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Revisions table a summary of the major revisions undertaken since first publication

Version	Revision description	Reason for change	Date
v1.1	Modifications to tables	Merged cells removed to meet accessibility requirements; some information condensed	23/09/2020
v1.2	Updated data sources/methodology for some sectors	Updates necessary to be consistent with changes in the 2019 NAEI (2021 submission)	11/02/2021

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Introduction

The National Atmospheric Emissions Inventory

The National Atmospheric Emissions Inventory (NAEI) work programme delivers air pollutant emissions estimates from all anthropogenic emission sources in the UK. The NAEI data underpin UK Government statutory reporting commitments under the 2018 National Emission Ceilings Regulations (NECR)[1] and the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP). Under these international mechanisms, the UK has agreed to achieve emission reductions against a baseline of emissions in 2005, to mitigate sources of air pollution that are linked to health and environmental concerns. The set of pollutants that are reported on, and are of primary policy interest are:

- Ammonia (NH_3)
- Non-Methane Volatile Organic Compounds (NMVOCs)
- Nitrogen Oxides (NOx)
- Particulate Matter ≤10µm (PM_{10})
- Particulate Matter ≤2.5µm ($PM_{2.5}$)
- Sulphur dioxide (SO_2)

The NAEI is compiled and updated annually, to report emissions of all pollutants for 1990 to the latest year for which data are available; for some pollutants and sources, data are available back to 1970. Each year the full time series of NAEI data and methods are reviewed and updated to take account of statistical revisions and, where applicable, to apply improved estimation methods. The NAEI data quality is assessed annually through international reviews (e.g. under CLRTAP), whereby teams of inventory experts assess the UK data and methods against the international good practice guidance that all countries are required to adhere to in the European Environment Agency's EMEP/EEA Air Pollutant Emission Inventory Guidebook.

The scope of NAEI reporting is consistent with the international guidance for all countries under NECR and LRTAP, as follows:

[1] These are UK regulations transposed from the EU's National Emission Ceilings Directive (NECD)

- ✓ Emissions are reported for all territories governed by the UK, except Overseas Territories (OTs);
- ✓ All emissions from the cruise phase of aviation activity and from international shipping movements are reported as memo items, but are not to be reported within national inventory totals;
- × Natural sources of emissions (e.g. from geological activity, forest fires, non-managed forests and grasslands, wild animals) are not included in UK inventory reported totals, as the primary aim is to estimate the impact of anthropogenic activity;
- × Secondary emission sources, such as from the resuspension of particulate matter (e.g. dust on roads) or from the formation of secondary pollutants in the atmosphere, are not reported as this would be a double-count of the primary emission sources;

Intended use of this document

This document presents a summary of the methodologies and data sources used for estimating emissions of pollutants from **key[2] emission sources** as well as information on the uncertainties and limitations of the inventory methods (e.g. assumptions applied where data / information are limited). A summary of the quality assurance and quality control (QA/QC) procedures employed to minimise the risk of error and any bias in the reported data is also given. The QA/QC summary also includes a statement on the Inventory Agency's approach to the treatment of confidential data.

The Informative Inventory Report (IIR) provides full, referenced details of the data sources and methods used to compile each years' inventory including method details for non-key sources, and information for a wider scope of pollutants such as metals and persistent organic pollutants. For details of recent trends and figures in pollutant emissions alongside contextual information, please see the latest statistical bulletin for emissions of air pollutants in the UK.

BEIS and Defra together manage a continuous improvement programme for the NAEI, to ensure that the best available data and methods are applied in the

[2] **Key sources** for a pollutant are those which either contribute significantly to the national inventory total in a given year ("LEVEL"), or that contribute significantly to the reported trend in the inventory since the base year ("TREND"). Level assessment: when emissions are summed across all source categories in descending order of magnitude, the key sources are those that contribute to the first 80% of inventory emissions totals. Trend assessment: when source categories are sorted by magnitude (highest to lowest) of their contribution to the total reported inventory trend since the base year, those source categories whose cumulative % contribution is greater than 80% of the total are identified as key sources.

inventory, reflecting latest research and scientific data. Therefore, the methods and data sources outlined in this document may change in future submissions.

Summary of general methodology

Emissions are estimated for each pollutant by sector which are allocated to sources using the Nomenclature for Reporting (NFR14) format as outlined by the UNECE. The NAEI website contains a glossary of all NFR14 source codes used.

In its simplest form, emission estimates for each pollutant are calculated as a function of the quantity of pollutant emitted per unit of activity that emits emissions:

Emission estimate = Activity Data (AD) · Emission Factor (EF)

The UK emission inventories are compiled according to international good practice guidance for national inventories; for air quality pollutant inventories the inventory methodological guidance is the EMEP/EEA Air Pollutant Emission Inventory Guidebook.

Each year the emission inventories are updated to include the latest data available and any new research to improve the emission estimation methods. Improvements to the inventory methodology are made and backdated to ensure a consistent time series for emissions reporting. Methodological changes are made to take account of new data sources, or new guidance from the EMEP/EEA Guidebook, relevant work by IPCC, new research, or specific research programmes sponsored by Defra or BEIS.

The method selected for each emission source is determined by the significance of that source in the overall UK inventory context, and the availability of UK-specific data or models. **A tiered approach** is taken according to EMEP/EEA guidelines, as follows:

- **Tier 1** methods are the most simplistic. UK activity data are combined with default EFs to generate emission estimates. The **default EFs** from EMEP/EEA Guidebook are selected to be representative of typical global average performance (e.g. of a combustion unit). Hence the Tier 1 estimates are associated with higher uncertainty, as the default EF may not accurately reflect UK circumstances, and are only used for minor sources;
- **Tier 2** methods combine UK activity data with EFs that are specific to the UK, usually derived from UK research, or derived from emissions reporting by plant operators which can then be extrapolated across all such sources (i.e. including where monitoring may not be feasible). As these EFs are more representative of the UK emission source, they are associated with lower

uncertainty than Tier 1 and are suitable for application for key source categories.

- **Tier 3** methods typically apply more complex modelling approaches that are developed to generate more accurate estimates than Tier 2, often through research to more fully understand high-emitting emission sources.

Note that all sources do not emit all pollutants. For example, typically emissions from fuel combustion will include NOx and particulate matter, and usually low levels of other pollutants such as NMVOCs from incomplete combustion; if the fuel contains sulphur then there may also be SO_2 emissions. The EMEP/EEA Guidebook provides default EFs only for those pollutants that are expected from a given source. Many industrial process or solvents-related emission sources may only emit one or two pollutants, such as NMVOCs or particulate matter. For information of the scope of pollutants for each emission source, please refer to the IIR.

Summary of main data sources

The UK inventory estimates are based on a wide range of data sources, and are underpinned by many long-standing UK national statistics datasets, sector surveys and the reporting of emissions under various legal and (in some cases) voluntary mechanisms.

For most of these key data inputs to the NAEI, there are established data quality requirements that help to ensure good quality data are available to the UK inventory. For details of these systems, please see the summary of the general QA/QC procedures at the end of this document or the relevant chapter of the IIR.

Emission factors are primarily derived from either the default EFs in the EMEP/EEA Guidebook, or from UK research to derive country-specific EFs for given source.

Emissions data for many sources are routinely reported for regulated activities such as high-emitting combustion, industrial production and waste management activities.

For example, for activities that fall under the scope of regulation by the 2019 **Environment and Wildlife Regulations (EWR)**[3] and **Environmental Permitting Regulations (EPR)** of the UK, there is a statutory requirement for all permitted installations to report annual estimates of pollutant emissions to the regulatory

[3] These are UK regulations transposed from the EU's Industrial Emissions Directive (IED)

authority, if they emit to a level above a reporting threshold for each pollutant. These data are reported to different agencies according to their location:

- The Environment Agency's **Pollution Inventory for England (PI)**;
- Natural Resources Wales's **Welsh Emissions Inventory (WEI)**;
- The Scottish Environment Protection Agency's **Scottish Pollutant Release Inventory (SPRI)**; and
- The **Northern Ireland Environment Agency's Pollution Inventory (NIPI)**.

These pollution inventories have not been operational throughout the entire time series of the NAEI (i.e. back to 1990), and hence there is only partial coverage from operator-reported data. In England and Wales, pollution inventory data are available for most pollutants back to 1998, and NO_X and SO_2 data are available back to 1990. The Scotland SPRI data are available for 2002 and 2004 onwards, whilst the Northern Ireland PI data are available from 2001 onwards. For the earlier years, estimates are often extrapolated back across the time series using EFs derived from the operator-reported data, and often using information on either production, fuel consumption or plant capacity to generate estimates.

Emissions and/or activity data are also provided through other regulations, such as the **EU Emissions Trading Scheme (EU ETS)**, for which data are available from 2005 onwards via BEIS. Emissions reporting by upstream oil and gas operators is regulated by the BEIS Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) team, with all upstream fixed and mobile installations reporting annual emission estimates for atmospheric pollutants to the **Environmental Emissions Monitoring System (EEMS)**.

Further information on emissions is also provided annually to the inventory agency for many high-emitting sectors via trade associations, statistical agencies or key operators, including:

- Production and fuel use emissions for the iron and steel sector, from the **Iron and Steel Statistics Bureau (ISSB)**;
- Air pollutant emissions by refinery for all UK refining operations from the **UK Petroleum Industries Association (UKPIA)**;
- Air pollutant emissions from sub-sources within integrated steelworks from operators such as **Tata Steel** (i.e. separate data for emissions from coke ovens, sinter plant, blast furnaces, power plant, basic oxygen furnaces, fugitives); and
- Activity data (fuel use and production of clinker) and emissions from UK cement kilns, from the **Mineral Products Association (MPA)**.

Activity data for the UK inventory methods are derived primarily from UK national statistics, augmented by some of the sector-specific inputs noted above, including:

- Annual fuel use for each economic sector which is used for all combustion sources and primary energy products in the energy sector is provided by **The Digest of UK Energy Statistics (DUKES)**
- Supplementary data on combustion sources and industrial production activity and emissions are provided by **European Union Emissions Trading System (EU ETS)**
- Transport statistics including road transport vehicle kilometre (vkm) data and Maritime Shipping statistics are provided by the **Department for Transport (DfT)**
- Housing statistics are provided by the **Ministry of Housing, Communities & Local Government (MHCLG)**
- Information on fugitive emissions from the energy sector is provided by the **Environmental and Emissions Monitoring System (EEMS)** for upstream oil and gas, whilst data for the downstream gas transmission and distribution network come from the **National Grid** and regional gas transporters (**Cadent Gas, Northern Gas, Wales and West, SGN**). Information on coal production is provided by annual statistics from the **Coal Authority**;
- Industrial production statistics are obtained from various trade associations (outlined above) as well as the **ONS** production and economic performance statistics;
- Agricultural estimates are derived from published surveys and statistical releases including June Agricultural Census (**Defra**) and **The British Survey of Fertiliser Practice**. Livestock and crop production surveys are also obtained from **Scottish and Welsh Government** and **DAERA** for Northern Ireland;
- Waste management statistics are obtained from a range of surveys and statistical releases from **Defra**, **Scottish and Welsh Government** and **DAERA**. Information on landfills is obtains from UK environmental regulators. Data on the emergence of anaerobic digestion and composting is taken from the **National Non-Food Crops Centre (NNFCC)** database;
- Information on land use and NH_3 emissions from natural sources are derived from surveys and modelling by the **Centre for Ecology and Hydrology (CEH)**.

References

For a complete list of the references used in this report, please refer to the IIR.

Energy Industries (1A1)

Summary

This sector comprises emissions from fuel combustion in the energy supply sector, including from power generation, exploration and production of crude oil and natural gas, the refining of crude oil into secondary oil products, and the production of solid fuels such as coal, coke and smokeless solid fuels.

Key sources and pollutants

Table 1 Key sources and pollutants in Energy Industries (1A1)

NFR14 source category	NFR14 source category name	Pollutant	Proportion of total emissions for pollutant in 2019 (%)	% Change in emissions (1990 - 2019)
1A1a	Public electricity and heat generation	SOx	7.2	-99.5
1A1a	Public electricity and heat generation	NOx	9.0	-89.5
1A1b	Petroleum refining	SOx	14.0	-83.3
1A1c	Manufacture of solid fuels and other energy industries	NOx	6.9	28.5

Data sources

Table 2 An overview of the methods and data sources used in Energy Industries (1A1)

NFR14 source category	NAEI source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
1A1a	Power stations	All	UK model	DUKES; EU ETS; Operators	Major fuels: Operator-reported; Minor fuels: Default EFs
1A1a	Heat supply	All	AD · EF	DUKES	MSW: Operator-reported; LFG: Default EFs
1A1a	Heat supply	All	AD · EF	DUKES	Sewage gas: Default EFs
1A1b	Refineries	All (except NH3)	AD · EF	DUKES; EU ETS	Operator-reported; Default EFs
1A1c	Coke production	All	UK model	DUKES; EU ETS; ISSB	Major fuels: Operator-reported; Minor fuels: Default EFs
1A1c	Collieries - fuel combustion	All	AD · EF	DUKES	Default EFs
1A1c	Gas production (downstream gas)	All	AD · EF	DUKES; EU ETS	Operator-reported; UKOOA research; Default EFs; operator-reported emissions (NOx & PM_{10} only and some sites only)
1A1c	Gas separation plant	All	AD · EF	DUKES; EEMS; EU ETS	Operator-reported; UKOOA / other UK-specific research; Default EFs
1A1c	Upstream gas production	All	AD · EF	DUKES; EEMS; EU ETS	Operator-reported; UKOOA / other UK-specific research; Default EFs
1A1c	Nuclear fuel production	All	AD · EF	DUKES	Default EFs
1A1c	Upstream oil production	All	AD · EF	DUKES; EEMS; EU ETS	Operator-reported; UKOOA / other UK-specific research; Default EFs
1A1c	Solid smokeless fuel production	All	AD · EF	DUKES; EU ETS	Default EFs
1A1c	Town gas manufacture	All	AD · EF	DUKES	Default EFs

Public electricity and heat generation (1A1a)

This category is dominated by emissions from the combustion of fuels (e.g. coal, natural gas, oils, wood/biomass) in UK power stations, but also includes some other sources that generate heat and power such as the use of biogas for power generation from landfill gas (LFG) engines, sewage gas engines and the combustion of Municipal Solid Waste (MSW) in Energy from Waste (EfW) plants in the UK.

Methodology

In most cases:

$$\textbf{UK emission} = \sum \textbf{Reported Site Emissions}$$

All of the high-emitting large UK power stations are regulated under EU ETS and EWR/EPR, and the operators are required to report annual estimates of pollutant releases to the regulatory authorities. In all such reporting, there are reporting thresholds for each pollutant; where an installation emits less than the reporting threshold, then operators may submit a return indicating “Below Reporting Threshold” (BRT) for that pollutant in that year. Further, where an installation closes mid-year, no report on environmental emissions may be submitted to regulators.

As the NAEI must report complete UK emissions, the inventory method uses the reported data and also applies assumptions (e.g. using plant capacity, duration of year in operation) to extrapolate from reported data to address any non-reporting sites, closed sites and BRT data.

Some smaller UK power stations are not obliged to report emissions and so these are estimated based on activity data from EU ETS or plant capacity information.

Petroleum refining (1A1b)

This sector includes emissions of all pollutants released from combustion of fuels in UK refineries, where crude oil is processed into secondary petroleum products including petrol, diesel, fuel oil, lubricants and other minor products. Included within the scope of 1A1b are the emissions from the regeneration of catalysts in fluid catalytic cracker units in refineries and also from any sub-units on site, such as for the production of hydrogen or anode-grade petroleum coke products.

Data sources

Activity data for the refinery sector are mostly taken from DUKES in the scenario when operators do not report emissions directly, except in a small number of instances where information from the EU ETS indicates a higher level of consumption than reported in DUKES, typically for fuels such as petroleum coke.

Methodology

As for power stations, in most cases the method applied is:

UK emission = ∑ Reported Site Emissions

All UK refineries are regulated under EWR/EPR and hence report annual emission estimates to the UK environmental regulatory agencies, and these data are used in the NAEI. In addition, further data at a higher resolution are provided by the voluntary reporting of operators via the trade association UKPIA. These additional data present a greater breakdown of emissions by source within UK refineries, for example setting out the different emission sources of NMVOCs from production processes, oil storage and transport.

Similar to the method for power stations, the inventory agency applies assumptions to address data gaps by extrapolating emissions data, typically using information on fuel consumption or plant capacity data.

Manufacture of solid fuels and other energy industries (1A1c)

This sector comprises a wide range of fuel combustion sources from installations linked to energy exploration, production and processing, including: the production of manufactured fuels (coke, other solid smokeless fuels (SSF) and town gas), coal extraction, oil and gas exploration and production, and running of compressors on the natural gas distribution systems of the UK.

Methodology

<u>Coke and Smokeless Solid Fuel Production:</u>

In most cases:

UK emission = ∑ Reported Site Emissions

All UK coke ovens and regulated SSF manufacturing plants report emissions in the PI or WEI. Small amounts of “Below Reporting Threshold” data are extrapolated based on plant capacity.

The approach taken to allocate reported emissions to fuels varies by pollutant:

- NOx: The main source is the combustion of coke oven gas. Literature EFs are used for minor sources and estimates from these are subtracted from the reported emissions data.
- SOx: Emissions data are split between coke oven gas combustion and process sources using a ratio based on reported emissions data for these sources.
- Other pollutants: No data are available for a data split. These emissions are allocated to a non-fuel specific source category (1B1b).

Gas Production (Downstream Gas):

Emissions are mainly from natural gas use at compressor stations on the UK transmission and distribution network.

Activity data for this source are taken mainly from DUKES, except in instances where information from the EU ETS indicates a higher level of consumption than reported in DUKES. Where available, site-specific emissions data for NO_X and PM_{10}, reported to UK regulators, are used as the basis of emission factors however this is not available for all sites and in all years so default EFs are used in these instances. For other pollutants, default EFs are applied.

Upstream Oil and Gas Exploration and Production (E&P):

This includes all emissions from fuel combustion at offshore and onshore oil and gas platforms, floating production storage and offloading (FPSO) vessels, and combustion sources at onshore terminals.

Offshore facilities emissions are operator-reported (EEMS) under BEIS OPRED, whilst onshore terminals and production sites report to the Environment Agency, Natural Resources Wales or the Scottish Environment Protection Agency under the EWR/EPR.

Data sources

The EEMS dataset includes activity data and emission estimates for NOx, SOx and NMVOCs for combustion of gas, gas oil and fuel oil.

Activity data are taken from DUKES except in instances where EU ETS and/or EEMS systems indicate a higher level of consumption than DUKES.

Emission factors are derived from EEMS and EWR/E-PRTR operator-reported data along with study data from UK Oil and Gas (pre-1998), and a revision of time series estimates provided in December 2005.

Emission estimates of PM_{10} are derived from the EMEP/EEA Guidebook for both the use of gas oil and natural gas by oil & gas production facilities, and process gas used as fuel at terminals.

Source-specific QA/QC and verification (1A1)

Activity data taken from DUKES are subject to regular QA audits and reviews stipulated within the UK Government's National Statistics Code of Practice. Similarly, emissions data that are reported to UK environmental regulatory agencies (e.g. published in the PI) are also subject to audit and review within established regulator QA systems.

The UK inventory team conducts a limited review of the data to identify outliers since there may be substantial year-on-year changes in the inventories and operators may change the basis on which they calculate emissions or submit incomplete or erroneous data. Where there are notable data gaps or outliers for significant emission sources and pollutants, the inventory agency may query the data with the PI teams, Site Inspectors / Process Engineers, operators or trade associations, and in some cases the data may be rejected by the UK Inventory Agency.

Emissions estimates based on site-specific emissions data provided by process operators are considered to be low uncertainty due to multiple parallel data reporting systems, allowing for some level of cross-checking. However, some subsectors consist of mostly smaller sites (e.g. power stations using gas oil or biomass as primary fuel) which are not obliged to report emissions. Gap-filling methods (extrapolation and assumptions using proxy data) are used for emissions estimates from these sites which are more uncertain.

Planned improvements in Energy Industries (1A1)

Since the future electricity supply market will include greater numbers of smaller generators, estimates using the current methodology will rely more heavily on more uncertain gap-filling methods. It is therefore a priority to improve these estimates.

Manufacturing Industries and Construction (1A2)

Summary

This sector comprises emissions from stationary combustion sources in manufacturing industries and construction, and from industrial off-road machinery.

Any process-related emissions from these sectors (e.g. dust from construction, NMVOCs from solvents, or fugitive emissions) are reported elsewhere in the inventory.

Key sources and pollutants

Table 3 Key sources and pollutants in Manufacturing Industries and Construction (1A2)

NFR14 source category	NFR14 source category name	Pollutant	Proportion of total emissions for pollutant in 2019 (%)	% Change in emissions (1990 - 2019)
1A2a	Stationary combustion (Iron and steel)	SOx	5.6	-67.3
1A2gvii	Mobile combustion (NRMM)	NOx	3.6	-73.8
1A2gvii	Mobile combustion (NRMM)	PM2.5	2.9	-72.0
1A2gvii	Mobile combustion (NRMM)	PM10	1.9	-72.0
1A2gviii	Stationary combustion (Other)	PM2.5	13.2	2.5
1A2gviii	Stationary combustion (Other)	SOx	11.7	-85.0
1A2gviii	Stationary combustion (Other)	PM10	8.7	0.8
1A2gviii	Stationary combustion (Other)	NOx	10.0	-20.1

Data sources (general)

Table 4 An overview of methods and data sources used in Manufacturing Industries and Construction (1A2)

NFR14 source category	NAEI source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
1A2a	Iron and steel (combustion plant)	All	UK model for integrated works; AD · EF	DUKES; EU ETS; ISSB	Operator-reported; Default EFs. UKPIA; others for fuel analysis for SOx
1A2gviii	Autogenerators	All	UK model for activity allocation to unit type; AD · EF	DUKES	Operator-reported; Default EFs. UKPIA; others for fuel analysis for SOx
1A2gviii	Other industrial combustion	All	UK model for activity allocation to unit type; AD · EF	DUKES (with data from other sources e.g. MPA); EU ETS data for OPG	Operator-reported; Default EFs (including HMIP). UKPIA; others for fuel analysis for SOx
1A2gvii	Industrial off-road mobile machinery	All	AD · EF	Bottom-up estimates in 2004 (Netcen survey). Estimates in other years based on studies and proxy statistics	Default EFs

Methodology (general) for stationary combustion

Somewhat different approaches are necessary for two groups of stationary sources within 1A2, those groups being: i) combustion as part of an industrial process, such as in cement & lime kilns, or blast furnaces; and ii) industrial combustion solely for energy generation, such as in boilers, gas turbines and engines. The first group consists entirely of large industrial facilities and site-specific emissions data for all of these sites are reported by site-operators to the various UK regulators, and can therefore be used as the basis of UK emission estimates. The second group covers a mix of small and large industrial plants and site-specific emissions data are only available for a proportion of sites. So, for this group, emissions are estimated by combining the site-specific emissions where we have that, with emissions based on default EMEP/EEA factors for the remainder, with activity data taken from DUKES.

Emissions are disaggregated on an industry sector basis in the case of the most significant fuels (coal, fuel oil, and gas oil and natural gas). However, data are lacking to allow a sectoral split for other fuels, so these are allocated to 1A2g, except for Other Petroleum Gas (OPG) which is split between 1A2c and 1A2g.

Specific Coal-fired Autogeneration methods:

Coal-fired autogeneration in the UK was once dominated by one large installation, and hence some historical EFs are based on emissions reported by that plant in the PI. That site is no longer an autogenerator so emissions are now calculated using default factors. SO_2, factors are based on data on sulphur in coal from coal suppliers.

Industrial Non-Road Mobile Machinery (1A2gvii)

The Non-Road Mobile Machinery (NRMM) category covers a wide range of off-road machinery in manufacturing industries, construction and quarrying sectors. The type of combustion units varies from large-scale mobile plant such as bulldozers, cranes and trucks to smaller plant such as mobile generators, and the fuels used are typically gas oil / diesel and petrol. However, this section only deals with the methods for estimating emissions from industrial NRMM sources since they are key sources of NOx and particulate matter.

Note that NRMM is dealt with within the Transport sector of the IIR where the methods for other NRMM sources (e.g. fuel use in mobile machinery in the agriculture sector, domestic house and garden machinery, and airport machinery) are also described. These methods are largely similar across sectors.

Data sources

Machinery (or engine-specific) fuel consumption and EFs (g/kWh) are mostly taken from the EMEP/EEA Guidebook (2009) for older models. For modern machinery, EFs are based on engine- or machinery-specific emission limits established in the EU NRMM Directives by assuming the maximum permitted for a given unit at the year of manufacture. The EU Fuel Quality Directive (2009/30/EC) is also taken into account which requires fuels used in NRMM to have a maximum sulphur content of 10ppm from 2011 onwards.

Activity data are derived from bottom-up estimates of population and hours of use of equipment in 2004 (Netcen survey). Various proxy statistics are used as activity drivers for different groups of machinery types to estimate fuel consumption and the turnover in the off-road engine fleet. A simple fleet turnover model is used to estimate the proportion of different legislative classes of NRMM in the fleet. These proxy statistics are also used to generate emissions and fuel consumption estimates across the time series. A BEIS energy projections driver for 'construction' is also to estimate activity rates of machinery from 2005 onwards based on ONS construction statistics for a number of different machinery types such as cranes, generators and rollers.

Methodology

A Tier 3 methodology is used to calculate emissions from individual types of mobile machinery as per the EMEP/EEA Guidebook.

For each class of machinery, the kilograms of emission per year are calculated using the equation:

$$\textbf{Emission} = N \cdot H \cdot P \cdot L \cdot Y \cdot W \cdot (1 + Y \cdot a / 2) \cdot e$$

- N = Population of class
- H = Annual usage of class (hours/year)
- P = Average power of class (kW)
- L = Load factor of class taken from Samaras, 1996
- Y = Lifetime of class (years)
- W = Engine design factor of class
- a = Age factor of class (per year)
- e = Emission factor of class (kg/kWh)

For the total kilograms of evaporative NMVOC emissions from machinery with petrol engines, the following equation is used:

$$\textbf{Emission} = N \cdot H \cdot e$$

After calculation of fuel consumption using a bottom-up method, figures for diesel engine machinery are allocated between gas oil and road diesel based on the results of a survey (Murrells *et al.,* 2011). A further fuel reconciliation procedure is undertaken for gas oil, taking into account consumption from all sources. The calculated gas oil consumption for each source is reconciled by aligning overall fuel totals with DUKES annual demand totals.

Source-specific QA/QC and verification (1A2)

Activity data are derived from BEIS publications which are subject to established QA/QC requirements, augmented by information from the EU ETS and trade associations such as the MPA.

For specific industry sectors (e.g. iron & steel, cement, lime, autogeneration), the quality of these data is also checked by the Inventory Agency by comparison with EU ETS data on emissions information and energy use data as well as operator-supplied activity data. Amendments of BEIS fuel allocations are made based on these checks.

Planned improvements in Manufacturing Industries and Construction (1A2)

Emission estimates for stationary plant use site-specific data wherever possible and default factors otherwise. The current inventory incorporates some improvement both in terms of greater use of site-specific data, but also in the selection of default factors. Previously, the default factors were the generic “Tier 1” factors given in the EMEP/EEA Guidebook, whereas now greater use is made of technology-specific “Tier 2” factors. The method still is relatively simple and cannot fully account for all of the specific characteristics of the sector in the UK (e.g. abatement level, fuel composition, or combustion appliance design). The 1A2 sector covers large numbers of both large and small plant, and a lack of detailed information about every site means that assumptions have to be made. In future, more data may be collected, particularly for medium-sized plant, and this might allow further refinement of emission estimates.

For larger plant, documents such as the permits of UK installations regulated under the EWR are becoming more readily available. These documents can contain information on plant design and abatement, including details on expected changes to emission levels of pollutants, and so could also help improve the estimates further. However, the improved estimates show that the majority of emissions of NO_X and

PM_{10} come from small and medium plant, so those plant need to be the priority for further improvements, subject to resources.

It is recognised that the data available to estimate NRMM activity and emissions are scarce in the UK, and that the source categories cover a wide range of machinery across many economic sectors. As a result, the current UK inventory estimates for NRMM are associated with high uncertainty. Work is currently being undertaken to obtain more up-to-date, detailed activity data for NRMM population and usage through consultation with various bodies in the construction and industrial machinery sector.

Road Transport (1A3b)

Summary

This category includes emissions of pollutants from hot and cold exhaust emissions (1A3bi-iv) and particulate matter emissions from tyre and brake wear and road abrasion (1A3bvi-ii). Evaporative emissions from petrol vehicles (1A3bv) are also calculated for national totals, but since emissions from this source are small, the details are excluded in this report and can be found in the IIR. Complete details for the methodology used to estimate emissions from road transport can be found in Brown *et al.* (2018).

Key sources and pollutants

Table 5 Key sources and pollutants in Road Transport (1A3b)

NFR14 source category	NFR14 source category name	Pollutant	Proportion of total emissions for pollutant in 2019 (%)	% Change in emissions (1990 - 2019)
1A3bi	Passenger cars	NOx	17.5	-83.0
1A3bi	Passenger cars	PM2.5	2.5	-52.7
1A3bi	Passenger cars	PM10	1.6	-52.7
1A3bii	LGVs	NOx	11.9	-6.7
1A3biii	HGVs and buses	NOx	3.7	-89.0
1A3bvi	Automobile tyre and brake wear	PM10	6.3	34.9
1A3bvi	Automobile tyre and brake wear	PM2.5	5.4	36.5
1A3bvii	Automobile road abrasion	PM10	3.3	33.8
1A3bvii	Automobile road abrasion	PM2.5	2.8	33.8

Data sources (general)

Table 6 An overview of methods and data sources in Road Transport (1A3b)

NAEI source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
All cars, LGVs, HGV rigid and articulated, buses and coaches, mopeds and motorcycles (exhaust emissions)	All	AD · EF. UK model for activity allocation to unit type	Vehicle km data, vehicle licensing statistics, and ANPR data (DfT); DUKES	Default EFs; Fuel analysis (UKPIA)
All cars, LGVs, HGV rigid and articulated, buses and coaches, mopeds and motorcycles (non-exhaust emissions)	PM	AD · EF. UK model for activity allocation to unit type	Vehicle km data (DfT)	Default EFs

Table 7 A summary of the activity data sources and related assumptions used in Road Transport (1A3b) emission calculations

Parameters	Region	Data source	Related assumptions
Annual vkm	GB	National Road Traffic Survey (DfT)	None
Annual vkm	NI	Annual Road Traffic Estimates (DRDNI)	• Vkm data for all vehicle types (except motorcycles) from 2015 onwards are not available and are extrapolated from 2014 vehicle km data for Northern Ireland based on the traffic growth rates in Great Britain. • Motorcycle vehicle km data are not available from the DRDNI data and so they are derived based on the ratio of motorcycles registered in Northern Ireland relative to Great Britain each year.
Petrol/Diesel mix	GB	ANPR data (DfT)	ANPR data are available for years between 2007 and 2011, then biannually. For years prior to 2007, the petrol/diesel mix is based on the trend as indicated by DfT Vehicle Licensing Statistics
Petrol/Diesel mix	NI	Northern Ireland Transport Statistics (DRDNI)	None
Vehicle size fractions	All	Vehicle licensing statistics (DfT); Road Freight Statistics (DfT); Fleet composition data (TfL); Local bus operator information	• Assumed larger cars do more annual mileage than smaller cars. • Assumed that 72% of all bus and coach km on urban and rural roads are done by buses (and 28% by coaches), while on motorways all the bus and coach km are done by coaches. • Assumed that 31% of buses are <15t and the remaining are 15-18t outside of London; for London buses, the split is defined by the fleet composition provided by TfL. • Assumed that mopeds (<50cc) operate only in urban areas, while only larger >750cc, 4-stroke motorcycles are used on motorways.
Age/ Euro standard mix	All	ANPR and Vehicle Licensing Statistics (DfT)	ANPR data are available for years between 2007 and 2011, then biannually. Fleet-adjustment scaling factors were developed for years prior to 2007.

Parameters	Region	Data source	Related assumptions
Vehicle speed data (to calculate speed-related EFs)	All	DfT statistics	Road speed limits are used where data are unavailable
Total fuel sales	All	DUKES	Adjustments are made for the small amount of consumption by inland waterways, off-road machinery and consumption in the Crown Dependencies.
Fuel quality	All	HMRC; Murrells and Li (2008)	• EFs are adjusted to take account of improvements in fuel quality for conventional petrol and diesel (mainly due to reductions in the fuel sulphur content of refinery fuels) and effects of the biofuel blended into conventional fossil fuel. • The introduction of road fuels with sulphur content less than 10ppm from January 2009 is taken into account according to Directive 2009/30/EC.
Impact of emission abatement technologies/ measures	All	Various	• COPERT provides separate EFs for Euro V heavy duty vehicles equipped with Selective Catalytic Reduction (SCR) and Exhaust Gas Recirculation NOx control technologies. It is assumed 75% of vehicles are equipped with SCR systems (EU ACEA). • Emissions from some Euro II buses and HGVs are scaled down according to the proportion fitted with oxidation catalysts or diesel particulate filters (DPFs) and the effectiveness of these measures in reducing emissions from the vehicles. • Assumptions about the proportion of failing catalysts in the petrol car fleet were derived following discussions with DfT. Assumed that the failure rate is 5% per annum for all Euro standards and only 20% of failed catalysts were rectified properly (for years up to 2008). From mid-2009 onwards, repair rates are assumed to be 100% for Euro 3 (or above) LDVs due to Regulations Controlling Sale and Installation of Replacement Catalytic Converters and Particle Filters.
Impact of emission abatement technologies/ measures	London	TfL	Effects of the Low Emission Zone (LEZ) on PM emissions from HGVs and buses, larger vans and minibuses are taken into account. Emission factors for London black cabs are assumed to be the same as a diesel LGVs.

Methodology (general)

A detailed bottom up (or so-called Tier 3) approach is used to calculate fuel consumption and all exhaust emissions of NMVOCs, NOx, PM and NH_3 from passenger cars, LGVs, heavy-duty vehicles (including buses and coaches) and motorcycles. Emissions of NMVOCs, NOx, PM and NH_3 are calculated on a fuel used basis from measured EFs expressed in g/km along with road traffic statistics.

EFs are based on experimental measurements of emissions from in-service vehicles of different types driven under test cycles with different average speeds. Road traffic statistics (or total vehicle km travelled data) by different vehicle types are provided by DfT (for Great Britain) and the Department for Regional Development Northern Ireland (DRDNI). Other datasets, such as the Automatic Number Plate Recognition (ANPR) data, are used to disaggregate the vehicle km (vkm) data further. Disaggregation is done by the composition of each vehicle type (fraction of diesel/petrol vehicles and different vehicle sizes) and by the fraction of each under different emissions regulations (i.e. Euro Standard) that applied when the vehicle was first registered.

It should be noted that emissions of NOx, NMVOCs, $PM_{2.5}$, NH_3 and SO_2 based on the fuel used approach are to be used for tracking compliance with the UK's emissions ceilings. However, the UK also reports road transport emission estimates based on the fuel consumed approach as part of the annual submission under the CLRTAP and NECR. In order to report emissions by vehicle types on a fuel sold basis, a normalisation process is applied based on the ratio of fuel sales according to DUKES and the fuel consumption estimates for each vehicle type derived from the bottom-up calculations.

Emissions of SO_2 are based on the total fuel consumed rather than the fuel sold method. This is because they vary in direct proportion to the amount of fuel consumed and the sulphur content of petrol and diesel fuels.

Hot exhaust emissions (Road Transport)

These are emissions from vehicle exhausts once the engine is at normal operating temperature. Vehicle types considered include petrol and diesel fuelled: cars, LGVs (<3.5t), rigid HGVs (>3.5t), articulated HGVs (>3.5t), buses and coaches and motorcycles.

Methodology

On a national scale it is sufficient to model hot exhaust emissions using EFs related to the average speed of the vehicle over the whole drive cycle (Brown *et al*., 2018). For each vehicle type on different road types:

Total emissions = EFs (g/km) for average speed on the road network · annual vehicle km

Data sources

Hot exhaust EFs are taken from COPERT 5 and the EMEP/EEA Guidebook. NMVOCs emissions are calculated from total hydrocarbon (THC) EFs. THC emissions include methane. Therefore, NMVOC emissions are derived by subtracting methane emissions from the THC emissions. For NH_3, the EFs take into account the vehicle's accumulated mileage and the fuel sulphur content.

Cold start emissions (Road Transport)

These are excess emissions that occur when a vehicle is started with its engine below its normal operating temperature. The excess emissions occur from petrol and diesel vehicles, but more significantly for petrol cars, because the three-way catalyst does not function properly and reduce emissions from the tailpipe until it has reached its normal operating temperature. Cold-start emissions data are not available for heavy-duty vehicles, but these are thought to be negligible (Boulter, 1996).

Methodology

Cold-start emissions are calculated based on recommendations by the Transport Research Laboratory (see review by Boulter & Latham, 2009). COPERT III (EEA, 2000) method was used to calculate cold-start emissions for NOx, PM and NMVOCs. It estimates emissions by using the proportion of distance travelled on each trip with the engine cold and a ratio of cold/hot EF:

$$E_{cold} = \beta \cdot E_{hot} \cdot (e_{cold}/e_{hot} - 1)$$

- E_{hot} = hot exhaust emission from the vehicle type
- β = fraction of km driven with cold engines. This value is taken from the EMEP/EEA Guidebook with average trip length given as 10km. The method is sensitive to the choice of average trip length in the calculation.
- e_{cold}/e_{hot} = ratio of cold to hot emissions by pollutant and vehicle type. The equations relating this ratio to ambient temperature for each pollutant and

vehicle type were taken from COPERT III and were used with monthly average temperatures for central England based on historic trends in UK Met Office data.

Cold-start emissions of NH_3 were estimated using a simpler method provided by COPERT 5 in the recent EMEP/EEA Guidebooks. It uses EFs (mg/km) in combination with distance for a vehicle travelled when not fully warm. For petrol cars and LGVs, the cold start EFs also take into account the vehicle's accumulated mileage and the fuel sulphur content, in the same way as for the hot exhaust emissions.

Non-exhaust Emissions of PM (Road Transport)

Particulate Matter is emitted from the mechanical wear of material used in vehicle tyres, brake linings and from road surfaces. See the Air Quality Expert Group's PM report (AQEG, 2005) for further details regarding non-exhaust emissions of PM.

Methodology

A Tier 2 approach is used to estimate non-exhaust emissions of PM from tyre and brake wear and road abrasion. Emissions are calculated by combining EFs with vehicle km data. For tyre and brake wear and road abrasion, EFs (g/km) are provided in the EMEP/EEA Guidebook for each vehicle type with speed correction factors.

Tyre and brake wear:

The EFs are given for different vehicle types with speed correction factors implying higher EFs at lower speeds. For heavy duty vehicles, a load correction factor is provided, and tyre wear is dependent on the number of axels. There are no regulations on emissions from tyre and brake wear, so values are constant for all years with no road type dependence.

Road abrasion:

The EFs are given in g/km for each main vehicle type and are constant for all years, with no road type dependence.

Domestic Navigation (1A3d)

Summary

This sector includes emission estimates for domestic coastal shipping and inland waterway (1A3dii), primarily from the combustion of gas oil and fuel oil in marine vehicles. Emissions from international, transit (passing the UK), or to/from/between Crown Dependencies by vessels can be distinguished in the methodology and are not included in UK emissions inventory totals. Estimates from fishing vessels and naval vessels are estimated separately, they are reported under 1A4ciii and 1A5b respectively (see the IIR for details).

Key sources and pollutants

Table 8 Key sources and pollutants in Domestic Navigation (1A3d)

NFR14 source category	NFR14 source category name	Pollutant	Proportion of total emissions for pollutant in 2019 (%)	% Change in emissions (1990 - 2019)
1A3dii	National navigation (shipping)	NOx	10.6	-38.9
1A3dii	National navigation (shipping)	SOx	7.0	-87.4
1A3dii	National navigation (shipping)	PM2.5	2.2	-84.4
1A3dii	National navigation (shipping)	PM10	1.5	-84.7

Data sources

Table 9 An overview of methods and data sources in Domestic Navigation (1A3d)

NFR14 source category	NAEI source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
1A3dii	Shipping (coastal)	All	AD · EF. UK model for activity allocation to unit type	Scarbrough *et al.* (2017) based on AIS data; Marine Statistics (DfT); OT port authorities (OT shipping)	Scarbrough *et al.* (2017); Default EFs. Fuel analysis (UKPIA)
1A3di	Inland waterways	All	AD · EF (see Walker *et al.,* 2011). UK model for activity allocation to unit type	Vessel population; statistics on expenditure on recreation (ONS), tourism (Visit England), port freight traffic (DfT), and inland waterways goods lifted (DfT)	Default EFs. Fuel analysis (UKPIA)

Coastal Shipping (1A3dii)

This is the main category of domestic voyages for coastwise shipping within and outside UK waters. Emissions from Fishing Vessels are calculated using the same methodology but categorised under 1A4ciii.

Data sources

EFs are based on detailed values for different main and auxiliary engine types, fuels, and vessel movement types consistent with those within the International Maritime Organization (IMO) global emissions inventory. Emission factors also account for regulations on fuel sulphur content in different sea territories around the UK.

EFs for NOx are assumed to reduce over time due to penetration of vessels with more recent engines that meet more stringent NO_x emissions tiers; PM EFs generally decrease with reductions in fuel sulphur content.

NH_3 EFs are not available in the EMEP/EEA Guidebook, and hence it is assumed they are equivalent to those of a diesel railway train using Tier 2 methodology (EMEP/EEA) and assumed to remain constant over time.

Methodology (AIS-based shipping model)

The UK applies a Tier 3 model (Scarbrough *et al*., 2017) to estimate emissions from National Navigation. The model estimates detailed fuel consumption and emissions for a base year (2014) using movement data from the terrestrial Automatic Identification System (AIS) from the Maritime and Coastguard Agency (MCA). The model also incorporates other shipping activity statistics (DfT) as proxy data to provide estimates for other years.

Emissions are calculated for each vessel (bottom-up approach) by multiplying an EF (g/kWh) by estimated engine demand (kWh). The methodology goes beyond the Tier 3 approach set out in the Guidebook by calculating fuel consumption and emissions for each part of a voyage using high resolution Automatic Identification System (AIS) vessel tracking data, rather than carrying out the calculation for each port-to-port voyage as a whole.

Vessel movements between the UK and Overseas Territories (1A3dii)

Emissions from vessel movements between the UK and Overseas Territories (OTs) were not included in Scarbrough *et al*. (2017) but are required for UK national totals.

Data sources

Average EFs are used taken from Scarbrough *et al*. (2017) for vessels involved in international voyages (between UK port and a non-UK destination). All fuel used for voyages between the UK and OTs is assumed to be fuel oil.

Freight shipping and passenger vessel movements by type were obtained from the ports database by DfT for years 2000 onwards (no published data available). Additional passenger vessel movement data was provided by individual OT port authorities.

Methodology

Freight shipping:

Vessel type information was taken from the EMEP/EEA Guidebook. Distances for each voyage were calculated using PortWorld by inputting departure and arrival ports. Total fuel consumed for each voyage was calculated using distance, average speed, engine power, and the engine's fuel consumption factor. Trends in fuel consumption between the UK and OTs for years prior to 2000 were taken from Entec (2010) calculations for all UK international shipping.

Passenger vessels:

The information held by OT port authorities indicated the only movements were by cruise ships (i.e. not ferries). Detailed movement data of voyages departing to/from the UK for 2003-2012 were provided by port authority of Gibraltar. Unpublished data on the number of UK port arrivals by cruise ships from OTs were also provided by DfT for 1999-2004.

The same methods were used as those for freight shipping (above) to calculate fuel consumption from cruise ships. The trend in fuel consumption by cruise ships between the UK and OTs for years prior to 1999 was defined using trends in total passengers on cruises beginning or ending at UK ports between 1990 and 1999 (DfT Maritime Statistics).

Inland waterways (1A3dii)

This category is included in domestic emission totals and includes emissions from fuel used for small passenger vessels, ferries, recreational watercraft, and other inland watercraft and gasoline-fuelled watercraft.

Vessels with more than 12 passengers and 3 or more engines operating in estuaries, tugs, cranes, and chartered commercial fishing vessels are included under coastal shipping.

Methodology

A Tier 3 bottom-up approach based on population and usage estimates of different types of inland waterways vessels is used to estimate emissions. See Walker *et al*. (2011) for details.

Data sources

Fuel-based EFs for all inland waterway vessels were taken from the EMEP/EEA Guidebook. Emission factors for SO_2 from vessels using gas oil take into account tighter limits on the sulphur content of gas oil for inland waterways use (the limit reduced to 10ppm from January 2011).

Estimates of population and usage of each type of vessel on inland waterways were made based on data collected from stakeholders (e.g. British Waterways, DfT) for the baseline year of 2008. It was assumed that privately-owned recreational vessels with diesel engines use Diesel Oil for Road Vehicles (DERV) fuel, whilst only commercial and service craft and canal boats use gas oil (Walker *et al*., 2011).

For years other than 2008, proxy statistics were used to estimate activities (fuel consumption) for different groups of vessels: Private leisure craft (ONS Social Trends 41 and the OECD, the Organisation for Economic Co-operation and Development), Commercial passenger/tourist craft (Visitor Attraction Trends in England, 2017) and Freight (Waterborne Freight in the UK, DfT).

Source-specific QA/QC and verification (1A3)

None. Please see the General Quality Assurance and Quality Control (QA/QC) procedures.

Planned improvements in Transport (1A3)

Most of the improvements in the transport sectors will depend on the availability of new or revised forms of activity data and EFs and not all of these can be anticipated at this stage. Particularly for the road transport sector, the evidence used to develop EFs changes frequently, especially as new evidence on ‘real-world’ EFs for NOx emissions from modern diesel vehicles emerges. A watching brief is kept on developments in EFs and activity data for all modes of transport, especially those that may arise from stakeholder initiatives and which can be reasonably incorporated in the inventory.

Domestic Combustion (1A4bi)

Summary

This sector is dominated by emissions from fuel combustion in the residential sector, including for fuels such as coal, SSF, wood, natural gas, gas oil and LPG. Information on emission estimates for other non-key sources in sector 1A4 (Combustion in the Residential/Commercial/Public Sectors) can be found in the IIR.

Key sources and pollutants

Table 10 Key sources and pollutants in Domestic Combustion (1A4bi)

NFR14 source category	NFR14 source category name	Pollutant	Proportion of total emissions for pollutant in 2019 (%)	% Change in emissions (1990 - 2019)
1A4bi	Residential combustion (stationary)	PM2.5	43.3	8.4
1A4bi	Residential combustion (stationary)	PM10	28.3	9.1
1A4bi	Residential combustion (stationary)	SOx	27.6	-60.0
1A4bi	Residential combustion (stationary)	NMVOC	5.9	-22.8
1A4bi	Residential combustion (stationary)	NOx	4.1	-62.2

Data sources

Table 11 An overview of methods and data sources in Domestic Combustion (1A4bi)

NAEI source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
Domestic combustion	All	UK model for allocation to unit type; AD · EF	DUKES	Default EFs (US EPA; EMEP/EEA); UK-specific research). Fuel analysis (UKPIA; others for fuel analysis for SOx)

Domestic Combustion (1A4bi)

Methodology

A top-down approach (comprised of both a Tier 1 and 2 method) is used based on UK activity data and the application of mainly literature EFs (AD · EF), with some UK-specific EFs (e.g. from the sulphur content of fuels) where available. This is because the residential sector comprises many thousands of individual combustion units of many designs, including boilers, stoves, open fireplaces and other heaters. Therefore, there are limited data on the UK population of different appliances, much less their utilisation, but there are overall fuel combustion statistics that inform the total activity data for the sector.

Data sources

Estimates of wood use in residential heating are taken from DUKES which are based on a 2014-15 survey by BEIS. However, estimates remain highly uncertain due to the lack of comprehensive fuel sales data (wood is plentiful outside conventional fuel markets). A key assumption based on the survey data was that the proportion of wood fuel used in open appliances (1970-90) compared to closed appliances was 3:1. This ratio was interpolated between 3:1 (1990) and about 1:1 for years 2014 onwards. For domestic natural gas consumption, a modelled approach is used to estimate changes in appliance technologies which allocates almost all natural gas burnt to boilers (>95%) and only a small contribution to room heaters (any appliance not categorised as central heating).

Emissions from domestic combustion are estimated using literature, Tier 1 default EFs (EMEP/EEA) for most fuels (except wood burning which uses Tier 2 EFs)

allocated to specific appliance types. The proportions for each type of appliance using each type of fuel are mainly based on the Eco-design preparatory study (2007). Assumptions are held constant from 1970-2017 since no other data are available.

Different EFs are used depending on data availability or based on review recommendations. For example, ammonia emissions from wood burning are calculated using a Tier 1 approach because a review revealed the 2016 EMEP/EEA based ammonia EFs on wildland fires which resulted in high uncertainty. For natural gas burnt in room heaters, revised EFs are used based on a review of boiler ages by King & Stewart (2017). Regarding the residential combustion of oils, SOx EFs are based on UK-specific data on fuel consumption. Finally, a model is used for domestic natural gas consumption, which assumes that EFs for new boilers are constant within different periods: default EMEP/EEA 2009 EFs for 1970-89; Ecodesign study EFs (derived from the GEMIS database for natural gas boilers) for 1990-2004; and Class 5 standard (EN 483) from 2004 onwards.

Source-specific QA/QC and verification (1A4bi)

None. Please see the General Quality Assurance and Quality Control (QA/QC) procedures.

Planned improvements in Domestic Combustion (1A4bi)

For domestic wood and natural gas combustion, the inventory method aims to reflect the change in EFs over time. However, there is a lack of data on the market share of different UK technologies and limited EFs available for each. The influence of technology is greatest in the domestic sector where wood and solid fuel open fires emit substantially more PM and NMVOCs than boilers, for example. The uncertainty for estimates of these pollutant emissions is most uncertain and will affect overall inventory uncertainty for pollutants with high contributions to UK totals (i.e. PM).

Therefore, methodology improvements in this sector are a priority, including improvements to the market share information on domestic wood burning appliances, the EFs for ammonia released from wood burning (currently based on wildfires), and the development of the approach for domestic combustion of coal and smokeless fuels (improvements beyond the Eco-design study).

Defra has commissioned a project to survey domestic burning in response to these issues.

Fugitive Emissions from Oil & Gas Industries (1B2)

Summary

The 1B sector includes fugitive emissions from fuels from extraction or production. Specifically, this category (1B2) includes fugitive emissions from oil & gas industries (exploration, production, transport, refining, storage, distribution, and venting and flaring). Due to the relatively low contribution to UK total emissions from sources related to the extraction and production of solid fuels (1B1), the methodology behind emissions calculations for these sources has been omitted from this document, but can be found in the IIR.

Key sources and pollutant

Table 12 Key sources and pollutants in Fugitive Emissions from Oil & Gas Industries (1B2)

NFR14 source category	NFR14 source category name	Pollutant	Proportion of total emissions for pollutant in 2019 (%)	% Change in emissions (1990 - 2019)
1B1b	Solid fuel transformation	SOx	3.7	-70.6
1B2ai	Oil (exploration, production and transport)	NMVOC	3.6	-88.7
1B2av	Distribution of oil products	NMVOC	2.7	-81.5
1B2aiv	Oil (refining / storage)	NMVOC	2.3	-81.6
1B2b	Natural gas (exploration, production, processing, transmission, storage, distribution and other)	NMVOC	2.7	-51.2
1B2c	Venting and flaring (oil, gas, combined oil and gas)	NMVOC	3.9	27.9

Data sources

Table 13 An overview of methods and data sources in Fugitive Emissions from Oil & Gas Industries (1B2)

NFR14 Source category	NAEI Source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
1B1b	Solid fuel transformation	SOx	Operator-reported; AD · EF	DUKES; EU ETS	Operator-reported; Literature sources
1B2ai	Offshore oil loading; Offshore well testing; Onshore oil loading	NOx; NMVOC; SOx	AD · EF	EEMS; UK Oil and Gas; DUKES	Operator-reported since 1998 (including AD); Estimates of UK Oil and Gas (BEIS) using BEIS production stats for earlier years
1B2ai	Oil terminal storage; Process emissions	NOx; NMVOC; SOx	Operator data; time-series assumptions	EEMS; UK Oil and Gas; DUKES	Operator-reported since 1998 (including AD); Estimates of UK Oil and Gas (BEIS) using BEIS production stats for earlier years
1B2ai	Petroleum processes	NOx; NMVOC; SOx	Operator-reported	DUKES	Operator-reported; UK operators
1B2aiv	Drainage; General; Process; Tankage	NMVOC; NH3	Operator-reported	UKPIA	Operator-reported; UKPIA for refinery sources
1B2av	Petrol stations; Petrol terminals	NMVOC	AD · EF	DUKES	UK periodic research; UKPIA (fuel vapour pressure); Met Office (temperature); IoP survey (abatement controls)
1B2av	Refineries (road/rail loading)	NMVOC	Trade association estimates	DUKES	UKPIA; Pre-1994 data scaled by DUKES for petrol use
1B2av	Sea going vessel loading	NMVOC	AD · EF	DUKES	UK periodic research (IoP); UKPIA (fuel vapour pressure); Met Office (temperature)

NFR14 Source category	NAEI Source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
1B2b	Upstream gas production (offshore well testing)	NOx; NMVOC; SOx	AD · EF	EEMS; UK Oil and Gas; DUKES	Operator-reported since 1998 (including AD); Estimates of UK Oil and Gas (BEIS) using BEIS production stats for earlier years
1B2b	Upstream gas production (gas terminal storage; process emissions)	NOx; NMVOC; SOx	Operator data; time-series assumptions	EEMS; UK Oil and Gas; DUKES	Operator-reported since 1998 (including AD); Estimates of UK Oil and Gas (BEIS) using BEIS production stats for earlier years
1B2b	Gasification processes	NOx; NMVOC; SOx	AD · EF	DUKES	Operator-reported
1B2b	Gas transmission network leakage; Gas distribution network leakage	NOx; NMVOC; SOx	UK gas leakage model	Cadent Gas; National grid; Northern Gas Networks; Airtricity; SGN; Wales and West Utilities	Annual gas compositional analysis by GB gas network operators
1B2b	Gas leakage at point of use	NOx; NMVOC; SOx	UK model	DUKES; Leakage % based on assumptions on unit leakage and operational cycles of gas-fired heaters, boilers, cookers	Annual gas compositional analysis by GB gas network operators
1B2c	Upstream gas production (gas flaring); Upstream oil production (gas flaring)	NOx; NMVOC; SOx; PM	AD · EF	EEMS; UK Oil and Gas; DUKES	Operator-reported since 1998 (including flaring AD); Estimates of UK Oil and Gas (BEIS) using BEIS production stats for earlier years
1B2c	Upstream gas production (gas venting); Upstream oil production (gas venting)	NOx; NMVOC; SOx; PM	Operator data; time-series assumptions	EEMS; UK Oil and Gas; DUKES	Operator-reported since 1998 (including flaring AD); Estimates of UK Oil and Gas (BEIS) using BEIS production stats for earlier years
1B2c	Refineries (flares)	NOx; NMVOC; SOx; PM	Trade association estimates	UKPIA	Operator-reported; UKPIA for refinery sources

Methodology (general)

The methods used across this sector are a wide range of approaches that reflect the individual nature of the emission sources. For several of the upstream oil and gas emission sources, such as venting and flaring, most emissions are operator-reported either to EEMS (for offshore assets) or to the EWR/EPR pollution inventories (for onshore production sites and terminals). For the leakage of NMVOCs from the downstream gas transmission and distribution system, a model developed by the UK gas industry is used, whilst for fugitive emissions from refineries data are reported by the trade association, UKPIA.

Solid Fuel Transformation – 1B1b

Fugitive emissions can occur both from the combustion of fuels used to provide heat required for solid fuel transformations, but also from fugitive releases from the transformation process. The main source of emissions within this category across the time series is coke production.

Methodology

In most cases:

$$\textbf{UK emission} = \sum \textbf{Reported Site Emissions}$$

Total emissions at UK coke ovens and certain solid smokeless fuel (SSF) manufacturing sites are reported annually to the IED/E-PRTR pollution inventories of the regulatory agencies, but it is not possible to reliably split these emissions data into a combustion component and a fugitive component. Where annual emissions are Below the Reporting Threshold, estimates are largely derived using plant operating capacity and extrapolating implied EFs from other reporting plants in the sector.

For other SSF production reporting is less comprehensive. Therefore, emissions are generally estimated using literature factors and, in some cases (e.g. SOx as SO2), using a mass balance approach.

Oil (Exploration, Production and Transport) - 1B2ai

This category includes reported emissions from: processes, oil loading at offshore platforms and storage units or from offshore terminals, fugitive releases and emissions from well testing.

Methodology

Estimates of all pollutants are operator-reported (via EEMS) from 1998 onwards, and from trade associations (UK Oil and Gas) for earlier years and 2005. Well testing emissions for 2017 are based on 2016 estimates scaled by 2016-17 trends in UK crude oil, condensate and natural gas production. This is due to incomplete reporting via a change in the regulatory reporting system. Onshore sites involved in oil extraction in England report their emissions annually under EWR/EPRTR to the Environment Agency.

Oil (Refining and Storage) – 1B2aiv

This sector includes release of NMVOC emissions from oil handling and process fugitive sources. These emissions occur at refineries from: the venting of process plants for safety reasons, the flaring of waste products, leakages from process plant components (e.g. flanges; valves), evaporation of organic contaminants in refinery wastewater, regeneration of catalysts by burning off carbon fouling, and storage of crude oil, intermediates and products at refineries.

Methodology

Emissions are reported annually via UKPIA since 1993 and are compiled by refinery operators using industry standard methods. Emissions for tankage and drainage systems are deemed to be applicable to years prior to 1993. Emissions from processes for years prior to 1993 have been extrapolated in line with changes in production. When data are unavailable, data from EWR/E-PRTR reporting mechanisms to UK regulators are used instead.

Distribution of Oil Products – 1B2av

NMVOC emissions occur from each storage and transfer stage of petrol distribution: loading onto vehicles from refineries, transit to petrol stations or intermediate terminals, storage at petrol stations, and distribution into fuel tanks of road vehicles.

Methodology

Petrol distribution emissions are calculated using petrol sales data taken from DUKES, and EFs calculated using the UK Institute of Petroleum's (IoP) protocol on estimation of emissions from petrol distribution (which accounts for average temperature, petrol Reid Vapour Pressure (RVP), and abatement measures). Temperature data are obtained from the Met Office (CET data), RVP estimates for

summer and winter blends of petrol are supplied by UKPIA, and abatement measures are given in the annual petrol retail survey of the IoP.

Natural Gas Transmission and Distribution – 1B2b

This sector covers leakages in the natural gas distribution network in the UK.

Methodology

Emission estimates are provided by the gas network operators: National Grid, Cadent Gas, SGN, Northern Gas Networks, Wales and West and Airtricity. Natural gas compositional analysis is provided by the gas network operators. Estimates for 1B2b also include emissions reported in the PI by operators at onshore installations extracting gas from onshore fields in England.

Most UK inventory emissions of NMVOCs from leaks are derived from industry models that calculate leakages from losses from high pressure (transmission) networks, losses from low pressure (distribution) networks, and other losses from above-ground installations and other sources.

Oil and Natural Gas (Venting and Flaring) – 1B2c

Emissions from gas flaring and venting at offshore oil & gas production sites and refineries are all included within 1B2c.

Methodology

The general methodology is the same as for sources detailed above in 1B2a. However, for upstream oil & gas flaring, both activity and emissions data are reported by plant operators in EEMS. For venting, the sum of operator-reported data is used (no activity data), reported via UKPIA. NMVOC emission estimates are the sum of operator-reported data for all years where reporting is complete (1998 onwards). Finally, industry-wide estimates are used based on periodic studies for earlier years (UKOOA, 1995; 19987; 2005).

Source-specific QA/QC and verification (1B2)

For sources in 1B2, there are additional quality checks that are beyond the general checks described in the general QA/QC procedures at the end of this document.

1B2ai and 1B2c:

BEIS OPRED, as the sector regulator provides emission estimation guidance for all operators to assist in the completion of EEMS and EU ETS returns to the UK environmental regulators. This includes the provision of appropriate default EFs for specific activities where installation-specific EFs are not available.

EEMS data have improved over recent years due to development of online reporting systems which have built-in quality checking functions. The Inventory Agency have also developed additional quality checking routines of EEMS data to assess consistency and completeness across the time-series and seeking to reconcile data on energy and emissions reported to BEIS and DUKES, EEMS and EU ETS.

The EEMS dataset is still subject to uncertainty due to reporting gaps for some sites and occasional reporting of identical estimates in consecutive years. However, the EEMS data are reviewed in detail each year by the Inventory Agency.

1B2aiv and 1B2av:

Emission estimates from refineries and petrol distribution are derived based on consistent industry standard methods and UK-specific EFs and models across the time-series.

Uncertainties arise from the use of EFs for different process designs and delivery systems, especially in the refinery storage, transfer and petrol distribution systems. Quality checking and verification involves time-series consistency checks and periodic benchmarking against international EFs for these sources.

1B2b:

Uncertainties in estimates from leakage from the gas transmission and distribution networks stem mainly from assumptions within the industry models that derive mass leakage estimates based on input data (e.g. network pipe replacement). Although the NMVOC content of gas is known, the mass emitted is estimated.

Estimates of emissions from leakage at the point of use are based on gas compositional analysis by network operators as detailed above, combined with a series of assumptions regarding leakage from commercial appliances. There is a high degree of uncertainty associated with the activity data for this source, but it is only a minor source of emission totals.

Quality checking and verification for these sources involves time-series consistency checks and periodic benchmarking against international EFs, as well as checks

between datasets from different UK network operators for UK-wide consistency checking.

Planned Improvements in Fugitive Emissions from Oil & Gas Industries (1B2)

BEIS has commissioned ongoing research into the data mechanisms that underpin the UK upstream oil and gas emission estimates, including to access and analyse new public domain data on production from the Oil and Gas Authority. This may lead to changes in the methods for the fugitive emission sources associated with the upstream sector including flaring, venting, oil loading and process fugitives.

Industrial Processes and Use of Solvents (2)

Summary

This category covers many different emission sources from industry (not including combustion) and consumer product use, many of which are low emitting in the UK inventory context. As such, detailed methodological descriptions are provided for high-emitting (key) source categories only (see Table 15). For details of emission estimation for other sources, please consult the IIR.

Key sources and pollutants

Table 14 Key sources and pollutants in Industrial Processes and Use of Solvents (2)

NFR14 source category	NFR14 source category name	Pollutant	Proportion of total emissions for pollutant in 2019 (%)	% Change in emissions (1990 - 2019)
2A5a	Quarrying and mining of minerals (other than coal)	PM10	5.7	-43.9
2A5b	Construction and demolition	PM10	14.9	-46.6
2A5b	Construction and demolition	PM2.5	2.3	-46.6
2C1	Iron and steel production	PM10	2.2	-58.1
2C1	Iron and steel production	PM2.5	1.9	-62.5
2D3a	Domestic solvent use (including fungicides)	NMVOC	19.9	13.6
2D3d	Coating applications	NMVOC	9.1	-70.5
2D3i	Other solvent use	NMVOC	3.9	-52.1
2H1	Pulp and paper industry	SOx	4.8	-13.2

NFR14 source category	NFR14 source category name	Pollutant	Proportion of total emissions for pollutant in 2019 (%)	% Change in emissions (1990 - 2019)
2H1	Pulp and paper industry	PM10	1.8	-13.2
2H1	Pulp and paper industry	PM2.5	2.1	-13.2
2H2	Food and beverages industry	NMVOC	13.8	36.3

Data sources

Table 15 An overview of methods and data sources in Industrial Processes and Use of Solvents (2)

NFR14 Source category	NAEI Source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
2A5a	Dewatering lead concentrates (Quarrying)	PM10; PM2.5	AD · EF	Statistics on extraction of various types of minerals: UK Minerals Yearbook (BGS)	Default EFs; Other literature EFs
2A5b	Construction of apartments and houses, Non-residential construction, and Road construction	PM10; PM2.5	AD · EF	Proxy statistics (MHCLG & NHBC for numbers and types of houses and apartments; ONS financial data for non-residential buildings; DfT for road length)	Default EFs
2C1	Electric arc furnaces; Integrated steelworks; Cold rolling of steel; Hot rolling of steel	All (except NH3)	Operator-reported supplemented by regulator data	Statistics on production of oxygen steel / electric steel (ISSB)	Operator-reported; Literature EFs (Default EFs; IPCC etc.)
2D3a	Agriculture (agrochemical use); Aerosols; Non-aerosol products	NMVOC; NH3	AD · EF	UK industry data (product consumption, sales, population and number of households, vehicle numbers and vkm for car-care products, adhesive use)	UK industry data (BAMA, UKCPI, ESIG); UK-specific and US emission EFs (UK industry including BASA; US EPA)

NFR14 Source category	NAEI Source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
2D3d	Decorative paint (retail; trade)	NMVOC; PM10; PM2.5	AD · EF	UK industry data (sales, consumption)	UK industry data and literature EFs (Default EFs, HMIP etc.)
2D3d	Industrial coatings	NMVOC; PM10; PM2.5	Site-specific emissions data (from regulators); AD · EF	Trade association data (sales; consumption)	UK industry data and literature EFs (Default EFs, HMIP etc.)
2D3d	Paper coating; Textile coating; Leather coating; Film coating	NMVOC; PM10; PM2.5	Site-specific emissions data (from regulators)	Operator-reported	Operator-reported
2D3i	Seed oil extraction	NMVOC	Site-specific emissions data (from regulators)	Operator-reported	Operator-reported
2D3i	Industrial adhesives (other)	NMVOC	AD · EF	UK industry data (consumption)	UK industry data (BASA, ESIG, country-specific EFs Giddings et al.)
2D3i	Other solvent use	NMVOC	Industry estimates (2008; 2013; 2015)	ONS, 2018 ; UK Government Statistics (manufacturing data for proxy of usage)	UK industry data (BASA, ESIG, country-specific EFs Giddings et al.)

NFR14 Source category	NAEI Source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
2D3i	Wood impregnation (LOSP; creosote)	NMVOC	Industry estimates (1990 & 2000)	ONS, 2018 (data on manufacturing output for proxy of usage for years other than 1990 & 2000); Giddings et al., 1991 (split of emissions from LOSP and creosote)	UK industry data (BASA, ESIG, country-specific EFs Giddings et al.)
2H1	Pulp and Paper Industry	All	AD · EF	Confederation of Paper Industries (via Forestry Commission)	Default EFs
2H2	Bread baking; Brewing (fermentation); Brewing (wort boiling); Cider manufacture; Malting; Other food (inc. sugar production); Spirit manufacture	NMVOC; NH3	AD · EF	Government statistics (e.g. HMRC Alcohol Bulletin; Defra Family Food Survey; Defra Agriculture in the UK; ONS population statistics); Trade associations (e.g. Scottish Whiskey Association; Maltsters Association of GB; Federation of Bakers)	Default EFs; Literature EFs (mainly from UK industry research; US EPA AP-42); Derived from emissions reported to EA for 1 UK sugar factory
2H2	Sugar beet processing	NMVOC; NH3	AD · EF	PI (for NMVOCs)	Literature EFs (mainly from UK industry research), some Default EFs for NMVOCs
2H2	Spirit manufacture (spent grain drying); Wine manufacture	NMVOC; NH3	AD · EF	Government statistics (e.g. HMRC Alcohol Bulletin); Trade associations (e.g. Scottish Whiskey Association; Maltsters Association of GB)	Literature EF (US EPA AP-42); Default EFs

Methodology (general)

To generate estimates of emissions from Industrial Processes, several methods may be used, depending on the data available for each source.

For industrial sectors where there is a high level of emissions reporting to environmental regulators (e.g. from the PI/SPRI/WEI/NIPI) across all installations in the sector (such as chemical processes or electric arc furnaces), the sum of reported emissions is used in the NAEI. In cases where there are also activity data (e.g. annual production data) for the sector, an Implied EF (IEF) can be calculated (= Emissions / Production) and used to validate the UK data against EMEP/EEA or other default EFs. Where there may be data gaps in the reporting (e.g. for a certain installation or pollutant, across the time series) then the inventory agency applies gap-filling assumptions using proxy data such as production data, economic indices, plant capacity data or emission trends of other pollutants.

For many industrial process emission sources, however, there are very few reported emissions data, and other methods are deployed, typically:

Emission = Activity Data · Emission Factor

Where available, emission factors are taken from the EMEP/EEA Guidebook, UK research or other literature sources, and are used in combination with activity data such as production and sales data from the ONS, for which the main dataset is the Production Communautaire (PRODCOM). However, this dataset is limited for many sectors due to aggregation across products / sectors (to protect commercially sensitive data), lack of explicit product mass data (as most data are in economic units) and categorisation of production data that are misaligned with inventory methods. Therefore, data are often supplemented through direct consultation with regulators, industry contacts and trade associations such as ISSB, British Geological Survey (BGS), MPA and British Glass amongst others. Other trade associations (e.g. the British Aerosol Manufacturers' Association) and industry contacts provide data periodically on product use, or annual sales data. However, domestic solvent consumption data supplied by industry contacts are often more reliable than production data for this sector due to the presence of numerous product types. Gap-filling techniques are applied to these consumption data where necessary using proxy statistics.

Quarrying and Mining of Minerals (2A5a)

There are few active underground mines in the UK; most minerals are extracted from quarries. Production is dominated by aggregate minerals, clays and industrial

materials. Emissions are predominantly from extraction of the minerals and primary processing stages e.g. crushing. These are generally fugitive and as such difficult to quantify.

Method

Emissions estimates for PM are based on the Tier 2 EFs from the EMEP/EEA Guidebook, assuming medium-high emissions (conservative approach since many UK quarries are regulated with dust suppression systems).

Data sources

Activity data are taken from BGS statistics which consist of production data for each product type (sandstone, clays etc.), but these are not available for all types in the very latest years due to a 1-year time lag in publishing. In such cases, the inventory agency has extrapolated data from the latest year of data availability.

Construction and Demolition (2A5b)

Method

Emissions of PM from construction are estimated using the default method given in the EMEP/EEA Guidebook.

Data sources

The EMEP/EEA Guidebook contains EFs for 4 types of construction: houses, apartments, non-residential buildings, and roads. Based on the method in the EMEP/EEA Guidebook, activity data for each type should be the annual area of new construction, but these do not exist for the UK. Thus, activity data are based on proxy statistics:

- **Houses and apartments:** The number and type of dwellings built (MHCLG); house type (NHBC, the National House-Building Council)
- **Non-residential buildings:** the value of construction work converted into Euros (ONS). This is multiplied by 0.001 to obtain the estimate for the affected area. Note that values will include road construction, so there is some degree of double-counting.
- **Roads:** The annually reported road length (DfT). The annual net change in road length is calculated for each road type. Annual increase in length is assumed to reflect the length of new roads constructed (and reported

reductions are disregarded assuming they are due to method changes or road removal).

Iron and Steel Production (2C1)

UK iron and steel production leads to emissions from integrated steelworks (excluding those from coke production), electric arc steelworks, downstream processes (e.g. continuous casting; rolling of steel), and iron and steel foundries.

Methodology

Emission estimates for all these processes are based on a bottom-up approach. Emissions are mostly obtained from operator data either directly or via inventories based on required reporting processes.

Data sources

For most UK integrated works data are normally taken directly from operators from 2000 onwards. Data gaps are filled using data in the PI and WEI. However, these data are less detailed (no disaggregation by activity) so reconciliation is achieved based on the reported split of emissions in other years. For other electric arc steelworks, emissions are reported in the PI/WEI/SPRI (no sites in NI). Data are also taken directly from operators of integrated steelworks (1998-1999). Emissions for the earlier part of the time-series for processes at integrated and electric arc steelworks are estimated by extrapolation of EFs from later years.

Literature EFs, including EMEP/EEA defaults are used for some minor emission sources that are not operator-reported.

Solvent and Other Product Use (including Coating Applications) - 2D3

Solvents are used by a wide range of industrial sectors and the general public (domestic solvent use). Industrial solvent applications (e.g. paints, inks, adhesives and other industrial coatings) often require that the solvent is evaporated at some stage. Similarly, in many consumer products (e.g. fragrances, polishes and aerosols), the solvents are expected to be released to the atmosphere upon product use.

Data sources

Most industrial solvent-using processes in England, Wales and NI are regulated by local authorities. Therefore, any operator-reported emissions data are managed across hundreds of Local Authority (LA) records, often in hard copy, and so difficult to obtain. The reporting of emissions from larger processes under the EWR/E-PRTR does allow the emission estimates to reflect NMVOC reductions at those sites, although these sites will only constitute a minor proportion of the sector.

As a result of the lack of data for most industrial sites where solvents are used, data are instead mainly provided by suppliers of solvents or solvent-containing products such as paints and adhesives. As a result, emission estimates may not fully take account of reductions due to end-of-pipe abatement methods, which solvent / product suppliers may not be fully aware of.

For NMVOC emissions from domestic solvent use in consumer products, information is obtained from a market research company (Euromonitor) and from regular consultation with UK trade bodies (e.g. BAMA, UKCPI).

Methodology

Emissions of NMVOCs from solvent use are mostly assumed equal to the solvent consumed in products after accounting for plant-level abatement measures in industrial processes. Some processes (e.g. publication gravure printing, seed oil extraction, and dry cleaning) include recovery and re-use of as much solvent as possible. For some applications (e.g. wood treatments and some bitumen grades) where the solvent is used but not entirely released, emissions are based on solvent consumption, but include allowances for solvent not released.

Some other uses of solvents (e.g. paint and ink manufacture) do not rely on the solvent being evaporated (and losses are prevented as far as possible). As such, estimates for these emissions can be made using EFs assuming some percentage loss of solvent.

Some solvent processes (industrial coating) emit dust (e.g. application of coatings by spraying). Thus UK-specific EFs for these processes have been developed by combining various assumptions. Assumptions include the proportion of coatings in each sector applied by spraying, the average solids contents of the coatings, the average efficiency of the spraying transfer process and dust emission abatement, as well as the particle size distribution of PM.

Pulp and Paper Industry (2H1)

Methodology

Emissions are estimated using the default method given in the EMEP/EEA Guidebook.

Data sources

Activity data are from the Forestry Commission. Data are for 2009-2018 only, so for other years, emissions are based on extrapolation using index of production data from the ONS.

EFs are default factors taken from the EMEP/EEA Guidebook.

Food and Beverages Industry (2H2)

Emissions occur from a variety of processes including bakeries, malting, animal feed manufacture, and production of fats and oils. However, the most significant emissions arise from the manufacture of Scotch Whisky and other spirits.

Data sources

Activity data are sources from a range of government statistics (e.g. HMRC Alcohol Bulletin; Defra Family Food Survey), together with industry-specific information from organisations (e.g. the Scottish Whisky Association; Maltsters Association of GB; Federation of Bakers).

EFs for spirits manufacturing and brewing are UK-specific and derived based on information supplied by industry, since NMVOC emitting processes are often outside the scope of the EWR. Bread baking emissions are calculated based on the EMEP/EEA Guidebook EF for “White bread, typical European” which is consistent with Campden BRI’s measurements (the organisation that invented the UK’s main break baking process, CBP), based on consultation with their experts. Emission factors for other significant sources are taken from the EMEP/EEA Guidebook.

Methodology

In most cases:

$$\textbf{Emission} = \textbf{Activity Data} \cdot \textbf{Emission Factor}$$

Industry data are unavailable for sugar production, but estimates are based on UK plants recovering sugar from sugar beet (who report emissions in the PI) and includes limited data on NMVOC emissions.

Source-specific QA/QC and verification (2)

Some emission estimates (for 2A, B, C, D and I) rely on emissions data reported in the PI/SPRI/WEI/NIPI. See QA/QC in the Energy 1A section for issues with these data.

QC of activity data for specific industries is also carried out between trade association data and other reference sources (e.g. comparison between Tata Steel and ISSB data). Discrepancies are investigated and resolved via stakeholder consultation. However, for many sources only one dataset is available, so cross-checking is not possible.

In the Construction and Demolition subcategory, both the EFs and activity data are highly uncertain for many sources, notably for this activity in the non-residential buildings and road construction sectors, where data are scarce.

Planned Improvements in Industrial Processes and Use of Solvents (2)

The industrial process and product use sector covers a diverse range of sources and for many of these there are little to no regular data. Most estimates rely heavily on site-specific emissions data from regulators or activity and/or emissions data from industrial trade bodies. However, the large number of individual sites and distinct source categories mean that maintaining or improving estimates is very resource intensive. Therefore, few routine improvements can be planned and instead, the inventory agency looks to engage with stakeholders periodically to help update the inventory.

For many NMVOC sources in 2D3 (except domestic solvent use, 2D3a), emission estimates are largely based on data gathered over many years on an ad-hoc basis from process operators, trade associations and regulators. Thus, regular stakeholder consultation (resource intensive) has to take place to supplement the data.

Many emission estimates for PM are highly uncertain since they are mostly fugitive and hard to quantify. Many dust-emitting processes are regulated by LAs, so emissions are estimated using a top-down approach (e.g. use of literature EFs), but this approach does not account for existing abatement strategies that must exist. Increasing the level of detail of activities in these sources remains a priority.

Agriculture (3)

Summary

The agriculture sector includes emissions from livestock and arable crop production; the sector is by far the greatest source of emissions of NH_3 in the UK across the time series of the NAEI. Dairy and beef cattle production contribute most to NH_3 emissions, but inorganic fertiliser application to crops is also a large contributor. Manure management within the agriculture sector is also a key source of NMVOC emissions. The methods for NH_3 and NMVOC emissions are described in this section; see the IIR for details on other pollutants.

Key sources and pollutants

Table 16 Key sources and pollutants in Agriculture (3)

NFR14 source category	NFR14 source category name	Pollutant	Proportion of total emissions for pollutant in 2019 (%)	% Change in emissions (1990 - 2019)
3B1a	Manure management (dairy cattle)	NH3	13.3	13.8
3B1a	Manure management (dairy cattle)	NMVOC	3.5	18.8
3B1b	Manure management (non-dairy cattle)	NH3	12.7	-8.3
3B1b	Manure management (non-dairy cattle)	NMVOC	3.5	-9.6
3B4gii	Manure management (broilers)	PM10	1.4	64.3
3Da1	Inorganic N-fertilizers	NH3	15.0	-29.5
3Da2a	Animal manure applied to soils	NH3	22.3	-21.1
3Da2a	Animal manure applied to soils	NMVOC	3.9	32.0

NFR14 source category	NFR14 source category name	Pollutant	Proportion of total emissions for pollutant in 2019 (%)	% Change in emissions (1990 - 2019)
3Da2c	Other organic fertilisers applied to soils	NH3	5.2	NA
3Da3	Grazing animals (N-excretion)	NH3	7.2	-14.7
3Dc	Farm-level agricultural operations	PM10	4.0	-5.8

Data sources

Table 17 An overview of methods and data sources in Agriculture (3)

NAEI source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
Agriculture livestock (all animals)	NH3; NOx; NMVOC; PM2.5; PM10	UK model (using the mass-flow approach) for NH3 and NOx see Webb & Misselbrook, 2004; AD · EF for NMVOC and PM	Livestock Management Practises: Defra Farm Practises Survey; Smith et al., 2000-01, EPRL & Fibropower (incinerated poultry litter); Livestock statistics: National Agricultural Survey & Cattle Tracing Scheme; Nitrogen Excretion: Thomas, 2004 & AFRC, 1993 (feed DM); Cottrill & Smith, 2007	Default EFs; UK EF (for NH3); NOx EFs are ratios of UK-specific N2O EFs
Agricultural livestock (animal manure applied to soils)	NH_3; NOx	UK model (using the mass-flow approach) for NH3 and NOx see Webb & Misselbrook, 2004	Livestock Management Practises: Defra Farm Practises Survey; Smith et al., 2000-01, EPRL & Fibropower (incinerated poultry litter); Livestock statistics: National Agricultural Survey & Cattle Tracing Scheme; Nitrogen Excretion: Thomas, 2004 & AFRC, 1993 (feed DM); Cottrill & Smith, 2007	UK EF (for NH3); NOx EFs are ratios of UK-specific N2O EFs
Agricultural soils (other organic	NH3; NOx	UK model (using the mass-flow approach) for	Feedstock quantities used in anaerobic digestion:	UK EF (for NH3); NOx EFs are

NAEI source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
fertilisers applied to soils)		NH3 and NOx see Webb & Misselbrook, 2004 for manure-based digestates; UK model (AD · EF for non-manure digestates	National Non-Food Crops Centre annual deployment report (NNFC, 2019); Digestate application practices: Tomlinson et al. (2019)	ratios of UK-specific N2O EFs
Agricultural soils (Inorganic N-fertilizers)	NH3; NOx	UK model (simple; process-based); Misselbrook et al., 2004 for NH3; AD · EF for NOx	British Survey of Fertiliser Practise; DAERA stats & NI Farm Business Survey (for NI)	UK EFs (model); NOx EFs are ratios of UK-specific N2O EFs
N-excretion on pasture range and paddock (unspecified)	NH3; NOx	AD · EF	Survey data (proportion of livestock grazing & proportion of year spent outdoors)	UK EFs
Agricultural soils (Farm-level agricultural operations)	PM2.5; PM10	AD · EF	Total area of each crop; Amount of times emitting practise carried out	Literature sources

Livestock management practises

Methodology

NH_3:

A Tier 3 methodology using the N-flow model is used for manure management using country-specific EFs for livestock housing, manure storage and manure spreading, and grazing. The N-flow model accounts for all N losses (NH_3, N_2O, NO, N_2) and transformations (mineralisation/immobilisation) through the manure management system with NH_3 EFs expressed as a proportion of the Total Ammoniacal N (TAN) in the manure for a given emission source (Webb & Misselbrook, 2004).

NH_3 EFs at each management stage are expressed as a percentage of the TAN present within that stage. Other N additions (e.g. from bedding addition and losses (e.g. via leaching or denitrification) are modelled at each stage (with all assumed to occur from the TAN content of the manure). Several abatement strategies are also incorporated in the methodology (Misselbrook *et al*., 2019).

NMVOC:

A Tier 2 approach is used to estimate NMVOCs from manure management whereby EFs taken from the latest EMEP/EEA Guidebook are applied to UK livestock numbers.

Soils

NH_3 emissions from soils derive from direct excretal returns by grazing livestock (including outdoor pigs and poultry), from manure application to land, from the application of other organic fertilisers to land (e.g. digestates from anaerobic digestion), and from synthetic N fertiliser application to land.

Data sources

Emissions from grazing livestock are estimated using UK-specific activity data on the proportion of livestock associated with grazing and the proportion of the year those livestock spend outdoors. Quantities of digestates applied to land, by feedstock type (livestock manure, crops, food waste, other) are taken from the National Non-Food Crops Centre annual deployment report (NNFC, 2019).

UK EFs for most sources are derived from experimental measurements (Misselbrook *et al.*, 2019). EFs for non-manure digestates are based on a review by Tomlinson *et al.* (2019).

Methodology

NH_3:

For livestock manure-based digestates, anaerobic digestion is included in the UK model as a manure management option, associated with a higher N mineralisation factor than for conventional manure storage, therefore giving a greater TAN content (as a proportion of the total N) at land spreading. NH_3 EFs expressed as a percentage of the TAN are assumed to be the same as for livestock slurries. From 2018, all digestates are assumed to be applied to land using low emission application techniques.

Emissions from fertiliser applications to agricultural land are estimated using a Tier 3 approach based on a simple process-based model (Misselbrook *et al*., 2004), modified according to data from a Defra project (NT26). Each EF is associated with a maximum EF value which is then further modified according to soil, weather and other management factors (e.g. application rate). Soil placement of N fertiliser is considered an abatement measure as is the use of a urease inhibitor with urea

fertiliser. The relationships are applied at a 10km^2 grid level across the UK using land use, soil, and climate data at that resolution combined with crop-specific fertiliser application rates (British Survey of Fertiliser Practice; NI Farm Business Survey) for each year and region.

Source-specific QA/QC and verification (3)

Model output including emissions estimates, activity data, and implied EFs are checked against default EF values and consistency with previous years. Trends in emissions per subcategory are plotted (from 1990) and any large deviations are scrutinised.

Following compilation, the inventory spreadsheet and report are checked by the wider compilation team (Rothamsted, ADAS, Cranfield University and CEH), and sent to the Inventory Agency and Defra for final checks.

The UK participates in the European Agricultural Gaseous Emissions Research (EAGER) network which has a strong focus on comparing approaches and parameter values used in the NH_3 emissions inventories of the participating countries (see Reidy *et al*. 2008; 09).

Planned Improvements in Agriculture (3)

There is continued reviewing of the scientific literature to revise and refine UK-specific EFs. Reviews of UK livestock feed data and N excretion by different livestock categories are underway in specific Defra projects.

Waste: Other (5E)

The waste sector includes emissions from a range of sources related to waste management, treatment and disposal. This includes emissions from equipment involved in the waste sector, incineration, and application and decomposition of waste. Emissions from most of these sources do not constitute a large proportion of UK emission totals and so the methodology is not included in this document (see the IIR for details). However, emissions from accidental fires and bonfire night are also reported within this category and are key inventory sources for $PM_{2.5}$.

Key sources and pollutants

Table 18 Key sources and pollutants in Waste: Other (5E)

NFR14 source category	NFR14 source category name	Pollutant	Proportion of total emissions for pollutant in 2019 (%)	% Change in emissions (1990 - 2019)
5E	Other waste	PM2.5	1.7	-39.2

Data sources

Table 19 An overview of methods and data sources in Waste: Other (5E)

NAEI source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
Accidental fires (dwellings, other buildings & vehicles)	NOx; NMVOC; PM	AD · EF	Government statistics for the number and type of incidents fire rescue services attended; Inventory Agency profiles to predict scale of fires and assumptions of quantity of material combusted	Mixture of US EPA (2004), EMEP/EEA default factors & UK-specific factors
Bonfire night	PM	AD · EF	Inventory Agency estimates of material burnt in bonfires and firework displays	UK EFs (domestic wood fire EFs are used for PM10)

Methodology

Accidental fires:

Government data on fire statistics are used for the number and type of incident the UK fire and rescue services are required to attend annually with the type of incident disaggregated by buildings and vehicles. Detailed statistics on the scale of the fire are only available for dwellings and other buildings for 1987-2001, and for vehicles for 1985-2007. For other years, the Inventory Agency makes assumptions about the quantity of material burnt and the scale of the fire by creating profiles for buildings for example (i.e. whole room/building destroyed etc.). For fires contained to a single item, it is assumed that 1kg of materials is combusted, for example. The mass of material can then be converted into a material type (e.g. wood, plastic, textiles etc.) after which EFs can be applied.

Bonfire night:

The celebration of Bonfire night in the UK (5th of November) is treated as a separate source from other domestic burning events due to its large-scale organised nature and the potential air quality impact over a short period of time. Backyard burning of waste and other bonfires throughout the year are reported elsewhere in the Waste category (Open burning of waste).

Emission estimates for Bonfire night are based on Inventory Agency estimates of material burnt in bonfires and firework displays. Emission factors for domestic wood fires (for PM_{10}) are used to generate emission estimates.

Source-specific QA/QC and verification (5E)

Please see the General Quality Assurance and Quality Control (QA/QC) procedures.

Data on waste sector activities are generally limited in coverage and detail across the time-series. Additional activity data and estimates for quantities of material burnt for bonfires are based on the UK Inventory Agency's estimates for the UK. These are highly uncertain due to the lack of viable UK data. Over recent years, the completeness and accuracy across the waste inventory has improved. However, certain elements (e.g. the number of accidental fires) will always be uncertain.

Planned Improvements in Waste: Other (5E)

None for 5E.

Other (6A)

The “Other” category captures sources not covered in other parts of the inventory. It includes emissions from non-agriculture livestock such as horses, domestic pets, non-agriculture fertiliser application (domestically and on parks and golf courses) and infant nappies. However, only the category of 6A is a key source of NH_3 and so only the methods behind calculating emissions from these sources are included in this section. Methods for calculating emissions from non-agriculture livestock can be found in the IIR.

Key sources and pollutants

Table 20 Key sources and pollutants in Other (6A)

NFR14 source category	NFR14 source category name	Pollutant	Proportion of total emissions for pollutant in 2019 (%)	% Change in emissions (1990 - 2019)
6A	Other	NH3	5.1	30.0

Data sources

Table 21 An overview of methods and data sources in Other (6A)

NFR14 source category	NAEI source sub-categories	Pollutant coverage	Method	Activity Data (AD)	Emission Factors (EF)
6A	Infant emissions from nappies	NH3	AD · EF	UK population data for <4 years	UK EFs
6A	Domestic pets	NH3	AD · EF	UK population data for domestic pets	UK EFs
6A	Domestic garden fertiliser application	NH3	AD · EF	Total amount of non-agriculture fertiliser used in the UK	Misselbrook *et al.,* 2017
6A	Park and garden, golf courses fertiliser application	NH3	AD · EF	Total amount of non-agriculture fertiliser used in the UK	Misselbrook *et al.,* 2017

Methodology

All ammonia emissions in this category are based on research by the CEH.

Infant emissions from nappies:

Population data for the under 4-year age group are used in combination with assumed NH_3-N generation rates for sewage to give kt of ammonia per head of population.

Domestic pets:

Ammonia emission estimates for domestic pets are provided by CEH based on the UK population estimates for cats and dogs and an EF estimate per animal. For example, the EF for cats is based on a cat's urinary excretion rate (kg of urinary N per cat each year) derived from assumptions of daily dietary N intake (Sutton, 2000)

Fertiliser application to golf courses, parks and gardens:

Ammonia emission estimates for this category are provided by CEH. The average ammonia volatilisation rate for fertiliser application is based on EFs for fertiliser application to agricultural grassland (Misselbrook *et al.*, 2017). For parks and gardens and golf courses an average of all fertiliser types was used.

For fertiliser application to domestic gardens, the total estimated amount of non-agriculture fertiliser used in the UK is used (Datamonitor, 1998) in combination with assumed rates of average N content and assumed rates of volatilisation (Misselbrook et al., 2017).

Source-specific QA/QC and verification (6A)

Many of the emission estimates reported under "Other" come from sources with more approximate activity data and emission factors based on literature. Where possible national statistics have been used to help better define the sources which have in-built QA/QC processes. Emission estimate methodologies have adopted innovative approaches to provide robust estimates.

Planned Improvements in Other (6A)

None.

Summary of Uncertainty

Table 22 A qualitative summary of the overall uncertainty for each pollutant

Pollutant	Chemical symbol	Overall uncertainty rating
Ammonia	NH_3	Moderate
Nitrogen Oxides	NO_x	Low
Non-Methane Volatile Organic Compounds	NMVOCs	Low
Particulate Matter	PM	High
Sulphur Dioxide	SO_2	Low

Uncertainty analysis for national estimates of NAEI pollutants is undertaken in accordance with the methodological guidance from the EMEP/EEA Guidebook, using both the Tier 1 uncertainty aggregation method and the more complex and comprehensive Tier 2 Monte-Carlo analysis which can more accurately combine large non-normally distributed uncertainties.

The results from these analyses can be found in the Informative Inventory Report (IIR), including a split by NFR14 code. Table 22 presents a qualitative summary of the overall uncertainty for each pollutant.

The uncertainty analyses results are also used to inform priorities for the inventory Improvement Programme, to improve UK data and methods.

Ammonia (NH_3)

NH_3 estimates are subject to higher uncertainty than most other pollutants (except PM) and this is due to uncertainties stemming from estimation of emissions from agricultural sources (the largest source for UK NH_3). Despite using a Tier 3 methodology to generate estimates, it is not currently possible to fully represent the many factors influencing emissions from diffuse sources such as animal stocking densities, weather, soil type and conditions etc. (which are reflected in the

uncertainties associated with individual EFs). Work is underway to characterise the uncertainty parameters for the revised agriculture model.

Nitrogen oxides

Uncertainty of NOx estimates are driven by uncertainty in emissions from fuel combustion, although this is relatively low compared with other sectors. There is uncertainty in the EFs and their choice within Road Transport (responsible for about a third of national NOx) as well as emissions from off-road machinery which has similar issues with EFs, but also lacks reliable activity data. Emissions from large stationary combustion plants are considered less uncertain due to no single plant constituting a large proportion of UK totals so there is scope for error compensation.

NMVOCs

Estimates of NMVOCs are more uncertain than those for SOx and NOx, partly due to the lack of quality EFs or estimates for many sectors (e.g. solvent use and industrial processes), and also the diffuse nature of the sources (scope for error compensation), but also due to the absence of reliable activity data for some sources. Uncertainty decreased in the 1990s and early 2000s due to work to acquire more data, but this work has ceased, resulting in increasing uncertainty.

Particulate Matter

PM_{10} estimates are subject to high uncertainty due to both uncertain EFs and activity data. For many sources, emissions data and/or EFs are available for total PM only and PM_{10} must be estimated based on assumptions about the size distribution of particle emissions from that source. This limitation can be worse for $PM_{2.5}$ estimates. Furthermore, uncertainty is increased since many sources of PM are diffuse or fugitive and thus difficult or impossible to measure accurately.

Sulphur Dioxide

SO_2 emissions are relatively accurate for the most important sources because emissions are related largely to the level of sulphur in solid and liquid fuels which is based on existing comprehensive analyses. However, uncertainty has increased since the early 2000s because a reduction in SO_2 emissions due to regulations on large emitters (e.g. power stations) has meant that fuels burnt in sectors with less regulation and less data (e.g. coal used as domestic fuel) have increased uncertainty relative to other sectors.

Summary of general Quality Assurance and Quality Control (QA/QC) procedures

The inventory aims to ensure high quality standards through transparency, completeness, consistency, comparability and accuracy (TCCCA). To achieve these objectives, the inventory is subject to rigorous QA/QC procedures that comply with the guidance published in the latest EMEP/EEA Guidebook, and the more comprehensive guidance on GHG inventories (Tier 1 procedures outlined in the 2006 IPCC Guidelines).

The QA/QC system for the UK NAEI, including verification and treatment of confidentiality issues, comprises:

- ***Quality Control*** (e.g. raw data checks, calculation checks, output checks) to minimise the risk of errors within the available resources to deliver the inventory.
- ***Quality Assurance*** (e.g. peer reviews, bilateral reviews, expert reviews) whereby independent experts periodically review all or part of the inventory to identify potential areas for improvement.
- ***Verification*** where alternate independent datasets are available to compare against inventory data and trends).

The NAEI complies with all the Tier 1 QA/QC requirements, but also goes further by undertaking source-specific (Tier 2) measures which are typically applied to key sources, or where complex estimation methods (Tier 2, Tier 3) are applied. The main elements of the Tier 1 QA system requirements are:

- There is an Inventory Agency (consortium managed by Ricardo Energy & Environment)
- A QA/QC plan
- A QA/QC manager
- Reporting documentation and archiving procedures
- General QC (checking) procedures
- Checks for data calculation errors and completeness
- Reviews of methods, data sources and assumptions
- Review of internal documentation
- Documentation of methodologies and underlying assumptions
- Documentation of QA/QC activities

Most of the compilation and maintenance of the NAEI is currently undertaken by Ricardo Energy & Environment, with Rothamsted Research responsible for compiling the inventory for the agriculture sector. Ricardo is also responsible for coordinating QA/QC activities across all inventory stakeholders.

Pre-inventory QA/QC (data suppliers)

Many of the datasets used by the Inventory Agency come from data provider organisations that are UK government departments, agencies, research establishments or consultants working on behalf of UK government or trade associations. Several of these (e.g. BEIS, DfT, Defra, ONS and BGS) qualify as UK National Statistical Agencies and thus abide by strict statistical QA/QC standards.

Other organisations supplying important datasets to the inventory (e.g. UK environmental regulatory agencies supplying installation-level data) have their own QA/QC systems. When data are taken from individual companies or organisations, the Inventory Agency requests annual information on the QA/QC systems and uncertainties related to the data.

Quality objectives

The objectives of the QA/QC plan are to ensure that estimates in the air pollutant inventory are of a suitably high quality to meet the methodological and reporting requirements for UK submissions to the UNECE, and EU, as set out within national inventory reporting guidance from the European Environment Agency (EEA).

Aside from quality, time and resource are also limiting factors for a given project. More time and resource are directed towards method development, compilation, reporting, and QA/QC activities for key source categories.

Roles and responsibilities

The inventory QA/QC plan sets out specific responsibilities for the different QA (review) and QC (data controls, checking) activities and to different roles within the inventory compilation and reporting team. These are embedded within compilation and processing spreadsheets and databases. Training and project management communication across the Inventory Agency ensures that these responsibilities are clear, with specific tasks and checks signed-off at appropriate stages throughout the inventory process. The following responsibilities are outlined in the UK inventory QA/QC plan:

- QA/QC manager
- Technical Directors / Knowledge leaders
- Project Manager
- Sector Experts
- External Review Experts

Quality Control and Documentation

NAEI Quality Control (checking, documentation and archiving) occurs throughout the data gathering, compilation and reporting cycle. Unless the data passes each step of the following quality criteria in order, it does not advance to the next stage in the QC process:

1. Checking of input data for scope, completeness and consistency with data for recent years and (where available) verification against other independent datasets
2. Analysis of internal inventory energy and mass balances and other statistics assumptions against National Statistics input data (e.g. DUKES and ONS).
3. Completeness checks (e.g. inclusion of all relevant pollutants, or missing estimates)
4. Recalculation checks (i.e. checks against the previous inventory)
5. Time series checks and benchmarking checks for step changes, trends and outliers.
6. Method implementation checks (e.g. unit checks; EFs are consistent across years; other sense checks etc.)
7. Reporting checks (i.e. correct allocation to the NFR14 categories.

Checking and documentation is facilitated by specific custom data storage and handling systems alongside procedures developed for the NAEI compilation including:

- A database of contacts
- Individual data processing tools
- A core database (NAEI database)
- Data extraction checking routines and procedures
- Official annual reports
- Archiving

Note that all data are traceable to its original source by assignment of a unique reference number.

Quality assurance and verification

These activities provide an objective, independent review of the data, methods and assumptions to assess compliance with reporting requirements, and identify areas of improvement.

The specific QA activities and procedures are:

- External peer review (including annual international reviews, for example under CLRTAP)
- Bilateral reviews with other countries
- Stakeholder consultation and user feedback
- Verification
- The 'Inventory Improvement Programme'
- Capacity building and knowledge sharing

Treatment of confidentiality

NAEI input data from some sources are subject to commercial confidentiality, notably where the production data and/or activity data for a specific installation or company are identifiable. For example, there are confidential data indicating the plant production capacity for specific industrial plant (e.g. cement kilns, chemical plant), annual sales data of specific commodities (e.g. sporting goods) and also details of fuel use for specific installations (e.g. plant-level data from EU ETS-regulated installations).

It is important therefore that in the management of these data within the NAEI system, and in the publication of emission estimates (and other data) relating to these data sources, that the NAEI does not disclose such commercially sensitive information.

There are several mechanisms that the Inventory Agency, Ricardo, its sub-contractors and the wider inventory compilation teams (e.g. Rothamsted Research) deploy to ensure that disclosure of confidential data does not occur:

- The provision of sensitive raw data to the inventory agency, if not through direct communication with the data source organisations, is managed via BEIS using file encryption with password protection;

- Confidential data, such as the EU ETS dataset, is managed by the Inventory Agency on a password-protected secure server which has limited access rights, i.e. access is limited to the relevant compilers and checkers only;

- Within the NAEI database tables, there are specific data fields to identify confidential data. These are applied to cover all the associated data, such as emissions, activity data and EFs, in order to minimise the risk of mistakenly releasing sufficient information that the confidential data can be inferred. These database data fields then enable ease of identification of risk of data disclosure in any NAEI database output (e.g. data at different spatial scales, such as for a specific DA, Local Authority or in mapping outputs);

- Confidential data assignations are periodically reviewed, and in every routine data request for input data for the NAEI the organisation providing the data is given an opportunity to identify confidential data;

- Where data outputs use the confidential data, the data are reported at an aggregated level – either with other sources (e.g. in the case of sporting goods), or over a larger geographical area (e.g. in the case of emissions mapping outputs which are usually at 1km x 1km resolution, data for some sources are aggregated and smeared over a larger area, typically 10km x 10km). This may mean that the UK cannot report exactly in line with the expected level of sectoral resolution as defined in the NFR reporting format for air pollutants, but this is considered an acceptable trade-off in data quality and is necessary to protect sensitive data.

Glossary

AD – Activity data
AIS – Automatic Identification System
ANPR – Automatic Number Plate Recognition
AQEG – Air Quality Expert Group
BAMA – British Aerosol Manufacturer's Association
BASA – British Adhesives and Sealants Association
BCF – British Coatings Federation
BEIS – Department for Business, Energy & Industrial Strategy BGS – British geological Survey
BRT – Below Reporting Threshold
CEH – Centre for Ecology & Hydrology
CET – Central England Temperature
CLRTAP – Convention on Long-Range Transboundary Air Pollution
CO_2 – Carbon dioxide
DA – Devolved Administration
DAERA – Department of Agriculture, Environment and Rural Affairs (Northern Ireland)
Defra – Department for Environment, Food & Rural Affairs
DERV – Diesel Oil for Road Vehicles
FPSO – Floating Production Storage and Offloading
GB – Great Britain
GEMIS - Global Emissions Model for integrated Systems
HGV – Heavy Goods Vehicle
HMRC – HM Revenue & Customs
IEF – Implied Emission Factor – Emissions divided by Production
IIR – Informative Inventory Report
IMO – International Maritime Organisation
IoP – UK Institute of Petroleum
IPCC – Intergovernmental Panel on Climate Change
ISSB – International Steel Statistics Bureau
LA – Local Authority
LFG – Landfill Gas
LGV – Light Goods Vehicle
LOSP – Light Organic Solvent Preservative
LPG – Liquid Petroleum Gas
MANDE – Manure analysis database
MCA – Maritime and Coastguard Agency
MHCLG – Ministry of Housing, Communities & Local Government
MPA – Mineral Products Association
MSW – Municipal Solid Waste
N – Nitrogen
N_2O – Nitrous oxide
NAEI – UK National Atmospheric Emissions Inventory
NECR – UK National Emission Ceilings Regulations
NFR14 – Nomenclature For Reporting 14
NH3 - Ammonia
NHBC – National House-Building Council
NI – Northern Ireland
NIPI – Northern Ireland Pollution Inventory
NMVOC – Non-methane Volatile Organic Compound
NNFCC – National Non-Food Crops Centre
DfT – Department for Transport
DRDNI – Department for Regional Development Northern Ireland
DUKES – Digest of UK Energy Statistics (BEIS)
EAGER - European Agricultural Gaseous Emissions Research
EEA – European Environment Agency
EEMS – Environmental and Emissions Monitoring System
EF – Emission factor
EfW – Energy from Waste
EMEP/EEA Guidebook – European Monitoring and Evaluation Programme/European Environment Agency Guidebook
EPR – Environmental Permitting Regulations
EPRL – Energy Power Resources Limited
E-PRTR – European Pollutant Release and Transfer Register
ESIG – European Solvents Industry Group
EU ETS – European Union Emission Trading System
EWR – Environment and Wildlife Regulations
NO_2 (NOx) – Nitrogen dioxide (Nitrogen oxides)
NRMM – Non-Road Mobile Machinery
OECD - Organisation for Economic Co-operation and Development
ONS – Office for National Statistics
OPG – Other Petroleum Gas
OPRED – Offshore Petroleum Regulator for Environment and Decommissioning
OT – Overseas Territory
PI – England's Pollution Inventory
PM – Particulate Matter
PRODCOM – Production Communautaire
QA/QC – Quality Assurance and Quality Control
RVP – Reid Vapour Pressure
SO_2 (SOx) – Sulphur dioxide (Sulphur oxides)
SPRI – Scottish Pollutant Release Inventory
SSF – Solid Smokeless Fuels
SWA – Scotch Whisky Association
TAN – Total Ammoniacal Nitrogen
TCCCA – Transparency, Completeness, Consistency, Comparability and Accuracy – QA/QC objectives
TfL – Transport for London
THC – Total Hydrocarbon
TRL – Transport Research Laboratory
UK – United Kingdom
UKOOA – UK Offshore Operators Association
UKPIA – UK Petroleum Industry Association
UNECE – United Nations Economic Commission for Europe
US EPA AP-42 – United States Environmental Protection Agency's Compilation of Air EFs
vkm – Vehicle kilometres
WEI – Welsh Emissions Inventory
WRAP – Waste & Resources Action Programme