



## **IRELAND**

# **INFORMATIVE INVENTORY REPORT 2020**

### **AIR POLLUTANT EMISSIONS IN IRELAND 1990–2018 REPORTED TO THE SECRETARIAT OF THE UNECE CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION AND TO THE EUROPEAN UNION**

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## EXECUTIVE SUMMARY

As a Party to the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP), Ireland is required to annually report emission data for a wide range of air pollutants and other substances released into the atmosphere. The data are needed to support the work of the Convention in addressing well-known environmental problems such as urban pollution, acidification and tropospheric ozone formation arising from classic pollutants, such as nitrogen oxides (NO<sub>x</sub>), sulphur dioxide (SO<sub>2</sub>), non-methane volatile organic compounds (NMVOCs), ammonia (NH<sub>3</sub>), carbon monoxide (CO) and particulate matter (PM), and for the implementation of its Protocols on Heavy Metals and Persistent Organic Pollutants.

The UNECE revised 2014 Reporting Guidelines, Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution<sup>1</sup>, describe the scope and reporting of the emission inventories and projections under the Convention. They specify the methodologies and procedures to be followed for submitting consistent and comparable data on an annual basis in a timely, efficient and transparent manner to meet the needs of the Convention. Under the Guidelines, Parties are strongly encouraged to submit an Informative Inventory Report (IIR) to support the evaluation of their up-to-date annual inventories and projections. The objective of the IIR is to describe the methodologies, input data, background information and the entire process of inventory compilation for transboundary air pollutant emissions and to give explanations for any improvements and recalculations of the inventories reported in previous submissions. The report is needed by expert review teams to assess the transparency, completeness and overall quality of the inventories as part of the review process of submissions from Parties to the Convention.

Member States of the European Union are required to report an Informative Inventory Report annually under Article 8(3) of Directive [\(EU\) 2016/2284](#). This Directive sets out reduction commitments of certain atmospheric pollutants and repeals Directive [2001/81/EC](#). This report to the European Union fulfils this reporting obligation.

The Environmental Protection Agency (EPA) in Ireland has overall responsibility for national air emission inventories and projections pursuant to the establishment of the National Atmospheric Inventory System (NAIS) in 2007. The EPA Office of Environmental Sustainability (OES) performs the role of inventory agency in Ireland and undertakes all aspects of inventory preparation and management and is responsible for the submission of the results to CLRTAP. The present report constitutes Ireland's eleventh IIR submitted under the Convention, covering annual inventories for the period 1990–2018. The report aims to provide a comprehensive description of the procedures, methodologies and activity data used for the compilation of Ireland's air emission inventories and projections as presented in Ireland's 2020 submission under CLRTAP and to the European Union under Directive (EU) 2016/2284. The report shows how Ireland follows the guidelines for estimating and reporting of emission data to ensure the transparency, accuracy, consistency, comparability and completeness of the reported emissions. In addition to complying with reporting requirements in this

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<sup>1</sup> [Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution](#)

regard, the 2020 IIR is intended to inform the Government Departments and institutions involved, as well as other stakeholders in Ireland, of the level of emissions and the state of the art of Ireland's emission inventories and projections as they address the challenges to comply with commitments already established for air pollutants and to control emissions in general. An attempt has been made to give adequate descriptions of all methodological approaches and to provide pertinent information to facilitate the assessment of the emission estimates and the understanding of emission trends. The IIR is published on the web site of the EPA (<http://www.epa.ie/pubs/reports/air/airemissions/airpollutantemissions/>). It will be further developed for future submissions and updated annually in accordance with the UNECE Reporting Guidelines and Directive (EU) 2016/2284.

# Chapter One

## Introduction

### 1.1 Convention on Long-Range Transboundary Air Pollution

The Convention on Long-Range Transboundary Air Pollution (CLRTAP) came into being in 1979 following the recognition that co-operation at international level was necessary to address environmental problems such as acidification associated with the transboundary transport and deposition of acidifying gases emitted into the atmosphere. The Convention was the first international legally binding instrument to deal with problems of air pollution on a broad regional basis. Besides laying down the general principles of international co-operation for air pollution abatement, the Convention sets up an institutional framework bringing together research and policy. The Executive Secretary of the United Nations Economic Commission for Europe (UNECE) acts as Secretariat to CLRTAP, and the Convention entered into force in 1983.

The aim of the Convention is that Parties shall endeavour to limit and, as far as possible, gradually reduce and prevent air pollution, including long-range transboundary air pollution. This objective is pursued under eight protocols that identify specific measures to be taken by Parties to cut their emissions of a wide range of air pollutants. The extent to which Parties to the Convention have ratified the various protocols varies. Of the eight protocols to date, Ireland has ratified the 1994 Oslo Protocol on Further Reduction of Sulphur Emissions and the 1988 Sofia Protocol concerning the Control of Emissions of Nitrogen Oxides.

### 1.2 Inventory Reporting and Review under the Convention on Long-Range Transboundary Air Pollution (CLRTAP)

The Guidelines for Reporting Emissions and Projections Data under the Convention on Long-Range Transboundary Air Pollution (ECE/EB.AIR/125)<sup>2</sup> specify the scope, methodologies, formats and deadlines for annual inventory submissions by Parties to the Convention. These Guidelines were adopted by the Executive Body in December 2013 (ECE/EB.AIR/122/Add.1, decisions 2013/3 and 2013/4) and published in 2014. They are a revised version of the 2009 Guidelines for Reporting Emission data under the Convention (ECE/EB.AIR/97), which were approved by the Executive Body in 2008 (ECE/EB.AIR/96, para. 83 (b)). While the Guidelines make it clear that Parties are required to report only on the substances and for the years set forth in the protocols that they have ratified and that have entered into force, Ireland endeavours to estimate and report emissions for the full range of substances set down in Annex I of the Guidelines. These substances are nitrogen oxides (NO<sub>x</sub>), sulphur oxides (SO<sub>x</sub>), non-methane volatile organic compounds (NMVOCs), carbon monoxide (CO), ammonia (NH<sub>3</sub>), particulate matter (PM), black carbon (BC), heavy metals (HM) and persistent organic pollutants (POPs).

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<sup>2</sup> The Guidelines for Reporting Emissions and Projections Data under the Convention on Long-Range Transboundary Air Pollution ([ECE/EB.AIR/125](#))

The Guidelines state that an Informative Inventory Report (IIR) should be prepared for inclusion in the annual submission and it is also required under Article 8(3) of Directive (EU) 2016/2284. The objective of the IIR is to describe the methodologies, input data, background information and the entire process of inventory compilation for air pollutants, as well as any improvements and recalculations of the inventories reported in previous submissions. The report is needed to support the evaluation of emission trends and may be used by expert review teams to assess the transparency, completeness and overall quality of the inventories as part of the review process established for submissions by the Parties to CLRTAP and the review process established under the NECD.

The present report constitutes Ireland's IIR for 2020, the eleventh such report. It contains specific information on the national inventory for the years 1990–2018 as submitted to CLRTAP in February 2020, including descriptions of methods, data sources, quality assurance/quality control (QA/QC) activities and trend analysis. The structure of the report follows the structure proposed in Annex II to the reporting guidelines.

The IIR focuses on the year 2018 and the status of the inventories achieved for the time series up to 2018 and is the basis for methodological description for the purposes of facilitating technical review and general assessment of Ireland's emission inventories. The IIR is designed to capture the cyclical nature of the reporting process and to clarify the chronology of changes and revisions that are part of normal inventory development. In this way, the report provides the basis for technical assessment and expert review of Ireland's air pollutant inventories. An attempt has been made to give adequate descriptions of all methodological approaches and to provide all the pertinent inventory information to facilitate the assessment of the emission estimates and the understanding of emission trends.

The IIR will be further developed and updated annually in accordance with the UNECE guidelines and is published on the web site of the EPA (<http://www.epa.ie/pubs/reports/air/airemissions/airpollutantemissions/>). Such updating is necessary to keep the UNECE Secretariat and other interested parties informed of the status of Ireland's air pollutant inventories and to document on-going improvements, recalculations and other developments affecting the estimates of emissions. Ireland is contributing to the Stage 3 in-depth review process for transboundary emission inventories by not only providing this IIR, but also providing expert reviewers to evaluate the submissions from other Parties to the Convention.

### 1.3 Inventory Reporting and Review under Directive (EU) 2016/2284

Directive (EU) 2016/2284<sup>3</sup> came into force on the 31<sup>st</sup> of December 2016. This inventory report and data submission fulfils Ireland's reporting requirements as set out in Article 10(2) of the directive. The inventory submission is fully consistent with the submission under the LRTAP Convention and will be subject to review in accordance with Article 10(3) of the directive.

Ireland's national total emissions of nitrogen oxides (NO<sub>x</sub>), ammonia (NH<sub>3</sub>) and non-methane volatile organic compounds (NMVOCs) are not in compliance with the ceilings in Article 4(1) and Annex I to

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<sup>3</sup> [DIRECTIVE \(EU\) 2016/2284 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC](#)

Directive 2001/81/EC<sup>4</sup>. Ireland has established adjusted annual national emission inventories for NO<sub>x</sub> and NMVOCs as allowed for under the flexibilities outlined in Articles 21(2) and 5(1) of the Directive 2001/81/EC. The adjusted inventories are established in accordance with Part 4 of Annex IV of the directive and are explained in detail in chapter 9 of this report.

## 1.4 Inventory Reporting by the Environmental Protection Agency

Under Section 52 of the Environmental Protection Agency Act, 1992 (DOE, 1992), the Agency is required to establish and maintain databases of information on the environment and to disseminate such information to interested parties. Section 55 of the Act states that the Agency must provide, of its own volition or upon request, information and advice to Ministers of the Government in the performance of their duties. This includes making available such data and materials as are necessary to comply with Ireland's reporting obligations and commitments within the framework of international agreements. These requirements are the regulatory basis on which the EPA prepares annual inventories of air pollutants in Ireland. The activities related to the compilation and reporting of air pollutant emissions constitute one specific on-going project in the Agency's work programme.

The Department of Communications, Climate Action and Environment (DCCA) has designated the EPA as the agency with responsibility for the submission of emission data to international bodies, including the Secretariat for CLRTAP and the European Union. The Agency's Office of Environmental Sustainability (OES) currently compiles the national air pollutant emission inventories on behalf of the DCCA for submission under CLRTAP and NECD.

### 1.4.1 National Atmospheric Inventory System

In 2005, UK consultants from the National Environmental Technology Centre (NETCEN) carried out a scoping study to identify the essential elements and structure of a national inventory system for Ireland to meet the needs of Decision 280/2004/EC (EP and CEU, 2004a) and to comply with obligations under Articles 5 and 7 of the Kyoto Protocol. The report (Thistlethwaite et al., 2005) describes how institutional arrangements among the EPA, its parent government department and other stakeholders may be reorganised, extended and legally consolidated across all participating institutions to strengthen inventory capacity within the EPA and to ensure that more formal and comprehensive mechanisms of data collection and processing are established for long-term implementation. The report sets out the extent of institutional participation, resource requirements and the form of legal arrangements necessary to perform the functions prescribed in the guidelines for national systems and enable Ireland to meet the objectives specified in those guidelines. The scoping study developed a QA/QC system as an integral part of the national system and the report made recommendations on internal inventory review and proposed a database system to facilitate more efficient data management and reporting. Whilst developed to meet the needs of Decision 280/2004/EC and the Kyoto Protocol, Ireland's national system is also implemented to achieve emission inventories for transboundary gases for submission under CLRTAP and NECD.

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<sup>4</sup> [DIRECTIVE 2001/81/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2001 on national emission ceilings for certain atmospheric pollutants](#)

The National Atmospheric Inventory System (NAIS) for Ireland was adopted by Government decision in April 2007. It establishes the necessary institutional, legal and procedural arrangements for the compilation of robust inventories of emissions of greenhouse gases (GHGs) and air pollutants to the atmosphere. It sets out formal procedures for the planning, preparation and management of the national atmospheric inventory and identifies clearly the roles and responsibilities of all the organisations involved in inventory compilation, reporting and review. A schematic overview of the national system is presented in Figure 1.1.

The principal objective of the NAIS is to ensure that Ireland can compile robust and verifiable annual inventories of emissions and report its emission estimates in accordance with relevant international obligations. The NAIS also facilitates the formal review of information submitted under international obligations, including the Kyoto Protocol, protocols under CLRTAP and the NECD. Implementation of the national system ensures the transparency, consistency, comparability, completeness and accuracy of the national inventory in accordance with the established reporting guidelines, which incorporate methodological guidance and good practice.

Within the NAIS, the EPA's Office of Environmental Sustainability (OES) is designated as the single national entity with overall responsibility for the national emission inventory in Ireland. The OES also performs the role of inventory agency, i.e. the Office compiles the annual inventory and delivers Ireland's submissions to the various international organisations (European Commission (EC), European Environment Agency (EEA), United Nations Framework Convention on Climate Change (UNFCCC) and UNECE in accordance with agreed deadlines and reporting formats. In addition to the primary data received from the Key Data Providers (KDPs), the inventory team obtains considerable supplementary information from other teams in the OES, the Office of Evidence and Assessment and the Office of Environmental Enforcement within the EPA. These sources include Annual Environmental Reports (AERs) submitted by licensed facilities and the National Waste Database. The inventory team also draws on national research related to air pollutant emissions and special studies undertaken from time to time to acquire the information needed to improve the estimates for categories and gases. The approval of the completed annual inventory involves sign-off by the QA/QC manager and the inventory manager before it is transmitted to the Board of Directors of the EPA via the Programme Manager of OES. Any issues arising from the Board of Directors' examination of the estimates are communicated to the inventory experts for resolution before final adoption of the inventory for submission and publication.

#### 1.4.2 Scope of Inventories under the LRTAP Convention and Directive (EU) 2016/2284

The scope of Ireland's emission inventories under LRTAP Convention and Directive (EU) 2016/2284 is provided in Annex A1. It covers a wide range of air pollutants and other substances, which are reported in a standard electronic format for a predefined nomenclature of source categories set down in the UNECE Reporting Guidelines. The air pollutants are referred to in seven groups as follows:

1. Main pollutants (NO<sub>x</sub>, NMVOCs, SO<sub>x</sub>, NH<sub>3</sub>, CO);
2. Particulate matter (PM<sub>2.5</sub>, PM<sub>10</sub>, total suspended particulates (TSP), black carbon (BC));
3. Priority heavy metals (lead (Pb), cadmium (Cd), mercury (Hg));

4. Other heavy metals (arsenic (As), chromium (Cr), copper (Cu), nickel (Ni), selenium (Se), zinc (Zn));
5. Annex I Persistent Organic Pollutants: the POPs listed in Annex I to the Protocol on POPs which are substances scheduled for elimination;
6. Annex II Persistent Organic Pollutants: the POPs listed in Annex II to the Protocol on POPs which are substances scheduled for restrictions on use;
7. Annex III Persistent Organic Pollutants: the POPs listed in Annex III to the Protocol on POPs which are substances referred to in Article 3, Para. 5 (a), of the Protocol. Polycyclic aromatic hydrocarbons (PAHs): for the purpose of the emission inventories, the following four indicator compounds should be used: benzo[b]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene and indeno [1,2,3-cd] pyrene. Hexachlorobenzene (HCB) is also included in Annex I to the Protocol as a substance for elimination.

The list of source categories for inventory purposes is known as the NFR (Nomenclature for Reporting). It comprises coded activities across all socio-economic sectors identified as sources of one or more of the substances listed above and provides for the inclusion of other activities that may be specific to individual countries. Many of the NFR categories are split into a varying number of subcategories, which are designed to reflect their importance as sources of one or more pollutants and to provide an adequate level of transparency. In the compilation of annual inventories, significant subdivision of the given NFR categories is normally applied for the process of calculating the relevant emissions. The NFR facilitates the comparison of emissions among reporting countries and the synthesis and assessment of submissions at the UNECE level. The current version of the NFR, NFR 19 is a revision of NFR14, which was included in Annex I of the Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution (ECE/EB.AIR/125), which were adopted by the Executive Body in December 2013. This revised NFR was approved by the Steering Body of the European Monitoring and Evaluation Programme (EMEP) during its 5<sup>th</sup> Joint Session in September 2019 and should be used for reporting under CLRTAP for 2020 onwards.

The reporting format also includes a number of *Memo Item* entries. These items refer to sources of emissions whose contributions are not included in a Party's national total but which are to be reported because of their importance in relation to the overall assessment of emissions and for comparisons among Parties. The notable emission sources excluded from the reported national total for transboundary gases and included as Memo Items are emissions from international and domestic aviation during the cruise phase of a flight, and international shipping.

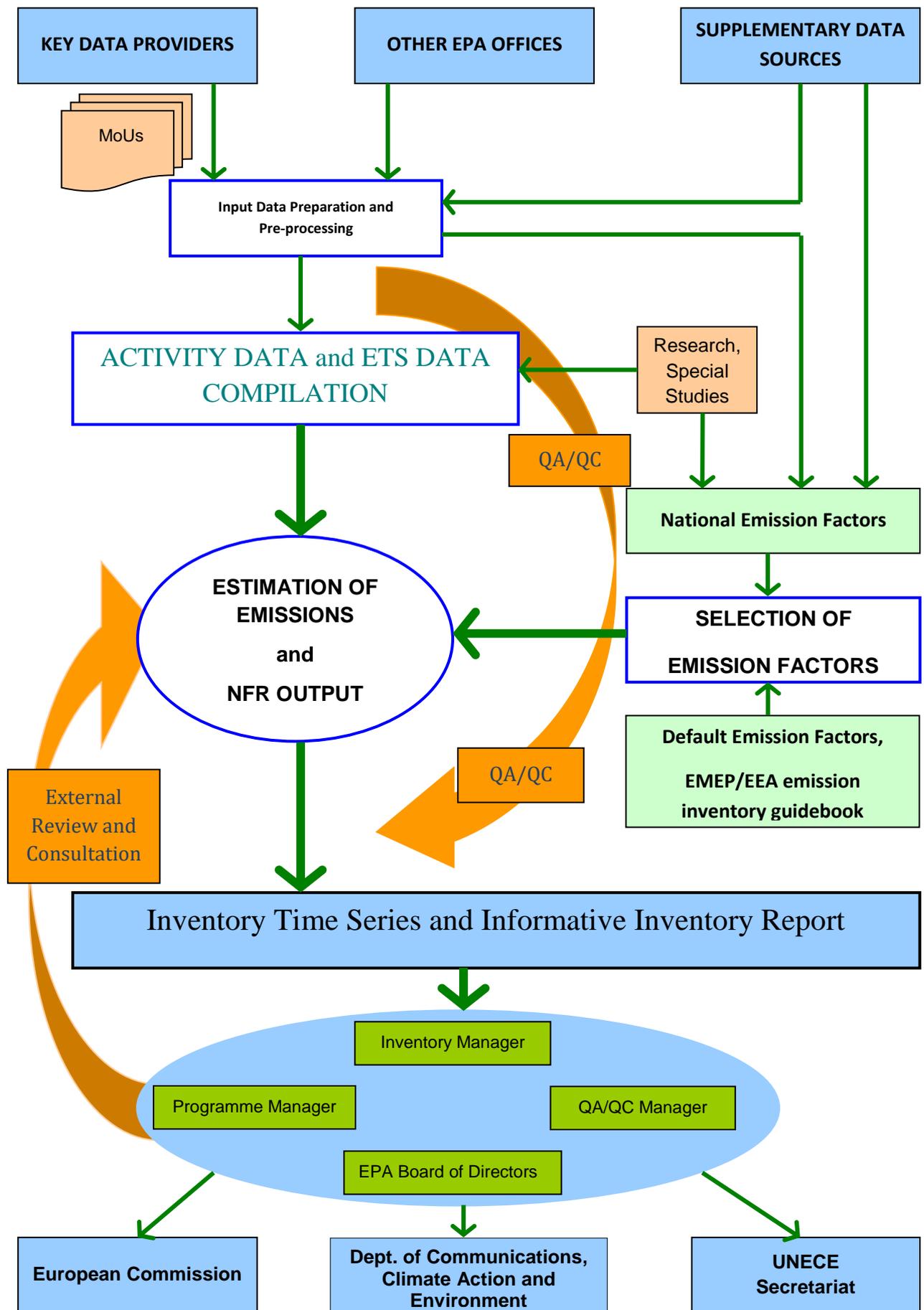


Figure 1.1. National Atmospheric Inventory System Overview

A set of notation keys has been adopted for use in completing the NFR templates to provide explanation and transparency where a numerical value does not appear for a particular pollutant and/or category combination. The notation keys are as follows:

- (a) NO (not occurring) for activities that do not occur in the country;
- (b) NE (not estimated) where emissions do occur but are not estimated, usually because they are considered negligible or the necessary data cannot be obtained;
- (c) NA (not applicable) for activities that do not generate emissions of a particular pollutant;
- (d) IE (included elsewhere) for emissions relating to a subcategory that are reported in another subcategory, usually at the next highest level;
- (e) C (confidential) for emissions that could lead to the disclosure of confidential information;
- (f) NR (not relevant) for emissions that are not required by the ratified protocols.

At four year intervals from 2017 onwards, the inventory submissions under CLRTAP should include compilations of emissions for a list of defined large point sources and aggregated sectoral gridded data for the European Monitoring and Evaluation Programme (EMEP) grid cells overlying the national territory. This information is used in EMEP models for evaluating long-range transport of air pollutants and for assessing emission deposition relationships in Europe. Ireland's 2017 submission contained data for large point sources and sectoral gridded data of emissions for 2015 on the EMEP grid. This information is provided in chapter 7 of this report.

Parties to the Gothenburg Protocol shall report national projections every four years from 2015 onwards, for the years 2020, 2025 and 2030 and where available, also for 2040 and 2050, by 15th March for the pollutants: SO<sub>x</sub> (as SO<sub>2</sub>), NO<sub>x</sub>, NMVOCs, NH<sub>3</sub> and PM<sub>2.5</sub>, with voluntary reporting for black carbon. Other Parties are encouraged to provide projections for these pollutants. The Directive (EU) 2016/2284 requires emission projections every two years from 2017 onwards from European Member States. Information on projections is provided in chapter 8 of this report.

### 1.4.3 Inventory Preparation

The air pollutant emission inventory database normally contains information on measured emission quantities, activity statistics (populations, fuel consumption, vehicle/kilometres of travel, industrial production and land areas), emission factors and the associated emission estimates for the NFR list of source categories. In practice, very few measured emission data are available for the range of gases covered and, consequently, the emissions from most activities are estimated by applying emission factors for each source/gas combination to appropriate activity data for the activity concerned. Virtually all emissions may be ultimately derived on the basis of the product of activity data and emission factor. Even in the case where emission estimates for particular categories are reported directly to the inventory agency they will normally have been derived in this manner.

The reporting guidelines provide the general guidance for the preparation and reporting of annual inventories by Parties. They incorporate the methodologies given in the EMEP/EEA (European Environment Agency) Emission Inventory Guidebook, hereafter referred to as the Inventory Guidebook. The inventory preparation process involves the acquisition of the required statistical data for the inventory year concerned and the application of emission factors that characterise the rate of emission of the gases concerned. Some data analysis and preparatory calculations are generally

needed to make available suitable combinations of activity data and emission factors at the level of disaggregation that gives the best estimate of emissions in the individual emission source categories. In the case of some source/gas combinations, it may be necessary to apply sophisticated models to generate the activity data, the emission factors or the emissions. The methods recommended by the Inventory Guidebook use a tiered system. This provides methodologies at different levels of detail and sophistication, which take account of these issues and other factors, such as data availability, technical expertise, inventory capacity and other circumstances, which may vary considerably across countries.

#### 1.4.4 Data Acquisition

In its capacity as the inventory agency, the OES of the EPA acquires the principal items of activity data from identified Key Data Providers (KDP) relevant to each of the NFR sectors. Most KDPs provide data directly to the OES, but some secondary KDPs provide their input to one of the primary KDPs for processing and incorporation into the information subsequently transmitted to the OES. Some KDPs may also deliver estimates of emissions or removals for their particular area of coverage or expertise. Table 1.1 lists the KDPs and the data they supply for use in transboundary air pollutant emission inventories.

The NAIS provides for a formal Memorandum of Understanding (MoU) between each KDP and the inventory agency regarding the scope, quality and submission date of the data to be provided for the purposes of the national emission inventory compilation. In the majority of cases, the data concerned are already routinely collected and published by the KDPs under existing mandates and established reporting programmes. Additional MoUs may be developed under the NAIS in cases where new or supplementary data sources need to be targeted. Under Section 69 of the EPA Act 1992, formal legal powers are assigned to the EPA, whereby the Agency may require any public body to provide information related to environmental quality and may make arrangements with other bodies for the provision of similar information. This provision can also be invoked by the OES to acquire specific information for inventory purposes as the need arises.

The Emissions Trading Unit was established under the EPA Office of Licensing and Guidance (OLG) in late 2003 to implement Directive 2003/87/EC (EP and CEU, 2003) in Ireland. The Emissions Trading Unit currently forms part of the OES and is another key component of the national system. Information compiled for participants in the Emissions Trading Scheme (ETS) under Directive 2003/87/EC is an important source of activity-specific and company-specific data on GHG emissions for approximately 100 installations in Ireland. The inventories for transboundary air pollutants draw on relevant information regarding fuel quantities and fuel properties available under the ETS for these installations and fuel data are used for reconciliation with the national energy balance for major categories and matching of activity data for GHG emission inventories. The inventory agency in the OES obtains useful support and activity data from other EPA offices and programme areas, including the Environmental Licensing Programme, Office of Environmental Enforcement, and the Environmental Research Programme. These programmes and offices make various contributions that are used to determine or substantiate the activity data or emission factors for particular categories or individual activities, which ensures that country-specific information is exploited to the maximum extent possible. In all cases, consistency is maintained with data application for GHG emission inventories and vice versa.

### 1.4.5 Quality Assurance and Quality Control (QA/QC)

**Quality Assurance (QA)** activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation and development process. Reviews, preferably by independent third parties, should be performed upon a finalised inventory following the implementation of QC procedures. Reviews verify that data quality objectives were met, ensure that the inventory represents the best possible estimates of emissions and sinks, given the current state of scientific knowledge and data available, and support the effectiveness of the QC programme.

A QA/QC spreadsheet tool has been developed to manage and maintain Ireland's QA/QC system. This tool consists of several spreadsheets that provide procedures, guidance, forms and templates as required for the general QA/QC functions. The supporting manual (Thistlethwaite et al., 2005) provides a general overview to the QA/QC system and guidance on the application of the plan and procedures. The QA/QC plan identifies the specific data quality objectives related to the principles of transparency, consistency, completeness, comparability and accuracy required for Ireland's national inventory and provides specific guidance and documentation forms and templates for the practical implementation of QA/QC procedures. The spreadsheets include a brief introduction and a statement of the data quality objectives (DQOs) and how they will be met through the QA/QC system with reference to the relevant spreadsheet tool template sheets and forms. The Introduction sheet links to the QA/QC plan which provides the schedules and procedures for the QA/QC system and lists all of the QA/QC activities that exist or are planned to make up Ireland's QA/QC system. The Plan sheet consists of tables that contain three different categories of QA/QC activity:

1. General activities covering the planning and management practices and procedures;
2. Activities that should be undertaken on an annual basis for management and preparation of the inventory;
3. Periodic activities that should be undertaken in response to specific events in the inventory and for periodic peer review or verification.

The inventory agency has implemented this approach to QA/QC for fourteen annual reporting cycles. This involved the allocation of responsibilities linked to the national system and the use of the template spreadsheet system to record the establishment and maintenance of general inventory checking and management activities covering the overall compilation process, as well as the undertaking of specific annual activities and any necessary periodic activities in response to specific events or outcomes in inventory reporting and review. The system facilitates record keeping related to the chain of activities from data capture, through emission calculations and checking, to archiving and the identification of improvements.

Ireland's calculation spreadsheets in all sectors are structured on a time-series basis. This organisation is designed to facilitate the QA/QC process as well as more efficient trend analysis and to ensure ease of transfer of the outputs to the NFR tables. The inventory compilation is directly linked to the primary statistical inputs, which facilitates rapid year-on-year extension of the time series and efficient updating and recalculation, where appropriate, in the annual reporting cycle. Internal aggregation to various levels corresponding to the NFR tables provides immediate and complete checks of the results.

**Quality Control (QC)** is a system of routine technical activities, to measure and control the quality of the inventory as it is being developed. The QC system is designed to:

- (i) Provide routine and consistent checks to ensure data integrity, correctness, and completeness;
- (ii) Identify and address errors and omissions;
- (iii) Document and archive inventory material and record all QC activities.

Quality control activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. Higher-tier QC activities include technical reviews of source categories, activity and emission factor data, and methods.

In recent years, the inventory agency has created and implemented a number of QA\QC tools. These spreadsheet-based tools are used to better inform the QA\QC process whilst providing transparent descriptions of the outcomes of checks. In each spreadsheet-based tool comments are added to explain anything highlighted by the checking process. The text from these tools (such as the recalculations assessment) then helps inform the update of the IIR. The tools used include:

1. Recalculations assessment – this spreadsheet tool calculates the percentage change of emission estimates between the current and previous inventory submissions using conditional formatting to highlight the significant changes. There is a separate table for each pollutant in which the entire time series is evaluated for all NFR codes. This check highlights the recalculations that have been made in the inventory so that they can be verified and justified by the inventory agency.
2. Trend assessment – this spreadsheet tool calculates the percentage change between the most recent year and the preceding year of the current inventory submission using conditional formatting to highlight the significant changes. There is a separate table for each pollutant in which the entire time series is evaluated for all NFR codes. This check helps identify any time series inconsistency with the newly reported data of the most recent year. Provided this is run annually and alongside the recalculations check, time series consistency should be maintained.
3. Pollutant specific assessments – there are two tools that check the following rules that should be maintained in an inventory:  $TSP \geq PM_{10} \geq PM_{2.5}$ ; Total PAHs (1-4) = B(a)p + B(b)F + B(k)P + I(123)-cd. These simple checks help maintain the accuracy of the inventory.
4. Data value assessment – two tools check the entire time series for all pollutants to ensure that none of the following are reported: zero values, errors, negative values. These simple checks help maintain the accuracy and transparency of the inventory.
5. Annex I reporting template assessment – this tool evaluates whether all compiled Annex I reporting template files are comparable in structure and content to the template. This helps maintain the comparability of the inventory.
6. Notation keys assessment – this tool summarises the use of the different notation keys within the inventory. This tool has been implemented for all NEC pollutants across the entire time series. The tool helps the inventory agency evaluate, justify and document the use of notation

keys in the inventory. By increasing the accuracy of the notation keys, the transparency of the inventory is improved and this allows the inventory agency to clearly identify areas where potential improvements could be made (e.g. the use of IE or NE).

The online tool provided by the Centre on Emissions Inventories and Projections (CEIP), RepDab, is used by the inventory agency to check the format, completeness and internal consistency of the Annex I reporting template submission files. Further details regarding the checks that are carried out can be found on the [CEIP](#) website.

In the 2020 reporting cycle, the inventory agency updated some of the default emission factors in accordance with the recently published EMEP/EEA Air Pollutant Emission Inventory Guidebook (2019) and implemented suggested changes/requests for further information as presented in the Final Review Report of the 2019 Comprehensive Technical Review of National Emission Inventories. These are outlined in the sectoral chapters of this report.

**Table 1.1 Key Data Providers and Information Covered by Memoranda of Understanding**

Key Data Provider	Data Supplied	Deadline	Sector in which Data are Used
Sustainable Energy Authority of Ireland (SEAI)	National Energy Balance; Detailed national energy consumption disaggregated by economic sector and fuel	30 September	Energy, Waste
Department of Agriculture Food and the Marine (DAFM)	Nitrogen fertiliser sales, cattle populations from the AIM (Animal Identification and Movement) database, sheep statistics, poultry statistics	30 September	Agriculture
Central Statistics Office (CSO)	Annual population, livestock populations, crop statistics, housing survey data	30 September	Agriculture, Industrial Processes, Waste
Gas Networks Ireland (GNI)	Analysis results for indigenous and imported natural gas	30 September	Energy
Marine Institute	Annual report on discharges, spills and emissions from offshore gas production installations	30 October	Energy
Emissions Trading Unit (OES, EPA)	Verified CO <sub>2</sub> estimates and related fuel and production data for installations covered by the EU ETS	30 April	Energy, Industrial Processes
Department of Communications, Climate Action and Environment (DCCA)	National Oil Balance (as a component of the energy balance)	30 September	Energy
Road Safety Authority (RSA)*	Road transport statistics from the National Car Testing (NCT) Service	30 April	Energy

\*These bodies have MoUs with the SEAI rather than with the OES.

### 1.4.6 Inventory Compilation

The source data, calculation workbooks and outputs for all emissions to air are held on EPA servers. The annual inventory compilation for transboundary gases is undertaken in separate *Data Processing* folders for each sector, which are linked to the *Source Data* folders for the respective sectors at the same level. The *Outputs* folder and the *QA/QC* folder are also at this level. The *Outputs* folder contains the files used for the official submissions to the EU and the UNECE and for preparing summary reports and relevant media statements at national level. All calculation workbooks for the individual sectors contain a *QA/QC* worksheet, which are compiled collectively in the *QA/QC* folder. Data processing to compute the emission estimates is carried out at the most detailed level of aggregation possible, consistent with data availability and the outputs needed to populate the reporting template format for the category concerned. These outputs are primarily the estimates of emissions and the corresponding activity data for each category.

Quality control procedures are an integral part of the inventory preparation and reporting cycle. Within the inventories team, quality control for each sector is undertaken by an inventory compiler who has not produced the emission estimates for that sector. Quality control involves a series of checks covering the

data inputs and any necessary pre-processing, the calculation of emissions, and the generation of the output records that are subsequently compiled in the NFR templates. The checks cover such items such as the comparison of inputs with those of previous years, the identification of errors and omissions, validating internal linking and calculation algorithms, replicating the aggregation of subcategories and ensuring an adequate level of completeness in NFR files to achieve transparency for external review purposes. A colour code system is used to distinguish between such elements as data taken from another spread sheet, calculated values, extrapolated or interpolated values, outputs for the NFR, and checks and annotations.

## 1.5 Key Category Analysis

Key category analysis for transboundary air emissions is explained in the Inventory Guidebook (EMEP/EEA, 2019), and is the same concept as that presented in the Intergovernmental Panel on Climate Change (IPCC) 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). This defines a key emission category as one that is prioritised within the national inventory system because its emission estimate has a significant influence on the Party's total inventory in terms of the absolute level of emissions, the trend in emissions, or both. The Inventory Guidebook provides several methods for undertaking the analysis of key categories that can be applied at any appropriate level of source aggregation, depending on the information available. The simplest approach (Approach 1) – identification based on contribution to emission level – is used here for the inventories of all substances to highlight which sources of emissions are the most important in Ireland.

In level assessment, key categories are those categories whose combined contribution to the total emission level, determined from the ranking of all categories on the basis of their individual contributions to the level, is 80 per cent. Information about key categories is considered to be crucial to the choice of methodology for individual sources and to the management and reduction of overall inventory uncertainty. The identification of such categories is recommended in order that inventory agencies can give them priority in the preparation of annual inventories, especially in cases where resources may be limited. Information on key categories is clearly also vital for the development of policies and measures for emissions reduction.

It is well established that fuel combustion in a small number of economic sectors is the major source of most air pollutants. This is true for classic pollutants such as SO<sub>x</sub> and NO<sub>x</sub>, which are reasonably well quantified in emission inventories and for which emissions have decreased considerably, and also for other substances (PM, POPs) for which inventories have much higher levels of uncertainty. The relative contributions of key categories are clearly shown by the results of the simple key category analysis shown in Table 1.2 and Annex A.2, Tables 1-15, which summarises NFR Level 2 key categories by pollutant. The dominance of categories under 1A (Energy: Combustion) highlights the importance of combustion sources. The four key categories (1A1a, 1A2f, 1A3b and 1A4b) dominate the results of the key category analysis presented in Table 1.2. Agriculture sources (3B, 3D) and are the main sources of emissions for NH<sub>3</sub>, NMVOC's and particulate matter and the additional categories 2D and 2H for NMVOCs. Waste sector sources are the main driver of emissions for As, Cr, dioxins and PCBs.

Table 1.2. Key Category Analysis of Ireland's Air Pollutant Inventory 2018

Pollutant	Key Categories									Total (%)
	1A3bi	3Da1	3Da3	1A3biii	1A3bii	1A1a	1A3dii	3Da2a	1A2f	
<b>NO<sub>x</sub></b>	1A3bi 14.80%	3Da1 14.30%	3Da3 11.10%	1A3biii 10.40%	1A3bii 7.50%	1A1a 6.10%	1A3dii 5.80%	3Da2a 5.50%	1A2f 4.60%	80.1%
<b>CO</b>	1A3bi 35.60%	1A4bi 25.00%	1A1a 13.30%	1A2f 6.10%	1A3biii 3.50%					83.5%
<b>NMVOC</b>	2H2 24.40%	3B1b 23.90%	2D3a 9.90%	3B1a 9.20%	1A4bi 6.90%	1B2aiv 2.50%	3B3 2.30%	2D3d 1.60%		80.7%
<b>SO<sub>x</sub></b>	1A4bi 48.70%	1A1a 23.20%	1A2f 11.80%							83.6%
<b>NH<sub>3</sub></b>	3Da2a 29.60%	3B1b 25.70%	3B1a 12.20%	3Da3 12.20%	3Da1 10.50%					90.1%
<b>TSP</b>	2D3b 49.10%	1A4bi 11.30%	3Da1 11.20%	2A5a 7.70%	1A3bvi 2.30%					81.7%
<b>PM<sub>10</sub></b>	3Da1 25.50%	1A4bi 23.50%	2D3b 14.80%	2A5a 8.60%	1A3bvi 3.90%	1A2f 3.10%	1A3bvii 2.10%			81.5%
<b>PM<sub>2.5</sub></b>	1A4bi 52.70%	1A2f 6.40%	1A3bvi 4.90%	1A2gviii 3.60%	1A3bvii 2.60%	1A3bi 2.60%	3B1b 2.50%	1A2e 2.50%	5E 2.40%	80.1%
<b>Pb</b>	1A4bi 38.10%	1A3bvi 28.40%	1A2f 13.00%	1A1a 6.80%						86.3%
<b>Cd</b>	1A2gviii 25.60%	1A1a 15.00%	2D3i 14.10%	1A4bi 13.40%	1A2f 11.60%	1A2e 5.60%				85.2%
<b>Hg</b>	1A4bi 27.60%	1A1a 22.60%	1A2f 10.20%	5A 6.90%	1A1c 6.70%	1A3bi 5.20%	1A2b 4.40%			83.6%
<b>As</b>	5C1bi 60.75%	1A1a 29.26%								90.0%
<b>Cr</b>	5C1bi 28.01%	1A3bvi 23.83%	1A4bi 8.91%	1A1a 8.76%	1A2f 8.60%	1A2gviii 7.12%				85.2%
<b>Cu</b>	1A3bvi 57.74%	2D3i 33.14%								90.9%
<b>Ni</b>	1A4ai 34.16%	1A2f 25.99%	1A2e 13.42%	1A2gviii 8.83%						82.4%
<b>Se</b>	1A4bi 63.35%	1A1a 33.52%								96.9%
<b>Zn</b>	1A3bvi 23.70%	2D3i 19.72%	1A4bi 19.54%	1A2gviii 14.21%	1A2f 8.68%					85.9%
<b>PCDD/F</b>	1A4bi 62.80%	5E 17.20%								80.0%
<b>PCBs</b>	5E 44.46%	1A4bi 31.54%	5C2 12.72%							88.7%
<b>HCB</b>	3Df 84.6%									84.6%
<b>PAHs</b>	1A4bi 89.3%									89.3%
	<b>1 Energy</b>		<b>2 IPPU</b>		<b>3 Agriculture</b>		<b>5 Waste</b>			

## 1.6 Uncertainty Assessment

Undertaking a quantitative estimate of emissions uncertainty requires a substantial amount of detailed data on the uncertainty of both activity data and emissions factors for a diverse range of source types. It has not been possible to collect these data in full. However, it has been possible to characterise the uncertainties associated with sources in a more approximate way.

A semi-quantitative uncertainty analysis has been used to determine the overall emissions uncertainty for a number of pollutants for 2018 data. This uses a Tier 1 propagation of errors to obtain an uncertainty for the total emission. However, the uncertainty assigned to the activity data and emission factor for each individual source is obtained from a combination of expert judgement and ranges of uncertainty obtained from the EMEP/EEA emission inventory guidebook. The results provide a good indication as to which sources are contributing the most to the overall uncertainty, and therefore where improvement effort should be targeted.

The methodology and results of the Tier 1 uncertainty analysis are presented in detail in Annex G, tables G.1 to G.6. The results can be summarised as follows:

**Table 1.3 Emissions Uncertainties**

Pollutant	Emission (kilotonnes, 2018)	Uncertainty in 2018 (%)	Trend Uncertainty 1990-2018 (%)
NO <sub>x</sub>	109.92	44.5	14.7
SO <sub>2</sub>	12.26	11.6	0.6
NMVOC	109.81	79.9	25.5
NH <sub>3</sub>	119.35	87.9	8.7
CO	78.06	17.2	1.6
PM <sub>2.5</sub>	12.13	96.1	15.3

The total uncertainty in the NO<sub>x</sub> emission in 2018 is dominated by the contribution inorganic N-fertilisers (3.D.a.1), animal manure applied to soils (3.D.a.2.a) and urine and dung deposited by grazing animals (3.D.a.3), ±200 per cent for each sub category of 3.D. These three categories combined account for 98.0 per cent of the total NO<sub>x</sub> emissions uncertainty. The next largest contributor to uncertainty for NO<sub>x</sub> emissions is landfill gas used as a fuel in Public electricity and Heat Production with an emission factor uncertainty of over 300 per cent.

Emissions of SO<sub>2</sub> are well characterised when compared to NO<sub>x</sub> for most emissions because they are combustion related, with emission factors for SO<sub>2</sub> (i.e. the sulphur content of the fuel) more readily determined than for NO<sub>x</sub>. Solid fuel combustion, coal, biomass and peat in the residential sector combined account for 91.9 per cent of the overall uncertainty.

Emissions of NMVOC from non-combustion sources are typically high in uncertainty because they are difficult to characterise by measurement. Manure management from cattle (3.B.1.a & 3.B.1.b) contributes to 92.6 per cent of the overall uncertainty because of the magnitude of the emission of these categories (33.1 per cent in 2018) and, as with all manure management categories, has poorly characterised emission factors (±300 per cent). Fugitive NMVOC losses from fuel extraction and

distribution (1.B.2) and domestic solvent use (2.D.3.a) are large contributors because they have poorly characterised emission factors and activity data, respectively.

The uncertainty associated in NH<sub>3</sub> emissions are driven by the emission factors, with the activity data; number of livestock and nitrogen amounts, typically being well characterised by comparison. The sources making the largest contributions to the overall uncertainty are ammonia losses from inorganic N-fertiliser use (3.D.a.1), animal manure applied to soils (3.D.a.2.a) and urine and dung deposited by grazing animals (3.D.a.3). The emission factors for these sources are currently assigned an uncertainty of ±200 per cent, and they contribute to 97.1 per cent of the overall uncertainty.

Emissions of PM<sub>2.5</sub> are generally high in uncertainty because many combustion sources are either not well characterised, or are variable in emission, with small changes to combustion conditions having very large impacts on PM<sub>2.5</sub> emissions. Residential coal, biomass and peat combustion (1.A.4.b) and road paving with asphalt (2.D.3.b) are the largest contributors to the overall uncertainty, contributing 98.4 per cent and 0.8 per cent respectively. These are relatively large sources with very uncertain emission factors.

It is interesting to note that electricity generation and industrial combustion do not feature as major contributors to the overall uncertainty for any pollutants. This is because the use of point specific data allows the emission estimates to be particularly well characterised.

## Chapter Two

# Analysis of Key Emission Trends

### 2.1 Introduction

Ireland's 2020 submission under the CLRTAP and the Directive (EU) 2016/2284 includes emission estimates for the period 1990–2018 in respect of all substances listed in Section 1.4.2 above. The primary emission time series is prepared on the basis of Ireland's published national energy balances, which record the amounts of fuels sold in the country. In recognition of the significant cross-border movement that occurs with respect to automotive fuels in some parts of Europe, the reporting guidelines allow for the reporting of emissions from road transport on the basis of fuels used within the country. This may result in a significant decrease in the national total emissions for some pollutants and the adjusted total is considered more appropriate for the assessment of performance in relation to certain protocols. This issue is relevant to Ireland in the case of the Sofia Protocol on NO<sub>x</sub> emissions and, to facilitate the assessment, Ireland has also submitted inventories in which the estimates for road transport are based on fuels used in the country. Emission inventories based on fuel sold and fuel used are provided in this submission for all pollutants for the period 1990–2018 and for the year 1987, the base year for the Sofia Protocol.

This chapter provides an overview of the emission trends for the period 1990–2018 for all substances included in Ireland's 2020 submission under the CLRTAP and NECD. The general analysis of trends is performed only in respect of emissions estimated on the basis of fuels sold in Ireland.

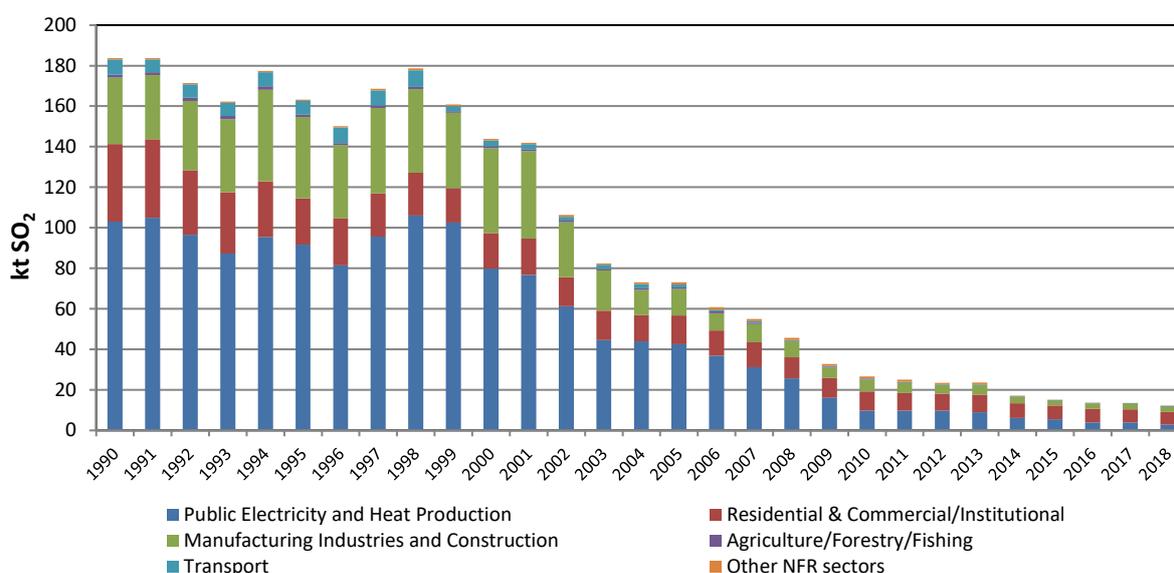
### 2.2 Main Pollutants

#### 2.2.1 Sulphur Dioxide (SO<sub>2</sub>)

Total sulphur dioxide emissions decreased by 93.3 per cent, from 183.64 kt in 1990 to 12.26 kt in 2018 (Figure 2.1). The Commercial/Institutional and Residential (1A4a and 1A4b) sectors combined account for 51.7 per cent of the total in 2018, and decreased by 83.5 per cent between 1990 (38.28 kt) and 2018 (6.34 kt). The Public Electricity and Heat Production (1A1a) sector remains one of the main sources of SO<sub>2</sub> emissions, contributing 23.2 per cent of the total in 2018, and decreased by 97.2 per cent between 1990 (103.04 kt) and 2018 (2.84 kt). An increase in consumption of coal, peat and oil in this sector in 1994 followed by decreased peat and oil consumption the following year caused a peak in emissions in 1994.

In 1998 an increase in consumption of coal followed by a decrease the following year caused another peak in emissions in 1998. Combustion sources in the Manufacturing Industries and Construction (1A2) sector largely account for the remainder of the emissions, with contribution of 21.8 per cent in

2018. Emissions in this sector peaked in 1994 due to an increase in SO<sub>2</sub> from oil combustion in the installation which is the main contributor to emissions in Non-ferrous metals (1A2b). Emissions in Manufacturing Industries and Construction (1A2) have decreased in the 1990-2018 time series by 91.9 per cent. Combustion in Agriculture/Forestry/Fishing (1A4c) sector accounts for 0.3 per cent and Transport (1A3) combustion sources account for 2.1 per cent of national total emissions of SO<sub>2</sub> in 2018. The remainder of the SO<sub>2</sub> emissions arise from combustion sources in the Petroleum Refining (1A1b) and Manufacture of Solid Fuels and Other Energy Industries (1A1c) sectors, Other Product Use (2G) Waste Incineration (5C1), which combined account for 1.1 per cent of the total in 2018 and are presented in Other NFR sectors in Figure 2.1. In 1990, coal combustion accounted for 51.4 per cent of SO<sub>2</sub> emissions and fuel oil contributed 30.3 per cent. By 2018, the share of SO<sub>2</sub> emissions from coal had decreased to 42.9 per cent and that from fuel oil had decreased to 7.6 per cent.



**Figure 2.1 Emission Trend for Sulphur Dioxide 1990–2018**

### 2.2.2 Nitrogen Oxides (NO<sub>x</sub>)

Total nitrogen oxides emissions have decreased by 38.4 per cent, from 174.92 kt in 1990 to 107.76 kt in 2018 (Figure 2.2). Road Transport (1A3b) is the principal source of NO<sub>x</sub> emissions, contributing 33.4 per cent (and 35.97 kt) of the total in 2018, with the transport sector as a whole accounting for 40.6 per cent (and 43.70 kt) of the national total. The Manufacturing Industries and Construction (1A2) sector accounts for an increasing percentage of the national total. The contribution of the sector in 1990 to the national total was 5.1 per cent (8.93 kt), which increased to 12.0 per cent share in 2007 (and 18.42 kt) as a result of the increases in cement production for construction during the economic boom in Ireland over the previous decade then reduced to 8.3 per cent share (8.46 kt) of the national total in 2011 due to the economic crisis impacting upon the sector. In 2018 the sector contribution increased to a 8.7 per cent share (and 9.42 kt) of the national total largely driven by an increase in cement production.

The Public Electricity and Heat Production (1A1a) sector is another main source of NO<sub>x</sub> emissions, accounting for 6.3 per cent of emissions in 2018. Emissions from this sector have decreased by 85.5 per cent between 1990 (46.37 kt) and 2018 (6.74 kt). Commercial/Institutional and Residential (1A4a

and 1A4b) sectors combined account for 7.4 per cent of the total and combustion sources in Agriculture/Forestry/Fishing (1A4c) sector account for 4.2 per cent in 2018. The remainder of the combustion sources of NO<sub>x</sub> arise in the Petroleum Refining (1A1b) and Manufacture of Solid Fuels and Other Energy Industries (1A1c) sectors, as well as combustion sources in Other product Use (2G) and the Waste sector (5C1), which are presented in Other NFR sectors that together account for 0.5 per cent of the total in 2018. Agricultural sources of NO<sub>x</sub>, accounted for 32.4 per cent of emissions in 2018 (34.93 kt), having increased by 6.1 per cent since 1990 (32.92 kt).

The largest sources of NO<sub>x</sub> emissions within agriculture are associated Inorganic fertilizer application (3Da1) and Urine and Dung Deposited by grazing animals (3Da3).

The reductions in NO<sub>x</sub> emissions arising from the use of catalytic converters in cars and heavy-duty vehicles have only become apparent in recent years, as the technology has been offset by large increases in vehicle numbers in the past 10 years. This effect is exaggerated in later years by so-called fuel tourism, whereby a significant proportion of the automotive fuel sold in Ireland – the basis for the emission time series given in Figure 2.2 – is used by vehicles in other countries. The estimated level of fuel tourism is given in Annex A.3, together with the adjusted annual NO<sub>x</sub> emissions based on fuels used in Ireland, which is relevant to the assessment of obligations in relation to the Sofia Protocol on NO<sub>x</sub> emissions.

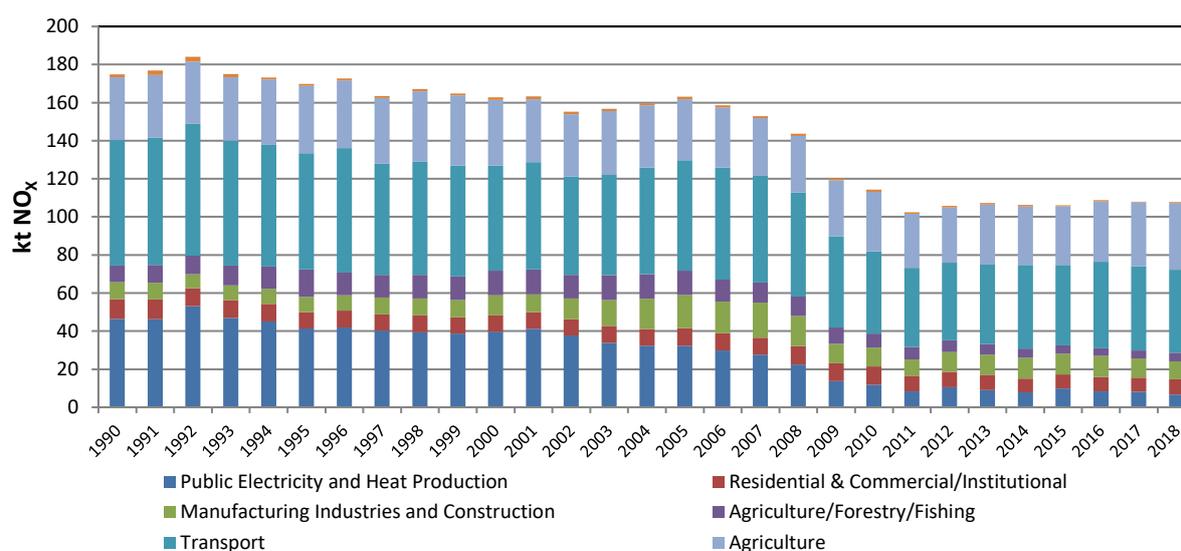


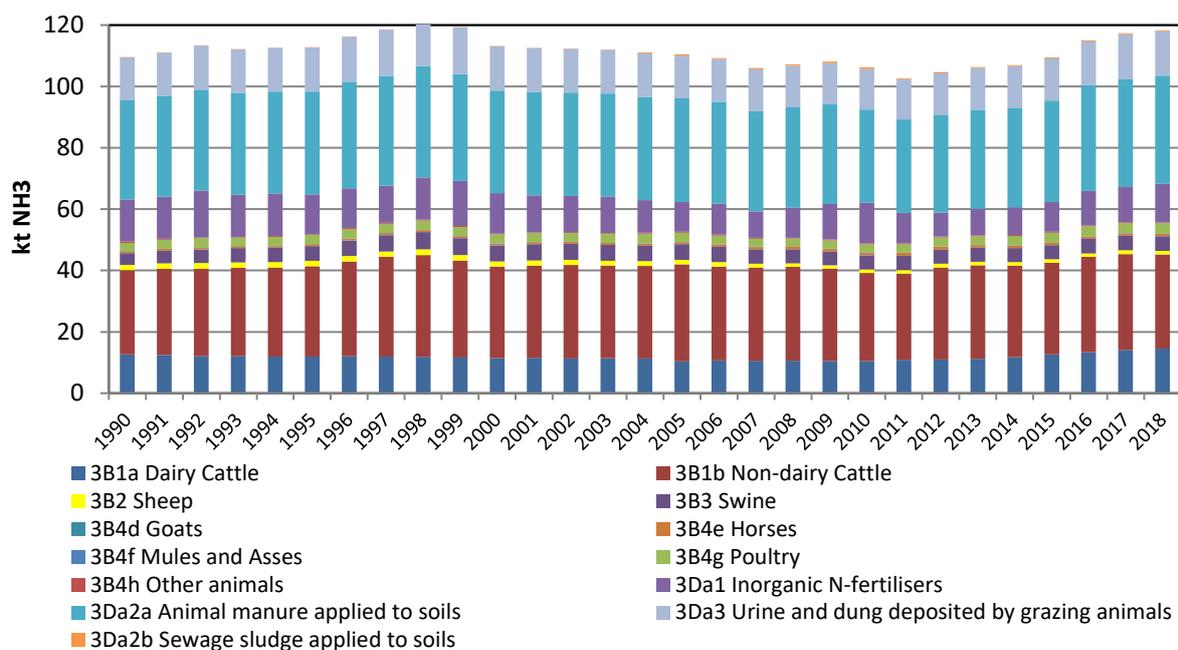
Figure 2.2 Emission Trend for Nitrogen Oxides 1990–2018

### 2.2.3 Ammonia (NH<sub>3</sub>)

Total ammonia emissions have increased by 7.9 per cent, from 109.8 kt in 1990 to 119.3 kt in 2018 (Figure 2.3). Livestock production has historically accounted for the bulk of national total ammonia emissions in Ireland and, in 2018, Manure Management (3B) and animal manure applied to soil (3Da2a) and nitrogen from urine and dung deposition by grazing animals combined accounted for 88.6 per cent of the national total. In 2018, Manure Management at 55.68 kt and 46.7 per cent share of the total in 2018 showed an increase by 12.6 per cent from 49.46 kt in 1990. Organic Fertilisers cover emissions from the two sectors: Animal Manure applied to soils (3Da2a) and Sewage Sludge applied

to soils (3Da2b), which combined at 35.56 kt accounted for 29.8 per cent of the total ammonia emissions in 2018 (indicating an 9.7 per cent increase from 32.40 kt in 1990). Urine and Dung deposited by grazing animals (3Da3) accounted for 12.2 per cent of total emissions in 2018 (14.50 kt), having increased by 4.2 per cent since 1990. Inorganic N-fertilizers applied to soils (sector 3Da1) decreased by 8.2 per cent from 1990 (13.69 kt) and at 12.57 kt in 2018 accounted for 10.5 per cent of the national total. The small contribution by Transport (1A3) sources peaked in 2005, the main driver of which has been the increased use of cars with early generation three way catalysts in Road Transport (1A3b). Transport emissions have increased from 0.05 kt in 1990 to 0.59 kt (and 0.5 per cent share of the total) in 2018. The remainder of the ammonia emissions arise from Commercial/Institutional and Residential (1A4a and 1A4b) sectors combined (0.1 per cent share) and Other NFR sectors (Combustion in Manufacturing Industries and Construction (1A2), Combustion in off road Agricultural machinery (1A4cii), Other Product Use (2G), Biological Treatment of Waste (5B1)) that together account for 0.04 per cent of the total in 2018.

Within livestock production, Manure Management (3B) at 55.68 kt in 2018 is the largest source of NH<sub>3</sub>. In Ireland, approximately two-thirds of animal manure is excreted at pasture annually, reflecting the relatively short period that the main livestock categories (cattle and sheep) are housed.



**Figure 2.3 Emission Trend for Ammonia 1990–2018**

Dairy Cattle (3B1a) and Non-Dairy Cattle (3B1b) account for the major part (38.2 per cent) of Agriculture sector ammonia emissions in 2018. Other livestock, which includes Sheep (3B2), Swine (3B3), Goats (3B4d), Horses (3B4e), Mules and asses (3B4f), Poultry (3B4g) and Other animals (3B4h), combined account for 8.8 per cent of total ammonia emissions from agriculture in 2018 (Figure 2.3). Throughout the 1990s, the cattle herd increased to reach a peak in 1998 of 7.6 million head, which along with associated increases in fertiliser nitrogen consumption increased ammonia emission totals from the whole agriculture sector, from 109.48 kt in 1990 to 122.19 kt in 1998. As a result of reforms to the Common Agricultural Policy (CAP), animal numbers and associated fertiliser nitrogen use have reduced, and ammonia emissions in agricultural sectors had fallen to 102.61 kt in 2011. However, in

response to growth plans for the agriculture sector in Ireland, emissions have increased in recent years with a total of 118.31 kt in 2018 largely as a result of increased dairy cattle and other cattle populations, increased fertilizer use and use of urea as an inorganic fertilizer.

## 2.2.4 Non-Methane Volatile Organic Compounds (NMVOCs)

Total non-methane volatile organic compound emissions have decreased by 23.3 per cent, from 143.09 kt in 1990 to 109.78 kt in 2018 (Figure 2.4). The NMVOC emissions are determined largely by the Agriculture sectors: 3B Manure Management and 3Da1 Inorganic N-fertilizers and emissions from solvents and other product use and the food and beverages industry. The Agriculture categories combined accounted for 39.4 per cent of the national total and showed an increase by 17.6 per cent between 1990 (36.76 kt) and 2017 (43.25 kt). The combined solvents use (2D and 2G) and fugitive emissions from oil sectors emissions (1.B.2.a) produced 20.8 per cent of the 2018 total of NMVOC emissions in Ireland, having decreased by 14.6 per cent between 1990 (26.80 kt) and 2018 (22.89 kt). The Food and Beverage Industry (2H2) contributed to 24.4 per cent of total emissions in 2018, having increased by 178.7 per cent from 9.62 kt in 1990 to 26.80 kt in 2018.

Combustion sources in the Residential (1A4b) and Commercial/Institutional (1A4a) sectors are also important sources, accounting for 7.5 per cent of national total NMVOC emissions in 2018, a reduction of 71.7 per cent between 1990 (28.99 kt) and 2018 (8.21 kt). Technological controls for volatile organic compounds (VOCs) emitted by motor vehicles have been more successful than in the case of NO<sub>x</sub> and have contributed to a significant reduction in emissions from Road Transport (1A3b), with the total transport sector's contribution having decreased by 88.0 per cent between 1990 (36.64 kt) and 2018 (4.40 kt). This equates to contributions to the national total of 25.6 per cent in 1990, falling to 4.0 per cent in 2018. A total of five NFR source categories make up the source Other NFR sectors (Figure 2.4) contributing 0.5 per cent of national total NMVOC emissions in 2018. The largest source of emissions within this categorisation is Solid waste disposal on land sector (5A).

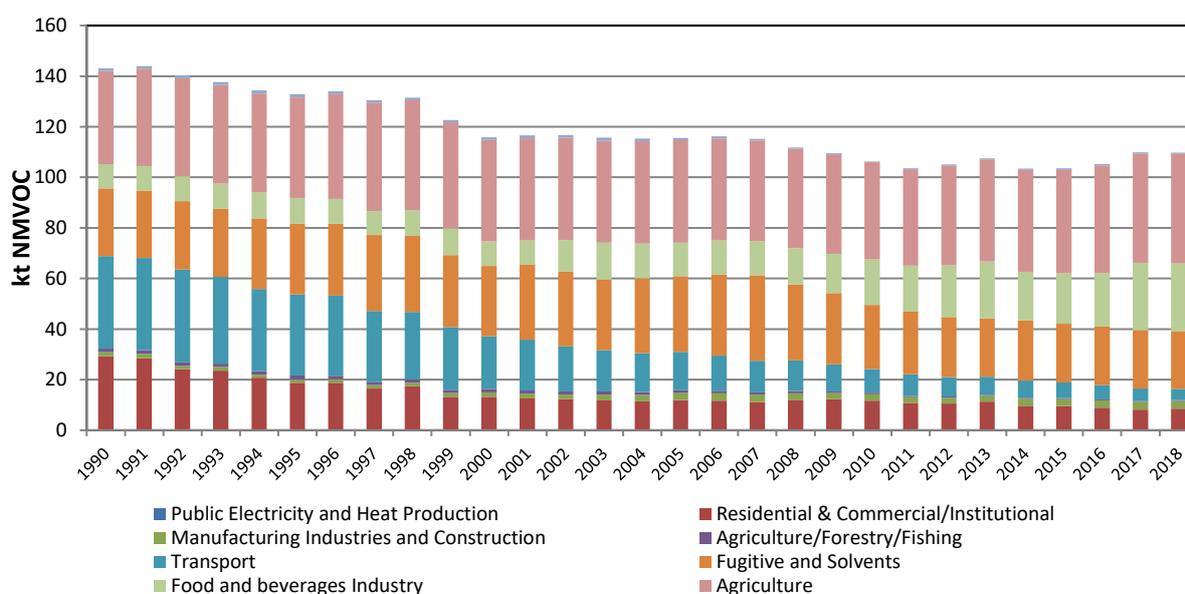
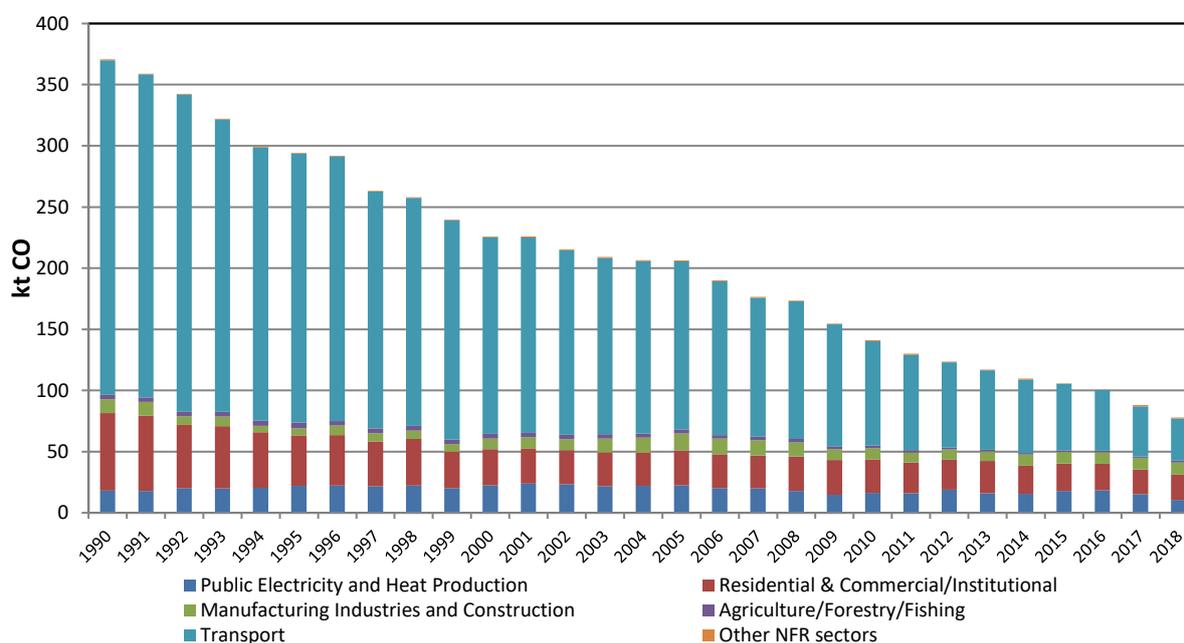


Figure 2.4 Emission Trend for Non-Methane Volatile Organic Compounds 1990–2018

## 2.2.5 Carbon Monoxide (CO)

Carbon monoxide emissions continue to decline, driven by major reductions due to three way catalysts in gasoline vehicles in Road Transport (1A3b), which is the principal source of CO, and a large decrease in the use of solid fuels for space heating in the Residential (1A4b) sector (Figure 2.5). National total CO emissions have reduced from 370.62 kt in 1990 to 77.76 kt in 2018, a reduction of 79.0 per cent.

The Transport sector accounted for 44.5 per cent of national total emissions in 2018, a major reduction (87.4 per cent) from 273.69 kt in 1990 to 34.62 kt in 2018. Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined are another important source, accounting for 26.8 per cent of national total CO emissions in 2018, a reduction of 67.2 per cent between 1990 (63.47 kt) and 2018 (20.84 kt). Public Electricity and Heat Production (1A1a) sector reached its peak in 2001 (23.82 kt) and has decreased by 51.2 per cent to reach 10.42 kt in 2017, a reduction of 42.6 per cent on 1990 levels (18.14 kt). Combustion sources from Manufacturing Industries and Construction (1A2) account for 12.8 per cent of the national total in 2018 and at 9.93 kt showed a 10.2 per cent decrease on their 1990 levels (11.06 kt). Agriculture/Forestry/Fishing (1A4c) combustion sources account for 1.7 per cent of the total CO emissions in 2018. Petroleum refining (1A1b), Manufacture of solid fuels and other energy industries (1A1c), Other Product Use (2G), Biological Treatment of waste (5B1) and Waste incineration (5C) emissions form the Other NFR sectors category and combined account for the remainder of CO emissions (0.8 per cent of the total) in 2018.



*Figure 2.5 Emission Trend for Carbon Monoxide 1990–2018*

## 2.3 Particulate Matter

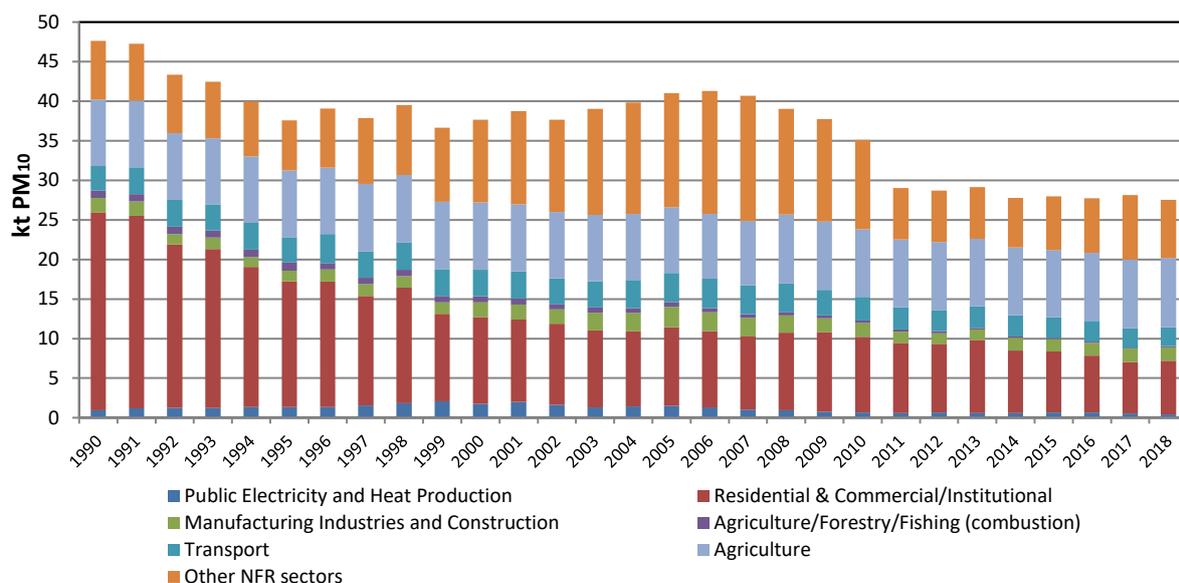
Particulate matter emission estimates include PM with diameter less than 10  $\mu\text{m}$  ( $\text{PM}_{10}$ ), PM with diameter less than 2.5  $\mu\text{m}$  ( $\text{PM}_{2.5}$ ) and total suspended particulates (TSP).

### 2.3.1 Particulate Matter <10 µm Diameter (PM<sub>10</sub>)

Emissions of particulate matter <10 µm diameter amounted to 27.52 kt in 2018, a 42.2 per cent reduction from 47.61 kt in 1990 (Figure 2.6). The main determinant of the trend in PM<sub>10</sub> emissions is Agriculture sector with 31.7 per cent share of the national total, and combustion in the Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined with 24.6 per cent share of the total in 2018.

Emissions from Agriculture arise from Inorganic N-fertilizers (3Da1), Farm-level agricultural operations including storage, handling and transport of agricultural products (3Dc), Off-farm storage, handling and transport of bulk agricultural products (3Dd) and Manure Management (3B) categories that together in 2018 at 8.73 kt indicated a 4.1 per cent increase on their 1990 levels. Part replacement of coal and peat in the Residential (1A4b) and Commercial/Institutional (1A4a) sectors are the second largest contributor to the total PM<sub>10</sub> emissions, with 72.9 per cent reduction in emissions from these sectors, from being the largest contributor to the PM<sub>10</sub> emissions (52.5 per cent of national total emissions) at 24.99 kt in 1990, emissions have fallen to 6.76 kt in 2018 (and 24.6 per cent of the national total emissions). Emissions from Transport (1A3), at 8.7 per cent share of the total in 2018 increased throughout the 1990s with increased total vehicle kilometre travel particularly of diesel vehicles. However, the effect of the increase in vehicle numbers seen over the last decade has been offset somewhat by changes in the age structure of the national fleet and developments in diesel fuel technology resulting in Transport emissions decreasing by 23.3 per cent (from 3.12 kt in 1990 to 2.40 kt in 2018).

Manufacturing Industries and the Construction sector (1A2) used to account for an increasing percentage of the national total PM<sub>10</sub>, until reaching its peak of 2.58 kt in 2005. This is also evident with some other pollutants, and is due to the increase in cement production post-2000 following the entry into the market of two new plants. Emissions for this sector have decreased since 2005, and accounted for 6.2 per cent of the national total in 2018 (1.70 kt), representing a decrease across the 1990-2018 time series of 5.6 per cent. Public Electricity and Heat Production (1A1a) sector emissions accounted for 1.6 per cent of the national total in 2018 and at 0.44 kt reduced by 54.5 per cent from 1990 levels (0.96 kt). The decrease was due to the increased use of natural gas and wind for electricity generation, in proportion to coal and peat which still account for a large share of the fuel mix used. More recently Ireland's only coal fired electricity generation station has been running at much reduced capacity levels. Petroleum refining (1A1b), Manufacture of solid fuels and other energy industries (1A1c), Fugitive emissions from solid fuels: Coal mining and handling (1B1a), Quarrying and mining of minerals other than coal (2A5a), Construction and demolition (2A5b), Road paving with asphalt (2D3b), Other solvent use (2D3i), Other product use (2G), Biological treatment of waste – solid waste (5A), Incineration (5C) and Other waste (5E) are included under the other NFR sectors heading, which combined accounted for 26.7 per cent of national emission in 2018. The largest contributors are within the other NFR grouping are Quarrying and mineral of minerals other than coal (2A5a) and Road paving with asphalt (2D3b).



**Figure 2.6 Emission Trend for Particulate Matter <10 µm in Diameter 1990–2018**

### 2.3.2 Particulate Matter <2.5 µm Diameter (PM<sub>2.5</sub>)

National total emissions of particulate matter <2.5 µm diameter amounted to 12.04 kt in 2018, a 62.8 per cent reduction on 32.40 kt in 1990 (Figure 2.7). Emissions from Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined are the main determinant of the trend with their 54.9 per cent share of the national total PM<sub>2.5</sub> emissions in 2018. There has, however, been a reduction of 73.0 per cent in emissions from these sectors between 1990 (24.48 kt and 75.6 per cent share) and 2018 (6.61 kt). Reduced use of coal and peat, with increased use of gasoil, kerosene and natural gas in the two sectors has resulted in lower emissions and a reduction in the contribution to the national total.

Emissions from Agriculture arise from Manure Management (3B), Inorganic N-fertilizers (3Da1), Farm level agricultural operations including storage, handling and transport of agricultural products (3Dc), Off-farm storage, handling and transport of bulk agricultural products (3Dd) sectors that together in 2017 at 0.89 kt accounted for 7.4 per cent of the national total and indicated a 7.1 per cent increase on their 1990 levels (0.83 kt). Transport (1A3) contributed 1.66 kt (13.8 per cent share) to the national total in 2018. Emissions from Transport sector (1A3), dominated by Road Transport (1A3b) increased from 1990 (2.79 kt) to a peak in 1996 (3.22 kt), but have been decreasing since 2005, with a 40.6 per cent reduction between 1990 and 2018 which is largely due to technological advances and the age structure of the national fleet which in turn have been balanced by the increases in vehicle numbers over the time series (see comments in section 2.3.1 on the trends of PM<sub>10</sub> emissions). Emissions from Manufacturing Industries and Construction (1A2) at 1.57 kt in are similar with equating to current emission being 1.4 per cent below those in 1990.

Electricity and Heat Production (1A1a) sector accounts for 2.3 per cent of the national total emissions in 2018, a reduction of 56.3 per cent from 0.65 kt in 1990 and 0.28 kt in 2018. Combustion from the Agriculture/Forestry/Fishing sector accounted for 1.2 per cent of national total PM<sub>2.5</sub> emissions in 2018 and has reduced by 84.6 per cent from 1990 when emissions were 0.93 kt, compared to 0.14 kt in 2018. The remainder of the PM<sub>2.5</sub> emissions arise from Petroleum refining (1A1b), Manufacture of

solid fuels and other energy industries (1A1c), Fugitive emissions from solid fuels: Coal mining and handling (1B1a), Quarrying and mining of minerals other than coal (2A5a), Construction and demolition (2A5b), Storage, handling and transport of mineral products (2A5c), Road paving with asphalt (2D3b), Other solvent use (2D3i), Other product use (2G), Biological treatment of waste – solid waste (5A), Incineration (5C) and Other waste (5E) are included under the other NFR sectors heading, which combined accounted for 7.5 per cent of national emission in 2018.

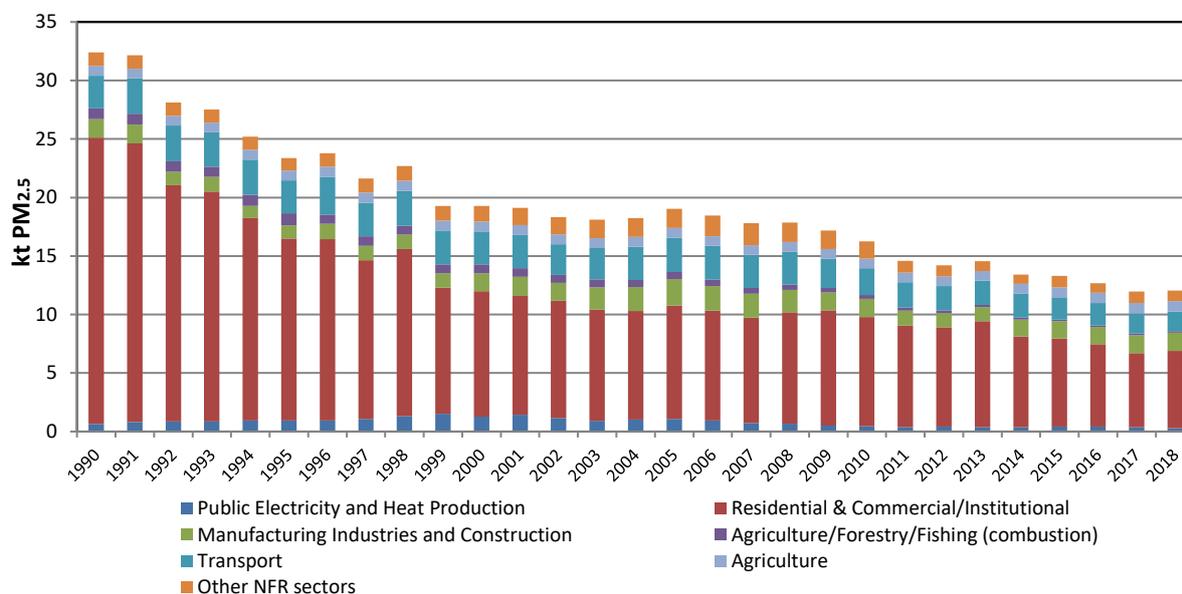
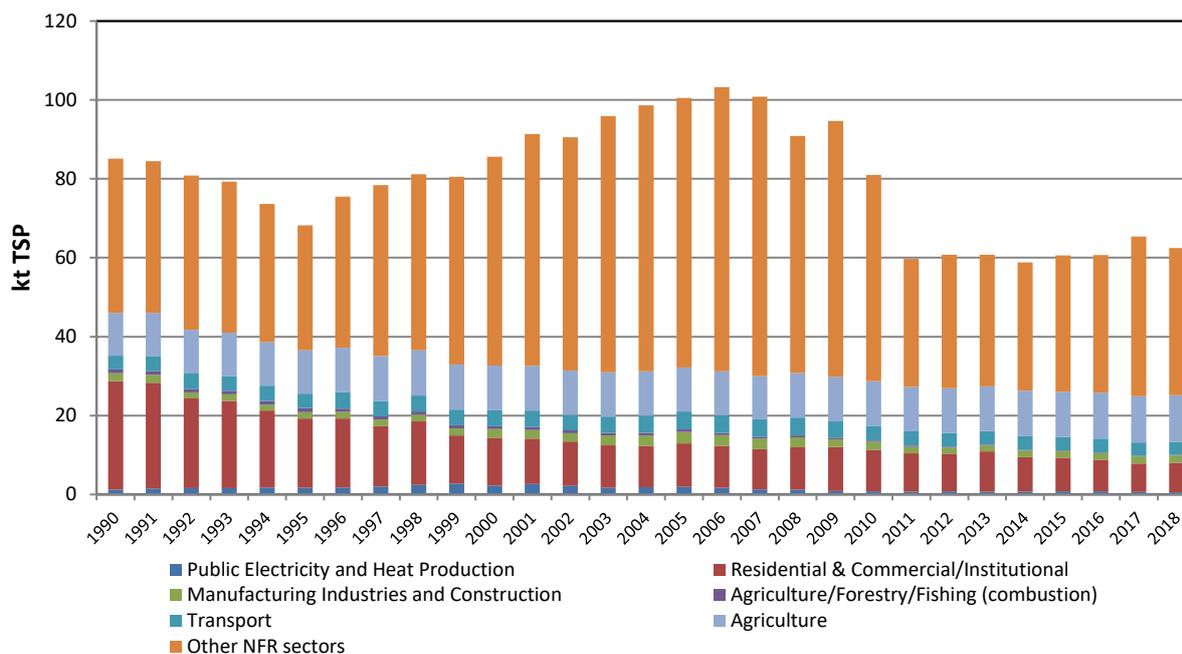


Figure 2.7 Emission Trend for Particulate Matter <2.5 μm in Diameter 1990–2018

### 2.3.3 Total Suspended Particulates (TSP)

Total suspended particulate emissions have decreased by 26.6 per cent, from 85.16 kt in 1990 to 62.48 kt in 2018 (Figure 2.8). The main driver of the TSP trend is emissions from Other NFR sectors which includes a wide range of source categories namely Petroleum refining (1A1b), Manufacture of solid fuels and other energy industries (1A1c), Fugitive emissions from solid fuels: Coal mining and handling (1B1a), Quarrying and mining of minerals other than coal (2A5a), Construction and demolition (2A5b), Storage, handling and transport of mineral products (2A5c), Road paving with asphalt (2D3b), Other solvent use (2D3i), Other product use (2G), Biological treatment of waste – solid waste (5A), Incineration (5C) and Other waste (5E) which combined accounted for 59.8 per cent of the national total in 2018. Road paving with asphalt (2D3b) accounts for the majority of emissions within this grouping (82.4 per cent). Emissions from the Other NFR sectors have reduced by 4.5 per cent from 39.11 kt in 1990 to 37.34 kt in 2018. Emissions from the agriculture (NFR 3) sector were 11.83 kt (and 18.9 per cent share of the total) in 2018, a 9.1 per cent increase from 1990 levels (10.84 kt). Combined emissions from Residential (1A4b) and Commercial/Institutional (1A4a) sectors were the third largest contributor to the total TSP emission in 2018. There has been, similar to emissions from both PM<sub>10</sub> and PM<sub>2.5</sub>, a reduction of 72.9 per cent in emissions from these sectors between 1990 (27.49 kt) and 2017 (7.44 kt). In the time series, the part replacement of coal and peat with natural gas, gasoil and kerosene has resulted in the contribution of these sectors falling from 32.3 per cent of the national total in 1990 to 11.9 per cent in 2018.



**Figure 2.8 Emission Trend for Total Suspended Particulates 1990–2018**

Emissions from Transport (1A3) decreased by 5.3 per cent to 2018 (3.30 kt and 5.3 per cent share of national total) compared to 1990 (3.50 kt and 4.1 per cent share). Manufacturing Industries and Construction (1A2) account for an increasing proportion of emissions post-2000 as a result of the entry into the market of two new cement production plants (Non-metallic minerals, 1A2f). Emissions from the 1A2 sector had their peak in 2005 (2.93 kt) and although have been generally declining since, emissions increased 26.4 per cent between 2013 and 2018. At 1.87 kt in 2018 (3.0 per cent of the total) emissions have decreased from 2005 by 36.0 per cent and by 8.1 per cent from 1990 (2.04 kt). Public Electricity and Heat Production sector (1A1a) emissions have decreased by 55.7 per cent over the time series, from 1.23 kt in 1990 to 0.54 kt (and 0.9 per cent share of the total emissions) in 2018. Emissions from Agriculture/Forestry/Fishing in 2018 (0.15 kt, 0.2 per cent of the national total) have decreased by 83.7 per cent since 1990 (0.94 kt).

### 2.3.4 Black Carbon (BC)

Black Carbon emissions have decreased by 55.5 per cent, from 4.16 kt in 1990 to 1.85 kt in 2018 (Figure 2.9). The main driver of the BC trend is emissions from Transport (1A3). Emissions from the sector have reduced by 41.9 per cent between 1990 (1.38 kt) and 2018 (0.80 kt). Combined emissions from Residential (1A4b) and Commercial/Institutional (1A4a) sectors were the second largest contributor to total BC emissions in 2018. In 2018, combined emissions from the sectors were 0.55 kt (29.8 per cent share) and have reduced by 69.7 per cent since 1990 (1.82 kt). Manufacturing Industry and Construction (1A2) emissions accounted for 20.8 per cent of the total in 2017 (0.38 kt) having increased by 13.4 per cent since 1990 (0.34 kt). Emissions from Agriculture/Forestry/Fishing in 2017 were 0.07 kt, which equates to an 86.0 per cent reduction on 1990 (0.51 kt). Public Electricity and Heat Production (1A1a) emissions have decreased by 73.1 per cent over the time series, from 0.02 kt in 1990 to 0.01 kt in 2018. The remaining 2.0 per cent in 2018 accounts for emissions from Petroleum

refining (1A1b), Manufacture of solid fuels and other energy industries (1A1c), Road paving with asphalt (2D3b), Other product use (2G), and Industrial waste incineration (5C1bi).

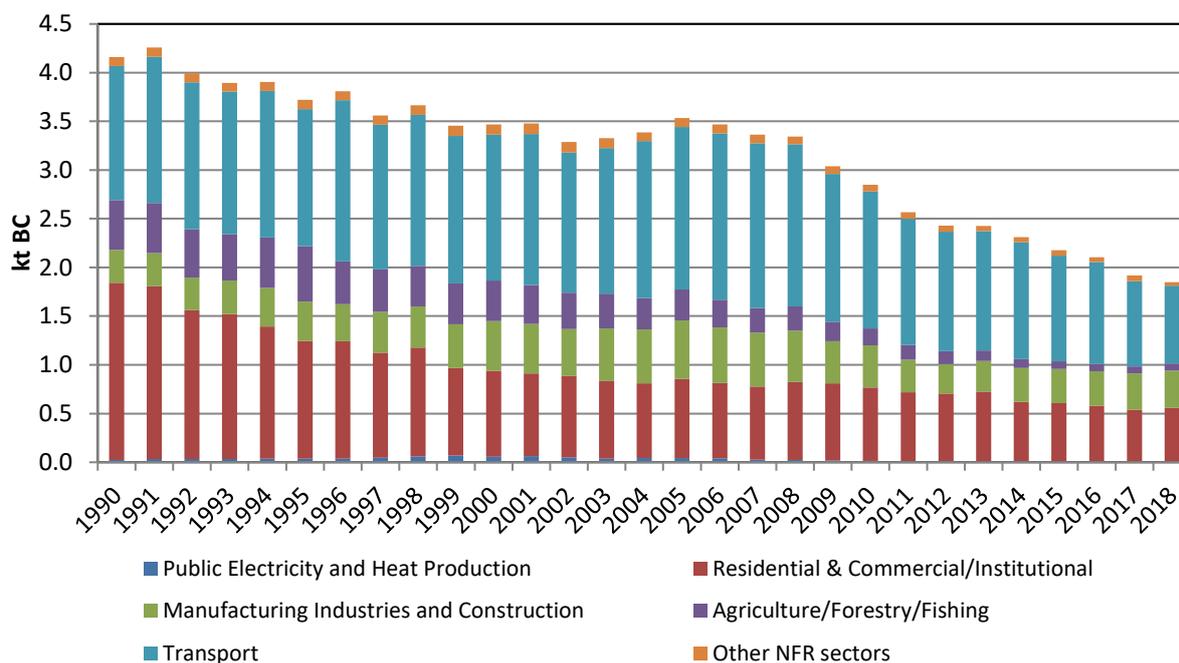


Figure 2.9 Emission Trend for Black Carbon 1990–2018

## 2.4 Priority Metals

### 2.4.1 Lead (Pb)

Over the 1990–2018 time series, total national Pb emissions have decreased by 97.0 per cent, from 170.06 t in 1990 to 5.03 t in 2018 (Figure 2.10). The Pb emissions trend is largely determined by Road Transport (1A3b). Emissions of Pb have decreased considerably since 1990. There was a marked decrease between 1999 and 2000 when the lead content of petrol was reduced. In addition there was an increase in the use of unleaded gasoline in road transport throughout the 1990s and the subsequent phasing out of leaded gasoline in 2000/2001. The contribution of Transport (1A3) to the much-reduced national total emissions has decreased by 99.1 per cent, from 155.68 t (91.5 per cent share) in 1990 to 1.39 t (27.6 per cent share) in 2018.

The second largest contributors to Pb emissions at 42.5 per cent share of national total in 2018 were the Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined. The use of coal and peat in the Residential (1A4b) and Commercial/Institutional (1A4a) sectors is being part replaced with natural gas, gasoil or kerosene. Emissions from these sources have fallen from 7.98 t in 1990 to 2.14 t in 2018, a reduction of 73.2 per cent. Combustion in Manufacturing Industries and Construction (1A2) accounted for 21.4 per cent share of the total in 2018, and emissions from Public Electricity and Heat Production sector (1A1a) were responsible for 7.4 per cent share in 2018. Emissions from Metal Production (2C) have decreased in recent years due to the closure of a number of foundries and were negligible in 2018. Similarly, emissions from Waste Incineration (5C) have also decreased to almost zero as a result of an outright ban on the incineration of clinical wastes in the mid-1990s. Incineration in 5C is now solely in relation to the destruction of vapours.

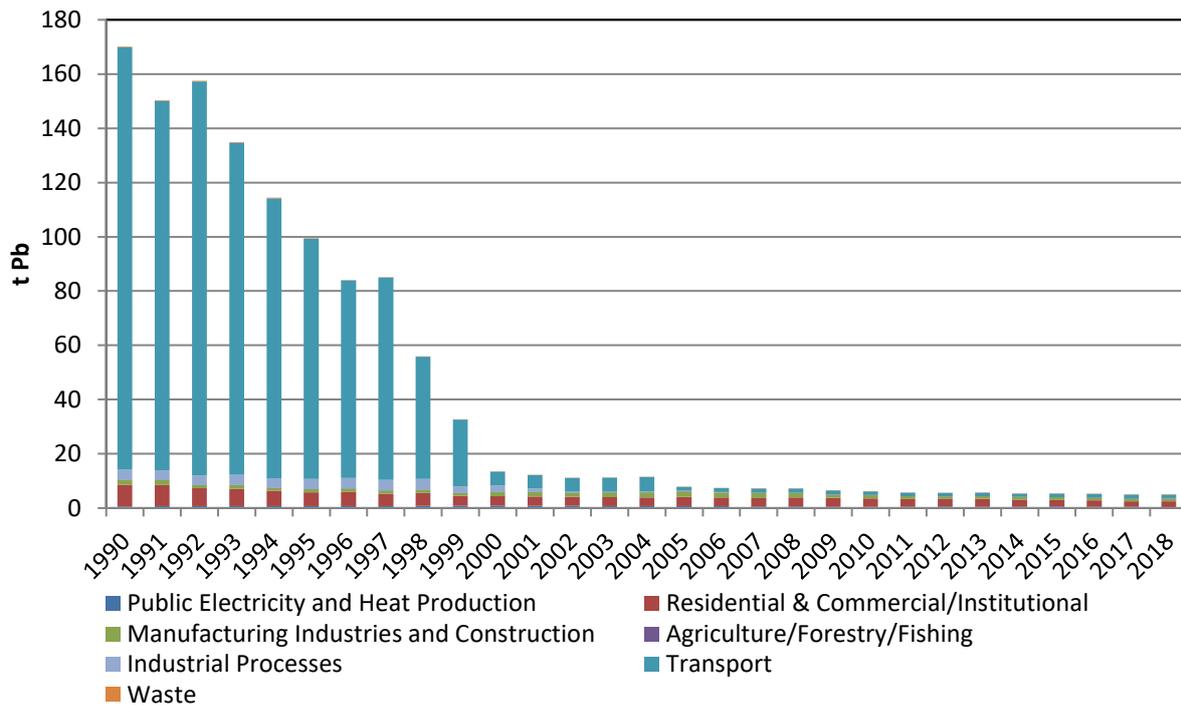


Figure 2.10 Emission Trend for Lead 1990–2018

### 2.4.2 Cadmium (Cd)

Total national emissions of Cd have decreased from 0.60 t in 1990 to 0.28 t in 2018 (Figure 2.11), a reduction of 53.2 per cent. Emissions of cadmium are largely determined by the Manufacturing Industries and Construction (1A2) sector (42.9 per cent share of national total in 2018), specifically combustion sources in Non-Ferrous Metals (1A2b). Across the time series, the contribution of combustion sources within the Manufacturing Industries and Construction (1A2) sector reached its peak in 2005 (0.12 t) subsequently decreasing to 0.08 t in 2012 and increasing back up to 2005 levels in 2014, 2015, 2016, 2017 and 2018. Public Electricity and Heat Production (1A1a) decreased from 1990 by 49.1 per cent and accounted for 16.4 per cent of the national total in 2018. Emissions from this source increased throughout the 1990s as a result of the combustion of increasing quantities of coal and peat for electricity generation. The use of coal has reduced across the time series.

Residential (1A4b) and Commercial/Institutional (1A4a) combustion is also an important source of Cd emissions, with combined emissions from these sectors accounting for 18.1 per cent of the national total in 2018 due to the continued use of the fossil fuels (coal, peat and oil); however, emissions from the sector have fallen by 57.7 per cent, from 0.12 t in 1990 to 0.05 t in 2018. Transport (1A3) sector emissions have been increasing in the time series (by 99.7 per cent) and in 2018 it accounted for 2.9 per cent of the national total cadmium emissions. Combustion sources from Agriculture/Forestry/Fishing (1A4c) sector accounted for 0.7 per cent of the total Cd emissions in 2018. As a result of the closure of the Irish Steel plant in late 2001, emissions from Metal Production (2C) accounted for a 18.6 per cent share in 2018 compared to a 51.7 per cent share (and main contributor to the total) in 1990.

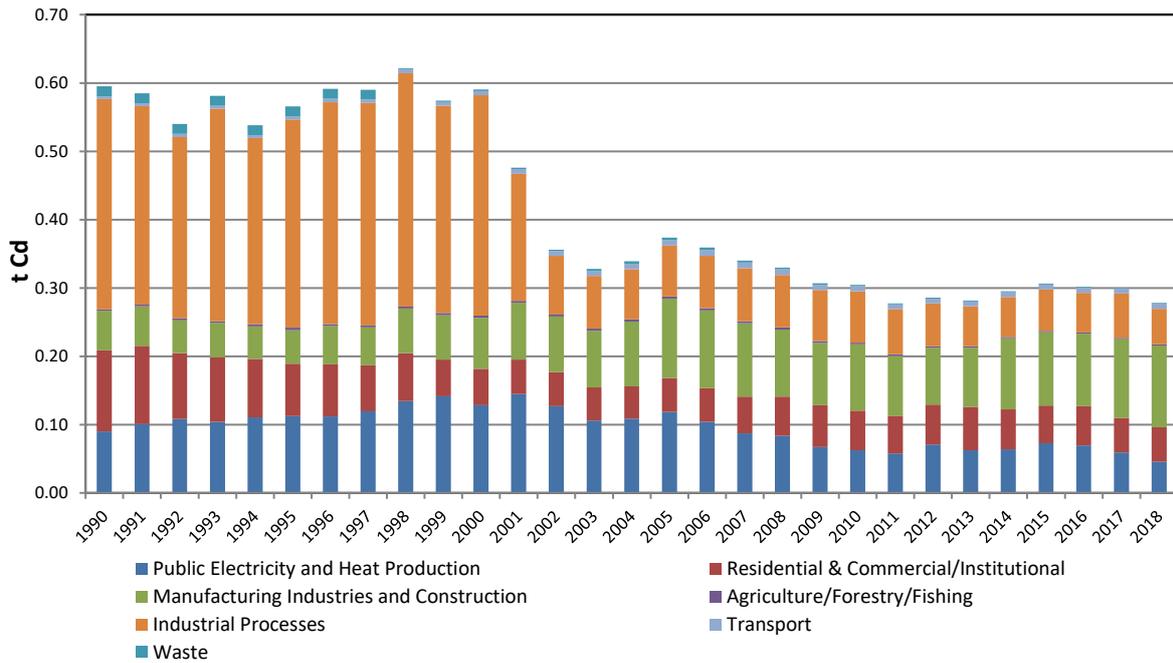


Figure 2.11 Emission Trend for Cadmium 1990–2018

### 2.4.3 Mercury (Hg)

Total national emissions of Hg have decreased from 0.83 t in 1990 to 0.30 t in 2018, a reduction of 63.6 per cent (Figure 2.12). Emissions from Public Electricity and Heat Production (1A1a) decreased by 36.6 per cent in the trend and accounted for 29.6 per cent (the largest source) of national total mercury emissions in 2018 (0.09 t). Emissions from Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined account for the second largest share of national total mercury emissions (29.0 per cent in 2018), having decreased by 71.4 per cent between 1990 and 2018 as a result of an increase in the use of natural gas, kerosene and gasoil and a decrease in the use of coal and peat. Combustion sources in Manufacturing Industries and Construction (1A2) accounted for 22.4 per cent of total emissions in 2018, a 22.1 per cent reduction since 1990. Emissions from this sector are largely dependent on the increased use of petroleum coke and coal as a fuel source in the cement industry after the entry of a number of additional cement producers into the Irish market post-2000 to reach their peak in 2005. The sectoral emissions decreased since 2005 and especially after 2008 when the Irish economy was impacted by the recession.

Biological treatment of waste – Solid waste disposal on land (5A) and Waste Incineration (5C) combined accounted for a 10.3 per cent share of total emissions in 2018. The Transport (1A3) sector accounted for 8.4 per cent and combustion sources from Agriculture/Forestry/Fishing (1A4c) sector accounted for 0.3 per cent of the total Hg emissions in 2018. Glass Production (2A3) and Metal Production (2C) are no longer occurring due to plant closures (glass since 2010 and metal since 2002).

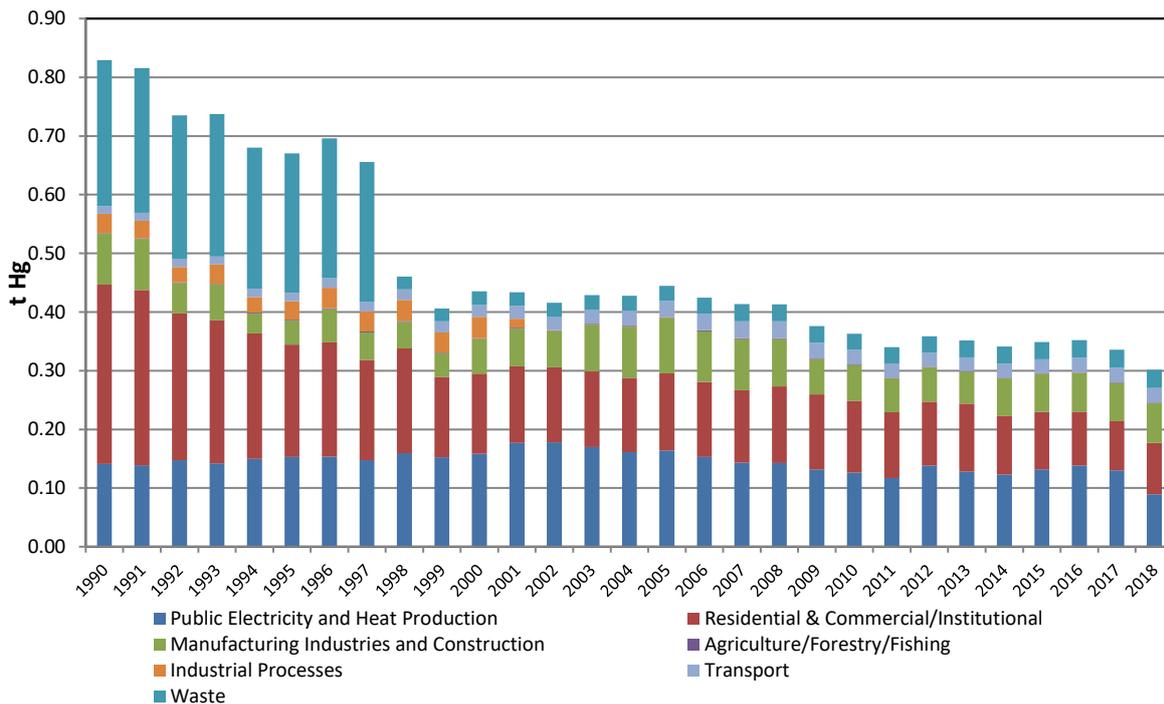


Figure 2.12 Emission Trend for Mercury 1990–2018

## 2.5 Other Metals

### 2.5.1 Arsenic (As)

Emissions of arsenic have decreased by 34.8 per cent from 1.64 t in 1990 to 1.07 t in 2018 (Figure 2.13). These emissions are largely dominated by incineration of hazardous and clinical wastes and crematoria in Waste Incineration sector (5C). Waste Incineration accounted for 60.8 per cent of national total arsenic emissions, having increased by 18.0 per cent from 0.55 t in 1990 to 0.65 t in 2018. The absolute and percentage contributions of this sector are increasing largely due to the increase in the number of cremations undertaken in Ireland which has increased since 1990 and incineration of wood products historically treated with a preservative containing arsenic. Continued use of coal, peat and fuel oil as part of the fuel mix contributes largely (30.1 per cent share of the total in 2018) to the trend in emissions from Public Electricity and Heat Production (1A1a); however, arsenic emissions from the sector have decreased by 47.9 per cent over the time series due to the replacement of less-efficient peat plants with new plant, reductions in the quantities of coal combusted and fuel switching from oil to natural gas and wind energy.

The continued use of fossil fuels in the Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined results in the sectors accounting for 5.0 per cent of national total emissions in 2018, however, they have decreased by 69.0 per cent in the trend. Within the Manufacturing Industries and Construction (1A2) sector, the sub-sector Non-metallic minerals (1A2f) is responsible for the majority of total sector's emissions due to the increase in cement production and associated fuel use in the sector, in particular petroleum coke post-2000 with the entry into the market of new cement plants and reflecting more recent post-recession decrease in production and consequential lower emissions

from the sector. The sector's As emissions contributed 3.5 per cent the total in 2018, a decrease of 42.2 per cent on the 1990 level. Metal Production (2C) is no longer an important source of As emissions, following the closure of the Irish Steel plant in 2001 and a reduction in emissions from Integrated Pollution Prevention and Control (IPPC)-licensed facilities. Emissions from this sector accounted for 13.2 per cent in 1990 (third largest contributor) and are reported as not occurring in 2018 due to the closure of the foundry which was a responsible for emissions from this sector between 2001 and 2013.

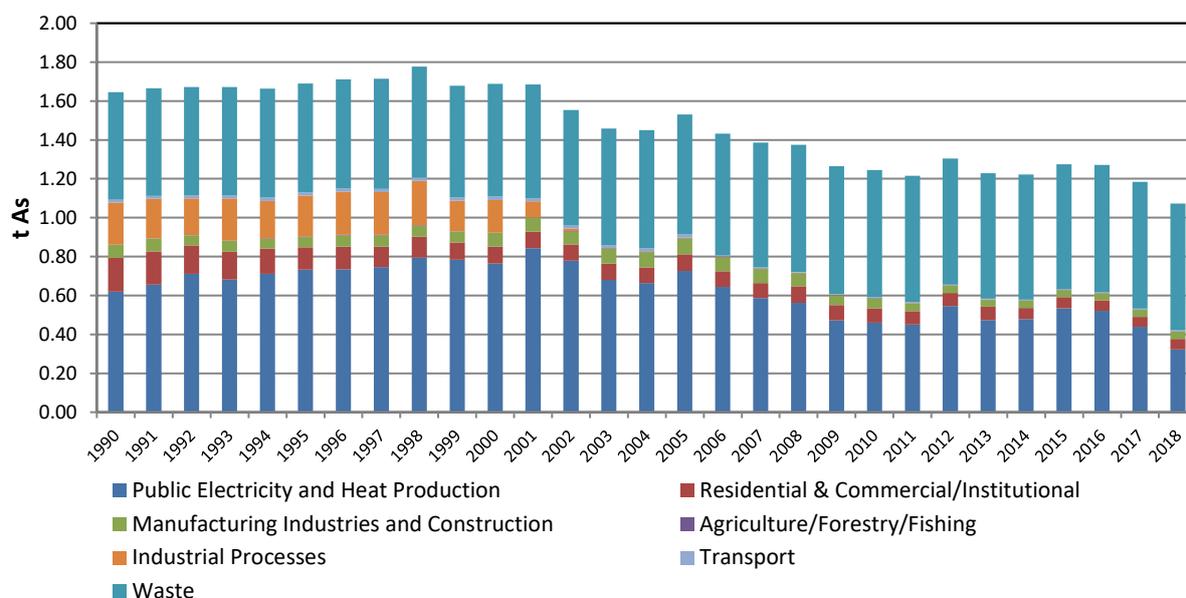


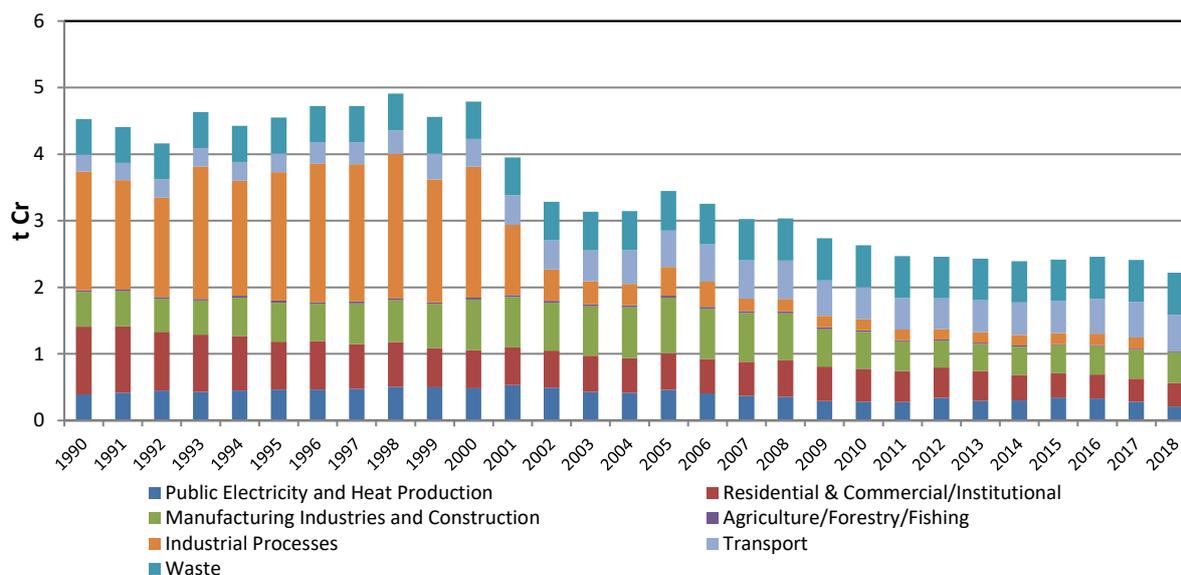
Figure 2.13 Emission Trend for Arsenic 1990–2018

## 2.5.2 Chromium (Cr)

Emissions of Cr have decreased by 51.0 per cent from 4.53 t in 1990 to 2.22 t in 2018 (Figure 2.14). Transport (1A3) and Waste Incineration (5C) sectors are the main two drivers of the chromium trend. The Transport (1A3) sector accounted for 24.6 per cent of estimated national total emissions in 2018. Emissions from this source category have increased by 114.1 per cent over the time series between 1990 (0.25 t) and 2018 (0.54 t) due to the large increase in vehicle numbers in Ireland. The incineration of hazardous and clinical wastes and crematoria contribute to emissions from Waste Incineration (5C). The sector is the largest source of chromium emissions and accounted for 28.4 per cent of 2018 national chromium emissions, an increase of 17.8 per cent in the trend. The absolute and percentage contributions of this sector are increasing largely due to an increase in industrial waste incineration (5C1bi) which includes the incineration of wood that has historically been treated with preservative containing chromium.

Continued use of coal, peat and fuel oil as part of the fuel mix for Public Electricity and Heat Production (1A1a) means that the sector contributed 9.5 per cent to the emissions total in 2018. However, there has been a reduction in emission levels of 46.2 per cent between 1990 and 2018 as a result of the replacement of less-efficient peat plants with new plant, reductions in the quantities of coal combusted and fuel switching from oil to natural gas and wind energy. Emissions from Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined accounted for 16.1 per cent of the

national total in 2018, having decreased, by 64.9 per cent over the time series, reflecting the part replacement of coal and peat with natural gas, gasoil and kerosene. Within the Manufacturing Industries and Construction (1A2) sector, the sub-sector Other (1A2f) is responsible for the majority of emissions largely due to the cement industry, as is evident with other heavy metal estimates. Emissions in 1A2 accounted for 20.6 per cent of national total chromium emissions and have decreased by 12.5 per cent in the whole trend. Similar to other heavy metals estimates, the closure of the Irish Steel plant in 2001 has significantly reduced the effect of Iron and Steel Production (2C1) on emission trends, from 39.4 per cent share of the total (and the main contributor to chromium emissions) in 1990 to a 0.02 per cent share in 2018 (an almost 100 per cent reduction).



**Figure 2.14 Emission Trend for Chromium 1990–2018**

### 2.5.3 Copper (Cu)

Total copper emissions in Ireland were steadily increasing over the 1990–2008 period and have been steadily decreasing since (Figure 2.15). Total emissions in 2018 (19.7 t) were 10.6 per cent lower than in their peak in 2007 (21.96 t) but they are 79.0 per cent higher than in 1990 (11.0 t). This trend is determined mostly by the Transport (1A3) sector that accounted for 57.3 per cent of estimated national total copper emissions in 2018. Emissions from this source category have increased by 124.0 per cent from 5.04 t in 1990 to 11.29 t in 2018 due to the increase in vehicle number across the timeseries.

Continued use of coal, peat and fuel oil as part of the fuel mix results in a contribution of 1.8 per cent to the total emissions from Public Electricity and Heat Production (1A1a) in 2018. However, a reduction in emission levels of 49.3 per cent is evident between 1990 and 2018 as a result of the replacement of older less-efficient generation plants, reductions in the quantities of coal combusted and fuel switching from oil to natural gas and wind energy. The Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined accounted for 2.1 per cent of emissions in 2018, showing a 71.3 per cent decrease in the trend. Waste Incineration (5C) emissions accounted for 1.8 per cent of the national total in 2018, having increased by 9.2 per cent since 1990 (0.32 t). Combustion sources from Agriculture/Forestry/Fishing (1A4c) sector accounted for 1.5 per cent of the total Cu

emissions in 2018 (17.4 per cent decrease since 1990). The Manufacturing Industries and Construction (1A2) sector has decreased by 33.6 per cent between 1990 and 2018 (accounting for 1.2 per cent of the total in 2018). Emissions from the sector were increasing proportionately since 1990 reaching their peak in 2005 as a result of the entry into the market of new operators in the cement production sub-sector post-2000. The use of fossil fuels for combustion decreasing since 2005 as a result of economic circumstances. Emissions from Industrial Processes, specifically Other solvent use (2D3i) and Other product use (2G) combined accounted for 34.3 per cent of the total in 2018. Emissions from 2D3i and 2G combined have increased by 145.4 per cent across the timeseries. The sources of emissions in these categories are lubricants in the case of category 2D3i and Tobacco and Fireworks in the case of category 2G.

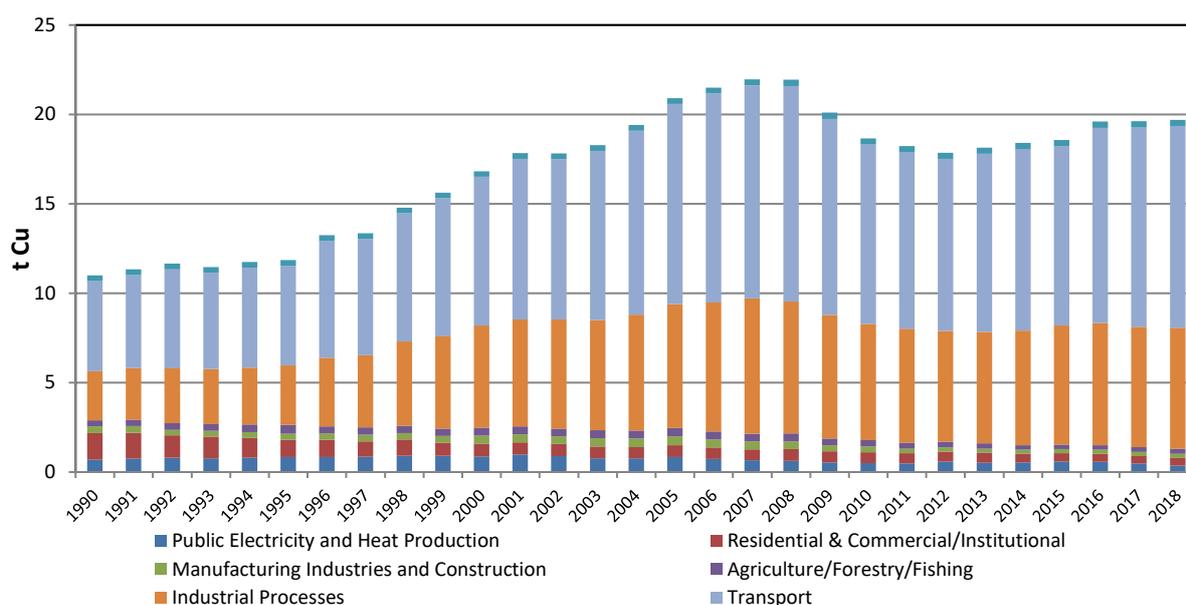


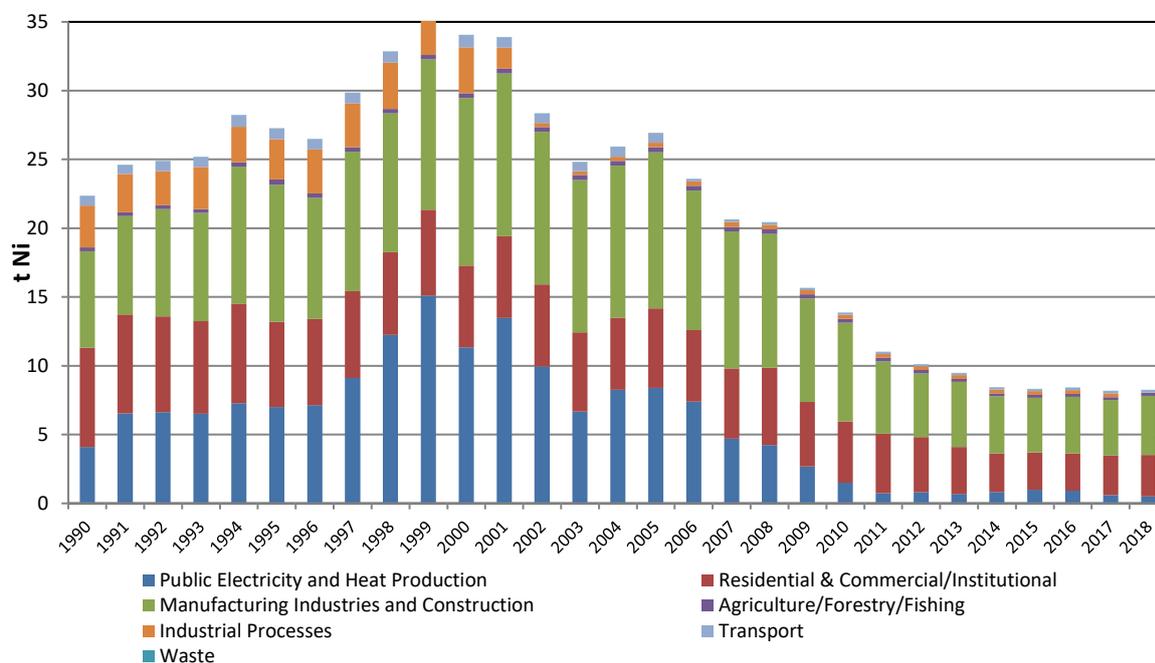
Figure 2.15 Emission Trend for Copper 1990–2018

### 2.5.4 Nickel (Ni)

National total emission estimates of nickel were steadily increasing over the 1990–1999 period and have been generally decreasing from 1999 onwards (Figure 2.16). Total emissions in 2018 (8.23 t) were 77.5 per cent lower than in their peak in 1999 (36.53 t) and 63.2 per cent lower than in 1990 (22.33 t). The main contributor to the trend is Manufacturing Industries and Construction (1A2) with a 52.4 per cent share in 2018 (4.31 kt) having reduced by 38.6 per cent since 1990 (7.02 kt). The second largest contributor to total Ni emissions in 2018 is emissions from the combined Residential (1A4b) and Commercial/Institutional (1A4a) sectors accounting for 36.5 per cent. A switch within these sectors from solid fuels (coal and peat) to less carbon intensive liquid fuels and natural gas has resulted in a 60.0 per cent in emissions since 1990. Public Electricity and Heat Production (1A1a) sector accounted for a 6.2 per cent share of the total nickel emissions in 2018. However, a reduction in emission levels of 87.5 per cent is evident between 1990 and 2018 as a result of the replacement of older less-efficient generation plants, reductions in the quantities of coal combusted and fuel switching from oil to natural gas and wind energy.

Combustion sources from Agriculture/Forestry/Fishing (1A4c) sector accounted for 2.8 per cent in 2018. Similar to other heavy metals estimates, the closure of the Irish Steel plant in 2001 has

significantly reduced the effect of Metal Production (2C) on emission trends, from 13.6 per cent share of the total (and fourth largest contributor to nickel emissions) in 1990. Emissions in 2017 were 0.01 t contributing to a 0.1 per cent share having reduced by 99.8 per cent.



**Figure 2.16 Emission Trend for Nickel 1990–2018**

### 2.5.5 Selenium (Se)

National total emission estimates of Se have decreased by 68.1 per cent, from 8.74 t in 1990 to 2.79 t in 2018 (Figure 2.17). The main contributor to the trend has been fuel combustion in the Residential (1A4b) and Commercial/Institutional (1A4a) sectors which combined accounted for 63.5 per cent of selenium emissions in 2018, having decreased by 73.9 per cent since 1990. The second largest contributor to the trend is the Public Electricity and Heat Production (1.A.1.a) sector and in 2018 it accounted for 33.7 per cent share of total selenium emissions. Emissions from this sector have decreased by 47.8 per cent from their 1990 level of 1.80 t to 0.94 t in 2018 due to the replacement of older less-efficient generation plants, reductions in the quantities of coal combusted and fuel switching from oil to natural gas and wind energy.

Transport (1A3) sector has been increasing in the time series and with its 0.7 per cent share of the national total in 2018, it has increased by 90.7 per cent since 1990. Emissions from Manufacturing Industries and Construction accounted for 0.5 per cent of the total, having decreased by 29.9 per cent from 1990. The remainder of the selenium emissions arise from combustion in Agriculture/Forestry/Fishing (1A4c) sector with its 0.2 per cent share of the national total in 2018. Glass production (2A3) under Industrial Processes and Product Use (IPPU) sector used to be an important contributor to the selenium emissions trend throughout the 1990s and up to 2002, accounting for an average of 1.4 per cent of the national total. This is no longer a contributor to the trend following closure of all glass production plants between 2002 and 2009. Metal Production (2C)

accounted on average for 0.1 per cent of selenium emissions up to 2001 when closure of Ireland’s only steel plant reduced emissions to negligible levels.

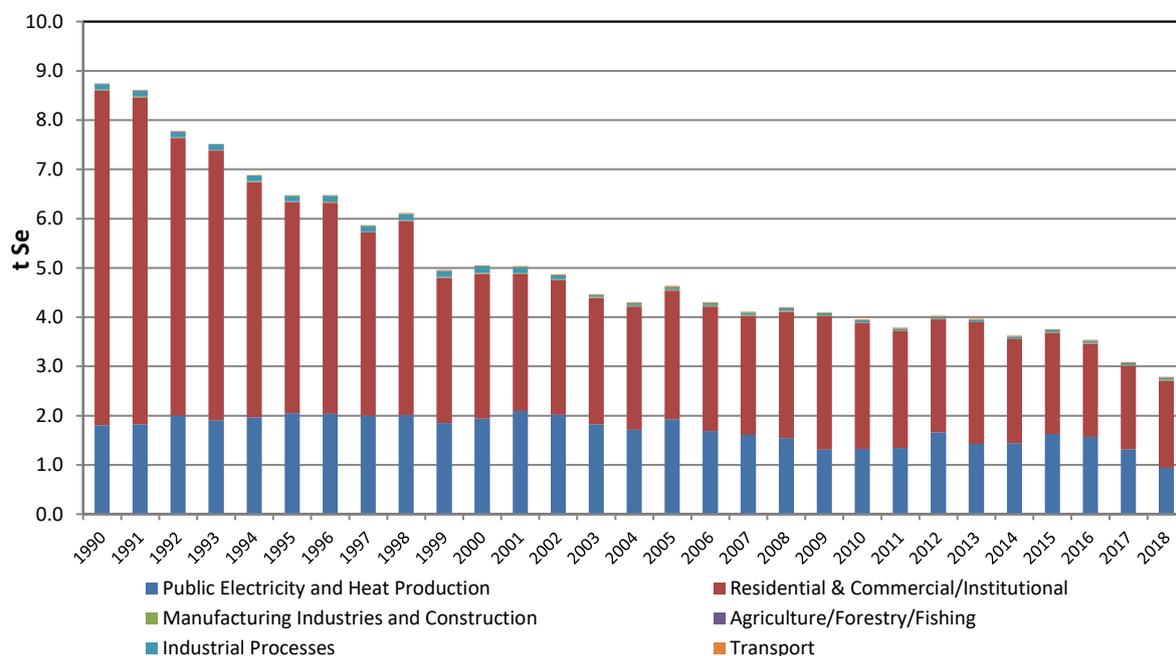


Figure 2.17 Emission Trend for Selenium 1990–2018

### 2.5.6 Zinc (Zn)

National total emissions of Zn amounted to 53.56 t in 1990 and have fallen by 63.6 per cent to 19.49 t in 2018. In the 1990–2001 period, the main determinant of the trend in zinc emissions was Metal Production (2C), accounting on average for 54.9 per cent of national total emissions throughout that period (Figure 2.18). However, following the closure of Ireland’s only steel plant in 2001, emissions from this source sector are now almost negligible and limited to relatively small IPPC-licensed foundries and galvanising plants. The main determinant for the trend since 2002 has been the Transport (1A3) sector (24.7 per cent of national total zinc emissions in 2018) specifically Road Transport (1A3b) sub-sector has increased significantly since 1990 as a result of the increase in the number of vehicles on Irish roads. As a result, emissions from Transport sector have increased substantially (122.3 per cent), from 2.16 t in 1990 to 4.81 t in 2018.

The second largest source is emissions from combustion in Manufacturing Industries and Construction (1A2) which accounts for 26.9 per cent share of emissions in 2018 having increased from 3.37 t in 1990 to 5.23 t in 2018 (55.3 per cent increase). Residential (1A4b) and Commercial/Institutional (1A4a) combined accounted for 22.3 per cent of the national total in 2018. However, reduced use of coal and peat through part replacement with natural gas and gasoil has resulted in the reduction of zinc emissions from these sectors by 68.7 per cent, from 13.88 t in 1990 to 4.35 t in 2018. Emissions from combustion in Public Electricity and Heat Production (1A1a) emissions have decreased by 64.4 per cent since 1990 and accounted for a 5.1 per cent share of national total in 2018. Similar to other pollutants the reduction is due the replacement of older less-efficient generation plants, reductions

in the quantities of coal combusted and fuel switching from oil to natural gas and wind energy. The remainder of the zinc emissions arise from combustion in Agriculture/Forestry/Fishing (1A4c) sector with its 1.0 per cent share of the national total in 2018. Clinical Waste Incineration (5C) accounted for 0.1 per cent of the national total in 1990 however, following an outright ban on incineration of clinical waste in hospitals in 1997, emission from 5C are no longer a source.

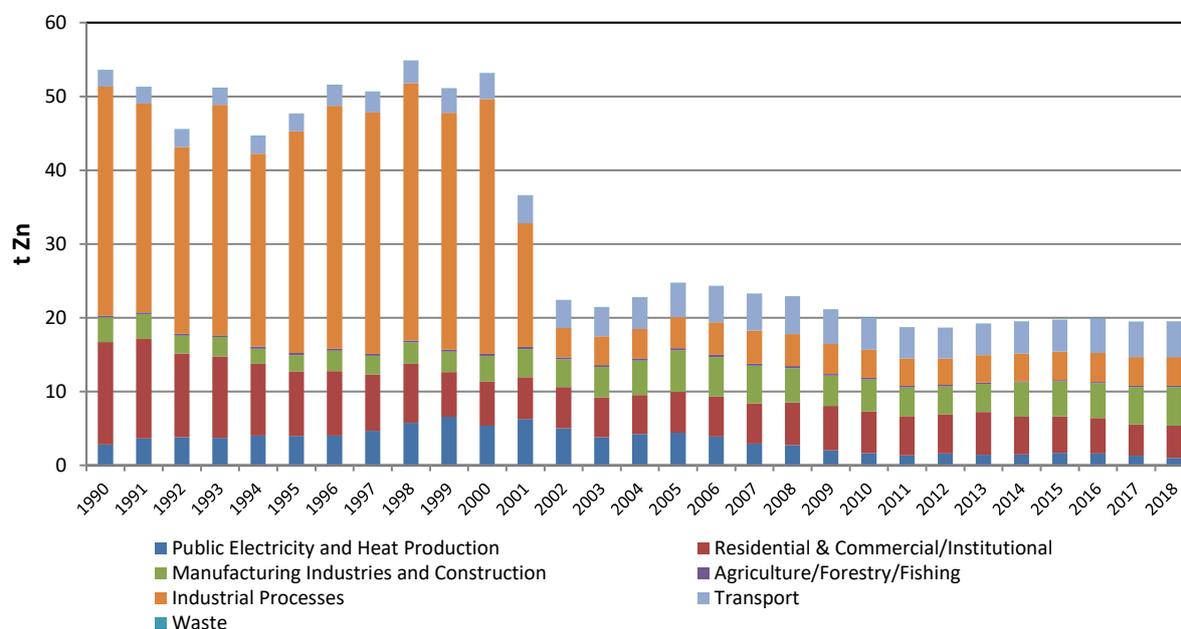


Figure 2.18 Emission Trend for Zinc 1990–2018

## 2.6 Persistent Organic Pollutants (POPs)

As part of Ireland’s emission inventory improvement programme, the inventory agency tendered a project in 2007 to develop an inventory of persistent organic pollutants in Ireland. The project report (AEA/CTC, 2008) provides detailed information in relation to the methodological choice and activity data for the diverse range of sources that give rise to emissions of POPs within Ireland. For the purposes of identifying the major contributors to the trend in PCDD/F, PCBs, HCB and PAHs, some of this information is provided in the following sections. The approach was updated subsequently as new versions of EMEP/EEA Inventory Guidebook have been published.

### 2.6.1 Dioxins and Furans (PCDD/F)

Dioxin and furan emission levels decreased from 59.81 g I-TEQ in 1990 to 19.81 g I-TEQ in 2018 (66.9 per cent reduction on 1990 levels). The main contributors to the trend are the Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined with a 63.8 per cent share of total emissions in 2018; however, emissions from these sectors have reduced (by 73.0 per cent) from 46.79 g I-TEQ in 1990 to 12.63 g I-TEQ in 2017 (Figure 2.19).

The second largest contributor to the trend is the Waste sector which is dominated by emissions from the Other Waste (5E) sector, where building and vehicle fires and residential burning of waste are the emission sources. Total emissions from the waste sector accounted for 27.2 per cent (5.39 g I-TEQ) of national total emissions in 2018, a reduction of 38.4 per cent on 1990 levels (8.75 g I-TEQ). Emissions

from the sector peaked in 2003 (8.92 g I-TEQ) due to an increase in the assumed combustion of household waste that remains unaccounted for in national statistics. The introduction of unleaded petrol and technological improvements in road vehicles has offset increased numbers of vehicles in the national fleet, with a 15.5 per cent decrease in emissions in Transport (1A3) between 1990 and 2018. Process emissions from the manufacture of cement (2A1) in Industrial Processes and Product Use sector, accounting for 0.1 per cent of national emissions in 2018 (0.02 g I-TEQ), a 98.8 per cent reduction on 1990 levels (1.45 g I-TEQ). Combustion in Agriculture/Forestry/Fishing (1A4c) sector accounted for 3.0 per cent of emissions in 2018 (0.60 g I-TEQ) a decrease of 48.2 per cent on the 1990 emissions (1.16 g I-TEQ). Public Electricity and Heat Production (1A1a) emissions have decreased by 53.7 per cent from their 1990 level of 0.59 g I-TEQ to 0.28 g I-TEQ and are responsible for a 1.4 per cent share of national total in 2018 due to the replacement of older less-efficient generation plants, reduction in the quantities of coal combusted and fuel switching from oil to natural gas and wind energy.

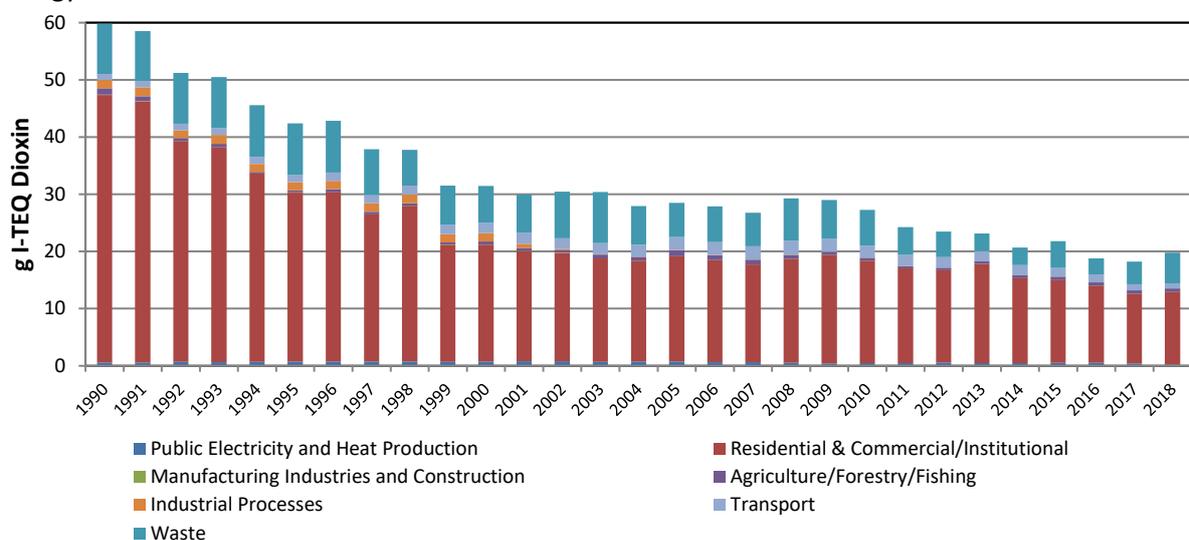


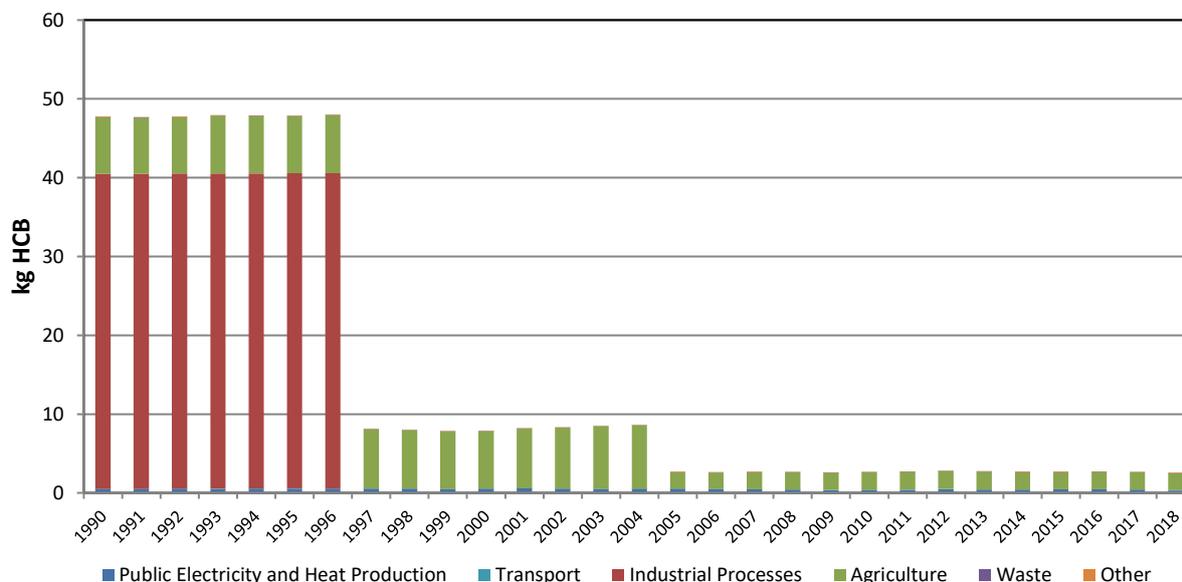
Figure 2.19 Emission Trend for Dioxins and Furans 1990–2018

## 2.6.2 Hexachlorobenzene (HCB)

Figure 2.20 outlines the trend in hexachlorobenzene emissions in Ireland across the 1990–2018 time series. The graph indicates that HCB emissions from Secondary Aluminium Processing (2C) which, for the period up to and including 1996, dominated the inventory with a contribution of 40 kg per year and is no longer a source of HCB emissions within Ireland due to the banning of hexachloroethane (HCE)-based cover gas use (HCB was present as a contaminant in such cover gases). Emissions since 1997 are more relevant to trend analysis up to 2017.

There is very limited information on the release of HCB to air for most source sectors in Ireland. The main source is the use of pesticides in agricultural practices significantly increasing up to 2003 (1.27 kg), reaching its peak in 2004 (8.05 kg) and decreasing to 2.05 kg in 2005 following a ban on the use of certain pesticides. Subsequently emission have increased and in 2018 were 2.16 kg representing a 84.6 per cent share. The Public Electricity and Heat Production (1A1a) sector was the second largest source in 2018 accounting for 0.31 kg and a 12.3 per cent share of the national total, having decreased by 35.6 per cent between 1990 and 2018.

Incineration of hazardous and clinical wastes and crematoria included in the waste incineration (5C) accounted for 0.2 per cent share of national emissions in 2018, a decrease of 91.8 per cent since 1990. The remainder of the HCB emissions arise mainly from combustion in the Residential (1A4b) and Commercial/Institutional (1A4a), Manufacturing Industries and Construction (1A2) and Agriculture/Forestry/Fishing (1A4c) sectors, which combined are presented as “Other” NFR sectors in Figure 2.20 and account for 2.6 per cent of the total in 2018. Transport (1A3) accounted for 0.3 per cent of national emissions in 2018.



**Figure 2.20 Emission Trend for Hexachlorobenzene 1990–2018**

### 2.6.3 Polychlorinated Biphenyls (PCBs)

Estimated national total emissions of polychlorinated biphenyls have decreased by 79.6 per cent from 38.99 kg in 1990 to 7.94 kg in 2018. Emissions peaked in 2003 (67.71 kg) (Figure 2.21). Other Waste (5E) is the second largest contributor to the trend in PCB emissions in Ireland. In 2018, the emissions from the Waste sector were 4.59 kg (57.9 per cent of national total emissions), a decrease of 70.4 per cent compared to 1990 (15.50 kg). Emissions from the Waste sector peaked in 2003 (59.93 kg) due to an estimated increase in the quantity of household waste that remains unaccounted for in national statistics and which is assumed to be burned. Combined emissions from the Residential (1A4b) and Commercial/Institutional (1A4a) sectors accounted for 31.5 per cent of the national total in 2018 (2.50 kg), a 74.6 per cent decrease from those estimated for 1990 (9.85 kg).

Of particular note for PCB emissions is the contribution of the NFR Sector 2L (Other Production, consumption, storage, transportation or handling of bulk products), which in Ireland’s inventory covers PCB use as dielectric fluid in electrical equipment such as transformers and capacitors. However, through the introduction of Hazardous Waste Management Plans and the Waste Electrical and Electronic Equipment (WEEE) Regulations, emissions since 2006 have been decreasing in general.

Public Electricity and Heat Production (1A1a) emissions were almost negligible in 2018. Emissions in this sector have reduced by 82.3 per cent since 1990 due to the replacement of older less-efficient

generation plants, a reduction in the quantities of coal combusted and fuel switching from oil to natural gas and wind energy. Increases in cement production have led to increases in fuel combustion based emissions in Manufacturing Industries and Construction (1A2) up until 2005. This source category's emissions have decreased by 21.2 per cent between 1990 (1.06 kg) and 2018 (0.83 kg), with a contribution of 10.5 per cent to the national total in 2018.

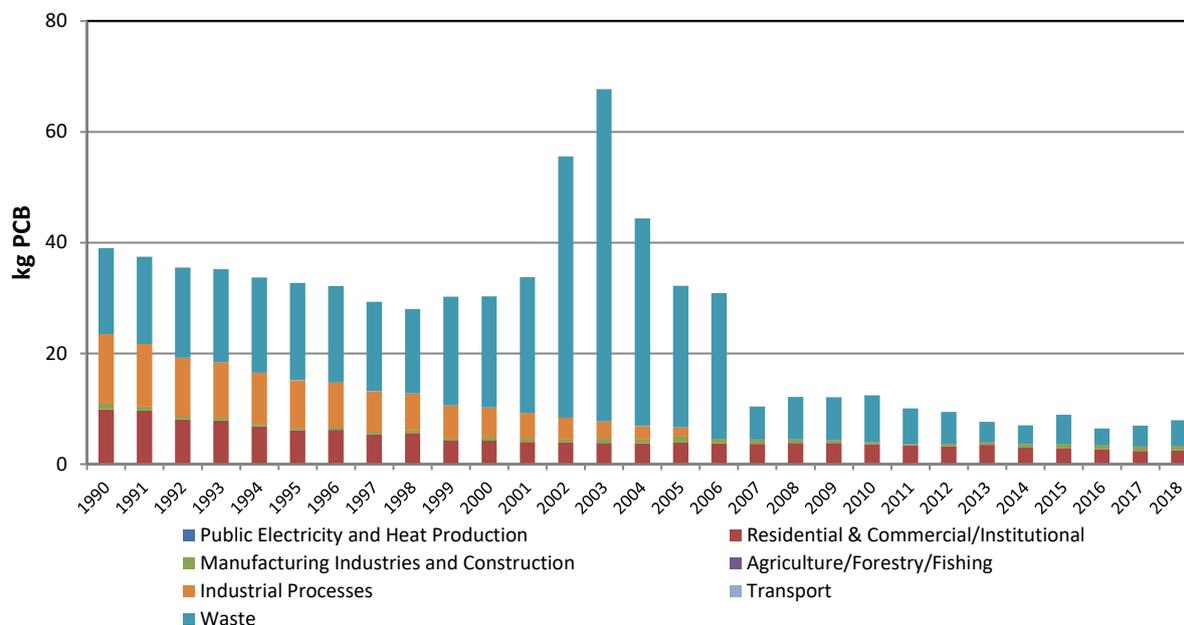
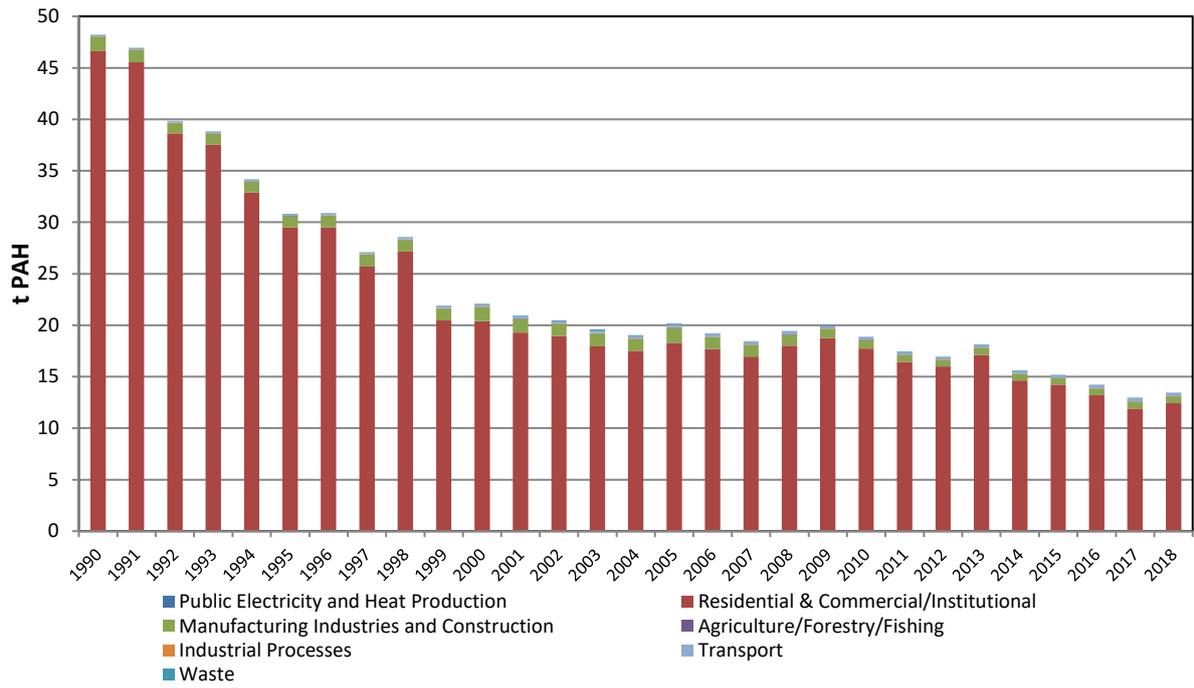


Figure 2.21 Emission Trend for Polychlorinated Biphenyls 1990–2018

## 2.6.4 Polycyclic Aromatic Hydrocarbons (PAHs)

For the purposes of this report, total PAHs in the form of the sum of emissions of benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, and indeno[1,2,3-cd] pyrene are presented in Figure 2.22. All together the emissions from these combined four pollutants decreased by 72.1 per cent between 1990 (48.22 t) and 2018 (13.46 t). For all four PAHs, the main source sectors are the same. The inventories are dominated by emissions from combustion in the Residential (1A4b) and Commercial/Institutional (1A4a) sectors. In the Residential (1A4b) sector (main driver of the trend), the lack of combustion controls or abatement, together with relatively low-temperature combustion conditions, leads to high emissions of PAHs. Even though national total emissions of PAHs have generally declined across the time series, the Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined accounted for 92.2 per cent of the national total in 2018, having decreased by 73.4 per cent from 46.62 t in 1990 to 12.42 t in 2018. The decline in emission levels is due primarily to the decline in the use of coal and sod peat for residential space heating, as reported in the National Energy Balance.

Combustion emissions in Manufacturing Industries and Construction (1A2) sector accounted for 4.8 per cent of the total in 2018 (0.65 t), a decrease of 53.2 per cent since 1990 (1.38 t). Emissions from Transport (1A3) have more than doubled (an increase of 165.7 per cent) to 0.32 t representing a 2.4 per cent share of the national total in 2018 for all four PAHs as compared to 0.2 per cent 1990 (0.12 t). Other Waste (5E) is the main driver in the Waste sector resulting in the Waste sector accounting for 0.3 per cent in the total PAHs emissions in 2018, a 22.6 per cent reduction since 1990.



**Figure 2.22 Emission Trend for Polycyclic Aromatic Hydrocarbons 1990–2018**

# Chapter Three

## Energy

### 3.1 Overview of the Energy (NFR 1) Sector

The Energy sector covers combustion and fugitive sources of emissions associated with the production, transport, conversion and use of fossil fuels. Emissions from combustion in this sector account for the bulk of total national emissions for the majority of substances covered in this IIR. Estimates of the various pollutants are included for all emission sources that occur in the country and the required level of disaggregation is achieved for sufficiently detailed completion of the NFR tables.

Annual energy balance sheets published by Sustainable Energy Authority Ireland (SEAI) are the principal source of activity data for computing the emissions in the Energy sector. Ireland's energy statistics are compiled using a combination of top-down and bottom-up methods and the annual energy balances have undergone major improvement over recent years to take account of emission inventory requirements and more harmonised reporting to Eurostat and the International Energy Agency (IEA). The annual submission of up-to-date energy balances from SEAI to the inventory agency is one of the primary data inputs covered by a MoU in Ireland's national system (Chapter One). A fully consistent set of energy balance sheets for the years 1990–2018 underlies the time-series estimates of emissions for *Energy* in this submission. The 2018 energy balance is provided in Annex B.

Substantial plant-level fuel-use data are also available for many important categories in the Energy sector, especially for more recent years, which allows bottom-up estimates to be derived for some pollutants using Tier 3 methods. These data are obtained through direct arrangements with the operators of certain plants through their returns under Chapter III the Large Combustion Plant (LCP) Chapter of the Industrial Emissions Directive and the EU ETS and under environmental reporting related to their IPPC permits.

The emissions of SO<sub>2</sub> from fuel combustion are determined from the fuel properties, and fully representative emission factors are readily obtained for the fossil fuels used in most emission categories in Ireland. In general, other pollutants emitted from combustion sources are heavily reliant on emission factors from non-national sources. For all other pollutants, the emission factors are taken from the inventory guidebook (EMEP/EEA, 2009, 2019). The Co-ordinated European Programme on Particulate Matter Emission Inventories, Projections and Guidance (CEPMEIP), which is aimed at supporting national experts in reporting PM emission inventories, serves as the reference for emission factors in the category 1A3a for the different forms of Particulate Matter (PM). PM emission factors for other sectors are derived from the Inventory Guidebook (EMEP/EEA, 2019). In the past, emission inventories for heavy metals and POPs received little attention in Ireland and special studies were necessary to compile national emission estimates for reporting purposes. The separate detailed studies on emissions of heavy metals and POPs in Ireland were undertaken by consultants (AEA/CTC, 2008; Netcen/CTC, 2006) and they made use of the best available emission factors for many emission sources, with strong dependence on UK information sources. The results from these studies were the basis for developing time-series emissions of heavy metals and POPs in the Energy sector in previous

submissions. In this submission, many of the EFs for heavy metals and POPs are from the Inventory Guidebook (EMEP/EEA, 2019).

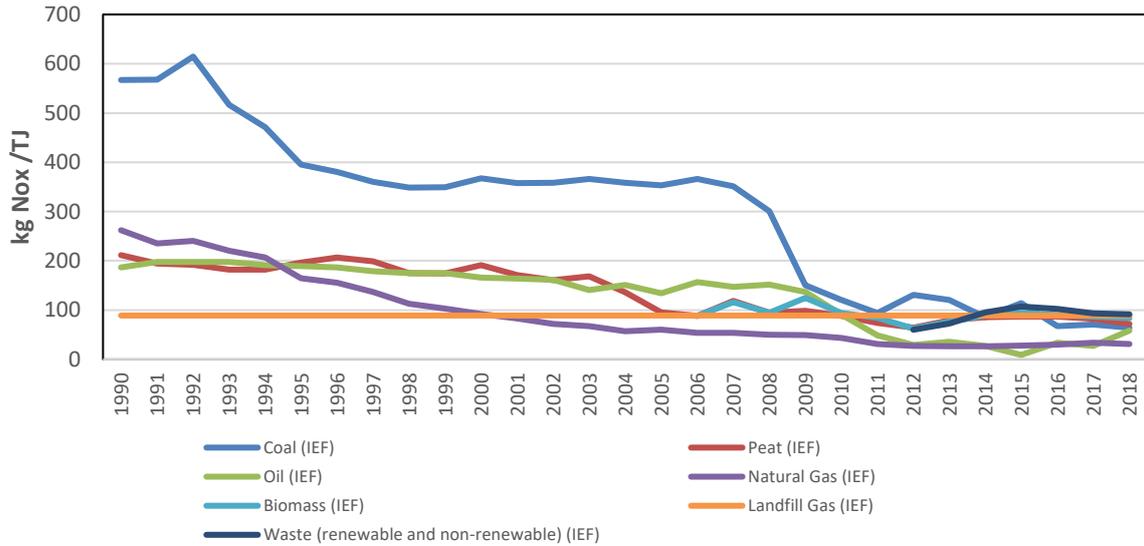
## 3.2 Public Electricity and Heat Production (NFR 1A1a)

The production of electricity and heat from fossil fuels has traditionally been the most important source of key pollutants such as SO<sub>2</sub> and NO<sub>x</sub> in most countries. Approximately 67.0 per cent of electricity production in Ireland (SEAI, 2019) is dependent on fossil fuels and Category 1A1a therefore remains one of the major emission categories. Emissions of SO<sub>2</sub>, NO<sub>x</sub>, CO, three particulate matter pollutants, BC, all nine heavy metals and POPs have decreased more or less significantly since 1990. NMVOCs were the only emissions that have increased in the time series due to the increase use of natural gas. The level of emissions in Sector 1A1a depends heavily on the mix of fossil fuels and renewables used for electricity production. In 1990, heavy fuel oil (HFO), coal, peat and natural gas were the principal fuels used. The use of HFO, coal and peat declined as natural gas became the preferred fuel during latter years. Incineration emissions from Ireland's waste-to-energy plants, however small, have been increasing since the first started operation in 2011 and the second in 2017.

### 3.2.1 Emissions of Sulphur Dioxide and Nitrogen Oxides

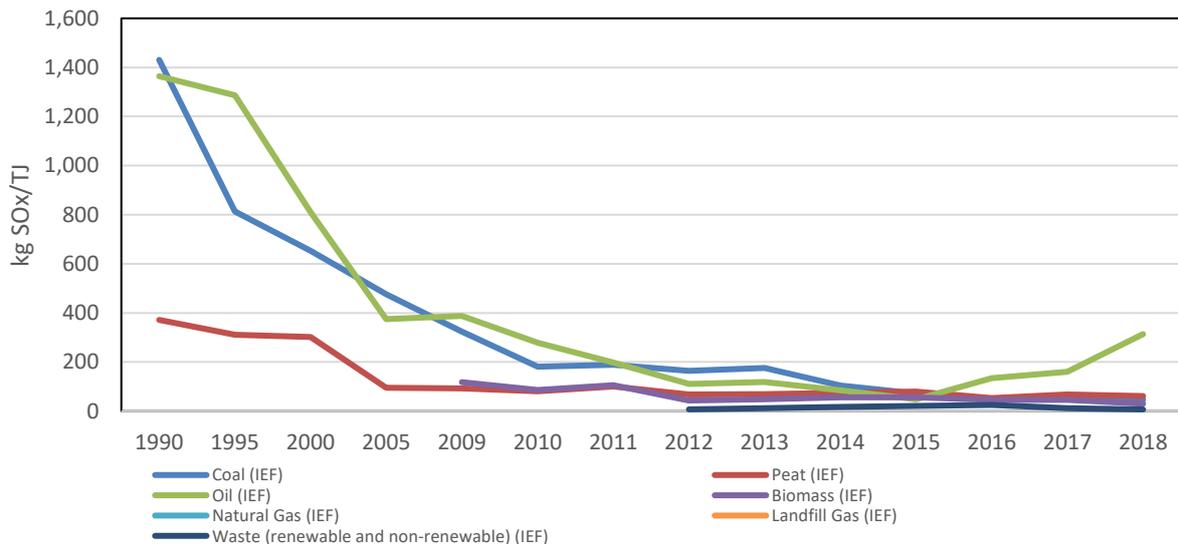
Until 2000, the Electricity Supply Board (ESB) operated all public electricity power plants in Ireland. After 2000, several new gas-fired plants and one peat-fired plant were built by other operators, while the ESB replaced old peat-burning stations with new stations also burning peat and has been engaged in a major retrofit and improvement programme for plants in general. The shift to natural gas and the use of low-sulphur coal, combined with a decline in the sulphur content of fuel oil, have reduced SO<sub>2</sub> emissions by 97.2 per cent from 103.04 kt in 1990 to 2.84 kt in 2018. The sector's contribution to the overall SO<sub>2</sub> emissions in 2018 was 23 per cent as opposed to 56.1 per cent share in 1990. Incineration of non-renewable waste in MSW accounted for 1.0 per cent of SO<sub>x</sub> emissions from power generation in 2018.

At the same time, the changed fuel mix, together with the application of extensive NO<sub>x</sub> emission control technology and the more modern plants, has decreased NO<sub>x</sub> emissions by 85.5 per cent from 46.37 kt (and 27.0 per cent share of total NO<sub>x</sub> emissions) in 1990 to 6.74 kt (and 6.3 per cent share of the total) in 2018. In comparison to the year 2017, NO<sub>x</sub> emissions decreased by 17 per cent in 2018, and SO<sub>2</sub> emissions decreased in 2018 by 28.7 per cent. The ESB has supplied estimates of SO<sub>2</sub> and NO<sub>x</sub> on a plant-by-plant basis to the inventory agency for all years since 1990, mainly for the purpose of compiling SO<sub>2</sub> and NO<sub>x</sub> inventories under Chapter III of the IED Directive. The emissions for power plants operated by other companies are obtained either directly from their LCP, AER or PRTR submissions or they can be estimated by the inventory agency from fuel data made available under the ETS. Ireland sought clarification from these power plants regarding the reporting of emission using validated average figures (after subtracting the value of the confidence interval). Three plants were discovered to be underreporting their emissions as a result of this exercise and corrected figures were supplied without subtraction of the confidence interval. These figures have been reported in 2020. Incineration of non-renewable waste in MSW accounted for 5.2 per cent of NO<sub>x</sub> emissions from power generation in 2018.



**Figure 3.1 Nitrogen Oxide Implied Emission Factors for Category 1A1a**

The weighted average emission factors of SO<sub>2</sub> and NO<sub>x</sub> per fuel type (coal, peat, oil, natural gas, biomass and waste (MSW)) in category 1A1a are given in Figures 3.1 and 3.2 as implied emission factors (IEFs) to illustrate the level of decrease due to the factors mentioned above. The SO<sub>2</sub> emission factors reflect the sulphur content and net calorific value of the fuels used in the particular year and they account for sulphur retention levels in the fuel ash of 5 per cent and 10 per cent for coal and peat, respectively. The NO<sub>x</sub> emission factors (apart from landfill gas) are compiled from plant-level estimates that are determined from measurement, unit load factor and plant performance. Emission factors for landfill gas are default values as per the revised Inventory Guidebook (EMEP/EEA, 2019).



**Figure 3.2 Sulphur Dioxide Implied Emission Factors for Category 1A1a**

### 3.2.2 Emissions of Other Substances

The emissions of all substances other than SO<sub>2</sub> and NO<sub>x</sub> in Category 1A1a are estimated by the inventory agency using the fuel-use energy data given by the national energy balance and appropriate emission factors taken from the Inventory Guidebook (EMEP/EEA, 2019) and plant-specific factors for non-renewable wastes from waste incineration. For the pollutants Cd, Hg, Pb, Dioxins, PCB, PAH and HCB Ireland utilises the emission factors presented in the 2019 EMEP/EEA Inventory Guidebook. Specifically, the emission factors for coal and peat are taken from Table 3-15, fuel oil from table 3-11, gasoil from table 3-19, natural gas and landfill gas from table 3-17. These emission factors are presented in Table C.1 Annex C. The activity data for 1A1a follows the format of that presented in Table B.1 Annex B for all years. Dioxins emissions for Peat power plants are estimated with plant specific emission factors. Furthermore, for Oil, there are no emission factors available for BaP, PCB and HCB in the 2019 EMEP/EEA Inventory guidebook. For natural gas and landfill gas there are no emission factors available for PCB and HCB in the 2019 EMEP/EEA Inventory guidebook. Ireland uses the same activity data for all air pollutant and greenhouse gas emission calculations to maintain consistency in approaches across inventories (see section 3.1). The emission factors for 2018 (split by pollutants and fuel type) and their sources are listed in Table C.1 of Annex C.

### 3.3 Petroleum Refining (NFR 1A1b)

Emissions from fuel combustion at one small oil refinery in Ireland are estimated in this source category. Detailed information on the fuels used in different parts of the refinery in recent years is available through the company's AER, PRTR and ETS submissions. This allows for the selection of appropriate emission factors from national data and from international literature sources recognised as being fit for purpose by the emissions inventory community. In the case of heavy metals and POPs, the estimates are based on emission factors from the Inventory Guidebook (EMEP/EEA, 2019). The emission factors for 2018 and their sources are listed in Table C.2 of Annex C.

### 3.4 Manufacture of Solid Fuels and Other Energy Industries (NFR 1A1c)

Emissions from this source category refer to combustion emissions from the production of peat briquettes from milled peat at two plants, one natural gas production platform and one new natural gas refinery in Ireland. As in the case of the oil refinery, the energy balance fuel-use data are supplemented by information reported by the plants under the ETS, which again allows for the selection of appropriate emission factors using national data and high-quality international sources. The estimates for heavy metals and POPs are based on emission factors from the Inventory Guidebook (EMEP/EEA, 2019). The emission factors for 2018 and their sources are listed in Table C.3 of Annex C.

### 3.5 Manufacturing Industries and Construction (NFR 1A2)

This category covers emissions from combustion in manufacturing industries and construction activities. Category 1A2 is split into the following seven subcategories:

- 1.A.2.a Iron and Steel
- 1.A.2.b Non-Ferrous Metals
- 1.A.2.c Chemicals
- 1.A.2.d Pulp, Paper and Print

#### 1.A.2.e Food Processing, Beverages and Tobacco

#### 1.A.2.f Non-metallic minerals

#### 1.A.2.g Other Industry

Where it is possible to separate process emissions from those associated with fuel use, the process emissions associated with these industrial groups are reported in the Industrial Processes (NFR 2) sector (Chapter Four). The relevant process emissions in Ireland are those related some metal industries.

Comparison of the Sustainable Energy Authority of Ireland (SEAI) Energy Balance data with ETS fuel-use data indicates that the combustion activities within the 1.A.2 category are dominated by a limited number of large industrial processing plants. It is assumed that all biomass reported as fuel use within the SEAI Energy Balance is clean untreated wood and wood-processing waste. The ETS data for major wood-processing facilities indicate the use of large-scale biomass boilers, fired using wood biomass, chippings, pulp and wood dust. EPA contacts indicate that none of these wood-based fuels are pre-treated and hence emission factors applicable to clean wood use in large-scale boilers have been used to estimate POP emissions from these sources.

The Iron and Steel (1A2a) sector was dominated in the 1990s by fuel use and emissions from one electric arc furnace but, since its closure in 2001, the fuel use reported in 2002 in this sector related to a small number of iron foundries, which in total used only a very small amount of gasoil and LPG and since 2003 combustion emissions are not occurring. For 1A2a 1990 was the only year in the timeseries for which coal was combusted as a fuel in the category (29 ktoe). The emission factors used are those presented in Table 3.2 of the 2019 EMEP/EEA Inventory Guidebook. The emission factor for coal is significantly higher than the emission factors associated with the other fuels combusted in the category, thus the combustion of coal in the category for the year 1990 has a significant influence on emissions for that year.

The process emissions from this industrial activity are described in chapter 4, section 4.4.1. The Non-Ferrous Metal (1A2b) subcategory is dominated by the very significant fuel use (mainly natural gas replacing fuel oil) reported at a single large alumina plant, whilst the Chemicals (1A2c) subcategory includes natural gas, kerosene, fuel oil, gasoil and LPG use at large chemical plants. The Food Processing, Beverages and Tobacco (1A2e) sector covers a diverse range of industrial plants, much of which is related to agriculture, with just under 30 installations reporting to the EU ETS and using predominantly natural gas and liquid fuels. The bulk of the fuel use reported in the energy balance under the 1A2f subcategory is accounted for by major cement works, lime producers, a small number of brickworks and fuel use at boiler plant within industries such as the pharmaceutical, glass and tile manufacturing sectors. There are at present four cement plants in Ireland, all of which use the dry kiln process, and they are currently fuelled by coal, petroleum coke and fuel oil, while meat and bone-meal, solid recovered fuels (SRF) and tyre derived fuels are co-incinerated at three of the four plants. The EMEP/EEA Guidebook (2019), provide some POP emission factors on an overall grams of pollutant per tonne of clinker produced basis. The guidebook states that these emissions should be allocated to combustion in cement manufacture. These emission factors have been used to determine the total emissions from cement plants. Fuel-use data are available from plant operators as part of their reporting requirements under the EU ETS (Directive 2003/87/EC). Residual fuel not used in the cement

manufacture sector but used in other manufacturing industries in 1A2f is calculated and emissions from fuel use are calculated using combustion emission factors in 1A2f, while the fuel use data from cement manufacture is removed to ensure there is no double counting. All other industrial fuel use is reported under subcategory 1A2g. This sector covers a diverse range of manufacturing branches ranging from textile and leather, through machinery, transport equipment, wood products, mining (excluding fuel mining) and quarrying to other manufacturing businesses. Ireland's national Energy statistics do not provide an estimate of fuel used in mobile construction. All emissions associated with the category 1A2g are reported in 1A2gviii, and mobile emissions, 1A2gvii, are reported as “included elsewhere” (IE) in 1A2gviii. Currently all fuel is assumed to be stationary as the energy balance does not provide an estimate for fuels used in mobile machinery. The inventory agency has tendered research to be undertaken to quantify the extent and amounts of fuel used by mobile combustion on construction sites, agricultural machinery, small gardening and handheld equipment as well as other mobile machinery and when available will include the results of this research in the national energy balance in consultation with the energy balance provider and estimate emissions accordingly.

The revised and expanded energy balance sheets developed by SEAI incorporate a mapping of industrial fuel use in combustion into the NFR subcategories 1A2a through 1A2g under sector 1A2 Manufacturing Industries and Construction. This facilitates the complete disaggregation of emissions at subcategory level. In addition, information on fuel consumption in 2018 was obtained in respect of a small number of energy-intensive industries (e.g. alumina production and cement manufacture) from their ETS returns, allowing their respective energy use amounts to be reconciled with the breakdown given in the national energy balance. Emissions in subcategories 1A2a through 1A2g are estimated on a top-down basis using disaggregated fuel use from the energy balance and the mix of country-specific and default emission factors as shown in Tables C.4 through C.10 of Annex C. The estimates for heavy metals and POPs are based on emission factors from the Inventory Guidebook (EMEP/EEA, 2019). Emission factors for heavy metals and POPs (including references) for NFR 1A2 (a-g) are shown in Table C.11 of Annex C.

Ireland used the emission factors from the EMEP/EEA 2009 Guidebook for liquid fuels. The Tier 1 EFs for liquid fuels in the EMEP/EEA 2019 Guidebook are an average of Tier 2 EFs and are not considered representative considering one of the liquid fuel values for NO<sub>x</sub> is 942g/GJ based on reciprocating engines which are not occurring in Ireland. The Tier 1 value of 100 g/GJ used by Ireland is still valid, as all the guidebook editions reference Chapter B216 originally. A generic emission factor of 100 g/GJ was applied for all liquid fuels for sectors 1A2f, which was obtained from “Table 3-4: Tier 1 emission factors for 1.A.2 combustion in industry using liquid fuels”, for “Other<sup>1</sup> Liquid Fuels” in page 16, 1.A.2 Manufacturing industries and construction (combustion), EMEP/EEA emission inventory guidebook 2009. Reference EMEP/CORINAIR B216. Table 1-1 of the Guidebook 2019 refers to the appropriate chapters for EFs, either 1A1, 1A2 or 1A4. Very few EFs were used from Chapter 1A2 as Ireland does not have these types of industry. EFs were again mainly sourced from the small combustion chapter (1A4) for boilers, as are the most appropriate for the boiler type used in Ireland. The average of Tier 2 EFs are not applicable as Ireland has no reciprocating engines or turbines.

Regarding NMVOC emissions in 1A2gviii, the fuel used for 3 large plants for all years where data is available (2005-2018, EU ETS), was subtracted from the total fuel use and a Tier 2 EF was used, 12kg/TJ

for NMVOC and all other pollutants, EMEP/EEA 2019, 1.A.4 Small Combustion, Table 3-48, 'wood'. The residual amount of biomass fuel uses the Tier 1 EF.

### 3.6 Transport (NFR 1A3)

As abatement measures continue to reduce emissions of key pollutants from major stationary combustion sources, transport in general, and road transport in particular, has become more important as a source of atmospheric emissions in many countries. The effects of technological emission controls for passenger cars and other vehicles in Ireland have, to a large extent, been offset by the substantial increases in vehicle numbers, with the result that major reductions in the emissions of pollutants such as NO<sub>x</sub> did not occur until 2007 when the economic situation caused an overall decrease in most emissions evident from 2008. In 2018 NO<sub>x</sub> emissions from this sector reached 45.86 kt (42.0 per cent share of total) reflecting a decrease by 24 per cent on 60.45 kt emissions (and 35.7 per cent share) in 1990.

Road transport in Ireland is a larger source of NO<sub>x</sub> than electricity production, and road traffic also continues to be the major source of CO, BC, Pb, Cr, Cu and Zn, although BC, Pb, Cr, Cu and Zn emissions are very small in absolute terms.

#### 3.6.1 Domestic and International LTOs (NFRs 1A3aii(i) and 1A3ai(i))

As a relatively small island state, aviation emissions are dominated by the international component. Under the LRTAP Convention, only the landing and take-off (LTO) component of emissions for both domestic and international flights is reported in the national total. The cruise component, domestic and international, is reported as a memo item. After the motorway network to Dublin from Galway and Cork was completed around 2008/09 and the upgrades of the Cork to Dublin rail line, domestic air travel was no longer competitive, leading to cessation of specific routes. Almost all flights ceased from Galway airport post 2011.

The fuel consumption associated domestic and international LTOs is estimated using a Tier 3b approach (Table 3.6.2, 2006 IPCC guidelines) based on origin and destination data for domestic air travel provided by EUROCONTROL (Eurocontrol, 2016), using an Advanced Emission Model (AEM) to estimate fuel burned and emissions for the full trajectory of each flight segment using aircraft and engine specific information. This is the second submission using the new approach replacing the previous approach, tier 3a, using data from the Irish Aviation Authority (IAA) and fuel consumption rates given by the Inventory Guidebook (EMEP/EEA, 2013) appropriate to the type of aircraft concerned and the length of the flights within Ireland. This new approach is used for all years from 2005 to 2018 where EUROCONTROL data is available. For the years 1990-2004, the number of flights for each airport was estimated based on domestic passenger and aircraft movement statistics as well as the relationship between all Irish airports and Dublin airport which is the principal destination of all domestic flights. Domestic LTO and Cruise fuel consumption rates for 1990-2004 are based on an average (2005 to 2011) for each departure airport using EUROCONTROL consumption rates.

Figures 3.3 and 3.4 and Table C.12 of Annex C present the number of LTOs, domestic and international, from Irish airports for all years from 1990 to 2018.

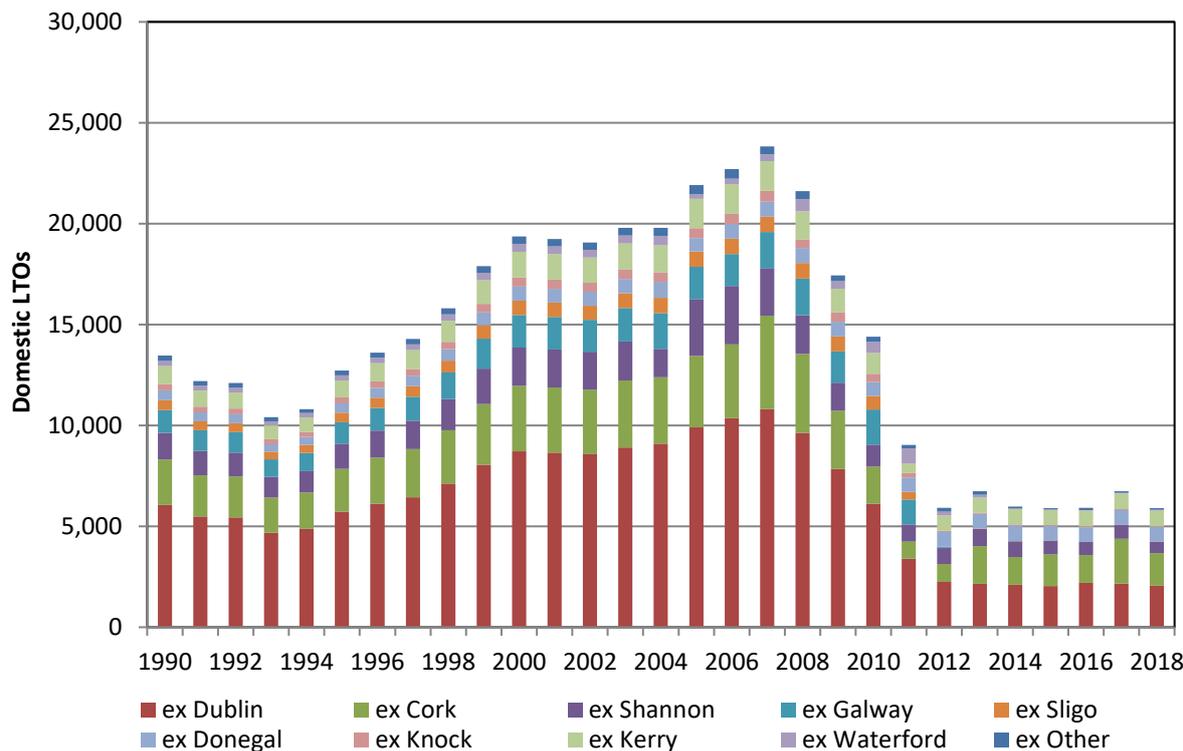


Figure 3.3 Number of Domestic LTOs from Irish airports 1990-2018

For data handling purposes, the inventory agency aggregated approximately 15 small regional airport/aerodrome pairs to “Other” which account for approximately 1.0 per cent of all domestic flights along with nine Irish airports which account for the remaining 99.0 per cent of all domestic flights in 2017. Emission factors associated with aviation emissions are presented in Annex C tables C.13 to C.18.

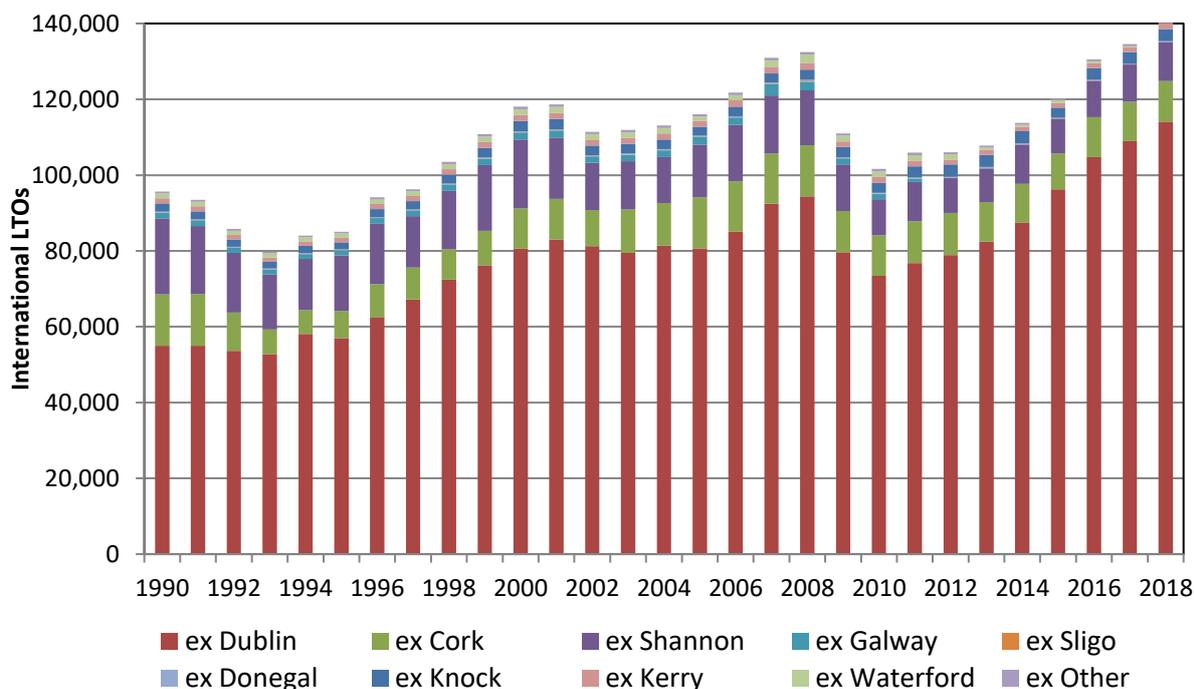


Figure 3.4 Number of International LTOs from Irish airports 1990-2018

### 3.6.2 Road Transport (NFR 1A3b)

The emissions of nine well-known pollutants (SO<sub>2</sub>, NO<sub>x</sub>, NMVOCs, NH<sub>3</sub>, CO, TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, BC) as well as seven heavy metals (Pb, Cd, Cu, Cr, Ni, Se, Zn) and POPs (Dioxins and Furans, PAHs) reported under sub-category 1.A.3.b Road Transport are estimated directly from the COPERT 5 model (Pastramas N. et al., 2014) developed within the CORINAIR programme for estimating a range of emissions from this important source.

The national total emissions in all cases are determined by the quantity of fuel sold in the country, as given by the energy balance. Approximately 65.82 petajoule (PJ) equivalent fuel energy from petrol, diesel, liquefied petroleum gas (LPG) and biofuels was consumed by road transport in Ireland in 1990. Consumption went up to 190.86 PJ in 2007 followed by a sharp decline to 145.88 PJ in 2012 and subsequently increasing to 165.36 PJ in 2018. The energy share in biofuel has continued to increase since its introduction in 2005 and increased to 6.46 PJ in 2018. It is known that significant proportions, e.g. -0.16 per cent of petrol and 6.22 per cent of diesel in 2018 sold in Ireland are consumed outside the country (referred to as fuel tourism) and therefore separate estimates of emissions are produced based on fuel amounts used within Ireland. The use of compressed natural gas (CNG) in road transport is recorded in national energy statistics for 2014 -2018, however, the emissions were not estimated as the fuel amounts were considered negligible. For some countries, including Ireland, the national totals determined by fuels used are the basis for assessment of their performance in relation to relevant Protocols under CLRTAP. Annex A.3 outlines the methodology used to estimate the quantities of automotive fuels used in Ireland and includes the adjusted annual emissions for 1987 and the years 1990–2018.

The emissions of SO<sub>2</sub> for road transportation are computed from the amounts of petrol and diesel used by motor vehicles, as reported in the energy balance, and the sulphur content of the fuels. For the other substances, the COPERT 5 model estimates emissions based on distance travelled using a detailed bottom-up approach (Tier 3) that accounts for such factors as fuel type, fuel consumption, engine capacity, driving speed and a wide range of applicable technological emission controls that may be applied across the different vehicle categories according to the age of vehicles.

A total of 217 vehicle categories are determined by these variables in COPERT 5. Figures C.1 through C.4 of Annex C show the trend in emission factors for NO<sub>x</sub>, SO<sub>2</sub>, NH<sub>3</sub> and NMVOCs per fuel type for road transportation over the period 1990–2018 determined by the COPERT variables for the vehicle fleet in Ireland. The methodologies for estimation of PM<sub>2.5</sub>, PM<sub>10</sub> and TSP are from the COPERT output of non-exhaust emission that includes brake and tyre wear emissions and road abrasion emissions for PM<sub>2.5</sub>, PM<sub>10</sub> and TSP were also calculated in COPERT.

The primary model inputs for each year are the populations of vehicles in the relevant categories, their annual kilometres of travel in three selected speed classes, total fuel amounts and the fuel specifications. The numbers of vehicles are taken from annual bulletins of vehicle and driver statistics (DTTAS, 2018) and these are allocated to the different control technologies (Euro I, Euro II, etc.) based on their age and the application dates of the controls in Ireland. Information to assign values of annual kilometres of travel for the three speed classes (corresponding to urban, rural and highway driving) used for the individual vehicle categories is taken from the National Roads Authority (NRA) and

odometer records from the National Car Testing (NCT) and Commercial Vehicle Roadworthiness Test (CVRT) Service. Before the emissions are estimated in COPERT 5, fuel balancing is undertaken in the model using inbuilt consumption rates for the different vehicle categories to ensure that the total fuel amounts calculated from annual kilometres and consumption rates for all vehicle categories match the input fuel quantities (the fuel sold as given in the energy balance or the fuel used as determined by Annex A.3) and therefore that emissions relate to the relevant total fuel amount. This fuel balancing may involve some adjustment to kilometres travelled or to the shares of total kilometres in the different road classes.

### 3.6.2.1 Trends in emissions in Road Transport

For NH<sub>3</sub>, COPERT generated NH<sub>3</sub> emission factors (g/km) for gasoline passenger car in 2005 for emission technology Euro 1 & Euro 2 are 30 percent and 52 per cent higher, respectively than those for 2004. This can be explained by a change in Sulphur content from 2004 (150ppm) to 2005 (109 ppm) for gasoline and from 208ppm to 37ppm for diesel in 2004 and 2005, respectively. In addition, gasoline use increased by 5.3 per cent between 2004 and 2005. This causes a resultant increase of 35% in emissions of NH<sub>3</sub> in 2005.

There was an increase in emissions of PM<sub>2.5</sub> and PM<sub>10</sub> from diesel passenger cars between 2006 and 2010 which can be explained by a combination of an increase in diesel passenger cars between the years 2006 and 2010, in part due to the indirect effect of motor taxation policy and economic growth leading to increased number of diesel cars less than 2L in the vehicle population, which more than offset reductions associated with the introduction of Euro 4 technology.

The fluctuations in NH<sub>3</sub> emissions for Light duty vehicles occurs because both gasoline fueled and diesel fueled light duty vehicles exist in Ireland. The NH<sub>3</sub> IEF (g/km) for gasoline and diesel fueled LDVs is between 0.001 and 0.004 g/km for the entire time series using the Tier 3 COPERT 5 model. These are similar to the Tier 2 diesel exhaust emission factors presented in the EMEP/EEA 2019 inventory guidebook. Furthermore, it should be noted that in 1990, 87.2 per cent of the total mileage for LDVs was from diesel fueled vehicles with the remainder being petrol fueled. This has grown to 99.8 per cent in 2018. The introduction of Euro 6 LDV vehicles in 2015 which have an increased emission factor (g/km) above Euro 1, 2, 3 and 4 associated with a 11.3 per cent increase in total mileage for diesel powered LDVs between 2013 and 2018 explains the increase in emissions of NH<sub>3</sub>.

Fluctuations in NH<sub>3</sub> emissions for Heavy Duty Vehicle (HDV) is due to increased IEF for HDV which is influenced by the increased activity by heavier engine size and lower activity in smaller engine size (e.g. Rigid <7.5 t have decreased from 19 per cent of the HDV activity in 2012 to 11 per cent of the HDV activity in 2018 while Rigid 14-20 t increased from 17 per cent of HDV fleet activity in 2012 to 25 per cent of HDV activity in 2018). In 2014, 2015 and 2016 there was an increase in HDV mileage x stock (4 per cent, 9 per cent and 11 per cent respectively). Despite this increase in activity in HDVs, NOx emissions from HDVs have decreased in 2015-2018, this is mainly due to the move from activity in older technologies into the newer Euro IV-VI classes for HDV which have improved emissions standards and hence lower emissions. For example, 53% of HDV activity was in the Conventional, Euro I, II and III classes in 2012, whereas in 2018 11% of HDV activity is in these Euro classes and 89% is in Euro IV-Euro VI.

Lubricant emissions from the road transport sector were estimated using COPERT 5 where the lubricant used was considered as an input in the model. Thus, emissions from lubricant for all engines including 2 and 4 stroke engines were included in COPERT output and reported under relevant categories in the NFR.

### 3.6.3 Railways (NFR 1A3c), National Navigation (NFR 1A3dii) and Other Transportation (NFR 1A3e)

The emissions under sub-categories 1A3c Railways and 1A3d National Navigation are calculated from the amounts of fuel used by these activities and the country-specific SO<sub>x</sub> emission factors and default Inventory Guidebook (EMEP/EEA, 2019) emission factors for oil. No solid fuels have been used in railways since 1970. All emission factors for railways and navigation are given in Table C.20 of Annex C. These are minor sources of emissions in Ireland. Emissions from military shipping are allocated to 1A3d, national navigation. or 1A3di(i), international maritime navigation, as appropriate.

The emissions reported in sub-category 1A3e Other Transportation refer to the use of natural gas in pipeline compressor stations and emission factors (country-specific and default values) for this sub-category are given in Table C.21 of Annex C. The fuel use is estimated as the difference between the value given for natural gas under own use/losses in the energy balance sheets (Annex B) and the amount of gas estimated to be lost from the distribution network.

## 3.7 Other Sectors (NFR 1A4)

The NFR Subcategory 1A4 Other Sectors covers combustion sources in the Commercial/Institutional (1A4a), the Residential (1A4b), and Agriculture/Forestry/Fishing (1A4c) sectors. The Residential sector remains the most important source of emissions for most substances in this subcategory in Ireland, while Agriculture/Forestry/Fishing is a major contributor to NO<sub>x</sub> emissions, largely because of the influence of agricultural (off-road) machinery. The activity data for all 1A4 subcategories are taken directly from the energy balance. As there are no fuels allocated to the sector 1A4aii Commercial/Institutional: Mobile or 1A4bii Residential: Household and Gardening (Mobile) in national energy statistics, it is accounted for in category 1A3b Road Transport where gasoline fuel is fully accounted. Sector Residential (1A4b) Tier 1 emission factors from the EMEP/EEA 2019 guidebook are used for all fuels with the exception of Biomass. A Tier 2 method is applied to emissions from Woody Biomass using emission factors from Chapter 1A4 Table 3-40 for wood and similar wood waste. The emission factors for sub-category 1A4 Other Sectors are given in Tables C.22 through C.28 of Annex C.

### 3.7.1 Agriculture/Forestry/Fishing (NFR 1A4ci and ii)

This subcategory covers both stationary combustion (1A4ci) and mobile combustion (1A4cii) in Agriculture. The energy balance does not currently provide information on the end use of gasoil in agriculture. However, based on information received from agricultural experts, 90 per cent of total gasoil in the sector is assigned to mobile machinery with the remainder assigned to stationary combustion. For both stationary and mobile combustion, the emission factors used are presented in Table C.26 of Annex C.

Ireland utilises the Tier 2 approach outlined in the Inventory Guidebook (EMEP/EEA 2019) to estimate emissions of NO<sub>x</sub>, NMVOC, CO, PM<sub>10</sub>, PM<sub>2.5</sub> and TSP from mobile combustion in this sector. The Tier 2 emission factors are based on data from the Danish Inventory (Winther and Nielsen, 2006). The emission factors are grouped according to the EU emission legislation stages, and three additional layers are added to cover the emissions from engines prior to the first EU legislation stages. The country-specific SO<sub>x</sub> emission factors and default Inventory Guidebook (EMEP/EEA, 2019) emission factors for NH<sub>3</sub> and BC are used for this sub-category. The implied emission factors are presented in Table C.27 of Annex C. Emission Factors for Heavy Metals and POPs are based on emission factors from the Inventory Guidebook (EMEP/EEA, 2009, 2019). The category 1A4ci Agriculture/Forestry/Fishing: Stationary, the NO<sub>x</sub> Tier 1 liquid fuel emission factors from the Inventory Guidebook (EMEP/EEA, 2019) are an average of Tier 2 EFs and are not considered representative for Ireland for the same reasons as described in section 3.5.

### 3.7.2 Agriculture/Forestry/Fishing: National Fishing (NFR 1A4ciii)

Emissions from this sub-category were reported for the first time in the 2013 submission. The national energy balance now includes marine diesel used in national fishing for the all years from 1990 to 2018. The emission factors used for this sub-category are country-specific (SO<sub>x</sub>) and Inventory Guidebook (EMEP/EEA, 2019) default values for all other pollutants and are presented in Table C.28 of Annex C.

## 3.8 Other Stationary and Mobile (including military) (NFR 1A5)

Ireland does not report any emissions under category 1A5. For NFR categories 1A5a and 1A5b notation key IE is used to indicate that military emissions (mobile and stationary) are included elsewhere as emissions are allocated in 1A4a and 1A3 (aviation and road). All stationary emissions from military are reported in sector 1A4a and all mobile military emission are reported under 1A3 (aviation and road).

## 3.9 Fugitive emissions from Solid Fuels (NFR 1B1)

### 3.9.1 Coal mining and handling (1B1a)

Emissions from the NFR subcategory 1B1a Coal mining are reported in this submission. The national energy balance includes coal mined in the years 1990 to 1995 when the last commercial coal mine was closed in Ireland. The emission factors used and the resulting time series of NMVOC, TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emissions are based on the Inventory Guidebook (EMEP/EEA, 2019) default values and are presented in Table 3.1.

Emissions of PM<sub>2.5</sub>, PM<sub>10</sub> and TSP from the handling and storage of coal other than the domestic production has been estimated using an estimate of the area of coal storage and tonnes of coal handled in Ireland's only coal burning power plant and emission factors from Inventory Guidebook (EMEP/EEA, 2019).

**Table 3.1. Fugitive Emissions from Coal mining and handling**

Activity Data		1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Coal mining	kt	25.00	1.00	NO											
Area of coal storage	ha	31.20	31.20	31.20	31.20	31.20	31.20	31.20	31.20	31.20	31.20	31.20	31.20	31.20	31.20
Coal handling	kt	1,867	2,248	2,145	2,130	1,165	1,305	1,373	1,745	1,459	1,417	1,695	1,656	1,305	735
<b>Emission Factors</b>															
Coal mining	kg NMVOC/t	0.80	0.80	NA											
Coal mining	kg TSP/t	0.09	0.09	NA											
Coal mining	kg PM <sub>10</sub> /t	0.04	0.04	NA											
Coal mining	kg PM <sub>2.5</sub> /t	0.01	0.01	NA											
Coal storage	t PM <sub>2.5</sub> /ha	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
Coal storage	t PM <sub>10</sub> /ha	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10	4.10
Coal storage	t TSP/ha	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25
Coal handling	g PM <sub>2.5</sub> /t	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Coal handling	g PM <sub>10</sub> /t	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Coal handling	g TSP/t	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
<b>Emissions</b>															
Coal mining	kt NMVOC	0.020	0.001	NO											
Coal mining	kt TSP	0.002	0.000	NO											
Coal mining	kt PM <sub>10</sub>	0.001	0.000	NO											
Coal mining	kt PM <sub>2.5</sub>	0.000	0.000	NO											
Coal storage	kt PM <sub>2.5</sub>	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Coal storage	kt PM <sub>10</sub>	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128
Coal storage	kt TSP	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320
Coal handling	kt PM <sub>2.5</sub>	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000
Coal handling	kt PM <sub>10</sub>	0.006	0.007	0.006	0.006	0.003	0.004	0.004	0.005	0.004	0.004	0.005	0.005	0.004	0.002
Coal handling	kt TSP	0.014	0.017	0.016	0.016	0.009	0.010	0.010	0.013	0.011	0.011	0.013	0.012	0.010	0.006

## 3.10 Fugitive emissions from Oil and Natural Gas (NFR 1B2)

### 3.10.1 Oil (NFR 1B2a)

The NFR subcategory 1B2a is an important source of fugitive NMVOC emissions. Emissions of NMVOCs are estimated from two sources, Refining/Storage (1B2aiv) and Distribution of Oil Products (1B2av). Emissions from Refining/Storage are estimated using a Tier 3 methodology using plant specific data for years 2007-2018 from Ireland's only refinery. An implied emission factor of 0.8818 kg/t was used for years before 2007 using an average of 2007-2016 implied emission factors and the crude oil throughput for the refinery.

The emissions from 1B2av, which is a key category, were estimated using a Tier 2 approach using emission factors and abatement efficiencies from the Inventory Guidebook (EMEP/EEA, 2019). The Stage I and Stage II abatement controls were applied as appropriate to the implementation of legislation in Ireland. The resulting time series of NMVOC emissions are presented in Table 3.2. Emissions of NMVOCs from these subcategories nearly doubled in the period from 1990 to 2007 in line with the increases in crude oil throughput for the refinery and petrol distribution for the transport sector but have since decreased due to the economic situation and the implementation of abatement controls in petrol distribution causing an overall decrease in most emissions. A slight increase in emissions in the Refining/Storage source can be seen from 2014 to 2017 due to increased crude oil throughput. The 2018 emissions have decreased in line with a decrease in crude oil throughput.

The refinery responded to a previous query from the inventory agency that the only fugitive emissions to air are for NMVOCs (emissions that occur through leakage, evaporation or other uncontrolled losses). The estimate is based on throughput, mass balance and industry (e.g. API) guideline emissions factors at the plant, tankage, jetty, road-loading and Waste Water Treatment Plant. Emissions from flaring are included in the totals for the other pollutants, as site emissions are calculated based on total metered fuel use. Therefore, reporting under 1A1b is complete for the plant and there should be no additional reporting under 1B2aiv except for NMVOC. The notation key "IE" included elsewhere is used for 1B2aiv for Cd, Hg and PCDD/F as all emissions from refineries including flaring are reported under category 1A1b. No heavy metal or dioxins to air are reported under LCP/PRTR/IPPC returns to the EPA in Ireland.

**Table 3.2. Fugitive Non-Methane Volatile Organic Compound Emissions**

<b>Activity Data</b>		<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>
Crude to refineries	kt	1,804	2,229	3,278	3,309	2,812	2,905	2,949	3,068	2,838	2,752	3,340	3,200	3,181	3,024
Petrol distribution	kt	885	1,037	1,493	1,711	1,537	1,387	1,314	1,195	1,124	1,064	1,009	942	849	771
<b>Emission Factors</b>															
Crude to refineries	kg NMVOC/t	0.88	0.88	0.88	0.88	0.99	0.92	0.84	0.81	0.86	0.95	0.84	0.85	0.85	0.90
Petrol distribution	kg NMVOC/t	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
<b>Emissions</b>															
Crude to refineries	kt NMVOC	1.59	1.97	2.89	2.92	2.80	2.66	2.49	2.48	2.45	2.62	2.80	2.73	2.72	2.73
Petrol distribution	kt NMVOC	1.79	2.10	3.30	3.81	3.39	3.15	2.97	2.60	2.22	2.12	1.95	1.76	1.77	1.37
Total emissions	kt NMVOC	3.38	4.06	6.19	6.73	6.19	5.80	5.46	5.08	4.67	4.74	4.75	4.50	4.49	4.10

### 3.10.2 Venting and flaring (oil, gas, combined oil and gas) (NFR1B2c)

Regarding the flares at refineries, all emissions have been included within the category 1A1b Petroleum Refining, as site emissions were calculated based on total metered fuel use.

## 3.11 Recalculations in the Energy Sector

The results of recalculations for the combustion categories 1A1, 1A2, 1A3 and 1A4 are given in Tables 3.3 through 3.7 below.

Recalculations have been undertaken for the years 1990–2017 in the Energy sector (combustion and fugitive) to account for the following changes. Emission factors have been updated to EMEP/EEA 2019 where relevant:

#### *1A1 Energy Industries*

- Revised NO<sub>x</sub> and SO<sub>2</sub> emissions from 1A1a Power Generation for years 2007-2014 to take into account the results of a survey of power plants regarding the reporting of emissions using validated average figures (after subtracting the value of the confidence interval). Three plants were discovered to be underreporting their emissions as a result of this exercise and corrected figures were supplied without subtraction of the confidence interval. This has resulted in a recalculation of emissions for years 2007-2014 for NO<sub>x</sub> and 2007-2017 for SO<sub>2</sub>.
- In 1A1b there was a revision to Natural Gas consumption for 2017 in the national energy balance, this resulted in a recalculation of the -6.2% for NMVOC and a 4% Arsenic and 6% Mercury recalculation.

#### *1A2 Manufacturing Industries and Construction*

- Revised fuel consumption in the national energy balance for fuels and years; natural gas (2009, 2013, 2015), fuel oil, biomass and non-renewable wastes (2017). This resulted in minor recalculations for 2009, 2013, 2015. A recalculation of 4.6% SO<sub>2</sub>, 3.8% NMVOC, 2% Pb and 4.3% Cd occurred. Recalculations are presented in table 3.4.
- The methodology for estimating POP emissions from cement manufacturing was updated using the gram pollutant per tonne of clinker emission factors in the EMEP/EEA guidebook 2019. The POP emissions were removed from 2A1 and reported under 1A2f as recommended in the guidebook Chapter 1.A.2. (EMEP/EEA, 2019). This has resulted in a significant decrease in POP emissions in the 1A2f category.

#### *1A3 Transport*

- Revised methodology used in 1A3a Aviation as described in section 3.6.1 which resulted in a recalculation across the entire time series for NO<sub>x</sub>, SO<sub>2</sub> and NMVOC
- The most recent submission included a fleet improvement where the methodology for estimating mileage for Buses was improved for 2013-2017. GDP is no longer used as a proxy to estimate bus mileage as this was creating an inaccurate increase in bus and coach mileage as GDP increased year on year. The new methodology uses the actual number of kilometers travelled by buses and coaches divided by the known fleet. This change in bus methodology required that the mileage and fuel be rebalanced for the years 2013 to 2017 for all vehicle categories which resulted in a recalculation for these years.
- The most recent submission corrected an error in fleet calculation for LCV and HDV for the years 2004, 2006 and 2007. This resulted in a slight recalculation for these years.

- A new version of COPERT was released in September 2019 (COPERT versions 5.3.0) which included new emission factors for moped and motorcycles as well as revised evaporation factors for Euro 6d-temp and Euro 6d passenger cars and light commercial vehicles. Light commercial vehicle Euro 6 NOx emission factors were also revised in this version as a result a recalculation is seen from the previous submission which was COPERT version 5.2.0 (August 2018 release)
- 1A3di National navigation had a recalculation in 2002- 2005 and 2011-2016 for SO<sub>2</sub> due a revision in the Sulphur content used in the estimation of emissions from Marine fuel oil for these years.

#### *1A4 Other Sectors*

- Sector 1A4a Commercial/Institutional has a 178% recalculation to SO<sub>2</sub> in 2017 due to a revision in the Sulphur content used in the estimation of emissions from gasoil used in this submission.
- A recalculation of 2.1% in 1A4b Residential SO<sub>2</sub> emissions in 2017 due to a revision in the Sulphur content used in the estimation of emissions in gasoil used in this submission.

**Table 3.3. Recalculations in Energy NFR 1A1**

<b>NFR Category</b>	<b>Pollutant</b>	<b>Unit</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	
<b>Submission 2019</b>																	
1A1a Public Electricity and Heat Production	NO <sub>x</sub>	kt	46.37	41.39	39.72	32.38	22.02	13.32	11.52	8.00	10.30	8.57	8.10	9.82	8.29	8.11	
	SO <sub>2</sub>	kt	103.04	91.63	79.87	42.50	25.19	15.69	9.46	9.38	9.58	8.69	6.20	5.51	3.84	3.89	
	NMVOOC	kt	0.19	0.25	0.36	0.37	0.38	0.35	0.37	0.31	0.30	0.27	0.26	0.26	0.30	0.30	
	Pb	t	0.63	0.75	0.78	0.73	0.54	0.45	0.44	0.44	0.54	0.47	0.48	0.54	0.52	0.45	
	Cd	t	0.09	0.11	0.12	0.11	0.08	0.06	0.06	0.06	0.06	0.07	0.06	0.06	0.07	0.07	
	Hg	t	0.12	0.13	0.13	0.13	0.11	0.09	0.09	0.09	0.09	0.11	0.09	0.10	0.11	0.11	0.10
1A1b Petroleum Refining	NO <sub>x</sub>	kt	0.47	0.52	0.77	0.94	0.77	0.75	0.80	0.63	0.68	0.58	0.54	0.38	0.32	0.26	
	SO <sub>2</sub>	kt	0.48	0.51	0.78	0.91	0.98	0.88	0.67	0.90	0.43	0.57	0.01	0.03	0.02	0.03	
	NMVOOC	kt	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
	Pb	t	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01
	Cd	t	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hg	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A1c Manufacture of Solid Fuels and Other Energy Industries	NO <sub>x</sub>	kt	0.16	0.12	0.15	0.29	0.38	0.25	0.32	0.21	0.18	0.22	0.22	0.24	0.32	0.11	
	SO <sub>2</sub>	kt	0.13	0.10	0.12	0.16	0.05	0.14	0.21	0.25	0.24	0.19	0.03	0.09	0.25	0.11	
	NMVOOC	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Pb	t	0.02	0.02	0.02	0.03	0.03	0.04	0.03	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02
	Cd	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hg	t	0.02	0.02	0.02	0.03	0.03	0.04	0.03	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03
<b>Submission 2020</b>																	
1A1a Public Electricity and Heat Production	NO <sub>x</sub>	kt	46.37	41.39	39.72	32.38	22.48	13.78	11.92	8.37	10.53	9.09	7.81	9.82	8.31	8.12	
	SO <sub>2</sub>	kt	103.04	91.63	79.87	42.50	25.66	16.11	9.78	9.73	9.84	8.95	6.20	5.51	3.96	3.98	
	NMVOOC	kt	0.19	0.25	0.36	0.37	0.38	0.35	0.37	0.31	0.30	0.27	0.26	0.26	0.30	0.30	
	Pb	t	0.63	0.75	0.78	0.73	0.54	0.45	0.44	0.44	0.54	0.47	0.48	0.54	0.52	0.45	
	Cd	t	0.09	0.11	0.12	0.11	0.08	0.06	0.06	0.06	0.06	0.07	0.06	0.06	0.07	0.07	
	Hg	t	0.12	0.13	0.13	0.13	0.11	0.09	0.09	0.09	0.09	0.11	0.09	0.10	0.11	0.11	0.10
1A1b Petroleum Refining	NO <sub>x</sub>	kt	0.47	0.52	0.77	0.94	0.77	0.75	0.80	0.63	0.68	0.58	0.54	0.38	0.32	0.26	
	SO <sub>2</sub>	kt	0.48	0.51	0.78	0.91	0.98	0.88	0.67	0.90	0.43	0.57	0.01	0.03	0.02	0.03	
	NMVOOC	kt	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01
	Pb	t	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01
	Cd	t	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hg	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A1c Manufacture of Solid Fuels and Other Energy Industries	NO <sub>x</sub>	kt	0.16	0.12	0.15	0.29	0.38	0.25	0.32	0.21	0.18	0.22	0.22	0.24	0.32	0.11	
	SO <sub>2</sub>	kt	0.13	0.10	0.12	0.16	0.05	0.14	0.21	0.25	0.24	0.19	0.03	0.09	0.25	0.11	
	NMVOOC	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Pb	t	0.02	0.02	0.02	0.03	0.03	0.04	0.03	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02
	Cd	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hg	t	0.02	0.02	0.02	0.03	0.03	0.04	0.03	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03

**Table 3.3. Recalculations in Energy NFR 1A1 (continued)**

<b>Table 3.3 Recalculations in Energy NFR 1A1</b>																		
<b>% Change in Emissions</b>		<b>Pollutant</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>		
1A1a Public Electricity and Heat Production		NO <sub>x</sub>	%	0.0%	0.0%	0.0%	0.0%	2.1%	3.5%	3.5%	4.7%	2.2%	6.1%	-3.6%	0.0%	0.2%	0.1%	
		SO <sub>2</sub>	%	0.0%	0.0%	0.0%	0.0%	1.9%	2.7%	3.5%	3.7%	2.8%	3.0%	0.1%	0.0%	3.0%	2.5%	
		NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Pb	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Cd	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Hg	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1A1b Petroleum Refining		NO <sub>x</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		SO <sub>2</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-6.2%	
		Pb	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		Cd	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	Hg	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-5.9%		
1A1c Manufacture of Solid Fuels and Other Energy Industries		NO <sub>x</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		SO <sub>2</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		Pb	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
		Cd	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	Hg	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 3.4. Recalculations in Energy NFR 1A2

<b>Table 3.4 Recalculations in Energy NFR 1A2</b>																
<b>NFR Category</b>	<b>Pollutant</b>	<b>Unit</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>
<b>Submission 2019</b>																
1A2 Manufacturing Industries and Construction	NO <sub>x</sub>	kt	8.93	8.05	10.53	17.31	15.73	10.34	9.93	8.46	10.46	10.53	10.98	11.04	11.18	10.27
	SO <sub>2</sub>	kt	32.79	40.18	42.03	13.13	7.90	5.11	5.86	5.24	4.49	4.87	3.34	2.46	2.57	2.75
	NMVOG	kt	1.67	1.27	1.77	2.78	2.75	2.34	2.46	2.25	2.23	2.28	2.76	2.88	2.90	3.20
	Pb	t	1.73	1.10	1.51	2.09	1.67	1.24	1.24	1.03	0.97	0.90	1.04	1.03	1.04	1.05
	Cd	t	0.06	0.05	0.08	0.12	0.10	0.09	0.10	0.09	0.08	0.09	0.10	0.11	0.11	0.12
	Hg	t	0.09	0.04	0.06	0.09	0.08	0.06	0.06	0.06	0.06	0.06	0.05	0.06	0.07	0.07
<b>Submission 2020</b>																
1A2 Manufacturing Industries and Construction	NO <sub>x</sub>	kt	8.93	8.05	10.53	17.31	15.73	10.35	9.93	8.46	10.46	10.53	10.98	10.96	11.18	10.16
	SO <sub>2</sub>	kt	32.79	40.18	42.03	13.13	7.90	5.11	5.87	5.24	4.49	4.87	3.34	2.46	2.57	2.63
	NMVOG	kt	1.67	1.27	1.77	2.78	2.75	2.34	2.46	2.25	2.23	2.28	2.76	2.88	2.90	3.07
	Pb	t	1.73	1.10	1.51	2.09	1.67	1.24	1.24	1.03	0.97	0.90	1.04	1.03	1.04	1.03
	Cd	t	0.06	0.05	0.08	0.12	0.10	0.09	0.10	0.09	0.08	0.09	0.10	0.11	0.11	0.12
	Hg	t	0.09	0.04	0.06	0.09	0.08	0.06	0.06	0.06	0.06	0.06	0.05	0.06	0.07	0.07
<b>% Change in Emissions</b>																
1A2 Manufacturing Industries and Construction	NO <sub>x</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.7%	0.0%	-1.0%
	SO <sub>2</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-4.6%
	NMVOG	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	-0.2%	0.0%	-3.8%
	Pb	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-2.0%
	Cd	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-4.3%
	Hg	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	-0.2%	0.0%	-0.4%

**Table 3.5. Recalculations in Energy NFR 1.A.3 (a & b)\***

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>Submission 2019</b>																
1A3a(i) & (ii) International and Domestic Aviation	NO <sub>x</sub>	kt	4.81	5.16	8.10	11.08	12.57	9.90	10.00	8.80	7.44	8.74	9.81	11.17	11.46	13.62
	SO <sub>2</sub>	kt	0.30	0.32	0.50	0.68	0.77	0.61	0.63	0.56	0.47	0.54	0.60	0.68	0.69	0.81
	NMVOOC	kt	0.24	0.24	0.37	0.43	0.54	0.44	0.48	0.42	0.38	0.41	0.42	0.44	0.45	0.47
1A3b Road Transportation	NO <sub>x</sub>	kt	55.09	55.54	61.83	56.78	50.05	43.17	38.48	37.23	35.42	36.78	38.18	39.14	39.01	37.33
	SO <sub>2</sub>	kt	5.37	5.13	1.66	0.54	0.14	0.05	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05
	NMVOOC	kt	33.56	31.34	23.10	15.62	11.94	10.43	9.07	8.21	7.35	6.83	6.40	5.92	5.33	4.41
	NH <sub>3</sub>	kt	0.04	0.41	1.69	2.50	2.08	1.80	1.53	1.35	1.17	1.07	0.97	0.88	0.80	0.68
	PM <sub>2.5</sub>	kt	2.29	2.61	3.47	3.10	2.85	2.56	2.35	2.19	2.04	2.05	2.03	2.00	1.92	1.65
	Pb	t	143.97	87.50	5.76	1.57	1.62	1.46	1.34	1.32	1.27	1.31	1.35	1.42	1.45	1.43
	Cd	t	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Hg	t	0.01	0.01	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
<b>Submission 2020</b>																
1A3a(i) & (ii) International and Domestic Aviation	NO <sub>x</sub>	kt	4.80	5.15	8.10	11.08	12.57	9.90	10.00	8.80	7.44	8.74	9.81	11.17	11.46	13.63
	SO <sub>2</sub>	kt	0.30	0.32	0.50	0.68	0.77	0.61	0.63	0.56	0.47	0.54	0.60	0.68	0.69	0.81
	NMVOOC	kt	0.24	0.24	0.37	0.43	0.54	0.44	0.48	0.42	0.38	0.41	0.42	0.44	0.45	0.47
1A3b Road Transportation	NO <sub>x</sub>	kt	55.09	55.54	61.81	56.79	50.03	43.18	38.50	37.22	35.44	37.00	38.63	39.48	39.28	37.24
	SO <sub>2</sub>	kt	5.37	5.13	1.66	0.54	0.14	0.05	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05
	NMVOOC	kt	33.55	31.32	23.08	15.60	11.92	10.40	9.05	8.19	7.33	6.88	6.42	5.95	5.27	4.41
	NH <sub>3</sub>	kt	0.04	0.42	1.70	2.50	2.08	1.80	1.53	1.35	1.17	1.06	0.96	0.89	0.80	0.68
	PM <sub>2.5</sub>	kt	2.29	2.61	3.47	3.10	2.85	2.56	2.35	2.19	2.04	2.06	2.05	2.03	1.91	1.65
	Pb	t	143.97	87.50	5.76	1.57	1.62	1.46	1.34	1.32	1.27	1.32	1.35	1.42	1.45	1.43
	Cd	t	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Hg	t	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
<b>% Change in Emissions</b>																
1A3a(i) & (ii) International and Domestic Aviation	NO <sub>x</sub>	%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SO <sub>2</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	NMVOOC	%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1A3b Road Transportation	NO <sub>x</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	1.2%	0.9%	0.7%	-0.3%
	SO <sub>2</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	NMVOOC	%	0.0%	0.0%	-0.1%	-0.1%	-0.2%	-0.3%	-0.2%	-0.2%	-0.2%	0.8%	0.4%	0.5%	-1.0%	0.0%
	NH <sub>3</sub>	%	0.0%	0.1%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.5%	-0.7%	1.0%	0.4%	0.4%
	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.6%	1.3%	1.1%	-0.6%	-0.1%
	Pb	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.4%	0.2%	-0.1%	-0.3%
	Cd	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.4%	0.1%	-0.4%	-0.2%
	Hg	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

\* Emissions from both LTO and cruise are included here to capture all possible recalculations. However, the cruise component is reported as a memo item under the LRTAP Convention.

Table 3.6. Recalculations in Energy NFR 1A3 (c, d & e)

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
<b>Submission 2019</b>																	
1A3c Railways	NO <sub>x</sub>	kt	2.20	1.84	2.03	2.02	2.31	2.03	2.01	2.03	1.95	1.94	1.78	1.81	1.85	1.91	
	SO <sub>2</sub>	kt	0.25	0.14	0.12	0.11	0.05	0.06	0.06	0.06	0.06	0.05	0.02	0.02	0.01	0.01	
	NMVOOC	kt	0.20	0.16	0.18	0.18	0.21	0.18	0.18	0.18	0.17	0.17	0.16	0.16	0.16	0.17	
	PM <sub>2.5</sub>	kt	0.06	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	
	Pb	t	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
	Cd	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Hg	t	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
1A3d(ii) National Navigation	NO <sub>x</sub>	kt	2.14	2.29	3.78	5.20	5.01	4.88	4.90	4.25	4.49	4.39	5.50	5.43	6.52	5.76	
	SO <sub>2</sub>	kt	1.16	1.26	1.22	0.49	0.08	0.10	0.10	0.07	0.10	0.10	0.10	0.10	0.12	0.09	
	NMVOOC	kt	0.07	0.08	0.13	0.18	0.18	0.17	0.17	0.15	0.16	0.16	0.20	0.19	0.23	0.21	
	PM <sub>2.5</sub>	kt	0.12	0.13	0.17	0.17	0.09	0.09	0.09	0.08	0.08	0.08	0.10	0.10	0.12	0.10	
	Pb	t	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
	Cd	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Hg	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
1A3e(i) Pipeline Compressors	NO <sub>x</sub>	kt	0.06	0.11	0.05	0.13	0.12	0.13	0.14	0.13	0.12	0.12	0.12	0.12	0.12	0.11	
	<b>Submission 2020</b>																
	1A3c Railways	NO <sub>x</sub>	kt	2.20	1.84	2.03	2.02	2.31	2.03	2.01	2.03	1.95	1.94	1.78	1.81	1.85	1.91
		SO <sub>2</sub>	kt	0.25	0.14	0.12	0.11	0.05	0.06	0.06	0.06	0.06	0.05	0.02	0.02	0.01	0.01
		NMVOOC	kt	0.20	0.16	0.18	0.18	0.21	0.18	0.18	0.18	0.17	0.17	0.16	0.16	0.16	0.17
		PM <sub>2.5</sub>	kt	0.06	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Pb	t	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Cd		t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Hg		t	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
1A3d(ii) National Navigation	NO <sub>x</sub>	kt	2.14	2.29	3.78	5.20	5.01	4.88	4.90	4.25	4.49	4.39	5.50	5.43	6.52	5.76	
	SO <sub>2</sub>	kt	1.16	1.26	1.22	0.67	0.08	0.10	0.10	0.08	0.09	0.08	0.05	0.03	0.03	0.09	
	NMVOOC	kt	0.07	0.08	0.13	0.18	0.18	0.17	0.17	0.15	0.16	0.16	0.20	0.19	0.23	0.21	
	PM <sub>2.5</sub>	kt	0.12	0.13	0.17	0.17	0.09	0.09	0.09	0.08	0.08	0.08	0.10	0.10	0.12	0.10	
	Pb	t	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
	Cd	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Hg	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
1A3e(i) Pipeline Compressors	NO <sub>x</sub>	kt	0.06	0.11	0.05	0.13	0.12	0.13	0.14	0.13	0.12	0.12	0.12	0.12	0.12	0.11	
	<b>% Change in Emissions</b>																
	1A3c Railways	NO <sub>x</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		SO <sub>2</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		NMVOOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Pb	%	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Cd		%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Hg		%	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
1A3d(ii) National Navigation	NO <sub>x</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	SO <sub>2</sub>	%	0.0%	0.0%	0.0%	36.8%	0.0%	0.0%	0.0%	8.6%	-9.1%	-17.9%	-50.9%	-63.9%	-72.1%	0.0%	
	NMVOOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	Pb	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	Cd	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	Hg	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
1A3e(i) Pipeline Compressors	NO <sub>x</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

**Table 3.7. Recalculations in Energy NFR 1A4**

<b>NFR Category</b>	<b>Pollutant</b>	<b>Unit</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>
<b>Submission 2019</b>																
1A4a Commercial/Institutional	NO <sub>x</sub>	kt	3.06	2.84	3.16	3.30	3.56	3.10	3.11	2.84	2.86	2.66	2.43	2.44	2.57	2.73
	SO <sub>2</sub>	kt	11.52	5.54	2.38	1.93	1.16	0.71	0.67	0.61	0.59	0.46	0.20	0.16	0.12	0.12
	NMVOG	kt	0.47	0.42	0.53	0.62	0.71	0.60	0.62	0.54	0.57	0.55	0.53	0.55	0.58	0.62
	NH <sub>3</sub>	kt	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.03	0.04	0.04	0.03	0.04	0.03
	PM <sub>2.5</sub>	kt	0.56	0.40	0.39	0.48	0.49	0.31	0.30	0.29	0.28	0.25	0.22	0.20	0.21	0.22
	Pb	t	0.58	0.38	0.37	0.49	0.49	0.29	0.27	0.27	0.25	0.22	0.19	0.17	0.18	0.19
	Cd	t	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02
	Hg	t	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A4b Residential	NO <sub>x</sub>	kt	7.33	5.79	5.43	5.92	6.11	6.14	6.34	5.43	5.16	5.35	4.76	4.97	4.94	4.66
	SO <sub>2</sub>	kt	26.76	17.32	15.07	12.22	9.21	9.15	8.80	8.05	7.62	8.29	7.00	6.69	6.66	6.03
	NMVOG	kt	28.52	18.05	12.35	10.99	10.78	11.38	10.75	9.97	9.73	10.46	8.93	8.68	8.05	7.24
	NH <sub>3</sub>	kt	0.15	0.10	0.06	0.05	0.05	0.06	0.06	0.05	0.06	0.07	0.06	0.06	0.06	0.06
	PM <sub>2.5</sub>	kt	23.91	15.16	10.34	9.21	9.04	9.55	9.03	8.37	8.19	8.81	7.53	7.33	6.82	6.13
	Pb	t	7.40	4.67	3.20	2.84	2.80	2.96	2.79	2.59	2.52	2.70	2.31	2.25	2.08	1.87
	Cd	t	0.11	0.07	0.05	0.04	0.04	0.05	0.05	0.04	0.04	0.05	0.04	0.04	0.04	0.04
	Hg	t	0.29	0.19	0.13	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.10	0.09	0.09	0.08
1A4c Agriculture/Forestry/Fishing	NO <sub>x</sub>	kt	8.76	14.31	12.91	12.76	10.27	8.57	7.43	6.56	6.19	5.55	4.84	4.27	4.05	4.21
	SO <sub>2</sub>	kt	1.41	1.34	0.94	0.86	0.37	0.42	0.37	0.06	0.09	0.08	0.05	0.04	0.04	0.05
	NMVOG	kt	1.38	1.71	1.35	1.09	0.86	0.69	0.60	0.53	0.48	0.40	0.34	0.30	0.29	0.29
	NH <sub>3</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	PM <sub>2.5</sub>	kt	0.93	1.05	0.76	0.60	0.47	0.37	0.32	0.28	0.25	0.21	0.17	0.15	0.14	0.14
	Pb	t	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
	Cd	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hg	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Submission 2020</b>																
1A4a Commercial/Institutional	NO <sub>x</sub>	kt	3.06	2.84	3.16	3.31	3.58	3.12	3.12	2.86	2.87	2.67	2.44	2.46	2.60	2.75
	SO <sub>2</sub>	kt	11.52	5.54	2.38	1.93	1.16	0.71	0.67	0.61	0.59	0.46	0.20	0.16	0.12	0.33
	NMVOG	kt	0.47	0.42	0.53	0.63	0.71	0.60	0.62	0.55	0.57	0.56	0.53	0.55	0.59	0.62
	NH <sub>3</sub>	kt	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.03	0.04	0.04	0.03	0.04	0.03
	PM <sub>2.5</sub>	kt	0.56	0.40	0.39	0.48	0.49	0.31	0.30	0.29	0.28	0.25	0.22	0.20	0.21	0.22
	Pb	t	0.58	0.38	0.37	0.49	0.49	0.29	0.27	0.27	0.25	0.22	0.19	0.17	0.18	0.19
	Cd	t	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02
	Hg	t	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A4b Residential	NO <sub>x</sub>	kt	7.33	5.79	5.43	5.92	6.11	6.14	6.34	5.43	5.16	5.35	4.76	4.97	4.94	4.66
	SO <sub>2</sub>	kt	26.76	17.32	15.07	12.22	9.21	9.15	8.80	8.05	7.62	8.29	7.00	6.69	6.66	6.16
	NMVOG	kt	28.52	18.05	12.35	10.99	10.78	11.38	10.75	9.97	9.73	10.46	8.93	8.68	8.05	7.24
	NH <sub>3</sub>	kt	0.15	0.10	0.06	0.05	0.05	0.06	0.06	0.05	0.06	0.07	0.06	0.06	0.06	0.06

1A4c Agriculture/Forestry/Fishing	PM <sub>2.5</sub>	kt	23.91	15.16	10.34	9.21	9.04	9.55	9.03	8.37	8.19	8.81	7.53	7.33	6.82	6.13
	Pb	t	7.40	4.67	3.20	2.84	2.80	2.96	2.79	2.59	2.52	2.70	2.31	2.25	2.08	1.87
	Cd	t	0.11	0.07	0.05	0.04	0.04	0.05	0.05	0.04	0.04	0.05	0.04	0.04	0.04	0.04
	Hg	t	0.29	0.19	0.13	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.10	0.09	0.09	0.08
	NO <sub>x</sub>	kt	8.76	14.31	12.91	12.76	10.27	8.57	7.43	6.56	6.19	5.55	4.84	4.27	4.05	4.21
	SO <sub>2</sub>	kt	1.41	1.34	0.94	0.86	0.37	0.42	0.37	0.06	0.09	0.08	0.05	0.04	0.04	0.05
	NM VOC	kt	1.38	1.71	1.35	1.09	0.86	0.69	0.60	0.53	0.48	0.40	0.34	0.30	0.29	0.29
	NH <sub>3</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	PM <sub>2.5</sub>	kt	0.93	1.05	0.76	0.60	0.47	0.37	0.32	0.28	0.25	0.21	0.17	0.15	0.14	0.14
	Pb	t	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Cd	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Hg	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

**Table 3.7 Recalculations in Energy NFR 1A4**

<b>% Change in Emissions</b>		<b>Pollutant</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	
1A4a Commercial/Institutional	NO <sub>x</sub>	%	0.0%	0.0%	0.0%	0.2%	0.5%	0.5%	0.6%	0.5%	0.4%	0.5%	0.6%	0.6%	0.8%	0.8%	
	SO <sub>2</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	173.1%	
	NM VOC	%	0.0%	0.0%	0.0%	0.4%	0.7%	0.9%	0.9%	0.8%	0.7%	0.8%	0.9%	0.9%	1.1%	1.0%	
	NH <sub>3</sub>	%				0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	
	Pb	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	Cd	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	Hg	%	0%	0%	0%	0%	0%	1%	1%	1%	0%	1%	1%	1%	1%	1%	
	1A4b Residential	NO <sub>x</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		SO <sub>2</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.1%
NM VOC		%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
NH <sub>3</sub>		%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
PM <sub>2.5</sub>		%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Pb		%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cd		%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Hg		%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
1A4c Agriculture/Forestry/Fishing		NO <sub>x</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		SO <sub>2</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	NM VOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	Pb	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	Cd	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	Hg	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

### 3.12 Quality Assurance/Quality Control

The time series spreadsheet system developed for individual categories, together with direct linking to the energy balance, allows for simple and efficient checking of activity data, emission factors, annual emissions and aggregated totals. Year-on-year changes immediately highlight any omissions, anomalies or internal errors. Initial checks are conducted by the inventory compiler as part of the calculation process, which is followed by a second check and completion of the QA/QC sheets which are integral to the calculation workbooks by another member of the inventories team. Cross-checks are performed for fuel data against the available supplementary sources for categories, such as 1A1a Public Electricity and Heat Production and some industrial processes, while maintaining consistency with fuel-use application in the estimation of GHG emissions. When new versions of the COPERT model are introduced for calculations in 1A3b, the previous year's activity data is run in the new model to compare with the current year, and the current year's activity data is run in the old version of the model to compare with the previous year. This allows firstly for identification of changes due to the model, and secondly for identification of changes due to the activity data.

### 3.13 Planned Improvements

The nature of the substances covered in transboundary emission inventories and the diverse range of sources involved, many of which are unintentional or uncontrolled releases, inevitably result in estimates that can be highly uncertain. There is heavy reliance on default emission factors made available through the Inventory Guidebook or other references, which are often based on limited information or which can only be applied in a limited or aggregated way because the necessary detailed activity data are not available. For some substances and categories, the emissions must be estimated in an indirect way, such as on a per-capita basis, which adds further to level of uncertainty.

This submission included checks on emission factors based on the latest Inventory Guidebook and this work will continue in future submissions with changes made where appropriate. The inventory agency plans to account more completely for technological improvements over time by attempting to apply Tier 2 emission factors that refer to different types of stationary combustion appliance for the fuels in common usage, especially in sub-categories 1A4a Commercial/Institutional combustion and 1A4b(i) Residential combustion. Ireland has investigated the use of Tier 2 method for 1A4bi Residential emissions of PAHs, PCBs, Cd, Hg, Pb and PCDD/F following a review recommendation (IE-1A4bi-2018-0002). The EU 28 average fuel use and technology type is not reflective of Irish conditions and technologies and the fuel use/technology type split are not available so Tier 1 must be used in Ireland's inventory for this category.

For category 1A2f Stationary Combustion in Manufacturing Industries and Construction; Non-metallic minerals a review recommendation (IE-1A2f-2018-0002) was made to calculate the Cd and Hg emissions using Tier 2 or Tier 3 methods. It is not possible to implement a Tier 2 approach for the entire sector 1A2f as fuel data is not available for every operation within this category. However, for the cement sector with 4 plants, fuel data is available for the years 2005 to 2018 from the EU Emissions Trading Scheme. Ireland investigated an approach for POPs in the cement sector for these years using EFs based on clinker production from Table 3-24 of the Guidebook 2019. The results of this are discussed in section 3.5 Manufacturing industries and Construction (NFR 1A2) and section 3.11

Recalculations in the Energy sector for 1990-2017 data. The inventory agency plans to review this approach for heavy metals for the next submission and will report on the outcome of this investigation in 2021. The inventory agency will also endeavour to reduce the remaining instances of the use of notation key “NE” by providing an estimate or concluding that the source category does not occur “NO” in future submissions.

Ireland is investigating the use of Tier 3 plant data for additional pollutants for the single coal fired plant in Ireland using data returned under PRTR. The results of this work will be available in the IIR for 2021 for 1990-2019 data.

All emissions associated with the category 1A2g are reported in 1A2gviii, and mobile emissions, 1A2gvii, are reported as “included elsewhere” (IE) in 1A2gviii. Currently all fuel is assumed to be stationary as the energy balance does not provide an estimate for fuels used in mobile machinery. The inventory agency has tendered research to be undertaken to quantify the extent and amounts of fuel used by mobile combustion in mobile machinery and this research is currently being carried out and will finish by the end of 2020. The outcomes of the project may be implemented for the inventory submission in 2021 for 1990-2019 data or if delayed in 2022.

For category 1A3dii National navigation (shipping) Ireland uses a Tier 1 method to estimate NO<sub>x</sub> emissions. Ireland will investigate the feasibility of using a higher Tier approach for this category in its next submission.

For fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other) (NFR 1B2b), a review of the reporting under this category is underway in conjunction with the operator of the natural gas refinery. In response to a question raised during the 2019 NECD review (IE-1B2b-2017-0001), the company which operates the ‘Bellanaboy Bridge Gas Terminal’ provided a statement in which it is stated that ‘no significant VOC emissions were observed’ when using a LIDAR system for measuring ambient NMVOC emissions. Ireland is currently investigating the use of existing information about leakage from greenhouse gas fugitive reporting to UNFCCC to estimate NMVOC. It is expected that fugitive losses of NMVOC from pipelines and distribution systems will be estimated and included in reporting for the 2021 submission.

Flaring has occurred at offshore gas facilities in the years 1999 and 2001 only, during commissioning of new wells. Only GHG emissions are reported in Ireland's inventories. It is planned to review information on fugitive emissions from natural gas flaring and report emissions of air pollutants where appropriate in the next submission. Ireland has 1 on-shore gas refinery (offshore wells are on the seabed) which commenced operation in late December 2015, which had flaring episodes in 2015 and in 2017. The emissions associated with these flaring episodes will be included in the next submission.

Review recommendations and responses are included in this report as Annex H.

### 3.14 Memo Items

The memo items of the NFR reporting format refer to activities for which the emissions are excluded from national totals. The use of fuels in domestic and international aviation (cruise phase) and marine bunkers are the most important of these activities. Some of the associated emissions, particularly from international aviation, are increasing very rapidly and it is therefore important that they are closely

monitored for comparison with other sources and for the benefit of the international organisations that will have to develop control strategies for them in the future. The estimation of emissions for memo items is described here because they are calculated as part of the general estimation procedures for the Energy sector.

The national energy balance sheets include marine bunkers as a specific item and the emissions may be calculated directly. The approach used to for the cruise element of aviation is explained in Section 3.6.1 and this data is provided to SEAI for inclusion in the national energy balance.

Emission factors for international cruise aviation and navigation are documented in Tables C.19 and C.29 of Annex C.

# Chapter Four

## Industrial Processes and Product Use

### 4.1 Overview of the Industrial Processes and Product Use (NFR 2) Sector

The Industrial Processes sector has historically not been a large source of emissions in Ireland. Indeed, major industrial processes within the chemical sector and metal production that are common to many other developed countries have never been part of the economy in Ireland. Hence, many of the production processes within this sector are not relevant to the inventories of air pollutants in Ireland. Also, of note is the fact that for a number of pollutants, it has not been possible to separate emissions from the combustion of fuel within industry and those associated with production processes. For all industries, fuel-based estimates of emissions have been collated and are reported under NFR Sector 1A2 (Manufacturing Industries and Construction). Where specific information is available in relation to process emissions as distinct from those associated with fuel combustion, they are reported under NFR Sector 2 (Industrial Processes and Product Use) and are discussed in this chapter. In most of these cases, process-specific information is sourced from Annual Environmental Reports, which form part of the reporting obligations under IPPC/IED permits in Ireland. In some cases, production data (estimated and/or calculated) are also used where available.

Relevant subcategories under Mineral Products (2A), Chemical Industry (2B), Metal Production (2C), Solvent and other product use (2D-2H) and Other Production Processes (2L) for which process emissions of various pollutants are reported under Industrial Processes and Product Use in Ireland are described in the following sections.

### 4.2 Mineral Products (NFR 2A)

The industrial processes for which estimates are included in Ireland's air pollution inventory under NFR 2.A are as follows:

- 2.A.1 Cement Production
- 2.A.2 Lime Production
- 2.A.3 Glass Production
- 2.A.5.a Quarrying and mining of minerals other than coal
- 2.A.5.b Construction and demolition
- 2.A.5.c Storage, handling and transport of mineral products
- 2.A.6 Other mineral products

#### 4.2.1 Cement Production (NFR 2A1)

Cement manufacture is a major mineral industry. During cement manufacture, raw materials, such as limestone, are finely ground and then transformed in a kiln at high temperatures (calcination) to produce clinker. Gypsum is then blended with clinker to produce cement. The combustion process in the cement kiln is an integral part of the production process, where the fuel ash becomes part of the cement clinker. It is therefore not possible in most cases to distinguish the process and combustion

emissions from one another. As a result, because most of the pollutants originate from the fuels used, emissions are generally reported under NFR Category 1A2f (Non-metallic minerals) and notation keys IE and NA are reported under 2A1 for these pollutants.

There are at present four cement plants in Ireland, all of which use the dry kiln process, and they are currently fuelled by coal, petroleum coke and fuel oil, with meat and bone-meal, solid recovered fuels (SRF) and tyre derived fuels co-incinerated at three of the four plants. Literature sources, in particular, the EMEP/EEA Guidebook (2019), provide some POP emission factors on an overall grams of pollutant per tonne of clinker produced basis. The guidebook states that these emissions are allocated to combustion in cement manufacture and so emissions of POPs are reported as NA for category 2A1. These emission factors have been used to determine the total emissions from cement plants. Fuel-use data are available from plant operators as part of their reporting requirements under the EU ETS (Directive 2003/87/EC). Residual fuel not used in the cement manufacture sector but in other manufacturing industry in 1A2f is calculated and emissions from fuel use are calculated using combustion emission factors in 1A2f, while the fuel use data from cement manufacture is removed to ensure there is no double counting.

#### 4.2.2 Lime Production (NFR 2A2)

The lime production process involves the grinding and “burning” of limestone ( $\text{CaCO}_3$ ) to produce what is commonly termed “quicklime” ( $\text{CaO}$ ). It can then be further treated by the addition of water, a process called slaking, to produce slaked lime ( $\text{CaOH}$ ), which generates large amounts of heat and steam. The finished product can then be packaged and distributed for use. Currently, there are two lime plants in Ireland and a third that operated until 1999. It is understood that all three utilised limestone quarries and kilns to burn the limestone raw material. The nature of the fuel used and the abatement in place varies from plant to plant.

Process emissions from lime production are obtained as the difference between total emissions on a “per unit production” basis and those estimated from fuel combustion. In this case, it was found that fuel combustion estimates of emissions were generally larger than those estimated on a “per unit production” basis and therefore all emissions from lime production are assumed to be included in those reported within Sector 1A2f and notation key IE is used for 2A2.

#### 4.2.3 Glass Production (NFR 2A3)

The manufacture of glass was not a predominant industry in Ireland, being limited to three sub-sectors: lead crystal, container glass, and glass wool. The only container glass plant closed in 2002, one of the lead crystal plants closed in early 2006, the glass wool plant closed in 2008 and the last one, (second of the two) lead crystal plant closed in 2009. Therefore, after this period, emissions of all pollutants are reported as ‘NO’ (not occurring). The pollutants for which process emission estimates have been made are particulate matter (TSP,  $\text{PM}_{10}$ ,  $\text{PM}_{2.5}$ , BC) priority metals (Pb, Cd and Hg), other metals (As, Cr, Cu, Ni, Se and Zn), and PCDD/F. In addition, fuel-derived emissions from the glass industry for 1990-2009 are already accounted for within the Manufacturing Industries and Construction (1A2) sector.

Metal emissions can occur from glass processes from the metals contained in fossil fuels burnt to melt the glass and from metal additives to the glass. Metal emissions from industry fossil fuel use are accounted for within NFR Sector 1A2g (Other Manufacturing Industries). The metals emitted from glass production processes depend on the type of glass produced. Lead oxide and sometimes arsenic trioxide are used in the production of lead crystal glass and both metals can be emitted to air. Selenium and chromium compounds are used as colouring agents for container glass. Metal compounds are not believed to be used to any great extent in the production of glass wool. Of the glass processes outlined, all the plants were regulated under Integrated Pollution Prevention Control IPPC licences. Therefore, there is some information available from their AERs until they closed. Other licence information includes some details of plant design and operation, including capacities, fuel types and operating hours. In addition, confidential information in relation to production statistics has also been supplied to the inventory team.

Emission data for individual metals reported in AERs are limited to Pb emissions from the two lead crystal installations. These data have been used to estimate emissions of Pb from lead crystal production, while emission factors are used for the other glass processes. Literature emission factors are used from the Inventory Guidebook (EMEP/EEA, 2019) and, where deemed more appropriate, emission factors from the UK National Atmospheric Emissions Inventory (NAEI) database. The emission factors used are presented in Table D.1, Annex D. Total emissions for each metal from glass production are presented in Table 4.2.

Emission estimates from particulate matter are included in the inventory in this submission. The methodology uses confidential production data and emission factors from the Inventory Guidebook (EMEP/EEA 2019). The emission factors used are presented in Table D.1, Annex D.

The potential for PCDD/F emissions from glass production is generally low because of the long residence times in high-temperature conditions, although chlorine can be introduced via fuels and raw materials, and therefore there is some potential for PCDD/F emissions. However, in the plants in Ireland, the main energy sources used were gas and electricity, and therefore PCDD/F emissions from fuel combustion were likely to be low. The information on abatement technology is uncertain for the glass manufacturing plants in Ireland. The URS Dames & Moore (2000) PCDD/F inventory report implies that one furnace would be fitted with abatement by 2005, but it is assumed that this is the large facility that closed in 2002. IPPC licence information implies that the environmental performance at the glass wool plant was improved in 1999, but the nature of the improvements is not clear.

Emission factors for PCDD/F are provided in the UNEP Toolkit (2013) for two different classes of facility: 0.2 µg I-TEQ/t of glass produced for a facility with no dust control, and 0.015 µg I-TEQ/t of glass produced for a facility with abatement. However, there have been improvements in environmental performance; therefore, the emission factor of 0.2 µg I-TEQ/t is used to estimate emissions in 1990, with a linear decrease to 0.11 µg I-TEQ/t in 2000 (URS Dames & Moore, 2000) and with a subsequent decrease to 0.015 µg I-TEQ/t by 2003 (when the container plant had closed) and remaining at this level up to 2009 when the last plant ceased its operation. Dioxin and furan emission estimates for glass production are presented in Table 4.1.

**Table 4.1. Emission Time Series from Glass Production**

Year	1990	1994	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2018
TSP (t)	22.56	22.56	22.56	21.88	22.20	14.04	5.62	5.44	6.01	6.21	6.07	5.08	0.01	NO	NO
PM <sub>10</sub> (t)	20.08	20.08	20.08	19.48	19.76	12.47	4.95	4.79	5.30	5.47	5.35	4.47	0.01	NO	NO
PM <sub>2.5</sub> (t)	17.68	17.68	17.68	17.15	17.40	10.98	4.37	4.23	4.67	4.82	4.71	3.94	0.01	NO	NO
BC (t)	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.08	0.09	0.10	0.09	0.08	0.00	NO	NO
As (kg)	17.57	17.57	17.57	17.55	17.56	8.87	0.17	0.16	0.18	0.18	0.18	0.15	NA	NO	NO
Cd (kg)	7.44	7.44	7.44	7.41	7.42	3.83	0.23	0.22	0.25	0.26	0.25	0.21	NA	NO	NO
Cr (kg)	23.90	23.90	23.90	23.69	23.79	12.76	1.65	1.60	1.77	1.85	1.80	1.50	NA	NO	NO
Cu (kg)	1.70	1.70	1.70	1.49	1.59	1.66	1.65	1.60	1.77	1.85	1.80	1.50	NA	NO	NO
Pb (Mg)	310.77	310.77	310.77	310.55	310.65	223.73	136.72	136.66	128.90	88.52	96.78	96.46	7.91	NO	NO
Hg (kg)	0.58	0.58	0.58	0.51	0.54	0.57	0.56	0.55	0.60	0.63	0.61	0.51	NA	NO	NO
Ni (kg)	18.46	18.46	18.46	18.25	18.35	11.22	4.02	3.96	4.00	3.36	3.46	3.16	0.14	NO	NO
Se (kg)	90.11	90.11	90.11	90.10	90.11	45.11	0.11	0.11	0.12	0.12	0.12	0.10	NA	NO	NO
Zn (kg)	33.47	33.47	33.47	31.07	32.21	33.03	32.97	32.34	33.57	30.32	30.63	27.13	0.80	NO	NO
PCDD/F (g I-TEQ)	0.54	0.39	0.39	0.26	0.17	0.11	0.01	0.02	0.01	0.01	0.01	0.01	0.00	NO	NO

#### 4.2.4 Quarrying and Mining of Minerals Other than Coal (NFR 2A5a)

Emissions of PM<sub>2.5</sub>, TSP and PM<sub>10</sub> have been estimated for all years of the time series 1990- 2018. Activity data was taken from national statistics from the CSO and emission factors from Chapter 2.A.5.a, Table 3.1 of the guidebook (EMEP/EEA, 2019). Activity data and emissions are presented in Table 4.2.

**Table 4.2 Quarrying and mining of minerals other than coal (2.A.5.a)**

Activity Data		1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Metallic minerals	Mt	2.68	2.60	3.49	4.65	4.23	4.28	4.18	4.21	3.82	3.66	3.40	2.60	2.31	2.31
Non-metallic minerals	Mt	28.82	26.81	63.10	94.46	57.97	37.97	34.52	30.78	32.49	31.68	33.63	42.08	45.09	45.09
<b>Emissions factors</b>															
TSP	g/t	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00	102.00
PM10	g/t	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
PM2.5	g/t	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
<b>Emissions</b>															
TSP	kt	3.21	3.000	6.792	10.110	6.344	4.310	3.947	3.569	3.704	3.605	3.777	4.558	4.835	4.835
PM10	kt	1.58	1.470	3.330	4.956	3.110	2.113	1.935	1.749	1.816	1.767	1.852	2.234	2.370	2.370
PM2.5	kt	0.158	0.147	0.333	0.496	0.311	0.211	0.193	0.175	0.182	0.177	0.185	0.223	0.237	0.237

#### 4.2.5 Construction and Demolition (NFR 2A5b)

Emissions of PM<sub>2.5</sub>, TSP and PM10 have been estimated for all years of the time series 1990- 2018. Activity data was taken from national statistics from the CSO and the US EPA Tier 1 methodology and emission factors from Chapter 2.A.5.b section 3.2 of the guidebook (EMEP/EEA, 2019). The emissions are presented in Table 4.3.

**Table 4.3 Construction and Demolition (2.A.5.b)**

Emissions		1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TSP	kt	1.74	1.93	1.55	6.25	7.97	12.49	0.53	0.74	1.85	1.17	1.38	1.15	3.27	0.97
PM10	kt	0.52	0.58	0.47	1.87	2.38	3.73	0.16	0.22	0.55	0.35	0.41	0.34	0.98	0.29
PM2.5	kt	0.052	0.058	0.047	0.187	0.238	0.373	0.016	0.022	0.055	0.035	0.041	0.034	0.098	0.029

## 4.2.6 Storage, Handling and Transport of Mineral Products (NFR 2A5c)

Emissions of PM<sub>2.5</sub> have been estimated for all years of the time series 1990- 2018. Activity data was taken from national statistics from the Central statistics office and emission factors from Table 3.4 Chapter 2.A.5.c of the guidebook (EMEP/EEA, 2019). Activity data and emissions are presented in Table 4.4.

**Table 4.4 Storage, handling and transport of mineral products (2.A.5.c)**

Activity Data		1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Metallic minerals	Mt	2.68	2.60	3.49	4.65	4.23	4.28	4.18	4.21	3.82	3.66	3.40	2.60	2.31	2.31
Non-metallic minerals	Mt	28.82	26.81	63.10	94.46	57.97	37.97	34.52	30.78	32.49	31.68	33.63	42.08	45.09	45.09
<b>Emissions factors</b>															
PM2.5-handling	g/t	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
<b>Emissions</b>															
PM2.5-handling	t	0.00002	0.00002	0.00004	0.00006	0.00004	0.00003	0.00002	0.00002	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003

## 4.2.7 Other (NFR 2A6)

The industrial processes included within NFR Sector 2A6 are Bricks and Ceramics Production and Asphalt Production. Each of these subcategories is described in the following sections in terms of the pollutants for which emission estimates are made.

### 4.2.7.1 Bricks and Ceramics Production

The production of bricks and ceramics is a small sector in Ireland with a total of four IPPC-licensed facilities in operation. Emission estimates are only made for PCDD/F as there are no data available in relation to process emissions of other pollutants and, furthermore, they are expected to be negligible (AEA/CTC, 2008). Direct production information in relation to the bricks and ceramics sector is not available; however, raw material input data are provided by the companies under the EU ETS. For the purposes of inventory estimates, as a worst-case scenario it is assumed that raw material input equals product output. Emission factors are sourced from the UNEP Toolkit (2013) in which two classes of facility are suggested: 0.2 µg I-TEQ/t of brick produced for a facility with no dust control and 0.02 µg I-TEQ/t of brick produced for a facility with abatement. The URS Dames & Moore (2000) report suggests an emission factor of 0.11 µg I-TEQ/t, which is the average of the two emission factors, and this value, has been used across the time series. The UNEP Toolkit (2013) does not include emission factors for ceramics production and therefore the emission factor for bricks is also applied to ceramics production. Dioxin and furan emission estimates for bricks and ceramics production are presented in Table 4.5.

**Table 4.5 Dioxin and Furan Emission Time Series from Bricks and Ceramics Production**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Bricks production</b>														
PCDD/F (mg I-TEQ)	12.14	13.02	15.38	15.34	1.80	1.74	2.48	0.08	0.07	NO	1.62	2.84	3.32	3.55
<b>Ceramics production</b>														
PCDD/F (mg I-TEQ)	NO	NO	NO	0.032	NO									

#### 4.2.7.2 Asphalt Production

In the context of this inventory, the term “asphalt” is used to describe a bituminous product that may contain varying amounts of aggregate, used to build and maintain roads, whilst “bitumen” is assumed to be a heavy oil tar product which is used at elevated temperatures particularly in roofing materials for some buildings. Currently, only PCDD/F emission estimates from asphalt are included in Ireland’s air pollution inventory.

Information in relation to the production of asphalt in Ireland is sourced from the European Asphalt Pavement Association (EAPA, 2001, 2007, 2012, 2016, 2018), which generates an annual report outlining the quantity and end use of asphalt produced in European countries. Production data are available from 1994 onwards, with pre-1994 production estimates assumed to be equal to those in 1994. The production levels until 2006 show an upward year-on-year trend due to increased road building in Ireland, from 2007 to 2014 the trend was decreasing but a slight increase is seen from 2015 to 2018.

In Ireland, bag filters were fitted to most asphalt production facilities prior to 2000 and it was suggested that all facilities would have bag filters by 2001 (URS Dames & Moore, 2000). The UNEP Toolkit (2013) gives a range in emission factors of 0.007 to 0.07 µg I-TEQ/t asphalt produced. Given the above information, the emission factor for PCDD/F from asphalt production of 0.07 µg I-TEQ/t is adopted for 1990. A linear decrease in the emission factor is then assumed to 0.039 µg I-TEQ/t by 2000, and a further linear decrease is assumed to 0.007 µg I-TEQ/t by the end of 2002. The emission factor is assumed to be 0.007 µg I-TEQ/t from 2003 and onwards. Dioxin and furan emission estimates for asphalt production are presented in Table 4.6.

**Table 4.6 Dioxin and Furan Emission Time Series from Asphalt Production**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
PCDD/F (mg I-TEQ)	154.0	92.2	111.7	23.8	23.1	16.1	12.6	13.3	16.1	12.6	13.3	13.3	14.7	14.4

### 4.3 Chemical Industry (NFR 2B)

The chemical industry is not a dominant industry in Ireland in relation to industrial processes and is not an important source of emissions. The only source of emissions for which estimates are collated are NO<sub>x</sub> emissions from Nitric Acid Production for the years 1990-2002.

#### 4.3.1 Nitric Acid Production (NFR 2B2)

Nitric acid is used as a raw material mainly in the manufacture of nitrogen-based fertiliser. It may also be used in the production of adipic acid and explosives, for metal etching, and in the processing of ferrous metals. In the manufacture of nitrogenous fertilisers, the Haber Bosch process is utilised in which NH<sub>3</sub> is made by combining nitrogen from the air with hydrogen from natural gas and water, using the energy from the gas and a catalyst. Nitric acid is produced by burning (oxidising) the NH<sub>3</sub> over a catalyst. The nitric acid is combined with more NH<sub>3</sub> to produce ammonium nitrate, which is solidified into granules or bead-like prills for application to land using a fertiliser spreader. Up to its closure in 2002, there was one such plant in Ireland, which utilised the above process to produce calcium ammonium nitrate and other nitrogenous fertiliser blends. The inventory agency received

direct correspondence from the plant in relation to the quantities of nitric acid produced and the measured emissions of NO<sub>x</sub>. Emission estimates and associated activity data for NO<sub>x</sub> emissions from nitric acid production are presented in Table 4.7. Abatement measures were installed at the plant in the mid-1990s and they are reflected in emission estimates from 1995.

**Table 4.7 Nitrogen Oxides Emission Time Series from Nitric Acid Production**

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Nitric acid (kt)	338.8	260	260	260	260	260	260	260	260	260	260	260	130
NO <sub>x</sub> (kt)	1.680	1.672	1.823	0.960	0.280	0.280	0.280	0.280	0.280	0.280	0.303	0.374	0.187

## 4.4 Metal Production (NFR 2C)

This category includes a wide range of processes such as primary and secondary iron and steel production, aluminium production and other non-ferrous production. In this category, emissions are estimated for the following subcategories and pollutants:

- 2C1 Iron and Steel Production – As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn, PCDD/F;
- 2C2 Ferroalloys Production – As, Cd, Cr, Ni, Pb, Zn, HCB;
- 2C3 Aluminium Production – Zn;
- 2C5 Lead production – Pb;
- 2C7 Other metal production – Cd, Cr, Cu, Ni, Pb, Zn;

Ireland is a major European producer of Zn and Pb ores. The preparation of Pb and Zn concentrates does not produce emissions and the concentrates are exported for further processing.

### 4.4.1 Iron and Steel Production (NFR 2C1)

This sector covers the manufacture of iron and steel, an energy-intensive process likely to generate high emissions to air from the use of furnaces and sintering processes, as well as the manual handling of the raw material to finished goods, which can include hot and cold rolling, and turning, temping and cutting of metal to reach a desired end product. Steel production in Ireland has been limited to a single large electric arc furnace installation, which closed in 2001 but was operational throughout the period 1990–2001. One small foundry remained in operation contributing a negligible amount of emissions after the large plant’s closure. The main plant produced up to 360 kt of steel per annum mainly from recycled scrap steel. It received an IPPC licence to operate just months before its closure, therefore no AERs were filed by the plant. However, some emission testing was carried out with respect to heavy metal emissions as part of its licence application.

Heavy metal emission estimates have been calculated using the aforementioned emission testing results for Cd, Cr, Pb, Ni and Zn, whilst for the remaining pollutants (i.e. As, Cu, Hg, and Se) Inventory Guidebook (EMEP/EEA, 2019) emission factors have been used, assuming no abatement at the plant. The emission factors used are presented in Table D.3, Annex D. Emission estimates for the 1990–2001 time series are shown in Table 4.8. Metal production data are available from the site for the period 1994–2001, with pre-1994 production assumed to be equal to that in 1994. Emission estimates are calculated by multiplying the production data by the relevant pollutant emission factor and assume that no abatement was in place at the plant.

**Table 4.8 Emission Time Series from Iron and Steel Production**

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
As (t)	0.130	0.117	0.103	0.130	0.106	0.124	0.136	0.135	0.143	0.134	0.144	0.060	NO
Cd (t)	0.216	0.194	0.170	0.216	0.176	0.205	0.226	0.223	0.237	0.222	0.239	0.099	NO
Cr (t)	1.428	1.284	1.126	1.428	1.165	1.358	1.494	1.476	1.568	1.467	1.577	0.657	NO
Cu (t)	0.023	0.021	0.018	0.023	0.019	0.022	0.024	0.024	0.025	0.023	0.025	0.011	NO
Pb (t)	1.753	1.576	1.382	1.753	1.430	1.667	1.834	1.812	1.925	1.802	1.936	0.807	NO
Hg (kg)	32.60	29.30	25.70	32.60	26.60	31.00	34.10	33.70	35.80	33.50	36.00	15.00	NO
Ni (t)	2.694	2.421	2.124	2.694	2.198	2.562	2.818	2.785	2.958	2.768	2.975	1.240	NO
Se (t)	0.007	0.006	0.005	0.007	0.005	0.006	0.007	0.007	0.007	0.007	0.007	0.003	NO
Zn (t)	27.75	24.94	21.87	27.75	22.64	26.38	29.02	28.68	30.47	28.51	30.64	12.77	NO
PCDD/F (g I-TEQ)	0.743	0.891	0.783	0.990	0.810	0.942	1.035	1.023	1.086	1.017	1.092	0.462	0.012
PCBs (kg)	0.619	IE											
B[a]p (t)	NE												

Electric arc furnaces are significant sources of POPs. The overall approach to report emissions of POPs from the iron and steel category has been to account for emissions from fuel combustion within Sector 1A2a, with the process emissions reported (where possible) under Sector 2C1, which have been estimated using the approach described with respect to Cement Production (2A1). Emission factors based on per unit production were used to calculate initial estimates of total emissions. These factors are sourced from the Inventory Guidebook (EMEP/EEA, 2019). The difference between estimates determined on this basis and those reported for fuel combustion sector 1A2a is then reported in sector 2C. Emission estimates for the sector are presented in Table 4.8 for PCDD/F. The notation key 'IE' (included elsewhere) is used for HCB emissions for years 1990-2002 and the notation key NO is used for the years 2003-2018. Emissions of HCB are reported and accounted for under NFR 1A2a as it has not been possible to separate process and fuel combustion related HCB emissions for the period 1990-2002 for which there was an iron and steel industry in Ireland.

#### 4.4.2 Ferroalloys Production (NFR 2C2)

This sector covers several secondary sites engaged in iron and steel manufacture. Two types of installation are distinguished. The first type covers installations involved in the manufacture of ductile iron for use in street furniture, public benches, waste bins and manhole covers, and the second is the manufacture of cast iron for appliances. The process of creating ductile iron utilises electric arc furnaces to smelt the raw materials, iron and magnesium. In the manufacture of cast iron, ferrous and non-ferrous metals, including scrap metal, are used within the process. Since 1990, there have been three relevant facilities in Ireland. Due to a change in operations, one of these plants reported negligible emission estimates from 2003 onwards; one facility closed in 2014 leaving a single operating facility from 2014 onwards.

A number of the larger metal processing sites are regulated under IPPC. Some metal emission estimates and particulate emission estimates have been reported in AERs; however, not all installations report emissions in all years. In some cases, only production data and emissions of TSP are available. Where production data only were provided by the plant operator, they were used to calculate emissions of TSP using USEPA factors for dust emissions from abated/unabated iron foundry cupola processes. Estimates for metal emissions were then obtained from the TSP estimates based on Inventory Guidebook (EMEP/EEA, 2019) dust composition data for foundry dust. Abatement

techniques are also taken into account in emission calculations at a plant-specific level, where this applies. Emission estimates of HCB for the time series 1990-1996 are presented in Table 4.9. The only source of HCB is the secondary manufacture of aluminium, for which the Inventory Guidebook (EMEP/EEA, 2019) indicates a factor of 5 g/t of aluminium. This factor has been used to estimate HCB emissions across the time series until use of the HCE-based cover gas was banned in 1996 and emissions are reported using the notation key NO for years after 1996.

Estimates for TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and BC have also been made for this category. Total Particulate Matter data reported in AERs were used to estimate emissions from TSP. Fractionation profiles based on the emission factors within the Inventory Guidebook (EMEP/EEA, 2019) were used to estimate PM<sub>10</sub>, PM<sub>2.5</sub> and BC emissions.

Where production data are not available, TSP estimates have been used to estimate metal production across the time series using the BiPRO waste report (2005), other POPs like PCDD/F, PCB and PAHs are reported under fuel combustion sector 1A2b. The HCB emission factor used is presented in Table D.3, Annex D, and process emission estimates for the 1990-1996 time series are presented in Table 4.9.

**Table 4.9 Emission Time Series from Ferroalloys Production**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TSP (Mg)	70.57	70.57	5.57	1.32	1.93	1.28	0.66	0.29	0.64	NO	NO	0.0002	0.0002	0.0002
PM <sub>10</sub> (Mg)	59.99	59.99	4.74	1.12	1.64	1.09	0.56	0.24	0.54	NO	NO	0.0002	0.0002	0.0001
PM <sub>2.5</sub> (Mg)	42.34	42.34	3.34	0.79	1.16	0.77	0.39	0.17	0.38	NO	NO	0.0001	0.0001	0.0001
Cr (Mg)	0.252	0.252	0.019	0.005	0.007	0.004	0.002	0.001	0.002	NO	NO	NO	NO	NO
As (Mg)	0.069	0.069	0.005	0.001	0.002	0.001	0.001	0.000	0.001	NO	NO	NO	NO	NO
Cd (Mg)	0.0325	0.0325	0.0028	0.0006	0.0013	0.0076	0.0004	0.0002	0.0004	0.0001	0.0001	NO	0.0001	0.0000
Ni (Mg)	0.115	0.115	0.008	0.002	0.003	0.002	0.001	0.000	0.001	NO	NO	NO	NO	NO
Pb (Mg)	1.712	1.712	0.183	0.031	0.047	0.035	0.016	0.007	0.015	0.0001	0.0001	NO	0.0000	0.0000
Zn (Mg)	1.407	1.407	0.345	0.022	0.040	0.041	0.011	0.005	0.011	0.0001	0.0001	0.0001	0.0000	0.0000
PCDD/F (g I-TEQ)	IE													
HCB (kg)	40.000	40.000	NO											
PCBs (kg)	NA													
B[a]p (Mg)	NA													

#### 4.4.3 Aluminium Production (NFR 2C3)

Ireland is an important producer of alumina at one large plant using the Bayer process (extraction of AlO<sub>3</sub> using NaOH). The production of alumina using the Bayer process does not give rise to significant metal emissions and therefore process emissions are not estimated for this source. Ireland has some secondary aluminium processing for which estimates of Zn have been made following reports from the plant involved. The plant closed in late 2006 and therefore estimates are only provided for the 1990–2006 time series as presented in Table 4.11. Production data for the plant are not available and therefore estimates were made using PM as an indicator. The UK NAEI emission factor of 2.725 g/t is then applied (Table D.3, Annex D).

**Table 4.10 Emission Time Series for Zinc from Aluminium Production**

Year	1990	1995	2000	2001	2002	2003	2004	2005	2006
Zn (t)	0.029	0.029	0.029	0.029	0.043	0.019	0.026	0.011	0.011

#### 4.4.4 Lead Production (NFR 2C5)

A significant quantity of Lead is mined in Ireland, but such mining is assumed not to be a significant source of emissions to air. Estimates at facility level of Lead emissions have been obtained from AERs. Emission estimates for the time series are presented in Table 4.11 and are reported as not occurring since 2009.

**Table 4.11 Emission Time Series for Lead Production**

Pollutant (unit)	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Pb (kg)	7.845	7.845	7.845	7.845	0.018	0.008	0.013	0.006	0.025	0.034	0.030	NO

#### 4.4.5 Other Metal Production (NFR 2C7)

This category covers all other metal manufacture and manipulation, including any emissions from the mining of raw materials. A significant quantity of Zn is mined in Ireland, but such mining is assumed not to be a significant source of emissions to air. Ireland has a number of small aluminium casting companies in addition to facilities for wire manufacture and the manufacture of refined or secondary Pb and Cu products, as well as a number of Zn galvanising plants.

Estimates at facility level of the heavy metals Cd, Cr, Cu, Ni, Pb and Zn have been obtained from AERs with respect to these secondary metal operations. Emission estimates for the time series are presented in Table 4.12. Emissions arise from 3 plants in the latter parts of the time series and are therefore very sensitive to changes in activity of individual plants.

**Table 4.12 Emission Time Series for Non-Ferrous Metal Production**

Pollutant	Units	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Cd (kg)	kg	0.02	0.02	0.02	0.02	0.02	NO	0.20	0.20	0.20	0.20	0.10	NO	0.10	0.10
Cr (kg)	kg	15.00	211.00	211.00	256.33	0.07	NO	NO	NO	NO	NO	NO	NO	NO	NO
Cu (kg)	kg	3.18	3.18	3.18	22.27	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Pb (kg)	kg	0.15	0.15	0.15	9.85	0.02	NO	0.30	0.30	0.40	0.41	0.30	0.20	0.30	0.17
Ni (kg)	kg	82.00	82.00	82.00	4.97	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Zn (kg)	kg	233.00	233.00	233.00	121.28	4.34	3.10	0.30	0.30	22.35	1.50	0.30	0.30	0.30	0.21

Process emissions of POPs (where applicable) are included in combustion emissions and reported as included elsewhere (IE) for category 2C7.

## 4.5 Overview of NMVOC emissions from Solvent and Other Product Use (NFR 2D-2L) Sector

The emission estimates presented in Solvent and Other Product Use (NFR 2D-2H) include Domestic solvent use including fungicides (2D3a), Road Paving with asphalt (2D3b), Coating Applications (2D3d), Degreasing and surface cleaning (2D3e), Dry Cleaning (2D3f), Chemical Products, Manufacture and

Processing (2D3g), Printing (2D3h), Other Solvent Use (Fat, Edible and non-edible oil extraction) (2D3i), Other Product use (Use of Tobacco products and Fireworks) (2G) and Food and Beverages industry (2H2). Emissions are the result of continuing improvement of NMVOC emission estimates for Ireland through the outsourcing of tendered projects by the EPA. For 2D3c Asphalt roofing it has been determined that the production of asphalt roofing materials does not occur in Ireland. This category is reported as NO.

In 2012, the inventory agency commissioned a research project to update the NMVOC emission inventory for 2006-2013. This was a follow-on project to CTC/AEA (2005) and Finn et al. (2001) and resulted in a revised dataset where new data and methodologies had become available. This approach was taken in accordance with the Inventory Guidebook (EMEP/EEA 2016) methodology for NMVOC emissions for Solvent and Other Product Use (NFR 2D-2L). The results of this project were provided in the 2016 submission. This project continued into 2016 and resulted in further improvements to the NMVOC emission inventory from Solvent Usage.

Emissions data were gathered using a similar methodology to previous approaches. Bottom-up data was mainly obtained from submissions of Annual Environmental reports (AERs) which detail emissions in a variety of reporting formats ranging from the Solvent Mass Balance Summary, Solvent Management Plan (SMP), Pollution Release and Transfer Register (PRTR), or the Annual Environmental Report returns Workbook. In addition, new data sources were used from legislation designed to limit and report solvent usage (Solvent Directive 1999/13/EC). In conjunction with these data, the number of operators within each category was estimated using NACE codes provided by the Central Statistics Office (CSO) or from expert opinion.

Top-down methods were used for activities not covered by the IPPC licensing system nor under the Solvent Directive (1999/13/EC). The most significant included the use of non-industrial paints, metal degreasing and the use of domestic solvents. Input in the form of activity data, solvent usage or VOC emissions data for each individual activity were collated into spreadsheets. Emissions were estimated by applying the Inventory Guidebook (EMEP/EEA 2019) methods, default emission factors and general guidance as appropriate. Scaling up to national level was applied where necessary. The emission factors used are presented in Table D.4, Annex D

Emissions reported in NFR 2019 format are aggregated from the Selected Nomenclature for Air Pollutants (SNAP) categories. SNAP codes are used in the Inventory Guidebook where sectoral emission sources and emission factors are provided in this system. Therefore, SNAP codes are adopted in these categories as it ensures that reporting of emissions is consistent with the guidebook and therefore other Parties submissions. Additionally, the use of SNAP codes facilitates a sub-sectoral analysis of drivers and trends.

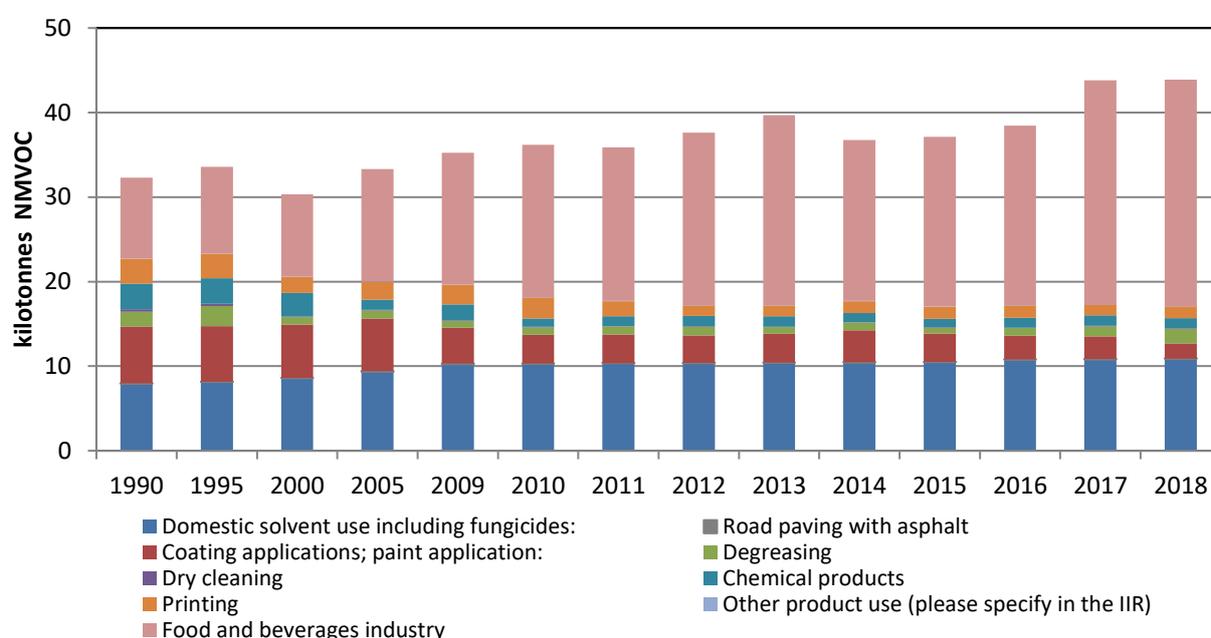
For a number of sources, it was not possible to obtain reliable country-specific data (SNAP 060107: Paint Application: Wood, SNAP 060109: Non-Industrial Paint Application, SNAP 060408: Domestic Solvent Use). As a consequence of this, UK and other Parties' emission factors, and in some cases activity data (scaled by surrogate data), were used in the estimation methodology.

Obtaining country-specific data has been identified as an important issue in the past (Barry, S. and Regan, B., 2014). While new activity data were obtained for sectors that previously relied upon proxy sources, a number of sectors are still estimated using proxy information sources. Further reducing the

dependence of these would require substantial investment, and the improvement that this would bring over using proxy-based data is thought to be relatively small due to the similarity in lifestyle behaviour between the countries operating within the EU (and in particular the United Kingdom) and therefore a common market place.

The main drivers associated with trends in implied emission factors relate to reduced solvent content of products, and paints. The trends in activity data reflect the fact that Ireland experienced rapid economic growth from the late 1990s to 2007. As a result, there was a substantial increase in the number of vehicles, growth in the number of individual households, and generally a higher per capita consumption of paints, cosmetics, toiletries, and other solvent containing products. Since 2007, there has been a rapid economic downturn, which has had a marked impact on consumption, and therefore emissions of NMVOC. As economic conditions began to improve emissions have also increased from 2012 to 2018.

Figure 4.1 illustrates the overall trend and shows a 38.1 per cent increase in total emissions between 1990 (33.0 kt of NMVOC) and 2018 (45.6 kt of NMVOC). The main contributor to the trend is sector 2H2 Food and Beverages industry, with 179 per cent increase between 1990 and 2018 and was responsible for 58.8 per cent share of emissions from solvent and other product use in 2018. The second largest contributor is sector 2D3a (Domestic Solvent Use including fungicides) with a contribution of 23.9 per cent of emissions from solvent and other product use (having increased by 37.1 per cent since 1990). Sector 2D3d (Coating Applications) accounted for 3.9 per cent in 2018 showing a decrease of 73.5 per cent between 1990 and 2018.



**Figure 4.1 NMVOC Emission Trend for 2D-2H Other Solvent and Product 1990–2018**

Sector 2D3a, (Domestic Solvent Use including fungicides) is the second largest contributor to NMVOC emissions (Table 4.13). A Tier 2 method was implemented in this submission. The method uses population data obtained from the C.S.O and per capita emission factors for product use from the

Inventory guidebook (EMEP/EEA, 2019). This approach was used as the statistics required for the use of Tier 2b approach were not complete in terms of the product types covered by domestic solvent use. For Hg no Tier 2 emission estimate is available for fluorescent tubes. The 2019 guidebook does not contain an emission factor for this source and states “Due to the uncertainty around these releases, this source is currently not considered in the Guidebook.” Therefore, this emission is not applicable.

Sector 2D3b (Road paving with asphalt) emissions contribute less than 0.1 per cent of 2018 emissions. Emissions from the sector have decreased by 6.8 per cent since 1990.

Emissions from Coating applications (2D3d) decreased between 2007 and 2012 before increasing in 2013 and 2014 and decreasing again from 2015 to 2017 and reaching their lowest level in 2018 (1.78 kt). The main driver of NMVOC emissions from this emission category is the application of decorative paint (SNAP codes:060103/060104). A number of factors contributed to the ongoing decrease in emissions including; the substantial reduction in the solvent content of paint in recent years to comply with the Deco-Paints Directive (EP and CEU, 2004b), a greater awareness of environmental issues from the general public in addition to the economic downturn in Ireland. From discussions with industry, pressure from some of the larger retailers is noted to be one of the key drivers for the decrease in solvent use in architectural paint. The sales of water-based paints have decreased by 26.9 per cent between 1990 and 2018 whereas solvent-based paint sales have decreased by 56.3 per cent over the same period.

Emissions from 2D3e (Degreasing) decreased by 2.09 per cent between 1990 and 2018. Emissions peaked in 1996 at 2.5 kt. The methodology is based on net consumption of solvents (imports minus exports) provided by the CSO. The analysis showed that the main solvent used in this sector is Dichloromethane. The reductions are assumed to be driven by improved management practices and abatement technologies (open-top tanks have been phased out in the European Union as a result of the Solvents Emissions Directive 1999/13/EC). Emissions from this emission source accounted for 3.7 per cent of the total emissions from solvent and other product use in 2018.

Data obtained under the reporting requirements of the Solvent Directive (1999/13/EC) was used to estimate emissions from 2D3f (Dry Cleaning). Solvent usage, emissions data and national statistics were used to estimate emissions from this emission source. Emissions decreased by 74.7 per cent over the 1990-2018 period. Emissions from 2D3f accounted for 0.16 per cent of the total emissions from solvent and other product use in 2018.

2D3g (Chemical products) accounts for 2.7 per cent of emissions in solvent and other product use in 2018. In 1990, this sector accounted for 9.2 per cent. This emission category consists of fourteen emission sources, however, the majority of the emissions sources contribute very little to the overall emissions from the Chemical products sector. The diversity within these sectors is very large in terms of the type of process, the products made and the scale involved. The main driver of emissions from this emission source is Pharmaceutical Production (SNAP code 060306). Emissions from pharmaceutical production accounted for 51.7 per cent of emissions in the 2D3g in 2018. Emissions from 2D3g decreased by 59.3 per cent between 1990 and 2018. Emissions decreased as a result of the introduction of new management practices or through the use of abatement technology (CTC/AEA,

2005 and Barry S. and O'Regan B., 2014). This indicates that current policy strategies are having an impact on solvent use and emissions. In addition, large reductions in emissions were found in several emission sources between 1990 and 2018. For instance, emissions reduced significantly from SNAP code 060303 (Polyurethane Processing), SNAP code 060305 (Rubber Processing). This was mainly a result of plant closures with the last rubber processing facility closing in 2016. 2D3h (Printing) emissions decreased 53 per cent over the 1990 to 2018. In 2018, the sector accounted for 3 per cent of total emissions from solvent and other product use. Emissions from this sector increased by 13.4 per cent in 2018. The economic downturn in Ireland in 2009 may be responsible for the prior decrease in emissions and a return to better economic conditions may be driving the emission increases in recent years. However, it's important to note that the print industry is included under the Solvent Directive (1999/13/EC) and is subject to IPPC licencing where applicable.

2D3i (Other Solvent use) emissions increased 144.5 per cent over the 1990 to 2018 timeseries. In 2018, the sector accounted for 3.8 per cent of total emissions from solvent and other product use. This emission category consists of 8 sources which include SNAP codes; 060401 (Glass Wool Enduction), 060402 (Mineral Wool Induction), 060404 (Fat, edible and non-edible oil extraction), 060405 (Application of Adhesives and Glues), 060406 (Preservation of Wood), 060407 (Underseal Treatment and Conservation of Vehicles), 060409 (Vehicle Dewaxing) and 060412 (Other). Application of Glues and Adhesives contribute 81.4 percent of total emissions from solvent and other product use in 2018. Emissions from this category have increased 158 per cent between 1990 and 2018 due to increased consumption of glue products. The methodology for reporting 060404 (Fat, edible and non-edible oil extraction) includes emissions from 1990 to 2018, the methodology is a Tier 2 method based on Oilseed rape crop yield data provided by the CSO and emission factor from the Inventory guidebook (EMEP/EEA 2019).

Emission sources from 2G4 include 060602 (Use of tobacco) and 060303 (Use of shoes). Emissions from SNAP code 060602 (Use of tobacco) has been included in this submission using Tier 2 emission factor from Inventory guidebook (EMEP/EEA 2019) and excise volumes data obtained from The Revenue Commissioners. Emissions from category 2G4 accounted for 0.02 per cent of emissions from solvent and other product use in 2018 and have decreased by 67.1 per cent between 1990 and 2018 as a large decrease in tobacco consumption was noted in 2018.

Sector 2H2 (Food and Beverage industry) is the largest contributor (58.8 per cent in 2018) to NMVOC emissions (Table 4.39-4.44). Tier 2 methodologies were applied to SNAP codes 040605 Bread, 040607 Production of Beer and 040608 Production of spirits, 040627 Meat frying and meat rendering, coffee roasting and feedstock, using activity data from C.S.O and Eurostat.

#### 4.5.1 Domestic Solvent Use including fungicides (NFR 2D3a)

This subcategory covers SNAP sector 060408. This category addresses NMVOC emissions from the general use of products containing solvents by members of the public in their homes, but does not include the use of decorative paints. Many domestic products are also used in industry and commerce and in many cases, it is difficult or impossible to separate total sales into domestic and industrial components. Products that contain VOCs can be divided into a number of categories such as Cosmetic and Personal Care Products, Household Products, DIY products, Car Care Products, Varnish remover,

Sealant and filling agents, Pharmaceutical Products Use and Pesticides. In this submission, a Tier 2 methodology was used with per-capita emission factors. This is the recommended approach to use where product statistics for the use of the Tier 2b approach are not complete in terms of the product types covered by domestic solvent use. Further study is planned to source appropriate product statistics. Estimates of NMVOC emissions from domestic solvent use are provided in Table 4.13.

**Table 4.13 Non-Methane Volatile Organic Compound Emissions from Domestic Solvent Use**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
kt	7.93	8.14	8.57	9.35	10.25	10.30	10.34	10.37	10.38	10.42	10.48	10.77	10.82	10.87

#### 4.5.2 Road Paving with asphalt (NFR 2D3b)

This sector covers the use of asphalt for road paving and covers SNAP sector 040611. This source is estimated using a Tier 2 methodology using annual weight of warm and hot mix asphalt used in Ireland for years 1993-2018 and the Tier 2 emission factor from the Inventory guidebook (EMEP/EEA 2019). PM<sub>2.5</sub>, PM<sub>10</sub>, TSP and BC are estimated for all years 1990-2018. Estimates of NMVOC, PM<sub>10</sub>, TSP, PM<sub>2.5</sub> and BC emissions from Road Paving with asphalt are provided in Table 4.14.

**Table 4.14 Emissions from Road Paving with Asphalt (NFR 2D3b)**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.04	0.03	0.05	0.05	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
TSP (kt)	33.0	25.5	43.50	51.00	49.50	34.50	27.00	28.50	27.00	27.00	28.50	28.50	31.50	30.75
PM10 (kt)	4.40	3.40	5.80	6.80	6.60	4.60	3.60	3.80	3.60	3.60	3.80	3.80	4.20	4.10
PM2.5 (kt)	0.22	0.17	0.29	0.34	0.33	0.23	0.18	0.19	0.18	0.18	0.19	0.19	0.21	0.21
BC (kt)	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

#### 4.5.3 Coating Application (NFR 2D3d)

This sector covers the use of paints within the industrial, trade and domestic sectors. The term paint includes pigmented coatings and clear coatings such as lacquers and varnishes, with the exception of glues, adhesives and inks. Unless captured on release and either recovered or destroyed, the solvent content of paint can be considered to be emitted to the atmosphere. The subcategories covered in this source category are presented below, with the relevant SNAP code in parentheses. SNAP codes not included below are deemed not to occur in Ireland.

- Paint Application – Car Repairing (060102)
- Paint Application – Construction and Buildings (060103)
- Paint Application – Domestic Use (060104)
- Paint Application – Boat Building (060106)
- Paint Application – Wood (060107)
- Paint Application – Other Industrial Paint Application (060108)
- Paint Application – Other Non-Industrial Paint Application (060109)

Dependent on the SNAP code of interest, both bottom-up and top-down approaches have been used in emission estimates. Where there is an absence of country-specific data, per-capita emission factors derived from a number of EU member states national inventories were used to estimate emissions in

Ireland using population statistics as a proxy. Further details of the methodological choices for this source category are provided in Barry and O’Regan. (2014), CTC/AEA (2005) and in Finn et al. (2001).

#### 4.5.3.1 Paint Application: Car Repairing (SNAP 060102)

Activity data was obtained from a number of sources. From 2006-2018, sales data was obtained from a large supplier and data was scaled up based on market share and expert opinion. Data used in 1998 was calculated by Finn et al. (2001), data for 2000 and 2001 was provided by the British Coating Federation. Data was extrapolated and interpolated for the intervening years using passenger car numbers reported by the Department of Transport, Tourism and Sport each year (DTTAS, 2019). Emission factors were obtained using survey data from AEA/CTC (2005) and Barry and O’Regan (2014), default emission factors provided by the Inventory Guidebook (EMEP/EEA 2019) and where necessary, emission factors were calculated based on the average decrease in VOC content in known coating applications. The emission estimate includes thinners (EF 1000-835g/L), body fillers (EF 249-175g/L), top coat (720-420g/L) and primers (720-540g/L). This is considered a Tier 2 method. Emission estimates are provided in Table 4.15.

**Table 4.15 Non-Methane Volatile Organic Compound Emissions from Paint Application: Car Repairing**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVO (kt)	0.19	0.21	0.31	0.43	0.44	0.38	0.36	0.26	0.24	0.25	0.22	0.19	0.16	0.16

#### 4.5.3.2 Paint Application: Construction and Building (SNAP 060103) and Domestic Use (SNAP 060104)

Activity data was obtained from the Irish Decorative Surface Coating Association (IDSCA) for the period 2006-2018. The Irish Business and Employers’ Confederation (IBEC) collated the total product sales for both water-based and solvent-based paints and provided the information to the inventory agency for the period 2000-2004. Following the experience in the UK (CTC/AEA, 2005), total product sales are proportioned between trade (Construction and Buildings) and retail (Domestic Use) use, assuming a 44:56 split in 1998, reaching 40:60 in 2003, and 30:70 in 2013. The split in 2018 is assumed to be the same as 2013. Estimates of paint sales prior to 1998 were extrapolated using GDP (R=0.70).

A number of emission factors were used to calculate NMVOC emissions from decorative coating applications. A survey of products found in popular retail chain stores was completed to establish a realistic emission factor for decorative surface coating products for recent years:

- Interior matt walls and ceiling paint was found to be 30g of VOC/l for solvent based paints and 22.5g of VOC/l for water based paints.
- Interior glossy walls and ceilings were found to have 76g of VOC/l for solvent based paint and 50g of VOC/l for water based paints.
- Exterior walls of mineral substrate were found to have 126g of VOC/l of solvent based paints and 9g of VOC/l for water based paints.
- Interior/external trim and cladding paints for wood and metal have an average solvent content of 324g of VOC/l of solvent based paints and 43g of VOC/l of water based paints.

- Primers were found to have an average solvent based paints of 201g of VOC/l and 45g of VOC/l for water based paints.

These emission factors were used for 2010-2018 while emission factors prior to this were assumed to be similar to 2007 limits outlined in the decorative paints directive. This is considered a Tier 2 method. Emission estimates for this category are provided in Table 4.16.

**Table 4.16 Non-Methane Volatile Organic Compound Emissions from Paint Application: Construction and Building (060103) and Domestic use (060104)**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
060104 kt	1.51	1.572	1.577	1.440	0.817	0.590	0.562	0.500	0.509	0.556	0.403	0.286	0.248	0.23
060103 kt	1.92	2.000	2.090	2.350	1.587	1.197	1.195	1.114	1.188	1.298	0.939	0.668	0.579	0.54

#### 4.5.3.3 Paint Application: Boat Building (SNAP 060106)

Paint application in the Marine Sector includes a diverse range of products designed to prevent corrosion and protect ships hulls against damage from fouling. The formulation varies depending on the area being coated and application techniques also vary ranging from spraying to brushing and application by roller.

Activity data were obtained from a major marine coating supplier from 2010-2018 and was upscaled based upon the company's market share. Previous annual emissions were assumed to be the same as 2010. The supplier also provided an estimated industry product breakdown. Emission factors between products are relatively similar with Top coats, primers and anti-corrosion products having an estimated VOC content of 400g of VOC per kg of product while anti-fouling products are estimated to contain 440g of VOC per kg of product.

Paint Application in the Marine Sector in Ireland can be divided into domestic sector, cargo or freight sector and the fishery sector. Larger vessels which require more product application are unable to dry dock in Ireland due to a lack of facilities to handle larger vessels. Therefore, sales data are adjusted based upon expert opinion to account for this (50 per cent of paint sales are applied elsewhere). This sector is a minor emission source for this reason. The methodology is considered a Tier 1 method. Estimates of NMVOC emissions from this source category are provided in Table 4.17.

**Table 4.17 Non-Methane Volatile Organic Compound Emissions from Paint Application: Boat Building**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.09	0.09	0.090	0.090	0.090	0.090	0.102	0.089	0.103	0.111	0.115	0.144	0.132	0.146

#### 4.5.3.4 Paint Application: Wood (SNAP 060107)

This subcategory refers to all paints used for the wood and wooden products sector but excludes the use of wood preservatives and creosote. Some activity data were available; however, no indication of the number of operators or market size was obtainable. Therefore, the emissions estimate was downscaled from UK data where consumption patterns and product range were considered to be comparable to Ireland. This involved using UK emissions data from the UK National Atmospheric Emissions Inventory (NAEI) and calculating per capita emissions (kg/per person) and applying this to

Ireland using national population statistics. The methodology is considered a Tier 1 method. Estimates of NMVOC emissions from this source sector are provided in Table 4.18.

**Table 4.18 Non-Methane Volatile Organic Compound Emissions from Paint Application: Wood**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	1.115	0.969	0.759	0.595	0.427	0.424	0.428	0.408	0.372	0.318	0.245	0.246	0.242	0.242

#### 4.5.3.5 Paint Application: Other Industrial Sources (SNAP 060108)

The methodology for this source category involves the use of IPPC emissions data and scaling up to account for emissions in the non-IPPC sector based on information obtained from reporting under the Solvent Directive 1999/13/EC. This category covers paints applied in industrial activities other than those already described in previous sections. Products painted include agricultural, construction and earth-moving equipment, aircraft, cans and drums, domestic appliances, electrical components, freight containers, machine tools, military vehicles, motor-vehicle components, office equipment, paper and plastics, and toys.

The scale of operation varies considerably from large operations employing automated roller coating to small-scale spraying painting. Processes may be enclosed or open air, and both air-dried and stove coatings are used. The emission estimate was up-scaled based on information obtained as a result of Solvents Directive 1999/13/EC. Estimates of NMVOC emissions from this source category are provided in Table 4.19. This methodology is considered a Tier 3 method

**Table 4.19 Non-Methane Volatile Organic Compound Emissions from Paint Application: Other Industrial Sources**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	1.425	1.321	1.019	0.996	0.633	0.461	0.483	0.587	0.671	0.828	0.950	0.771	0.789	0.729

#### 4.5.3.6 Paint Application: Other Non-Industrial Sources (SNAP 060109)

This category refers to the use of high performance protective and/or anti corrosive paints applied to structural steel, concrete and other substrates and any other non-industrial coatings. The sector includes coatings for offshore drilling rigs, production platforms and similar structures as well as road marking paints and non-decorative floor paints. Finn et al. (2001) obtained the activity data for this category as the difference between total paint sales in Ireland according to CSO data on paint sales and that used in other SNAP sectors under SNAP 0601. However, as no other data are available, emissions have been calculated following the advice of CTC/AEA (2005) using extrapolation from UK per capita estimates.

In order to establish whether the use of UK data is appropriate, per capita emissions were compared to other reporting parties. It was found that per capita emissions from this category range from 0.08 to 0.45 kg/person. The UK's per capita estimate is calculated at 0.14 kg per person. This is considered to be a realistic estimate for Irish emissions and was used to estimate emissions. This involved calculating UK per capita emissions (kg/per person) and applying this to Ireland using national population statistics Estimates of NMVOC emissions from this source category are provided in Table 4.20. The methodology is considered a Tier 1 method

**Table 4.20 Non-Methane Volatile Organic Compound Emissions from Paint Application: Other Non-Industrial Sources**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOOC (kt)	0.490	0.401	0.466	0.337	0.264	0.234	0.268	0.298	0.317	0.443	0.502	0.507	0.509	0.509

#### 4.5.4 Degreasing and Dry Cleaning (NFR 2D3e and 2D3f)

Degreasing and Dry Cleaning (2D3e and 2D3f) covers the four subcategories that constitute SNAP Sector 0602. The subcategories for which emission estimates have been made are as follows with the relevant SNAP code in parentheses:

Metal Degreasing (060201)

Dry Cleaning (060202)

Electronic Components (060203)

Other Industrial Cleaning (060204)

Activity data were obtained in the form of net consumption statistics (import minus exports) supplied by the CSO. Solvents included in the emissions estimate include perchloroethylene, dichloromethane, trichloroethylene and hydrocarbons from 1992-2018 before which time data are not available. The methodologies outlined in the Inventory Guidebook (EMEP/EEA 2019) and emissions data collected under the Solvents Directive 1999/13/EC are used to derive emission estimates. Further details of the methodological choices for this source category are provided in Barry, S. and O’Regan B. (2014).

##### 4.5.4.1 Metal Degreasing (SNAP 060201), Electronics Manufacture (SNAP 060203) and Other Industrial Cleaning (SNAP 060204)

Degreasing is a process for cleaning water-insoluble substances, such as grease, fats, oils, waxes, carbon deposits, fluxes and tars, primarily from various metal products, but plastic, fibreglass, printed circuit boards and other products may also be treated by the same process. Therefore, a wide range of activities is covered.

The metalworking industries are the major users of solvent degreasing. Many manufacturers of electronic components also employ degreasing, but it is difficult to differentiate between the emissions emanating from degreasing and those from other sources. As a result, for the purposes of inventory estimates, emissions from Other Industrial Cleaning (060204) and Electronic Manufacture (060203) are included with Metal Degreasing (060201) as national statistics do not facilitate disaggregation of individual sectors.

The Inventory Guidebook (EMEP/EEA 2019) Tier 1 methodology is used for inventory estimates, and solvent consumption statistics (import minus exports) are used as the activity data. The default emission factor of 460g of VOC per kg of cleaning product is used. As data are not available for 1990-1991, the annual emission estimates for these years are assumed to be the same as 1992. Estimates of NMVOOC emissions from this source category are provided in Table 4.21.

**Table 4.21 Non-Methane Volatile Organic Compound Emissions from Metal Degreasing, Electronics Manufacture and Other Industrial Cleaning**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOOC (kt)	1.743	2.388	0.847	0.953	0.789	0.885	0.925	1.004	0.795	0.885	0.686	0.885	1.187	1.707

#### 4.5.4.2 Dry Cleaning (SNAP 060202)

Dry cleaning refers to any process to remove contamination from furs, leather, down leathers, textiles or other objects made of fibres, using organic solvents. Dry cleaning can be defined as the use of chlorinated organic solvents, principally perchloroethylene, to clean clothes and other textiles.

Emissions and usage data were obtained from the Solvents Directive 1999/13/EC for the years 2008-2010. In addition, the CSO provides information directly to the inventory agency in relation to perchloroethylene imports and exports. It is assumed that the net consumption (imports minus exports) in any year are used in that year for inventory estimates, even if there is some carryover of stock between years. Data are available for the years 1992 to 2018. Based on the percentage of perchloroethylene used in Dry Cleaning compared to national consumption in 2008-2010 and 2012, emissions were calculated for 1990-2007, 2011 and for 2013-2018. Estimates of NMVOC emissions from this source sector are provided in Table 4.22. The methodology is considered a Tier 3 methodology.

**Table 4.22 Non-Methane Volatile Organic Compound Emissions from Dry Cleaning**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOOC (kt)	0.282	0.270	0.090	0.085	0.063	0.053	0.058	0.075	0.057	0.069	0.044	0.062	0.064	0.071

#### 4.5.5 Chemical Products, Manufacture and Processing (NFR 2D3g)

The mapping of Chemical Products, Manufacture and Processing (2D3g) to SNAP covers 14 subcategories in SNAP Code 0603. These subcategories are all industrial applications and, similar to Coating Application (2D3d), emission sources not included including Asphalt blowing and Leather tanning activities do not occur in Ireland and the notation key “NO” is used for emissions from these categories. The 9 subcategories for which emission estimates are made are as follows with the relevant SNAP code in parentheses:

- PVC Processing (060302)
- Polyurethane Processing (060303)
- Rubber Processing (060305)
- Pharmaceutical Products Manufacturing (060306)
- Paints Manufacturing (060307)
- Inks Manufacturing (060308)
- Adhesives Manufacturing (060309)
- Adhesive and Magnetic Tapes, Films and Photographs Manufacturing (060311)
- Textile Finishing (060312)

Information pertaining to these sectors has been obtained from IPPC licenced companies with the exclusion of PVC processing (060302) which is based upon expert opinion from Finn et al. (2001).

Estimates were up-scaled to reflect national emissions using the number of companies for each sector classified under European industrial activity classifications (NACE Rev.2) provided by the CSO. Emissions from Adhesive and Magnetic Tapes, Films and Photographs Manufacturing (060311) are included under SNAP code (060405) Industrial adhesive usage in section 4.5.7.3 Other Use of Solvents and Related Activities (2D3i-2G). Further details as to the exact methodological choices and the use of Inventory Guidebook (EMEP/EEA 2019) methodologies applied in estimating emissions can be found in Finn et al. (2001), CTC/AEA (2005), and Barry and O’Regan (2014).

#### 4.5.5.1 Polyvinyl Chloride (PVC) Processing (SNAP 060302)

The manufacture of polyvinyl chloride plastic involves an enclosed reaction or polymerisation step using the basic monomer to produce the resin, a drying step, and a final treating and forming step. Plastics are polymerised in completely enclosed vessels. Treatment of the resin after polymerisation varies with the proposed use. The major sources of air emission in plastics manufacture are the raw materials or monomers, solvents, or other volatile liquids emitted during the reaction, sublimed solids such as phthalic anhydride emitted in alkyd production, and solvents lost during storage and handling of thinned resins. Processing of PVC is not significant in Ireland. Emission data have been sourced from the installations involved which suggest an emission of 5 t/annum (Finn et al., 2001). The methodology is considered a Tier 1 method.

#### 4.5.5.2 Polyurethane Processing (SNAP 060303)

This category deals with the application and subsequent discharge of organic compounds as blowing agents for creating polyurethane foams. Emissions are from the release of these blowing agents during foaming, or subsequently by the long-term release over several years. Polyurethane is used in building construction, for heat insulation, and for packaging material. For soft polyurethane foams, water may be used. Hard polyurethane foams utilise organic liquids as blowing agents.

Emission data have been sourced from IPPC-licensed companies involved in the manufacture of polyurethane and other foams. Estimates of NMVOC emissions from this category are provided in Table 4.23. The methodology is considered a Tier 1 method.

**Table 4.23 Non-Methane Volatile Organic Compound Emissions from Polyurethane Processing**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.162	0.162	0.080	0.044	0.027	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004

#### 4.5.5.3 Rubber Processing (SNAP 060305)

No detailed information for rubber processing is available within the Inventory Guidebook (EMEP/EEA 2016). Therefore, it is assumed in inventory estimates that this category includes processes such as moulding and mixing of natural and synthetic rubbers. Operations involving trimming and cutting are ignored since NMVOC emissions would not be associated with such operations.

Emission data have been sourced from IPPC-licensed companies involved in rubber processing that utilise organic solvents. Estimates of NMVOC emissions from this category sector are provided in Table 4.25. Emissions from this sector were dominated by the manufacture of tennis balls from two companies both of which have ceased operation and account for the steep decline in emissions. The

last rubber processing facility closed in 2016 and emissions thereafter are reported using the notation key NO. The methodology is considered a Tier 2 method.

**Table 4.24 Non-Methane Volatile Organic Compound Emissions from Rubber Processing**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.423	0.424	0.422	0.199	0.001	0.001	0.001	0.001	0.001	0.001	0.001	NO	NO	NO

#### 4.5.5.4 Pharmaceutical Products Manufacturing (SNAP 060306)

Depending on the nature of the pharmaceutical manufacturing facility, organic chemicals are used in the synthesis, extraction, fermentation and purification of Active Pharmaceutical Ingredients. Solvents are also used in the dilution of liquids, granulation, packaging and film coating. Thousands of individual products are categorised as pharmaceuticals. These products are usually produced in modest quantities in relatively small plants using batch processes. A typical pharmaceutical plant will use the same equipment to make several different products at different times.

The pharmaceutical industry is well established in Ireland and subject to IPPC licence requirements. Emission estimates have been made for 1998 and 2004 using an emission factor of 2 per cent of usage data (Finn et al. 2001, CTC/AEA, 2005) and for 2006-2018 using reported fugitive emissions data supplied by IPPC licenced facilities to the EPA. Other years (1990-1997 and 2005 emissions estimates) are interpolated or extrapolated from these estimates. The methodology is considered a Tier 3 method. Estimates of NMVOC emissions from this source category are provided in Table 4.25.

**Table 4.25 Non-Methane Volatile Organic Compound Emissions from Pharmaceutical Products Manufacturing**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	2.124	2.124	2.072	0.769	1.727	0.873	1.029	1.129	1.121	0.969	0.767	0.802	0.757	0.637

#### 4.5.5.5 Coating Manufacture: Paint (SNAP 060307)

The manufacture of paint involves the dispersion of coloured oil or pigments in a vehicle, usually an oil or resin, followed by the addition of an organic solvent for viscosity adjustment. Only the physical processes of weighing, mixing, grinding, tinting, thinning and packaging take place. No chemical reactions are involved.

Input and usage data have been sourced from a number of installations for 1998 and 2004 and from 2007 to 2018 emissions data was obtained from AERs. Emissions data were upscaled based on national statistics to reflect national emissions. Emissions were assumed to remain at 1998 levels for the period 1990-1997 as no emissions data was available. Other years in the time series are estimated by interpolation and extrapolation. This methodology is considered a Tier 3 method. Emission estimates for NMVOC are provided in Table 4.26

**Table 4.26 Non-Methane Volatile Organic Compound Emissions from Paint Manufacture**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.162	0.162	0.117	0.083	0.060	0.043	0.027	0.039	0.051	0.052	0.152	0.300	0.415	0.534

#### 4.5.5.6 Inks Manufacturing (SNAP 060308)

There are four major classes of printing ink: letterpress and lithographic inks, commonly called oil or paste inks, and flexographic and rotogravure inks, which are referred to as solvent inks. These inks vary considerably in physical appearance, composition, method of application, and drying mechanism. Flexographic and rotogravure inks have many elements in common with the paste inks but differ in that they are of very low viscosity, and they almost always dry by evaporation of highly volatile solvents.

Emissions data were obtained from IPPC licensed facilities for 2008-2018. Where emissions estimates are based on usage data they are calculated based on an assumed emission factor of 2.5 per cent, which is the UK NAEI emission factor for this category (CTC/AEA, 2005). Emissions were assumed to remain at 1998 levels for the period 1990-1997 as no emissions data were available. Gaps in the time series were then filled by interpolation and extrapolation. The methodology is considered a Tier 2 method. Estimates of NMVOC emissions from this source category are provided in Table 4.27.

**Table 4.27 Non-Methane Volatile Organic Compound Emissions from Inks Manufacturing**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (t)	1.844	1.844	0.630	0.436	0.145	0.131	0.141	0.136	0.073	0.021	0.005	0.005	0.002	0.006

#### 4.5.5.7 Adhesives Manufacturing (SNAP 060309)

This category includes the manufacture of glues and adhesives as it was difficult to derive separate activity data for glues and adhesives from those obtained from IPPC-licensed installations.

Emissions and usage data were supplied for a number of years in the time series (1998, 2006-2018). Emissions were assumed to remain at 1998 levels for the period 1990-1997 as no emissions data were available for that period. The methodology is considered a Tier 3 method. Estimates of NMVOC emissions from this source category are provided in Table 4.28.

**Table 4.28 Non-Methane Volatile Organic Compound Emissions from Adhesives Manufacturing**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.051	0.051	0.034	0.051	0.036	0.041	0.051	0.016	0.036	0.022	0.027	0.057	0.062	0.050

#### 4.5.5.8 Textile Finishing (SNAP 060312)

Textile fabric finishing is part of the textile finishing industry. In fabric printing, a decorative pattern or design is applied to constructed fabric by roller, flat-screen or rotary-screen methods. Pollutants of interest in fabric printing are VOCs from mineral spirit solvents in print pastes or inks. Solvent use in this sector is usually associated with dry processing rather than wet processing of textiles.

Very little information is available for this activity. Two IPPC-regulated companies provided information to allow estimates to be made for a limited number of years (1998, 2004 and 2006-2015). Emissions were assumed to remain at 1998 levels for the period 1990-1997 as no emissions data were available. The remaining years were extrapolated. This is considered a Tier 1 method. The last company closed in 2016 and emissions are reported using the notation key NO for 2016 -2018. Estimates of NMVOC emissions from textile finishing are provided in Table 4.29.

**Table 4.29 Non-Methane Volatile Organic Compound Emissions from Textile Finishing**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.078	0.078	0.049	0.033	0.030	0.030	0.030	0.028	0.028	0.028	0.028	NO	NO	NO

#### 4.5.6 Printing (2D3h)

Printing involves the use of various types of inks, which may contain a proportion of organic solvents which may be diluted before use. Different inks have different proportions of organic solvents and require dilution to different extents. Printing can also require the use of cleaning solvents and organic dampeners. The main printing techniques identified include offset, cold-set web offset, heat-set web offset, sheet-fed offset, rotogravure, flexography, letterpress, and screen-printing.

Usage and emission data are sourced from IPPC-regulated companies and scaled for those not regulated by IPPC based on national statistics and average emissions. Estimates of NMVOC emissions from printing are provided in Table 4.30. The large decrease in emissions is due to abatement measures introduced by the companies operating in Ireland due to the Solvent Directive (1999/13/EC) and a general greater awareness of environmental issues by the print industry. While the printing industry was affected by the economic recession from 2008 in Ireland and resulted in a decreasing emission trend, emissions increased in 2009 due to emissions from two IPPC licenced facilities. The methodology is considered a Tier 3 method.

**Table 4.30 Non-Methane Volatile Organic Compound Emissions from Printing**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	2.912	2.912	1.946	2.126	2.360	2.474	1.788	1.217	1.283	1.400	1.462	1.468	1.206	1.368

#### 4.5.7 Other Use of Solvents and Related Activities (2D3i-2G)

This sector consists of 11 subcategories, which are a mixture of industrial and non-industrial activities, only 8 of which are applicable to Ireland. In NFR 2D3i (Other solvent use) the categories; Mineral wool enduction (060402) and Other (060412) are not considered to occur in Ireland. In NFR 2G4 Other product use the category Use of shoes (060602) is not estimated for Ireland. The 8 subcategories for which emission estimates are made are as follows with the relevant SNAP code in parentheses:

NFR 2D3i;

- Glass Wool Blowing/Enduction (060401)
- Fat, edible and non-edible oil extraction (060404)
- Application of Glues and Adhesives (060405)
- Preservation of Wood (060406)
- Underseal Treatment and Conservation of Vehicles (060407)
- Vehicle Dewaxing (060409)

NFR 2G4;

- Use of Fireworks (060601)
- Use of Tobacco (060602)

Both bottom-up and top-down approaches are used in the estimation of emissions from the subcategories outlined, depending on the availability of data for each subcategory. Similar to the other categories, further information in relation to subcategory estimation methodologies can be found in Finn et al. (2001), CTC/AEA (2005) and Barry and O'Regan (2014).

#### 4.5.7.1 Glass Wool Blowing/Enduction (SNAP 060401)

Glass fibre manufacturing is the high-temperature conversion of various raw materials into a homogeneous melt, followed by the fabrication of this melt into glass fibres. The two basic types of glass fibre products, textile and wool, are manufactured by similar processes. Within the category in Ireland, formaldehyde and phenol are used. Usage and emission data have been sourced from one IPPC-regulated company which ceased operation in 2009. Estimates of NMVOC emissions from this source category are provided in Table 4.31.

**Table 4.31 Non-Methane Volatile Organic Compound Emissions from Glass Wool Blowing/Enduction**

Year	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
NMVOC (kt)	0.003	0.003	0.003	0.003	0.003	0.003	0.005	0.005	0.005	0.005	0.001

#### 4.5.7.2 Fat, edible and non-edible oil extraction (SNAP 060404)

This sector covers solvent extraction of edible oils from oilseeds and drying of leftover seeds before resale as animal feed. The extraction of oil from oil seeds is performed either mechanically or through the use of solvents, or both. Where solvent is used, it is generally recovered and cleaned for reuse. The seed may be subjected to solvent treatment many times before all the oil is extracted. The remaining seed residue is then dried and may be used as an animal feed. Emissions of NMVOC, TSP, PM<sub>10</sub> and PM<sub>2.5</sub> for this sector were estimated using statistics obtained from the C.S.O on the national yield of oilseed. The Inventory Guidebook (EMEP/EEA, 2019) Tier 2 emission factors from Table 3-4 were applied. Estimates of NMVOC, TSP, PM<sub>10</sub> and PM<sub>2.5</sub> are given in Table 4.32.

**Table 4.32 Emissions from Fat, edible and non-edible oil extraction**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.031	0.020	0.014	0.022	0.037	0.044	0.088	0.092	0.077	0.054	0.063	0.054	0.066	0.064
TSP (kt)	0.022	0.014	0.009	0.016	0.026	0.031	0.061	0.065	0.054	0.038	0.044	0.038	0.046	0.045
PM10 (kt)	0.018	0.012	0.008	0.013	0.021	0.025	0.050	0.053	0.044	0.031	0.036	0.031	0.038	0.037
PM2.5 (kt)	0.012	0.008	0.005	0.009	0.014	0.017	0.034	0.035	0.030	0.021	0.024	0.020	0.025	0.025

#### 4.5.7.3 Application of Glues and Adhesives (SNAP 060405)

This sector covers the use of all adhesives excluding domestic adhesive usage and includes adhesive and magnetic tape production (SNAP 060311). These data include adhesives used for publications and packaging, footwear, construction, transport equipment, rubber and plastic products, abrasives, engineering, laminating and other sectors.

This estimate is based upon net consumption statistics (import minus export data) and the Inventory Guidebook (EMEP/EEA, 2019) default emission factor of 522 g/kg of adhesive. The methodology is

considered a Tier 2 method. Estimates of NMVOC emissions from the application of glues and adhesives are provided in Table 4.33.

**Table 4.33 Non-Methane Volatile Organic Compound Emissions from Application of Glues and Adhesives**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.540	0.313	0.755	2.986	2.031	1.121	1.293	0.872	0.702	0.972	1.123	1.064	1.116	1.396

#### 4.5.7.4 Preservation of Wood (SNAP 060406)

This section refers to emissions from the industrial use of wood preservatives. It does not include emissions from the surface coating of timber with paints, varnishes or lacquer (which are covered under SNAP 060107), and it does not cover the use of wood preservatives by the public at large (which is covered under SNAP 060408). Wood preservation is carried out using solvent-based preservatives, water-based preservatives or creosote. Creosote is an oil product, prepared from coal tar distillation, and contains a high proportion of aromatic compounds such as PAHs. Regulations banning the sale of creosote took effect from June 2003. However, creosote may still be used for industrial applications, e.g. railway sleepers, telegraph poles and fencing, but with tougher restrictions on its composition and how it is applied. Creosote is gradually being replaced by water-borne preservatives. Preservatives based on organic solvents have a wide-ranging content of organic solvent, usually white spirit or other petroleum-based hydrocarbons. Water-borne preservatives consist of solutions of inorganic salts in water, with Cu, Cr and As (CCA)-based preservatives being the most widely used. Water-borne preservatives are not of concern to this inventory, as they do not contain VOCs.

In addition to bottom-up IPPC-licensed data, usage data was provided by the sole Creosote using company in Ireland. The Inventory Guidebook (EMEP/EEA, 2019) emission factor of 105 g/litre creosote applied is used. The methodology is considered a Tier 3 method. Estimates of NMVOC emissions from wood preservation are provided in Table 4.34.

**Table 4.34 Non-Methane Volatile Organic Compound Emissions from Preservation of Wood**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.092	0.122	0.216	0.090	0.130	0.292	0.239	0.536	0.342	0.354	0.236	0.252	0.241	0.254

#### 4.5.7.5 Underseal Treatment and Conservation of Vehicles (SNAP 060407)

The application of coatings to the underside of car bodies is conducted for protection from stone chips and for sound deadening. In the aftermarket sector, coatings are applied to the underside of cars only during repair of damaged bodywork. Finn et al. (2001) stated that sources within the trade suggested that application of underseal in Ireland was zero or minimal. However, further contact with suppliers revealed that a market of 650 l/annum existed at the time (1998). It is assumed that this market existed for all years prior to 1998. However, CTC/AEA (2005) suggested that this market no longer exists in Ireland and that emissions decreased in a linear fashion up to 2003, after which emissions from the activity no longer occur. The approach uses an average solvent content of 20 per cent, a density of 1,000 kg/m<sup>3</sup>, and assumes that 100 per cent of the solvent is emitted. Estimates of NMVOC emissions from this source category are provided in Table 4.35.

**Table 4.35 Non-Methane Volatile Organic Compound Emissions from Underseal Treatment and Conservation of Vehicles**

Year	1990	1995	2000	2001	2002	2003
NMVOG (Kg)	130	130	87	65	43	22

#### 4.5.7.6 Vehicle Dewaxing (SNAP 060409)

In the past, some manufacturers of new cars applied a protective covering to parts of the car body after painting to provide protection during transport. Removal of this coating was carried out at the import centres using solvents. However, car manufacturers now invariably use either water-soluble wax that can be removed using hot water or self-adhesive film instead of wax. Consequently, it is assumed that emissions from this activity are now zero. Discussion with car distributors suggested that, historically, 20 per cent of new cars in Ireland were dewaxed and that the practice was discontinued after 2003. An emission factor of 1 kg/car is applied to estimate emissions using vehicle statistics provided by the CSO (Finn et al., 2001). Estimates of NMVOG emissions from vehicle dewaxing are provided in Table 4.36.

**Table 4.36 Non-Methane Volatile Organic Compound Emissions from Vehicle Dewaxing**

Year	1990	1995	2000	2001	2002	2003
NMVOG (kt)	0.035	0.035	0.023	0.017	0.012	0.006

#### 4.5.7.7 Use of Tobacco (SNAP 060602)

This category comprises NMVOG, NO<sub>x</sub>, CO, NH<sub>3</sub>, TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and BC emissions from the combustion (smoking) of tobacco products. Activity data was obtained from The Office of the Revenue Commissioners regarding the excise volumes of tobacco and includes an estimation of Illegal tobacco imported to Ireland from an illegal products research report produced by the Office of the Revenue Commissioners (Office of the Revenue Commissioners, 2017). A significant decrease in tobacco products was noted in 2018. The Inventory guidebook (EMEP/EEA, 2019) Tier 2 emission factors in table 3-15 are applied. Estimates of emissions from Use of Tobacco are provided in Table 4.37.

**Table 4.37 Emissions from Use of Tobacco**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOG (kt)	0.034	0.037	0.039	0.032	0.027	0.024	0.025	0.023	0.020	0.019	0.020	0.017	0.022	0.011
NO <sub>x</sub> (kt)	0.013	0.014	0.015	0.012	0.010	0.009	0.009	0.008	0.007	0.007	0.008	0.006	0.008	0.004
CO (kt)	0.386	0.419	0.449	0.360	0.310	0.278	0.280	0.257	0.224	0.213	0.230	0.194	0.250	0.127
NH <sub>3</sub> (kt)	0.029	0.032	0.034	0.027	0.023	0.021	0.021	0.019	0.017	0.016	0.017	0.015	0.019	0.010
TSP (kt)	0.189	0.205	0.220	0.176	0.152	0.136	0.137	0.126	0.110	0.104	0.113	0.095	0.123	0.062
PM <sub>10</sub> (kt)	0.189	0.205	0.220	0.176	0.152	0.136	0.137	0.126	0.110	0.104	0.113	0.095	0.123	0.062
PM <sub>2.5</sub> (kt)	0.189	0.205	0.220	0.176	0.152	0.136	0.137	0.126	0.110	0.104	0.113	0.095	0.123	0.062
BC (kt)	0.076	0.082	0.088	0.070	0.061	0.054	0.055	0.050	0.044	0.042	0.045	0.038	0.049	0.025

#### 4.5.7.8 Use of Fireworks (SNAP 060601)

This category comprises NO<sub>x</sub>, CO, SO<sub>2</sub>, TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emissions from the use of fireworks. Activity data was obtained from The Department of Justice and Equality and relates to the professional use of fireworks in displays. The Inventory guidebook (EMEP/EEA, 2019) Tier 2 emission factors in Table 3-14 are applied. Estimates of emissions from Use of Fireworks are provided in Table 4.38.

**Table 4.38 Emissions from Use of Fireworks**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NOx (t)	0.011	0.012	0.012	0.012	0.012	0.012	0.011	0.011	0.010	0.010	0.008	0.007	0.009	0.009
CO (t)	0.315	0.331	0.340	0.335	0.344	0.326	0.307	0.293	0.283	0.262	0.208	0.199	0.240	0.252
SO2 (t)	0.133	0.140	0.143	0.141	0.145	0.138	0.130	0.124	0.119	0.111	0.088	0.084	0.101	0.106
TSP (t)	4.835	5.091	5.218	5.145	5.279	5.011	4.717	4.505	4.340	4.021	3.193	3.059	3.687	3.865
PM10 (t)	4.399	4.632	4.747	4.681	4.803	4.559	4.291	4.098	3.949	3.659	2.905	2.783	3.354	3.516
PM2.5 (t)	2.287	2.408	2.468	2.433	2.497	2.370	2.231	2.130	2.053	1.902	1.510	1.447	1.744	1.828

#### 4.5.8 Food and Beverage Industry (NFR 2H2)

According to the EMEP/EEA Guidebook (EMEP/EEA, 2019) this sector includes emissions from all processes in the food production chain which occur after the slaughtering of animals and the harvesting of crops as well as drink manufacturing including production of alcoholic beverages. For Ireland, Wine production (040606) is not occurring, Sugar production (040625) has not occurred since 2005, when the last sugar factory was closed (no activity data available), and Flour production (040626) does not occur on a large scale (no activity data available), margarine and fats production is not thought to occur (no activity data available). Emissions include Spirit production, Animal feed production and Bread production which are the most significant source of emissions in the Food and Beverage industry in Ireland. The 6 subcategories for which emission estimates are made for Ireland are as follows with the relevant SNAP code in parentheses, where applicable:

Bread (SNAP 040605)

Beer (SNAP 040607)

Spirits (SNAP 040608)

Meat fish etc. frying/curing (SNAP 040627)

Coffee Roasting

Feedstock

##### 4.5.8.1 Bread (SNAP 040605)

This sector includes bread, cakes and baking products. Activity data on white bread and bread products production was obtained from EUROSTAT for years 1995 to 2018. The data for years 1990-1994 was taken to be the same as 1995 as no data was available for these years. Emissions from cakes are not included in this estimate as no activity data is available. Tier 2 emission factors from the Inventory guidebook (EMEP/EEA, 2019) were used for bread and cakes, biscuits and breakfast cereals i.e. baking goods. The NMVOC emissions from Bread is given in table 4.39.

**Table 4.39 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Bread**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	1.707	1.707	1.006	1.374	1.472	2.577	1.707	1.593	1.838	1.714	1.696	1.643	1.749	2.848

##### 4.5.8.2 Beer (SNAP 040607)

This includes mainstream beer production and craft beer production which has seen a steady increase since 2005 and a significant increase in Ireland since 2010. Activity data was obtained from a variety

of sources including the Irish Brewers Association reports (ABFI, 2013, 2014, 2015, 2017 & 2018) and Independent Craft Brewers of Ireland and Bord Bia Report (Feeney, 2015). The Inventory Guidebook (EMEP/EEA, 2019) Tier 2 emission factor of 0.035 kg/hL was used. The NMVOC emissions from Beer production is given in table 4.40.

**Table 4.40 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Beer**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.194	0.207	0.225	0.250	0.274	0.274	0.274	0.288	0.282	0.258	0.276	0.275	0.289	0.300

#### 4.5.8.3 Spirits (SNAP 040608)

Spirit production is a significant source of NMVOC emissions within the Food and Beverage industry due to the growth of the Whiskey production industry in Ireland. In the current submission activity data is based on national statistics for the years 1999-2018. Other years were extrapolated using this data. A Tier 2 emission factor of 15kg/hl alcohol was used from the Inventory Guidebook (EMEP/EEA, 2019). NMVOC emissions from Spirit production in Ireland in given in table 4.41.

**Table 4.41 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Spirits**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	3.97	4.68	4.90	8.53	11.12	12.29	13.31	14.69	16.29	13.56	14.38	15.50	20.44	19.28

#### 4.5.8.4 Meat, fish etc., frying/curing (SNAP 040627)

Emissions mainly occur from the cooking of meat, fish and poultry, releasing fats and oils and their degradation products. Emissions from fish frying and curing were not estimated due to absence of accurate activity data. Activity data for fish frying is under investigation and included in the planned improvement section 4.10. Activity data was obtained from the CSO on tonnes of animal slaughterings in Ireland which is taken to be the equivalent of meat rendered in Ireland the Inventory guidebook (EMEP/EEA, 2019) emission factor of 0.33 kg/Mg of meat rendered was used. Activity data on human consumption of meat from the CSO was taken to equate to meat frying and using the Inventory Guidebook (EMEP/EEA, 2019) emission factor of 0.3 kg/Mg product was used this is considered a Tier 2 method. The NMVOC emissions from meat frying/curing is given in table 4.42.

**Table 4.42 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Meat, fish etc. frying/curing**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.398	0.402	0.450	0.438	0.405	0.425	0.426	0.415	0.424	0.457	0.457	0.481	0.497	0.509

#### 4.5.8.5 Coffee Roasting

The roasting of coffee beans is a source of NMVOC emissions. This activity does not have a relevant SNAP code. Activity data for unroasted coffee imports was obtained from the UN Comtrade Database and the Tier 2 emission factor from the Inventory Guidebook (EMEP/EEA, 2019) was used to estimate emissions as can be seen in table 4.43.

**Table 4.43 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Coffee roasting**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.001	0.001	0.002	0.003	0.001	0.001	0.003	0.003	0.003	0.003	0.005	0.006	0.007	0.007

#### 4.5.8.6 Feedstock

The processing of by-products to produce animal feeds is a source of NMVOC emissions in Ireland. The tonnage of animal feed produced was sourced from the CSO and the Inventory Guidebook (EMEP/EEA, 2019) emission factor of 1 kg/Mg feed was used to estimate emissions from this source as can be seen in table 4.44.

Table 4.44 *Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Feedstock*

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	3.351	3.222	3.100	2.700	2.263	2.490	2.466	3.425	3.655	3.040	3.228	3.337	3.595	3.854

### 4.6 Other production, consumption, storage, transportation or handling of bulk product (NFR 2L)

The Other production, consumption, storage, transportation or handling of bulk product category in Ireland's air pollutant inventory includes emissions of PCDD/F and PCBs from leakage from electrical equipment and emissions of PCBs from fragmentisers and shredders. The main use of PCBs since the 1970s, when open uses were banned, has been as dielectric fluids in electrical equipment such as transformers and capacitors. However, the production and use of dielectric fluid containing PCBs has been highly regulated since 1986. Releases to the environment have decreased since 1990 as older PCB-containing equipment is taken out of service and is replaced by PCB-free equipment, which reduces the stocks that may lead to PCB emissions. It is also taken into consideration that, in some cases, trace PCDD/F may be present in PCB dielectric fluid. These arise from the original PCB synthesis process and from oxidation during dielectric breakdown events.

Electrical equipment, including white goods and electronic equipment, is partly recycled by breaking down the products in fragmentisers and shredders. Fragments are separated into ferrous scrap, a fraction containing non-ferrous scrap (which would then be processed separately), and a waste fraction that is typically disposed to landfill. Polychlorinated biphenyls are present in the capacitors of old electrical equipment. Hence, there is potential for PCBs to be released to air during fragmentiser operations.

#### 4.6.1 Leakage from Electrical Equipment (NFR 2L)

The release of PCBs to the environment from electrical equipment is very difficult to estimate with any accuracy due to the large number of components potentially containing PCBs, the range of lifetime and replacement rates for PCB components, and the difficulties for users in identifying such components. Polychlorinated biphenyls have never been manufactured in Ireland. Production ceased in the UK in 1977 and in the rest of Europe and North America in 1986. Manufacturers of electrical equipment were then supplied with alternative dielectric media and replacement products entered the market. However, some countries outside the EU and North America continued to produce these substances until recently. Hence, products from those countries may have continued to contain PCBs until the mid-1990s. Current releases to the environment arise principally from the closed electrical appliances that still exist, as their useful life could be up to 40 years.

Activity data are very difficult to obtain on quantities of PCBs in existing transformers and associated leakage rates. A National Inventory of PCB Holdings for Ireland was originally prepared in 2001. This inventory has been updated a number of times, the most recent data corresponding to 2018. The report for this inventory provides an estimate of the total volume of PCB oil (confirmed and suspected) for 2018 of 12.98 m<sup>3</sup>. This estimate includes both inventoried (confirmed) large and small holdings and estimated non-inventoried (suspected) holdings. Indications are that this is an overestimate and that many of the suspected holdings do not contain any PCBs. The estimate of holdings for 2018 represents a substantial decrease on the peak value in 2009 (522.06 m<sup>3</sup>) following a large decrease in 2008 (114.29 m<sup>3</sup>). This is partly due to methodological changes in the inventory compilation, which has given rise to a step change in the emission estimates. This issue requires further investigation to determine the level of inconsistency that may have been introduced across the current time series. The European Union's Chemical Legislation European Enforcement Network (CLEEN) initiated a project to compare inventories of PCBs in Member States of the EU. The CLEEN project documents summarise a large amount of information held within the EU offices (on PCB stocks) that have been reported by Member States to the EC but have not to date been published or synthesised by the Commission itself. Analysis of the CLEEN data indicates that Ireland has a lower than average PCB per-capita stock when compared with other Member States. All of this qualitative information points towards a lower than average prevalence of PCB-containing materials within electrical equipment in Ireland and this has been taken into consideration in the estimation method used for category 2L.

The derivation of activity data outlined above provides a time series of estimates of PCB-containing oil stocks in Ireland, based on a worst-case assumption that all of the as yet unreported transformer stocks do contain PCBs. The estimates range from 417,620 dm<sup>3</sup> of oil in 1990 to 12,983 dm<sup>3</sup> of oil (as reported by the EPA) in 2018. Data from the UK NAEI indicate that annual emissions of PCBs derived from dielectric fluid stocks can be estimated as 0.5 g PCBs/kg fluid, of which emissions to air comprise 0.06 g PCBs/kg emitted, with the remainder emitted to land. In the absence of source activity and monitoring data, these factors have been used to estimate Ireland's PCB emission estimates. The time series of PCB emissions from leakage of electrical equipment is presented in Table 4.45. As noted above, the current data gives rise to a sharp increase in emissions for 2009 to decrease again in 2010 and further in each consecutive year, caused by a change in the methodology used for estimating the volume of dielectric fluid containing PCBs. Total quantity of PCB containing oil contained in equipment in-situ at start of year for 2018 is substantially lower than previous years, resulting in decreased emissions.

The data on PCDD/F concentrations in dielectric PCB fluid from Dyke (1997) give a concentration in PCB dielectric fluid of 83.5 µg I-TEQ/kg of PCBs. It is assumed that the evaporation rate is the same for PCBs and PCDD/F so that for every kilogram of PCBs that is emitted to air, 83.5 µg I-TEQ of PCDD/F are emitted. Using this factor, estimates for PCDD/F emissions to air from dielectric fluid stocks in Ireland have been made. The time series of PCDD/F emissions from leakage from electrical equipment is presented in Table 4.45.

**Table 4.45 Time Series of Polychlorinated Biphenyls and Dioxin and Furan Emissions from Leakage from Electrical Equipment**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
PCDD/F (µg I-TEQ)	1.034	1.034	0.842	0.790	1.293	0.625	0.546	0.172	0.061	0.055	0.036	0.032	0.032	0.032
PCBs (kg)	0.0124	0.0124	0.0101	0.0095	0.0155	0.0075	0.0065	0.0021	0.0007	0.0007	0.0004	0.0004	0.0004	0.0004

#### 4.6.2 Fragmentisers and Shredders (NFR 2L)

The practice of fragmenting or shredding electrical equipment currently occurs in a small number of IPPC-licensed facilities, where any suspected POP-containing components (e.g. capacitors) are removed and the residual material is then exported. White goods are also exported for recovery or treatment. The recycling of electrical and electronic goods has also been improved since the introduction of the WEEE Regulations in 2005. However, prior to the commencement of the WEEE Regulations and the All Island Fridge & Freezer Collection and Export Scheme in 2004, it is possible that white goods may have been shredded within Ireland, although there is little evidence that such practice was widespread. To provide a worst-case estimate for this potential emission, the UK NAEI activity data have been scaled on a per-capita basis to prepare estimates for Ireland for 1990–2005.

The shredding of End-of-Life Vehicles (ELVs) is another operation that may result in the possible emissions of POPs, and it has been found to be a relatively significant source in other European countries. Currently, two companies operate ELV shredders at three locations. The larger company operates two shredders but undertakes no monitoring of POPs on incoming vehicles or auto residue post-shredding. However, due to the ELV regulations all vehicles are “de-polluted” either on-site or prior to receipt from dismantlers, with all suspected contaminated materials being removed. In addition, the de-polluting process is expected to further improve in future years. Approximately 30,000 tonnes of auto residue (de-polluted vehicles) are shredded annually. Prior to the implementation of the ELV regulations the entire intact vehicle was shredded. Therefore, it can be assumed that for earlier years the shredding of ELVs would have resulted in larger quantities of shredded auto residue, with a higher potential for release of POPs.

Very limited data are available on emissions of POPs to air from fragmentisers, especially for the early part of the time series. Emission estimates for POPs are based on the Inventory Guidebook (2000) factor of 0.004 g/capita/year for PCB emissions from fragmentisers, which is considered to apply in the early part of the time series, around the time of the banning of PCBs (1985). The starting point for the time series of estimates of emissions from fragmentisers in Ireland is the estimated emissions in 1986 using population data and the factor of 0.004 g/capita/year, and this leads to an initial estimate of 14 kg PCBs emitted to air in Ireland in 1986. Assuming a 20-year lifespan of electronic equipment, it is reasonable to assume that 5 per cent of the 1986 emissions are removed each year, as old PCB-containing equipment is disposed of and new PCB-free equipment is used as replacements. This assumption leads to an estimated time series of PCB emissions to air of 11.9 kg in 1990, falling to zero emissions by 2006 and are reported using the notation key “NO” for the period 2006 to 2018. Although this is a very broad “top-down” approach and is subject to significant uncertainty, there are very little additional data available to inform more accurate estimates. Emission estimates for the time series are presented in Table 4.46.

Table 4.46 *Emission Time Series for Polychlorinated Biphenyls from Fragmentisers and Shredders*

Year	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2018
PCBs (kg)	11.920	8.643	5.305	4.617	3.917	3.184	2.427	1.654	NO	NO	NO

## 4.7 Recalculations in the Industrial Processes Sector

### 4.7.1 Heavy Metals recalculations

There were no recalculations to emission estimates for 1990–2017 as shown in Table 4.48.

### 4.7.2 Particulate matter recalculations

There were recalculations in Quarrying and Mining of minerals other than coal (NFR 2A5a) which was due to updated activity data from CSO, which resulted in recalculated emission estimates for TSP, PM<sub>10</sub> and PM<sub>2.5</sub> for 2008-2017 of 1.3 per cent to 30.1 per cent as can be seen in table 4.49. The TSP, PM<sub>10</sub> and PM<sub>2.5</sub> for 2D3b was recalculated by 10.5 per cent due to an update to activity data for 2017.

### 4.7.3 Nitrogen Oxides (NOx) recalculations

There were no recalculations to emission estimates for 1990-2017 as can be seen in table 4.50.

### 4.7.4 Non- Methane Volatile Organic Compounds (NMVOC) recalculations

Recalculations occurred in this reporting round due to updates to activity data in category 2H2 Food and Beverages industry. Revisions were made to activity data by the CSO for years 2005, 2007 and 2009 which resulted in a change in the emissions estimates for these years as can be seen in Table 4.50.

## 4.8 Quality Assurance/Quality Control

Section 4.7 outlines the recalculations which were undertaken in the Industrial Processes sector in this reporting round. The inventory agency will continue to implement QA/QC procedures with respect to the estimates from the Industrial Processes sector in future submissions. The time series spreadsheet system developed for individual categories as described in Section 1.3.5 now allows for simple and efficient checking of activity data, emission factors, annual emissions and aggregated totals. Year-on-year changes immediately highlight any omissions, anomalies or internal errors. Initial checks are conducted by the inventory compiler as part of the calculation process, which is followed by a second check by another member of the inventories team and completion of the QA/QC sheets in calculation workbooks.

## 4.9 Overview of Notation Keys

Table 4.47 describes the notation keys used in the 2018 NMVOC emission inventory for Other Solvent and Product Use (2D-2L).

**Table 4.47 Notation keys used in 2018 NMVOC inventory**

<b>NFR</b>	<b>Snap</b>	<b>Description</b>	<b>Notation Key</b>	<b>Reason</b>
2D3a	060411	Domestic use of pharmaceutical products	IE	Included in 060408
2D3e	060203	Electronic components manufacturing	IE	Included under metal degreasing
2D3e	060204	Other industrial cleaning	IE	Included under metal degreasing

2D3g	060311	Adhesive, magnetic tapes, films and photographs manufacturing	IE	Included under 060405
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## 4.10 Planned Improvements

The inventory team will continue to review emission estimates for this sector in light of any new information that may become available for future submissions. In addition, the inventory team also plans to continue to outsource contracts on a periodic basis to re-examine and extend the inventory time series with respect to emissions of heavy metals and POPs.

Ireland is aware of the EFs for Hg in the 2019 Guidebook for NFR sector 2D3c Asphalt roofing. Data was requested from the Irish Asphalt Producers association (IAPA), the PRODCOM data was requested from the national statistics agency (CSO) however, neither of these organizations could provide a suitable data source. It has been determined that the production of asphalt roofing materials does not occur in Ireland. This category is thus reported using the notation key “NO”. In relation to emissions of Hg from NFR 2K, Ireland notes that a Tier 1 approach is available in the 2019 EMEP/EEA Inventory Guidebook and continue to investigate whether mercury containing button cell batteries data is available in Ireland. Latest efforts to source activity data on button cell batteries included contacting the national statistics agency (CSO), Producer Register Ireland and Waste Electrical and Electronic Equipment Ireland (WEEE) as well as metal recyclers in Ireland, however a reliable source of this data has not yet been found.

The levels of solvent use and the emissions from solvents are changing substantially in response to product replacement and reformulation and emission controls being implemented under IPPC and the Solvents Directive (1999/13/EC). The reduction of solvent content has been captured in the methodologies, but this has relied on a number of assumptions, and the collection of real data is required to determine emissions with improved confidence.

In addition, liaison with industry will allow refinement of the estimates for activities subject to licensed controls and to reflect abatement measures in the time series. However, the per capita approach to estimating NMVOC emissions will remain the only option in several important categories, such as SNAP code 060107 (Paint Application: Wood). For category 2D3a Domestic Solvent Use including fungicides) The 2019 Guidebook (EMEP/EEA, 2019) does not have an emission factor for this source and states “Due to the uncertainty around these releases, this source is currently not considered in the Guidebook.” and so it is reported as NA.

Review recommendations and responses are included in this report as Annex H.

**Table 4.48 Recalculations for Industrial Processes 1990–2017 (Heavy Metals)**

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>Submission 2019</b>																
2A3 Glass Production	Pb	t	0.311	0.311	0.311	0.129	0.096	0.008	NO							
2A3 Glass Production	Cd	t	0.007	0.007	0.007	0.000	0.000	NA	NO							
2A3 Glass Production	Hg	t	0.001	0.001	0.001	0.001	0.001	NA	NO							
2C Metal Production	Pb	t	3.473	3.387	2.127	0.041	0.027	0.047	0.035	0.016	0.007	0.016	0.001	0.000	0.000	0.000
2C Metal Production	Cd	t	0.249	0.238	0.241	0.001	0.001	0.001	0.008	0.001	0.000	0.001	0.000	0.000	0.000	0.000
2C Metal Production	Hg	t	0.033	0.031	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<b>Submission 2020</b>																
2A3 Glass Production	Pb	t	0.311	0.311	0.311	0.129	0.096	0.008	NO							
2A3 Glass Production	Cd	t	0.007	0.007	0.007	0.000	0.000	NA	NO							
2A3 Glass Production	Hg	t	0.001	0.001	0.001	0.001	0.001	NA	NO							
2C Metal Production	Pb	t	3.473	3.387	2.127	0.041	0.027	0.047	0.035	0.016	0.007	0.016	0.001	0.000	0.000	0.000
2C Metal Production	Cd	t	0.249	0.238	0.241	0.001	0.001	0.001	0.008	0.001	0.000	0.001	0.000	0.000	0.000	0.000
2C Metal Production	Hg	t	0.033	0.031	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<b>% Change in Emissions</b>																
2A3 Glass Production	Pb	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%								
2A3 Glass Production	Cd	%	0.0%	0.0%	0.0%	0.0%	0.0%									
2A3 Glass Production	Hg	%	0.0%	0.0%	0.0%	0.0%	0.0%									
2C Metal Production	Pb	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-20.0%
2C Metal Production	Cd	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%
2C Metal Production	Hg	%	0.0%	0.0%	0.0%											

**Table 4.49 Recalculations for Industrial Processes 1990–2017 (Particulates and NOx)**

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>Submission 2019</b>																
2A3 Glass Production	TSP	kt	0.023	0.023	0.022	0.006	0.005	0.000	NO							
2A3 Glass Production	PM <sub>10</sub>	kt	0.020	0.020	0.019	0.005	0.004	0.000	NO							
2A3 Glass Production	PM <sub>2.5</sub>	kt	0.018	0.018	0.017	0.005	0.004	0.000	NO							
2A5a Quarrying and mining of minerals other than coal	TSP	kt	3.213	2.999	6.792	10.110	9.838	6.455	4.442	4.090	3.629	3.751	3.716	3.716	3.716	3.716
2A5a Quarrying and mining of minerals other than coal	PM <sub>10</sub>	kt	1.575	1.470	3.330	4.956	4.823	3.164	2.178	2.005	1.779	1.839	1.822	1.822	1.822	1.822
2A5a Quarrying and mining of minerals other than coal	PM <sub>2.5</sub>	kt	0.158	0.147	0.333	0.496	0.482	0.316	0.218	0.200	0.178	0.184	0.182	0.182	0.182	0.182
2A5b Construction and Demolition	TSP	kt	1.739	1.928	1.552	6.247	7.227	7.968	12.493	0.527	0.744	1.852	1.171	1.377	1.145	3.270
2A5b Construction and Demolition	PM <sub>10</sub>	kt	0.522	0.578	0.465	1.871	2.165	2.384	3.733	0.159	0.224	0.555	0.351	0.414	0.345	0.979
2A5b Construction and Demolition	PM <sub>2.5</sub>	kt	0.052	0.058	0.047	0.187	0.216	0.238	0.373	0.016	0.022	0.055	0.035	0.041	0.034	0.098
2A5c Storage and Handling of mineral products	PM <sub>2.5</sub>	kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2B10b Storage, handling and transport of chemical products	TSP	kt	NO													
2B10b Storage, handling and transport of chemical products	PM <sub>10</sub>	kt	NO													
2B10b Storage, handling and transport of chemical products	PM <sub>2.5</sub>	kt	NO													
2C Metal Production	TSP	kt	0.071	0.071	0.006	0.001	0.001	0.002	0.001	0.001	0.000	0.001	NO	NO	0.000	0.000
2C Metal Production	PM <sub>10</sub>	kt	0.060	0.060	0.005	0.001	0.001	0.002	0.001	0.001	0.000	0.001	NO	NO	0.000	0.000
2C Metal Production	PM <sub>2.5</sub>	kt	0.042	0.042	0.003	0.001	0.001	0.001	0.001	0.000	0.000	0.000	NO	NO	0.000	0.000
2D3b Road Paving	TSP	kt	33.000	25.500	43.500	51.000	42.000	49.500	34.500	27.000	28.500	27.000	27.000	28.500	28.500	28.500
2D3b Road Paving	PM <sub>10</sub>	kt	4.400	3.400	5.800	6.800	5.600	6.600	4.600	3.600	3.800	3.600	3.600	3.800	3.800	3.800
2D3b Road Paving	PM <sub>2.5</sub>	kt	0.220	0.170	0.290	0.340	0.280	0.330	0.230	0.180	0.190	0.180	0.180	0.190	0.190	0.190
2D3i Other solvent use	TSP	kt	0.022	0.014	0.009	0.016	0.022	0.026	0.031	0.061	0.065	0.054	0.038	0.044	0.038	0.046
2D3i Other solvent use	PM <sub>10</sub>	kt	0.018	0.012	0.008	0.013	0.018	0.021	0.025	0.050	0.053	0.044	0.031	0.036	0.031	0.038
2D3i Other solvent use	PM <sub>2.5</sub>	kt	0.012	0.008	0.005	0.009	0.012	0.014	0.017	0.034	0.035	0.030	0.021	0.024	0.020	0.025
<b>Submission 2020</b>																
2A3 Glass Production	TSP	kt	0.023	0.023	0.022	0.006	0.005	0.000	NO							
2A3 Glass Production	PM <sub>10</sub>	kt	0.020	0.020	0.019	0.005	0.004	0.000	NO							
2A3 Glass Production	PM <sub>2.5</sub>	kt	0.018	0.018	0.017	0.005	0.004	0.000	NO							
2A5a Quarrying and mining of minerals other than coal	TSP	kt	3.213	3.000	6.792	10.110	9.711	6.344	4.310	3.947	3.569	3.704	3.605	3.777	4.558	4.835
2A5a Quarrying and mining of minerals other than coal	PM <sub>10</sub>	kt	1.575	1.470	3.330	4.956	4.760	3.110	2.113	1.935	1.749	1.816	1.767	1.852	2.234	2.370
2A5a Quarrying and mining of minerals other than coal	PM <sub>2.5</sub>	kt	0.158	0.147	0.333	0.496	0.476	0.311	0.211	0.193	0.175	0.182	0.177	0.185	0.223	0.237
2A5b Construction and Demolition	TSP	kt	1.739	1.928	1.552	6.247	7.227	7.968	12.493	0.527	0.744	1.852	1.171	1.377	1.145	3.270
2A5b Construction and Demolition	PM <sub>10</sub>	kt	0.522	0.578	0.465	1.871	2.165	2.384	3.733	0.159	0.224	0.555	0.351	0.414	0.345	0.979
2A5b Construction and Demolition	PM <sub>2.5</sub>	kt	0.052	0.058	0.047	0.187	0.216	0.238	0.373	0.016	0.022	0.055	0.035	0.041	0.034	0.098

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
2A5c Storage and Handling of mineral products	PM <sub>2.5</sub>	kt	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2B10b Storage, handling and transport of chemical products	TSP	kt	NO													
2B10b Storage, handling and transport of chemical products	PM <sub>10</sub>	kt	NO													
2B10b Storage, handling and transport of chemical products	PM <sub>2.5</sub>	kt	NO													
2C Metal Production	TSP	kt	0.071	0.071	0.006	0.001	0.001	0.002	0.001	0.001	0.000	0.001	NO	NO	0.000	0.000
2C Metal Production	PM <sub>10</sub>	kt	0.060	0.060	0.005	0.001	0.001	0.002	0.001	0.001	0.000	0.001	NO	NO	0.000	0.000
2C Metal Production	PM <sub>2.5</sub>	kt	0.042	0.042	0.003	0.001	0.001	0.001	0.001	0.000	0.000	0.000	NO	NO	0.000	0.000
2D3b Road Paving	TSP	kt	33.000	25.500	43.500	51.000	42.000	49.500	34.500	27.000	28.500	27.000	27.000	28.500	28.500	31.500
2D3b Road Paving	PM <sub>10</sub>	kt	4.400	3.400	5.800	6.800	5.600	6.600	4.600	3.600	3.800	3.600	3.600	3.800	3.800	4.200
2D3b Road Paving	PM <sub>2.5</sub>	kt	0.220	0.170	0.290	0.340	0.280	0.330	0.230	0.180	0.190	0.180	0.180	0.190	0.190	0.210
2D3i Other solvent use	TSP	kt	0.022	0.014	0.009	0.016	0.022	0.026	0.031	0.061	0.065	0.054	0.038	0.044	0.038	0.046
2D3i Other solvent use	PM <sub>10</sub>	kt	0.018	0.012	0.008	0.013	0.018	0.021	0.025	0.050	0.053	0.044	0.031	0.036	0.031	0.038
2D3i Other solvent use	PM <sub>2.5</sub>	kt	0.012	0.008	0.005	0.009	0.012	0.014	0.017	0.034	0.035	0.030	0.021	0.024	0.020	0.025
<b>% Change in Emissions</b>																
2A3 Glass Production	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-
2A3 Glass Production	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-
2A3 Glass Production	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-
2A5a Quarrying and mining of minerals other than coal	TSP	%	0.0%	0.0%	0.0%	0.0%	-1.3%	-1.7%	-3.0%	-3.5%	-1.7%	-1.3%	-3.0%	1.6%	22.6%	30.1%
2A5a Quarrying and mining of minerals other than coal	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	-1.3%	-1.7%	-3.0%	-3.5%	-1.7%	-1.3%	-3.0%	1.6%	22.6%	30.1%
2A5a Quarrying and mining of minerals other than coal	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	-1.3%	-1.7%	-3.0%	-3.5%	-1.7%	-1.3%	-3.0%	1.6%	22.6%	30.1%
2A5b Construction and Demolition	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2A5b Construction and Demolition	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2A5b Construction and Demolition	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2A5c Storage and Handling of mineral products	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	-1.3%	-1.7%	-3.0%	-3.5%	-1.7%	-1.3%	-3.0%	1.6%	22.6%	30.1%
2B10b Storage, handling and transport of chemical products	TSP	%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2B10b Storage, handling and transport of chemical products	PM <sub>10</sub>	%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2B10b Storage, handling and transport of chemical products	PM <sub>2.5</sub>	%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2C Metal Production	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	0.0%	0.0%
2C Metal Production	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	0.0%	0.0%
2C Metal Production	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	0.0%	0.0%
2D3b Road Paving	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.5%
2D3b Road Paving	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.5%

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
2D3b Road Paving	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.5%
2D3i Other solvent use	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2D3i Other solvent use	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2D3i Other solvent use	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>Submission 2019</b>																
2B2 Nitric Acid Production	NOx	kt	0.960	0.280	0.302	NO										
<b>Submission 2020</b>																
2B2 Nitric Acid Production	NOx	kt	0.960	0.280	0.302	NO										
<b>% Change in Emissions</b>																
2B2 Nitric Acid Production	NOx	%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	-	-	-

**Table 4.50 Recalculations for Industrial Processes 1990–2017 (NMVOC)**

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>Submission 2019</b>																
2D3a Domestic solvent use including fungicides	NMVOC	kt	7.927	8.143	8.568	9.347	10.141	10.250	10.298	10.344	10.368	10.385	10.422	10.481	10.767	10.818
2D3b Road Paving	NMVOC	kt	0.035	0.027	0.046	0.054	0.045	0.053	0.037	0.029	0.030	0.029	0.029	0.030	0.030	0.034
2D3c Asphalt Roofing	NMVOC	kt	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2D3d Coating Applications	NMVOC	kt	6.742	6.560	6.315	6.238	5.432	4.259	3.373	3.394	3.259	3.402	3.800	3.369	2.811	2.678
2D3e Degreasing	NMVOC	kt	1.743	2.388	0.847	0.953	1.531	0.789	0.885	0.925	1.004	0.795	0.885	0.686	0.885	1.187
2D3f Dry Cleaning	NMVOC	kt	0.282	0.270	0.090	0.085	0.093	0.063	0.053	0.058	0.075	0.057	0.069	0.044	0.062	0.064
2D3g Chemical products manufacturing or processing	NMVOC	kt	3.023	3.024	2.786	1.189	1.486	1.888	0.999	1.149	1.224	1.248	1.082	0.986	1.168	1.243
2D3h Printing	NMVOC	kt	2.912	2.912	1.946	2.126	1.393	2.360	2.474	1.788	1.217	1.283	1.400	1.462	1.468	1.206
2D3i Other solvent use	NMVOC	kt	0.701	0.493	1.011	3.103	3.346	2.198	1.457	1.620	1.501	1.121	1.379	1.422	1.370	1.423
2G Other product use	NMVOC	kt	0.034	0.037	0.039	0.032	0.028	0.027	0.024	0.025	0.023	0.020	0.019	0.020	0.017	0.022
2H2 Food and Beverages Industry	NMVOC	kt	9.617	10.216	9.683	14.059	14.332	15.905	18.052	18.184	20.412	22.492	19.031	20.041	21.241	26.574
<b>Submission 2020</b>																
2D3a Domestic solvent use including fungicides	NMVOC	kt	7.927	8.143	8.568	9.347	10.141	10.250	10.298	10.344	10.368	10.385	10.422	10.481	10.767	10.818
2D3b Road Paving	NMVOC	kt	0.035	0.027	0.046	0.054	0.045	0.053	0.037	0.029	0.030	0.029	0.029	0.030	0.030	0.034
2D3c Asphalt Roofing	NMVOC	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3d Coating Applications	NMVOC	kt	6.742	6.560	6.315	6.238	5.432	4.259	3.373	3.394	3.259	3.402	3.800	3.369	2.811	2.661
2D3e Degreasing	NMVOC	kt	1.743	2.388	0.847	0.953	1.531	0.789	0.885	0.925	1.004	0.795	0.885	0.686	0.885	1.187
2D3f Dry Cleaning	NMVOC	kt	0.282	0.270	0.090	0.085	0.093	0.063	0.053	0.058	0.075	0.057	0.069	0.044	0.062	0.064
2D3g Chemical products manufacturing or processing	NMVOC	kt	3.023	3.024	2.786	1.189	1.486	1.888	0.999	1.149	1.224	1.248	1.082	0.986	1.168	1.243
2D3h Printing	NMVOC	kt	2.912	2.912	1.946	2.126	1.393	2.360	2.474	1.788	1.217	1.283	1.400	1.462	1.468	1.206
2D3i Other solvent use	NMVOC	kt	0.701	0.493	1.011	3.103	3.346	2.198	1.457	1.620	1.501	1.121	1.379	1.422	1.370	1.423
2G Other product use	NMVOC	kt	0.034	0.037	0.039	0.032	0.028	0.027	0.024	0.025	0.023	0.020	0.019	0.020	0.017	0.022
2H2 Food and Beverages Industry	NMVOC	kt	9.617	10.216	9.683	13.296	14.332	15.540	18.052	18.184	20.412	22.492	19.031	20.041	21.241	26.575
<b>% Change in Emissions</b>																
2D3a Domestic solvent use including fungicides	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2D3b Road Paving	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2D3c Asphalt Roofing	NMVOC	%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2D3d Coating Applications	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.6%
2D3e Degreasing	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2D3f Dry Cleaning	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2D3g Chemical products manufacturing or processing	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2D3h Printing	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2D3i Other solvent use	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2G Other product use	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2H2 Food and Beverages Industry	NMVOC	%	0.0%	0.0%	0.0%	-5.4%	0.0%	-2.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

## Chapter Five

### Agriculture

#### 5.1 Overview of the Agriculture (NFR 3) Sector

The Agriculture sector is the largest source of NH<sub>3</sub> in Ireland and at 118.31 kt accounted for 99.1 per cent of national total NH<sub>3</sub> emissions (119.34 kt) in 2018. The majority of the remainder of national total emissions is attributable to Road Transport (1A3b) and smaller fractions to combustion in the Manufacturing Industry and Construction (1A2), Commercial (1A4a) and Residential (1A4b), Agriculture/Forestry/Fishing: Off-road vehicles and other machinery (1A4cii) sectors, Other product Use (2G) and Biological treatment of waste – Composting (5B1).

Emissions of NH<sub>3</sub> from agriculture in Ireland's inventory are calculated using a Tier 2 approach developed by a member of the inventory team. The methodologies employed follow those utilised by Misselbrook et al. (2004, 2010, 2016) and the Inventory Guidebook (EMEP/EEA, 2019) and are described in the following sections. The methodology is based largely on the UK National Ammonia Reduction Strategy Evaluation System (NARSES) model for emissions from livestock and where required the Inventory Guidebook (EMEP/EEA, 2019) is also used (poultry and minor livestock species). For the calculation of NH<sub>3</sub> emissions from nitrogen fertilizer application the Tier 2 approach provided in the Inventory Guidebook (EMEP/EEA, 2019) is adopted.

The trend in emissions of NH<sub>3</sub> from agricultural sources is shown in Figure 5.1. Management of animal manures (3B) produced 47.1 per cent of NH<sub>3</sub> emissions from agriculture in 2018, with the application of inorganic fertiliser, sewage sludge and animal manures deposited and applied to soils (52.9%) accounting for the remainder. The NH<sub>3</sub> emission trend is largely determined by the cattle population and shows a steady increase up to 122.19 kt in 1998 (an increase by 11.6 per cent from 1990). There has been some decline in the populations of cattle and sheep since 1999, as well as a decrease in fertiliser use, which contributed to a downturn in NH<sub>3</sub> emissions in the 1999–2011 period. The NH<sub>3</sub> emissions from the agriculture sector in 2018 were 8.1 per cent higher than the emission levels in 1990 (109.48 kt) and 3.2 per cent lower than the peak levels in 1998.

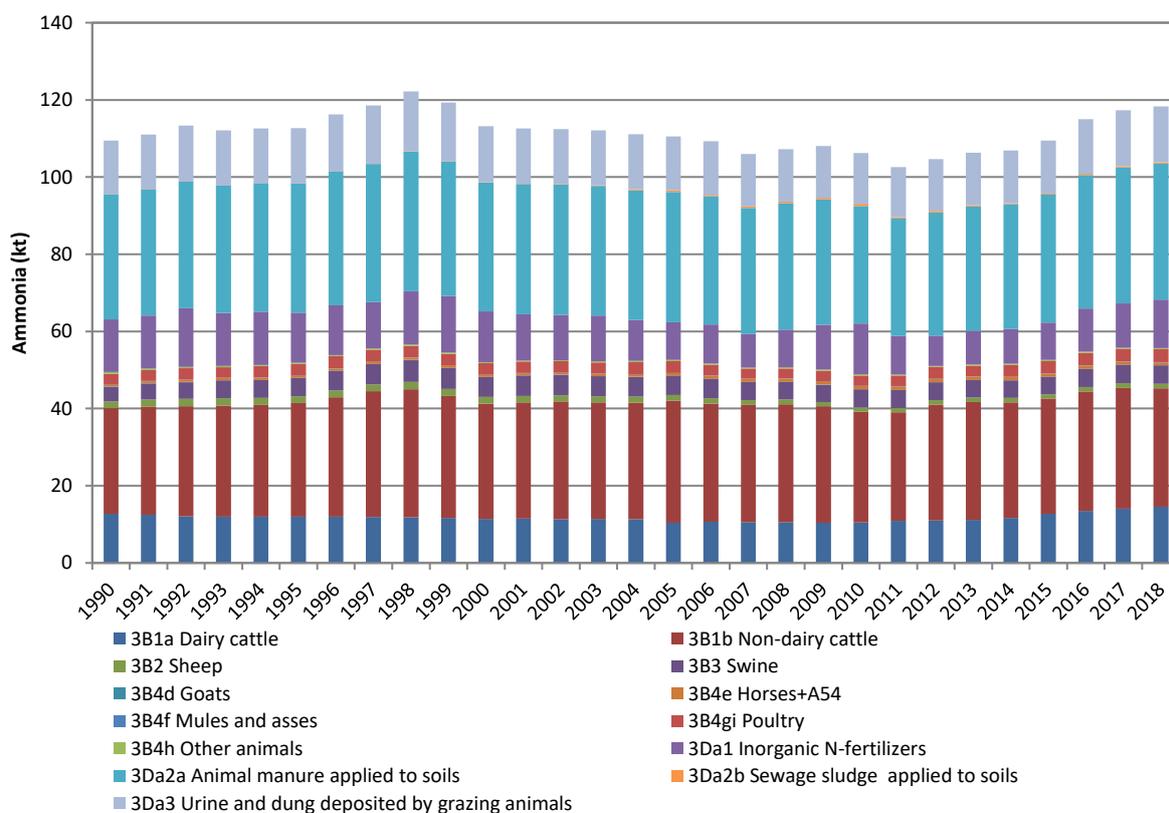
NMVOCs from agriculture are estimated to be 43.25 kt in 2018, accounting for 39.4 per cent of the NMVOC inventory total (109.77 kt). Emissions from manure management (3B) make up 98.4 per cent of agriculture related NMVOC in 2018, with the remaining 1.6 per cent from cultivated crops (3De). For the calculation of NMVOC emissions, a Tier 2 methodology is adopted for cultivated crops (3De) included in 2019 EMEP/EEA Guidebook 3D Table 3.4 which exist in Ireland (namely Wheat, Rape and Grass). The Inventory Guidebook (EMEP/EEA, 2019) Tier 1 approach is adopted for cultivated crops (3De) not included in Table 3.4. A Tier 2 approach is utilised for NMVOC emissions from manure management (3B). The trend in NMVOC emissions from agriculture is shown in Figure 5.2.

NO<sub>x</sub> emissions from agriculture are estimated to be 34.9 kt in 2018, accounting for 45 per cent of the national total. Emissions from manure management (3B) make up 2.4 per cent of the agriculture related NO<sub>x</sub> with Inorganic N-fertilizers (3Da1), Animal manure applied to soils (3Da2a), Sewage sludge applied to soils (3Da2b), and Urine and dung deposited by grazing animals (3Da3) accounting for 45 per cent, 17.3 per cent, 0.2 per cent and 35.1 per cent of total agriculture emissions, respectively.

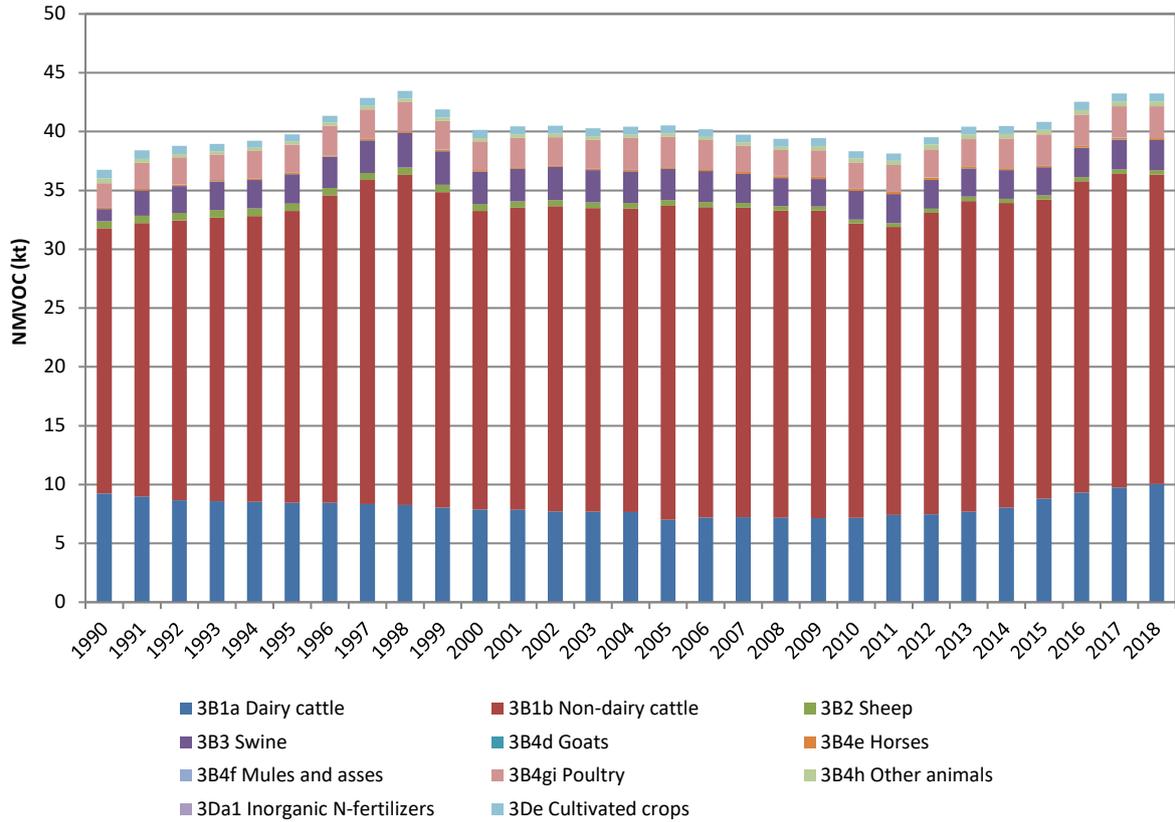
Emissions in 2018 were 6.1 per cent above those in 1990 (32.92 kt). Estimates from manure management (3B) are derived from the Tier 2 mass flow approach to estimate NH<sub>3</sub> emissions, whilst emissions from agricultural soils (3D) utilise the Tier 1 emission factor presented in the Inventory Guidebook. The trend in NO<sub>x</sub> emissions from agriculture is shown in Figure 5.3.

Estimates for agriculture emissions of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> contribute significantly to national totals for these pollutants, accounting for 18.9 per cent, 31.7 per cent and 7.4 per cent of national totals respectively. For these calculations, Tier 1 and 2 approaches provided in the Inventory Guidebook (EMEP/EEA, 2016) are adopted. For PM<sub>2.5</sub> Dairy cattle (3B1a) and Non-dairy cattle (3B1b) are the main drivers of the trend accounting for 57.3 per cent of emissions in 2018. For PM<sub>10</sub> the main driver of the trend in emissions from agriculture is Inorganic N-fertilizers (3Da1) which accounted for 80.7 per cent of emissions in 2018. The second and third largest sources are Non-dairy cattle (3B1b) and Dairy cattle (3B1a) accounting for 5.3 per cent and 3.6 per cent, respectively of the agricultural total in 2018. A similar trend is evident for TSP with Inorganic N-fertilizers (3Da1), Non-dairy cattle (3B1b) and Dairy cattle (3B1a) accounting for 59.5 per cent, 8.6 per cent and 5.8 per cent, respectively of the agriculture sector total in 2018. The trend in PM<sub>2.5</sub> is presented in Figure 5.4.

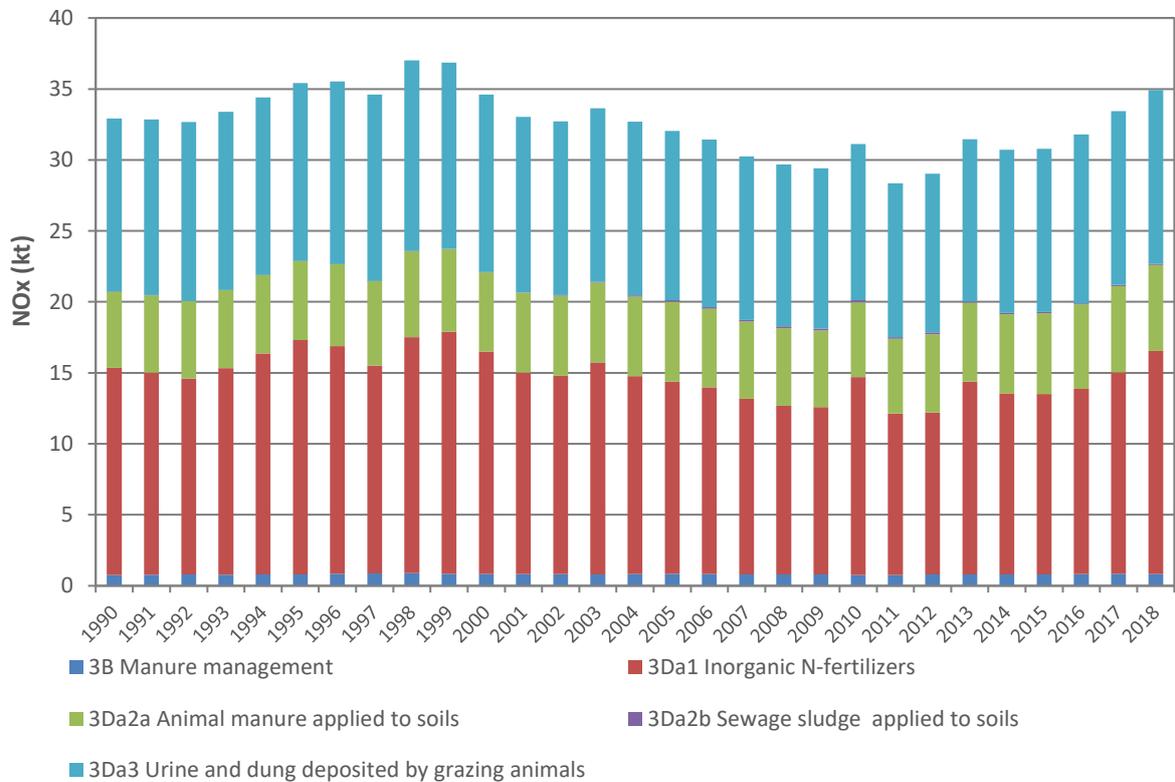
The use of some pesticides for arable farming can be a source of POP emissions, notably due to the trace content of HCB within some pesticides as a contaminant from the manufacturing process. Emissions of HCB from NFR Sector 3Df (Use of pesticides) are a key category in 2018, accounting for 85.1 per cent of national total HCB emissions.



**Figure 5.1. Emission Trend for Ammonia from Agriculture 1990–2018**



**Figure 5.2. Emission Trend for NMVOC from Agriculture 1990–2018**



**Figure 5.3. Emission Trend for NO<sub>x</sub> from Agriculture 1990–2018**

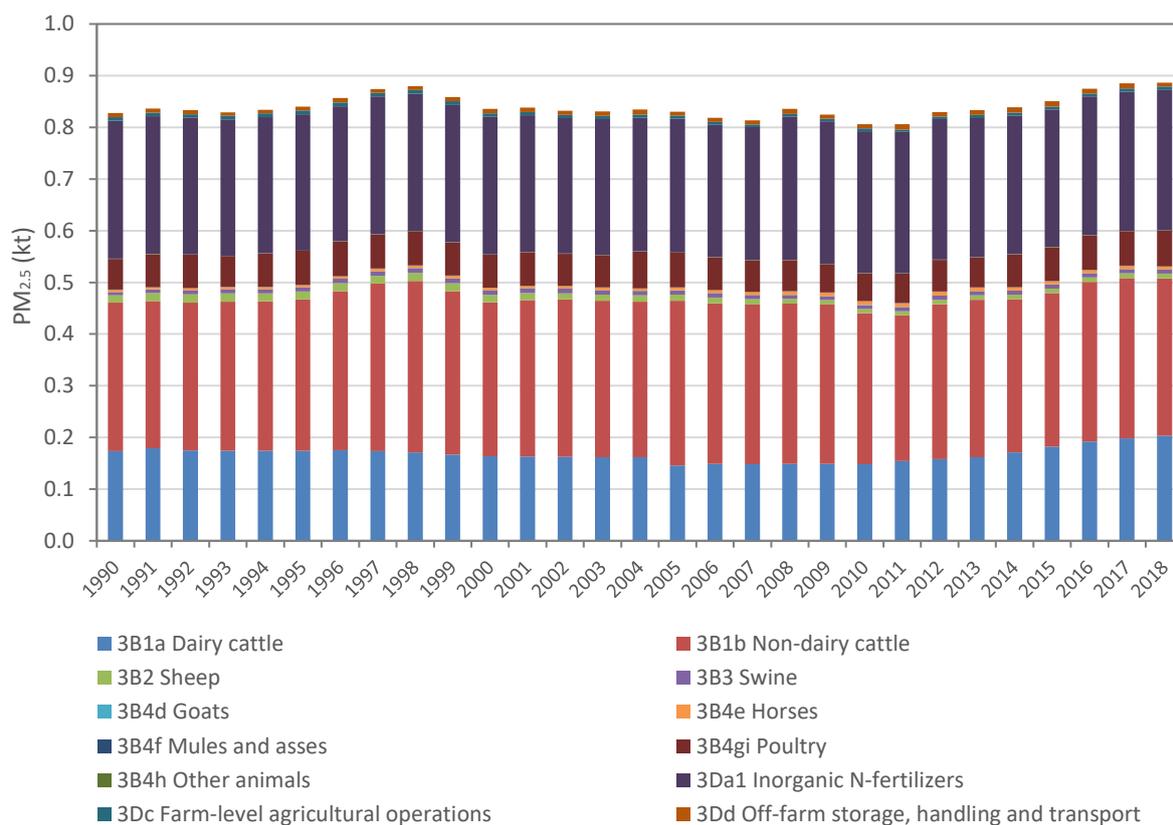


Figure 5.4. Emission Trend for PM<sub>2.5</sub> from Agriculture 1990–2018

## 5.2 Manure Management (NFR 3B)

The following sections outline the activity data, assumptions and calculations utilised in estimating NH<sub>3</sub>, NMVOC, NO<sub>x</sub>, TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emissions from agriculture in Ireland. For NH<sub>3</sub> and NO<sub>x</sub>, the Tier 2 methodology uses a mass flow approach based on the concept of the flow of Total Ammoniacal Nitrogen (TAN) through the manure management system. Emissions are calculated for the same animal sub-categories as those utilised in Ireland’s national greenhouse gas inventory (Table E.1 Annex E). The first step in the mass flow approach is the estimation of total annual nitrogen excretion by the animals. For dairy cows and other cattle, Ireland utilises the method described in IPCC (2006), chapter 10, further enhanced by country-specific data on feeding practices and milk production (O’Mara, 2007, Duffy et al., 2020) to estimate N excretion. For all other categories of livestock, national values are utilised. Total nitrogen excretion is then apportioned to that which is deposited in buildings, collection yards (only applicable to dairy cows during lactation) and grazing. See Table E.3 Annex E for animal nitrogen excretion.

The method used to estimate NMVOC emissions is the tier 2 approach based on emission factors from Table 3.11 and Table 3.12 of the Inventory Guidebook (EMEP/EEA, 2019) for all livestock categories. The tier 2 approach considers NMVOC emissions from the following; silage stores, silage for feeding, housing, outdoor manure stores, manure application and from grazing animals as outlined in section 3.4 of the Inventory Guidebook (EMEP/EEA, 2019).

For TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emissions are estimated based upon animal numbers using the Tier 1 method and emission factors from the Inventory Guidebook (EMEP/EEA, 2019). See Table E.7 of Annex E for additional information of the EFs used for NH<sub>3</sub>, NMVOC, TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emission estimation.

### 5.2.1 Cattle (NFR 3B1)

A Farm Facilities Survey conducted in 2003 (Hyde et al., 2008) provides the basis for the calculation of the number of days housed and the number of days spent grazing by cattle on farms in Ireland. National averages are used for the purpose of inventory calculations. Data for the number of days housed are presented in Table E.2.1. The number of days spent grazing is then calculated by subtracting these values from 365 (i.e. days in a year).

Two housing types are distinguished for cattle production systems in Ireland – liquid (slurry-based) and solid manure-based housing. As a result of differing management practices on farms, a proportion of each of the cattle subdivisions is not housed (out-wintered) and therefore graze pasture for the full year. The proportion of each sub-category of cattle that is managed in this manner is accounted for in Table E.2.1. For liquid manure-based housing an emission factor of 27.7 per cent of the TAN available in liquid-based housing is applied (Misselbrook et al., 2016). The TAN in cattle manure is assumed to be 60 per cent. For solid manure-based housing, emission factors of 16.8 per cent and 4.2 per cent of the TAN available in solid manure-based housing are applied to cattle housed on straw and calves housed on straw, respectively (Misselbrook et al., 2016).

In addition to animal housing, emissions are estimated for cow collecting yards used during milking utilising an emission factor of 22.5 per cent of the TAN available (Misselbrook et al., 2016).

The storage of both liquid and solid manure is considered. Liquid manure is stored either below the animals in slatted floor housing or removed from the house to outdoor storage. Emissions are calculated separately for indoor and outdoor storage. It is assumed that a crust will form in the indoor under slat storage. In addition, a fraction of the organic nitrogen in liquid manure is mineralised to TAN before emissions are calculated. A value of 0.1 (Dammgen et al., 2007) is applied as suggested in the Inventory Guidebook (EMEP/EEA, 2019). To fully account for all losses of N from liquid manure during storage, estimates are made of N<sub>2</sub>O, NO and N<sub>2</sub> losses during storage utilising the emission factors provided in the Inventory Guidebook (EMEP/EEA, 2019). An emission factor of 5 per cent of the TAN available in liquid manure stores is applied to estimate NH<sub>3</sub> emissions from liquid manure storage in covered stores and 10 per cent of the TAN available in liquid manure stored in uncovered stores (Misselbrook et al., 2016).

Solid manure is generally stored in the shed or outside in heaps. The contribution of the nitrogen content of straw used for bedding is accounted for based on national data on straw used for bedding and the length of the housing period (Hyde et al., 2008). Where manures are managed as solid, a fraction of the TAN is immobilised in organic matter. Immobilisation of nitrogen reduces the potential for NH<sub>3</sub> emissions from solid manures during storage and after landspreading. The value proposed in the Inventory Guidebook (EMEP/EEA, 2019) of 0.0067 kg kg<sup>-1</sup> (Kirchmann and Winter, 1989) is applied. To fully account for all losses of N from solid manure during storage, estimates are made of N<sub>2</sub>O, NO and N<sub>2</sub> losses during storage utilising the emission factors provided in the Inventory Guidebook (EMEP/EEA, 2019). An emission factor of 35 per cent of the TAN available in solid manure stores is utilised (Misselbrook et al., 2016).

Landspreading emissions are calculated by estimating the quantity of TAN available post storage of the manure (both liquid and solid) and accounting for the period of the year in which it is spread (i.e. spring, summer, autumn and winter) as outlined in Table E.5 Annex E. For liquid manure, a dry matter value of 6 per cent is assumed and two emission factors are applied, 48.4 per cent of the TAN available for the proportion applied in summer and 26.1 per cent for proportion applied in spring, autumn and winter (Misselbrook et al., 2016). For solid manure, an emission factor of 68.3 per cent of the TAN available is applied regardless of the period of the year in which it is spread (Misselbrook et al., 2016). It is assumed that all cattle slurry is applied using the splashplate method and that all solid manure is broadcast spread. The emission factor presented in the Inventory Guidebook (EMEP/EEA, 2019) of 0.04 kg NO per kg of nitrogen is applied to calculate NO<sub>x</sub> emissions from manure (solid and liquid) application to soil.

For cattle grazing an emission factor of 6 per cent of the TAN available at grazing is applied for all cattle categories (Misselbrook et al., 2016). The emission factor presented in the Inventory Guidebook (EMEP/EEA, 2019) of 0.04 kg NO per kg of nitrogen is applied to calculate NO<sub>x</sub> emissions from excreta deposited during grazing.

NMVOC emissions are estimated using Tier 2 emission factors from the Inventory Guidebook (EMEP/EEA, 2019). Estimates are made for housed cattle, silage feeding, silage store, manure storage, manure application and grazing. The emission factors for silage feeding and silage storage, housing and grazing are combined with the feed intake values (MJ feed intake) from Ireland's Tier 2 approach to the estimation of CH<sub>4</sub> emissions from enteric fermentation and manure management. The feed intake values for silage and grass are presented in Table E.6, Annex E with the emission factors used presented in Table E.7. Emissions of NMVOC from manure storage and manure application use the Inventory Guidebook (EMEP/EEA, 2019) approach whereby the NMVOC emissions from livestock buildings are coupled with the ratio of NH<sub>3</sub> emissions from storage and application with those in livestock buildings, respectively.

Emissions of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> are estimated using Tier 1 emission factors split by cattle type and housing category (slurry/solid housing). The emission factors used are presented in Table E.7, Annex E.

### 5.2.2 Sheep (3B2)

Sheep in Ireland are categorised into those on upland and those on lowland areas. Four subcategories exist within both upland and lowland areas, namely ewes, rams, lambs and other sheep more than 1 year old. The CSO publishes sheep population statistics on an annual basis and, to derive the number of heads on both lowland and upland areas, several assumptions are made as follows based on expert opinion. Total ewe and ram numbers are taken as the mean of the June and December CSO censuses. On this basis, the number of ewes and rams are subdivided using the ratio 55:45 (lowland/upland) for years up to and including 1997. For 1998 to 2004 inclusive, a ratio of 70:30 is used, reflecting the destocking of upland areas. For 2005 onwards, a ratio of 80:20 is used. The total number of lambs slaughtered in any 1-year period is used as the activity data for lambs. Monthly lamb slaughtering figures are available from the CSO. From 2001 onwards, these numbers are adjusted for the number of lambs that originate in Northern Ireland and that are slaughtered in the Republic of Ireland and for the number of lambs that are reared in the Republic but slaughtered in Northern Ireland. National totals are then subdivided similarly to the other categories of sheep. The numbers of other sheep over

1 year old are calculated from unpublished CSO data. Population statistics for each subcategory of sheep are presented in Table E.1, Annex E. Input data with respect to manure management practices are presented in Table E.2 Annex E. Nitrogen excretion coefficients for all sub categories of sheep are provided in Table E.3 Annex E.

Similar to cattle, the proportion of TAN in the nitrogen excreted by sheep is assumed to be 60 per cent. The emission factor for sheep housing is derived by adjusting the housing emission factor for beef cattle on solid manure systems by the ratio of excretal outputs of sheep and beef cattle which is then back-calculated to derive a value of 21.6 per cent of the TAN available in sheep housing (Misselbrook et al. 2016). Information on the number of days that sheep are housed during the winter period is derived from the Farm Facilities Survey (Hyde et al., 2008), which suggests sub-category specific housing period lengths (Table E.2.2 Annex E). More specifically, lowland and upland ewes are assumed to be housed for 61 and 85 days/year. No differentiation is made for upland and lowland rams, lambs and other sheep >1 year old - being housed for 85, 58 and 61 days/year respectively. In Ireland, sheep are generally housed in solid-manure-based housing systems.

The NH<sub>3</sub> emission factors used for the storage and landspreading of solid manure used for Cattle (3B1) are also considered appropriate for sheep manure (Misselbrook et al., 2016). For storage of solid manure and subsequent landspreading the emission factor for solid manure from cattle is used (68.3 per cent of TAN available at landspreading). Account is also taken of the nitrogen added from straw used for bedding and the immobilisation of TAN in organic matter when solid manures are managed following the approach adopted for solid manure from cattle. The emission factors presented in the Inventory Guidebook (EMEP/EEA, 2019) are used to estimate NO, N<sub>2</sub>O and N<sub>2</sub> emissions from manure management. The emission factor presented in the Inventory Guidebook (EMEP/EEA, 2019) of 0.04 kg NO per kg of nitrogen is applied to calculate NO<sub>x</sub> emissions from excreta deposited during grazing and the application of solid manure to soil. For sheep grazing, the emission factor applied for cattle of 6 per cent of the TAN available at grazing is utilised to estimate NH<sub>3</sub> emissions from grazing sheep (Misselbrook et al., 2016).

NMVOC emissions are estimated using Tier 2 emission factors from the Inventory Guidebook (EMEP/EEA, 2019) based on volatile solid (VS) excretion data as estimated in the national greenhouse gas inventory for agriculture. Estimates are made for housed sheep, manure storage, manure application and grazing sheep. The emission factors used are presented in Table E.7, Annex E.

Emissions of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> are estimated using Tier 1 emission factors in the Inventory Guidebook (EMEP/EEA, 2019) The emission factors used are presented in Table E.7, Annex E.

### 5.2.3 Swine (NFR 3B3)

Detailed population statistics are available for seven subcategories of pigs in Ireland using national statistics published by the CSO as follows: sows in pig, gilts in pig, other breeding sows, boars, gilts not yet served and two categories of fattening pigs (<20 kg and >20 kg live weight). The CSO undertakes and publishes two censuses per year, one in June and one in December. The average of the two census values is used in deriving the pig populations in the seven subcategories, thus providing an appropriate measure of the number of pigs on farms for the purposes of the annual NH<sub>3</sub> emission inventory.

For the NH<sub>3</sub> inventory, it is assumed that all pigs are housed and that the housing systems are liquid/slurry-based. Furthermore, it is assumed that the proportion of TAN in nitrogen excreted is 70 per cent. An emission factor of 33.2 per cent of the TAN in slurry produced by gilts in pig, gilts not yet served and pigs greater than 20 kgs is applied. For sows in pig, other sows for breeding and boars, an emission factor of 19.0 per cent of the TAN produced in the slurry of these pig sub-categories is used and an emission factor of 14.8 per cent of the TAN in slurry produced by pigs under 20 kg (Misselbrook et al., 2016).

For slurry storage, emissions of NH<sub>3</sub> are calculated separately for covered and uncovered stores based on the proportion of slurry stored in covered and uncovered storage (Hyde et al., 2008). Emission factors of 13.0 per cent of the TAN available in covered storage and 52.0 per cent of the TAN available in uncovered slurry stores are applied (Misselbrook et al., 2016). As is the case with cattle slurry, account is taken of the losses of N<sub>2</sub>O, NO and N<sub>2</sub> using the emission factors presented in the Inventory Guidebook (EMEP/EEA, 2019) and the mineralisation of organic nitrogen in the liquid manure is also accounted for (Dammgen et al., 2007). It is assumed that all pig slurry is applied using the splashplate method. An emission factor of 19.0 per cent (Misselbrook et al., 2016) of the TAN available post storage is applied on the basis that pig slurry contains less than 4 per cent DM.

The emission factor presented in the Inventory Guidebook (EMEP/EEA, 2019) of 0.04 kg NO per kg of nitrogen is applied to calculate NO emissions from the application of liquid manure to soil.

NMVOC emissions are estimated using Tier 2 emission factors from the Inventory Guidebook (EMEP/EEA, 2019) based on volatile solid (VS) excretion data as estimated in the national greenhouse gas inventory for agriculture. Estimates are made for housed pigs, manure storage and manure application. The emission factors used are presented in Table E.7, Annex E.

Emissions of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> are estimated using Tier 1 emission factors from the Inventory Guidebook (EMEP/EEA, 2019). The emission factors used are presented in Table E.7, Annex E.

#### 5.2.4 Poultry (NFR 3B4g)

Detailed population statistics are available for eight subcategories of poultry in Ireland using national statistics collated by the Department of Agriculture and the CSO as follows: layers, broilers, layer breeders, broiler breeders, turkeys, turkey breeders, geese and ducks. The population statistics are provided in Table E.1, Annex E. The estimation of NH<sub>3</sub> emissions from poultry production utilises bird places as opposed to bird numbers so that production cycles are considered. The number of bird places is estimated from the annual bird population assuming that all bird places are full throughout the year after rest periods have been taken into account (rest periods are those periods after a production cycle in which the housing systems are emptied of all manure and bedding, thoroughly washed and prepared for the next batch of birds). In the case of broilers, there are 5.5 production cycles per year, with a 3- to 4-week rest period between production cycles. In the case of turkeys, there are 2.5 production cycles per year of approximately 120 days in length, with a 3- to 4-week rest period also applied. All other poultry subcategories have production cycles of over 1 year, and therefore no adjustments to population statistics are made.

It is assumed that all poultry are housed in some form of solid manure housing system and that the proportion of TAN in nitrogen excreted by poultry is 70 per cent. For a proportion of laying birds, free-

range systems are in use, which consist of an area of grassland beside the bird house which the birds are allowed onto for a period of hours during the day. The percentage of laying birds that are housed in this type of system is based on statistics supplied by the Department of Agriculture, Food and Marine. An emission factor of 35 per cent of TAN is applied to the quantity of TAN which is deposited outdoors. Emission factors of 41.0 per cent, 28.0 per cent, and 35.0 per cent, 57 per cent and 24.0 per cent of TAN are applied to layer, broiler, turkey, geese and duck housing, respectively (EMEP/EEA, 2019). The storage of poultry manure is separated into two classes, litter and layer manure. An emission factor of 17.0 per cent of TAN is applied to broiler manure, 14.0 per cent for layer manure, 24.0 per cent for turkey manure, 16.0 per cent for geese manure and 24.0 per cent for duck manure (Inventory Guidebook, 2016). To account for the loss of other nitrogen compounds, account is taken of the losses of N<sub>2</sub>O, NO and N<sub>2</sub> using the emission factors presented in the Inventory Guidebook (EMEP/EEA, 2019). It is assumed that all poultry manure is broadcast spread and emission factors of 69.0 per cent, 66.0 per cent, 54.0 per cent, 45 per cent and 54.0 per cent of the TAN available post storage, are adopted for layers, broilers, turkeys, geese and ducks respectively (EMEP/EEA, 2019). The emission factor presented in the Inventory Guidebook (EMEP/EEA, 2019) of 0.04 kg NO per kg of nitrogen is applied to calculate NO emissions from excreta deposited during grazing and the application of manure to soil.

NMVOC, TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emissions are estimated using Tier 1 emission factors from the Inventory Guidebook (EMEP/EEA, 2019). The emission factors used are presented in Table E.7, Annex E.

### 5.2.5 Other livestock – Goats (NFR 3B4d), Horses (3B4e), Mules and Asses (NFR 3B4f) and Other Animals (3B4h)

The remaining livestock categories include goats, horses, mules and asses, deer, mink and foxes and estimates are made for emissions of NH<sub>3</sub>, NO, NMVOC, TSP, PM<sub>10</sub> and PM<sub>2.5</sub>.

For NH<sub>3</sub> emissions the emission factors used are the default Tier 2 factors presented in the Inventory guidebook (EMEP/EEA, 2019) for each step in the manure management chain. As part of the mass flow approach, inventory guidebook emission factors for NO, N<sub>2</sub>O and N<sub>2</sub> emissions from manure management are also estimated. The emission factor presented in the Inventory Guidebook (EMEP/EEA, 2019) of 0.04 kg NO per kg of nitrogen is applied to calculate NO<sub>x</sub> emissions from excreta deposited during grazing and the application of manure to soil.

NMVOC emissions are estimated for goats (3B4d), Horses (3B4e) and Mules and asses (3B4f) using the Tier 2 emission factors from the Inventory Guidebook (EMEP/EEA, 2019). In the case of other animals (3B4h) the Tier 1 emission factors presented in the inventory guidebook (EMEP/EEA, 2019) are used. The emission factors applied are presented in Table E.7, Annex E.

Tier 1 emission factors from the Inventory Guidebook (EMEP/EEA, 2019) are applied to estimate emissions of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> from the livestock categories described except for deer for which no emission factor is supplied in the Inventory Guidebook (EMEP/EEA, 2019).

In the period 2010 to 2011 there was a change in the Agricultural Waste Management System (AWMS) for mink (3B4h) production from 100% solid manure-based in the period 1990-2010 to 52% liquid/slurry-based and 48% solid manure-based AWMS resulting in a decrease in associated NH<sub>3</sub> emissions for category 3B4h.

## 5.2.6 Uncertainties

There is extensive and up-to-date statistical data on all aspects of the agriculture sector in Ireland. Most of this data is compiled and published by the Central Statistics Office and is the official source of the basic data for inventory purposes. The exception is for statistics on synthetic fertiliser use and the poultry population which are obtained from the Department of Agriculture Food and the Marine (DAFM). The CSO and DAFM are key data providers whose annual statistical inputs to the inventory agency are covered by Memorandum of Understanding (MOU) in Ireland's national inventory system. As a result, the uncertainty associated with animal population statistics is low, at 1 per cent. The emission factor uncertainty associated with NH<sub>3</sub> emission factors for dairy and other cattle is 50 per cent, and for all other livestock categories 100 per cent. Much of NH<sub>3</sub> emission research is aimed at dairy cattle and other cattle therefore emissions from these categories are relatively well quantified in comparison to the other livestock categories. In comparison, the uncertainties associated with NMVOC and PM<sub>10</sub> emissions in agriculture are largely due to the uncertainty (300 per cent) associated with the emission factors for both pollutants as discussed in the Inventory Guidebook (EMEP/EEA, 2019).

## 5.3 Agricultural Soils (NFR 3D)

### 5.3.1 Direct Soil Emissions - Inorganic N-fertilizers (NFR 3Da1)

The calculation of NH<sub>3</sub> emissions from nitrogen fertilizer application to agricultural soils utilises the Tier 2 approach outlined in the Inventory Guidebook (EMEP/EEA, 2019). Total fertilizer sales and emission estimates for each year of the time series 1990-2018 (Table E.4, Annex E) are apportioned into the categories, Ammonium sulphate, CAN, NK mixtures, NPK mixtures, NP mixtures, Other straight N compounds, Urea, and protected urea products, according to the known sales of these compounds in each year as supplied to the inventory agency by the DAFM. Table E.8 of Annex E includes additional information on the methodological approach, quantities of individual fertilizer types, the emission factors used and resultant emissions. The emission factor presented in the Inventory Guidebook (EMEP/EEA, 2019) of 0.04 kg NO per kg of nitrogen is applied to calculate NO<sub>x</sub> emissions from the application of inorganic N-fertilizers to soil. Ireland, in previous submissions, reported emissions of PM<sub>10</sub>, PM<sub>2.5</sub> and TSP from farm-level agricultural operations under 3Da1, to separate these emissions from those previously reported under 2B10b. These are now reported under 3Dc following a recommendation in the NECD expert review of Ireland's 2018 submission. The default emission factors presented in the Inventory Guidebook (EMEP/EEA, 2019) are applied (Table E.8, Annex E) coupled with the total utilisable agricultural area (Table E.9, Annex E).

### 5.3.2 Direct Soil Emissions – Livestock manure applied to soils (NFR 3Da2a)

The calculation of NH<sub>3</sub> emissions from livestock manure applied to soil is discussed in sections 5.2.1 to 5.2.5 inclusive. Emissions for each of the livestock species are summed and reported under 3Da2a. The default emission factor of 0.04 kg NO per kg of nitrogen is applied to calculate NO<sub>x</sub> emissions from the application of livestock manure to soils.

### 5.3.3 Direct Soil Emissions – Sewage sludge applied to soils (NFR 3Da2b)

Estimates of NH<sub>3</sub> were estimated from the application of sewage sludge (3Da2b) for the first time in Ireland's 2015 submission. The quantity of sewage sludge applied to land is estimated as part of the

calculations for emissions of CH<sub>4</sub> and N<sub>2</sub>O from wastewater in Ireland's Greenhouse Gas Inventory. The fraction of nitrogen volatilised is 0.13 kg NH<sub>3</sub> per kg N applied (EMEP/EEA, 2019). With respect to NO emissions, the default Tier 1 emission factor of 0.04 kg NO per kg of nitrogen is applied to calculate NO<sub>x</sub> emissions from the application of sewage sludge to soils.

#### 5.3.4 Direct Soil Emissions – Other organic fertilizers applied to soils (NFR 3Da2c)

Emissions of NH<sub>3</sub> and NO from this source category are currently reported as NE. Information on the quantities of other organic fertilizers applied to agricultural soils does not exist in Ireland and is considered negligible compared to the total quantity of nitrogen applied in manures or deposited during grazing.

#### 5.3.5 Direct Soil Emissions – Urine and dung deposited during grazing (NFR 3Da3)

The calculation of NH<sub>3</sub> emissions from urine and dung deposited on soil during grazing is discussed in sections 5.2.1 to 5.2.5 inclusive. Emissions for each of the livestock species are summed and reported under 3Da3. The default emission factor of 0.04 kg NO per kg of nitrogen is applied to calculate NO<sub>x</sub> emissions from urine and dung deposited on soil during grazing.

#### 5.3.6 Farm-level agricultural operations (NFR 3Dc)

Emissions of PM<sub>10</sub>, PM<sub>2.5</sub> and TSP are reported under NFR 3Dc. Previously the emission reported in this category were reported under 2B10b, however in response to the 2017 NECD expert review, these emissions have now been reallocated to 3Dc. Emissions are estimated using the total quantity of fertilizers (by weight) applied to soils in Ireland. The emission factors applied are those provided in CEPMEIP (2001) and are presented in Table E.8 Annex E. The total quantity of fertilizers (by weight) applied to agricultural soils is presented in Table E.9, Annex E. In addition, Ireland also reports emissions of PM<sub>10</sub>, PM<sub>2.5</sub> and TSP from farm level agricultural operations under 3Dc in this submission following a recommendation from the NECD review in 2018. These emissions were reported in previous submissions under 3Da1 to separate these emissions from those previously reported under 2B10b.

#### 5.3.7 Off-farm storage, handling and transport (NFR 3Dd)

In this category, fugitive PM emissions in the form of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> are estimated from the bulk handling of cereal grains. The general method for estimating fugitive PM emissions involves multiplying the amount of material, which in this case is cereal grain (barley, wheat and oats), by an emission factor. Given the importance of agriculture to Ireland's economy, production statistics are freely available (Table E.9, Annex E). Data in relation to the production of cereal grains are collated and provided by the Central Statistics Office (CSO). Emission factors of 100 g/t, 25 g/t and 4 g/t from CEPMEIP (2001) are utilised in the calculation of emissions of TSP, PM<sub>10</sub> and PM<sub>2.5</sub>, respectively.

#### 5.3.8 Cultivated crops (NFR 3De)

Emissions of NMVOCs are estimated using the default emission factor of 0.86 kg/ha for those crops not listed in Table 3.3 Chapter 3.D of the inventory guidebook (EMEP/EEA, 2019) and the crop areas presented in Table E.9, Annex E. For wheat, rape and grass (15°C), the Tier 2 emission factors presented in Table 3.4 Chapter 3.D of the inventory guidebook (EMEP/EEA, 2019) are used. The areas of these crops and grassland area are presented in Table E.9, Annex E.

### 5.3.9 Use of Pesticides (NFR 3Df)

The main source of POPs from pesticides is HCB contamination of currently used pesticides. Where available, annual pesticides usage data have been used. Pesticide usage surveys are available for 2003, 2004, 2011, 2012, 2013 and 2014 from the DAFM. Interpolation and extrapolation are used for the remaining years up to the date at which usage stopped for particular pesticides as described in Table 4 annex to chapter 3.D.f-3.I of the inventory guidebook (EMEP/EEA, 2019). Both the activity data used and impurity factors for each active ingredient are presented in Table E.10 of Annex E.

Table 5.1 *Emission Estimates for Hexachlorobenzene Emissions from Pesticide Use*

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
HCB (kg)	7.163	7.247	7.299	2.054	2.200	2.236	2.273	2.309	2.280	2.224	2.177	2.212	2.212	2.164

### 5.4 Field burning of agricultural residues (NFR 3F)

Field burning of agricultural residues is the practice whereby crop residues are burnt as a means of clearing land to allow tillage operations to proceed. As stated in chapter 3F of the EMEP/EEA Guidebook 2019 the practice is largely outlawed. Prescribed burning of agricultural residues in Ireland may only be allowed in the case of disease or maintenance of soil organic matter as detailed in GAEC 6 page 52 of the cross-compliance handbook (DAFM, 2015). In addition, the inventory agency has undertaken some analysis on this issue (Zimmerman, 2014) which suggests that fires on agricultural land are in general fires that have occurred due to fires in adjoining forestry or peatland, for example, and are not the anthropogenic burning of agricultural residues. The inventory agency continues to discuss with relevant agencies with respect to the identification of fires due to its importance in the estimation of non-CO<sub>2</sub> gases within the Land Use, Land Use Change and Forestry sector.

### 5.5 Uncertainties associated with Synthetic Fertilizer (3Da1), Organic fertilizers (3Da2c) and urine and dung deposited by grazing animals (3Da3).

Although losses of NH<sub>3</sub> from N-fertilisers applied to grass grazed by livestock are difficult to distinguish from subsequent NH<sub>3</sub> emissions from urine patches produced by grazing animals, those two emissions are calculated separately with emissions from grazing reported in 3Da3. The sources making the largest contributions to the overall uncertainty are ammonia losses from synthetic fertiliser use and animal manures deposited to pasture, range and paddock. The emission factors for these sources are currently assigned an uncertainty of  $\pm 200\%$ , and they contribute to 95.6 per cent of the overall uncertainty.

### 5.6 Recalculations in the Agriculture Sector

For the calculation of NMVOC emissions, a Tier 2 methodology was adopted for cultivated crops (3De) included in 2016 EMEP/EEA Guidebook 3D Table 3.4 which exist in Ireland (namely Wheat, Rape and Grass). The Inventory Guidebook (EMEP/EEA, 2016) Tier 1 approach was adopted for cultivated crops (3De) not included in Table 3.4. This is a change to previous submissions in which a Tier 1 approach was applied to all crops. This results in a 7.3 per cent reduction in total agricultural NMVOC emissions on average in the period 2011 to 2017. Revised estimates of HCB were undertaken for this submission based on the revised guidance provided in the inventory guidebook for this the NFR category 3Df.

## 5.7 Quality Assurance/Quality Control

The general QA/QC procedures set down in Ireland's QA/QC plan have been undertaken for the Agriculture sector. The spreadsheets incorporate transparent linking between input data statistics and calculations, as well as internal checks on the calculations and the outputs. The inventory experts are actively involved in assessing the outcomes of NH<sub>3</sub> emission research in Ireland and continually re-examine the underlying assumptions in inventory estimates with sector-specific experts in the Department of Agriculture and other related bodies.

## 5.8 Planned Improvements

A large number of input variables determine emissions in the Agriculture sector and the final results are very sensitive to changes in many of these variables. Assumptions relating to some parameters have an important bearing on the outcome. Whilst methodologies for the agricultural emission sources that are relevant in Ireland are now very comprehensive, they remain generalised and necessarily simplified considering the complex systems and processes involved. The key to developing better estimates and reducing uncertainty is to take full account of national circumstances of climate, soil types, livestock- and crop-production practices, manure management systems and other influencing factors in a robust and justifiable manner when applying these methodologies. This requires detailed data from research programmes, and large amounts of statistical data. Nevertheless, the inventory agency is continually developing emission estimates so that they fully reflect national circumstances within the availability of reliable statistics and research studies.

The inventory agency will consider revising the ammonia emission factors, if necessary, based on any updates in the Inventory Guidebook and following the publication of any relevant country-specific research for the next annual submission.

Review recommendations and responses are included in this report as Annex H.

**Table 5.2. NH3 Recalculations for Agriculture 1990–2017**

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>Submission 2019</b>																
3B1a Manure management - Dairy cattle	NH3	kt	12.70	11.95	11.45	10.38	10.57	10.45	10.50	10.90	10.97	11.20	11.68	12.71	13.44	14.10
3B1b Manure management - Non-dairy cattle	NH3	kt	27.41	29.46	29.80	31.61	30.57	30.15	28.74	28.15	30.04	30.49	29.91	29.86	31.02	31.30
3B2 Manure management - Sheep	NH3	kt	1.72	1.75	1.75	1.51	1.18	1.11	1.09	1.11	1.16	1.16	1.14	1.13	1.13	1.19
3B3 Manure management - Swine	NH3	kt	3.85	4.79	5.20	5.03	4.57	4.47	4.65	4.70	4.64	4.53	4.60	4.54	4.72	4.83
3B4d Manure management - Goats	NH3	kt	0.03	0.03	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
3B4e Manure management - Horses	NH3	kt	0.53	0.58	0.60	0.68	0.82	0.84	0.91	0.91	0.95	0.87	0.81	0.80	0.79	0.73
3B4f Manure management - Mules and asses	NH3	kt	0.05	0.04	0.03	0.03	0.05	0.05	0.04	0.05	0.06	0.05	0.05	0.05	0.05	0.06
3B4gi Manure management - Laying hens	NH3	kt	0.64	0.45	0.43	0.49	0.46	0.54	0.54	0.54	0.66	0.72	0.74	0.83	0.84	0.88
3B4gii Manure management - Broilers	NH3	kt	0.97	1.35	1.51	1.55	1.18	1.44	1.44	1.40	1.40	1.31	1.47	1.48	1.49	1.49
3B4giii Manure management - Turkeys	NH3	kt	1.00	1.07	0.87	0.84	0.88	0.58	0.58	0.71	0.81	0.74	0.79	0.81	0.84	0.84
3B4giv Manure management - Other poultry	NH3	kt	0.11	0.11	0.11	0.16	0.12	0.10	0.08	0.08	0.08	0.08	0.09	0.09	0.10	0.10
3B4h Manure management - Other animals (please specify in IIR)	NH3	kt	0.46	0.27	0.30	0.29	0.28	0.35	0.33	0.27	0.29	0.29	0.29	0.29	0.29	0.29
3Da1 Inorganic N-fertilizers (includes also urea application)	NH3	kt	13.69	13.01	13.17	9.76	9.75	11.58	13.16	9.96	7.84	8.69	9.03	9.65	11.19	11.41
3Da2a Animal manure applied to soils	NH3	kt	32.38	33.49	33.41	33.79	32.80	32.50	30.44	30.46	31.89	32.24	32.33	33.15	34.58	35.32
3Da2b Sewage sludge applied to soils	NH3	kt	0.02	0.02	0.10	0.39	0.41	0.43	0.54	0.38	0.44	0.34	0.28	0.30	0.29	0.30
3Da3 Urine and dung deposited by grazing animals	NH3	kt	13.92	14.34	14.44	13.96	13.56	13.41	13.17	12.99	13.43	13.63	13.69	13.70	14.14	14.53
<b>Total</b>	<b>NH3</b>	<b>kt</b>	<b>109.48</b>	<b>112.71</b>	<b>113.17</b>	<b>110.49</b>	<b>107.21</b>	<b>108.03</b>	<b>106.25</b>	<b>102.62</b>	<b>104.68</b>	<b>106.34</b>	<b>106.91</b>	<b>109.41</b>	<b>114.93</b>	<b>117.38</b>
<b>Submission 2020</b>																
3B1a Manure management - Dairy cattle	NH <sub>3</sub>	kt	12.70	11.95	11.45	10.38	10.57	10.45	10.50	10.90	10.97	11.20	11.68	12.71	13.44	14.10
3B1b Manure management - Non-dairy cattle	NH3	kt	27.41	29.46	29.80	31.61	30.57	30.16	28.73	28.15	30.04	30.49	29.91	29.86	31.02	31.26
3B2 Manure management - Sheep	NH3	kt	1.72	1.75	1.75	1.51	1.18	1.11	1.09	1.11	1.16	1.16	1.14	1.13	1.13	1.21
3B3 Manure management - Swine	NH3	kt	3.85	4.79	5.20	5.03	4.57	4.47	4.65	4.70	4.64	4.53	4.60	4.54	4.72	4.83
3B4d Manure management - Goats	NH3	kt	0.03	0.03	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
3B4e Manure management - Horses	NH3	kt	0.53	0.58	0.60	0.68	0.82	0.84	0.91	0.91	0.95	0.87	0.81	0.80	0.79	0.73
3B4f Manure management - Mules and asses	NH3	kt	0.05	0.04	0.03	0.03	0.05	0.05	0.04	0.05	0.06	0.05	0.05	0.05	0.05	0.06
3B4gi Manure management - Laying hens	NH3	kt	0.64	0.45	0.43	0.49	0.46	0.54	0.54	0.54	0.66	0.72	0.74	0.83	0.84	0.88
3B4gii Manure management - Broilers	NH3	kt	0.97	1.35	1.51	1.55	1.18	1.44	1.44	1.40	1.40	1.31	1.47	1.48	1.49	1.48
3B4giii Manure management - Turkeys	NH3	kt	1.00	1.07	0.87	0.84	0.88	0.58	0.58	0.71	0.81	0.74	0.79	0.81	0.84	0.84
3B4giv Manure management - Other poultry	NH3	kt	0.11	0.11	0.11	0.16	0.12	0.10	0.08	0.08	0.08	0.08	0.09	0.09	0.10	0.10
3B4h Manure management - Other animals (please specify in IIR)	NH3	kt	0.46	0.27	0.30	0.29	0.28	0.35	0.33	0.27	0.29	0.29	0.29	0.29	0.29	0.29
3Da1 Inorganic N-fertilizers (includes also urea application)	NH3	kt	13.69	13.01	13.17	9.76	9.75	11.58	13.16	9.96	7.84	8.69	9.03	9.68	11.23	11.46
3Da2a Animal manure applied to soils	NH3	kt	32.38	33.49	33.41	33.79	32.80	32.50	30.44	30.46	31.89	32.24	32.33	33.15	34.58	35.29

3Da2b Sewage sludge applied to soils	NH <sub>3</sub>	kt	0.02	0.02	0.10	0.39	0.41	0.43	0.54	0.38	0.44	0.34	0.28	0.30	0.29	0.30
3Da3 Urine and dung deposited by grazing animals	NH <sub>3</sub>	kt	13.92	14.34	14.44	13.96	13.56	13.43	13.15	12.99	13.43	13.63	13.69	13.70	14.14	14.51
<b>Total</b>	<b>NH<sub>3</sub></b>	<b>kt</b>	<b>109.48</b>	<b>112.71</b>	<b>113.17</b>	<b>110.49</b>	<b>107.21</b>	<b>108.07</b>	<b>106.21</b>	<b>102.62</b>	<b>104.68</b>	<b>106.34</b>	<b>106.91</b>	<b>109.44</b>	<b>114.97</b>	<b>117.33</b>
<b>% Change in Emissions</b>																
3B1a Manure management - Dairy cattle	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B1b Manure management - Non-dairy cattle	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
3B2 Manure management - Sheep	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%
3B3 Manure management - Swine	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4d Manure management - Goats	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4e Manure management - Horses	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4f Manure management - Mules and asses	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4gi Manure management - Laying hens	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4gii Manure management - Broilers	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-1.3%
3B4giii Manure management - Turkeys	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4giv Manure management - Other poultry	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4h Manure management - Other animals	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3Da1 Inorganic N-fertilizers (includes urea application)	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.4%	0.4%
3Da2a Animal manure applied to soils	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
3Da2b Sewage sludge applied to soils	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3Da3 Urine and dung deposited by grazing animals	NH <sub>3</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	-0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
<b>Total</b>	<b>NH<sub>3</sub></b>	<b>%</b>	<b>0.0%</b>													

Table 5.3. NMVOC Recalculations for Agriculture 1990–2017

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>Submission 2019</b>																
3B1a Manure management - Dairy cattle	NMVOC	kt	9.23	8.45	7.87	7.01	7.18	7.14	7.16	7.43	7.48	7.69	8.05	8.80	9.30	9.74
3B1b Manure management - Non-dairy cattle	NMVOC	kt	22.56	24.81	25.39	26.67	26.09	26.15	25.04	24.46	25.59	26.41	25.87	25.41	26.46	26.74
3B2 Manure management - Sheep	NMVOC	kt	0.59	0.62	0.59	0.48	0.38	0.35	0.32	0.33	0.36	0.36	0.37	0.36	0.36	0.38
3B3 Manure management - Swine	NMVOC	kt	1.02	2.50	2.74	2.66	2.39	2.33	2.43	2.47	2.44	2.39	2.43	2.39	2.48	2.54
3B4d Manure management - Goats	NMVOC	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4e Manure management - Horses	NMVOC	kt	0.11	0.13	0.13	0.15	0.18	0.18	0.20	0.20	0.20	0.19	0.18	0.17	0.17	0.16
3B4f Manure management - Mules and asses	NMVOC	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B4gi Manure management - Laying hens	NMVOC	kt	0.31	0.23	0.26	0.32	0.30	0.35	0.35	0.35	0.43	0.47	0.48	0.54	0.55	0.57
3B4gii Manure management - Broilers	NMVOC	kt	0.87	1.20	1.34	1.38	1.05	1.29	1.29	1.24	1.24	1.16	1.31	1.32	1.33	1.33
3B4giii Manure management - Turkeys	NMVOC	kt	0.74	0.79	0.65	0.62	0.65	0.43	0.43	0.53	0.60	0.55	0.58	0.60	0.62	0.62
3B4giv Manure management - Other poultry	NMVOC	kt	0.18	0.18	0.18	0.26	0.21	0.17	0.14	0.14	0.14	0.13	0.14	0.15	0.16	0.16
3B4h Manure management - Other animals	NMVOC	kt	0.41	0.25	0.29	0.29	0.29	0.37	0.36	0.36	0.38	0.38	0.38	0.38	0.38	0.38
3Da1 Inorganic N-fertilizers (includes urea application)	NMVOC	kt	NA													
3De Cultivated crops	NMVOC	kt	3.82	3.77	3.82	3.70	3.98	3.95	3.93	3.92	3.90	3.85	3.84	3.81	3.82	3.84
<b>Total</b>	<b>NMVOC</b>	<b>kt</b>	<b>39.85</b>	<b>42.93</b>	<b>43.27</b>	<b>43.56</b>	<b>42.70</b>	<b>42.71</b>	<b>41.65</b>	<b>41.43</b>	<b>42.78</b>	<b>43.60</b>	<b>43.64</b>	<b>43.95</b>	<b>45.65</b>	<b>46.47</b>
<b>Submission 2020</b>																
3B1a Manure management - Dairy cattle	NMVOC	kt	9.23	8.45	7.87	7.01	7.18	7.14	7.16	7.43	7.48	7.69	8.05	8.80	9.31	9.75
3B1b Manure management - Non-dairy cattle	NMVOC	kt	22.56	24.81	25.39	26.67	26.09	26.15	25.04	24.46	25.59	26.41	25.87	25.41	26.46	26.65
3B2 Manure management - Sheep	NMVOC	kt	0.59	0.62	0.59	0.48	0.38	0.35	0.32	0.33	0.36	0.36	0.37	0.36	0.36	0.39
3B3 Manure management - Swine	NMVOC	kt	1.02	2.50	2.74	2.66	2.39	2.33	2.43	2.47	2.44	2.39	2.43	2.39	2.48	2.54
3B4d Manure management - Goats	NMVOC	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4e Manure management - Horses	NMVOC	kt	0.11	0.13	0.13	0.15	0.18	0.18	0.20	0.20	0.20	0.19	0.18	0.17	0.17	0.16
3B4f Manure management - Mules and asses	NMVOC	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B4gi Manure management - Laying hens	NMVOC	kt	0.31	0.23	0.26	0.32	0.30	0.35	0.35	0.35	0.43	0.47	0.48	0.54	0.55	0.57
3B4gii Manure management - Broilers	NMVOC	kt	0.87	1.20	1.34	1.38	1.05	1.29	1.29	1.24	1.24	1.16	1.31	1.32	1.33	1.31
3B4giii Manure management - Turkeys	NMVOC	kt	0.74	0.79	0.65	0.62	0.65	0.43	0.43	0.53	0.60	0.55	0.58	0.60	0.62	0.62
3B4giv Manure management - Other poultry	NMVOC	kt	0.18	0.18	0.18	0.26	0.21	0.17	0.14	0.14	0.14	0.13	0.14	0.15	0.16	0.16
3B4h Manure management - Other animals	NMVOC	kt	0.41	0.25	0.29	0.29	0.29	0.37	0.36	0.36	0.38	0.38	0.38	0.38	0.38	0.38
3Da1 Inorganic N-fertilizers (includes urea application)	NMVOC	kt	NA													
3De Cultivated crops	NMVOC	kt	0.73	0.60	0.71	0.67	0.66	0.66	0.61	0.61	0.64	0.67	0.67	0.68	0.71	0.70
<b>Total</b>	<b>NMVOC</b>	<b>kt</b>	<b>36.76</b>	<b>39.76</b>	<b>40.16</b>	<b>40.52</b>	<b>39.38</b>	<b>39.43</b>	<b>38.33</b>	<b>38.12</b>	<b>39.53</b>	<b>40.42</b>	<b>40.47</b>	<b>40.82</b>	<b>42.54</b>	<b>43.23</b>
<b>% Change in Emissions</b>																
3B1a Manure management - Dairy cattle	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
3B1b Manure management - Non-dairy cattle	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.3%

3B2 Manure management - Sheep	NMVOG	%	0.0%	0.0%	-0.3%	0.0%	-0.3%	0.0%	0.0%	0.0%	-0.3%	0.0%	0.0%	0.0%	0.0%	0.8%
3B3 Manure management - Swine	NMVOG	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4d Manure management - Goats	NMVOG	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4e Manure management - Horses	NMVOG	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4f Manure management - Mules and asses	NMVOG	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4gi Manure management - Laying hens	NMVOG	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4gii Manure management - Broilers	NMVOG	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-1.3%
3B4giii Manure management - Turkeys	NMVOG	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4giv Manure management - Other poultry	NMVOG	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4h Manure management - Other animals	NMVOG	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3Da1 Inorganic N-fertilizers (includes urea application)	NMVOG	%	NA													
3De Cultivated crops	NMVOG	%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Total</b>	<b>NMVOG</b>	<b>%</b>	<b>-7.7%</b>	<b>-7.4%</b>	<b>-7.2%</b>	<b>-7.0%</b>	<b>-7.8%</b>	<b>-7.7%</b>	<b>-8.0%</b>	<b>-8.0%</b>	<b>-7.6%</b>	<b>-7.3%</b>	<b>-7.3%</b>	<b>-7.1%</b>	<b>-6.8%</b>	<b>-7.0%</b>

Table 5.4. TSP Recalculations for Agriculture 1990–2017

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>Submission 2019</b>																
3B1a Manure management - Dairy cattle	TSP	kt	0.59	0.59	0.55	0.49	0.50	0.50	0.50	0.52	0.53	0.54	0.57	0.61	0.65	0.67
3B1b Manure management - Non-dairy cattle	TSP	kt	0.95	0.97	0.99	1.06	1.03	1.02	0.97	0.94	1.00	1.01	0.98	0.99	1.03	1.03
3B2 Manure management - Sheep	TSP	kt	0.10	0.11	0.10	0.08	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07
3B3 Manure management - Swine	TSP	kt	0.98	1.24	1.36	1.32	1.20	1.17	1.22	1.24	1.23	1.20	1.22	1.20	1.25	1.28
3B4d Manure management - Goats	TSP	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4e Manure management - Horses	TSP	kt	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
3B4f Manure management - Mules and asses	TSP	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4gi Manure management - Laying hens	TSP	kt	0.35	0.26	0.30	0.37	0.34	0.41	0.41	0.41	0.49	0.54	0.55	0.62	0.63	0.66
3B4gii Manure management - Broilers	TSP	kt	0.32	0.44	0.50	0.51	0.39	0.48	0.48	0.46	0.46	0.43	0.49	0.49	0.49	0.49
3B4giii Manure management - Turkeys	TSP	kt	0.17	0.18	0.15	0.14	0.15	0.10	0.10	0.12	0.13	0.12	0.13	0.14	0.14	0.14
3B4giv Manure management - Other poultry	TSP	kt	0.05	0.05	0.05	0.08	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
3B4h Manure management - Other animals	TSP	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3Da1 Inorganic N-fertilizers (includes urea application)	TSP	kt	6.93	6.85	6.93	6.71	7.22	7.17	7.13	7.11	7.07	6.99	6.97	6.91	6.94	6.97
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	TSP	kt	0.18	0.19	0.17	0.15	0.12	0.12	0.14	0.12	0.12	0.15	0.14	0.14	0.14	0.16
3Dd Off-farm storage, handling and transport of bulk agricultural products	TSP	kt	0.20	0.18	0.22	0.19	0.25	0.21	0.20	0.25	0.21	0.24	0.26	0.26	0.23	0.24
<b>Submission 2020</b>																
3B1a Manure management - Dairy cattle	TSP	kt	0.59	0.59	0.55	0.49	0.50	0.50	0.50	0.52	0.53	0.54	0.57	0.61	0.65	0.66
3B1b Manure management - Non-dairy cattle	TSP	kt	0.95	0.97	0.99	1.06	1.03	1.02	0.97	0.94	1.00	1.01	0.98	0.99	1.03	1.03
3B2 Manure management - Sheep	TSP	kt	0.10	0.11	0.10	0.08	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07
3B3 Manure management - Swine	TSP	kt	0.98	1.24	1.36	1.32	1.20	1.17	1.22	1.24	1.23	1.20	1.22	1.20	1.25	1.28
3B4d Manure management - Goats	TSP	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4e Manure management - Horses	TSP	kt	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
3B4f Manure management - Mules and asses	TSP	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4gi Manure management - Laying hens	TSP	kt	0.35	0.26	0.30	0.37	0.34	0.41	0.41	0.41	0.49	0.54	0.55	0.62	0.63	0.66
3B4gii Manure management - Broilers	TSP	kt	0.32	0.44	0.50	0.51	0.39	0.48	0.48	0.46	0.46	0.43	0.49	0.49	0.49	0.49
3B4giii Manure management - Turkeys	TSP	kt	0.17	0.18	0.15	0.14	0.15	0.10	0.10	0.12	0.13	0.12	0.13	0.14	0.14	0.14
3B4giv Manure management - Other poultry	TSP	kt	0.05	0.05	0.05	0.08	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
3B4h Manure management - Other animals	TSP	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3Da1 Inorganic N-fertilizers (includes urea application)	TSP	kt	6.93	6.85	6.93	6.71	7.22	7.17	7.13	7.11	7.07	6.99	6.97	6.91	6.96	7.00
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	TSP	kt	0.18	0.19	0.17	0.15	0.12	0.12	0.14	0.12	0.12	0.15	0.14	0.14	0.14	0.16
3Dd Off-farm storage, handling and transport of bulk agricultural products	TSP	kt	0.20	0.18	0.22	0.19	0.25	0.21	0.20	0.25	0.21	0.24	0.26	0.26	0.23	0.24

<b>% Change in Emissions</b>																
3B1a Manure management - Dairy cattle	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.4%
3B1b Manure management - Non-dairy cattle	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%
3B2 Manure management - Sheep	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%
3B3 Manure management - Swine	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4d Manure management - Goats	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4e Manure management - Horses	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4f Manure management - Mules and asses	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4gi Manure management - Laying hens	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4gii Manure management - Broilers	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-1.3%
3B4giii Manure management - Turkeys	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4giv Manure management - Other poultry	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4h Manure management - Other animals	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3Da1 Inorganic N-fertilizers (includes urea application)	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.4%
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3Dd Off-farm storage, handling and transport of bulk agricultural products	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 5.5. *PM<sub>10</sub> Recalculations for Agriculture 1990–2017*

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>Submission 2019</b>																
3B1a Manure management - Dairy cattle	PM <sub>10</sub>	kt	0.27	0.27	0.25	0.22	0.23	0.23	0.23	0.24	0.24	0.25	0.26	0.28	0.29	0.30
3B1b Manure management - Non-dairy cattle	PM <sub>10</sub>	kt	0.43	0.44	0.45	0.48	0.47	0.46	0.44	0.43	0.45	0.46	0.45	0.45	0.47	0.47
3B2 Manure management - Sheep	PM <sub>10</sub>	kt	0.04	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
3B3 Manure management - Swine	PM <sub>10</sub>	kt	0.15	0.18	0.20	0.19	0.18	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.19
3B4d Manure management - Goats	PM <sub>10</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4e Manure management - Horses	PM <sub>10</sub>	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B4f Manure management - Mules and asses	PM <sub>10</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4gi Manure management - Laying hens	PM <sub>10</sub>	kt	0.07	0.05	0.06	0.08	0.07	0.09	0.09	0.09	0.10	0.11	0.12	0.13	0.13	0.14
3B4gii Manure management - Broilers	PM <sub>10</sub>	kt	0.16	0.22	0.25	0.26	0.19	0.24	0.24	0.23	0.23	0.22	0.24	0.24	0.25	0.25
3B4giii Manure management - Turkeys	PM <sub>10</sub>	kt	0.17	0.18	0.15	0.14	0.15	0.10	0.10	0.12	0.13	0.12	0.13	0.14	0.14	0.14
3B4giv Manure management - Other poultry	PM <sub>10</sub>	kt	0.05	0.05	0.05	0.08	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
3B4h Manure management - Other animals	PM <sub>10</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3Da1 Inorganic N-fertilizers (includes urea application)	PM <sub>10</sub>	kt	6.93	6.85	6.93	6.71	7.22	7.17	7.13	7.11	7.07	6.99	6.97	6.91	6.94	6.97
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM <sub>10</sub>	kt	0.06	0.06	0.06	0.05	0.04	0.04	0.05	0.04	0.04	0.05	0.04	0.04	0.05	0.05
3Dd Off-farm storage, handling and transport of bulk agricultural products	PM <sub>10</sub>	kt	0.05	0.04	0.05	0.05	0.06	0.05	0.05	0.06	0.05	0.06	0.06	0.07	0.06	0.06
<b>Submission 2020</b>																
3B1a Manure management - Dairy cattle	PM <sub>10</sub>	kt	0.27	0.27	0.25	0.22	0.23	0.23	0.23	0.24	0.24	0.25	0.26	0.28	0.29	0.30
3B1b Manure management - Non-dairy cattle	PM <sub>10</sub>	kt	0.43	0.44	0.45	0.48	0.47	0.46	0.44	0.43	0.45	0.46	0.45	0.45	0.47	0.47
3B2 Manure management - Sheep	PM <sub>10</sub>	kt	0.04	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
3B3 Manure management - Swine	PM <sub>10</sub>	kt	0.15	0.18	0.20	0.19	0.18	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.19
3B4d Manure management - Goats	PM <sub>10</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4e Manure management - Horses	PM <sub>10</sub>	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B4f Manure management - Mules and asses	PM <sub>10</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4gi Manure management - Laying hens	PM <sub>10</sub>	kt	0.07	0.05	0.06	0.08	0.07	0.09	0.09	0.09	0.10	0.11	0.12	0.13	0.13	0.14
3B4gii Manure management - Broilers	PM <sub>10</sub>	kt	0.16	0.22	0.25	0.26	0.19	0.24	0.24	0.23	0.23	0.22	0.24	0.24	0.25	0.24
3B4giii Manure management - Turkeys	PM <sub>10</sub>	kt	0.17	0.18	0.15	0.14	0.15	0.10	0.10	0.12	0.13	0.12	0.13	0.14	0.14	0.14
3B4giv Manure management - Other poultry	PM <sub>10</sub>	kt	0.05	0.05	0.05	0.08	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
3B4h Manure management - Other animals	PM <sub>10</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3Da1 Inorganic N-fertilizers (includes urea application)	PM <sub>10</sub>	kt	6.93	6.85	6.93	6.71	7.22	7.17	7.13	7.11	7.07	6.99	6.97	6.91	6.96	7.00
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM <sub>10</sub>	kt	0.06	0.06	0.06	0.05	0.04	0.04	0.05	0.04	0.04	0.05	0.04	0.04	0.05	0.05
3Dd Off-farm storage, handling and transport of bulk agricultural products	PM <sub>10</sub>	kt	0.05	0.04	0.05	0.05	0.06	0.05	0.05	0.06	0.05	0.06	0.06	0.07	0.06	0.06

<b>% Change in Emissions</b>																
3B1a Manure management - Dairy cattle	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.4%
3B1b Manure management - Non-dairy cattle	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%
3B2 Manure management - Sheep	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%
3B3 Manure management - Swine	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4d Manure management - Goats	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4e Manure management - Horses	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4f Manure management - Mules and asses	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4gi Manure management - Laying hens	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4gii Manure management - Broilers	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-1.3%
3B4giii Manure management - Turkeys	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4giv Manure management - Other poultry	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4h Manure management - Other animals	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3Da1 Inorganic N-fertilizers (includes urea application)	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.4%
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3Dd Off-farm storage, handling and transport of bulk agricultural products	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 5.6. *PM<sub>2.5</sub> Recalculations for Agriculture 1990–2017*

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>Submission 2019</b>																
3B1a Manure management - Dairy cattle	PM <sub>2.5</sub>	kt	0.17	0.17	0.16	0.15	0.15	0.15	0.15	0.15	0.16	0.16	0.17	0.18	0.19	0.20
3B1b Manure management - Non-dairy cattle	PM <sub>2.5</sub>	kt	0.29	0.29	0.30	0.32	0.31	0.31	0.29	0.28	0.30	0.30	0.30	0.30	0.31	0.31
3B2 Manure management - Sheep	PM <sub>2.5</sub>	kt	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B3 Manure management - Swine	PM <sub>2.5</sub>	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B4d Manure management - Goats	PM <sub>2.5</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4e Manure management - Horses	PM <sub>2.5</sub>	kt	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B4f Manure management - Mules and asses	PM <sub>2.5</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4gi Manure management - Laying hens	PM <sub>2.5</sub>	kt	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B4gii Manure management - Broilers	PM <sub>2.5</sub>	kt	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
3B4giii Manure management - Turkeys	PM <sub>2.5</sub>	kt	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
3B4giv Manure management - Other poultry	PM <sub>2.5</sub>	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B4h Manure management - Other animals	PM <sub>2.5</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3Da1 Inorganic N-fertilizers (includes urea application)	PM <sub>2.5</sub>	kt	0.27	0.26	0.27	0.26	0.28	0.28	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM <sub>2.5</sub>	kt	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01
3Dd Off-farm storage, handling and transport of bulk agricultural products	PM <sub>2.5</sub>	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
<b>Submission 2020</b>																
3B1a Manure management - Dairy cattle	PM <sub>2.5</sub>	kt	0.17	0.17	0.16	0.15	0.15	0.15	0.15	0.15	0.16	0.16	0.17	0.18	0.19	0.20
3B1b Manure management - Non-dairy cattle	PM <sub>2.5</sub>	kt	0.29	0.29	0.30	0.32	0.31	0.31	0.29	0.28	0.30	0.30	0.30	0.30	0.31	0.31
3B2 Manure management - Sheep	PM <sub>2.5</sub>	kt	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B3 Manure management - Swine	PM <sub>2.5</sub>	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B4d Manure management - Goats	PM <sub>2.5</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4e Manure management - Horses	PM <sub>2.5</sub>	kt	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B4f Manure management - Mules and asses	PM <sub>2.5</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B4gi Manure management - Laying hens	PM <sub>2.5</sub>	kt	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B4gii Manure management - Broilers	PM <sub>2.5</sub>	kt	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
3B4giii Manure management - Turkeys	PM <sub>2.5</sub>	kt	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
3B4giv Manure management - Other poultry	PM <sub>2.5</sub>	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3B4h Manure management - Other animals	PM <sub>2.5</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3Da1 Inorganic N-fertilizers (includes urea application)	PM <sub>2.5</sub>	kt	0.27	0.26	0.27	0.26	0.28	0.28	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM <sub>2.5</sub>	kt	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01
3Dd Off-farm storage, handling and transport of bulk agricultural products	PM <sub>2.5</sub>	kt	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

<b>% Change in Emissions</b>																	
3B1a Manure management - Dairy cattle	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.4%
3B1b Manure management - Non-dairy cattle	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%
3B2 Manure management - Sheep	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%
3B3 Manure management - Swine	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4d Manure management - Goats	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4e Manure management - Horses	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4f Manure management - Mules and asses	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4gi Manure management - Laying hens	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4gii Manure management - Broilers	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-1.3%
3B4giii Manure management - Turkeys	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4giv Manure management - Other poultry	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4h Manure management - Other animals	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3Da1 Inorganic N-fertilizers (includes urea application)	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.4%
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3Dd Off-farm storage, handling and transport of bulk agricultural products	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

# Chapter Six

## Waste

### 6.1 Overview of the Waste (NFR 5) Sector

Emissions from the Waste sector cover a number of different source categories and pollutants. These are detailed below in Table 6.1. All sources are considered in detail in this chapter.

Table 6.1 *Pollutant Emissions by Waste Source Category*

NFR Source Category	Pollutants
5A Biological treatment of waste - Solid waste disposal on land	NMVOC, Hg, PCDD/F, PCB, TSP, PM <sub>10</sub> , PM <sub>2.5</sub>
5B1 Biological treatment of waste - Composting	NH <sub>3</sub> , CO
5B2 Biological treatment of waste - Anaerobic digestion at biogas facilities	NO, NA, NE
5C1a Municipal waste incineration	NO
5C1bi Industrial waste incineration	NO <sub>x</sub> , SO <sub>2</sub> , NMVOC, CO, TSP, PM <sub>2.5</sub> , PM <sub>10</sub> , BC, Pb, Cd, Hg, As, Cr, Cu, Ni, PCDD/F, B[a]P, B[b]F, B[k]F, HCB, PCB
5C1bii Hazardous waste incineration	IE (5C1bi)
5C1biii Clinical waste incineration	NO <sub>x</sub> , SO <sub>2</sub> , NMVOC, CO, TSP, PM <sub>2.5</sub> , PM <sub>10</sub> , BC, Pb, Cd, Hg, As, Cr, Cu, Ni, PCDD/F, B[a]P, B[b]F, B[k]F, HCB, PCB
5C1biv Sewage sludge incineration	NO, NA, IE
5C1bv Cremation	NO <sub>x</sub> , SO <sub>2</sub> , NMVOC, CO, TSP, PM <sub>2.5</sub> , PM <sub>10</sub> , BC, Pb, Cd, Hg, As, Cr, Cu, Ni, PCDD/F, B[a]P, B[b]F, B[k]F, HCB, PCB
5C1bvi Other waste incineration	NO, NA, NE
5C2 Open burning of waste	PCDD/F, B[a]P, B[b]F, B[k]F, PCB
5D Waste-water handling	NA, NE
5E Other waste	PM <sub>2.5</sub> , PM <sub>10</sub> , TSP, PCDD/F, B[a]P, B[b]F, B[k]F, I[123-cd]P, PCB

The Waste sector contains four key categories for six pollutants. Category Industrial waste incineration (5C1bi) is a key category for two pollutants: As and Cr, accounting for 60.8 per cent and 28.0 per cent of national total emissions, respectively. This category is the largest source of As and Cr in Ireland's 2018 inventory. The second key category in the waste sector is Other waste (5E) for two pollutants: PCDD/F and PCBs. The category accounts for 44.5 per cent of national total PCB emissions in Ireland's 2018 inventory. The category also accounts for 17.2 per cent of national total PCDD/F emissions. Other waste (5E) is also a key category for PM<sub>2.5</sub> accounting for 2.4 per cent of emissions. Open burning of waste (5C2) is a key category for PCBs accounting for 12.7 per cent of emissions. Solid waste disposal on land (5A) is a key category for Mercury (Hg). The sector accounted for 6.9 per cent of national total Hg emissions in 2018.

## 6.2 Biological treatment of waste - Solid waste disposal on land (NFR 5A)

### 6.2.1 Main Pollutants

Landfill gas generated at solid waste disposal sites is a source of NMVOC emissions. In Ireland sector 5A has been responsible on average for 0.5 per cent of national total emissions across the time series 1990-2018, showing a decrease of 47.4 per cent from 0.83 kt in 1990 to 0.44 kt in 2018. Emission factors for NMVOC were sourced from the Inventory Guidebook (EMEP/EEA, 2019) and are listed in Table F1 of Annex F. The activity data used is the net fugitive methane emissions from SWDS (kt) as calculated in the national greenhouse gas inventory, which are converted to landfill gas data (Gm<sup>3</sup>) using standard temperature and pressure (STP) molar conversion factors.

Emission of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> are also estimated. Emission factors from the Inventory Guidebook (EMEP/EEA, 2019) are applied to annual MSW data. Resulting emission estimates are included in Table 6.2 below.

**Table 6.2 Emission Time Series for NMVOC TSP, PM<sub>10</sub> and PM<sub>2.5</sub> from Solid Waste Disposal on Land**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NMVOC (kt)	0.83	1.01	0.80	0.64	0.18	0.18	0.24	0.19	0.29	0.41	0.46	0.47	0.45	0.44
TSP (t)	0.89	0.90	1.01	0.88	0.83	0.69	0.62	0.51	0.36	0.29	0.30	0.37	0.31	0.21
PM <sub>10</sub> (t)	0.42	0.43	0.48	0.42	0.39	0.33	0.30	0.24	0.17	0.13	0.14	0.18	0.15	0.10
PM <sub>2.5</sub> (t)	0.06	0.06	0.07	0.06	0.06	0.05	0.04	0.04	0.03	0.02	0.02	0.03	0.02	0.02

### 6.2.2 Heavy Metals

The relevant emissions in the Category 5A Solid Waste Disposal on Land sector in Ireland's air pollutant inventory include emissions of Hg from the disposal of batteries, electrical equipment, fluorescent lighting tubes, and measurement and control equipment in solid waste disposal sites (landfills). There is no direct estimate of the scale of disposal of the items mentioned at landfills in Ireland. However, Netcen/CTC (2006) provides a methodology to estimate emissions in Ireland using UK emission estimates, scaling by population for batteries and by household numbers for electrical equipment, fluorescent lighting and measurement and control equipment. Emission estimates for the above sources of Hg are presented in Table 6.3.

**Table 6.3 Emission Time Series for Mercury from Solid Waste Disposal on Land**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Hg (kg)	28.96	18.27	18.68	20.08	21.94	21.71	22.35	22.06	21.88	21.72	21.42	21.54	21.37	20.85

No data are available on emissions of POPs to air from municipal solid waste (MSW) disposal, although the emissions are likely to be negligible. There is potential for POP emissions to air from landfill gas (LFG) as described in the following section.

### 6.2.3 Landfill Gas and Persistent Organic Pollutants

There is potential for releases of POPs in landfill gas (LFG) through the transfer of POPs present in solid waste to the LFG that is generated by the waste. A proportion of this LFG escapes to air, with the remainder captured for flaring or utilisation for energy recovery. The proportion of LFG that is utilised for electricity generation is not considered in this chapter as it is accounted for in NFR Category 1A1a

Public Energy and Heat Production (Chapter Three), from which POP emissions are negligible. There is currently no information in Ireland on the release of POPs from LFG and therefore emission estimates are based on the UK inventory.

Activity data on the quantity of LFG flared and LFG that escapes to the atmosphere have been obtained from Ireland's GHG emission inventory for the 1990–2018 time series. Emission factors have been taken from the UK NAEI (2006) for PCDD/F as 0.953 µg I-TEQ/t of escaping LFG and 0.614 µg I-TEQ/t of flared LFG (Table F.1 of Annex F). The emission factor for PCBs is 0.0008 kg/t of escaping gas (UK NAEI). Emission estimates and activity data for PCDD/F and PCBs are presented in Table 6.4.

**Table 6.4 Time Series of Activity Data and Emissions of Dioxins and Furans and Polychlorinated Biphenyls from Landfill Gas**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
LFG emitted (kt)	105.4	127.4	101.5	80.6	22.8	22.3	30.5	24.2	36.9	51.8	58.2	60.0	57.4	55.4
LFG flared (kt)	NO	NO	3.9	28.6	52.1	49.9	44.2	45.1	39.0	25.5	15.6	13.1	12.0	14.2
PCDD/F (g I-TEQ)	0.100	0.121	0.101	0.112	0.086	0.083	0.083	0.078	0.083	0.081	0.075	0.073	0.070	0.070
PCBs (kg)	0.084	0.102	0.081	0.064	0.018	0.018	0.024	0.019	0.029	0.041	0.046	0.048	0.046	0.044

### 6.3 Biological treatment of waste - Composting (NFR 5B1)

Composting of organic waste, such as food waste, garden and park waste has taken place in Ireland since 2001. It consists of organic waste collected at kerbside and brought to civic amenity/temporary collections sites, as well as organic material composted at households. Activity data is sourced from National Waste Database Reports published by the EPA on a regular basis. Composting is a source of emissions of NH<sub>3</sub> and CO and the Tier 2 emission factors in the Inventory Guidebook (EMEP/EEA, 2019) of 0.66 kg/Mg waste and 0.56 kg/Mg waste are used, respectively. Emission estimates and activity data are presented in Table 6.5.

**Table 6.5 Time Series of Activity Data and Emissions of NH<sub>3</sub> and CO from Composting**

Year	2001	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Waste composted (kt)	22.2	80.3	122.9	122.4	133.6	130.7	132.5	112.5	120.5	116	149.5	149.5
NH <sub>3</sub> (kt)	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
CO (kt)	0.01	0.04	0.07	0.07	0.07	0.07	0.07	0.06	0.07	0.06	0.08	0.23

### 6.4 Waste Incineration (NFR 5C)

Ireland carries out relatively little waste incineration compared with some European countries and there is currently no incineration, without energy recovery, of MSW. The Waste Incineration (5C) category includes estimates of air pollutant emissions from the incineration of clinical waste (5C1biii), industrial waste (5C1bi), including hazardous waste (5C1bii), emissions from crematoria (5C1bv), and the open burning/combustion of waste materials such as farm plastics (5C2).

There is incineration of municipal wastes in Ireland following the commissioning of one incinerator in 2011 and a further one in 2017. However, these are waste-to-energy facilities, and as such emissions are reported under Public electricity and heat production (1A1a).

Approximately 50 per cent of health-care waste was incinerated during the 1990s, with a total of 150 incinerators in operation. By 1999, only two of these remained in operation and both closed the following year.

Most of the industrial installations that incinerate hazardous industrial wastes are in the pharmaceutical sector.

The practice of cremation is also less common in Ireland than in other countries but has increased in recent years due to the decrease in available burial plots, particularly in larger cities and towns in Ireland.

All the above are sources of heavy metals, POPs and combustion pollutants (NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, CO, TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and BC) in Ireland and are discussed in detail in the following sections.

#### 6.4.1 Clinical Waste (5C1biii)

The incineration of Clinical Waste is no longer carried out in Ireland. The bulk of hazardous clinical waste in Ireland is now treated using non-incineration technologies (namely sterilisation and shredding), with the remaining waste disposed of through landfilling, exported for incineration or used as a fuel in cement kilns. In the early 1990s, most hospitals operated on-site incinerator units where hazardous clinical waste was incinerated. A number of hospitals operated the practice of incinerating both hazardous and non-hazardous waste. Due to the implementation of stricter standards on incineration and the requirement for facilities to be licensed by the EPA, all incinerators were closed by the mid- to late-1990s. Prior to the closure of these facilities, a number of applications were made to the EPA in respect of IPPC licences. National reports and Government records contain some information on the quantity of health-care waste incinerated during the period of operation of the incinerators. From these sources, it was determined that an estimated 4,000 t of health-care waste was incinerated per annum. This value was used across the time series for the period 1990–1997, after which negligible quantities of health-care waste were incinerated up until the closure of the two remaining incinerators in 2000.

Emission estimates were derived for heavy metals using the quantity of health-care waste determined to be incinerated and Inventory Guidebook (EMEP/EEA, 2019) emission factors for As, Cd, Cr, Cu, Pb, Hg and Ni, assuming controlled air flow with no abatement. The emission factor for Zn was sourced from the UK NAEI. Emission factors are provided in Table F.1 of Annex F. Emission estimates for heavy metals are presented in Table 6.6.

Emissions of POPs from clinical wastes have been estimated using emission factors sourced from the UK NAEI. Dioxin and furan emission estimates are made utilising an emission factor of 372.1 µg I-TEQ/t health-care waste incinerated. This emission factor is used in the inventory for the period 1990–1997 until closure of all major plants. The PCB emission factor of 3.15 kg/Mt in 1990 reduces to 2.87 kg/Mt by 1995 and 2.36 kg/Mt by 1997, the last year of clinical waste incineration on the basis that

environmental performance at the plants would have improved as in the UK. The emission factors for HCB from health-care waste incinerators have been estimated by taking the UK NAEI factor of 0.5 kg/Mt for 2006 and estimating the historical emission factors for 1990 and 1995 in proportion to those for PCBs in order to take account of the improvements in environmental performance that would have been introduced at some incinerators. Emission factors for intervening years are interpolated. Emission factors for 2006 are also available from the UK NAEI for benzo[a]pyrene, benzo[b]fluoranthene and benzo[k]fluoranthene, but there are no data for indeno[1,2,3-cd]pyrene. The emission factors for 2006 have been used to estimate emission factors for 1990 and 1995, scaling back in proportion to the emission factors for PCBs similar to that undertaken for HCB emission factors. Emission factors are given in Table F.1 of Annex F and the estimates for POPs are presented in Table 6.6.

Emission factors for: NO<sub>x</sub>, CO, NMVOC, SO<sub>x</sub>, TSP, PM<sub>10</sub> and PM<sub>2.5</sub> were sourced from the Inventory guidebook (EMEP/EEA, 2019), using a Tier 1 approach, and are listed in Table F1 of Annex F. Resulting emission estimates 1990-1997 are included in Table 6.6.

**Table 6.6 Time Series of Emissions from the Incineration of Clinical Waste**

Year	1990	1991	1992	1993	1994	1995	1996	1997
NO <sub>x</sub> (kt)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CO (t)	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
NMVOC (t)	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80
SO <sub>x</sub> (t)	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16
TSP (kt)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
PM <sub>10</sub> (kt)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
PM <sub>2.5</sub> (kt)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
As (kg)	0.40	0.40	0.40	0.40	0.40	0.40	NO	NO
Cd (t)	0.01	0.01	0.01	0.01	0.01	0.01	NO	NO
Cr (kg)	1.60	1.60	1.60	1.60	1.60	1.60	NO	NO
Cu (kg)	24.00	24.00	24.00	24.00	24.00	24.00	NO	NO
Pb (t)	0.14	0.14	0.14	0.14	0.14	0.14	NO	NO
Hg (t)	0.22	0.22	0.22	0.22	0.22	0.22	NO	NO
Ni (kg)	1.20	1.20	1.20	1.20	1.20	1.20	NO	NO
Zn (t)	0.07	0.07	0.07	0.07	0.07	0.07	NO	NO
PCDD/F (g-I-TEQ)	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
PCBs (kg)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
HCB (kg)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
B[a]p (kg)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
B[b]F (kg)	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
B[k]F (kg)	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04

#### 6.4.2 Industrial Waste (5C1bi), Hazardous Waste (5C1bii) and Sewage Sludge (5C1biv)

The category Hazardous Waste Incineration (5C1bii) is reported in Industrial Waste Incineration (5C1bi) and reported as IE under the latter category. EU Directives on waste management have set the basis for strict regulatory control on the environmental performance of hazardous industrial waste incinerators. The incineration of Industrial Waste (5C1bi) (including hazardous waste) is now highly

regulated in Ireland. There are currently only a small number of facilities based in the pharmaceutical and chemical sectors that operate incinerators for the treatment of hazardous waste. The facilities that operate these units report emissions to the atmosphere to the EPA as part of IPPC licensing requirements. The disposal of CCA treated wood (CCA being a preservative containing copper, chromium and arsenic) by burning is also included as a source in this sector.

Estimates of the quantity of hazardous waste incinerated at the relevant facilities, determined from returns to the National Waste Database (Carey et al, 1996; Crowe et al, 2000; Meaney et al, 2003; Collins et al, 2004a; Collins et al, 2004b; Collins et al, 2005; Le Bolloch et al, 2006; Le Bolloch et al, 2007; Le Bolloch et al, 2009; McCoole et al, 2009; McCoole et al, 2011; McCoole et al, 2012; McCoole et al, 2013, <http://www.epa.ie/nationalwastestatistics/>), and information supplied by the facilities involved allows for the calculation of heavy metal emission estimates. Emission factors sourced from the Inventory Guidebook (EMEP/EEA 2019) for As, Cd, Pb, Hg, Ni and the UK NAEI for Cr and Cu are used to estimate emissions. Emission estimates are presented in Table 6.7, while the emission factors used are presented in Table F.1 of Annex F.

**Table 6.7 Time Series of Emissions from the Incineration of Industrial (incl. Hazardous & Sludge) Waste**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NO <sub>x</sub> (kt)	0.02	0.02	0.02	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CO (t)	1.90	1.90	1.40	2.54	1.50	1.28	0.88	1.06	1.01	0.92	0.93	0.52	0.58	0.58
NM VOC (kt)	0.20	0.20	0.15	0.27	0.16	0.13	0.09	0.11	0.11	0.10	0.10	0.06	0.06	0.06
SO <sub>x</sub> (t)	1.27	1.27	0.94	1.70	1.00	0.86	0.59	0.71	0.68	0.62	0.62	0.35	0.39	0.39
TSP (t)	0.27	0.27	0.20	0.36	0.21	0.18	0.13	0.15	0.14	0.13	0.13	0.07	0.08	0.08
PM <sub>10</sub> (t)	0.19	0.19	0.14	0.25	0.15	0.13	0.09	0.11	0.10	0.09	0.09	0.05	0.06	0.06
PM <sub>2.5</sub> (t)	0.11	0.11	0.08	0.14	0.09	0.07	0.05	0.06	0.06	0.05	0.05	0.03	0.03	0.03
As (t)	0.55	0.56	0.58	0.62	0.66	0.65	0.65	0.65	0.65	0.64	0.64	0.65	0.65	0.65
Cd (kg)	2.71	2.71	2.00	3.62	2.14	1.82	1.26	1.51	1.44	1.31	1.33	0.75	0.82	0.82
Cr (t)	0.53	0.54	0.56	0.60	0.63	0.63	0.63	0.63	0.62	0.62	0.62	0.63	0.63	0.63
Cu (t)	0.29	0.30	0.31	0.33	0.35	0.35	0.35	0.35	0.34	0.34	0.34	0.35	0.35	0.35
Pb (t)	0.04	0.04	0.03	0.05	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
Hg (kg)	1.52	1.52	1.12	2.03	1.20	1.02	0.71	0.85	0.81	0.73	0.74	0.42	0.46	0.46
Ni (kg)	0.38	0.38	0.28	0.51	0.30	0.26	0.18	0.21	0.20	0.18	0.19	0.10	0.12	0.12
Zn (t)	NE													
PCDD/F (g-I-TEQ)	0.03	0.03	0.08	0.02	0.42	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.61	1.31
PCBs (kg)	0.09	0.08	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
HCB (kg)	0.05	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
B[a]p (kg)	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B[b]F (kg)	0.07	0.05	0.02	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01
B[k]F (kg)	0.07	0.05	0.02	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01

The hazardous waste incinerators currently in use in Ireland are relatively modern units designed to optimise the burning process, with wet scrubber abatement systems in place to reduce the emissions of POPs to air. Further to the use of incinerators, there are also a number of facilities that use thermal oxidisers, which are subject to emission limit values. Annual Environmental Reports and IPPC Licence Applications provide adequate information in relation to the monitoring of PCDD/F emissions to air with limited information on the other relevant POPs. With respect to emissions of PAHs, emission factors sourced from the UK NAEI were applied to the tonnage of waste incinerated for each year.

Pollutant-specific emission factors are presented in Table F.1 of Annex F. Emission estimates for POPs are presented in Table 6.7.

Emission factors for: NO<sub>x</sub>, CO, NMVOC, SO<sub>x</sub>, TSP, PM<sub>10</sub> and PM<sub>2.5</sub> were sourced from the Inventory Guidebook (EMEP/EEA, 2019), using a Tier 1 approach, and are listed in Table F.1 of Annex F. Resulting emission estimates are included in Table 6.7.

### 6.4.3 Crematoria (5C1bv)

The practice of cremation is less popular in Ireland than in other countries. However, due to the decrease in the number of burial plots available, particularly in larger cities and towns, the number of cremations in Ireland has been steadily increasing. There are currently seven crematoria operating in Ireland. Cremation has been in operation in Ireland for over a decade, with one of the crematoria open since the early 1990s. A pet crematorium is also currently operating in Ireland; however, emissions from this source are regarded as negligible. Data on the number of cremations in Ireland have been obtained via correspondence with crematoria operators.

Heavy metals emissions are estimated using Inventory Guidebook (EMEP/EEA, 2019) emission factors for As, Cd, Pb, Cr, Hg, Ni, Cu Se and Zn and are presented in Table F.1 of Annex F. Emissions of POPs from crematoria include PCDD/F, HCB and benzo[a]pyrene. Inventory Guidebook (EMEP/EEA, 2019) emission factors are used to derive emission estimates for the years 1990–2018 (Table F.1 of Annex F). Emission factors for: NO<sub>x</sub>, CO, NMVOC, SO<sub>x</sub>, TSP, PM<sub>10</sub> and PM<sub>2.5</sub> were sourced from the Inventory guidebook (EMEP/EEA, 2019), using a Tier 1 approach, and are listed in Table F.1 of Annex F. Resulting emission estimates are included in Table 6.8.

**Table 6.8 Time Series of Emissions from Crematoria**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NO <sub>x</sub> (t)	1.24	1.24	1.82	2.03	3.14	2.54	2.75	3.07	3.37	3.73	4.11	4.52	4.92	5.34
CO (t)	0.21	0.21	0.31	0.34	0.53	0.43	0.47	0.52	0.57	0.63	0.70	0.77	0.84	0.91
NMVOC (t)	0.02	0.02	0.03	0.03	0.05	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.08	0.08
SO <sub>x</sub> (t)	0.17	0.17	0.25	0.28	0.43	0.35	0.38	0.42	0.46	0.51	0.56	0.62	0.67	0.73
TSP (t)	0.06	0.06	0.08	0.09	0.15	0.12	0.13	0.14	0.16	0.17	0.19	0.21	0.23	0.25
PM <sub>10</sub> (t)	0.05	0.05	0.08	0.09	0.13	0.11	0.12	0.13	0.14	0.16	0.17	0.19	0.21	0.22
PM <sub>2.5</sub> (t)	0.05	0.05	0.08	0.09	0.13	0.11	0.12	0.13	0.14	0.16	0.17	0.19	0.21	0.22
As (g)	20.42	20.42	29.94	33.45	51.72	41.96	45.38	50.62	55.54	61.48	67.85	74.49	81.18	88.17
Cd (g)	7.55	7.55	11.07	12.36	19.11	15.51	16.77	18.71	20.53	22.72	25.07	27.53	30.00	32.58
Cr (g)	20.34	20.34	29.83	33.32	51.53	41.81	45.21	50.43	55.34	61.25	67.60	74.21	80.89	87.84
Cu (g)	18.65	18.65	27.35	30.55	47.23	38.32	41.44	46.23	50.73	56.15	61.96	68.03	74.14	80.52
Pb (g)	45.05	45.05	66.07	73.80	114.11	92.58	100.12	111.68	122.55	135.65	149.70	164.35	179.13	194.53
Hg (kg)	2.24	2.24	3.28	3.66	5.66	4.59	4.97	5.54	6.08	6.73	7.43	8.15	8.89	9.65
Ni (kg)	0.03	0.03	0.04	0.04	0.07	0.05	0.06	0.06	0.07	0.08	0.09	0.09	0.10	0.11
PCDD/F (g-I-TEQ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HCBs (g)	0.23	0.23	0.33	0.37	0.57	0.46	0.50	0.56	0.61	0.68	0.75	0.82	0.89	0.97
B[a]p (g)	0.02	0.02	0.03	0.03	0.05	0.04	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.09

## 6.4.4 Open Burning of Agricultural Wastes (5C2)

Open Burning of Agricultural Wastes, which includes the burning of crop residues, animal carcasses and poultry litter is a practice generally not undertaken in Ireland. Therefore, emission estimates from these sources are reported as “NO” (not occurring) for Heavy Metals.

Emissions from the open burning of farm plastics are the only source of emissions from agricultural wastes for which estimates are made. Information on the quantity of waste farm plastics that are burned in open fires is difficult to obtain. One of the largest sources of waste farm plastic, is waste plastic silage wrap and to a lesser extent synthetic fertiliser bags. The increased replacement of conventional silage with plastic wrapped silage bales, which use substantially more plastic, has seen an increase in the quantity of this waste stream. A number of different sources of information were utilised in the derivation of emission estimates. Information on the quantities of silage plastic on the market was obtained from the Irish Farm Film Producers Group (IFFPG), and national agricultural statistics were provided by the CSO and the National Farm Survey. Using the area of land utilised for silage for each year of the time series, an estimate of the plastic used for conventional (pit) silage and baled silage is made. Account is taken of plastic recovery under the silage plastics collection service operated by both the IFFPG and the Farm Relief Services. The plastic collected is recycled and used to make products such as park benches, plastic bags, garden furniture and plastic piping. The remaining plastic is assumed to be burned. In the period 2006 to 2007, there were separate silage plastic collections organised by the then Department of Environment. These were subsequently discontinued. As a result the IFFPG in the period to 2011, increased the quantity collected significantly which is the reason emissions decreased significantly in 2011.

Dioxin and furan emissions from the open burning of farm plastics are determined using estimates of the quantities of material burned and the UNEP Toolkit (2013) emission factor of 300 µg I-TEQ/t burned for the open burning of municipal wastes. The UK NAEI provides an emission factor of 510 kg/Mt burned for the estimation of PCB emissions. There is minimal data available on emission factors for PAHs; however, the emission factors from the UK NAEI for small-scale waste burning are used as a best estimate. Emission factors of 89.5 kg/Mt for benzo[a]pyrene, 405 kg/Mt for benzo[b]fluoranthene and 405 kg/Mt for benzo[k]fluoranthene are applied. No data is available for indeno[1,2,3-cd] pyrene. Emission factors are compiled in Table F.2 of Annex F and the emission estimates are presented in Table 6.9.

Emissions of NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, CO and particles from this small source are not estimated, and are therefore reported as “NE”.

**Table 6.9 Time Series of Emissions from the Open Burning of Farm Plastics**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
PCDD/F (g-I-TEQ)	0.94	1.10	0.65	0.23	1.15	1.15	0.30	0.39	0.28	0.45	0.49	0.46	0.50	0.59
PCBs (kg)	1.59	1.86	1.11	0.39	1.95	1.96	0.50	0.67	0.48	0.77	0.84	0.78	0.84	1.01
B[a]p (kg)	0.28	0.33	0.20	0.07	0.34	0.34	0.09	0.12	0.08	0.13	0.15	0.14	0.15	0.18
B[b]F (kg)	1.26	1.48	0.88	0.31	1.55	1.55	0.40	0.53	0.38	0.61	0.67	0.62	0.67	0.80
B[k]F (kg)	1.26	1.48	0.88	0.31	1.55	1.55	0.40	0.53	0.38	0.61	0.67	0.62	0.67	0.80

## 6.5 Wastewater handling (NFR 5D)

Emissions of NMVOC from wastewater treatment plants may in some cases be significant in urban areas and may contribute at a national level. In Ireland’s case, based on the use of the emission factor of 15mg/m<sup>3</sup> of wastewater handled from EMEP/EEA 2019 guidebook and wastewater quantities handled in Ireland the emissions were estimated to be 0.004 per cent of national NMVOC emissions. Therefore, Ireland considers emissions from this source as negligible and NE is reported for this source.

## 6.6 Other Waste (NFR 5E)

This NFR category includes emissions from accidental vehicle and building fires and other burning, which constitutes bonfires, domestic burning of MSW and burning of construction wastes. These are all sources of POPs, TSP, PM<sub>10</sub> and PM<sub>2.5</sub>. Each of these combustion sources is described in the following sections. The activity data associated with each type of fire is shown in Table 6.10.

### 6.6.1 Accidental Fires

Accidental fires are poorly controlled combustion events that can release large quantities of POPs and particulates into the environment. These include accidental fires of houses, other buildings and cars. A variety of materials can be burned in accidental fires, which can lead to some difficulty in obtaining detailed activity data and applying emission factors correctly. However, there are some data available in Ireland in relation to accidental building and vehicle fires from the Fire Services Department (Table 6.10).

**Table 6.10 Time Series of activity data from Accidental Fires from Vehicles and Buildings**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Vehicle fires	4130	4130	7749	4907	6079	4534	3541	2937	1609	1637	2681	1607	2137	2667
Building fires-detached	1344	1344	1344	1263	1676	1671	1462	1306	800	770	1392	621	860	1099
Building fires-undetached	2015	2015	2015	1894	2515	2506	2194	1959	1200	1155	2088	931	1290	1649
Apartment fires	426	426	426	470	288	245	271	246	242	214	240	192	211	229
Industrial fires	508	508	508	433	393	453	391	343	270	288	458	234	317	400

Vehicle fire statistics are only available since 2000, with the number of fires ranging from 1,600 to 7,700 per annum. With respect to earlier years, the URS Dames & Moore (2000) report suggests that the number of vehicle fires in 1998 was 4,130. It is assumed that, in the absence of any information, the number of vehicle fires per year in the period 1990–1997 is equal to that in 1998. Dioxin and furan emissions from vehicle fires are estimated using the UNEP Toolkit 2013 emission factor of 100 µg I-TEQ/vehicle fire. An emission factor of 25.5 mg/vehicle fire based on the NAEI emission factor of 510 kg/Mt burned for small scale domestic waste burning (UK NAEI) for PCB emissions from the open burning of MSW is used for accidental vehicle fires, assuming that on average 50 kg of material are burnt per fire (Dyke, 1997), while those in relation to PAHs, also based on the mass of material burnt, sourced from the UK NAEI, suggest values for benzo[a]pyrene of 0.06 mg/vehicle fire, for benzo[b]fluoranthene of 0.095 mg/vehicle fire, for benzo[k]fluoranthene of 0.03 mg/vehicle fire, and for indeno[1,2,3-cd]pyrene of 0.065 mg/vehicle fire. With respect to TSP, PM<sub>10</sub> and PM<sub>2.5</sub>, the Tier 2 emission factors presented in the EMEP/EEA 2019 Guidebook are adopted.

The Fire Services Department also provides information in relation to building fires, which is disaggregated into the type of building and the number of fires that are chimney fires. Information is only available for the years 2000–2018 at this level of disaggregation. For data prior to 2000, no differentiation was made between chimney fires and other types of building fires. The proportion of chimney fires to the total number of building fires post-2000 is therefore used to estimate the number of chimney fires annually prior to 2000. Limited information is available on the quantity of material burnt in accidental fires both in Ireland and internationally. The assumed quantity of material burnt in each building fire is 2.28 t per fire (Lorenz et al., 1996) and approximately 10 kg in each chimney fire. Dioxin and furan emissions are estimated using an emission factor of 400 µg I-TEQ/t of material burned (UNEP Toolkit, 2013). For PCB emissions, the emission factor of 510 kg/Mt burned (UK NAEI) for the open burning of MSW is applied, while, for PAH emissions (UK NAEI), the emission factors equate to 1.2 kg/Mt for benzo[a]pyrene, 1.9 kg/Mt for benzo[b]fluoranthene, 0.67 kg/Mt for benzo[k]fluoranthene and 1.3 kg/Mt for indeno[1,2,3-cd]pyrene. Accidental vehicle fires and building fires emission estimates are summed to provide an estimate of the total emissions from accidental fires. Emission estimates for the 1990–2018 time series are presented in Table 6.11. Emission factors are compiled in Table F.2 of Annex F. Ireland has included estimates of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emissions in this using the emission factors from the Inventory Guidebook (EMEP/EEA, 2019).

**Table 6.11 Time Series of Emissions from Accidental Fires from Vehicles and Buildings**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
PCDD/F (g-I-TEQ)	5.038	5.038	3.866	3.392	4.451	4.285	3.707	3.288	2.002	1.933	3.457	1.589	2.187	2.785
PCBs (kg)	6.003	6.003	4.138	3.824	5.055	5.001	4.366	3.893	2.389	2.297	4.134	1.862	2.570	3.278
B[a]p (kg)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B[b]F (kg)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B[k]F (kg)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
I(123-cd)P (kg)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TSP (kt)	0.359	0.359	0.368	0.342	0.433	0.428	0.376	0.335	0.211	0.203	0.358	0.165	0.226	0.287
PM10 (kt)	0.359	0.359	0.368	0.342	0.433	0.428	0.376	0.335	0.211	0.203	0.358	0.165	0.226	0.287
PM2.5 (kt)	0.359	0.359	0.368	0.342	0.433	0.428	0.376	0.335	0.211	0.203	0.358	0.165	0.226	0.287

### 6.6.2 Other Burning

This section includes the emission of POPs from domestic bonfires, the burning of domestic waste both indoors and outdoors and the open burning of construction waste. Domestic bonfires normally include a variety of garden wastes (e.g. wood, leaves, etc.), and their importance with respect to POP emissions is greatly increased in cases where other wastes are added to the bonfires (e.g. plastics). Some households are not covered, or opt not to be covered, by waste collection systems and may burn household waste. Combustion of treated wood that has been used for construction, fencing and furniture can be a particularly significant source of POP emissions. For example, where wood is pre-treated with chlorinated fungicides, such as lindane or pentachlorophenol, its combustion can be a potentially significant source of PCDD/F emissions to air, whilst wood pre-treatment with creosote is a potential source for PAH emissions. However, the use of these chemicals has been significantly reduced in Ireland since the early 1990s.

For domestic bonfires, activity data are determined on a per-capita basis using the UK inventory as the reference, as no information is available in Ireland. For the burning of household waste, estimates for uncollected household waste were obtained for each of the years 2001 through to 2013, as well as for 1998 and 1995 from National Waste Reports (Carey et al., 1996; Crowe et al., 2000; Collins et al., 2004a, 2004b; Le Bolloch et al., 2006, 2007, 2009, McCoolle et al, 2009; McCoolle et al, 2011; McCoolle et al, 2012; McCoolle et al, 2013, <http://www.epa.ie/nationalwastestatistics>), with data calculated for other years using waste statistical data. “Uncollected waste” refers to the waste produced by the portion of the population not provided with, or not availing of, a waste collection service, corrected to take account of local conditions. This is calculated according to a standard methodology at the local authority level, based on total numbers of households, numbers of households served with waste collection, and quantities of waste collected per household in each local authority area. In addition, a proportion of households share waste collections services. Only the fraction of household waste that is combustible is burned. Compositional statistics at a national level are applied to estimate the quantities of combustible materials burnt.

Information on construction and demolition waste is available from National Waste Reports. The proportion of wood within this waste stream is estimated using data collected but not published in the National Waste Reports for the years 2004 and 2006, based on estimates of both authorised and unauthorised construction and demolition waste disposal. These values have been used for all other years in the absence of any other information. The URS Dames & Moore study (2000) suggests that 5 per cent of construction and demolition waste wood arising is burned on construction sites, whereas the UK NAEI suggests a value of 0.1 per cent. The value of 5 per cent is applied for the years 1990–1998, linearly decreasing for the years 1999–2003, with the value of 0.1 per cent applied for the period 2004–2018, based on correspondence with representatives from the National Construction and Demolition Waste Council who indicate that they would expect virtually no uncontrolled burning in urban areas.

The UNEP toolkit for open burning of construction and demolition waste wood (60 µg-I-TEQ/t burned) is applied to estimate PCDD/F emissions from bonfires on the basis that bonfires contain mainly wood and garden waste. Domestic burning of MSW contains material that varies and that often includes plastics and sometimes specific chemicals that potentially affect PCDD/F emissions. The UNEP 2013 toolkit emission factor of 40 µg-I-TEQ/t burned is used for burning of household waste. This emission factor not only takes into account the wide range of materials in household waste but also other materials such as treated and untreated wood. In relation to PCDD/F emissions from wood burning, an emission factor of 60 µg I-TEQ/t is applied.

The estimated emission factor of 1.14 kg/Mt burned for PCBs from bonfires has been taken as the average of the UK NAEI emission factors for domestic wood combustion (e.g. fireplaces) (1.99 kg/Mt burned) and open burning of crop residues (0.29 kg/Mt). For the open burning of domestic wastes, the UK NAEI emission factor of 510 kg/Mt burned has been adopted for PCBs. There are no specific data on PCB emissions from the open burning of construction wood, but emission factors from the NAEI for industrial combustion of wood indicate no difference for treated and untreated wood. Emission factors for domestic wood combustion from the NAEI and the Inventory Guidebook range from 1.99 to 6 kg/Mt burned. The emission factor of 1.99 kg/Mt has been adopted for open burning of construction waste wood in Ireland.

Emission factors with respect to PAH emission estimates are also sourced from the UK NAEI. For bonfires, the emission factors are 1,300 kg/Mt for benzo[a]pyrene, 1,500 kg/Mt for benzo[b]fluoranthene, 500 kg/Mt for benzo[k]fluoranthene and 90 kg/Mt for indeno[1,2,3-cd] pyrene. For the open burning of domestic wastes, emission factors for small-scale waste burning are applied as follows: 89.5 kg/Mt for benzo[a]pyrene, 405 kg/Mt for both benzo[b]fluoranthene and benzo[k]fluoranthene. No data are available for indeno[1,2,3-cd] pyrene. These emission factors are also used to estimate emissions from the open burning of wood at construction sites.

The three sources of emissions described in previous paragraphs are summed to provide total emission estimates for Category 5.E Other Waste. Emission factors are compiled in Table F.2 of Annex F. Emission estimates for the 1990–2017 time series are presented in Table 6.12.

**Table 6.12 Time Series of Emissions from Other Waste Burning**

Year	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
PCDD/F (g+-TEQ)	1.15	1.29	1.72	2.24	0.67	0.72	0.73	0.70	0.66	0.62	0.62	0.63	0.63	0.63
PCBs (kg)	7.73	9.46	14.75	21.21	0.69	1.43	1.48	1.15	0.70	0.24	0.24	0.25	0.25	0.25
B[a]p (t)	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
B[b]F (t)	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
B[k]F (t)	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
I(123-cd)P (kg)	0.82	0.83	0.85	0.87	0.92	0.92	0.92	0.91	0.91	0.91	0.90	0.92	0.92	0.92

## 6.7 Recalculations in the Waste Sector

Recalculations in the waste sector (Table 6.13) in this submission are limited to estimates from:

### *Solid Waste Disposal to Land (5A)*

A transcription error in relation to activity data for municipal solid waste at disposal sites was identified during QA/QC activities which is corrected in this submission. This has resulted in a recalculation of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emissions for the years 1990-2010 with an average increase of 2.6 per cent per annum in emissions of these pollutants over this period.

Updated landfill survey returns resulted in an update in the methane recovered for the years 2015-2017. This resulted in a recalculation of NMVOC, Dioxins and PCBs for these years with an average decrease of 2 per cent in dioxin emissions and 2.5 per cent decrease in NMVOC and PCB emissions.

There was an update to activity data concerning the number of households for years 2011-2017 as presented in national statistics published by the CSO. This resulted in a recalculation in Mercury (Hg) emission of 3.7 per cent on average in emissions annually in this period.

### *Composting (5B1)*

Recalculations to emissions estimates of NH<sub>3</sub> and CO from composting is a result of an update to activity data, on the quantities of household organic waste collected at kerbside and brought to civic amenity/temporary collection sites. This applies to the year 2017 with an increase of 36.2 per cent in NH<sub>3</sub> and CO emissions as a result.

### *Waste Incineration (5C)*

A transcription error was identified as part of QA/QC activities with respect to the number of bodies cremated in Ireland. This has resulted in the recalculations for POPs for all years 1990-2017. In terms of HCB emissions this results in an average increase of 5.7 per cent per annum for the years 2007-2015 and 17.6 per cent increase per annum for the years 2016 and 2017. For indeno[1,2,3-cd] pyrene emissions, this results in an average increase of 192 per cent per annum for the years 2007-2009 and 495 per cent increase per annum for the years 2010-2017. Revised to activity data for 2017 results in a decrease of 15.2 per cent in dioxin emissions for that year.

### *Other waste (5E)*

An update to activity data from the Department of Housing and Local Government on the numbers of accidental fires in 2017 was included in this submission which resulted in a recalculation of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> (an increase of 36.8 per cent in emissions) as well as PCBs and Dioxins (an increase of 37.5 and 27.2 per cent in emissions) for the year 2017.

## 6.8 Quality Assurance/Quality Control

As identified in section 6.7 the implementation of QA/QC activities ensures that the estimates in the Waste sector are now fully consistent with estimates of greenhouse gas emissions from the sector.

## 6.9 Planned Improvements

The inventory team will continue to review emission estimates for this sector in light of any new information that may become available for future submissions.

Review recommendations and responses are included in this report as Annex H.

**Table 6.13 Recalculations for Waste 1990–2017**

<b>NFR Category</b>	<b>Pollutant</b>	<b>Unit</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>
<b>Submission 2019</b>																
5A Solid waste disposal on land	NMVOC	kt	0.83	1.01	0.80	0.64	0.29	0.18	0.18	0.24	0.19	0.29	0.41	0.47	0.49	0.47
5A Solid waste disposal on land	TSP	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5A Solid waste disposal on land	PM <sub>10</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5A Solid waste disposal on land	PM <sub>2.5</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5A Solid waste disposal on land	Hg	t	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
5A Solid waste disposal on land	PCDD/F	g-l-TEQ	0.10	0.12	0.10	0.11	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07
5A Solid waste disposal on land	PCBs	kg	0.08	0.10	0.08	0.06	0.03	0.02	0.02	0.02	0.02	0.03	0.04	0.05	0.05	0.05
<b>Submission 2020</b>																
5A Solid waste disposal on land	NMVOC	kt	0.83	1.01	0.80	0.64	0.29	0.18	0.18	0.24	0.19	0.29	0.41	0.46	0.47	0.45
5A Solid waste disposal on land	TSP	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5A Solid waste disposal on land	PM <sub>10</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5A Solid waste disposal on land	PM <sub>2.5</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5A Solid waste disposal on land	Hg	t	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
5A Solid waste disposal on land	PCDD/F	g-l-TEQ	0.10	0.12	0.10	0.11	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07
5A Solid waste disposal on land	PCBs	kg	0.08	0.10	0.08	0.06	0.03	0.02	0.02	0.02	0.02	0.03	0.04	0.05	0.05	0.05
<b>% Change in Emission</b>																
5A Solid waste disposal on land	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-2.1%	-2.4%	-3.2%
5A Solid waste disposal on land	TSP	%	2.5%	2.5%	3.8%	1.3%	1.3%	1.5%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5A Solid waste disposal on land	PM <sub>10</sub>	%	2.5%	2.5%	3.8%	1.3%	1.3%	1.5%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5A Solid waste disposal on land	PM <sub>2.5</sub>	%	2.5%	2.5%	3.8%	1.3%	1.3%	1.5%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5A Solid waste disposal on land	Hg	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	4.0%	4.0%	4.0%	4.0%	2.8%	2.9%
5A Solid waste disposal on land	PCDD/F	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-1.5%	-1.8%	-2.6%
5A Solid waste disposal on land	PCBs	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-2.1%	-2.4%	-3.2%

<b>NFR Category</b>	<b>Pollutant</b>	<b>Unit</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>
<b>Submission 2019</b>																
5B Biological treatment of waste - Composting	NH3	kt	NO	NO	NO	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
5B Biological treatment of waste - Composting	CO	kt	NO	NO	NO	0.04	0.05	0.07	0.07	0.07	0.07	0.07	0.06	0.07	0.06	0.06
<b>Submission 2020</b>																
5B Biological treatment of waste - Composting	NH3	kt	NO	NO	NO	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
5B Biological treatment of waste - Composting	CO	kt	NO	NO	NO	0.04	0.05	0.07	0.07	0.07	0.07	0.07	0.06	0.07	0.06	0.08
<b>% Change in Emission</b>																
5B Biological treatment of waste - Composting	NH3	%				0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	36.2%
5B Biological treatment of waste - Composting	CO	%				0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	36.2%

<b>NFR Category</b>	<b>Pollutant</b>	<b>Unit</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>	<b>2005</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>
<b>Submission 2019</b>																
5C Waste Incineration	NO <sub>x</sub>	kt	0.03	0.03	0.02	0.03	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.01	0.01
5C Waste Incineration	NMVOG	kt	0.20	0.20	0.15	0.27	0.15	0.16	0.13	0.09	0.11	0.11	0.10	0.10	0.06	0.06
5C Waste Incineration	SO <sub>2</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	TSP	kt	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	PM <sub>10</sub>	kt	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	PM <sub>2.5</sub>	kt	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	Cd	t	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	Pb	t	0.18	0.18	0.03	0.05	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
5C Waste Incineration	Hg	t	0.22	0.22	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5C Waste Incineration	PCDD/F	g-I-TEQ	2.46	2.62	0.73	0.25	2.26	1.56	1.16	0.31	0.40	0.29	0.46	0.51	0.47	1.30
5C Waste Incineration	PCBs	kg	1.69	1.95	1.14	0.42	1.96	1.97	1.97	0.51	0.68	0.49	0.78	0.85	0.79	0.85
5C Waste Incineration	HCB	t	0.06	0.05	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
5C Waste Incineration	B[a]P	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	B[b]F	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	B[k]F	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	I[123-cd]P	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Submission 2020</b>																
5C Waste Incineration	NO <sub>x</sub>	kt	0.03	0.03	0.02	0.03	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.01	0.01
5C Waste Incineration	NMVOG	kt	0.20	0.20	0.15	0.27	0.15	0.16	0.13	0.09	0.11	0.11	0.10	0.10	0.06	0.06
5C Waste Incineration	SO <sub>2</sub>	kt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	TSP	kt	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	PM <sub>10</sub>	kt	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	PM <sub>2.5</sub>	kt	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	Cd	t	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	Pb	t	0.18	0.18	0.03	0.05	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
5C Waste Incineration	Hg	t	0.22	0.22	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5C Waste Incineration	PCDD/F	g-I-TEQ	2.46	2.62	0.73	0.25	2.26	1.56	1.16	0.31	0.40	0.29	0.46	0.51	0.48	1.10
5C Waste Incineration	PCBs	kg	1.69	1.95	1.15	0.42	1.96	1.97	1.97	0.51	0.68	0.49	0.78	0.85	0.79	0.85
5C Waste Incineration	HCB	t	0.06	0.05	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
5C Waste Incineration	B[a]P	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	B[b]F	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	B[k]F	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5C Waste Incineration	I[123-cd]P	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

<b>% Change in Emission</b>																
5C Waste Incineration	NO <sub>x</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5C Waste Incineration	NM VOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5C Waste Incineration	SO <sub>2</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5C Waste Incineration	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5C Waste Incineration	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5C Waste Incineration	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5C Waste Incineration	Cd	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5C Waste Incineration	Pb	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5C Waste Incineration	Hg	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5C Waste Incineration	PCDD/F	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.2%	0.9%	0.3%	0.0%	0.1%	-15.2%
5C Waste Incineration	PCBs	%	0.0%	0.0%	0.1%	0.2%	0.1%	0.1%	0.1%	0.3%	0.2%	0.3%	0.2%	0.2%	0.3%	0.3%
5C Waste Incineration	HCB	%	0.4%	0.5%	1.8%	1.8%	3.5%	3.4%	4.1%	6.5%	6.1%	7.0%	8.4%	9.1%	17.5%	17.7%
5C Waste Incineration	B[a]P	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
5C Waste Incineration	B[b]F	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5C Waste Incineration	B[k]F	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5C Waste Incineration	I[123-cd]P	%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	192.3%	192.3%	473.0%	499.6%	502.8%	521.2%	473.2%	481.7%	486.6%	529.2%

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>Submission 2019</b>																
5E Other Waste	TSP		0.36	0.36	0.37	0.34	0.43	0.43	0.43	0.38	0.34	0.21	0.20	0.36	0.17	0.17
5E Other Waste	PM <sub>10</sub>		0.36	0.36	0.37	0.34	0.43	0.43	0.43	0.38	0.34	0.21	0.20	0.36	0.17	0.17
5E Other Waste	PM <sub>2.5</sub>		0.36	0.36	0.37	0.34	0.43	0.43	0.43	0.38	0.34	0.21	0.20	0.36	0.17	0.17
5E Other Waste	PCDD/F	g-I-TEQ	6.19	6.33	5.59	5.63	5.06	5.12	5.01	4.43	3.99	2.66	2.55	4.08	2.22	2.22
5E Other Waste	PCBs	kg	13.73	15.46	18.89	25.04	5.59	5.75	6.43	5.85	5.04	3.09	2.54	4.38	2.05	2.05
5E Other Waste	B[a]P	t	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5E Other Waste	B[b]F	t	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
5E Other Waste	B[k]F	t	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5E Other Waste	I[123-cd]P	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Submission 2020</b>																
5E Other Waste	TSP		0.36	0.36	0.37	0.34	0.43	0.43	0.43	0.38	0.34	0.21	0.20	0.36	0.17	0.23
5E Other Waste	PM <sub>10</sub>		0.36	0.36	0.37	0.34	0.43	0.43	0.43	0.38	0.34	0.21	0.20	0.36	0.17	0.23
5E Other Waste	PM <sub>2.5</sub>		0.36	0.36	0.37	0.34	0.43	0.43	0.43	0.38	0.34	0.21	0.20	0.36	0.17	0.23
5E Other Waste	PCDD/F	g-I-TEQ	6.19	6.33	5.59	5.63	5.06	5.12	5.01	4.43	3.99	2.66	2.55	4.08	2.22	2.82
5E Other Waste	PCBs	kg	13.73	15.46	18.89	25.04	5.59	5.75	6.43	5.85	5.04	3.09	2.54	4.38	2.11	2.82
5E Other Waste	B[a]P	t	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5E Other Waste	B[b]F	t	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
5E Other Waste	B[k]F	t	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5E Other Waste	I[123-cd]P	t	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>% Change in Emission</b>																
5E Other Waste	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	36.8%
5E Other Waste	PM <sub>10</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	36.8%
5E Other Waste	PM <sub>2.5</sub>	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	36.8%
5E Other Waste	PCDD/F	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	27.2%
5E Other Waste	PCBs	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.0%	37.5%
5E Other Waste	B[a]P	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
5E Other Waste	B[b]F	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%
5E Other Waste	B[k]F	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	1.0%
5E Other Waste	I[123-cd]P	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%

\*Prior to 1998, emissions were only reported for the sub-category 5Cbiii (Clinical waste incineration). For the years 1998-2015 this sub-category is NO. Other sub-categories of 5C are reported as NO, NA, IE, and NE.

## Chapter Seven

### Gridded and LPS data

#### 7.1 Overview of Gridded and LPS data reporting

It is mandatory to report gridded emissions and emissions from large point sources every four years both under the Convention on Long-Range Transboundary Air Pollution and under Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants (the revised National Emission Ceilings Directive).

The Guidelines for Reporting Emissions and Projections Data under the Convention on Long-Range Transboundary Air Pollution (ECE/EB.AIR/125), adopted in 2014, specify the scope, methodologies, formats and deadlines for annual inventory submissions by Parties to the Convention. The guidelines specify that at four yearly intervals, starting in 2017, Parties shall report updated aggregated sectoral (GNFR) gridded emissions and LPS emissions. The EMEP grid is defined in paragraph 14 of the reporting guidelines and refers to a 0.1°x0.1° latitude-longitude projection in the geographic coordinate World Geodetic System (WGS) latest revision, WGS 84. The EMEP domain covers the geographic domain between 30°N-82°N latitude and 30°W-90°E longitude.

The reporting guidelines under the Convention refers to the EMEP/EEA Guidebook for technical guidance on the spatial distribution of emissions. Directive (EU) 2016/2284 refers to the reporting guidelines under the Convention and as such the requirements under the two reportings are identical.

The development of a high-resolution model for distribution of emissions is part of an on-going research project funded by the EPA ("National mapping of GHG and non-GHG emissions sources". Ref: 2015-CCRP-MS.26). The project has developed a model for distributing emissions at a resolution of 1 km x 1 km covering all sectors and pollutants included in the official Irish emission inventory. The generated spatial emissions data (GNFR) is fully consistent with the reported emission inventories (NFR) under the LRTAP Convention. A list of GNFR categories is presented in Table 7.1 and the relationship between NFR and GNFR is presented in Table 7.2.

**Table 7.1. List of GNFR categories**

<b>GNFR</b>
A_PublicPower
B_Industry
C_OtherStationaryComb
D_Fugitive
E_Solvents
F_RoadTransport
G_Shipping
H_Aviation
I_Offroad
J_Waste
K_AgriLivestock
L_AgriOther
M_Other
<b>'MEMO' ITEMS - NOT TO BE INCLUDED IN NATIONAL TOTALS</b>
O_AviCruise
P_IntShipping
z_Memo
N_Natural

**Table 7.2. Correspondence list for GNFR and NFR categories**

<b>NFR</b>	<b>NFR name</b>	<b>GNFR</b>
1A1a	Public electricity and heat production	A_PublicPower
1A1b	Petroleum refining	B_Industry
1A1c	Manufacture of solid fuels and other energy industries	B_Industry
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	B_Industry
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	B_Industry
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	B_Industry
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	B_Industry
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	B_Industry
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	B_Industry
1A2gvii	Mobile Combustion in manufacturing industries and construction	I_Offroad
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	B_Industry
1A3ai(i)	International aviation LTO (civil)	H_Aviation
1A3aai(i)	Domestic aviation LTO (civil)	H_Aviation
1A3bi	Road transport: Passenger cars	F_RoadTransport
1A3bii	Road transport: Light duty vehicles	F_RoadTransport
1A3biii	Road transport: Heavy duty vehicles and buses	F_RoadTransport
1A3biv	Road transport: Mopeds & motorcycles	F_RoadTransport
1A3bv	Road transport: Gasoline evaporation	F_RoadTransport
1A3bvi	Road transport: Automobile tyre and brake wear	F_RoadTransport
1A3bvii	Road transport: Automobile road abrasion	F_RoadTransport
1A3c	Railways	I_Offroad
1A3di(ii)	International inland waterways	G_Shipping

<b>NFR</b>	<b>NFR name</b>	<b>GNFR</b>
1A3dii	National navigation (shipping)	G_Shipping
1A3ei	Pipeline transport	I_Offroad
1A3eii	Other (please specify in the IIR)	I_Offroad
1A4ai	Commercial/institutional: Stationary	C_OtherStationaryComb
1A4aii	Commercial/institutional: Mobile	I_Offroad
1A4bi	Residential: Stationary	C_OtherStationaryComb
1A4bii	Residential: Household and gardening (mobile)	I_Offroad
1A4ci	Agriculture/Forestry/Fishing: Stationary	C_OtherStationaryComb
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	I_Offroad
1A4ciii	Agriculture/Forestry/Fishing: National fishing	I_Offroad
1A5a	Other stationary (including military)	C_OtherStationaryComb
1A5b	Other, Mobile (including military, land based and recreational boats)	I_Offroad
1B1a	Fugitive emission from solid fuels: Coal mining and handling	D_Fugitive
1B1b	Fugitive emission from solid fuels: Solid fuel transformation	D_Fugitive
1B1c	Other fugitive emissions from solid fuels	D_Fugitive
1B2ai	Fugitive emissions oil: Exploration, production, transport	D_Fugitive
1B2aiv	Fugitive emissions oil: Refining / storage	D_Fugitive
1B2av	Distribution of oil products	D_Fugitive
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	D_Fugitive
1B2c	Venting and flaring (oil, gas, combined oil and gas)	D_Fugitive
1B2d	Other fugitive emissions from energy production	D_Fugitive
2A1	Cement production	B_Industry
2A2	Lime production	B_Industry
2A3	Glass production	B_Industry
2A5a	Quarrying and mining of minerals other than coal	B_Industry
2A5b	Construction and demolition	B_Industry
2A5c	Storage, handling and transport of mineral products	B_Industry
2A6	Other mineral products	B_Industry
2B1	Ammonia production	B_Industry
2B10a	Chemical industry: Other (please specify in the IIR)	B_Industry
2B10b	Storage, handling and transport of chemical products (please specify in the IIR)	B_Industry
2B2	Nitric acid production	B_Industry
2B3	Adipic acid production	B_Industry
2B5	Carbide production	B_Industry
2B6	Titanium dioxide production	B_Industry
2B7	Soda ash production	B_Industry
2C1	Iron and steel production	B_Industry
2C2	Ferroalloys production	B_Industry
2C3	Aluminium production	B_Industry
2C4	Magnesium production	B_Industry
2C5	Lead production	B_Industry
2C6	Zinc production	B_Industry
2C7a	Copper production	B_Industry
2C7b	Nickel production	B_Industry
2C7c	Other metal production	B_Industry
2C7d	Storage, handling and transport of metal products	B_Industry
2D3a	Domestic solvent use including fungicides	E_Solvents
2D3b	Road paving with asphalt	E_Solvents
2D3c	Asphalt roofing	B_Industry
2D3d	Coating applications	B_Industry
2D3e	Degreasing	E_Solvents
2D3f	Dry cleaning	E_Solvents
2D3g	Chemical products	E_Solvents
2D3h	Printing	E_Solvents
2D3i	Other solvent use	E_Solvents
2G	Other product use	E_Solvents
2H1	Pulp and paper industry	B_Industry
2H2	Food and beverages industry	B_Industry

<b>NFR</b>	<b>NFR name</b>	<b>GNFR</b>
2H3	Other industrial processes	B_Industry
2I	Wood processing	B_Industry
2J	Production of POPs	B_Industry
2K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)	B_Industry
2L	Other production, consumption, storage, transportation or handling of bulk products	B_Industry
3B1a	Manure management - Dairy cattle	K_AgriLivestock
3B1b	Manure management - Non-dairy cattle	K_AgriLivestock
3B2	Manure management - Sheep	K_AgriLivestock
3B3	Manure management - Swine	K_AgriLivestock
3B4a	Manure management - Buffalo	K_AgriLivestock
3B4d	Manure management - Goats	K_AgriLivestock
3B4e	Manure management - Horses	K_AgriLivestock
3B4f	Manure management - Mules and asses	K_AgriLivestock
3B4gi	Manure management - Laying hens	K_AgriLivestock
3B4gii	Manure management - Broilers	K_AgriLivestock
3B4giii	Manure management - Turkeys	K_AgriLivestock
3B4giv	Manure management - Other poultry	K_AgriLivestock
3B4h	Manure management - Other animals	K_AgriLivestock
3Da1	Inorganic N-fertilizers (includes also urea application)	L_AgriOther
3Da2a	Animal manure applied to soils	L_AgriOther
3Da2b	Sewage sludge applied to soils	L_AgriOther
3Da2c	Other organic fertilisers applied to soils (including compost)	L_AgriOther
3Da3	Urine and dung deposited by grazing animals	L_AgriOther
3Da4	Crop residues applied to soils	L_AgriOther
3Db	Indirect emissions from managed soils	L_AgriOther
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	L_AgriOther
3Dd	Off-farm storage, handling and transport of bulk agricultural products	L_AgriOther
3De	Cultivated crops	L_AgriOther
3Df	Use of pesticides	L_AgriOther
3F	Field burning of agricultural residues	L_AgriOther
3I	Agriculture other	L_AgriOther
5A	Biological treatment of waste - Solid waste disposal on land	J_Waste
5B1	Biological treatment of waste - Composting	J_Waste
5B2	Biological treatment of waste - Anaerobic digestion at biogas facilities	J_Waste
5C1a	Municipal waste incineration	J_Waste
5C1bi	Industrial waste incineration	J_Waste
5C1bii	Hazardous waste incineration	J_Waste
5C1biii	Clinical waste incineration	J_Waste
5C1biv	Sewage sludge incineration	J_Waste
5C1bv	Cremation	J_Waste
5C1bvi	Other waste incineration	J_Waste
5C2	Open burning of waste	J_Waste
5D1	Domestic wastewater handling	J_Waste
5D2	Industrial wastewater handling	J_Waste
5D3	Other wastewater handling	J_Waste
5E	Other waste	J_Waste
6A	Other (included in national total for entire territory)	M_Other
<b>'MEMO' ITEMS - NOT TO BE INCLUDED IN NATIONAL TOTALS</b>		
1A3ai(ii)	International aviation cruise (civil)	O_AviCruise
1A3aii(ii)	Domestic aviation cruise (civil)	O_AviCruise
1A3di(i)	International maritime navigation	P_IntShipping
1A5c	Multilateral operations	z_Memo
1A3	Transport (fuel used)	z_Memo
6B	Other not included in national total of the entire territory	z_Memo
11A	Volcanoes	N_Natural
11B	Forest fires	N_Natural
11C	Other natural emissions	N_Natural

## 7.2 Mapping methodology

The methodology used in the emissions mapping follow the guidelines in the 2016 EMEP/EEA emission inventory guidebook. The overall approach aims to allocate the national total emissions to the geographical location where they occur as accurately as possible. A distinction is made between point sources and area sources. Point sources are sources that can be treated individually and have an exact location, e.g. industrial plants. Area sources cover a group of minor emission sources with similar characteristics that cannot be treated individually because of the number of sources, e.g. residential plants. Some sectors are covered only by point sources or only by area sources, but many sectors cover both point and area sources. In the latter case point and area sources are treated separately in the data processing and following they are combined on sectoral level in the spatial emission mapping.

Emissions from point sources can be allocated to an exact location, e.g. the location of a power plant or an industrial plant. Activity data and/or emissions are available for a number of large plants e.g. from PRTR/E-PRTR reporting. These data are used either directly (emissions) or indirectly (activity data) to allocate point source emissions. Both locations and emissions are generally very accurate for point sources.

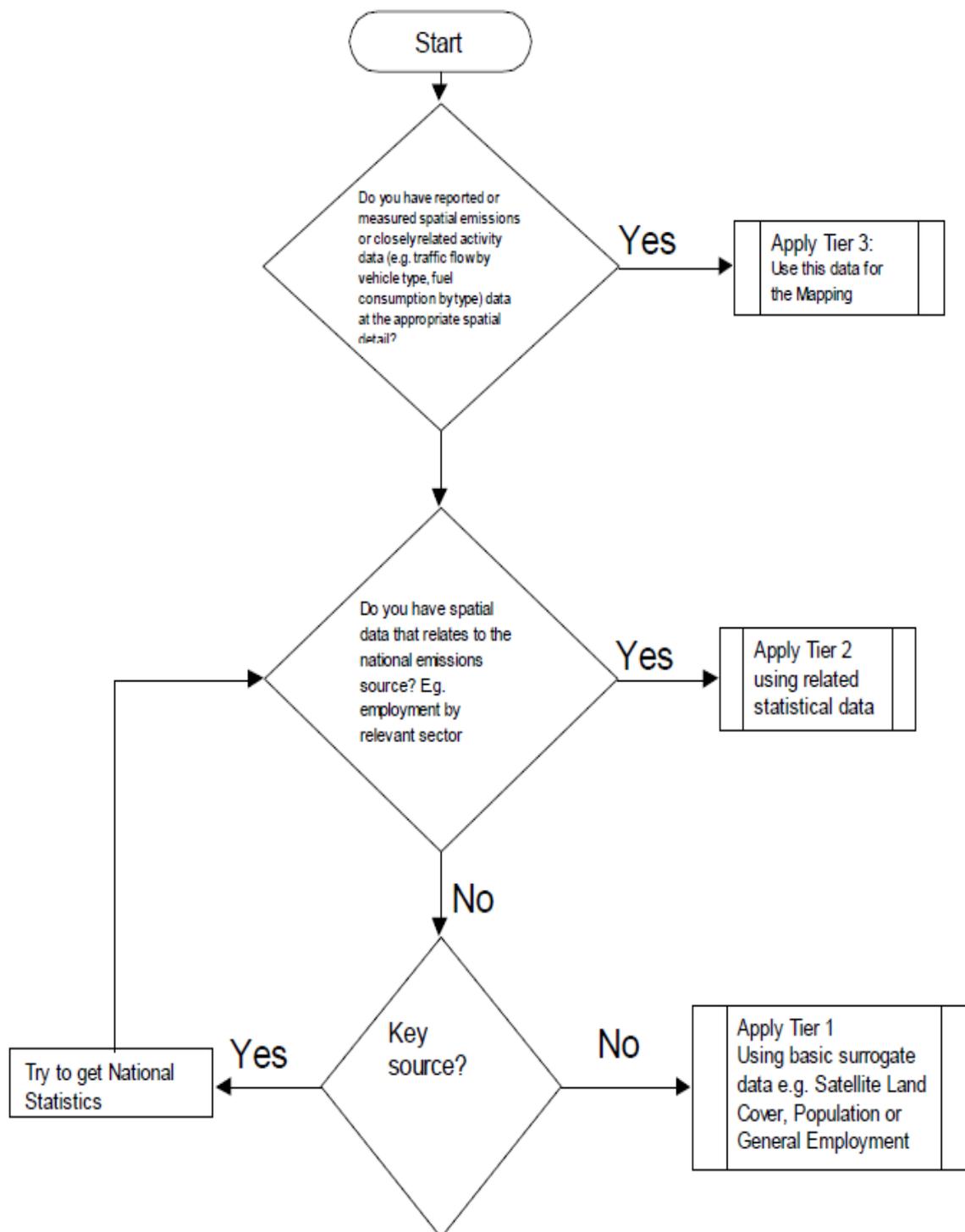
The individual source contribution cannot be determined for area sources, and emissions allocations are based on a number of spatial data sets. For each area source related available spatial data are evaluated and the closest related are used for emission mapping, taking into account completeness (must cover the entire national area), spatial resolution, accuracy, update frequency etc.

The 2016 EMEP/EEA Guidebook describes a tiered approach for spatial distribution of emissions, depending on the data availability and level of detail for the individual emission sources/sectors. Furthermore, different methodological tiers can be used for different pollutants from a source, e.g. point source emission data are most often available only for some pollutants, while emission mapping for remaining pollutants follow a lower tier method.

The concept of tiered mapping is summarised as follows:

- **Tier 3 methods** are based on closely related spatial emission or activity data, e.g. data for regulated processes and industries, and road traffic flows by vehicle type derived from surveys.
- **Tier 2 methods** are based on the use of surrogate statistics relate to the sector, e.g. heat demand for the residential sector, agricultural animal statistics, and land parcel identification system data
- **Tier 1 methods** are based on loosely related surrogate statistics, e.g. building use, population density, and land use.

The tiered methodology is outlined in the decision tree in Figure 7.1



*Figure 7.1 General decision tree for emissions mapping (EMEP/EEA 2016)*

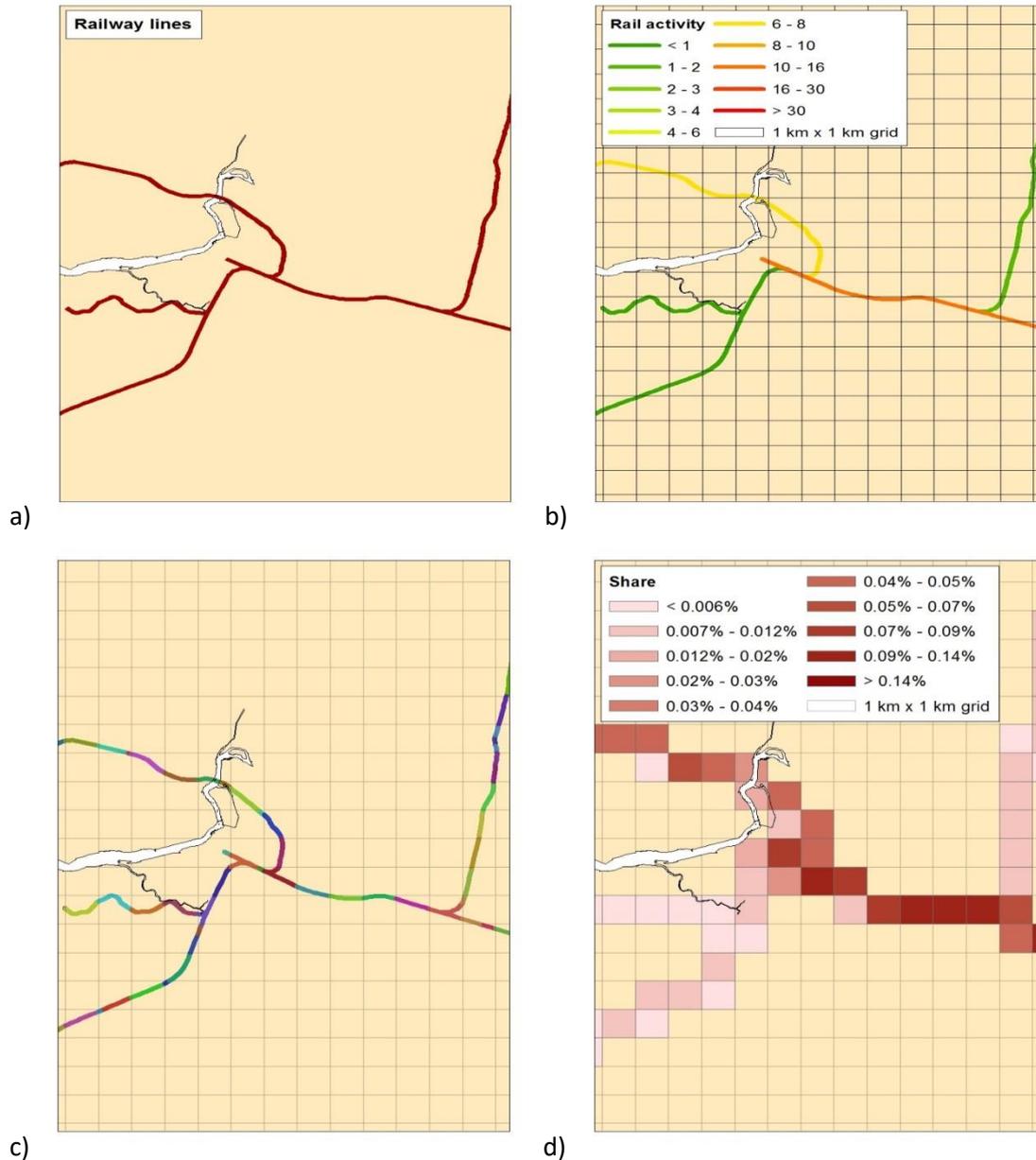
Mapping of Ireland's emissions is done on a highly disaggregated level both regarding sectoral and spatial resolution. Spatial distribution keys (GeoKeys) are set up for each NFR category with a spatial resolution of 1 km x 1 km. GeoKeys are normalised tables including the share of an emission source that should be allocated to each grid cell. Some GeoKeys are used for all pollutants from a sector, while others are pollutant specific. Further, some sectors have been disaggregated into different sources and GeoKeys have been set up on source level and afterwards combined to create one overall

GeoKey for the NFR sector. In this way, a high level of accuracy is ensured in the emission mapping as the highest tier level methodology is applied for all sources.

GeoKeys for the individual sectors/sources are built from a number of different spatial data. Some of the spatial data sets describe the emission allocation very accurate, e.g. E-PRTR reporting, while others are proxies for activity level or other related parameters; some being good proxies, e.g. mileage data for emissions from road transport, others being less good proxies, e.g. population density for domestic solvent use.

The common methodological approach is to make an overlay analysis of one or more spatial layers and the 1 km x 1 km grid in a Geographical Information System (GIS).

Preparation of the GeoKey for railway transport is described here as an example, and related maps are shown in Figure 7.2. Railway transport is an area source, and the emissions are spatially allocated to the railway network. The railway network is available as a digital map including the network as lines (Figure 7.2 a), which allow for the emissions to be distributed evenly to the railway network. Activity data based on railway statistics are added to the map's attribute data, and are used to improve the spatial distribution to allocate emissions according to the activity levels. An overlay of the railway network including activity data and the 1 km x 1 km grid is made in GIS (Figure 7.2 b), and the layers are intersected to cut the railway lines by the grid (Figure 7.2 c). The length of each line segment is calculated using standard GIS tools, and the share of each railway line in each grid cell is calculated. As more line segments can occur in the same grid cell, e.g. when two railway lines meet, the shares are summarised by grid cell to generate the GeoKey, which holds the share of the national emission by grid cell (Figure 7.2 d).



*Figure 7.2 Example of GeoKey preparation*

The emission mapping is made using an orthogonal grid with a resolution of 1 km x 1 km in the Irish projection TM65. The spatial emissions are redistributed into the reporting grid, the EMEP/EEA grid with a spatial resolution of 0.1 degree x 0.1 degree, using the share of each 1 km x 1 km grid cell that intersects the individual 0.1 degree x 0.1 degree grid cells.

### 7.3 Mapping methods for each GNFR

A summary of the data and mapping approaches used in compilation of the spatial inventory for Ireland are outlined in the tables below by GNFR sector. An indication of the tier 1-3 categorisation has also been provided as a simple measure of uncertainty in the approach applied. A more detailed description of the methodologies applied is available in Plejdrup et al. (2017)

### 7.3.1 Public Power (GNFR A\_PublicPower)

Detailed location information for this sector were available on the individual large point sources for the NFR sector 1A1a Public Power. The emissions for some pollutants were available for the individual point sources, and in these cases, the data were used directly. For the pollutants where plant specific data were not available, the distribution is based on the activity data. The use of plant specific data and exact location of the emissions corresponds to a tier 3 method.

### 7.3.2 Industry (GNFR B\_Industry)

As shown in Table 7.1, this GNFR covers many different source categories and hence the available spatial data vary across sectors. The categories include both combustion related categories and categories where the emissions are related to the process.

Where detailed emissions and location information were available, e.g. from the E-PRTR or the EU ETS on the individual point source emissions for the NFR sectors in GNFR B Industrial Combustion sector, these were used to map emissions to the known location. This is the case for e.g. emissions from refining and other energy industries (NFR categories 1A1b and 1A1c respectively).

For other source categories, some data are available at point source level, but the coverage does not match the national total. In these cases the emissions covered by point sources are allocated to the relevant point sources and the residual emission is distributed according to a more general spatial distribution key, e.g. industrial heat demand. These two distributions are then combined to one GeoKey covering the total sectoral emission. This approach is considered a tier 2 or tier 3 method.

### 7.3.3 Other stationary combustion (GNFR C\_OtherStationaryComb)

This GNFR category covers combustion in three subsectors, i.e. commercial/institutional, residential and agriculture. The most important sector in terms of emission contribution is residential combustion.

For commercial/institutional plants, the distribution is based on heat demand for commercial and public buildings as calculated by the Irish Heat Map. The Heat Map is based on a study from 2015 commissioned by SEAI to fulfil Ireland's requirements under article 14 of the Energy Efficiency Directive (2012/27/EU). As part of this study a spatial representation of Ireland's heat demand was developed.

For residential plants, the distribution is based on information from the 2011 census on primary fuel types in households combined with an estimated unit consumption calibrated with the estimated national residential fuel consumption and the emission factors used in the emission inventory.

For the agricultural sector, the spatial data on farmyards and buildings from the Land Parcel Information System (LPIS) were used. This is considered tier 2/3 methodologies.

### 7.3.4 Fugitive Emissions (GNFR D\_Fugitive)

This sector covers both categories estimated as point sources (e.g. coal mining/handling, service stations and flaring) and area sources (e.g. natural gas distribution).

The point source data have been used to allocate emissions and, where available, activity data have been incorporated to further improve the distribution of emissions. Information on coal mining areas as well as coal consumers were provided by the EPA, while a list of service stations was provided by the CSO. For natural gas distribution, the spatial information included for gas use in the Heat Map was utilised to distribute emissions.

This is considered tier 2/3 methodologies.

### 7.3.5 Solvents (GNFR E\_Solvents)

The national emissions from domestic solvent use were mapped across the country using population density as spatial proxy. This approach is a tier 2 method.

For the remaining solvent use categories, there was some spatial information available, e.g. location of dry cleaners. However, both population density and industrial heat demand were used as spatial proxies to map emissions from coating applications, chemical products and printing. This is considered tier 1/2/3 methodologies.

### 7.3.6 Road transport (GNFR F\_RoadTransport)

Spatial mileage data for national roads (NR) provided by TII for total mileage and % heavy vehicles are used to allocate emissions from road transport on NR. Road transport on other roads is estimated as the residual of the national total mileage used in the inventory, and emissions are allocated to roads other than national roads. As mileage data is not available for other roads than NR a polygon map of the road network is applied for mapping, thereby using road area as a proxy for the activity level. Separate GeoKeys are prepared for passenger cars including vans and 2-wheelers (PC), heavy vehicles including busses (HV), and all vehicles (PC+HV). The approaches used are tier 3 for national roads and tier 2 for remaining roads.

### 7.3.7 National navigation (GNFR G\_Shipping)

The estimates of the emissions from national navigation were mapped using a buffer zone of six nautical miles around the coast of Ireland. The buffer zone was adjusted to take into account the shortest path between headlands in Ireland. This approach is a tier 2 method.

### 7.3.8 Aviation (LTO) (GNFR H\_Aviation)

National total emissions from aircraft operating on the ground and in the air over Ireland, up to an altitude of 1000 m (equating to the take offs and landing – LTO) were mapped at the locations of the airports including a five-kilometre buffer zone. The number of LTOs at each airport was used to further improve the distribution of emissions. This approach is a tier 3 method.

### 7.3.9 Off road mobile sources (GNFR I\_Offroad)

This GNFR category comprises several different activities such as railways, fishing and agricultural machinery.

For railways, the railway network and data for annual passages were provided by Irish Rail and this information has been used to develop a GeoKey for this sector.

For fishing, the emissions have been distributed based on data for fishing areas within the Irish exclusive economic zone and fishing statistics.

For agricultural machinery, data on the number of different types of machinery at county level were obtained from the CSO and this information was combined with the land information from LPIS on cropland and improved grassland. This is considered tier 2/3 methodologies.

#### 7.3.10 Waste handling and treatment (GNFR J\_Waste)

The estimates of the emissions from solid waste disposal on land were mapped at the locations of landfill sites. For composting 75 % of the emission were allocated to the licensed facilities while the remaining 25 % were allocated to non-urban residential buildings.

Emissions from clinical waste incineration, industrial waste incineration and cremation were mapped at the locations of the known facilities. Activity and location data for industrial waste incinerators and crematoria were available and used to weight emissions to areas of known activity proportionally.

Estimates of the national emissions from other waste handling (e.g. accidental fires) were mapped according to population density.

This is considered tier 1/2/3 methodologies

#### 7.3.11 Agricultural livestock (GNFR K\_AgriLivestock)

National emissions from pigs and poultry were distributed based on detailed data on farms and animal numbers from the 2010 agricultural census provided by UCD.

National emissions from mink were distributed based on farm locations and animal numbers provided by EPA.

National emissions from cattle, sheep and horses were distributed based on data from the 2010 agricultural census provided by CSO on the number of animals per electoral district combined with the Land Parcel Identification System (LPIS) data on location of farmyards and buildings.

National emissions from goats, mules and asses, and deer were distributed based on data from the 2010 agricultural census provided by CSO on the number of animals per county combined with the Land Parcel Identification System (LPIS) data on location of farmyards and buildings. This approach is a tier 2/3 method.

#### 7.3.12 Agricultural soils (Other emissions) (GNFR L\_AgriOther)

National emissions from sources related to agricultural soils, e.g. application of fertiliser and manure as well as grazing animals were distributed on cropland and/or grassland from LPIS, taking into account the animal density when distributing emissions from animal manure. This approach is a tier 1/2 method.

#### 7.3.13 Aviation (Cruise) (GNFR O\_AviCruise)

This category includes cruise emissions from both national and international aviation. For national cruise emissions, the distribution is based on information on the number of flights between Irish airports and emissions are allocated to great circle lines between these airports.

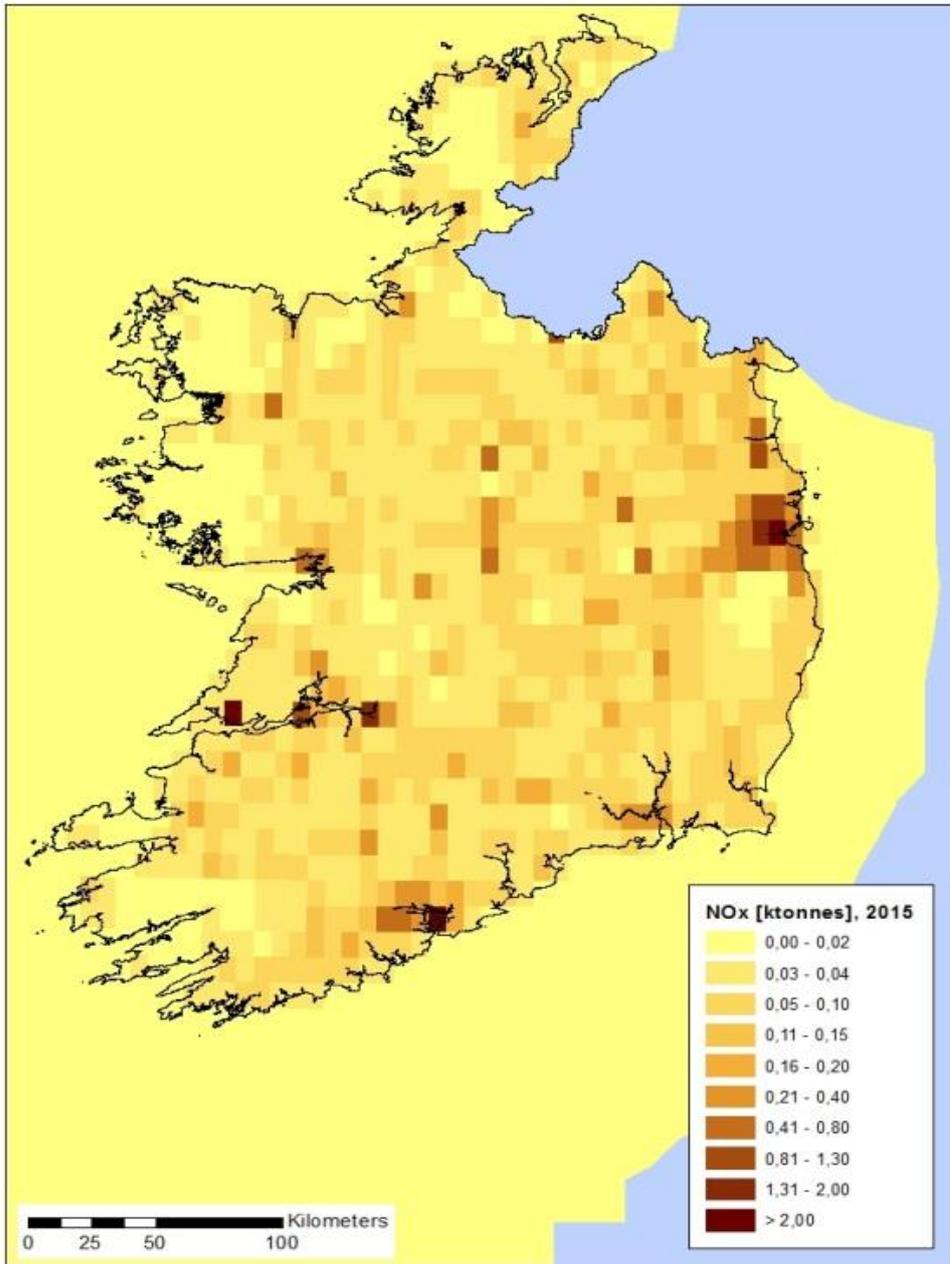
For international cruise emissions, the majority of emissions will occur outside the Irish territory, but for the purposes of the submission, emissions are allocated evenly across the entire Irish area outlined by the Irish Exclusive Economic Zone (EEZ).

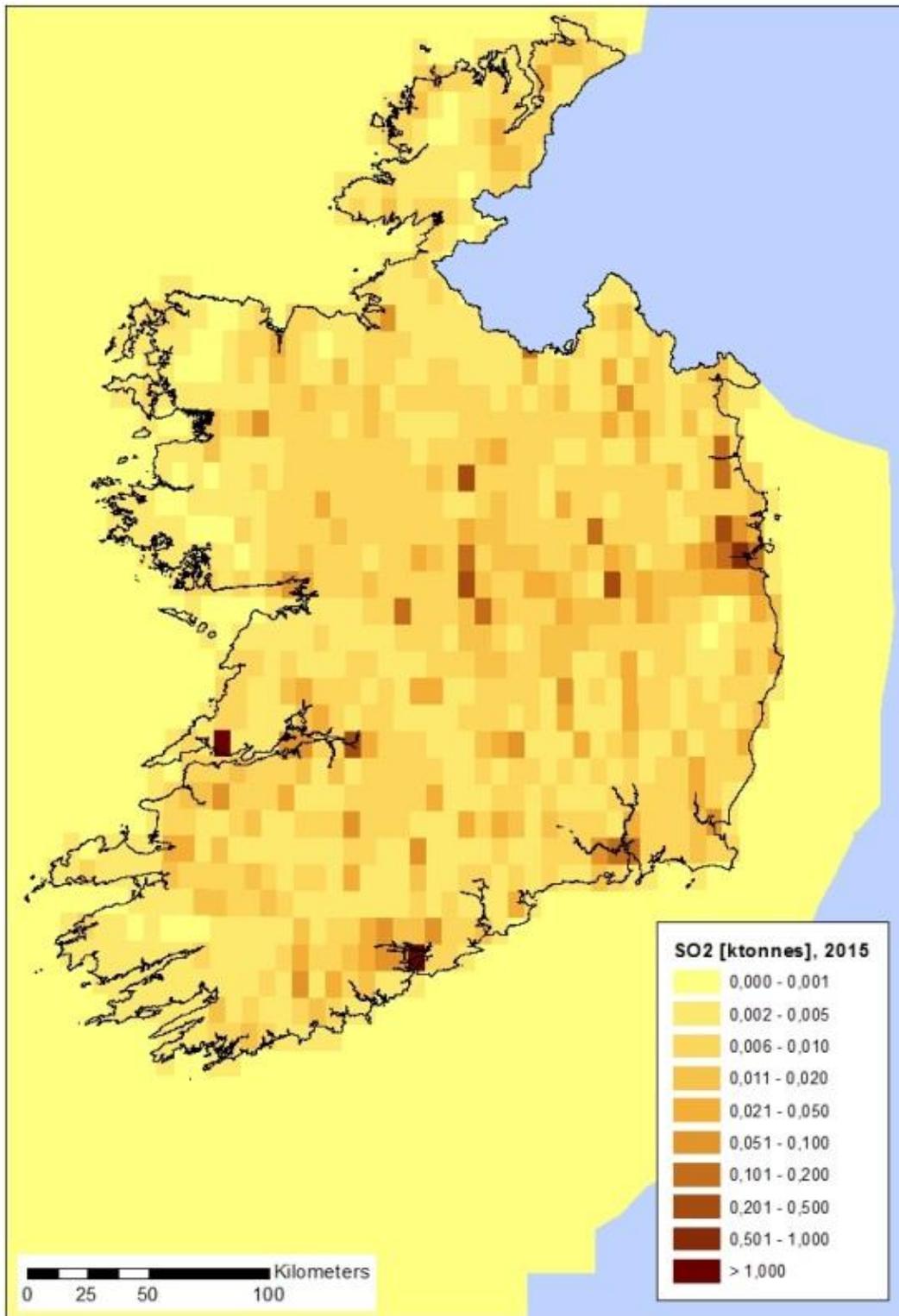
#### 7.3.14 International navigation (GNFR P\_IntShipping)

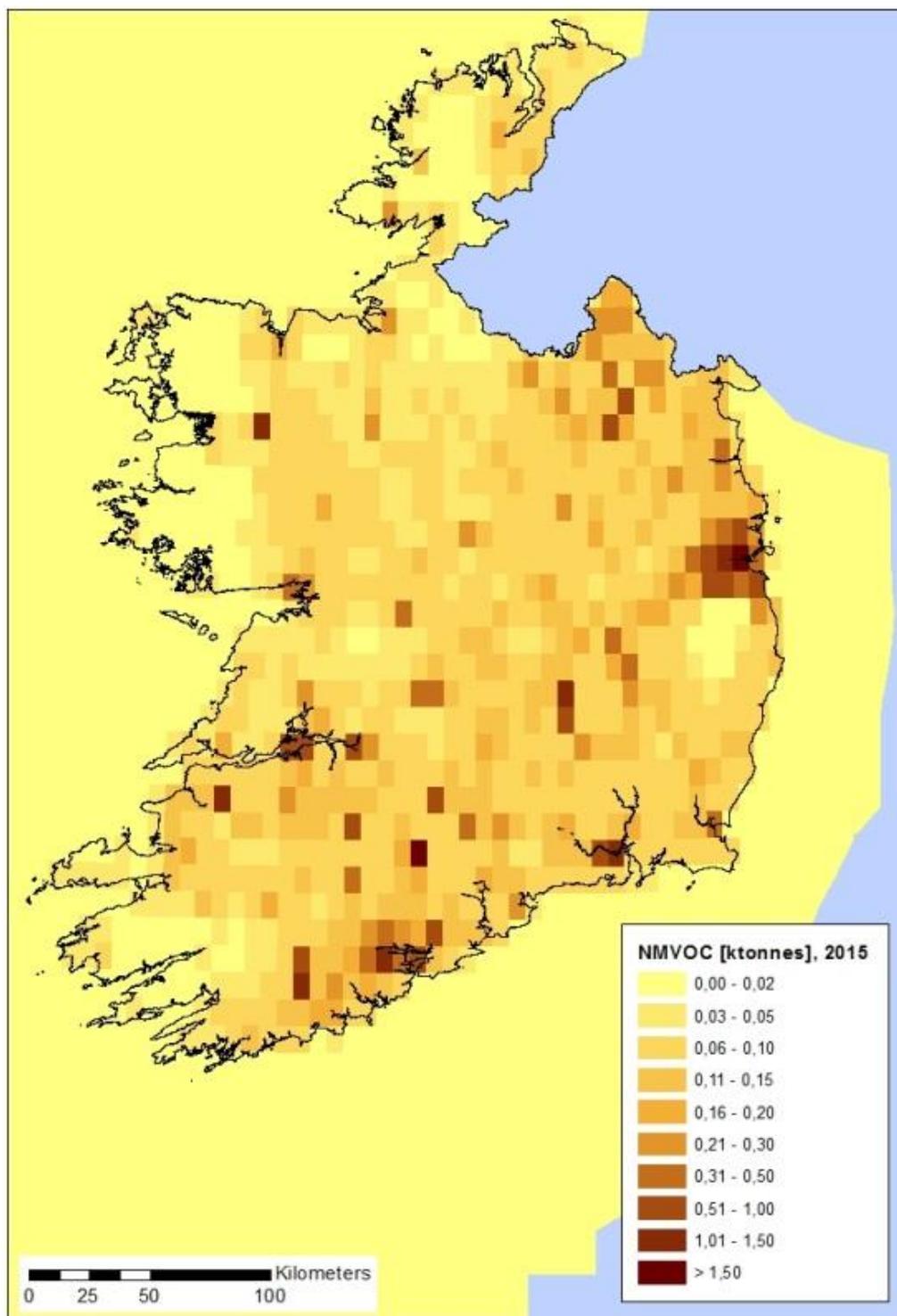
Emissions from international navigation will largely occur outside the Irish territory, but for the purposes of the submission, emissions are allocated evenly across the sea area outlined by the Irish Exclusive Economic Zone (EEZ).

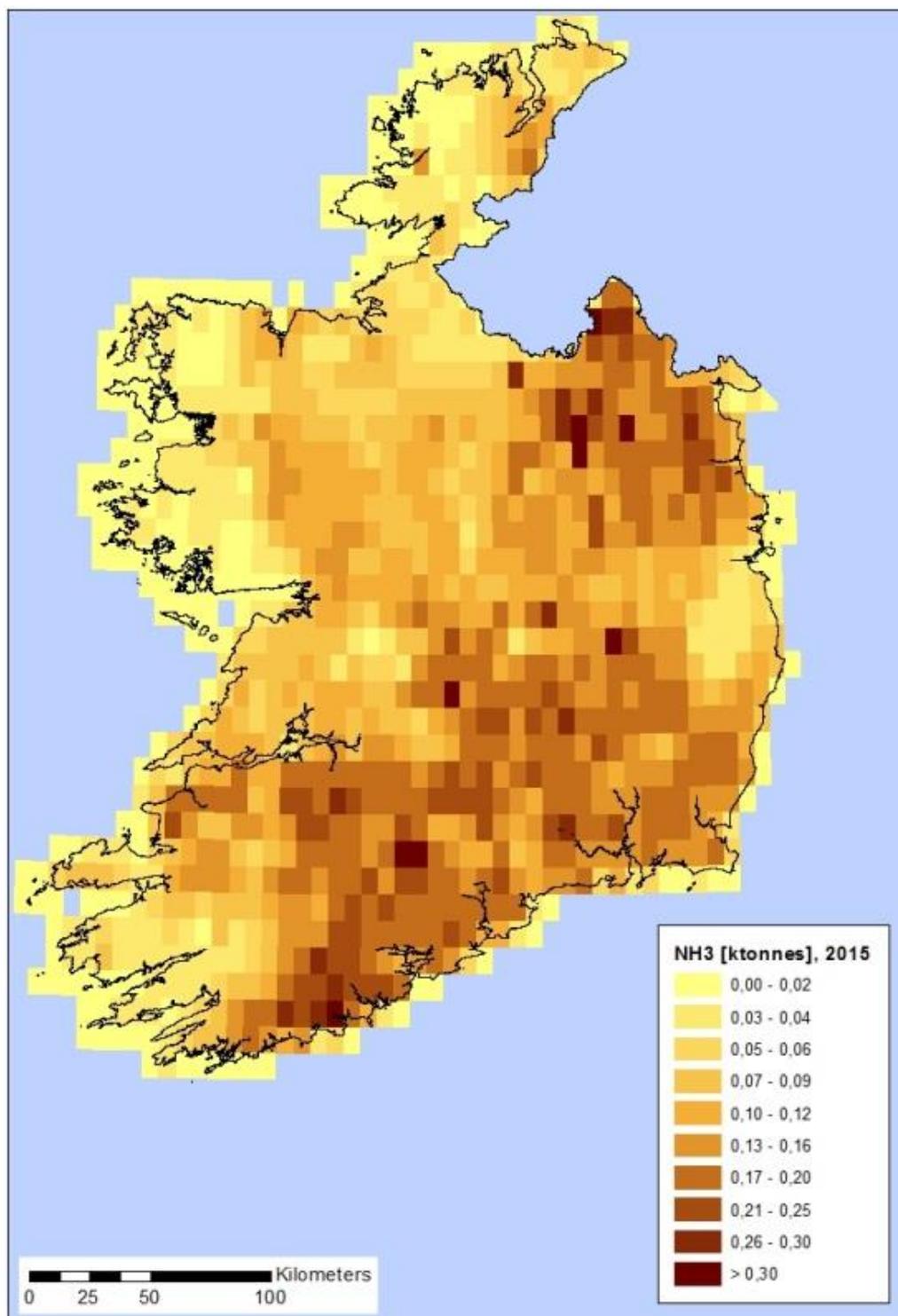
#### 7.4 National total emission mapped by the EMEP 0.1 degree x 0.1 degree grid

Figure 7.3 a-e present the mapped national total emissions for NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub>, and PM<sub>2.5</sub> in Ireland by EMEP 0.1 x 0.1 degree grid.









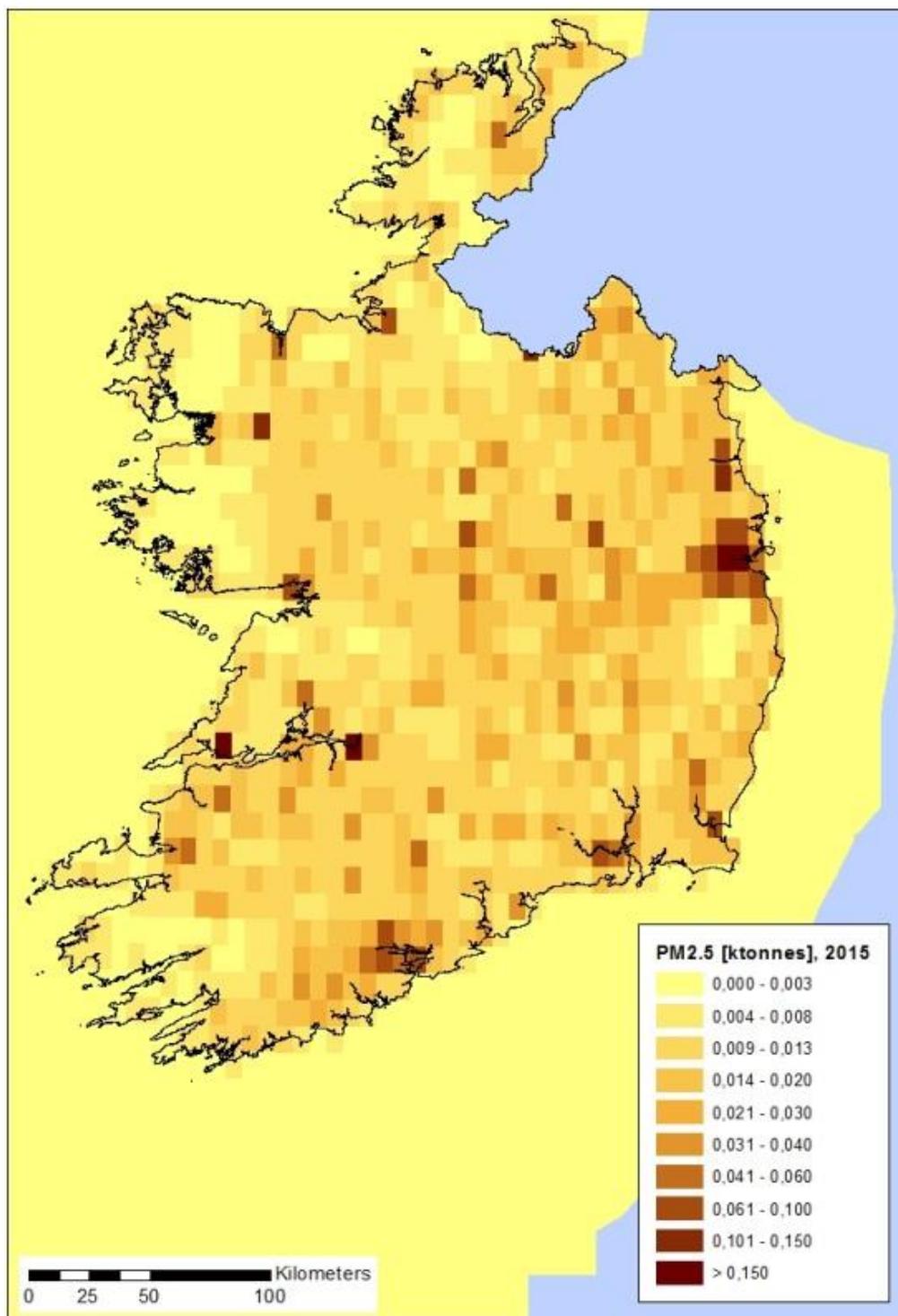


Figure 7.3 National Total Emissions in 2015 for a)  $\text{NO}_x$ , b)  $\text{SO}_2$ , c) NMVOC, d)  $\text{NH}_3$ , and e)  $\text{PM}_{2.5}$

# Chapter Eight

## Projections

### 8.1 Overview of Emissions Projections

Ireland's Environmental Protection Agency (EPA) is responsible for developing, preparing and reporting periodic projections of air pollutants. The EPA is also the responsible body for preparing greenhouse gas emissions projections that are submitted under the Monitoring Mechanism Regulation (Regulation 525/2013). This chapter presents an update on the emission projections that have been compiled for reporting under the National Emissions Ceiling Directive (2016/2284/EU) which harmonises the reporting obligations under the Convention on Long Range Transboundary Air Pollution (CLRTAP).

Section 8.2 describes emission reduction targets for 2020 and 2030. Section 8.3 provides a short explanation of how energy projections are generated for both "*With Measures*" and "*With Additional Measures*" scenarios. Information on key assumptions and underlying data are also provided.

Section 8.4 presents the emission projections for each of the pollutants covered, and considers the key trends across the time series. Sections 8.5 to 8.13 presents the key input assumptions and methodologies for the main sectors which include the impact of national policies and measures aimed at reducing greenhouse gas emissions and how these affect air pollutant emission levels.

Article 8 of Directive (2016/2284/EU) requires biennial reporting from 2017 of projected emissions for SO<sub>2</sub>, NO<sub>x</sub>, NH<sub>3</sub>, NMVOC, PM<sub>2.5</sub> and, if available, Black Carbon (BC) covering projection years 2020, 2025, 2030 and, where available, 2040 and 2050. Although 2020 is an intervening year with no mandatory reporting, the EPA has updated its air pollutant projections this year.

The CLRTAP guidelines for reporting emissions and projections data state that parties to the Gothenburg Protocol within the geographical scope of the EMEP shall regularly update their projections and report every four years from 2015 onwards their updated projections, for the years 2020, 2025 and 2030 and, where available, also for 2040 and 2050. Parties to the other protocols are encouraged to regularly update their projections and report every four years from 2015. In addition, parties should provide a "*With Measures*" (WM) and where relevant a "*With Additional Measures*" (WAM) projection estimate.

Projected emission estimates and supporting quantitative information are reported for SO<sub>2</sub>, NO<sub>x</sub>, NH<sub>3</sub>, NMVOC, PM<sub>2.5</sub> and BC under Directive (2016/2284/EU) utilising the reporting template contained within annex IV of the Guidelines for Reporting Emissions and Projections Data under the CLRTAP<sup>5</sup>.

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<sup>5</sup> [http://www.ceip.at/reporting\\_instructions/annexes\\_to\\_guidelines/](http://www.ceip.at/reporting_instructions/annexes_to_guidelines/)

This chapter details emission projections under both the *With Measures* scenario and *With Additional Measures* scenario for the following pollutants which are subject to emission reduction targets for the period 2018-2030: NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub>.

## 8.2 Emission Reduction Targets for 2020 and 2030

The National Emission Ceilings Directive (NECD, 2001/81/EC) was reviewed as part of the Clean Air Policy Package and a new Directive came into effect in December 2016<sup>6</sup>. Emission reduction commitments have been set for Ireland for 2020 and 2030 for NO<sub>x</sub>, SO<sub>x</sub>, NMVOC, NH<sub>3</sub>, and PM<sub>2.5</sub>. Table 8.1 details the emission reduction targets in place for each pollutant for 2020 and 2030 for Ireland under the new National Emissions Ceilings Directive.

**Table 8.1. Emission Reduction Commitments for 2020 and 2030 (expressed as a percentage reduction on 2005 levels)**

Pollutant	SO <sub>2</sub>	NO <sub>x</sub>	NH <sub>3</sub>	NMVOC	PM <sub>2.5</sub>
<b>2020</b>	65%	49%	1%	25%	18%
<b>2030</b>	85%	69%	5%	32%	41%

## 8.3 With Measures and With Additional Measures Scenarios - Approach

This year's projections take into account updated projected activity data provided by a number of key data providers including:

- Energy projections underpinning the 2020 emissions projections were prepared by Sustainable Energy Authority of Ireland in conjunction with the Economic and Social Research Institute (ESRI) and University College Cork. The ESRI produce energy demand projections using the I3E model (Ireland Environment, Energy and Economy model)<sup>7</sup>.
- Agricultural projections provided by Teagasc (Agriculture and Food Development Authority) in November 2019 which considers the impact of Food Wise 2025<sup>8</sup> for the agriculture sector.

SEAI compile two energy projections scenarios, which are used in national emission projections:

- The *Baseline* energy projections projects forward Ireland's energy demand, incorporating the expected impacts of policies and measures that were in place (e.g. legislatively provided for) by the end of 2018. It represents a hypothetical future scenario in which no further policy actions or measures have been taken.
- The *Advanced* energy projections presents an alternative view of future energy demand that accounts for further implementation of the *With Measures* scenario in addition to the implementation of planned government policies and measures such as Ireland's 2019 Climate Action Plan<sup>9</sup>.

<sup>6</sup> DIRECTIVE (EU) 2016/2284 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC

<sup>7</sup> <https://www.esri.ie/current-research/the-i3e-model>

<sup>8</sup> <http://www.agriculture.gov.ie/foodwise2025/>

<sup>9</sup> <https://www.dccae.gov.ie/en-ie/climate-action/publications/Pages/Climate-Action-Plan.aspx>

The *Baseline* energy projection underpins the *With Measures* emission projection for the energy sector and the *Advanced* energy projection underpins the *With Additional Measures* projection for the energy sector.

For the energy demand projections, the Economic and Social Research Institute (ESRI) used the I3E model<sup>10</sup>.

The I3E model is an intertemporal computable general equilibrium (CGE) model, which reproduces the structure of the economy in its entirety, including productive sectors, households, and the government, among others. In the model the nature of all existing economic transactions among diverse economic agents is quantified. According to micro economic behaviour, producers and consumers maximise their profits/utility given their budget constraints. In other words, a CGE model examines how inputs and outputs flow between production sectors of the economy and finally result in final goods consumed by households. The model combines theory and data to examine energy use changes due to developments in the economy, labour market, policies and international prices.

The explicit modelling of sectorial inter-linkages makes it possible to investigate the wider economic impacts of a specific shock or policy through the different transmission channels in the economy. Therefore, CGE models have become a standard tool of empirical analysis, and are widely used to analyse the welfare and distributional impacts of policies whose effects may be transmitted through multiple markets. Because of its nature, CGE modelling is significantly useful for policy design and evaluation specifically when policy measures are expected to lead to indirect as well as direct effects, as in the case of energy-related policies. For example, the economic implications of an energy tax in the transport sector can be evaluated both for the transport sector and other sectors through inter-sectoral spill-overs.

The I3E model includes energy flows in addition to the standard monetary flows. Each production sector produces an economic commodity using labour, capital, material inputs, and energy inputs. The I3E model explicitly comprises a set of carbon commodities including peat, coal, natural gas, crude oil, fuel oil, LPG, gasoline, diesel, kerosene, and other petroleum products. Production activities produce in the cheapest way possible by using the optimal set of capital, labour, energy and other intermediate inputs based on both relative prices and substitution possibilities. When an energy policy is implemented (e.g. an increase in carbon tax) or in case of an external shock (e.g. an increase in international energy prices or ETS price), production sectors will where possible substitute energy inputs for other inputs and/or decrease the carbon content of their energy inputs by demanding cleaner energy. From the consumers' perspective, higher prices of goods with higher carbon content will encourage them to consume less carbon-intensive products.

I3E is a dynamic model, which incorporates economic growth over the modelling horizon. Economic growth originates from three sources; the growth of employment driven by population growth, the growth in capital stock driven by investment, and the growth in total factor productivity or productivity of factors of production. It is assumed that the total population grows at a constant rate and the technology, i.e. the productivity of labour force grows at a constant rate. In the current version, the

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<sup>10</sup> <https://www.esri.ie/current-research/the-i3e-model>

values of population growth and economic growth are retrieved from the medium-run estimates of the macro econometric forecast model of the ESRI, namely COSMO (COre Structural MOdel for Ireland).

### *Baseline Assumptions*

In CGE modelling, a change in a policy variable/parameter or a set of policy variables/parameters is defined as a shock process or experiment. The effects of the experiment are given as the paths of variables that are solved within the model and are reported in terms of a percentage change with respect to the baseline. The baseline is a path such that there is no change in any policy variables/parameters, but an economy evolves according to its internal dynamics. For instance, since the internal dynamics of the I3E model are driven by the population and labour productivity growths, the Irish economy would grow at 3.3% per annum without any policy intervention. Since there are no external interventions in the economy, the base path is also called the business-as-usual path. Therefore, in the base path, the current carbon tax of €20 is continued but not increased.

### *Fossil Fuel Prices*

Future international fossil fuel prices are given as input to the I3E model. For the low fossil fuel price scenario (i.e. in the case of the energy related projections described in this document), the UK Department for Business, Energy and Industrial Strategy (BEIS) low price scenario is applied<sup>11</sup> (oil, gas and coal price projections). Furthermore, how other fuel prices (gasoline, diesel, kerosene, LPG, fuel oil and other petroleum products) fluctuate with the oil price are econometrically estimated. These estimated relationships are used to project future international prices of all fuel types.

### *Carbon prices*

The recommended ETS carbon prices are based on the EU Reference Scenario.

The I3E model implements two carbon prices, namely the Irish carbon tax and the EU ETS price. The EU ETS price projections are taken from the EU reference scenario. The Irish carbon tax currently stands at €20 a tonne. Two Irish carbon tax scenarios are run; one (*With Measures* scenario) with a €20 carbon tax into the future and one (*With Additional Measures* scenario) with an increasing tax in line with the Climate Action Plan. In the latter scenario, the carbon tax of €80 per tonne in 2030 is achieved by gradually increasing the carbon tax over time.

The software used for to model the Irish Electricity Market is PLEXOS which is a power systems modelling tool used for electricity market modelling and planning.

To produce the finalised *Baseline* energy projections, SEAI amends the output of the energy demand produced by ESRI to take account of the expected impact of energy efficiency measures put in place before the end of 2018 but which are considered too recent to be detectable in any time-series analysis. The *Advanced* energy projections builds on the *Baseline* projections with adjustments made to account for implementation of additional policies and measures outlined in Ireland's 2019 Climate Action Plan.

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<sup>11</sup>[https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/764342/BEIS\\_2018\\_Fossil\\_Fuel\\_Price\\_Assumptions.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/764342/BEIS_2018_Fossil_Fuel_Price_Assumptions.pdf)

The model input assumptions for the latest SEAI Energy Projections were finalised in quarter 1 of 2020. Determination of anticipated progress in the implementation of policies and measures was coordinated by the SEAI in discussion with the relevant Government Departments. Table 8.2 shows the key parameters underlying the macroeconomic outlook and therefore the *With Measures* and *With Additional Measures* emission projections scenarios.

Further details on the models used for preparing the energy projections (i.e. I3E, Plexos Integrated Energy Model, SEAI's Energy Scenario Tool, SEAI BioHeat Model) are included in the 2020 submission made under Article 14 of the Monitoring Mechanism Regulation (Regulation 525/2013). This is available in the relevant 2020 submission folder at the following link:

[https://cdr.eionet.europa.eu/ie/eu/mmr/art04-13-14\\_lcds\\_pams\\_projections/projections/](https://cdr.eionet.europa.eu/ie/eu/mmr/art04-13-14_lcds_pams_projections/projections/)

**Table 8.2. Key assumptions underpinning the energy projections**

	2019 – 2020	2021-2025	2026-2030
<b>Average Annual % Growth Rate</b>			
<b>GDP</b>	3.32	3.32	3.31
<b>GNP</b>	3.32	3.32	3.31
<b>Personal Consumption</b>	3.34	3.30	3.30
	<b>2020</b>	<b>2025</b>	<b>2030</b>
<b>Housing Stock ('000)</b>	2,071	2,196	2,322
<b>Population ('000)</b>	4,824	5,021	5,225
<b>EUETS: Carbon €<sub>2016</sub>/tCO<sub>2</sub></b>	15.5	23.3	34.7
<b>Carbon tax €/tCO<sub>2</sub> (WM Scenario)</b>	20	20	20
<b>Coal \$<sub>2016</sub>/boe</b>	11.21	10.88	10.52
<b>Oil \$<sub>2016</sub>/boe</b>	46.30	46.23	45.79
<b>Gas \$<sub>2016</sub>/boe</b>	24.68	23.05	20.93

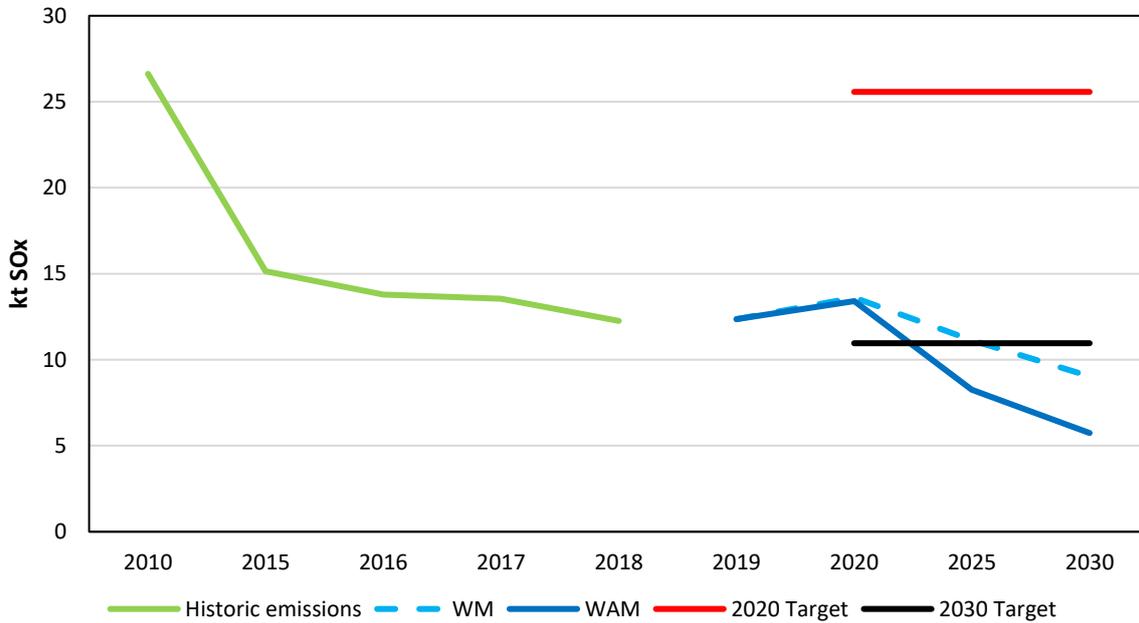
## 8.4 Key Trends

In the following sections, both *the With Measures* (WM) and *With Additional Measures* (WAM) scenarios are presented in the context of emission reduction targets set for 2020 and 2030. The WAM scenario is then considered in more detail. The 1990-2018 inventory was used as the baseline historic inventory for the emissions projections. Figures in the following sections include historic air pollutant emission estimates from 2000-2018. Tables in the following sections present projected emission estimates up to and including 2030 under both the WM and WAM scenarios.

### 8.4.1 Sulphur Dioxide (SO<sub>2</sub>)

Emission projections for SO<sub>2</sub> for the WM and WAM scenarios are presented in Figure 8.1. The emission reduction targets for 2020 and 2030 are also presented. The emission projections predict compliance with the 2020 and 2030 emission reduction target throughout the projected period. Key sources of SO<sub>2</sub> emissions include electricity generation and emissions from residential, commercial and industry.

Total SO<sub>2</sub> emissions under the WAM scenario are projected to be 13.4 kt in 2020. The emission projections predict compliance with the 2020 emission reduction target by 12.1 kt. Total SO<sub>2</sub> emissions are projected to be 5.7 kt in 2030 under the WAM scenario which is below the emission reduction target (10.9 kt) for that year.



**Figure 8.1 SO<sub>2</sub> Emission Projections for the With Measures and With Additional Measures Scenarios**

SO<sub>2</sub> emissions under the WAM scenario by source sector are presented in Figure 8.2. Emissions from Public Electricity and Heat Production (1A1a) contribute approximately 23.7 per cent and 5.7 per cent of national total emissions of SO<sub>2</sub> in 2020 and 2030, respectively. The reduction in 2030 is largely attributed to coal and peat no longer being used for electricity generation. The combined Residential and Commercial sectors account for 51 per cent and 41 per cent of emissions in 2020 and 2030 respectively.

Table 8.3 presents the projected Emissions of SO<sub>2</sub> under the WM and WAM by sector over the period 2018 to 2030.

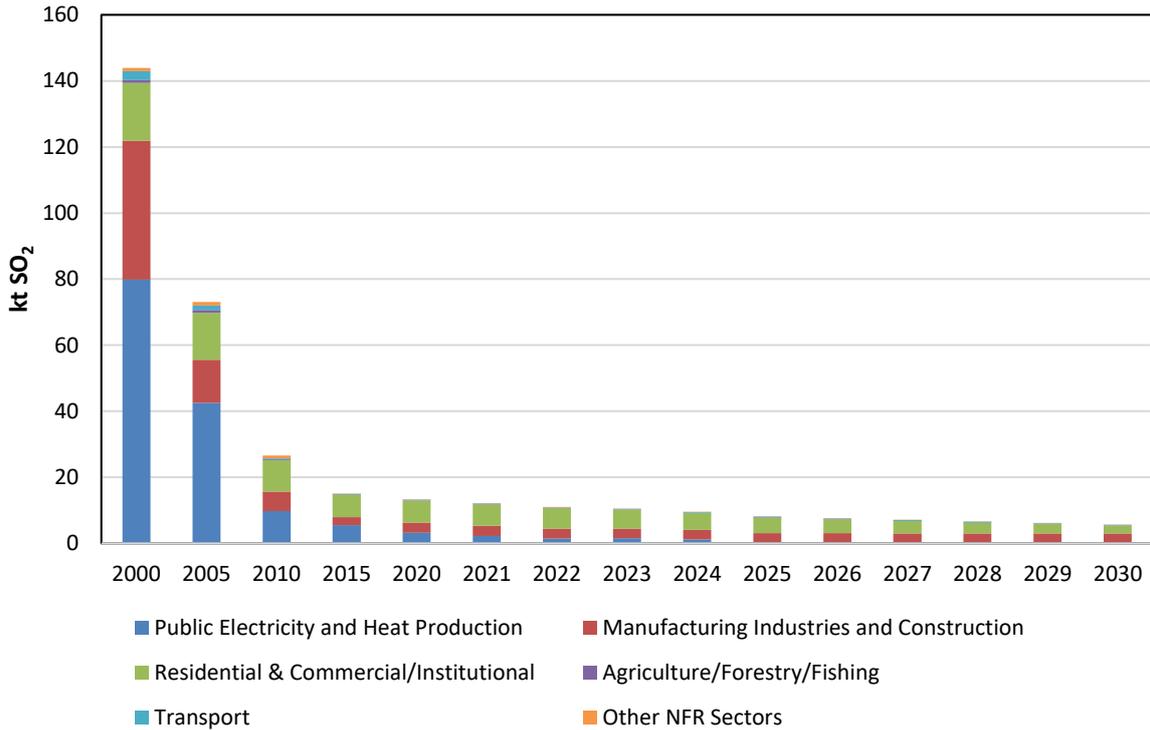


Figure 8.2 SO<sub>2</sub> Emission Projections for the With Additional Measures Scenario by Source Sector

Table 8.3. Projected Emissions of SO<sub>2</sub> under the With Measures and With Additional Measures Scenarios (kt)

With Measures scenario				
	2018	2020	2025	2030
Public Electricity and Heat Production	2.8	3.1	1.7	0.6
Manufacturing Industries and Construction	2.7	3.2	3.2	3.2
Residential & Commercial/Institutional	6.3	6.9	5.9	4.7
Agriculture/Forestry/Fishing	0.0	0.1	0.1	0.1
Transport	0.3	0.2	0.2	0.2
Other NFR Sectors	0.1	0.1	0.1	0.1
<b>TOTAL</b>	<b>12.3</b>	<b>13.6</b>	<b>11.1</b>	<b>9.0</b>
With Additional Measures scenario				
Public Electricity and Heat Production	2.8	3.2	0.3	0.3
Manufacturing Industries and Construction	2.7	3.1	2.8	2.7
Residential & Commercial/Institutional	6.3	6.7	4.7	2.3
Agriculture/Forestry/Fishing	0.0	0.1	0.0	0.0
Transport	0.3	0.2	0.2	0.2
Other NFR Sectors	0.1	0.1	0.1	0.1
<b>TOTAL</b>	<b>12.3</b>	<b>13.4</b>	<b>8.2</b>	<b>5.7</b>

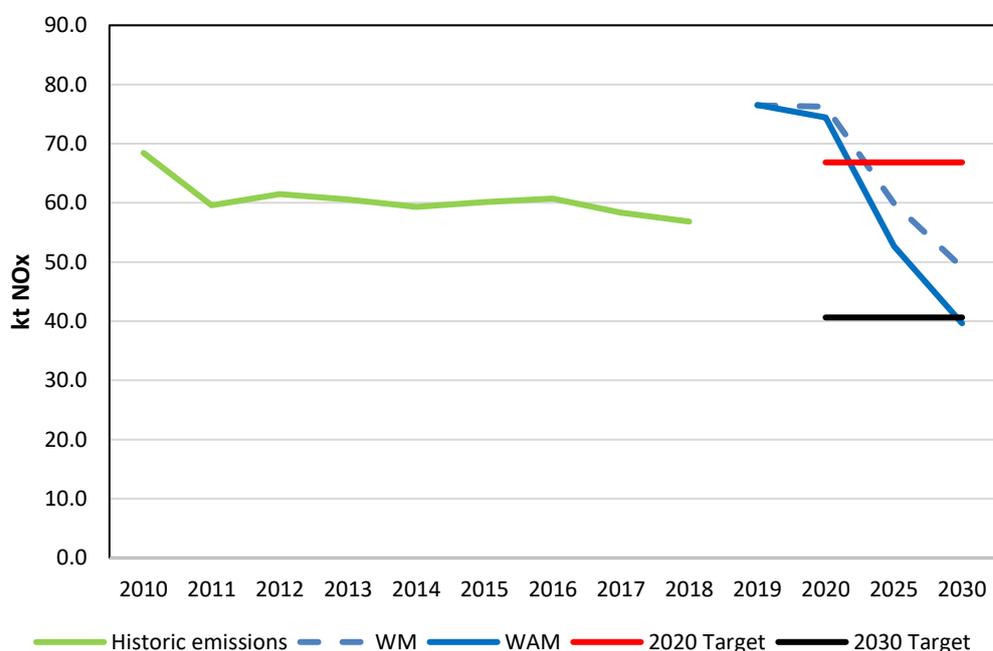
## 8.4.2 Nitrogen Oxides (NO<sub>x</sub>)

Emission projections for NO<sub>x</sub> for the WM and WAM scenarios are presented in Figure 8.3. The emission reduction targets for 2020 and 2030 are also presented.

Article 4 (3) of the National Emission Ceiling Directive provides that emissions of nitrogen oxides from categories 3B (manure management) and 3D (agricultural soils) are not accounted for the purpose of complying with 2020 and 2030 targets. The WM emissions and WAM emissions (in addition to 2020 and 2030 targets) displayed in Figure 8.3 excludes emissions from these categories (3B and 3D) for the period 2020 to 2030 for the purposes of the reduction target compliance assessment. The historic NO<sub>x</sub> levels in the graph include the adjusted NO<sub>x</sub> inventory for the years 2010-2018. Refer to chapter 9 in the IIR on annual adjusted national emission inventories for further information.

Emission projections predict non-compliance with the 2020 emission reduction target under the WM and WAM scenarios. Emissions from transport is the largest contributor to NO<sub>x</sub> emissions. The projections predict compliance with the 2030 emission reduction target under the WAM scenarios as a result of the higher uptake of electric vehicles in this scenario.

Total NO<sub>x</sub> emissions (excluding agricultural categories 3B and 3D) under the WAM scenario are projected to be 74.4 kt in 2020 which is a non-compliance with the 2020 emission reduction target by 7.5 kt. Total NO<sub>x</sub> emissions in 2030 are projected to be 39.6 kt, which is a compliance with the emission reduction target for that year by 0.9 kt.

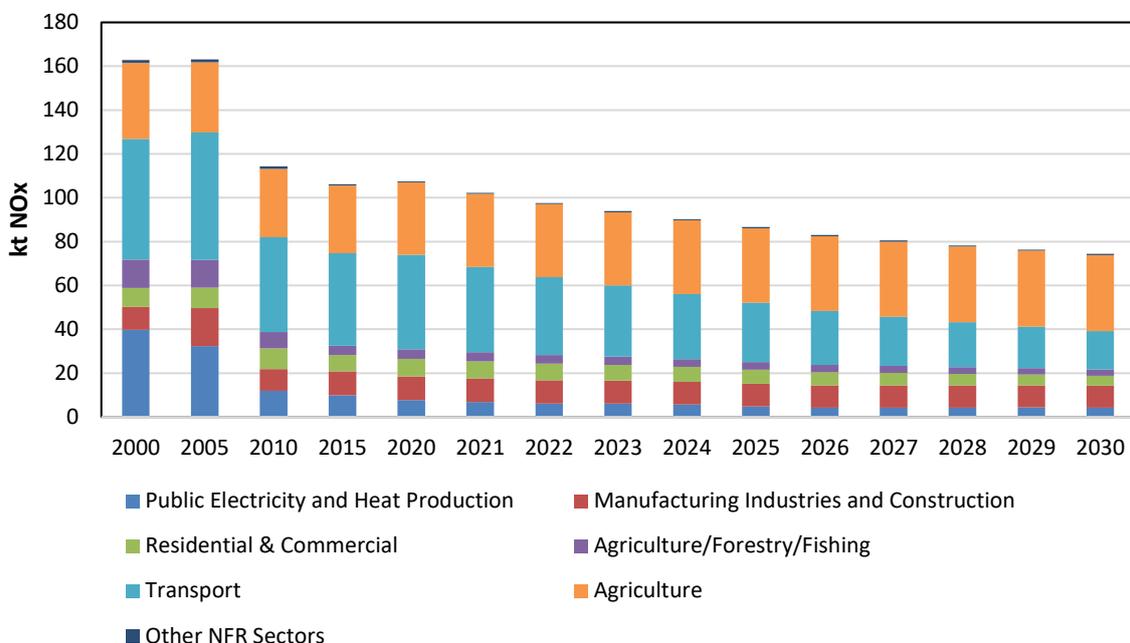


*Figure 8.3 NO<sub>x</sub> Emission Projections for the With Measures and With Additional Measures Scenarios*

Figure 8.4 presents the total NO<sub>x</sub> emissions under the WAM scenario by source sector. The largest sectoral contribution is from agriculture and transport. In terms of compliance assessment (i.e.

excluding agricultural categories 3B and 3D) transport accounts for 57.8 per cent and 43.9 per cent share of emissions in 2020 and 2030 respectively.

Table 8.4 presents the projected Emissions of NO<sub>x</sub> under the WM and WAM by sector over the period 2018 to 2030.



*Figure 8.4 NO<sub>x</sub> Emission Projections for the With Additional Measures Scenario by Source Sector*

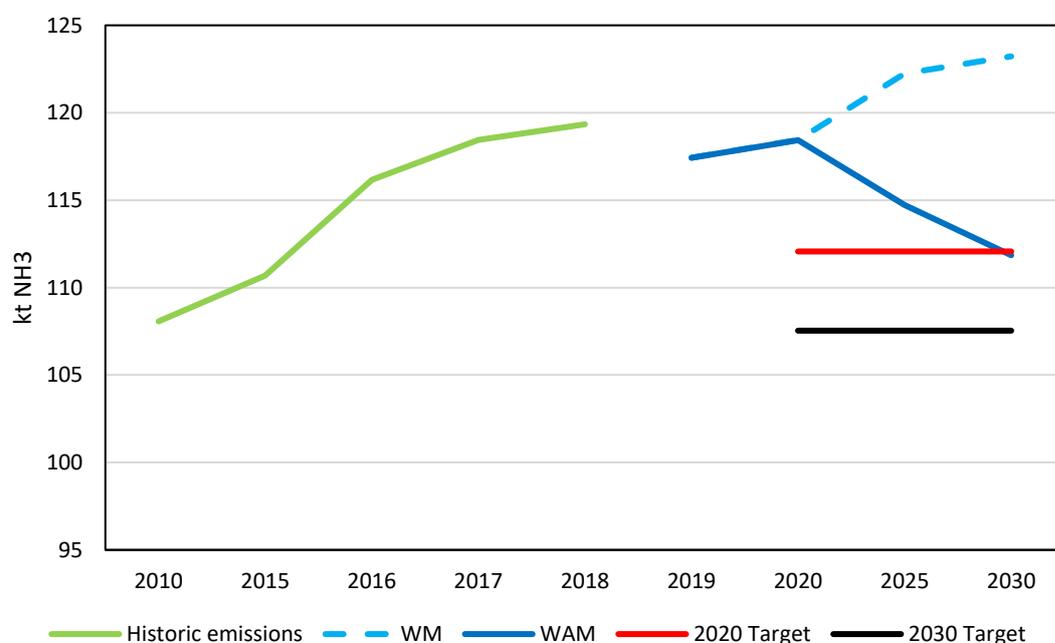
**Table 8.4. Projected Emissions of NO<sub>x</sub> under the With Measures and With Additional Measures Scenarios (kt)**

<b>With Measures scenario</b>				
	<b>2018</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>
Public Electricity and Heat Production	6.7	7.9	6.9	5.8
Manufacturing Industries and Construction	9.4	11.1	11.5	12.0
Residential & Commercial	7.9	8.2	7.7	7.4
Agriculture/Forestry/Fishing	4.5	4.6	3.8	3.2
Transport	43.7	44.0	29.5	20.2
Agriculture	34.9	33.1	33.9	34.8
Other NFR Sectors	0.5	0.5	0.5	0.5
<b>TOTAL</b>	<b>107.8</b>	<b>109.4</b>	<b>93.8</b>	<b>83.9</b>
<b>With Additional Measures scenario</b>				
Public Electricity and Heat Production	6.7	7.7	4.8	4.2
Manufacturing Industries and Construction	9.4	10.8	10.3	10.1
Residential & Commercial	7.9	8.0	6.4	4.6
Agriculture/Forestry/Fishing	4.5	4.4	3.5	2.9
Transport	43.7	43.1	27.2	17.4
Agriculture <sup>14</sup>	34.9	33.1	33.9	34.8
Other NFR Sectors	0.5	0.5	0.5	0.5
<b>TOTAL</b>	<b>107.8</b>	<b>107.5</b>	<b>86.6</b>	<b>74.4</b>

### 8.4.3 Ammonia (NH<sub>3</sub>)

Figure 8.5 presents the emission projections for NH<sub>3</sub> for the WM and WAM scenarios. The emission reduction targets for 2020 and 2030 are also presented. Overall the Ammonia emission projections predict non-compliance with the 2020 and 2030 emission reduction target under both the WM and WAM scenarios. The majority of projected emissions come from agriculture sources (agriculture accounted for 99 per cent of emissions in 2018) and this is maintained throughout the projection period.

Total NH<sub>3</sub> emissions under the WAM scenario are projected to be 118.43 kt in 2020. As a result, an exceedance of the 2020 emission reduction target by 6.3 kt is projected. Post 2020, emissions are projected to decrease to 111.8 kt in 2030. Ireland's 2030 emission target of a 5 per cent reduction on 2005 levels results in a distance to the emission reduction target in 2030 of 4.3 kt under the WAM scenario. Compliance with emission reduction targets is a challenge for the agricultural sector.



**Figure 8.5 NH<sub>3</sub> Emission Projections for the With Measures and With Additional Measures Scenarios**

The reduction in the WAM scenario compared to the WM scenario over the period 2021-2030 is attributable to measures that are included in the Teagasc Marginal Abatement Cost Curve<sup>12</sup>), where data is available. Key measures include, for example, low emission slurry spreading, use of inhibited urea fertiliser products and a reduction of crude protein in pig diets.

<sup>12</sup> <https://www.teagasc.ie/media/website/publications/2015/An-Analysis-of-the-Cost-of-the-Abatement-of-Ammonia-Emissions-in-Irish-Agriculture-to-2030.pdf>  
<https://www.teagasc.ie/media/website/publications/2018/An-Analysis-of-Abatement-Potential-of-Greenhouse-Gas-Emissions-in-Irish-Agriculture-2021-2030.pdf>

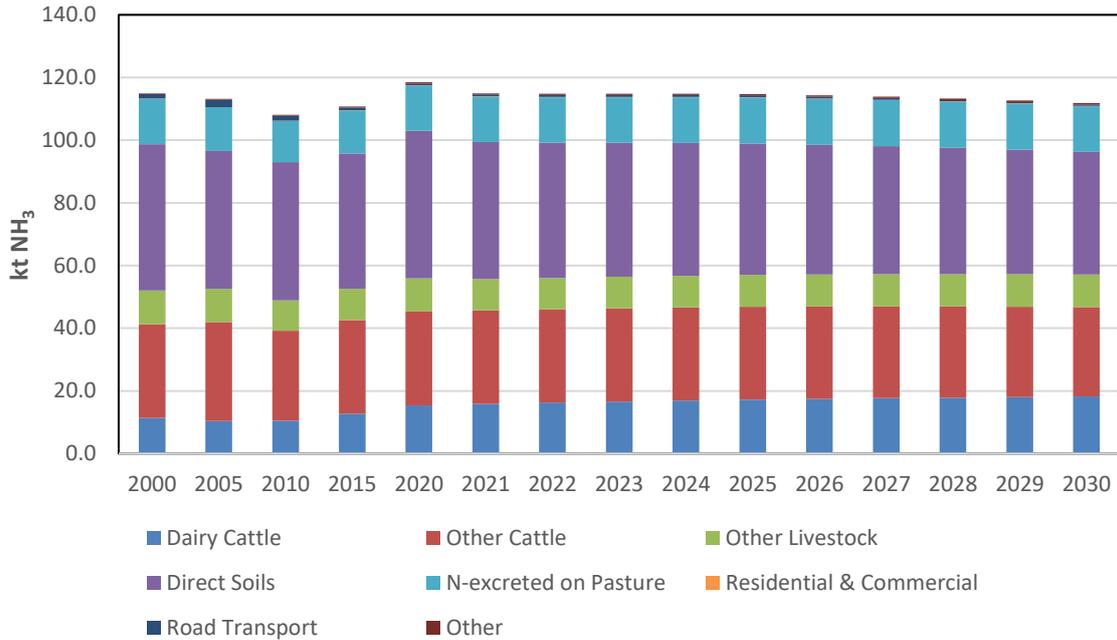


Figure 8.6 NH<sub>3</sub> Emission Projections for the With Additional Measures Scenario by Source Sector

Ammonia emissions by source sector under the WAM scenario are presented in Figure 8.6. Table 8.5 presents the projected ammonia emissions under the WM and WAM by sector over the period 2018 to 2030.

Table 8.5. Projected Emissions of NH<sub>3</sub> under the With Measures and With Additional Measures Scenarios (kt)

With Measures Scenario				
	2018	2020	2025	2030
Dairy Cattle	14.5	15.4	17.2	18.2
Other Cattle	30.7	29.9	29.6	28.6
Other Livestock	10.5	10.6	10.8	11.1
Direct Soils	48.1	47.1	48.7	49.6
N-excreted on Pasture	14.5	14.4	14.6	14.6
Residential & Commercial	0.1	0.1	0.1	0.1
Road Transport	0.6	0.7	0.6	0.6
Other	0.4	0.3	0.4	0.5
<b>Total</b>	<b>119.3</b>	<b>118.4</b>	<b>122.2</b>	<b>123.2</b>
With Additional Measures Scenario				
Dairy Cattle	14.5	15.4	17.2	18.2
Other Cattle	30.7	29.9	29.6	28.6
Other Livestock	10.5	10.6	10.1	10.4
Direct Soils	48.1	47.1	41.9	39.0
N-excreted on Pasture	14.5	14.4	14.6	14.6
Residential & Commercial	0.1	0.1	0.1	0.1
Road Transport	0.6	0.6	0.6	0.4
Other	0.4	0.3	0.5	0.5
<b>Total</b>	<b>119.3</b>	<b>118.4</b>	<b>114.7</b>	<b>111.9</b>

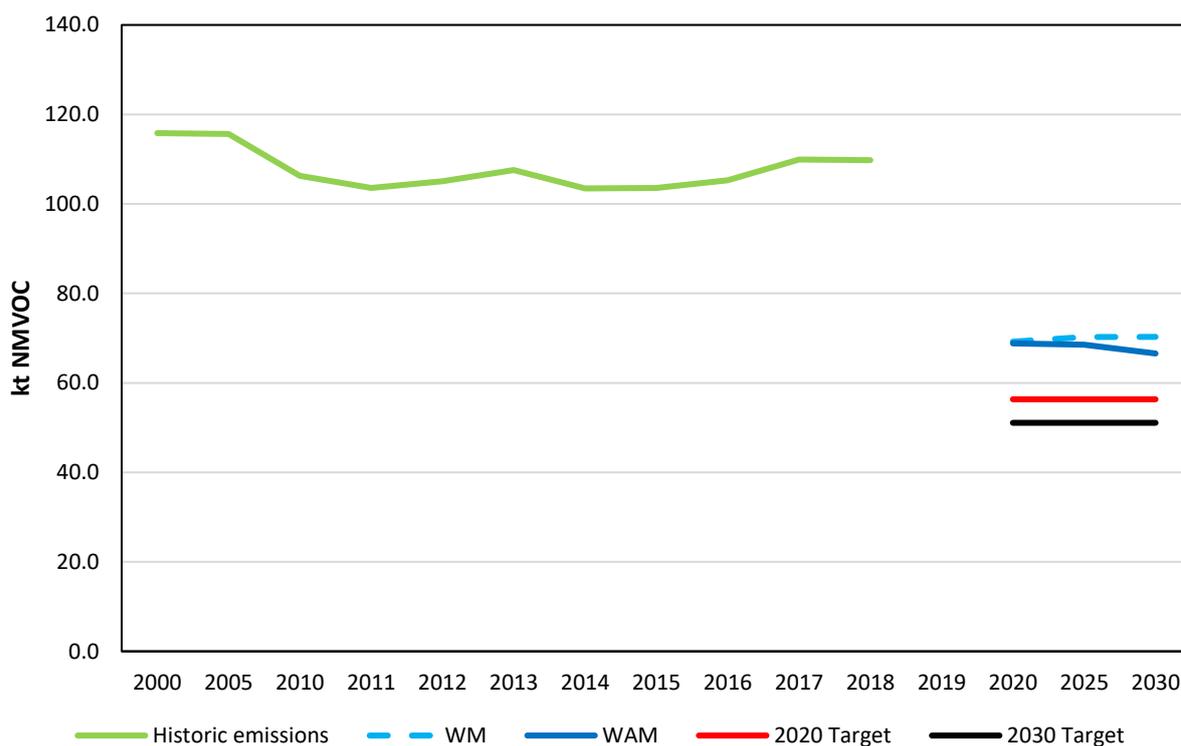
### 8.4.4 Non-Methane Volatile Organic Compounds (NMVOCs)

Figure 8.7 presents the emissions projections for NMVOC for the WM and WAM scenarios. The emission reduction targets for 2020 and 2030 are also presented.

Overall NMVOCs emission projections predict non-compliance with the 2020 and 2030 emission reduction target under both the WM and WAM scenarios. Large emission sources include solvents and other product use, and emissions from food and beverages industry.

Article 4 (3) of the National Emission Ceiling Directive provides that emissions of non-methane volatile organic compounds from categories 3B (manure management) and 3D (agricultural soils) are not accounted for the purpose of complying with 2020 and 2030 targets. The WM and WAM emissions (in addition to 2020 and 2030 targets displayed) in Figure 8.7 exclude emissions from these categories (3B and 3D).

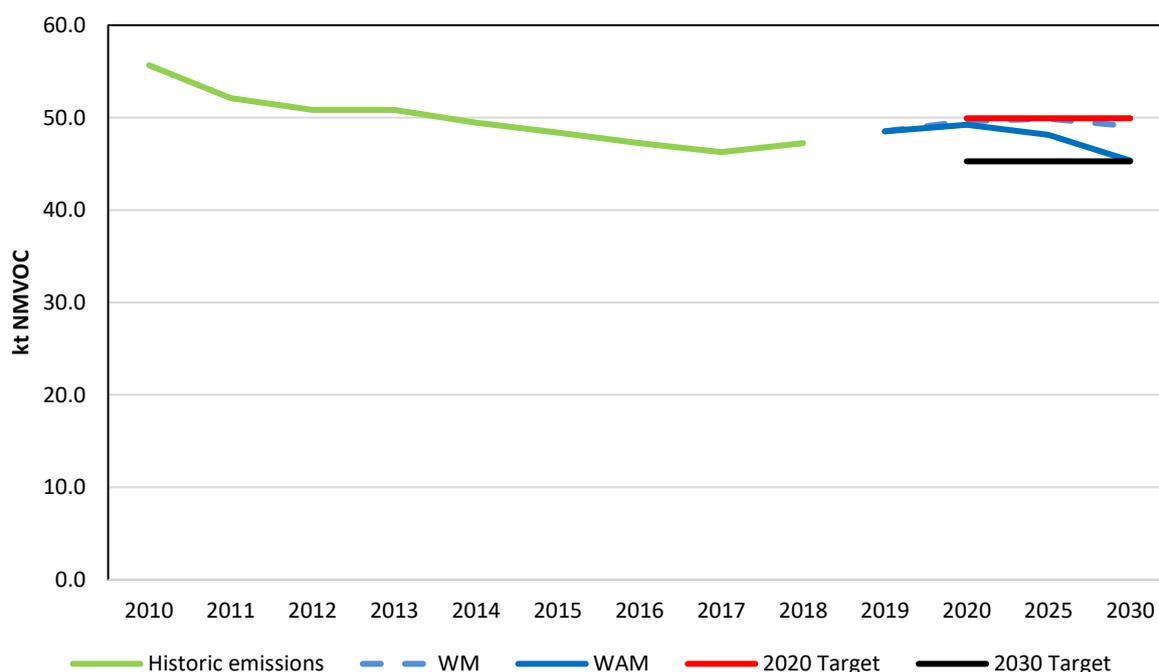
Total NMVOC emissions under the WAM scenario (excluding emissions from agricultural categories 3B and 3D) are projected to be 68.8 kt in 2020. The emission projections predict non-compliance with the 2020 target by approximately 12.4 kt. Emissions in 2030 are projected to be 66.6 kt which is approximately 15.5 kt above the emission reduction target for 2030.



**Figure 8.7 NMVOC Emission Projections for the With Measures and With Additional Measures Scenarios<sup>13</sup>**

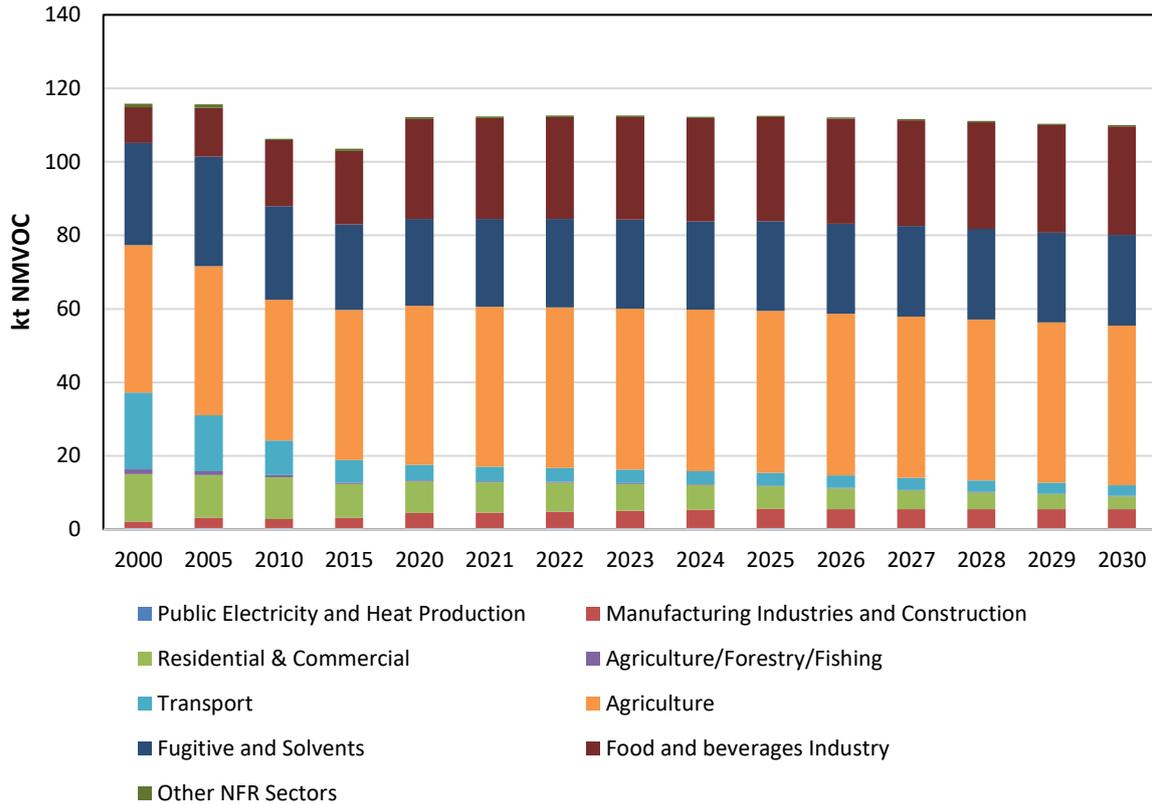
<sup>13</sup> Article 4 (3) of the National Emission Ceiling Directive provides that emissions of non-methane volatile organic compounds from categories 3B (manure management) and 3D (agricultural soils) are not accounted for the purpose of complying with 2020 and 2030 targets. The *With Measures* emissions and *With Additional Measures* emissions in addition to 2020 and 2030 targets displayed in this graph exclude emissions from these categories (3B and 3D)

Figure 8.8 presents a scenario where projected adjustments to the national emission inventory in relation to emissions from spirit production are accepted for the compliance assessment. This is on the basis that NMVOCs from category 2.H (Spirits) were included in the 1990-2015 inventory for the February 2017 Inventory submission (after the 2016 NEC Directive came into effect). The historic NMVOC levels in the graph include the adjusted NMVOC inventory for the years 2010-2018. Refer to chapter 9 for further information. In the WAM scenario that assumes adjustments for the category spirit production are accepted, the emission projections predict compliance with the 2020 target by approximately 0.7 kt. Emissions in 2030 are projected to be 45.3 kt which is approximately 0.08 kt above emission reduction target for 2030.



**Figure 8.8 NMVOC Emission Projections for the With Measures and With Additional Measures Scenarios<sup>14</sup>**

<sup>14</sup> The *With Measures* emissions and *With Additional Measures* emissions in addition to 2020 and 2030 targets displayed in this graph exclude emissions from NFR categories 3B (manure management) and 3D (agricultural soils), and category 2H (Spirits)



**Figure 8.9 NMVOC Emission Projections for the With Additional Measures Scenario by Source Sector**

Projected total NMVOC emissions by source sector under the WAM scenario are presented in Figure 8.9. In terms of compliance assessment (which exclude agricultural categories 3B and 3D) projected emissions from Solvents and Fugitive emission account for approximately 34.2 per cent and 37.1 per cent in 2020 and 2030 under the WAM scenario respectively. Food and Beverages account for 39.5 per cent and 44.3 per cent of emissions in 2020 and 2030 respectively.

Projected emissions across the time series show a slight increase in both the WM and WAM scenarios over the projected period to 2030. The trend of reduced emissions in the Residential and Commercial and Transport sectors are counteracted by the increase in emissions from solvents and fugitive emissions and the food and beverages industry.

Table 8.6 presents the projected NMVOC emissions under the WM and WAM by sector over the period 2018 to 2030.

**Table 8.6. Projected Emissions of NMVOC under the With Measures and With Additional Measures Scenarios (kt)**

<b>With Measures Scenario</b>				
	<b>2018</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>
Public Electricity and Heat Production	0.3	0.3	0.4	0.4
Manufacturing Industries and Construction	3.1	4.2	5.2	5.3
Residential & Commercial	8.2	8.8	7.5	6.2
Agriculture/Forestry/Fishing	0.3	0.3	0.2	0.1
Transport	4.4	4.3	3.6	3.2
Agriculture <sup>11</sup>	43.2	43.3	44.0	43.4
Fugitive and Solvents	22.9	23.6	24.6	25.2
Food and beverages Industry	26.8	27.2	28.3	29.5
Other NFR Sectors	0.5	0.5	0.4	0.3
<b>Total</b>	<b>109.8</b>	<b>112.5</b>	<b>114.3</b>	<b>113.7</b>
<b>With Additional Measures Scenario</b>				
Public Electricity and Heat Production	0.3	0.3	0.3	0.3
Manufacturing Industries and Construction	3.1	4.1	5.2	5.2
Residential & Commercial	8.2	8.6	6.2	3.5
Agriculture/Forestry/Fishing	0.3	0.3	0.2	0.1
Transport	4.4	4.2	3.5	2.9
Agriculture <sup>11</sup>	43.2	43.3	44.0	43.4
Fugitive and Solvents	22.9	23.6	24.4	24.7
Food and beverages Industry <sup>12</sup>	26.8	27.2	28.3	29.5
Other NFR Sectors	0.5	0.5	0.4	0.3
<b>Total</b>	<b>109.8</b>	<b>112.1</b>	<b>112.6</b>	<b>110.0</b>

#### 8.4.5 Particulate Matter < 2.5 µm in diameter (PM<sub>2.5</sub>)

Emissions projections for PM<sub>2.5</sub> for the WM and WAM scenarios are presented in Figure 8.10. The emission reduction targets for 2020 and 2030 are also presented. Overall the PM<sub>2.5</sub> emission projections predict compliance with the 2020 and 2030 emission reduction target under both the WM and WAM scenarios. Emissions from Residential and Commercial combined are the largest contribution to the projected emissions.

Total PM<sub>2.5</sub> emissions under the WAM scenario are projected to be 12.9 kt in 2020. The emission projections under the WAM scenario predict compliance with both the 2020 and 2030 emission reduction targets by a margin of 2.7 kt and 2.9 kt, respectively.

Table 8.7 presents the projected PM<sub>2.5</sub> emissions under the WM and WAM by sector over the period 2018 to 2030.

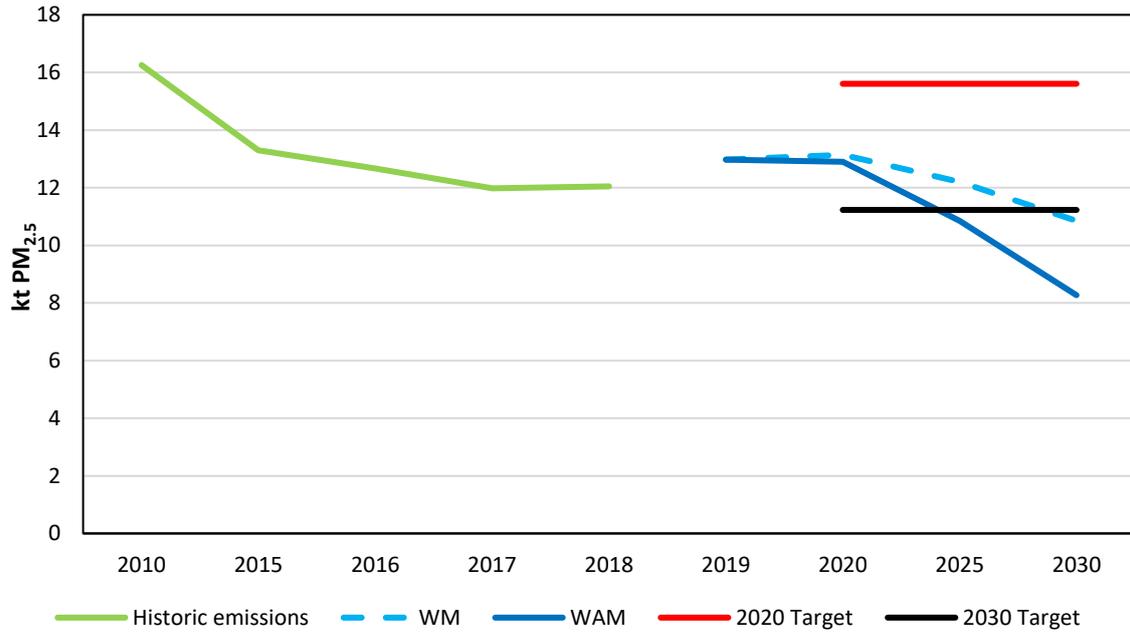


Figure 8.10 PM<sub>2.5</sub> Emission Projections for the With Measures and With Additional Measures Scenarios

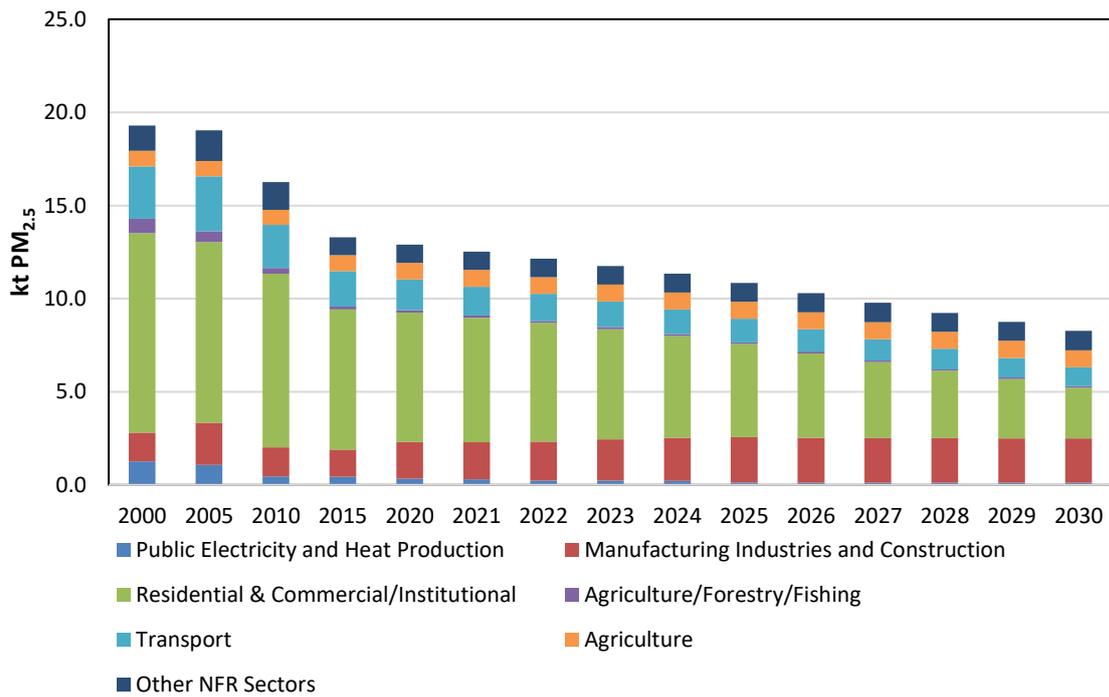


Figure 8.11 PM<sub>2.5</sub> Emission Projections for the With Additional Measures Scenario by Source Sector

Projected emissions across the time series show a decline for both the WM and WAM scenarios up to 2030 (Figure 8.11). This trend is largely the result of projected reductions in emissions in the combined Residential and Commercial sectors.

Table 8.7. Projected Emissions of PM<sub>2.5</sub> under the With Measures and With Additional Measures Scenarios (kt)

<b>With Measures scenario</b>				
	<b>2018</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>
Public Electricity and Heat Production	0.3	0.4	0.2	0.2
Manufacturing Industries and Construction	1.6	2.0	2.4	2.5
Residential & Commercial/Institutional	6.6	7.1	6.1	4.9
Agriculture/Forestry/Fishing	0.1	0.1	0.1	0.1
Transport	1.7	1.7	1.4	1.3
Agriculture	0.9	0.9	0.9	0.9
Other NFR Sectors	0.9	1.0	1.0	1.0
<b>TOTAL</b>	<b>12.0</b>	<b>13.1</b>	<b>12.2</b>	<b>10.9</b>
<b>With Additional Measures scenario</b>				
Public Electricity and Heat Production	0.3	0.3	0.1	0.1
Manufacturing Industries and Construction	1.6	2.0	2.4	2.4
Residential & Commercial/Institutional	6.6	6.9	5.0	2.7
Agriculture/Forestry/Fishing	0.1	0.1	0.1	0.1
Transport	1.7	1.7	1.3	1.0
Agriculture	0.9	0.9	0.9	0.9
Other NFR Sectors	0.9	1.0	1.0	1.0
<b>TOTAL</b>	<b>12.0</b>	<b>12.9</b>	<b>10.9</b>	<b>8.3</b>

## 8.5 Energy Industries (NFR 1A1)

Public Electricity and Heat Production (1A1a) covers all electricity generation including electricity generated from renewable sources. The Plexos\_Ireland model was used to model projected future electricity generation. As an electrical systems model, the core input data comprises technical details of generators, transmission lines and loads as well as fuel costs, operational costs and emission reduction rates and costs.

In the *Baseline* energy projection, the renewable energy generated shows Ireland reaching approximately 37.6 per cent of electricity consumption from renewable energy by 2020. Renewable electricity generation capacity is dominated by wind. In 2030 it is estimated that renewable energy generation increases to approximately 55 per cent of electricity consumption.

The use of peat/biomass in three peat stations is determined by the plants operation in the electricity market taking into account supports (Public Service Obligation (PSO)/REFIT<sup>15</sup>) and maximum levels of peat likely to be permitted under planning permission.

<sup>15</sup><https://www.dccae.gov.ie/en-ie/energy/topics/Renewable-Energy/electricity/renewable-electricity-supports/refit/Pages/REFIT-3.aspx>

In the assumptions underpinning the baseline scenario, two peat stations are eligible for PSO support for peat up to the end of 2019 and REFIT3 for 30 per cent biomass cofiring up to the end of 2030. A third peat station is eligible for REFIT3 30 per cent biomass cofiring up to the end of 2030.

The following are the maximum levels of peat use for two peat stations:

- 2019 up to 100 per cent peat
- 2020-2024: up to 60 per cent peat
- 2025-2027: up to 40 per cent peat
- 2028 onwards: 0 per cent peat

The following is the maximum level of peat use at the third peat station:

- 2019-2024: up to 60 per cent peat
- 2025-2027: up to 40 per cent peat
- 2028 onwards: 0 per cent peat

One coal plant is assumed to operate in the market up to end 2025 at which point it no longer generates electricity from coal.

It is assumed there will be a roll out of approximately 2.25 million smart meters by 2024, on a phased basis starting in 2019.

In the *Advanced* energy projection (and therefore the *With Additional Measures* emissions scenario) it is assumed that for 2020 there is a 36.3 per cent share of renewable energy in electricity generation. In 2030 it is estimated that renewable energy generation increases to approximately 70 per cent of electricity consumption. This is mainly a result of additional expansion in wind energy and Solar PV.

Two peat stations are assumed to run on 100% peat to the end of 2020 but PSO support ends at the end of 2019. For 2020 the operation of the stations will be determined by the stations' operation in the electricity market. A third station operates to the end of 2023 with 30 per cent cofiring.

One coal plant is assumed to operate in the market up to end 2024 at which point it no longer generates electricity from coal.

In terms of inter-connection, it is assumed that the Greenlink 500MW interconnector to the UK to come on stream in 2025 and the Celtic 700MW interconnector to France to come on stream in 2026.

Emission factors for NO<sub>x</sub> and SO<sub>2</sub> predominantly are based on those used for the year 2018 in the national inventory (1990-2018). Based on available data the projections take into account emission limit values provided in the transitional national plan for large combustion plants (e.g. coal fired electricity generation plant).

There has been significant reduction in the use of oil in electricity generation due to the closure and decommissioning of oil fuelled generation plants. Oil is also used as a start-up fuel in coal and peat fired generation stations. The 2018 SO<sub>2</sub> inventory emission factor for oil is assumed for all future years.

NMVOC and PM<sub>2.5</sub> emission factors for most of the other relevant fuel types (i.e. coal, peat, biomass and non-renewable wastes) are assumed to remain constant at the 2018 value utilised in the national inventory (1990-2018).

### 8.5.1 Oil and Gas Refining and Solid Fuel Manufacturing (NFR 1A1b and 1A1c)

Projected NO<sub>x</sub>, SO<sub>2</sub>, NMVOC and PM<sub>2.5</sub> for oil refining and solid fuel manufacture are based on data provided by the relevant operators as energy demand from these sectors is not included in SEAI's energy projections. The oil refining sector (1.A.1.b) in Ireland consists of a single installation. Projections are based on the growth rate of projected greenhouse gas emissions, which are provided to the EPA by the relevant installation operators.

## 8.6 Manufacturing Industries and Construction (NFR 1A2)

Projected NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> emissions are based on SEAI's *Baseline* and *Advanced* energy projections and are therefore estimated for both the WM and WAM scenarios.

Energy projections are provided to the EPA at an aggregated level only (i.e. 1A2) and underpin the air pollutant projections for this sector. The projected emission factors for NO<sub>x</sub> and SO<sub>2</sub> from the combustion of coal, natural gas and petroleum coke are based on the weighted average emission factor for coal, natural gas and petroleum coke across the sub sectors 1A2a – 1A2g from previous inventory values or from specific 1a2 categories in the latest inventory where appropriate.

The following policies and measures relevant to the industry sector are included in the *Baseline* (WM) Projection:

- SEAI Large Industry Programme
- Accelerated Capital Allowances - Industry
- Combined Heat and Power
- Excellence in Energy Efficiency Design (EXEED) Industry

The *Advanced* (WAM) Projection includes an extension of the above policies and measures.

## 8.7 Transport (NFR 1A3)

Transport emissions cover Aviation (1A3a), Road Transportation (1A3b), Rail (1A3c), Navigation (1A3d) and Other transportation (Natural gas pipeline compressors, 1A3e). Projected emissions of NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> from road transport are based on SEAI's *Baseline* and *Advanced* energy projections and are therefore estimated for both the WM and WAM scenarios.

It is assumed that fuel use in rail will remain constant at 2018 levels for each year out to 2030.

Projected fuel combustion from navigation is assumed to be equal to that combusted in the sector in 2018 for each projected year to 2030. Emissions for each of the pollutants are therefore assumed to remain constant at 2018 levels for each future year.

Other Transportation (1A3e) refers to the use of natural gas for combustion in natural gas pipeline compressor stations. Emissions from this sector are inferred from projected gas demand in the residential, industrial and commercial and institutional services sectors from the energy projections provided by SEAI and are calculated for both the WM and WAM scenarios.

### 8.7.1 Domestic aviation (NFR 1A3a)

NO<sub>x</sub>, SO<sub>2</sub>, NMVOC and PM<sub>2.5</sub> emission projections from aviation are estimated using the 2018 inventory and also projected data, where available, related to aircraft movements as provided to the EPA by the relevant airport authority. Emissions associated with all LTO (landing and take-off) cycles are calculated. It is assumed that NO<sub>x</sub>, SO<sub>2</sub>, NMVOC and PM<sub>2.5</sub> emission factors remain constant for all projected years based on the average of the previous 5 years (i.e. 2014-2018) used in the 2018 national inventory.

### 8.7.2 Road transportation (NFR 1A3b)

The transport sector is a large energy using sector and is reliant on imported fossil fuels in the form of petroleum products and biofuels. Freight transport energy demand is strongly influenced by the level of commercial activity in the economy. Personal transport energy demand is influenced by both the level of employment as well as the oil price. Biofuel uptake in Ireland is driven primarily through the Biofuel Obligation Scheme<sup>16</sup>, an obligation on fuel suppliers to blend an increasing percentage of biofuel with their fuel.

Energy projections provide future demand for petrol, diesel, renewables and electricity use in the road transport sector for both the WM and WAM scenarios.

Projected emissions (NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub>) for road transport for the 2020 submission were produced using the COPERT 5.3 model. An updated projected fleet model was also produced in order to prepare data needed for the COPERT modelling. To produce the fleet model, an analysis was carried out on the inventory passenger car and light goods vehicles fleet data to ascertain the life cycle patterns for each of the vehicle Euro classes. This analysis was used to model future curves for each existing vehicle Euro class. Along with projected transport fuel projections, the EPA was also provided with projected total passenger car fleet data over the projected period which included projected electric vehicle uptake under both the WM and WAM scenarios. Gaps between the fleet model passenger car numbers and total projected fleet number were then populated with the latest Euro vehicles (e.g. Euro class 6 for passenger cars).

The same approach was applied to the heavy-duty trucks and buses, however the overall fleet data total for this section was based on a 2014 national research report<sup>17</sup> containing projected fleet numbers. A more up to date total fleet number for this vehicle class will be included in future refinements of the fleet model, subject to availability of information.

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<sup>16</sup><https://www.dccae.gov.ie/en-ie/energy/topics/RenewableEnergy/transport/biofuels/Pages/Biofuels.aspx>

<sup>17</sup><https://www.esri.ie/publications/demographic-and-economic-forecasting-report-national-transport-model-volume-3>

The Biofuel Obligation Scheme places an obligation on fuel suppliers to blend an increasing percentage of biofuel with their fuel. In terms of biofuels used in road transport fuel in the WM scenario a statutory target of approximately 11% from 1<sup>st</sup> January 2019 under the Biofuels Obligation Scheme is assumed. This increases to approximately 12% from 1<sup>st</sup> January 2020.

For the WAM scenario, it is assumed that the Biofuel Obligations Scheme is developed further. Incremental increases are assumed to occur with 10% blend for petrol (E10) and a 12% blend for diesel (B12) in place in 2030.

In terms of Electric Vehicles, the WM energy projection assumes approximately 488,830 Electric Vehicles on the road by 2030 (includes 326,002 Passenger Battery Electric Vehicles, 148,183 Passenger Plug in Hybrid Electric Vehicles). The WAM Scenario assumes 935, 800 Electric Vehicles on the road by 2030 (includes 550,000 Passenger Battery Electric Vehicles, 288,000 Plug in Hybrid Electric Vehicles).

### 8.7.3 Rail (NFR 1A3c)

NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> emission projections from rail transport are estimated. It is assumed that fuel use in the sector will remain constant at 2018 levels for each year out to 2030. It is also assumed that NO<sub>x</sub>, NMVOC, NH<sub>3</sub> PM<sub>2.5</sub> emission factors remain the same as in the 2018 national inventory. Due to the variability in the sulphur content of gas oil in recent years an average SO<sub>2</sub> emission factor over the 2014-2018 period was used for projected years.

### 8.7.4 Navigation (NFR 1A3d)

NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> emission projections from navigation are estimated. Gasoil/diesel consumption in in-land navigation is assumed to remain constant at the 2018 level out to 2030. NO<sub>x</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> emission factors are assumed to remain constant at the 2018 level. Due to the variability in the sulphur content of gas oil in recent years an average SO<sub>2</sub> emission factor over the 2014-2018 period was used for projected years.

### 8.7.5 Gas Transmission (NFR 1A3e)

Emissions projections for NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, and PM<sub>2.5</sub> from natural gas transmission in Ireland's natural gas pipeline network are estimated. Future gas demand for "own use and transformation" is inferred based on projected gas demand in the residential, commercial services and industrial sectors. Subtracting the amount of gas estimated to be lost from the distribution network allows "own use" gas demand and associated emissions to be estimated. It is assumed that NO<sub>x</sub>, SO<sub>2</sub>, NMVOC and PM<sub>2.5</sub> emission factors remain the same as in the 2018 national inventory.

## 8.8 Residential and Commercial/Institutional (NFR 1A4)

### 8.8.1 Commercial/Institutional (NFR 1A4a)

Projected NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> emissions are based on SEAI's *Baseline* and *Advanced* energy projections and are therefore estimated for both the WM and WAM scenarios. Oil and gas account for the majority of non-electricity energy demand in this sector. These fuels are used predominantly for space-heating purposes. Projected emissions of NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> are estimated.

It is assumed that NO<sub>x</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> emission factors remain the same as in the 2018 national inventory. SO<sub>2</sub> emission factors for oil-derived fuels for the projected period are based on an average of the last 5 years (i.e. 2014-2018).

The following policies and measures are included in the *Baseline energy* (WM) projection:

- ReHeat
- Public Sector Programme
- Public Sector Capital Exemplars
- Small and Medium Enterprises (SME) Programme
- Accelerated Capital Allowances - Services
- Supports for Exemplar Energy Efficiency Projects (SEEEP) and Energy Efficiency Retrofit Fund (EERF) and Better Energy Workplaces
- 2005/2008 Building Regulations - Buildings other than dwellings
- 2018 Building Regulations - Buildings other than dwellings
- Excellence in Energy Efficiency Design (EXEED) - Services
- Better Energy Communities - Services
- Supplier Obligation Non-Grant - Non-Residential
- Heat Pump Supports - Non-Domestic

The *Advanced energy* (WAM) Projection includes an extension of the following policies and measures:

- Public Sector Programme
- Public Sector Capital Exemplars
- SME Programme
- Accelerated Capital Allowances – Services
- EXEED - Services
- Better Energy Communities - Services
- Supplier Obligation Non-Grant - Non-Residential
- Heat Pump Supports - Non-Domestic

### 8.8.2 Residential (1A4b)

Projected NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> emissions are based on SEAI's *Baseline* and *Advanced* energy projections and are therefore estimated for both the WM and WAM scenarios.

Projected emissions of NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> are estimated. It is assumed that NO<sub>x</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> emission factors remain the same as in the 2018 national inventory. SO<sub>2</sub> emission factors for oil-derived fuels for the projected period are based on an average of the last 5 years (i.e. 2014-2018).

The following policies and measures are included in the *Baseline* (WM) energy projection:

- ReHeat
- 2002 Building Regulations -Dwellings
- 2008 Building Regulations -Dwellings
- 2011 Building Regulations -Dwellings
- 2019 Building Regulations - Dwellings
- Greener Homes Scheme

- Energy Efficient Boiler Regulation
- Domestic Lighting
- Warmer Homes Scheme
- Warmth and Wellbeing Pilot
- Deep Retrofit Pilot
- Better Energy Communities - Household
- Better Energy Homes
- Major Renovations - Dwellings
- Smart Meter Roll-Out - Household
- Supplier Obligation Non-Grant - Residential
- Heat Pump Supports – Domestic
- Other Domestic Retrofit

The *Advanced energy* (WAM) projection includes an extension of the following policies and measures:

- Warmer Homes Scheme
- Warmth and Wellbeing Pilot
- Deep Retrofit Pilot
- Better Energy Communities - Household
- Better Energy Homes
- Smart Meter Roll-Out – Household
- Heat Pump Supports – Domestic
- Other Domestic Retrofit

## 8.9 Combustion in Agriculture and Fishing (NFR 1A4c)

Projected emissions of NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> are estimated for the combustion of diesel in the Agriculture sector and the combustion of diesel and fuel oil in the Fishing sector. Projected fuel use in the agriculture sector is included in the energy projections. It is assumed that NO<sub>x</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> emission factors remain the same as in the 2018 national inventory. SO<sub>2</sub> emission factors for oil-derived fuels for the projected period are based on an average of the last 5 years (i.e. 2014-2018).

### ***Cross cutting measures impacting key energy sectors***

There are cross cutting measures that have a significant impact across a number of sectors in terms of energy consumption and a reduction in emissions. These included carbon tax and supports for renewable heat which are described below.

- Carbon tax is a cross cutting measure that applies to industry, residential, commercial services, transport and agriculture fuel. Under the WM scenario, the current rate of carbon tax (€20 per tonne of CO<sub>2</sub>) is assumed across the projected period. Under the WAM scenario the carbon tax increases to €80 per tonne of CO<sub>2</sub> by 2030.
- In terms of renewable heat, both the WM and WAM scenario assumes 1,600GWh of additional renewable heat (six year ramp up 2020 to 2025) supported under the Support Scheme for Renewable Heat (SSRH)<sup>18</sup>.

<sup>18</sup> <https://www.seai.ie/business-and-public-sector/business-grants-and-supports/support-scheme-renewable-heat/>

- It is also assumed that 175,000 heat pumps replace residential oil boilers by 2030 under the WM scenario. Under the WAM scenario it is assumed that 385,000 existing residential oil boilers, gas boilers and electric heaters are replaced with heat pumps. District heating is also assumed to be deployed (additional 120 GWh by 2028 growing linearly from 2023).
- Under the WAM scenario, a total of 1,600GWh of biogas use across the heat and transport sectors by 2030 is assumed (linear increase from 2025 is assumed).

## 8.10 Mineral Products (NFR 2A)

Emission of air pollutants (e.g. NO<sub>x</sub> and SO<sub>2</sub> emissions) from Industrial Processes cannot usually be separated from the emissions from fuel combustion in industry. Emissions from industrial processes are therefore assumed to be included in projected estimates for the Manufacturing Industries and Construction (1.A.2) sector.

## 8.11 Non-Energy Products from Fuels and Non-Energy Products from Fuels and Solvent Use (NFR 2D)

Emissions projections of NMVOCs from solvent use and other products are estimated. Population growth is used to project emissions out to 2030 with the 2018 inventory used as a starting point.

## 8.12 Agriculture (NFR 3)

The Agriculture sector is the largest source of NH<sub>3</sub> emissions in Ireland. Projected estimates of NH<sub>3</sub> from the Agriculture sector are undertaken using the same methodological approach as the current national inventory.

Two scenarios were developed for agricultural emission projections, a WM scenario and a WAM scenario. Projected activity data (animal numbers, crop areas and fertiliser use) are provided by Teagasc (The Irish Agriculture and Food Development Authority) to the EPA in Q4 2019 in order to prepare agricultural emission projections. This includes proposed national herd, crop areas and fertilizer use to meet the overarching objectives of Food Wise 2025.

The FAPRI-Ireland model was used for preparing agricultural forecast data to underpin the emissions projections. This model is linked to the FAPRI world modelling system and so takes account of and contributes to, the projections for prices obtained and quantities traded on the world markets. The activity data assumes that there is an expansion in the value of Irish agriculture over the period to 2025 to meet the targets set out in “Food Wise 2025”<sup>19</sup> published by the Department of Agriculture, Food and the Marine in 2015. The main growth projections set out in this document are as follows:

- Increasing the value of agri-food exports by 85 per cent to €19 billion.
- Increasing the value added in the agri-food, fisheries and wood products sector by 70 per cent to in excess of €13 billion.
- Increasing the value of Primary Production by 65 per cent to almost €10 billion.

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<sup>19</sup> Food Wise 2025. A 10-year vision for Irish agri-industry. Department of Agriculture, Food and the Marine, 2015. <https://www.agriculture.gov.ie/foodwise2025/>

The majority of the data supplied to the EPA is disaggregated at the level of that used in inventory estimates.

Under WM scenario dairy cow numbers are projected to increase reflecting the continuing profitability of dairy production in Ireland. Dairy cow numbers in 2030 reach 1.636 million. This represent a 15% increase relative to 2018. In contrast, the continuing low levels of profitability of beef cow production systems is reflected in a projected contraction of beef cow inventories. Beef cow numbers in 2030 are projected to decline to 0.76 million. This represent a 25% decrease relative to 2018. Total cattle inventories in 2030 are projected to be 7.1 million. This represent a 2% decrease relative to 2018.

Even though total cattle inventories are relatively stable over the projection period, projected growth in dairy cow numbers and contraction in beef cow numbers leads to a change in the composition of the Irish bovine inventory and in the intensity of grassland use. Dairy production systems operate at a higher stocking rate than beef production systems and this higher stocking rate is reflected in higher projected use of nitrogen fertiliser per hectare and in total aggregate nitrogen fertiliser use by the Irish agricultural sector.

Total nitrogen fertiliser use in 2030 is projected to be 398,000 tonnes. This represent a 3% decrease relative to 2018. Due to adverse weather in 2018, fertiliser use in that year was particularly elevated.

Irish ewe and total sheep numbers are projected to contract over the period to 2030. By 2030 total Irish sheep numbers are projected to decline to 4.65 m. This represent a 10% decrease relative to 2018. This contraction reflects the low profitability of this farming activity on a per hectare basis.

The total crop land area is projected to continue to decline due to the higher level of profits per hectare in dairy farming as compared to tillage farming. By 2030 total cereal area harvested in Ireland is projected to decline to 223,000 hectares. This represent a 14% decrease relative to 2018.

The WAM scenario assumes mitigation over the period 2021-2030 attributable to measures that are included in the Teagasc Marginal Abatement Cost Curve<sup>20</sup>, where data is available. Some of the key measures include low emission slurry spreading, use of urea stabilisers and reduction of crude protein in pig diets.

Projected emissions of NMVOC and PM<sub>2.5</sub> from manure management are estimated using the same approaches and methodologies as the national inventory. Projected activity data that is utilized for NH<sub>3</sub> emission projections is also used to estimate projected emissions of NMVOC and PM<sub>2.5</sub> for the Agriculture sector.

### 8.13 Waste (NFR 5)

Air pollutant emission projections in the form of NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub> are estimated for the waste sector. Non-methane volatile organic compounds are estimated from landfill gas production, whilst NO<sub>x</sub>, SO<sub>2</sub> and PM<sub>2.5</sub> emissions are estimated from the incineration of industrial

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<sup>20</sup> <https://www.teagasc.ie/media/website/publications/2015/An-Analysis-of-the-Cost-of-the-Abatement-of-Ammonia-Emissions-in-Irish-Agriculture-to-2030.pdf> (in addition to further information from Teagasc to reflect updated projected activity data produced in 2018)  
<https://www.teagasc.ie/media/website/publications/2018/An-Analysis-of-Abatement-Potential-of-Greenhouse-Gas-Emissions-in-Irish-Agriculture-2021-2030.pdf>

waste and from cremation. NH<sub>3</sub> emissions are estimated from composting. PM<sub>2.5</sub> emissions are estimated from Solid waste disposal to landfill (5A).

Solid waste disposal to landfill produces significant quantities of landfill gas. Projected landfill gas production is based on greenhouse gas emission estimates for the sector undertaken by the EPA and submitted to the European Commission under Regulation 525/2013. The emission factor utilized in the national inventory of 5.65 gm<sup>-3</sup> NMVOC/m<sup>3</sup> landfill gas is used in projected emission estimates. Ireland has met all Landfill Directive<sup>21</sup> targets for diversion of biodegradable municipal waste from landfill to date.

The incineration of Industrial waste (5Cb) is highly regulated in Ireland. There are currently only a small number of facilities based in the pharmaceutical and chemical sectors that operate incinerators for the treatment of industrial waste. It is assumed that the quantity of industrial waste incinerated and the emissions of NO<sub>x</sub>, SO<sub>2</sub>, NMVOC and PM<sub>2.5</sub> at these facilities will remain constant at the 2018 level for each projected year to 2030.

The practice of Cremation (5C1bv) is less popular in Ireland than in other countries. However, due to the decrease in the number of burial plots available, particularly in larger cities and towns, the number of cremations in Ireland has increased. There are currently five crematoria operating in Ireland. It is assumed that the number of cremations will increase for each projected year to 2030 at the average of the 1997-2017 activity level.

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<sup>21</sup> Council Directive 1999/31/EC on the landfill of waste

## Chapter Nine

### Adjusted annual national emission inventories

#### 9.1 Introduction

Ireland is a signatory to the Gothenburg Protocol but has not yet ratified it and so is not formally covered by its emission ceilings or the associated adjustment mechanism. However, Ireland had national emissions ceilings for sulphur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), non-methane volatile organic compounds (NMVOCs) and ammonia (NH<sub>3</sub>) under the Directive 2001/81/EC (National Emissions Ceilings Directive) for 2010. Furthermore, article 4 of the new National Emissions Ceilings Directive (2016/2284/EU) ensures that the commitments of Directive 2001/81/EC continue to apply until 31<sup>st</sup> December 2019.

Article 21(2) of Directive (EU) 2016/2284 indicates that Member States may apply Article 5(1) of the Directive in relation to the ceilings in Annex I to Directive 2001/81/EC. Article 5(1) allows Member States to establish adjusted annual national emission inventories where non-compliance with emission ceilings or reduction commitments occur due to applying improved emission inventory methods in accordance with best science. The information provided in this chapter follows the reporting requirements of the adjustment process presented in Article 5 and Part 4 of Annex IV of the Directive (EU) 2016/2284.

Ireland's latest inventory submission estimates emissions of NO<sub>x</sub> and NMVOC as presented in Table 9.1. For both NO<sub>x</sub> and NMVOC national emission ceilings are exceeded for all years since 2010 and the emission ceiling for NH<sub>3</sub> is exceeded in 2016, 2017 and 2018. Ireland considers that this has arisen due to several factors including;

- New sources that have been added to the inventory, which were either not known when the NECD (2001/81/EC) ceilings were set, or for which there was no available methodology at the time
- Emission factors and methodologies which have been improved in accordance with best practice, resulting in an increase to the estimated emissions. These revisions were not foreseen when the NECD (2001/81/EC) ceilings were set.

**Table 9.1. Summary of National Emissions and the NECD Emission Ceilings**

	2010	2011	2012	2013	2014	2015	2016	2017	2018
NO <sub>x</sub> National Total (kt NO <sub>2</sub> )	114.32	102.46	105.80	107.26	106.30	106.19	108.83	107.96	107.76
NO <sub>x</sub> NECD 2010 Ceiling (kt of NO <sub>2</sub> )	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00
NMVOC (kt)	106.29	103.56	105.05	107.56	103.47	103.58	105.27	109.94	109.78
NMVOC NECD 2010 Ceiling (kt)	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00

Ireland has undertaken a detailed assessment of the new and revised sources within the national inventory in the context of the requirements outlined in Part 4 of Annex IV in Directive (EU) 2016/2284, and is of the view that several changes to the national inventory should be included in the adjusted annual national emission inventory. The proposed adjustments for NO<sub>x</sub> and NMVOC are summarised in the Tables 9.2a and 9.2b below.

The resulting adjusted annual national emission inventories show Ireland to be in compliance with the NMVOC ceiling and the NO<sub>x</sub> emission ceiling from 2011 onwards.

The justification and quantification of each adjustment application is provided in detail in the following sections and is also summarised in the excel spreadsheet (Annex VII Adjustment summary) that was submitted with the national emission inventory. The established adjusted annual emission inventory outlined here will be subject to a review by the European Commission as outlined in Article 5(6) of Directive (EU) 2016/2284, to assess whether Member States have fulfilled the relevant conditions set out in Article 5(1) and Part 4 of Annex IV. These adjustments were approved in 2018 and 2019.

Without the adjustments indicated above, it is estimated that under the With Additional Measures scenario (WAM), Ireland would not reach compliance with the NO<sub>x</sub> and NMVOC ceiling before compliance requirements change to emission reduction commitments post 2020.

**Table 9.2a. Summary of NOx Adjustments**

NFR	Source Sector Name	2010	2011	2012	2013	2014	2015	2016	2017	2018	Comments
	<b>NOx Adjustments (kt NO<sub>2</sub>)</b>	<b>-45.884</b>	<b>-42.881</b>	<b>-44.297</b>	<b>-46.717</b>	<b>-47.012</b>	<b>-46.049</b>	<b>-48.107</b>	<b>-49.610</b>	<b>-50.924</b>	
1A3bi	Road transport - Passenger Cars	-5.562	-6.038	-6.915	-6.676	-7.451	-7.536	-8.931	-9.409	-9.499	<i>Current (COPERT5) - Original (COPERT2 EFs x Current Fleet)</i>
1A3bii	Road transport - Light Duty Vehicles	-0.026	-0.035	-0.052	-0.109	-0.236	-0.308	-0.537	-0.706	-0.307	
1A3biii	Road transport - Heavy Duty Vehicles	-2.317	-2.381	-2.056	-2.106	-2.007	-1.508	-1.062	-0.433	0.182	
1A3biii	Road transport - Buses	-0.394	-0.298	-0.253	-0.298	-0.369	0.055	0.557	0.654	0.578	
1A3biv	Road transport - Mopeds & Motorcycles	-0.005	-0.003	-0.002	-0.002	-0.001	0.000	0.002	0.003	0.005	
1A3c	Rail	-0.665	-0.673	-0.644	-0.641	-0.588	-0.600	-0.611	-0.630	-0.637	<i>"Original EFs" confirmed as being used in 1999 submission</i>
1A3dii	National Navigation	-2.249	-1.953	-2.064	-2.019	-2.527	-2.492	-2.995	-2.645	-2.925	
1A4ai	Commercial Combustion (Stationary)	-1.281	-1.194	-1.183	-1.079	-0.969	-0.965	-1.019	-1.083	-1.141	
1A4bi	Residential	-0.457	-0.442	-0.436	-0.495	-0.395	-0.359	-0.298	-0.230	-0.238	
1A4ciii	National Fishing	-1.813	-1.502	-1.662	-1.850	-1.762	-1.549	-1.423	-1.685	-2.011	
3B1a	Manure management - Dairy cattle	-0.041	-0.042	-0.043	-0.044	-0.045	-0.049	-0.052	-0.055	-0.056	<i>New EF's in 2019 guidebook.</i>
3B1b	Manure management - Non-dairy cattle	-0.512	-0.505	-0.541	-0.530	-0.530	-0.537	-0.554	-0.555	-0.543	
3B2	Manure management - Sheep	-0.047	-0.048	-0.050	-0.050	-0.049	-0.049	-0.049	-0.052	-0.051	
3B3	Manure management - Swine	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	
3B4d	Manure management - Goats	-0.002	-0.002	-0.001	-0.001	-0.001	-0.002	-0.001	-0.001	-0.001	
3B4e	Manure management - Horses	-0.039	-0.039	-0.041	-0.037	-0.035	-0.034	-0.034	-0.031	-0.031	
3B4f	Manure management - Mules and asses	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.003	-0.002	
3B4gi	Manure management - Laying hens	-0.018	-0.018	-0.021	-0.023	-0.024	-0.027	-0.027	-0.029	-0.030	
3B4gii	Manure management - Broilers	-0.070	-0.068	-0.068	-0.063	-0.071	-0.072	-0.072	-0.071	-0.071	
3B4giii	Manure management - Turkeys	-0.020	-0.025	-0.028	-0.026	-0.027	-0.028	-0.029	-0.029	-0.032	
3B4giv	Manure management - Other poultry	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.005	-0.005	-0.005	
3B4h	Manure management - Other animals (please specify in IIR)-solid	-0.012	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	
3B4h	Manure management - Other animals (please specify in IIR)-slurry	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
3Da1	Inorganic N-fertilizers (includes also urea application)	-13.943	-11.381	-11.409	-13.583	-12.765	-12.695	-13.047	-14.201	-15.717	
3Da2a	Animal manure applied to soils	-5.257	-5.260	-5.499	-5.557	-5.567	-5.696	-5.940	-6.062	-6.057	
3Da2b	Sewage sludge applied to soils	-0.159	-0.111	-0.131	-0.100	-0.082	-0.090	-0.087	-0.089	-0.085	
3Da3	Urine and dung deposited by grazing animals	-10.989	-10.850	-11.183	-11.414	-11.494	-11.494	-11.883	-12.254	-12.244	

NFR	Source Sector Name	2010	2011	2012	2013	2014	2015	2016	2017	2018	Comments
	Agreed adjustment (kt NO <sub>2</sub> )	-45.884	-42.881	-44.297	-46.717	-47.012	-46.049	-48.107	-49.610	-50.924	Subtracted from Annex 1
	NOx National Total (kt NO <sub>2</sub> )	114.317	102.464	105.796	107.257	106.305	106.187	108.828	107.963	107.755	All adjustments (agreed and for review)
	NOx Adjusted Total (kt NO <sub>2</sub> )	68.433	59.584	61.499	60.540	59.292	60.138	60.720	58.353	56.832	
	NOx NECD Ceiling (kt NO <sub>2</sub> )	65.000	65.000	65.000	65.000	65.000	65.000	65.000	65.000	65.000	

**Table 9.2b. Summary of NMVOC Adjustments**

NFR	Source Sector Name	2010	2011	2012	2013	2014	2015	2016	2017	2018	Comments
	NMVOC Adjustments (kt)	-50.617	-51.432	-54.213	-56.706	-54.029	-55.201	-58.038	-63.669	-62.530	Agreed subtracted from Annex 1
2H2	Food and beverages industry	-12.286	-13.308	-14.688	-16.290	-13.560	-14.379	-15.500	-20.438	-19.284	"New" source
3B	Manure Management	-37.725	-37.517	-38.882	-39.748	-39.797	-40.143	-41.833	-42.535	-42.547	
3De	Inorganic N Fertilisers	-0.607	-0.608	-0.643	-0.668	-0.672	-0.679	-0.706	-0.696	-0.699	
	NMVOC National Total (kt)	106.288	103.559	105.049	107.555	103.467	103.577	105.269	109.942	109.784	
	NMVOC Adjusted Total (kt)	55.671	52.127	50.836	50.850	49.438	48.376	47.231	46.273	47.254	
	NMVOC NECD Ceiling (kt)	55.000	55.000	55.000	55.000	55.000	55.000	55.000	55.000	55.000	

## 9.2 Meeting the Requirements for an Adjustment

### 9.2.1 New Emission Sources

Part 4.1.d.i of Annex IV of Directive (EU) 2016/2284 indicates that for new emission source categories, evidence must be provided that:

1. The new source category is acknowledged in scientific literature (and/or the EMEP/EEA Guidebook).
2. The source category was not included in the relevant historic national emissions inventory when the ceilings were set.
3. The emissions from a new source category contribute to the MS not complying with their 2010 emissions ceilings under Directive 2001/81/EC.

All of the new sources identified in this adjustment application are included in the current version of the EMEP/EEA Guidebook, and were not included in the national emissions inventory in 1999 (when the targets contained within Directive 2001/81/EC were set). Tables 9.2a and 9.2b demonstrate that the identified new sources contribute to the exceedance of the NECD emissions ceilings.

As such, it is considered that all of the criteria are met for the new sources that have been identified.

Quantification of the adjustment for each of the new sources is presented in detail in sections 9.3 and 9.4. But the following general approach has been used:

The adjustment for new source has been obtained by multiplying the emission by -1.

### 9.2.2 Significantly Different Emission Factors

Part 4.1.d.ii of Annex IV of Directive (EU) 2016/2284 indicates that where significantly different emission factors (EFs) are used, the following evidence is required:

1. The original EF, and information on its origin or derivation.
2. Evidence that the original EF was used in determining the emission ceilings when they were set.
3. The updated EF, and information on its origin or derivation.
4. A comparison of the original and updated EFs, demonstrating that the change contributes to a MS being in exceedance.
5. A rationale for deciding whether the changes in EF are significant.

Section 9.3 and 9.4 below present the original and updated EFs and the quantified impact on the emissions estimates of the change. The sources of the EFs are also presented, and the original EFs were all used in the emission inventory in 1999, when the emission ceilings were set.

All of the changes to emission factors that are presented contribute to moving Ireland's national total emissions into compliance. All of changes are therefore considered to be "significant" in the context of attaining compliance with emission ceilings.

In calculating adjustments for revised EFs, it is not necessary to present the current activity data (since this can be derived from the current emission and the current emission factor). In presenting information to quantify the adjustment, the following approach has been used:

$$\text{Adjustment} = (\text{EF}_{\text{Original}} \times \text{AD}_{\text{Current}}) - (\text{E}_{\text{Current}})$$

$$\text{Given that: } \text{AD}_{\text{Current}} = \text{E}_{\text{Current}} / \text{EF}_{\text{Current}}$$

The adjustment can be written:

$$\text{Adjustment} = (\text{EF}_{\text{Original}} \times \text{E}_{\text{Current}} / \text{EF}_{\text{Current}}) - \text{E}_{\text{Current}}$$

The information provided in the tables for each of the adjustments in the following sections should therefore be sufficient to allow a review of the adjustment quantification.

The final adjustment value has been determined and provided at the individual NFR category level. Where there have been revisions to emission factors for sources within an NFR category, all revisions have been included i.e. both increases and decreases to emission factors have been included. This avoids selectively including only EF revisions which would result in a favourable revision of the national emissions inventory total – a process which is not considered to be appropriate. As a result, the adjustment values that are shown for each NFR category can be considered “net” adjustment values.

## 9.3 NO<sub>x</sub> Adjustment Applications

### 9.3.1 1A3b Road Transport (NO<sub>x</sub>)

#### Justification – Significantly Different EFs

Emission factors for NO<sub>x</sub> from road transport were included in the EMEP/CORINAIR Emissions Inventory Guidebook (version 2) in 1999 which were applicable when the emission ceilings were set. However, the EFs used in the current national emissions inventory are higher than these original EFs. Ireland considers that the current NO<sub>x</sub> EFs for this source are significantly different, as defined by the Directive (EU) 2016/2284 and are eligible for an adjustment

Overall emissions from the different vehicle categories within road transport for the period 2010 to 2018 are;

- passenger cars (1A3bi) are now on average 108.5 per cent higher
- light duty vehicles (1A3bii) are now on average 3.7 per cent higher
- heavy duty vehicles (1A3biii) are now on average 44.3 per cent higher
- buses and coaches (1A3biii) are now on average 0.5 per cent lower (3.9 per cent higher on average in the period 2010-2014)
- mopeds and motorcycles (1A3biv) are now on average 1.9 per cent higher (10.7 per cent higher on average in the period 2010-2014)

#### Quantification

The adjustment quantification is explained for each mode of road transport in Tables 9.3 to 9.8.

The general approach for quantification is presented in section 9.2.2. In this case the original emission factors are those that were used in the national inventory submission in 1999 and were derived from the COPERT II model using a Tier 3 methodology. The current EFs were derived from the COPERT 5 model using a Tier 3 methodology. The 2020 adjustment application for NO<sub>x</sub> submitted under the NECD is based on the same methodology as used for the original approved adjustment application with slight changes to IEFs due to the revisions included in COPERT 5.3 in comparison to COPERT 5.2 (which was the model version used for the 2019 submission). The adjustment has been reviewed and approved by the EC in 2017, 2018 and 2019.

**Table 9.3 Adjustment Quantification for Road Transport-1A3bi Passenger Cars (NO<sub>x</sub>)**

Activity (NFR)	Activity technology	Emission Factors		Current NO <sub>x</sub> emission (tonnes)									
		Current EF (g/km)	"Original" EF (g/km)	2010	2011	2012	2013	2014	2015	2016	2017	2018	
1A3bi Passenger Cars	Conventional	0.520	0.548	87.10	67.66	61.83	27.96	23.47	18.24	12.26	6.30	3.71	
	PC Euro 1 - 91/441/EEC	0.458	0.574	600.68	373.71	278.82	85.54	71.39	56.37	38.09	19.65	11.64	
	PC Euro 2 - 94/12/EEC	0.301	0.283	3281.97	2658.03	2174.00	1795.11	1430.01	1089.34	772.56	396.97	248.05	
	PC Euro 3 - 98/69/EC	0.238	0.254	5249.20	4811.94	4502.47	3909.98	3521.81	2971.05	2546.92	1309.53	889.88	
	Stage2000			5687.08	5354.26	5453.82	5260.47	5348.63	4893.76	4928.04	3541.63	3082.39	
	PC Euro 4 - 98/69/EC	0.281	0.101	0.00	1418.16	2606.62	2935.78	4117.89	4164.25	4836.15	5312.30	5063.25	
	Stage2005	0.472	0.123	0.00	0.00	0.00	0.00	0.00	928.63	2409.54	3477.29	3226.11	
	PC Euro 5 - EC 715/2007			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1487.79	2798.14
	PC Euro 6 – 1 - EC 715/2007	0.283	0.119	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1487.79	2798.14
	PC Euro 6 – 2 - EC 715/2007			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1487.79
					<b>14906.02</b>	<b>14683.76</b>	<b>15077.56</b>	<b>14014.84</b>	<b>14513.20</b>	<b>14121.63</b>	<b>15543.56</b>	<b>15551.46</b>	<b>15323.18</b>
					<b>Adjustment (tonnes)</b>								
		Conventional			2.25	1.76	1.62	0.77	0.65	0.51	0.34	0.17	0.10
		PC Euro 1 - 91/441/EEC			130.38	83.85	61.49	22.00	16.75	13.94	9.57	5.05	2.94
		PC Euro 2 - 94/12/EEC			-490.60	-366.32	-297.55	-203.14	-140.83	-86.55	-53.84	-16.45	-14.89
		PC Euro 3 - 98/69/EC			-1437.92	-1181.92	-1128.90	-851.16	-733.82	-521.07	-407.15	38.75	59.56
		Stage2000			-3766.22	-3524.46	-3617.34	-3477.02	-3552.06	-3238.08	-3264.52	-2264.40	-1971.87
		PC Euro 4 - 98/69/EC			0.00	-1051.36	-1935.01	-2167.76	-3041.53	-3075.47	-3578.23	-3929.90	-3749.05
		Stage2005			0.00	0.00	0.00	0.00	0.00	-629.54	-1636.75	-2373.42	-2202.95
	PC Euro 5 - EC 715/2007			0.00	0.00	0.00	0.00	0.00	0.00	0.00	-869.15	-1622.60	
	PC Euro 6 – 1 - EC 715/2007			0.00	0.00	0.00	0.00	0.00	0.00	0.00	-869.15	-1622.60	
	PC Euro 6 – 2 - EC 715/2007			0.00	0.00	0.00	0.00	0.00	0.00	0.00	-869.15	-1622.60	
				<b>-5562.10</b>	<b>-6038.44</b>	<b>-6915.70</b>	<b>-6676.31</b>	<b>-7450.84</b>	<b>-7536.26</b>	<b>-8930.58</b>	<b>-9409.35</b>	<b>-9498.76</b>	

**Table 9.4 Adjustment Quantification for Road Transport-1A3bii Light Duty Vehicles (NO<sub>x</sub>)**

Activity (NFR)	Activity technology	Emission Factors		Current NO <sub>x</sub> emission (tonnes)									
		Current EF (g/km)	"Original" EF (g/km)	2010	2011	2012	2013	2014	2015	2016	2017	2018	
1A3bii Light Duty Vehicles	Conventional	1.283	1.190	83.91	59.30	29.37	28.00	25.03	19.50	8.92	5.62	3.45	
	LD Euro 1 - 93/59/EEC	1.104	0.497	236.98	196.62	159.26	181.05	156.00	122.51	74.26	49.71	31.98	
	LD Euro 2 - 96/69/EEC	1.105	0.298	914.32	782.09	632.08	690.49	555.75	460.41	398.37	326.09	248.13	
	LD Euro 3 - 98/69/EC Stage2000	0.934	1.066	1784.06	1669.57	1516.00	1905.15	1814.94	1625.72	1284.01	1063.84	836.54	
	LD Euro 4 - 98/69/EC Stage2005	0.750	0.876	2051.92	2009.71	1911.29	2422.57	2401.15	2247.31	1963.70	1747.61	1537.13	
	LD Euro 5 - 2008 Standards	1.227	0.876	0.00	350.47	717.91	1387.89	2086.44	2062.25	2225.65	2203.11	2169.67	
	LD Euro 6-1	1.001	0.876	0.00	0.00	0.00	0.00	0.00	702.10	1729.30	2509.53	2566.74	
	LD Euro 6-2	0.366	0.876	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	329.01
					<b>5071.19</b>	<b>5067.74</b>	<b>4965.92</b>	<b>6615.15</b>	<b>7039.31</b>	<b>7239.78</b>	<b>7684.20</b>	<b>7905.52</b>	<b>7722.65</b>
					<b>Adjustment (tonnes)</b>								
		Conventional			-3.18	-2.05	-1.15	-1.29	-1.29	-1.15	-0.51	-0.36	-0.25
		LD Euro 1 - 93/59/EEC			-123.81	-103.13	-83.68	-95.78	-83.52	-66.17	-40.09	-27.07	-17.58
		LD Euro 2 - 96/69/EEC			-653.11	-559.51	-452.68	-495.14	-399.59	-332.14	-288.55	-237.08	-181.17
		LD Euro 3 - 98/69/EC Stage2000			310.65	286.15	257.54	318.86	294.21	254.30	196.32	157.86	118.46
		LD Euro 4 - 98/69/EC Stage2005			443.55	425.26	398.52	500.93	480.89	433.00	358.81	307.53	257.79
	LD Euro 5 - 2008 Standards			0.00	-82.20	-170.51	-336.83	-526.80	-540.20	-605.15	-613.57	-620.49	
	LD Euro 6-1			0.00	0.00	0.00	0.00	0.00	-55.23	-157.46	-292.84	-320.74	
	LD Euro 6-2			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	457.20	
				<b>-25.90</b>	<b>-35.47</b>	<b>-51.96</b>	<b>-109.25</b>	<b>-236.10</b>	<b>-307.60</b>	<b>-536.63</b>	<b>-705.53</b>	<b>-306.78</b>	

**Table 9.5 Adjustment Quantification for Road Transport-1A3biii Heavy Duty Vehicles (NO<sub>x</sub>)**

Activity (NFR)	Activity technology	Emission Factors		Current NO <sub>x</sub> emission (tonnes)									
		Current EF (g/km)	"Original" EF (g/km)	2010	2011	2012	2013	2014	2015	2016	2017	2018	
1A3biii Heavy Duty Vehicles	Conventional	5.759	5.996	152.12	128.13	90.33	55.09	44.98	34.70	19.19	10.76	6.43	
	HD Euro I - 91/542/EEC Stage I	4.373	3.915	251.40	212.02	179.57	98.82	76.44	55.49	28.84	20.58	12.65	
	HD Euro II - 91/542/EEC Stage II	4.907	3.086	1686.50	1601.27	1263.88	660.63	589.65	428.49	320.89	238.53	192.20	
	HD Euro III - 2000 Standards	3.833	2.179	2098.57	2210.12	1936.65	1824.82	1751.05	1511.48	1382.70	1128.31	887.42	
	HD Euro IV - 2005 Standards	2.696	1.513	1649.92	1777.81	1616.79	2359.76	2262.87	2097.17	2254.73	1997.05	1758.43	
	HD Euro V - 2008 Standards	1.632	1.534	0.00	89.76	187.92	416.44	641.96	647.90	796.90	834.48	864.55	
	HD Euro VI	0.132	1.529	0.00	0.00	0.00	0.00	0.00	24.06	63.46	99.06	137.88	
					<b>5838.51</b>	<b>6019.12</b>	<b>5275.14</b>	<b>5415.56</b>	<b>5366.94</b>	<b>4799.29</b>	<b>4866.70</b>	<b>4328.77</b>	<b>3859.58</b>
					<b>Adjustment (tonnes)</b>								
		Conventional			-33.90	-26.81	-16.03	-6.45	-5.45	-3.46	-1.50	0.72	0.27
		HD Euro I - 91/542/EEC Stage I			-26.41	-22.28	-18.97	-10.56	-8.11	-6.24	-2.97	-2.12	-1.32
		HD Euro II - 91/542/EEC Stage II			-632.56	-600.34	-474.05	-249.49	-221.75	-160.75	-119.88	-88.60	-71.34
		HD Euro III - 2000 Standards			-905.66	-954.92	-837.73	-790.21	-757.44	-654.53	-597.14	-486.08	-382.81
		HD Euro IV - 2005 Standards			-718.26	-774.70	-705.02	-1037.34	-994.51	-922.12	-989.49	-874.91	-771.36
	HD Euro V - 2008 Standards			0.00	-1.73	-4.31	-11.46	-19.94	-22.77	-34.21	-41.52	-51.94	
	HD Euro VI			0.00	0.00	0.00	0.00	0.00	261.47	682.75	1059.75	1460.99	
				<b>-2316.79</b>	<b>-2380.79</b>	<b>-2056.11</b>	<b>-2105.51</b>	<b>-2007.20</b>	<b>-1508.40</b>	<b>-1062.44</b>	<b>-432.75</b>	<b>182.49</b>	

**Table 9.6 Adjustment Quantification for Road Transport-1A3biii Heavy Duty Vehicles, Buses (NO<sub>x</sub>)**

Activity (NFR)	Activity technology	Emission Factors		Current NO <sub>x</sub> emission (tonnes)									
		Current EF (g/km)	"Original" EF (g/km)	2010	2011	2012	2013	2014	2015	2016	2017	2018	
1A3biii Heavy Duty Vehicles (Buses)	Conventional	13.791	10.595	398.65	320.41	255.04	297.27	408.32	68.68	17.64	10.79	11.06	
	HD Euro I - 91/542/EEC Stage I	8.454	7.417	801.50	710.59	554.15	521.05	519.06	230.99	69.27	57.78	14.86	
	HD Euro II - 91/542/EEC Stage II	7.612	11.743	3501.65	3148.28	2912.29	2955.75	2923.29	2657.26	2433.92	2342.46	1815.43	
	HD Euro III - 2000 Standards	6.230	3.300	3152.55	2721.72	2498.35	2566.50	2583.17	2403.95	2431.93	2394.26	2401.72	
	HD Euro IV - 2005 Standards	4.306	3.255	1462.46	1347.31	1299.06	1477.69	1696.20	1721.48	1810.75	1791.24	1855.68	
	HD Euro V - 2008 Standards	3.701	3.465	93.82	150.21	290.66	440.89	453.27	454.89	579.62	576.87	667.13	
	HD Euro VI	0.292	3.510	0.00	0.00	0.00	0.00	0.00	29.11	93.04	93.87	111.15	
					<b>9410.62</b>	<b>8398.52</b>	<b>7809.55</b>	<b>8259.15</b>	<b>8583.31</b>	<b>7566.35</b>	<b>7436.17</b>	<b>7267.27</b>	<b>6877.03</b>
					<b>Adjustment (tonnes)</b>								
		Conventional			-8.16	-7.87	-6.62	-4.41	-1.10	-2.59	-4.28	-2.62	-2.56
		HD Euro I - 91/542/EEC Stage I			-165.11	-146.11	-113.67	-106.81	-106.46	-47.85	-12.95	-11.37	-1.82
		HD Euro II - 91/542/EEC Stage II			1543.08	1406.69	1331.09	1394.59	1411.15	1349.94	1245.06	1245.72	985.19
					-	-	-	-	-	-	-	-	-
		HD Euro III - 2000 Standards			1441.37	1246.52	1151.07	1197.06	1217.80	1153.65	1160.74	1141.62	1129.72
	HD Euro IV - 2005 Standards			-321.53	-300.38	-295.92	-353.02	-422.61	-441.64	-461.46	-450.49	-453.17	
	HD Euro V - 2008 Standards			-0.67	-3.82	-16.88	-31.51	-31.90	-20.74	-37.70	-34.01	-42.52	
	HD Euro VI			0.00	0.00	0.00	0.00	0.00	371.32	988.95	1047.96	1222.93	
				<b>-393.75</b>	<b>-297.99</b>	<b>-253.07</b>	<b>-298.23</b>	<b>-368.71</b>	<b>54.79</b>	<b>556.87</b>	<b>653.59</b>	<b>578.33</b>	

Table 9.7 Adjustment Quantification for Road Transport-1A3biv Mopeds and Motorcycles (NO<sub>x</sub>)

Activity (NFR)	Activity technology	Emission Factors		Current NO <sub>x</sub> emission (tonnes)									
		Current EF (g/km)	"Original" EF (g/km)	2010	2011	2012	2013	2014	2015	2016	2017	2018	
1A3biv Mopeds and Motorcycles	Conventional	0.052	0.041	0.10	0.08	0.06	0.06	0.05	0.04	0.04	0.04	0.03	
	Mop - Euro I	0.184	0.116	0.48	0.39	0.34	0.35	0.32	0.29	0.29	0.28	0.21	
	Mop - Euro II	0.157	0.083	0.26	0.21	0.19	0.20	0.17	0.16	0.17	0.18	0.15	
	Mop - Euro III	0.272	0.195	0.52	0.49	0.47	0.53	0.54	0.56	0.66	0.69	0.75	
	Conventional	0.203	0.115	10.02	8.55	6.98	7.84	6.89	6.22	5.90	5.46	4.44	
	Mot - Euro I	0.353	0.221	12.88	11.54	10.26	11.73	11.36	10.73	11.10	10.59	9.14	
	Mot - Euro II	0.156	0.221	3.74	3.43	3.03	3.52	3.20	3.17	3.41	3.57	3.29	
	Mot - Euro III	0.065	0.221	1.73	1.82	1.76	2.23	2.39	2.61	3.16	3.28	4.01	
					<b>29.71</b>	<b>26.51</b>	<b>23.08</b>	<b>26.46</b>	<b>24.93</b>	<b>23.78</b>	<b>24.72</b>	<b>24.07</b>	<b>22.02</b>
					<b>Adjustment (tonnes)</b>								
		Conventional			-0.02	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
		Mop - Euro I			-0.18	-0.14	-0.12	-0.13	-0.12	-0.11	-0.11	-0.10	-0.08
		Mop - Euro II			-0.12	-0.10	-0.09	-0.09	-0.08	-0.08	-0.08	-0.08	-0.07
		Mop - Euro III			-0.15	-0.14	-0.13	-0.15	-0.15	-0.16	-0.19	-0.19	-0.21
		Conventional			-4.74	-4.02	-3.26	-3.68	-3.21	-2.88	-2.68	-2.45	-1.92
	Mot - Euro I			-4.88	-4.37	-3.88	-4.41	-4.27	-4.03	-4.16	-3.97	-3.43	
	Mot - Euro II			1.29	1.22	1.10	1.35	1.26	1.28	1.39	1.46	1.37	
	Mot - Euro III			4.14	4.37	4.21	5.35	5.75	6.26	7.58	7.88	9.63	
				<b>-4.65</b>	<b>-3.20</b>	<b>-2.18</b>	<b>-1.77</b>	<b>-0.83</b>	<b>0.28</b>	<b>1.75</b>	<b>2.52</b>	<b>5.29</b>	

**Table 9.8 Adjustment Quantification for Road Transport-1A3b Road Transport (NO<sub>x</sub>)**

Activity (NFR)	Activity technology	Current NO <sub>x</sub> emission (tonnes)								
		2010	2011	2012	2013	2014	2015	2016	2017	2018
1A3b Road Transport	1A3bi Passenger Cars	14906.02	14683.76	15077.56	14014.84	14513.20	14121.63	15543.56	15551.46	15323.18
	1A3bii Light Duty Vehicles	5071.19	5067.74	4965.92	6615.15	7039.31	7239.78	7684.20	7905.52	7722.65
	1A3biii Heavy Duty Vehicles and buses	15249.13	14417.64	13084.69	13674.72	13950.25	12365.64	12302.87	11596.04	10736.61
	1A3biv Mopeds and Motorcycles	29.71	26.51	23.08	26.46	24.93	23.78	24.72	24.07	22.02
		<b>35256.05</b>	<b>34195.65</b>	<b>33151.24</b>	<b>34331.17</b>	<b>35527.70</b>	<b>33750.84</b>	<b>35555.36</b>	<b>35077.08</b>	<b>33804.45</b>
		Adjustment (tonnes)								
	1A3bi Passenger Cars	-5562.10	-6038.44	-6915.70	-6676.31	-7450.84	-7536.26	-8930.58	-9409.35	-9498.76
	1A3bii Light Duty Vehicles	-25.90	-35.47	-51.96	-109.25	-236.10	-307.60	-536.63	-705.53	-306.78
	1A3biii Heavy Duty Vehicles and buses	-2710.54	-2678.78	-2309.18	-2403.74	-2375.91	-1453.61	-505.57	220.84	760.82
	1A3biv Mopeds and Motorcycles	-4.65	-3.20	-2.18	-1.77	-0.83	0.28	1.75	2.52	5.29
	<b>-8303.19</b>	<b>-8755.90</b>	<b>-9279.02</b>	<b>-9191.07</b>	<b>-10063.69</b>	<b>-9297.19</b>	<b>-9971.04</b>	<b>-9891.52</b>	<b>-9039.43</b>	

### 9.3.2 1A3c Railways (NO<sub>x</sub>)

#### Justification – Significantly Different EFs

Emission factors for NO<sub>x</sub> from Railways (1A3c) were included in the EMEP/CORINAIR Emissions Inventory Guidebook (version 2) in 1999 which were applicable when the emission ceilings were set. Ireland used an EF from the “Handbook of Emission Factors, Non Industrial Sources”, (Ministry of Health and Environmental Protection, The Netherlands, 1980) in the emission inventory when the emissions ceilings were set. However, the EF used in the current national emissions inventory is higher than this original EF. Ireland considers that the current NO<sub>x</sub> EF for this source is significantly different, as defined by the Directive (EU) 2016/2284 and is eligible for an adjustment.

The current EF for NO<sub>x</sub> is 49% higher than the original EF.

#### Quantification

The adjustment quantification is explained in Table 9.9.

The general approach for quantification is presented in section 9.2.2. The original EF for railways (1A3c) is from the “Handbook of Emission Factors, Non Industrial Sources”, (Ministry of Health and Environmental Protection, The Netherlands, 1980). Tables 53, 55 and 57 on pages 80-81 refer to diesel locomotives for freight and passenger trains and for shunting locomotives and show an EF for NO<sub>x</sub> of 35g/kg of fuel or 808.2 kg/TJ (NCV of Gasoil, 43.31 MJ/kg). This EF is rounded up in the original inventory to 810 kg/TJ.

Ireland now uses the EF from the Inventory Guidebook (EMEP\EEA, 2016) to replace the above referenced EF which was published in 1980. The 2020 adjustment application for NO<sub>x</sub> submitted under the NECD is based on the same methodology as used for the original approved adjustment application which has been reviewed and approved by the EC in 2017, 2018 and 2019.

**Table 9.9. Adjustment Quantification for Railways (NO<sub>x</sub>)**

Activity (Fuel)	Emission Factors		Current NO <sub>x</sub> emissions (tonnes)								
	Current EF (kg/TJ)	"Original" EF (kg/TJ)	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gasoil/Diesel	1,209.93	810	2,013.05	2,034.85	1,948.41	1,940.35	1,780.01	1,814.06	1,847.51	1,907.17	1,927.17
			Adjustments (tonnes)								
Gasoil/Diesel			-665.39	-672.60	-644.03	-641.36	-588.36	-599.62	-610.68	-630.40	-637.01
			Total Adjustment (ktonnes)								
Railways			-0.67	-0.67	-0.64	-0.64	-0.59	-0.60	-0.61	-0.63	-0.64

### 9.3.3 1A3dii National Navigation (NO<sub>x</sub>)

#### Justification – Significantly Different EFs

Emission factors for NO<sub>x</sub> from National Navigation (1A3dii) were included in the EMEP/CORINAIR Emissions Inventory Guidebook (version 2) in 1999 when the emission ceilings were set. Ireland used an EF for shipping from the “Handbook of Emission Factors, Non Industrial Sources”, (Ministry of Health and Environmental Protection, The Netherlands, 1980) in the emission inventory when the

emissions ceilings were set. However, the EF used in the current national emission inventory is higher than this original EF. Ireland considers that the current NO<sub>x</sub> EF for this source is significantly different, as defined by the Directive (EU) 2016/2284 and is eligible for an adjustment.

The current EF for NO<sub>x</sub> is 85% higher than the original EF.

### Quantification

The adjustment quantification is explained in the Table 9.10.

The general approach for quantification is presented in section 9.2.2. The original EF for shipping/navigation (1A3dii) is from the “Handbook of Emission Factors, Non Industrial Sources”, (Ministry of Health and Environmental Protection, The Netherlands, 1980). Table 66 on page 91 refer to sea-going vessels and show an EF for NO<sub>x</sub> ranging from 35g/kg of fuel to 44 g/kg fuel depending on the percentage power in use. This would equate to an EF for NO<sub>x</sub> between 808.2 kg/TJ to 1015.9 kg/TJ (NCV of Gasoil, 43.31 MJ/kg).

Ireland now uses the EF from the Inventory Guidebook (EMEP\EEA, 2016) to replace the above referenced EF which was published in 1980. The 2020 adjustment application for NO<sub>x</sub> submitted under the NECD is based on the same methodology as used for the original approved adjustment application which has been reviewed and approved by the EC in 2017, 2018 and 2019.

**Table 9.10. Adjustment Quantification for National Navigation (NO<sub>x</sub>)**

Activity (Fuel)	Emission Factors		Current NO <sub>x</sub> emissions (tonnes)								
	Current EF (kg/TJ)	"Original" EF (kg/TJ)	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gasoil /Diesel	1,812.59	980	4,897.08	4,251.32	4,492.80	4,394.62	5,501.37	5,426.06	6,520.50	5,757.59	6,368.16
Gasoil/Diesel			Adjustments (tonnes)								
			-	-	-	-	-	-	-	-	-
National Navigation			Total Adjustment (ktonnes)								
			-2.25	-1.95	-2.06	-2.02	-2.53	-2.49	-3.00	-2.64	-2.93

### 9.3.4 1A4ai Commercial/Institutional Stationary Combustion (NO<sub>x</sub>)

#### Justification – Significantly Different EFs

Emission factors for NO<sub>x</sub> from Commercial/Institutional stationary combustion (1A4ai) are included in the EMEP/CORINAIR Emissions Inventory Guidebook (version 2) in 1999 when the emission ceilings were set. Ireland used EFs for combustion in commercial from Table 3.4 page 16 of “Corinair 1990 Emission Inventory for Ireland” report published by the Environmental Research Unit in July 1993. These EFs can also be referenced as Table 2.2 of “Corinair Technical annexes Volume 2, Default emission factors handbook” published by the European Commission in 1994. However, the EFs used in the current national emission inventory are higher than these original EFs. Ireland considers that the current NO<sub>x</sub> EFs for these sources are significantly different, as defined by the Directive (EU) 2016/2284 and are eligible for an adjustment.

The current EFs for each fuel for this source;

- Fuel oil is 17% lower
- LPG is 48% higher
- Gasoil is 100% higher
- Natural Gas is 48% higher
- Biomass is 82% higher
- Biogas is 48% higher

than the original EFs.

### Quantification

The adjustment quantification is explained in Table 9.11.

The general approach for quantification is presented in section 9.2.2. The original EFs for combustion in commercial (1A4ai) are from Table 3.4 page 16 of “Corinair 1990 Emission Inventory for Ireland” report published by the Environmental Research Unit in July 1993. These EFs can also be referenced in Table 2.2 of “Corinair Technical annexes Volume 2, Default emission factors handbook” published by the European Commission in 1994. There are additional older references also available if needed.

Ireland now uses the EFs from the Inventory Guidebook (EMEP\EEA, 2016) to replace the above referenced EFs which were published in 1987, 1993 and 1994. The 2020 adjustment application for NO<sub>x</sub> submitted under the NECD is based on the same methodology as used for the original approved adjustment application which has been reviewed and approved by the EC in 2017, 2018 and 2019.

**Table 9.11. Adjustment Quantification for Commercial/Institutional Stationary Combustion (NO<sub>x</sub>)**

Activity (Fuel)	Emission Factors		Current NO <sub>x</sub> emissions (tonnes)								
	Current EF (kg/TJ)	Original EF (kg/TJ)	2010	2011	2012	2013	2014	2015	2016	2017	2018
Fuel Oil	100	120	28.22	23.05	19.05	17.11	14.54	13.11	5.89	5.22	5.22
LPG	74	50	24.05	22.93	22.12	26.79	24.07	24.43	26.17	26.79	29.19
Gasoil / Diesel	100	50	1,575.75	1,547.39	1,436.99	1,195.48	978.94	944.54	957.98	1,035.99	1,075.61
Natural Gas	74	50	1,420.62	1,178.29	1,295.51	1,306.85	1,286.15	1,382.23	1,468.77	1,561.27	1,692.36
Biomass	91	50	45.74	60.04	72.82	95.58	106.01	63.59	94.22	80.21	68.87
Biogas	74	50	30.04	26.57	24.97	27.27	31.55	31.69	41.99	44.31	45.16
			Adjustments (tonnes)								
Fuel Oil			5.64	4.61	3.81	3.42	2.91	2.62	1.18	1.04	1.04
LPG			-7.80	-7.44	-7.17	-8.69	-7.81	-7.92	-8.49	-8.69	-9.47
Gasoil / Diesel			-787.88	-773.70	-718.50	-597.74	-489.47	-472.27	-478.99	-518.00	-537.81
Natural Gas			-460.74	-382.15	-420.16	-423.84	-417.13	-448.29	-476.36	-506.36	-548.87
Biomass			-20.61	-27.05	-32.81	-43.06	-47.76	-28.65	-42.45	-36.14	-31.03
Biogas			-9.74	-8.62	-8.10	-8.84	-10.23	-10.28	-13.62	-14.37	-14.65
			Total Adjustment (ktonnes)								
<b>Comm/ Instit Stationary Combustion</b>			<b>-1.28</b>	<b>-1.19</b>	<b>-1.18</b>	<b>-1.08</b>	<b>-0.97</b>	<b>-0.96</b>	<b>-1.02</b>	<b>-1.08</b>	<b>-1.14</b>

### 9.3.5 1A4bi Residential Stationary Combustion (NO<sub>x</sub>)

#### Justification – Significantly Different EFs

Emission factors for NO<sub>x</sub> from Residential stationary combustion (1A4bi) were included in the EMEP/CORINAIR Emissions Inventory Guidebook (version 2) in 1999 when the emission ceilings were set. Ireland used EFs for combustion in residential from Table 3.4 page 16 of “Corinair 1990 Emission Inventory for Ireland” report published by the Environmental Research Unit in July 1993. These EFs can also be referenced as Table 2.2 of “Corinair Technical annexes Volume 2, Default emission factors handbook” published by the European Commission in 1994. However, the EFs used in the current national emission inventory are generally higher than these original EFs. Ireland considers that the current NO<sub>x</sub> EFs for these sources are significantly different, as defined by the Directive (EU) 2016/2284 and are eligible for an adjustment.

The current EFs for each fuel for this source;

- Bituminous coal and Anthracite are 120% higher
- Lignite, sod peat and peat briquettes are 10% higher
- Kerosene and Gasoil are 2% higher
- Petroleum coke is 49% lower
- Natural Gas and LPG are 16% lower
- Biomass is 20% lower

than the original EFs.

#### Quantification

The adjustment quantification is explained in Table 9.12.

The general approach for quantification is presented in section 9.2.2. The original EFs for stationary combustion (1A4bi) in the residential sector are from Table 3.4 page 16 of “Corinair 1990 Emission Inventory for Ireland” report published by the Environmental Research Unit in July 1993. These EFs can also be referenced in Table 2.2 of “Corinair Technical annexes Volume 2, Default emission factors handbook” published by the European Commission in 1994. There are additional older references also available if needed.

Ireland now uses the EFs from the Inventory Guidebook (EMEP/EEA, 2016) to replace the above referenced EFs which were published in 1987, 1993 and 1994, respectively. The 2020 adjustment application for NO<sub>x</sub> submitted under the NECD is based on the same methodology as used for the original approved adjustment application which has been reviewed and approved by the EC in 2017, 2018 and 2019.

**Table 9.12. Adjustment Quantification for Residential Stationary Combustion (NO<sub>x</sub>)**

Activity (Fuel)	Emission Factors		Current NO <sub>x</sub> emissions (tonnes)								
	Current EF (kg/TJ)	"Original" EF (kg/TJ)	2010	2011	2012	2013	2014	2015	2016	2017	2018
Bituminous Coal	110.00	50.00	816.80	698.46	759.37	796.71	612.03	578.96	463.91	340.33	357.05
Anthracite <sup>1</sup>	110.00	50.00	306.56	310.39	300.19	381.04	338.19	312.50	315.74	303.61	322.99
Lignite	110.00	100.00	47.81	48.38	54.87	79.68	58.36	58.22	43.73	40.92	34.66
Sod Peat	110.00	100.00	761.99	749.14	588.14	588.14	588.14	588.14	588.14	588.14	588.14
Briquettes	110.00	100.00	405.68	362.01	399.88	415.41	332.81	335.73	318.62	279.21	317.02
Kerosene	51.00	50.00	2,157.51	1,705.30	1,457.41	1,507.66	1,428.64	1,653.96	1,740.79	1,650.23	1,819.19
LPG	42.00	50.00	65.67	60.27	58.13	70.41	63.25	64.20	68.78	70.39	76.71
Gasoil / Diesel	51.00	50.00	431.93	413.83	394.34	341.96	306.40	295.18	309.95	321.21	341.56
Petroleum Coke	51.00	100.00									
Natural Gas	42.00	50.00	28.36	18.49	21.14	23.36	18.07	13.89	11.75	8.07	7.50
Biomass <sup>2</sup>	50.00	100.00	1,248.03	1,001.04	1,055.94	1,066.00	941.96	976.14	989.99	976.82	1,062.27
			<b>6,299.56</b>	<b>5,395.10</b>	<b>5,119.22</b>	<b>5,302.44</b>	<b>4,715.17</b>	<b>4,903.34</b>	<b>4,875.75</b>	<b>4,600.72</b>	<b>4,949.12</b>
			<b>Adjustments (tonnes)</b>								
Bituminous Coal			-445.53	-380.98	-414.20	-434.57	-333.83	-315.80	-253.04	-185.64	-194.76
Anthracite <sup>1</sup>			-167.22	-169.30	-163.74	-207.84	-184.47	-170.46	-172.22	-165.61	-176.18
Lignite			-4.35	-4.40	-4.99	-7.24	-5.31	-5.29	-3.98	-3.72	-3.15
Sod Peat			-69.27	-68.10	-53.47	-53.47	-53.47	-53.47	-53.47	-53.47	-53.47
Briquettes			-36.88	-32.91	-36.35	-37.76	-30.26	-30.52	-28.97	-25.38	-28.82
Kerosene			-42.30	-33.44	-28.58	-29.56	-28.01	-32.43	-34.13	-32.36	-35.67
LPG			12.51	11.48	11.07	13.41	12.05	12.23	13.10	13.41	14.61
Gasoil / Diesel			-8.47	-8.11	-7.73	-6.71	-6.01	-5.79	-6.08	-6.30	-6.70
Petroleum Coke			27.25	17.77	20.31	22.44	17.36	13.34	11.29	7.75	7.20
Natural Gas			237.72	190.68	201.13	203.05	179.42	185.93	188.57	186.06	202.34
Biomass <sup>2</sup>			39.92	35.50	41.00	43.03	37.87	42.96	41.33	35.56	36.56
			<b>-456.614</b>	<b>-441.819</b>	<b>-435.548</b>	<b>-495.219</b>	<b>-394.654</b>	<b>-359.290</b>	<b>-297.599</b>	<b>-229.692</b>	<b>-238.033</b>
			<b>Total Adjustment (ktonnes)</b>								
<b>Residential Stationary Combustion</b>			<b>-0.46</b>	<b>-0.44</b>	<b>-0.44</b>	<b>-0.50</b>	<b>-0.39</b>	<b>-0.36</b>	<b>-0.30</b>	<b>-0.23</b>	<b>-0.24</b>

<sup>1</sup> Includes Manufactured Ovoids,

<sup>2</sup> Biomass has a T2 method applied except to residential stoves and fireplaces for nontraded wood with EF 80kg/TJ

### 9.3.6 1A4ciii National Fishing (NO<sub>x</sub>)

#### Justification – A New Source/Significantly Different EFs

Activity data to estimate emission of NO<sub>x</sub> from National Fishing (1A4ciii) did not exist in Ireland's national energy balance until 2012, when they were first introduced for the 1990-2010 energy balance. Marine diesel used in National Fishing is now included in the energy balance for all years from 1990 to 2018.

For a new source, Directive (EU) 2016/2284 requires that the source is currently included in scientific literature (such as the EMEP/EEA Guidebook), and that the source was not included in the historic national emissions inventory when emission ceilings were set. Both of these criteria are met, and it is therefore concluded that NO<sub>x</sub> emissions from national fishing (1A4ciii) are a new source and are eligible for an adjustment.

The fuel allocated to National Fishing (1A4ciii) since 2012 did not increase the overall gasoil/diesel use in the energy balance estimates, as the fuel was re-allocated from the category Commercial/Institutional (1A4ai) stationary combustion. So while National Fishing is in effect a new source introduced in 2012, to avoid double counting it is more appropriate that an adjustment is considered on the basis of significantly different EFs.

#### Quantification

The adjustment quantification is explained in the table 9.13 below.

The general approach for quantification is presented in section 9.2.2. Ireland used EFs for stationary combustion in the commercial/Institutional category (1A4ai) from Table 3.4 page 16 of "Corinair 1990 Emission Inventory for Ireland" report published by the Environmental Research Unit in July 1993. These EFs can also be referenced in Table 2.2 of "Corinair Technical annexes Volume 2, Default emission factors handbook" published by the European Commission in 1994.

Ireland now uses an EF for NO<sub>x</sub> for National Fishing from the 2016 version of the EMEP/EEA Emissions Inventory Guidebook and is used to estimate emissions of NO<sub>x</sub> for all years from 1990 to 2017 in the current inventory submission.

**Table 9.13. Adjustment Quantification for National Fishing (NO<sub>x</sub>)**

Activity (Fuel)	Emission Factors		Current NO <sub>x</sub> emissions (tonnes)								
	Current EF (kg/TJ)	"Original" EF (kg/TJ)	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gasoil/Diesel	1,812.59	50.00	1864.20	1544.13	1709.37	1902.07	1812.30	1593.33	1463.08	1732.52	2067.98
Gasoil/Diesel			Adjustments (tonnes)								
			-1812.78	-1501.54	-1662.22	-1849.60	-1762.30	-1549.38	-1422.72	-1684.73	-2010.93
National Fishing			Total Adjustment (ktonnes)								
			-1.86	-1.54	-1.71	-1.90	-1.81	-1.59	-1.46	-1.73	-2.07

The current EF for gasoil for this source is 3525% higher than the original EF. The 2020 adjustment application for NO<sub>x</sub> submitted under the NECD is based on the same methodology as used for the

original approved adjustment application which has been reviewed and approved by the EC in 2017, 2018 and 2019.

### 9.3.7 3B1a-3B4h Manure Management (NO<sub>x</sub>)

#### Justification – New emission source

Emissions of NO<sub>x</sub> from Manure Management were not included in Ireland’s national emissions inventory in 1999, when the ceilings were set. This sector is to be considered as a new source compared to when the emission ceilings were set, since default methodologies and emission factors were not available in the EMEP/EEA Guidebook until the 2009 edition. A methodology is presented in the 2019 EMEP/EEA Guidebook, and this is currently used to estimate emissions that are included in the Irish national emissions inventory. For a new source, the Directive (EU) 2016/2284 requires that the source is currently included in scientific literature (such as the EMEP/EEA Guidebook), and that the source was not included in the historic national emissions inventory when emission ceilings were set. Both of these criteria are met, and it is therefore concluded that NO<sub>x</sub> emissions from manure management are a new source and are eligible for an adjustment.

#### Quantification

Emissions have been calculated by using the Tier 2 mass-flow methodology for NH<sub>3</sub> and the default emission factors presented in the Inventory Guidebook (EMEP/EEA, 2019), Chapter 3. B Manure Management Table 3-10. As a new source, quantification of the adjustment is achieved by subtracting the emissions from the national inventory total as shown in Table 9.14.

Table 9.14. Adjustments for Manure Management (NO<sub>x</sub>)

Source Sector	Adjustments (ktonnes)								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Manure Management – 3B1a Dairy cattle	-0.041	-0.042	-0.043	-0.044	-0.045	-0.049	-0.052	-0.055	-0.056
Manure Management – 3B1b Non-dairy cattle	-0.512	-0.505	-0.541	-0.530	-0.530	-0.537	-0.554	-0.555	-0.543
Manure Management – 3B2 Sheep	-0.047	-0.048	-0.050	-0.050	-0.049	-0.049	-0.049	-0.052	-0.051
Manure Management – 3B3 Swine	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
Manure Management – 3B4d Goats	-0.002	-0.002	-0.001	-0.001	-0.001	-0.002	-0.001	-0.001	-0.001
Manure Management – 3B4e Horses	-0.039	-0.039	-0.041	-0.037	-0.035	-0.034	-0.034	-0.031	-0.031
Manure Management – 3B4f Mules and asses	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.003	-0.002
Manure Management - 3B4gi Laying hens	-0.018	-0.018	-0.021	-0.023	-0.024	-0.027	-0.027	-0.029	-0.030
Manure Management - 3B4gii Broilers	-0.070	-0.068	-0.068	-0.063	-0.071	-0.072	-0.072	-0.071	-0.071
Manure Management - 3B4giii Turkeys	-0.020	-0.025	-0.028	-0.026	-0.027	-0.028	-0.029	-0.029	-0.032
Manure Management - 3B4giv Other poultry	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.005	-0.005	-0.005
Manure Management – 3B4h Other animals (solid)	-0.012	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006
Manure Management – 3B4h Other animals (slurry)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<b>Total Adjustment – 3B Manure Management</b>	<b>-0.768</b>	<b>-0.760</b>	<b>-0.808</b>	<b>-0.788</b>	<b>-0.798</b>	<b>-0.813</b>	<b>-0.835</b>	<b>-0.839</b>	<b>-0.830</b>

### 9.3.8 3D Fertilisers applied to soils (NO<sub>x</sub>)

#### Justification – New Emission source

Emissions from fertiliser applied to soils were not included in Ireland’s national emissions inventory in 1999, when the ceilings were set. This sector is to be considered as a new source compared to when the emission ceilings were set. A methodology is presented in the 2019 EMEP/EEA Guidebook, and this is currently used to estimate emissions that are included in the Irish national emissions inventory.

For a new source, the Directive (EU) 2016/2284 requires that the source is currently included in scientific literature (such as the EMEP/EEA Guidebook), and that the source was not included in the historic national emissions inventory when emission ceilings were set. Both of these criteria are met, and it is therefore concluded that NO<sub>x</sub> emissions from fertiliser applied to soils are a new source and are eligible for an adjustment.

### Quantification

Emissions for 3Da1 (Inorganic N-fertilizers including urea application), 3D2a (Animal manure applied to soils), 3Da2b (Sewage sludge applied to soils) and 3Da3 (Urine and Dung deposited by grazing animals) have been calculated by using the Tier 1 methodology and emission factors presented in the Inventory Guidebook (EMEP/EEA, 2019), Chapter 3. D Crop production and agricultural soils Table 3-1. as shown in table 9.15.

**Table 9.15. Adjustments for Fertiliser applied to soils (NO<sub>x</sub>)**

Source Sector	Adjustments (ktonnes)								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Inorganic N-fertilizers (includes also urea application)-3Da1	-13.943	-11.381	-11.409	-13.583	-12.765	-12.695	-13.047	-14.201	-15.717
Animal manure applied to soils 3Da2a	-5.257	-5.260	-5.499	-5.557	-5.567	-5.696	-5.940	-6.062	-6.057
Sewage sludge applied to soils 3Da2b	-0.159	-0.111	-0.131	-0.100	-0.082	-0.090	-0.087	-0.089	-0.085
Urine and dung deposited by grazing animals -3Da3	-10.989	-10.850	-11.183	-11.414	-11.494	-11.494	-11.883	-12.254	-12.244
<b>Total Adjustment – 3D Fertiliser application</b>	<b>-30.348</b>	<b>-27.602</b>	<b>-28.222</b>	<b>-30.654</b>	<b>-29.909</b>	<b>-29.974</b>	<b>-30.957</b>	<b>-32.607</b>	<b>-34.102</b>

## 9.4 NMVOC Adjustment Applications

### 9.4.1 Food and Beverage Industry, 2H2: Spirits (NMVOC)

#### Justification - A New Source

NMVOC emissions from the food and beverage industry were not included in Ireland’s national emissions inventory in 1999, when the ceilings were set. A methodology is presented in the 2019 EMEP/EEA Guidebook, and this is currently used to estimate emissions that are included in the Irish national emissions inventory.

For a new source, the Directive (EU) 2016/2284 requires that the source is currently included in scientific literature (such as the EMEP/EEA Guidebook), and that the source was not included in the historic national emissions inventory when emission ceilings were set. Both of these criteria were not met, however paragraph 2 bis (a) (i) of Decision 2012/12 (as amended by ECE.EB.AIR/127/Add.1 (2014/1)), indicates that a new source is eligible for an adjustment for a new source if a methodology existed in the relevant version of the EMEP/EEA Guidebook, but the “Party can demonstrate that it was unable to apply this methodology due to a lack of relevant national statistical data...”. The national data for spirit manufacture was confidential and was therefore not available when the ceilings were

set. It was therefore concluded that NMVOC emissions from the food and beverage industry are a new source and are eligible for an adjustment.

### Quantification

Emissions have been calculated by using the Tier 2 methodologies presented in the Inventory Guidebook (EMEP/EEA, 2016), with EFs taken from Chapter 2H2, Table 3-28

As a new source, quantification of the adjustment is achieved by subtracting the emissions from the national inventory total as shown in Table 9.16. The 2020 adjustment application for NMVOC submitted under the NECD is based on the same methodology as used for the original approved adjustment application which has been reviewed and approved by the EC in 2017, 2018 and 2019.

**Table 9.16. Adjustments for emissions from the Food and Beverage Industry (NMVOC)**

Source Sector	Adjustments (ktonnes)								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Food and Beverages industry: Spirits	-12.29	-13.31	-14.69	-16.29	-13.56	-14.38	-15.50	-20.44	-19.28

## 9.4.2 Manure Management, 3B (NMVOC)

### Justification - A New Source

NMVOC emissions from manure management were not included in Ireland’s national emissions inventory in 1999, when the ceilings were set. Emission factors and methodological approaches were included for the first time in the 2013 edition of the Inventory Guidebook. A methodology is presented in the 2019 EMEP/EEA Guidebook, and this is currently used to estimate emissions that are included in the Irish national emissions inventory.

For a new source, the Directive (EU) 2016/2284 requires that the source is currently included in scientific literature (such as the EMEP/EEA Guidebook), and that the source was not included in the historic national emissions inventory when emission ceilings were set. Both of these criteria are met, and it is therefore concluded that NMVOC emissions from manure management are a new source and are eligible for an adjustment.

### Quantification

Emissions have been calculated by using the methodology presented in the Inventory Guidebook (EMEP/EEA, 2019), Chapter 3B, Section 3.4 using a Tier 2 approach. Estimates are undertaken for each livestock type. Animal population data are combined with data on time spent in housing or at pasture combined with EFs from the Inventory Guidebook (EMEP/EEA, 2019) to give NMVOC emission estimates from housing, storage and application for each livestock type.

As a new source, quantification of the adjustment is achieved by subtracting the emissions from the national inventory total as shown in Table 9.17. The 2020 adjustment application for NMVOC submitted under the NECD is based on the same methodology as used for the original approved adjustment application which has been reviewed and approved by the EC in 2017, 2018 and 2019.

**Table 9.17. Adjustments from Manure Management (NMVOC)**

Source Sector	Adjustments (ktonnes)								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Manure Management – 3B1a Dairy cattle	-7.16	-7.43	-7.48	-7.69	-8.05	-8.80	-9.31	-9.75	-10.06
Manure Management – 3B1b Non-dairy cattle	-25.04	-24.46	-25.59	-26.41	-25.87	-25.41	-26.46	-26.65	-26.30
Manure Management – 3B2 Sheep	-0.32	-0.33	-0.36	-0.36	-0.37	-0.36	-0.36	-0.39	-0.38
Manure Management – 3B3 Swine	-2.43	-2.47	-2.44	-2.39	-2.43	-2.39	-2.48	-2.54	-2.54
Manure Management – 3B4d Goats	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manure Management – 3B4e Horses	-0.20	-0.20	-0.20	-0.19	-0.18	-0.17	-0.17	-0.16	-0.16
Manure Management – 3B4f Mules and asses	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Manure Management - 3B4gi Laying hens	-0.35	-0.35	-0.43	-0.47	-0.48	-0.54	-0.55	-0.57	-0.59
Manure Management - 3B4gii Broilers	-1.29	-1.24	-1.24	-1.16	-1.31	-1.32	-1.33	-1.31	-1.30
Manure Management - 3B4giii Turkeys	-0.43	-0.53	-0.60	-0.55	-0.58	-0.60	-0.62	-0.62	-0.67
Manure Management - 3B4giv Other poultry	-0.14	-0.14	-0.14	-0.13	-0.14	-0.15	-0.16	-0.16	-0.16
Manure Management – 3B4h Other animals	-0.36	-0.36	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38
<b>Total Adjustment – 3B Manure Management</b>	<b>-37.72</b>	<b>-37.52</b>	<b>-38.88</b>	<b>-39.75</b>	<b>-39.80</b>	<b>-40.14</b>	<b>-41.83</b>	<b>-42.54</b>	<b>-42.55</b>

### 9.4.3 Cultivated Crops, 3De (NMVOC)

#### Justification - A New Source

NMVOC emissions from Cultivated Crops were not included in Ireland’s national emissions inventory in 1999, when the ceilings were set. A methodology is presented in the 2019 EMEP/EEA Guidebook, and this is currently used to estimate emissions that are included in the Irish national emissions inventory.

For a new source, the Directive (EU) 2016/2284 requires that the source is currently included in scientific literature (such as the EMEP/EEA Guidebook), and that the source was not included in the historic national emissions inventory when emission ceilings were set. Both of these criteria are met, and it is therefore concluded that NMVOC emissions from manure management are a new source and are eligible for an adjustment.

#### Quantification

As a new source, quantification of the adjustment is achieved by subtracting the emissions from the national inventory total as shown in Table 9.18. The 2020 adjustment application for NMVOC submitted under the NECD is based on a different methodology than that used for the original approved adjustment application which has been reviewed and approved by the EC in 2017, 2018 and 2019. In the original approved adjustment application and subsequent application in 2019 the default emission factor of 0.86 kg/ha presented in Table 3.3 Chapter 3.D of the Inventory Guidebook (EMEP/EEA, 2019) was applied. However, on foot of a recommendation from the NECD review 2019 (IE-3-2019-001), the TERT suggested that emissions of NMVOC from 3De should be calculated using a Tier 2 methodology using the emission factors presented for the relevant crops in Table 3.4 Chapter 3.D of the Inventory Guidebook (EMEP/EEA, 2019) which exist in Ireland. Furthermore, the TERT suggested that Ireland continue to use the weighted Tier 1 emission factor (0.86 kg/ha) for those crops

not included in Table 3.4 which exist in Ireland. This is now the approach used in estimating emissions of NMVOC from this source category

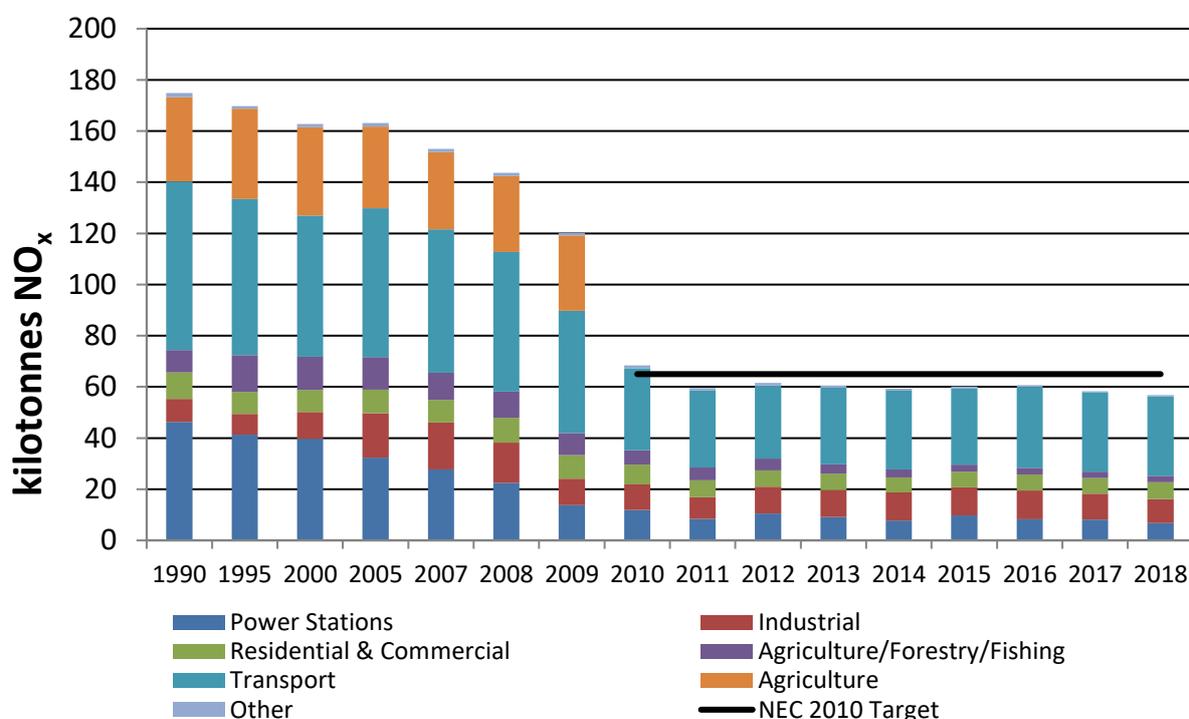
**Table 9.18. Adjustment from Inorganic N Fertilisers (NMVOC)**

Source Sector	Adjustments (ktonnes)								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Inorganic N Fertilisers	-0.607	-0.608	-0.643	-0.668	-0.672	-0.679	-0.706	-0.696	-0.699

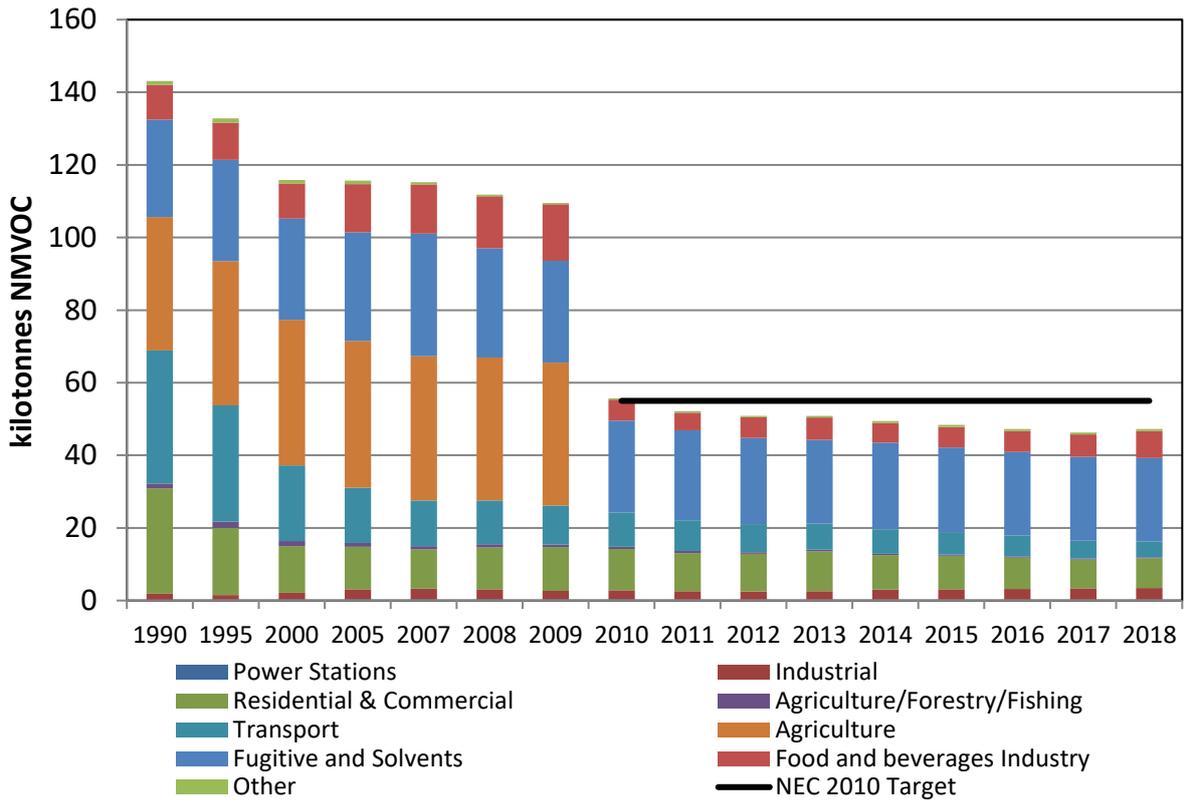
## 9.5 Impact of the flexibility on compliance

The established adjusted annual national emission inventories as allowed under the flexibility in Article 5(1) of Directive (EU) 2016/2284 show Ireland to be in compliance with the NMVOC ceiling and the NO<sub>x</sub> emission ceiling from 2011 onwards.

The adjusted national inventories for NO<sub>x</sub> and NMVOC are presented in Figures 9.1 and 9.2



**Figure 9.1 Emission Trend for NO<sub>x</sub> 1990–2018 (Adjusted Article 5(1))**



*Figure 9.2 Emission Trend for NMVOC 1990–2018 (Adjusted Article 5(1))*

## Glossary

<b>ADDF</b>	Annual Average Daily Flow
<b>AER</b>	Annual Environmental Report
<b>AIM</b>	Animal Identification and Movement
<b>As</b>	Arsenic
<b>B[a]P</b>	Benzo[a]pyrene
<b>B[b]F</b>	Benzo[b]fluoranthene
<b>B[k]F</b>	Benzo[k]fluoranthene
<b>BCF</b>	British Coatings Federations
<b>CAP</b>	Common Agricultural Policy
<b>Cd</b>	Cadmium
<b>CEPE</b>	European Council of Producers and Importers of Paints, Printing Inks and Artists Colours
<b>CEPMEIP</b>	Co-ordinated European Programme on Particulate Matter Emission Inventories, Projections and Guidance
<b>CLEEN</b>	Chemical Legislation European Enforcement Network
<b>CLRTAP</b>	Convention on Long Long-Range Transboundary Air Pollution
<b>CO</b>	Carbon monoxide
<b>CORINAIR</b>	Co-ordinated Information on the environment in the European Community-AIR. CORINAIR was one of several collaborative exercises initiated under the CORINE programme to harmonise the collection and dissemination of information on the environment in the EU
<b>CMMS</b>	Cattle Movement and Monitoring Scheme
<b>Cr</b>	Chromium
<b>CSO</b>	Central Statistics Office
<b>Cu</b>	Copper
<b>DEHLG</b>	Department of Environment, Heritage and Local Government
<b>DM</b>	Dry matter
<b>DTTAS</b>	Department of Transport, Tourism and Sport
<b>DQO</b>	Data quality objective
<b>EAPA</b>	European Asphalt Pavement Association
<b>ED</b>	Electoral Division
<b>ELV</b>	End-of-Life Vehicle
<b>EMEP</b>	European Monitoring and Evaluation Programme, a co-operative programme for monitoring and evaluation of the long-range transmissions of air pollutants in Europe
<b>EPA</b>	Environmental Protection Agency
<b>E-PRTR</b>	European Pollutant Release and Transfer Register
<b>ESB</b>	Electricity Supply Board
<b>ESP</b>	Electrostatic precipitators
<b>ETS</b>	Emissions Trading Scheme
<b>EUROSTAT</b>	Statistical Agency of the European Union
<b>FFS</b>	Farm Facilities Survey
<b>Fossil Fuel</b>	Peat, coal, oil and natural gas and associated derivatives
<b>FUS</b>	Fertiliser Use Survey
<b>GHG</b>	Greenhouse gas
<b>Gg</b>	Gigagram (10 <sup>9</sup> g) = kilotonne = 1,000 tonnes

<b>GNFR</b>	Gridded Nomenclature for Reporting Codes
<b>HCB</b>	Hexachlorobenzene
<b>HFO</b>	Heavy fuel oil
<b>Hg</b>	Mercury
<b>IBEC</b>	Irish Business and Employers' Confederation
<b>IEA</b>	International Energy Agency
<b>IEF</b>	Implied Emission Factor
<b>IFFPG</b>	Irish Farm Film Producers Group
<b>IIR</b>	Informative Inventory Report
<b>I[123-cd]P</b>	Indeno[1,2,3-cd]pyrene
<b>IPC</b>	Integrated Pollution Control
<b>IPCC</b>	Intergovernmental Panel on Climate Change
<b>IPPC</b>	Integrated Pollution Prevention and Control
<b>KDP</b>	Key Data Provider
<b>ktoe</b>	Kilotonnes of oil equivalent
<b>LCP</b>	Large Combustion Plant Directive
<b>LFG</b>	Landfill gas
<b>LPS</b>	Large Point Source
<b>LTO</b>	Landing and take-off
<b>MoU</b>	Memorandum of Understanding
<b>MSW</b>	Municipal solid waste
<b>NAIS</b>	National Atmospheric Inventory System
<b>NAEI</b>	National Atmospheric Emissions Inventory
<b>NCT</b>	National Car Testing
<b>NETCEN</b>	National Environmental Technology Centre
<b>NEC</b>	National Emission Ceilings
<b>NFR</b>	Nomenclature for Reporting Codes
<b>NH<sub>3</sub></b>	Ammonia
<b>Ni</b>	Nickel
<b>NMVOC</b>	Non-methane volatile organic compound
<b>NO<sub>x</sub></b>	Nitrogen oxides
<b>NRA</b>	National Roads Authority
<b>OCLR</b>	Office of Climate, Licensing, Research and Resource Use
<b>OLG</b>	Office of Licensing and Guidance
<b>PAH</b>	Polycyclic aromatic hydrocarbon
<b>Pb</b>	Lead
<b>PCB</b>	Polychlorinated biphenyl
<b>PER</b>	Pollution Emissions Register
<b>PM</b>	Particulate matter
<b>PM<sub>10</sub></b>	Particulate matter <10 µm in diameter
<b>PM<sub>2.5</sub></b>	Particulate matter <2.5 µm in diameter
<b>POP</b>	Persistent organic pollutant
<b>PVC</b>	Polyvinyl chloride
<b>QA/QC</b>	Quality assurance/quality control
<b>S.I.</b>	Statutory Instrument
<b>Se</b>	Selenium
<b>SEAI</b>	Sustainable Energy Authority of Ireland
<b>SNAP</b>	Selected Nomenclature for Air Pollution

<b>SO<sub>2</sub></b>	Sulphur dioxide
<b>SO<sub>x</sub></b>	Sulphur oxides
<b>TAN</b>	Total ammoniacal nitrogen
<b>Teagasc</b>	Irish Agriculture and Food Development Authority
<b>TPM</b>	Total particulate matter
<b>TSP</b>	Total suspended particulates
<b>UAN</b>	Uric acid nitrogen
<b>UK NAEI</b>	United Kingdom National Atmospheric Emission Inventory
<b>UNECE</b>	United Nations Economic Commission for Europe
<b>VOC</b>	Volatile organic compounds
<b>WEEE</b>	Waste Electrical and Electronic Equipment Regulation
<b>Zn</b>	Zinc

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## Annex A to H

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## Annex H

### **2019 NECD Review findings and responses**

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Party response	IIR Section
IE-1A3dii-2017-0001	1A3dii National navigation (shipping), NOx, 1990-2015	<p>The TERT notes with reference to key category 1A3dii National navigation (shipping) for NOx emissions that a tier 1 method is used for a key category. The TERT notes that using a tier 1 method is not best practice and could result in an over and/or underestimate of emissions. This over/underestimate may have an impact on total emissions that is above the threshold of significance. Ireland has not provided a revised estimate. It is currently not possible for the TERT to provide a numerical emission estimate based on a tier 1/tier 2 method, and therefore the issue will be flagged as Potential Technical Correction and will be assessed as a high priority item in future reviews.</p> <p><b>The TERT recommends that Ireland calculates NOx emissions from 1A3dii category using a tier 2 or tier 3 method for inclusion in next years' inventory submission.</b></p>		
IE-1A2gvii-2017-0002	1A2gvii Mobile Combustion in manufacturing industries and construction: Other, SO2, NOx, NH3, NMVOC, PM2.5, 1990-2015	<p>With reference to the previous review recommendation IE-1A2gviii-2017-0001, for categories 1A2gvii Mobile Combustion in manufacturing industries and construction: Other and 1A2gviii Stationary combustion in manufacturing industries and construction: Other, for all pollutants and all years, the TERT noted that emissions are not disaggregated between the two categories but sufficient explanations on the notation keys used are provided in the IIR. The IIR stated that "The inventory agency has however advertised for tendered research to be undertaken to quantify the extent and amounts of fuel used by mobile combustion on construction sites and when available will include the results of this research in the national energy balance in consultation with the energy balance provider and estimate emissions accordingly." (p. 46). In response to a question raised during the review, Ireland stated that depending on the timely delivery of the research project, it may be possible to deliver in February 2021 for the 1990-2019 inventory.</p> <p><b>The TERT agrees with this approach and recommends Ireland put effort into calculating emissions from these two categories separately and to provide an update on the status of this issue in the upcoming IIR submissions.</b></p>	Included an explanation in IIR we do not have information on fuel split to estimate emissions separately for stationary and mobile combustion	Section 3.5 p 50

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Party response	IIR Section
IE-1A2gviii-2017-0001	1A2gviii Stationary combustion in manufacturing industries and construction: Other, SO <sub>2</sub> , NO <sub>x</sub> , NH <sub>3</sub> , NMVOC, PM <sub>2.5</sub> , 2000-2017	<p>The TERT reiterates the previous recommendation IE-1A2gviii-2017-0001 to split fuel consumption into 1A2gviii stationary and 1A2gvii mobile combustion which differ significantly in specific emissions. This issue could potentially have an impact around the threshold of significance. In a response during the 2019 review, Ireland confirmed that a research project has commenced in June 2019 and will be finished by end of 2020. The outcomes of the project may be implemented for the inventory submission in 2021 for 1990-2019 data or if delayed in 2022.</p> <p><b>The TERT commends Ireland for the ongoing research and recommends that Ireland reports on the progress of this project in the IIR in the next submission.</b></p>	<p>A research project is due to begin in 2019 and will finish by end of 2020. The outcomes of the project may be implemented for the inventory submission in 2021 for 1990-2019 data or if delayed in 2022.</p>	Section 3.5 p 50 and Section 3.12 planned improvements
IE-1B2b-2017-0001	1B2b Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other), NMVOC, 1990-2015	<p>For 1B2b and NMVOC, the TERT noted that emissions are not estimated although the 2016 EMEP/EEA Guidebook provides a methodology for estimation. This was raised during the 2017 review. In response to a question raised during the 2019 NECD review, Ireland provided a statement from the company which operates the 'Bellanaboy Bridge Gas Terminal' in which it is stated that 'no significant VOC emissions were observed' when using a LIDAR system for measuring ambient NMVOC emissions. The TERT recommends that Ireland includes this information into the relevant chapter of the IIR and consider the specific issue as resolved.</p> <p><b>However, the TERT reiterates its recommendation to estimate NMVOC from natural gas losses (in pipelines and distribution systems), e.g. by assuming a certain NMVOC content (C<sub>x</sub>H<sub>y</sub> compounds other than CH<sub>4</sub>) of natural gas and using existing information about leakage from GHG reporting under the UNFCCC.</b></p>	included explanation in IIR	section 3.13 p 72
IE-1A1a-2018-0001	1A1a Public Electricity and Heat Production, Cd, Hg, PCBs, 1990, 2005, 2016	<p>For Cd, Hg and HCB emissions from category 1A1a, Public Electricity and Heat Production, which is key category for these emissions, Ireland responded to a question raised during the review that a Tier 1 method is applied to calculate the emissions. According to the reporting guidelines, countries should make every effort to use a Tier 2 or higher (detailed) methodology, including country-specific information. The TERT recommends that Ireland calculates the emissions of Cd, Hg and HCB in category 1A1a using a Tier 2 or Tier 3 methodology for the next submission. The TERT also notes that progress in the implementation of the improvement will be reviewed in 2019. For 1A1a Public Electricity and Heat Production, Cd, Hg and HCB the TERT notes that it is key source and that a Tier1 methodology is used. This was raised during the 2018 NECD review. In response to a question raised during the review, Ireland explained that for heavy metals (and HCB) the 2016 EMEP/EEA Guidebook Tier 1 Tables 3-2 to 3-7 show the same values as the Tier 2 Tables 3-9 to 3-18 and that the references will be amended in the next IIR.</p> <p><b>The TERT recommends that Ireland changes the references for heavy metals (and HCB) emission factors to the Tier2 tables in its next IIR .</b></p>	Updated references for HMs and HCB to T2 tables	section 3.2.2

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Party response	IIR Section
IE-1A2f-2018-0002	1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals, Cd, Hg, 2000-2016	For category 1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals, for Cd and Hg and all years, the TERT noted that it is key source and that Ireland uses a Tier 1 methodology. This was raised during the 2018 review. In a response to a question raised during the 2019 review, Ireland responded that it will look for existing flue gas concentration data of single plants and years. The TERT recommends Ireland to do so and that this proves the possibility of deriving representative emission factors for Hg and Cd (e.g. in the form of mg/t cement clinker), which may be applied for the whole time series. <b>In the case that it is not possible to increase accuracy with plant specific data, the TERT recommends that Ireland explains in its IIR that the use of a country specific or 2016 EMEP/EEA Guidebook Tier 2 methodology would not increase the accuracy of the current estimates .</b>		
IE-1A4bi-2018-0002	1A4bi Residential: Stationary, PAHs, PCBs, Cd, Hg, Pb, PCDD/F, 2000-2017	For NFR category 1A4bi Residential: Stationary for PAHs, PCBs, Cd, Hg, Pb and PCDD/F, the TERT noted that a Tier 1 methodology is applied. This was raised during the 2018 review. In a response to a question raised during the review, Ireland explained that it uses Tier 2 emission factors for liquid, gaseous and biomass fuels where possible and will check for more appropriate Tier 2 emission factors for residential stationary emissions from solid fuels for POPs and heavy metals. Ireland also explained that it will endeavour to improve accuracy of estimates based on best available information and expert judgement on technology splits. <b>The TERT recommends that Ireland makes use of an expert judgement for the technology split in the case that statistical data is not available and that it applies a Tier 2 method for heavy metals and POPs in its future submission. The TERT also recommends that Ireland clarifies the methodological Tier(s) used in the 2020 submission .</b>	Clarified methodological Tiers used in IIR 2020. Need to do further work on POPs and metals in 1A4bi to see if a Tier 2 can be applied in future submissions	Section 3.7
IE-1B2aiv-2018-0001	1B2aiv Fugitive Emissions Oil: Refining / Storage, Cd, Hg, PCDD/F, 1990, 2005, 2016	During the 2018 review, the TERT noted, with reference to NFR category 1B2aiv Fugitive Emissions Oil: Refining / Storage, that no emissions of PCDD/F, Pb, Cd and Hg are reported for all years, while a method is available in the 2016 EMEP/EEA Guidebook. In a response during the 2019 review, Ireland confirmed that all emissions from refineries including flaring are reported under category 1A1b. <b>The TERT recommends that Ireland uses the notation key 'IE' for 1B2aiv and PCDD/F, Pb, Cd and Hg and clearly explain in the IIR where these emissions are included .</b>	Updated NK and explanation in the IIR 2020	Section 3.10.1
IE-1A3bii-2019-0001	1A3bii Road transport: Light duty vehicles, NH3, 2000-2015	For category 1A3bii Road Transport: Light Duty Vehicles and pollutant NOX for years 2000-2015 the TERT noted that recalculations were performed (>10% change) and relevant information was not provided in the IIR. In response to a question raised during the review, Ireland explained that these recalculations occurred due to fleet improvements in the 2019 submission (LDV fleet was disaggregated into N1-I, N1-II and N1-III weight classes and different emission factors applied for each category). The TERT agreed with the explanation provided by Ireland. <b>The TERT recommends that Ireland includes relevant information on recalculations in the 2020 IIR submission.</b>	included explanation on recalculations in IIR 2020	Chapter 3 section 3.11

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Party response	IIR Section
IE-1A3biii-2019-0001	1A3biii Road Transport: Heavy Duty Vehicles and Buses, NOX, 2000-2011	For category 1A3bii Road Transport: Heavy Duty Vehicles and Buses and pollutant NOX for years 2000-2011 the TERT noted that recalculations were performed, and relevant information was not included in the IIR. In response to a question raised during the review, Ireland explained that a fleet improvement was performed (LDV fleet was disaggregated to from N1-II to N1-I, N1-II and N1-III, thus leading to different emission factors). <b>The TERT agreed with the explanation provided by Ireland and recommends that Ireland includes relevant information on recalculations in the 2020 IIR submission.</b>	included explanation on recalculations in IIR 2020	Chapter 3 section 3.11
IE-1A3bi-2019-0001	1A3bi Road Transport: Passenger Cars, Hg, 2016	Recommendation For category 1A3bi Road Transport: Passenger Cars and pollutant Hg for 2016, the TERT notes that recalculations were performed, and relevant information was not included in the 2019 IIR submission. In response to a question raised during the review, Ireland explained that in the 2018 submission Ireland incorrectly reported the total Hg emissions for all categories in 1A3b as 1A3bi across the entire time series 1990-2016; this was corrected in the 2019 submission. The TERT agreed with the explanation provided by Ireland. <b>The TERT recommends that Ireland includes relevant information on recalculations in the 2020 IIR submission .</b>	included explanation on recalculations in IIR 2020	Chapter 3 section 3.12
IE-2A2-2017-0001	2A2 Lime production, PM2.5, 1990-2015	During the 2018 review for category 2A2 Lime production and pollutant PM2.5 for the years 1990-2015 the TERT noted that with reference to the observation IE-2A2-2017-0001 that was raised during the 2017 NECD Review that Ireland still reported the notation keys 'NA' and 'NO' inconsistently over the years instead of 'IE' for PM2.5, although Ireland has stated in the IIR that those emissions are assumed to be included in those reported within NFR 1A2f. In response to a question raised during the review, Ireland explained that Ireland has 3 lime producing plants which all use multiple fuels, one of them produce Periclase where lime is an intermediary product, and because of that it is not possible to ascertain which fuel is used and the amount used for lime production only. Preliminary estimates indicate the issue is below the threshold of significance and due to current resource constraints Ireland considers this not feasible to calculate the emissions for the whole time series before the review ends. Ireland stated that they will consider this issue for the 2019 reporting of emissions. The TERT agreed with the explanation provided by Ireland and noted that the issue is below the threshold of significance for technical correction. During the 2019 review, the TERT found that emissions were still reported as 'NA' and asked about the progress made during the past year. Ireland informed the TERT that there is no plan to disaggregate the emissions for PM2.5 for 2A2, and that the notation key will be changed to 'IE' in the next submission. <b>The TERT agrees with this way forward and recommends Ireland to change notation keys accordingly for the next submission, and to disaggregate emissions of PM2.5 for 2A2 should more information become available .</b>	Changed NK to IE for PM2.5 for 2020 submission	Annex 1

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Party response	IIR Section
IE-2A3-2017-0001	2A3 Glass production, PM2.5, 1990-2017	<p>For category 2A3 Glass Production and pollutant PM2.5 for all years, the TERT reiterated a question and subsequent recommendation that address a possible over-estimation of emissions. The possibility of double counted emissions cannot be excluded due to the fact that a Tier 1 emission factor has been used for emissions from source category 1A2, and emissions are also calculated under 2A3. The TERT subsequently recommended to apply a higher Tier for the calculation of emissions from category 1A2 to which Ireland responded that they will consider applying a higher Tier in the future, but only if the necessary data on specific fuels used becomes available.</p> <p><b>The TERT thus recommends Ireland again to apply a higher Tier method for the calculation of emissions of PM2.5 for these source categories in order to avoid double counting.</b></p>	Have not applied a higher Tier method, do not have fuel used	section 4.2.3 p 76
IE-2D3c-2017-0001	2D3c Asphalt roofing, NMVOC, PM2.5, 1990-2017	<p>For category 2D3c Asphalt Roofing and pollutants NMVOC and PM2.5 for all years, the TERT reiterated a question regarding reporting of emissions from asphalt roofing as 'NE'. The first time this question was asked was in 2017 and follow up questions were asked in the subsequent years. In 2019, Ireland was able to provide the results of their investigation; the production of asphalt roofing materials does not occur in Ireland, and that they will change the notation key to 'NO' in the 2020 submission.</p> <p><b>The TERT recommends Ireland to change notation key in the NFR and add a short explanation in the IIR in the 2020 submission .</b></p>	Added an explanation in the IIR and changed NK to NO for 2020 submission	section 4.10
IE-2-2018-0001	2K Consumption of POPs and Heavy Metals, Hg, 1990, 2005, 2016	<p>For category 2D3c Asphalt Roofing and 2K Consumption of POPs and Heavy Metals and pollutant Hg for all years, the TERT reiterated a question regarding the fact that emissions of Hg reported were significantly lower than those reported in the independent TNO inventory. This resulted in Ireland investigating Hg emissions from those two source categories. It was found that asphalt roofing materials are not produced in Ireland, and thus emissions from this source will be reported as 'NO' in the next submission. In response to the question raised, Ireland informed the TERT that they are currently investigating sourcing activity data on mercury containing battery usage, which would lead to an update of emissions in sector 2K, and if data was sourced, would be included in the 2020 reporting.</p> <p><b>The TERT recommends Ireland to continue their efforts on sourcing AD, and to provide an update on the progress in their next IIR .</b></p>	included explanation in IIR	section 4.10 p 109

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Party response	IIR Section
IE-2D3a-2018-0001	2D3a Domestic Solvent Use Including Fungicides, Hg, 1990, 2005, 2016	<p>For category 2D3a, Domestic Solvent Use Including Fungicides, and pollutant Hg for the years 1990, 2005 and 2016 the TERT noted that Ireland reported the notation key 'NE' while the 2016 EMEP/EEA Guidebook provides Tier 1 and Tier 2 EFs for Hg from fluorescent tubes. In response to a question raised during the review, Ireland explained that they attempted to find country specific information and determined that newer fluorescent lamps contain 3-4mg of mercury and there should be no mercury emission from an intact fluorescent, so the Tier 1 EF is not considered to be appropriate. This review is undertaken against the 2016 version of the Guidebook, which includes an EF for Hg. However, the TERT is aware that this EF will not be included in the 2019 version of the Guidebook, and therefore it is not currently sensible to add this source.</p> <p><b>The TERT recommends that Ireland review their inventory against the 2019 version of the Guidebook and update it, if necessary, before their next submission .</b></p>	The 2019 Guidebook does not have an EF for this source an explanation has been included in the IIR	section 4.5
IE-3-2019-0001	3De Cultivated Crops, NMVOC, 1990-2017	<p>The TERT notes with reference to NMVOC emissions for 3De Cultivated Crops that the emission is based on a Tier 1 approach, which needs to be corrected to Tier 2 because it's a key source. In response to a question raised during the review Ireland responded that the plan for the next submission is to include the Tier 2 methodology for 3De for relevant crops included in 2016 EMEP/EEA Guidebook 3D Table 3.4 which exist in Ireland. For those crops which are not included in Table 3.4 Ireland will continue to use the weighted Tier 1 emission factor presented in Table 3.3.</p> <p><b>The TERT recommends that Ireland continues with the planned improvement as indicated and estimates the NMVOC emission with a Tier 2 approach, where applicable.</b></p>	Tier 2 methodology applied for 3De for relevant crops included in 2016 EMEP/EEA Guidebook 3D Table 3.4 which exist in Ireland (wheat, rape and grass)	section 5.3.8
IE-3B1a-2019-0002	3B1a Manure Management - Dairy Cattle, NH3, 1990-2017	<p>For category 3B1a Manure Management - Dairy Cattle and pollutant NH3 for years 1990-2017 the TERT noted that the NH3 IEF is very low, between 3.3 - 3.9 kg NH3/cow/yr. In response to a question raised during the review Ireland explained that the activity data reported in the NFR are incorrect and the correct activity data lead to an IEF of 9.9 - 10.2 kg NH3/cow/yr. The TERT agreed with the information provided by Ireland and notes that the revised activity data brings the IEF to a much more reasonable level compared to other countries.</p> <p><b>The TERT recommends that Ireland correct the activity data in the 2020 submission.</b></p>	Activity data in NFR corrected. This does not affect IIR.	N/A
IE-3B1a-2019-0001	3B1a Manure Management - Dairy Cattle, NMVOC, 2000-2017	<p>For NFR 3B1a Manure Management - Dairy Cattle and NMVOC for years 2000-2017, the TERT notes that a Tier 2 approach is used, but also notes that the implied emission factor is significantly lower (2.3 - 2.8 kg NMVOC/head/yr) than the Tier 1 default (17.937 - 8.047 kg NMVOC/head/yr). In response to a question raised during the review Ireland informed the TERT that the activity data reported in the NFR tables were incorrect. The correct number of dairy cattle, as given in IIR Table E.1 Annex E, increase the IEF to approximately 7 kg NMVOC/head/yr, which is considered as a much more reasonable level.</p> <p><b>The TERT recommended Ireland corrects the number of dairy cattle in the NFR for the 2020 submission.</b></p>	Activity data in NFR corrected. This does not affect IIR.	N/A

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Party response	IIR Section
IE-3B4h-2019-0001	3B4h Manure Management - Other Animals, NH3, NOX, 2010, 2011	For category 3B4h Manure Management - Other Animals and NO2 for years 2010 and 2011, the TERT noted a significant decrease in the IEF. The number of animals is not changing dramatically, despite a 30% decrease in NO2 emission. The same trend is observable for NH3. No specific information is given in IIR. In response to a question raised during the review, Ireland stated that the category includes several animal species, i.e. mink, fox and deer. Ireland further stated that in the period 2010 to 2011 there was a change in the Agricultural Waste Management System (AWMS) for mink production from 100% solid manure based in the period 1990-2010 to 52% liquid/slurry based and 48% solid manure based AWMS. The TERT agrees with the explanation provided by Ireland. <b>The TERT recommends that Ireland includes the information in the 2020 submission as part of the trend discussion for this category.</b>	Included explanation in specified section of IIR	Section 5.2.5
IE-3D-2019-0001	3D Crop Production and Agricultural Soils, PM2.5, 1990-2017	The TERT noted with reference to 3D Crop Production and Agricultural Soils for years 1990-2017 that there may be an over-estimate of PM2.5 emissions. Ireland estimates PM2.5 emissions from three different NFR categories; 3Da1, 3De and 3Dd, while the 2016 EMEP/EEA Guidebook only includes methodology for NFR 3De. In response to a question raised during the review Ireland explained how the calculation has been done and provided the TNO CEPMEIP database, which includes the EFs used. The estimate reported under NFR 3De is based on the Guidebook, while the estimates for 3Da1 and 3Dd are based on the CEPMEIP database. <b>Based on the response from Ireland the TERT recommends that Ireland keep the PM2.5 emission split in three NFR categories as done in the 2019 submission. However, the TERT recommends Ireland includes more information in the IIR on the calculation methodology and EF used for 3D1a and 3Dd and provides information on AD (amount of fertiliser) for 3Da1 and 3De (cultivated area). To improve the transparency, the TERT further recommends Ireland to correct the references in Table E.10.</b>	Maintained PM2.5 emission split in three NFR categories. More information on calculation methodology in specified sections of IIR. AD data in Tables E.9 and E.10, Annex E.	Sections 5.3.1, 5.3.6, 5.3.7
IE-3Df-2019-0002	3Df Use of Pesticides, HCB, 1990-2017	For 3Df Use of Pesticides, HCB, 1990-2017, the TERT noted that there is a lack of transparency regarding the calculation of HCB emissions. The description in the IIR is not transparent and no detailed information is given on activity data and EF used. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Ireland explained that they are aware of the October 2018 update of the 2016 EMEP/EEA guidebook and Ireland confirmed that they will update the emission estimate as appropriate. <b>The TERT recommends that Ireland updates the estimates as appropriate and provides enhanced documentation in the IIR in the 2020 submission.</b>	Revised description of methodology in IIR	Section 5.3.9
IE-3F-2019-0001	3F Field Burning of Agricultural Residues, SO2, NOX, NH3, NMVOC, PM2.5, BaP, PAHs, PCBs, HCB, Cd, Hg, Pb, PCDD/F, 1990-2017	For category 3F Field Burning of Agricultural Residues no emission is calculated for years 1990-2017. However, the TERT noted that three different notation keys are used; 'NE', 'NA' and 'NO'. In response to a question raised during the review Ireland responded that field burning of agricultural residues does not occur in Ireland, and that they would report all emissions as not occurring 'NO' in the next submission. <b>The TERT recommends that Ireland corrects the notation keys .</b>	Changed notation key to "NO" for category 3F in submission	N/A

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Party response	IIR Section
IE-5D-2017-0001	5D Wastewater Handling, NMVOC, 2005-2017	For category 5D Wastewater Handling and NMVOC for years 2005-2017 the TERT noted that NMVOC emissions have been reported as 'NE' (not estimated). This issue was already raised in the 2017 and 2018 review. In response to a question raised during the review, Ireland explained that this recommendation is reflected in the improvement plan (section 6.9) and will include an appropriate response in its next submission. <b>The TERT agreed with the explanation provided by Ireland and recommends providing emission estimates for NMVOC from 5D in its next submission.</b>	Included in IIR	Section 6.6.1 p 143 and Table 6.10
IE-5C2-2018-0003	5C2 Open Burning of Waste, PAHs, 1990-2016	For category 5C2 Open Burning of Waste and pollutants PAHs for years 1990-2016 the TERT noted a significant increase in PAHs emissions for category 5C2 between 2007 to 2008 (>1000%), for the years 2009 and 2010 emissions are relatively constant, and in 2011 emissions decrease by 74%, which was not sufficiently explained in the IIR (page 130-131). In response to a question raised during the review, Ireland explained that as a result of the discontinuation of the Department of Environment funded collections, that the Irish Farm Film Producers Group increased the quantity significantly. This is the rationale for the decrease shown in 2011. Ireland will amend the text in the IIR to enhance transparency. <b>The TERT agreed with the explanation provided by Ireland and recommends Ireland amend the text in the IIR to increase transparency .</b>	Included in IIR	Section 6.4.4 p 142-143
IE-0A-2019-0001	5C1bv Cremations, BaP, PCDD/F, HCB, PAHs, PCBs, 1990-2006	During the review, the TERT noted that some emissions were reported with zero values in the NFR, namely benzo(a)pyrene, PAHs, HCB and PCDD/F from 5C1bv Cremations. Further, the TERT noted upon further examination that emissions of selenium, zinc, benzo(b)fluoranthene, benzo(k)fluoranthene and PCBs are reported as either 'NO' or 'NE' during the time series and that 2016 EMEP/EEA Guidebook Chapter 5C1bv Table 3-1 provides default emission factors for these pollutants. In response to a question raised during the review, Ireland explained that an error had occurred so that not all crematoria had been included in the estimation. Ireland further indicated that the error would be corrected in the 2020 submission. The TERT notes that the emissions are below the threshold of significance. <b>The TERT recommends that Ireland corrects the error and reports on the recalculations in the next IIR.</b>	Error corrected in 2020 submission and recalculations explained in IIR	Section 6.
IE-5B2-2019-0001	5B2 Biological Treatment of Waste - Anaerobic Digestion at Biogas Facilities, NH <sub>3</sub> , 2000-2017	For category 5B2 Biological Treatment of Waste - Anaerobic Digestion at Biogas Facilities and pollutants NH <sub>3</sub> for years 2000-2017, the TERT noted that emissions are reported as 'NO' (not occurring). In response to a question raised during the review, Ireland explained that it is currently investigating the relevant sources of information with respect to anaerobic digestion, which is in its infancy in Ireland. Therefore, emissions are expected to be very low. <b>The TERT agreed with the explanation provided by Ireland and recommends Ireland includes information on the status of anaerobic digestion and NH<sub>3</sub> emission estimates for 5B2 in the 2020 submission.</b>		

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Party response	IIR Section
IE-5C1bi-2019-0001	5C1bi Industrial Waste Incineration, PCDD/F, 2006, 2007, 2009, 2010, 2016, 2017	For category 5C1bi Industrial Waste Incineration and pollutants PCDD/F for years 2006, 2007, 2009, 2010, 2016 and 2017, the TERT noted that there is an annual change greater than or equal to a factor of 10 at least three times in the time series. In response to a question raised during the review, Ireland explained that there are currently only a small number of facilities in the pharmaceutical and chemical sectors that operate incinerators for the treatment of hazardous waste. The emission estimates are based on the reported quantities of emissions of PCDD/F included in annual returns to the EPA. The inter-annual changes are as a result of inter-annual changes in production at the 10 installations which provide emission estimates of PCDD/F to the EPA. <b>The TERT agreed with the explanation and recommends Ireland include a trend explanation in its next IIR.</b>		
IE-5C1biv-2019-0001	5C1biv Sewage Sludge Incineration, SO2, NOX, NH3, PM2.5, PAHs, 2000-2017	For category 5C1biv Sewage Sludge Incineration and pollutants SO2, NOX, NH3, PM2.5, PAHs for years 2000-2017 the TERT noted that different notation keys are used ('NO' and 'IE'), without further explanation. In response to a question raised during the review, Ireland explained that for all pollutants the notation key 'not occurring (NO)' should be used as the incineration of sewage sludge does not occur in Ireland. <b>The TERT agreed with the explanation provided and recommends Ireland report the correct notation key in its next submission .</b>		
IE-5C2-2019-0001	5C2 Open Burning of Waste, PM2.5, NMVOC, SO2, NOX, 2009-2016	For category 5C2 Open Burning of Waste and pollutants PM2.5, NMVOC, SO2, NOX for years 2009-2016 the TERT noted that emissions have been reported as 'NE' (not estimated). In response to a question raised during the review, Ireland references its IIR (chapter 6.4.4) and clarified that emissions relate to the open burning of farm plastics, and therefore only HM and POPs emissions were reported. The TERT agreed with the explanation provided by Ireland but notes that activity data can include domestic open burning of green waste, bonfires, agricultural plastics, orchard/vineyards waste and similar. <b>If this kind of activity is forbidden in the country, the TERT recommends Ireland include information on and the reference to this legislation, including the implementation date and the type of waste this legislation refers to in the IIR.</b>		