Addendum to the UK Informative Inventory Report (1990 to 2020) on Emission Projections

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A copy of this report and related documentation may be found on the NAEI website maintained by Ricardo Energy & Environment on behalf of BEIS and Defra: https://naei.beis.gov.uk/

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III Glossary

AnD	Anaerobic Digestion
BAMA	British Aerosol Manufacturers Association
BASA	British Adhesives and Sealants Association
BAT	Best Available Techniques
BCC	British Ceramics Confederation
BCF	British Coatings Federation
BEIS	Department for Business, Energy and Industrial Strategy
BG	British Glass
BLA	British Lime Association
CAA	Civil Aviation Authority
CIA	Chemical Industries Association
CLRTAP	Convention on Long-Range Transboundary Air Pollution
COG	Coke Oven Gas
COPERT	Computer Programme to calculate Emissions from Road Transport
DA	Devolved Administration
DfT	Department for Transport
DUKES	Digest of UK Energy Statistics
EEDI	Energy Efficiency Design Index
EEP NZ	Energy and Emissions Projections Net Zero
ELV	Emission Limit Values
EMEP/EEA	European Monitoring an Evaluation Programme/European Environment Agency
E-PRTR	European Pollutant Release and Transfer Register
EU ETS	EU Emission Trading Scheme
FAPRI	Food and Agriculture Policy Research Institute
FDF	Food and Drink Federation
FES	Future Energy Scenarios
HFO	Heavy Fuel Oil
ICE	Internal Combustion Engines
IED	Industrial Emissions Directive
IMO	International Maritime Organization
LEZ	Low Emission Zone
MARPOL	International Convention for the Prevention of Pollution from Ships
MDO	Marine Diesel Oil
MPA	Mineral Products Association
MTS	Mayor's Transport Strategy
NAEI	National Atmospheric Emissions Inventory
NAPCP	National Air Pollutant Control Programme
NECD	National Emissions Ceilings Directive
NECR	National Emissions Ceilings Regulations
NRMM	Non-Road Mobile Machinery
ONS	Office of National Statistics
PI	Pollutant Inventory
REM	Rail Emissions Model
RHI	Renewable Heating Incentive
RTFO	Renewable Transport Fuel Obligation
SECA	Sulphur Emission Control Areas
SMT	Scenario Modelling Tool
SP	Steady Progress
SSF	Solid Smokeless Fuels
ULEZ	Ultra-Low Emission Zone
WM	With Measures
WoM	Without Measures

1. Background

The UK has emission reduction commitments (ERCs) for five pollutants ($PM_{2.5}$, NO_x, SO_2, NH_3, NMVOC) under the 2018 NECR[1] and the CLRTAP Gothenburg Protocol[2]. Projected emissions are compiled by the Inventory Agency to enable comparisons with these commitments. Emission projections are required under the Gothenburg Protocol every 4 years starting from 2015 while reporting of projections is required every 2 years under the NECR.

Whilst 2022 is not a mandatory year for compiling or publishing projections, the UK provides annual projections in order to support the work of policy makers and modellers and for transparency to our stakeholders and the public.

The dataset presented here is based on the latest version of the UK inventory (the 2020 NAEI), as submitted under NECR and CLRTAP on 14th February 2022. The projections rely upon data from various sources, key among which are the updated Energy and Emissions Projections, issued by BEIS 7 December 2021[3], data from DfT, including updated Road Traffic Forecasts, agriculture forecasts based on the Scenario Modelling Tool (SMT, Defra project ECM 55618) and other forecasts. Further details of data and assumptions are given in section 1.1.

The emission projections take account of measures in place as far as is possible, given the data available, but do not reflect measures that are still in development. UK Projections 'with additional measures' (as defined by the latest EMEP/EEA guidebook) will be explored in line with the Clean Air and Net Zero Strategy commitments and included in the updated National Air Pollutant Control Programme (NAPCP) which is currently being drafted.

1.1. Overview of data and input assumptions

The UK projections are compiled in line with the latest EMEP/EEA guidebook. They take, as their starting point, the estimates of the latest historical time series (i.e. 2020 NAEI) which are then extrapolated into the future taking into account forecasts of energy consumption, road traffic, and other activity data, as well as assumptions about the impact of environmental policies and measures on emissions. For more details about the data and methodology used to compile the historical time series data please see the latest Informative Inventory Report[4].

As part of the projections compilation we also take account of events outside the historic time series, for example known plant closures or significant events that might have occurred in the preceding year. The COVID-19 pandemic, which started in 2020, is one of these significant events, and we have, where data or information is available for future years, reflected the long term impacts of the pandemic as accurately as possible.

The following sector specific sections give details on this modelling.

1 The NECD has been transposed into UK law via the 232/2018 - European Union (National Emission Ceilings) Regulations 2018, see The National Emission Ceilings Regulations 2018 (legislation.gov.uk)

2 See http://www.ceip.at/ms/ceip_home1/ceip_home/reporting_instructions/reporting_programme/ for reporting requirements of estimating and reporting emissions data under the CLRTAP.

3 https://www.gov.uk/government/publications/energy-and-emissions-projections-net-zero-strategy-baseline-partial-interim-update-december-2021

4 Report: UK Informative Inventory Report (1990 to 2020) - NAEI, UK (beis.gov.uk) https://naei.beis.gov.uk/reports/reports?report_id=1071

1.1.1. Standard Approach

The projections are based on the latest version of the UK inventory (available on the NAEI website). Data from this inventory are used as a baseline for the projections:

- activity data from the most up to date timeseries, are used as the starting point for activity projections for 2025, 2030, 2035 and 2040 by applying suitable assumptions about the growth or decline in each activity
- emission factors for 2020 are assumed to be appropriate for future years as well, unless we have data to indicate that emission reductions will occur, for example due to regulation or through improvements in technology.

Typically, the latest year in the historic time series is used as the starting point for the projections. For this set of projections, this is 2020. However, other years may be used as the starting point in the projection calculations, depending upon the data and assumptions being applied. For example, the projections rely upon information supplied by various trade bodies during 2018 and 2019 and most of this information requires the use of 2017 figures from the latest inventory. Note, however, that the projections will still be consistent with the latest inventory submission.

Table 1-1 below summarises the Government statistics and other annually available datasets that are inputs for the emission projections.

Table 1-1 Government statistics and other annual inputs for the emission projections

Sector	Data Type	Dataset	Coverage	Data Provider	Publication date
Energy including transport	Energy use projections	EEP Net Zero Strategy baseline(EEP NZ)	2000-2040	BEIS, EEP team	7 December 2021
Industry	GDP projections				
Cross-cutting	Projected population & household numbers				
Industry, off-road vehicle	Industry sector growth indices				
Oil & gas	Production forecasts	UK crude oil and gas production forecasts	1998-2050	Oil & Gas Authority	September 2021
Agriculture	Emission projections	Scenario Modelling Tool (SMT, Defra project ECM 55618)	2020-2040	Rothamsted	Currently unpublished
	Activity data projections	FAPRI Baseline Briefing Book (2021)	2020-2040	AFBI	November 2021
Road Transport	Data related to future activity levels for road transport	Road Traffic Forecasts for Great Britain (GB)	2015-2050 (5-year intervals)	DfT	Bespoke data/ unpublished December 2021
		Car and LGVs mileage splits by fuel type	2015-2050	DfT	Bespoke data/ unpublished

Sector	Data Type	Dataset	Coverage	Data Provider	Publication date
					December 2021
		UK New Car and LCV Registrations Outlook to 2023	2016-2023	SMMT	October 2021
		Traffic and fleet composition projections data for London	2008-2030	TfL	Bespoke data/ unpublished Feb 2019 (traffic) and Feb 2020 (fleet)
Aviation	CO_2 projections	UK aviation forecasts 2017 (LHR Northwest Runway central growth)	2015, 2020 2030, 2040 and 2050	DfT	2017
Off-road machinery: domestic	Household projections	EEP Net Zero Strategy baseline	2000-2040	BEIS, EEP team	7 December 2021
Off-road machinery: airport	Passenger numbers	UK aviation forecasts 2017	2016, 2020, 2030, 2035 and 2040	DfT	2017
Rail	Activity projections	Rail Emissions Model (REM)	2020-2050	DfT	Bespoke data/ unpublished provided in 2016
Shipping	Emission projections	Scarbrough *et al*. (2017)	2025 and 2030	NAEI	2017
Waste	Methane emission projections	Non-CO_2 GHG Projections	2010-2030	BEIS	2015
	Ammonia emission projections from anaerobic digestion	Electricity generated from anaerobic digestion	2020-2030	BEIS (DUKES)	2020

In addition to the Government data and scientific studies referred to in Table 1-1, information provided on an ad-hoc basis from certain industrial trade associations, following extensive consultation with industry by Defra in particular, and by Ricardo Energy & Environment is also used. Organisations providing information related to projections include:

- British Adhesives and Sealants Association (BASA)
- British Aerosol Manufacturers Association (BAMA)
- British Ceramics Confederation (BCC)
- British Coatings Federation (BCF)
- British Glass (BG)
- British Lime Association (BLA)
- Chemical Industries Association (CIA)
- Energy UK

- Food & Drink Federation (FDF)
- Mineral Products Association (MPA)
- Steel UK

To produce emission projections, it is necessary to generate projections of activity, and to decide what emission factors are appropriate for the future. Most of the activity projections including almost all related to fuel consumption and many relating to industrial processes are based on data given in the annual 'Energy & Emissions Projections Net Zero' (EEP NZ) dataset produced by BEIS. A summary report and annexes, published in December 2021, give an overview of methods and assumptions used in EEP NZ. These documents can be obtained from https://www.gov.uk/government/publications/energy-and-emissions-projections-net-zero-strategy-baseline-partial-interim-update-december-2021. The BEIS energy projections include the impact on fuel consumption of emission source regulation, including the UK Emission Trading Scheme (ETS) and the Industrial Emissions Directive (IED).

The data we receive from the BEIS team are for the central 'Reference' scenario, and include the following for 2025, 2030, 2035 and 2040:

- a site-by-site forecast for coal use at individual coal-fired power stations;
- sectoral projections for use of each fuel type (coal, fuel oil, gas oil, gas, biomass) by other major industrial sub-sectors such as other power stations, refineries, and steelmaking;
- higher-level projections for use of each fuel type (coal, fuel oil, gas oil, gas, biomass) for the rest of industry combined, and for non-industrial and residential sectors;
- some additional indices that relate to output from various industrial sub-sectors, such as food and drink manufacture, non-ferrous metals etc.;
- projected household numbers and GDP.

These forecast data from BEIS are used to generate our own estimates of activity data for the years to 2040, as required for the inventory forecasts, for almost all NAEI stationary combustion source categories and for many industrial process-related source categories. The GDP and population projections are used to forecast activity for non-combustion sources where use of such broad indicators is considered more reliable than the sector-specific data in the EEP dataset. For example, domestic products such as aerosols are sources of NMVOC emissions and for this source, population is considered to be a more reliable indicator of future consumption than, say EEP drivers for the chemical sector. For a handful of minor combustion source categories relating to use of fuels in narrowly-defined sectors (e.g. use of certain fuels at blast furnaces, dolomitic lime kilns, and collieries), we consider the use of any of the BEIS forecasts less ideal, and so in these cases we will normally assume no change in fuel use from the base year onwards. Similarly, for industrial processes where there are only one or a few sites operating that type of process, we generally assume that activity remains constant unless we have information indicating either closures of sites or proposals to increase capacity or to construct new sites.

In the previous submission, the EEP projections (EEP 2019) did not account for the impacts of COVID-19 on future years (ie years 2020 onward) and so we used Government statistics and industry data in preference to EEP2019 for many stationary source categories. In the current set of projections the impact of the COVID-19 pandemic is captured within the historic time series which now extends to the year 2020. Therefore for the current submission we have reverted back to using EEP data throughout for all years in the emission projections. We have tried, as far as is possible, to take account of the fact that activity levels in 2020 were impacted by the pandemic whereas future years will presumably be less impacted, if at all. This may sometimes require us to use the latest data relating to

the year 2019 as a starting point for projections (ie pre pandemic emission level), rather than data for 2020, as we do for example for the rail sector.

Details of assumptions and data that are specific for sub-sectors of the inventory are given below in Table 1-2. In this table, the methods given are:

- WM 'with measures' i.e. including the impact of regulations or other actions that seek to reduce emissions
- WoM 'without measures' i.e. assuming no impacts from regulations or other actions.

Measures are included wherever the data is available to support this - without measures calculations imply a lack of available data. Within a reporting category, there may be some emission sources for which it has been possible to project the impact of measures, and other sources where this is not the case. These are labelled as WoM/WM in the table below.

Table 1-2 Summary of assumptions for emission projections by NFR19 category

NFR19 Category	NFR Name	Method	Comments
1A1a	Energy industries (Combustion in power plants & Energy Production)	WM	All regulated. Projections assume power plants either meet IED limits for NO_x, SO_x, PM or else continue to emit at current levels if these levels appear to be below that required by IED.
1A1b	Energy industries (Combustion in power plants & Energy Production)	WM	All regulated. Recent permit review documents suggest that refinery sites are often already compliant with BAT conclusions. In some instances, operators will have to improve control of SO_x, NO_X or NMVOC emissions from some parts of refinery operations in order to comply, and forecasts have been developed to reflect this.
1A1c	Energy industries (Combustion in power plants & Energy Production)	WoM / WM	All regulated. In general, no projection of emission factors. Due to lack of data on current level of emission control and information on how this will change in the future we assume factors do not change after the projection base year. The sole exception relates to SO_x emissions from coke ovens where the fitting of abatement will lead to further reductions by 2025.
1A2	Manufacturing Industries and Construction (Combustion in industry including Mobile)	WoM / WM	Partly regulated. We use Guidebook emission factors for much of 1A2 and these are held constant across the historical timeseries, and are also kept constant in the projections. The main exception to that is for cement kilns and lime kilns (1A2f) where we do have projections for NO_X, SO_x & PM. These take account both of information available from permit review documents and information provided by industry on future levels of production and emission rates.
1A3b	Road Transport	WM	All regulated (except non-exhaust emissions). Relatively sophisticated forecasts which take account of changes in traffic and technologies.
1A3a, 1A3c, 1A3dii, 1A3eii, 1A2gvii, 1A4bii, 1A4cii, 1A4ciii, 1A5b	Other transport (aviation, off-road mobile machinery, navigation, rail etc.)	WoM/ WM	Mostly regulated. Relatively simple forecasts using proxy data to project activity data.
1A4a/1A4c	Other sectors (Commercial, institutional, agriculture and fishing stationary)	WoM	Partly regulated. We mainly use Guidebook emission factors for 1A4a/1A4c and these are held constant across the historical timeseries, and are also kept constant in the projections.

NFR19 Category	NFR Name	Method	Comments
1A4b	Domestic Combustion	WM	Some regulation (over new builds and new appliances). For gas, oil & wood, relatively simple forecasts that attempt to model the change in aggregate emission factors due to the gradual replacement of older equipment with newer appliances. For coal, because use of this fuel is in decline, we have not developed full WM projections and emission factors are unchanged. However, the projections do take account of the prohibition on the sale of house coal in England introduced by the Air Quality (Domestic Solid Fuels Standards) (England) Regulations 2020.
1B1b	Coke ovens	WoM / WM	Regulated. Due to lack of data on current level of emission control and information on how this will change in the future we generally assume factors do not change after the projection base year. The sole exception relates to SO_x emissions from coke ovens where the fitting of abatement will lead to large reductions in emissions by 2025.
2A	Mineral Processes	WoM / WM	Mostly regulated processes. Generally, WoM due to lack of data on current level of emission control and information on how this will change in the future so emission factors for 2025-2040 are assumed to be the same as in the base year. Industry have provided data for projections of dust emissions from the production of flat glass, container glass and continuous filament glass fibres.
2B	Chemical Processes	WoM / WM	Regulated processes. Generally, WoM due to lack of data on current level of emission control and information on how this will change in the future so emission factors for 2025-2040 are assumed to be the same as in the base year. However, industry have provided conservative estimates of reductions in NMVOC emissions from a small number of large-scale organic chemical processes and these have been adopted as a conservative estimate of reductions. In practice, other sites will likely reduce emissions in order to comply with regulation and so larger reductions are likely.

NFR19 Category	NFR Name	Method	Comments
2C	Metal Processes	WoM / WM	Mostly regulated processes. Partly WoM due to a lack of data on current level of emission control and information on how this will change in the future, particularly for smaller processes. Some emission factors for 2020-2040 are therefore assumed to be the same as in the base year. Permit review documents for steelworks and large non-ferrous metal processes have been analysed and suggest these sites are largely already compliant with BAT conclusions. The emission projections do take account of any aspects of these processes requiring upgrades to meet BAT.
2D	Solvent	WoM / WM	Mixture of regulated industries and consumer product use. Emission factors for 2025-2040 are generally assumed to be the same as in the (2020) base year. Almost all industrial solvent use has been regulated in the UK since the mid-1990s and emissions in many sectors have reduced substantially since 1990. The potential for further reductions is therefore often quite limited. In a number of important instances (use of paints, printing inks, adhesives and sealants), trade bodies have provided forecasts extending to 2030 (BASA) or 2050 (BCF) and these have been adopted for the UK projections. Emissions from other industrial uses of solvent have generally been assumed to remain fairly constant, in the absence of any data from industry. We have assumed no reduction in emission rates for solvent use in non-coatings related consumer products (such as household products and cosmetics) in the absence of any regulation that explicitly drives reductions in NMVOC content.
2G, 2H	Other product use	WoM	Mostly not regulated and so the potential for reduction is low and WoM forecasts are therefore acceptable.
2I	Industrial Processes	WoM	Regulated processes. Assumed to be fully controlled already so no further change assumed.
3	Agriculture	WM	Projections calculated using the Scenario Modelling Tool (SMT, Defra project ECM 55618) based on the year of 2020 of NAEI. Activity data projections for livestock numbers, milk yield, crop areas and production to 2040 were derived from the FAPRI Baseline Briefing Book (2021), and for quantities of digestate to be applied to land to 2035 by Ricardo, based on energy production projections.

NFR19 Category	NFR Name	Method	Comments
5	Waste	WoM	Partly regulated. Due to lack of data on current level of emission control and information on how this will change in the future, mostly assume no change in emission factors but there are some sectors (NMVOC from landfill) where there is some modelling.
6	Other (included in National Total for Entire Territory)	WoM	Sources are generally uncontrolled so WoM is acceptable.

For most industrial sources, emissions of air quality pollutants have been regulated for several decades. While we have had, for many years, a lot of information on the historical emissions at these sites (via operator reporting to regulators and via them, the E-PRTR), we have until recently had almost no information on the emission limit values (ELVs) and other conditions placed on individual operators to achieve those annual emissions. Additionally, previously we have had little information on the requirements that are being placed on those individual operators in order to ensure compliance with regulations. In the last few years more information has become available as regulators have published permits and BAT decision documents online for some processes. These are large documents which contain much detail on the processes being regulated: the process technology; techniques used to control emissions; current ELVs and other conditions of operation; improvements that might be needed to comply in future. The documents may also provide estimates of the reductions in emissions that would result from future improvements but not always. Nonetheless the information contained in the documents can be used to develop simple projections that take account of planned/proposed improvements. To date, permit reviews do not seem to have been published for all permitted sites. Of those that are published, we have prioritised the analysis of documents for cement kilns, lime kilns, refineries, oxygen steelworks, electric arc steelworks (for which we have documents for only 2 out of 6 sites) and non-ferrous metal processes. This prioritization was on the basis that these were the most significant sectors for which we had no existing method for incorporating the impact of existing policies and measures. Documentation for further processes may become available in future, allowing us to better understand the potential for reductions at those sites also.

For sectors where we have been able to obtain and review documents, it is then possible to generate simple projections that take account of the current level of compliance and improvements necessary to comply where this does not already occur. But for other sectors, such as for combustion in 1A2/1A4a/1A4c and most chemical sector process sources, we do not have this information and so have to assume a somewhat 'worst-case' scenario where emission factors in future years are the same as in the base year. This is not a particularly significant issue for NH_3, where combustion and processes are minor sources, or for SO_x where changes in fuel use, included through the use of EEP NZ data, are likely to be far more significant than changes in emission factors. It could be a more significant issue for the remaining pollutants simply because stationary combustion and processes are highly important sources. Emission projections might therefore be somewhat conservative for these pollutants.

Further detail on projections is given in the following sections.

1.2. Description of Sectoral Projections

1.2.1. NFR 1A1a: Power Stations

The EEP dataset contains detailed forecasts for fossil-fuel fired power stations including site-by-site figures for the small number of coal-fired power stations that remain in use in the UK in 2020. No power stations are forecast in EEP NZ to still be burning coal in 2025 i.e. all will have closed or have

been converted to other fuels. Projections for other fuels such as natural gas and oils are UK-wide figures rather than being disaggregated into consumption at individual sites.

Almost all of the UK sites which are treated as fossil fuel-burning power stations in the UK inventory are sufficiently large to be regulated under IED and to report historical emissions in the inventories maintained by regulators. The exceptions will be a number of small generating stations located on Scottish islands. Historical emissions and fuel use data can be used to generate emission factors for power stations in the base year, and these factors can be compared with those that would be expected for plant that are compliant with IED. This analysis suggests that major UK power stations are already close to, or sometimes already meet IED limits for NO_X and particulate matter.

For projections, we adopt the trends in fuel consumption for 2025 to 2040 given in the EEP dataset, and then applied pollutant specific assumptions.

For NO_X, we use the lower of:

- The base year (2020) emission factor, or
- An emission factor consistent with ELVs appropriate under IED.

As already mentioned, in most cases, UK power stations appear to be operating close to or even within the limits specified in IED, so future changes in emissions are mostly due to changes in fuel consumption (such as the closure of the remaining UK coal-fired power stations).

For SO_x and $PM_{10}/_{2.5}$, we adopt a similar approach as for NO_X: comparing historical factors with those expected under IED and using the lower for projections. As with other pollutants, historical factors are fairly close to those expected in the future and so the main factor driving change in emissions is fuel use.

Factors for NMVOC are held constant into the future and so emission projections only reflect changes in fuel use. Power stations are a minor source of NMVOC emissions and so we regard the generation of more sophisticated NMVOC projections for this source as a low priority at this time.

EEP NZ only gives total consumption of renewable energy sources for electricity generation: these figures will include both thermal and non-thermal sources, such as wind and solar. We therefore use projections from National Grid's Future Energy Scenarios (FES) to disaggregate the renewables figures down into different energy types. Details of the methodology for FES and data are available from http://fes.nationalgrid.com/. FES 2020 contains different scenarios, but the Steady Progress (SP) scenario was used as it was the closest match to EEP in terms of projections for total renewables. The emission projections are highly sensitive to changes in the relative proportion of thermal/non-thermal sources. It is expected that the next projections will likely change as more information on renewable components have recently become available from BEIS. Emission factors for renewable energy sources are held constant at 2020 levels since we have no data that support a change to the factors. A comparison of current NO_X emission factors for wood stations with factors that are consistent with the requirements of IED suggests that UK biomass stations are already compliant. In the case of power generation using engines burning biogases (landfill gas, sewage gas, gas from anaerobic digestion of other wastes), we use the same literature factors both for the historical inventory and for the projections.

1.2.2. NFR 1A1b/1A1c Other Energy Industries & 1B Fugitive Emissions

The EEP dataset contains specific forecasts for fuels used by refineries, and for natural gas used by the offshore oil & gas industry, and these provide the trends used in NAEI projections. For other sectors within 1A1c (such as downstream gas facilities such as gas compressor stations), EEP does not have separate forecasts and so we use trends for the broad 'industry' category.

Emission factors for many of the sources covered by 1A1b and 1A1c are held constant at base year (2020) levels. Exceptions are emissions of SO_x and PM from refineries. Emissions from large combustion plant and catalytic crackers at refineries are expected to reduce at some sites in order to comply with the relevant standards, as established in BAT conclusions for the refinery sector. We have made simple forecasts that aim to model the impact of compliance, though these are subject to some uncertainty.

Fugitive and process emissions of NMVOC from refineries seem to be largely compliant with BAT conclusions, with the exception of marine loading operations at some sites. As with combustion-related emissions, we have developed simple projections that model the impact of progress towards compliance at these sites. Future emission factors for other sources within 1B are maintained at the same level as in 2020.

1.2.3. NFR 1A2/1A4a/1A4c: Other Stationary Combustion

EEP NZ is used to produce estimates of fuel use for 2025 onwards. EEP only has relatively broad categories of industrial fuel use and these have to be used for all of the detailed sectors in the NAEI i.e. all of these categories are assumed to follow the same trend as the broad category in EEP.

The historical method in the NAEI for these sources is to use Tier 1 or Tier 2 emission factors from the latest EMEP/EEA Guidebook. Tier 2 factors are used for NO_X and PM_{10}, while Tier 1 factors are used for other pollutants. The method for NO_X and PM_{10} also makes use of some Tier 3 data i.e. emissions reported by operators for individual large sites. The use of a Tier 1 method does not allow any account to be taken of abatement. The higher tier method for NO_X and PM_{10} also does not currently allow any projection of emission factors, so the historical factors for 2020 are also retained through to 2040. More data on the compliance status of individual large sites and more detailed modelling of medium-sized plant would be required to develop projections that took full account of measures.

For cement kilns and lime kilns we also take account of any known closures and any improvement conditions that we have evidence for (though these particular sectors should already have complied with BAT conclusions i.e. should already be using BAT). We are aware of one cement kiln that was mothballed in 2020 and this site is assumed to effectively be permanently closed, so emissions from the sector are assumed to be slightly lower in future years because of the closure of this site.

The use of biomass as a non-residential fuel is forecast to increase notably in EEP NZ. We assume that all of this growth is linked to new biomass-fired plant which are brought into operation after the base year, for example in response to the UK Government's Renewable Heat Incentive (RHI). Emission factors for these new plants are taken either from the latest EMEP/EEA Guidebook (using factors for automatic boilers burning wood) or from the minimum standard for particulate matter or NO_X required under RHI. For some pollutants (NMVOC, PM_{10}, $PM_{2.5}$), this results in a decrease in the overall emission factor over time as the new plant should be capable of emitting lower levels of pollutants. However, for NO_X, emission factors for newer appliances will be slightly higher than those for the existing population of combustion plant, so the aggregate emission factor used for the sector as a whole rises over time. This is consistent with higher temperatures and improved combustion efficiency in modern appliances which would be expected to reduce PM (and CO and NMVOC) but which might be expected to increase NOx somewhat.

1.2.4. NFR 1A3b: Road transport

The methodologies used to calculate the road transport emissions projections are consistent with those used in the historic inventory and are described in Section 3.3 of this report.

The key input data and assumptions include:

- DfT's road traffic forecasts for Great Britain (DfT, 2021d) – projected vehicle kilometres were derived by applying DfT's traffic growth rates relative to the 2019 inventory year as the latest inventory year 2020 is affected by the impacts of COVID-19 pandemic. DfT's traffic forecasts have not yet considered the recovery in traffic activity from the pandemic. Traffic forecasts for GB reflect the Renewable Transport Fuel Obligation (RTFO), latest fuel efficiency policies for cars, vans, HGVs and PSVs (buses), rail electrification and active travel spending. However, the traffic forecasts do not include the measures to phase out Internal Combustion Engines (ICE) vehicles from 2030. Additionally, DfT provided updated assumptions relating to the mileage splits by fuel type for cars and LGVs complying to the Transport Decarbonisation Plan which includes core ULEV uptake, 2030 EU regulations and HGV regulations (DfT, 2021g).
- DfT's future sales of cars – updated forecasts were provided by DfT (DfT, 2021g) which assume all currently firm and funded policies as listed above.
- For Northern Ireland (NI), traffic is assumed to follow the GB growth rates due to lack of suitable traffic projections data for NI.
- For London, traffic projections based on the Mayor's Transport Strategy (MTS) reference case were provided by Transport for London (TfL, 2019). Updated forecasts on future baseline fleet composition data for London (TfL, 2020) were provided by Transport for London which take into account the Ultra Low Emission Zone (ULEZ) in Central London in 2019, the LEZ tightening in 2020 (Euro VI requirement for heavy-duty vehicles), and the expanded area of the ULEZ introduced in 2021.
- To account for COVID-19 impacts on road traffic in London for future years, DfT's estimated road traffic by vehicle type, road class and country in GB for 2020 and 2019 (DfT, 2021h) were used. The reduction rate calculated between traffic in 2019 and in 2020 was applied to adjust TfL's traffic forecasts for 2020. The impacts from COVID-19 pandemic have not been taken into account in the UK's projections for 2025, 2030 and 2040
- Extensive improvement work was carried out in 2021 in the road transport historic inventory included the adoption of the 2019 EMEP/EEA Guidebook- update October 2020 and COPERT v5.4 emission factors, a revised NAEI fleet turnover model with updated vehicle survival rates and mileage with age profiles and the implementation of new basemap speeds. These have fed through into the UK's road transport emission projections presented in this report.
- Updated forecast sales of new HGVs and buses are also used in this set of UK's road transport projections.

The main recalculations seen in the road transport emission projections for all pollutants (as compared to the previous submission) are a result of the extensive improvement work mentioned above that affects all reported years. Additionally, the emission projections have been revised due to updated mileage of electric vehicles in place of petrol and diesel vehicles (as compared to the previous set of projections).

1.2.5. NFR 1A3a,c,d,e: Other transport and non-road mobile sources

Aviation (1A3a)

Activity data for domestic and international aviation are projected to align with DfT's central growth CO_2 forecast (DfT, 2017) that includes a Northwest Runway at Heathrow Airport. However, these forecasts are assumed to have been set back by five years due to the COVID-19 pandemic. This assumption is in line with Eurocontrol's 7-year forecast for Europe 2021-2027 (https://www.eurocontrol.int/covid19). The base year (2020) is aligned to actual DUKES data. Intermediate years (notably 2030) are interpolated from the original DfT data having been set back by five years. For example, 2030 is interpolated from 2025 (originally 2020 data) and 2035 (originally

2030 data). Activity data for military aviation are held constant at 2020 levels (emissions from this source are reported under 1A5b).

Emission factors for all pollutants are held constant at 2020 levels.

Non-road mobile sources (1A2gvii, 1A3eii, 1A4bii, 1A4cii)

Machinery or engine-specific fuel consumption and emission factors (g/kWh) are taken from the EMEP/EEA 2009 Guidebook. Emission factors for more modern machinery are based on engine or machinery-specific emission limits established in the EU Non-Road Mobile Machinery (NRMM) Directives. The projections cover the stages of the Directive up to Stage IV. Emission factors for engines meeting Stage V limits to be introduced from 2019 have not yet been introduced into the projections.

Activity data are derived from bottom-up estimates of population and hours of use of equipment in 2004. Various proxy statistics are used as activity drivers for different groups of machinery types to estimate the turnover in the off-road engine fleet and emissions and fuel consumption in future years relative to the latest 2020 base year. For machinery used in industry, a BEIS sector-weighted energy projections driver for industry is used; for machinery used in construction the BEIS energy projections driver for 'construction' is used; for machinery used in quarrying the BEIS energy projections driver for 'Non-metallic mineral products' is used. For machinery used in agriculture, the activity driver is held constant at 2020 levels. For domestic house and garden machinery, a driver based on future trends in the number of households from the Ministry of Housing, Communities & Local Government is used. For machinery used in airports, projections in the number of terminal passengers at UK airports are used. These are taken from DfT's aviation forecasts. For further information see Aviation.

The methodology described above does not apply to all machinery types in the 2020 year due to the COVID-19 pandemic. The impacts of the pandemic were accounted for in the machinery used in construction and airports as available data exists. For machinery used in construction in 2020, the ONS (2021g) output data for the construction industry is used. For machinery used in airports, activity data were scaled from the 2020 predicted value in line with terminal passenger numbers at UK airports reported on a monthly basis by the Civil Aviation Authority (CAA).

The EU Fuel Quality Directive (2009/30/EC) has required fuels used in non-road mobile machinery to have a maximum sulphur content of 10ppm since 2011. Apart from this Directive, and including the EU NRMM Directives up to Stage IV, no specific emission reduction policies and measures are taken into account for the off-road sector.

Rail (1A3c)

Energy consumption forecasts for intercity and regional passenger and freight trains are taken from the Rail Emissions Model (REM) developed by DfT (2016b). These are normalised to BEIS EEP_NZS energy projections for total gas oil (diesel) used in the rail sector to provide separate activity drivers for passenger and freight train types, in the emission projections. Those activity drivers are used to scale 2019 historic fuel consumption to estimate future energy consumption as the latest inventory year 2020 is affected by the impacts of COVID-19 pandemic.

Taking into account the current fleet structure, the projections consider how this might change in future years for the intercity, regional passenger and freight diesel rail fleets as they approach compliance with Stage IIIB emission limits. The projections account for the EU Fuel Quality Directive (2009/30/EC) which has required fuels used by railways to have a maximum sulphur content of 10ppm from 2012.

The impact of the COVID-19 outbreak was accounted for in the most updated 2020 inventory year, however the projections are still re-based on activity data of 2019 inventory year, whilst the fleet composition is based on 2020 inventory year.

Inland waterways (1A3dii)

For the activity data, proxy statistics are used to estimate activities for the latest reported historic year and projected years. The emission factors for all projected years are assumed to remain constant at the emission factor values for the latest reported historic year, currently 2020. For future activities by inland waterways, the latest BEIS sector-weighted energy projections driver for industry is used, re-based to the latest 2020 inventory year. The projections account for the EU Fuel Quality Directive (2009/30/EC) which has required fuels used by inland waterways to have a maximum sulphur content of 10ppm from 2011. Recalculations occur due to the application of updated EEP_NZS projections drivers, updated proxy data for scaling the historic years, and rebasing to 2020.

Shipping (1A3dii)

The method for forecasting emissions from shipping is described in the forecasting section of the report on the methodology for estimating emissions from shipping by Scarbrough et al. (2017)[5].

Activity projections are based on examination of recent trends in port activity shown in DfT statistics, Government forecasts of national demand for port capacity with growth factors for different vessel types carried out by MDS Transmodal and the growth rates forecast at each of 7 individual ports based on port Master Plans. The activity projections are re-based to the total UK domestic shipping fuel consumption estimated for the latest year in the inventory, 2020. Activity growth is compensated for by increases in shipping transport fuel efficiency improvements over time in response to financial and regulatory drivers, namely the IMO Energy Efficiency Design Index (EEDI) requirements for new ships.

The relevant fuel sulphur requirements from MARPOL Annex VI and from Directive 1999/32/EC are taken into account. Within Sulphur Emission Control Areas, fuel sulphur content is limited to 0.1% from January 2015. To achieve this, any HFO consumption in a SECA is assumed to switch to MDO consumption from 2015 onwards. Sulphur is limited to 0.1% for vessels at berth. Any HFO consumption out of SECA is assumed to switch to 0.5% sulphur HFO from 2020. This leads to a reduction in factors for SO2 and PM2.5 emissions from shipping.

Future NOX emissions factors reduce over time firstly due to continued turnover in the fleet leading to larger proportions of vessels with more recent engines which meet later (more stringent) NOX emission tiers under the IMO MARPOL Annex VI NOX Technical Code for ship engines; and secondly, due to the NOx ECA designation of the North Sea and English Channel agreed by the IMO with Tier III NOx emission reduction requirements placed on engines in ships constructed from 2021. It is assumed that this will be partially achieved by switching to LNG which will also lead to further reductions in PM2.5.

Recalculations occur due to the application of updated proxy data for scaling the historic years and rebasing to 2020.

1.2.6. NFR 1A4bi: Domestic combustion

Projections of future fuel use by the residential sector are based on EEP NZ. For residential use of gas, oil and wood, we assume that new appliances will replace old ones going forward and that these replacement appliances will have lower emission characteristics than those they replace. For gas and oil-fired boilers, we assume an age profile based on data for London (UK-wide data are not available). For wood, we assume that the strong growth in consumption will be fuel burnt in new appliances, i.e.

[5] https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1712140936_ED61406_NAEI_shipping_report_12Dec2017.pdf

new appliances will be purchased between, say, 2020 and 2025 to burn the increased quantities of wood that are forecast to be burnt by then. Under the Air Quality (Domestic Solid Fuels Standards, England) Regulations 2020[6] the sale of wet wood and household coal will be phased out between 2021 and 2023. EEP NZ does not appear to reflect these regulations and assumes that substantial quantities of coal are burnt in the residential sector from 2025 onwards. We therefore made some simple changes relative to EEP to model the impact. The regulation is only valid for England rather than the UK as a whole, and so we have first assumed that we can split the coal demand figures in EEP into an England and a non-England component using the same split as in the historical DA inventories[7]. This means that about 60% of the residential coal in EEP is assumed to be consumed in England. We then assumed that all of this ~60% of coal in England should instead be changed to zero in 2025 and after, and that the public in England will instead use an identical quantity of solid smokeless fuels (SSF). In reality, we assume that some users of coal in England could switch to wood or other fuels rather than SSF, however in the absence of any detailed assessment we have opted for this simple approach. The regulations will also control the quality of wood fuels available in England, however the Guidebook factors used in the NAEI do not allow us to model changes to the quality of wood fuels. There are currently no separate emission factors for the two types of wood (dry and wet wood) however work is currently underway to review this. While it might be reasonable to assume that all wood used in 2025 - 2040 would be dry, we also do not have any historical activity data which would allow us to distinguish between wet and dry wood in the base year or 2020.

We assume lower NO_X emission factors for gas and oil-fired boilers to reflect the Ecodesign Directive, using the limits set out in the regulation. For new biomass fuel appliances, we use EMEP/EEA Guidebook emission factors for NO_X, NMVOC and PM for eco-labelled appliances.

For other fuels and for pollutants other than NO_X we do not have enough information to predict how emission factors might change in the future, if at all. Therefore, emission factors are held constant at 2020 levels for:

- PM_{10}, $PM_{2.5}$, SO_x & NMVOC from domestic use of natural gas and all oils
- All pollutants from domestic use of coal, anthracite and coal-based fuels
- All pollutants from domestic use of petroleum coke
- All pollutants from domestic use of peat and charcoal

1.2.7. NFR 2A: Mineral Processes

Emissions from manufacture of bricks, ceramics, and glass, quarrying and construction are reported in NFR 2A. Industrial trade bodies representing the brick/ceramics sector and manufacture of flat/container/continuous filament glass have proposed growth rates or future activity estimates for their sectors. For other sub-sectors of the glass industry, and for quarrying and construction, we have used trends given in EEP for the 'other minerals and mineral processing' and 'construction and other industry' sectors respectively in order to forecast activity levels in 2025 to 2040.

The glass industry has provided estimates of future levels of dust emissions which take account of the fitting of particulate matter abatement systems at those remaining glass kilns that are unabated. These estimates have been used to generate emission factors for 2025-2040. The glass industry also suggested emission estimates for NO_X and SO_x in 2025-2040, however, because glass kilns are not included as a separate source in the UK inventory, it has not been possible to incorporate these forecasts in the UK emission projections. For these pollutants and for all other sources within 2A,

[6] https://www.legislation.gov.uk/ukdsi/2020/9780348210194/contents
[7] Report: Air Quality Pollutant Inventories for England, Scotland, Wales and Northern Ireland: 2005-2019 - NAEI, UK (beis.gov.uk)

factors have been held at the same level as in 2020 in the absence of any information on changes in abatement.

1.2.8. NFR 2B: Chemical Processes

The chemical industry is represented in the NAEI using a combination of general categories, covering multiple sites, and highly specific categories that often relate to only one or two sites in the UK. As a general rule, we use the trend in EEP for 'chemicals and man-made fibres' for the former, and generally assume no change in activity for the latter unless we have specific information on either closures, plant expansions or new plants. The rationale for this is that we assume that all plants operating in the base year will be operating fairly close to their design capacity and that substantial changes in activity will only occur through closure of sites and/or construction of new or larger plants.

Historical emission estimates for NFR 2B are all based on Tier 3 type methods i.e. site-specific emissions data. However, we have no information on any abatement currently in place or any information on any changes in abatement that might be required in future. Therefore, our default assumption is to assume that emission factors for the 2020 base year are appropriate for 2025-2040 also. The only exception to this is for NMVOC emissions from large-scale organic chemical processes. Here, the trade body has collected information from members which indicated that operators of two sites expected to reduce NMVOC emissions by 1.1 kt by 2022, while another operator expected no change in the future. The trade body recommended this 1.1 kt figure be used as an assumption for the total reduction from the sector, while highlighting that it is likely to be a substantial underestimate since it was based on only 3 out of more than 25 sites. We have therefore estimated NMVOC emissions from NFR 2B based on a reduction of 1.1 kt after 2020. We have also taken account of the small number of recent closures of chemical sites in the UK, so the total reduction compared with 2020 is slightly higher than 1.1 kt.

1.2.9. NFR 2C: Metal Processes

Emissions reported in 2C are dominated by those emissions from manufacture of steel, either in integrated works, or using electric arc furnaces. There is relatively little production of primary non-ferrous metals in the UK. The UK now has only two integrated steelworks and three large electric arc steelworks. Activity forecasts for the main fuel-related sources at integrated works are based on EEP fuel use forecasts. For electric arc furnaces and other process sources we adopt the trends given in EEP for 'iron and steel', 'non-ferrous metals' or 'engineering & allied industries'.

Emission factors are mostly assumed to stay at the same level as in 2020. As with other sectors, this partly reflects a lack of information on the current level of abatement of emissions at individual sites, or any information on changes in abatement systems that are likely in future. For steelworks we have previously assumed reductions in emissions of SO_x that are expected to occur due to the introduction of desulphurisation of coke oven gas (COG) at both integrated works. However, this does not seem to have happened at Port Talbot and the coke ovens at Scunthorpe may now close so upgrading of that plant seems to be doubtful, according to a document available from the Environment Agency[8]. Therefore we now assume no change in SO_2 emission rates at these two sites.

Consultation with the operators and/or regulators of the two steelworks might be useful in future, and could allow us to better understand the future status of these sites, and the scheduling and impact of any planned improvements.

[8]https://consult.environment-agency.gov.uk/psc/dn16-1bp-british-steel-limited-epr-rp3206be-v004/supporting_documents/Supporting%20Document_2.pdf

1.2.10. NFR 2D: Solvent Use

Solvent use can be split into that which is consumed by industry in various manufacturing processes, and that which is in consumer products such as paints and cosmetics, used by the general public. In the former case, it is possible to regulate that use in a number of ways and significant reductions in levels of emissions have in fact been made since the mid-1990s as a result of regulation introduced both by the UK, and later by the EU. In the case of solvent use in consumer products, emissions can only be reduced by eliminating or reducing the levels of solvent in those products, and since there has been comparatively little regulation specifically of the VOC content of many of these consumer products, we have assumed that emissions have not reduced to the same extent.

Due to the significant reductions in NMVOC emissions from industrial solvent use since the late-1990s, we consider that further large reductions are unlikely in many sectors. Many of the largest industrial users of solvent have installed abatement equipment to reduce NMVOC emissions and should already be compliant with IED. In most sectors it is likely that there will continue to be modest reductions in emissions over time as business develops improvements in processes or reformulates products to reduce the need for solvents. However, quantifying any changes is difficult and so for many sectors we adopt the conservative approach of assuming no change in emission factors between 2020-2040. For some of the most important sectors, we do have information from industry:

- The British Coatings Federation (BCF) has provided estimates for NMVOC emissions in 2030 and 2050 from the use of decorative paints, industrial paints, and inks, which we have used as a basis for forecasts. The BCF do expect further reductions in solvent content of certain types of coating in the period from 2020 to 2040, and also expect some reductions in sales of some coatings due to changes in the market.
- The British Adhesives & Sealants Association (BASA) have provided NMVOC forecasts to 2030 for both industrial and consumer/DIY adhesives. As with the BCF data, BASA predict changes in the markets for different types of adhesive formulation although the overall impact on NMVOC emissions is relatively small.
- For non-aerosol consumer products, we have estimated consumption to 2023 for many categories of product, these estimates having been developed by market research organisation Euromonitor. For the period from 2024 onwards, we assume the same average annual change as is predicted for the 2019-2023 period. Emission factors for each category of product are assumed to remain unchanged to 2040.
- For aerosols, the British Aerosol Manufacturers Association (BAMA) have indicated that assuming that emissions change in line with population is a reasonable approach in the absence of detailed data.

The information from BCF, BASA, Euromonitor and BAMA covers a large proportion of emissions reported in 2D3 (roughly 60% in 2020). Emission factors for the remaining sectors are assumed to remain constant in the absence of information from industry: as indicated above, this is likely to be conservative but unlikely to lead to a large overestimation due to the fact that significant industrial solvent users are already regulated and have been for many years.

1.2.11. NFR 2G: Other product use

The sources in NFR 2G include fireworks and cigarettes. In the case of fireworks, 2020 was an atypical year since the beginning of the second UK-wide lockdown would have meant that communal fireworks displays did not happen in November 2020, and it is likely that sales to the public were also much lower. Following the closure of the last UK manufacturer, all fireworks are now imported and import figures confirm that demand was much lower in 2020 than the previous year. We assume that sales

return to pre-Covid levels by 2025, and that consumption actually grows with increasing population relative to 2019 levels. Emission factors are assumed to be the same in all years.

For cigarettes, consumption has been in steady decline in the UK for decades and, although tobacco sales increased by 7% in 2020, the overall downward trend seen over the past two decades is assumed to continue after 2020. This equates to an annual reduction in tobacco consumption of about 2.4%. As with fireworks, emission factors are held constant.

1.2.12. NFR 2H: Food & drink manufacture & Paper Production

The food and drink sector is a substantial contributor to NMVOC emissions, mainly due to the ethanol emissions associated with the manufacture of alcoholic drinks, but also due to other sources such as baking and cooking and processing of meats, fats, oils and animal feeds. NMVOC emissions from these sources are not regulated and so emission factors for 2020 are considered equally appropriate for 2025-2040. Activity projections generally rely on the EEP industrial output projection for the food, drink and tobacco sector.

1.2.13. NFR 2I: Wood products manufacture

Historical emission estimates for NMVOC from processes manufacturing fibreboard, chipboard and similar wood products are based on site-specific emissions data. We have no information on any abatement currently in place or any information on any changes in abatement that might be required in future at these sites and therefore, as a conservative approach, assume that 2020 emission factors are also appropriate for 2025 onwards. The trend given in EEP for the 'construction and other industry' sector have been used to forecast activity levels in 2025-2040.

1.2.14. NFR 3: Agriculture

Air quality pollutant emission projections have been made for the UK Agriculture sector for the years 2021-2040 using the Scenario Modelling Tool (SMT, Defra project ECM 55618) to provide scaled projections based on the year 2020 of NAEI. Activity data projections for livestock numbers, milk yield, crop areas and production to 2030 were derived from the FAPRI Baseline Briefing Book (2021), and for quantities of digestate to be applied to land to 2035 by Ricardo, based on energy production projections. The FAPRI projections are at the Devolved Administration (DA) level for most categories, and were therefore applied at this level in the SMT. As the SMT does not account for non-linear increases in N and VS excretion associated with increases in dairy cow milk yield, a post-SMT uplift in emissions from dairy cows was applied to reflect this.

Summary projections of the air quality pollutant emissions are given in Table 1-3, showing a 4.5% increase in ammonia emissions between 2020 and 2040, primarily due to a projected increase in spreading of digestate to land.

Agriculture is the dominant source of ammonia emissions in the UK; the trend in ammonia emissions from agriculture from 1990 and projected to 2040 is given in Figure 1. Baselines for 1990 and 2005 are shown, relevant to the previous NECD and current revised NECR emission ceilings target setting process. An estimated ammonia emission reduction of 19% is projected for the agriculture sector between 1990 and 2030, and just a 1% reduction between 2005 to 2030.

The underlying trends in activity data for livestock numbers, nitrogen fertiliser use and quantity of digestate spread to land are given in Figures 2 to 4. The reduction in ammonia emissions over the period 1990-2008 can clearly be linked to declining livestock numbers across most livestock sectors and to a reduction in the use of fertiliser nitrogen. The more recent upturn in emissions is largely as a

result of increasing livestock numbers, increasing milk yield (and hence nitrogen excretion) in dairy cows, increasing quantities of digestate being applied to land and an increase in the proportion of nitrogen fertiliser that is applied as urea, which is associated with a much higher emission factor than other fertiliser types. This latter activity represents perhaps one of the largest uncertainties in the projection estimates for ammonia emissions, where the proportion of urea fertiliser use has been assumed to stay constant from 2017. Projected emissions then increase slightly to 2031 with increasing digestate application, offset to some extent by declining cattle numbers.

Table 1-3 Summary air quality pollutant emission projections (kt pollutant) to 2040 for the UK Agriculture sector

	2020	2025	2030	2035	2040
Ammonia	225.90	232.42	235.20	236.02	236.02
NOx	27.08	27.91	28.06	28.12	28.12
TPM	25.11	26.39	26.10	26.10	26.10
PM10	15.43	16.17	16.04	16.04	16.04
PM2.5	2.73	2.79	2.75	2.75	2.75
NMVOC	130.31	133.39	131.59	131.48	131.48

Figure 1-1 Trend and projections for ammonia emissions from UK agriculture, 1990 – 2040; horizontal grey lines are the emission totals for the base years 1990 and 2005

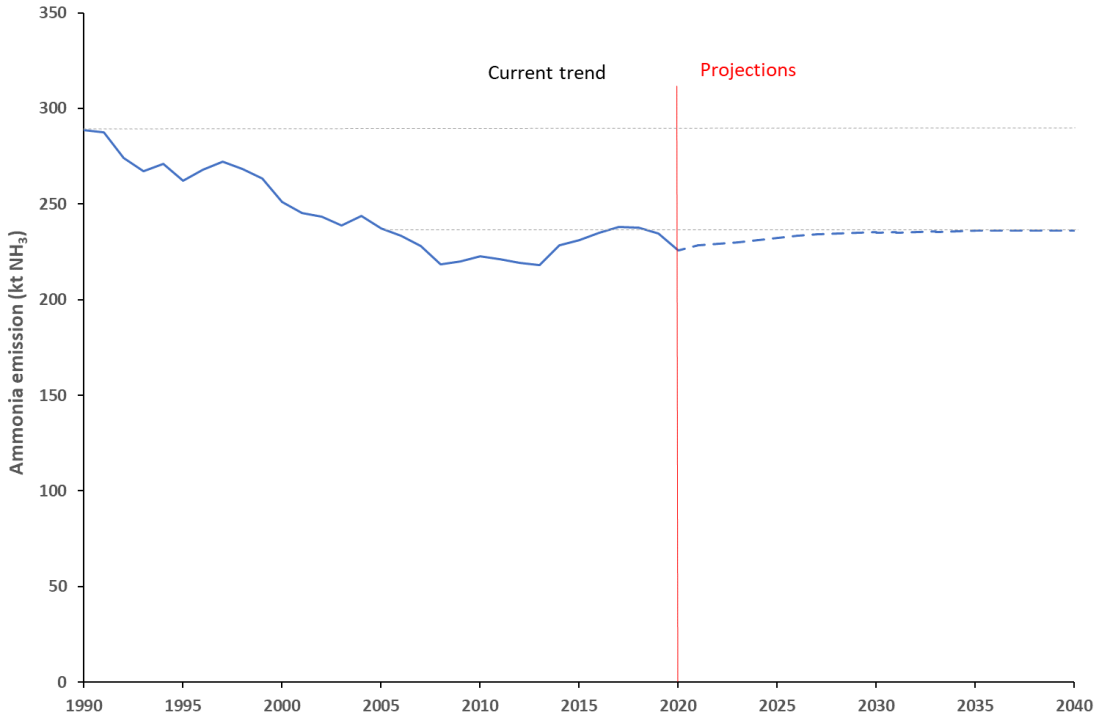


Figure 1-2 Trend and projections in UK livestock numbers, 1990 – 2030

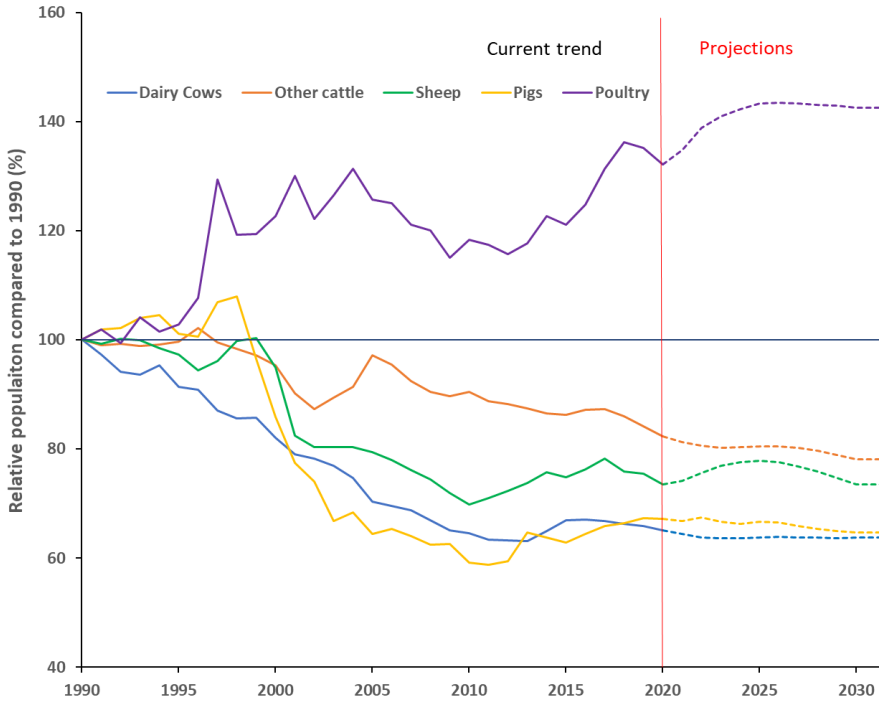


Figure 1-3 Trend and projections in UK fertiliser nitrogen use, 1990 – 2040

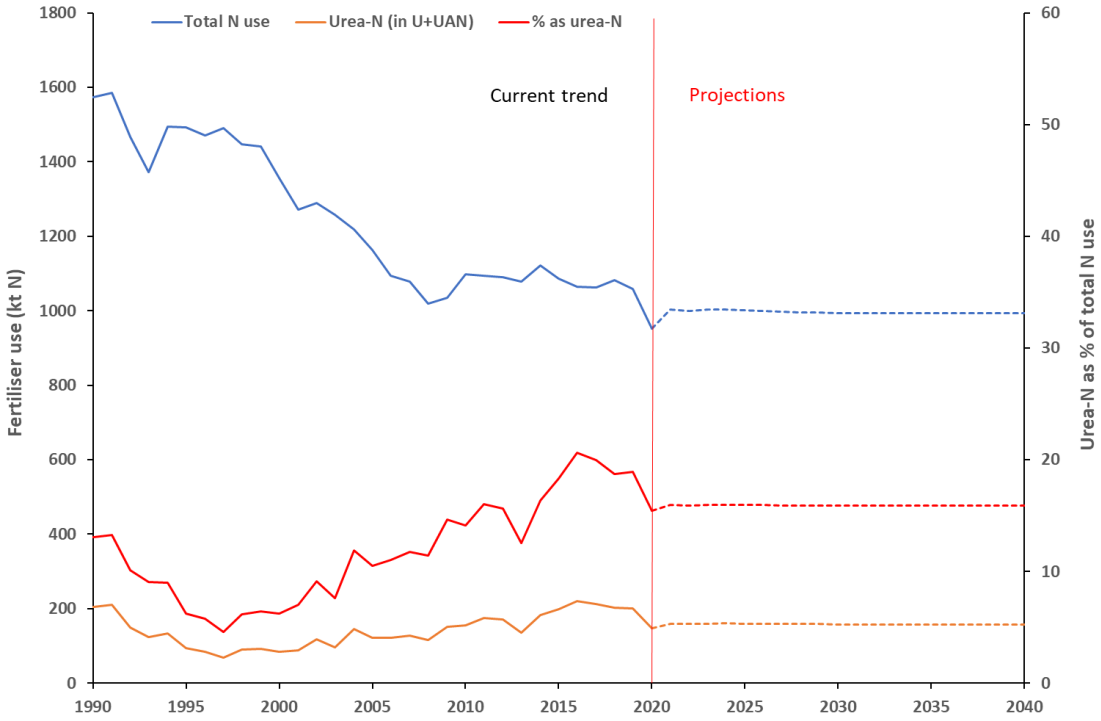
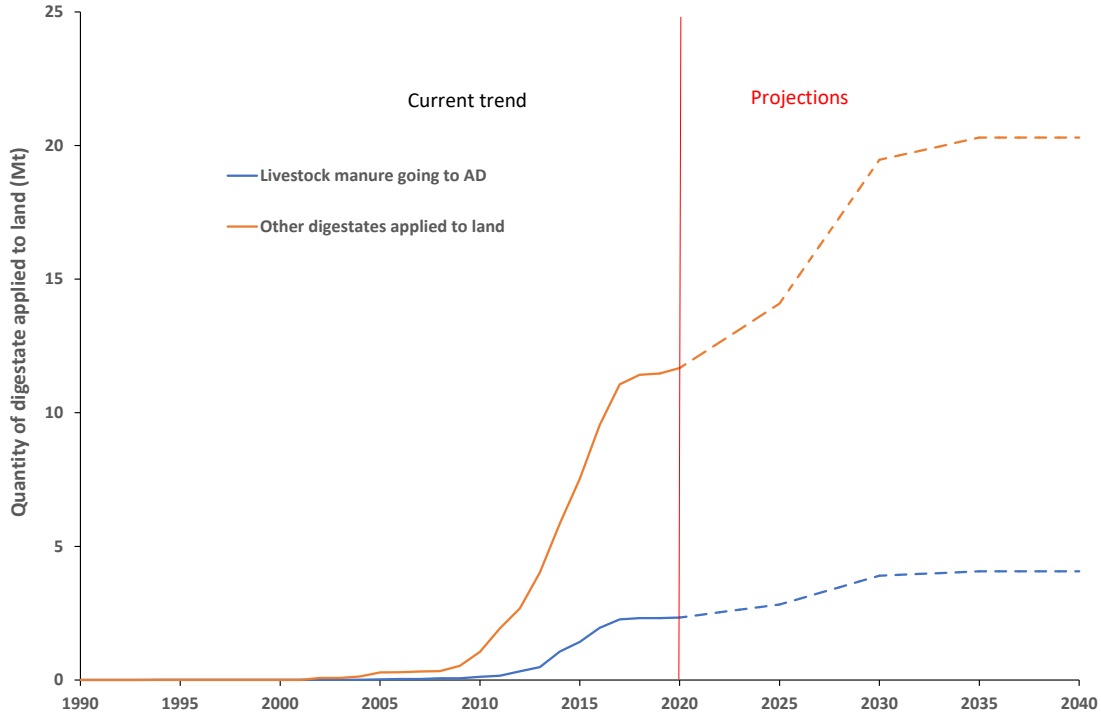


Figure 1-4 Trend and projections for digestate application to land in the UK, 1990 - 2040



1.2.14.1. Notes on methodology

Livestock numbers

Livestock number projections to 2030 for major livestock categories (dairy cows, beef cows, ewes, sows) were taken from the FAPRI Baseline Briefing Book (2021), with scalars derived for each livestock category between a 2020 baseline and subsequent projection years. These scalars were applied in the SMT to the SMT 2020 baseline numbers. All dairy followers were assumed to have the same projection scalars as for dairy cows. Similarly, all subcategories for beef cattle, sheep and pigs used the same scalars as for beef cows, ewes and sows. Poultry numbers were linked to the FARPI scalars for total poultry production (UK level).

For years 2031-2040, livestock numbers were flat-lined at the 2031 values. Livestock subcategory numbers within cattle, sheep, pigs and poultry were assumed to remain at the same ratio as for 2030 for each of the subsequent projection years.

No projections were made for numbers of horses, goats or deer (these are minor livestock categories); 2021-2040 numbers for these categories were kept at a constant value corresponding to the 2020 numbers.

Dairy cow milk yield

Milk yield projections were provided by FAPRI at the UK level. For the period 2031-2040, milk yield was kept constant at the projected 2030 value.

N excretion by livestock

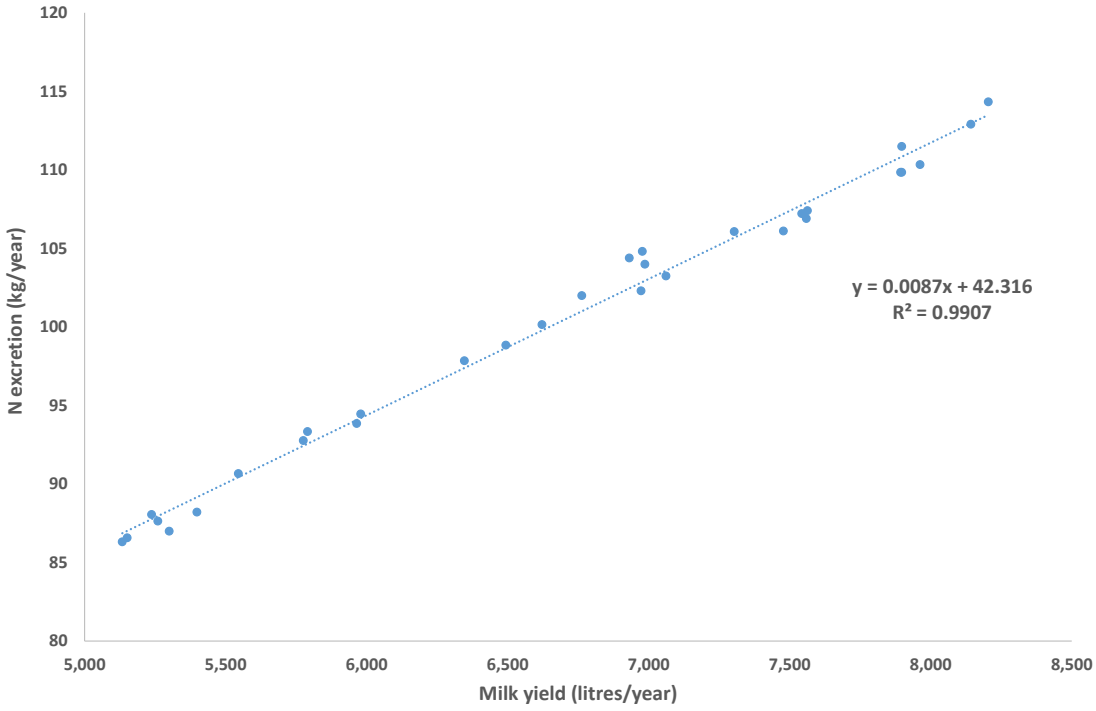
A historical relationship between dairy cow milk yield and N excretion was derived (Fig. 5) and used to apply an uplift to the SMT projected emission outputs for dairy cows. A scalar based on this relationship and the projected milk yield per dairy cow (Table 1-4) was applied to NH_3, NO_x and

NMVOC (on the assumption that the same or similar relationship would hold between milk yield and VS excretion) emissions for dairy cows. For all other livestock, annual N excretion for the years 2021-2040 was assumed to be the same as the 2020 value.

Table 1-4 Uplift scalars applied to the SMT output for NH_3, NO_x and NMVOC emissions from dairy cows

	2021	2025	2030
Scalar	1.008	1.021	1.038

Figure 1-5 Relationship between dairy cow N excretion and milk yield, based on UK inventory values 1990 – 2019



Crop areas, production and fertiliser N use

The FAPRI report did not include any explicit projections for total fertiliser N use. Projections of crop area and production were included for some major crops (wheat, barley, oilseed rape) for the period 2021 -2030 and these were used to generate projections of total N use based on the existing inventory N application rates per crop for 2020. For the period 2031-2040, fertiliser N use values were kept constant at the 2030 value. The use of urease inhibitors with urea fertiliser applications was kept at 2020 values for the period 2021-2040.

Manure management systems

The proportion of manure from each livestock category managed according to the different manure management systems was kept constant at the 2020 value for the period 2021-2040.

Uncertainties

Fertiliser use – in addition to uncertainties in total fertiliser N use, emission projections are very sensitive to changes in the relative proportion of different fertiliser types (urea in particular). Future updates would benefit from industry forecasts regarding urea use (and use of urease inhibitors), if available, and/or providing scenarios based around probable uncertainty bounds.

Livestock management practice data – projections presented here assume no changes in livestock and manure management practices (e.g. feeding practices, housing types, housing periods, manure storage methods). Future updates would benefit from industry forecasts regarding management practices, if available, and/or providing scenarios based around probable uncertainty bounds.

Implementation of mitigation methods - projections presented here assume no changes in the implementation rates of included mitigation methods under the 'business as usual' scenario. Future updates would benefit from industry forecasts and DA policy regarding uptake of mitigation practices such as low emission manure application methods and slurry store covers, and/or providing scenarios based around probable uncertainty bounds.

Emission factors – all emission factors (or algorithms determining emission factors) remain constant over the projections period and no potential influences of any climate changes have been factored in.

1.2.15. NFR 5: Waste

Emissions of NMVOC from landfills have been projected from emission projections for methane. These are available from BEIS (at https://www.gov.uk/government/statistical-data-sets/non-co2-greenhouse-gas-emissions-projections-report-summer-2015) and they are converted into NMVOC projections by assuming that NMVOC emissions continue to have the same relationship to methane emissions as in the 2020 base year. The BEIS projections for methane assume that quantities of waste sent to landfill decline over time as a result of the Landfill Directive, and that there are also small improvements in landfills which reduce methane emissions. A similar approach is used for emissions of NH_3 and particulate matter with emissions in 2025-2040 assumed to follow the exact same trend as methane.

Emissions from composting, both by households and at waste disposal sites are also based on the BEIS methane emission projections, with trends for ammonia emissions assumed to follow the same trend as given for methane.

Projected ammonia emissions from anaerobic digestion (AnD) have been calculated based on data in DUKES for historical electricity generation from AnD in 2016 – 2020, and with the assumption that electricity generation from this sector is expected to grow, in line with the Government's objectives, as set out in Defra's "Anaerobic Digestion Strategy and Action Plan" (2011) and BEIS' "Consultation Stage IA: Future Support for Low Carbon Heat" (2020).

Based on the most recent data and literature available, the best estimate emission factor for fugitive and storage emissions at UK AnD plants (weighted average) is 0.08 kg NH_3-N/ t fresh weight feedstocks (range 0.04 – 0.14 kg/t) (Tomlinson et al., 2019). The 2020 emissions estimate has been used as the baseline for the projected emissions. All inputs to AnD plants that were classed as manure or slurry, along with all digestate production, were not used to calculate emissions from storage and processing at AnD plants in 2020. This information was used instead within the agricultural inventory.

For waste incineration, we have assumed that activity levels are proportional to population (in the case of clinical waste incineration and cremation), stay constant (in the case of sewage sludge incineration and animal carcass incineration, or are proportional to chemical sector output (in the case of chemical waste incineration). In the case of cremation (and possibly clinical waste incineration as well), 2020 was an atypical year with excess deaths due to the Covid pandemic. Therefore we use 2019 activity data as the starting point for our future activity data, not 2020 data i.e. we scale the 2019 activity data forward to 2025 and beyond using change in population between 2019 and those future years.

Note that sewage could realistically be assumed to grow with population, but the UK only incinerates sewage sludge at a handful of sites and because we are not aware of any further incinerators being planned, we assume constant activity in this sector. We have no information on any abatement currently in place at any of the incinerator sites or any information on any changes in abatement that might be required in future and therefore, as a conservative approach, we assume that 2019 emission factors are also appropriate for 2020 and 2040.

Emissions from small-scale waste burning, such as burning of waste on open grate fires and outside, on garden bonfires, is assumed to stay constant at 2020 levels. Population in the UK is increasing but the use of open grate fires is very likely to be declining, and we also believe that the use of garden bonfires is also in decline. As a result, we consider that holding emissions constant for this source is still a conservative approach, despite the rising UK population.

Emission factors for waste-water treatment are held constant at 2020 levels but the level of activity is assumed to change: in line with population growth for public sewage treatment works, and in line with growth in the food, drink and tobacco sector for industrial waste-water plant.

1.2.16. 6A Other (included in National Total for Entire Territory)

The projections in this sector are derived by scaling the latest inventory year, 2020, with projected population figures provided by BEIS (EEP NZ).

Emissions of non-agricultural horses are assumed to be constant from 2020 onwards.

1.3. Impact of the COVID-19 Pandemic on 2020 emissions

General uncertainties in emissions are outlined in chapter 11.17 of the UK Informative Inventory Report (1990 to 2020)[9]; those associated with the impact of COVID-19 are outlined below.

The Covid-19 pandemic which started to impact the UK in late February 2020, had a significant impact on UK emissions to air in that year. Some emission sources, such as aviation, were especially impacted by the pandemic, but there are likely to be very few activities that weren't affected to some extent. Because of the economic damage from the pandemic, the impacts are mostly such that they would be expected to lead to emission reductions. In the case of a few sources though, emissions will have increased. The prime example of that is the use of alcohol-based hand-sanitizers, consumption of which increased markedly during the pandemic, leading to increased NMVOC emissions from that source. At the time of writing, Covid-19 and post-pandemic recovery continues to impact activity in the UK, and so we do not necessarily have a good understanding of what sort of 'normal' each emission source will ultimately return to. This is particularly so for hand sanitizer use – we assume that much higher levels of sanitizer continue to be used in early 2022 than was the case before the pandemic and it is unclear to us how far that usage might decline over time into the future. Similarly, some industry sectors (construction, for example) suffered significant downturns in 2020 and these industries may still be impacted to some extent in future years. One particularly notable issue for the projections is that we use 2020 emissions data from the various regulators' inventories as the starting point for projections, and we do not know if these base year emissions are affected by the pandemic or not. We assume future emission rates for many sources remain at the same level as in the base year, and so if those 2020 emissions are lower because of the pandemic, then we might be underestimating future emissions. We have reviewed the regulator inventory data carefully and have concluded that:

- While there are installations that reported much lower emissions in 2020 than in 2019, there are also others that reported higher emissions. This pattern of a mixture of large increases and large

[9] Report: UK Informative Inventory Report (1990 to 2020) - NAEI, UK (beis.gov.uk)

decreases is not unusual since it is common to see large inter-annual changes in emissions at many sites;

- Installations reporting in the regulators inventories. are permitted and may be required by regulators to improve the plant so that compliance is achieved with standards set out in the BAT conclusions. So lower emissions in 2020 could be the result of permanent improvement in emissions control;
- Operators may have also made improvements to processes or changes to input materials that result in lower emissions for reasons other than environmental permitting – perhaps improving the efficiency of a process or lowering costs;
- At least some of the emission reductions at sectoral level occur because sites close and these closures are assumed to be permanent, regardless of whether they result indirectly from the pandemic or not;
- Limited consultation with industry in 2021 suggested that many industrial sectors were not greatly affected by the pandemic, at least in terms of overall output. For example the iron & steel and chemicals sectors.
- It is not possible to separate out the causes of changes in emissions reported for each site, so it is impossible to quantify the impact of the pandemic at any site.

In view of the above, we have concluded that it is better to continue to use 2020 as a base year for the projections and to use 2020 emission factors for 2025 onwards. Projection methods for industrial sources are slightly conservative anyway, and so overall we think it is justified to use the very latest available emissions data as a guide for future emissions.

For other sources, we have attempted as far as is possible to ensure that the projections are not unrealistically affected by the atypical nature of the 2020 base year data. But as mentioned above, there is uncertainty over how each source/sector will evolve after the pandemic and this does translate into additional uncertainty in the projections, perhaps particularly for 2025.

1.4. Progress against UK air quality emission commitments

The emission projections take account of measures in place as far as is possible, given the data available, but do not reflect measures which are still in development.

The Gothenburg Protocol sets emission reduction commitments (ERCs) for NO_x, SO_x, NMVOCs, NH_3 and for $PM_{2.5}$ to be achieved in 2020 and beyond. The NECR sets emission reduction commitments for 2020 to 2029 (in line with the Gothenburg Protocol commitments – though the totals for compliance differ slightly for NMVOCs and NO_x as is explained below) as well as more stringent targets for 2030 for the same air pollutants. These are ambitious reduction commitments, which aim to reduce the health impacts of poor air quality by half by 2030.

Table 1-5 shows how the latest emission totals compare with 2020 to 2029 targets based on applying the NECR and Gothenburg Protocol ERCs to the current 2005 baseline. The National Totals used for compliance assessment under the NECR and Gothenburg Protocol differ. Under the NECR, NMVOCs and NO_x emissions from 3B (Manure Management) and 3D (Crop Production and Agricultural Soils) are not accounted in the National Total for the purpose of complying with the 2020 to 2029 (or 2030) emission reduction commitments. Under the Gothenburg Protocol these exceptions are not valid, and the National Totals include emissions of subsectors including 3B and 3D. Thus, emissions of NMVOCs and NO_x are displayed in two separate columns, one column showing emissions excluding emissions from 3B and 3D (*NO_x (exclude 3B and 3D)*, *NMVOC (exclude 3B and 3D)*) and one column showing total emissions (*NMVOC*, *NO_x*).

The progress made towards the 2020 - 2029 ERCs has been shown in two ways. Firstly, the reduction achieved in emissions between the 2005 base year and 2020 has been shown as a percentage of the reduction required to meet the ERCs (see row '**Progress to date towards 2020 – 2029 ERC**'). Secondly, the row '**Emission reduction required from 2020**' shows the amount of reduction required by 2025 from current (i.e. 2020) emissions to reach the 2020 - 2029 commitment. This shows that the reductions required to meet the estimated 2020 - 2029 emission targets for SO_x, NOx, NMVOC and $PM_{2.5}$ emissions have been achieved in 2020 already. Emissions of NH_3 were at similar levels in both 2005 and 2020 so further reductions would be required to meet the 2020 – 2029 and 2030 ERCs. Further discussion of the UK's status of compliance with regards to the 2020 ERC for ammonia can be found in Chapter 10 – Adjustment of the IIR.

Similarly,

Table 1-6 shows how the latest emission totals compare with 2030 based on applying the NECR 2030 ERCs to the current 2005 baseline.

Table 1-5 Comparison of UK 2020 national emissions, projected emission estimates for year 2025 and 2020 - 2029 NECR / Gothenburg ERCs. Emissions data have been rounded.

Pollutant	NH_3	NO_x (excludes 3B and 3D)[b]	NO_x[c]	SO_x	NMVOC (excludes 3B and 3D)[b]	NMVOC[c]	$PM_{2.5}$
2005 National Compliance Total, kilotonnes	280.01	1737.40	1767.80	787.94	1124.70	1240.30	121.41
2020 National Compliance Total, kilotonnes	259.20	675.27	702.35	136.16	654.80	785.11	80.09
Emission reduction commitment (ERC)	8%	55%	55%	59%	32%	32%	30%
2020 - 2029 target, kilotonnes[a]	257.61	781.83	795.51	323.05	764.80	843.41	84.99
Progress to date towards 2020 - 2029 ERCs	93%	111%	110%	140%	131%	115%	113%
Emission reduction required to date from 2020 onwards	**1.59**	0	0	0	0	0	0
Projected **2025** National Total, kilotonnes	268.08	619.74	647.66	138.91	659.55	792.95	80.61
Above or below 2020 - 2029 targets in 2025, kilotonnes	**10.47**	-162.09	-147.86	-184.14	-105.24	-50.46	-4.37

a The 2020 and 2030 emission targets have been calculated using the 2005 emissions of the current inventory submission as the base year.

b The NMVOCs and NOx figures quoted in this column exclude emissions from 3B and 3D. Under the NECR, NMVOCs and NOx emissions from 3B and 3D are not accounted in the National Total for the purpose of complying with the 2020 (or 2030) emission reduction commitments.

c Under the Gothenburg Protocol NMVOCs and NOx emissions from 3B and 3D are counted in the National Total for the purpose of complying with the 2020 (and beyond) emission reduction commitments.

Table 1-6 Comparison of UK 2020 national emissions, projected emission estimates for year 2030 and 2030 NECR ERCs. Emissions data have been rounded.

Pollutant	NH_3	NO_x (excludes 3B and 3D)[b]	SO_x	NMVOC (excludes 3B and 3D)[b]	$PM_{2.5}$
2005 National Compliance Total, kilotonnes	280.01	1737.40	787.94	1124.70	121.41
2020 National Compliance Total, kilotonnes	259.20	675.27	136.16	654.80	80.09
Emission reduction commitment	16%	73%	88%	39%	46%
2030 target, kilotonnes[a]	235.21	469.10	94.55	686.07	65.56
Progress to date towards 2030 ERCs	46%	84%	94%	107%	74%
Emission reduction required from 2020	23.99	206.17	41.61	0.00	14.53
Projected **2030** National Total, kilotonnes	272.07	532.97	122.21	654.56	79.87
Above or below 2030 targets by, kilotonnes	**36.87**	**63.87**	**27.66**	-31.50	**14.31**

a The 2020 and 2030 emission targets have been calculated using the 2005 emissions of the current inventory submission as the base year.

b The NMVOCs and NOx figures quoted in this column exclude emissions from 3B and 3D. Under the NECR, NMVOCs and NOx emissions from 3B and 3D are not accounted in the National Total for the purpose of complying with the 2020 (or 2030) emission reduction commitments.

Based on these latest projections, the UK will need to take further action to meet its 2020 -2029 ERCs under both the NECR and Gothenburg Protocol for NH_3 and 2030 ERCs under NECR for NOx, NH_3, SOx and $PM_{2.5}$. Emission projections described in this report take account of measures in place as far as is possible given the data available, but do not reflect measures which are still in development. Table 9-2, earlier in the chapter, shows how the projections are a mixture of WM (with measures) and WoM (without measures). In general, projections for stationary sources are conservative with the exception of projections for a small number of source categories which consist of small numbers of large, regulated sites, such as power stations, cement kilns, steelworks or crude oil refineries. Projections for industrial-scale combustion and most smaller industrial processes will assume no change in emission factors beyond 2020. The UK is currently reviewing the National Air Pollution Control Plan (NAPCP) which sets out how the UK can limit anthropogenic emissions to meet 2020-29 and 2030 emissions reduction commitments.

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