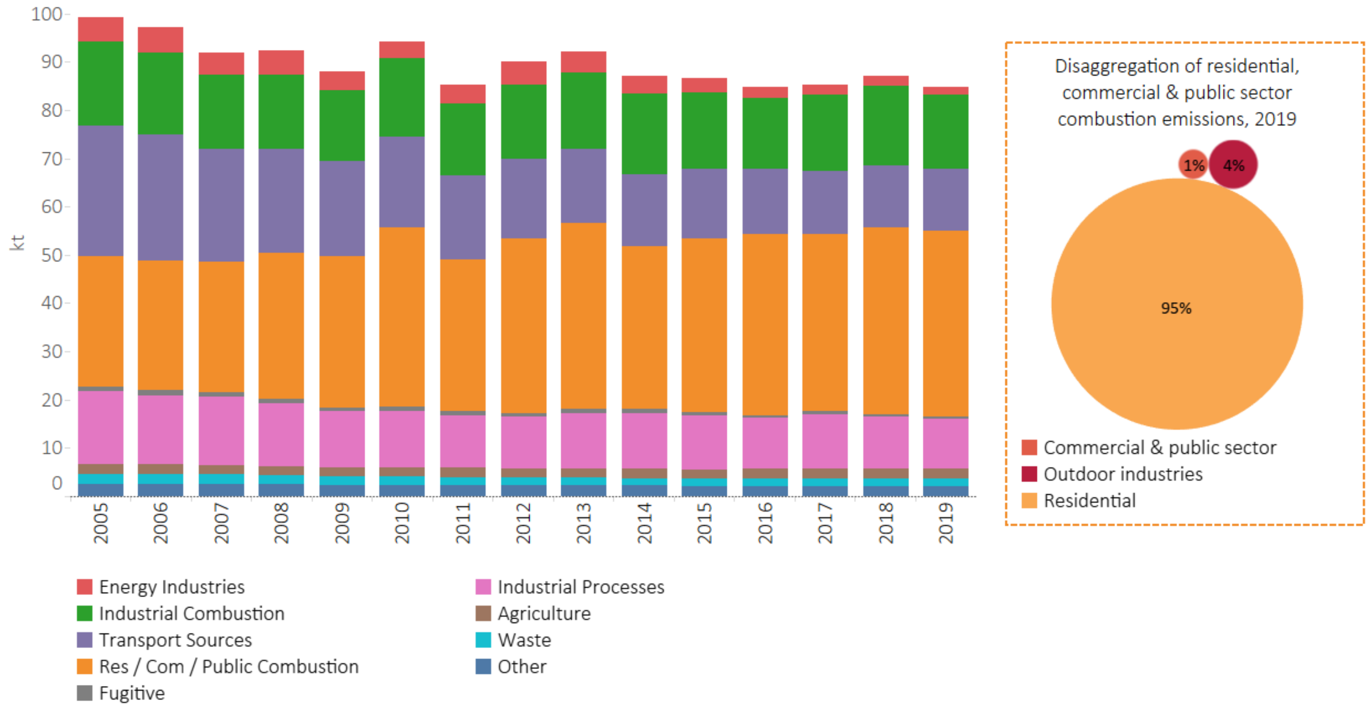
Emissions of **non-methane volatile organic compounds** in England were estimated to be 535kt in 2019, representing 66% of the UK total in 2019. Emissions have declined by 37% since 2005. The decline in emissions is driven by reductions in emissions from transport and fugitive sources. Emissions from road transport sources, including evaporative losses of fuel vapour from petrol vehicles, have declined over time due to emission control technologies introduced in new petrol vehicles since the early 1990s and continue to affect the observed trend since 2005. The reduction in emissions also occurs to a lesser extent due to the introduction of petrol vapour recovery systems at filling stations. As a result of the reduction in transport emissions, solvent processes are now the most important source of NMVOC emissions, predominantly from solvent use in domestic and industrial settings.

Figure 6 – PM_{10} Emissions in England



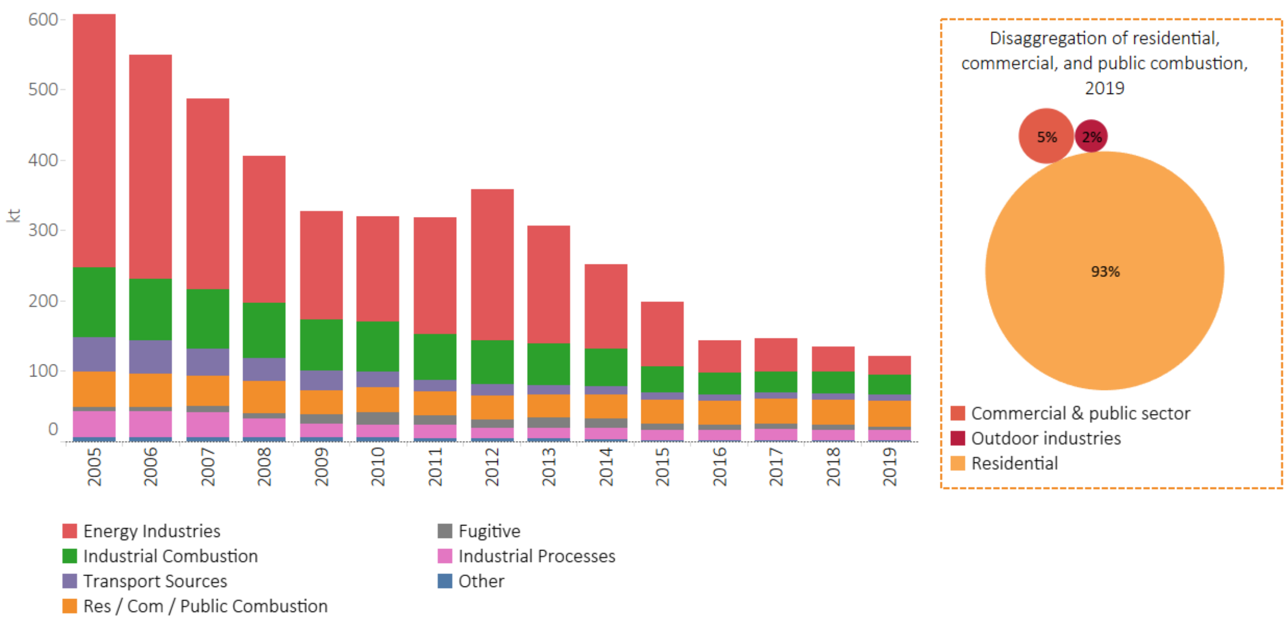
Emissions of **PM_{10}** in England were estimated to be 135kt in 2019 and have declined by 17% since 2005. They accounted for 79% of the UK total in 2019. Unlike most other pollutants, the emissions profile of PM_{10} is diverse: transport sources, residential combustion, industrial processes, and industrial combustion, each accounting for over 10% of total emissions in 2019. Some sources are more significant, with emissions from industrial processes alone accounting for around one-third of total emissions in England during 2019. PM_{10} exhaust emissions from diesel vehicles have been decreasing due to the successive introduction of tighter emission standards over time, causing a decline in the contribution of transport sources since 2005. However, since 2009, increased emissions from the combustion of biomass in unclassified industries (i.e. NFR code 1A2gviii) and domestic wood combustion have offset reductions, causing the national trend to plateau.

Figure 7 – $PM_{2.5}$ Emissions in England[4]



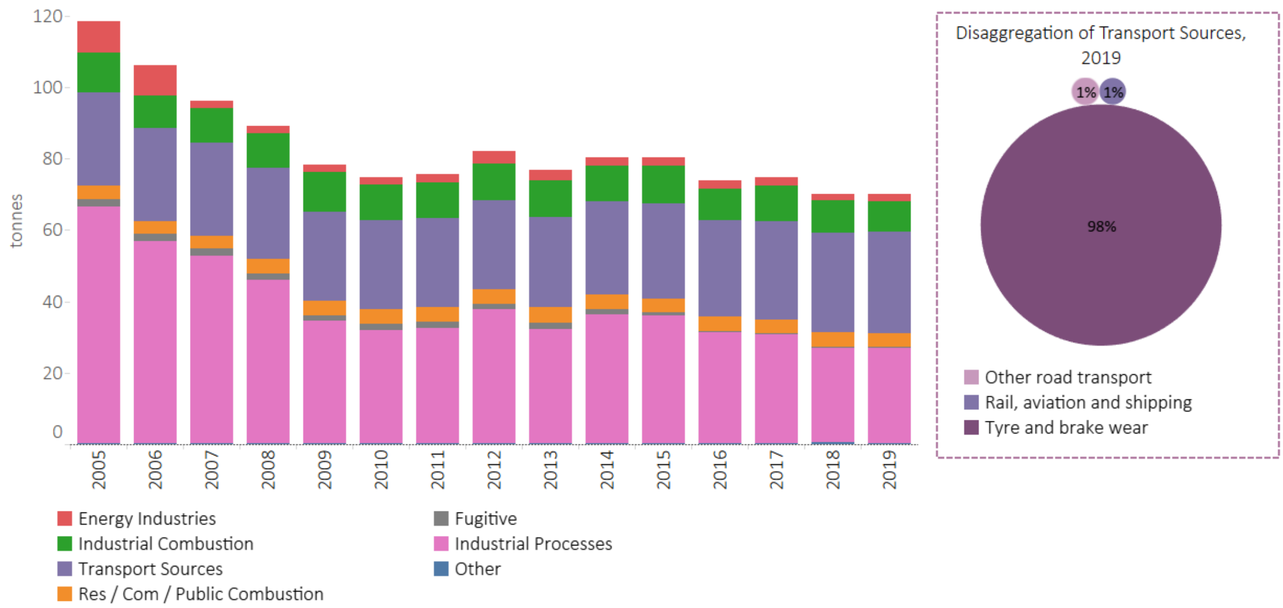
Emissions of **$PM_{2.5}$** in England were estimated to be 85kt in 2019 and have declined by 15% since 2005. Emissions in England account for 78% of the UK total in 2019. As with PM_{10}, $PM_{2.5}$ emissions have a large number of significant sources. Since combustion tends to produce finer particles, emissions from these sources (e.g. energy industries, industrial combustion) are of greater importance for this size fraction compared to PM_{10}. For $PM_{2.5}$, the residential, commercial, and public sector combustion category accounts for 45% of 2019 emissions. Residential emissions (NFR 1A4b) alone have increased by 66% since 2005. The primary drivers behind the national-level decline in emissions since 2005 include the continued switch in the fuel mix used in electricity generation away from coal and towards natural gas, and reductions in emissions in the transport sector due to the introduction of progressively more stringent emissions standards through time. These savings are partially offset by the increase in residential combustion noted above, however, with recent increases in wood combusted domestically principally behind this trend.

Figure 8 - Sulphur Dioxide Emissions in England[4]



Emissions of **sulphur dioxide** in England were estimated to be 121kt in 2019, representing 74% of the UK total. Emissions have declined by 80% since 2005, which has been dominated by significant reduction in energy industries emissions, coincident with large changes in the power generation sector. These include 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; installation of flue gas desulphurisation at select power stations; and the rapid expansion of the renewable share of electricity generation (BEIS, 2020b). The increase in emissions in 2012 was due to an increase in the use of coal in power generation relative to previous years (BEIS, 2020b). Transport sources emissions have also declined, coincident with the reduced sulphur content of road fuels, both petrol and diesel. Emissions from industrial combustion have declined by 73% since 2005, mainly due to a reduction in coal and fuel oil use in the chemicals sector and other industries.

Figure 9 – Lead Emissions in England



Emissions of **lead** in England were estimated to be 70 tonnes in 2019, representing 76% of the UK total. Emissions have declined by 41% since 2005. The trend is driven principally by decline in emissions from industrial processes, including the reduction of activities at iron and steelworks and a decline in emissions from alkyl lead production (NFR 2B10a). Reductions in the energy sector also contribute to the overall trend, and is linked to a reduction in coal use principally and tighter regulations at power stations and from burning municipal solid waste in waste-to-energy plants.

Table 2 below provides a summary of the percentage contribution of each sector for each pollutant in 2019. 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}, $PM_{2.5}$, B[a]p and Dioxins, accounting for at least 29% 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 2019

Sector	NH_3	CO	NO_X	VOC	PM_{10}	$PM_{2.5}$	SO_2	Pb	B[a]p	Dioxins	Hg
Agriculture	84.8%	0.0%	0.3%	13.0%	8.8%	2.3%	0.0%	0.0%	0.0%	0.0%	0.0%
Energy Industries	0.0%	3.0%	12.1%	0.0%	1.4%	1.8%	22.3%	3.0%	3.2%	1.6%	20.0%
Fugitive	0.0%	0.1%	0.0%	9.8%	0.5%	0.7%	3.8%	0.4%	0.5%	0.0%	0.0%
Industrial Combustion	0.0%	29.9%	19.3%	3.3%	11.8%	18.1%	22.5%	12.1%	0.0%	15.2%	17.7%
Industrial Processes	1.6%	6.1%	0.0%	9.0%	30.6%	12.2%	11.7%	38.2%	1.2%	7.7%	21.5%
Residential, Commercial & Public Sector Combustion	1.1%	37.5%	10.5%	7.9%	29.3%	45.5%	30.6%	5.5%	88.5%	38.9%	6.3%
Solvent Processes	0.0%	0.0%	0.0%	48.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Transport Sources	2.1%	21.7%	51.5%	6.6%	14.0%	15.2%	7.6%	40.4%	2.1%	3.9%	6.9%
Waste	3.1%	0.6%	0.0%	0.0%	1.2%	1.8%	0.0%	0.0%	3.8%	32.1%	27.3%
Other	7.3%	1.0%	6.4%	1.7%	2.4%	2.6%	1.6%	0.4%	0.7%	0.6%	0.3%

* 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 30**.

Figure 10 – Ammonia Emissions in England, 2019

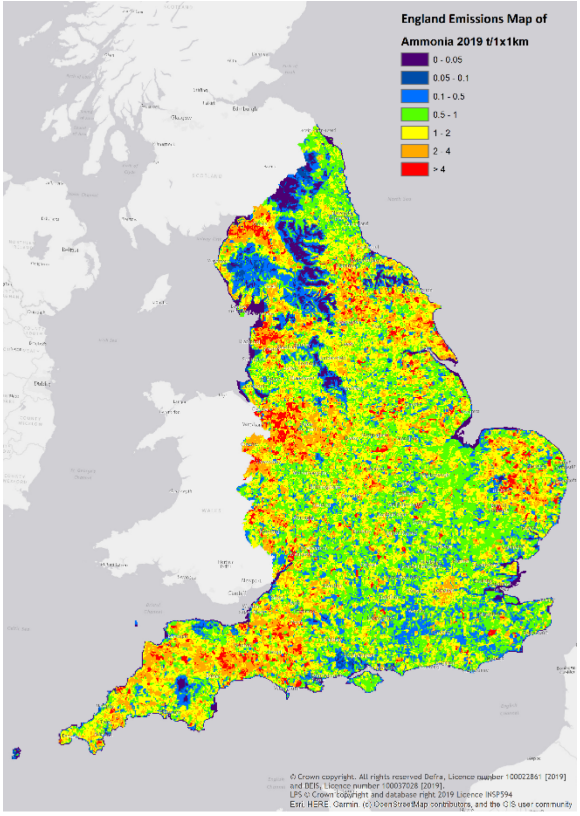


Figure 11 – Carbon Monoxide Emissions in England, 2019

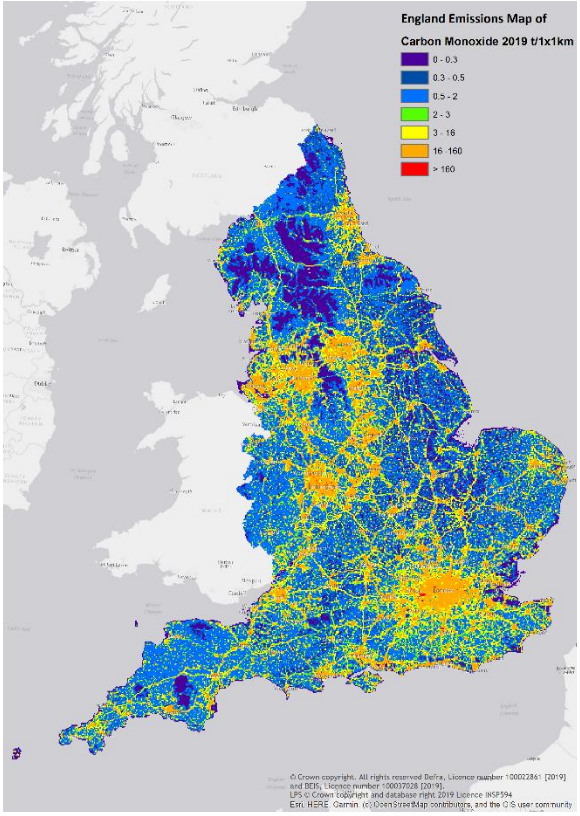


Figure 12 – Nitrogen Oxides Emissions in England, 2019

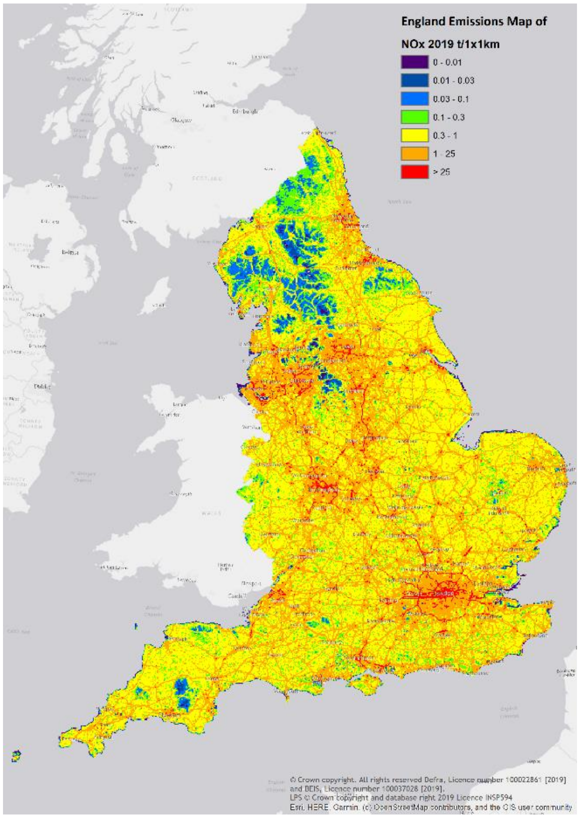


Figure 13 – NMVOC Emissions in England, 2019

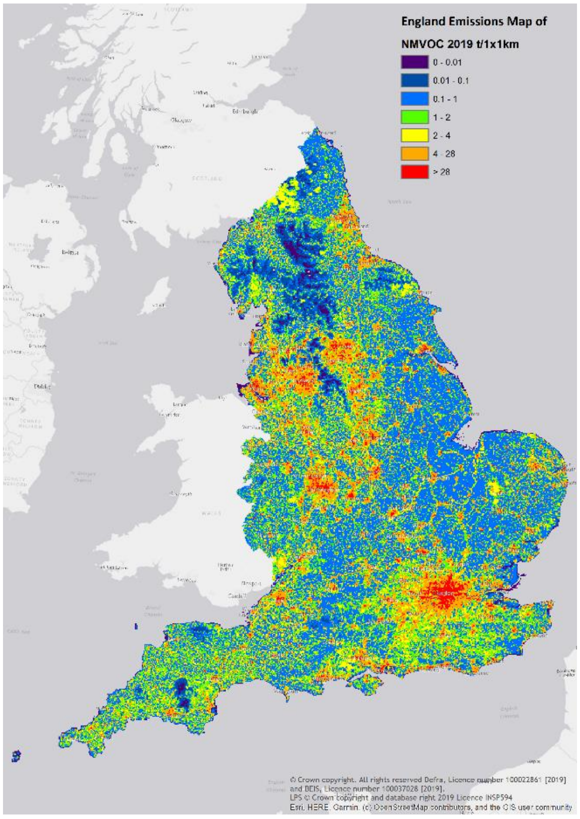


Figure 14 - PM_{10} Emissions in England, 2019

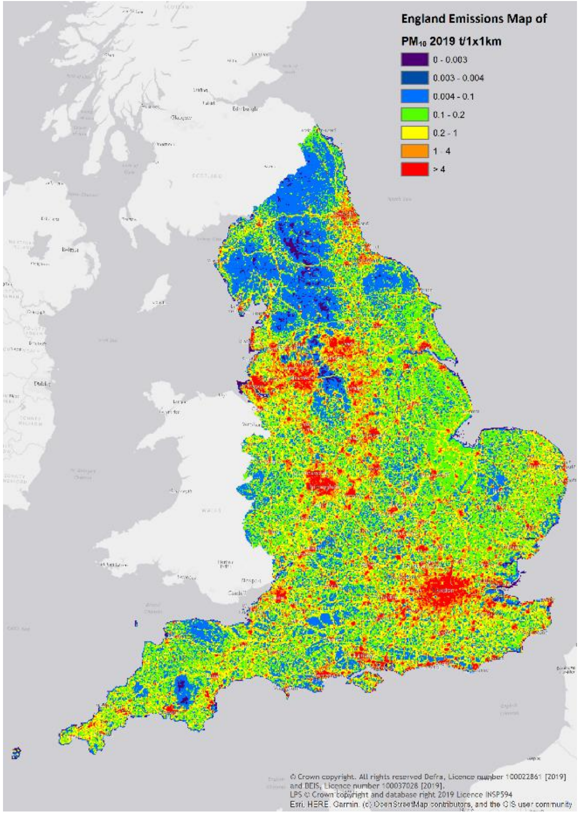


Figure 15 – $PM_{2.5}$ Emissions in England, 2019

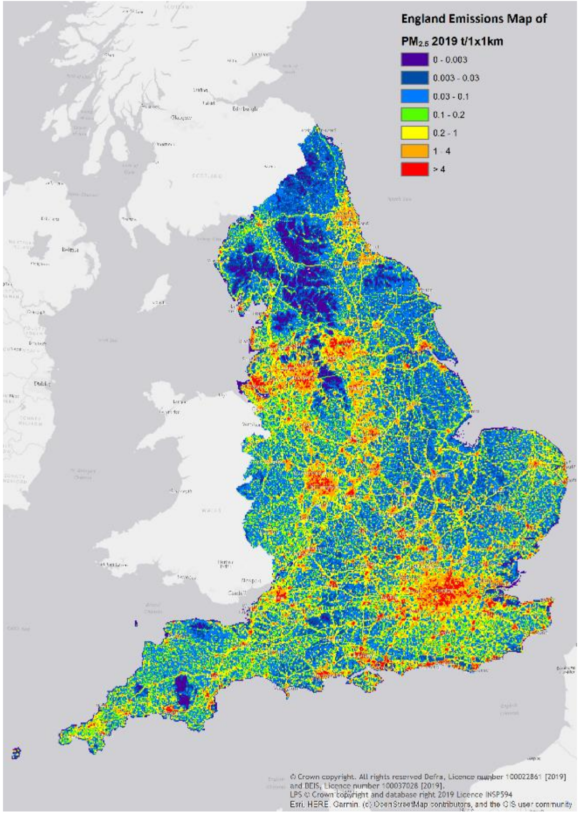


Figure 16 – Lead Emissions in England, 2019

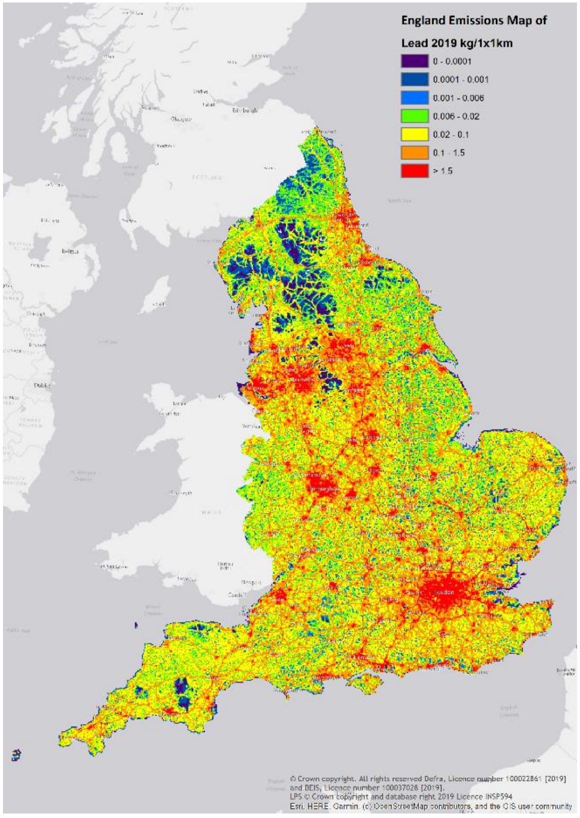
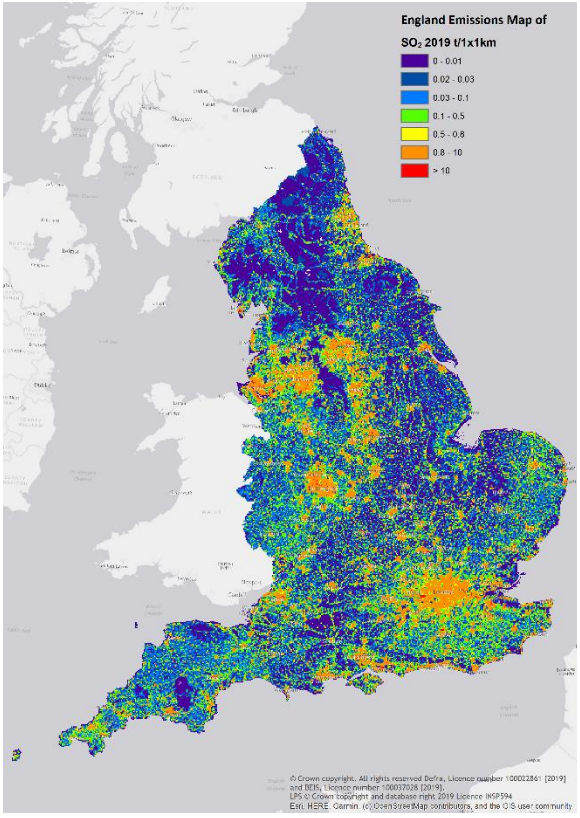


Figure 17 – Sulphur Dioxide Emissions in England, 2019



2.2 Scotland

The following section provides a summary of emissions in Scotland for the eight priority air pollutants: NH_3, CO, NO_X, NMVOCs, PM_{10}, $PM_{2.5}$, SO_2, and Pb. Information is also presented for emissions of PCDD/Fs ,B[a]p, and Hg, with more detailed information for these three pollutants presented in **Appendix C.2**. Emissions of PCDD/Fs, B[a]p, and Hg should be considered as experimental statistics only[3]. **Appendix F** presents the DA inventory data summary tables, whilst **Appendix G** presents source category mapping used in the report**.**

Figure 18 shows emissions of all eleven air pollutants normalised against the 2005 baseline to illustrate the relative trends since then. This graph shows that most pollutant levels are lower in 2019 than they were in 2005. The greatest rate of decline is observed in the trend for SO_2 emissions, principally due to the reduction in coal use within the economy, with more modest declines observable for CO, NO_X, Hg, Pb, VOCs, $PM_{2.5}$ and PM_{10}. By contrast, emissions of NH_3 are less varied over the time series with no strong decline observed since 2005. Emissions from B[a]p have increased over the time series, a trend principally resulting from increases in wood combustion in residential settings.

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

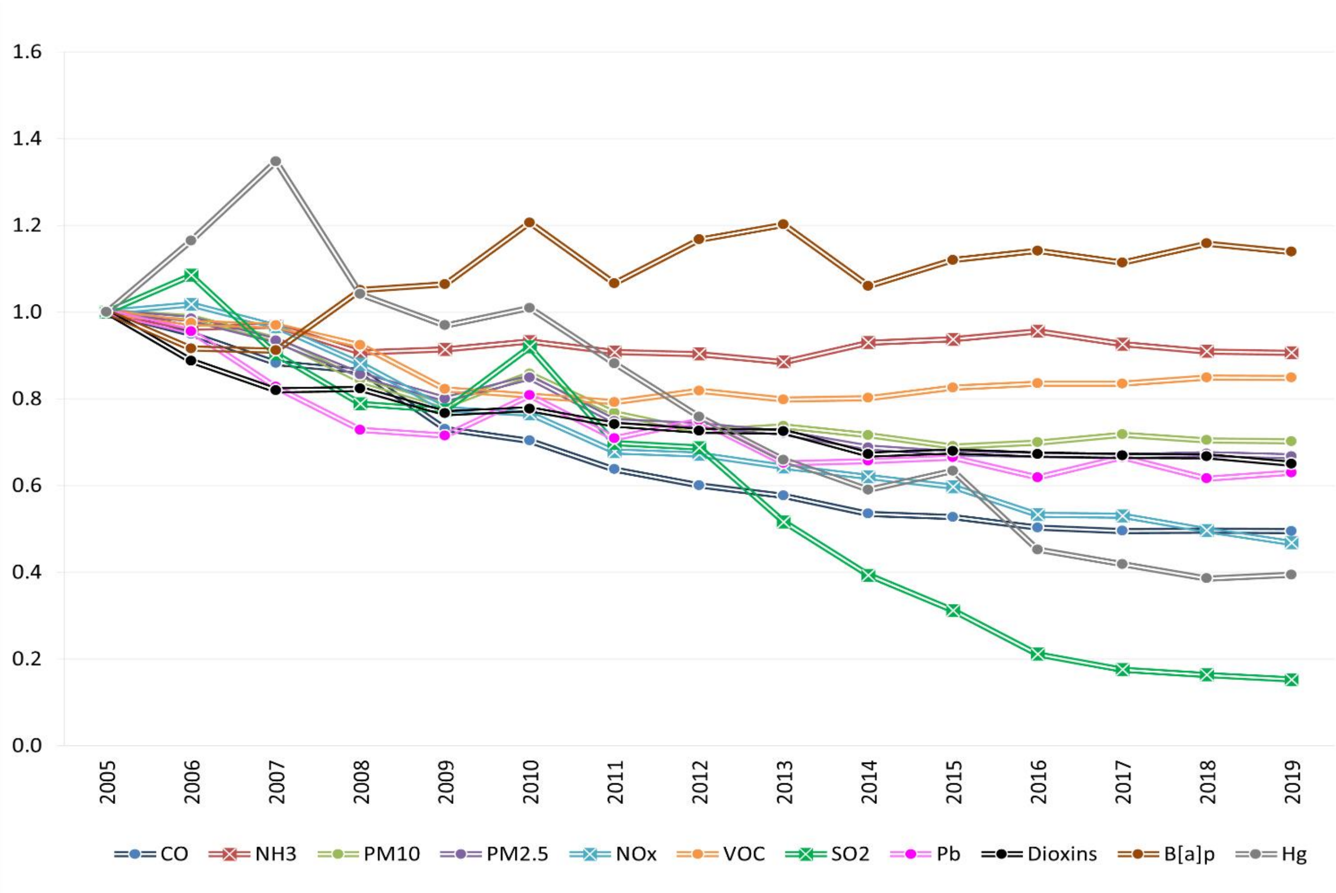
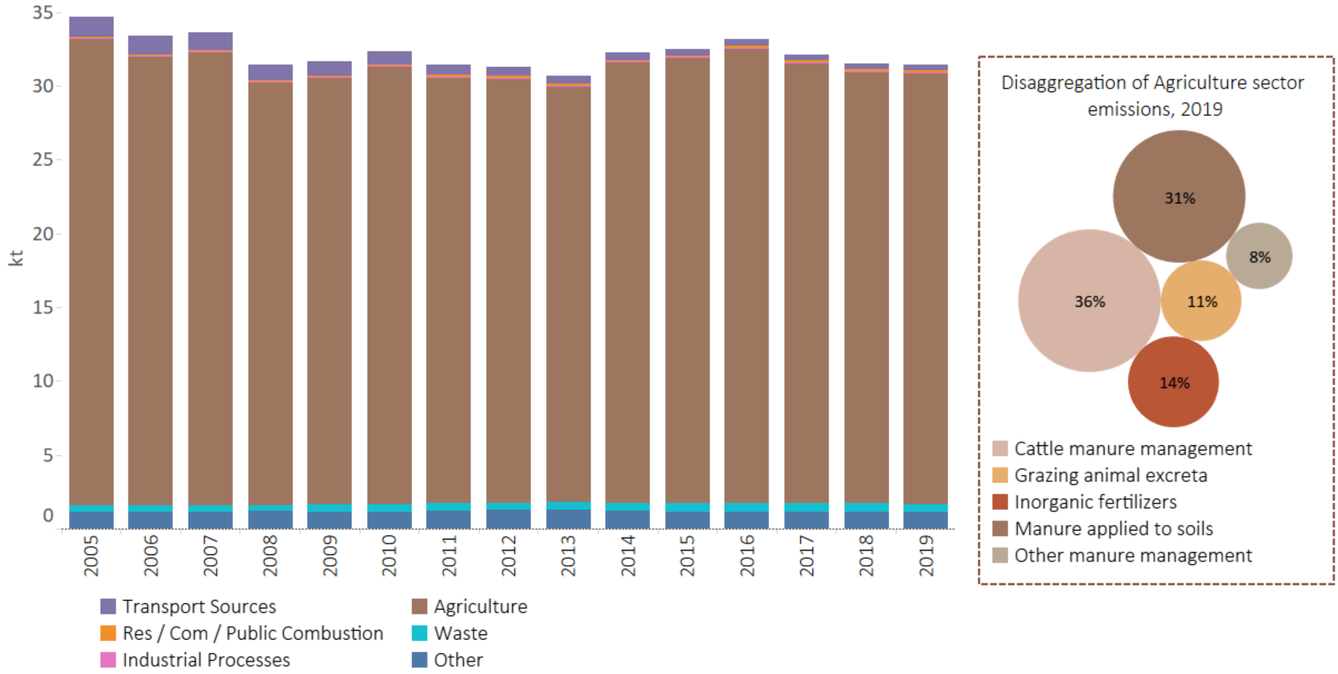
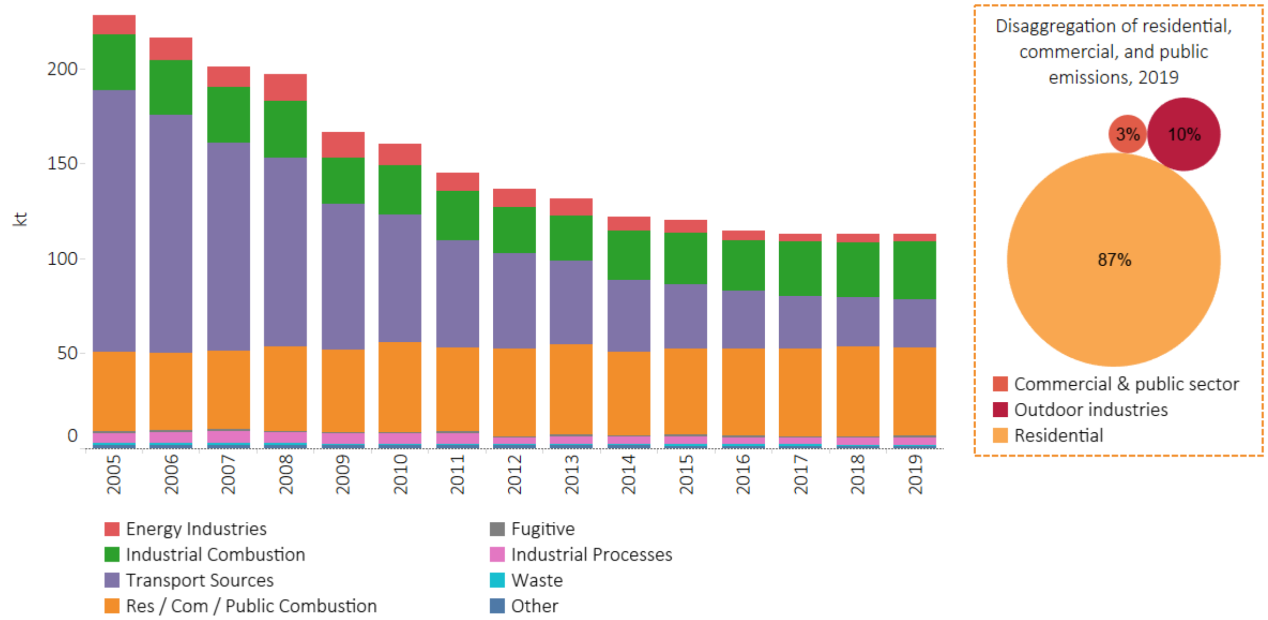


Figure 19 – Ammonia Emissions in Scotland



Emissions of **ammonia** in Scotland were estimated to be 31kt in 2019. These emissions have declined by 9% since 2005 and accounted for 12% of the UK total in 2019. Agriculture sources have dominated the inventory throughout the time series, with cattle manure management accounting for at least 33% of the emissions from this sector across the entire time series. The initial trends in NH_3 emissions were primarily driven by decreases in livestock numbers (except for poultry) and declines in the use of nitrogen-based fertilisers. After 2010, however, the decline began to be offset by increased application of urea-based and organic fertilisers such as digestate to agricultural soils causing fluctuating emissions totals since 2008, with no significant trends across these years.

Figure 20 – Carbon Monoxide Emissions in Scotland[5]

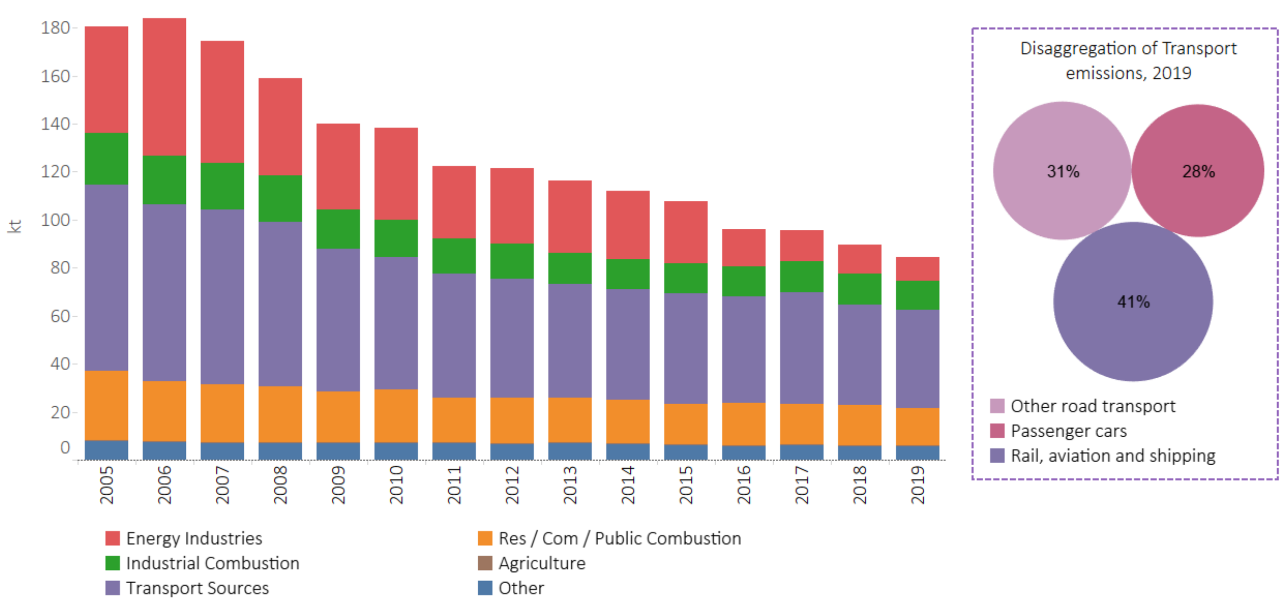


Emissions of **carbon monoxide** in Scotland were estimated to be 113 kt in 2019 and have declined by 51% since 2005. Emissions in Scotland accounted for 7% of the UK total in 2019. This decline in emissions stems from changes in the contribution of transport sources, particularly in the road sector where emissions have

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

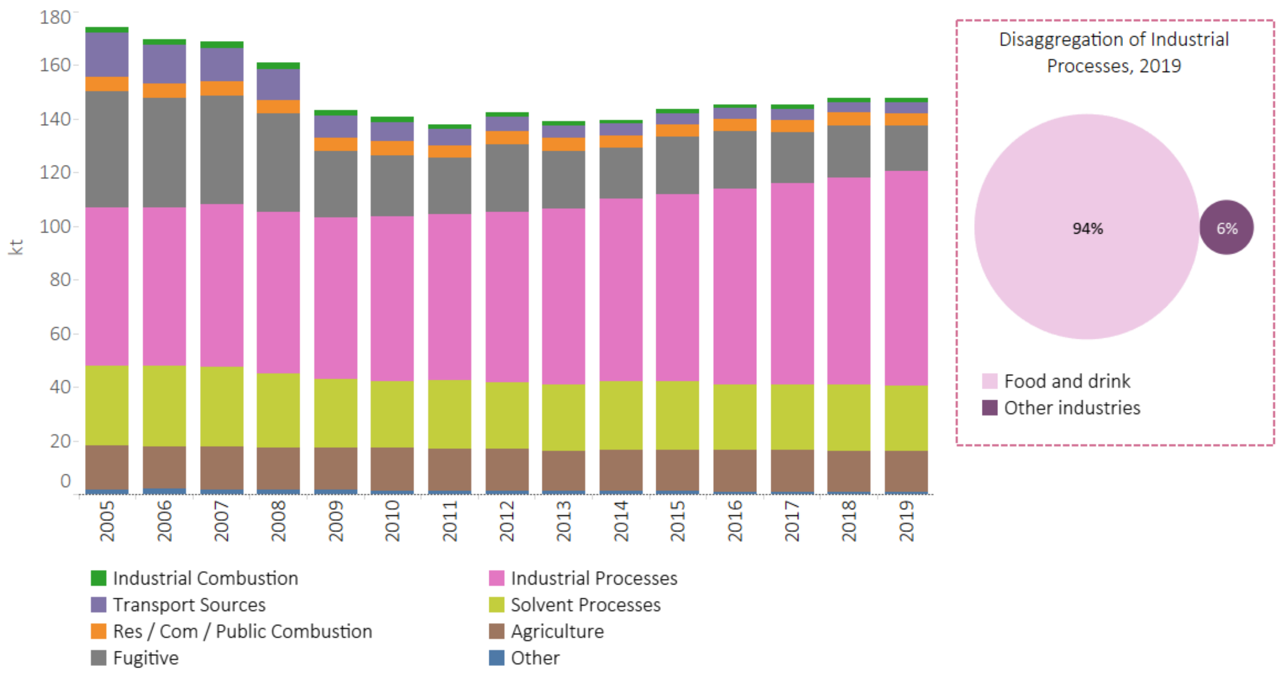
declined by 86% since 2005 (contributing to 95% of the national trend in CO emissions). This decline is primarily to the penetration into the fleet of vehicles compliant with more recent Euro standards, which required the fitting of emission controls (e.g. three-way catalytic converters) in new petrol vehicles. Improved catalyst repair rates resulting from regulations controlling the sale and installation of replacement catalytic converters and particle filters for light-duty vehicles in 2008 also contribute to the trend. More recently, the switch from petrol cars to diesel cars, which have lower associated CO emissions rates, has also contributed to the observed trend. Emissions from the residential, commercial and public sector combustion have steadily increased since 2005, which corresponds with an increase in use of wood fuel in the domestic sector (BEIS, 2020a).

Figure 21 – Nitrogen Oxides Emissions in Scotland



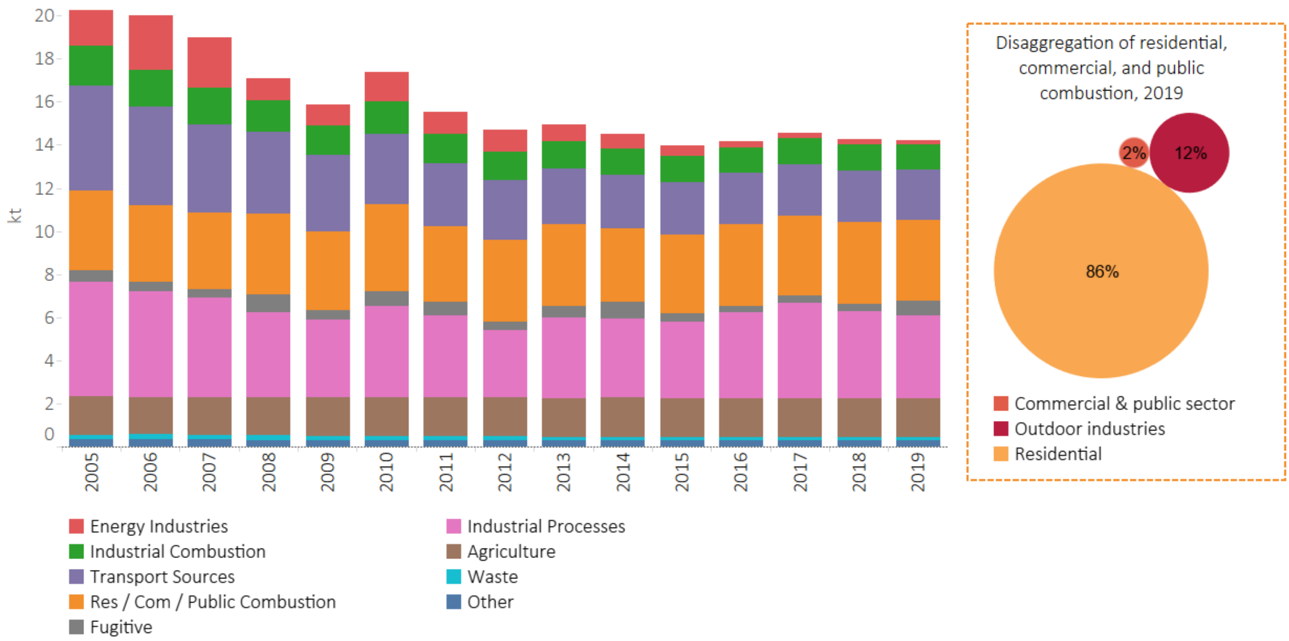
Emissions of **nitrogen oxides** in Scotland were estimated to be 85kt in 2019, representing 10% of the UK total. Emissions have declined by 53% since 2005, mainly due to changes in transport sources, particularly in road transport. This decline is driven by the successive introduction of tighter Euro emission standards, and the continued penetration of vehicles which comply with these standards. In addition, improvements in catalyst repair rates resulting from regulations controlling the sale and installation of replacement catalytic converters and particle filters for light-duty vehicles contributes to the decline since 2008. However, the recent preferred uptake of diesel cars over petrol cars partly offsets these emissions reductions, because diesel cars emit higher NO_X relative to their petrol counterparts (88% of 2019 passenger car emissions were due to diesel cars). The peak in NO_X emissions in 2006 is due 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, 2020a). Energy industry emissions have declined across the time series, and is linked to Boosted Over-Fire Air (BOFA) abatement systems which were fitted to all four of Longannet's units, to reduce NO_X emissions from coal-fired generation by up to 25% (Scottish Power, 2012). BOFA systems were also fitted on all four units at Cockenzie power station which then closed in 2013 (Scottish Power, 2011). Longannet power station closed in March 2016 marking the end of coal combustion for power generation in Scotland, and causing a step-change in emissions between 2015 and 2016.

Figure 22 – NMVOC Emissions in Scotland



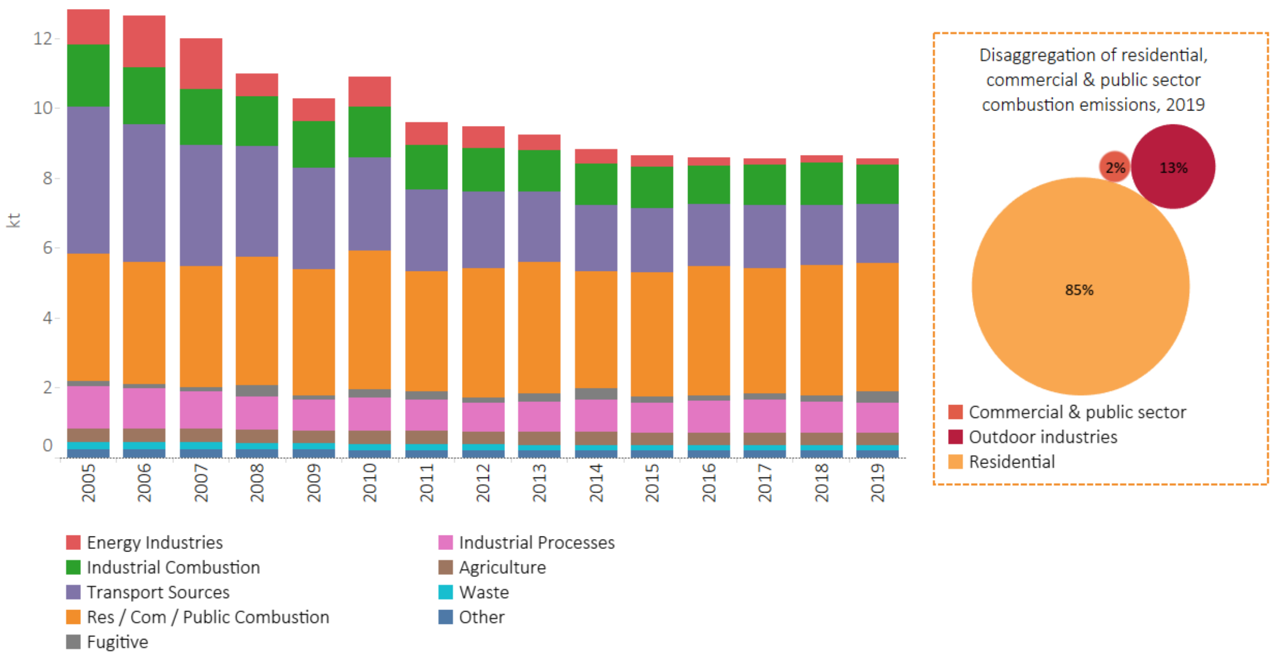
Emissions of **non-methane volatile organic compounds** in Scotland were estimated to be 148kt in 2019, representing 18% of the UK total. Emissions have declined by 15% since 2005. This reduction is a result of reductions in fugitive and transport emissions which have declined 66% and 75% since 2005, respectively. The declining trend seen in fugitive emissions is 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 around 94% of industrial processes emissions in 2019) have increased since 2009 due to the increased production and storage of whisky. In total, spirit manufacture contributed approximately 49% of NMVOC emissions in Scotland in 2019. Emissions from road transport sources, including evaporative losses of fuel vapour from petrol vehicles have also declined over time due to emission control technologies that have progressively been 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[5]



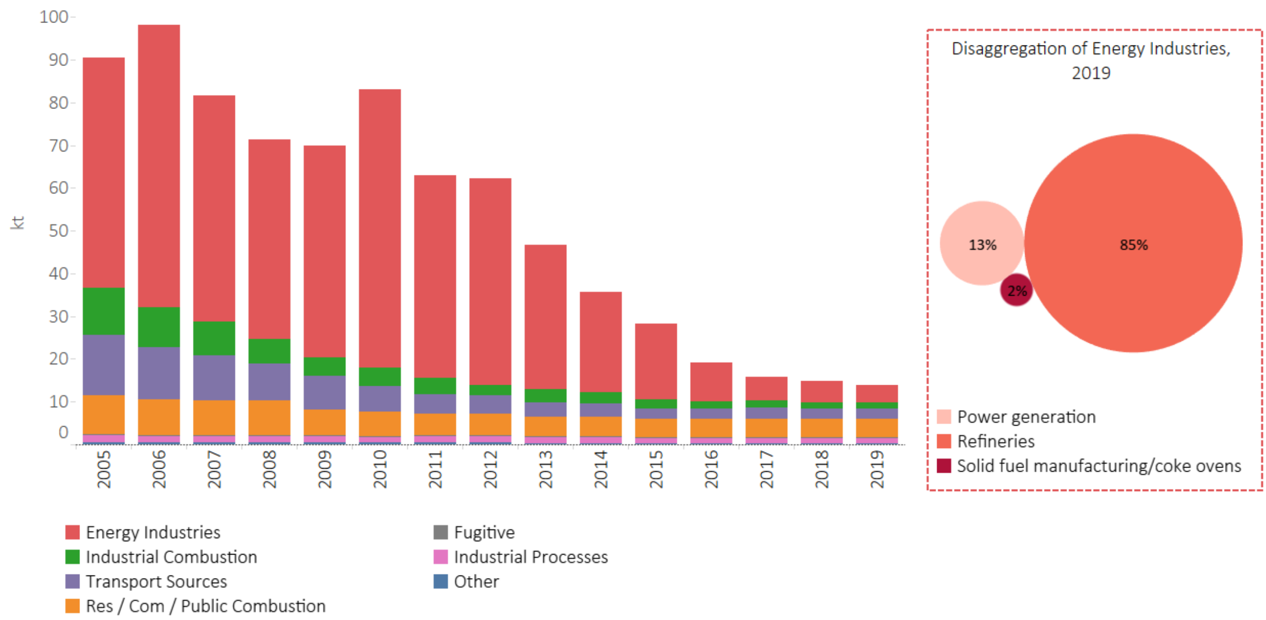
Emissions of **PM_{10}** in Scotland were estimated to be 14kt in 2019, declining by 30% since 2005. These emissions account for 8% of the UK total. Unlike most other pollutants, the emissions profile of PM_{10} is diverse: transport sources, residential and industrial processes each accounted for over 16% of total emissions in 2019. 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 natural gas in energy generation (which has negligible PM_{10} emissions) in place of coal (BEIS, 2020a), as well as the continued increasing share of renewables in the energy mix. PM_{10} exhaust emissions from diesel-fuelled vehicles have been decreasing due to the continued fleet penetration of vehicles complying with more recent and more stringer Euro emissions standards. 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 2019, 79% 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, 2020a).

Figure 24 – $PM_{2.5}$ Emissions in Scotland[5]



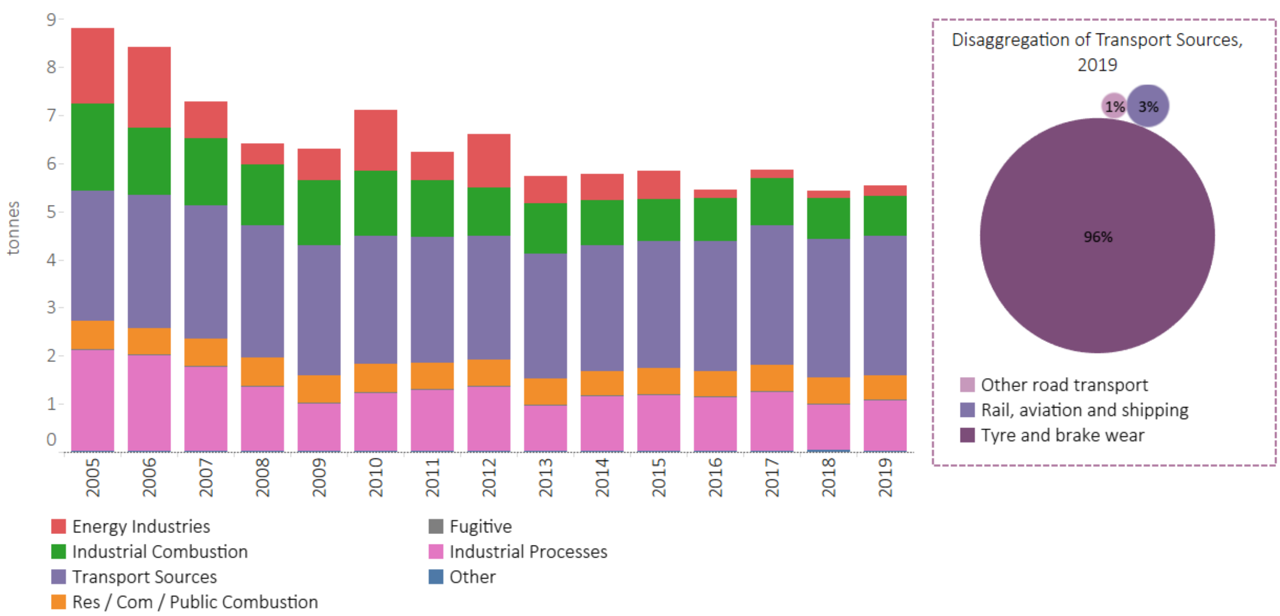
Emissions of **$PM_{2.5}$** in Scotland were estimated to be 9kt in 2019, declining by 33% since 2005. These emissions account for 8% of the UK total in 2019. As with PM_{10}, $PM_{2.5}$ emissions have a large number of significant sources. However, process emissions tend to produce coarser PM fractions and as such, combustion emissions are of greater importance for $PM_{2.5}$ compared to PM_{10}. For $PM_{2.5}$, the residential, commercial, and public sector combustion category (which includes agricultural combustion and fishing vessels – NFR code 1A4c) accounts for 43% of 2019 emissions. The primary drivers for the decline in emissions since 2005 are the continued switch from coal to natural gas in electricity generation, and reductions in emissions from the transport sector due to the introduction of progressively more stringent emissions standards through time. However, these declines in emissions have been offset by increases in emissions from the residential sector, and in particular, the combustion of wood. Emissions from the residential sector (NFR 1A4b) have increased by 50% since 2005.

Figure 25 – Sulphur Dioxide Emissions in Scotland



Emissions of **sulphur dioxide** in Scotland were estimated to be 14kt in 2019, representing 8% of the UK total in 2019. Emissions have declined by 85% since 2005 because of continued changes in the power generation sector. Such changes 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 an FGD (flue-gas desulphurization) plant at Longannet power station; the use of coal of lower sulphur content in later years to Cockenzie (Scottish Power, 2012) before its closure in March 2013, and finally the complete cessation of coal combustion for power generation in Scotland in 2016 after the closure of Longannet. SO_2 emissions from transport sources have also declined, coincident with the reduced sulphur content of road fuels, for both petrol and diesel.

Figure 26 – Lead Emissions in Scotland



Emissions of **lead** in Scotland were estimated to be 5.5 tonnes in 2019, representing 6% of the UK total. Emissions have declined by 37% since 2005 due to changes in energy sources, industrial combustion, and industrial processes. Emissions from power stations have decreased by 86% since the base year, due to the phase out of coal from the energy generation mix, with the closure of Longannet in 2016 marking the end of the use of coal in energy generation in Scotland. Transport sources, in particular non-exhaust emissions (such as tyre and brake wear) account for 96% of the transport sector, (and 50% of total lead emissions in

2019). Unlike exhaust emissions which have been subject to the continued implementation of more stringent European regulation, non-exhaust emissions are not regulated and are strongly linked to the v-km driven on Scotland's roads. Non-exhaust emissions have increased by 11% since the 2005 baseline. Industrial combustion accounting for 15%, and use of fireworks contributing a further 10%. Three of the seven sites in the UK which manufacture fibreboard, chipboard and oriented strand board are located in Scotland, and are key sites for lead emissions due to the burning of waste wood as fuel.

Table 3 below provides a summary of the percentage contribution of each sector for each pollutant in 2019. 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 is an important sector when considering emissions of CO, SO_2, PM_{10} and $PM_{2.5}$, B[a]P and dioxins.

Industrial Processes is also notable, especially for NMVOCs, 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 2019

Sector	NH_3	CO	NO_X	VOC	PM_{10}	$PM_{2.5}$	SO_2	Pb	B[a]p	Dioxin s	Hg
Agriculture	92.8%	0.0%	0.1%	10.3%	12.8%	4.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Energy Industries	0.0%	3.4%	12.1%	0.0%	1.5%	2.0%	28.8%	3.9%	0.0%	1.3%	5.6%
Fugitive	0.0%	1.0%	0.0%	11.5%	4.6%	3.7%	1.2%	0.0%	0.0%	0.0%	0.0%
Industrial Combustion	0.0%	26.9%	14.3%	1.1%	8.2%	13.2%	11.1%	15.0%	0.0%	11.7%	10.8%
Industrial Processes	0.2%	3.0%	0.0%	54.3%	27.0%	10.2%	9.2%	19.4%	1.4%	6.2%	16.3%
Residential, Commercial & Public Sector Combustion	0.5%	41.2%	18.0%	3.1%	26.3%	42.7%	31.5%	9.2%	90.4%	42.9%	11.7%
Solvent Processes	0.0%	0.0%	0.0%	16.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Transport Sources	1.2%	22.8%	48.3%	2.7%	16.4%	19.9%	16.9%	52.3%	2.7%	4.8%	16.0%
Waste	1.7%	0.6%	0.0%	0.0%	1.1%	1.7%	0.0%	0.0%	4.6%	32.6%	39.4%
Other	3.7%	1.1%	7.2%	0.7%	2.0%	2.3%	1.3%	0.3%	0.8%	0.5%	0.2%

* 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 30**.

Figure 27 – Ammonia Emissions in Scotland, 2019

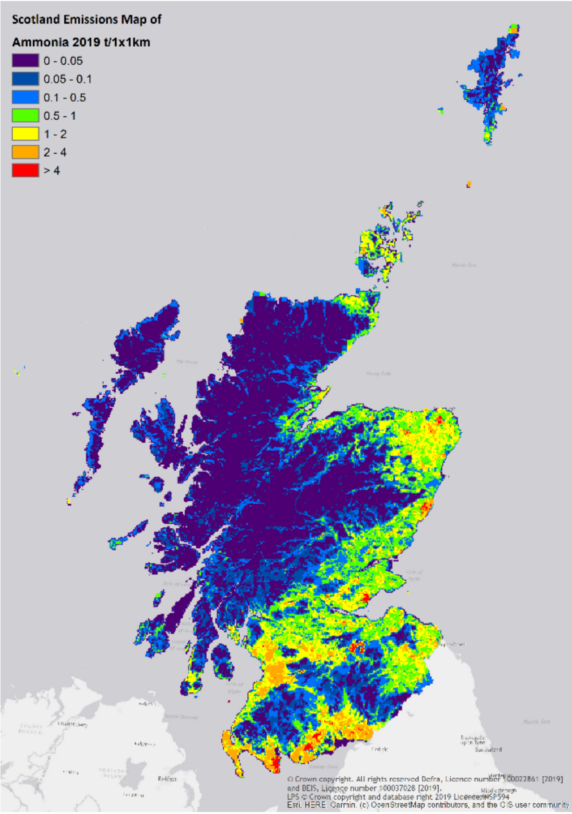


Figure 28 – Carbon Monoxide Emissions in Scotland, 2019

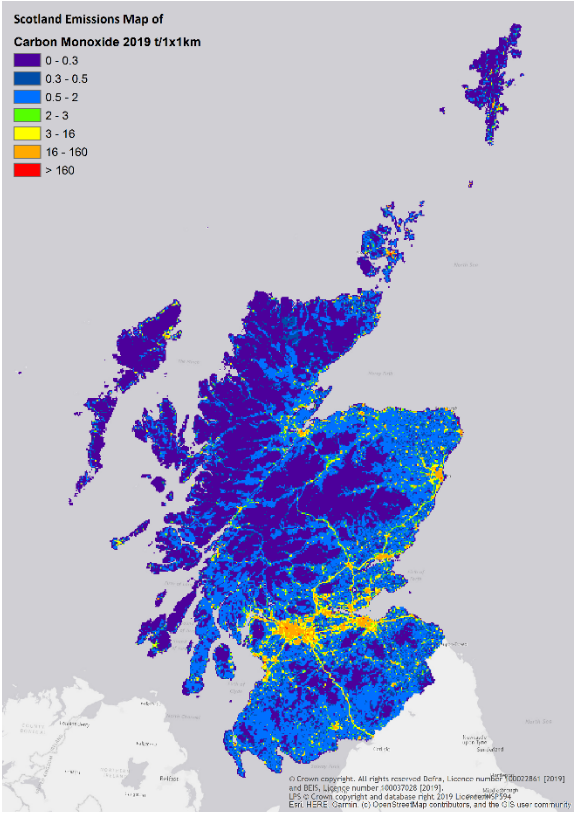


Figure 29 – Nitrogen Oxides Emissions in Scotland, 2019

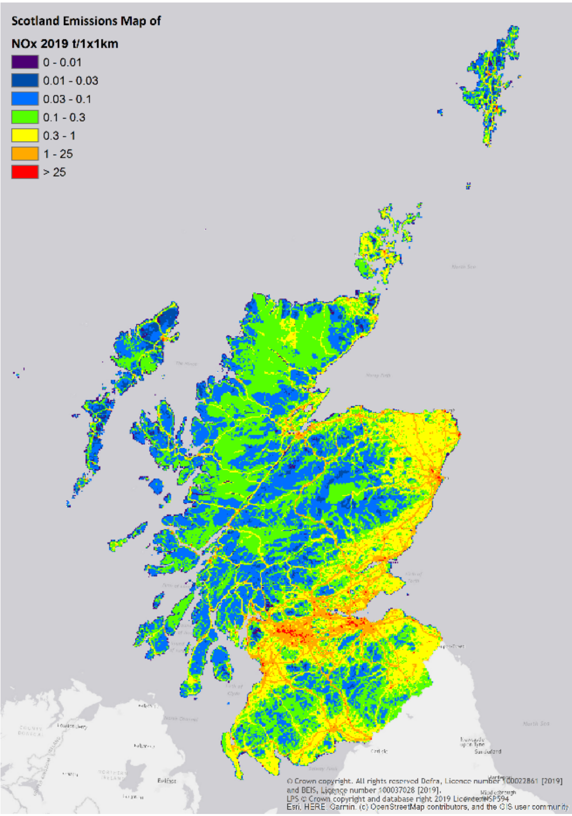


Figure 30 – NMVOC Emissions in Scotland, 2019

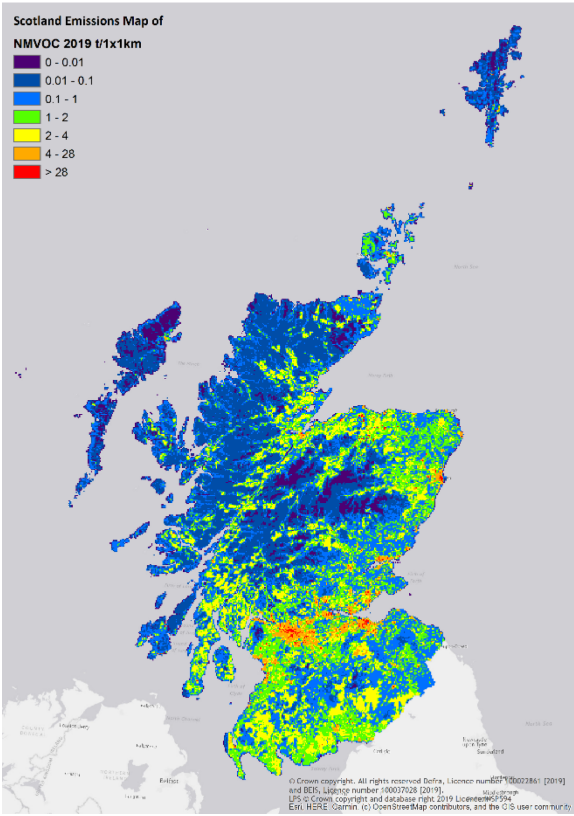


Figure 31 – PM_{10} Emissions in Scotland, 2019

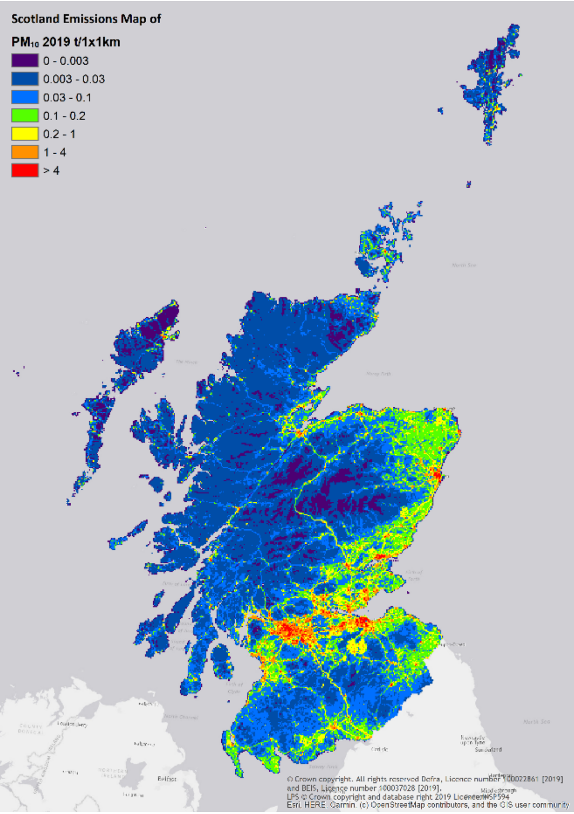


Figure 32 – $PM_{2.5}$ Emissions in Scotland, 2019

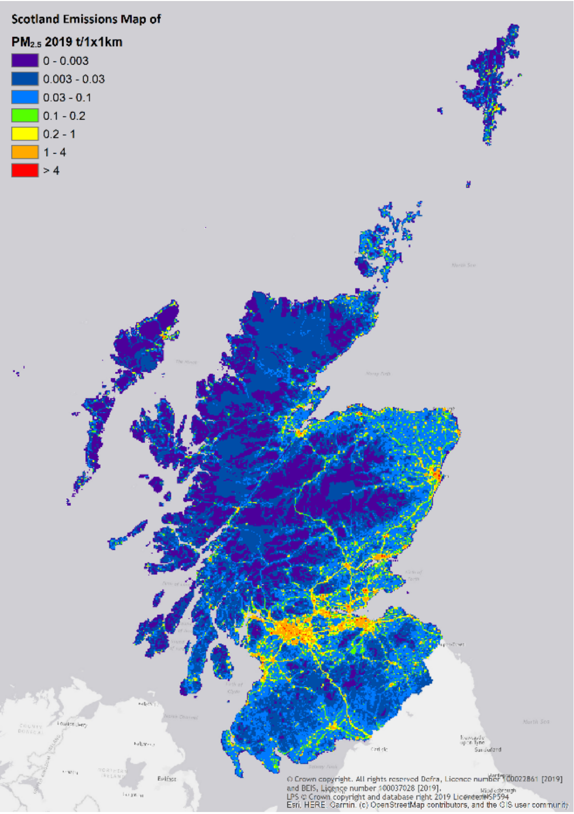


Figure 33 – Lead Emissions in Scotland, 2019

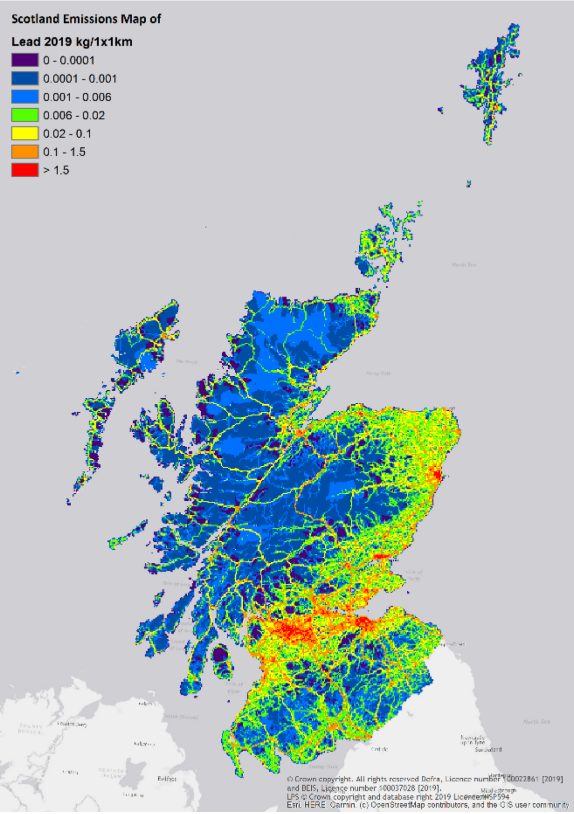
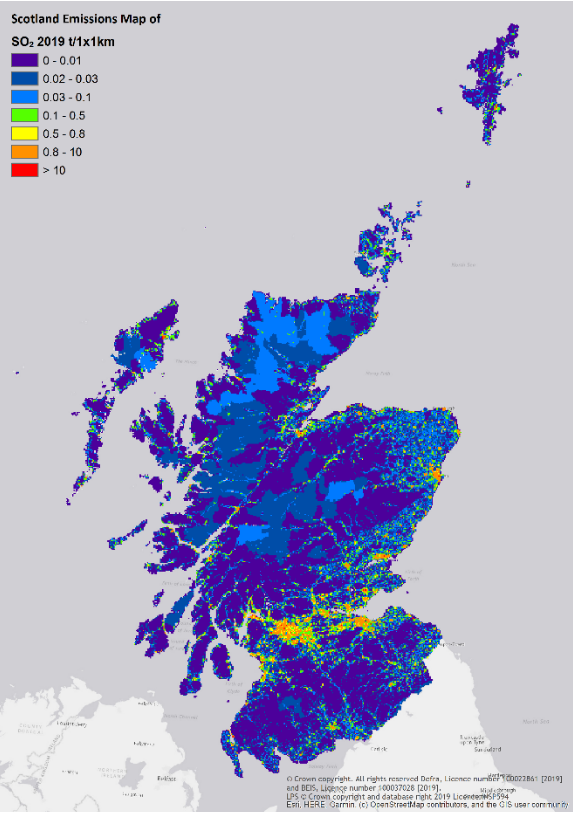


Figure 34 – Sulphur Dioxide Emissions in Scotland, 2019



2.3 Wales

The following section provides a summary of emissions in Wales for the eight priority air pollutants: NH_3, CO, NO_X, NMVOCs, PM_{10}, $PM_{2.5}$, SO_2, and Pb. Information is also presented for emissions of PCDD/Fs, B[a]p, and Hg, with more detailed information for these three pollutants presented in **Appendix C.2**. Emissions of PCDD/Fs, B[a]p, and Hg should be considered as experimental statistics only[3]. **Appendix F** presents the DA inventory data summary tables, whilst **Appendix G** presents source category mapping used in the report**.**

Figure 35 shows emissions of all eleven air pollutants normalised against the 2005 baseline to illustrate the relative trends since then. This graph shows that most pollutant levels are lower in 2019 than they were in 2005. The greatest rate of decline is observed in the trend for SO_2 with more modest declines observable for NO_X, Pb, VOCs, PM_{10}, and $PM_{2.5}$. Reductions in SO_2 since 2006 are due, primarily, to the retrofitting 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.

Emissions of NH_3 have been rising in recent years due to increases in activity from several sources; urea-based fertiliser application; increases in housed cattle numbers and subsequent manure spreading on soils; and increases in digestate and other organic fertilisers which are applied to soils. Emissions of B[a]p have increased over the time series, a trend principally dictated by increases in wood combustion in residential settings.

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 SO_2, CO, and Hg (and to some extent dioxins).

Figure 35 – Wales normalised trends for all pollutants

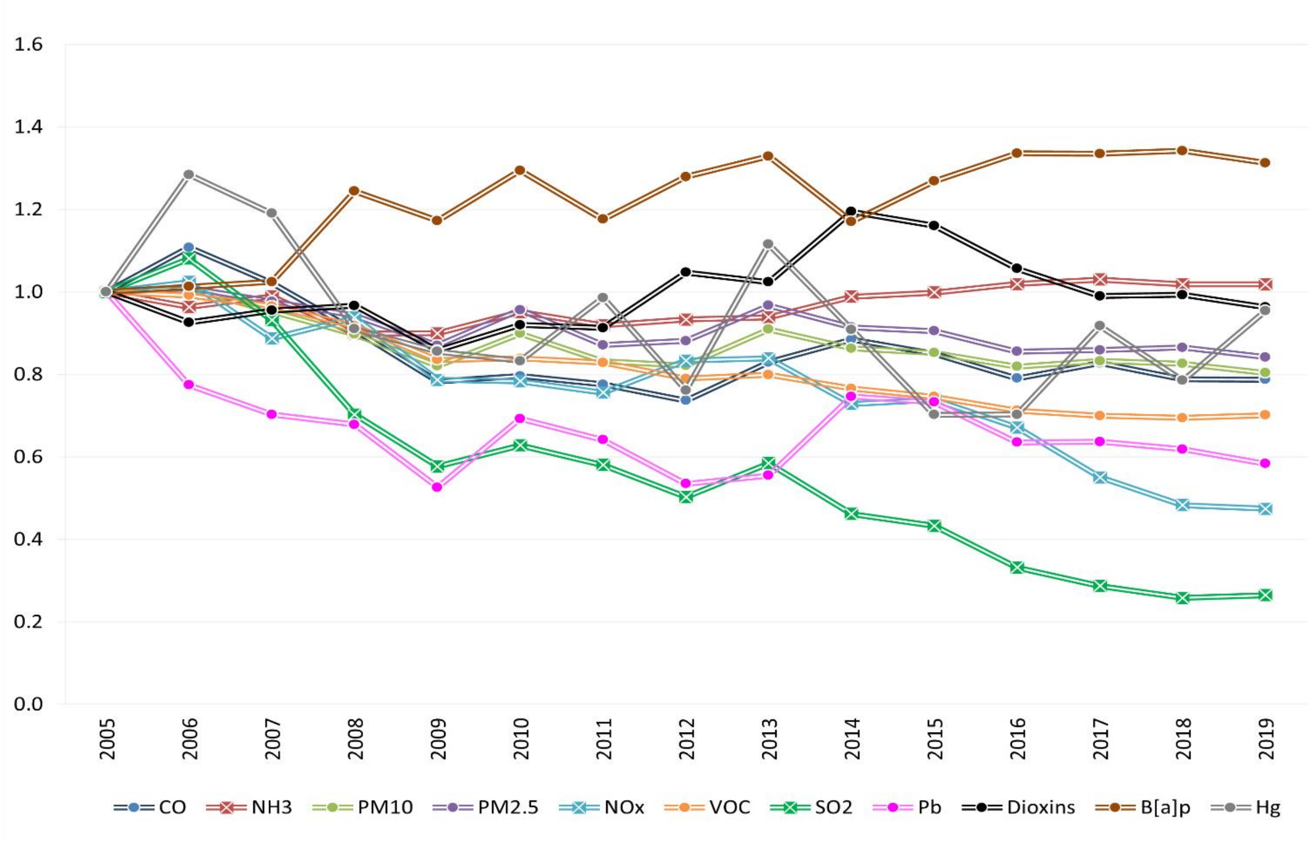
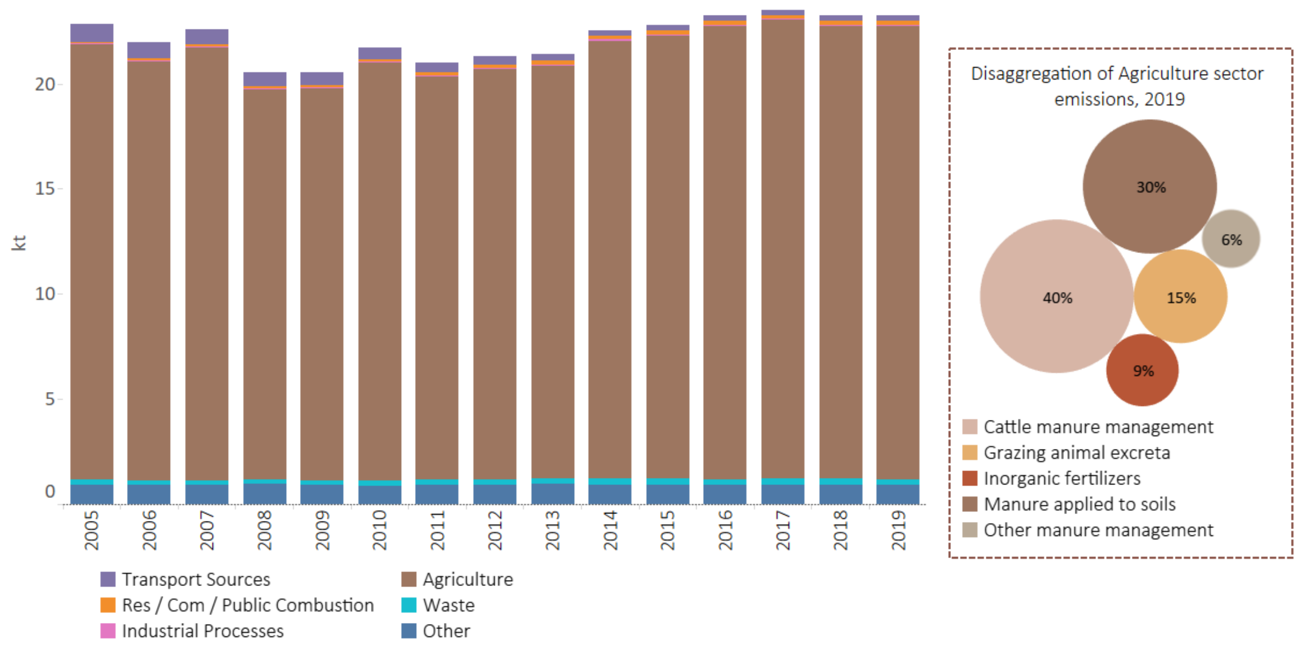
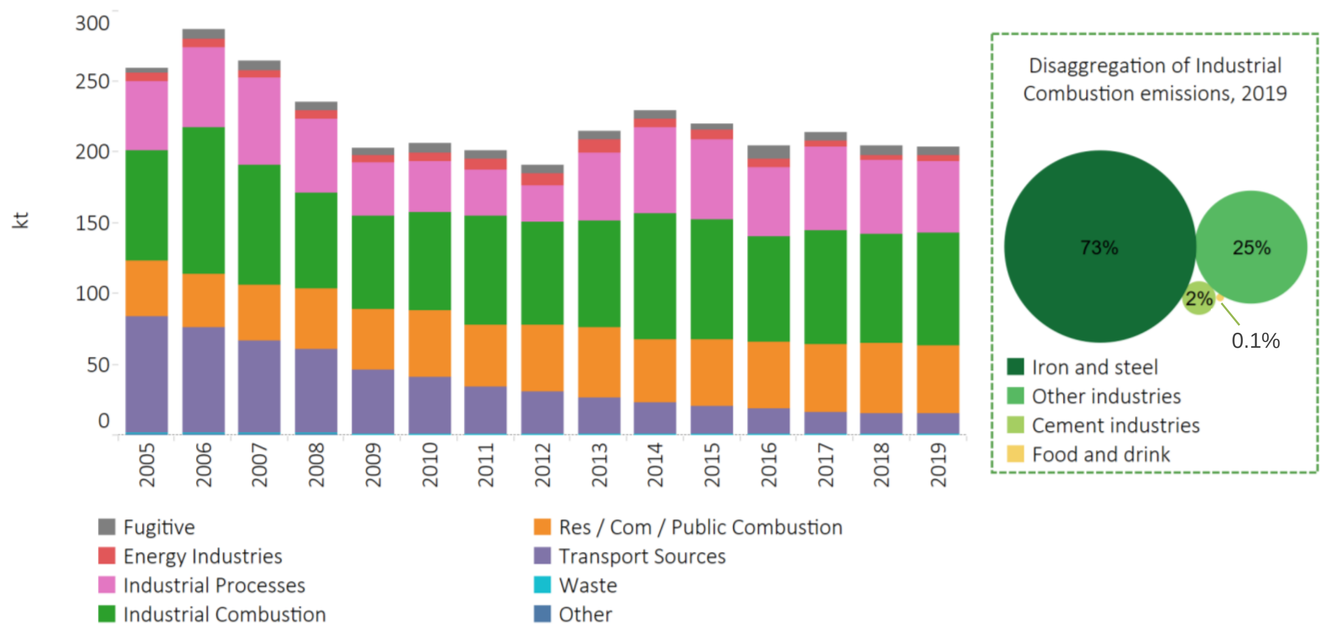


Figure 36 – Ammonia Emissions in Wales



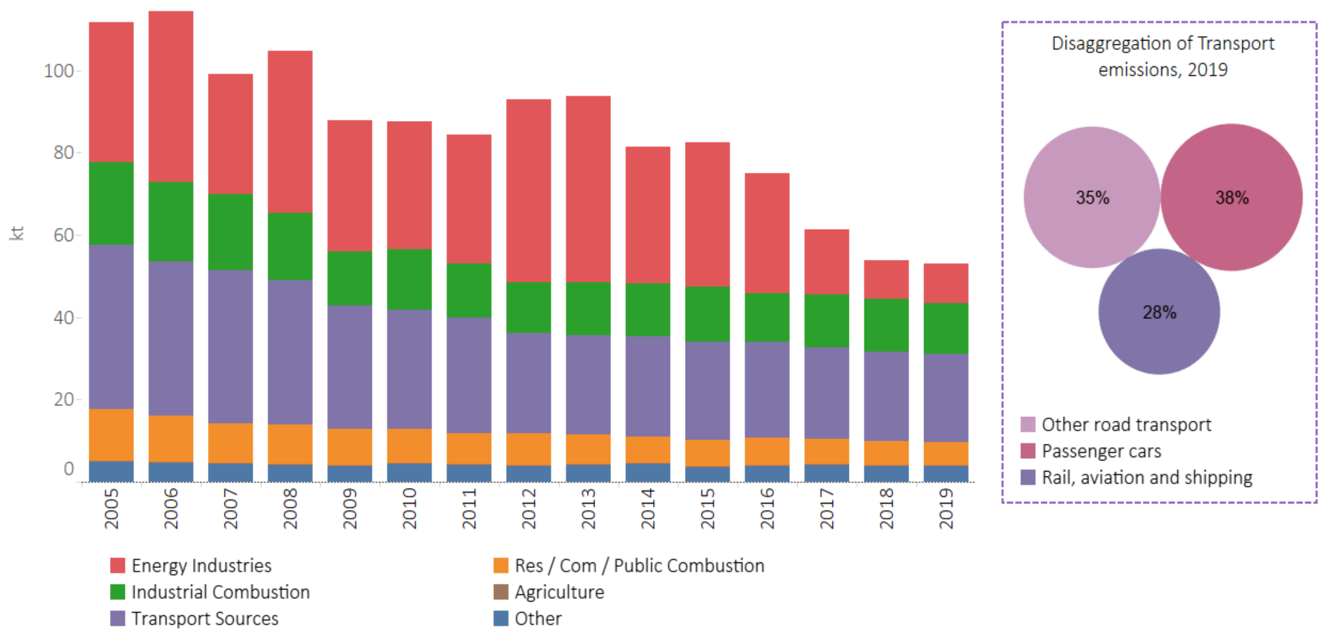
Emissions of **ammonia** in Wales were estimated to be 23kt in 2019. These emissions are at a similar level in 2019 to 2005 and account for 9% of the UK total. Agriculture sources have dominated the time series, with cattle manure management alone accounting for at least 42% of emissions throughout. Emissions increases since 2008 have been driven largely by emissions from manure management practices, particularly for dairy cattle, and from the application of urea-based fertilisers and digestate to soils. A decline in emissions from transport sources is observed since 2005: although initially implemented to target NO_X emissions from road transport, increased prevalence in improved catalytic systems has contributed to the decline in emissions of NH_3.

Figure 37 – Carbon Monoxide Emissions in Wales



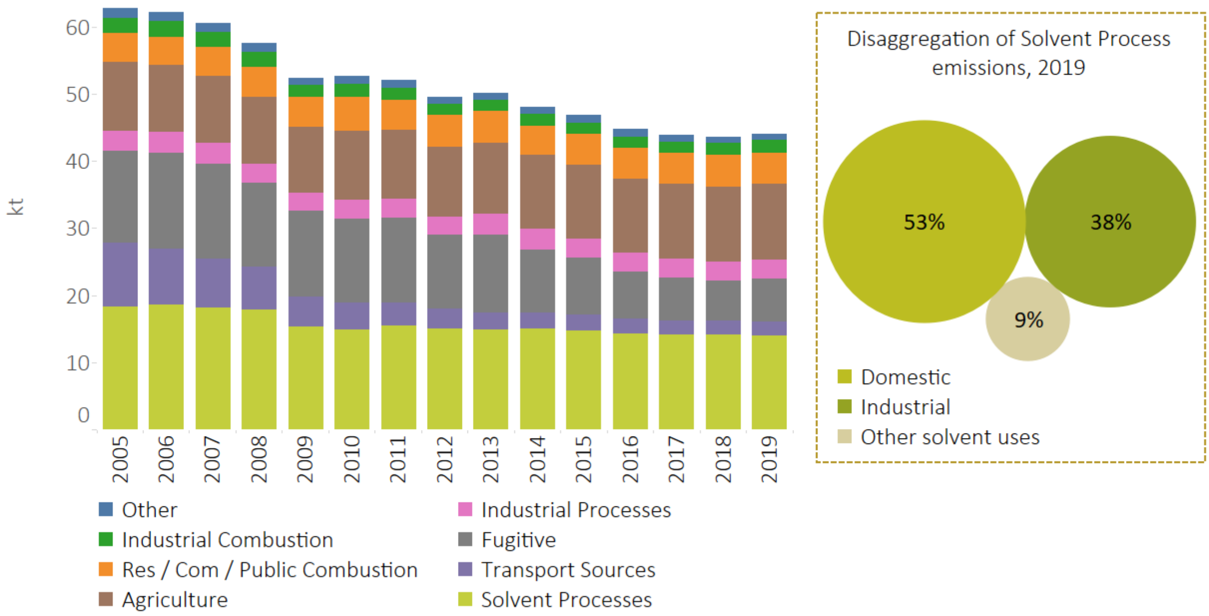
Emissions of **carbon monoxide** in Wales were estimated to be 204kt in 2019 and have declined by 21% since 2005. Emissions in Wales accounted for 13% of the UK total in 2019. This decline in emissions stems from changes in the contribution of transport sources, particularly in the road sector where emissions have declined by 86% since 2005. This decline is primarily to the penetration of vehicles compliant with more recent Euro standards, which required the fitting of emission controls (e.g. three-way catalytic converters) in new petrol vehicles. Improved catalyst repair rates resulting from regulations controlling the sale and installation of replacement catalytic converters and particle filters for light-duty vehicles in 2008 also contribute to the trend. More recently, the switch from petrol cars to diesel cars, which have lower associated CO emissions rates, has also contributed to the observed trend. In more recent years, the industrial combustion sector has been growing in importance, showing a strong relationship with levels of activity within the iron and steel industry subsector.

Figure 38 – Nitrogen Oxides Emissions in Wales



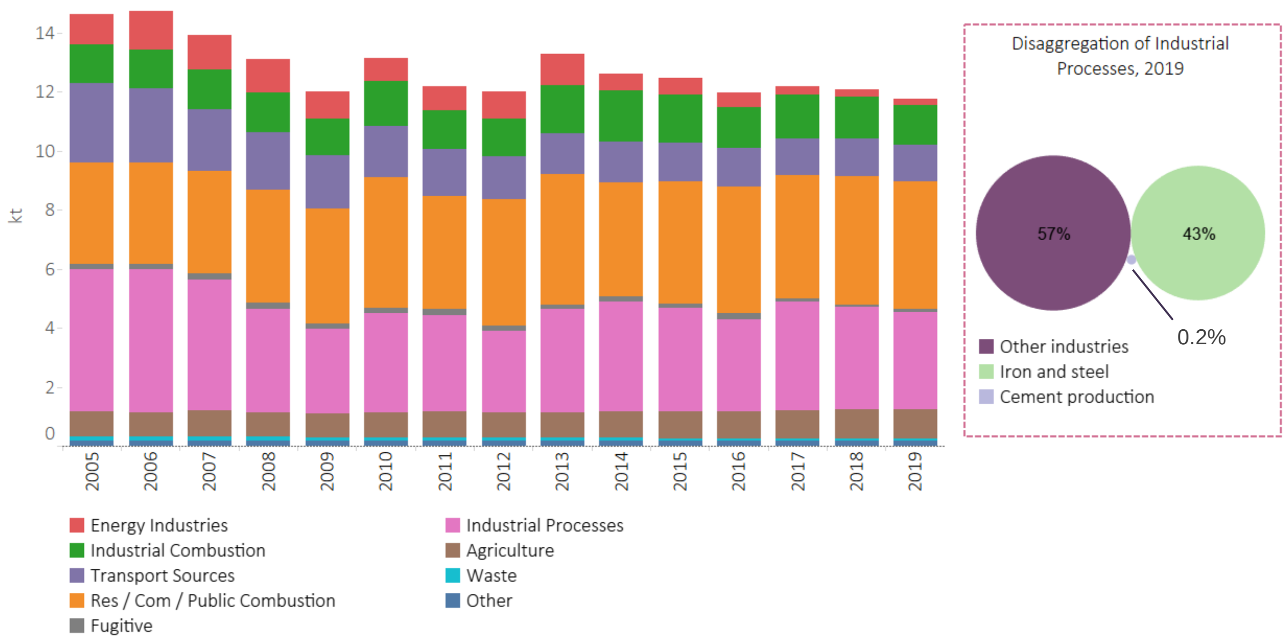
Emissions of **nitrogen oxides** in Wales were estimated to be 53kt in 2019, representing 6% of the UK total. Emissions have declined by 53% since 2005, mainly due to changes in transport sources, particularly in road transport. This decline is driven by the successive introduction of tighter Euro emission standards, and the continued penetration of vehicles which comply with these standards. In addition, improvements in catalyst repair rates resulting from regulations controlling the sale and installation of replacement catalytic converters and particle filters for light-duty vehicles contributes to the decline since 2008. However, the recent preferred uptake of diesel cars over petrol cars partly offsets these emissions reductions, because diesel cars emit higher NO_X relative to their petrol counterparts. The reduction in emissions from energy industries more recently corresponds to the reduction in coal use at Aberthaw power station since 2013, but in particular between 2017 and 2019.

Figure 39 – NMVOC Emissions in Wales



Emissions of **non-methane volatile organic compounds** in Wales were estimated to be 44kt in 2019, representing 5% of the UK total. Emissions have declined by 30% since 2005. 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 coincides with the increasing proportion of diesel-fuelled vehicles in the passenger fleet which are associated with lower emissions rates of NMVOCs. 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 in recent years, with the largest amount of emissions arising from domestic solvent applications, and to a lesser extent industrial applications.

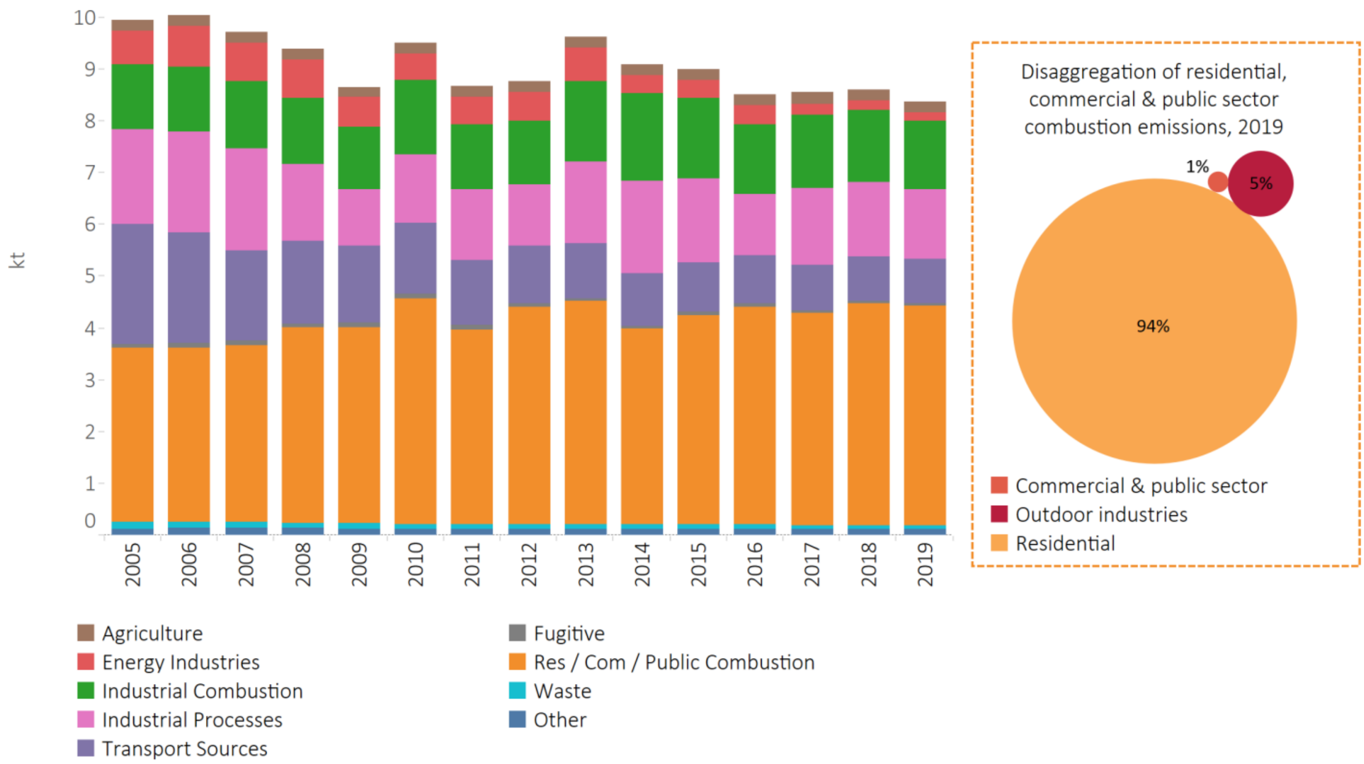
Figure 40 – PM_{10} Emissions in Wales



Emissions of PM_{10} in Wales were estimated to be 12kt in 2019 and have declined by 20% since 2005. These emissions account for 7% of the UK total in 2019. Unlike most other pollutants, the emissions profile of PM_{10} is diverse: transport sources, industrial combustion, and industrial processes each account for significant fractions of the total, although the largest individual source is residential combustion, which accounts for

35% of the 2019 total. Iron and steel process sources such as sinter plants, basic oxygen furnaces and blast furnaces, and combustion sources, account for a further 14%. Recent trends have been influenced by both of these sectors, although there is no strong variation in overall emissions since 2011. In recent years, emissions from residential, commercial and public sector combustion have increased somewhat, and this is primarily due to increasing wood fuel use in the residential sector (BEIS, 2020a)

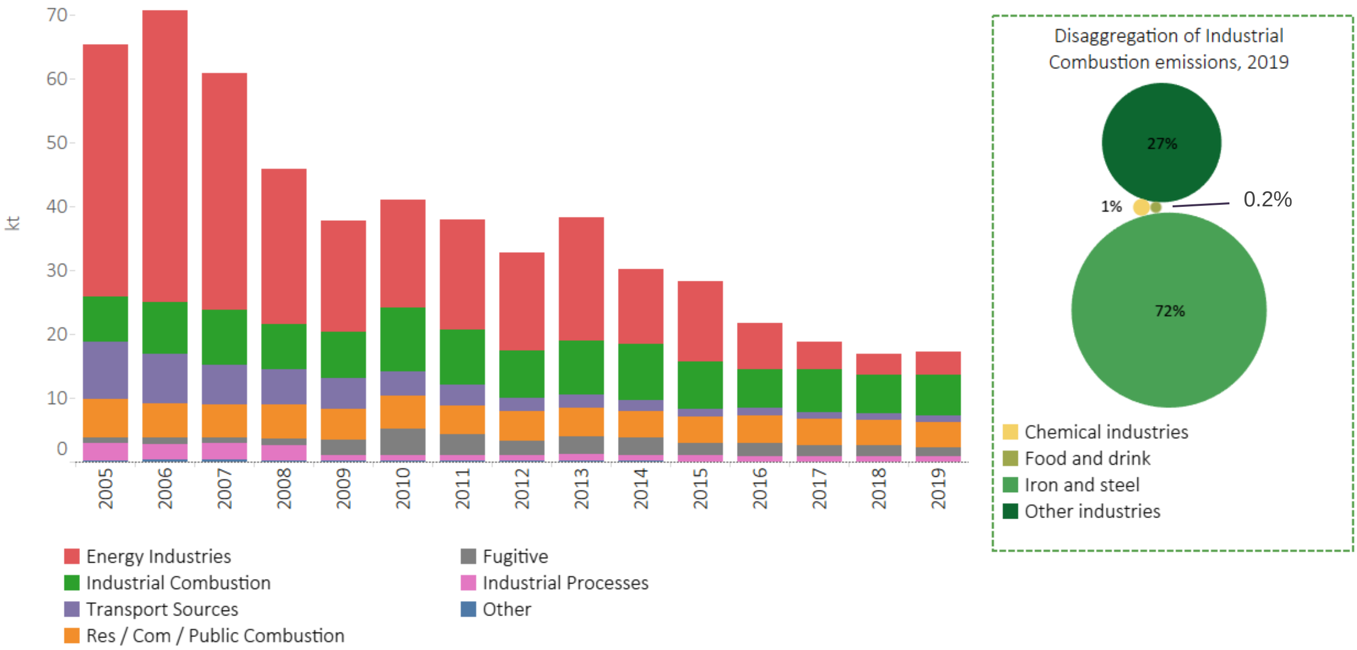
Figure 41 – $PM_{2.5}$ Emissions in Wales[6]



Emissions of **$PM_{2.5}$** in Wales were estimated to be 8kt in 2019 and have declined by 16% since 2005. These emissions account for 8% of the UK total in 2019. 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 $PM_{2.5}$, the residential, commercial, and public sector combustion category (NFR 1A4, which also includes agricultural combustion and fishing vessels) accounts for 51% of 2019 emissions. The primary declines in emissions since 2005 are the continued switch in the fuel mix used in electricity generation away from coal and towards natural gas, and reductions in emissions from the transport sector due to the turnover of the vehicle fleet, with the continued penetration of vehicles that comply with more stringent exhaust emissions standards over time. However, declines in emissions have been offset by increases in emissions from the residential sector, and in particular, the combustion of wood.

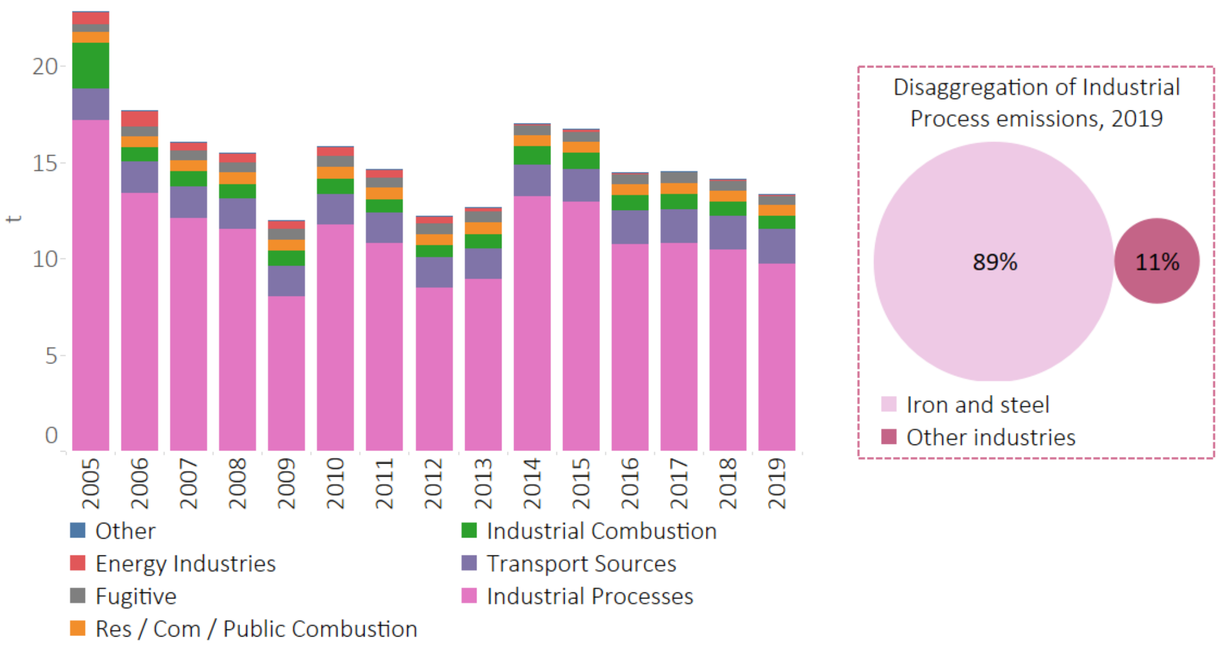
[6] Outdoor industries presented in the bubble graph relate to combustion emissions from machinery in the agriculture, forestry and fishing industries.

Figure 42 – Sulphur Dioxide Emissions in Wales



Emissions of **sulphur dioxide** in Wales were estimated to be 17kt in 2019, representing 11% of the UK total. Emissions have declined by 74% since 2005, which has been dominated by reductions in energy industries emissions. This reduction coincides with the continued 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** in Wales were estimated to be 13 tonnes in 2019, representing 14% of the UK total. Emissions have declined by 42% since 2005 due to reductions within industrial processes. However, it remains the most substantive source of emissions, particularly as a result of metal production - 89% of emissions from industrial processes are produced from the iron and steel industry. The importance of the sector to overall emissions means that the volatility in levels of production at Port Talbot steelworks play a primary role in dictating interannual trends, particularly in recent years where emissions have been highly variable.

Table 4 below provides a summary of the percentage contribution of each sector for each pollutant in 2019. 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 2019

Sector	NH_3	CO	NO_X	VOC	PM_{10}	$PM_{2.5}$	SO_2	Pb	B[a]p	Dioxins	Hg
Agriculture	92.7%	0.0%	0.2%	25.8%	8.3%	2.7%	0.0%	0.0%	0.0%	0.0%	0.0%
Energy Industries	0.0%	2.1%	18.2%	0.0%	1.8%	1.9%	21.1%	0.4%	0.3%	0.7%	2.7%
Fugitive	0.0%	3.0%	0.0%	14.6%	0.9%	0.6%	8.7%	3.5%	7.9%	0.0%	0.0%
Industrial Combustion	0.0%	39.0%	23.3%	4.1%	11.5%	15.7%	36.7%	5.3%	0.0%	5.3%	17.0%
Industrial Processes	0.2%	24.9%	0.0%	6.2%	28.0%	16.1%	4.2%	73.0%	2.1%	56.2%	64.7%
Residential, Commercial & Public Sector Combustion	0.9%	23.5%	10.7%	10.6%	36.8%	50.5%	23.1%	4.2%	86.2%	24.6%	4.0%
Solvent Processes	0.0%	0.0%	0.0%	31.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Transport Sources	1.0%	7.0%	40.1%	4.7%	10.6%	10.3%	5.8%	13.5%	1.2%	1.2%	2.4%
Waste	1.2%	0.2%	0.0%	0.0%	0.8%	1.0%	0.0%	0.0%	2.0%	11.4%	8.5%
Other	4.0%	0.3%	7.5%	2.1%	1.4%	1.3%	0.5%	0.1%	0.4%	0.6%	0.6%

* 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 30**.

Figure 44 – Ammonia Emissions in Wales, 2019

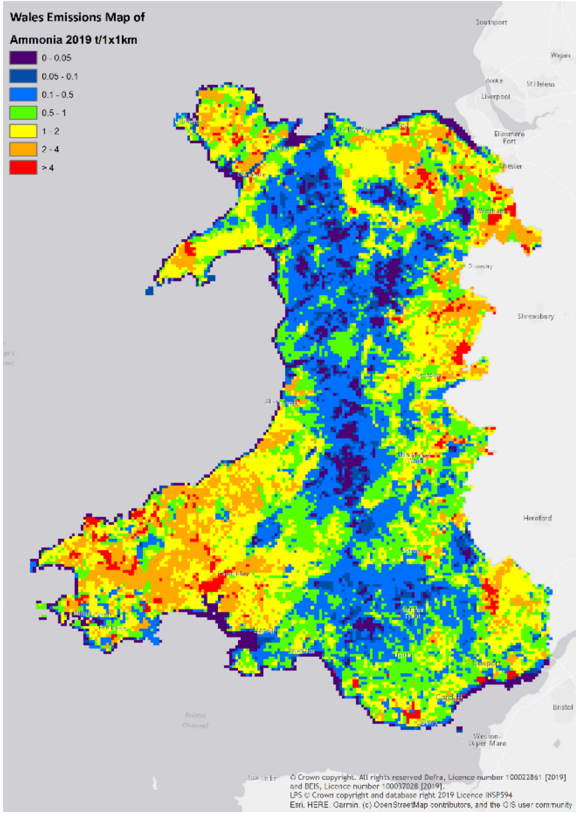


Figure 45 – Carbon Monoxide Emissions in Wales, 2019

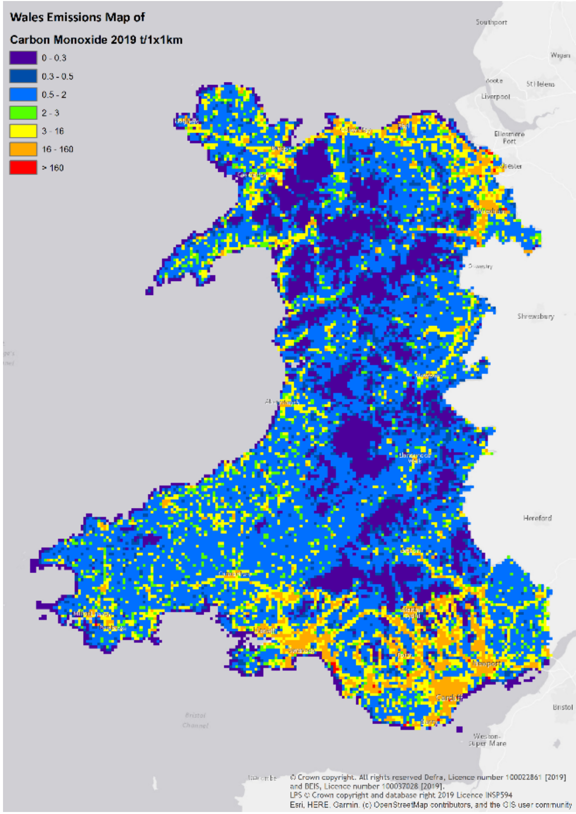


Figure 46 – Nitrogen Oxides Emissions in Wales, 2019

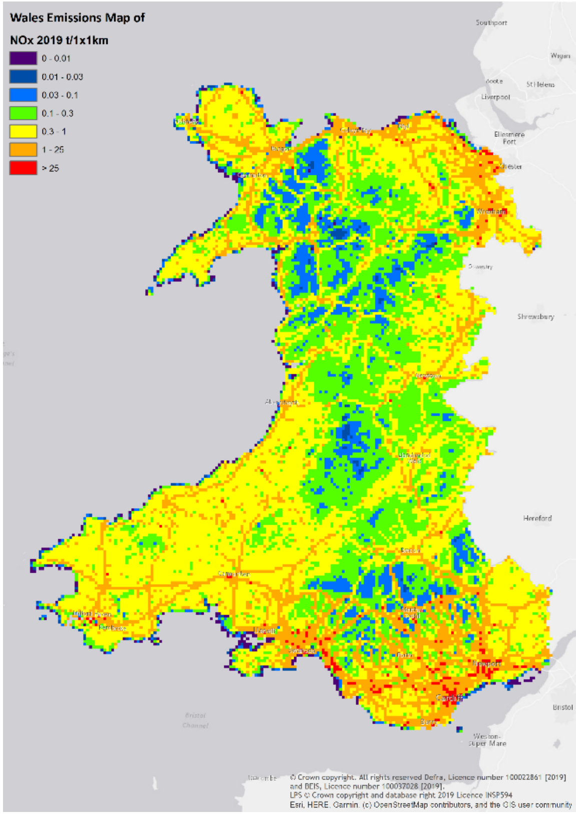


Figure 47 – NMVOC Emissions in Wales, 2019

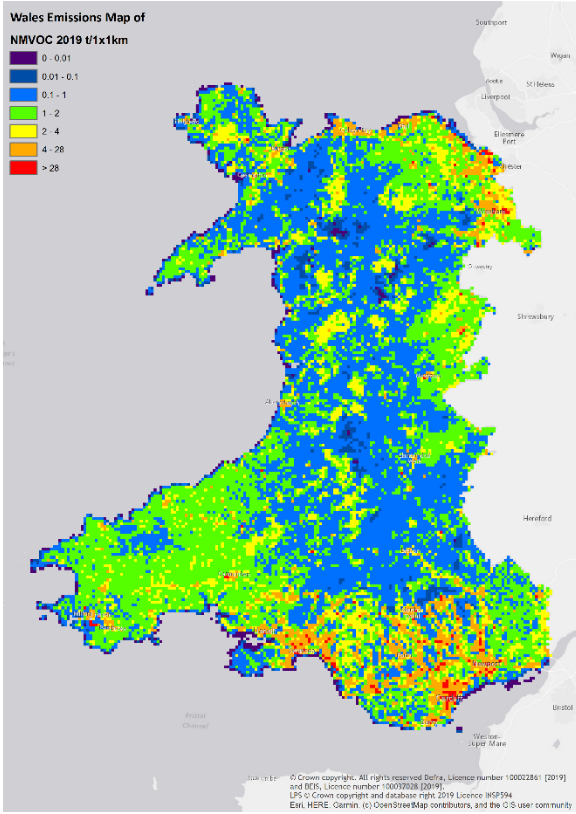


Figure 48– PM_{10} Emissions in Wales, 2019

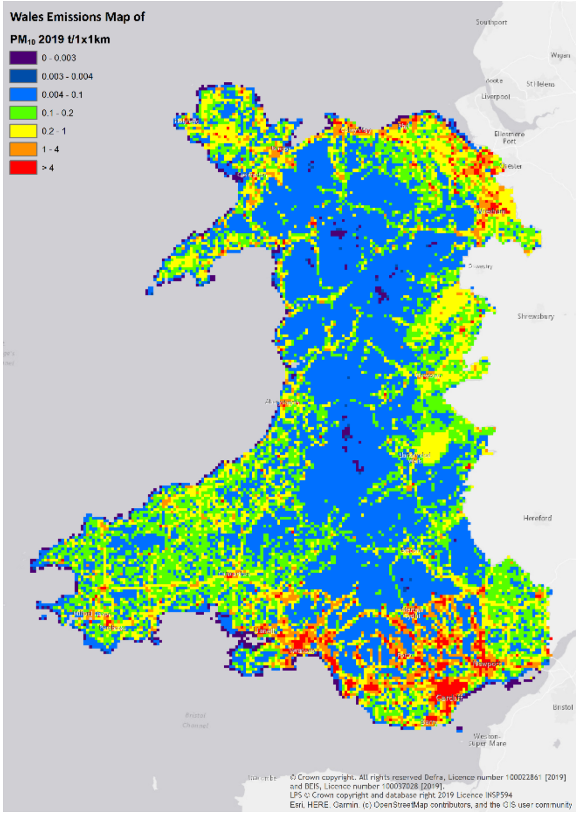


Figure 49 – $PM_{2.5}$ Emissions in Wales, 2019

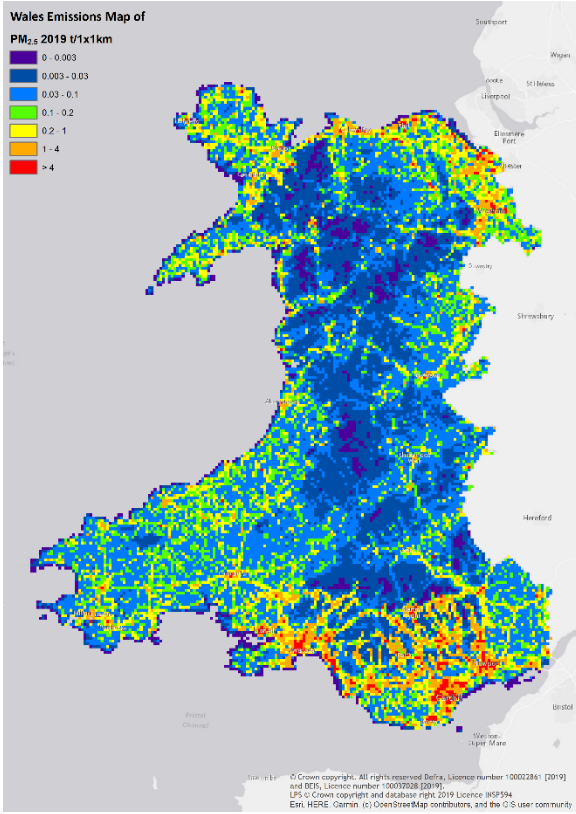


Figure 50 – Lead Emissions in Wales, 2019

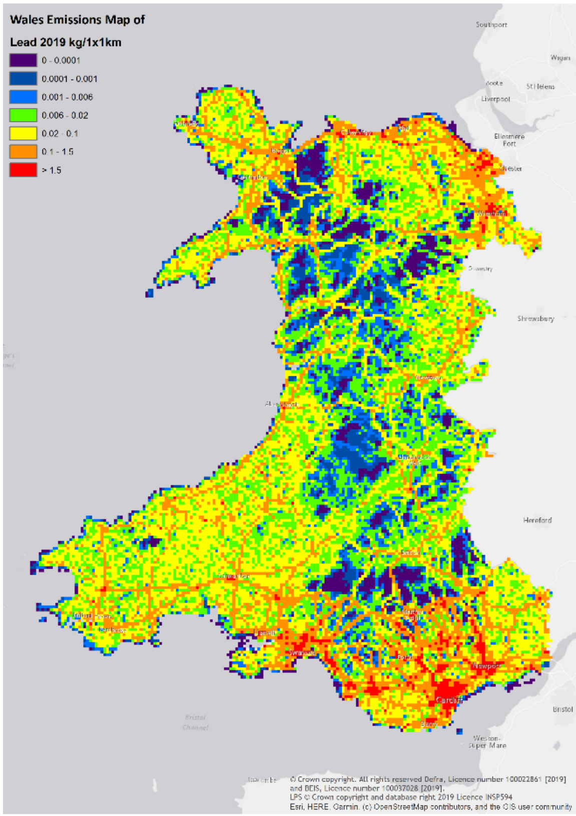
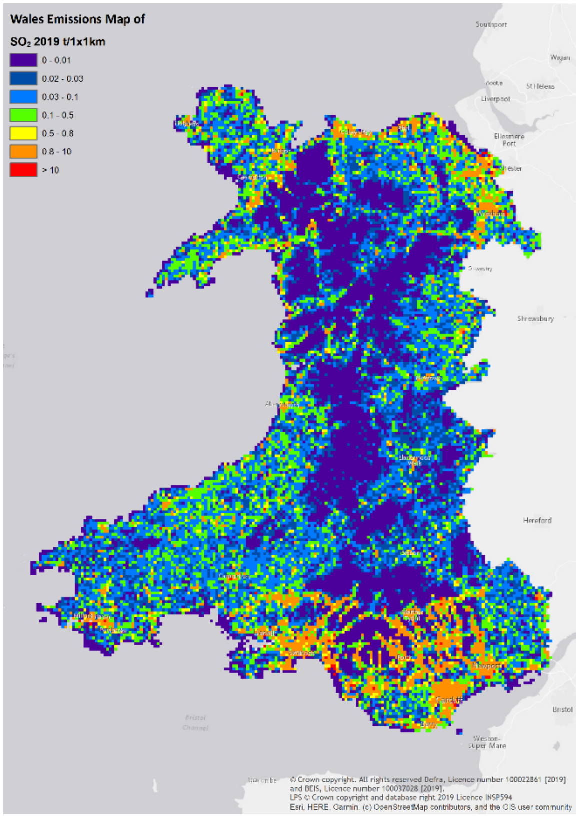


Figure 51 – Sulphur Dioxide Emissions in Wales, 2019



2.4 Northern Ireland

The following section provides a summary of emissions in Northern Ireland for the eight priority air pollutants: NH_3, CO, NO_X, NMVOCs, PM_{10}, $PM_{2.5}$, SO_2, and Pb. Information is also presented for emissions of PCDD/Fs, B[a]p, and Hg, with more detailed information for these three pollutants presented in **Appendix C.2**. Emissions of PCDD/Fs, B[a]p, and Hg should be considered as experimental statistics only[3]. **Appendix F** presents the DA inventory data summary tables, whilst **Appendix G** presents source category mapping used in the report**.**

Figure 52 shows emissions of all eleven air pollutants normalised to provide the relative rate of decline since 2005. This graph shows that most pollutant levels are lower in 2019 than they were in 2005. The greatest rate of decline is observed in the trend for SO_2 with more modest declines observable for NO_X and CO. Reductions in in SO_2 since 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 that enabled fuel switching away from coal and oil-fired generation (BEIS, 2020b). NH_3 emissions, by contrast, have increased since 2010 due to rising dairy cattle numbers, and hence emissions from manure management practices for these animals, and also from the spreading of cattle manure to agricultural soils. In addition, there has been an increase in other nitrogen-based fertiliser use, primarily urea-based and digestate fertilisers. The trend for B[a]p is dominated by changes in emissions from domestic combustion, and in particular the growing use of wood as a fuel.

Figure 52 – Northern Ireland normalised trends for all pollutants

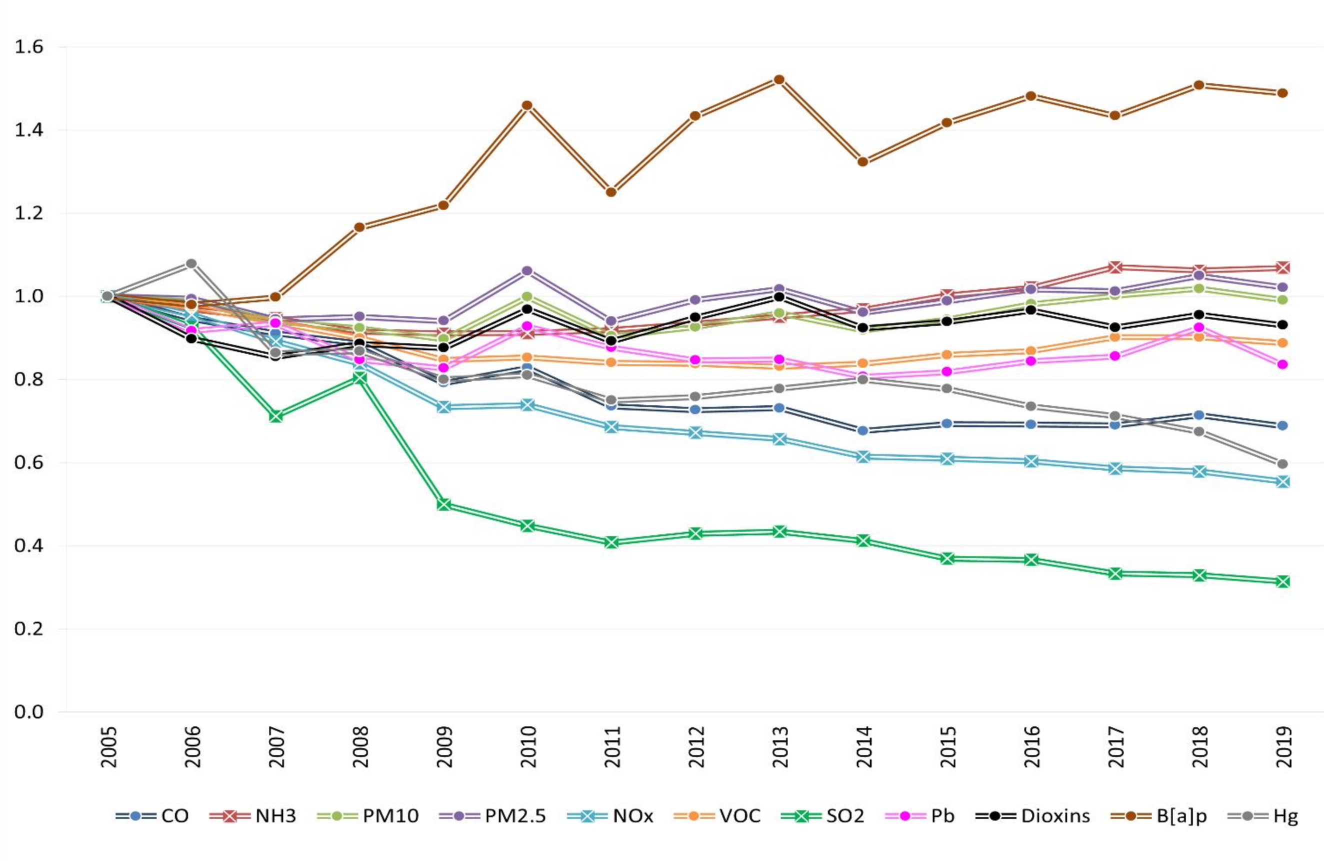
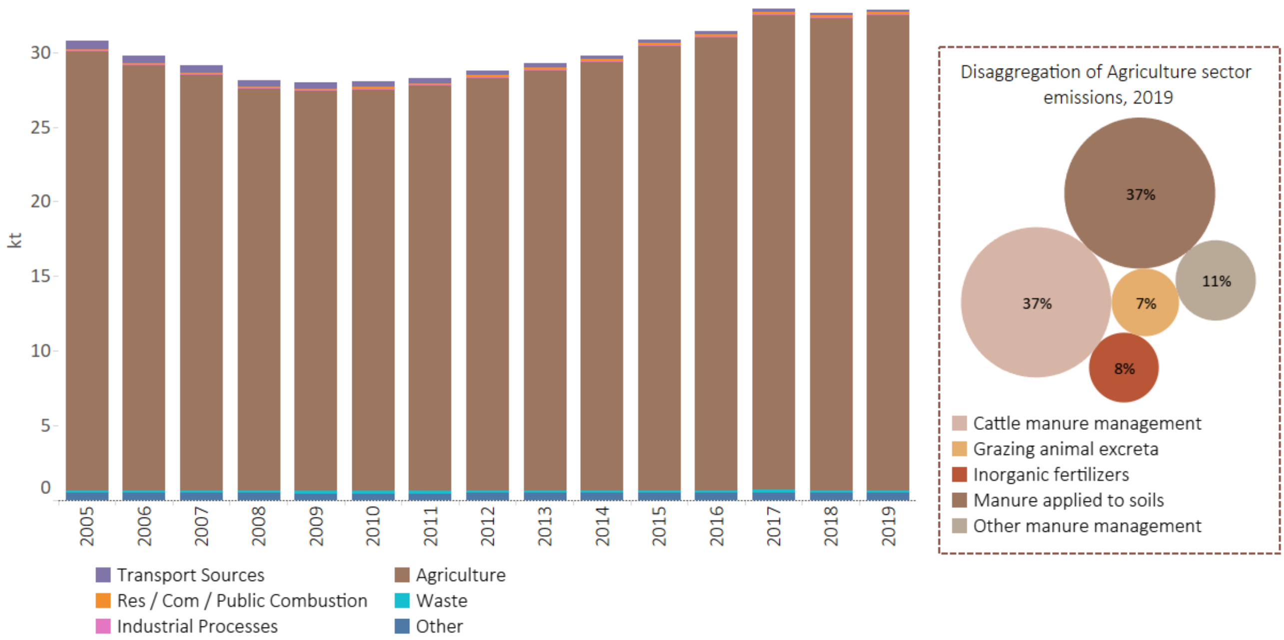
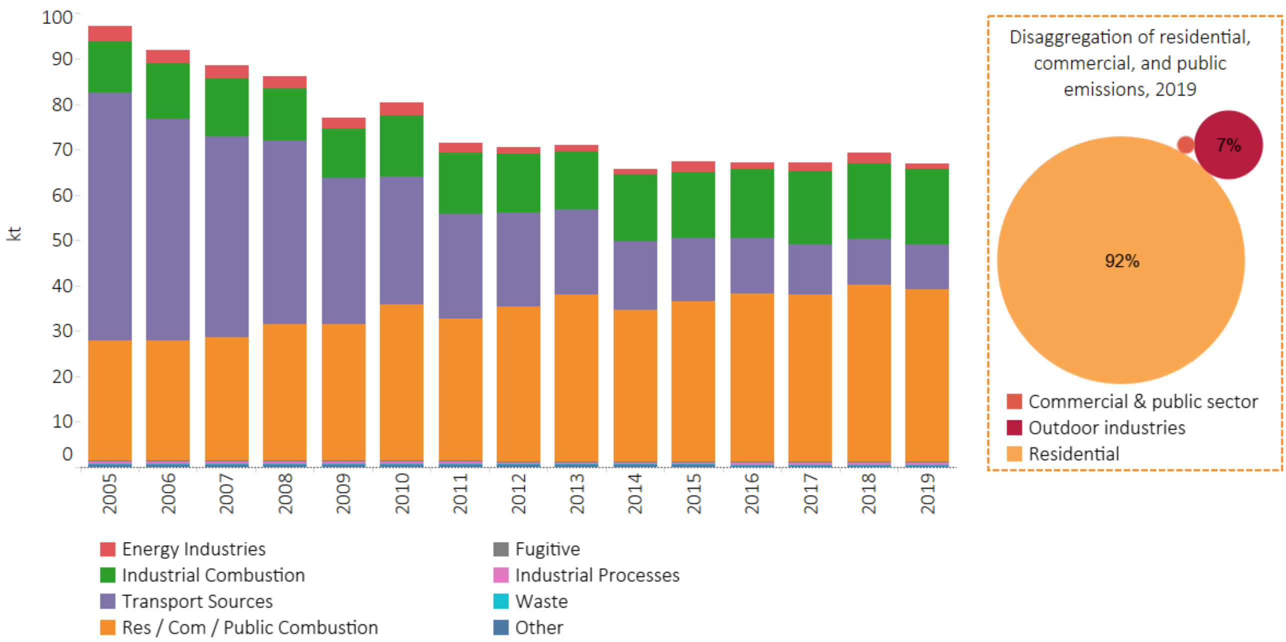


Figure 53 – Ammonia Emissions in Northern Ireland



Emissions of **ammonia** in Northern Ireland were estimated to be 33kt in 2019. Emissions have increased overall by 7% since 2005 and account for 12% of the UK total in 2019. Agriculture sources have dominated the inventory throughout the time series, with cattle manure management accounting for at least 45% of the emissions from this sector. NH_3 emissions have increased since 2011 largely due to increasing dairy cow numbers and emissions associated with dairy manure management. Since 2017, the trend has plateaued, however, with slight declines in dairy cattle numbers and in mineral fertiliser use being offset by an increase in poultry numbers.

Figure 54 – Carbon Monoxide Emissions in Northern Ireland[7]

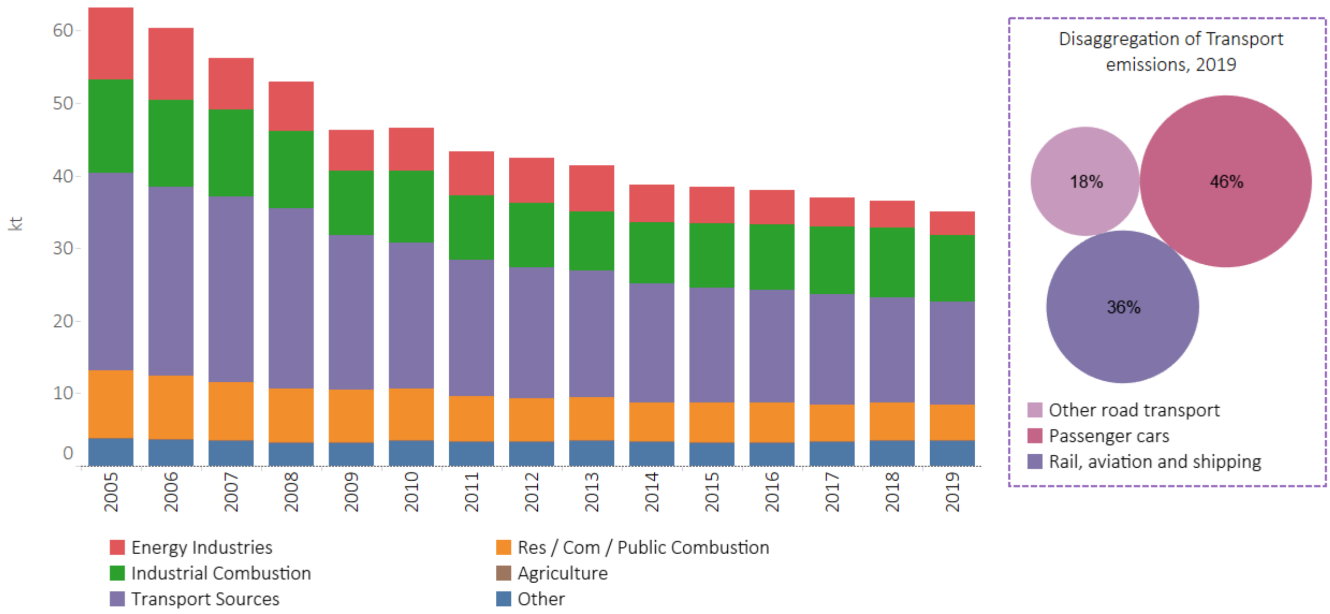


Emissions of **carbon monoxide** in Northern Ireland were estimated to be 67kt in 2019 and have declined by 31% since 2005. Emissions in Northern Ireland accounted for 4% of the UK total in 2019. The decline in emissions stems largely from trends in residential combustion and from transport sources, particularly road transport. The decline is driven by the continuation and development of Euro standards first introduced in

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

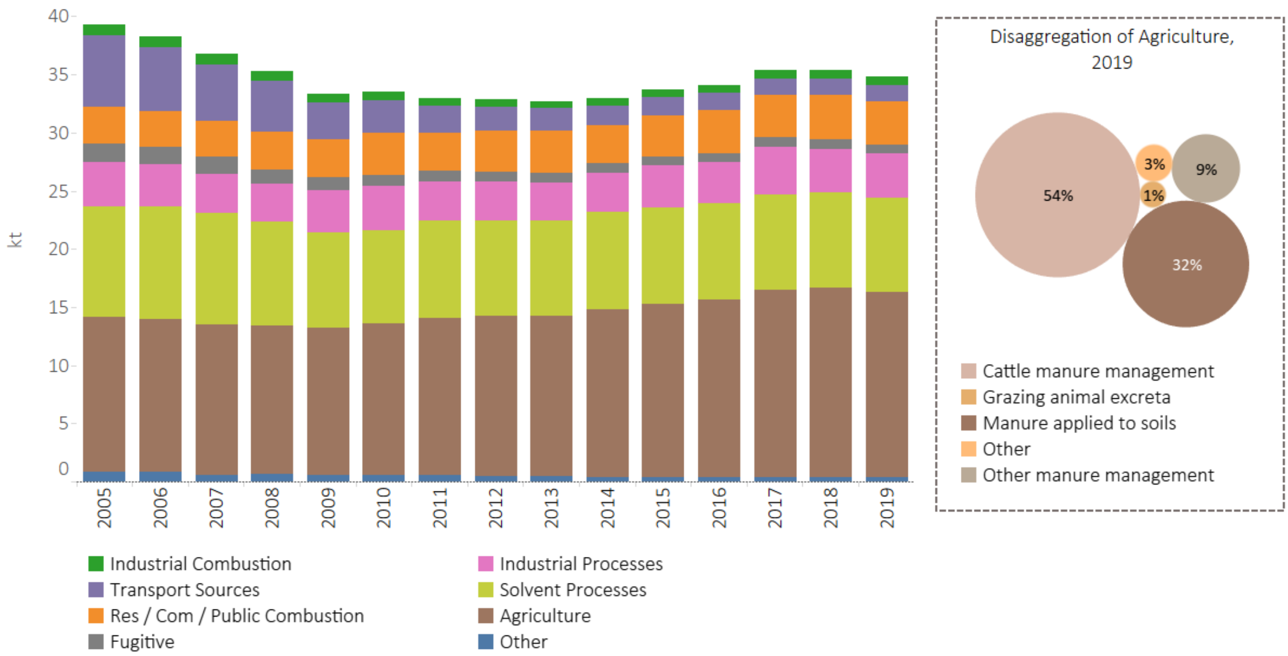
1992 which requires fitting of emission controls (e.g. three-way catalytic converters) in new vehicles. Emissions from petrol vehicles, associated with higher emissions rates of CO, have been most impacted by these regulations. The more recent preference of diesel cars over petrol cars has further led to an decline in CO emissions from the transport sector. Finally, improvements in catalyst repair rates resulting from the introduction of regulations controlling the sale and installation of replacement catalytic converters and particle filters in light-duty vehicles, dictated by regulation from 2008, have contributed to a further decline. In all, emissions from the road transport sector have declined by 85% since 2005. The impact of the expansion of the gas network in Northern Ireland in the early part of the time series is overshadowed by increases in the quantity of wood burned in the residential sector (BEIS, 2020a), which is behind a 50% increase in emissions since 2005 (from NFR sector 1A4b).

Figure 55 - Nitrogen Oxides Emissions in Northern Ireland



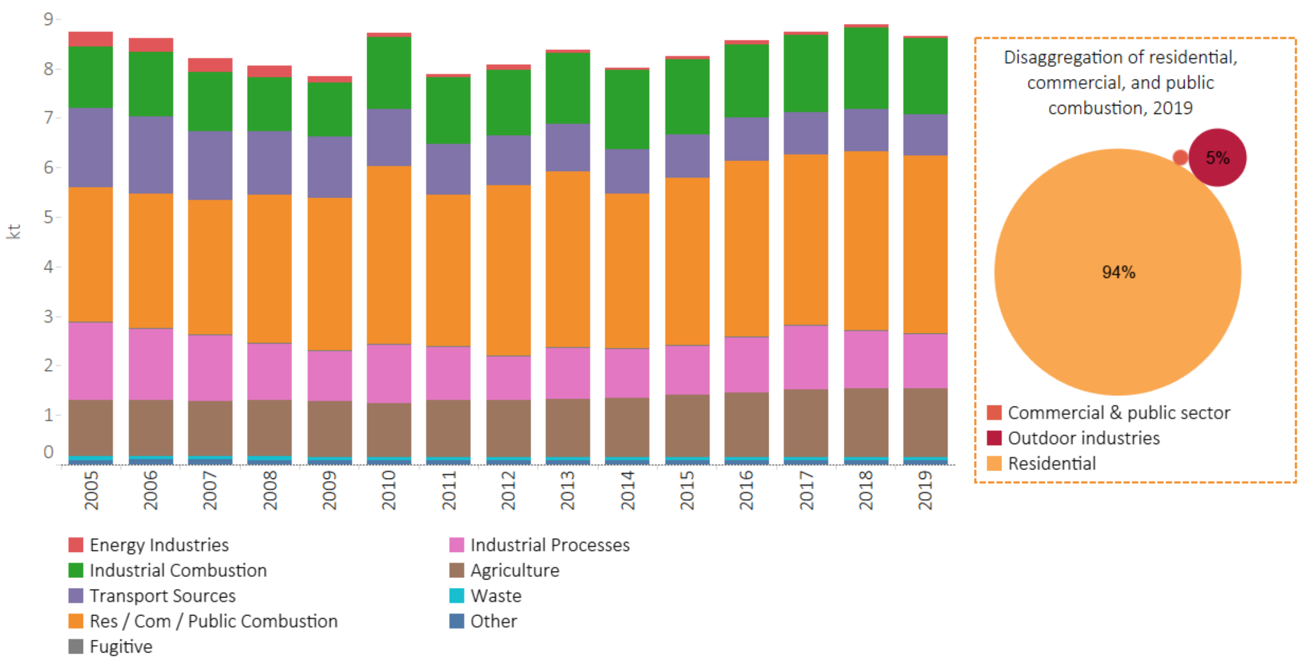
Emissions of **nitrogen oxides** in Northern Ireland were estimated to be 35kt in 2019, representing 4% of the UK total. Emissions have declined by 45% since 2005, principally due to changes in transport sources, particularly in road transport. The successive introduction of tighter exhaust emission standards for vehicles over the past few decades, and the associated penetration of vehicles that comply with these standards into the fleet. In addition, 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 recent preferential uptake of diesel cars over petrol counterparts works to offset these reductions, as diesel cars are association with higher NO_X emissions rates. Energy industries have also had a notable impact on the trend, due to the implementation of abatement technologies, and, more recently, the reductions in the amount of coal used as operations at Kilroot power station begin to phase down.

Figure 56 – NMVOC Emissions in Northern Ireland



Emissions of **non-methane volatile organic compounds** in Northern Ireland were estimated to be 35kt in 2019, representing 4% of the UK total. Emissions have declined by 11% since 2005 driven by reductions in the transport sector in the early portion of the time series. This decline is coincident with the increasing proportion of diesel fuelled vehicles in the passenger fleet and improved fuel economy. Whilst transport emissions continually decreased across the time series, annual reductions slowed after 2012. The reduction in emissions also occurs to a lesser extent due to the introduction of petrol vapour recovery systems at filling stations. Agriculture is the most important source of NMVOC emissions, more specifically emissions from cattle manure management. Emissions from agriculture have increased across the time series and accounted for 46% of total NMVOC emissions in 2019.

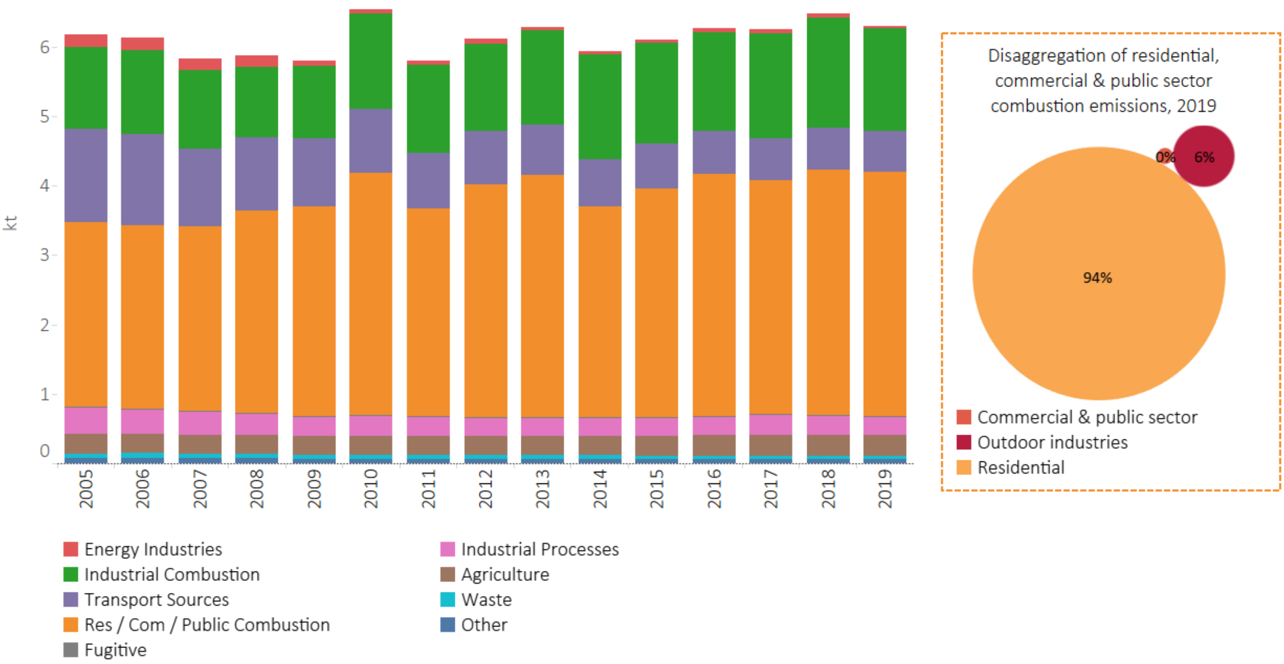
Figure 57 – PM_{10} Emissions in Northern Ireland[7]



Emissions of **PM_{10}** in Northern Ireland were estimated to be 8.7kt in 2019 and accounted for 5.1% of the UK total. Emissions have declined by 0.9% since 2005. PM_{10} exhaust emissions from vehicles have been decreasing due to the successive introduction of tighter emission standards over time, while non-exhaust

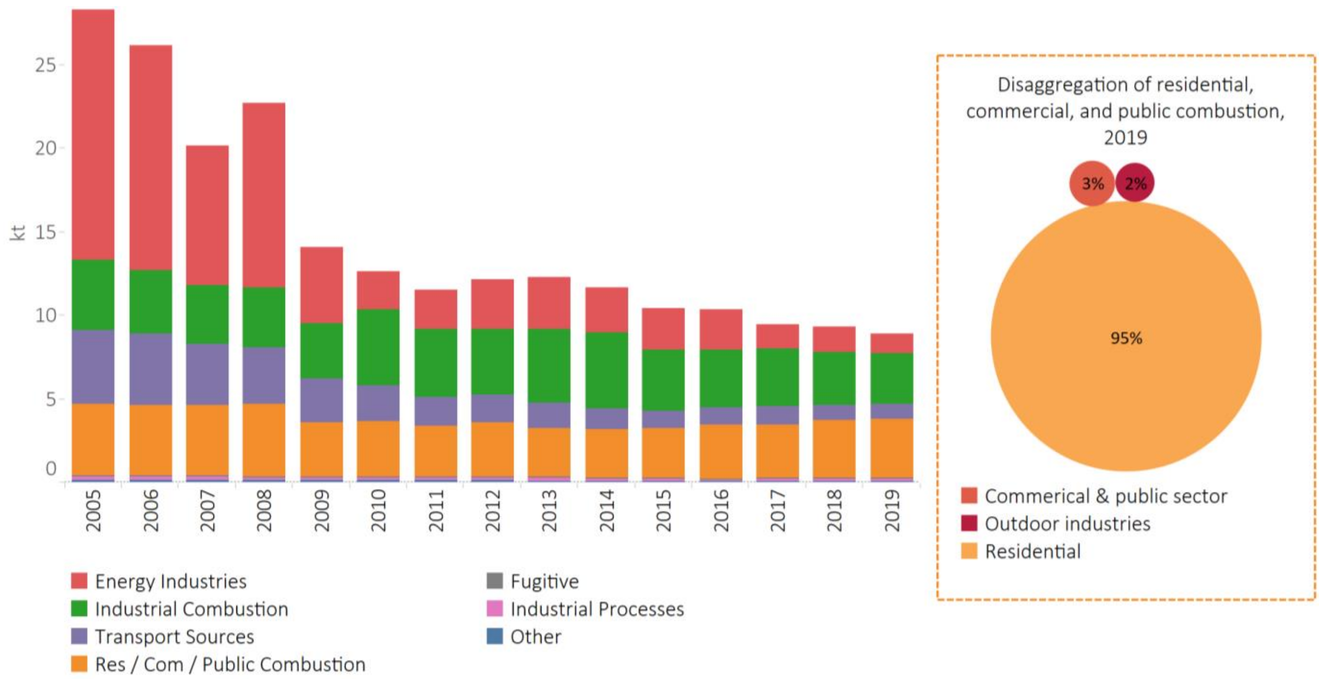
PM_{10} emissions from vehicles have been increasing due to increasing traffic activity. In recent years, emissions from residential, commercial and public sector combustion have primarily increased coincident with increasing wood fuel use in the residential sector (BEIS, 2020a). These two trends offset one another meaning that there is no major trend in PM_{10} emissions across the time series.

Figure 58 - $PM_{2.5}$ Emissions in Northern Ireland[7]



Emissions of **$PM_{2.5}$** in Northern Ireland were estimated to be 6.3kt in 2019 and accounted for 5.8% of the UK total. Emissions have increased 2.1% since 2005. 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 combustion alone accounts for 54% of 2019 emissions. Emissions from transport have decreased 57% since 2005, due to progressively more stringent exhaust emissions standards over time. However, declines in emissions have been offset by increases in emissions from the residential sector, and in particular, the combustion of wood, as described for the coarser PM fraction, PM_{10}.

Figure 59 – Sulphur Dioxide Emissions in Northern Ireland



Emissions of **sulphur dioxide** in Northern Ireland were estimated to be 8.9kt in 2019, representing 5.4% of the UK total. Emissions have declined by 69% since 2005, which has been dominated by the 92% reduction in power station emissions due to the introduction of CCGT (Combined Cycle Gas Turbine) plants, which are more efficient than conventional coal and oil power 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. SO_2 emissions from road transport have also declined, coincident with the reduced sulphur content of road fuels, both petrol and diesel.

Figure 60 – Lead Emissions in Northern Ireland

Emissions of **lead** in Northern Ireland were estimated to be 3.4 tonnes in 2019, representing 3.7% of the UK total. The most important sources of emissions are industrial combustion and transport sources, which account for 31% and 39% of the 2019 Northern Ireland total, respectively. Transport source emissions have been increasing since the baseline in 2005 due to increases in vehicle traffic on the roads. Non-exhaust emissions (such as brake wear and tyre wear) are related to the vehicle-kilometres driven, and unlike exhaust emissions, are unregulated. Therefore, the trend in road transport emissions is a reflection of the vehicle-kilometres driven on Northern Ireland's roads. Since 2005, emissions of Pb from non-exhaust road transport source have increased by 9%. Emissions from the industrial combustion sector show a high degree of volatility across the time series, particularly from unallocated sectors (NFR sector 1A2gviii) and is driven by the interannual variation in the use of fuels associated with high levels of Pb emissions, such as wood and municipal solid waste (MSW).

Table 5 below provides a summary of the percentage contribution of each sector for each pollutant in 2019. The table is shaded according to the overall contribution of that sector to the pollutant total. The table indicates that the residential, commercial & public combustion sector is a substantial sector when considering emissions for CO, B[a]p, Dioxins, 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 important when considering all pollutants, it becomes more important when considering emissions of NMVOCs.

Table 5 – Source Emission Contributions Ranked by Sector, Northern Ireland 2019

Sector	NH_3	CO	NO_X	VOC	PM_{10}	$PM_{2.5}$	SO_2	Pb	B[a]p	Dioxins	Hg
Agriculture	96.9%	0.0%	0.3%	45.7%	16.1%	4.7%	0.0%	0.0%	0.0%	0.0%	0.0%
Energy Industries	0.0%	1.8%	9.2%	0.0%	0.5%	0.6%	13.2%	1.7%	0.2%	0.4%	10.6%
Fugitive	0.0%	0.0%	0.0%	2.1%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Industrial Combustion	0.0%	24.7%	26.1%	2.2%	17.8%	23.6%	33.8%	39.4%	0.0%	19.2%	46.9%
Industrial Processes	0.0%	0.8%	0.0%	11.0%	12.7%	4.2%	2.3%	10.7%	0.2%	0.5%	6.4%
Residential, Commercial & Public Sector Combustion	0.5%	57.1%	14.1%	10.8%	41.5%	55.7%	40.0%	13.8%	96.7%	62.9%	16.1%
Solvent Processes	0.0%	0.0%	0.0%	23.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Transport Sources	0.5%	14.7%	40.5%	4.0%	9.7%	9.3%	10.2%	34.2%	1.0%	2.5%	7.8%
Waste	0.5%	0.4%	0.0%	0.0%	0.6%	0.8%	0.0%	0.0%	1.6%	14.3%	12.1%
Other	1.5%	0.5%	9.8%	1.0%	1.0%	1.0%	0.6%	0.1%	0.4%	0.2%	0.1%

* 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 30**.

Figure 61 – Ammonia Emissions in Northern Ireland, 2019

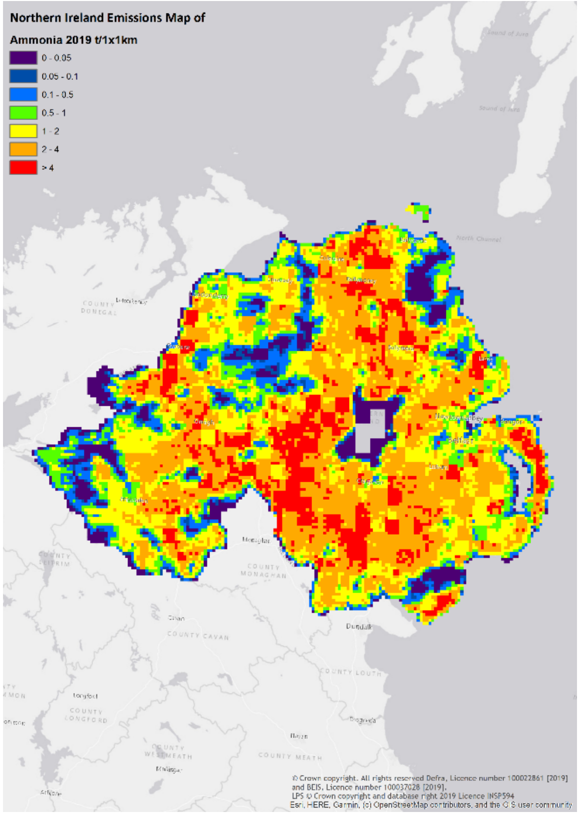


Figure 62 – Carbon Monoxide Emissions in Northern Ireland, 2019

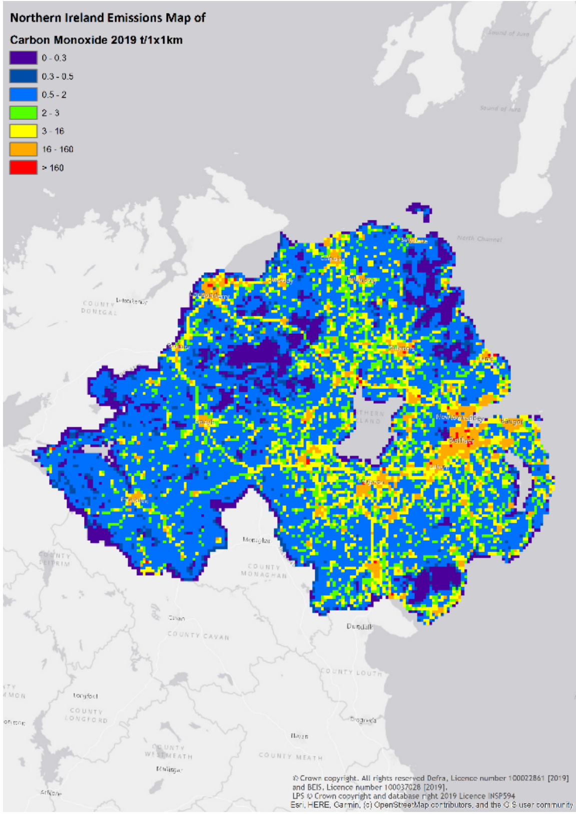


Figure 63 – Nitrogen Oxides Emissions in Northern Ireland, 2019

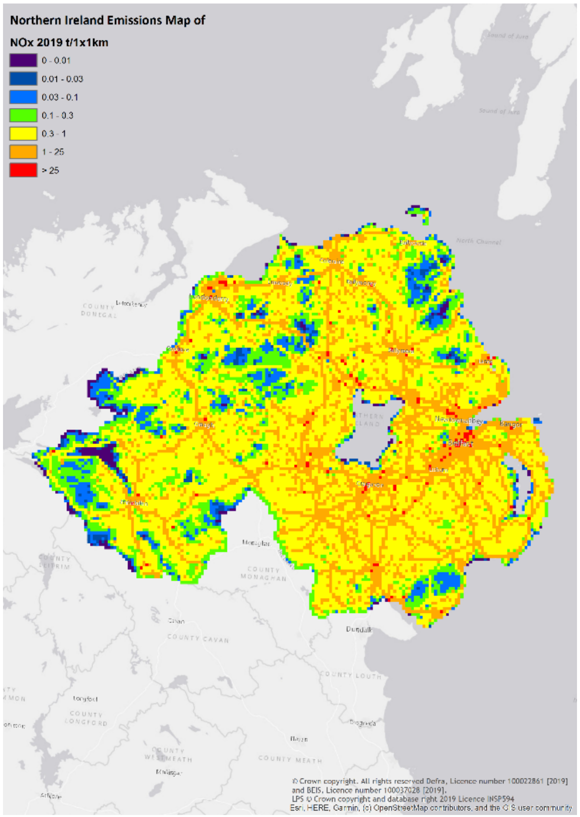


Figure 64 – NMVOC Emissions in Northern Ireland, 2019

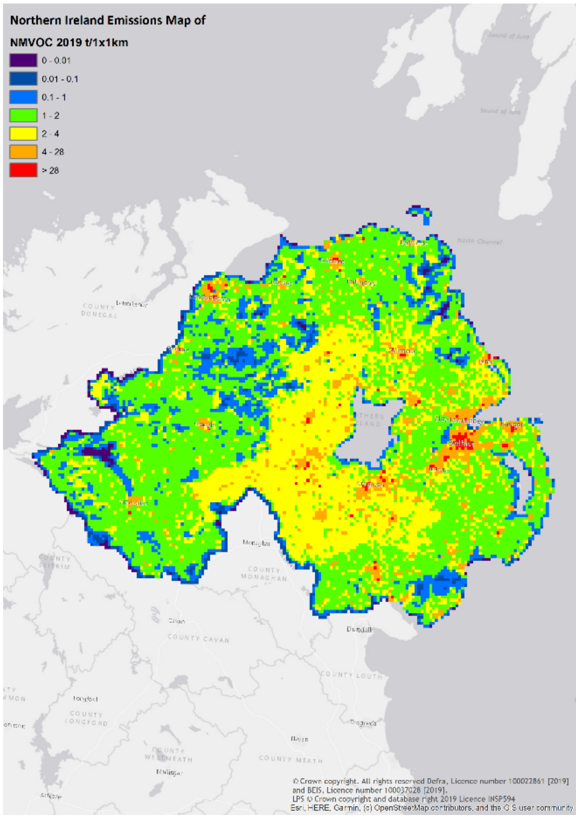


Figure 65 – PM_{10} Emissions in Northern Ireland, 2019

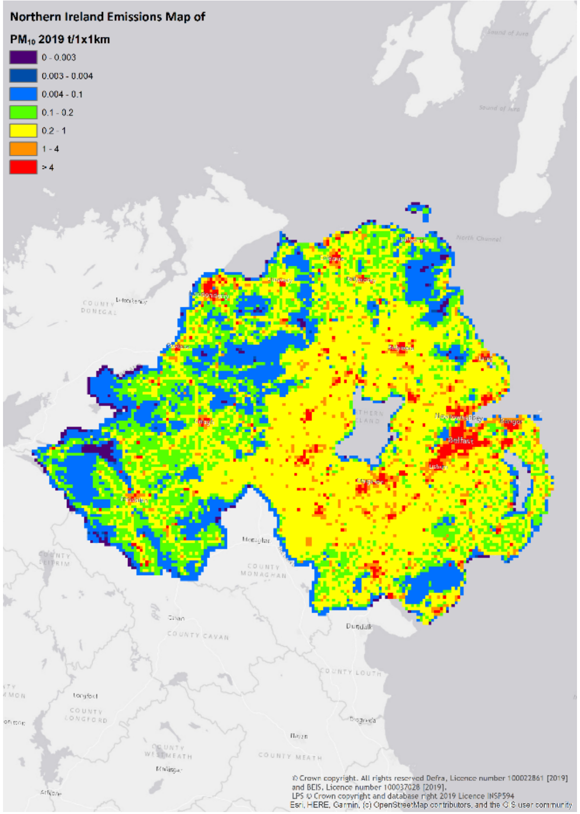


Figure 66 – $PM_{2.5}$ Emissions in Northern Ireland, 2019

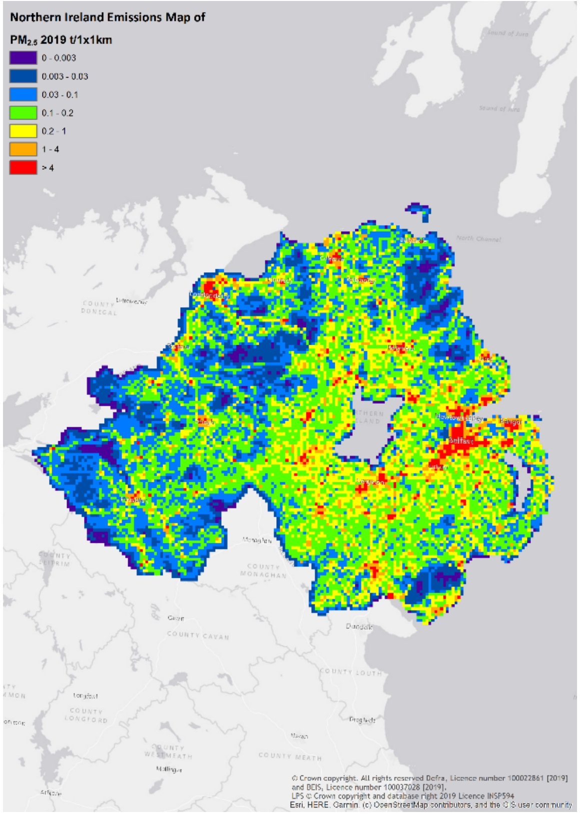


Figure 67 – Lead Emissions in Northern Ireland, 2019

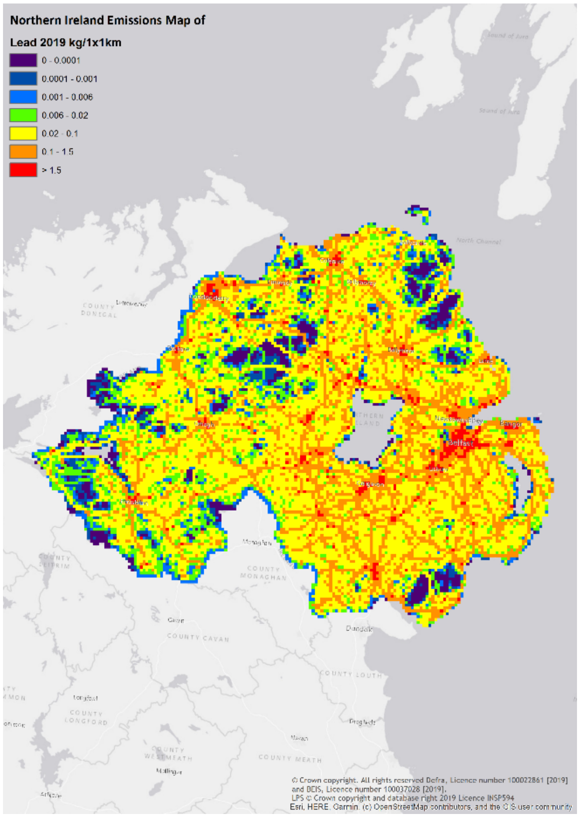
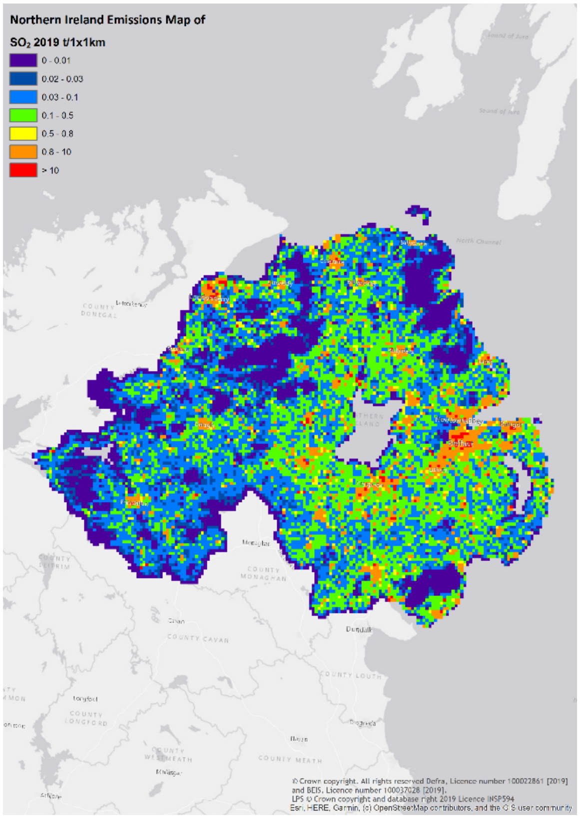


Figure 68 – Sulphur Dioxide Emissions in Northern Ireland, 2019



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Appendix A Background to Inventory Development

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

The latest inventory data shows that the UK continues to meet international ceilings for nitrogen oxides, ammonia, non-methane volatile organic compounds, and sulphur dioxide emissions. Further information on UK emissions trends can be found in the Defra National Statistics Release: Emissions of air pollutants in the UK, 1970 to 2019, see: https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-background

In 2019, the UK Government published its Clean Air Strategy (Defra, Clean Air Strategy 2019, 2019), which sets out how it will achieve the 2020 and 2030 emission reduction commitments established through the regulations and mechanisms outlined below. Similarly, the Devolved Administrations have also developed national plans and strategies to drive effective action at the local level. Scotland's 'Cleaner air for Scotland: the road to a healthier future', was published in 2015, and Wales' Clean Air Plan for Wales: Healthy Air, Healthy Wales' was recently published in August 2020. DAERA is preparing a separate Clean Air Strategy for Northern Ireland at the time of writing.

A.1 National Emissions Ceilings Directive

In 2001, the EU's National Emission Ceilings Directive (NECD or Directive 2001/81/EC) was agree. The NECD set 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 European Commission has since revised the NECD, repealing the original Directive and replacing it with a new legislative instrument (Directive 2016/2284/EU), ensuring the emissions ceilings initially set continue through to 2020. In addition, new national emission reduction commitments (ERCs) are applicable from 2020 and 2030 onwards for SO_2, NO_X, NMVOC, NH_3, and $PM_{2.5}$ to cut the health impact attributed to air pollution by approximately half when compared to 2005. The NECD has been transposed into UK law as the National Emissions Ceilings Regulations 2018. In addition, in 2019, the UK published its National Air Pollution Control Programme (NAPCP) describing the potential policies and measures required to meet the 2020 and 2030 ERCs (Defra, 2019).

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) to address 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 a 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 and the addition of emission reduction commitments for $PM_{2.5}$.

A.3 Industrial Emissions Directive

The Industrial Emissions Directive (IED, Directive 2010/75/EU) entered into force in 2011 and aims to minimise pollution from applicable industrial sources throughout the EU, consolidating previous 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. Enactment of the IED domestically for England and Wales was carried out through The Environmental Permitting (England and Wales) (Amendment) Regulations 2013, amending the existing permitting regime at the time, the Environmental Permitting (England and Wales) Regulations 2010. Scotland and Northern Ireland similarly implemented the IED through analogous legislation: the Pollution Prevention and Control (Scotland) Regulations 2012 and the Pollution Prevention and Control (Industrial Emissions) Regulations (Northern Ireland) 2012.

The IED requires these permits to consider and base permit conditions upon 'Best Available Techniques (BAT)', as concluded by the BAT conclusions of the BAT reference documents, or 'BREFs', a review process facilitated by the European IPPC Bureau, to assess environmental performance across industrial sectors (European Commission, 2020). In this manner, the IED helps aid the technological development and performance of specific sites. The IED also includes a requirement to share and engage the public in determining the permit, and a requirement for public access to emission data, made available through a separate reporting flow, the UK Pollutant Transfer and Release Register (UK-PRTR)[8].

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 Techniques (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 particulate matter and the specific heavy metals (cadmium, lead, and mercury), applicable for specific combustion and other industrial emission sources. 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 and the Stockholm Convention

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; of which B[a]p is one)

[8] https://www.gov.uk/guidance/uk-pollutant-release-and-transfer-register-prtr-data-sets

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 1998 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.

In 2001, the Stockholm Convention on POPs was adopted which built on the 1998 Protocol raising the profile of POPs aimed at prohibiting, or gradually reducing, the production and use of persistent organic chemicals worldwide. There are currently 30 POPs listed in the Convention which fall into three broad categories: pesticides, industrial chemicals, and unintentional by-products of combustion and some industrial and non-industrial processes. An updated version of the UK's National Implementation Plan (NIP) which will set out how the UK will implement their obligations under the Convention is due to be published later in 2021 and has been developed by Defra in agreement with the Scottish Government, Welsh Government, DAERA, and other relevant Government Departments and Agencies.

A.6 Sulphur Content of Liquid Fuels Directive

The EC's Directive to limit the 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 the UK

In July 2017, the Government published the UK plan for tackling roadside nitrogen dioxide concentrations, followed by a supplement in October 2018 – together referred to as the 'NO_2 plan'. The NO_2 plan sets out how Government will achieve compliance with legal limits for nitrogen dioxide in the shortest possible time, supported by a £3.8 billion investment into air quality and cleaner transport. As part of this, the Government has been working closely with 61 English local authorities, placing legal duties on them, underpinned by £880 million in funding, to tackle their nitrogen dioxide exceedances and achieve compliance with NO_2 legal limits in the shortest possible time.

Due to the highly localised nature of the problem, local knowledge is crucial in solving pollution problems in these hotspots. The Government is taking a national leadership role and is providing financial and expert support to local authorities to develop innovative plans.

The Air Quality Standards Regulations 2010 set concentration limit values for seven pollutants, including NO_X, SO_2, PM_{10} and CO and an exposure reduction target for $PM_{2.5}$. There are also target values for a further five substances (heavy metals and polycyclic aromatic hydrocarbons). 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.

Appendix B Inventory Methodology

This Appendix provides further detail on the methodology used to compile the emissions inventories and the data sources used during compilation. This information supports **Section 1.3** of the main report.

The disaggregation of air pollutant emissions across England and the Devolved Administrations (DAs) of the UK is part of a programme of ongoing data and methodology improvement. 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 England and the 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, 2020b). 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 to reduce 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 the Industrial Emissions Directive (IED). Major sources include power stations, cement and lime kilns, iron & steel works, aluminium, and other non-ferrous metal plant, and chemical industries.
- Emissions from **oil and gas terminals** and offshore platforms and rigs, are based on operator estimates reported to the BEIS OPRED team (BEIS OPRED, 2020) 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 & Gilhespy (2021). 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, 2020) 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 in 2018 for the 1990-2016 dataset. 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, 2019) are used to estimate fuel use and emissions back to 2005 and forecast to 2019. Emissions from shipping were split between the DAs using the methodology described in the 1990-2016 DA Air Pollutant Inventory report, published in 2018 (Jones, et al., 2018).

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., 2020).

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. Installation-specific fuel use data for major industrial plants are available over the time series onwards under the EU ETS, and from sites regulated under Environmental Permitting Regulations / Industrial Emissions Directive (EPR/IED). The data quality from these environmental regulatory systems has evolved over the years as monitoring, reporting and quality checking methods and protocols have developed meaning that fuel use estimates in earlier years of the time series are subject to greater levels of uncertainty. This also impacts the accuracy of the reported emissions of air pollutants 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 E**.

There are a number of resources that have been used to estimate 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).

By analysing the time series of data and reviewing the latest emission estimates, the point source data is amended as appropriate to fill in gaps and rectify any errors. This has been formalised in a recent upgrade to the processing in the NAEI, with the development of a new integrated database that ensures consistency in approach between sectors and sites. 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. 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 based on reported 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 website 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., 2020).

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 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.

B.2.3 Methodological choice by NFR sector

The table below provides a summary of the method and data availability for each sector in the DA inventories 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 (2020a,b), SEPA (2020a,b), Natural Resources Wales (2020a,b) NIEA (2020a,b). Exceptions are minor fuels: sewage gas use is estimated based on UK-wide estimates disaggregated using DA share of UK population (ONS, 2020); landfill gas use is based on the emission of methane from landfills from the MELMod model (Ricardo, 2020).
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 (2020).
1A1c	Coke & SSF production (all fuels)	Point source data provided by plant operators (see 1A1a). Regional iron & steel production and fuel use data (ISSB, 2020). UK fuel use data from BEIS (2020a).
	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 (2020).
	Gas production, downstream network (all fuels)	EU ETS installation data for natural gas use from 2005-2019. Environment Agency (2020b), SEPA (2020b), Natural Resources Wales (2020b), NIEA (2020b). Colliery methane use based on deep-mined coal production, data from the Coal Authority (2020).
	Upstream oil & gas, including gas separation plant (all fuels)	BEIS OPRED (2020) 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, and fuel combustion at iron & steel plants	Point source data provided by plant operators (see 1A1a), supplemented by site-specific breakdown of emissions by source from Tata Steel (2020).

NFR Sector	Source	Disaggregation Method
1A2b	Combustion in non-ferrous metals manufacturing industry	Pollution Inventory (EA 2020a, SEPA 2020a, NRW 2020a, NIEA 2020a), EU ETS (EA 2020b, SEPA 2020b, NRW 2020b, NIEA 2020b) IDBR and employment data (ONS, 2020). Overall analysis of the 1A2b,c,d,e and point source emissions and employment by sector used to constrain the DA totals to previous 1A2 DA estimates, using 1A2g Other Industry as residual allocation for emissions in the UK inventory not assigned to 1A2b,c,d, or e. Detailed analysis conducted for 2008-2018; 1A2b,c,d,e 2005-2008 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, 2020b) 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, whilst it is assumed that all scrap tyre combustion occurs in England also.
1A2g	Refractory & ceramic production	Regional GDP data (ONS, 2020).
	Other industrial combustion (oils)	Sub-national energy statistics, BEIS (2020b), and analysis of point source data derived from EU ETS and IED data. Environment Agency (2020a,b), SEPA (2020a,b), NRW (2020a, b) NIEA (2020a,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 (2020), Northern Gas Networks (2020), Scotia Gas Networks (2020), Wales & West Utilities (2020), Airtricity (2020), Firmus Energy (2020), Vayu (2020). Sub-national energy statistics, BEIS (2020b), and analysis of point source data derived from EU ETS and IED data. Environment Agency (2020a,b), SEPA (2020a,b), NRW (2020a,b), NIEA (2020a,b).
	Other industrial combustion (wood)	Regional GDP data (ONS, 2019).
	Industrial off-road machinery (all fuels)	Mapping grids are used, interpolated between 2007 and 2010, with the 2011 grid used for later years
1A3ai (i)	Aircraft – international take-off and landing (all fuels)	Civil Aviation Authority (CAA) (2020), 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, 1A3bii, 1A3biii, 1A3biv, 1A3bv, 1A3bv, 1A3bvii	Road Transport	Vehicle km, DfT (for GB), NI Department for Regional Development (DRD) up until 2015 (for later years, GB growth factors are then applied as data no longer available). Emission factors: Boulter et al. (2009) COPERT 4 (EEA, 2018) Fuel efficiency: Road Freight Statistics, DfT (2020) Composition of fleet: GB - Vehicle Licensing Statistics Report, DfT (2020) NI - Dept. of Regional Development (2020) Traffic data: National Traffic Statistics, DfT (England, Scotland, Wales: 1990-2019) Traffic and Travel Information, DRDNI (NI: 2005- 2015) Fuel consumption: Digest of UK Energy Statistics (1990-2019) (BEIS, 2020a)
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., or from a recent

NFR Sector	Source	Disaggregation Method
		study by the Rail Safety and Standards Board (RSSB) to determine emission factors by notch. Data from UKPIA on sulphur content of gas oil. Gas oil consumption data from Office of Rail Regulation for passenger and freight trains for 2005-2009 combined with trends in train km to estimate consumption for other years. Train km data from REM are used to provide the breakdown between train classes. Fuel consumption: Digest of UK Energy Statistics (1990-2019) (BEIS, 2020a).
1A3dii	Coastal shipping (all fuels)	UK Maritime and Coastguard Agency, DfT Maritime Statistics (2020). MMO Fishing statistics (MMO, 2016). Scarbrough et al., (2017), IMO (2015) Estimates for all inland waterways are based on population (ONS, 2020).
1A3eii	Aircraft support vehicles (gas oil)	Regional aircraft movements, DfT (2020d).
1A4a	Railways – stationary combustion	Sub-national energy statistics, BEIS (2020b). Natural gas use all in England.
	Industrial & commercial combustion	Sub-national energy statistics, BEIS (2020b), 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 (2020b) and Housing Condition Survey data. Domestic peat combustion data from CEH (Personal communication, 2018). Northern Ireland gas use in the residential sector is based on estimates from all energy suppliers in Northern Ireland (Airtricity, Firmus Energy, Vayu; all 2020). 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, 2019).
1A4ci	Agriculture – Stationary combustion	Agricultural employment data, Defra (2020a) used for allocation of solid and gaseous fuels. Regional energy statistics, BEIS (2020b) 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, 2020b).
1A4ciii	Fishing vessels	UK Maritime and Coastguard Agency, DfT Maritime Statistics (2020). MMO Fishing statistics (MMO, 2016). Scarbrough et al., (2017), IMO (2015).
1A5b	Military aircraft and naval shipping	Regional GDP data (ONS, 2020).
1B1a	Deep-mined coal	Regional deep mine production, Coal Authority (2020). Emissions from closed coal mines derived from WSP report (Fernando, 2011), updated to account for deviations from the projected closure dates assumed in the original study.
1B1b	Charcoal, Coke & SSF production	Charcoal production estimates based on regional GDP data (ONS, 2019). Coal feed to coke ovens, ISSB, WS, BEIS and (1999-2004) PI. 2005 onwards: EU ETS (EA 2020b, SEPA 2020b, NRW 2020b, NIEA 2020b).
	Iron & steel flaring	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 occur offshore (and therefore are unallocated).

NFR Sector	Source	Disaggregation Method
	Upstream oil & gas: process emissions, onshore oil loading, oil terminal storage	Emissions derived from BEIS OPRED (2020) EEMS point source dataset.
1B2aiv	Refinery process emissions (drainage, tankage, general)	Point source data provided by plant operators (see 1A1a), UKPIA (2020) and analysed using the NAEI point source database.
1B2av	Petrol terminal storage and loading, Refinery road and rail haulage emissions	Point source data provided by plant operators (see 1A1a), supplemented by refinery road/rail loading estimates from UKPIA (2020).
	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, 2020).
	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 OPRED, 2020) and PI/SPRI (Environment Agency 2020a; SEPA 2020a; NRW 2020a).
	Gas leakage from supply infrastructure	Leakage data provided by gas network operators: National Grid (2020), Northern Gas Networks (2020), Scotia Gas Networks (2020), Wales & West Utilities (2020), Airtricity (2020).
1B2c	Upstream oil & gas: flaring & venting	Emissions derived from the EEMS dataset (BEIS OPRED, 2020).
	Refinery flaring	Point source data provided by plant operators (see 1A1a) supplemented by data from the trade association (UKPIA, 2020).
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 in each DA are assumed proportional to emissions from other glass production processes.
2A5	Construction, asphalt manufacture	Regional GDP data (ONS, 2020).
	Quarrying (aggregates)	Emissions based on historic mapping grids for 2005-2008 and extrapolated for remainder of time series.
	Dewatering of lead concentrates	All emissions are 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, ceramics and refractory manufacture based on regional GDP statistics (ONS, 2020).
2B2	Nitric acid production	Point source data provided by plant operators (see 1A1a). Now all England.
2B6	Chemical industry – titanium dioxide	All emissions are in England.
2B7	Chemical industry – soda ash manufacture	All emissions are in England.

NFR Sector	Source	Disaggregation Method
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). 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, 2020).
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, 2020).
	Process emissions from: blast furnaces, electric arc furnaces, basic oxygen furnaces, 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 (2020), SSI (2014) and the ISSB (2020).
	Flaring & stockpile emissions at iron & steelworks	Regional iron & steel production and fuel use data (ISSB, 2020).
2C3	Alumina production	All emissions are in Scotland.
	Primary and secondary aluminium production	Estimates based on point source data provided by plant operators (see 1A1a).
2C4	Magnesium alloying	Regional GDP data (ONS, 2020).
2C5	Secondary lead manufacture	Estimates based on point source data provided by plant operators (see 1A1a).
	Lead battery manufacture	Regional GDP data (ONS, 2020).
2C6	Zinc oxide, alloy, and semis production	Regional GDP data (ONS, 2020).
2C7	Nickel and tin production	Regional GDP data (ONS, 2020).
	Other non-ferrous metal production processes	All emissions are in England.
	Non-ferrous metal processes	All emissions are in England.
	Copper alloy and semis production	Estimates based on point source data provided by plant operators (see 1A1a).
	Foundries	Foundries based on mapping grids, derived through methods described in Section B.2.2.
2D3a	Aerosol and non-aerosol products (cosmetics & toiletries, household products, paint thinners),	Population data, ONS (2020).
	Agrochemical use	Based on arable land mapping grids, based on mapping grids, derived through methods described in Section B.2.2.
2D3b	Road dressings	Road dressing mapping grid, based on mapping grids, derived through methods described in Section B.2.2.

NFR Sector	Source	Disaggregation Method
	Bitumen use	Population data (ONS, 2020).
	Asphalt manufacture	Regional GDP data (ONS, 2020).
2D3d	Trade & retail decorative paints,	Population data, ONS (2020).
	Industrial coatings: Aircraft, agricultural and construction vehicles, coil coating, leather coating	Regional GDP data (ONS, 2020).
	Industrial coatings: wood, metal, plastic, marine, vehicle refinishing.	Various coatings mapping distribution grids are used based on surveys of locations of such processes, derived through methods described in Section B.2.2.
	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 (2020).
	Leather coating and degreasing	Regional GDP data (ONS, 2020).
2D3f	Dry cleaning (solvent use)	Dry cleaning mapping grid, derived through methods described in Section B.2.2.
2D3g	Rubber & plastic products	Population data, ONS (2020).
	Foam blowing	Regional GDP data (ONS, 2020).
	Industrial coating manufacture: adhesives, inks, solvents and pigments, tyre manufacture	Various industry-specific coatings mapping distribution grids, derived through methods described in Section B.2.2.
2D3h	Printing – flexible packaging, publication gravure	Point source data provided by plant operators (see 1A1a).
	Other printing sources	Population data, ONS (2020).
2D3i	Seed oil extraction	All emissions are in England.
	Wood impregnation – creosote, LOSP	Wood impregnation mapping grid.
	Industrial adhesives and sealants	Regional GDP data (ONS, 2020).
	Solvent Use	Population data, ONS (2020).
2G	Cigarette smoking and fireworks	Population data, ONS (2020).
	Lubricant use in road vehicle engines	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.
2H1	Paper production	GDP data, ONS (2020).
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.

NFR Sector	Source	Disaggregation Method
	Food & drink process industries: meat & fish, margarine, cakes & biscuits, animal feed, coffee roasting	Population used to disaggregate emissions (ONS, 2020).
	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, 2019).
2I	Wood product process emissions (including creosote use)	Wood coating mapping grid, derived through methods described in Section B.2.2.
3A	Manure management	DA splits for manure management based on regional pollutant-specific emissions data provided by Rothamsted Research (2020).
3B	Inorganic N fertilizers	DA splits for fertilizers based on regional pollutant-specific emissions data provided by Rothamsted Research (2020).
3D	Agricultural soil emissions	DA splits for agricultural soils based on regional pollutant-specific emissions data provided by Rothamsted Research (2020).
3F	Field burning of agricultural wastes	Field burning estimates from Rothamsted Research (2020).
5A	Landfills	DA-specific models based on country-specific waste landfilling data published by the Environment Agency, Scottish Environmental Protection Agency, Natural Resources Wales, and Northern Ireland Environment Agency (2020).
5B	Composting	Population data, ONS (2020).
5C1	Incineration: MSW, crematoria, chemical waste	Point source data provided by plant operators (see 1A1a).
	Incineration: Clinical waste, sewage sludge	Population data, ONS (2020).
	Incineration: animal carcasses	Based on arable land mapping grids, based on mapping grids, derived through methods described in Section B.2.2.
5C2	Open-burning of waste	Population data, ONS (2020).
	Agricultural waste burning (not animal carcasses)	Based on arable land mapping grids, based on mapping grids, derived through methods described in Section B.2.2.
5D1	Sewage sludge decomposition	Population data, ONS (2020).
6A	Other sources: accidental fires, bonfires, cigarettes, fireworks, infant emissions from nappies, domestic pets	Population data, ONS (2020).
	Non-agricultural horses, professional horses	Driver for non-agricultural horses based on activity data time series from Rothamsted Research and CEH (2020).
	Parks, gardens, and golf courses	Data on non-fuel fertiliser use, Rothamsted (2020).

B.2.4 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 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, 2018), other gas network operators, the Coal Authority (Coal Authority, 2019) and the Department for Business, Energy & Industrial Strategy (BEIS, 2019a). 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 2019. These data are used to underpin many of the air pollutant emission estimates from small-scale (non-regulated) combustion sources such as residential, commercial, public administration and small-scale industrial sectors.
- 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, 2020) database of flight movements, fuel use data (BEIS, 2019a), aircraft fleet information (CAA, 2020) 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, 2020).
- **Regional iron and steel production data**, and regional fuel use data in the iron and steel industry (Tata Steel, 2020), (ISSB, 2020).
- Site-specific emissions data split by combustion and process sources for all **UK refineries**, and refinery production capacities (UKPIA, 2020).
- Site-specific cement production capacities and UK-wide **cement industry** fuel use data (MPA, 2020).
- 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, 2020).

Appendix C Experimental inventories for PCDD/Fs, benzo[a]pyrene and mercury

C.1 Background

In addition to the core suite of air pollutants that have been reported in inventories for England and the Devolved Administrations, for which source data and inventory methods are well-established, this publication includes an experimental set of inventory statistics of: (i) dioxins and furans (PCDD/Fs), (ii) benzo[a]pyrene (B[a]p), and (iii) mercury (Hg). These are toxic pollutants, emission estimates for which are included within the scope of UK inventory submissions under the Convention on Long-Range Transboundary Air Pollution (CLRTAP).

DA-level estimates have been developed for these three pollutants, and the data quality at sub-national level is such that the data are regarded as **experimental statistics only**. These inventories have the potential to enhance the evidence-base for decision-making processes and identify priorities for action, both on a national and local scale. However, without further work to assess the completeness, interrogate outliers, and apply good practice gap-filling techniques to installation-level data, or to study regional variations of unregulated combustion (such as residential burning) to consider country-specific trends, then the inventory estimates will remain highly uncertain and should only be used for indicative purposes. They are not yet suitable for use as a tool to prioritise policies and measures.

Benzo[a]pyrene, B[a]p, is a toxic polycyclic aromatic hydrocarbon (PAH), one of a group of persistent organic pollutants (POPs) that contain two or more benzene rings. The International Agency for Research on Cancer (IARC) has determined that B[a]p is a carcinogen. Its primary mechanism for formation is incomplete combustion, predominantly from vehicle exhausts, wood and coal fires, whilst trace amounts are also found in cigarette smoke.

Like other POPs, B[a]p accumulates in organisms that are exposed to it; it binds strongly to sediments, soils and other solid matter, and it is stable so remains in the environment making it a concern at a local and a global scale. Industrial emissions in the UK are controlled through the UK Pollution, Prevention and Control (PPC) Regulations and the subsequent Industrial Emissions Directive (IED).

Dioxins and furans (PCDD/Fs) are toxic chemicals which are not intentionally manufactured but are released to the atmosphere as by-products from a number of processes including waste incineration, fuel combustion (industrial, domestic and transport), and metal processing. As with B[a]p, trace amounts are found in cigarette smoke. Dioxins released to the air are deposited to ground, and watercourses, where livestock and fish may ingest them; dioxins bio-accumulate and concentrate through food chains, are stable and persistent in the environment, and hence can be transported long distances and even re-suspended to the atmosphere, again making them a local and global concern. Humans may ingest or inhale dioxins, and whilst health effects depend on the precise speciation, several dioxin substances are determined to be carcinogenic. Industrial emissions of dioxins are controlled through the Pollution, Prevention and Control (PPC) Regulations, Industrial Emissions Directive (IED) and Waste Incineration Directive (WID) and associated UK regulations.

Mercury (Hg) is a heavy metal neurotoxin, and in its organic form, methylmercury (MeHg) is associated with neurocognitive deficiencies in foetuses and can cause cardiovascular issues in adults. Acute exposure to elemental mercury can also lead to the irritation of the lung causing coughing, chest pain, and shortness of breath, with very high levels impacting the central nervous system. Atmospheric mercury chemistry is complex and, once emitted, cycles between the atmosphere, land, and surface waters through a series of physical and chemical transformations that can have far-reaching impacts on the environment and biological toxicity. Once deposited it can be transformed and bioaccumulated by aquatic organisms or resuspended for deposition elsewhere. Bioaccumulation represents the primary route to exposure for humans and wildlife, with the exact toxicity related to the speciation of mercury. Emissions of Hg in the UK are regulated by the 1998 Protocol on Heavy Metals, which obliges signatories to reduce emissions below 1990 levels, as well as specifying limit values for emissions from stationary sources and requires the use of Best Available Techniques (BAT) to minimise emissions as far as possible. The protocol was amended in 2012 to introduce more stringent emission limit values applicable to specific combustion and industrial emissions sources.

C.2 Key Sources and Emission Trends

C.2.1 Dioxins and Furans

PCDD/Fs are primarily formed during incomplete combustion. In the UK, for example, the key source categories are primarily in the small-scale combustion (NFR 1A4) and waste management (NFR 5) sectors. Since the combustion of solid and liquid fuels are more complex and often heterogeneous, the PCDD/F emissions from their combustion is greater than those from gaseous fuels. Emissions of PCDD/Fs declined significantly between 1990 and 2000 (Churchill, et al., 2021), with a steadier decline observed across the reported time series here (2005-2019). Sector-specific trends are;

- **Power station emissions:** emissions of dioxins from combustion for electricity generation at power stations have declined across the time series, reflecting the reduced amount of coal in the energy mix for this sector.
- **Road transport emissions:** emissions from road transport declined considerably between 1990 and 2005, after the phase out of leaded petrol from general sale by the end of 1999. Since then, improvements in engine efficiencies, driven by the requirements of EURO standards adoption, have continued to reduce emissions from this sector.
- **Small Stationary Combustion**: Dioxin emissions in this sector are dominated by residential burning of coal and wood. Coal use has declined significantly over the time series, whilst wood burning in the residential sector has increased substantially in the last 10-15 years across the UK and has become one of the main source categories for dioxin emissions in recent years.
- **Waste management**: Dioxin emissions from waste management sources have been substantially reduced across the time series in the UK, primarily driven by the introduction of more stringent regulatory controls for incineration of wastes through: technical guidance for waste incineration processes regulated under the integrated process control (IPC) regime (Environment Agency, 1996); the EU Waste Incineration Directive (2000/76/EC); and subsequent UK regulations such as the Environmental Permitting (England and Wales) Regulations 2010 SI 2010 No.675. In the 2005-2019 time series, trends are driven by reductions in the amount of household waste burned on domestic open fires, and reductions in emissions from accidental fires of buildings.

C.2.2 Benzo[a]pyrene

Similar to dioxins, UK emissions of benzo[a]pyrene are formed principally in non-optimal combustion conditions, in particular in the combustion of solid and liquid fuels. Whilst emissions declined significantly between 1990 and 2004, as a result of the decline of the primary aluminium production sector in the UK and the cessation of anode baking, emissions have increased across the time series presented here. This is driven almost entirely by trends in the residential combustion sector (NFR 1A4b), and in particular the use of wood and coal in fireplaces. This source dominates the UK and DA inventories for B[a]p across all years of the time series.

C.2.3 Mercury

In the UK, emissions of mercury across the time series emerge from three main sources: energy generation at power stations (NFR 1A1), activity at crematoria (NFR 5C) and through its use in industrial processes, most commonly in mercury cells within chlor-alkali production to produce caustic soda and chlorine. As a result, the trends exhibited are largely related to the activities within these sectors, most notably:

- **Power stations**: highest emission rates of mercury are associated with the use of coal at power stations, and so emissions have declined considerably between 2005 and 2019 as a result of the reduction in the use of coal in the electricity-generating fuel mix.
- **Chloralkali process emissions:** emissions have declined as a result of reduced use of mercury cells in the production process, and due to improved techniques being used at installations, driven in part by the EPR/IED regulations.
- **Crematoria emissions:** show a decline across the time series between 2005 and 2019, but are subject to volatile interannual trends and are highly sensitive to changes in activity at different crematoria sites.

C.3 Development of experimental inventories

The DA inventories for PCDD/Fs, B[a]p, and Hg have been derived using the same methodology as for the other air pollution inventories, that is to derive the best available 'driver' data to disaggregate the reported UK emissions totals from the latest Informative Inventory Report (Churchill, et al., 2021). To maximise the use of resources available to develop these experimental inventories, the inventory agency has sought to prioritise analysis to derive accurate DA estimates as far as practicable for Key Categories. Future work may help to further refine the data, methods and extend the analysis to further improve the evidence base for inventory stakeholders.

The methods used to derive emissions estimates for the most important sources mirrors those outlined in Table 6 above, with more simplistic methods for less important categories being used (such as the use of carbon emissions information from point sources for sectors that are small emitters of B[a]p, dioxins, or Hg).

C.3.1 Key Category Emission Sources for POPs

For **B[a]p**, the IIR describes the UK inventory Key Category Analysis for the latest year of emissions data, 2019, indicating that the only key category is residential combustion (NFR sector 1A4bi), due to the very high emissions reported for residential fuel combustion, driven in recent years by the burning of wood in residential fireplaces, stoves and boilers.

In addition to 1A4bi, and considering the impact of other source categories on the reported inventory trends, the inventory agency considers that qualitative key categories for B[a]p also include the following sources, in approximate order of significance:

- NFR 5E: Accidental fires. The most significant sources here are the emissions from fires in dwellings and other buildings;
- NFR 5C2: Waste burning. A larger source in 2005 which has since declined in significance due to recent reductions in the amount of waste burning in open residential fires.

For **PCDD/Fs**, the IIR describes five key categories in 2019 emissions:

- NFR 1A4bi: Residential fuel combustion. Similar to for B[a]p, the highest emission source in 2019 is emissions from residential fuel combustion, and wood burning in particular, following a decline in coal and anthracite burning over time, replaced in recent years by a growth in wood use. Whilst the level and trend of recent wood use is somewhat uncertain, with the UK energy statistics dependent on a small number of residential fuel use surveys, work continues within Defra and BEIS to further improve the data used to estimate emissions from domestic combustion.
- NFR 5E: Accidental fires. The most significant sources here are the emissions from fires in dwellings and other buildings, and also PCDD/F emissions on bonfire night;
- NFR 2C1: Iron and Steel Process emissions. Emissions of PCDD/Fs are primarily from sinter plant in integrated iron and steel works.
- NFR 1A2gviii: Other industrial combustion of fuels. These emissions are dominated by emissions from burning of solid fuels: wood, coal, and biomass.
- NFR 5C2: Waste burning. PCDD/F emissions are derived from both agricultural waste burning, which has all but disappeared as an activity in recent years, but also from small-scale waste burning. As noted above for B[a]p, the activity data and emission factors to accurately estimate these emissions are scarce, and hence these emission estimates are associated with quite high uncertainty.

For **Hg**, the IIR describes eight key categories:

- NFR 1A1a: Public electricity generation. Emissions are dominated by coal use in power stations and have declined significantly since the 2005 base year as a result of the phase out of coal use in electricity generation over this period.
- NFR 5C1bv: Crematoria. Emissions have declined by roughly a third across the time series but interannual trends remain volatile.
- NFR 2C1: Iron and steel production. As with 1A1a, emissions from the iron and steel production sector arise from dust particles in electric arc furnaces and during sinter production.
- NFR 2C7c: Other metal production. Emissions here are principally associated with processes at foundries, and are intrinsically tied to levels of steel production in the UK and as such are sensitive to changes in activity, and also to the mercury content of scrap metal melted in furnaces.
- NFR 5A: Biological treatment of waste – solid waste disposal on land. Emissions of Hg are primarily related to the disposal of measurement and control equipment.
- NFR 1A2gviii: Other industrial combustion – as with 1A1a, the emissions from this sector are related to amount of mercury content within the fuels used industrially, with coal typically having the highest mercury content and thus the greatest contribution to emissions, but also petroleum coke and biomass contributing to emissions from this sector considerably.

- NFR 1A2f: Stationary combustion in non-metallic minerals production – as with 1A1a, the emissions from this sector, which relate to the production of cement, are related to the mercury content of the fuels used and are most sensitive to variability in coal combustion
- NFR: 1A4bi: Residential stationary combustion. Once again, emissions here are related to the combustion of fuels which have a larger mercury content, with coal, solid smokeless fuels (SSF), wood, and petroleum coke the dominant fuels.

C.3.2 Inventory Uncertainty

Inventories for persistent organic pollutants (POPs) are more uncertain than those for gaseous pollutants, PM_{10}, and metals. This is largely due to the paucity of emission factor measurements on which to base emission estimates and the complexity of dealing with POPs as families of congeners (PCDD/PCDFs, PAHs). The issue is further exacerbated by a lack of activity data for some important sources, for example small scale waste burning.

Where emissions in the DA and UK inventories are based on installation-level reported data by operators (which is the case for many high-emitting energy sector, industrial combustion, industrial process and waste management sources such as incineration), the emissions data reported for PCDD/Fs and B[a]p are typically less complete (than for other pollutants, e.g. NO_X, SO_2, PM_{10}) due to the reporting thresholds within the regulators' inventories: PI/SPRI/WEI/NIPI. Through analysis of the reported time series by many installations, the inventory agency further notes that reporting of POPs is typically more susceptible to reporting errors by operators, often by several orders of magnitude. In the compilation of the UK inventories for these species, therefore, the inventory agency makes every effort to (i) identify outliers in the reported data by installation operators, and (ii) apply inventory good practice gap-filling techniques (such as data interpolation and extrapolation, or use of year to year trends in other reported emissions as a proxy) to derive a more consistent, complete and accurate inventory time series.

This susceptibility to operator reporting errors for high-emitting industrial sources exacerbates the limitations in activity data and research to inform accurate emission factors for many POPs emission sources, adding to the overall level of uncertainty in UK and DA reported levels and trends of POPs emissions.

Emissions from unregulated sectors, such as through the combustion of wood and coal domestically, are yet more uncertain. For the UK inventory, the Digest of UK Energy Statistics (DUKES) is used to inform the activity (or amount) of fuel that is consumed in a given year. Sub-national energy statistics and emission maps, based predominantly on periodic user surveys and available data from censuses and housing condition surveys, are used to estimate the DA shares of this UK activity. The fuel use data at DA-level is less uncertain for metered fuels (i.e. natural gas and electricity), but more uncertain for those fuels that are the main source of POPs emissions, such as wood and coal.

Mercury emissions are considered to be slightly less uncertain than the inventory for Pb, another toxic heavy metal. The difference in uncertainties between heavy metals is characterised by the relative contribution of sources for which strong regulation has required improvements in data collection and reporting, particularly of the amount of fuel combusted. Characterising the metal content of the fuel itself can be challenging, however, and is highly sensitive to the heterogeneity of the fuel used. The uncertainty is also influenced by the relative contribution of sources for which data are less widely available or more uncertain, such as the distribution of fuel used in domestic combustion or the distribution of facilities using mercury cells in chlor-alkali production processes.

The UK inventory quantifies Tier 1 uncertainty aggregation estimates for B[a]p. The method has been replicated here, following the same procedure as outlined in Appendix E, with the results presented in the table below.

Table 7 – Tier 1 uncertainty aggregation for B[a]p for each DA.

	Emissions			Estimated uncertainty		
DA	2005 (kg)	2019 (kg)	Trend (%)	2005 (kg)	2019 (kg)	Trend (%)
England	4,588	6,285	37%	310%	400%	54%
Scotland	466	530	14%	260%	370%	150%

DA	Emissions			Estimated uncertainty		
	2005 (kg)	2019 (kg)	Trend (%)	2005 (kg)	2019 (kg)	Trend (%)
Wales	544	714	31%	270%	360%	150%
Northern Ireland	353	526	49%	360%	430%	210%

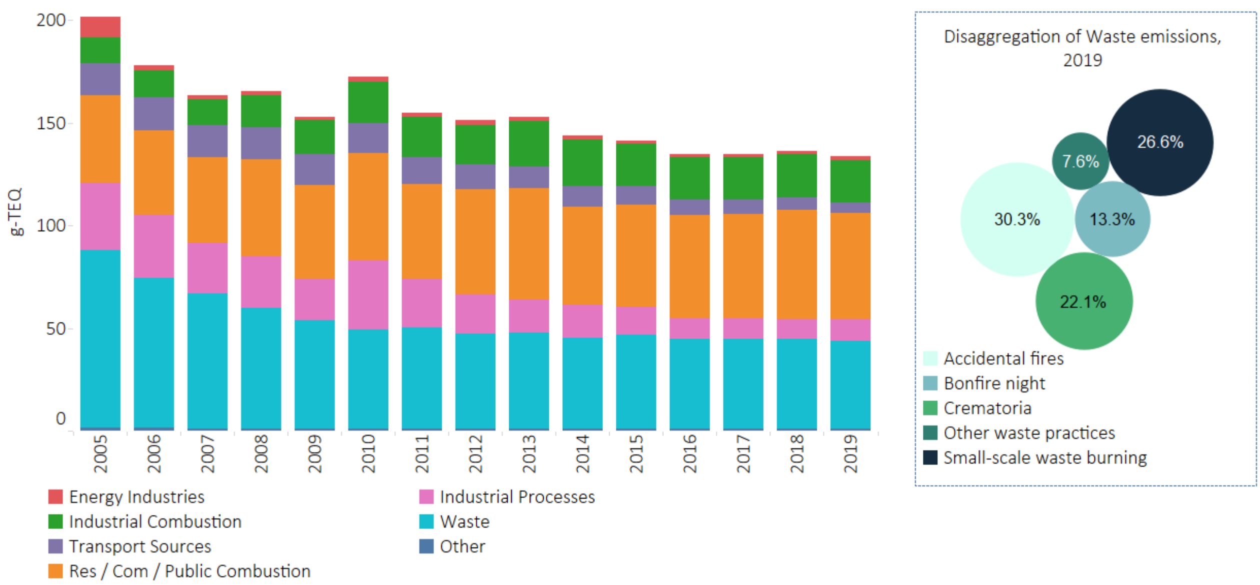
The UK inventory does not quantify the uncertainty of the PCDD/Fs or Hg inventory using an error propagation approach, and therefore no similar estimates for the DA inventories are possible. The IIR (Churchill, et al., 2021) does estimate uncertainties of these pollutants using a Tier 2 Monte Carlo approach (which is not included under the scope of current DA uncertainty calculations. The results of this are estimates of uncertainty of:

- PCDD/Fs: +/- > 50%
- Hg: between -30 and +50%

C.4 Benzo[a]pyrene, dioxin, and mercury inventories for England, Scotland, Wales, and Northern Ireland.

C.4.1 England

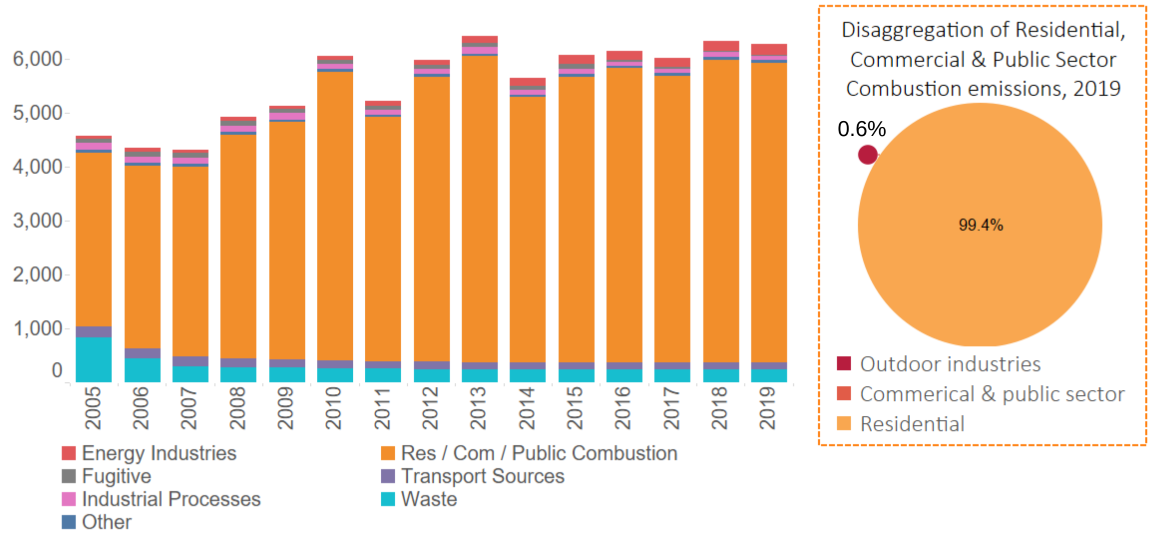
Figure 69 Dioxins emissions in England[9]



Emissions of **dioxins** in England were estimated to be 134g I-TEQ in England in 2019, representing 74% of the UK total. Emissions have declined by 34% since 2005. The emissions of PCCD/Fs have declined since 2005, tracking trends in reducing coal-firing at power stations and the introduction of more stringent regulatory controls and the promotion of alternative waste disposal and recycling streams to reduce small-scale open waste burning of household and garden waste.

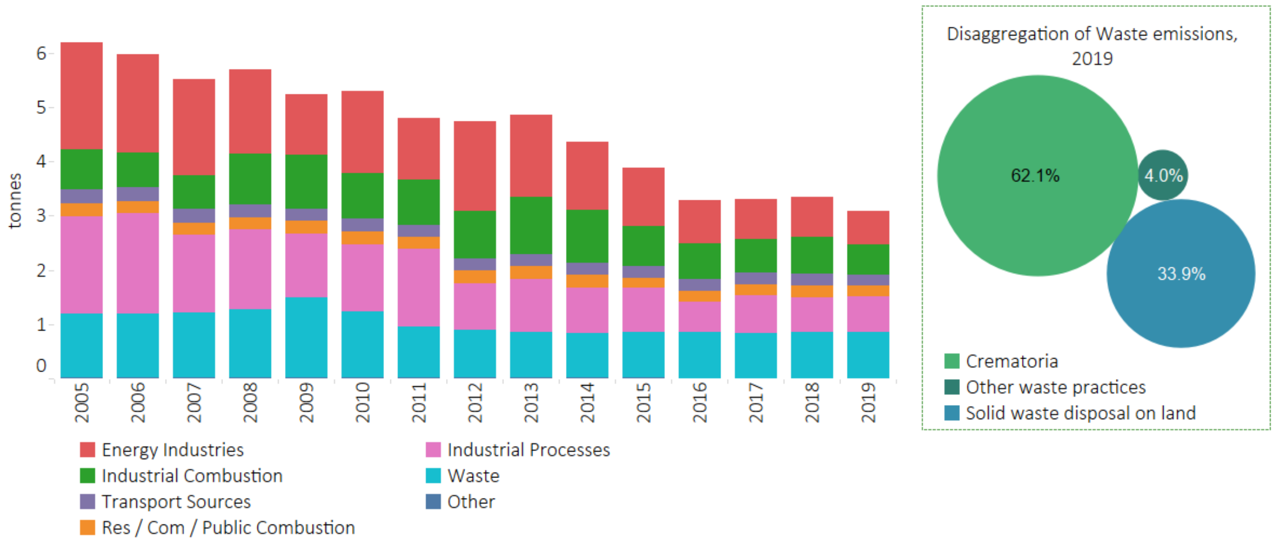
[9] Outdoor industries presented in the bubble graph relate to combustion emissions from machinery in the agriculture, forestry and fishing industries.

Figure 70 B[a]p emissions in England



Emissions of **benzo(a)pyrene** in England were estimated to be 6,285 kg in 2019, representing 78% of the UK total. Emissions have increased 37% since 2005. The increase has been dominated by the residential sector, particularly due to the increase in domestic wood combustion by 72% since 2005.

Figure 71 Hg Emissions in England



Emissions of **Hg** in England were estimated to be 3.1 t in 2019 and have declined by 50% since 2005 (Figure 71). Emissions in England account for 77% of the UK total in 2019. This decline in emissions stems from changes in combustion in power and heat generation and chlor-alkali process emissions, with a 43% and 28% contribution to the overall trend respectively. The decline in emissions from power and heat generation is driven by the reduction in combustion of coal.

Figure 72 Dioxin Emissions in England, 2019

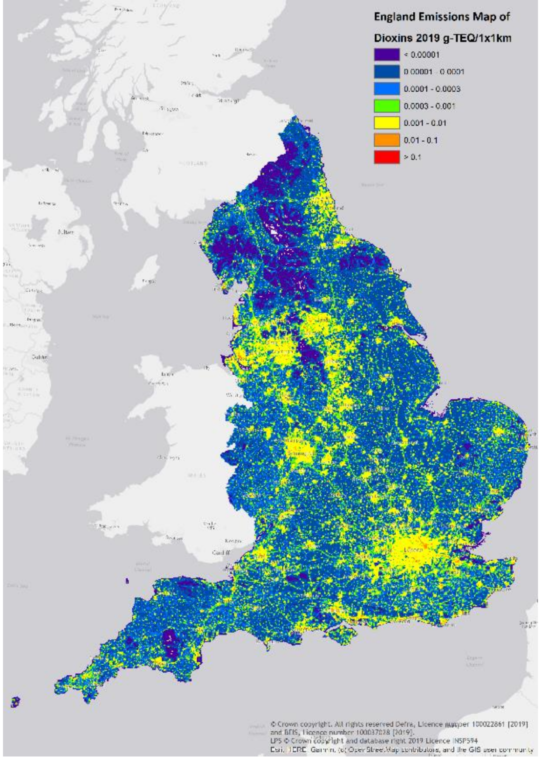


Figure 73 B[a]p Emissions in England, 2019

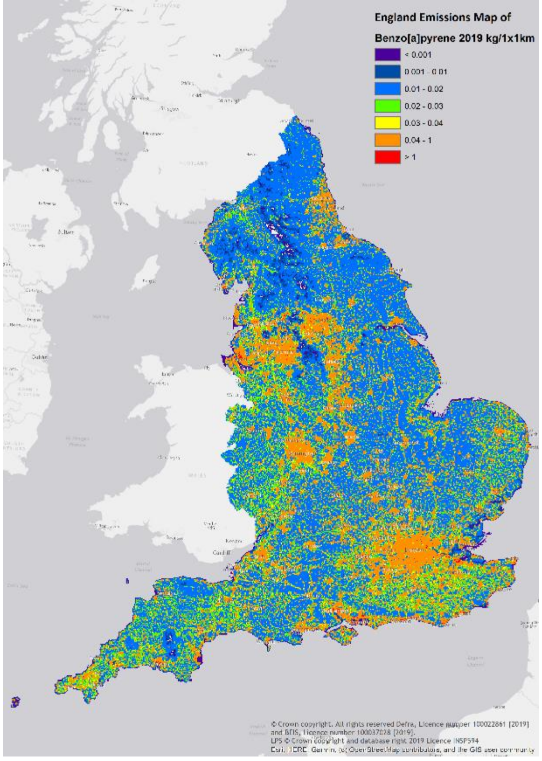
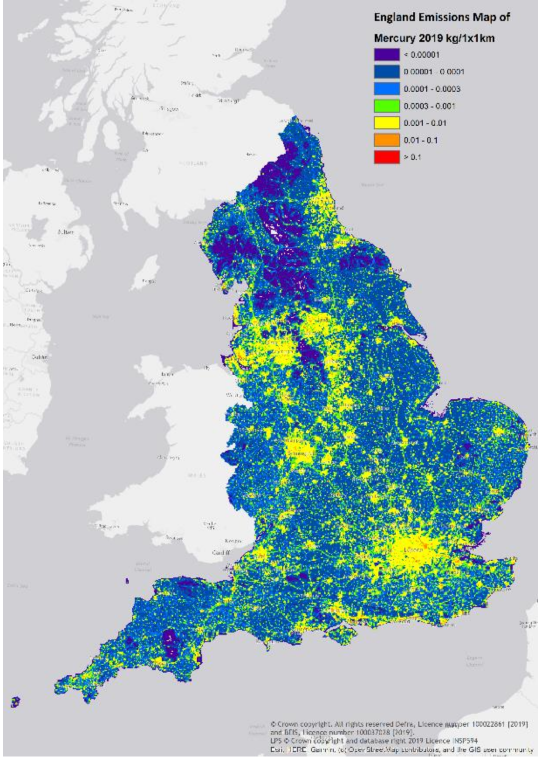
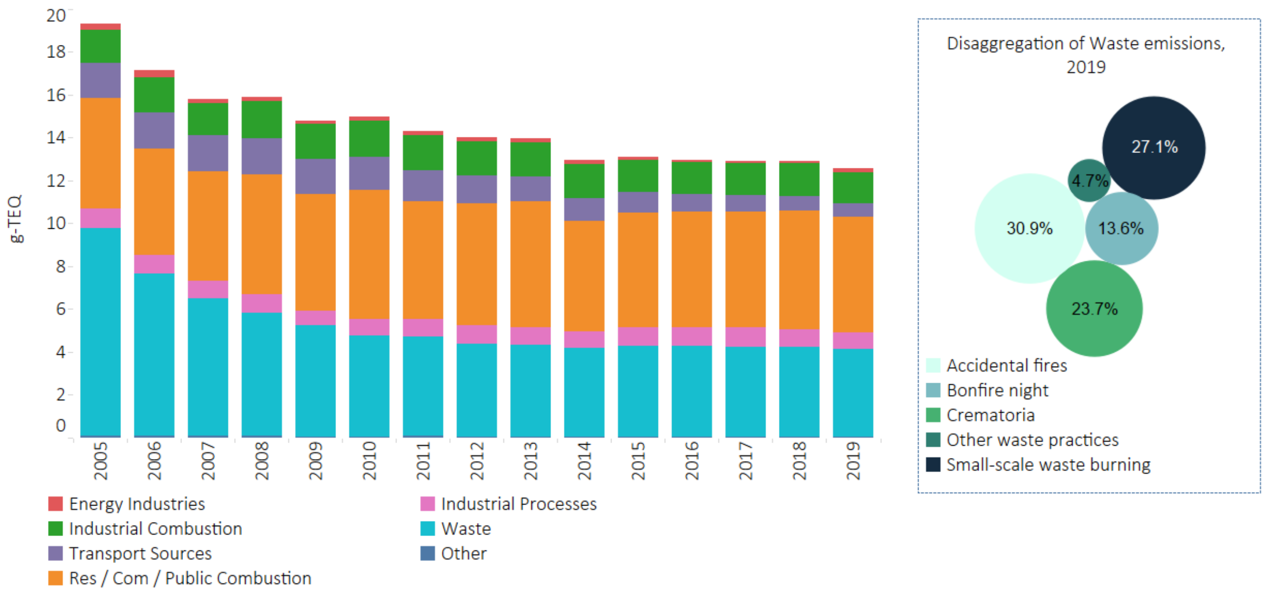


Figure 74 – Hg emissions in England, 2019



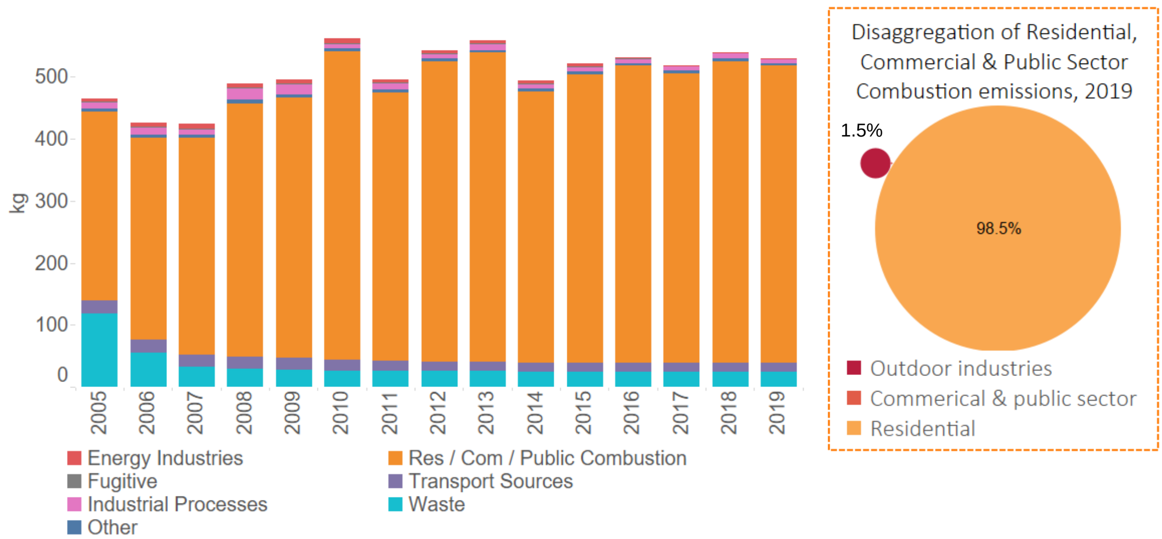
C.4.2 Scotland

Figure 75 Dioxins Emissions in Scotland



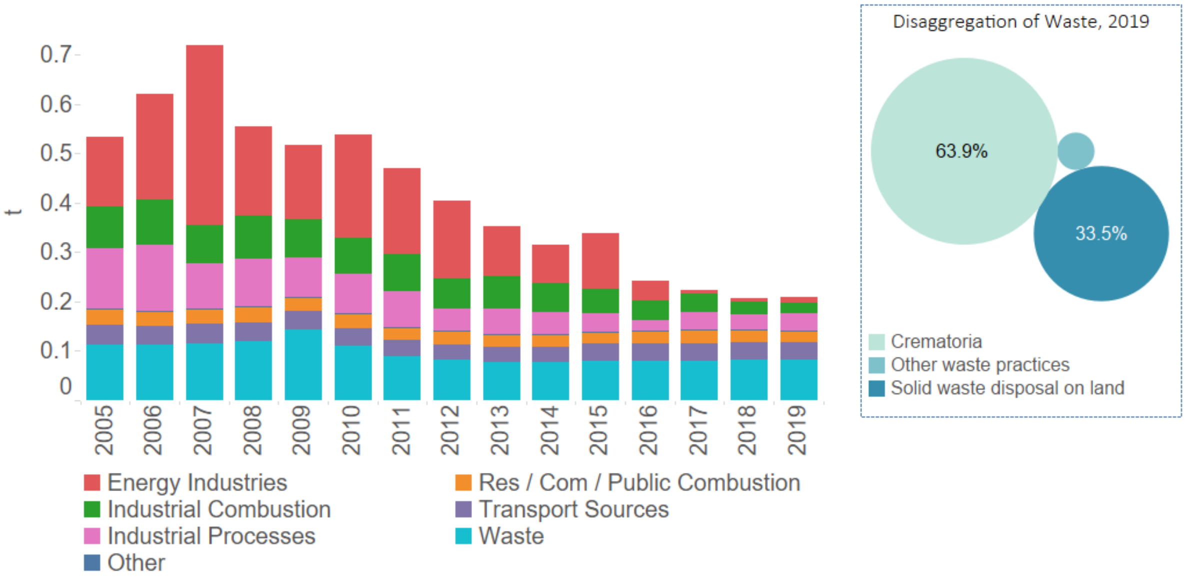
Emissions of **dioxins** in Scotland were estimated to be 12.5g I-TEQ in Scotland in 2019, representing 7% of the UK total. Emissions have declined by 35% since 2005, mainly driven by a reduction in emissions from the waste sector. The decline in dioxin emissions since 2005 tracks the trend of a reduction in coal use in power stations, and the introduction of more stringent regulatory controls and the promotion of alternative waste disposal and recycling streams to reduce small-scale open waste burning of household and garden waste.

Figure 76 B[a]p emissions in Scotland



Emissions of **benzo(a)pyrene** in Scotland were estimated to be 530 kg in 2019, representing 7% of the UK total. Emissions have increased 14% since 2005, primarily driven by an increase in domestic wood combustion which accounts for 58% of emissions within the residential sector.

Figure 77 Hg emissions in Scotland



Emissions of **Hg** in Scotland were estimated to be 0.21 t in 2019 and have declined by 61% since 2005 (**Figure 77**). Emissions in Scotland account for 5% of the UK total in 2019. This decline in emissions stems from changes to combustion in power and heat generation and chlor-alkali process emissions, with a 39% and 24% contribution to the overall trend respectively. The decline in emissions from power and heat generation is driven by the reduction in combustion of coal. As observed above, the emissions from energy industries have been negligible since 2017 since the cessation of coal used for energy generating purposes in Scotland. Since then, emissions from crematoria have been the largest source of emissions.

Figure 78 Dioxin Emissions in Scotland, 2019

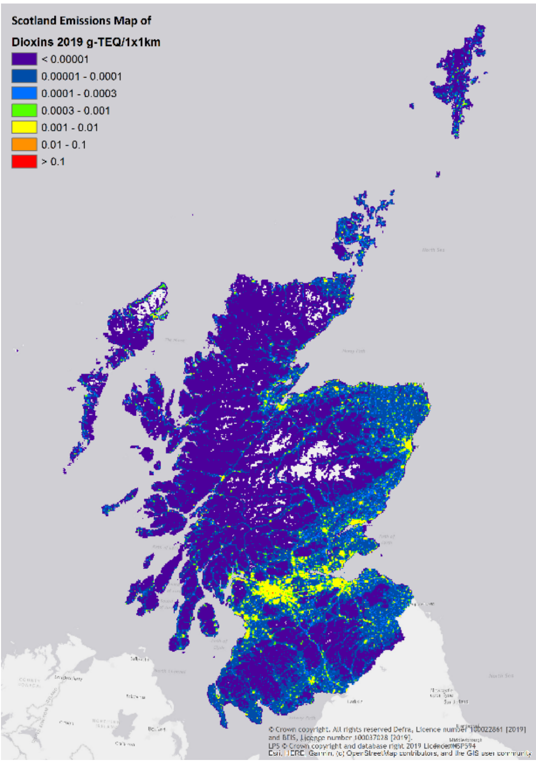


Figure 79 B[a]p Emissions in Scotland, 2019

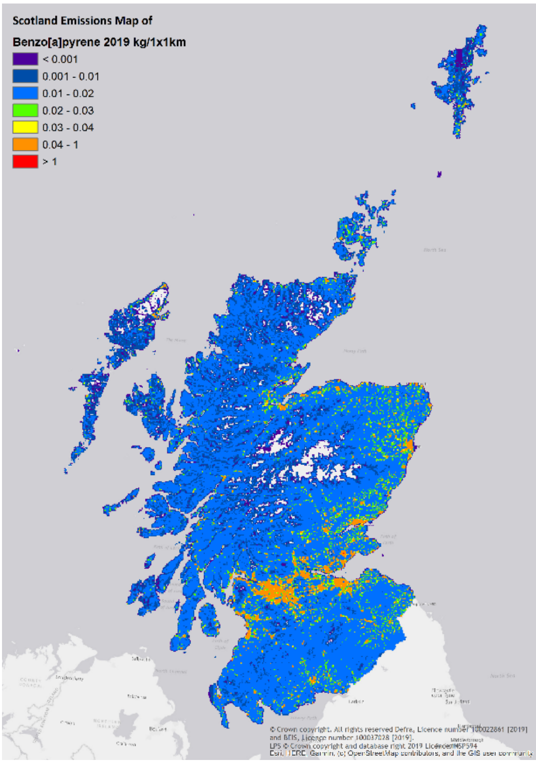
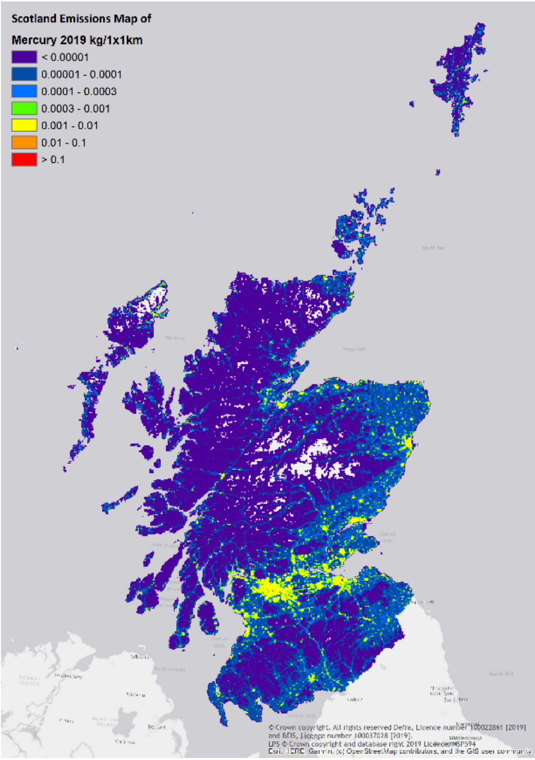
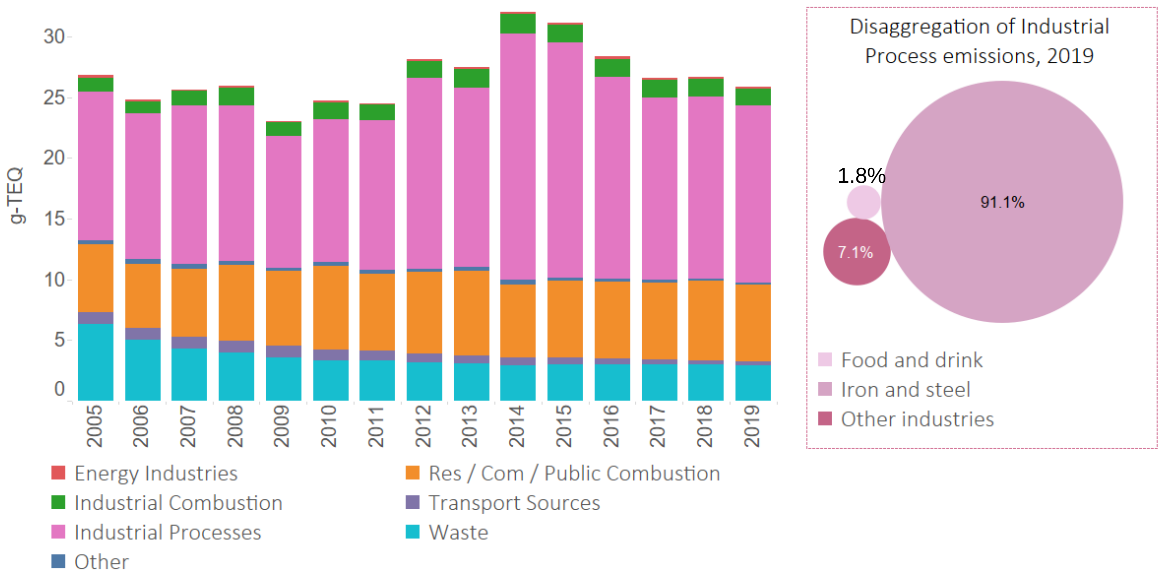


Figure 80 Hg Emissions in Scotland, 2019



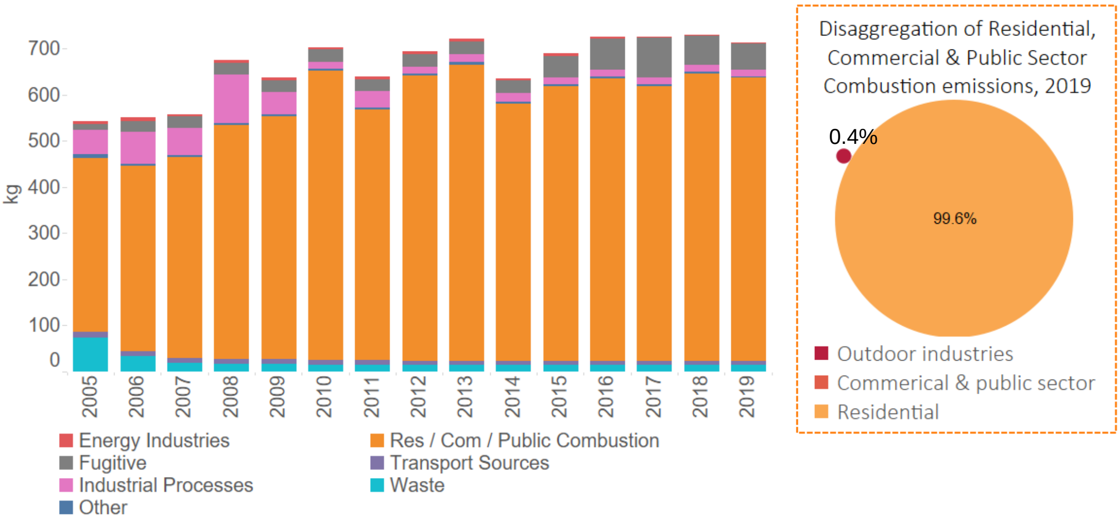
C.4.3 Wales

Figure 81 Dioxins Emissions in Wales



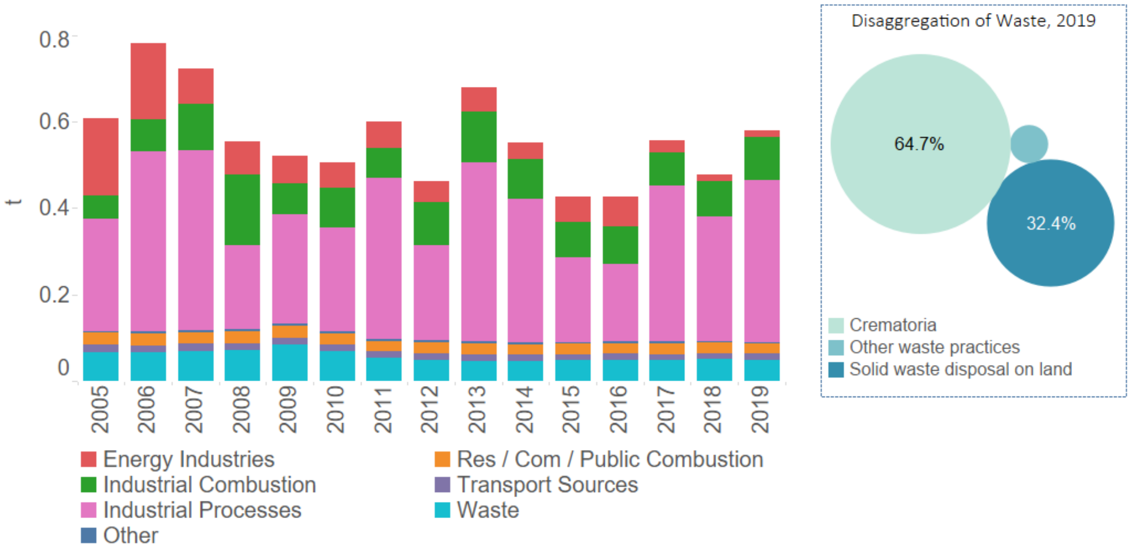
Emissions of **dioxins** in Wales were estimated to be 26g I-TEQ in Wales in 2019, representing 14% of the UK total. Emissions are 4% lower in 2019 compared to 2005. The iron and steel sector, particularly emissions from sinter production, influences the change in emissions from industrial processes.

Figure 82 B[a]p Emissions in Wales



Emissions of **benzo(a)pyrene** in Wales were estimated to be 714 kg in 2019, representing 9% of the UK total. Emissions have increased 31% since 2005 due to the increase in domestic wood combustion within the residential sector, accounting for 64% of the emissions from that sector.

Figure 83 Hg Emissions in Wales



Emissions of **Hg** in Wales were estimated to be 0.58 t in 2019 and have declined by 4.5% since 2005 (Figure 81). Emissions in Wales account for 14% of the UK total in 2019. This decline in emissions stems from changes to combustion in power and heat generation and chloralkali process emissions. The decline in emissions from power and heat generation is driven by the reduction in combustion in coal and liquid biofuels. However, while emissions from these sectors are reducing, emissions from combustion in cement industries have increased by 285% between 2005 and 2019 reducing the overall reduction in Hg emissions in Wales. The apparent volatility in the time-series in more recent years is principally driven by variations in the activity at Port Talbot steelworks: the site reports high variability in emissions on an inter-annual basis and with emissions from associated electric arc furnaces, sinter production, and blast furnaces varying accordingly.

Figure 84 Dioxin Emissions in Wales, 2019

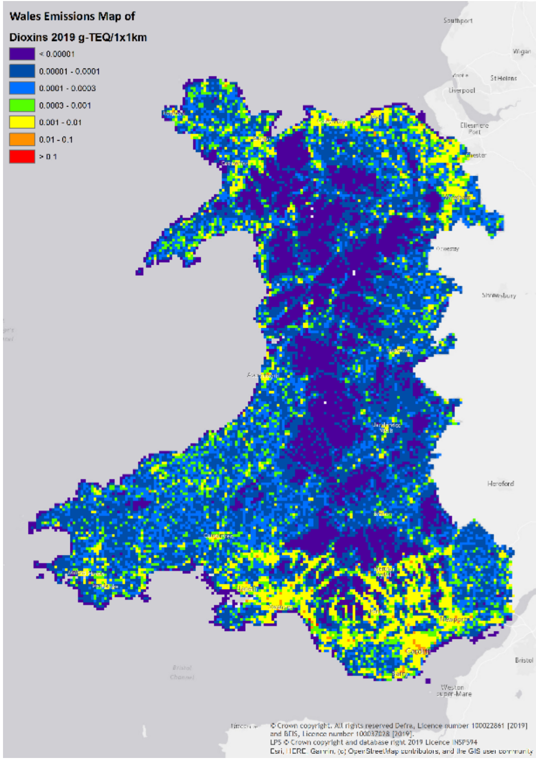


Figure 85 B[a]p Emissions in Wales, 2019

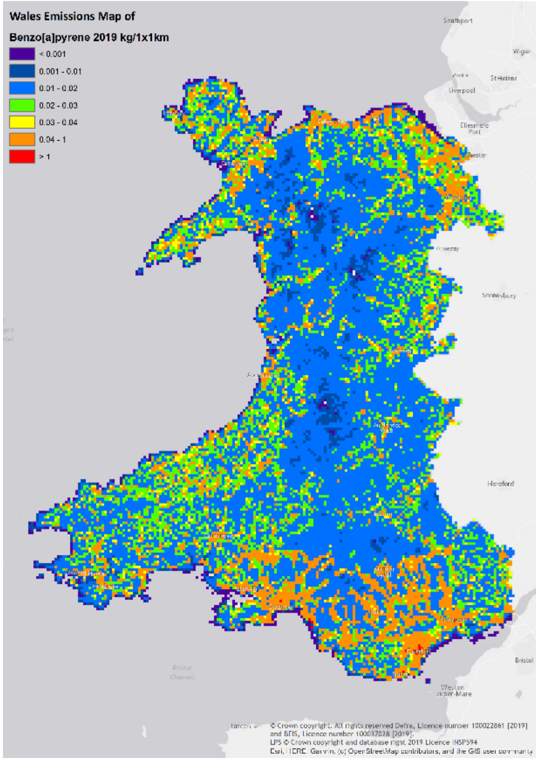
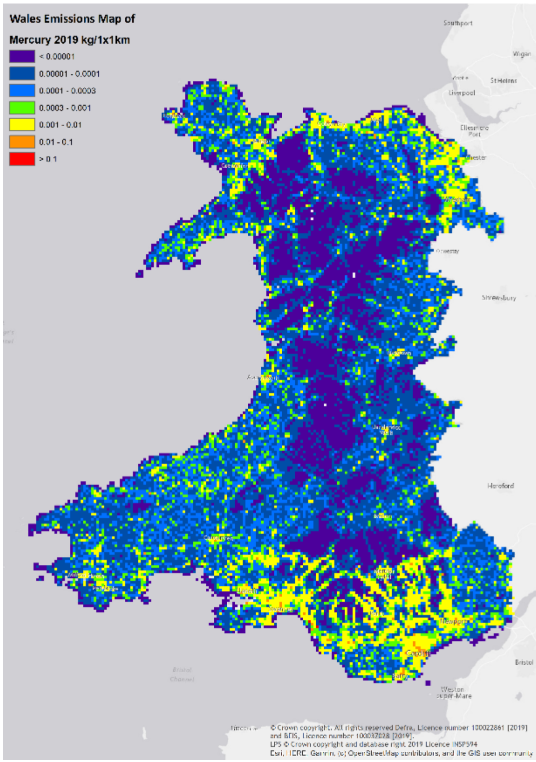
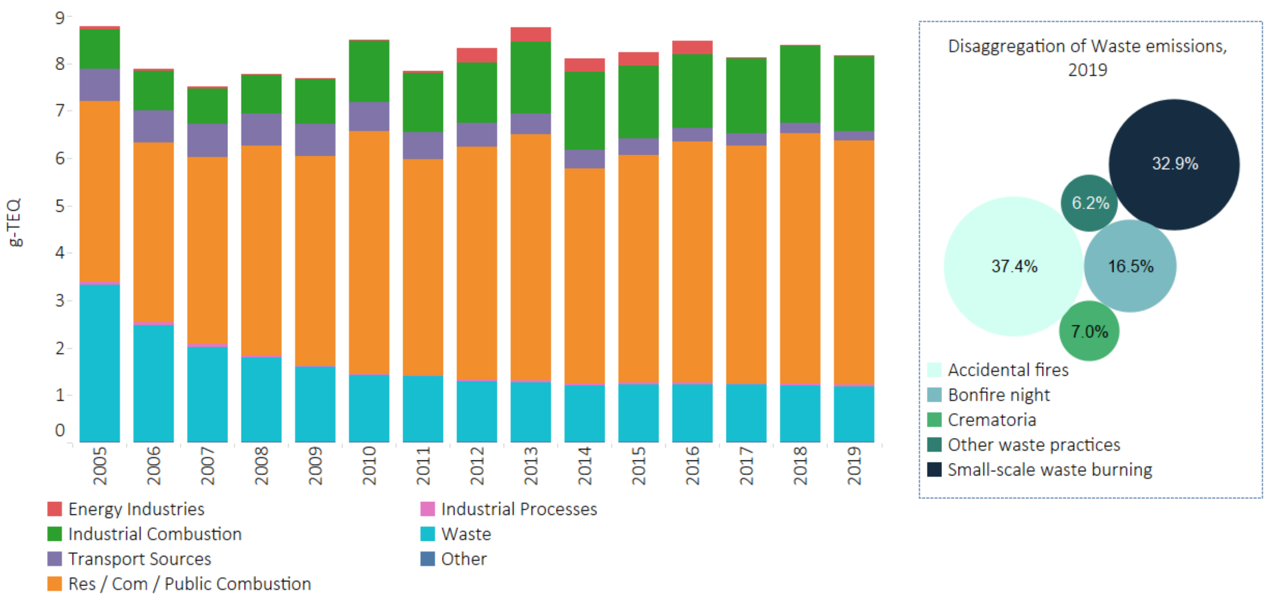


Figure 86 Hg Emissions in Wales, 2019



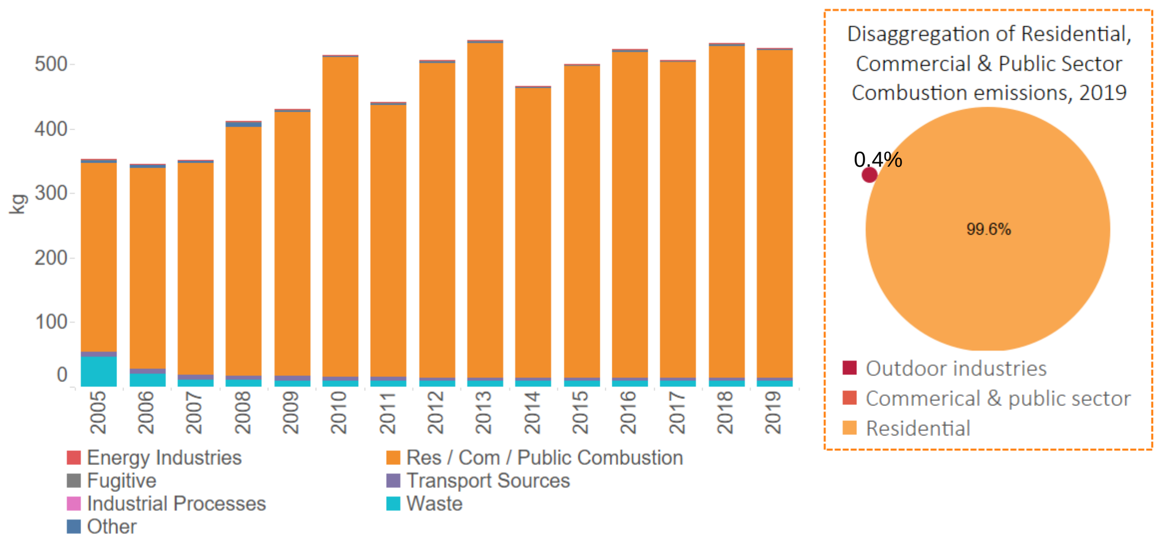
C.4.4 Northern Ireland

Figure 87 Dioxins Emissions in Northern Ireland



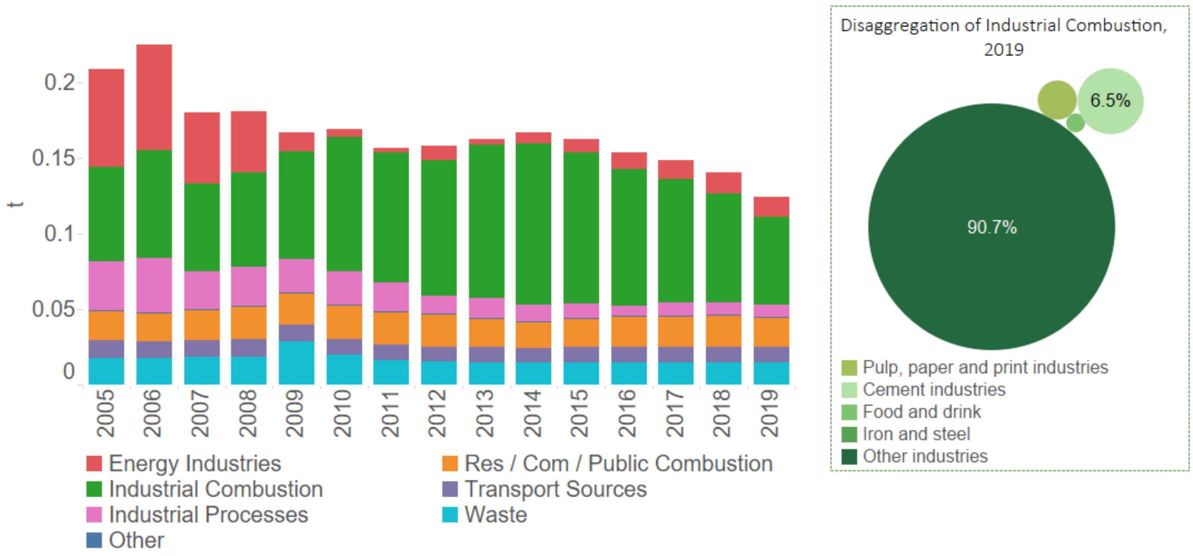
Emissions of **dioxins** in Northern Ireland were estimated to be 8.2g I-TEQ in 2019, representing 5% of the UK total. Emissions have fluctuated but declined overall by 7% since 2005, largely driven by reductions in emissions from residential combustion, as natural gas has penetrated the residential fuel market to displace oils and solid fuels. More recently, however, increased wood and other biomass combustion in residential and unallocated industries (1A4bi and 1A2gviii respectively) have opposed the continued decline in emissions and held a fairly stable trend since 2008.

Figure 88 B[a]p Emissions in Northern Ireland



Emissions of **benzo(a)pyrene** in Northern Ireland were estimated to be 526 kg in 2019, representing 7% of the UK total. This trend is driven by residential combustion practices, primarily the increased use of wood for residential heating. Domestic wood combustion comprises 73% of emissions from the residential sector.

Figure 89 Hg Emissions in Northern Ireland



Emissions of **Hg** in Northern Ireland were estimated to be 0.12 t in 2019 and have declined by 40% since 2005. Emissions in Northern Ireland account for 3% of the UK total in 2019. This decline in emissions stems from changes to combustion in power and heat generation and chlor-alkali process emissions, with a 61% and 28% contribution to the overall trend respectively. The decline in emissions from power and heat generation is driven by the reduction in combustion of natural gas and power station oil.

Figure 90 Dioxin Emissions in Northern Ireland, 2019

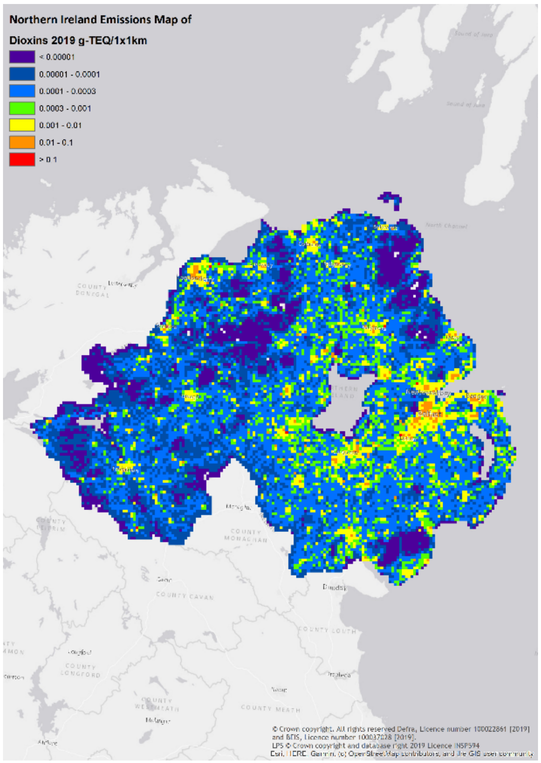


Figure 91 B[a]p Emissions in Northern Ireland, 2019

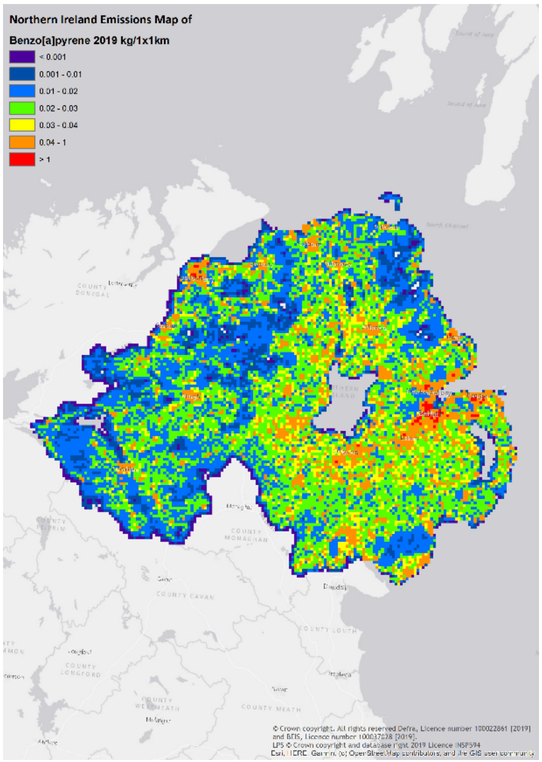
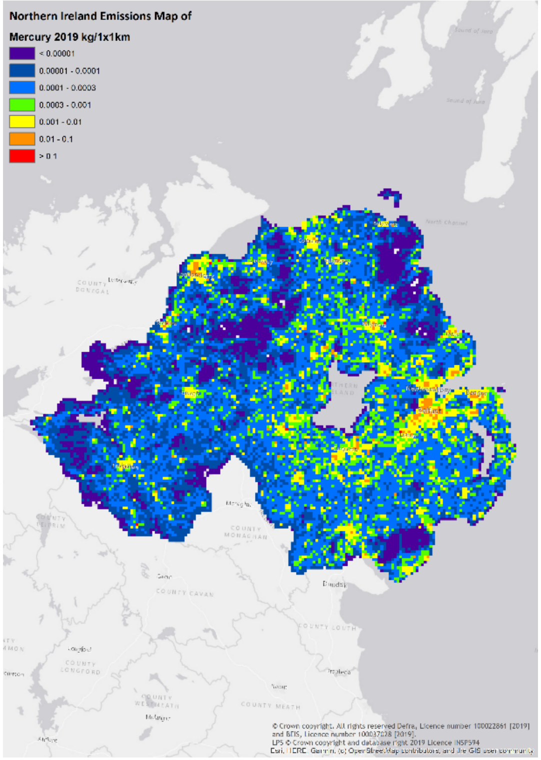


Figure 92 Hg Emissions in Northern Ireland, 2019



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) (Churchill, et al., 2021). The most significant changes for each pollutant in the most recent inventory for 2018 are given in the tables below (note the shading within columns indicates magnitude of absolute emission recalculations). Recalculations to the B[a]p and Dioxins inventories are not included in this section as emissions from these pollutant groups are included for the first time this compilation cycle.

In these tables, 'Change in 2018' refers to the change in emission estimate for 2018 between the previous inventory and the current inventory.

Table 8 - Recalculations to 2018 estimates for ammonia between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)
Overall change		**-3.40**	**-1.8%**	**0.57**	**1.9%**	**0.033**	**0.1%**	**0.19**	**0.6%**
Transport Sources	Recalculations to estimates of vkm travelled in road transport, as a result of recalculations to the underlying DfT dataset. DfT undertake a routine exercise to re-baseline the traffic estimates for minor roads in Great Britain, which last occurred in 2019 and results in recalculations in vkm travelled estimates for the years 2010 to 2018. As NI emissions estimates have been extrapolated using DfT trends since the last time data was provided by the Department for Regional Development (DRDNI), recalculations are translated to NI emissions for 2016-18 also.	0.20	5.3%	0.008	2.1%	0.015	6.6%	0.005	3.0%
Residential, Commercial & Public Sector Combustion	Minor recalculations	0.002	0.1%	0.000	0.1%	0.000	0.1%	0.000	0.1%
Industrial Processes	Minor recalculations	0.005	0.2%	0.003	4.3%	-0.009	-14%	0.009	168%
Agriculture	Upward revised estimates for other organic fertilisers applied to soils (NFR code 3Da2c) due to replacement of scaled data with actual data and inclusion of new sources for spread, food and crop digestates.	-1.2	-0.8%	0.73	2.5%	0.18	0.8%	0.38	1.2%
Waste	Correction of method of ammonia emission calculation from composting at permit sites to remove NH_3-N factor that was erroneously placed on input data	-0.83	-12%	-0.071	-11%	-0.033	-10%	-0.021	-10%
Other	Changes principally due to the allocation of ammonia emissions associated with rearing of professional and domestic horses, forced by changes in the format of activity data used for these emissions. The activity data has also changed for much of the time series	-1.5	-10%	-0.093	-7.4%	-0.12	-12%	-0.18	-27%

Table 9 - Recalculations to 2018 estimates for carbon monoxide (CO) between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)
Overall change		**60**	**5.4%**	**5.9**	**5.5%**	**3.5**	**1.8%**	**3.1**	**4.7%**
Energy Industries	Greater resolution in DUKES T6.6 allows has dictated a reallocation of biogas use from autogenerators from energy industries (NFR 1A1a) to industrial combustion (NFR 1A2gviii)	-5.7	-11%	0.075	1.7%	-0.62	-15%	-0.91	-26%
Industrial Combustion	Greater resolution in DUKES T6.6 allows has dictated a reallocation of biogas use from autogenerators from energy industries (NFR 1A1a) to industrial combustion (NFR 1A2gviii). Additionally, the emission factor for biomass combustion in other industrial combustion has been updated to align with EMEP/EEA Guidebook 2019 for this emission source. Smaller changes are seen in the use of petrol and gas oil in industrial off-road machinery as a result of revisions to DUKES and data on construction statistics published by ONS for 2018	10	3.1%	0.58	2.0%	0.88	1.2%	1.1	6.8%
Transport Sources	Recalculations to estimates of vkm travelled in road transport, as a result of recalculations to the underlying DfT dataset. DfT undertake a routine exercise to re-baseline the traffic estimates for minor roads in Great Britain, which last occurred in 2019 and results in recalculations in vkm travelled estimates for the years 2010 to 2018. As NI emissions estimates have been extrapolated using DfT trends since the last time data was provided by the Department for Regional Development (DRDNI), recalculations are translated to NI emissions for 2016-18 also.	20	8.6%	0.67	2.7%	1.3	10%	0.45	4.7%
Residential, Commercial & Public Sector Combustion	Correction to sectoral allocation of petroleum coke activity data causes an increase in emissions estimates, and recalculations to the activity data on imports	16	3.8%	1.1	2.4%	1.3	2.8%	2.1	5.5%

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)
	and exports of charcoal provided by FAO dominate reasons for change from this sector implies greater charcoal use in the sector.								
Industrial Processes	Emissions of CO from paper production included for the first time after the introduction of emission factors in EMEP/EEA Guidebook 2019	19	38%	3.5	1853%	0.60	1.2%	0.47	861%
Fugitive	Minor recalculation	0.018	1.3%	0.048	6.6%	0.000	0.0%	0.000	0.0%
Waste	Minor recalculation	0.025	0.3%	0.002	0.3%	0.001	0.3%	0.001	0.3%
Other	Minor recalculation	0.018	0.1%	0.001	0.1%	0.001	0.1%	0.000	0.1%

Table 10 - Recalculations to 2018 estimates for nitrogen oxides (NO_X) between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)
Overall change		**34**	**5.7%**	**3.8**	**4.4%**	**2.5**	**4.9%**	**1.2**	**3.5%**
Energy Industries	Greater resolution in DUKES T6.6 allows has dictated a reallocation of biogas use from autogenerators from energy industries (NFR 1A1a) to industrial combustion (NFR 1A2gviii)	-12	-12%	1.5	13%	-0.30	-3.1%	-1.5	-28%
Industrial Combustion	Greater resolution in DUKES T6.6 allows has dictated a reallocation of biogas use from autogenerators from energy industries (NFR 1A1a) to industrial combustion (NFR 1A2gviii). Smaller revisions include updates to DUKES activity data for many fuels, and improvements in the approach for natural gas use from other industrial combustion to integrate a composite factor to consider small, medium, and large sites separately	16	14%	0.57	4.7%	0.86	7.2%	1.1	13%
Transport Sources	Recalculations to estimates of vkm travelled in road transport, as a result of recalculations to the underlying DfT dataset. DfT undertake a routine exercise to re-baseline the traffic estimates for minor roads in Great Britain, which last occurred in 2019 and results in recalculations in vkm travelled estimates for the years 2010 to 2018. As NI emissions estimates have been extrapolated using DfT trends since the last time data was provided by the Department for Regional Development (DRDNI), recalculations are translated to NI emissions for 2016-18 also.	22	7.2%	0.73	1.8%	1.7	8.3%	0.63	4.5%
Residential, Commercial & Public Sector Combustion	DUKES revisions to gas oil use in agricultural mobile machinery and natural gas use in public sector combustion, coupled with an update to the emission factor for natural gas use in the public sector to account for different emissions rates for small, medium, and large buildings	1.8	2.8%	0.17	1.0%	0.077	1.3%	0.056	1%

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)
Agriculture	Greater resolution and changes to activity data on spread amounts by source category cause recalculations to NO_X emissions from digestate, compost, and sludge cake	0.81	104%	0.088	236%	0.040	76%	0.088	1577%
Other	Inclusion of emissions estimates for NO_X from paper production for the first time due to the inclusion of new emission factors in the EMEP/EEA Guidebook 2019 and updates to activity data for application of various nitrogen compounds on grassland (particularly ammonium nitrate) dominate the reasons for change from this category.	5.9	18%	0.79	16%	0.21	5.8%	0.81	31%

Table 11 - Recalculations to 2018 estimates for NMVOCs between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)
Overall change		**15**	**2.8%**	**3.4**	**2.3%**	**1.9**	**4.6%**	**1.7**	**5.0%**
Industrial Combustion	Main reason for change is recalculations in DUKES activity data for gas oil use in industrial off-road machinery	0.93	5.5%	0.070	4.3%	0.070	4.2%	0.060	8.3%
Transport Sources	Recalculations to estimates of vkm travelled in road transport, as a result of recalculations to the underlying DfT dataset. DfT undertake a routine exercise to re-baseline the traffic estimates for minor roads in Great Britain, which last occurred in 2019 and results in recalculations in vkm travelled estimates for the years 2010 to 2018. As NI emissions estimates have been extrapolated using DfT trends since the last time data was provided by the Department for Regional Development (DRDNI), recalculations are translated to NI emissions for 2016-18 also.	2.6	8.0%	0.018	0.4%	0.17	8.9%	0.043	3.2%
Residential, Commercial & Public Sector Combustion	Correction to sectoral allocation of petroleum coke activity data causes an increase in emissions estimates, and recalculations to the activity data on imports and exports of charcoal provided by FAO dominate reasons for change from this sector implies greater charcoal use in the sector.	0.67	1.6%	0.002	0.0%	0.058	1.2%	0.091	2.4%
Fugitive	Emissions estimates revised down for the calendar year 2018 following a re-evaluation of the linkages between the underlying data sources (Pollution inventory and EEMS), particularly for onshore oil loading at Sullom Voe and Seal Sands, and updates to the mapping grid use to distribute VOC emissions from petroleum processes and emissions from fuel station forecourts during vehicle refueling	-13	-20%	0.16	0.8%	-0.18	-2.9%	-0.048	-5.8%

Industrial Processes	Revisions to point source data within UK estimates, impacting upon DAs, for NFR code 2D3a, domestic solvent use, following consultation with BAMA.	6.4	15%	0.58	0.8%	0.30	12%	0.22	6.3%
Solvent Processes	Change to activity data for aerosols to integrate new estimates of aerosol use from BAMA for each type of aerosol (cosmetics & toiletries, household products, car-care products). This refinement in process has led to recalculations in the overall AD for this sector	8.9	3.5%	0.75	3.1%	0.71	5.3%	0.45	5.9%
Agriculture	There was an upward revision due to changes in livestock numbers, farm type allocation, and full inclusion of anaerobic digestion within manure management.	8.7	14%	1.8	13%	0.80	7.8%	0.88	5.7%
Other	Greater resolution in DUKES T6.6 allows has dictated a reallocation of biogas use from autogenerators from energy industries (NFR 1A1a) to industrial combustion (NFR 1A2gviii)	-0.003	0.0%	0.032	3.2%	0.000	0.0%	-0.017	-4.6%

Table 12 - Recalculations to 2018 estimates for PM_{10} between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)
Overall change		**1.3**	**1.0%**	**-0.88**	**-5.8%**	**0.12**	**1.0%**	**-0.049**	**-0.6%**
Energy Industries	Greater resolution in DUKES T6.6 allows has dictated a reallocation of biogas use from autogenerators from energy industries (NFR 1A1a) to industrial combustion (NFR 1A2gviii)	-0.49	-15%	0.011	4.5%	-0.022	-8.0%	-0.053	-44%
Industrial Combustion	Changes include recalculations to DUKES AD for coal combustion from other industrial combustion, and changes to point source data for the same source, which has led to readjustments to the distribution of emissions, and the inclusion of biogas use in autogeneration under NFR 1A2gviii following improvements in the resolution available in DUKES T6.6	1.5	9.8%	0.066	5.7%	0.18	13.9%	0.016	1.0%
Transport Sources	Recalculations to estimates of vkm travelled in road transport, as a result of recalculations to the underlying DfT dataset. DfT undertake a routine exercise to re-baseline the traffic estimates for minor roads in Great Britain, which last occurred in 2019 and results in recalculations in vkm travelled estimates for the years 2010 to 2018. As NI emissions estimates have been extrapolated using DfT trends since the last time data was provided by the Department for Regional Development (DRDNI), recalculations are translated to NI emissions for 2016-18 also.	1.5	8.9%	0.024	1.0%	0.11	9.3%	0.040	5.0%
Residential, Commercial & Public Sector Combustion	Correction to sectoral allocation of petroleum coke activity data causes an increase in emissions estimates, and recalculations to the activity data on imports and exports of charcoal provided by FAO dominate reasons for change from this sector implies greater charcoal use in the sector.	0.38	1.0%	0.012	0.3%	0.027	0.6%	0.044	1.2%
Industrial Processes	Replacement of rolled data with actual data for road construction in 2018 (2A5b) causes	-1.4	-3.0%	-0.13	-3.2%	-0.06	-1.7%	-0.034	-2.8%

	significant recalculations from this sector. In addition, emissions from paper production are estimated for the first time after the inclusion of emission factors in the EMEP/EEA Guidebook 2019.								
Agriculture	Downward revision due to disaggregation of agricultural operations by land area and activity	-0.18	-1.5%	-0.86	-32%	-0.11	-10.1%	-0.062	-4.3%
Fugitive	Minor recalculations	0.000	0.0%	-0.002	-0.6%	0.000	0.2%	0.000	0.0%
Waste	Minor recalculations	-0.021	-1.3%	-0.002	-1.3%	-0.001	-1.3%	-0.001	-1.3%
Other	Minor recalculations	-0.019	-0.6%	0.000	0.2%	0.001	0.9%	0.001	0.7%

Table 13 - Recalculations to 2018 estimates for sulphur dioxide (SO_2) between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)
Overall change		**16**	**13%**	**1.4**	**10%**	**0.71**	**4.4%**	**0.70**	**8.2%**
Energy Industries	Greater resolution in DUKES T6.6 allows has dictated a reallocation of biogas use from autogenerators from energy industries (NFR 1A1a) to industrial combustion (NFR 1A2gviii). Changes to emissions from coal combustion at power stations due to DUKES activity data revisions and changes to the site-specific normalisation approach after the integration of an improved system to consistently develop emissions estimates in the point source datasets.	-2.0	-5.3%	0.25	5.5%	-0.092	-2.8%	-0.17	-10%
Industrial Combustion	Correction to the activity data for petroleum coke use in other industrial combustion affects England emissions only, as all emissions from petcoke use in NFR 1A2gviii are assumed to occur there, and the inclusion of biogas use in autogeneration under NFR 1A2gviii following improvements in the resolution available in DUKES T6.6 affects all DAs	3.1	11%	-0.004	-0.3%	-0.002	0.0%	-0.058	-1.8%
Transport Sources	Recalculations to estimates of vkm travelled in road transport, as a result of recalculations to the underlying DfT dataset. DfT undertake a routine exercise to re-baseline the traffic estimates for minor roads in Great Britain, which last occurred in 2019 and results in recalculations in vkm travelled estimates for the years 2010 to 2018. As NI emissions estimates have been extrapolated using DfT trends since the last time data was provided by the Department for Regional Development (DRDNI), recalculations are translated to NI emissions for 2016-18 also.	-0.66	-6.8%	-0.066	-2.8%	-0.033	-3.3%	-0.033	-3.4%
Residential, Commercial & Public Sector Combustion	Correction to sectoral allocation of petroleum coke activity data causes an increase in emissions estimates, affecting	2.1	6.3%	0.57	15%	-0.31	-7.0%	0.76	28%

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)
	emissions from domestic combustion and smokeless solid fuel production								
Industrial Processes	Increase in emissions due to the estimates of SO_2 emissions from paper production being included for the first time after emission factors were provided in the most recent update to the EMEP/EEA Guidebook (2019)	7.6	101%	0.64	103%	0.26	52%	0.20	23006%
Fugitive	Improvement to the method to estimate the relative contributions of coal and petroleum coke to the solid smokeless fuel production mix imply greater use of petcoke (which is associated with a greater SO_2 emission factor) and lower use of anthracite, meaning that emissions are increased significantly for England and Wales. Minor changes elsewhere	5.6	649%	0.000	-0.2%	0.88	111%	0.000	
Other	Minor recalculations	0.002	0.1%	0.000	0.1%	0.000	0.1%	0.000	0.1%

Table 14 - Recalculations to 2018 estimates for lead (Pb) between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (t)	Change in 2018 (t)	Change in 2018 (t)	Change in 2018 (t)	Change in 2018 (t)	Change in 2018 (t)	Change in 2018 (t)	Change in 2018 (t)
Overall change		**1.1**	**1.6%**	**-0.46**	**-7.8%**	**-0.042**	**-0.3%**	**0.23**	**6.5%**
Energy Industries	Emission factor for coal combustion at power stations has been substantially revised in the updated version of the EMEP/EEA Guidebook (2019), affecting emissions totals here. As Pb emission factors for wood are derived through the normalisation of reported emissions at power station sites, the overall emission factor for wood combustion has increased, causing significant increases, particularly in Scotland where no coal combustion occurs anymore, and in NI where coal combustion is low, as this offsets recalculations in the other DAs.	-0.070	-3.5%	-0.074	-35%	-0.003	-5.5%	-0.013	-33%
Industrial Combustion	Update to previously extrapolated numbers for cement non-decarbonising emissions, update to DUKES activity for industrial off-road machinery use of gas oil and biomass combustion in other industrial combustion all affect emissions estimates in later years particularly.	0.59	7.0%	-0.018	-2.1%	0.014	1.9%	0.26	18%
Transport Sources	Recalculations to estimates of vkm travelled in road transport, as a result of recalculations to the underlying DfT dataset. DfT undertake a routine exercise to re-baseline the traffic estimates for minor roads in Great Britain, which last occurred in 2019 and results in recalculations in vkm travelled estimates for the years 2010 to 2018. As NI emissions estimates have been extrapolated using DfT trends since the last time data was provided by the Department for Regional Development (DRDNI), recalculations are translated to NI emissions for 2016-18 also.	1.4	5.3%	-0.18	-5.8%	0.094	5.6%	-0.003	-0.3%
Residential, Commercial & Public Sector Combustion	Correction to sectoral allocation of petroleum coke activity data causes an	0.069	1.7%	0.006	1.1%	0.005	0.9%	0.018	3.7%

	increase in emissions estimates, and recalculations to the activity data on imports and exports of charcoal provided by FAO dominate reasons for change from this sector implies greater charcoal use in the sector.								
Industrial Processes	Cessation of particleboard production at Coleraine affects NI estimates, whilst changes to ONS statistics on indices of production, updates to previously extrapolated emissions database from the Pollution Inventory, and integration of new mapping grids for wood production and foundries cause emissions estimates from this sector.	-0.89	-3.3%	-0.20	-17%	-0.15	-1.4%	-0.033	-9.0%
Fugitive	Minor recalculations	0.000	0.0%	0.000		0.000	0.0%	0.000	
Other	Minor recalculations	0.000		0.000		0.000		0.000	

Table 15 - Recalculations to 2018 estimates for $PM_{2.5}$ between previous and current inventory submissions

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)
Overall change		**4.00**	**5%**	**0.21**	**3%**	**0.30**	**4%**	**0.07**	**1%**
Energy Industries	Greater resolution in DUKES T6.6 allows has dictated a reallocation of biogas use from autogenerators from energy industries (NFR 1A1a) to industrial combustion (NFR 1A2gviii)	-0.47	-18%	0.001	0.6%	-0.022	-10%	-0.052	-48%
Industrial Combustion	Changes include recalculations to DUKES AD for coal combustion from other industrial combustion, and changes to point source data for the same source, which has led to readjustments to the distribution of emissions, and the inclusion of biogas use in autogeneration under NFR 1A2gviii following improvements in the resolution available in DUKES T6.6	1.4	9.2%	0.062	5.4%	0.17	14%	0.015	1.0%
Transport Sources	Recalculations to estimates of vkm travelled in road transport, as a result of recalculations to the underlying DfT dataset. DfT undertake a routine exercise to re-baseline the traffic estimates for minor roads in Great Britain, which last occurred in 2019 and results in recalculations in vkm travelled estimates for the years 2010 to 2018. As NI emissions estimates have been extrapolated using DfT trends since the last time data was provided by the Department for Regional Development (DRDNI), recalculations are translated to NI emissions for 2016-18 also.	1.1	9.3%	0.031	1.8%	0.077	9.7%	0.032	5.7%
Residential, Commercial & Public Sector Combustion	Correction to sectoral allocation of petroleum coke activity data causes an increase in emissions estimates, and recalculations to the activity data on imports and exports of charcoal provided by FAO dominate reasons for change from this sector implies greater charcoal use in the sector.	0.36	0.9%	0.010	0.3%	0.025	0.6%	0.043	1.2%

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)	Change in 2018 (kt)
Industrial Processes	Replacement of rolled data with actual data for road construction in 2018 (2A5b) causes significant recalculations from this sector. In addition, emissions from paper production are estimated for the first time after the inclusion of emission factors in the EMEP/EEA Guidebook 2019.	1.7	18%	0.13	17%	0.061	4.5%	0.045	20%
Agriculture	Downward revision due to disaggregation of agricultural operations by land area and activity.	0.01	0%	-0.02	-5%	0.00	-2%	-0.01	-4%
Fugitive	Revisions insignificant	0.00	0%	0.00	-1%	0.00	0%	0.00	0%
Waste	Revisions insignificant	-0.02	-1%	0.00	-1%	0.00	-1%	0.00	-1%
Other	Revisions insignificant	-0.01	0%	0.00	0%	0.00	0%	0.00	0%

Table 16 - Recalculations to 2018 estimates for B[a]p between previous and current inventory submissions – note these are experimental statistics only.

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (kg)	Change in 2018 (%)	Change in 2018 (kg)	Change in 2018 (%)	Change in 2018 (kg)	Change in 2018 (%)	Change in 2018 (kg)	Change in 2018 (%)
Overall change		**70**	**1.1%**	**4.1**	**0.8%**	**5.3**	**0.7%**	**8.4**	**1.6%**
Energy Industries	Minor recalculations by magnitude	-0.024	0.0%	0.001	0.2%	0.001	0.0%	-0.003	-0.3%
Transport Sources	Recalculations to estimates of vkm travelled in road transport, as a result of recalculations to the underlying DfT dataset. DfT undertake a routine exercise to re-baseline the traffic estimates for minor roads in Great Britain, which last occurred in 2019 and results in recalculations in vkm travelled estimates for the years 2010 to 2018. As NI emissions estimates have been extrapolated using DfT trends since the last time data was provided by the Department for Regional Development (DRDNI), recalculations are translated to NI emissions for 2016-18 also.	8.7	7.2%	0.19	1.3%	0.73	9.3%	0.16	3.2%
Residential, Commercial & Public Sector Combustion	The 2018 value for the import and export of charcoal in the UK has increased (imports more so than exports) compared to the values published last year in the FAO stats, affecting emissions of B[a]p from charcoal combustion in residential settings	50	0.9%	3.0	0.6%	5.2	0.8%	7.9	1.6%
Industrial Processes	Revisions of data in the Pollution Inventory from coal tar distillation affects the country-averaged emission factor for B[a]p emissions from the process. This dominates the reason for change across all DAs.	11	14%	1.0	13%	0.73	4.6%	0.40	44%
Fugitive	Previously extrapolated data for emissions of B[a]p from individual coke production sites has now been updated, causing a reallocation of emissions between England and Wales. Scotland and NI are unaffected	1.1	3.8%	0.000		-1.1	-1.8%	0.000	
Waste	Improvements to the method for extrapolating emissions from accidental fires (particularly buildings) causes an increase in activity data for the whole of	1.1	0.5%	0.11	0.4%	0.063	0.4%	0.038	0.4%

	the UK, and is distributed across the DAs accordingly.								
Other	Revisions to emissions reported to the Pollution Inventory for clinker production, and changes to the activity data for industrial off-road machinery use of gas oil in DUKES cause recalculations to this category	-1.8	-3.5%	-0.29	-5.7%	-0.36	-9.7%	-0.17	-7.7%

Table 17 - Recalculations to 2018 estimates for dioxins between previous and current inventory submissions – note these are experimental statistics only.

Category	Reason for the change in emissions	England		Scotland		Wales		Northern Ireland	
		Change in 2018 (g-TEQ)	Change in 2018 (%)	Change in 2018 (g-TEQ)	Change in 2018 (%)	Change in 2018 (g-TEQ)	Change in 2018 (%)	Change in 2018 (g-TEQ)	Change in 2018 (%)
Overall change		**4.78**	**4%**	**0.30**	**2%**	**0.32**	**1%**	**0.43**	**5%**
Energy Industries	Changes to the method to allocate emissions from MSW use in power stations, to align more closely with the data provided within the Pollution Inventory causes recalculations to emissions of dioxins from energy industries	0.16	12%	-0.003	-3.1%	0.006	4.3%	-0.003	-9.3%
Industrial Combustion	Principally due to the revisions in DUKES for biomass combustion in other industrial combustion	1.2	6.3%	0.075	5.3%	0.10	7.6%	0.096	6.3%
Transport Sources	Recalculations to estimates of vkm travelled in road transport, as a result of recalculations to the underlying DfT dataset. DfT undertake a routine exercise to re-baseline the traffic estimates for minor roads in Great Britain, which last occurred in 2019 and results in recalculations in vkm travelled estimates for the years 2010 to 2018. As NI emissions estimates have been extrapolated using DfT trends since the last time data was provided by the Department for Regional Development (DRDNI), recalculations are translated to NI emissions for 2016-18 also.	0.27	4.9%	0.031	4.9%	0.015	4.6%	0.009	4.2%
Residential, Commercial & Public Sector Combustion	Correction to sectoral allocation of petroleum coke activity data causes an increase in emissions estimates, and recalculations to the activity data on imports and exports of charcoal provided by FAO dominate reasons for change from this sector implies greater charcoal use in the sector.	2.3	4.5%	0.16	2.9%	0.18	2.9%	0.31	6.2%
Industrial Processes	Correction to sectoral allocation of petroleum coke activity data causes an increase in emissions estimates, and recalculations to the activity data on imports and exports of charcoal provided by FAO dominate reasons for change from	0.085	0.9%	-0.029	-3.4%	-0.029	-0.2%	0.000	0.8%

	this sector implies greater charcoal use in the sector.								
Waste	Improvements to the method for extrapolating emissions from accidental fires (particularly buildings) causes an increase in activity data for the whole of the UK, and is distributed across the DAs accordingly.	0.74	1.7%	0.070	1.7%	0.041	1.4%	0.025	2.2%
Other	Minor recalculations	0.000	0.0%	0.000	0.0%	0.000	0.0%	0.000	0.0%

Appendix E Uncertainties

Uncertainties in the UK inventory are associated with the availability and quality of activity data, emission factors, and the methodologies used in emissions calculations throughout the time series. These uncertainties are quantified in assessments using a 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 2019)’ (Churchill, et al., 2021). For England’s and the Devolved Administration’s air pollutant inventories, uncertainties are assessed for the NECR and Gothenburg Protocol base year (2005) and the most recently reported year by source sector and by pollutant using the Tier 1 approach. Full details of the approach can be found in Chapter 5 of the EMEP/EEA Guidebook (2019).

The Tier 1 method estimates uncertainties by source category using an error propagation approach, using simplistic rules for the base year and the latest year and the trend between them. This method does not account for correlations and dependencies between source categories that may occur because the same activity data or emission factors may be used for multiple emissions estimates. Potential examples of this include cases where the total consumption of a fuel is more certain than the consumption disaggregated by source category which implies that hidden dependencies exist within the statistics because of the constraints required to scale to overall consumption. Dependency and consumption is somewhat addressed here by aggregating source categories to a level across NFR sectors before uncertainties are combined, resulting in some loss of detail but minimising the influence of these potential hidden dependencies.

Additional considerations are needed for the air pollutant inventories for England and the Devolved Administrations due to the uncertainties associated with the method used to derive them. The inventories are derived by disaggregating UK emissions across the four countries and the unallocated region, and so the UK-wide uncertainty is compounded by further uncertainty introduced by the methods developed to split emissions on a source-activity scale. To account for this, and to ensure treatment of the DAs in a consistent manner but assuming independency between DAs, the uncertainty associated with activity is expressed as:

$$\overline{U}_{Ai} = U_A w_i \frac{\sum_i |E_i|}{\sqrt{\sum_i w_i^2 E_i^2}}$$

Where U_A is the uncertainty in the UK activity, w_i is the weighting factor for each DA representing the relative uncertainty in the activity, and E_i is the emission for each DA. If we additionally assume that the source comprises a large number of similar sources (e.g. factories, houses and fields) distributed throughout the UK then we can apply the weighting expressed as:

$$w_i = \frac{1}{\sqrt{|E_i|}}$$

So that choosing an emissions sensitivity of a half would yield:

$$\overline{U}_{Ai} = U_A \sqrt{\frac{\sum_i |E_i|}{|E_i|}}$$

By applying this DA-specific activity uncertainty to the UK-wide activity uncertainties derived for Churchill *et al*., (2021), it is possible to apply the formulaic approach outlined in Chapter 5 of the EMEP/EEA Guidebook (2019). In general, the NAEI is regarded as an international leader in terms of quality and accuracy, e.g. through the application of higher Tier methodologies, particularly for key sources, the strength of data provision agreements, and a continuous improvement process that addresses sensitivities for major and emerging sources.

E.1 Ammonia

Ammonia emission estimates are more uncertain than those for SO_2, NO_X and VOCs and are dominated by uncertainties in the estimates of emissions from agricultural sources, which represent the majority of the national total ammonia emissions. Although the DA inventories use a detailed (largely Tier 3) approach to estimating emissions from agriculture which accounts for different animal sub-categories and management systems, it is not possible to fully represent the many factors influencing emissions from what are often diffuse emission sources including things such as animal stocking densities, daily weather, soil type and conditions, etc. These are therefore reflected in the uncertainties associated with individual emission factors. Further work to characterise the uncertainty parameters for the revised UK agriculture model are ongoing and will be fully reported in the future submissions.

Table 18 – Tier 1 uncertainties for ammonia emissions by NFR sector for the DA inventories

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
England							
1A	6.9	143%	5%	4.30	72%	1.7%	0.6%
1B	0.3	39%	0%	0.16	47%	0.0%	0.0%
2A	0.4	32%	0%	0.33	32%	0.1%	0.0%
2B	4.0	24%	1%	1.83	28%	0.3%	0.0%
2C	0.0	91%	0%	0.00	91%	0.0%	0.0%
2D	1.0	145%	1%	1.02	159%	0.9%	0.7%
2G	0.2	67%	0%	0.13	62%	0.0%	0.0%
2H	0.9	133%	1%	0.76	133%	0.6%	0.0%
3B	70.5	49%	19%	60.89	46%	15.2%	10.4%
3D	83.2	96%	44%	95.33	98%	51.1%	3.0%
5A	0.9	62%	0%	0.18	62%	0.1%	0.0%
5C	0.7	440%	2%	0.67	255%	0.9%	0.1%
5B	2.0	37%	0%	4.36	21%	0.5%	0.4%
5D	1.5	95%	1%	1.23	93%	0.6%	0.2%
6A	10.3	130%	7%	11.66	121%	7.7%	3.7%
Total	**182.9**	**49%**	**49%**	**182.86**	**54%**	**53.9%**	**11.5%**
Scotland							
1A	0.5	149%	2%	0.37	87%	1.0%	0.9%
1B	0.0	59%	0%	0.00	59%	0.0%	0.0%
2A	0.0	46%	0%	0.04	46%	0.1%	0.1%
2B	0.0	135%	0%	0.00	135%	0.0%	0.0%
2D	0.1	214%	1%	0.10	301%	1.0%	1.1%
2G	0.0	113%	0%	0.01	108%	0.0%	0.0%
2H	0.0	608%	0%	0.00	608%	0.0%	0.0%
3B	15.1	61%	27%	12.73	57%	23.2%	23.2%
3D	16.5	95%	46%	16.42	90%	47.2%	6.0%
5A	0.1	80%	0%	0.02	79%	0.0%	0.0%
5C	0.1	448%	1%	0.07	245%	0.5%	0.2%
5B	0.2	107%	1%	0.38	48%	0.6%	0.7%
5D	0.1	125%	1%	0.12	105%	0.4%	0.3%
6A	1.0	178%	5%	1.04	163%	5.4%	5.8%
Total	**33.8**	**54%**	**54%**	**31.30**	**53%**	**52.9%**	**24.7%**
Wales							
1A	0.3	145%	2%	0.31	114%	1.6%	1.5%
1B	0.0	39%	0%	0.02	48%	0.0%	0.0%
2A	0.0	48%	0%	0.03	48%	0.1%	0.1%
2B	0.0	135%	0%	0.01	135%	0.1%	0.0%

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
2D	0.1	256%	1%	0.06	379%	0.9%	1.3%
2G	0.0	138%	0%	0.01	134%	0.0%	0.1%
2H	0.0	608%	0%	0.00	608%	0.0%	0.0%
3B	9.8	80%	35%	9.90	81%	34.6%	39.1%
3D	10.9	113%	56%	11.65	115%	58.3%	8.6%
5A	0.1	88%	0%	0.01	84%	0.1%	0.1%
5C	0.0	450%	1%	0.05	217%	0.5%	0.3%
5B	0.1	154%	1%	0.18	65%	0.5%	0.7%
5D	0.1	145%	1%	0.07	114%	0.3%	0.3%
6A	0.8	236%	8%	0.77	217%	7.2%	8.0%
Total	**22.3**	**66%**	**66%**	**23.08**	**68%**	**68.2%**	**40.9%**
NI							
1A	0.2	145%	1%	0.23	135%	1.0%	1.0%
1B	0.0	182%	0%	0.00	184%	0.0%	0.0%
2A	0.0	96%	0%	0.01	88%	0.0%	0.0%
2D	0.0	315%	0%	0.03	476%	0.5%	0.7%
2G	0.0	174%	0%	0.00	167%	0.0%	0.0%
2H	0.0	608%	0%	0.00	609%	0.0%	0.0%
3B	14.8	65%	32%	15.24	61%	28.5%	32.0%
3D	14.7	113%	55%	16.60	108%	54.8%	7.3%
5A	0.0	95%	0%	0.01	97%	0.0%	0.0%
5C	0.0	442%	1%	0.05	204%	0.3%	0.2%
5B	0.1	192%	0%	0.12	81%	0.3%	0.4%
5D	0.0	174%	0%	0.04	127%	0.2%	0.2%
6A	0.4	271%	4%	0.42	254%	3.2%	4.3%
Total	**30.3**	**63%**	**63%**	**32.75**	**62%**	**61.9%**	**33.2%**

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 higher uncertainty in emission factors for these sources, emission estimates for CO are much more uncertain than other pollutants such as NO_X (as NO_2) and SO_2. Unlike the cases of NO_X (as NO_2) and NMVOC, a few sources dominate the inventory and there is limited potential for error compensation.

Note that no Tier 1 uncertainties are computed for the UK inventory, and as such DA estimates of uncertainty are not provided for this pollutant. The carbon monoxide emissions estimates are considered to have moderate uncertainty.

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 substantial variation. 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, substantial variation in measured emission factors has 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, and comparable to 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.

Table 19 - Tier 1 uncertainties for nitrogen oxide (NO_X) emissions by NFR sector for the DA inventories

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
England							
1A	1286.4	7%	7%	587.24	9%	9.0%	2.4%
1B	0.3	27%	0%	0.17	32%	0.0%	0.0%
2B	1.3	26%	0%	0.74	49%	0.1%	0.0%
2C	1.1	24%	0%	0.32	33%	0.0%	0.0%
2G	0.1	91%	0%	0.05	89%	0.0%	0.0%
2H	3.8	121%	0%	3.39	121%	0.7%	0.0%
3B	1.1	66%	0%	1.00	71%	0.1%	0.0%
3D	20.4	59%	1%	20.21	63%	2.1%	0.1%
5C	1.5	29%	0%	1.30	31%	0.1%	0.0%
5E	0.3	88%	0%	0.10	84%	0.0%	0.0%
6A	0.3	125%	0%	0.31	123%	0.1%	0.0%
Total	**1316.5**	**7%**	**7%**	**614.84**	**9%**	**9.2%**	**2.4%**
Scotland							
1A	174.3	12%	12%	79.43	15%	13.9%	7.7%
1B	0.7	40%	0%	0.15	37%	0.1%	0.0%
2B	0.0	57%	0%	0.01	57%	0.0%	0.0%
2C	0.0	60%	0%	0.00	30%	0.0%	0.0%
2G	0.0	131%	0%	0.00	132%	0.0%	0.0%
2H	0.3	123%	0%	0.29	123%	0.4%	0.0%
3B	0.3	96%	0%	0.26	100%	0.3%	0.1%
3D	4.8	72%	2%	4.28	77%	3.9%	0.4%
5C	0.1	66%	0%	0.10	68%	0.1%	0.0%
5E	0.0	88%	0%	0.01	84%	0.0%	0.0%
6A	0.0	395%	0%	0.02	426%	0.1%	0.1%
Total	**180.7**	**12%**	**12%**	**84.54**	**14%**	**14.5%**	**7.7%**
Wales							
1A	107.3	14%	14%	49.42	15%	13.8%	7.7%
1B	0.1	18%	0%	0.05	18%	0.0%	0.0%

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
2B	0.0	57%	0%	0.03	57%	0.0%	0.0%
2C	0.5	19%	0%	0.26	23%	0.1%	0.0%
2G	0.0	156%	0%	0.00	159%	0.0%	0.0%
2H	0.2	124%	0%	0.13	124%	0.3%	0.0%
3B	0.2	104%	0%	0.16	106%	0.3%	0.1%
3D	3.2	96%	3%	2.80	90%	4.8%	0.5%
5C	0.1	80%	0%	0.07	80%	0.1%	0.1%
5E	0.0	88%	0%	0.01	84%	0.0%	0.0%
6A	0.0	362%	0%	0.03	391%	0.2%	0.1%
Total	**111.6**	**14%**	**14%**	**52.94**	**15%**	**14.6%**	**7.7%**
NI							
1A	59.8	20%	18%	31.80	20%	18.4%	12.3%
1B	0.0	130%	0%	0.00	130%	0.0%	0.0%
2B	0.0	57%	0%	0.00	57%	0.0%	0.0%
2G	0.0	191%	0%	0.00	193%	0.0%	0.0%
2H	0.1	126%	0%	0.09	126%	0.3%	0.1%
3B	0.1	119%	0%	0.13	112%	0.4%	0.2%
3D	3.0	94%	5%	2.95	95%	8.0%	0.8%
5C	0.0	138%	0%	0.02	147%	0.1%	0.1%
5E	0.0	88%	0%	0.00	84%	0.0%	0.0%
6A	0.0	560%	0%	0.01	590%	0.2%	0.2%
Total	**63.1**	**19%**	**19%**	**35.00**	**20%**	**20.0%**	**12.3%**

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 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 potential for error compensation. Error compensation is where an underestimate in emissions in one sector can be compensated by an overestimated of emissions in another sector when a large number of independent sources are utilised, with none dominating. A recent increase in the importance of solvent processes and agriculture sectors to the NMVOC inventory, which have higher uncertainty, means that the uncertainty rating of this inventory has been revised from low to moderate in this submission.

Table 20 - Tier 1 uncertainties for non-methane volatile organic compounds (NMVOCs) emissions by NFR sector for the DA inventories

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
England							
1A	234.9	19%	5%	97.34	36%	6.5%	1.8%
1B	159.2	25%	5%	52.67	22%	2.2%	0.3%
2A	1.9	38%	0%	1.03	36%	0.1%	0.0%
2B	30.3	56%	2%	7.64	56%	0.8%	0.0%
2C	1.1	84%	0%	0.41	75%	0.1%	0.0%

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
2D	310.1	13%	5%	260.54	25%	12.1%	9.2%
2G	0.2	196%	0%	0.13	190%	0.0%	0.0%
2H	37.5	138%	6%	38.01	162%	11.5%	0.3%
2I	1.3	121%	0%	0.81	121%	0.2%	0.1%
3B	42.4	147%	7%	42.57	144%	11.5%	1.7%
3D	20.5	114%	3%	27.17	120%	6.1%	0.4%
5A	5.2	34%	0%	1.66	34%	0.1%	0.0%
5C	3.2	271%	1%	3.07	281%	1.6%	0.2%
5D	0.2	489%	0%	0.36	505%	0.3%	0.3%
5E	1.3	88%	0%	0.49	85%	0.1%	0.0%
6A	1.2	97%	0%	1.31	98%	0.2%	0.1%
Total	**850.6**	**13%**	**13%**	**535.21**	**22%**	**22.3%**	**9.5%**
Scotland							
1A	24.5	21%	3%	10.47	39%	2.8%	2.5%
1B	43.4	29%	7%	16.95	23%	2.6%	0.6%
2A	0.0	60%	0%	0.02	60%	0.0%	0.0%
2B	7.2	57%	2%	3.78	57%	1.5%	0.0%
2C	0.0	80%	0%	0.01	84%	0.0%	0.0%
2D	29.7	38%	7%	24.25	71%	11.7%	13.8%
2G	0.0	219%	0%	0.01	216%	0.0%	0.0%
2H	51.5	22%	6%	76.26	21%	11.1%	6.0%
2I	0.1	233%	0%	0.05	237%	0.1%	0.1%
3B	11.2	140%	9%	9.98	132%	8.9%	3.7%
3D	5.3	112%	3%	5.21	112%	3.9%	0.4%
5A	0.5	60%	0%	0.17	60%	0.1%	0.1%
5C	0.4	323%	1%	0.36	337%	0.8%	0.4%
5D	0.0	1501%	0%	0.04	1581%	0.4%	0.4%
5E	0.1	88%	0%	0.05	85%	0.0%	0.0%
6A	0.1	170%	0%	0.09	180%	0.1%	0.1%
Total	**174.1**	**16%**	**16%**	**147.69**	**19%**	**19.3%**	**15.7%**
Wales							
1A	16.7	25%	7%	9.06	53%	10.9%	7.7%
1B	13.7	30%	7%	6.42	29%	4.3%	1.2%
2A	0.0	61%	0%	0.02	61%	0.0%	0.0%
2B	0.3	52%	0%	0.13	53%	0.2%	0.0%
2C	0.6	82%	1%	0.47	94%	1.0%	0.1%
2D	18.4	47%	14%	14.05	91%	29.2%	28.7%
2G	0.0	236%	0%	0.01	234%	0.0%	0.0%
2H	2.0	144%	5%	2.05	166%	7.7%	0.8%
2I	0.1	242%	0%	0.05	242%	0.3%	0.2%
3B	7.6	160%	19%	8.00	169%	30.8%	10.8%
3D	2.7	100%	4%	3.34	96%	7.3%	1.5%
5A	0.3	71%	0%	0.13	66%	0.2%	0.2%
5C	0.1	302%	1%	0.13	319%	1.0%	0.7%
5D	0.0	1967%	0%	0.02	2078%	1.0%	0.9%

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
5E	0.1	89%	0%	0.03	85%	0.1%	0.0%
6A	0.1	159%	0%	0.10	169%	0.4%	0.3%
Total	**62.8**	**26%**	**26%**	**44.01**	**45%**	**45.3%**	**31.7%**
NI							
1A	10.6	31%	8%	6.03	70%	12.1%	11.2%
1B	1.6	43%	2%	0.74	34%	0.7%	0.5%
2A	0.0	103%	0%	0.00	95%	0.0%	0.0%
2B	0.1	57%	0%	0.10	57%	0.2%	0.0%
2C	0.0	94%	0%	0.00	95%	0.0%	0.0%
2D	9.5	68%	17%	8.08	123%	28.5%	35.5%
2G	0.0	263%	0%	0.00	261%	0.0%	0.0%
2H	3.7	60%	6%	3.69	69%	7.3%	4.8%
2I	0.0	300%	0%	0.04	282%	0.3%	0.3%
3B	9.4	149%	36%	10.17	149%	43.5%	18.3%
3D	3.9	125%	12%	5.78	126%	20.9%	3.8%
5A	0.3	79%	1%	0.08	81%	0.2%	0.2%
5C	0.1	361%	1%	0.07	379%	0.8%	0.9%
5D	0.0	2577%	1%	0.01	2680%	0.9%	1.2%
5E	0.0	89%	0%	0.02	85%	0.0%	0.0%
6A	0.1	224%	0%	0.05	235%	0.3%	0.4%
Total	**39.3**	**42%**	**42%**	**34.86**	**58%**	**57.8%**	**42.0%**

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.

Table 21 - Tier 1 uncertainties for $PM_{2.5}$ emissions by NFR sector for the DA inventories

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
England							
1A	77.1	33%	26%	68.39	67%	54.5%	16.5%
1B	0.9	8%	0%	0.58	465%	3.2%	0.0%
2A	6.5	19%	1%	4.54	129%	6.9%	0.5%
2B	0.4	0%	0%	0.10	35%	0.0%	0.0%

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
2C	2.6	9%	0%	1.52	196%	3.5%	0.1%
2D	0.5	11%	0%	0.49	191%	1.1%	0.2%
2G	2.1	44%	1%	1.09	172%	2.2%	0.4%
2H	2.8	29%	1%	2.37	870%	24.4%	0.2%
2I	0.8	66%	1%	0.72	246%	2.1%	0.6%
3B	1.4	16%	0%	1.33	281%	4.4%	0.5%
3D	0.6	13%	0%	0.60	543%	3.8%	0.1%
5A	0.0	2%	0%	0.00	62%	0.0%	0.0%
5C	1.4	83%	1%	1.44	418%	7.1%	1.6%
5E	2.2	30%	1%	1.52	365%	6.5%	0.5%
6A	0.0	15%	0%	0.02	1233%	0.3%	0.1%
Total	**99.3**	**26%**	**26%**	**84.70**	**61%**	**61.4%**	**16.7%**
Scotland							
1A	10.7	30%	25%	6.69	70%	54.5%	35.3%
1B	0.2	5%	0%	0.31	96%	3.5%	0.1%
2A	0.6	11%	1%	0.37	82%	3.6%	1.1%
2B	0.0	0%	0%	0.01	91%	0.1%	0.0%
2C	0.1	2%	0%	0.14	109%	1.7%	0.1%
2D	0.0	8%	0%	0.03	273%	1.0%	0.3%
2G	0.2	25%	0%	0.11	187%	2.3%	0.9%
2H	0.2	16%	0%	0.20	870%	20.7%	0.4%
2I	0.1	34%	0%	0.05	319%	1.8%	1.1%
3B	0.3	10%	0%	0.26	224%	6.9%	1.8%
3D	0.1	6%	0%	0.10	436%	4.9%	0.2%
5A	0.0	1%	0%	0.00	79%	0.0%	0.0%
5C	0.2	45%	1%	0.15	463%	8.0%	4.0%
5E	0.2	17%	0%	0.15	372%	6.4%	1.2%
6A	0.0	8%	0%	0.00	1324%	0.2%	0.1%
Total	**12.8**	**25%**	**25%**	**8.56**	**60%**	**60.1%**	**35.7%**
Wales							
1A	7.6	46%	35%	6.57	88%	68.9%	52.1%
1B	0.1	3%	0%	0.05	218%	1.3%	0.1%
2A	0.3	12%	0%	0.17	72%	1.4%	0.9%
2B	0.0	0%	0%	0.00	91%	0.0%	0.0%
2C	1.2	10%	1%	0.98	94%	10.9%	0.7%
2D	0.0	5%	0%	0.02	238%	0.7%	0.3%
2G	0.1	21%	0%	0.06	199%	1.4%	0.9%
2H	0.1	13%	0%	0.09	871%	9.7%	0.3%
2I	0.0	33%	0%	0.05	323%	1.7%	1.4%
3B	0.2	13%	0%	0.20	276%	6.5%	2.3%
3D	0.0	2%	0%	0.02	397%	1.1%	0.1%
5A	0.0	1%	0%	0.00	84%	0.0%	0.0%
5C	0.1	44%	0%	0.08	558%	5.1%	3.9%
5E	0.1	15%	0%	0.08	378%	3.8%	1.2%
6A	0.0	8%	0%	0.00	1281%	0.3%	0.2%

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
Total	**10.0**	**35%**	**35%**	**8.38**	**71%**	**71.1%**	**52.4%**
NI							
1A	5.4	55%	48%	5.62	95%	84.4%	78.6%
1B	0.0	5%	0%	0.01	500%	1.1%	0.1%
2A	0.2	8%	0%	0.13	165%	3.4%	1.3%
2B	0.0	0%	0%	0.00	700%	0.0%	0.0%
2C	0.0	1%	0%	0.01	362%	0.4%	0.0%
2D	0.0	6%	0%	0.01	280%	0.5%	0.4%
2G	0.1	19%	0%	0.04	216%	1.3%	1.1%
2H	0.1	12%	0%	0.06	871%	8.3%	0.4%
2I	0.0	29%	0%	0.03	354%	1.7%	1.9%
3B	0.3	12%	1%	0.28	257%	11.5%	4.1%
3D	0.0	2%	0%	0.01	451%	1.0%	0.1%
5A	0.0	1%	0%	0.00	97%	0.0%	0.0%
5C	0.0	39%	0%	0.04	652%	4.6%	4.8%
5E	0.1	13%	0%	0.05	387%	3.1%	1.5%
6A	0.0	7%	0%	0.00	1506%	0.2%	0.2%
Total	**6.2**	**48%**	**48%**	**6.30**	**86%**	**85.8%**	**78.9%**

Table 22 - Tier 1 uncertainties for PM_{10} emissions by NFR sector for the DA inventories

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
England							
1A	87.4	30%	16%	76.24	60%	34.0%	10.3%
1B	1.6	128%	1%	0.65	114%	0.6%	0.0%
2A	43.3	71%	19%	32.12	74%	17.8%	2.6%
2B	0.6	64%	0%	0.13	36%	0.0%	0.0%
2C	4.4	118%	3%	2.74	148%	3.0%	0.2%
2D	1.3	270%	2%	1.38	223%	2.3%	0.3%
2G	2.9	284%	5%	1.43	249%	2.6%	0.3%
2H	4.7	685%	20%	3.84	728%	20.8%	0.1%
2I	1.0	145%	1%	0.90	145%	1.0%	0.4%
3B	6.9	416%	18%	6.65	420%	20.8%	0.9%
3D	4.8	323%	10%	5.21	328%	12.7%	0.3%
5A	0.0	62%	0%	0.01	62%	0.0%	0.0%
5C	1.6	387%	4%	1.59	408%	4.8%	1.1%
5E	2.3	288%	4%	1.63	365%	4.4%	0.3%
6A	0.0	1218%	0%	0.04	1233%	0.3%	0.1%
Total	**162.9**	**38%**	**38%**	**134.56**	**51%**	**50.6%**	**10.8%**
Scotland							
1A	12.1	27%	16%	7.48	63%	33.2%	22.9%
1B	0.5	355%	9%	0.65	68%	3.1%	0.2%
2A	4.5	71%	16%	3.12	74%	16.3%	6.5%
2B	0.0	696%	0%	0.02	91%	0.1%	0.0%

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
2C	0.1	245%	1%	0.17	92%	1.1%	0.1%
2D	0.1	330%	2%	0.10	291%	1.9%	0.6%
2G	0.3	292%	4%	0.14	259%	2.5%	0.7%
2H	0.4	686%	14%	0.33	729%	16.9%	0.3%
2I	0.1	246%	1%	0.06	250%	1.0%	0.9%
3B	0.9	315%	13%	0.86	342%	20.8%	2.5%
3D	0.9	284%	13%	0.96	265%	17.9%	0.9%
5A	0.0	80%	0%	0.00	79%	0.0%	0.0%
5C	0.2	435%	4%	0.16	453%	5.2%	2.7%
5E	0.2	292%	3%	0.16	372%	4.1%	0.8%
6A	0.0	1338%	0%	0.00	1324%	0.2%	0.1%
Total	**20.3**	**34%**	**34%**	**14.22**	**50%**	**49.7%**	**24.2%**
Wales							
1A	8.5	42%	24%	7.14	81%	49.3%	36.3%
1B	0.2	198%	2%	0.11	206%	1.8%	0.1%
2A	2.3	76%	12%	1.54	78%	10.3%	6.3%
2B	0.0	90%	0%	0.01	91%	0.1%	0.0%
2C	2.1	102%	15%	1.45	67%	8.3%	1.0%
2D	0.1	279%	1%	0.07	243%	1.4%	0.7%
2G	0.2	299%	3%	0.08	267%	1.8%	0.8%
2H	0.2	686%	9%	0.15	729%	9.3%	0.3%
2I	0.1	255%	1%	0.06	255%	1.2%	1.2%
3B	0.5	299%	10%	0.57	325%	15.7%	3.2%
3D	0.3	300%	7%	0.41	316%	11.0%	0.7%
5A	0.0	88%	0%	0.00	84%	0.0%	0.0%
5C	0.1	522%	3%	0.08	547%	3.9%	2.8%
5E	0.1	295%	3%	0.09	378%	2.9%	0.9%
6A	0.0	1301%	0%	0.00	1281%	0.3%	0.2%
Total	**14.6**	**35%**	**35%**	**11.76**	**56%**	**55.7%**	**37.2%**
NI							
1A	5.9	52%	35%	6.01	87%	60.6%	56.9%
1B	0.0	130%	0%	0.01	130%	0.2%	0.0%
2A	1.3	86%	13%	0.90	89%	9.2%	8.0%
2B	0.0	696%	0%	0.00	700%	0.0%	0.0%
2C	0.0	179%	0%	0.01	262%	0.3%	0.0%
2D	0.0	343%	1%	0.03	291%	1.1%	0.9%
2G	0.1	310%	4%	0.05	279%	1.6%	1.0%
2H	0.1	686%	10%	0.10	729%	8.2%	0.4%
2I	0.0	311%	1%	0.04	293%	1.3%	1.6%
3B	0.9	364%	36%	1.14	383%	50.4%	7.0%
3D	0.3	365%	11%	0.25	368%	10.8%	0.7%
5A	0.0	95%	0%	0.00	97%	0.0%	0.0%
5C	0.0	611%	3%	0.05	639%	3.6%	3.7%
5E	0.1	301%	3%	0.05	387%	2.5%	1.2%
6A	0.0	1496%	0%	0.00	1506%	0.2%	0.2%

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
Total	**8.7**	**54%**	**54%**	**8.65**	**81%**	**80.6%**	**58.1%**

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.

Table 23 - Tier 1 uncertainties for sulphur dioxide (SO_2) emissions by NFR sector for the DA inventories

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
England							
1A	561.9	9%	8%	101.89	34%	28.2%	1.4%
1B	6.2	10%	0%	4.58	25%	0.9%	0.0%
2A	17.2	14%	0%	5.32	14%	0.6%	0.1%
2B	7.4	23%	0%	0.76	43%	0.3%	0.0%
2C	4.4	15%	0%	0.56	37%	0.2%	0.0%
2G	0.7	77%	0%	0.76	78%	0.5%	0.1%
2H	7.6	182%	2%	6.77	182%	10.2%	0.1%
5C	0.7	109%	0%	0.46	156%	0.6%	0.0%
Total	**606.2**	**9%**	**9%**	**121.10**	**30%**	**30.0%**	**1.4%**
Scotland							
1A	88.4	10%	10%	12.32	26%	23.2%	2.9%
1B	0.4	35%	0%	0.16	46%	0.5%	0.0%
2B	0.0	30%	0%	-	0%	0.0%	0.0%
2C	0.8	25%	0%	0.63	12%	0.5%	0.1%
2G	0.1	240%	0%	0.07	250%	1.3%	0.3%
2H	0.7	183%	1%	0.58	183%	7.7%	0.2%
5C	0.1	148%	0%	0.05	203%	0.7%	0.0%
Total	**90.4**	**10%**	**10%**	**13.80**	**24%**	**24.5%**	**2.9%**
Wales							
1A	61.8	12%	12%	15.06	20%	17.5%	3.6%
1B	1.0	13%	0%	1.50	14%	1.2%	0.2%
2B	0.0	30%	0%	-	0%	0.0%	0.0%
2C	2.3	16%	1%	0.41	40%	0.9%	0.1%
2G	0.0	306%	0%	0.04	314%	0.8%	0.3%
2H	0.3	184%	1%	0.27	184%	2.8%	0.2%
5C	0.0	127%	0%	0.02	128%	0.2%	0.0%
Total	**65.4**	**12%**	**12%**	**17.30**	**18%**	**17.9%**	**3.6%**
NI							
1A	28.0	18%	18%	8.66	38%	37.5%	8.6%
2B	0.0	30%	0%	-	0%	0.0%	0.0%
2G	0.0	384%	0%	0.03	385%	1.3%	0.6%
2H	0.2	185%	1%	0.17	185%	3.6%	0.3%

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
5C	0.0	170%	0%	0.01	165%	0.2%	0.1%
Total	**28.3**	**18%**	**18%**	**8.87**	**38%**	**37.7%**	**8.6%**

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.

Table 24 - Tier 1 uncertainties for lead (Pb) emissions by NFR sector for the DA inventories

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
England							
1A	50.3	82%	35%	43.2	106%	64.9%	4.2%
1B	1.9	104%	2%	0.3	112%	0.5%	0.0%
2A	0.5	66%	0%	0.2	82%	0.2%	0.0%
2B	13.0	50%	5%	3.3	52%	2.5%	0.0%
2C	37.4	109%	34%	15.0	164%	34.9%	0.7%
2I	0.0	90%	0%	0.0	90%	0.0%	0.0%

NFR sector	2005			2019			
	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Emissions (t)	Combined uncertainty for sector	Uncertainty as % of DA total	Uncertainty introduced into trend in DA total
5C	15.6	67%	9%	8.5	81%	9.9%	3.7%
Total	**118.8**	**50%**	**50%**	**70.5**	**74%**	**74.3%**	**5.6%**
Scotland							
1A	6.7	65%	50%	4.5	97%	78.3%	19.2%
2A	0.1	90%	1%	0.0	90%	0.3%	0.1%
2C	0.6	382%	25%	0.4	467%	29.6%	0.0%
5C	1.5	127%	21%	0.7	135%	17.5%	13.7%
Total	**8.8**	**59%**	**59%**	**5.6**	**85%**	**85.5%**	**23.6%**
Wales							
1A	5.3	58%	13%	3.1	96%	22.6%	6.3%
1B	0.4	104%	2%	0.5	134%	4.7%	0.1%
2A	0.0	112%	0%	0.0	90%	0.1%	0.0%
2B	0.8	135%	5%	0.1	240%	1.5%	0.0%
2C	15.4	109%	74%	9.2	106%	72.5%	3.2%
5C	0.9	158%	6%	0.5	178%	6.2%	4.6%
Total	**22.8**	**75%**	**75%**	**13.3**	**76%**	**76.4%**	**8.4%**
NI							
1A	3.4	81%	68%	3.1	79%	70.4%	38.9%
2A	0.0	107%	1%	0.0	110%	0.1%	0.1%
2C	0.1	282%	9%	0.1	436%	9.3%	0.1%
5C	0.5	200%	26%	0.3	221%	18.9%	20.6%
Total	**4.1**	**73%**	**73%**	**3.4**	**74%**	**73.5%**	**44.0%**

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 23**.

A full dataset is published alongside this report, available to download from the NAEI website.

F.1 Summary Air Pollutant Emission Estimates for England

Table 25 - Summary of air pollutant emission estimates for England (2005-2019)*

	Category	2005	2010	2014	2015	2016	2017	2018	2019
Ammonia (kt)	Transport Sources	13.1	8.44	4.81	4.35	4.14	4.00	3.88	3.82
	Residential, Commercial & Public Sector Combustion	0.70	1.22	1.50	1.69	1.82	1.81	1.98	2.04
	Industrial Processes	5.53	4.47	3.06	2.23	2.59	3.03	2.60	3.03
	Agriculture	154	147	153	157	158	158	158	156
	Waste	4.41	5.06	6.23	6.13	6.38	6.58	6.21	5.78
	Other	11.9	12.8	13.1	13.2	13.2	13.4	13.4	13.4
	Total	**189**	**179**	**182**	**184**	**187**	**187**	**186**	**184**
Carbon monoxide (kt)	Energy Industries	67.9	59.1	61.7	54.1	37.3	35.8	44.5	35.2
	Fugitive	4.76	4.48	3.89	2.83	1.44	1.41	1.40	1.41
	Industrial Combustion	433	318	376	371	333	342	347	346
	Transport Sources	1,446	678	381	343	304	274	256	251
	Residential, Commercial & Public Sector Combustion	338	399	393	411	416	423	443	435
	Industrial Processes	120	97.6	96.1	84.7	66.7	68.5	68.2	71.2
	Waste	9.82	7.86	7.32	7.36	7.39	7.35	7.33	7.25
	Other	16.0	16.3	13.9	13.2	12.7	12.5	12.3	12.2
	Total	**2,434**	**1,581**	**1,333**	**1,287**	**1,178**	**1,164**	**1,180**	**1,160**
Nitrogen oxides (kt)	Energy Industries	345	209	183	149	93.2	91.4	84.4	74.5
	Industrial Combustion	227	151	117	124	118	123	127	119
	Transport Sources	591	415	364	358	345	329	323	316
	Residential, Commercial & Public Sector Combustion	104	80.2	63.7	65.4	66.4	64.4	65.6	64.6
	Agriculture	0.69	0.77	1.13	1.31	1.45	1.54	1.59	1.60
	Other	48.6	48.3	41.8	37.7	35.9	37.4	37.8	39.1
	Total	**1,317**	**905**	**770**	**736**	**660**	**646**	**639**	**615**

	Category	2005	2010	2014	2015	2016	2017	2018	2019
NMVOC (kt)	Fugitive	159	92.9	69.9	65.2	56.0	55.1	53.7	52.7
	Industrial Combustion	25.9	19.9	16.0	17.3	16.3	17.4	17.8	17.4
	Transport Sources	166	67.5	41.9	39.6	37.5	35.8	35.2	35.5
	Residential, Commercial & Public Sector Combustion	38.2	41.3	36.5	39.2	40.3	40.3	42.6	42.1
	Industrial Processes	72.3	55.6	50.9	48.6	47.6	49.6	48.2	48.0
	Solvent Processes	310	261	268	269	264	263	264	261
	Agriculture	62.9	62.7	65.5	66.0	66.9	69.2	70.6	69.7
	Other	16.0	12.3	10.2	9.76	9.26	9.29	9.25	9.17
	Total	**851**	**613**	**559**	**555**	**538**	**539**	**541**	**535**
PM_{10} (kt)	Energy Industries	8.48	5.43	6.01	4.66	3.03	2.93	2.73	1.86
	Fugitive	1.61	1.37	1.17	0.95	0.67	0.67	0.67	0.65
	Industrial Combustion	18.2	17.0	17.8	16.8	15.3	16.5	17.0	15.9
	Transport Sources	32.7	24.2	20.4	19.9	19.4	18.9	18.8	18.9
	Residential, Commercial & Public Sector Combustion	27.5	38.0	34.5	36.9	38.3	37.5	39.6	39.4
	Industrial Processes	56.9	46.0	39.9	39.5	42.8	48.2	43.7	41.2
	Agriculture	11.7	11.5	11.6	11.4	11.6	11.8	11.8	11.9
	Waste	2.35	1.83	1.66	1.67	1.68	1.67	1.66	1.63
	Other	3.51	3.24	3.26	3.21	3.20	3.22	3.23	3.24
	Total	**163**	**149**	**136**	**135**	**136**	**141**	**139**	**135**
Sulphur dioxide (kt)	Energy Industries	358	149	119	91.3	45.3	46.9	35.5	27.0
	Fugitive	6.18	17.5	13.1	9.81	7.78	6.89	6.42	4.58
	Industrial Combustion	100	72.0	53.8	37.9	30.6	30.3	30.7	27.2
	Transport Sources	49.0	21.2	12.3	9.35	9.15	8.92	9.09	9.22
	Residential, Commercial & Public Sector Combustion	49.3	35.8	34.4	33.8	33.6	35.1	35.8	37.0
	Industrial Processes	37.3	18.9	15.5	14.0	14.7	16.1	15.1	14.2
	Other	6.02	5.34	3.31	1.96	1.85	1.89	1.89	1.95
	Total	**606**	**320**	**252**	**198**	**143**	**146**	**134**	**121**
Lead (tonnes)	Energy Industries	8.88	2.16	2.33	2.55	2.43	2.39	1.90	2.09
	Fugitive	1.92	1.66	1.52	1.03	0.31	0.29	0.29	0.29
	Industrial Combustion	11.1	9.97	10.1	10.4	8.72	10.0	9.01	8.51
	Transport Sources	26.0	25.0	26.1	26.6	27.1	27.5	27.8	28.3
	Residential, Commercial & Public Sector Combustion	3.77	4.20	4.26	3.85	3.90	4.00	4.10	3.86
	Industrial Processes	66.4	31.7	36.0	35.7	31.2	30.5	26.5	26.8
	Other	0.33	0.29	0.28	0.26	0.23	0.24	0.49	0.25
	Total	**118**	**75.0**	**80.5**	**80.5**	**74.0**	**74.9**	**70.1**	**70.1**

	Category	2005	2010	2014	2015	2016	2017	2018	2019
$PM_{2.5}$ (kt)	Energy Industries	5.22	3.55	3.64	2.97	2.29	2.20	2.11	1.49
	Fugitive	0.91	0.83	0.77	0.68	0.59	0.59	0.59	0.58
	Industrial Combustion	17.4	16.2	16.9	15.9	14.7	15.8	16.4	15.3
	Transport Sources	27.0	18.9	14.8	14.3	13.7	13.1	12.9	12.8
	Residential, Commercial & Public Sector Combustion	26.9	37.1	33.7	36.0	37.4	36.7	38.7	38.5
	Industrial Processes	15.2	11.8	11.6	11.2	10.6	11.4	10.8	10.3
	Agriculture	1.98	1.93	1.93	1.91	1.93	1.95	1.93	1.93
	Waste	2.18	1.70	1.54	1.55	1.56	1.55	1.54	1.52
	Other	2.44	2.32	2.21	2.14	2.13	2.14	2.15	2.17
	Total	**99.3**	**94.3**	**87.1**	**86.6**	**84.9**	**85.4**	**87.1**	**84.7**
B[a]p (kg)	Energy Industries	67.2	68.6	138	171	159	161	184	201
	Fugitive	64.5	78.9	73.4	85.4	32.2	39.2	29.9	29.1
	Transport Sources	190	144	131	130	130	130	129	129
	Residential, Commercial & Public Sector Combustion	3,235	5,368	4,922	5,302	5,461	5,323	5,622	5,564
	Industrial Processes	136	94.1	103	99.2	81.9	80.5	91.9	76.4
	Waste	841	255	241	242	243	242	241	239
	Other	54.2	46.2	42.7	45.0	44.3	47.4	48.5	46.3
	Total	**4,588**	**6,056**	**5,650**	**6,075**	**6,151**	**6,023**	**6,346**	**6,285**
Dioxins (g I-TEQ)	Energy Industries	10.0	2.43	1.81	1.67	1.66	1.56	1.49	2.15
	Industrial Combustion	12.6	20.2	22.8	20.9	20.3	20.9	20.9	20.3
	Transport Sources	15.7	14.5	9.80	8.60	7.57	6.66	5.84	5.15
	Residential, Commercial & Public Sector Combustion	42.7	52.5	47.8	49.9	50.4	51.0	53.4	52.0
	Industrial Processes	32.5	33.4	16.0	13.9	9.95	10.1	9.74	10.3
	Waste	86.9	48.4	44.3	45.6	43.9	43.8	43.7	42.9
	Other	1.27	1.07	1.09	0.98	0.95	0.93	0.91	0.85
	Total	**202**	**172**	**144**	**141**	**135**	**135**	**136**	**134**
Hg (t)	Energy Industries	1.99	1.51	1.24	1.08	0.79	0.73	0.75	0.62
	Industrial Combustion	0.74	0.84	0.99	0.72	0.67	0.61	0.68	0.54
	Transport Sources	0.26	0.23	0.21	0.22	0.22	0.22	0.22	0.21
	Residential, Commercial & Public Sector Combustion	0.24	0.24	0.24	0.20	0.20	0.21	0.21	0.20
	Industrial Processes	1.80	1.25	0.83	0.80	0.56	0.70	0.65	0.66
	Waste	1.16	1.21	0.82	0.85	0.84	0.83	0.85	0.84
	Other	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01
	Total	**6.20**	**5.30**	**4.35**	**3.88**	**3.29**	**3.30**	**3.36**	**3.08**

* 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 26 - Summary of air pollutant emission estimates for Scotland (2005-2019)*

	Category	2005	2010	2014	2015	2016	2017	2018	2019
Ammonia (kt)	Transport Sources	1.36	0.87	0.49	0.44	0.42	0.39	0.38	0.38
	Residential, Commercial & Public Sector Combustion	0.06	0.10	0.12	0.13	0.14	0.14	0.15	0.16
	Industrial Processes	0.08	0.07	0.05	0.05	0.05	0.05	0.06	0.05
	Agriculture	31.6	29.6	29.8	30.2	30.8	29.8	29.2	29.1
	Waste	0.42	0.48	0.57	0.57	0.58	0.60	0.56	0.52
	Other	1.16	1.16	1.17	1.14	1.14	1.16	1.15	1.16
	Total	**34.7**	**32.3**	**32.2**	**32.5**	**33.1**	**32.1**	**31.5**	**31.4**
Carbon monoxide (kt)	Energy Industries	10.1	11.4	7.20	6.81	5.29	4.19	4.46	3.79
	Fugitive	0.97	0.90	0.97	1.17	0.82	0.60	0.77	1.16
	Industrial Combustion	29.5	25.8	25.9	27.0	26.5	28.3	29.0	30.3
	Transport Sources	137	66.9	38.2	33.9	30.2	27.9	25.7	25.6
	Residential, Commercial & Public Sector Combustion	42.1	47.5	43.5	45.4	45.9	46.1	47.5	46.4
	Industrial Processes	5.25	5.24	3.87	3.89	3.73	3.74	3.65	3.43
	Waste	0.99	0.79	0.72	0.72	0.72	0.72	0.71	0.70
	Other	1.63	1.65	1.42	1.35	1.29	1.28	1.25	1.24
	Total	**228**	**160**	**122**	**120**	**115**	**113**	**113**	**113**
Nitrogen oxides (kt)	Energy Industries	44.6	38.4	28.4	25.8	15.8	13.2	12.3	10.2
	Industrial Combustion	21.6	15.6	12.5	12.5	12.1	12.8	12.8	12.1
	Transport Sources	77.5	55.2	46.1	46.1	44.5	46.5	41.6	40.9
	Residential, Commercial & Public Sector Combustion	29.0	21.7	18.1	17.0	17.6	16.9	17.1	15.2
	Agriculture	0.05	0.05	0.07	0.08	0.12	0.12	0.13	0.13
	Other	7.98	7.30	6.84	6.37	5.99	6.18	5.82	6.11
	Total	**181**	**138**	**112**	**108**	**96.2**	**95.8**	**89.8**	**84.5**
NMVOC (kt)	Fugitive	43.4	22.7	19.3	21.5	21.4	19.0	19.5	17.0
	Industrial Combustion	2.20	1.90	1.52	1.67	1.55	1.71	1.70	1.69
	Transport Sources	16.4	7.15	4.43	4.22	4.05	4.08	3.93	3.99
	Residential, Commercial & Public Sector Combustion	5.33	5.24	4.29	4.46	4.59	4.52	4.65	4.52
	Industrial Processes	58.8	61.4	68.0	69.9	72.9	75.2	77.2	80.1
	Solvent Processes	29.7	24.7	25.5	25.4	24.4	24.5	24.6	24.2
	Agriculture	16.5	16.1	15.4	15.5	15.5	15.3	15.2	15.2
	Other	1.81	1.43	1.11	1.09	1.01	1.01	1.01	0.97
	Total	**174**	**141**	**140**	**144**	**145**	**145**	**148**	**148**

	Category	2005	2010	2014	2015	2016	2017	2018	2019
PM_{10} (kt)	Energy Industries	1.69	1.36	0.66	0.50	0.31	0.23	0.26	0.22
	Fugitive	0.53	0.65	0.75	0.38	0.32	0.36	0.34	0.65
	Industrial Combustion	1.81	1.50	1.24	1.23	1.14	1.20	1.24	1.17
	Transport Sources	4.87	3.25	2.48	2.44	2.40	2.41	2.35	2.33
	Residential, Commercial & Public Sector Combustion	3.71	4.08	3.42	3.63	3.78	3.68	3.82	3.74
	Industrial Processes	5.34	4.25	3.67	3.57	3.98	4.40	4.05	3.85
	Agriculture	1.77	1.80	1.84	1.79	1.80	1.81	1.79	1.82
	Waste	0.24	0.18	0.16	0.16	0.16	0.16	0.16	0.16
	Other	0.32	0.30	0.29	0.28	0.28	0.28	0.28	0.28
	Total	**20.3**	**17.4**	**14.5**	**14.0**	**14.2**	**14.5**	**14.3**	**14.2**
Sulphur dioxide (kt)	Energy Industries	53.7	65.1	23.3	17.6	8.93	5.49	4.86	3.98
	Fugitive	0.41	0.15	0.31	0.11	0.08	0.10	0.15	0.16
	Industrial Combustion	11.1	4.35	2.71	2.13	1.79	1.82	1.56	1.53
	Transport Sources	14.0	5.92	3.02	2.48	2.44	2.62	2.30	2.33
	Residential, Commercial & Public Sector Combustion	9.12	5.83	4.60	4.32	4.36	4.37	4.46	4.34
	Industrial Processes	1.52	1.31	1.33	1.33	1.31	1.30	1.27	1.28
	Other	0.55	0.49	0.31	0.18	0.17	0.17	0.17	0.18
	Total	**90.4**	**83.1**	**35.5**	**28.2**	**19.1**	**15.9**	**14.8**	**13.8**
Lead (tonnes)	Energy Industries	1.56	1.26	0.54	0.61	0.17	0.16	0.14	0.21
	Fugitive	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Industrial Combustion	1.82	1.37	0.94	0.86	0.88	0.98	0.86	0.83
	Transport Sources	2.71	2.65	2.62	2.65	2.70	2.91	2.88	2.90
	Residential, Commercial & Public Sector Combustion	0.58	0.59	0.51	0.53	0.53	0.53	0.54	0.51
	Industrial Processes	2.13	1.22	1.16	1.19	1.15	1.26	0.97	1.07
	Other	0.02	0.02	0.01	0.01	0.01	0.01	0.04	0.01
	Total	**8.80**	**7.11**	**5.78**	**5.85**	**5.44**	**5.85**	**5.42**	**5.54**
$PM_{2.5}$ (kt)	Energy Industries	1.03	0.86	0.41	0.33	0.24	0.19	0.20	0.18
	Fugitive	0.15	0.23	0.33	0.18	0.16	0.18	0.17	0.31
	Industrial Combustion	1.76	1.44	1.18	1.18	1.10	1.17	1.20	1.13
	Transport Sources	4.21	2.66	1.90	1.85	1.80	1.78	1.72	1.70
	Residential, Commercial & Public Sector Combustion	3.64	3.99	3.35	3.55	3.70	3.60	3.73	3.66
	Industrial Processes	1.21	0.94	0.91	0.85	0.90	0.94	0.90	0.87
	Agriculture	0.39	0.38	0.37	0.37	0.37	0.37	0.36	0.36
	Waste	0.22	0.17	0.15	0.15	0.15	0.15	0.15	0.15
	Other	0.23	0.22	0.21	0.20	0.19	0.20	0.20	0.20

	Category	2005	2010	2014	2015	2016	2017	2018	2019
	Total	**12.8**	**10.9**	**8.82**	**8.66**	**8.60**	**8.56**	**8.63**	**8.56**
B[a]p (kg)	Energy Industries	5.21	7.09	4.72	4.03	0.93	0.49	0.23	0.22
	Fugitive	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Transport Sources	22.1	17.1	14.5	14.6	14.6	14.6	14.6	14.6
	Residential, Commercial & Public Sector Combustion	304	498	437	465	479	466	486	479
	Industrial Processes	11.9	8.44	7.87	8.35	8.07	8.36	9.03	7.38
	Waste	118	26.5	24.7	24.8	24.8	24.6	24.5	24.2
	Other	5.05	4.94	4.27	4.31	4.29	4.57	4.71	4.46
	Total	**466**	**562**	**494**	**521**	**531**	**519**	**539**	**530**
Dioxins (g I-TEQ)	Energy Industries	0.29	0.20	0.20	0.18	0.10	0.10	0.09	0.16
	Industrial Combustion	1.51	1.66	1.60	1.49	1.48	1.51	1.50	1.47
	Transport Sources	1.66	1.56	1.07	0.93	0.83	0.76	0.68	0.60
	Residential, Commercial & Public Sector Combustion	5.15	6.03	5.15	5.37	5.39	5.41	5.55	5.39
	Industrial Processes	0.91	0.77	0.78	0.87	0.88	0.88	0.83	0.77
	Waste	9.71	4.69	4.11	4.21	4.21	4.19	4.17	4.09
	Other	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06
	Total	**19.3**	**15.0**	**13.0**	**13.1**	**13.0**	**12.9**	**12.9**	**12.5**
Hg (t)	Energy Industries	0.14	0.21	0.08	0.11	0.04	0.01	0.01	0.01
	Industrial Combustion	0.09	0.07	0.06	0.05	0.04	0.04	0.02	0.02
	Transport Sources	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
	Residential, Commercial & Public Sector Combustion	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
	Industrial Processes	0.12	0.08	0.04	0.04	0.02	0.04	0.03	0.03
	Waste	0.11	0.11	0.08	0.08	0.08	0.08	0.08	0.08
	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.53**	**0.54**	**0.31**	**0.34**	**0.24**	**0.22**	**0.21**	**0.21**

* 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 27 - Summary of air pollutant emission estimates for Wales (2005-2019) *

	Category	2005	2010	2014	2015	2016	2017	2018	2019
Ammonia (kt)	Transport Sources	0.84	0.53	0.30	0.27	0.26	0.24	0.24	0.24
	Residential, Commercial & Public Sector Combustion	0.07	0.13	0.15	0.17	0.19	0.19	0.20	0.21
	Industrial Processes	0.06	0.06	0.06	0.05	0.05	0.05	0.06	0.05
	Agriculture	20.7	19.9	20.8	21.1	21.6	21.8	21.5	21.5
	Waste	0.23	0.25	0.29	0.29	0.30	0.30	0.29	0.27
	Other	0.92	0.89	0.93	0.93	0.90	0.92	0.92	0.93
	Total	**22.8**	**21.7**	**22.6**	**22.8**	**23.3**	**23.5**	**23.2**	**23.2**
Carbon monoxide (kt)	Energy Industries	6.10	6.56	6.33	6.87	5.90	4.22	3.47	4.38
	Fugitive	3.11	6.38	5.62	4.63	9.54	6.21	6.17	6.13
	Industrial Combustion	77.7	69.5	88.6	84.8	74.2	80.6	77.3	79.5
	Transport Sources	82.5	39.7	22.2	19.8	17.6	15.6	14.6	14.3
	Residential, Commercial & Public Sector Combustion	39.4	47.3	44.7	46.7	47.1	47.5	49.1	47.9
	Industrial Processes	48.9	35.5	60.7	56.4	49.3	59.3	52.6	50.8
	Waste	0.58	0.46	0.42	0.42	0.42	0.41	0.41	0.41
	Other	0.77	0.78	0.66	0.63	0.60	0.59	0.58	0.57
	Total	**259**	**206**	**229**	**220**	**205**	**214**	**204**	**204**
Nitrogen oxides (kt)	Energy Industries	33.9	31.0	33.1	35.2	29.1	15.9	9.49	9.66
	Industrial Combustion	20.0	14.6	12.8	13.2	11.8	12.8	12.8	12.3
	Transport Sources	40.1	29.0	24.4	23.8	23.4	22.3	21.7	21.2
	Residential, Commercial & Public Sector Combustion	12.5	8.47	6.46	6.41	6.55	6.23	6.06	5.68
	Agriculture	0.02	0.03	0.06	0.07	0.09	0.09	0.09	0.09
	Other	5.11	4.40	4.58	3.79	3.96	4.18	3.83	3.94
	Total	**112**	**87.5**	**81.3**	**82.5**	**74.9**	**61.4**	**53.9**	**52.9**
NMVOC (kt)	Fugitive	13.7	12.6	9.34	8.46	6.90	6.32	6.07	6.42
	Industrial Combustion	2.23	1.96	1.70	1.72	1.68	1.77	1.73	1.81
	Transport Sources	9.43	3.95	2.46	2.31	2.21	2.07	2.06	2.06
	Residential, Commercial & Public Sector Combustion	4.29	4.95	4.27	4.52	4.66	4.60	4.77	4.69
	Industrial Processes	3.02	2.83	3.06	2.92	2.81	2.82	2.78	2.72
	Solvent Processes	18.4	14.9	15.0	14.8	14.4	14.2	14.1	14.1
	Agriculture	10.3	10.2	11.1	11.0	11.0	11.1	11.1	11.3
	Other	1.45	1.19	1.12	1.10	1.09	1.00	0.96	0.92

Air Pollutant Inventories for England, Scotland, Wales, and Northern Ireland: 2005-2019

	Category	2005	2010	2014	2015	2016	2017	2018	2019
	Total	**62.8**	**52.6**	**48.1**	**46.8**	**44.7**	**43.9**	**43.6**	**44.0**
PM_{10} (kt)	Energy Industries	1.04	0.79	0.56	0.56	0.49	0.29	0.25	0.21
	Fugitive	0.16	0.20	0.18	0.16	0.19	0.10	0.09	0.11
	Industrial Combustion	1.30	1.52	1.77	1.62	1.40	1.46	1.44	1.36
	Transport Sources	2.69	1.73	1.37	1.32	1.30	1.25	1.25	1.24
	Residential, Commercial & Public Sector Combustion	3.44	4.44	3.86	4.14	4.30	4.19	4.37	4.32
	Industrial Processes	4.83	3.37	3.72	3.50	3.12	3.70	3.48	3.29
	Agriculture	0.84	0.85	0.91	0.91	0.92	0.93	0.96	0.98
	Waste	0.14	0.11	0.09	0.09	0.09	0.09	0.09	0.09
	Other	0.19	0.17	0.17	0.17	0.17	0.17	0.17	0.17
	Total	**14.6**	**13.2**	**12.6**	**12.5**	**12.0**	**12.2**	**12.1**	**11.8**
Sulphur dioxide (kt)	Energy Industries	39.5	16.9	11.8	12.6	7.27	4.25	3.24	3.66
	Fugitive	0.97	4.12	2.67	1.97	2.00	1.79	1.68	1.50
	Industrial Combustion	7.16	10.0	8.76	7.42	6.05	6.74	6.07	6.34
	Transport Sources	8.99	3.74	1.72	1.20	1.19	1.07	0.99	1.01
	Residential, Commercial & Public Sector Combustion	5.90	5.26	4.22	4.09	4.25	4.06	4.06	3.99
	Industrial Processes	2.62	0.77	0.91	0.93	0.86	0.77	0.77	0.72
	Other	0.26	0.22	0.14	0.09	0.08	0.08	0.08	0.08
	Total	**65.4**	**41.1**	**30.2**	**28.3**	**21.7**	**18.8**	**16.9**	**17.3**
Lead (tonnes)	Energy Industries	0.67	0.47	0.10	0.14	0.13	0.07	0.05	0.06
	Fugitive	0.40	0.56	0.56	0.54	0.52	0.53	0.50	0.47
	Industrial Combustion	2.37	0.81	0.93	0.81	0.79	0.81	0.73	0.71
	Transport Sources	1.61	1.57	1.65	1.68	1.73	1.73	1.77	1.79
	Residential, Commercial & Public Sector Combustion	0.57	0.61	0.55	0.57	0.57	0.58	0.58	0.56
	Industrial Processes	17.2	11.8	13.2	13.0	10.7	10.8	10.4	9.73
	Other	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01
	Total	**22.8**	**15.8**	**17.0**	**16.7**	**14.5**	**14.5**	**14.1**	**13.3**
$PM_{2.5}$ (kt)	Energy Industries	0.63	0.51	0.36	0.36	0.36	0.22	0.19	0.16
	Fugitive	0.07	0.09	0.06	0.05	0.07	0.04	0.04	0.05
	Industrial Combustion	1.27	1.46	1.69	1.55	1.34	1.41	1.39	1.31
	Transport Sources	2.31	1.38	1.01	0.97	0.93	0.88	0.87	0.86
	Residential, Commercial & Public Sector Combustion	3.37	4.35	3.78	4.05	4.21	4.10	4.28	4.23
	Industrial Processes	1.83	1.31	1.79	1.61	1.19	1.49	1.43	1.35
	Agriculture	0.22	0.21	0.21	0.21	0.22	0.22	0.22	0.22
	Waste	0.13	0.10	0.09	0.09	0.09	0.09	0.09	0.08

	Category	2005	2010	2014	2015	2016	2017	2018	2019
	Other	0.13	0.12	0.11	0.11	0.11	0.11	0.11	0.11
	Total	**9.95**	**9.52**	**9.10**	**9.01**	**8.51**	**8.55**	**8.61**	**8.38**
B[a]p (kg)	Energy Industries	6.71	4.80	5.11	5.36	4.66	1.99	2.19	2.36
	Fugitive	13.3	26.8	27.2	46.3	66.6	86.0	61.4	56.2
	Transport Sources	12.3	9.45	8.49	8.42	8.48	8.37	8.56	8.34
	Residential, Commercial & Public Sector Combustion	376	628	558	596	614	596	623	615
	Industrial Processes	52.3	15.5	19.3	15.9	15.2	15.5	16.4	14.7
	Waste	73.5	15.5	14.5	14.4	14.4	14.3	14.3	14.2
	Other	9.37	3.42	3.80	3.51	3.40	3.37	3.36	3.17
	Total	**544**	**704**	**637**	**690**	**727**	**726**	**730**	**714**
Dioxins (g I-TEQ)	Energy Industries	0.21	0.12	0.15	0.16	0.19	0.15	0.15	0.18
	Industrial Combustion	1.20	1.37	1.64	1.51	1.48	1.46	1.43	1.38
	Transport Sources	0.96	0.90	0.60	0.52	0.46	0.40	0.35	0.31
	Residential, Commercial & Public Sector Combustion	5.59	6.89	6.06	6.33	6.36	6.37	6.55	6.35
	Industrial Processes	12.2	11.8	20.3	19.3	16.6	15.0	15.0	14.5
	Waste	6.35	3.30	2.94	3.03	2.99	2.99	3.00	2.94
	Other	0.28	0.34	0.34	0.25	0.23	0.21	0.17	0.16
	Total	**26.8**	**24.7**	**32.0**	**31.1**	**28.3**	**26.6**	**26.6**	**25.8**
Hg (t)	Energy Industries	0.18	0.06	0.04	0.06	0.07	0.03	0.02	0.02
	Industrial Combustion	0.05	0.09	0.09	0.08	0.09	0.08	0.08	0.10
	Transport Sources	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
	Residential, Commercial & Public Sector Combustion	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02
	Industrial Processes	0.26	0.24	0.33	0.19	0.18	0.36	0.29	0.38
	Waste	0.07	0.07	0.05	0.05	0.05	0.05	0.05	0.05
	Other	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.61**	**0.51**	**0.55**	**0.43**	**0.43**	**0.56**	**0.48**	**0.58**

* 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 28 - Summary of air pollutant emission estimates for Northern Ireland (1990-2019) *

	Category	2005	2010	2014	2015	2016	2017	2018	2019
Ammonia (kt)	Transport Sources	0.59	0.39	0.22	0.20	0.19	0.18	0.18	0.17
	Residential, Commercial & Public Sector Combustion	0.06	0.11	0.13	0.15	0.16	0.16	0.17	0.18
	Industrial Processes	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Agriculture	29.5	26.9	28.8	29.8	30.4	31.9	31.6	31.8
	Waste	0.15	0.16	0.18	0.18	0.19	0.19	0.18	0.17
	Other	0.47	0.46	0.48	0.48	0.47	0.49	0.49	0.49
	Total	**30.8**	**28.0**	**29.8**	**30.8**	**31.4**	**32.9**	**32.7**	**32.9**
Carbon monoxide (kt)	Energy Industries	3.41	2.91	1.31	2.29	1.51	1.90	2.54	1.18
	Fugitive	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Industrial Combustion	11.2	13.6	14.5	14.6	15.2	16.2	16.5	16.5
	Transport Sources	54.6	28.2	15.3	13.9	12.2	10.9	10.1	9.85
	Residential, Commercial & Public Sector Combustion	26.5	34.4	33.4	35.4	37.1	36.9	39.0	38.2
	Industrial Processes	0.66	0.60	0.59	0.54	0.51	0.54	0.53	0.53
	Waste	0.34	0.27	0.25	0.25	0.25	0.25	0.25	0.24
	Other	0.45	0.45	0.38	0.36	0.35	0.35	0.34	0.33
	Total	**97.2**	**80.5**	**65.7**	**67.4**	**67.2**	**67.0**	**69.3**	**66.8**
Nitrogen oxides (kt)	Energy Industries	9.82	5.95	5.25	5.10	4.86	4.07	3.75	3.22
	Industrial Combustion	12.9	9.86	8.36	8.80	8.93	9.30	9.55	9.15
	Transport Sources	27.2	20.2	16.4	15.9	15.6	15.2	14.6	14.2
	Residential, Commercial & Public Sector Combustion	9.39	7.13	5.40	5.48	5.51	5.05	5.19	4.93
	Agriculture	0.00	0.02	0.04	0.04	0.07	0.09	0.09	0.09
	Other	3.83	3.48	3.30	3.16	3.14	3.31	3.40	3.44
	Total	**63.1**	**46.6**	**38.8**	**38.5**	**38.1**	**37.0**	**36.5**	**35.0**
NMVOC (kt)	Fugitive	1.62	0.92	0.83	0.80	0.79	0.78	0.78	0.74
	Industrial Combustion	0.90	0.75	0.62	0.69	0.67	0.75	0.79	0.78
	Transport Sources	6.21	2.76	1.67	1.57	1.48	1.43	1.39	1.38
	Residential, Commercial & Public Sector Combustion	3.13	3.68	3.30	3.53	3.71	3.65	3.83	3.77
	Industrial Processes	3.80	3.77	3.31	3.57	3.48	4.10	3.76	3.83
	Solvent Processes	9.50	8.03	8.39	8.33	8.35	8.26	8.23	8.08
	Agriculture	13.3	13.0	14.4	14.9	15.2	16.1	16.3	15.9
	Other	0.82	0.57	0.40	0.42	0.38	0.34	0.36	0.33

	Category	2005	2010	2014	2015	2016	2017	2018	2019
	Total	**39.3**	**33.5**	**32.9**	**33.8**	**34.1**	**35.4**	**35.4**	**34.9**
PM_{10} (kt)	Energy Industries	0.29	0.08	0.04	0.06	0.08	0.06	0.07	0.04
	Fugitive	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Industrial Combustion	1.24	1.47	1.60	1.52	1.48	1.57	1.66	1.54
	Transport Sources	1.59	1.15	0.90	0.88	0.87	0.86	0.85	0.84
	Residential, Commercial & Public Sector Combustion	2.71	3.57	3.11	3.37	3.55	3.44	3.62	3.59
	Industrial Processes	1.58	1.20	1.00	1.00	1.13	1.28	1.15	1.10
	Agriculture	1.12	1.09	1.21	1.26	1.30	1.38	1.39	1.39
	Waste	0.08	0.06	0.06	0.06	0.06	0.06	0.06	0.05
	Other	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09
	Total	**8.73**	**8.72**	**8.02**	**8.25**	**8.57**	**8.75**	**8.89**	**8.65**
Sulphur dioxide (kt)	Energy Industries	14.9	2.32	2.68	2.50	2.44	1.39	1.49	1.17
	Fugitive	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Industrial Combustion	4.20	4.56	4.52	3.67	3.42	3.51	3.18	3.00
	Transport Sources	4.42	2.15	1.28	1.00	1.00	1.04	0.93	0.90
	Residential, Commercial & Public Sector Combustion	4.33	3.28	2.86	3.02	3.24	3.23	3.44	3.55
	Industrial Processes	0.23	0.21	0.22	0.20	0.19	0.21	0.20	0.20
	Other	0.16	0.14	0.08	0.05	0.05	0.05	0.05	0.05
	Total	**28.3**	**12.7**	**11.6**	**10.4**	**10.4**	**9.42**	**9.30**	**8.87**
Lead (tonnes)	Energy Industries	0.05	0.05	0.04	0.05	0.07	0.03	0.03	0.06
	Fugitive	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Industrial Combustion	1.87	1.70	1.32	1.28	1.29	1.37	1.75	1.35
	Transport Sources	1.10	1.11	1.09	1.11	1.14	1.16	1.17	1.17
	Residential, Commercial & Public Sector Combustion	0.41	0.51	0.43	0.45	0.48	0.47	0.50	0.47
	Industrial Processes	0.67	0.44	0.43	0.46	0.48	0.47	0.34	0.37
	Other	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00
	Total	**4.11**	**3.81**	**3.31**	**3.36**	**3.47**	**3.51**	**3.80**	**3.43**
$PM_{2.5}$ (kt)	Energy Industries	0.18	0.06	0.04	0.05	0.07	0.05	0.06	0.03
	Fugitive	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Industrial Combustion	1.18	1.38	1.52	1.45	1.42	1.51	1.59	1.49
	Transport Sources	1.34	0.91	0.67	0.64	0.62	0.61	0.59	0.58
	Residential, Commercial & Public Sector Combustion	2.66	3.49	3.04	3.30	3.48	3.37	3.54	3.51
	Industrial Processes	0.38	0.29	0.26	0.26	0.27	0.29	0.27	0.26
	Agriculture	0.28	0.27	0.27	0.28	0.29	0.30	0.30	0.30
	Waste	0.07	0.06	0.05	0.05	0.05	0.05	0.05	0.05

	Category	2005	2010	2014	2015	2016	2017	2018	2019
	Other	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06
	Total	**6.17**	**6.55**	**5.93**	**6.10**	**6.27**	**6.25**	**6.48**	**6.30**
B[a]p (kg)	Energy Industries	1.87	0.91	1.00	0.99	1.11	0.75	0.86	0.94
	Fugitive	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Transport Sources	7.84	6.22	5.32	5.25	5.26	5.28	5.24	5.18
	Residential, Commercial & Public Sector Combustion	294	496	450	483	506	489	515	509
	Industrial Processes	1.22	0.96	0.90	0.93	0.98	1.04	1.31	0.90
	Waste	46.2	9.28	8.69	8.71	8.71	8.66	8.63	8.57
	Other	2.44	1.91	1.82	1.90	1.88	1.94	1.99	1.85
	Total	**353**	**515**	**467**	**501**	**524**	**507**	**533**	**526**
Dioxins (g I-TEQ)	Energy Industries	0.06	0.02	0.29	0.29	0.30	0.03	0.03	0.03
	Industrial Combustion	0.83	1.28	1.64	1.53	1.54	1.57	1.61	1.57
	Transport Sources	0.68	0.63	0.39	0.34	0.30	0.26	0.23	0.21
	Residential, Commercial & Public Sector Combustion	3.83	5.10	4.55	4.82	5.08	5.00	5.28	5.14
	Industrial Processes	0.06	0.03	0.03	0.03	0.04	0.04	0.03	0.04
	Waste	3.31	1.41	1.19	1.21	1.21	1.20	1.19	1.17
	Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Total	**8.78**	**8.50**	**8.11**	**8.24**	**8.48**	**8.12**	**8.39**	**8.17**
Hg (t)	Energy Industries	0.06	0.00	0.01	0.01	0.01	0.01	0.01	0.01
	Industrial Combustion	0.06	0.09	0.11	0.10	0.09	0.08	0.07	0.06
	Transport Sources	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Residential, Commercial & Public Sector Combustion	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Industrial Processes	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01
	Waste	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.02
	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.21**	**0.17**	**0.17**	**0.16**	**0.15**	**0.15**	**0.14**	**0.12**

* 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 22 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 also 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 23** below for further information.

Table 29 - 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 / Tyre and brake wear for Pb only
1A3bvii	Road transport: Automobile road abrasion	Transport Sources	Other road transport
1A3c	Railways	Transport Sources	Rail, aviation, and shipping
1A3dii	National navigation (shipping)	Transport Sources	Rail, aviation, and shipping
1A3eii	Other (please specify in the IIR)	Transport Sources	Rail, aviation, and shipping
1A4ai	Commercial/institutional: Stationary	Residential, Commercial &	Commercial & public sector

NFR Code	NFR Source Description	Sector Category	Sub-sector Category
		Public Sector Combustion	
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
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

NFR Code	NFR Source Description	Sector Category	Sub-sector Category
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
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

NFR Code	NFR Source Description	Sector Category	Sub-sector Category
5C1bv	Cremation	Waste	Waste[10]
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

[10] For Hg, cremation is separated from the "Waste" category to aid visualisation of the distribution of waste emissions

Table 30 - Summary of the sector categories included in “Other” for each pollutant

Sector Category	CO	NH_3	NO_X	Pb	PM_{10}	SO_2	VOC	$PM_{2.5}$	B[a]p	Dioxins	Hg
Agriculture			✓								
Energy Industries		✓					✓				
Fugitive		✓	✓							✓	✓
Industrial Combustion		✓							✓		
Industrial Processes			✓								
Other	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Solvent Processes		✓			✓			✓	✓	✓	
Waste	✓		✓	✓	✓	✓	✓	✓			
Residential, Commercial & Public Combustion											