



Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

Ireland's Informative Inventory Report 2023

Air Pollutant Emissions 1990-2021



ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

The work of the EPA can be divided into three main areas:

Regulation: *We implement effective regulation and environmental compliance systems to deliver good environmental outcomes and target those who don't comply.*

Knowledge: *We provide high quality, targeted and timely environmental data, information and assessment to inform decision making at all levels.*

Advocacy: *We work with others to advocate for a clean, productive and well protected environment and for sustainable environmental behaviour.*

Our Responsibilities

Licensing

We regulate the following activities so that they do not endanger human health or harm the environment:

- waste facilities (e.g. landfills, incinerators, waste transfer stations);
- large scale industrial activities (e.g. pharmaceutical, cement manufacturing, power plants);
- intensive agriculture (e.g. pigs, poultry);
- the contained use and controlled release of Genetically Modified Organisms (GMOs);
- sources of ionising radiation (e.g. x-ray and radiotherapy equipment, industrial sources);
- large petrol storage facilities;
- waste water discharges;
- dumping at sea activities.

National Environmental Enforcement

- Conducting an annual programme of audits and inspections of EPA licensed facilities.
- Overseeing local authorities' environmental protection responsibilities.
- Supervising the supply of drinking water by public water suppliers.
- Working with local authorities and other agencies to tackle environmental crime by co-ordinating a national enforcement network, targeting offenders and overseeing remediation.
- Enforcing Regulations such as Waste Electrical and Electronic Equipment (WEEE), Restriction of Hazardous Substances (RoHS) and substances that deplete the ozone layer.
- Prosecuting those who flout environmental law and damage the environment.

Water Management

- Monitoring and reporting on the quality of rivers, lakes, transitional and coastal waters of Ireland and groundwaters; measuring water levels and river flows.
- National coordination and oversight of the Water Framework Directive.
- Monitoring and reporting on Bathing Water Quality.

Monitoring, Analysing and Reporting on the Environment

- Monitoring air quality and implementing the EU Clean Air for Europe (CAFÉ) Directive.
- Independent reporting to inform decision making by national and local government (e.g. *periodic reporting on the State of Ireland's Environment and Indicator Reports*).

Regulating Ireland's Greenhouse Gas Emissions

- Preparing Ireland's greenhouse gas inventories and projections.
- Implementing the Emissions Trading Directive, for over 100 of the largest producers of carbon dioxide in Ireland.

Environmental Research and Development

- Funding environmental research to identify pressures, inform policy and provide solutions in the areas of climate, water and sustainability.

Strategic Environmental Assessment

- Assessing the impact of proposed plans and programmes on the Irish environment (e.g. *major development plans*).

Radiological Protection

- Monitoring radiation levels, assessing exposure of people in Ireland to ionising radiation.
- Assisting in developing national plans for emergencies arising from nuclear accidents.
- Monitoring developments abroad relating to nuclear installations and radiological safety.
- Providing, or overseeing the provision of, specialist radiation protection services.

Guidance, Accessible Information and Education

- Providing advice and guidance to industry and the public on environmental and radiological protection topics.
- Providing timely and easily accessible environmental information to encourage public participation in environmental decision-making (e.g. *My Local Environment, Radon Maps*).
- Advising Government on matters relating to radiological safety and emergency response.
- Developing a National Hazardous Waste Management Plan to prevent and manage hazardous waste.

Awareness Raising and Behavioural Change

- Generating greater environmental awareness and influencing positive behavioural change by supporting businesses, communities and householders to become more resource efficient.
- Promoting radon testing in homes and workplaces and encouraging remediation where necessary.

Management and structure of the EPA

The EPA is managed by a full time Board, consisting of a Director General and five Directors. The work is carried out across five Offices:

- Office of Environmental Sustainability
- Office of Environmental Enforcement
- Office of Evidence and Assessment
- Office of Radiation Protection and Environmental Monitoring
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet regularly to discuss issues of concern and provide advice to the Board.



IRELAND

INFORMATIVE INVENTORY REPORT 2023

AIR POLLUTANT EMISSIONS IN IRELAND 1990–2021 REPORTED TO THE SECRETARIAT OF THE UNECE CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION AND TO THE EUROPEAN UNION

B. Hyde, P. Duffy, A.M. Ryan, J. Murphy, D. Fahey, S. Monaghan, B MacFarlane and A. Kehoe

Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil
PO Box 3000, Johnstown Castle, Co. Wexford. Ireland

Telephone: +353 53 9160600 Fax: +353 53 9160699
Email: info@epa.ie Web site: www.epa.ie
LoCall: 0818 335 599

ISBN 978-1-80009-089-7

Contents

List of Tables	x
List of Figures	xii
EXECUTIVE SUMMARY	1
Chapter One Introduction	3
1.1 Convention on Long-Range Transboundary Air Pollution.....	3
1.2 Inventory Reporting and Review under the Convention on Long-Range Transboundary Air Pollution (CLRTAP).....	3
1.3 Inventory Reporting and Review under Directive (EU) 2016/2284	4
1.4 Inventory Reporting by the Environmental Protection Agency	5
1.4.1 National Atmospheric Inventory System.....	5
1.4.2 Scope of Inventories under the LRTAP Convention and Directive (EU) 2016/2284	6
1.4.3 Inventory Preparation.....	9
1.4.4 Data Acquisition	10
1.4.5 Quality Assurance and Quality Control (QA/QC).....	11
1.4.6 Inventory Compilation	13
1.5 Key Category Analysis	14
1.6 Uncertainty Assessment.....	16
Chapter Two.....	18
Analysis of Key Emission Trends.....	18
2.1 Introduction.....	18
2.2 Main Pollutants	18
2.2.1 Sulphur Dioxide (SO ₂).....	18
2.2.2 Nitrogen Oxides (NO _x)	19
2.2.3 Ammonia (NH ₃).....	20
2.2.4 Non-Methane Volatile Organic Compounds (NMVOCs)	22
2.2.5 Carbon Monoxide (CO).....	23
2.3 Particulate Matter	23
2.3.1 Particulate Matter <10 µm Diameter (PM ₁₀)	24
2.3.2 Particulate Matter <2.5 µm Diameter (PM _{2.5}).....	25
2.3.3 Total Suspended Particulates (TSP).....	26
2.3.4 Black Carbon (BC)	27
2.4 Priority Metals	28
2.4.1 Lead (Pb).....	28
2.4.2 Cadmium (Cd)	29

2.4.3 Mercury (Hg)	30
2.5 Other Metals.....	31
2.5.1 Arsenic (As).....	31
2.5.2 Chromium (Cr).....	32
2.5.3 Copper (Cu)	33
2.5.4 Nickel (Ni)	34
2.5.5 Selenium (Se).....	35
2.5.6 Zinc (Zn)	36
2.6 Persistent Organic Pollutants (POPs).....	37
2.6.1 Dioxins and Furans (PCDD/F).....	37
2.6.2 Hexachlorobenzene (HCB).....	38
2.6.3 Polychlorinated Biphenyls (PCBs)	39
2.6.4 Polycyclic Aromatic Hydrocarbons (PAHs).....	40
Chapter Three.....	42
Energy	42
3.1 Overview of the Energy (NFR 1) Sector	42
3.2 Public Electricity and Heat Production (NFR 1A1a).....	43
3.2.1 Emissions of Sulphur Dioxide and Nitrogen Oxides	43
3.2.2 Emissions of Other Substances	45
3.3 Petroleum Refining (NFR 1A1b).....	45
3.4 Manufacture of Solid Fuels and Other Energy Industries (NFR 1A1c)	46
3.5 Manufacturing Industries and Construction (NFR 1A2)	46
3.6 Transport (NFR 1A3).....	48
3.6.1 Domestic and International LTOs (NFRs 1A3aii(i) and 1A3ai(i)).....	49
3.6.2 Road Transport (NFR 1A3b)	50
3.6.3 Railways (NFR 1A3c).....	53
3.6.4 National Navigation (NFR 1A3dii)	53
3.6.5 Other Transportation (NFR 1A3e).....	54
3.7 Other Sectors (NFR 1A4)	54
3.7.1 Commercial / Institutional (NFR 1A4a) and Residential (1A4b).....	54
3.7.2 Agriculture/Forestry/Fishing (NFR 1A4ci and ii)	54
3.7.3 Agriculture/Forestry/Fishing: National Fishing (NFR 1A4ciii)	55
3.8 Other Stationary and Mobile (including military) (NFR 1A5).....	55
3.9 Fugitive emissions from Solid Fuels (NFR 1B1)	55
3.9.1 Coal mining and handling (1B1a).....	55
3.10 Fugitive emissions from Oil and Natural Gas (NFR 1B2)	57
3.10.1 Oil (NFR 1B2a).....	57

3.10.2 Natural Gas (NFR 1B2b)	57
3.10.3 Venting and flaring (oil, gas, combined oil and gas) (NFR1B2c)	59
3.11 Recalculations in the Energy Sector	59
3.12 Quality Assurance/Quality Control.....	72
3.13 Planned Improvements.....	72
3.14 Memo Items	72
Chapter Four	73
Industrial Processes and Product Use	73
4.1 Overview of the Industrial Processes and Product Use (NFR 2) Sector.....	73
4.2 Mineral Products (NFR 2A).....	73
4.2.1 Cement Production (NFR 2A1)	73
4.2.2 Lime Production (NFR 2A2)	74
4.2.3 Glass Production (NFR 2A3).....	75
4.2.4 Quarrying and Mining of Minerals Other than Coal (NFR 2A5a)	76
4.2.5 Construction and Demolition (NFR 2A5b).....	77
4.2.6 Storage, Handling and Transport of Mineral Products (NFR 2A5c).....	77
4.2.7 Other (NFR 2A6)	78
4.3 Chemical Industry (NFR 2B).....	79
4.3.1 Nitric Acid Production (NFR 2B2).....	79
4.3.2 Storage, handling and transport of chemical products (NFR 2B10b).....	79
4.4 Metal Production (NFR 2C).....	80
4.4.1 Iron and Steel Production (NFR 2C1)	80
4.4.2 Ferroalloys Production (NFR 2C2).....	81
4.4.3 Aluminium Production (NFR 2C3)	82
4.4.4 Lead Production (NFR 2C5).....	83
4.4.5 Other Metal Production (NFR 2C7)	83
4.5 Overview of NMVOC emissions from Solvent and Other Product Use (NFR 2D-2L) Sector	84
4.5.1 Domestic Solvent Use including fungicides (NFR 2D3a).....	88
4.5.2 Road Paving with asphalt (NFR 2D3b)	89
4.5.3 Coating Application (NFR 2D3d).....	89
4.5.4 Degreasing and Dry Cleaning (NFR 2D3e and 2D3f).....	92
4.5.5 Chemical Products, Manufacture and Processing (NFR 2D3g)	94
4.5.6 Printing (2D3h)	97
4.5.7 Other Use of Solvents and Related Activities (2D3i-2G).....	98
4.5.8 Food and Beverage Industry (NFR 2H2).....	102

4.6 Consumption of POPs and heavy metals 2K (e.g. electrical and scientific equipment)	104
4.7 Other production, consumption, storage, transportation or handling of bulk product (NFR 2L)	104
4.7.1 Leakage from Electrical Equipment (NFR 2L)	105
4.7.2 Fragmentisers and Shredders (NFR 2L)	106
4.8 Recalculations in the Industrial Processes Sector	107
4.8.1 Heavy Metals recalculations	107
4.8.2 Particulate matter recalculations	107
4.8.3 Nitrogen Oxides (NO _x) recalculations	107
4.8.4 Non- Methane Volatile Organic Compounds (NMVOC) recalculations	107
4.9 Quality Assurance/Quality Control	107
4.10 Overview of Notation Keys	107
4.11 Planned Improvements	108
Chapter Five	115
Agriculture	115
5.1 Overview of the Agriculture (NFR 3) Sector	115
5.2 Manure Management (NFR 3B)	118
5.2.1 Cattle (NFR 3B1)	119
5.2.2 Sheep (3B2)	121
5.2.3 Swine (NFR 3B3)	122
5.2.4 Poultry (NFR 3B4g)	123
5.2.5 Other livestock – Goats (NFR 3B4d), Horses (3B4e), Mules and Asses (NFR 3B4f) and Other Animals (3B4h)	124
5.2.6 Uncertainties	124
5.3 Agricultural Soils (NFR 3D)	124
5.3.1 Direct Soil Emissions - Inorganic N-fertilizers (NFR 3Da1)	124
5.3.2 Direct Soil Emissions – Livestock manure applied to soils (NFR 3Da2a)	125
5.3.3 Direct Soil Emissions – Sewage sludge applied to soils (NFR 3Da2b)	125
5.3.4 Direct Soil Emissions – Other organic fertilizers applied to soils (NFR 3Da2c)	125
5.3.5 Direct Soil Emissions – Urine and dung deposited during grazing (NFR 3Da3)	125
5.3.6 Farm-level agricultural operations (NFR 3Dc)	126
5.3.7 Off-farm storage, handling and transport (NFR 3Dd)	126
5.3.8 Cultivated crops (NFR 3De)	126
5.3.9 Use of Pesticides (NFR 3Df)	126
5.4 Field burning of agricultural residues (NFR 3F)	126
5.5 Uncertainties associated with Synthetic Fertilizer (3Da1), Organic fertilizers (3Da2c) and urine and dung deposited by grazing animals (3Da3)	127

5.6 Recalculations in the Agriculture Sector	127
5.7 Quality Assurance/Quality Control.....	127
5.8 Planned Improvements.....	127
Chapter Six.....	138
Waste.....	138
6.1 Overview of the Waste (NFR 5) Sector.....	138
6.2 Biological treatment of waste - Solid waste disposal on land (NFR 5A)	138
6.2.1 Main Pollutants	138
6.2.2 Heavy Metals	139
6.3 Biological treatment of waste - Composting (NFR 5B1)	139
6.4 Waste Incineration (NFR 5C)	140
6.4.1 Clinical Waste (5C1biii)	140
6.4.2 Industrial Waste (5C1bi), Hazardous Waste (5C1bii) and Sewage Sludge (5C1biv)	142
6.4.3 Crematoria (5C1bv)	143
6.4.4 Open Burning of Agricultural Wastes (5C2)	144
6.5 Wastewater handling (NFR 5D)	145
6.6 Other Waste (NFR 5E).....	145
6.6.1 Accidental Fires	145
6.6.2 Other Burning	147
6.7 Recalculations in the Waste Sector.....	148
6.8 Quality Assurance/Quality Control.....	149
6.9 Planned Improvements.....	149
Chapter Seven	155
Gridded and LPS data	155
7.1 Overview of Gridded and LPS data reporting	155
7.2 Mapping methodology	159
7.3 Mapping methods for each GNFR.....	162
7.3.1 Public Power (GNFR A_PublicPower)	163
7.3.2 Industry (GNFR B_Industry).....	163
7.3.3 Other stationary combustion (GNFR C_OtherStationaryComb).....	163
7.3.4 Fugitive Emissions (GNFR D_Fugitive)	163
7.3.5 Solvents (GNFR E_Solvents)	164
7.3.6 Road transport (GNFR F_RoadTransport)	164
7.3.7 National navigation (GNFR G_Shipping)	164
7.3.8 Aviation (LTO) (GNFR H_Aviation).....	164
7.3.9 Off road mobile sources (GNFR I_Offroad)	164

7.3.10 Waste handling and treatment (GNFR J_Waste).....	165
7.3.11 Agricultural livestock (GNFR K_AgriLivestock)	165
7.3.12 Agricultural soils (Other emissions) (GNFR L_AgriOther).....	165
7.3.13 Aviation (Cruise) (GNFR O_AviCruise).....	165
7.3.14 International navigation (GNFR P_IntShipping).....	166
7.4 National total emission mapped by the EMEP 0.1 degree x 0.1 degree grid	166
Chapter Eight	172
Projections.....	172
8.1 Overview of Emissions Projections	172
8.2 Emission Reduction Commitments for 2020 and 2030	173
8.3 With Measures and With Additional Measures Scenarios - Approach	173
8.4 Key Trends.....	176
8.4.1 Sulphur Dioxide (SO ₂).....	177
8.4.2 Nitrogen Oxides (NO _x).....	178
8.4.3 Ammonia (NH ₃).....	181
8.4.4 Non-Methane Volatile Organic Compounds (NMVOCs)	183
8.4.5 Particulate Matter < 2.5 µm in diameter (PM _{2.5})	186
8.5 Energy Industries (NFR 1A1).....	188
8.5.1 Oil and Gas Refining and Solid Fuel Manufacturing (NFR 1A1b and 1A1c).....	189
8.6 Manufacturing Industries and Construction (NFR 1A2)	189
8.7 Transport (NFR 1A3).....	189
8.7.1 Domestic aviation (NFR 1A3a)	190
8.7.2 Road transportation (NFR 1A3b).....	190
8.7.3 Rail (NFR 1A3c).....	190
8.7.4 Navigation (NFR 1A3d)	190
8.7.5 Gas Transmission (NFR 1A3e).....	191
8.8 Residential and Commercial/Institutional (NFR 1A4)	191
8.8.1 Commercial/Institutional (NFR 1A4a)	191
8.8.2 Residential (1A4b).....	192
8.9 Combustion in Agriculture and Fishing (NFR 1A4c)	193
8.10 Fugitive emissions (NFR 1B)	193
8.11 Mineral Products (NFR 2A), Chemical industry (NFR 2B), Metal Industry (NFR 2C)	194
8.12 Non-Energy Products from Fuels and Non-Energy Products from Fuels and Solvent Use (NFR 2D) and NFR 2H, I, J,K,L	195
8.13 Agriculture (NFR 3).....	195
8.14 Waste (NFR 5).....	197

Chapter Nine	198
Adjusted annual national emission inventories.....	198
9.1 Meeting the Requirements for an Adjustment in the period 2020 to 2030.....	198
9.1.1 Emission Reduction Commitments.....	198
9.1.2 NMVOC Adjustment Application	199
Glossary	201
References.....	203
Annex A to H.....	217
Annex H.....	218
2022 NECD Review findings and responses	218

List of Tables

Table 1.2. Key Category Analysis of Ireland’s Air Pollutant Inventory 2021	15
Table 3.1. Fugitive Emissions from Coal mining and handling	56
Table 3.2. Fugitive Non-Methane Volatile Organic Compound Emissions	58
Table 3.3. Recalculations in Energy NFR 1A1	65
Table 3.3. Recalculations in Energy NFR 1A1 (continued)	66
Table 3.4. Recalculations in Energy NFR 1A2	67
Table 3.5. Recalculations in Energy NFR 1.A.3 (a & b)*	68
Table 3.6. Recalculations in Energy NFR 1A3 (c, d & e)	69
Table 3.7. Recalculations in Energy NFR 1A4	70
Table 4.0. Emission Time Series of particulates from Cement and Lime Production	74
Table 4.1. Emission Time Series from Glass Production	76
Table 4.2 Quarrying and mining of minerals other than coal (2.A.5.a)	77
Table 4.3 Construction and Demolition (2.A.5.b)	77
Table 4.4 Storage, handling and transport of mineral products (2.A.5.c)	77
Table 4.5 Dioxin and Furan Emission Time Series from Bricks and Ceramics Production	78
Table 4.6 Dioxin and Furan Emission Time Series from Asphalt Production	79
Table 4.7 Nitrogen Oxides Emission Time Series from Nitric Acid Production	79
Table 4.8 Particulate matter emission time-series from the Storage and Handling of Fertilizers	80
Table 4.9 Emission Time Series from Iron and Steel Production	81
Table 4.10 Emission Time Series from Ferroalloys Production	82
Table 4.11 Emission Time Series for Zinc from Aluminium Production	83
Table 4.12 Emission Time Series for Lead Production	83
Table 4.13 Emission Time Series for Non-Ferrous Metal Production	84
Table 4.14 Non-Methane Volatile Organic Compound Emissions from Domestic Solvent Use	88
Table 4.15 Emissions from Road Paving with Asphalt (NFR 2D3b)	89
Table 4.16 Non-Methane Volatile Organic Compound Emissions from Paint Application: Car Repairing	90
Table 4.17 Non-Methane Volatile Organic Compound Emissions from Paint Application: Construction and Building (060103) and Domestic use (060104)	90
Table 4.18 Non-Methane Volatile Organic Compound Emissions from Paint Application: Boat Building	91
Table 4.19 Non-Methane Volatile Organic Compound Emissions from Paint Application: Wood	91
Table 4.20 Non-Methane Volatile Organic Compound Emissions from Paint Application: Other Industrial Sources	92
Table 4.21 Non-Methane Volatile Organic Compound Emissions from Paint Application: Other Non-Industrial Sources	92
Table 4.22 Non-Methane Volatile Organic Compound Emissions from Metal Degreasing, Electronics Manufacture and Other Industrial Cleaning	93
Table 4.23 Non-Methane Volatile Organic Compound Emissions from Dry Cleaning	94
Table 4.24 Non-Methane Volatile Organic Compound Emissions from Polyurethane Processing	95
Table 4.25 Non-Methane Volatile Organic Compound Emissions from Rubber Processing	95
Table 4.26 Non-Methane Volatile Organic Compound Emissions from Pharmaceutical Products Manufacturing	96
Table 4.27 Non-Methane Volatile Organic Compound Emissions from Paint Manufacture	96
Table 4.28 Non-Methane Volatile Organic Compound Emissions from Inks Manufacturing	97
Table 4.29 Non-Methane Volatile Organic Compound Emissions from Adhesives Manufacturing	97
Table 4.30 Non-Methane Volatile Organic Compound Emissions from Textile Finishing	97
Table 4.31 Non-Methane Volatile Organic Compound Emissions from Printing	98
Table 4.32 Non-Methane Volatile Organic Compound Emissions from Glass Wool Blowing/Enduction	99
Table 4.33 Emissions from Fat, edible and non-edible oil extraction	99
Table 4.34 Non-Methane Volatile Organic Compound Emissions from Application of Glues and Adhesives	99
Table 4.35 Non-Methane Volatile Organic Compound Emissions from Preservation of Wood	100
Table 4.36 Non-Methane Volatile Organic Compound Emissions from Underseal Treatment and Conservation of Vehicles	100
Table 4.37 Non-Methane Volatile Organic Compound Emissions from Vehicle Dewaxing	100
Table 4.38 Emissions from Use of Tobacco	101
Table 4.39 Emissions from Use of Fireworks	101
Table 4.40 Emissions from 4-stroke oil combustion in road transport	102

Table 4.41 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Bread -----	102
Table 4.42 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Beer -----	103
Table 4.43 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Spirits -----	103
Table 4.44 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Meat, fish etc. frying/curing -----	103
Table 4.45 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Coffee roasting -----	103
Table 4.46 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Feedstock -----	104
Table 4.47 Time Series of Polychlorinated Biphenyls and Dioxin and Furan Emissions from Leakage from Electrical Equipment -----	106
Table 4.48 Emission Time Series for Polychlorinated Biphenyls from Fragmentisers and Shredders -----	107
Table 4.49 Notation keys used in 2021 NMVOC inventory -----	108
Table 4.50 Recalculations for Industrial Processes 1990–2020 (Heavy Metals) -----	110
Table 4.51 Recalculations for Industrial Processes 1990–2020 (Particulates and NO _x) -----	111
Table 4.52 Recalculations for Industrial Processes 1990–2020 (NMVOC) -----	114
Table 5.1 Emission Estimates for Hexachlorobenzene Emissions from Pesticide Use -----	126
Table 5.2. NH ₃ Recalculations for Agriculture 1990–2020 -----	129
Table 5.3. NMVOC Recalculations for Agriculture 1990–2020 -----	131
Table 5.4. TSP Recalculations for Agriculture 1990–2020 -----	132
Table 5.5. PM ₁₀ Recalculations for Agriculture 1990–2020 -----	134
Table 5.6. PM _{2.5} Recalculations for Agriculture 1990–2020 -----	136
Table 6.1 Pollutant Emissions by Waste Source Category -----	138
Table 6.2 Emission Time Series for NMVOC TSP, PM ₁₀ and PM _{2.5} from Solid Waste Disposal on Land -----	139
Table 6.3 Emission Time Series for Mercury from Solid Waste Disposal on Land -----	139
Table 6.4 Time Series of Activity Data and Emissions of NH ₃ and CO from Composting -----	140
Table 6.5 Time Series of Emissions from the Incineration of Clinical Waste -----	141
Table 6.6 Time Series of Emissions from the Incineration of Industrial (incl. Hazardous & Sludge) Waste -----	142
Table 6.7 Time Series of Emissions from Crematoria -----	144
Table 6.8 Time Series of Emissions from the Open Burning of Farm Plastics -----	145
Table 6.9 Time Series of activity data from Accidental Fires from Vehicles and Buildings -----	146
Table 6.10 Time Series of Emissions from Accidental Fires from Vehicles and Buildings -----	147
Table 6.11 Time Series of Emissions from Other Waste Burning -----	148
Table 6.12 Recalculations for Waste 1990–2020 -----	150
Table 7.1. List of GNFR categories -----	156
Table 7.2. Correspondence list for GNFR and NFR categories -----	156
Table 8.1. Emission Reduction Commitments for 2020 and 2030 (expressed as a percentage reduction on 2005 levels) --	173
Table 8.2. Key assumptions underpinning the energy projections -----	175
Table 8.3. Projected Emissions of SO ₂ under the With Measures and With Additional Measures Scenarios (kt) -----	178
Table 8.4. Projected Emissions of NO _x under the With Measures and With Additional Measures Scenarios (kt) -----	180
Table 8.5. Projected Emissions of NH ₃ under the With Measures and With Additional Measures Scenarios (kt) -----	182
Table 8.6. Projected Emissions of NMVOC under the With Measures and With Additional Measures Scenarios (kt) -----	185
Table 8.7. Projected Emissions of PM _{2.5} under the With Measures and With Additional Measures Scenarios (kt) -----	187
Table 9.1 Summary of National Emissions in 2005 and 2021, the ERCs for 2020-2030 and actual emission reduction -----	199
Table 9.2. Adjustments for emissions from the Food and Beverage Industry (NMVOC) -----	200

List of Figures

Figure 1.1. National Atmospheric Inventory System Overview	8
Table 1.1 Key Data Providers and Information Covered by Memoranda of Understanding	13
Figure 2.1 Emission Trend for Sulphur Dioxide 1990–2021	19
Figure 2.2 Emission Trend for Nitrogen Oxides 1990–2021	20
Figure 2.3 Emission Trend for Ammonia from agriculture 1990–2021	21
Figure 2.4 Emission Trend for Non-Methane Volatile Organic Compounds 1990–2021	22
Figure 2.5 Emission Trend for Carbon Monoxide 1990–2021	23
Figure 2.6 Emission Trend for Particulate Matter <10 µm in Diameter 1990–2021	25
Figure 2.7 Emission Trend for Particulate Matter <2.5 µm in Diameter 1990–2021	26
Figure 2.8 Emission Trend for Total Suspended Particulates 1990–2021	27
Figure 2.9 Emission Trend for Black Carbon 1990–2021	28
Figure 2.10 Emission Trend for Lead 1990–2021	29
Figure 2.11 Emission Trend for Cadmium 1990–2021	30
Figure 2.12 Emission Trend for Mercury 1990–2021	31
Figure 2.13 Emission Trend for Arsenic 1990–2021	32
Figure 2.14 Emission Trend for Chromium 1990–2021	33
Figure 2.15 Emission Trend for Copper 1990–2021	34
Figure 2.16 Emission Trend for Nickel 1990–2021	35
Figure 2.17 Emission Trend for Selenium 1990–2021	36
Figure 2.18 Emission Trend for Zinc 1990–2021	37
Figure 2.19 Emission Trend for Dioxins and Furans 1990–2021	38
Figure 2.21 Emission Trend for Polychlorinated Biphenyls 1990–2021	40
Figure 2.22 Emission Trend for Polycyclic Aromatic Hydrocarbons 1990–2021	41
Figure 3.1 Nitrogen Oxide Implied Emission Factors for Category 1A1a	44
Figure 3.2 Sulphur Dioxide Implied Emission Factors for Category 1A1a	45
Figure 3.3 Number of Domestic LTOs from Irish airports 1990–2021	49
Figure 3.4 Number of International LTOs from Irish airports 1990–2021	50
Figure 4.1 NMVOC Emission Trend for 2D-2H Other Solvent and Product 1990–2021	86
Figure 5.1. Emission Trend for Ammonia from Agriculture 1990–2021	117
Figure 5.2. Emission Trend for NMVOC from Agriculture 1990–2021	117
Figure 5.3. Emission Trend for NO _x from Agriculture 1990–2021	118
Figure 5.4. Emission Trend for PM _{2.5} from Agriculture 1990–2021	118
Figure 7.1 General decision tree for emissions mapping (EMEP/EEA 2019)	160
Figure 7.2 Example of GeoKey preparation	162
Figure 7.3 National Total Emissions in 2015 for a) NO _x , b) SO ₂ , c) NMVOC, d) NH ₃ , and e) PM _{2.5}	171
Figure 8.1 SO ₂ Emission Projections for the With Existing Measures and With Additional Measures Scenarios	177
Figure 8.2 SO ₂ Emission Projections for the With Additional Measures Scenario by Source Sector	178
Figure 8.3 NO _x Emission Projections for the With Measures and With Additional Measures Scenarios	179
Figure 8.4 NO _x Emission Projections for the With Additional Measures Scenario by Source Sector	180
Figure 8.5 NH ₃ Emission Projections for the With Measures and With Additional Measures Scenarios	181
Figure 8.6 NH ₃ Emission Projections for the With Additional Measures Scenario by Source Sector	182
Figure 8.7 NMVOC Emission Projections for the With Existing Measures and With Additional Measures Scenarios	183
Figure 8.8 NMVOC Emission Projections for the With Measures and With Additional Measures Scenarios where an adjustment is applied for category 2H2 Spirit production	184
Figure 8.9 NMVOC Emission Projections for the With Additional Measures Scenario by Source Sector	185
Figure 8.10 PM _{2.5} Emission Projections for the With Measures and With Additional Measures Scenarios	186
Figure 8.11 PM _{2.5} Emission Projections for the With Additional Measures Scenario by Source Sector	187

Acknowledgements

The authors wish to express their appreciation to the various Government Departments, the Sustainable Energy Authority of Ireland, the Central Statistics Office, the Electricity Supply Board and the many other data suppliers and individuals who have contributed to the subject matter of this inventory report.

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_x), sulphur dioxide (SO₂), non-methane volatile organic compounds (NMVOCs), ammonia (NH₃), 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 Pollution¹, 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 emission 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 Evidence and Assessment (OEA) 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 fourteenth IIR submitted under the Convention, covering annual inventories for the period 1990–2021. 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 2023 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 (TACCC) of the reported emissions. In addition to complying with reporting

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

requirements in this regard, the 2023 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 (<https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/>). 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, the 1988 Sofia Protocol concerning the Control of Emissions of Nitrogen Oxides, the 1998 Aarhus Protocol on Persistent Organic Pollutants (POPs) and the 1998 Aarhus Protocol on Heavy Metals.

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)² 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_x), sulphur oxides (SO_x), non-methane volatile organic compounds (NMVOCs), carbon monoxide (CO), ammonia (NH₃), particulate matter (PM), black carbon (BC), heavy metals (HM) and persistent organic pollutants (POPs).

² The Guidelines for Reporting Emissions and Projections Data under the Convention on Long-Range Transboundary Air Pollution ([ECE/EB.AIR/125](https://www.unece.org/ece/doc/air/125.pdf))

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 is 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 2023, the fourteenth such report. It contains specific information on the national inventory for the years 1990–2021 as submitted to CLRTAP in 2023, 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 2021 and the status of the inventories achieved for the time series up to 2021 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 (<https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/>) 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) 2016/2284³ came into force on the 31st 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.

For 2021 Ireland's national total emissions of ammonia (NH₃) and non-methane volatile organic compounds (NMVOCs) are not in compliance with the emission reduction commitments shown in Annex II of Directive 2016/2284. Ireland has established adjusted annual national emission inventories

³ [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](#)

for NMVOCs as allowed for under the flexibilities outlined in 5(1) of the Directive 2016/2284. The adjusted inventory is established in accordance with Part 4 of Annex IV of the directive and is 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 Environment, Climate and Communications (DECC) 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 Evidence and Assessment (OEA) currently compiles the national air pollutant emission inventories on behalf of the DECC for submission under the CLRTAP and the 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 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 the CLRTAP and the NECD.

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 the 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 Evidence and Assessment (OEA) is designated as the single national entity with overall responsibility for the national emission inventory in Ireland. The OEA also performs the role of inventory agency, i.e. it 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 OEA, the Office of Environmental Sustainability 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 OEA. 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 the LRTAP Convention and Directive (EU) 2016/2284 is provided in this report. 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_x, NMVOCs, SO_x, NH₃, CO);
2. Particulate matter (PM_{2.5}, PM₁₀, 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 5th 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.

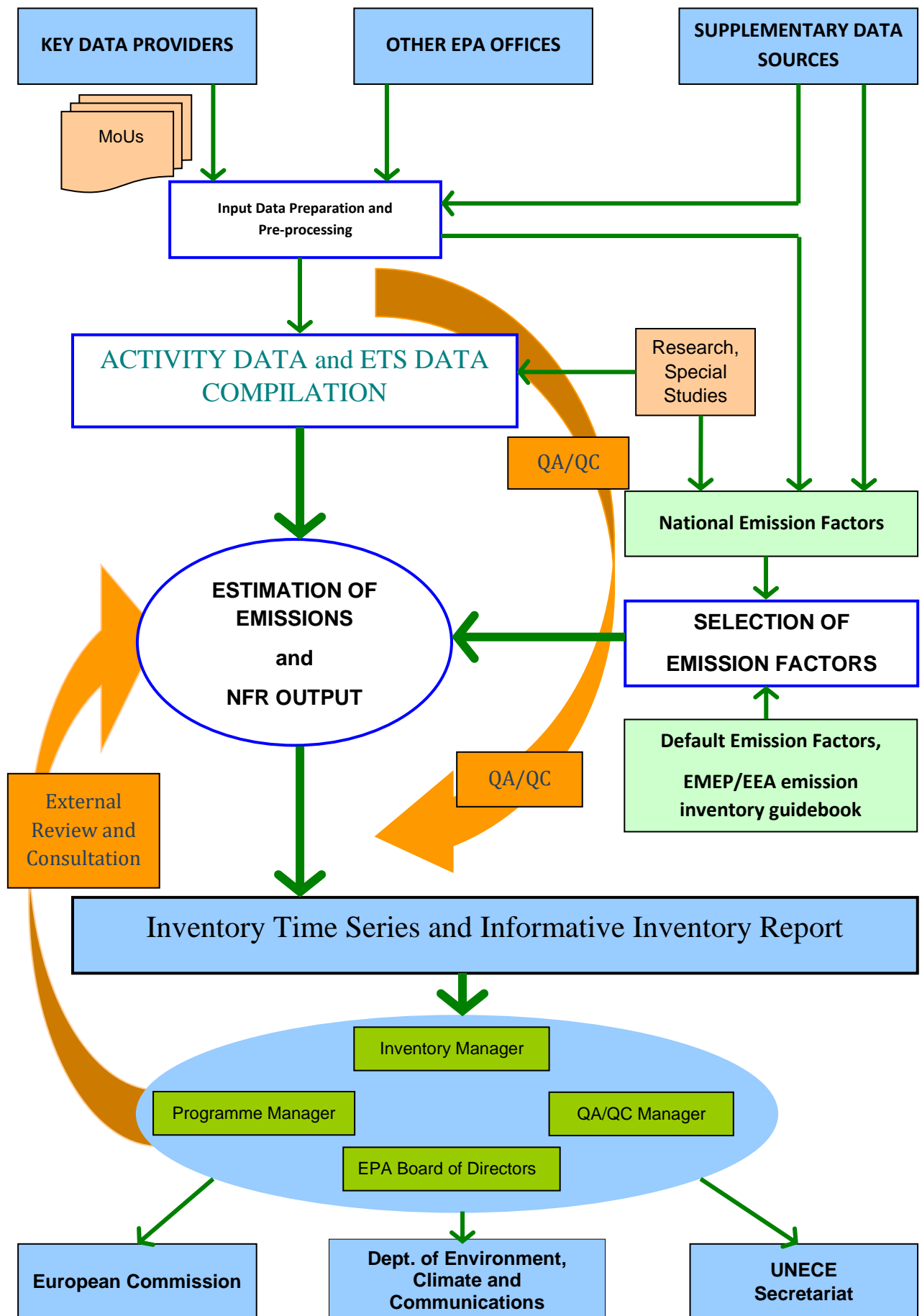


Figure 1.1. National Atmospheric Inventory System Overview

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 2023 submission contains data for large point sources and sectoral gridded data of emissions on the EMEP grid that were submitted as required in 2021. 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_x (as SO₂), NO_x, NMVOCs, NH₃ and PM_{2.5}, 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. Ireland produces national air pollutant emission projections on an annual basis. Information on emission 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 OEA 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 OEA, but some secondary KDPs provide their input to one of the primary KDPs for processing and incorporation into the information subsequently transmitted to the OEA. Some KDPs may also deliver estimates of emissions 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 OEA 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 OEA 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, 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, accuracy, consistency, completeness, and comparability (TACCC) 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 seventeen 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.

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 2023 reporting cycle, the inventory agency updated some of the default emission factors in accordance with the EMEP/EEA Air Pollutant Emission Inventory Guidebook (2019) and implemented suggested changes/requests for further information as presented in the Final NECD Review Report of the 2022 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 ₂ estimates and related fuel and production data for installations covered by the EU ETS	30 April	Energy, Industrial Processes
Department of Environment, Climate and Communications (DECC)	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 inventory 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_x and NO_x, 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) are the main sources of emissions for NH₃, NMVOC's and particulate matter and the additional categories 2D and 2H for NMVOCs. Waste sector sources are main driver of emissions for As and PCBs and an important source for Cr and Dioxins.

Table 1.2. Key Category Analysis of Ireland's Air Pollutant Inventory 2021

Pollutant	Key Categories									Total (%)
	3Da1	3Da3	1A3bi	1A1a	1A3biii	1A3bii	3Da2a	1A3dii	1A4bi	
NO _x	15.35%	12.38%	9.60%	8.52%	8.21%	7.50%	7.44%	7.16%	5.96%	82.12%
CO	1A4bi 65.09%	1A3bi 10.52%	1A1a 10.23%							85.83%
NMVOC	2H2 25.89%	3B1b 20.14%	3B1a 9.96%	2D3a 9.78%	1A4bi 8.30%	3De 3.90%	1A3bi 2.62%			80.58%
SO _x	1A4bi 58.18%	1A1a 26.02%								84.20%
NH ₃	3Da2a 29.20%	3B1b 28.49%	3B1a 12.50%	3Da3 11.55%						81.74%
TSP	2D3b 46.18%	1A4bi 10.95%	3Da1 10.41%	2A5a 10.09%	2A5b 4.72%					82.35%
PM ₁₀	3Da1 22.08%	1A4bi 21.40%	2D3b 13.06%	2A5a 10.49%	1A3bvi 3.92%	3Dc 3.34%	2A5b 3.00%			80.22%
PM _{2.5}	1A4bi 51.55%	1A2f 6.29%	1A3bvi 4.93%	1A1a 4.22%	2A1 3.94%	1A2gviii 3.77%	3B1b 2.55%	2A5a 2.53%	1A3bvii 2.15%	81.93%
Pb	1A3bvi 59.85%	1A4bi 20.59%								80.45%
Cd	1A2gviii 25.38%	1A1a 22.12%	2D3i 11.37%	1A4bi 9.74%	1A3bvi 7.45%	2G 7.00%				83.06%
Hg	1A2f 23.21%	1A1a 21.36%	1A4bi 20.81%	5A 6.28%	1A1c 5.71%	5C1bv 3.99%				81.37%
As	5C1bi 54.32%	1A1a 28.32%								82.64%
Cr	1A3bvi 48.89%	5C1bi 18.80%	1A1a 6.91%	1A4bi 5.47%						80.07%
Cu	1A3bvi 83.67%									83.67%
Ni	1A1a 45.73%	1A4ai 20.49%	1A2gviii 10.11%	1A2f 5.15%						81.48%
Se	1A4bi 64.37%	1A1a 28.93%								93.30%
Zn	1A3bvi 42.03%	1A1a 15.38%	1A4bi 12.44%	2D3i 10.27%						80.12%
PCDD/F	1A4bi 71.26%	5E 16.16%								87.42%
PCBs	5E 41.27%	1A4bi 39.59%								80.86%
HCB	3Df 82.00%									82.00%
PAHs	1A4bi 89.72%									89.72%
	1 Energy		2 IPPU		3 Agriculture		5 Waste			

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 2021 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, 2021)	Uncertainty in 2021 (%)	Trend Uncertainty 1990-2021 (%)
NO _x	100.04	50.7	18.4
SO ₂	11.77	11.8	0.6
NMVOC	115.88	71.3	22.0
NH ₃	124.84	85.5	12.1
CO	123.38	45.9	2.6
PM _{2.5}	12.69	90.0	18.6

The total uncertainty in the NO_x emission in 2021 is dominated by the contribution of 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 98.6 per cent of the total NO_x emissions uncertainty. The next largest contributor to uncertainty for NO_x 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 SO₂ are well characterised when compared to NO_x for most emissions because they are combustion related, with emission factors for SO₂ (i.e. the sulphur content of the fuel) more readily determined than for NO_x. Solid fuel combustion, coal, biomass and peat in the residential sector combined account for 95.4 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 89.3 per cent of the overall uncertainty because of the magnitude of the emission of these categories (30.1 per cent in 2021) 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 NH₃ 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 96.3 per cent of the overall uncertainty.

Emissions of PM_{2.5} 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_{2.5} 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 97.6 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 2023 submission under the CLRTAP and the Directive (EU) 2016/2284 includes emission estimates for the period 1990–2021 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_x 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 1990–2021 and for the year 1987, the base year for the Sofia Protocol.

This chapter provides an overview of the emission trends for the period 1990–2021 for all substances included in Ireland's 2023 submission under the CLRTAP and the NECD. The general analysis of trends is performed only in respect of emissions estimated on the basis of fuels used in Ireland.

2.2 Main Pollutants

2.2.1 Sulphur Dioxide (SO₂)

Total sulphur dioxide emissions decreased by 93.6 per cent, from 183.84 kt in 1990 to 11.77 kt in 2021 (Figure 2.1). The Commercial/Institutional and Residential (1A4a and 1A4b) sectors combined account for 59.5 per cent of the total in 2021, and decreased by 81.6 per cent between 1990 (38.09 kt) and 2021 (7.00 kt). The Public Electricity and Heat Production (1A1a) sector remains one of the main sources of SO₂ emissions, contributing 26.0 per cent of the total in 2021, and decreased by 97.0 per cent between 1990 (103.04 kt) and 2021 (3.06 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. Emissions from Public Electricity and Heat Production increased in 2021 by 53.0 per cent as a result of the tripling of both coal and fuel oil use in electricity generation. Combustion sources in the Manufacturing Industries and Construction (1A2) sector largely account for the remainder of the emissions, with contribution of 10.9 per cent in 2021. Emissions in this sector peaked in 1994 due to an increase in SO₂ from oil combustion in an installation which is the main

contributor to emissions in Non-ferrous metals (1A2b). Emissions in Manufacturing Industries and Construction (1A2) have decreased in the 1990-2021 time series by 96.1 per cent. Combustion in Agriculture/Forestry/Fishing (1A4c) sector accounts for 0.2 per cent and Transport (1A3) combustion sources account for 1.9 per cent of national total emissions of SO₂ in 2021. The remainder of the SO₂ 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 1.6 per cent of the total in 2021 and are presented in Other NFR sectors in Figure 2.1. In 1990, coal combustion accounted for 51.4 per cent of SO₂ emissions and fuel oil contributed 30.3 per cent. By 2021, the share of SO₂ emissions from coal had decreased to 45.6 per cent and that from fuel oil had decreased to 15.7 per cent.

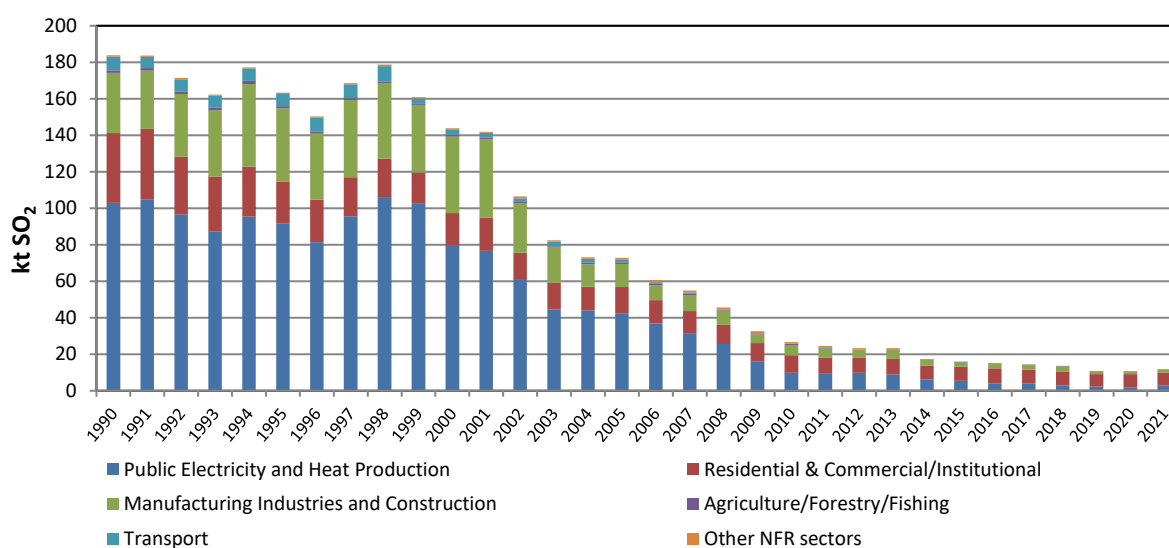


Figure 2.1 Emission Trend for Sulphur Dioxide 1990–2021

2.2.2 Nitrogen Oxides (NO_x)

Total nitrogen oxides emissions have decreased by 43.8 per cent, from 174.89 kt in 1990 to 98.21 kt in 2021 (Figure 2.2). Road Transport (1A3b) is a major source of NO_x emissions, contributing 25.8 per cent (and 25.33 kt) of the total in 2021, with the transport sector as a whole accounting for 33.8 per cent (and 33.17 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 5.2 per cent (9.07 kt), which increased to 11.1 per cent share in 2007 (and 17.35 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 7.2 per cent share (7.57 kt) of the national total in 2011 due to the economic crisis impacting upon the sector. In 2021 the sector contribution increased to an 8.6 per cent share (and 8.43 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_x emissions, accounting for 8.7 per cent of emissions in 2021. Emissions from this sector have decreased by 81.6 per cent between 1990 (46.37 kt) and 2021 (8.53 kt). Emissions from Public Electricity and Heat Production increased in 2021 by 52.6 per cent as a result of the tripling of both coal and fuel oil use in electricity generation. Commercial/Institutional and Residential (1A4a and 1A4b) sectors combined

account for 8.1 per cent of the total and combustion sources in Agriculture/Forestry/Fishing (1A4c) sector account for 3.5 per cent in 2021. The remainder of the combustion sources of NO_x 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 2021. Agricultural sources of NO_x, accounted for 36.9 per cent of emissions in 2021 (36.19 kt), having increased by 9.6 per cent since 1990 (33.02 kt).

The largest sources of NO_x emissions within agriculture are associated with Inorganic nitrogen fertilizer application (3Da1) and Urine and Dung Deposited by grazing animals (3Da3).

The reductions in NO_x 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 decade. This effect is exaggerated in later years by so-called fuel tourism, whereby a 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_x emissions based on fuels used in Ireland, which is relevant to the assessment of obligations in relation to the Sofia Protocol on NO_x emissions.

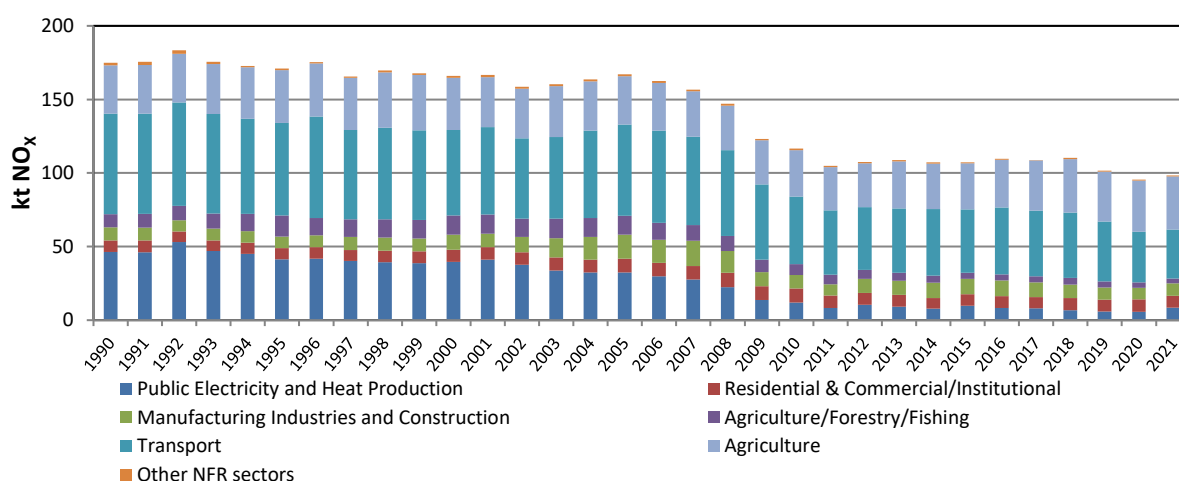


Figure 2.2 Emission Trend for Nitrogen Oxides 1990–2021

2.2.3 Ammonia (NH₃)

Agriculture accounted for 99.4 per cent of total ammonia emissions in 2021. National total emissions have increased by 12.6 per cent, from 110.70 kt in 1990 to 124.65 kt in 2021. Livestock production has historically accounted for the bulk of national total ammonia emissions in Ireland and, in 2021, Manure Management (3B) and Animal manure applied to soil (3Da2a) and nitrogen from urine and dung deposition by grazing animals combined accounted for 90.4 per cent of the national total. In 2021, Manure Management at 61.70 kt and 49.5 per cent share of the total in 2021 showed an increase by 26.0 per cent from 48.96 kt in 1990. Organic fertiliser use covers emissions from the two sectors: Animal Manure applied to soils (3Da2a) and Sewage Sludge applied to soils (3Da2b), which combined at 36.65 kt accounted for 29.4 per cent of the total ammonia emissions in 2021 (indicating an 7.1 per

cent increase from 34.21 kt in 1990). Urine and Dung deposited by grazing animals (3Da3) accounted for 11.5 per cent of total emissions in 2021 (14.39 kt), having increased by 8.3 per cent since 1990. Inorganic/synthetic N-fertilizers applied to soils (sector 3Da1) decreased by 18.5 per cent from 1990 (13.69 kt) and at 11.15 kt in 2021 accounted for 8.9 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 exhaust catalysts in Road Transport (1A3b). Transport emissions have increased from 0.05 kt in 1990 to 0.44 kt (and 0.4 per cent share of the total) in 2021. 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 0.2 per cent of the total in 2021.

Within livestock production, Manure Management (3B) at 61.70 kt in 2021 is the largest source of NH₃. 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.

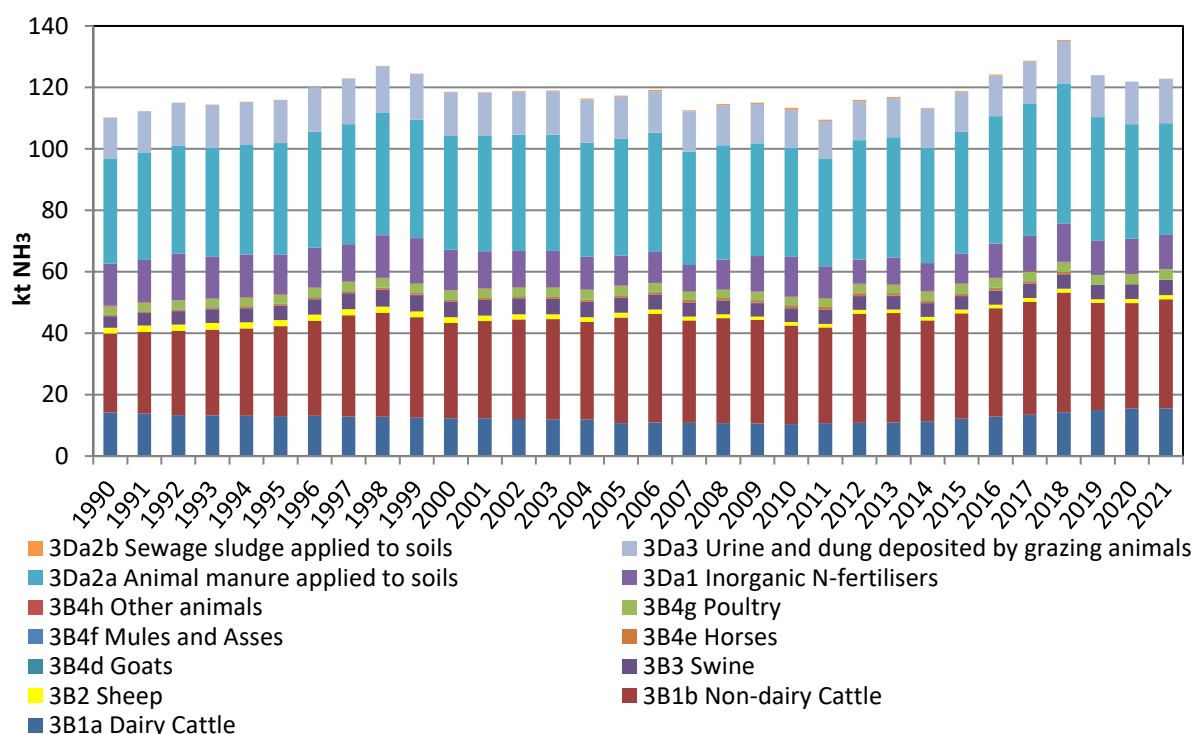


Figure 2.3 Emission Trend for Ammonia from agriculture 1990–2021

Dairy Cattle (3B1a) and Non-Dairy Cattle (3B1b) account for the major part (41.2 per cent) of Agriculture sector ammonia emissions in 2021. 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 8.6 per cent of total ammonia emissions from agriculture in 2021 (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 110.15 kt in 1990 to 126.91 kt in 1998. As a result of reforms to the Common Agricultural Policy (CAP), animal numbers and associated fertiliser nitrogen use

subsequently reduced, and ammonia emissions in agricultural sectors had fallen to 109.50 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 123.89 kt in 2021 largely as a result of increased dairy cattle and other cattle populations, increased fertilizer use and continued use of urea as an inorganic nitrogen fertilizer. The increased use of abatement options such as inhibited urea fertiliser and low emission slurry spreading techniques in recent years are showing some reductions.

2.2.4 Non-Methane Volatile Organic Compounds (NMVOCs)

Total non-methane volatile organic compound emissions have decreased by 25.0 per cent, from 151.60 kt in 1990 to 113.67 kt in 2021 (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 38.2 per cent of the national total and showed an increase of 6.1 per cent between 1990 (40.88 kt) and 2021 (43.38 kt). The combined solvents use (2D and 2G) and fugitive emissions from the oil sector (1.B.2.a) produced 18.9 per cent of the 2021 total of NMVOC emissions in Ireland, having decreased by 21.0 per cent between 1990 (27.25 kt) and 2021 (21.53 kt). The Food and Beverage Industry (2H2) contributed to 26.4 per cent of total emissions in 2021, having increased by 212.0 per cent from 9.62 kt in 1990 to 30.00 kt in 2021.

Combustion sources in the Residential (1A4b) and Commercial/Institutional (1A4a) sectors are also important sources, accounting for 8.9 per cent of national total NMVOC emissions in 2021, a reduction of 71.6 per cent between 1990 (35.53 kt) and 2021 (10.10 kt). Technological controls for volatile organic compounds (VOCs) emitted by motor vehicles have been more successful than in the case of NO_x and have contributed to a significant reduction in emissions from Road Transport (1A3b), with the total transport sector's contribution having decreased by 88.2 per cent between 1990 (34.01 kt) and 2021 (4.01 kt). This equates to contributions to the national total of 22.4 per cent in 1990, falling to 3.5 per cent in 2021. A total of five NFR source categories make up the source Other NFR sectors (Figure 2.4) contributing 0.7 per cent of national total NMVOC emissions in 2021. The largest source of emissions within this categorisation is Solid waste disposal on land sector (5A).

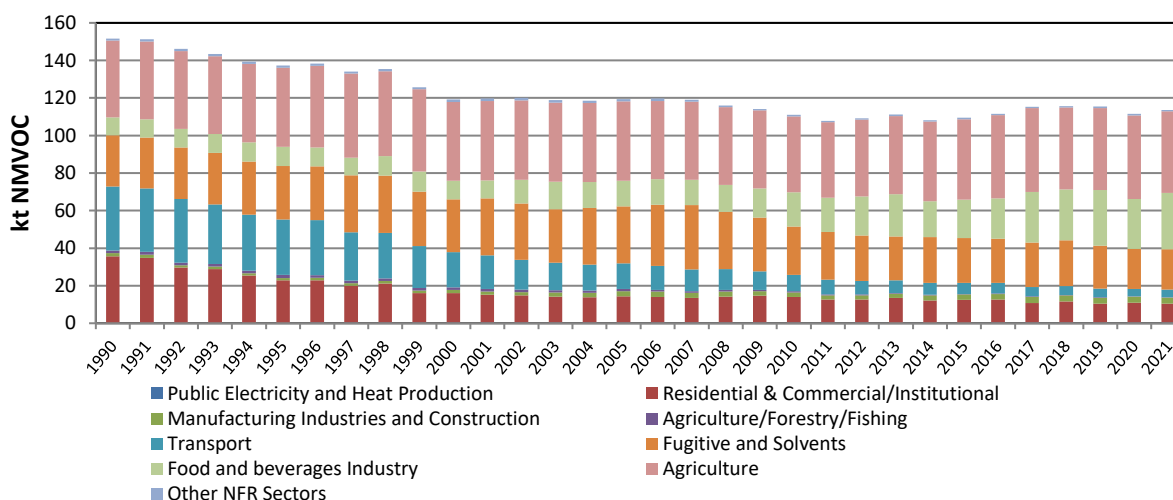


Figure 2.4 Emission Trend for Non-Methane Volatile Organic Compounds 1990–2021

2.2.5 Carbon Monoxide (CO)

Carbon monoxide emissions continue to decline, driven by a large decrease in the use of solid fuels for space heating in the Residential (1A4b) sector, which is the principal source of CO, and major reductions due to three way exhaust catalysts in gasoline vehicles in Road Transport (1A3b) (Figure 2.5). National total CO emissions have reduced from 579.63 kt in 1990 to 123.09 kt in 2021, a reduction of 78.8 per cent.

Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined, account for 66.1 per cent of national total CO emissions in 2021, a reduction of 72.2 per cent between 1990 (292.82 kt) and 2021 (81.33 kt). The Transport sector is another important source and accounted for 14.6 per cent of national total emissions in 2021, a major reduction (92.9 per cent) from 253.29 kt in 1990 to 17.94 kt in 2021. Public Electricity and Heat Production (1A1a) sector reached its peak in 2001 (23.82 kt) and has decreased by 47.0 per cent to reach 12.62 kt in 2021, a reduction of 30.4 per cent on 1990 levels (18.14 kt). Emissions increased in 2021 by 91.0 per cent as a result of a tripling of coal and fuel oil use in electricity generation. Combustion sources from Manufacturing Industries and Construction (1A2) account for 7.6 per cent of the national total in 2021 and at 9.34 kt showed a 16.0 per cent decrease on their 1990 levels (11.12 kt). Agriculture/Forestry/Fishing (1A4c) combustion sources account for 1.0 per cent of the total CO emissions in 2021. Petroleum refining (1A1b), Manufacture of soil 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 (0.5 per cent of the total) in 2021.

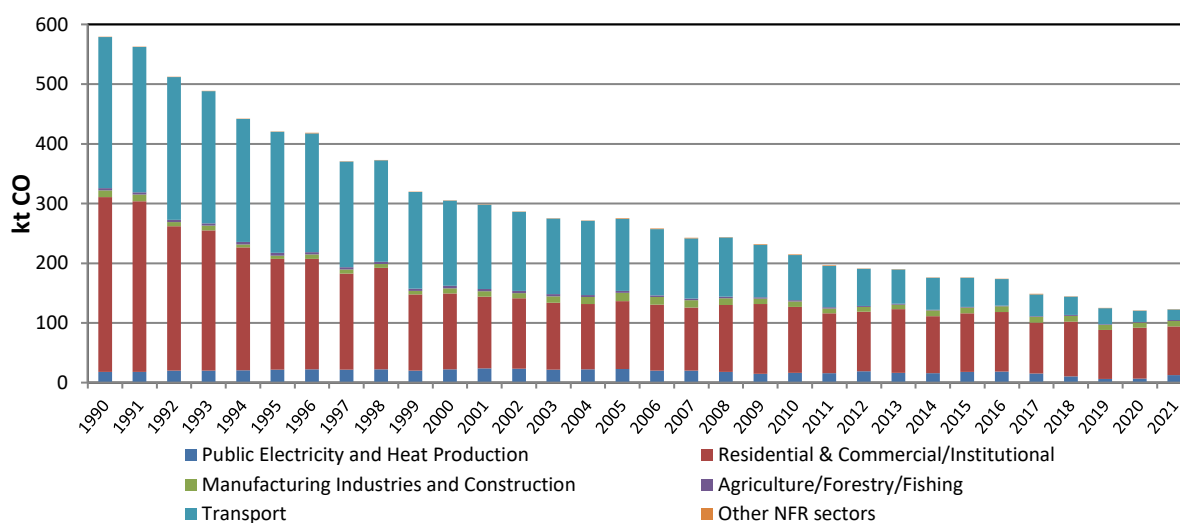


Figure 2.5 Emission Trend for Carbon Monoxide 1990–2021

2.3 Particulate Matter

Particulate matter emission estimates include PM with diameter less than 10 μm (PM₁₀), PM with diameter less than 2.5 μm (PM_{2.5}) and total suspended particulates (TSP).

2.3.1 Particulate Matter <10 µm Diameter (PM₁₀)

Emissions of particulate matter <10 µm diameter amounted to 30.49 kt in 2021, a 32.5 per cent reduction from 45.17 kt in 1990 (Figure 2.6). The main determinant of the trend in PM₁₀ emissions are Agriculture and Other sectors with 31.4 per cent and 31.7 per cent share, respectively of the national total, and combustion in the Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined with 22.1 per cent share of the total in 2021.

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 2021 at 9.57 kt indicated a 0.2 per cent increase on their 1990 levels. Part replacement of coal and peat in the Residential (1A4b) and Commercial/Institutional (1A4a) sectors are the third largest contributor to the total PM₁₀ emissions, with 68.1 per cent reduction in emissions from these sectors, from being the largest contributor to the PM₁₀ emissions (46.7 per cent of national total emissions) at 21.11 kt in 1990, emissions have fallen to 6.74 kt in 2021 (and 22.1 per cent of the national total emissions). Emissions from Transport (1A3), at 6.9 per cent share of the total in 2021 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 26.7 per cent (from 2.88 kt in 1990 to 2.11 kt in 2021).

Manufacturing Industries and the Construction sector (1A2) used to account for an increasing percentage of the national total PM₁₀, until reaching its peak of 2.47 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 5.1 per cent of the national total in 2021 (1.57 kt), representing a decrease across the 1990-2021 time series of 14.6 per cent. Public Electricity and Heat Production (1A1a) sector emissions accounted for 2.4 per cent of the national total in 2021 and at 0.72 kt reduced by 24.8 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. In recent years Ireland's only coal fired electricity generation station has been running at much reduced capacity levels. However the tripling of coal and fuel oil use in electricity generation in 2021 led to a 106.1 per cent increase in emissions from Public Electricity and Heat production in comparison in 2020. Petroleum refining (1A1b), Manufacture of solid fuels and other energy industries (1A1c), Fugitive emissions from soil 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 31.7 per cent of national emission in 2021. 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).

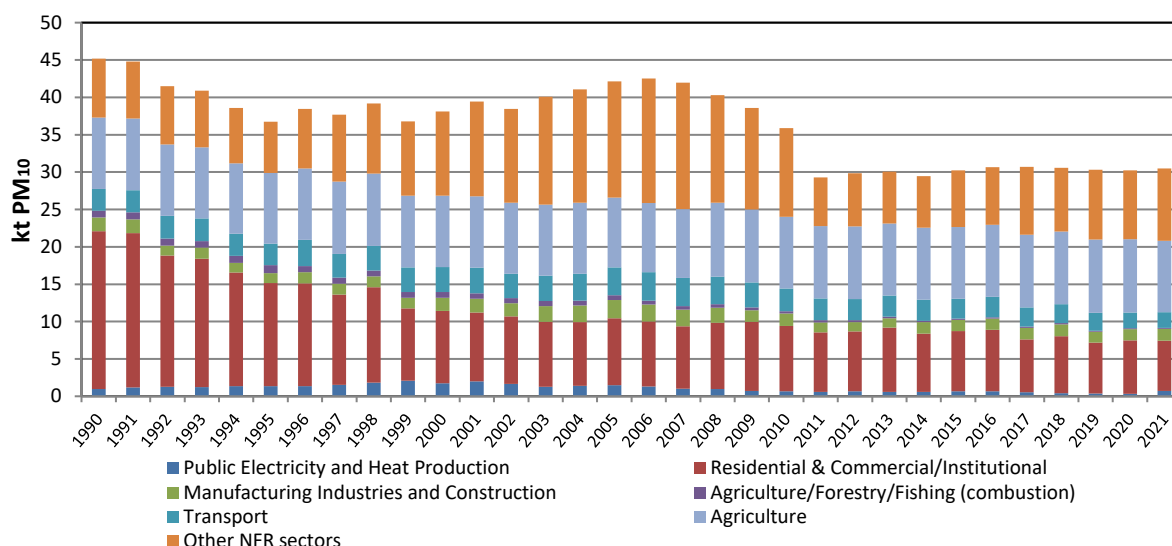


Figure 2.6 Emission Trend for Particulate Matter <10 µm in Diameter 1990–2021

2.3.2 Particulate Matter <2.5 µm Diameter (PM_{2.5})

National total emissions of particulate matter <2.5 µm diameter amounted to 12.60 kt in 2021, a 56.4 per cent reduction on 28.88 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 53.1 per cent share of the national total PM_{2.5} emissions in 2021. There has, however, been a reduction of 68.1 per cent in emissions from these sectors between 1990 (20.95 kt and 72.5 per cent share) and 2021 (6.69 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 2021 at 0.96 kt accounted for 7.6 per cent of the national total and indicated a 6.5 per cent increase on their 1990 levels (0.90 kt). Transport (1A3) contributed 1.33 kt (10.6 per cent share) to the national total in 2021. Emissions from Transport sector (1A3), dominated by Road Transport (1A3b) increased from 1990 (2.50 kt) to a peak in 1996 (3.01 kt), but have been decreasing since 2005, with a 46.8 per cent reduction between 1990 and 2021 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 PM₁₀ emissions). Emissions from Manufacturing Industries and Construction (1A2) at 1.46 kt in 2021 are 11.6 per cent below those in 1990.

Electricity and Heat Production (1A1a) sector accounted for 4.2 per cent of the national total emissions in 2021, a reduction of 17.1 per cent from 0.65 kt in 1990 and 0.54 kt in 2021. However, the tripling of coal and fuel oil use in electricity generation in 2021 led to a 112.8 per cent increase in emissions from Public Electricity and Heat production in comparison in 2020. Combustion from the Agriculture/Forestry/Fishing sector accounted for 0.8 per cent of national total PM_{2.5} emissions in 2021 and have reduced by 88.5 per cent from 1990 when emissions were 0.93 kt, compared to 0.11 kt in

2021. The remainder of the PM_{2.5} emissions arise from Petroleum refining (1A1b), Manufacture of soil 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 12.1 per cent of national emission in 2021.

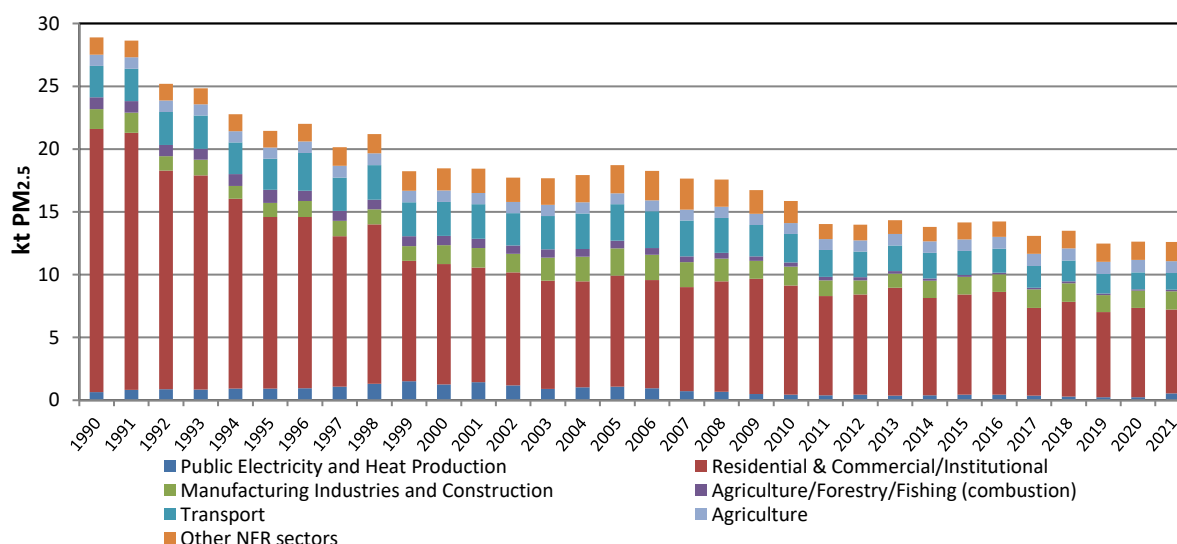


Figure 2.7 Emission Trend for Particulate Matter <2.5 µm in Diameter 1990–2021

2.3.3 Total Suspended Particulates (TSP)

Total suspended particulate emissions have decreased by 17.7 per cent, from 80.63 kt in 1990 to 66.39 kt in 2021 (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 soil 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 62.7 per cent of the national total in 2021. Road paving with asphalt (2D3b) accounts for the majority of emissions within this grouping (72.1 per cent). Emissions from the Other NFR sectors have increased by 4.5 per cent from 39.81 kt in 1990 to 41.62 kt in 2021. Emissions from the agriculture (NFR 3) sector were 11.78 kt (and 17.7 per cent share of the total) in 2021, an 9.6 per cent increase from 1990 levels (10.75 kt). Combined emissions from Residential (1A4b) and Commercial/Institutional (1A4a) sectors were the third largest contributor to the total TSP emission in 2021. There has been, similar to emissions from both PM₁₀ and PM_{2.5}, a reduction of 67.5 per cent in emissions from these sectors between 1990 (22.56 kt) and 2021 (7.34 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 28.0 per cent of the national total in 1990 to 11.1 per cent in 2021.

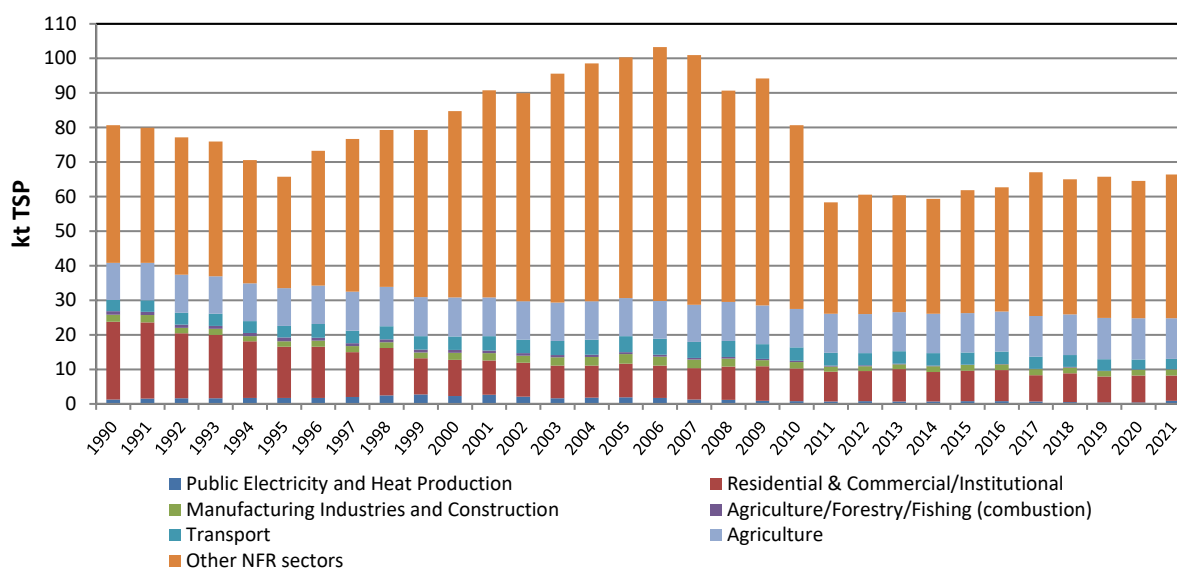


Figure 2.8 Emission Trend for Total Suspended Particulates 1990–2021

Emissions from Transport (1A3) decreased by 11.2 per cent to 2021 (2.92 kt and 4.4 per cent share of national total) compared to 1990 (3.28 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 (2.79 kt) and although have been generally declining since. At 1.71 kt in 2021 (2.6 per cent of the total) emissions have decreased from 2005 by 38.9 per cent and by 17.9 per cent from 1990 (2.08 kt). Public Electricity and Heat Production sector (1A1a) emissions have decreased by 25.0 per cent over the time series, from 1.23 kt in 1990 to 0.92 kt (and 1.4 per cent share of the total emissions) in 2021. However, the tripling of coal and fuel oil use in electricity generation in 2021 led to a 107.0 per cent increase in emissions from Public Electricity and Heat production in comparison in 2020. Emissions from Agriculture/Forestry/Fishing in 2021 (0.12 kt, 0.2 per cent of the national total) have decreased by 87.6 per cent since 1990 (0.94 kt).

2.3.4 Black Carbon (BC)

Black Carbon emissions have decreased by 64.0 per cent, from 4.35 kt in 1990 to 1.56 kt in 2021 (Figure 2.9). The main driver of the BC trend is combined emissions from Residential (1A4b) and Commercial/Institutional (1A4a) sectors emissions. In 2021, combined emissions from the sectors were 0.62 kt (39.9 per cent share) and have reduced by 71.7 per cent since 1990 (2.2 kt). Emissions from Transport sector (1A3) were the second largest contributor to total BC emissions in 2021, emissions have reduced by 61.4 per cent between 1990 (1.16 kt) and 2021 (0.45 kt). Manufacturing Industry and Construction (1A2) emissions accounted for 22.3 per cent of the total in 2021 (0.35 kt) having decreased by 1.1 per cent since 1990. Emissions from Agriculture/Forestry/Fishing in 2021 were 0.05 kt, which equates to an 89.5 per cent reduction on 1990 (0.51 kt). Public Electricity and Heat Production (1A1a) emissions have decreased by 3.1 per cent over the time series. The tripling of coal and fuel oil use in electricity generation in 2021 led to a 170.4 per cent increase in emissions from Public Electricity and Heat production in comparison to 2020. The remaining 4.3 per cent in 2021 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).

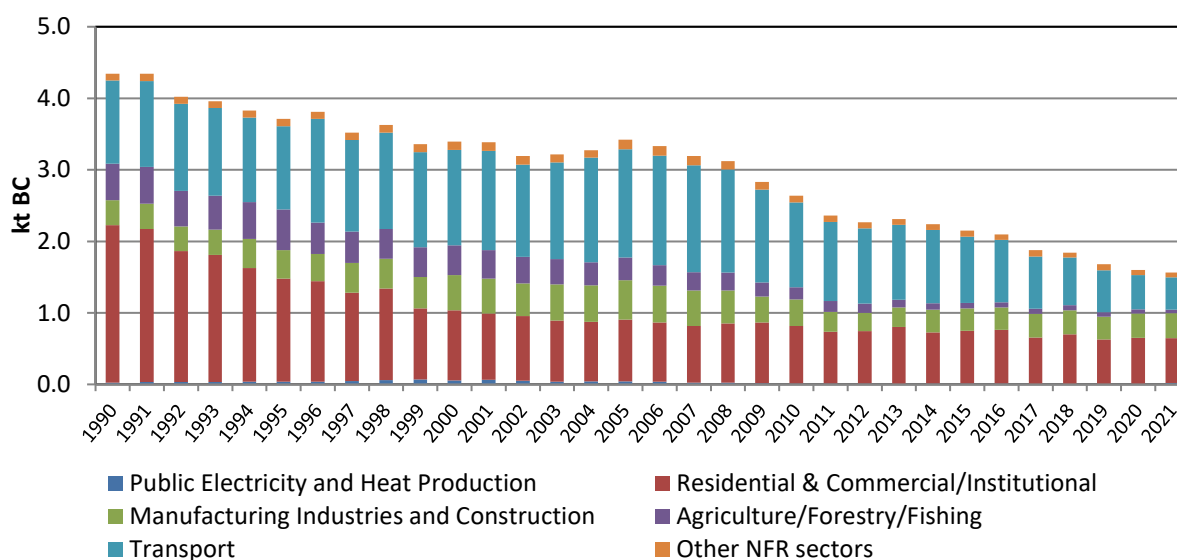


Figure 2.9 Emission Trend for Black Carbon 1990–2021

2.4 Priority Metals

2.4.1 Lead (Pb)

Over the 1990–2021 time series, total national Pb emissions have decreased by 95.7 per cent, from 173.1 t in 1990 to 7.36 t in 2021 (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 97.0 per cent, from 160.78 t (92.9 per cent share) in 1990 to 4.82 t (65.5 per cent share) in 2021.

The largest contributors to Pb emissions at 22.9 per cent share of national total in 2021 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 6.27 t in 1990 to 1.69 t in 2021, a reduction of 73.1 per cent. Combustion in Manufacturing Industries and Construction (1A2) accounted for 4.7 per cent share of the total in 2021, and emissions from Public Electricity and Heat Production sector (1A1a) were responsible for 6.4 per cent share in 2021. Emissions from Metal Production (2C) have decreased in recent years due to the closure of a number of foundries and were negligible in 2021 (0.1 per cent). 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.

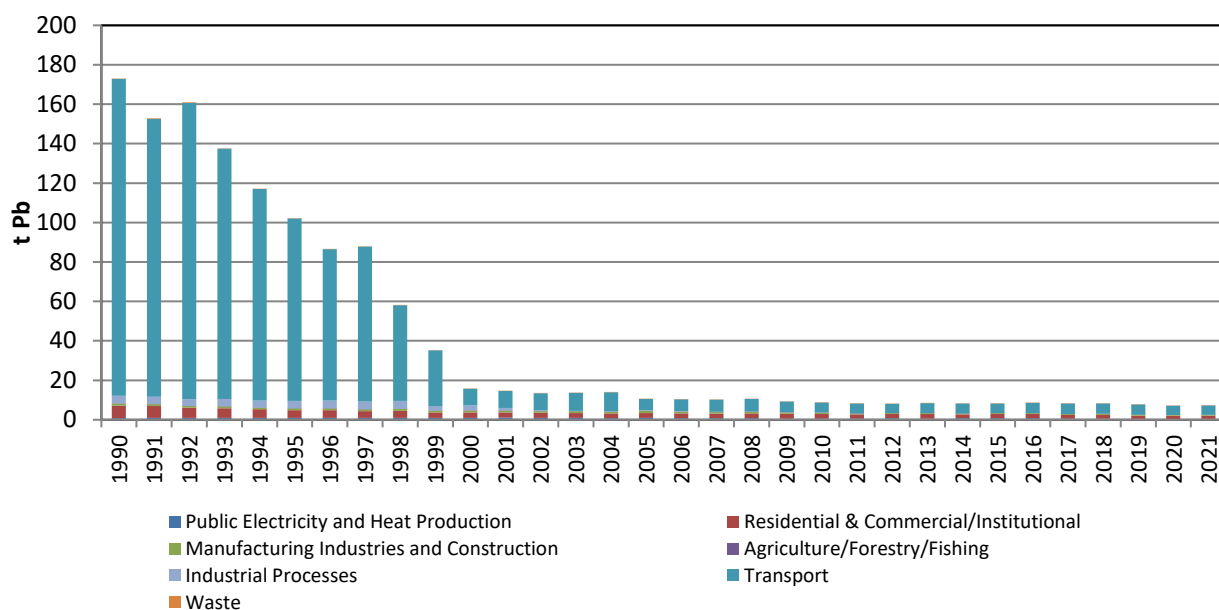


Figure 2.10 Emission Trend for Lead 1990–2021

2.4.2 Cadmium (Cd)

Total national emissions of Cd have decreased from 0.57 t in 1990 to 0.27 t in 2021 (Figure 2.11), a reduction of 52.8 per cent. Emissions of cadmium are largely determined by the Manufacturing Industries and Construction (1A2) sector, specifically combustion sources in Non-Ferrous Metals (1A2b). Manufacturing Industries and Construction (1A2) accounted for 32.5 per cent of total emissions in 2021 having increased by 61.4 per cent since 1990 (0.05 t and 9.5 per cent share). Public Electricity and Heat Production (1A1a) decreased from 1990 by 39.3 per cent and accounted for 25.9 per cent of the national total in 2021. 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. However in 2021 there was a tripling of coal oil for electricity generation which result in a 43.5 per cent increase in emissions from this source.

Residential (1A4b) and Commercial/Institutional (1A4a) combustion is also an important source of Cd emissions, with combined emissions from these sectors accounting for 14.3 per cent of the national total in 2021 due to the continued use of the fossil fuels (coal, peat and oil); however, emissions from the sector have decreased by 39.7 per cent, from 0.06 t in 1990 to 0.04 t in 2021. Transport (1A3) sector emissions have been increasing in the time series (by 97.2 per cent) and in 2021 it accounted for 7.7 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 2021. As a result of the closure of the Irish Steel plant in late 2001, emissions from Metal Production (2C) accounted for a 18.5 per cent share in 2021 compared to a 54.3 per cent share (and main contributor to the total) in 1990.

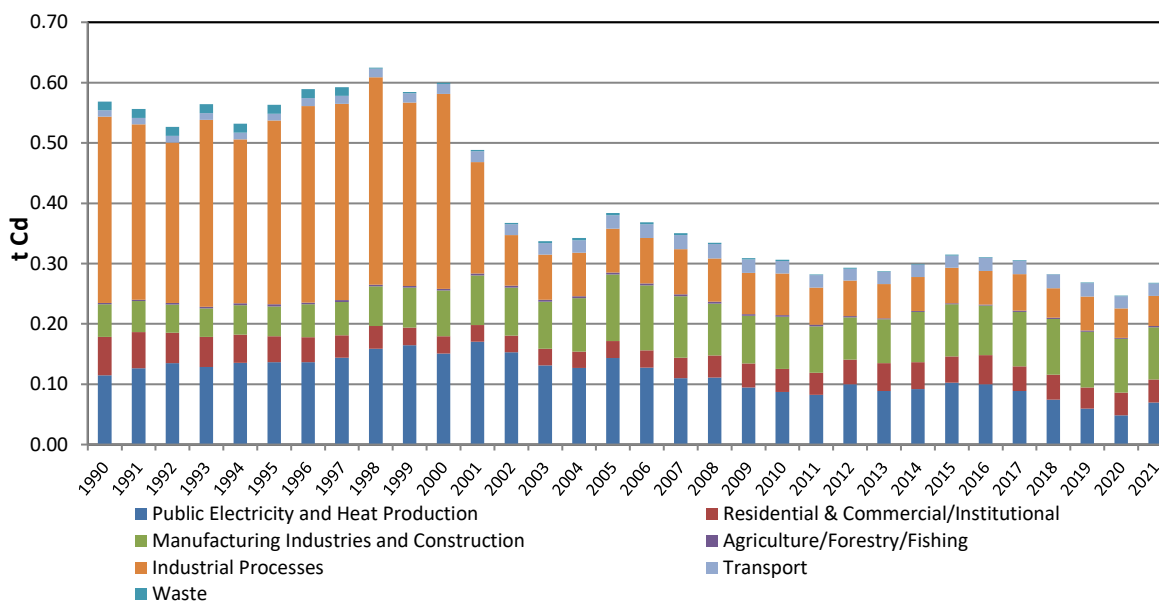


Figure 2.11 Emission Trend for Cadmium 1990–2021

2.4.3 Mercury (Hg)

Total national emissions of Hg have decreased from 0.75 t in 1990 to 0.34 t in 2021, a reduction of 54.2 per cent (Figure 2.12). Emissions from Public Electricity and Heat Production (1A1a) decreased by 47.6 per cent in the trend and accounted for 27.4 per cent (the second largest source) of national total mercury emissions in 2021 (0.09 t). Combustion sources in Manufacturing Industries and Construction (1A2) account for the largest share of national total mercury emissions (33.6 per cent in 2021), having decreased by 46.1 per cent between 1990 and 2021. 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. Emissions from the combined Residential (1A4b) and Commercial/Institutional (1A4a) are the third largest source and accounted for 21.6 per cent of total emissions in 2021, a 61.7 per cent decrease since 1990. Emissions from this source are the result of an increase in the use of natural gas, kerosene and gasoil and a decrease in the use of coal and peat.

Biological treatment of waste – Solid waste disposal on land (5A) and Waste Incineration (5C) combined accounted for a 10.4 per cent share of total emissions in 2021. The Transport (1A3) sector accounted for 6.9 per cent and combustion sources from Agriculture/Forestry/Fishing (1A4c) sector accounted for 0.2 per cent of the total Hg emissions in 2021. Glass Production (2A3) and Metal Production (2C) are no longer occurring due to plant closures (glass since 2010 and metal since 2002).

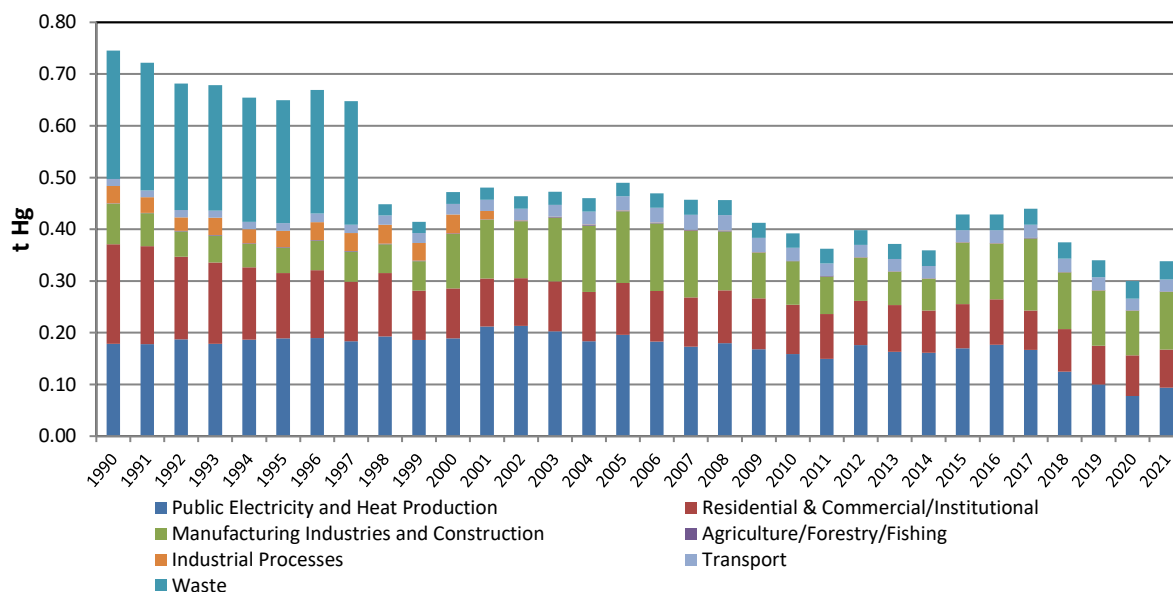


Figure 2.12 Emission Trend for Mercury 1990–2021

2.5 Other Metals

2.5.1 Arsenic (As)

Emissions of arsenic have decreased by 31.7 per cent from 1.81 t in 1990 to 1.24 t in 2021 (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 54.4 per cent of national total arsenic emissions, having increased by 21.9 per cent from 0.55 t in 1990 to 0.67 t in 2021. 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 (but decreasing) use of coal, peat and fuel oil as part of the fuel mix contributes largely (29.1 per cent share of the total in 2021) to the trend in emissions from Public Electricity and Heat Production (1A1a); however, arsenic emissions from the sector have decreased by 54.8 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 2.8 per cent of national total emissions in 2021, however, they have decreased by 69.8 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 9.2 per cent the total in 2021, an increase of 24.0 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 12.0 per cent in 1990 (third largest contributor) and are reported as not occurring in

2021 due to the closure of the foundry which was a responsible for emissions from this sector between 2001 and 2013.

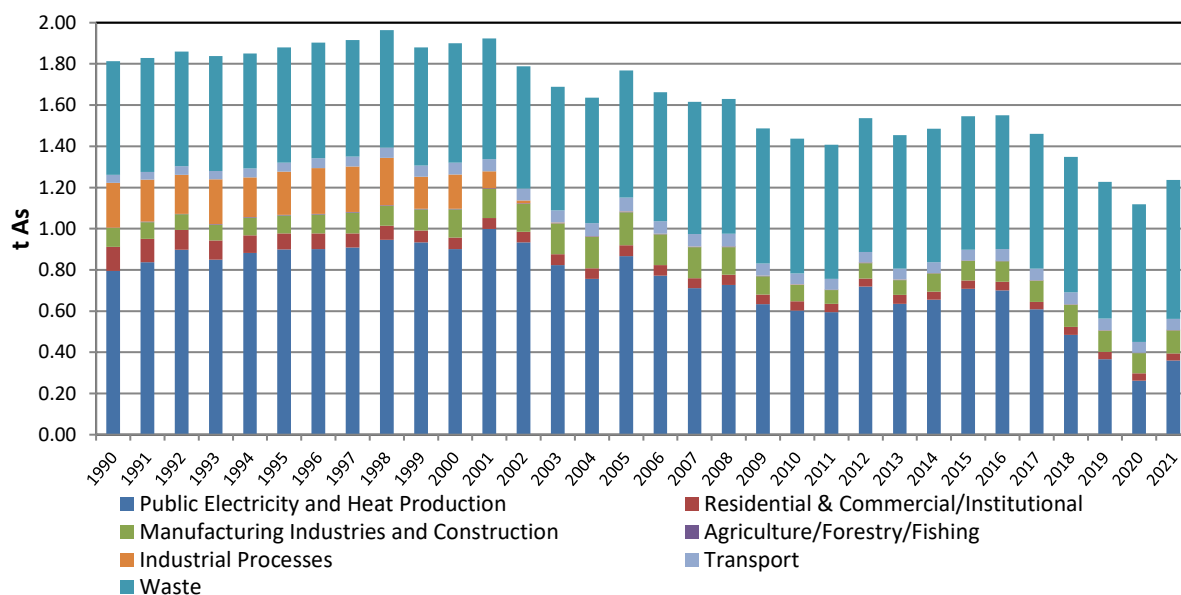


Figure 2.13 Emission Trend for Arsenic 1990–2021

2.5.2 Chromium (Cr)

Emissions of Cr have decreased by 34.6 per cent from 5.13 t in 1990 to 3.36 t in 2021 (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 48.3 per cent of estimated national total emissions in 2021. Emissions from this source category have increased by 97.7 per cent over the time series between 1990 (0.82 t) and 2021 (1.62 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 second largest source of chromium emissions and accounted for 19.4 per cent of 2021 national chromium emissions, an increase of 21.7 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 8.1 per cent to the emissions total in 2021. However, there has been a reduction in emission levels of 47.3 per cent between 1990 and 2021 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 8.6 per cent of the national total in 2021, having decreased, by 68.8 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 11.2 per cent of national total chromium emissions in 2021 and have decreased by 28.4 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 34.7 per cent share of the total (and the main contributor to chromium emissions) in 1990 to a 3.8 per cent share in 2021.

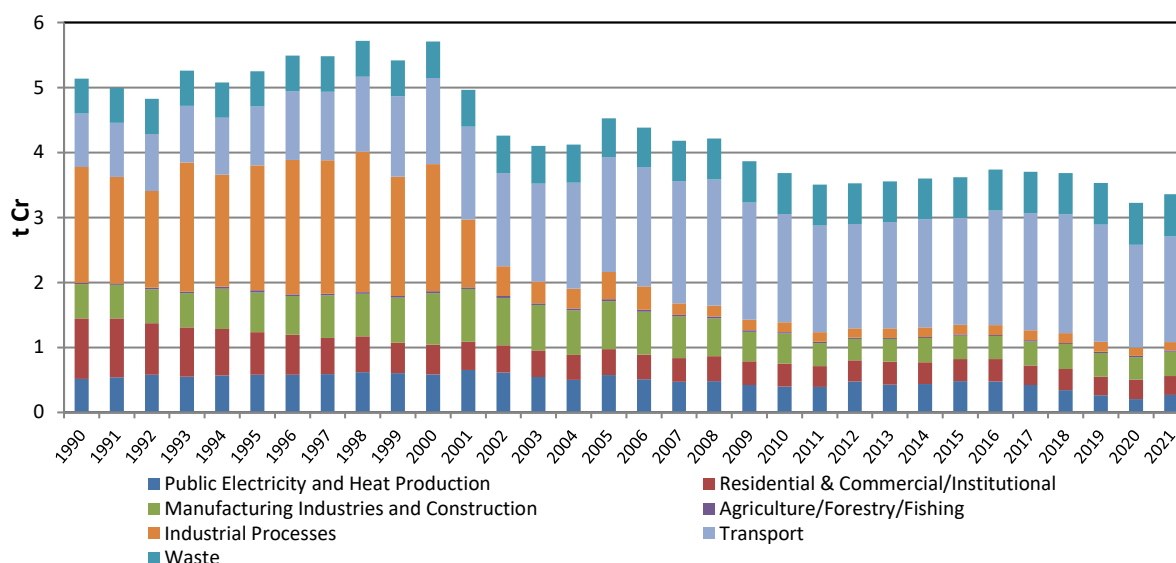


Figure 2.14 Emission Trend for Chromium 1990–2021

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 2021 (42.14 t) were 17.2 per cent lower than in their peak in 2008 (50.88 t) but they are 100.4 per cent higher than in 1990 (17.50 t). This trend is determined mostly by the Transport (1A3) sector that accounted for 83.2 per cent of estimated national total copper emissions in 2021.

Continued use of coal, peat and fuel oil as part of the fuel mix results in a contribution of 1.1 per cent to the total emissions from Public Electricity and Heat Production (1A1a) in 2021. However, a reduction in emission levels of 23.0 per cent is evident between 1990 and 2021 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. Emissions from this source increased by 102.5 per cent in 2021 due to a tripling of coal and fuel oil use compared to 2020. The Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined accounted for 0.9 per cent of emissions in 2021, showing a 72.3 per cent decrease in the trend. Waste Incineration (5C) emissions accounted for 0.9 per cent of the national total in 2021, having increased by 12.9 per cent since 1990 (0.32 t). Combustion sources from Agriculture/Forestry/Fishing (1A4c) sector accounted for 0.7 per cent of the total Cu emissions in 2021 (16.4 per cent decrease since 1990). The Manufacturing Industries and Construction (1A2) sector has decreased by 15.9 per cent between 1990 and 2021 (accounting for 0.8 per cent of the total in 2021). 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 and increasing used or waste as a fuel. Emissions from Industrial Processes, specifically Other solvent use (2D3i) and Other product use (2G) combined accounted for 12.4 per cent of the total in 2021. Emissions from 2D3i and 2G combined have increased by 99.9 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.

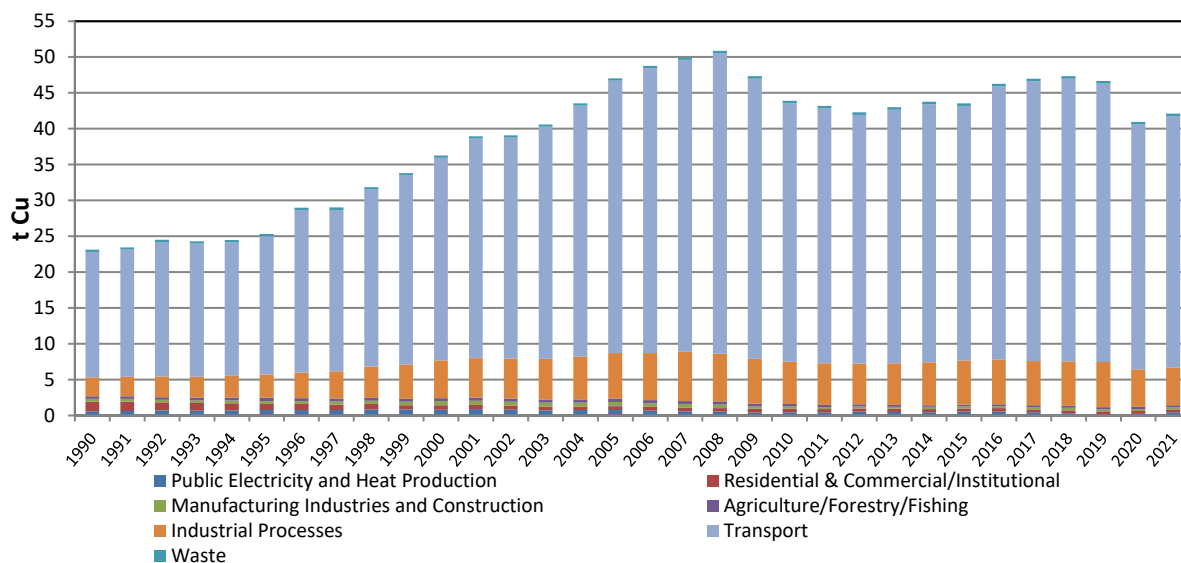


Figure 2.15 Emission Trend for Copper 1990–2021

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 2021 (8.20 t) were 76.0 per cent lower than in their peak in 1999 (34.12 t) and 62.6 per cent lower than in 1990 (21.91 t). Public Electricity and Heat Production (1A1a) sector accounted for a 46.3 per cent share of the total nickel emissions in 2021. However, a reduction in emission levels of 10.0 per cent is evident between 1990 and 2021 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. A tripling in coal and fuel oil use in electricity generation resulted in 203.3 per cent increase in emissions from Public Electricity and Heat Production in 2021 compared to 2020. The second largest contributor to total Ni emissions in 2021 is emissions from the combined Residential (1A4b) and Commercial/Institutional (1A4a) sectors accounting for 22.4 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 reduction of 72.6 per cent in emissions since 1990. The third largest contributor is Manufacturing Industries and Construction (1A2) with a 21.3 per cent share in 2021 (1.75 kt) having reduced by 74.7 per cent since 1990 (6.90 kt).

Combustion sources from Agriculture/Forestry/Fishing (1A4c) sector accounted for 2.8 per cent in 2021. 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 13.8 per cent share of the total (and fourth largest contributor to nickel emissions) in 1990. Emissions in 2021 were 0.22 t contributing to a 2.7 per cent share having reduced by 92.6 per cent since 1990.

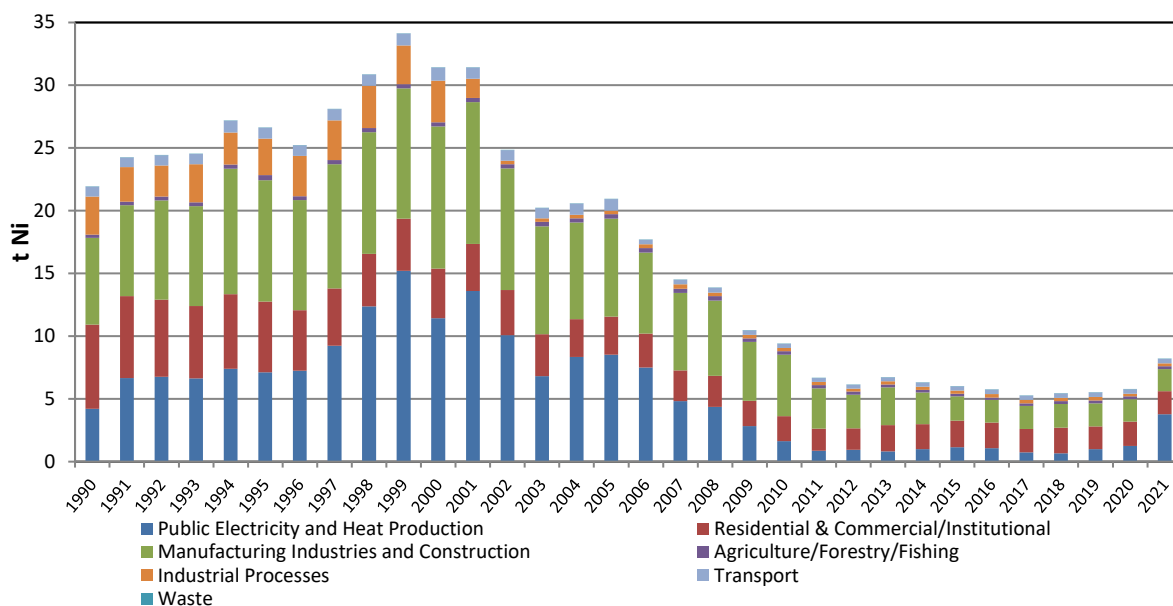


Figure 2.16 Emission Trend for Nickel 1990–2021

2.5.5 Selenium (Se)

National total emission estimates of Se have decreased by 69.4 per cent, from 9.33 t in 1990 to 2.85 t in 2021 (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 64.5 per cent of selenium emissions in 2021, having decreased by 72.9 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 2021 it accounted for 29.2 per cent share of total selenium emissions. Emissions from this sector have decreased by 64.5 per cent from their 1990 level of 2.35 t to 0.83 t in 2021 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. In 2021 there was a 35.3 per cent increase in Selenium emissions from this sector due to a tripling of both coal and fuel oil use in electricity generation.

Transport (1A3) sector has been increasing in the time series and with its 1.5 per cent share of the national total in 2021, it has increased by 108.3 per cent since 1990. Emissions from Manufacturing Industries and Construction accounted for 3.6 per cent of the total in 2021, having increased by 88.1 per cent from 1990. The remainder of the selenium emissions arise from combustion in Agriculture/Forestry/Fishing (1A4c) sector with its 0.1 per cent share of the national total in 2021. 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 1.3 per cent of the national total in that period. In 2021 Industrial Processes accounted for 1.1 per cent of national total emissions.

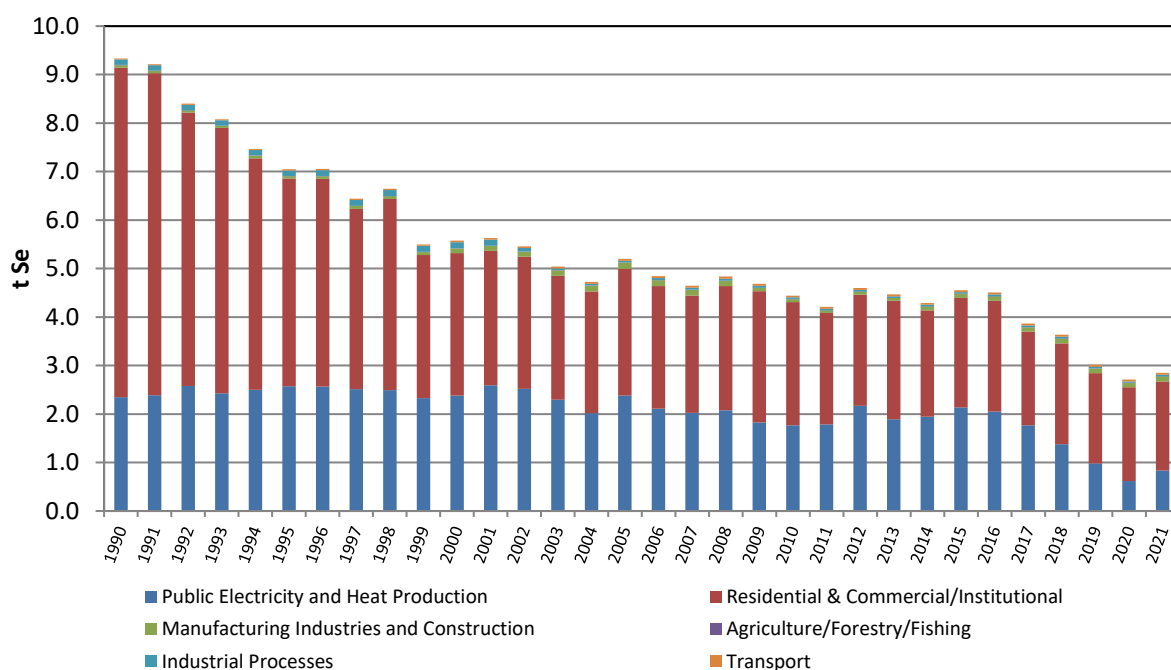


Figure 2.17 Emission Trend for Selenium 1990–2021

2.5.6 Zinc (Zn)

National total emissions of Zn amounted to 59.32 t in 1990 and have fallen by 51.5 per cent to 28.75 t in 2021. In the 1990–2001 period, the main determinant of the trend in zinc emissions was Metal Production (2C), accounting on average for 47.5 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 (41.5 per cent of national total zinc emissions in 2021) 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 (104.2 per cent), from 5.84 t in 1990 to 11.92 t in 2021.

The second largest source in 2021 is emissions from combustion in Manufacturing Industries and Construction (1A2) which accounts for 16.9 per cent share of emissions in 2021 having increased from 3.26 t (5.5 per cent share) in 1990 to 4.86 t in 2021 (49.3 per cent increase). Emissions from combustion in Public Electricity and Heat Production (1A1a) emissions have decreased by 25.9 per cent since 1990 and accounted for a 16.1 per cent share of national total in 2021. Similar to other pollutants the overall 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. However in 2021 an increase of 132.6 per cent occurred due to the tripling of both coal and fuel oil use in electricity generation. Residential (1A4b) and Commercial/Institutional (1A4a) combined accounted for 14.3 per cent of the national total in 2021. 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 67.6 per cent, from 12.74 t in 1990 to 4.13 t in 2021. The remainder of the zinc emissions arise from combustion in Agriculture/Forestry/Fishing (1A4c) sector with its 0.7 per cent

share of the national total in 2021. Waste Incineration (5C) accounted for 0.01 per cent of the national total in 1990 however, following an outright ban on incineration of clinical waste in hospitals in 1997, emission from Clinical Waste Incineration 5Cbiii are no longer a source.

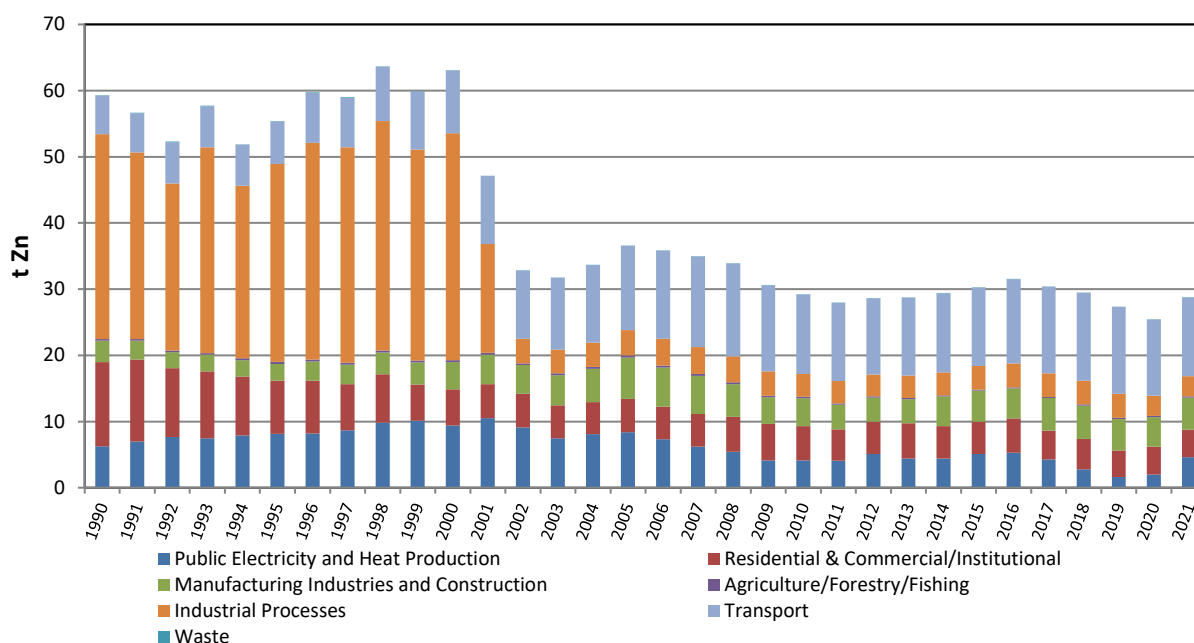


Figure 2.18 Emission Trend for Zinc 1990–2021

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 has been 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 44.29 g I-TEQ in 1990 to 16.88 g I-TEQ in 2021 (61.9 per cent reduction on 1990 levels). The main contributors to the trend are the Residential (1A4b) and Commercial/Institutional (1A4a) sectors combined with a 72.1 per cent share of total emissions in 2021; however, emissions from these sectors have reduced (by 60.9 per cent) from 31.18 g I-TEQ (and 70.4 per cent share) in 1990 to 12.18 g I-TEQ in 2021 (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 18.9 per cent (3.18 g I-TEQ) of national total emissions in 2021, a reduction of 64.4 per cent on 1990 levels (8.94 g I-TEQ). The introduction of unleaded petrol and technological improvements in road vehicles has offset increased numbers of vehicles in the national fleet, with a 2.7 per cent share of national total emissions for

emissions in Transport (1A3) in 2021. 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 2021 (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 2.4 per cent of emissions in 2021 (0.41 g I-TEQ) a decrease of 64.8 per cent on the 1990 emissions (1.17 g I-TEQ). Public Electricity and Heat Production (1A1a) emissions have decreased by 26.2 per cent from their 1990 level of 0.84 g I-TEQ to 0.62 g I-TEQ and are responsible for a 3.7 per cent share of national total in 2021 due to the replacement of older less-efficient generation plants, reduction in the quantities of coal combusted overall and fuel switching from oil to natural gas and wind energy.

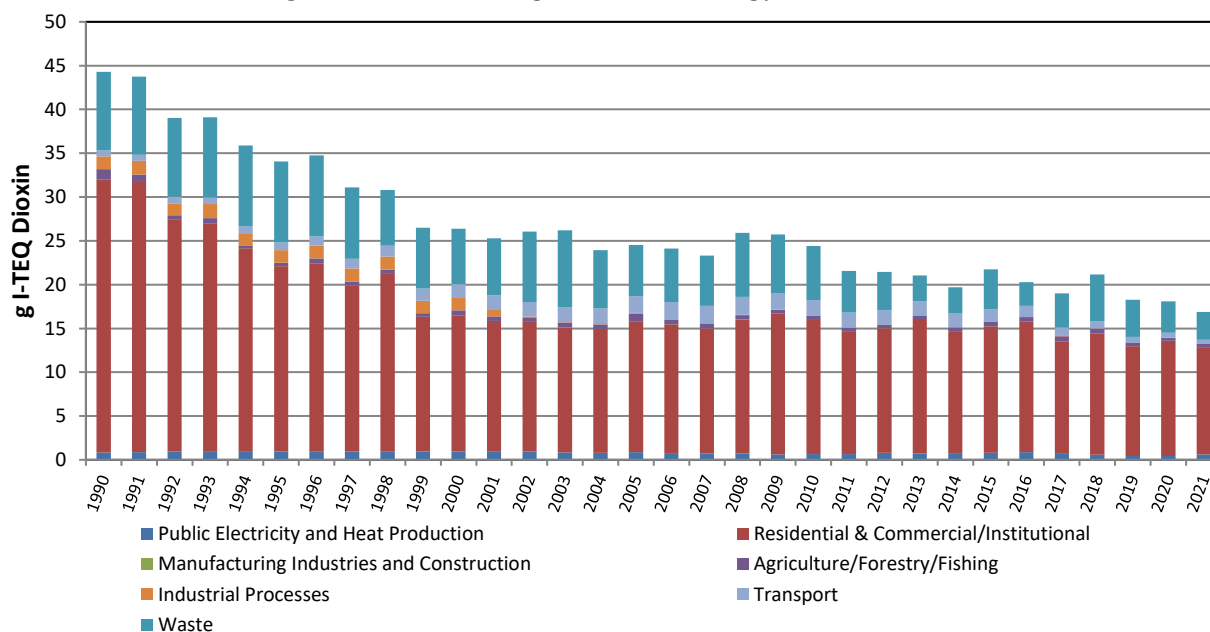


Figure 2.19 Emission Trend for Dioxins and Furans 1990–2021

2.6.2 Hexachlorobenzene (HCB)

Figure 2.20 outlines the trend in hexachlorobenzene emissions in Ireland across the 1990–2021 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 2021.

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 2004 (8.03 kg), and decreasing to 2.03 kg in 2005 following a ban on the use of certain pesticides. Subsequently emissions have increased up to 2012, before subsequently decreasing and in 2021 were 2.07 kg representing an 82.0 per cent share. The Public Electricity and Heat Production (1A1a) sector was the second largest source in 2021 accounting for 0.39 kg and a 15.3 per cent share of the national total, having decreased by 21.0 per cent between 1990 and 2021.

Incineration of hazardous and clinical wastes and crematoria included in the waste incineration (5C) accounted for 0.3 per cent share of national emissions in 2021, a decrease of 89.1 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 2.1 per cent of the total in 2021. Transport (1A3) accounted for 0.4 per cent of national emissions in 2021.

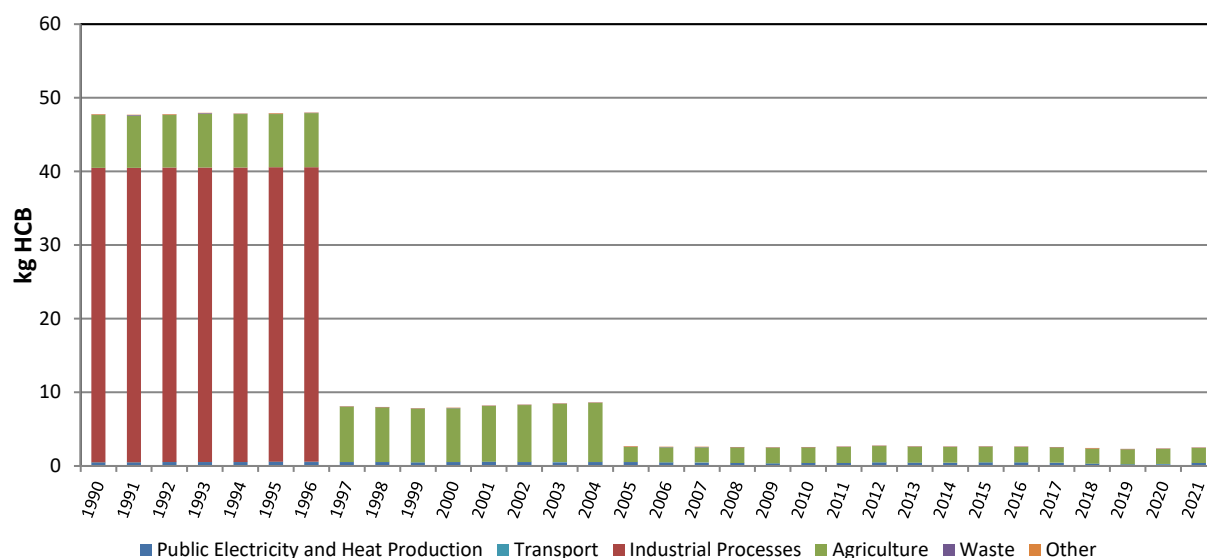


Figure 2.20 Emission Trend for Hexachlorobenzene 1990–2021

2.6.3 Polychlorinated Biphenyls (PCBs)

Estimated national total emissions of polychlorinated biphenyls have decreased by 83.3 per cent from 39.26 kg in 1990 to 6.57 kg in 2021. Emissions peaked in 2003 (67.59 kg) (Figure 2.21). Other Waste (5E) is the largest contributor to the trend in PCB emissions in Ireland accounting for 2.71 kg in 2021. In 2021, the emissions from the Waste sector as a whole were 3.48 kg (53.0 per cent of national total emissions), a decrease of 78.0 per cent compared to 1990 (15.79 kg). Emissions from the Waste sector peaked in 2003 (59.84 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 39.6 per cent of the national total in 2021 (2.60 kg), a 73.6 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 0.01 kg in 2021 and contributed 0.2 per cent of the total. 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 56.0 per cent between 1990 (1.06 kg) and 2021 (0.47 kg), with a contribution of 7.1 per cent to the national total in 2021.

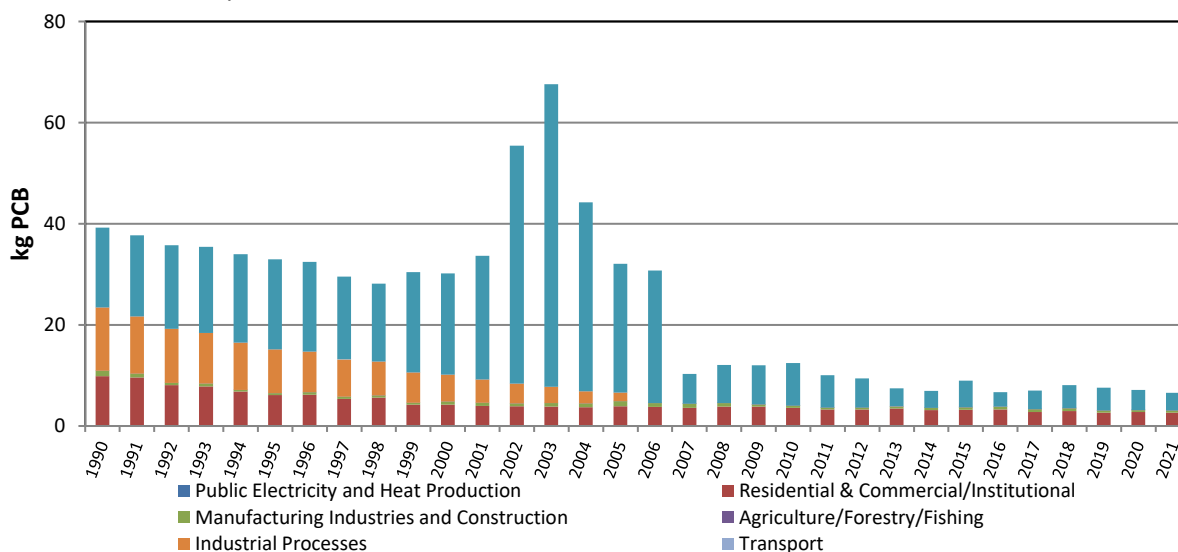


Figure 2.21 Emission Trend for Polychlorinated Biphenyls 1990–2021

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 59.8 per cent between 1990 (29.76 t) and 2021 (11.98 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 92.1 per cent of the national total in 2021, having decreased by 60.8 per cent from 28.13 t in 1990 to 11.03 t in 2021. 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 4.9 per cent of the total in 2021 (0.59 t), a decrease of 58.6 per cent since 1990 (1.42 t). Emissions from Transport (1A3) have increased by 137.0 per cent to 0.26 t representing a 2.2 per cent share of the national total in 2021 for all four PAHs as compared to 0.4 per cent 1990 (0.11 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 2021, a 21.1 per cent reduction since 1990.

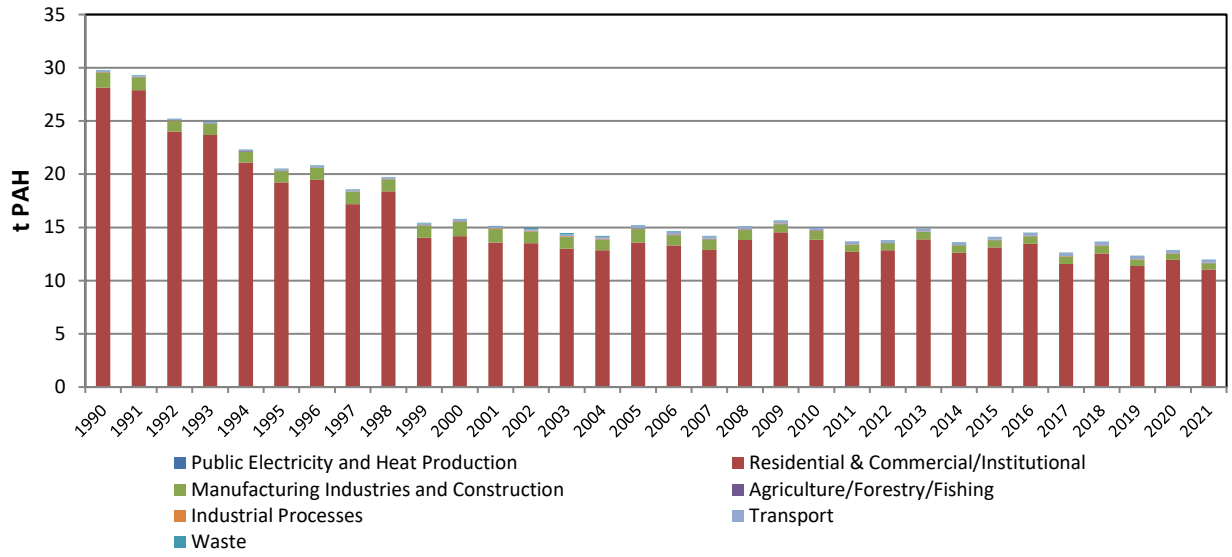


Figure 2.22 Emission Trend for Polycyclic Aromatic Hydrocarbons 1990–2021

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 1990–2021 underlies the time-series estimates of emissions for *Energy* in this submission. The 2021 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) of the Industrial Emissions Directive and the EU ETS and under environmental reporting related to their IPPC permits.

The emissions of SO₂ 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 and 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). Particulate Matter 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 SO₂ and NO_x in most countries. Approximately 71.5 per cent of electricity production in Ireland (SEAI, 2022) is dependent on fossil fuels and Category 1A1a therefore remains one of the major emission categories. Emissions of SO₂, NO_x, 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 increased 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 has declined as natural gas became the preferred fossil fuel during latter years. For example, in 2019 coal used for electricity generation fell by 69 percent year on year following a 44 per cent decrease in 2018 and a further 70 per cent in 2019. However, 2020 saw consumption increase by 32 per cent compared to 2019. In 2021, coal consumption increased again by 246 per cent compared to 2020. Incineration emissions from Ireland's waste-to-energy plants, however small, have been increasing since the first such installation came into operation in 2011 and a 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 SO₂ emissions by 97.0 per cent from 103.04 kt in 1990 to 3.06 kt in 2021. The sector's contribution to the overall SO₂ emissions in 2021 was 26.0 per cent as opposed to 56.1 per cent share in 1990. However, this is a 1.06 kt and increase from 2020 due to a tripling of coal and oil use in electricity generation as some gas fired plants were offline in 2021. Incineration of non-renewable waste in MSW accounted for 0.8 per cent of SO_x emissions from power generation in 2021.

At the same time, the changed fuel mix, together with the application of extensive NO_x emission control technology and more modern plants, has decreased NO_x emissions by 81.6 per cent from 46.37 kt (and 26.5 per cent share of total NO_x emissions) in 1990 to 8.53 kt (and 8.5 per cent share of the total) in 2021. In comparison to 2020, NO_x emissions increased by 52.6 per cent and SO₂ emissions increased by 53.0 per cent in 2021 due to the lower natural gas consumption as gas fired plants were offline and increased coal and oil use in response. The ESB has supplied estimates of SO₂ and NO_x on a plant-by-plant basis to the inventory agency for all years since 1990, mainly for the purpose of compiling SO₂ and NO_x 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). In this submission all

relevant plants have reported correctly to the inventory agency. Incineration of non-renewable waste in MSW accounted for 4.0 per cent of NO_x emissions from power generation in 2021.

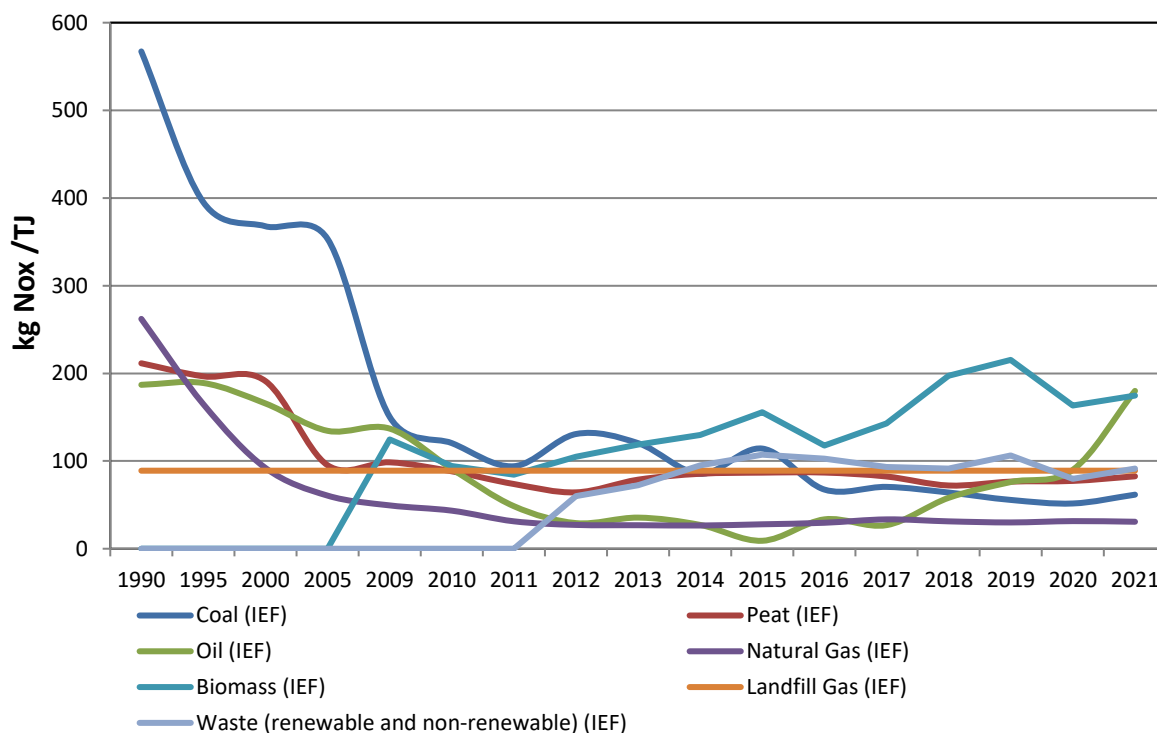


Figure 3.1 Nitrogen Oxide Implied Emission Factors for Category 1A1a

The weighted average emission factors of SO₂ and NO_x 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 SO₂ 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_x 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).

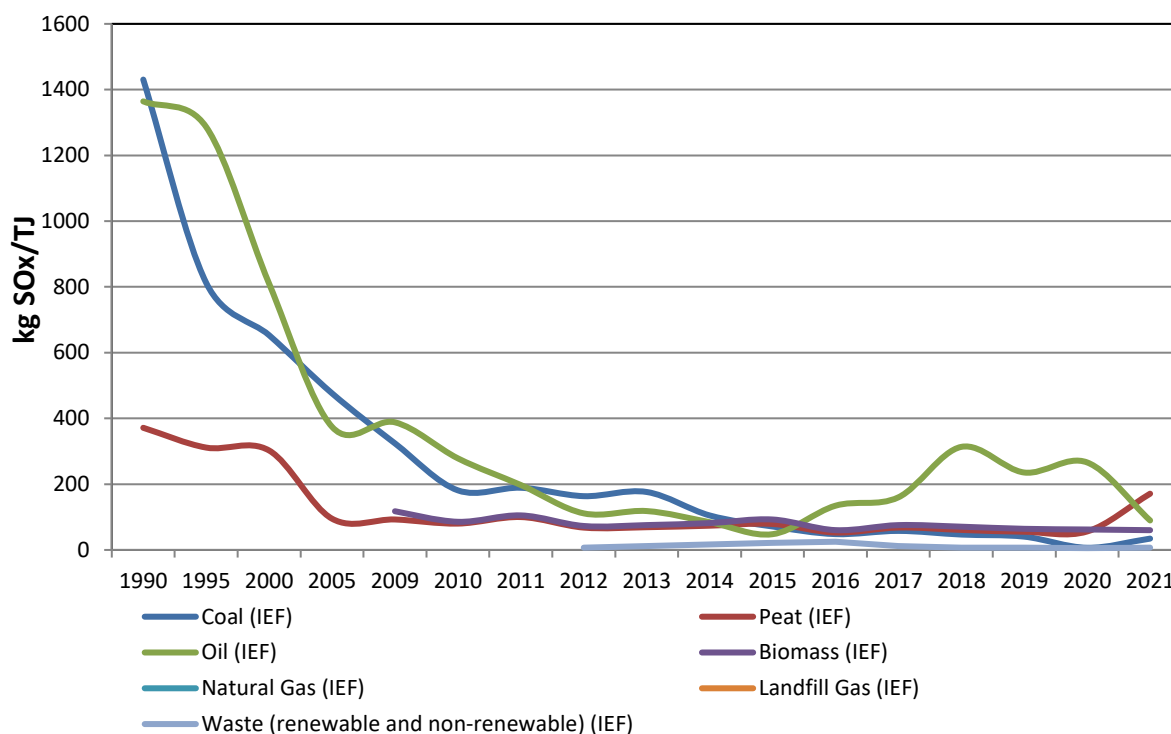


Figure 3.2 Sulphur Dioxide Implied Emission Factors for Category 1A1a

3.2.2 Emissions of Other Substances

The emissions of all substances other than SO₂ and NO_x 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, natural gas and landfill gas from table 3-4. 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 also 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 2021 (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 used 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 of which closed in 2019), one natural gas production platform (which ceased production in July 2020) 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 used 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 to 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. Knowledge of these installations indicates 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 relates to a small number of iron foundries. These iron foundries 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 Inventory Guidebook (EMEP/EEA, 2019). 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 of these 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 Inventory Guidebook (EMEP/EEA, 2019), provides 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. The same method is used for heavy metals in 1A2f. Emissions for individual cement plants were collected for all available years for Cadmium, Mercury and Lead and a plant specific g/t emission factor was determined using clinker production. This was then used to calculate emissions for years where plant emissions data was not available. For other metals As, Cr, Cu, Ni, Se, Zn the Tier 2 emission factors from Table 3-24 Chapter 1A2 of the Inventory guidebook (EMEP/EEA, 2019) were used with plant clinker production to estimate emissions. Residual fuel not used in the cement manufacture sector but used in other manufacturing industries in 1A2f is calculated and emissions from this fuel use are calculated using combustion emission factors appropriate to 1A2f. 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 within category 1A2g. The inventory agency tendered research to be undertaken to quantify the extent and amounts of fuel used by mobile combustion on construction sites following the conclusion of this research project did not obtain any data which is useable in estimating emissions from mobile machinery.

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 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 uses the emission factors from the Inventory Guidebook (EMEP/EEA, 2009) for liquid fuels. The Tier 1 EFs for liquid fuels in the latest version of the Inventory Guidebook are an average of Tier 2 EFs and are not considered representative considering one of the liquid fuel values for NO_x is 942g/GJ based on reciprocating engines which are not present in Ireland. The Tier 1 value of 100 g/GJ used by Ireland is still valid, as all the guidebook editions reference Chapter B216 of older editions of guidebook. 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’ Liquid Fuels” in page 16, 1.A.2 Manufacturing industries and construction (combustion), EMEP/EEA emission inventory guidebook 2009 (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. Emission factors were again mainly sourced from the small combustion chapter (1A4) for boilers, as these are the most appropriate for the boiler types used in Ireland. The average of Tier 2 EFs are not applicable as Ireland has no reciprocating engines or turbines.

When estimating emissions for 1A2gviii, the fuel used for 3 large plants for all years where data is available (2005-2021, EU ETS), was subtracted from the total fuel use and a Tier 2 EF (EMEP/EEA 2019, Chapter 1.A.4 Small Combustion, Table 3-48, 'wood') was used for NMVOC and all other pollutants. The residual amount of biomass fuel, after the fuel used for 3 large plants is removed, uses the Tier 1 EFs. The emission factors used are presented in Annex C, Table C.10.

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_x did not occur until 2007 when the economic situation caused an overall decrease in most emissions evident from 2008. In 2021 NO_x emissions from transport were 33.17 kt (33.8 per cent share of total) and a decrease of 51.4 per cent is evident since 1990 (68.25 kt and 39.0 per cent share).

Road transport in Ireland is a larger source of NO_x 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 the cessation of specific internal routes within Ireland.

The fuel consumption associated with 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, 2021), 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 approach was developed in 2019 and retrospectively applied from 2005 to 2021 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 2021.

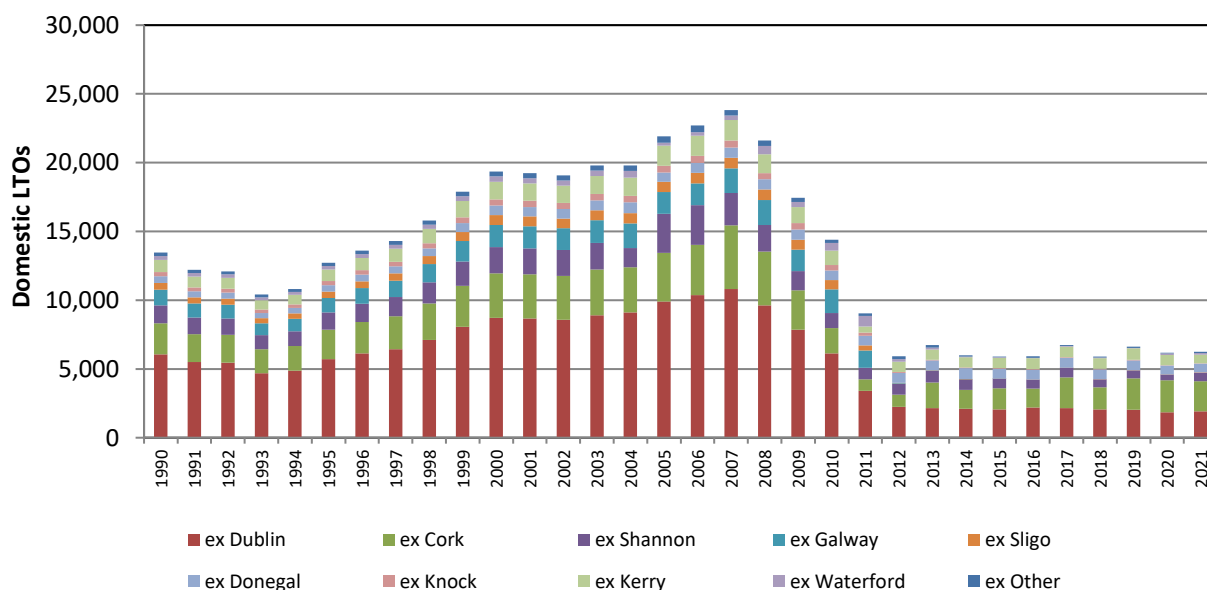


Figure 3.3 Number of Domestic LTOs from Irish airports 1990-2021

For data handling purposes, the inventory agency aggregated approximately 15 small regional airport/aerodrome pairs to “Other” which account for approximately 1.5 per cent of all domestic flights along with nine Irish airports which account for the remaining 98.5 per cent of all domestic flights in 2021. Emission factors associated with aviation emissions are presented in Annex C tables C.13 to C.18.

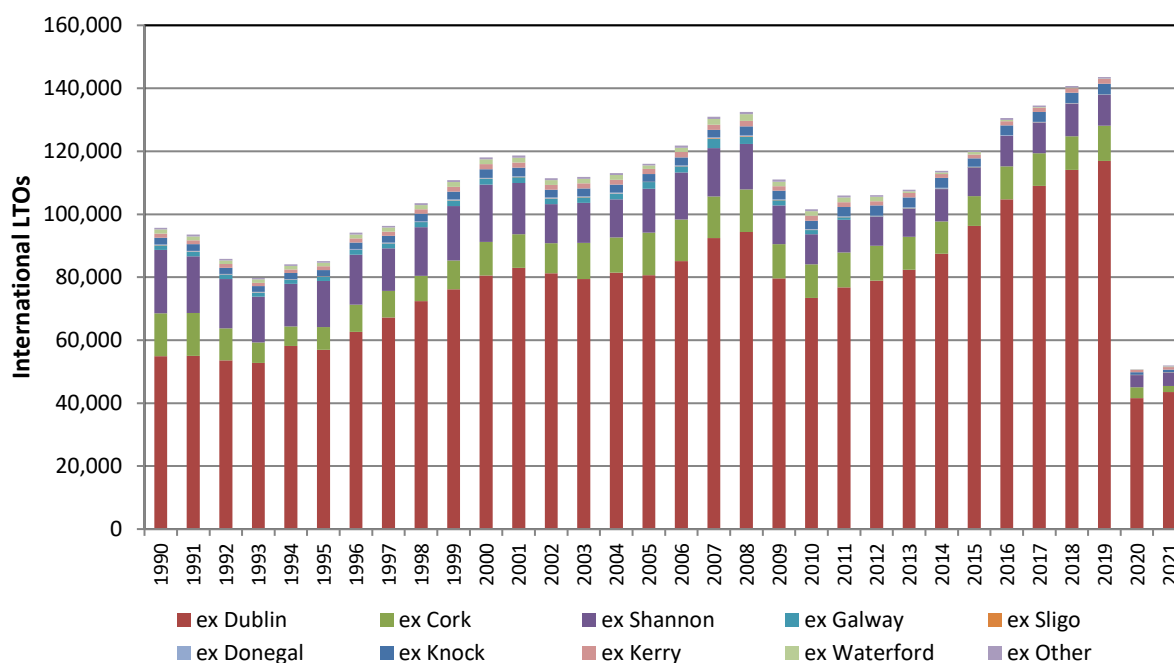


Figure 3.4 Number of International LTOs from Irish airports 1990-2021

3.6.2 Road Transport (NFR 1A3b)

The emissions of nine well-known pollutants (SO₂, NO_x, NMVOCs, NH₃, CO, TSP, PM₁₀, PM_{2.5}, 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 166.12 PJ in 2019, with a direct reduction immediately in 2020 to 138.94 PJ, mainly attributed to the COVID impact and travel restrictions. In 2021, consumption increased to 147.75 due to easing of COVID-related travel restrictions. The energy share in biofuel has continued to increase since its introduction in 2005 and increased to 7.47 PJ in 2021.

Separate estimates of emissions are produced based on fuel types and amounts used for fuel purchased in Ireland and then subsequently used outside of Ireland. While it is known that 7.3 per

cent of diesel sold in Ireland in 2021 was consumed outside the country, there is no value available for petrol sales of this nature and therefore a value of 0% was used. 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 1990–2021.

The emissions of SO₂ 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 272 vehicle categories are determined by these variables in COPERT 5. Annex C shows the trend in emission factors for NO_x, SO₂, NH₃ and NMVOCs, CO and Particulate Matter per vehicle type for road transportation over the period 1990–2021 determined by the COPERT variables for the vehicle fleet in Ireland. For PM_{2.5}, PM₁₀ and TSP, non-exhaust emission that includes brake and tyre wear emissions and road abrasion emissions for PM_{2.5}, PM₁₀ and TSP are also presented as estimated using the COPERT model.

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 (urban, rural and highway), total fuel amounts and the fuel specifications. The numbers of vehicles are taken from annual bulletins of vehicle and driver statistics (e.g. DTTAS, 2021) and these are allocated to the different control technologies (PRE ECE; ECE 15/00-01; ECE 15/02; ECE 15/03; ECE 15/04; Euro 1; Euro 2; Euro 3; Euro 4; Euro 5; Euro 6 a/b/c & Euro 6 d-temp) 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 the Commercial Vehicle Roadworthiness Test (CVRT) Service. However, in 2021, NCT mileage data for passenger cars was unavailable to a large extent due to the continuation of COVID-related lockdown periods and as a result the following methodology was applied for 2021:

Step 1

- Balanced mileage brought across from last year's file for 1990-2020.
- Petrol vehicles were all increased by 5.9 per cent initially i.e. overall gasoline increase from 2020
- Diesel vehicles were increased by 6.7 per cent i.e. overall gas oil increase compared to 2020

Step 2

- COPERT model ran unbalanced
- The differences in petrol were spread across all petrol vehicles i.e. the adjusted mileage was multiplied by the excess / deficit in fuel

- The diesel car mean mileages were adjusted to reflect a similar reduction in petrol cars

Step 3

- Repeat step 2 above with excess diesel spread across LCV and HGV
- Once the statistical fuel input is within approx. 1.0 per cent of the fuel output (energy consumption), the model can be run balanced

COPERT 5.6.1. was then run in “energy balance” mode and in turn the small difference between the statistical quantities input and the energy consumption values was balanced.

The above methodology is not expected to be applied in future years. This bespoke approach was taken in the absence of reliable mileage as a result of COVID-related lockdowns preventing NCT and CVRT testing to be completed. The expected approach in future years will be to input odometer readings per vehicle type. The emissions are then 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

Liquid fuel consumption increased until it peaked in 2007 after which it declined until 2012 with a subsequent return to growth in emissions thereafter until 2016. The aforementioned trends appear to follow Ireland’s economic growth patterns whereas the 4 years 2016-2019, we have seen emissions relatively stable despite increases in vehicle population. This is a result of improved vehicle technologies and increased biofuel penetration. In 2021 there was an increase in emissions of air pollutants due to the easing of restrictions on passenger car journeys in 2020 in response to the COVID-19 pandemic.

In terms of input parameters to calculating air pollutant emissions, the three most influential parameters include fleet, fuel inputs and allocation of mileage per technology type. Overall fleet population has increased by 174.0 per cent from 1990-2021 (Diesel passenger cars have exponentially jumped by 1628.1 per cent in the same period). The energy content (TJ) for all combustion fuels has more than doubled from 1990-2021. Biofuel was incorporated into the mix of available fuel types in 2005 as a measure to reduce road transport emissions and has increased from 45.98 TJ in 2005 to 7,467 TJ in 2021. In addition, overall mileage has more than doubled from 21.9 billion in 1990 to 49.4 billion in 2021.

NOx emissions rose from 56.6 kt in 1990 to a peak in 2000 of 66.1 kt as a result of increasing diesel cars and overall fleet population. These emissions remained relatively stable until 2007 but thereafter, we have witnessed a persistent decline from 62.2 kt in 2007 to 26.6kt in 2020. The introduction of improved technologies and the rollover of newer euro classes was a major contributing factor. We have seen a further decline in 2021, with NOx emissions at an all-time low at 25.3 kt. Despite an increase in activity in HDVs, NOx emissions from HDVs have decreased in 2015-2021 and 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.

There was an increase in emissions of PM_{2.5} and PM₁₀ between 2006 and 2013 which can be explained by a combination of an increase in diesel passenger cars during this period, 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 and 5 technology in the fleet. A similar trend is evident from the PM_{2.5} & PM₁₀ data where we see a steady increase from 1990-2000, relatively stable until 2007 and a downward trend thereafter where once again 2021 is the low point throughout the timeseries.

SO₂ has seen dramatic reductions from a high in 1990 of 5.5 kt to 0.14 in 2008 as a result of reduced sulphur content within the fuels. From 2009-2020, there was a further decline albeit relatively small in comparison to previous years i.e., 0.055 kt in 2009 to 0.034 in 2020. SO₂ emissions increased to 0.041 in 2021 due to an increase in diesel use as pandemic-related road travel restrictions lessened across the country. NMVOC emissions have fallen steadily from 31.1 kt in 1990 to 3.5 in 2021. CO emissions have decreased from 232.6 kt in 1990 to 16.6 kt in 2021.

NH₃ emissions on the other hand have increased from 0.04 kt in 1990 to 0.46 kt in 2021, which is over a 10-fold increase. NH₃ emissions come mostly from hot emissions and as a result are dependent on the mileage of each vehicle category. NH₃ emissions did rise steadily from 1990 up to 2008 which coincides with increased mileage. NH₃ emissions have been declining in recent years as a result of improved technologies and the removal of older vehicles from the national car fleet. Fluctuations in NH₃ emissions for Heavy Duty Vehicle (HDV) is due to an increase in mileage by stock from 1996-2000 of 20 per cent on average over these four years. This level of activity was maintained at this level from 2001-2007 after which there was a decrease from 2008-2012 of 12 per cent on average for these four years due to the economic recession in Ireland. As a result, emissions fluctuated with the increasing and decreasing HDV activity. A recovery can be seen in 2013, 2014, 2015 and 2016 where there was an increase in HDV mileage x stock (5 per cent, 2 per cent, 8 per cent and 13 per cent respectively).

3.6.3 Railways (NFR 1A3c)

The emissions under sub-category 1A3c Railways are calculated from the amounts of fuel used by these activities and the country specific SO_x emission factors and default Inventory Guidebook (EMEP/EEA, 2019) emission factors for gasoil for all other pollutants. No solid fuels have been used in railways since 1970. All emission factors for railways are given in Table C.20 of Annex C.

3.6.4 National Navigation (NFR 1A3dii)

The emissions NO_x and PM are estimated using a Tier 2 approach and emission factors from Table 3-4 of the Inventory Guidebook (EMEP/EEA, 2019). All other pollutants are estimated using default emission factors from Table 3-1 for bunker Fuel Oil and Table 3-2 for Marine Diesel of the Inventory Guidebook (EMEP/EEA, 2019). All emission factors for national navigation are given in Table C.20 of Annex C.

3.6.5 Other Transportation (NFR 1A3e)

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_x 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 all gasoline fuel is fully accounted. Sector Residential (1A4b) uses Tier 2 emission factors from the Inventory guidebook (EMEP/EEA, 2019) for all fuels. The Tier 2 methodology uses an assumption for solid fuel fireplace and stove use. The split of stove/fireplace usage is based EPA and CSO data when available and on expert opinion. These splits and the updated Tier 2 emission factors for 1A4b are referenced in Tables C.24 and C.25 of Annex C. The emission factors for sub-category 1A4 Other Sectors are given in Tables C.22 through C.28 of Annex C.

3.7.1 Commercial / Institutional (NFR 1A4a) and Residential (1A4b)

Combustion in the residential sector is one of the principal sources of emissions, contributing 58.2 per cent of SO₂ emissions, 65.2 per cent of CO emissions, and 51.9 per cent of PM_{2.5} of emissions in Ireland in 2021. This sector also contributed 21.2 per cent and 20.7 per cent of Ireland's Pb and Hg 2021 emissions. This sector is also one of the principal sources of emissions of Dioxins and PAHs contributing 71.4 per cent and 89.9 per cent respectively in 2021. Coal burning in the residential sector is also an important but declining source of NMVOC emissions as coal consumption decreases, accounting for 8.5 per cent of national emissions in 2021. Significant fuel switching has been seen in the residential sector, with a continuous reduction in the use of coal (down 70.4 per cent) and peat (down 75.2 per cent) since 1990. Increased use of liquid fuels gasoil and kerosene (304.9 per cent), natural gas (407.4 per cent), and renewables (91.0 per cent) in this sector has resulted in significant decreases in emissions since 1990. Between 1990 and 2021, decreases have been seen in SO₂ emissions (81.6 per cent), NMVOC emissions (71.6 per cent), CO (72.2 per cent), PM_{2.5} (68.1 per cent), Pb (73.1 per cent), Hg (61.7 per cent), Dioxins (60.9 per cent) and PAHs (60.8 per cent) in the Commercial/Institutional and Residential sectors.

3.7.2 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_x, NMVOC, CO, PM₁₀, PM_{2.5} 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_x emission factors and default Inventory Guidebook (EMEP/EEA, 2019) emission factors for NH₃ 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). For category 1A4ci Agriculture/Forestry/Fishing: Stationary, the NO_x 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.

3.7.3 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 2021. The emission factors used for this sub-category are country specific (SO_x) 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 the 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, PM₁₀ and PM_{2.5} emissions are based on the Inventory Guidebook (EMEP/EEA, 2019) default values and are presented in Table 3.1.

Emissions of PM_{2.5}, PM₁₀ and TSP from the handling and storage of coal other than 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 the Inventory Guidebook (EMEP/EEA, 2019).

Table 3.1. Fugitive Emissions from Coal mining and handling

Activity Data		1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Coal mining	kt	25.00	1.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	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	31.20	31.20
Coal handling	kt	1,867	2,248	2,145	2,130	1,305	1,373	1,745	1,459	1,414	1,693	1,658	1,304	736	222	293	293
Emission Factors																	
	kg																
Coal mining	NM VOC/t	0.80	0.80	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Coal mining	kg TSP/t	0.09	0.09	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Coal mining	kg PM ₁₀ /t	0.04	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Coal mining	kg PM _{2.5} /t	0.01	0.01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Coal storage	t PM _{2.5} /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	0.41	0.41
Coal storage	t PM ₁₀ /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	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	10.25	10.25
Coal handling	g PM _{2.5} /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	0.30	0.30
Coal handling	g PM ₁₀ /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	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	7.50	7.50
Emissions																	
Coal mining	kt NM VOC	0.020	0.001	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Coal mining	kt TSP	0.002	0.000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Coal mining	kt PM ₁₀	0.001	0.000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Coal mining	kt PM _{2.5}	0.000	0.000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Coal storage	kt PM _{2.5}	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	0.013	0.013
Coal storage	kt PM ₁₀	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	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	0.320	0.320
Coal handling	kt PM _{2.5}	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Coal handling	kt PM ₁₀	0.006	0.007	0.006	0.006	0.004	0.004	0.005	0.004	0.004	0.005	0.005	0.004	0.002	0.001	0.001	0.001
Coal handling	kt TSP	0.014	0.017	0.016	0.016	0.010	0.010	0.013	0.011	0.011	0.013	0.012	0.010	0.006	0.002	0.002	0.002

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 2007-2021 from Ireland's only refinery. An implied emission factor of 0.8818 kg/t is 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, 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 2018-2020 emissions have decreased in line with a decrease in crude oil throughput with a slight increase seen in 2021.

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 Wastewater 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.

3.10.2 Natural Gas (NFR 1B2b)

Fugitive losses of NMVOC from pipelines and distribution systems were estimated for the first time in the 2021 submission. The methodology is continued for this the 2023 submission. These emissions are based on activity data of fugitive methane releases and gas analysis reports which give gas composition supplied by Gas Networks Ireland (GNI) in the greenhouse gas emission inventory. The description of this methodology is in section 3.3.2.2.3 of Irelands NIR (EPA 2023). Ireland has used existing information about leakage from greenhouse gas fugitive emission reporting to the UNFCCC to estimate NMVOC emissions under this source category.

Table 3.2. Fugitive Non-Methane Volatile Organic Compound Emissions

Activity Data		1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Crude to refineries	kt	1,804	2,229	3,278	3,309	2,905	3,068	2,838	2,752	3,366	3,200	3,181	3,024	2,531	2,838	3,025
Petrol distribution	kt	885	1,037	1,493	1,711	1,387	1,195	1,124	1,064	1,009	942	849	774	733	543	575
Emission Factors																
Crude to refineries	kg NMVOC/t	0.88	0.88	0.88	0.88	0.92	0.81	0.86	0.95	0.83	0.85	0.85	0.90	0.89	0.79	0.77
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	0.001
Emissions																
Crude to refineries	kt NMVOC	1.59	1.96	2.89	2.92	2.66	2.48	2.45	2.62	2.80	2.73	2.72	2.73	2.25	2.25	2.32
Petrol distribution	kt NMVOC	1.79	2.10	3.30	3.81	3.15	2.60	2.22	2.12	1.95	1.75	1.77	1.37	1.30	1.00	0.83
Total emissions	kt NMVOC	3.37	4.06	6.18	6.72	5.80	5.08	4.67	4.74	4.75	4.49	4.49	4.10	3.56	3.25	3.15

3.10.3 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. Ireland carried out a review of emission factors and updated all air pollutant, heavy metals and POPs to the most recent version of Inventory guidebook (EMEP/EEA, 2019) where appropriate.

1A1a Public Electricity and Heat Production

There were minor recalculations in this sector for years 2011-2020 due to updated values for the fuel categories landfill gas, non-renewables (waste), biomass and renewable waste. Additionally, there were small recalculations of -0.69 per cent and -0.39 per cent in natural gas quantities for the sector in 2019 and 2020, respectively. As a result, NO_x NMVOC, CO, TSP, PM2.5, PM10, and BC all experienced recalculations during this period of up to 0.04%.

1A2 Manufacturing Industry and Construction sector

In this submission, there are slight recalculation changes across all 1A2 'Manufacturing Industry and Construction' subsectors based on revisions to the historical energy balances going back as far as 1990. This is because the national energy balance provided by SEAI now incorporates a major data set on business energy use. This Business Energy Use Survey (BEUS), was first published by the Central Statistics Office (CSO) in December 2018. This valuable new data source provides a new basis for the breakdown of energy use in the commercial services, public services and industrial sectors, at a level of detail not previously available. SEAI have revised the National Energy Balances from 1990 to 2020 incorporating this new improved data. In some cases, the revisions to estimates of business energy use have had knock on effects in other sectors, particularly the residential sector, leading to revisions there also.

The national energy balance was previously based on a top-down approach whereas the new Business Energy use survey compiles aggregated data based on a bottom-up approach with individual businesses grossed to national level. The revised bottom-up approach now draws on a cross-sourcing of data using the emissions trading scheme, and various energy efficiency measures such as the large industry energy network, public sector energy programme, census of industrial production and others. The revised approach (BEUS) has focused on data from 2009 to 2018 with energy data for 2019, 2020, and 2021 based on the 2018 breakdowns between sectors. As a result, there was a reallocation of oil out of 1A2 and into 1A4 'Other Sectors' with an average of reduction of 987 TJ per annum across the entire timeseries. From 2001 to 2020, there was a significant quantity of natural gas reallocated from 1A4a 'Commercial & Public Services' into 1A2 'Industry', resulting in an average increase of 1,843 TJ per annum across this time period. These changes affected all air.

1A2b Non-ferrous Metals

The Non-ferrous metals subsector experienced increases in various air pollutants from 2009 to 2013 due to the reallocation of coal into the sector from 1A2g 'Other' during these years, with the largest

average annual increases occurring in dioxin (19.80 per cent), Zn (6.67 per cent), Se (4.85 per cent), B(a)p (4.15 per cent), CO (3.36 per cent), Hg (3.15 per cent), B(k)f (2.56 per cent), Pb (2.36 per cent), I(123-cd)P (2.36 per cent), and NO_x (2.13 per cent) emissions during this period.

1A2c Chemicals

The Chemicals subsector experienced increases in various air pollutants from 2009 to 2013 due to the reallocation of coal into the sector from 1A2g 'Other' during these years, with the largest average annual increases occurring in dioxin (55.21 per cent), SO₂ (13.89 per cent), Zn (12.58 per cent), Pb (7.41 per cent), B(a)p (6.55 per cent), Cd (4.33 per cent), PM_{2.5} (4.08 per cent), PM₁₀ (3.56 per cent), TSP (3.04 per cent), CO (2.34 per cent), Se (2.03 per cent) and Cu (2.02 per cent), emissions during this period.

1A2d Pulp, Paper, and Print

The 1A2d 'Pulp, Paper, and Print' subsector experienced large recalculations from 2009 to 2020 due to changes in the quantities of natural gas, oil, and coal within the sector. From 2009 to 2018, an average of 0.43ktoe of oil, 4.43ktoe of natural gas, and 0.1 ktoe of coal was added to the sector per annum. This caused annual average recalculations of 95.54 per cent in NO_x, 46.76 per cent in SO_x, 127.66 per cent in NMVOC, 146.86 per cent in CO, 50.51 per cent in TSP, 66.03 per cent in PM_{2.5}, 57.66 per cent in PM₁₀, 20.59 per cent in BC, 67.88 per cent in Pb, 53.46 per cent in Cd, 167.73 per cent in Hg, 60.91 per cent in As, 21.71 per cent in Cr, 30.19 per cent in Cu, 15.01 per cent in Ni, 133.90 per cent in Se, 167.58 per cent in Zn, and 562.60 per cent in dioxin, 153.3 per cent in B(a)p, 72.06 per cent in B(b)f, 123.62 per cent in B(k)f, 120.48 per cent in I(123-cd)P in the period 2009 to 2018.

In 2019 and 2020, an average of -0.34 and -0.22 ktoe of oil and natural gas were reallocated for the two years, causing downwards recalculations of -9.00 per cent in NO_x, -57.29 per cent in SO_x, -3.94 per cent in NMVOC, -9.14 per cent in CO, -48.74 per cent in TSP, -43.08 per cent in PM_{2.5}, -46.19 per cent in PM₁₀, -59.08 per cent in BC in air pollutants, -60.47 per cent in Pb, -59.27 per cent in Cd, -2.39 per cent in Hg, -32.64 per cent in As, -60.29 per cent in Cr, -60.64 per cent in Cu, -60.81 per cent in Ni, -10.81 per cent in Se, -30.00 per cent in Zn, -13.06 per cent in dioxin, -14.75 per cent in B(a)p, -23.01 per cent in B(b)f, -9.96 per cent in B(k)f, and -9.19 per cent in I(123-cd)P.

1A2f Non-Metallic Minerals

There were significant recalculations in the 1A2f 'Non-metallic minerals' subsector due to a correction to activity data for cement production for 2013-2020. Other process carbonate by-products were removed, and clinker only was included as activity data. As a plant specific g/t emission factor was determined using clinker production which was then used to calculate emissions for years where plant emissions data was not available, the updated AD impacted on the entire timeseries 1990-2020 and not just those years where AD changed. The corrected AD to include only cement clinker caused an average annual recalculation in emissions of -0.47 per cent in dioxin, -9.93 per cent in PCB, -1.45 per cent in B(a)p, -4.92 per cent in B(b)f, -1.41 per cent in B(k)f, -1.19 per cent in I(123-cd)P, -11.69 per cent in HCB in POPs, -0.64 per cent in Pb, 7.14 per cent in Cd, 33.06 per cent in Hg, -11.38 per cent in As, -11.33 per cent in Cr, -11.33 per cent in Cu, -11.22 per cent in Ni, -11.44 per cent in Se, -11.13 per cent in Zn in heavy metals, and -0.20 per cent in NO_x, -0.52 per cent in SO_x, 0.30 per cent in NMVOC, -0.07 per cent in CO, -0.69 per cent in TSP, -0.49 per cent in PM_{2.5}, -0.59 per cent in PM₁₀, -1.41 per cent in BC in air pollutants across the 1990-2020 time series.

In this submission there was also a correction to fuel data for the years 2010 and 2011 in the subsector due to the omission of residual fuel data in the calculations for POPs emissions in the previous submission, with the recalculation causing an increase in emissions of dioxin 636.3 per cent, 604.7 per cent in B(a)p, 326.6 per cent in B(k)f, 290.9 per cent in I(123-cd)P, 108.5 per cent in B(b)f, and 33.6 per cent in PCB for this period.

1A2g Other

The 1A2g 'Other' subsection experienced recalculations from 2009 to 2013 and 2015 due to the reallocation of coal during these years, contributing to average annual emission reductions of -9.66 per cent in SO_x, -1.11 per cent in CO, -0.84 per cent in TSP, -2.35 per cent in PM_{2.5}, -2.65 per cent in PM₁₀, -2.97 per cent in BC, -5.08 per cent in Pb, -0.25 per cent in Cd, -6.56 per cent in As, -2.75 per cent in Cr, -4.97 per cent in Cu, -7.88 per cent in Ni, -1.58 per cent in Se, -0.41 per cent in Zn, 5.80 per cent in dioxin, -36.13 per cent in PCB, -6.36 per cent in B(a)p, -4.33 per cent in B(b)f, -2.14 per cent in B(k)f, and -1.0 per cent in I(123-cd)P. NO_x, NMVOC, and Hg emissions experienced increases in emissions of 3.0 per cent, 3.04 per cent, and 2.54 per cent respectively during the same period.

1A3b Road Transport

The 2023 submission consists of a number of changes/improvements to the disaggregated input data and also software input updates:

- Average trip lengths and durations for road transport journeys were separated on a vehicle category basis for the first time. Passenger cars, light commercial vehicles, and L-category vehicles maintained average trip lengths and durations of 14.5 km and 0.3 hours, while Heavy Duty Trucks and Buses received an updated average trip length of 44 km and duration of 0.9 hours.
- Sulphur content values (ppm) were updated for Petrol Grade 1 & 2 (3.4 to 3.2) and Diesel Grade 1 (6.1 to 6.9) from 2020 to 2021.
- Electricity was included in total fuel sales to capture the outputs related to the new inclusion of battery electric vehicles (BEV).
- Battery Electric Cars were included for the first time, retrospectively incorporating vehicle numbers from 2010 onwards. This was the first year that COPERT could accommodate BEVs in the fleet mix
- Euro 6d included for the first time as 2021 registered cars fall under this euro class category
- Revision of non-exhaust PM emissions e.g. Introduction of BEVs and impact of vehicle weight; Impact of regenerative braking; New Non-Exhaust emission factors; Measurements on WLTP brake cycle and revision of brake wear emission factors for PCs and LCVs; Higher brake wear emissions in ICE cars in 5.6.1 Vs 5.5.1 due to WLTP brake cycle tests
- There was also a number of bug corrections to the latest software version 5.6.1 i.e. PM and SPN23 hot emission factors of HDVs and buses; Cold PM and SPN23 emissions of Euro 6 PCs and LCVs; Brake and tyre non-exhaust heavy metal emissions; Hot emission factors for LCVs N1-1

As a result of the above changes, there are numerous recalculations at a disaggregated level for air pollutant emissions within this submission using COPERT 5.6.1 compared to the previous submission.

- NO_x, CO & NH₃ increase in emissions for most recent years (2016-2020). This is the result of a revision to cold start methodology only for Euro 6 and revision of degradation methodology based on recent / the most up to date data.
- CO: There was between 2-4% increase in recent years from 2017 to 2020 as a result of correcting PM emission factors and debugging fixes within the software
- SO₂: Approximate 2% increase annually across the time series due to an increase in the sulphur content values (diesel increased from 6.1 ppm to 6.9 ppm in this submission).
- NMVOC: Large increases encountered from 2017-2020 with the introduction of cold emissions of VOC for Euro V and VI diesel HDVs and buses. Emission factors were also updated for Euro 6 LPG passenger cars. The updates to trip lengths would also have had an impact across the timeseries, with more breakdown available within this submission for each of the vehicle categories.
- PM_{2.5} & PM₁₀: The significant changes in recent years is predominantly a result of correcting PM emissions factors (mainly non-exhaust emission) following measurements on WLTP brake cycle and revision of brake wear emission factors for PCs and LCVs. The introduction of fully electric cars within the model this year has also been factored in, with effects as a result of the impact of vehicle weight & regenerative braking. There is also higher brake wear emissions in ICE cars in 5.6.1 Vs 5.5.1 due to WLTP brake cycle tests carried out by Emisia.
- TSP: The increasing trend in TSP from 2006-2020 is a result of correcting the ratios of TSP of brake and tyre non-exhaust heavy metal emissions
- BC: Changes encountered here are also the result of correcting PM emission factors and debugging fixes with the software.

Heavy Metals emissions have generally increased year-on-year over the entire time series. The latest COPERT version 5.6.1 has included several software debugging fixes along with corrections to PM emission factors. As a result, Cd, As, Cr, Cu, Ni, Se and Zn have more than doubled each year. The significant increase in Pb from 2005 onwards is following the update and reduction of PM emission factors from that year for passenger cars, whereas there were increases in PM emission factors for tyre and brake wear from 2005 onwards.

1A3dii National navigation

A revised approach was implemented in this submission for NO_x, PM_{2.5}, PM₁₀ and TSP using a Tier 2 approach and emission factors from Table 3-4 of the Inventory Guidebook (EMEP/EEA, 2019) for the first time in last year's 2022 submission. There was a 5% recalculated increase in NO_x emissions for the year 2020 as a result of an update and an increase to the diesel quantities in the energy balance used for the 2023 submission. Emissions of NO_x are now on average 9.4 per cent lower across the timeseries 1990-2020 with emissions in recent years, 2006 onwards, on average 20.9 per cent lower.

Emissions of PM_{2.5} are on average 33.2 per cent lower across the timeseries 1990-2020 with emissions in recent years, 2006 onwards, on average 7.4 per cent lower. The level of recalculation was dependent on the proportion of HFO and marine diesel used in the sector.

1A4a Commercial/Institutional

In this submission, there are recalculation changes for 1990-2020 based on revisions to the historical energy balances going back as far as 1990. This is because the national energy balance provided by SEAI now incorporates a major new data set on business energy use. This Business Energy Use Survey (BEUS), was first published by the Central Statistics Office (CSO) in December 2018. This valuable new

data source provides a new basis for the breakdown of energy use in the commercial services, public services and industrial sectors, however the survey has a time lag of 2 years and so updates to commercial and residential splits occur when a new survey is received.

These revisions included the reallocation of 286 TJ of oil per annum from 1990 to 1994. Additionally, from 2009 to 2020 there were recalculations in the quantities of coal for the sector with an average change of 0.59 ktoe per annum and the most significant years being 2010 and 2011 with increases of 2.95 and 3.40 ktoe, respectively. This resulted in large recalculations in emissions in 2010 and 2011 for the sector with the most significant increases across the two years being in PCB (1163.13 per cent), Hg (21.2 per cent), dioxin (13.43 per cent), 3.63 per cent in B(a)p, and Zn (3.10 per cent).

1A4b Residential

In this submission, there are recalculation changes for 1990-2020 based on revisions to the historical energy balances. These historical revisions included significant quantities of oil being reallocated from 1A2 'Industry' and 1A4a 'Commercial/Institutional' into 1A4b 'Residential' with an average increase of 1,941TJ per annum for the sector across the time series. This effected all emission types including average annual changes of 2.22 per cent in NO_x, 0.69 per cent in SO_x, -0.04 per cent in CO, -0.01 per cent in TSP, -0.01 per cent in PM_{2.5}, -0.01 per cent in PM₁₀, -0.05 per cent in Pb, -0.02 per cent in Cd, 0.23 per cent in Hg, 0.12 per cent in Cr, -0.05 per cent in Se, 0.07 per cent in Zn, -0.02 per cent in dioxin, -0.05 per cent in PCBs, -0.04 per cent in B(a)p, -0.05 per cent in B(b)f, -0.04 per cent in B(k)f, and -0.03 per cent in I(123-cd)P across the timeseries.

Additionally, there are recalculations in emissions associated with the reallocation of coal out of 1A4b 'Residential' and into 1A4a 'Commercial/Institutional' in 2010 and 2011 (123 and 143 TJ respectively) resulting in an average recalculation of 2.44 per cent in NO_x, 0.40 per cent in SO_x, -0.63 per cent in CO, -0.57 per cent in TSP, -0.57 per cent in PM_{2.5}, -0.57 per cent in PM₁₀, -0.67 per cent in Pb, -0.33 per cent in Cd, -0.22 per cent in Hg, -0.34 per cent in Cr, -0.66 per cent in Se, -0.56 per cent in Zn, -0.60 per cent in dioxin, -0.66 per cent in PCB, -0.64 per cent in B(a)p, -0.65 per cent in B(b)f, -0.64 per cent in B(k)f, and 0.62 per cent in I(123-cd)P emissions for these years.

1A4c Agriculture/Forestry/Fishing

There were recalculations in 2019 & 2020 for this subsector due to minor changes in oil quantities for these years

1B2a Fugitive emissions from oil refining

For fugitive emissions from oil refining there was a recalculation for the 1B2av category. In 2021 updated information on the level of Stage II abatement in place in Ireland was received. Abatement was estimated at 35 per cent from 2017 to 2020. However it was noted that for 2017-2020 the incorrect % figure was applied to the percentage of stations without Stage II abatement. It was incorrectly 60 per cent, 55 per cent, 50 per cent 50 per cent for 2017-2020 instead of 65 per cent for each year. This has now been corrected. Stage II abatement remains at 35 per cent for 2021.

1B2b Fugitive emissions from Natural gas

For fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other) (NFR 1B2b), a review of the reporting under this category was undertaken 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 has used existing information about leakage from greenhouse gas emissions from fugitive sources as reported to the UNFCCC to estimate NMVOC emissions. Fugitive losses of NMVOC from pipelines and distribution systems are estimated in this submission.

Overall recalculations are presented in Tables 3.3-3.7 below

Table 3.3. Recalculations in Energy NFR 1A1

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
Submission 2022																		
1A1a Public Electricity and Heat Production	NO _x	kt	46.37	41.39	39.72	32.38	11.92	8.37	10.53	9.09	7.81	9.82	8.31	8.12	6.74	5.99	5.59	
	SO ₂	kt	103.04	91.63	79.87	42.50	9.78	9.73	9.84	8.95	6.20	5.51	3.96	3.98	2.84	2.24	2.00	
	NMVOC	kt	0.19	0.25	0.36	0.37	0.37	0.31	0.30	0.27	0.26	0.26	0.30	0.30	0.29	0.29	0.29	
	Pb	t	0.82	0.93	0.93	0.89	0.61	0.61	0.75	0.67	0.70	0.75	0.76	0.67	0.56	0.44	0.34	
	Cd	t	0.11	0.13	0.14	0.13	0.08	0.07	0.09	0.08	0.08	0.09	0.09	0.08	0.06	0.05	0.04	
	Hg	t	0.15	0.17	0.16	0.16	0.13	0.12	0.15	0.13	0.13	0.15	0.15	0.14	0.10	0.08	0.06	
1A1b Petroleum Refining	NO _x	kt	0.47	0.52	0.77	0.94	0.80	0.63	0.68	0.58	0.54	0.38	0.32	0.26	0.33	0.29	0.29	
	SO ₂	kt	0.48	0.51	0.78	0.91	0.67	0.90	0.43	0.57	0.01	0.03	0.02	0.03	0.03	0.03	0.04	
	NMVOC	kt	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	
	Pb	t	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	
	Cd	t	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	0.01	0.01	
	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 _x	kt	0.16	0.12	0.15	0.29	0.32	0.21	0.18	0.22	0.22	0.24	0.32	0.11	0.53	0.21	0.18	
	SO ₂	kt	0.13	0.10	0.12	0.16	0.21	0.25	0.24	0.19	0.03	0.09	0.25	0.11	0.37	0.13	0.14	
	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	0.00	
	Pb	t	0.02	0.02	0.02	0.03	0.03	0.02	0.03	0.03	0.02	0.02	0.02	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	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.02	0.02	
	Submission 2023																	
	1A1a Public Electricity and Heat Production	NO _x	kt	46.37	41.39	39.72	32.38	11.92	8.37	10.53	9.09	7.81	9.82	8.31	8.12	6.74	5.99	5.59
		SO ₂	kt	103.04	91.63	79.87	42.50	9.78	9.73	9.84	8.95	6.20	5.51	3.96	3.98	2.84	2.24	2.00
NMVOC		kt	0.19	0.25	0.36	0.37	0.37	0.31	0.30	0.27	0.26	0.26	0.30	0.30	0.29	0.29	0.29	
Pb		t	0.82	0.93	0.93	0.89	0.61	0.61	0.75	0.67	0.70	0.75	0.76	0.67	0.56	0.44	0.34	
Cd		t	0.11	0.13	0.14	0.13	0.08	0.07	0.09	0.08	0.08	0.09	0.09	0.08	0.06	0.05	0.04	
Hg		t	0.15	0.17	0.16	0.16	0.13	0.12	0.15	0.13	0.13	0.15	0.15	0.14	0.10	0.08	0.06	
1A1b Petroleum Refining	NO _x	kt	0.47	0.52	0.77	0.94	0.80	0.63	0.68	0.58	0.54	0.38	0.32	0.26	0.33	0.29	0.29	
	SO ₂	kt	0.48	0.51	0.78	0.91	0.67	0.90	0.43	0.57	0.01	0.03	0.02	0.03	0.03	0.03	0.04	
	NMVOC	kt	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	
	Pb	t	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	
	Cd	t	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	0.01	0.01	
	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 _x	kt	0.16	0.12	0.15	0.29	0.32	0.21	0.18	0.22	0.22	0.24	0.32	0.11	0.53	0.21	0.18	
	SO ₂	kt	0.13	0.10	0.12	0.16	0.21	0.25	0.24	0.19	0.03	0.09	0.25	0.11	0.37	0.13	0.14	
	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	0.00	
	Pb	t	0.02	0.02	0.02	0.03	0.03	0.02	0.03	0.03	0.02	0.02	0.02	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	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.02	0.02	

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

% Change in Emissions	Pollutant		1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1A1a Public Electricity and Heat Production	NO _x	%	0.0%	0.0%	0.0%	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 ₂	%	0.0%	0.0%	0.0%	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%	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 _x	%	0.0%	0.0%	0.0%	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 ₂	%	0.0%	0.0%	0.0%	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%	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%
1A1c Manufacture of Solid Fuels and Other Energy Industries	NO _x	%	0.0%	0.0%	0.0%	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 ₂	%	0.0%	0.0%	0.0%	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%	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%

Table 3.4. Recalculations in Energy NFR 1A2

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022																	
1A2 Manufacturing Industries and Construction	NO _x	kt	9.11	8.04	10.32	16.48	9.06	7.47	9.31	9.50	10.35	10.35	10.64	9.80	9.17	8.24	7.91
	SO ₂	kt	33.04	40.22	42.02	12.74	5.81	4.92	4.20	4.63	3.22	2.37	2.45	2.53	2.67	1.46	1.21
	NMVOG	kt	1.69	1.26	1.72	2.69	2.47	2.19	2.15	2.24	2.74	2.86	2.90	3.10	3.14	2.99	3.19
	Pb	t	1.20	0.85	1.08	1.16	0.65	0.53	0.48	0.49	0.50	0.52	0.48	0.49	0.50	0.37	0.35
	Cd	t	0.05	0.05	0.07	0.11	0.09	0.08	0.07	0.07	0.08	0.09	0.08	0.09	0.09	0.09	0.09
	Hg	t	0.08	0.05	0.08	0.10	0.06	0.06	0.06	0.06	0.06	0.12	0.11	0.14	0.11	0.11	0.05
Submission 2023																	
1A2 Manufacturing Industries and Construction	NO _x	kt	9.07	7.96	10.23	16.44	9.13	7.57	9.45	9.60	10.46	10.42	10.69	9.88	9.25	8.30	7.93
	SO ₂	kt	32.98	40.16	41.95	12.67	5.78	4.89	4.18	4.60	3.20	2.36	2.43	2.48	2.61	1.40	1.16
	NMVOG	kt	1.69	1.25	1.72	2.70	2.51	2.25	2.20	2.28	2.79	2.90	2.94	3.15	3.19	3.04	3.24
	Pb	t	1.20	0.84	1.07	1.15	0.64	0.51	0.47	0.48	0.49	0.50	0.46	0.46	0.47	0.34	0.33
	Cd	t	0.05	0.05	0.08	0.11	0.09	0.08	0.07	0.07	0.08	0.09	0.08	0.09	0.09	0.09	0.09
	Hg	t	0.08	0.05	0.11	0.15	0.09	0.08	0.09	0.07	0.06	0.12	0.11	0.14	0.11	0.11	0.09
% Change in Emissions																	
1A2 Manufacturing Industries and Construction	NO _x	%	-0.5%	-0.9%	-0.9%	-0.3%	0.8%	1.3%	1.5%	1.0%	1.1%	0.7%	0.5%	0.8%	0.9%	0.7%	0.3%
	SO ₂	%	-0.2%	-0.2%	-0.2%	-0.6%	-0.5%	-0.6%	-0.6%	-0.6%	-0.4%	-0.6%	-0.6%	-1.8%	-2.1%	-3.7%	-4.5%
	NMVOG	%	-0.3%	-0.6%	-0.5%	0.4%	1.5%	2.3%	2.7%	1.9%	1.9%	1.4%	1.4%	1.6%	1.8%	1.8%	1.5%
	Pb	%	-0.6%	-1.4%	-1.1%	-1.2%	-1.8%	-2.7%	-2.2%	-2.9%	-3.0%	-3.7%	-5.3%	-5.3%	-6.0%	-8.3%	-6.5%
	Cd	%	-0.2%	-0.4%	1.4%	1.5%	1.1%	0.7%	1.1%	-0.5%	-0.5%	-0.7%	-0.9%	-0.8%	-0.6%	-0.6%	-0.6%
	Hg	%	0.6%	0.9%	35.4%	41.2%	43.3%	35.5%	35.0%	1.7%	1.4%	0.3%	0.5%	1.0%	1.5%	1.4%	68.0%

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

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
Submission 2022																		
1A3a(i) & (ii) International and Domestic Aviation	NO _x	kt	4.80	5.15	8.10	11.08	10.00	8.80	7.44	8.74	9.81	11.17	11.46	13.63	14.57	15.12	5.56	
	SO ₂	kt	0.30	0.32	0.50	0.68	0.63	0.56	0.47	0.54	0.60	0.68	0.69	0.81	0.88	0.89	0.32	
	NMVOOC	kt	0.24	0.24	0.37	0.43	0.48	0.42	0.38	0.41	0.42	0.44	0.45	0.47	0.48	0.47	0.14	
1A3b Road Transportation	NO _x	kt	57.59	58.30	67.68	63.34	43.11	41.12	39.07	40.46	41.71	42.19	41.40	38.98	37.27	33.54	25.93	
	SO ₂	kt	5.37	5.13	1.66	0.54	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.04	0.04	0.03	
	NMVOOC	kt	31.41	29.08	21.09	14.48	8.47	7.68	6.87	6.41	5.99	5.56	4.94	4.17	3.69	3.34	2.76	
	NH ₃	kt	0.04	0.44	1.86	2.62	1.57	1.40	1.20	1.09	0.99	0.91	0.80	0.67	0.60	0.55	0.43	
	PM _{2.5}	kt	2.13	2.45	3.47	3.15	2.23	2.09	1.94	1.95	1.94	1.90	1.77	1.55	1.46	1.37	1.10	
	Pb	t	144.07	87.53	5.72	1.53	1.35	1.32	1.27	1.30	1.33	1.39	1.41	1.39	1.41	1.42	1.20	
	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	0.01	
	Hg	t	0.01	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
Submission 2023																		
1A3a(i) & (ii) International and Domestic Aviation	NO _x	kt	4.80	5.15	8.10	11.08	10.00	8.80	7.44	8.74	9.81	11.17	11.46	12.79	13.62	13.80	5.05	
	SO ₂	kt	0.30	0.32	0.50	0.68	0.63	0.56	0.47	0.54	0.60	0.68	0.69	0.81	0.88	0.89	0.32	
	NMVOOC	kt	0.24	0.24	0.37	0.43	0.48	0.42	0.38	0.41	0.42	0.44	0.45	0.51	0.52	0.52	0.16	
1A3b Road Transportation	NO _x	kt	56.62	57.44	66.09	61.99	42.54	40.61	38.62	40.03	41.31	41.87	41.28	38.99	38.02	34.37	26.61	
	SO ₂	kt	5.46	5.22	1.68	0.54	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.04	0.03	
	NMVOOC	kt	36.50	33.76	23.62	16.82	10.82	9.95	9.06	8.56	8.04	7.58	6.94	6.19	5.77	5.51	4.80	
	NH ₃	kt	0.04	0.44	1.85	2.59	1.57	1.40	1.20	1.09	0.99	0.91	0.80	0.67	0.60	0.54	0.43	
	PM _{2.5}	kt	2.07	2.40	3.44	3.16	2.30	2.17	2.03	2.05	2.04	2.01	1.89	1.66	1.57	1.48	1.19	
	Pb	t	148.15	90.86	8.82	5.19	4.70	4.62	4.46	4.57	4.69	4.91	5.01	4.97	5.01	5.05	4.26	
	Cd	t	0.01	0.01	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	
	Hg	t	0.01	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
% Change in Emissions																		
1A3a(i) & (ii) International and Domestic Aviation	NO _x	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-6.1%	-6.5%	-8.8%	-9.1%
	SO ₂	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	
	NMVOOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.0%	9.5%	11.4%	10.0%	
1A3b Road Transportation	NO _x	%	-1.7%	-1.5%	-2.3%	-2.1%	-1.3%	-1.2%	-1.2%	-1.0%	-1.0%	-0.8%	-0.3%	0.0%	2.0%	2.5%	2.6%	
	SO ₂	%	1.6%	1.6%	1.6%	1.7%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	
	NMVOOC	%	16.2%	16.1%	12.0%	16.1%	27.7%	29.5%	31.8%	33.4%	34.2%	36.3%	40.5%	48.5%	56.4%	65.0%	73.9%	
	NH ₃	%	-0.2%	-0.3%	-0.8%	-0.8%	-0.3%	-0.2%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.2%	-0.5%	
	PM _{2.5}	%	-3.0%	-1.8%	-0.9%	0.3%	3.3%	3.9%	4.4%	4.8%	5.3%	5.8%	6.6%	7.3%	7.9%	8.2%	8.6%	
	Pb	%	2.8%	3.8%	54.3%	238%	248%	250%	252%	252%	253%	252%	255%	257%	256%	257%	256%	
	Cd	%	210%	213%	205%	206%	213%	214%	216%	217%	218%	218%	217%	218%	218%	219%	219%	
	Hg	%	1.8%	1.7%	1.7%	1.7%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.3%	1.3%	1.3%	1.3%	1.3%	

* 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	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022																	
1A3c Railways	NO _x	kt	2.20	1.84	2.03	2.02	2.01	2.03	1.95	1.94	1.78	1.81	1.85	1.91	1.93	2.02	1.61
	SO ₂	kt	0.25	0.14	0.12	0.11	0.06	0.06	0.06	0.05	0.02	0.02	0.01	0.01	0.00	0.00	0.00
	NMVOOC	kt	0.20	0.16	0.18	0.18	0.18	0.18	0.17	0.17	0.16	0.16	0.16	0.17	0.17	0.18	0.14
	PM _{2.5}	kt	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04
	Pb	t	NE	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	0.00
	Hg	t	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1A3d(ii) National Navigation	NO _x	kt	2.24	2.42	3.76	4.73	3.78	3.28	3.49	3.37	4.23	4.16	5.01	4.40	4.85	5.23	6.20
	SO ₂	kt	1.16	1.26	1.22	0.67	0.10	0.08	0.09	0.08	0.05	0.03	0.03	0.09	0.11	0.11	0.13
	NMVOOC	kt	0.07	0.08	0.13	0.18	0.17	0.15	0.16	0.16	0.20	0.19	0.23	0.21	0.23	0.24	0.28
	PM _{2.5}	kt	0.05	0.05	0.08	0.10	0.08	0.07	0.07	0.07	0.09	0.09	0.11	0.09	0.10	0.11	0.13
	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	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	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
1A3e(i) Pipeline Compressors	NO _x	kt	0.06	0.11	0.05	0.13	0.14	0.13	0.12	0.12	0.12	0.12	0.12	0.11	0.12	0.12	0.13
Submission 2023																	
1A3c Railways	NO _x	kt	2.20	1.84	2.03	2.02	2.01	2.03	1.95	1.94	1.78	1.81	1.85	1.91	1.93	2.02	1.61
	SO ₂	kt	0.25	0.14	0.12	0.11	0.06	0.06	0.06	0.05	0.02	0.02	0.01	0.01	0.00	0.00	0.00
	NMVOOC	kt	0.20	0.16	0.18	0.18	0.18	0.18	0.17	0.17	0.16	0.16	0.16	0.17	0.17	0.18	0.14
	PM _{2.5}	kt	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04
	Pb	t	NE	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	0.00
	Hg	t	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1A3d(ii) National Navigation	NO _x	kt	2.24	2.42	3.76	4.73	3.78	3.28	3.49	3.37	4.23	4.16	5.01	4.40	4.85	5.23	6.51
	SO ₂	kt	1.16	1.26	1.22	0.67	0.10	0.08	0.09	0.08	0.05	0.03	0.03	0.09	0.11	0.11	0.13
	NMVOOC	kt	0.07	0.08	0.13	0.18	0.17	0.15	0.16	0.16	0.20	0.19	0.23	0.21	0.23	0.24	0.30
	PM _{2.5}	kt	0.05	0.05	0.08	0.10	0.08	0.07	0.07	0.07	0.09	0.09	0.11	0.09	0.10	0.11	0.14
	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	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	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
1A3e(i) Pipeline Compressors	NO _x	kt	0.06	0.11	0.05	0.13	0.14	0.13	0.12	0.12	0.12	0.12	0.12	0.11	0.12	0.12	0.13
% Change in Emissions																	
1A3c Railways	NO _x	%	0.0%	0.0%	0.0%	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 ₂	%	0.0%	0.0%	0.0%	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%	0.0%
	PM _{2.5}	%	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	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	%	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	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%	5.1%
1A3d(ii) National Navigation	NO _x	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%
	SO ₂	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%
	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%	5.1%
	PM _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%
	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%	5.1%
	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%	5.1%
	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%
1A3e(i) Pipeline Compressors	NO _x	%	0.0%	0.0%	0.0%	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

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022																	
1A4a Commercial/Institutional	NO _x	kt	2.88	2.70	2.58	2.56	2.28	2.18	2.26	2.38	2.25	2.32	2.38	2.34	2.47	2.47	2.49
	SO ₂	kt	11.27	5.37	1.84	1.33	0.35	0.31	0.27	0.28	0.16	0.15	0.16	0.25	0.22	0.20	0.20
	NMVOG	kt	0.46	0.42	0.49	0.58	0.52	0.51	0.54	0.55	0.51	0.53	0.54	0.54	0.58	0.58	0.58
	NH ₃	kt	0.00	0.00	0.00	0.00	0.02	0.02	0.03	0.04	0.04	0.03	0.04	0.03	0.03	0.02	0.02
	PM _{2.5}	kt	0.53	0.37	0.27	0.34	0.17	0.16	0.16	0.19	0.19	0.18	0.20	0.18	0.18	0.18	0.18
	Pb	t	0.55	0.36	0.26	0.35	0.15	0.14	0.14	0.17	0.16	0.16	0.16	0.17	0.16	0.16	0.16
	Cd	t	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01
	Hg	t	0.01	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
	1A4b Residential	NO _x	kt	4.85	4.74	5.61	6.78	7.44	6.39	5.97	5.80	5.11	5.53	5.75	5.44	5.88	5.63
SO ₂		kt	26.76	17.46	15.62	12.95	9.23	8.21	8.01	8.41	7.47	7.55	8.22	7.32	7.27	6.56	6.93
NMVOG		kt	35.07	22.18	15.17	13.49	13.19	11.96	11.91	12.70	11.40	11.70	11.89	10.08	10.84	9.70	10.09
NH ₃		kt	0.40	0.24	0.15	0.12	0.12	0.10	0.11	0.12	0.10	0.11	0.11	0.10	0.10	0.09	0.09
PM _{2.5}		kt	20.41	13.30	9.32	8.53	8.58	7.82	7.85	8.40	7.58	7.83	8.02	6.84	7.39	6.65	6.94
Pb		t	5.71	3.60	2.47	2.19	2.16	1.95	1.94	2.07	1.86	1.91	1.94	1.64	1.76	1.58	1.64
Cd		t	0.05	0.04	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Hg		t	0.18	0.12	0.09	0.09	0.09	0.08	0.08	0.09	0.08	0.08	0.08	0.08	0.07	0.08	0.07
1A4c Agriculture/Forestry/Fishing		NO _x	kt	8.76	14.31	12.91	12.76	7.43	6.56	6.19	5.55	4.84	4.27	4.05	4.21	4.50	4.12
	SO ₂	kt	1.41	1.34	0.94	0.86	0.37	0.06	0.09	0.08	0.05	0.04	0.04	0.05	0.03	0.02	0.02
	NMVOG	kt	1.38	1.71	1.35	1.09	0.60	0.53	0.48	0.40	0.34	0.30	0.29	0.29	0.30	0.28	0.24
	NH ₃	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	0.00
	PM _{2.5}	kt	0.93	1.05	0.76	0.60	0.32	0.28	0.25	0.21	0.17	0.15	0.14	0.14	0.14	0.13	0.11
	Pb	t	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.02	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	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
	Submission 2023																
1A4a Commercial/Institutional	NO _x	kt	2.92	2.70	2.51	2.36	1.98	1.86	1.91	2.09	1.93	2.05	2.03	1.95	2.08	2.02	2.09
	SO ₂	kt	11.33	5.37	1.80	1.25	0.34	0.31	0.23	0.25	0.15	0.13	0.14	0.21	0.19	0.15	0.15
	NMVOG	kt	0.46	0.42	0.49	0.54	0.47	0.45	0.46	0.48	0.44	0.47	0.47	0.46	0.49	0.49	0.50
	NH ₃	kt	0.00	0.00	0.00	0.00	0.02	0.02	0.03	0.04	0.04	0.03	0.04	0.03	0.03	0.02	0.02
	PM _{2.5}	kt	0.54	0.37	0.26	0.31	0.16	0.15	0.14	0.17	0.17	0.16	0.17	0.15	0.16	0.14	0.15
	Pb	t	0.56	0.36	0.25	0.33	0.14	0.14	0.12	0.15	0.15	0.14	0.14	0.13	0.14	0.12	0.13
	Cd	t	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01
	Hg	t	0.01	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
	1A4b Residential	NO _x	kt	4.85	4.79	5.72	6.96	7.61	6.55	6.12	5.94	5.26	5.69	5.97	5.67	6.11	5.89
SO ₂		kt	26.76	17.53	15.72	13.09	9.27	8.24	8.07	8.46	7.50	7.57	8.26	7.41	7.36	6.66	7.02
NMVOG		kt	35.07	22.18	15.17	13.49	13.12	11.87	11.90	12.69	11.39	11.70	11.89	10.08	10.84	9.71	10.09
NH ₃		kt	0.40	0.24	0.15	0.12	0.12	0.10	0.11	0.12	0.10	0.11	0.11	0.10	0.10	0.09	0.09
PM _{2.5}		kt	20.41	13.31	9.32	8.54	8.53	7.77	7.85	8.40	7.58	7.84	8.02	6.84	7.39	6.65	6.95
Pb		t	5.71	3.60	2.47	2.19	2.14	1.94	1.94	2.07	1.86	1.91	1.94	1.64	1.76	1.58	1.64
Cd		t	0.05	0.04	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Hg		t	0.18	0.12	0.09	0.09	0.09	0.08	0.08	0.09	0.08	0.08	0.08	0.08	0.07	0.08	0.07
1A4c Agriculture/Forestry/Fishing		NO _x	kt	8.76	14.31	12.91	12.76	7.43	6.56	6.19	5.55	4.84	4.27	4.05	4.21	4.50	4.12
	SO ₂	kt	1.41	1.34	0.94	0.86	0.37	0.06	0.09	0.08	0.05	0.04	0.04	0.05	0.03	0.02	0.02
	NMVOG	kt	1.38	1.71	1.35	1.09	0.60	0.53	0.48	0.40	0.34	0.30	0.29	0.29	0.30	0.28	0.24
	NH ₃	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	0.00
	PM _{2.5}	kt	0.93	1.05	0.76	0.60	0.32	0.28	0.25	0.21	0.17	0.15	0.14	0.14	0.14	0.13	0.11
	Pb	t	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02	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	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

% Change in Emissions		Pollutant	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
1A4a Commercial/Institutional	NOx	%	1.6%	0.0%	-2.5%	-8.0%	-13.2%	-14.9%	-15.5%	-12.0%	-14.2%	-11.5%	-14.6%	-16.4%	-15.6%	-18.3%	-16.1%	
	SO2	%	0.5%	0.0%	-2.1%	-5.6%	-2.5%	0.1%	-12.9%	-9.6%	-10.1%	-8.2%	-14.2%	-18.3%	-13.3%	-25.9%	-24.4%	
	NMVOG	%	1.0%	0.0%	-1.3%	-6.0%	-10.1%	-12.6%	-14.6%	-11.6%	-14.3%	-11.5%	-13.6%	-15.3%	-15.6%	-16.3%	-15.0%	
	NH3	%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	PM2.5	%	1.4%	0.0%	-3.9%	-7.0%	-9.8%	-7.2%	-15.0%	-10.8%	-11.8%	-10.8%	-14.8%	-16.9%	-13.9%	-21.7%	-17.8%	
	Pb	%	1%	0%	-4%	-6%	-8%	-4%	-15%	-11%	-12%	-11%	-15%	-17%	-14%	-23%	-18%	
	Cd	%	1%	0%	-4%	-7%	-3%	-2%	-3%	-2%	-2%	-2%	-3%	-3%	-4%	-3%	-6%	-5%
	Hg	%	0%	0%	-2%	-2%	20%	23%	-10%	-8%	-10%	-11%	-11%	-13%	-13%	-16%	-15%	
	1A4b Residential	NOx	%	0.0%	1.1%	1.9%	2.6%	2.3%	2.6%	2.6%	2.5%	2.9%	2.8%	3.9%	4.3%	3.8%	4.6%	3.5%
SO2		%	0.0%	0.4%	0.7%	1.1%	0.4%	0.4%	0.8%	0.6%	0.4%	0.3%	0.5%	1.3%	1.2%	1.4%	1.3%	
NMVOG		%	0.0%	0.0%	0.0%	0.0%	-0.6%	-0.7%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
NH3		%	0.0%	0.0%	0.0%	0.0%	-0.3%	-0.4%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	
PM2.5		%	0.0%	0.0%	0.0%	0.0%	-0.5%	-0.6%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	
Pb		%	0.0%	0.0%	0.0%	0.0%	-0.6%	-0.7%	-0.1%	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%	-0.3%	-0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Hg		%	0.0%	0.1%	0.2%	0.3%	-0.2%	-0.3%	0.3%	0.3%	0.3%	0.3%	0.5%	0.6%	0.5%	0.7%	0.5%	
1A4c Agriculture/Forestry/Fishing		NOx	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	SO2	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	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%	0.0%	
	NH3	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	PM2.5	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.3%	4.7%
	Pb	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	5%
	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%	3.9%	4.7%
	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%	0.4%	5.0%

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

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. 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 was due to finish by the end of 2020. One of the main outcomes of this project was that there is still significant issues with the availability of a robust dataset on fuel used in non-road mobile machinery for use in national emission inventory calculations. Review recommendations and responses are included in this report in 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) since 2005. 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, as is discussed in Chapter 3, section 3.5 of this report. In this submission emissions of particulates are reported for the first time see table 4.0, using EFs from Table 3.1 EMEP/EEA Guidebook (2019).

Table 4.0. Emission Time Series of particulates from Cement and Lime Production

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2020	2021
Cement production 2A1														
TSP (t)	418.7	416.3	808.5	1144.0	533.9	569.2	535.0	697.3	785.3	851.5	869.8	913.3	900.2	851.1
PM ₁₀ (t)	376.8	374.7	727.6	1029.6	480.5	512.2	481.5	627.6	706.8	766.3	782.8	821.9	810.2	766.0
PM _{2.5} (t)	209.3	208.2	404.2	572.0	267.0	284.6	267.5	348.7	392.7	425.7	434.9	456.6	450.1	425.5
BC (t)	6.3	6.2	12.1	17.2	8.0	8.5	8.0	10.5	11.8	12.8	13.0	13.7	13.5	12.8
Lime production 2A2														
TSP (t)	102.1	89.4	99.3	94.7	101.1	113.0	100.6	103.1	94.5	91.8	105.6	95.3	86.2	71.7
PM ₁₀ (t)	51.0	44.7	49.7	47.3	50.5	56.5	50.3	51.5	47.3	45.9	52.8	47.7	43.1	35.9
PM _{2.5} (t)	7.7	6.7	7.4	7.1	7.6	8.5	7.5	7.7	7.1	6.9	7.9	7.1	6.5	5.4
BC (t)	0.04	0.03	0.03	0.03	0.03	0.04	0.03	0.04	0.03	0.03	0.04	0.03	0.03	0.02

4.2.2 Lime Production (NFR 2A2)

The lime production process involves the grinding and “burning” of limestone (CaCO₃) to produce what is commonly termed “quicklime” (CaO). It can then be further treated by the addition of water, a process called slaking, to produce slaked lime (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, with the exception of particulates, are assumed to be included in those reported within Sector 1A2f and the notation key IE (Include elsewhere) is used for 2A2. In this submission emissions of particulates are reported for the first time, see Table 4.0, using EFs from Chapter 2.A.2 Table 3.3. Lime production (controlled) EMEP/EEA Guidebook (2019). Use of controlled emission factors are appropriate because lime facilities both have

BAT abatement techniques in use to minimise/prevent diffuse dust emission from dusty operations, bulk storage areas and other operations on site.

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, PM₁₀, 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.

Heavy 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 have been 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.

Ireland includes process emissions for PM_{2.5} from 2A3 Glass production using confidential production data and the Tier 2 emission factors presented in Tables 3.3, 3.5 and 3.6 from Chapter 2A3 of the 2019 EMEP/EEA Inventory guidebook (EMEP/EEA 2019). However, the Guidebook (chapter 1.A.2) notes that, Tier 1 emission factors from combustion in the industrial sector (NFR 1A2) would overlap at least partly with the estimate from process emissions in NFR 2A3. Therefore, Ireland estimates the emissions from category NFR 2A3 and subtracts those estimates from the total emissions calculated for category NFR 1A2f to avoid double counting of these emissions. 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
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
PM ₁₀ (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
PM _{2.5} (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
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
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
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
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
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
Pb (Mg)	311	311	311	311	311	224	137	137	129	88.52	96.78	96.46	7.91	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
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
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
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
PCDD/F (g I-TEQ)	0.54	0.46	0.39	0.26	0.17	0.11	0.01	0.02	0.01	0.01	0.01	0.01	0.00	NO

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

Emissions of PM_{2.5}, TSP and PM₁₀ have been estimated for all years of the time series 1990- 2021. Activity data was taken from national statistics from the CSO and emission factors from Chapter 2.A.5.a, Table 3.1 of the Inventory 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	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Metallic minerals	Mt	2.68	2.60	3.49	4.65	4.28	4.21	3.82	3.66	3.40	2.60	2.31	2.20	2.46	2.54	2.63
Non-metallic minerals	Mt	29	27	63	94	38	30	29	29	34	42	46	50	58	60	61.65
Emissions factors																
TSP	g/t	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
PM ₁₀	g/t	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
PM _{2.5}	g/t	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Emissions																
TSP	kt	3.21	3.00	6.79	10.11	4.31	3.53	3.35	3.38	3.78	4.52	4.88	5.36	6.14	6.35	6.56
PM ₁₀	kt	1.58	1.47	3.33	4.96	2.11	1.73	1.64	1.66	1.85	2.22	2.39	2.63	3.01	3.11	3.21
PM _{2.5}	kt	0.16	0.15	0.33	0.50	0.21	0.17	0.16	0.17	0.19	0.22	0.24	0.26	0.30	0.31	0.32

4.2.5 Construction and Demolition (NFR 2A5b)

Emissions of PM_{2.5}, TSP and PM₁₀ have been estimated for all years of the time series 1990- 2021. 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). Ireland checked for sources of required data to implement a Tier 2 method and determined it is not possible to source any of the required data. The methodologies provided by US EPA with AP-42 require very detailed local data e.g. material silt content, road surface silt content, material moisture content, medium wind speed, mean vehicle weight, mean vehicle speed, vehicle kilometre travelled (VKT)etc. The 2019 EEA/EMEP guidebook states that collection of such data is likely to be possible only for individual large point sources. Ireland does not have this data available for any construction and demolition sites and will continue to use the Tier 1 method to estimate emissions from this source. The emission estimates are presented in Table 4.3.

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

Emissions		1990	1995	2000	2005	2010	2011	2013	2014	2015	2016	2017	2018	2019	2020	2021
TSP	kt	1.74	1.93	1.55	6.25	12.49	0.53	1.85	1.17	1.37	1.14	3.27	0.95	2.82	2.99	3.06
PM ₁₀	kt	0.52	0.58	0.47	1.87	3.73	0.16	0.55	0.35	0.41	0.34	0.98	0.29	0.85	0.90	0.92
PM _{2.5}	kt	0.052	0.058	0.047	0.187	0.373	0.016	0.055	0.035	0.041	0.034	0.098	0.029	0.085	0.090	0.092

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

Emissions of PM_{2.5} have been estimated for all years of the time series 1990- 2021. Activity data was taken from national statistics from the CSO and emission factors from Table 3.4 Chapter 2.A.5.a of the guidebook (EMEP/EEA, 2019). Activity data and emission estimates 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	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Metallic minerals	Mt	2.68	2.60	3.49	4.65	4.28	4.21	3.82	3.66	3.40	2.60	2.31	2.20	2.46	2.54	2.62
Non-metallic minerals	Mt	28.82	26.81	63.10	94.46	37.96	30.41	29.03	29.47	33.63	41.74	45.54	50.30	57.74	59.62	61.56
Emissions factors																
PM _{2.5} -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	0.60
Emissions																
PM _{2.5} -handling	kg	0.19	0.18	0.40	0.59	0.25	0.21	0.20	0.20	0.22	0.27	0.29	0.32	0.36	0.37	0.39

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	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Bricks production															
PCDD/F (mg I-TEQ)	12.18	13.06	15.42	15.38	1.74	2.48	0.07	NO	1.62	2.84	3.32	3.55	3.34	2.91	3.54
Ceramics production															
PCDD/F (mg I-TEQ)	NO	NO	NO	2.071	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	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 emission 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), and the Irish Asphalt Pavement Producers Association (IAPA 2019, 2020, 2021) which generates an annual report outlining the quantity and end use of asphalt produced in European countries and Ireland. 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 2019 and a decrease was noted in 2020 which was partly related to COVID restrictions. An increase has been seen in 2021 with an increase in road building activity.

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	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
PCDD/F (mg I-TEQ)	154	92.2	112	23.8	16.1	13.3	12.6	12.6	13.3	13.3	14.7	14.4	14.0	13.3	14.0

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_x 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 NH₃ 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 NH₃ over a catalyst. The nitric acid is combined with more NH₃ 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_x. Emission estimates and associated activity data for NO_x 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 _x (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

4.3.2 Storage, handling and transport of chemical products (NFR 2B10b)

Emissions of TSP, PM₁₀ and PM_{2.5} are reported in category 2.B.10.b in this submission following a 2022 review recommendation. Emissions reported from storage, handling and transport of fertilisers were reallocated from category 3Dc. Emissions are estimated using emission factors from CEPMEIP database for SNAP 040415 storage and handling of NPK fertilisers. Emission factors of 100 g/t, 32 g/t and 4 g/t from CEPMEIP (2001) are utilised in the calculation of emissions of TSP, PM₁₀ and PM_{2.5}, respectively.

Table 4.8 Particulate matter emission time-series from the Storage and Handling of Fertilizers

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Fertilizer (kt)	1793	1921	1730	1479	1424	1231	1487	1403	1395	1412	1553	1715	1547	1592	1685
TSP (kt)	0.179	0.192	0.173	0.148	0.142	0.123	0.149	0.140	0.140	0.141	0.155	0.171	0.155	0.159	0.169
PM ₁₀ (kt)	0.057	0.061	0.055	0.047	0.046	0.039	0.048	0.045	0.045	0.045	0.050	0.055	0.050	0.051	0.054
PM _{2.5} (kt)	0.007	0.008	0.007	0.006	0.006	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.006	0.006	0.007

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 4.9. 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 4.9 Emission Time Series from Iron and Steel Production

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
As (Mg)	0.13	0.12	0.10	0.13	0.11	0.12	0.14	0.13	0.14	0.13	0.14	0.06	NO
Cd (Mg)	0.22	0.19	0.17	0.22	0.18	0.21	0.23	0.22	0.24	0.22	0.24	0.10	NO
Cr (Mg)	1.43	1.28	1.13	1.43	1.17	1.36	1.49	1.48	1.57	1.47	1.58	0.66	NO
Cu (Mg)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.01	NO
Pb (Mg)	1.75	1.58	1.38	1.75	1.43	1.67	1.83	1.81	1.93	1.80	1.94	0.81	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 (Mg)	2.69	2.42	2.12	2.69	2.20	2.56	2.82	2.78	2.96	2.77	2.98	1.24	NO
Se (Mg)	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 (Mg)	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	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
B[a]p (Mg)	0.009	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

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 4.9 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 2003-2021. 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 4.10. 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, PM₁₀, PM_{2.5} 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 PM₁₀, PM_{2.5} 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 4.10.

Table 4.10 Emission Time Series from Ferroalloys Production

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
TSP (Mg)	70.57	70.57	5.57	1.32	1.28	0.29	0.64	NO	NO	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001
PM ₁₀ (Mg)	59.99	59.99	4.74	1.12	1.09	0.24	0.54	NO	NO	0.0002	0.0002	0.0001	0.0001	0.0002	0.0001
PM _{2.5} (Mg)	42.34	42.34	3.34	0.79	0.77	0.17	0.38	NO	NO	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
Cr (Mg)	0.252	0.252	0.019	0.005	0.004	0.001	0.002	NO	NO	NO	NO	NO	NO	NO	NO
As (Mg)	0.069	0.069	0.005	0.001	0.001	0.000	0.001	NO	NO	NO	NO	NO	NO	NO	NO
Cd (Mg)	0.0325	0.0325	0.0028	0.0006	0.0076	0.0002	0.0004	0.0001	0.0001	NO	0.0001	0.0001	0.0001	0.0000	0.0001
Ni (Mg)	0.115	0.115	0.008	0.002	0.001	0.001	NO	NO	NO	NO	NO	NO	NO	NO	0.000
Pb (Mg)	1.712	1.712	0.183	0.031	0.035	0.007	0.015	0.0001	0.0001	NO	0.0001	0.0000	0.0001	0.0003	0.0001
Zn (Mg)	1.407	1.407	0.345	0.022	0.041	0.005	0.011	0.0001	0.0001	0.0001	0.0001	0.00001	0.0000	0.0001	0.0001
PCDD/F (g I-TEQ)	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
HCB (kg)	40.000	40.000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
PCBs (kg)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B[a]p (Mg)	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

4.4.3 Aluminium Production (NFR 2C3)

Ireland is an important producer of alumina at one large plant using the Bayer process (extraction of AlO₃ 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 4.11 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 and PRTR data, and this facility reporting is a metal processing facility which carries out secondary lead production and processes lead and lead alloys from scrap lead. Abatement using bag filters is in place in this facility and no fugitive releases of lead have been reported since 2009. No other pollutants are reported by the facility for the years 1990-2009. Emission estimates for the time series are presented in Table 4.12 and are reported as not occurring since 2009.

Table 4.12 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. The emissions reported in 2C7c Other metal production (Cd, Cr, Cu, Pb, Ni and Zn) have been obtained from AERs and PRTR reporting with respect to these secondary metal operations. The notation key “NA” is used for other metals in category 2C7c as the activity occurs, but the individual metals are reported as not emitted by the facilities. Installation of abatement equipment resulted in some emissions to air falling below detection limits, hence reporting of various metals ceases for some facilities in certain years. In the case of 2C7c, Cu is reported from metal plating facilities until 2008, table 4.13 gives total Cu emissions reported under 2C7 which includes those reported under 2C7a and 2C7c which is why the IIR does not match 2C7c emission values. Emission estimates for the time series are presented in Table 4.13. 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. The emissions reported (Cu only) in 2C7a Copper Production were taken from the annual reporting of monitoring results from a licenced facility that granulates copper cables. Installation of abatement equipment resulted in all emissions to air falling below detection limits, hence reporting of Cu ceased in 2007. As no roasting, smelting, converting, refining or electro-refining of copper is carried out at this facility, the emissions associated with Primary and Secondary copper production are not occurring. The notation key NA is used for other metals in category 2C7a for years 1990-2006 and notation key “NO” is used for years 2007-2021 as emissions do not occur.

Table 4.13 Emission Time Series for Non-Ferrous Metal Production

Pollutant	Units	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Cd (kg)	kg	0.02	0.02	0.02	0.02	NO	0.20	0.20	0.20	0.10	NO	0.10	0.10	0.10	0.13	0.10
Cr (kg)	kg	15.0	211.0	211.0	256.3	NO	NO	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	NO
Pb (kg)	kg	0.15	0.15	0.15	9.85	NO	0.30	0.40	0.41	0.30	0.20	0.30	0.17	0.30	0.48	0.30
Ni (kg)	kg	82.00	82.00	82.00	4.97	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Zn (kg)	kg	233.0	233.0	233.0	121.3	3.1	0.3	22.4	1.5	0.3	0.3	0.3	0.2	0.2	0.3	0.3

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. The Irish Asphalt Pavement Producers Association (IAPA) and the Bitumen suppliers were contacted with regards to the production of asphalt roofing in Ireland. They confirmed that asphalt roofing materials are imported from the UK and not manufactured in Ireland. The CSO was contacted to determine if any production statistics exist and only import and export figures are reported for asphalt roofing materials. 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 2016 and since updated to 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 (EMEP/EEA 2019) 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 over the period 2012 to 2021.

Figure 4.1 illustrates the overall trend and shows a 44.5 per cent increase in total emissions between 1990 (33.5 kt of NMVOC) and 2021 (48.4 kt of NMVOC). The main contributor to the trend is sector 2H2 Food and Beverages industry, with 212 per cent increase between 1990 and 2021 and was responsible for 62.0 per cent share of emissions from solvent and other product use in 2021. In 2021 an increase of 12.7 per cent was seen in this sector compared to 2020 emissions. The second largest contributor is sector 2D3a (Domestic Solvent Use including fungicides) with a contribution of 23.4 per cent of emissions from solvent and other product use (having increased by 43 per cent since 1990). Sector 2D3d (Coating Applications) accounted for 5.0 per cent in 2021 showing a decrease of 64.6 per cent between 1990 and 2021.

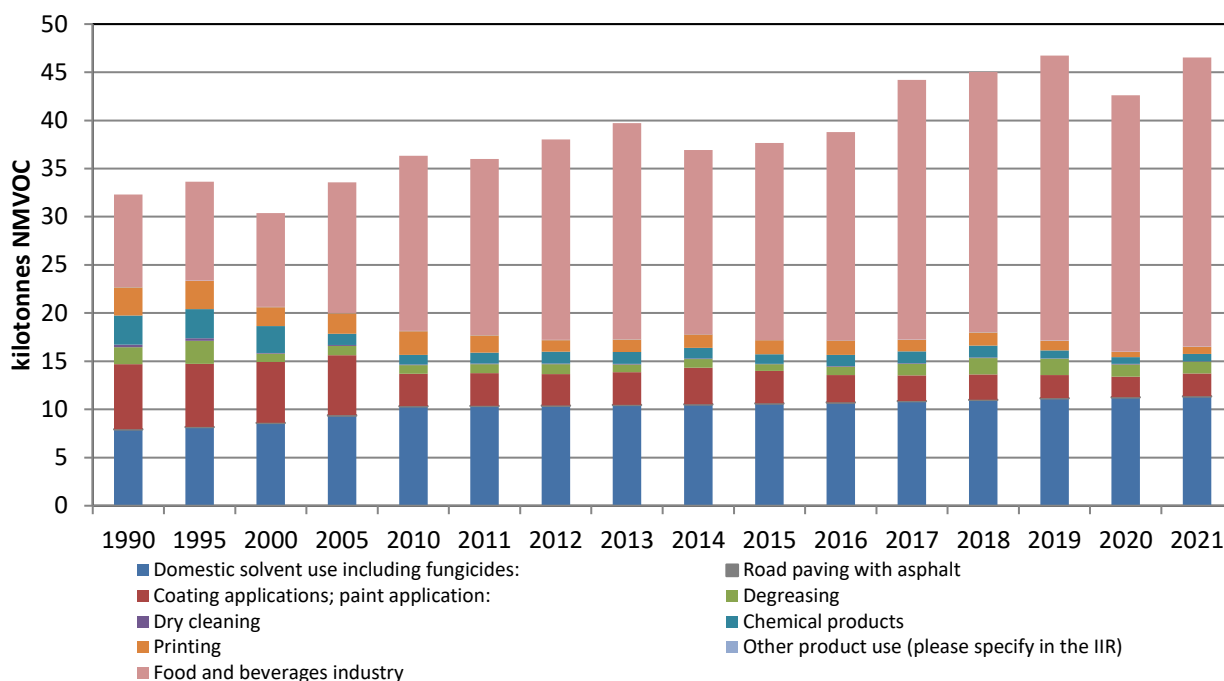


Figure 4.1 NMVOC Emission Trend for 2D-2H Other Solvent and Product 1990–2021

Sector 2D3a, (Domestic Solvent Use including fungicides) is the second largest contributor to NMVOC emissions (Table 4.14). A Tier 2 method was implemented which uses population data obtained from the CSO 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. Further work is currently underway by the Inventory team to collect suitable activity data to improve the estimation of emissions from Domestic Solvent use including fungicides. For Hg no Tier 2 emission estimate is available for fluorescent tubes. The 2019 Inventory 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 reported as not applicable (NA).

Sector 2D3b (Road paving with asphalt) emissions contribute less than 0.1 per cent of 2021 emissions. Emissions from the sector have decreased by 9.1 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 2019 and reaching their lowest level in 2020 (21.2 kt) and a slight increase was seen in 2021 when emissions were 23.8 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 23.3 per cent

between 1990 and 2021 whereas solvent-based paint sales have decreased by 54.1 per cent over the same period.

Emissions from 2D3e (Degreasing) decreased by 30.85 per cent between 1990 and 2021. 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 2.5 per cent of the total emissions from solvent and other product use in 2021.

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 80.1 per cent over the 1990-2021 period. Emissions from 2D3f accounted for 0.12 per cent of the total emissions from solvent and other product use in 2021.

2D3g (Chemical products) accounts for 1.6 per cent of emissions in solvent and other product use in 2021. In 1990, this sector accounted for 9.0 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 82.7 per cent of emissions in the 2D3g category in 2021. Emissions from 2D3g decreased by 75.2 per cent between 1990 and 2021. 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 2021. 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 74.5 per cent over the 1990 to 2021. In 2021, the sector accounted for 1.5 per cent of total emissions from solvent and other product use. Emissions from this sector decreased by 38.0 per cent in 2021. This was due to a change to water-based solvents and outsourcing of solvent based printing to the UK by some of the larger companies. It is important to note that the print industry is included under the Solvent Directive (1999/13/EC) and is subject to IPPC licencing where applicable which is most likely responsible for the decrease in emissions.

2D3i (Other Solvent use) emissions increased 60.9 per cent over the 1990 to 2021 timeseries. In 2021, 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 58.7 per cent of total emissions from solvent and other product use in 2021.

Emissions from this sub-category have increased 102.0 per cent between 1990 and 2021 due to increased consumption of glue products. The methodology for reporting 060404 (Fat, edible and non-edible oil extraction) includes emissions from 1990 to 2021, 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 0.03 per cent of emissions from solvent and other product use in 2021 and have decreased by 50.2 per cent between 1990 and 2021 as a 50 per cent decrease in tobacco consumption was noted in 2018 with a recovery in consumption and increase of 55 per cent seen in 2019 and a 7 per cent decrease in consumption seen in 2020 and a 5 per cent increase in 2021.

Sector 2H2 (Food and Beverage industry) is the largest contributor (62.0 per cent in 2021) to NMVOC emissions (Table 4.41-4.46). 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 CSO and Eurostat. There has been an annual average 9.6 per cent increase in spirit production since 2014 with a notable increase in production (+32 per cent) seen in 2017 followed by a decrease of 6.2 per cent in 2018 and a 16 per cent increase in 2019 and decrease of 9 per cent in 2020 followed by a 17.4 per cent increase in 2021. Spirit sales dropped by approximately 4.8 per cent in Ireland in 2020 while exports dropped an estimated 16 per cent due to the impact of COVID-19 hospitality closures and travel restrictions (Drinks Ireland, 2021). A marked recovery was seen in 2021 with exports up by approximately 25 per cent.

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 4.14.

Table 4.14 Non-Methane Volatile Organic Compound Emissions from Domestic Solvent Use

Year	1990	1995	2000	2005	2010	2011	2013	2014	2015	2016	2017	2018	2019	2020	2021
kt	7.93	8.14	8.57	9.35	10.30	10.39	10.43	10.50	10.60	10.72	10.84	10.98	11.13	11.25	11.33

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 1993-2021 and the Tier 2 emission factor from the Inventory guidebook (EMEP/EEA 2019). PM_{2.5}, PM₁₀, TSP and BC are estimated for all years 1990-2021. Estimates of NMVOC, PM₁₀, TSP, PM_{2.5} and BC emissions from Road Paving with asphalt are provided in Table 4.15.

Table 4.15 Emissions from Road Paving with Asphalt (NFR 2D3b)

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.04	0.03	0.05	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
TSP (kt)	33.00	25.50	43.50	51.00	34.50	28.50	27.00	27.00	28.50	28.50	31.50	30.75	30.00	28.50	30.00
PM10 (kt)	4.40	3.40	5.80	6.80	4.60	3.80	3.60	3.60	3.80	3.80	4.20	4.10	4.00	3.80	4.00
PM2.5 (kt)	0.22	0.17	0.29	0.34	0.23	0.19	0.18	0.18	0.19	0.19	0.21	0.21	0.20	0.19	0.20
BC (kt)	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	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. Activity data sources are described for the subcategories in sections 4.5.3.1 to 4.5.3.6. 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 2006-2021, 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, each year (DoT, 2022). 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 4.16.

Table 4.16 Non-Methane Volatile Organic Compound Emissions from Paint Application: Car Repairing

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVO (kt)	0.19	0.21	0.31	0.43	0.38	0.26	0.24	0.25	0.22	0.19	0.16	0.16	0.16	0.15	0.18

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 2006-2021. 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 for the period 2014-2021 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 ceiling paint were found to have 76g of VOC/l for solvent based paint and 50g of VOC/l for water based paints.
- Exterior wall paint 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/exterior 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 on average for solvent based primers 201g of VOC/l and 45g of VOC/l for water based primers.

These emission factors were used for 2010-2021 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 4.17.

Table 4.17 Non-Methane Volatile Organic Compound Emissions from Paint Application: Construction and Building (060103) and Domestic use (060104)

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
060104 kt	1.510	1.572	1.577	1.440	0.590	0.500	0.509	0.556	0.403	0.286	0.248	0.232	0.229	0.257	0.244
060103 kt	1.922	2.000	2.090	2.350	1.197	1.114	1.188	1.298	0.939	0.668	0.579	0.542	0.535	0.599	0.570

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 2010-2021 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 4.18.

Table 4.18 Non-Methane Volatile Organic Compound Emissions from Paint Application: Boat Building

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.090	0.090	0.090	0.090	0.090	0.089	0.103	0.111	0.115	0.144	0.132	0.146	0.158	0.069	0.072

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 4.19.

Table 4.19 Non-Methane Volatile Organic Compound Emissions from Paint Application: Wood

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.24	0.26	0.27	0.24	0.24	0.24	0.26	0.27	0.24	0.24	0.24	0.26	0.27	0.24	0.24

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 4.20. This methodology is considered a Tier 3 method

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

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	1.425	1.321	1.019	0.996	0.461	0.587	0.671	0.828	0.950	0.771	0.789	0.729	0.567	0.392	0.656

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 4.21. The methodology is considered a Tier 1 method

Table 4.21 Non-Methane Volatile Organic Compound Emissions from Paint Application: Other Non-Industrial Sources

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.490	0.401	0.466	0.337	0.234	0.298	0.319	0.446	0.508	0.505	0.512	0.538	0.501	0.417	0.418

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 1992-2021 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 NMVOC emissions from this source category are provided in Table 4.22.

Table 4.22 Non-Methane Volatile Organic Compound Emissions from Metal Degreasing, Electronics Manufacture and Other Industrial Cleaning

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	1.743	2.388	0.847	0.953	0.885	1.004	0.795	0.885	0.686	0.885	1.189	1.708	1.675	1.256	1.206

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 2021. 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 2013-2021. Estimates of NMVOC emissions from this source sector are provided in Table 4.23. The methodology is considered a Tier 3 methodology.

Table 4.23 Non-Methane Volatile Organic Compound Emissions from Dry Cleaning

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.28	0.27	0.09	0.09	0.05	0.07	0.06	0.07	0.04	0.06	0.06	0.07	0.06	0.07	0.06

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)

Activity data sources are described for the subcategories in sections 4.5.5.1 to 4.5.5.8. Information on activity data pertaining to these subcategories 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 4.24. The methodology is considered a Tier 1 method.

Table 4.24 Non-Methane Volatile Organic Compound Emissions from Polyurethane Processing

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.162	0.162	0.080	0.044	0.004	0.004	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 2019). 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 4.25 Non-Methane Volatile Organic Compound Emissions from Rubber Processing

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.423	0.424	0.422	0.199	0.001	0.001	0.001	0.001	0.001	NO	NO	NO	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 2006-2021 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 4.26.

Table 4.26 Non-Methane Volatile Organic Compound Emissions from Pharmaceutical Products Manufacturing

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	2.124	2.124	2.072	0.769	0.873	1.129	1.121	0.969	0.767	0.802	0.757	0.637	0.572	0.509	0.620

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 2021 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 4.27

Table 4.27 Non-Methane Volatile Organic Compound Emissions from Paint Manufacture

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.162	0.162	0.117	0.083	0.043	0.039	0.051	0.052	0.152	0.300	0.415	0.534	0.218	0.118	0.016

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 2008-2021. 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 4.28.

Table 4.28 Non-Methane Volatile Organic Compound Emissions from Inks Manufacturing

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NM VOC (t)	18.444	18.444	6.300	4.360	1.311	1.359	0.727	0.210	0.053	0.045	0.022	0.058	0.032	0.052	0.046

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, 2006-2021). 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 4.29.

Table 4.29 Non-Methane Volatile Organic Compound Emissions from Adhesives Manufacturing

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NM VOC (kt)	0.051	0.051	0.034	0.051	0.041	0.016	0.036	0.022	0.027	0.057	0.062	0.050	0.030	0.059	0.105

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 -2021. Estimates of NMVOC emissions from textile finishing are provided in Table 4.30.

Table 4.30 Non-Methane Volatile Organic Compound Emissions from Textile Finishing

Year	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2017	2018	2019	2020	2021
NM VOC (kt)	0.078	0.078	0.049	0.033	0.030	0.030	0.028	0.028	0.028	0.028	NO	NO	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.

Activity data information includes usage and emission data, 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 4.31. 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 and 2010 due to emissions from two IPPC licenced facilities. An overall decrease in emissions has been seen since then. The methodology is considered a Tier 3 method.

Table 4.31 Non-Methane Volatile Organic Compound Emissions from Printing

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	2.912	2.912	1.946	2.126	2.474	1.217	1.283	1.400	1.462	1.468	1.206	1.368	0.986	0.539	0.742

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)
- 4-stroke engine oil burning

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 4.32.

Table 4.32 Non-Methane Volatile Organic Compound Emissions from Glass Wool Blowing/Enduction

Year	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
NMVOG (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 NMVOG, TSP, PM₁₀ and PM_{2.5} for this sector were estimated using statistics obtained from the CSO on the national yield of oilseed. The Inventory Guidebook (EMEP/EEA, 2019) Tier 2 emission factors from Table 3-4 were applied. Estimates of NMVOG, TSP, PM₁₀ and PM_{2.5} are given in Table 4.33.

Table 4.33 Emissions from Fat, edible and non-edible oil extraction

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOG (kt)	0.031	0.020	0.014	0.022	0.044	0.092	0.077	0.054	0.063	0.054	0.065	0.064	0.060	0.071	0.082
TSP (kt)	0.022	0.014	0.009	0.016	0.031	0.065	0.054	0.038	0.044	0.038	0.046	0.045	0.042	0.050	0.050
PM10 (kt)	0.018	0.012	0.008	0.013	0.025	0.053	0.044	0.031	0.036	0.031	0.038	0.037	0.035	0.041	0.041
PM2.5 (kt)	0.012	0.008	0.005	0.009	0.017	0.035	0.030	0.021	0.024	0.020	0.025	0.025	0.023	0.027	0.027

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 NMVOG emissions from the application of glues and adhesives are provided in Table 4.34.

Table 4.34 Non-Methane Volatile Organic Compound Emissions from Application of Glues and Adhesives

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOG (kt)	0.540	0.313	0.755	2.986	1.121	0.872	0.701	0.972	1.123	1.064	1.122	1.388	1.505	1.373	1.092

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 4.35.

Table 4.35 Non-Methane Volatile Organic Compound Emissions from Preservation of Wood

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.55	0.58	0.65	0.63	0.76	1.00	0.75	0.82	0.74	0.77	0.80	0.79	0.69	0.67	0.69

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/m³, and assumes that 100 per cent of the solvent is emitted. Estimates of NMVOC emissions from this source category are provided in Table 4.36.

Table 4.36 Non-Methane Volatile Organic Compound Emissions from Underseal Treatment and Conservation of Vehicles

Year	1990	1995	2000	2001	2002	2003
NMVOC (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 NMVOC emissions from vehicle dewaxing are provided in Table 4.37.

Table 4.37 Non-Methane Volatile Organic Compound Emissions from Vehicle Dewaxing

Year	1990	1995	2000	2001	2002	2003
NMVOC (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 NMVOC, NO_x, CO, NH₃, TSP, PM₁₀, PM_{2.5} 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, 2021). An increase of 5 per cent consumption of tobacco products was seen in 2021. 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 4.38.

Table 4.38 Emissions from Use of Tobacco

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.034	0.037	0.039	0.032	0.024	0.023	0.020	0.019	0.020	0.017	0.022	0.011	0.017	0.016	0.017
NO _x (kt)	0.013	0.014	0.015	0.012	0.009	0.008	0.007	0.007	0.008	0.006	0.008	0.004	0.006	0.006	0.006
CO (kt)	0.386	0.419	0.449	0.360	0.278	0.257	0.224	0.213	0.230	0.194	0.250	0.127	0.196	0.183	0.192
NH ₃ (kt)	0.029	0.032	0.034	0.027	0.021	0.019	0.017	0.016	0.017	0.015	0.019	0.010	0.015	0.014	0.014
TSP (kt)	0.189	0.205	0.220	0.176	0.136	0.126	0.110	0.104	0.113	0.095	0.123	0.062	0.096	0.090	0.094
PM ₁₀ (kt)	0.189	0.205	0.220	0.176	0.136	0.126	0.110	0.104	0.113	0.095	0.123	0.062	0.096	0.090	0.094
PM _{2.5} (kt)	0.189	0.205	0.220	0.176	0.136	0.126	0.110	0.104	0.113	0.095	0.123	0.062	0.096	0.090	0.094
BC (kt)	0.076	0.082	0.088	0.070	0.054	0.050	0.044	0.042	0.045	0.038	0.049	0.025	0.038	0.036	0.038

4.5.7.8 Use of Fireworks (SNAP 060601)

This category comprises NO_x, CO, SO₂, TSP, PM₁₀ and PM_{2.5} 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 4.39.

Table 4.39 Emissions from Use of Fireworks

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NO _x (t)	0.011	0.012	0.012	0.012	0.012	0.011	0.010	0.010	0.008	0.007	0.009	0.009	0.010	0.002	0.002
CO (t)	0.315	0.331	0.340	0.335	0.326	0.293	0.283	0.262	0.208	0.199	0.240	0.252	0.272	0.068	0.056
SO ₂ (t)	0.133	0.140	0.143	0.141	0.138	0.124	0.119	0.111	0.088	0.084	0.101	0.106	0.115	0.029	0.024
TSP (t)	4.835	5.091	5.218	5.145	5.011	4.505	4.340	4.021	3.193	3.059	3.687	3.865	4.174	1.038	0.859
PM ₁₀ (t)	4.399	4.632	4.747	4.681	4.559	4.098	3.949	3.659	2.905	2.783	3.354	3.516	3.798	0.945	0.782
PM _{2.5} (t)	2.287	2.408	2.468	2.433	2.370	2.130	2.053	1.902	1.510	1.447	1.744	1.828	1.974	0.491	0.406

4.5.7.9 4-stroke engine lubricant consumption

The COPERT model used for estimating emissions of air pollutants from road transport includes heavy metal emissions from lubricant oil. These metals are assumed to be emitted to the atmosphere when oil burning occurs in the engine combustion chamber. Lubricant consumption in 2-stroke engines is considered intentional, therefore emissions must be reported under 1A3b. On the other hand 4-stroke engine lubricant consumption is undesirable and should not take place. However small amounts are consumed in the combustion chamber and their emissions are reported in 2D3i. Emissions of heavy metals are shown in Table 4.40.

Table 4.40 Emissions from 4-stroke oil combustion in road transport

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Pb (t)	0.0001	0.0001	0.0002	0.0003	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002
Cd (t)	0.0149	0.0181	0.0303	0.0367	0.0343	0.0329	0.0338	0.0347	0.0359	0.0364	0.0359	0.0361	0.0367	0.0306	0.0306
Cr (t)	0.0627	0.0763	0.1275	0.1543	0.1445	0.1386	0.1422	0.1462	0.1512	0.1534	0.1513	0.1520	0.1544	0.1289	0.1289
Cu (t)	2.5399	3.0901	5.1682	6.2539	5.8539	5.6175	5.7607	5.9252	6.1270	6.2176	6.1321	6.1593	6.2552	5.2239	5.2239
Ni (t)	0.1041	0.1267	0.2118	0.2563	0.2399	0.2303	0.2361	0.2429	0.2511	0.2549	0.2514	0.2525	0.2564	0.2141	0.2141
Se (t)	0.0148	0.0180	0.0302	0.0365	0.0342	0.0328	0.0336	0.0346	0.0358	0.0363	0.0358	0.0359	0.0365	0.0305	0.0305
Zn (t)	1.4697	1.7881	2.9906	3.6189	3.3874	3.2506	3.3335	3.4287	3.5455	3.5979	3.5484	3.5642	3.6197	3.0229	3.0229

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 2021. The data for years 1990-1994 was taken to be the same as 1995 as no data was available for these years. 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 4.41.

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

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	1.707	1.707	1.006	1.374	2.577	1.593	1.838	1.714	1.696	1.643	1.749	2.848	1.922	1.630	1.839

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, 2020)

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 4.42.

Table 4.42 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Beer

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.194	0.207	0.225	0.250	0.274	0.288	0.282	0.258	0.276	0.274	0.286	0.297	0.294	0.253	0.137

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 1999-2021. 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 4.43.

Table 4.43 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Spirits

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	3.97	4.68	4.90	8.38	12.29	14.69	16.29	13.56	14.48	15.60	20.56	19.28	22.41	20.34	23.87

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. This is considered a Tier 2 method. The NMVOC emissions from meat frying/curing is given in table 4.44.

Table 4.44 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Meat, fish etc. frying/curing

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.398	0.402	0.450	0.438	0.425	0.415	0.424	0.457	0.457	0.481	0.500	0.510	0.515	0.528	0.524

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 4.45.

Table 4.45 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Coffee roasting

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.001	0.001	0.002	0.003	0.001	0.003	0.003	0.003	0.005	0.006	0.007	0.007	0.006	0.005	0.004

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 4.46.

Table 4.46 Non-Methane Volatile Organic Compound Emissions from Food and Beverage Industry; Feedstock

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	3.351	3.291	3.168	3.090	2.636	3.801	3.621	3.142	3.529	3.611	3.856	4.070	4.431	3.861	3.625

4.6 Consumption of POPs and heavy metals 2K (e.g. electrical and scientific equipment)

Ireland does not estimate emissions for 2K for the entire timeseries, even though there is a Tier 1 method in the 2019 EMEP/EEA Guidebook. Ireland has reviewed the limited activity data available by contacting the European Recycling Platform (ERP) Ireland. ERP manage compliance of WEEE and waste batteries and have provided an estimate for 2018 of 0.95kg of batteries in the mercuric oxide category as placed on the market in Ireland by their Battery Producer members in Ireland. WEEE Ireland also provided information from the main waste collection facility of hazardous waste including batteries. They estimate approximately 4,000kg per year of button cells are collected and sent outside of Ireland for recycling, however it is not known what proportion of button cells contain mercury. Ireland has a functional waste collection system, and all batteries are collected and sent to hazardous waste collection facilities which export this waste to hazardous recycling or disposal facilities outside of Ireland. We do not believe that this waste stream results in mercury emissions to air and any mercury containing products which are placed on the market are collected in the battery mix.

4.7 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.

4.7.1 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 2021. The report for this inventory provides an estimate of the total volume of PCB oil (confirmed and suspected) for 2021 of 8.29 m³. 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 2021 represents a substantial decrease on the peak value in 2009 (522.06 m³) following a large decrease in 2008 (114.29 m³). 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 dm³ of oil in 1990 to 8,296 dm³ of oil (as reported by the EPA) in 2021. 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 4.47. 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.

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 4.47.

Table 4.47 Time Series of Polychlorinated Biphenyls and Dioxin and Furan Emissions from Leakage from Electrical Equipment

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
PCDD/F (µg I-TEQ)	1.034	1.034	0.842	0.790	0.625	0.546	0.172	0.061	0.055	0.036	0.032	0.032	0.031	0.031	0.023
PCBs (kg)	0.0124	0.0124	0.0101	0.0095	0.0075	0.0065	0.0021	0.0007	0.0007	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003

4.7.2 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 2021. 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 4.48.

Table 4.48 Emission Time Series for Polychlorinated Biphenyls from Fragmentisers and Shredders

Year	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2018	2019	2020	2021
PCBs (kg)	11.920	8.643	5.305	4.617	3.917	3.184	2.427	1.654	NO	NO	NO	NO	NO	NO

4.8 Recalculations in the Industrial Processes Sector

4.8.1 Heavy Metals recalculations

There were no recalculations to emission estimates for 1990-2020. Recalculations are as shown in Table 4.50.

4.8.2 Particulate matter recalculations

There were no significant recalculations in particulate matter emissions, TSP, PM_{2.5} and PM₁₀. Recalculations to emission estimates for 1990-2020 can be seen in table 4.51.

4.8.3 Nitrogen Oxides (NOx) recalculations

There were no recalculations to emission estimates for 1990-2020 as can be seen in table 4.51.

4.8.4 Non- Methane Volatile Organic Compounds (NMVOC) recalculations

No significant recalculations occurred in NMVOC for 1990-2020 as can be seen in Table 4.52.

4.9 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.

4.10 Overview of Notation Keys

Table 4.49 describes the notation keys used in the 2021 NMVOC emission inventory for Other Solvent and Product Use (2D-2L).

Table 4.49 Notation keys used in 2021 NMVOC inventory

NFR	Snap	Description	Notation Key	Reason
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

4.11 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.

With reference to category 2A5a Quarrying and Mining of Minerals Other Than Coal and emissions of particulate matter for all years an issue was raised in the NEC review 2022 regarding the use of a Tier 1 method for a key category. The TERT was of the view that the use of a Tier 2 or Tier 3 method could be possible if Ireland could use data from the mining companies. Ireland has reviewed the Tier 2 methodology and determined the level of detail of data required is not available as the number and types of quarries in addition to mines makes moving to a Tier 2 impossible. The recommendation mentions mining companies, however as stated in our answer during the review, it is not possible for Ireland to source the data required to estimate these emissions using a Tier 2 method, nor is it appropriate to apply the Tier 2 model using the context of a different country such as that on which the model has been developed. Ireland does not have information on the type of processing occurring on quarries, internal transport movements, drilling and blasting activity, material handling, stockpile sizes, abatement technologies used or annual output of quarries. Ireland does not have this data available for any mining and quarry sites which would be numerous, of varying sizes and mainly under private ownership (and not owned by large companies) and will continue to use the Tier 1 method to estimate emissions from this source.

Ireland is aware of the EFs 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. Ireland has a functional waste collection system, and all batteries are collected and sent to hazardous waste collection facilities which export this waste to hazardous recycling or disposal facilities outside of Ireland. We do not believe that this waste stream results in mercury emissions to air and any mercury containing products which are placed on the market are collected in the battery mix.

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 4.50 Recalculations for Industrial Processes 1990–2020 (Heavy Metals)

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022																	
2A3 Glass Production	Pb	t	0.311	0.311	0.311	0.129	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A3 Glass Production	Cd	t	0.007	0.007	0.007	0.000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A3 Glass Production	Hg	t	0.001	0.001	0.001	0.001	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C Metal Production	Pb	t	3.473	3.387	2.127	0.041	0.035	0.016	0.007	0.016	0.001	0.000	0.000	0.000	0.000	0.000	0.001
2C Metal Production	Cd	t	0.249	0.238	0.241	0.001	0.008	0.001	0.000	0.001	0.000	0.000	0.000	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	0.000
Submission 2023																	
2A3 Glass Production	Pb	t	0.311	0.311	0.311	0.129	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A3 Glass Production	Cd	t	0.007	0.007	0.007	0.000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A3 Glass Production	Hg	t	0.001	0.001	0.001	0.001	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C Metal Production	Pb	t	3.473	3.387	2.127	0.041	0.035	0.016	0.007	0.016	0.001	0.000	0.000	0.000	0.000	0.000	0.001
2C Metal Production	Cd	t	0.249	0.238	0.241	0.001	0.008	0.001	0.000	0.001	0.000	0.000	0.000	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	0.000
% Change in Emissions																	
2A3 Glass Production	Pb	%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	-	-	-
2A3 Glass Production	Cd	%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	-	-	-
2A3 Glass Production	Hg	%	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%	0.0%	0.0%
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%	0.0%
2C Metal Production	Hg	%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	-	-	-	-

Table 4.51 Recalculations for Industrial Processes 1990–2020 (Particulates and NOx)

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022																	
2A3 Glass Production	TSP	kt	0.023	0.023	0.022	0.006	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A3 Glass Production	PM10	kt	0.020	0.020	0.019	0.005	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A3 Glass Production	PM2.5	kt	0.018	0.018	0.017	0.005	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A5a Quarrying and mining of minerals other than coal	TSP	kt	3.213	3.000	6.792	10.11 0	4.309	3.063	3.531	3.350	3.379	3.777	4.523	4.880	5.355	6.140	6.345
2A5a Quarrying and mining of minerals other than coal	PM10	kt	1.575	1.470	3.330	4.956	2.112	1.501	1.731	1.642	1.656	1.852	2.217	2.392	2.625	3.010	3.110
2A5a Quarrying and mining of minerals other than coal	PM2.5	kt	0.158	0.147	0.333	0.496	0.211 12.49	0.150	0.173	0.164	0.166	0.185	0.222	0.239	0.263	0.301	0.311
2A5b Construction and Demolition	TSP	kt	1.739	1.928	1.552	6.247	3	0.527	0.744	1.852	1.171	1.377	1.145	3.269	0.954	2.933	3.003
2A5b Construction and Demolition	PM10	kt	0.522	0.578	0.465	1.871	3.733	0.159	0.224	0.555	0.351	0.414	0.345	0.979	0.288	0.879	0.900
2A5b Construction and Demolition	PM2.5	kt	0.052	0.058	0.047	0.187	0.373	0.016	0.022	0.055	0.035	0.041	0.034	0.098	0.029	0.088	0.090
2A5c Storage and Handling of mineral products	PM2.5	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	0.000
2B10b Storage, handling and transport of chemical products	TSP	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10b Storage, handling and transport of chemical products	PM10	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10b Storage, handling and transport of chemical products	PM2.5	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C Metal Production	TSP	kt	0.071	0.071	0.006	0.001	0.001	0.001	0.000	0.001	NO	NO	0.000	0.000	0.000	0.000	0.000
2C Metal Production	PM10	kt	0.060	0.060	0.005	0.001	0.001	0.001	0.000	0.001	NO	NO	0.000	0.000	0.000	0.000	0.000
2C Metal Production	PM2.5	kt	0.042	0.042	0.003	0.001	0.001	0.000	0.000	0.000	NO	NO	0.000	0.000	0.000	0.000	0.000
			33.00	25.50	43.50	51.00	34.50	27.00	28.50	27.00	27.00	28.50	28.50	31.50	30.75	30.00	28.50
2D3b Road Paving	TSP	kt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2D3b Road Paving	PM10	kt	4.400	3.400	5.800	6.800	4.600	3.600	3.800	3.600	3.600	3.800	3.800	4.200	4.100	4.000	3.800
2D3b Road Paving	PM2.5	kt	0.220	0.170	0.290	0.340	0.230	0.180	0.190	0.180	0.180	0.190	0.190	0.210	0.205	0.200	0.190
2D3i Other solvent use	TSP	kt	0.022	0.014	0.009	0.016	0.031	0.061	0.065	0.054	0.038	0.044	0.038	0.046	0.045	0.042	0.050
2D3i Other solvent use	PM10	kt	0.018	0.012	0.008	0.013	0.025	0.050	0.053	0.044	0.031	0.036	0.031	0.038	0.037	0.035	0.041
2D3i Other solvent use	PM2.5	kt	0.012	0.008	0.005	0.009	0.017	0.034	0.035	0.030	0.021	0.024	0.020	0.025	0.025	0.023	0.027
Submission 2023																	
2A3 Glass Production	TSP	kt	0.023	0.023	0.022	0.006	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
2A3 Glass Production	PM10	kt	0.020	0.020	0.019	0.005	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A3 Glass Production	PM2.5	kt	0.018	0.018	0.017	0.005	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A5a Quarrying and mining of minerals other than coal	TSP	kt	3.213	3.000	6.792	0	4.309	3.063	3.531	3.350	3.379	3.777	4.523	4.880	5.355	6.140	6.345
2A5a Quarrying and mining of minerals other than coal	PM10	kt	1.575	1.470	3.330	4.956	2.112	1.501	1.731	1.642	1.656	1.852	2.217	2.392	2.625	3.010	3.110
2A5a Quarrying and mining of minerals other than coal	PM2.5	kt	0.158	0.147	0.333	0.496	0.211	0.150	0.173	0.164	0.166	0.185	0.222	0.239	0.263	0.301	0.311
2A5b Construction and Demolition	TSP	kt	1.739	1.928	1.552	6.247	2	0.527	0.747	1.845	1.171	1.374	1.140	3.265	0.952	2.821	2.988
2A5b Construction and Demolition	PM10	kt	0.522	0.578	0.465	1.871	3.733	0.159	0.225	0.553	0.351	0.413	0.343	0.977	0.287	0.846	0.896
2A5b Construction and Demolition	PM2.5	kt	0.052	0.058	0.047	0.187	0.373	0.016	0.022	0.055	0.035	0.041	0.034	0.098	0.029	0.085	0.090
2A5c Storage and Handling of mineral products	PM2.5	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	0.000
2B10b Storage, handling and transport of chemical products	TSP	kt	0.179	0.192	0.173	0.148	0.142	0.120	0.123	0.149	0.140	0.140	0.141	0.155	0.171	0.155	0.159
2B10b Storage, handling and transport of chemical products	PM10	kt	0.057	0.061	0.055	0.047	0.046	0.039	0.039	0.048	0.045	0.045	0.045	0.050	0.055	0.050	0.051
2B10b Storage, handling and transport of chemical products	PM2.5	kt	0.007	0.008	0.007	0.006	0.006	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.006	0.006
2C Metal Production	TSP	kt	0.071	0.071	0.006	0.001	0.001	0.001	0.000	0.001	NO	NO	0.000	0.000	0.000	0.000	0.000
2C Metal Production	PM10	kt	0.060	0.060	0.005	0.001	0.001	0.001	0.000	0.001	NO	NO	0.000	0.000	0.000	0.000	0.000
2C Metal Production	PM2.5	kt	0.042	0.042	0.003	0.001	0.001	0.000	0.000	0.000	NO	NO	0.000	0.000	0.000	0.000	0.000
			33.00	25.50	43.50	51.00	34.50	27.00	28.50	27.00	27.00	28.50	28.50	31.50	30.75	30.00	28.50
2D3b Road Paving	TSP	kt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2D3b Road Paving	PM10	kt	4.400	3.400	5.800	6.800	4.600	3.600	3.800	3.600	3.600	3.800	3.800	4.200	4.100	4.000	3.800
2D3b Road Paving	PM2.5	kt	0.220	0.170	0.290	0.340	0.230	0.180	0.190	0.180	0.180	0.190	0.190	0.210	0.205	0.200	0.190
2D3i Other solvent use	TSP	kt	0.022	0.014	0.009	0.016	0.031	0.061	0.065	0.054	0.038	0.044	0.038	0.046	0.045	0.042	0.050
2D3i Other solvent use	PM10	kt	0.018	0.012	0.008	0.013	0.025	0.050	0.053	0.044	0.031	0.036	0.031	0.038	0.037	0.035	0.041
2D3i Other solvent use	PM2.5	kt	0.012	0.008	0.005	0.009	0.017	0.034	0.035	0.030	0.021	0.024	0.020	0.025	0.025	0.023	0.027
% Change in Emissions																	
2A3 Glass Production	TSP	%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	-	-	-
2A3 Glass Production	PM10	%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	-	-	-
2A3 Glass Production	PM2.5	%	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%	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	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
2A5a Quarrying and mining of minerals other than coal	PM10	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2A5a Quarrying and mining of minerals other than coal	PM2.5	%	0.0%	0.0%	0.0%	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	TSP	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	-0.4%	0.0%	-0.3%	-0.5%	-0.1%	-0.2%	-3.8%	-0.5%
2A5b Construction and Demolition	PM10	%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.3%	-0.4%	0.0%	-0.3%	-0.5%	-0.1%	-0.2%	-3.8%	-0.5%
2A5b Construction and Demolition	PM2.5	%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.3%	-0.4%	0.0%	-0.3%	-0.5%	-0.1%	-0.2%	-3.8%	-0.5%
2A5c Storage and Handling of mineral products	PM2.5	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2B10b Storage, handling and transport of chemical products	TSP	%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2B10b Storage, handling and transport of chemical products	PM10	%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2B10b Storage, handling and transport of chemical products	PM2.5	%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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%	0.0%
2C Metal Production	PM10	%	0.0%	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	PM2.5	%	0.0%	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%	0.0%	0.0%
2D3b Road Paving	PM10	%	0.0%	0.0%	0.0%	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	PM2.5	%	0.0%	0.0%	0.0%	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	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%	0.0%
2D3i Other solvent use	PM10	%	0.0%	0.0%	0.0%	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	PM2.5	%	0.0%	0.0%	0.0%	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	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022																	
2B2 Nitric Acid Production	NOx	kt	0.960	0.280	0.302	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Submission 2023																	
2B2 Nitric Acid Production	NOx	kt	0.960	0.280	0.302	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
% Change in Emissions																	
2B2 Nitric Acid Production	NOx	%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	-	-	-	-

Table 4.52 Recalculations for Industrial Processes 1990–2020 (NMVOC)

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022																	
2D3a Domestic solvent use including fungicides	NMVOC	kt	7.927	8.143	8.568	9.347	10.298	10.344	10.368	10.385	10.422	10.481	10.767	10.818	10.869	11.128	11.254
2D3b Road Paving	NMVOC	kt	0.035	0.027	0.046	0.054	0.037	0.029	0.030	0.029	0.029	0.030	0.030	0.034	0.033	0.032	0.030
2D3c Asphalt Roofing	NMVOC	kt	NO	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	3.373	3.394	3.259	3.402	3.800	3.369	2.811	2.663	2.597	2.418	2.235
2D3e Degreasing	NMVOC	kt	1.743	2.388	0.847	0.953	0.885	0.925	1.004	0.795	0.885	0.686	0.885	1.189	1.708	1.675	1.256
2D3f Dry Cleaning	NMVOC	kt	0.282	0.270	0.090	0.085	0.053	0.058	0.075	0.057	0.069	0.044	0.062	0.064	0.072	0.058	0.070
2D3g Chemical products manufacturing or processing	NMVOC	kt	3.023	3.024	2.786	1.189	0.999	1.149	1.224	1.248	1.082	0.986	1.168	1.243	1.230	0.830	0.696
2D3h Printing	NMVOC	kt	2.912	2.912	1.946	2.126	2.474	1.788	1.217	1.283	1.400	1.462	1.468	1.206	1.368	0.986	0.539
2D3i Other solvent use	NMVOC	kt	1.155	0.953	1.444	3.642	1.926	2.088	1.968	1.523	1.846	1.930	1.890	1.983	2.242	2.271	2.101
2G Other product use	NMVOC	kt	0.034	0.037	0.039	0.032	0.024	0.025	0.023	0.020	0.019	0.020	0.017	0.022	0.011	0.017	0.016
2H2 Food and Beverages Industry	NMVOC	kt	9.617	10.285	9.751	13.686	18.198	18.281	20.788	22.457	19.133	20.342	21.514	26.836	27.017	29.581	26.728
Submission 2023																	
2D3a Domestic solvent use including fungicides	NMVOC	kt	7.927	8.143	8.568	9.347	10.298	10.344	10.386	10.434	10.503	10.599	10.716	10.836	10.982	11.128	11.254
2D3b Road Paving	NMVOC	kt	0.035	0.027	0.046	0.054	0.037	0.029	0.030	0.029	0.029	0.030	0.030	0.034	0.033	0.032	0.030
2D3c Asphalt Roofing	NMVOC	kt	NO	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	3.373	3.394	3.260	3.405	3.806	3.377	2.808	2.664	2.605	2.417	2.116
2D3e Degreasing	NMVOC	kt	1.743	2.388	0.847	0.953	0.885	0.925	1.004	0.795	0.885	0.686	0.885	1.189	1.708	1.675	1.256
2D3f Dry Cleaning	NMVOC	kt	0.282	0.270	0.090	0.085	0.053	0.058	0.075	0.057	0.069	0.044	0.062	0.064	0.072	0.058	0.070
2D3g Chemical products manufacturing or processing	NMVOC	kt	3.023	3.024	2.786	1.189	0.999	1.149	1.224	1.248	1.082	0.986	1.168	1.243	1.230	0.830	0.696
2D3h Printing	NMVOC	kt	2.912	2.912	1.946	2.126	2.474	1.788	1.217	1.283	1.400	1.462	1.468	1.206	1.368	0.986	0.539
2D3i Other solvent use	NMVOC	kt	1.155	0.953	1.444	3.642	1.926	2.088	1.968	1.523	1.846	1.930	1.890	1.983	2.242	2.260	2.114
2G Other product use	NMVOC	kt	0.034	0.037	0.039	0.032	0.024	0.025	0.023	0.020	0.019	0.020	0.017	0.022	0.011	0.017	0.016
2H2 Food and Beverages Industry	NMVOC	kt	9.617	10.285	9.751	13.531	18.198	18.281	20.788	22.457	19.133	20.442	21.617	26.959	27.017	29.581	26.618
% Change in Emissions																	
2D3a Domestic solvent use including fungicides	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.5%	0.8%	1.1%	-0.5%	0.2%	1.0%	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%	0.0%
2D3c Asphalt Roofing	NMVOC	%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2D3d Coating Applications	NMVOC	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	-0.1%	0.0%	0.3%	0.0%	-5.3%
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%	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%	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%	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%	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%	-0.5%	0.6%
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%	0.0%
2H2 Food and Beverages Industry	NMVOC	%	0.0%	0.0%	0.0%	-1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.5%	0.5%	0.0%	0.0%	-0.4%

Chapter Five

Agriculture

5.1 Overview of the Agriculture (NFR 3) Sector

The Agriculture sector is the largest source of NH₃ in Ireland and at 123.9 kt accounted for 99.4 per cent of national total NH₃ emissions (124.7 kt) in 2021. 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 NH₃ 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), Misselbrook and Gilhespy (2020), 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 NH₃ emissions from nitrogen fertilizer application the Tier 2 approach provided in the Inventory Guidebook (EMEP/EEA, 2019) is adopted.

The trend in emissions of NH₃ from agricultural sources is shown in Figure 5.1. Management of animal manures (3B) produced 49.8 per cent of NH₃ emissions from agriculture in 2021, with the application of inorganic fertiliser, sewage sludge and animal manures deposited and applied to soils (50.2%) accounting for the remainder. The NH₃ emission trend is largely determined by the cattle population and shows a steady increase up to 128.0 kt in 1998 (an increase by 15.2 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 NH₃ emissions in the 1999–2014 period. Emissions for the period 2015 onwards are on an upward trajectory in response to growth plans for the agricultural sector in Ireland and the removal of milk quotas in 2015. Emissions peaked in 2018 at 135.4 kt. The NH₃ emissions from the agriculture sector in 2021 were 12.5 per cent higher than the emission levels in 1990 and 8.5 per cent lower than the peak levels in 2018 and 2.4 per cent lower than the previous peak in emission levels in 1998.

NMVOCs from agriculture are estimated to be 43.38 kt in 2021, accounting for 38.2 per cent of the NMVOC inventory total (113.7 kt). Emissions from manure management (3B) make up 89.6 per cent of agriculture related NMVOC in 2021, with the remaining 10.4 per cent from cultivated crops (3De). For the calculation of NMVOC emissions, a Tier 2 methodology is adopted for cultivated crops (3De) included Chapter 3D Table 3.4 of the 2019 Inventory Guidebook (EMEP/EEA, 2019) 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_x emissions from agriculture are estimated to be 36.2 kt in 2021, accounting for 36.9 per cent of the national total (98.2 kt). Emissions from manure management (3B) make up 2.7 per cent of the agriculture related NO_x 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 42.4 per cent, 20.5 per cent, 0.2 per cent and 34.2 per cent of total agriculture emissions, respectively. Emissions in 2021 were 9.6 per cent above those in 1990. Estimates from manure management (3B) are derived from the Tier 2 mass flow approach to estimate NH₃ emissions, whilst emissions from agricultural soils (3D) utilise the Tier 1 emission factor presented in the Inventory Guidebook. The trend in NO_x emissions from agriculture is shown in Figure 5.3.

Estimates for agriculture emissions of TSP, PM₁₀ and PM_{2.5} contribute significantly to national totals for these pollutants, accounting for 17.7 per cent, 31.4 per cent and 7.6 per cent of national totals respectively. For these calculations, Tier 1 and 2 approaches provided in the Inventory Guidebook (EMEP/EEA, 2019) are adopted. For PM_{2.5} Dairy cattle (3B1a) and Non-dairy cattle (3B1b) are the main drivers of the trend accounting for 56.5 per cent of emissions from agriculture in 2021. For PM₁₀ the main driver of the trend in emissions from agriculture is Inorganic N-fertilizers (3Da1) which accounted for 70.7 per cent of emissions from agriculture in 2021. The second and third largest sources are Non-dairy cattle (3B1b) and Dairy cattle (3B1a) accounting for 3.8 per cent and 4.8 per cent, respectively of the agricultural total in 2021. A similar trend is evident for TSP with Inorganic N-fertilizers (3Da1), Non-dairy cattle (3B1b) and Dairy cattle (3B1a) accounting for 57.4 per cent, 8.6 per cent and 6.7 per cent, respectively of the agriculture sector total in 2021. The trend in PM_{2.5} 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 2021, accounting for 82.0 per cent of national total HCB emissions.

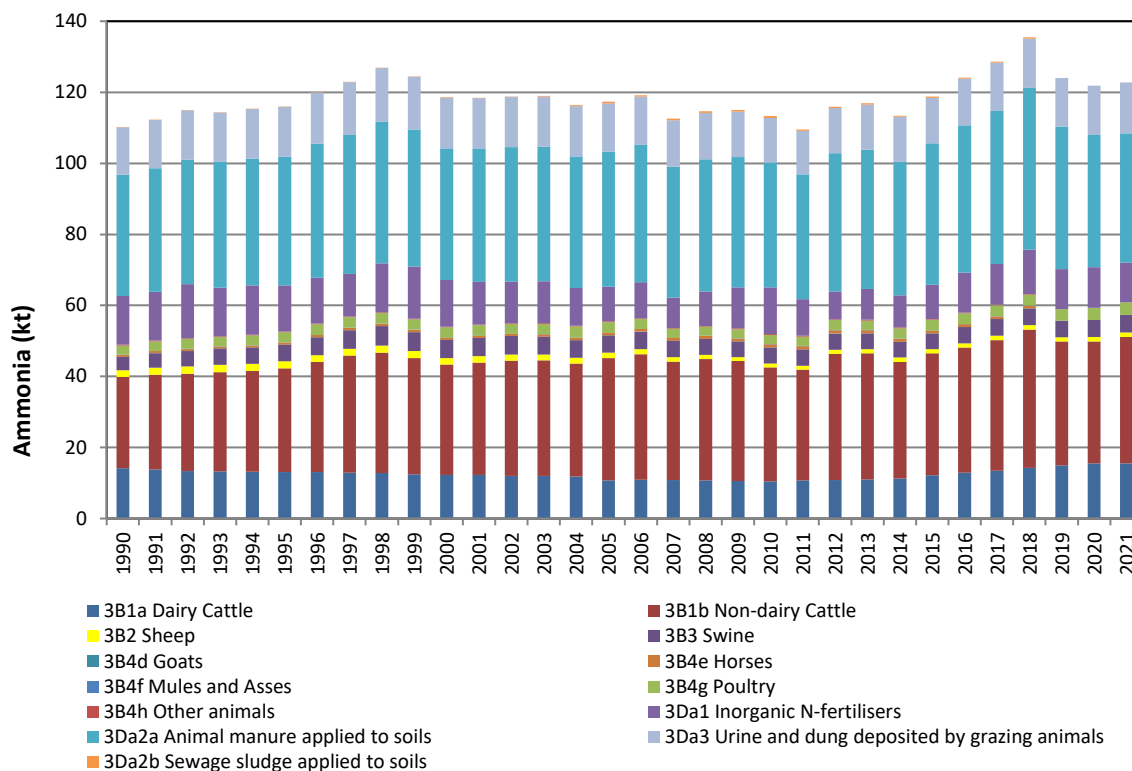


Figure 5.1. Emission Trend for Ammonia from Agriculture 1990–2021

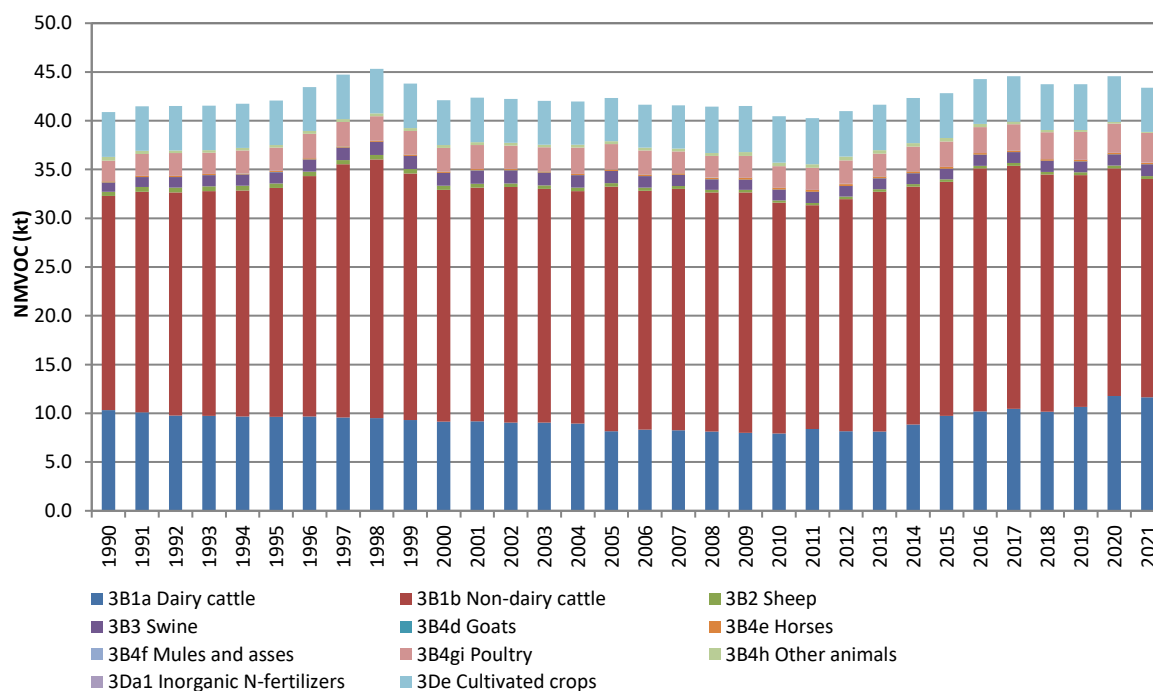


Figure 5.2. Emission Trend for NMVOC from Agriculture 1990–2021

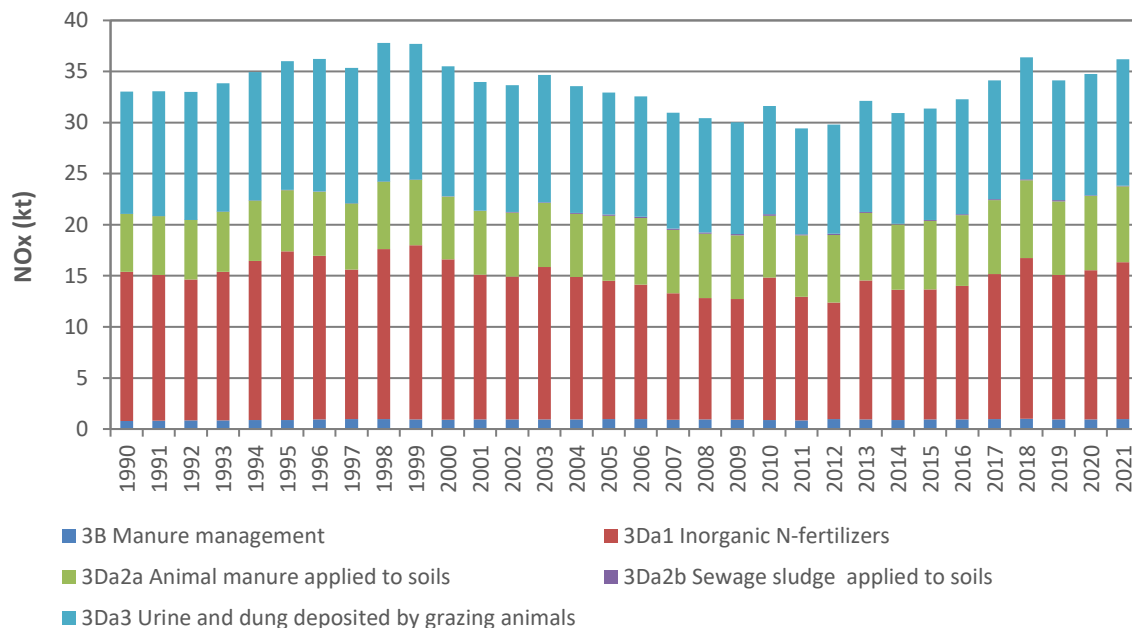


Figure 5.3. Emission Trend for NO_x from Agriculture 1990–2021

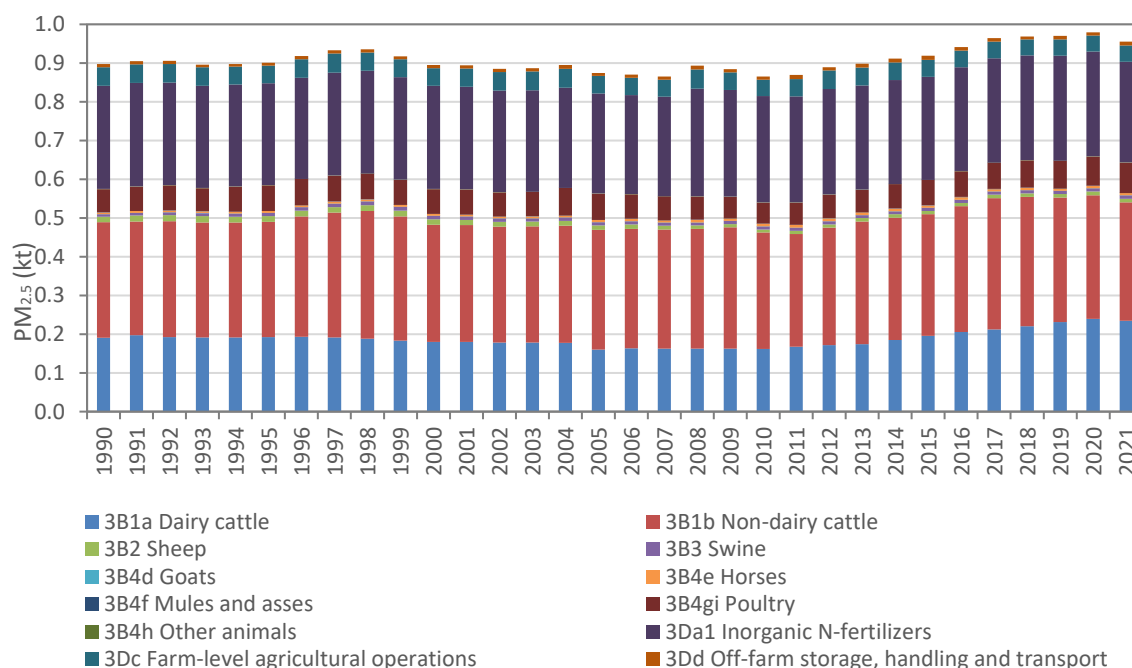


Figure 5.4. Emission Trend for PM_{2.5} from Agriculture 1990–2021

5.2 Manure Management (NFR 3B)

The following sections outline the activity data, assumptions and calculations utilised in estimating NH₃, NMVOC, NO_x, TSP, PM₁₀ and PM_{2.5} emissions from agriculture in Ireland. For NH₃ and NO_x, 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., 2022) 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. Nitrogen excretion values are presented in Table E.3 Annex E.

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 Chapter 3.B of the Inventory Guidebook (EMEP/EEA, 2019).

For TSP, PM₁₀ and PM_{2.5} emissions are estimated based upon animal numbers using the Tier 1 method and emission factors from the Inventory Guidebook (EMEP/EEA, 2019). Additional information with respect to the EFs used for NH₃, NMVOC, TSP, PM₁₀ and PM_{2.5} emission estimation is provided in Table E.7 of Annex E for.

5.2.1 Cattle (NFR 3B1)

A Farm Facilities Survey conducted in 2003 (Hyde et al., 2008) and recent analysis by Teagasc (Buckley et al., 2023) 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 across the timeseries. National averages are used for the purpose of inventory calculations. Data for the number of days housed and proportion of manure and therefore nitrogen deposited in the manure in housing systems are presented in Table E.2.1. The number of days spent grazing and the proportion of nitrogen excreted at pasture is then calculated by subtracting these values from the total number of days in the year and the total nitrogen excreted.

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, however this proportion has reduced across the timeseries. 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 and Gilhespy, 2020). 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 and Gilhespy, 2020).

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 and Gilhespy, 2020).

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 N₂O, NO and N₂ 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 NH₃ emissions from liquid manure storage in covered stores and 10 per cent of the TAN available in liquid manure stored in uncovered stores (Misselbrook and Gilhespy, 2020).

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, Buckley et al., 2023). Where manures are managed as a solid, a fraction of the TAN is immobilised in organic matter. Immobilisation of nitrogen reduces the potential for NH₃ emissions from solid manures during storage and after landspreading. The value proposed in the Inventory Guidebook (EMEP/EEA, 2019) of 0.0067 kg kg⁻¹ (Kirchmann and Winter, 1989) is applied. To fully account for all losses of N from solid manure during storage, estimates are made of N₂O, NO and N₂ losses during storage utilising the emission factors provided in the Inventory Guidebook (EMEP/EEA, 2019). An emission factor of 26.3 per cent of the TAN available in solid manure stores is utilised (Misselbrook and Gilhespy, 2020).

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. Additionally, information on the use of low emission spreading techniques (Buckley et al., 2023) is included in emission estimates. Data on broadcast spreading (splashplate), trailing hose application, trailing shoe application and injection are included. For liquid manure, a dry matter value of 6 per cent is assumed and two emission factors are applied for the proportion that is broadcast spread, 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 and Gilhespy, 2020). With respect to low emission spreading techniques the values presented in the UNECE Guidance document on preventing and abating ammonia emissions from agricultural sources (UNECE, 2014) are adopted which equate to a 30 per cent, 60 per cent and 70 per cent reduction in emission levels with the use of trailing hose, trailing shoe and injection, respectively. 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 and Gilhespy, 2020). 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_x emissions from manure (solid and liquid) application to soil.

For cattle (both dairy and non-dairy cattle) grazing an emission factor of 6 per cent of the TAN available at grazing is applied for all cattle categories (Misselbrook and Gilhespy, 2020). 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_x 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 CH₄ emissions from enteric fermentation and manure management. The feed intake values for silage, grass and concentrates 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 NH₃ emissions from storage and application with those in livestock buildings, respectively.

Emissions of TSP, PM₁₀ and PM_{2.5} 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 hill and lowland flock data from National Farm Surveys (lowland/upland) for years 2010-2021. The lowland/upland split for years 1990-2009 is extrapolated from the trendline of the 2010-2021 data. 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.2.2 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. An emission factor of 21.6 per cent of the TAN available in sheep housing (Misselbrook and Gilhespy, 2020) is applied. 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 84 and 85 days/year. No differentiation is made for upland and lowland rams, lambs and other sheep >1 year old - being housed for 56, 28 and 67 days/year respectively. In Ireland, sheep are generally housed in solid-manure-based housing systems.

The NH₃ emission factors used for the storage and landspreading of solid manure used for Cattle (3B1) are also considered appropriate for sheep manure (Misselbrook and Gilhespy, 2020). For storage of solid manure and subsequent landspreading the emission factors for solid manure from cattle are used (26.3 per cent of TAN available in the manure store and 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, N₂O and N₂ 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_x 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 NH₃ emissions from grazing sheep (Misselbrook and Gilhespy, 2020).

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, PM₁₀ and PM_{2.5} 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 average annual pig populations in the seven subcategories, thus providing an appropriate measure of the number of pigs on farms for the purposes of the annual NH₃ emission inventory.

For the NH₃ 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 29.2 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 28.6 per cent of the TAN produced in the slurry of these pig sub-categories is used and an emission factor of 12.9 per cent of the TAN in slurry produced by pigs under 20 kg (Misselbrook and Gilhespy, 2022).

For slurry storage, emissions of NH₃ 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 and Gilhespy, 2020). As is the case with cattle slurry, account is taken of the losses of N₂O, NO and N₂ 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 as no information is currently available on the use of low emission spreading techniques for pig slurry. An emission factor of 19.2 per cent (Misselbrook and Gilhespy, 2020) 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, PM₁₀ and PM_{2.5} 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 NH₃ 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 for housing of 20.0 per cent, 21.0 per cent, and 35.0 per cent, 57.0 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 30.0 per cent of TAN is applied to broiler manure, 8.0 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 (EMEP/EEA, 2019). To account for the loss of other nitrogen compounds, account is taken of the losses of N₂O, NO and N₂ 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 45.0 per cent, 38.0 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.

NM VOC, TSP, PM₁₀ and PM_{2.5} 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 NH₃, NO, NMVOC, TSP, PM₁₀ and PM_{2.5}.

For NH₃ 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, N₂O and N₂ 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_x 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, PM₁₀ and PM_{2.5} 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 NH₃ and NO_x emissions for category 3B4h in the period.

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 NH₃ emission factors for dairy and other cattle is 50 per cent, and for all other livestock categories 100 per cent. Much of NH₃ 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 PM₁₀ 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 NH₃ 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 1990-2021 (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_x emissions from the application of inorganic N-fertilizers to soil. Ireland, in previous submissions, reported emissions of PM₁₀, PM_{2.5} 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 2019 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 NH₃ 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_x emissions from the application of livestock manure to soils. Emissions of NMVOC from 3Da2a are estimated based on the Tier 2 approach and have been reported along with emissions from manure management in NFR 3B. The notation key included elsewhere (IE) is used for NMVOC for 3Da2a.

From 2018-2021 a significant decrease in NH₃ emissions from application of animal manure on soils is seen, and information regarding the use of low emission spreading techniques (LESS) is sourced from Teagasc's national Farm Survey (Buckley et al., 2023).

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

Estimates of NH₃ 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 CH₄ and N₂O from wastewater in Ireland's Greenhouse Gas Inventory. The fraction of nitrogen volatilised is 0.13 kg NH₃ 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_x 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 NH₃ 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. Emissions of NMVOC from 3Da3 are estimated based on the Tier 2 approach and have been reported along with emissions from manure management in NFR 3B. The notation key included elsewhere (IE) is used for NMVOC for 3Da3.

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

The calculation of NH₃ 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_x emissions from urine and dung deposited on soil during grazing.

5.3.6 Farm-level agricultural operations (NFR 3Dc)

Ireland reports emissions of PM₁₀ and PM_{2.5} from farm level agricultural operations under 3Dc in this submission following a recommendation from the NECD review in 2018. These emissions are estimated using Tier 2 emission factors for crop operations in wet climate conditions Table 3.5 and Table 3.7, Chapter 3.D of the inventory guidebook (EMEP/EEA, 2019)

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

In this category, fugitive PM emissions in the form of TSP, PM₁₀ and PM_{2.5} 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, PM₁₀ and PM_{2.5}, 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 - 2018 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	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
HCB (kg)	7.163	7.247	7.299	2.030	2.151	2.200	2.172	2.152	2.124	2.090	2.089	2.041	2.039	2.056	2.072

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 and research projects with respect to the identification of fires due to its importance in the estimation of non-CO₂ 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 NH₃ from N-fertilisers applied to grass grazed by livestock are difficult to distinguish from subsequent NH₃ 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

Recalculations in the agriculture sector are highlighted in tables 5.2 to 5.6. For NH₃ emissions from agriculture, there is a 0.6 per cent increase annually on average across the timeseries 1990-2020, largely due to updated AWMS data and upland/lowland split activity data for sheep reported using National Farm Survey data. In addition NH₃ emission factors for swine were updated based on updates to UK emission factors. An annual average decrease of 3.9 per cent for NMVOC emissions across the time series is evident, due to updated upland/lowland split activity data for sheep reported using National Farm Survey data. Emissions of TSP, PM₁₀ and PM_{2.5} emissions from 3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products (fertilisers) were reallocated to 2B10b following a review recommendation. The remaining emissions from handling of crops in this category were estimated in this submission using the tier 2 methodology which resulted in an increased emissions of PM₁₀ and PM_{2.5} across the timeseries 1990-2020.

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 NH₃ 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 the NARSES model and following the publication of any relevant country-specific research for the next annual submission. The inventory agency also continues to engage with the DAFM and various other bodies including the research community to identify new mechanisms for the capture of the use of abatement technologies.

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

Table 5.2. NH₃ Recalculations for Agriculture 1990–2020

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022																			
3B1a Manure management - Dairy cattle	NH ₃	kt	14.18	13.06	12.25	10.72	10.71	10.58	10.45	10.75	10.84	10.97	11.31	12.22	12.89	13.47	14.09	14.50	15.06
3B1b Manure management - Non-dairy cattle	NH ₃	kt	25.68	29.19	31.10	34.41	34.19	33.75	32.06	31.16	35.54	35.56	32.81	34.28	35.25	36.51	38.92	35.07	34.68
3B2 Manure management - Sheep	NH ₃	kt	1.48	1.51	1.51	1.30	1.02	0.95	0.94	0.96	1.00	1.00	0.98	0.97	0.97	1.04	1.01	0.99	1.06
3B3 Manure management - Swine	NH ₃	kt	3.80	4.70	5.10	4.92	4.47	4.37	4.55	4.58	4.51	4.41	4.48	4.42	4.59	4.69	4.68	4.71	4.89
3B4d Manure management - Goats	NH ₃	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	0.02	0.02	0.02
3B4e Manure management - Horses	NH ₃	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	0.72	0.70	0.75
3B4f Manure management - Mules and asses	NH ₃	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	0.05	0.06	0.06
3B4gi Manure management - Laying hens	NH ₃	kt	0.34	0.24	0.23	0.26	0.25	0.29	0.29	0.29	0.35	0.38	0.40	0.44	0.45	0.47	0.49	0.50	0.51
3B4gii Manure management - Broilers	NH ₃	kt	1.08	1.49	1.67	1.73	1.31	1.60	1.60	1.55	1.55	1.45	1.63	1.65	1.66	1.64	1.62	1.73	1.85
3B4giii Manure management - Turkeys	NH ₃	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	0.91	0.86	0.91
3B4giv Manure management - Other poultry	NH ₃	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	0.11	0.12	0.13	0.14
3B4h Manure management - Other animals (please specify in IIR)	NH ₃	kt	0.30	0.18	0.19	0.19	0.18	0.23	0.21	0.21	0.23	0.23	0.23	0.20	0.18	0.16	0.14	0.12	0.09
3Da1 Inorganic N-fertilizers (includes also urea application)	NH ₃	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	12.57	11.02	11.44
3Da2a Animal manure applied to soils	NH ₃	kt	33.98	35.94	36.85	37.92	37.13	36.58	35.15	35.03	38.83	39.08	37.50	39.74	41.35	42.67	44.89	40.16	37.18
3Da2b Sewage sludge applied to soils	NH ₃	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	0.29	0.34	0.25
3Da3 Urine and dung deposited by grazing animals	NH ₃	kt	12.98	13.70	14.08	13.56	12.93	12.70	12.42	12.16	12.55	12.68	12.57	12.68	13.07	13.51	13.84	13.66	13.80
Total	NH₃	kt	109.25	114.88	117.87	116.90	114.23	114.66	113.01	108.78	115.60	116.54	112.97	118.36	123.73	127.66	134.37	124.55	122.68
Submission 2023																			
3B1a Manure management - Dairy cattle	NH ₃	kt	14.16	13.05	12.24	10.72	10.71	10.58	10.45	10.75	10.84	10.97	11.31	12.21	12.89	13.40	14.21	14.98	15.49
3B1b Manure management - Non-dairy cattle	NH ₃	kt	25.68	29.19	31.10	34.41	34.19	33.75	32.06	31.16	35.54	35.56	32.81	34.28	35.25	36.82	39.00	34.86	34.32
3B2 Manure management - Sheep	NH ₃	kt	1.90	1.98	1.85	1.53	1.21	1.13	1.09	1.12	1.18	1.18	1.19	1.16	1.17	1.25	1.23	1.20	1.30
3B3 Manure management - Swine	NH ₃	kt	3.79	4.69	5.09	4.92	4.46	4.36	4.54	4.57	4.51	4.41	4.48	4.42	4.59	4.69	4.68	4.71	4.81
3B4d Manure management - Goats	NH ₃	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	0.02	0.02	0.02
3B4e Manure management - Horses	NH ₃	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	0.72	0.70	0.75
3B4f Manure management - Mules and asses	NH ₃	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	0.05	0.06	0.06
3B4gi Manure management - Laying hens	NH ₃	kt	0.34	0.24	0.23	0.26	0.25	0.29	0.29	0.29	0.35	0.38	0.40	0.44	0.45	0.47	0.49	0.50	0.51
3B4gii Manure management - Broilers	NH ₃	kt	1.08	1.49	1.67	1.73	1.31	1.60	1.60	1.55	1.55	1.45	1.63	1.65	1.66	1.64	1.62	1.73	1.85
3B4giii Manure management - Turkeys	NH ₃	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	0.91	0.86	0.91
3B4giv Manure management - Other poultry	NH ₃	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	0.11	0.12	0.13	0.14
3B4h Manure management - Other animals (please specify in IIR)	NH ₃	kt	0.30	0.18	0.19	0.19	0.18	0.23	0.21	0.21	0.23	0.23	0.23	0.20	0.18	0.16	0.14	0.12	0.09
3Da1 Inorganic N-fertilizers (includes also urea application)	NH ₃	kt	13.69	13.01	13.17	9.76	9.75	11.58	13.16	10.33	7.84	8.69	9.03	9.69	11.23	11.46	12.57	11.23	11.44
3Da2a Animal manure applied to soils	NH ₃	kt	34.18	36.18	37.03	38.03	37.23	36.67	35.23	35.11	38.92	39.17	37.61	39.84	41.45	43.13	45.48	40.17	37.24

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
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	0.29	0.34	0.25
3Da3 Urine and dung deposited by grazing animals	NH3	kt	13.29	14.05	14.28	13.66	13.02	12.80	12.50	12.25	12.64	12.78	12.68	12.79	13.19	13.54	13.91	13.66	13.87
Total	NH3	kt	110.15	115.92	118.58	117.34	114.61	115.01	113.31	109.50	115.95	116.92	113.39	118.76	124.15	128.63	135.43	125.24	123.03
<i>% Change in Emissions</i>																			
3B1a Manure management - Dairy cattle	NH ₃	%	-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%	-0.5%	0.8%	3.3%	2.8%
3B1b Manure management - Non-dairy cattle	NH ₃	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	0.2%	-0.6%	-1.0%
3B2 Manure management - Sheep	NH ₃	%	28.2%	31.4%	22.9%	17.5%	18.7%	18.6%	16.1%	17.3%	17.3%	18.7%	20.7%	19.7%	20.4%	20.6%	21.5%	20.8%	22.6%
3B3 Manure management - Swine	NH ₃	%	-0.4%	-0.2%	-0.1%	-0.1%	-0.2%	-0.2%	-0.2%	-0.1%	-0.1%	0.0%	0.0%	0.0%	-0.1%	-0.1%	0.0%	0.0%	-1.7%
3B4d Manure management - Goats	NH ₃	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 ₃	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 ₃	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 ₃	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 ₃	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4giii Manure management - Turkeys	NH ₃	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 ₃	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 ₃	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 ₃	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.8%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	1.9%	0.0%
3Da2a Animal manure applied to soils	NH ₃	%	0.6%	0.7%	0.5%	0.3%	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%	0.3%	0.2%	0.2%	1.1%	1.3%	0.0%	0.1%
3Da2b Sewage sludge applied to soils	NH ₃	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 ₃	%	2.4%	2.5%	1.4%	0.7%	0.7%	0.7%	0.7%	0.8%	0.7%	0.8%	0.9%	0.8%	0.9%	0.3%	0.5%	0.0%	0.5%
Total	NH3	%	0.8%	0.9%	0.6%	0.4%	0.3%	0.3%	0.3%	0.7%	0.3%	0.3%	0.4%	0.3%	0.3%	0.8%	0.8%	0.6%	0.3%

Table 5.3. NMVOC Recalculations for Agriculture 1990–2020

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022																			
3B1a Manure management - Dairy cattle	NMVOC	kt	10.32	9.63	9.16	8.16	8.12	8.00	7.92	8.38	8.16	8.13	8.85	9.75	10.20	10.49	10.22	10.75	11.31
3B1b Manure management - Non-dairy cattle	NMVOC	kt	21.96	23.48	23.76	25.08	24.52	24.66	23.67	22.95	23.79	24.59	24.38	23.98	24.91	24.95	24.37	23.76	23.45
3B2 Manure management - Sheep	NMVOC	kt	0.57	0.60	0.57	0.46	0.37	0.34	0.31	0.32	0.35	0.35	0.36	0.35	0.35	0.37	0.37	0.36	0.38
3B3 Manure management - Swine	NMVOC	kt	1.11	2.76	3.06	2.98	2.66	2.59	2.70	2.76	2.73	2.68	2.72	2.68	2.78	2.83	2.85	2.88	2.96
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	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	0.16	0.15	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	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	0.59	0.60	0.62
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	1.30	1.39	1.48
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	0.67	0.64	0.67
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	0.18	0.19	0.21	0.23
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	0.35	0.31	0.27	0.23	0.20	0.14
3Da1 Inorganic N-fertilizers (includes urea application)	NMVOC	kt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3De Cultivated crops	NMVOC	kt	4.58	4.56	4.59	4.43	4.78	4.76	4.75	4.74	4.69	4.65	4.63	4.60	4.62	4.66	4.68	4.70	4.70
Total	NMVOC	kt	41.17	43.81	43.98	44.14	43.12	43.14	42.12	41.98	42.72	43.30	44.02	44.50	46.01	46.43	45.64	45.63	46.12
Submission 2023																			
3B1a Manure management - Dairy cattle	NMVOC	kt	10.32	9.63	9.16	8.16	8.12	8.00	7.92	8.38	8.16	8.13	8.85	9.75	10.20	10.46	10.17	10.66	11.79
3B1b Manure management - Non-dairy cattle	NMVOC	kt	21.96	23.48	23.76	25.08	24.52	24.66	23.67	22.95	23.79	24.59	24.38	23.98	24.91	24.91	24.31	23.76	23.31
3B2 Manure management - Sheep	NMVOC	kt	0.44	0.46	0.44	0.36	0.28	0.26	0.24	0.25	0.27	0.27	0.28	0.27	0.27	0.29	0.28	0.28	0.30
3B3 Manure management - Swine	NMVOC	kt	0.95	1.15	1.30	1.27	1.07	1.04	1.10	1.12	1.09	1.11	1.13	1.09	1.13	1.13	1.14	1.14	1.15
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	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	0.16	0.15	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	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	0.59	0.60	0.62
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	1.30	1.39	1.48
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	0.67	0.64	0.67
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	0.18	0.19	0.21	0.23
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	0.35	0.31	0.27	0.23	0.20	0.14
3Da1 Inorganic N-fertilizers (includes urea application)	NMVOC	kt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3De Cultivated crops	NMVOC	kt	4.58	4.56	4.59	4.43	4.78	4.76	4.75	4.74	4.69	4.65	4.63	4.60	4.62	4.66	4.68	4.70	4.70
Total	NMVOC	kt	40.88	42.07	42.09	42.33	41.46	41.53	40.45	40.27	40.99	41.65	42.35	42.83	44.28	44.58	43.75	43.73	44.55
% Change in Emissions																			
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%	0.0%	-0.3%	-0.4%	-0.8%	4.2%
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%	-0.2%	-0.3%	0.0%	-0.6%
3B2 Manure management - Sheep	NMVOC	%	-22.7%	-22.6%	-22.8%	-22.9%	-22.9%	-22.9%	-22.9%	-22.8%	-22.9%	-22.8%	-22.8%	-22.8%	-22.7%	-22.7%	-22.7%	-22.7%	-22.2%
3B3 Manure management - Swine	NMVOC	%	-14.5%	-58.2%	-57.6%	-57.4%	-59.7%	-59.6%	-59.3%	-59.3%	-60.1%	-58.5%	-58.5%	-59.3%	-59.3%	-60.2%	-59.9%	-60.4%	-61.2%
3B4d Manure management - Goats	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%	0.0%	0.0%
3B4e Manure management - Horses	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%	0.0%	0.0%
3B4f Manure management - Mules and asses	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%	0.0%	0.0%
3B4gi Manure management - Laying hens	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%	0.0%	0.0%
3B4gii Manure management - Broilers	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%	0.0%	0.0%
3B4giii Manure management - Turkeys	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%	0.0%	0.0%
3B4giv Manure management - Other poultry	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%	0.0%	0.0%
3B4h Manure management - Other animals	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%	0.0%	0.0%
3Da1 Inorganic N-fertilizers (includes urea application)	NMVOC	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3De Cultivated crops	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%	0.0%	0.0%
Total	NMVOC	%	-0.7%	-4.0%	-4.3%	-4.1%	-3.9%	-3.8%	-4.0%	-4.1%	-4.0%	-3.8%	-3.8%	-3.7%	-3.8%	-4.0%	-4.2%	-4.2%	-3.4%

Table 5.4. TSP Recalculations for Agriculture 1990–2020

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022																			
3B1a Manure management - Dairy cattle	TSP	kt	0.64	0.64	0.60	0.54	0.55	0.55	0.54	0.56	0.58	0.59	0.62	0.66	0.69	0.71	0.73	0.75	0.78
3B1b Manure management - Non-dairy cattle	TSP	kt	0.99	0.98	1.00	1.02	1.02	1.04	0.99	0.96	1.00	1.05	1.04	1.04	1.08	1.10	1.10	1.07	1.06
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	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	1.28	1.30	1.35
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	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	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	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	0.68	0.69	0.71
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	0.48	0.51	0.55
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	0.15	0.14	0.15
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	0.06	0.06	0.07
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	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	7.05	7.06	7.04
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	0.17	0.15	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	0.19	0.24	0.20
Submission 2023																			
3B1a Manure management - Dairy cattle	TSP	kt	0.64	0.64	0.60	0.54	0.55	0.55	0.54	0.56	0.58	0.59	0.62	0.66	0.69	0.71	0.74	0.78	0.81
3B1b Manure management - Non-dairy cattle	TSP	kt	0.99	0.98	1.00	1.02	1.02	1.04	0.99	0.96	1.00	1.05	1.04	1.04	1.08	1.12	1.11	1.06	1.06
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	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	1.28	1.30	1.32
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	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	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	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	0.68	0.69	0.71
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	0.48	0.51	0.55
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	0.15	0.14	0.15
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	0.06	0.06	0.07
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	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	7.05	7.06	7.04
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	TSP	kt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
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	0.19	0.24	0.20
% Change in Emissions																			
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%	0.2%	2.0%	4.3%	3.9%
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%	1.9%	0.6%	-0.3%	-0.7%
3B2 Manure management - Sheep	TSP	%	-0.1%	0.1%	-0.2%	-0.3%	-0.2%	-0.2%	-0.2%	-0.1%	-0.3%	-0.2%	-0.1%	-0.1%	0.0%	-0.1%	0.0%	-0.1%	0.6%
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%	0.0%	0.0%	-2.2%
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%	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%	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%	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%	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%	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	2018	2019	2020
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%	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%	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%	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%	0.0%	0.0%	0.0%	0.0%	0.0%
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	TSP	%																	
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%	0.0%	0.0%	0.0%

Table 5.5. PM₁₀ Recalculations for Agriculture 1990–2020

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022																		
3B1a Manure management - Dairy cattle	PM ₁₀	kt	0.29	0.29	0.27	0.24	0.25	0.25	0.26	0.26	0.27	0.28	0.30	0.31	0.32	0.33	0.34	0.35
3B1b Manure management - Non-dairy cattle	PM ₁₀	kt	0.44	0.44	0.45	0.46	0.47	0.45	0.44	0.46	0.47	0.47	0.47	0.49	0.50	0.50	0.48	0.48
3B2 Manure management - Sheep	PM ₁₀	kt	0.04	0.05	0.04	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
3B3 Manure management - Swine	PM ₁₀	kt	0.15	0.18	0.20	0.19	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.19	0.19	0.20
3B4d Manure management - Goats	PM ₁₀	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	0.00	0.00
3B4e Manure management - Horses	PM ₁₀	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	0.01	0.01
3B4f Manure management - Mules and asses	PM ₁₀	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	0.00	0.00
3B4gi Manure management - Laying hens	PM ₁₀	kt	0.07	0.05	0.06	0.08	0.09	0.09	0.09	0.10	0.11	0.12	0.13	0.13	0.14	0.14	0.15	0.15
3B4gii Manure management - Broilers	PM ₁₀	kt	0.16	0.22	0.25	0.26	0.24	0.24	0.23	0.23	0.22	0.24	0.24	0.25	0.24	0.24	0.26	0.27
3B4giii Manure management - Turkeys	PM ₁₀	kt	0.17	0.18	0.15	0.14	0.10	0.10	0.12	0.13	0.12	0.13	0.14	0.14	0.14	0.15	0.14	0.15
3B4giv Manure management - Other poultry	PM ₁₀	kt	0.05	0.05	0.05	0.08	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.07
3B4h Manure management - Other animals	PM ₁₀	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	0.00	0.00
3Da1 Inorganic N-fertilizers (includes urea application)	PM ₁₀	kt	6.93	6.85	6.93	6.71	7.17	7.13	7.11	7.07	6.99	6.97	6.91	6.96	7.00	7.05	7.06	7.04
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM ₁₀	kt	0.06	0.06	0.06	0.05	0.04	0.05	0.04	0.04	0.05	0.04	0.04	0.05	0.05	0.05	0.05	0.05
3Dd Off-farm storage, handling and transport of bulk agricultural products	PM ₁₀	kt	0.05	0.04	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.06	0.07	0.06	0.06	0.05	0.06	0.05
Submission 2023																		
3B1a Manure management - Dairy cattle	PM ₁₀	kt	0.29	0.29	0.27	0.24	0.25	0.25	0.26	0.26	0.27	0.28	0.30	0.31	0.32	0.34	0.35	0.37
3B1b Manure management - Non-dairy cattle	PM ₁₀	kt	0.44	0.44	0.45	0.46	0.47	0.45	0.44	0.46	0.48	0.47	0.47	0.49	0.51	0.50	0.48	0.48
3B2 Manure management - Sheep	PM ₁₀	kt	0.04	0.05	0.04	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
3B3 Manure management - Swine	PM ₁₀	kt	0.15	0.18	0.20	0.19	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.19	0.19	0.19
3B4d Manure management - Goats	PM ₁₀	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	0.00	0.00
3B4e Manure management - Horses	PM ₁₀	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	0.01	0.01
3B4f Manure management - Mules and asses	PM ₁₀	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	0.00	0.00
3B4gi Manure management - Laying hens	PM ₁₀	kt	0.07	0.05	0.06	0.08	0.09	0.09	0.09	0.10	0.11	0.12	0.13	0.13	0.14	0.14	0.15	0.15
3B4gii Manure management - Broilers	PM ₁₀	kt	0.16	0.22	0.25	0.26	0.24	0.24	0.23	0.23	0.22	0.24	0.24	0.25	0.24	0.24	0.26	0.27
3B4giii Manure management - Turkeys	PM ₁₀	kt	0.17	0.18	0.15	0.14	0.10	0.10	0.12	0.13	0.12	0.13	0.14	0.14	0.14	0.15	0.14	0.15
3B4giv Manure management - Other poultry	PM ₁₀	kt	0.05	0.05	0.05	0.08	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.07
3B4h Manure management - Other animals	PM ₁₀	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	0.00	0.00
3Da1 Inorganic N-fertilizers (includes urea application)	PM ₁₀	kt	6.93	6.85	6.93	6.71	7.17	7.13	7.11	7.07	6.99	6.97	6.91	6.96	7.00	7.05	7.06	7.04
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM ₁₀	kt	1.18	1.10	1.09	1.10	1.13	1.03	1.12	1.17	1.14	1.13	1.08	1.06	1.04	1.00	1.01	1.00
3Dd Off-farm storage, handling and transport of bulk agricultural products	PM ₁₀	kt	0.05	0.04	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.06	0.07	0.06	0.06	0.05	0.06	0.05
% Change in Emissions																		
3B1a Manure management - Dairy cattle	PM ₁₀	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	1.9%	4.2%	3.8%
3B1b Manure management - Non-dairy cattle	PM ₁₀	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%	0.8%	-0.4%	-0.6%
3B2 Manure management - Sheep	PM ₁₀	%	-0.1%	0.1%	-0.2%	-0.3%	-0.2%	-0.2%	-0.1%	-0.3%	-0.2%	-0.1%	-0.1%	0.0%	-0.1%	0.0%	-0.1%	0.6%
3B3 Manure management - Swine	PM ₁₀	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-1.9%
3B4d Manure management - Goats	PM ₁₀	%	0.0%	0.0%	0.0%	0.0%	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 ₁₀	%	0.0%	0.0%	0.0%	0.0%	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 ₁₀	%	0.0%	0.0%	0.0%	0.0%	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 ₁₀	%	0.0%	0.0%	0.0%	0.0%	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	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
3B4gii Manure management - Broilers	PM ₁₀	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4giii Manure management - Turkeys	PM ₁₀	%	0.0%	0.0%	0.0%	0.0%	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 ₁₀	%	0.0%	0.0%	0.0%	0.0%	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 ₁₀	%	0.0%	0.0%	0.0%	0.0%	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 ₁₀	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM ₁₀	%	1959%	1688%	1873%	2214%	2905%	2166%	2795%	2878%	2289%	2421%	2323%	2240%	1985%	1719%	%	%
3Dd Off-farm storage, handling and transport of bulk agricultural products	PM ₁₀	%	0.0%	0.0%	0.0%	0.0%	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_{2.5} Recalculations for Agriculture 1990–2020

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022																			
3B1a Manure management - Dairy cattle	PM _{2.5}	kt	0.19	0.19	0.18	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.19	0.20	0.21	0.21	0.22	0.22	0.23
3B1b Manure management - Non-dairy cattle	PM _{2.5}	kt	0.30	0.30	0.30	0.31	0.31	0.31	0.30	0.29	0.30	0.32	0.32	0.31	0.33	0.33	0.33	0.32	0.32
3B2 Manure management - Sheep	PM _{2.5}	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	0.01	0.01	0.01
3B3 Manure management - Swine	PM _{2.5}	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	0.01	0.01	0.01
3B4d Manure management - Goats	PM _{2.5}	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	0.00	0.00	0.00
3B4e Manure management - Horses	PM _{2.5}	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	0.01	0.01	0.01
3B4f Manure management - Mules and asses	PM _{2.5}	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	0.00	0.00	0.00
3B4gi Manure management - Laying hens	PM _{2.5}	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	0.01	0.01	0.01
3B4gii Manure management - Broilers	PM _{2.5}	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	0.02	0.02	0.03
3B4giii Manure management - Turkeys	PM _{2.5}	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	0.03	0.03	0.03
3B4giv Manure management - Other poultry	PM _{2.5}	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	0.01	0.01	0.01
3B4h Manure management - Other animals	PM _{2.5}	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	0.00	0.00	0.00
3Da1 Inorganic N-fertilizers (includes urea application)	PM _{2.5}	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	0.27	0.27	0.27
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM _{2.5}	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	0.01	0.01	0.01
3Dd Off-farm storage, handling and transport of bulk agricultural products	PM _{2.5}	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	0.01	0.01	0.01
Submission 2023																			
3B1a Manure management - Dairy cattle	PM _{2.5}	kt	0.19	0.19	0.18	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.19	0.20	0.21	0.21	0.22	0.23	0.24
3B1b Manure management - Non-dairy cattle	PM _{2.5}	kt	0.30	0.30	0.30	0.31	0.31	0.31	0.30	0.29	0.30	0.32	0.32	0.31	0.33	0.34	0.33	0.32	0.32
3B2 Manure management - Sheep	PM _{2.5}	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	0.01	0.01	0.01
3B3 Manure management - Swine	PM _{2.5}	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	0.01	0.01	0.01
3B4d Manure management - Goats	PM _{2.5}	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	0.00	0.00	0.00
3B4e Manure management - Horses	PM _{2.5}	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	0.01	0.01	0.01
3B4f Manure management - Mules and asses	PM _{2.5}	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	0.00	0.00	0.00
3B4gi Manure management - Laying hens	PM _{2.5}	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	0.01	0.01	0.01
3B4gii Manure management - Broilers	PM _{2.5}	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	0.02	0.02	0.03
3B4giii Manure management - Turkeys	PM _{2.5}	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	0.03	0.03	0.03
3B4giv Manure management - Other poultry	PM _{2.5}	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	0.01	0.01	0.01
3B4h Manure management - Other animals	PM _{2.5}	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	0.00	0.00	0.00
3Da1 Inorganic N-fertilizers (includes urea application)	PM _{2.5}	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	0.27	0.27	0.27
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM _{2.5}	kt	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04
3Dd Off-farm storage, handling and transport of bulk agricultural products	PM _{2.5}	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	0.01	0.01	0.01
% Change in Emissions																			
3B1a Manure management - Dairy cattle	PM _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	2.0%	4.3%	3.8%
3B1b Manure management - Non-dairy cattle	PM _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.9%	0.6%	-0.3%	-0.7%
3B2 Manure management - Sheep	PM _{2.5}	%	-0.1%	0.1%	-0.2%	-0.3%	-0.2%	-0.2%	-0.2%	-0.1%	-0.3%	-0.2%	-0.1%	-0.1%	0.0%	-0.1%	0.0%	-0.1%	0.6%
3B3 Manure management - Swine	PM _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-1.8%

NFR Category	Pollutant	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
3B4d Manure management - Goats	PM _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3B4giii Manure management - Turkeys	PM _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM _{2.5}	%	573%	493%	551%	664%	891%	875%	640%	842%	868%	677%	713%	687%	667%	587%	496%	573%	548%
3Dd Off-farm storage, handling and transport of bulk agricultural products	PM _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	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 ₁₀ , PM _{2.5}
5B1 Biological treatment of waste - Composting	NH ₃ , CO
5B2 Biological treatment of waste - Anaerobic digestion at biogas facilities	NO, NA, NE
5C1a Municipal waste incineration	NO
5C1bi Industrial waste incineration	NO _x , SO ₂ , NMVOC, CO, TSP, PM _{2.5} , PM ₁₀ , 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 _x , SO ₂ , NMVOC, CO, TSP, PM _{2.5} , PM ₁₀ , 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 _x , SO ₂ , NMVOC, CO, TSP, PM _{2.5} , PM ₁₀ , 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 _{2.5} , PM ₁₀ , 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 five pollutants. Category Industrial waste incineration (5C1bi) is a key category for two pollutants: As and Cr, accounting for 54.3 per cent and 18.8 per cent of national total emissions, respectively. This category is the largest source of As in Ireland's 2021 inventory. The second key category in the waste sector is Other waste (5E) for two pollutants: PCDD/F and PCBs. The category accounts for 41.3 per cent of national total PCB emissions in Ireland's 2021 inventory. The category also accounts for 16.2 per cent of national total PCDD/F emissions. Solid waste disposal on land (5A) is a key category for Mercury (Hg) accounting for 6.3 per cent of the national total in 2021. Cremation (5C1bv) is a key category for mercury (Hg) and accounts for 4.0 percent of the national total in 2021.

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

1990-2021, showing a decrease of 52.4 per cent from 0.83 kt in 1990 to 0.40 kt in 2021. 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 volume of landfill gas (Gm³) using standard temperature and pressure (STP) molar conversion factors.

Emission of TSP, PM₁₀ and PM_{2.5} 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, PM₁₀ and PM_{2.5} from Solid Waste Disposal on Land

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NMVOC (kt)	0.83	1.01	0.80	0.64	0.18	0.19	0.29	0.41	0.46	0.47	0.45	0.44	0.42	0.42	0.40
TSP (t)	0.89	0.90	1.01	0.88	0.69	0.51	0.36	0.29	0.30	0.37	0.31	0.21	0.19	0.17	0.18
PM ₁₀ (t)	0.42	0.43	0.48	0.42	0.33	0.24	0.17	0.13	0.14	0.18	0.15	0.10	0.09	0.08	0.08
PM _{2.5} (t)	0.06	0.06	0.07	0.06	0.05	0.04	0.03	0.02	0.02	0.03	0.02	0.02	0.01	0.01	0.01

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	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Hg (kg)	28.96	18.27	18.68	20.15	22.00	22.46	22.35	22.28	22.08	21.98	21.93	21.75	21.63	21.55	21.33

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 currently no information in Ireland on the release of POPs from landfill gas and no emission factors are given in the Inventory Guidebook (EMEP/EEA, 2019).

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 NH₃ 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 6.4.

Table 6.4 Time Series of Activity Data and Emissions of NH₃ and CO from Composting

Year	2001	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Waste composted (kt)	22.2	271.4	284.5	283.2	257.1	259	239.4	231.2	228.4	254.7	244.3	259.1	247.3	254.6
NH ₃ (kt)	0.01	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.05	0.06	0.06	0.06	0.06	0.06
CO (kt)	0.01	0.15	0.16	0.16	0.14	0.15	0.13	0.13	0.13	0.14	0.14	0.15	0.14	0.14

6.4 Waste Incineration (NFR 5C)

Ireland carries out less waste incineration compared with some European countries and there is currently no incineration of MSW without energy recovery occurring in Ireland. 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_x, SO₂, NMVOC, CO, TSP, PM₁₀, PM_{2.5} 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 6.5.

Emission factors for: NO_x, CO, NMVOC, SO_x, TSP, PM₁₀ and PM_{2.5} 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 6.5.

Table 6.5 Time Series of Emissions from the Incineration of Clinical Waste

Year	1990	1991	1992	1993	1994	1995	1996	1997
NO _x (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 _x (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 ₁₀ (kt)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
PM _{2.5} (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	0.40	0.40
Cd (t)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cr (kg)	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Cu (kg)	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
Pb (t)	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Hg (t)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Ni (kg)	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Zn (t)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
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

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 6.5.

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.

Table 6.6 Time Series of Emissions from the Incineration of Industrial (incl. Hazardous & Sludge) Waste

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NO _x (kt)	0.02	0.02	0.02	0.03	0.02	0.01	0.01	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	1.28	1.06	1.01	0.92	0.93	0.52	0.58	0.48	0.65	0.67	0.76
NMVOG (kt)	0.20	0.20	0.15	0.27	0.13	0.11	0.11	0.10	0.10	0.06	0.06	0.05	0.07	0.07	0.08
SO _x (t)	1.27	1.27	0.94	1.70	0.86	0.71	0.68	0.62	0.62	0.35	0.39	0.32	0.44	0.45	0.51
TSP (t)	0.27	0.27	0.20	0.36	0.18	0.15	0.14	0.13	0.13	0.07	0.08	0.07	0.09	0.10	0.11
PM ₁₀ (t)	0.19	0.19	0.14	0.25	0.13	0.11	0.10	0.09	0.09	0.05	0.06	0.05	0.07	0.07	0.08
PM _{2.5} (t)	0.11	0.11	0.08	0.14	0.07	0.06	0.06	0.05	0.05	0.03	0.03	0.03	0.04	0.04	0.04
As (t)	0.55	0.56	0.58	0.62	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.66	0.66	0.67	0.67
Cd (kg)	2.71	2.71	2.00	3.62	1.82	1.51	1.44	1.31	1.33	0.75	0.82	0.68	0.93	0.96	1.08
Cr (t)	0.53	0.54	0.56	0.60	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.64	0.64	0.65	0.65
Cu (t)	0.29	0.30	0.31	0.33	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.36	0.36
Pb (t)	0.04	0.04	0.03	0.05	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Hg (kg)	1.52	1.52	1.12	2.03	1.02	0.85	0.81	0.73	0.74	0.42	0.46	0.38	0.52	0.53	0.60
Ni (kg)	0.38	0.38	0.28	0.51	0.26	0.21	0.20	0.18	0.19	0.10	0.12	0.10	0.13	0.13	0.15
Zn (t)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PCDD/F (g-I-TEQ)	0.03	0.03	0.08	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.61	1.31	0.35	0.01	0.00
PCBs (kg)	0.09	0.08	0.03	0.03	0.01	0.01	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	0.00	0.00	0.00	0.00	0.00	0.01
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	0.00
B[b]F (kg)	0.07	0.05	0.02	0.03	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.01	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	0.00	0.01	0.00	0.01	0.01	0.01

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 6.6, while the emission factors used are presented in Table F.1 of Annex F. 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 6.6.

Emission factors for: NO_x, CO, NMVOC, SO_x, TSP, PM₁₀ and PM_{2.5} 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 6.6.

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 a significant period, 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 1990–2021 (Table F.1 of Annex F). Emission factors for: NO_x, CO, NMVOC, SO_x, TSP, PM₁₀ and PM_{2.5} 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.

Table 6.7 Time Series of Emissions from Crematoria

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NO _x (t)	1.24	1.24	1.82	2.03	2.54	3.07	3.37	3.73	4.11	4.52	4.92	5.34	5.81	6.81	7.51
CO (t)	0.21	0.21	0.31	0.34	0.43	0.52	0.57	0.63	0.70	0.77	0.84	0.91	0.99	1.16	1.27
NMVOG (t)	0.02	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.11	0.12
SO _x (t)	0.17	0.17	0.25	0.28	0.35	0.42	0.46	0.51	0.56	0.62	0.67	0.73	0.80	0.93	1.03
TSP (t)	0.06	0.06	0.08	0.09	0.12	0.14	0.16	0.17	0.19	0.21	0.23	0.25	0.27	0.32	0.35
PM ₁₀ (t)	0.05	0.05	0.08	0.09	0.11	0.13	0.14	0.16	0.17	0.19	0.21	0.22	0.24	0.29	0.32
PM _{2.5} (t)	0.05	0.05	0.08	0.09	0.11	0.13	0.14	0.16	0.17	0.19	0.21	0.22	0.24	0.29	0.32
As (g)	20.42	20.42	29.94	33.45	41.96	50.62	55.54	61.48	67.85	74.49	81.18	88.17	95.88	112.31	123.89
Cd (g)	7.55	7.55	11.07	12.36	15.51	18.71	20.53	22.72	25.07	27.53	30.00	32.58	35.44	41.51	45.79
Cr (g)	20.34	20.34	29.83	33.32	41.81	50.43	55.34	61.25	67.60	74.21	80.89	87.84	95.53	111.90	123.44
Cu (g)	18.65	18.65	27.35	30.55	38.32	46.23	50.73	56.15	61.96	68.03	74.14	80.52	87.57	102.57	113.15
Pb (g)	45.05	45.05	66.07	73.80	92.58	111.68	122.55	135.65	149.70	164.35	179.13	194.53	211.56	247.81	273.36
Hg (kg)	2.24	2.24	3.28	3.66	4.59	5.54	6.08	6.73	7.43	8.15	8.89	9.65	10.50	12.30	13.56
Ni (kg)	0.03	0.03	0.04	0.04	0.05	0.06	0.07	0.08	0.09	0.09	0.10	0.11	0.12	0.14	0.16
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	0.00
HCBs (g)	0.23	0.23	0.33	0.37	0.46	0.56	0.61	0.68	0.75	0.82	0.89	0.97	1.06	1.24	1.37
B[a]p (g)	0.02	0.03	0.03	0.03	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.09	0.09	0.11	0.12

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. This is as a result of requirements imposed on farmers who are in receipt of payments under the Common Agricultural Policy and national agri-environmental schemes⁴. Therefore, emission estimates from these sources are reported as “NO” (not occurring).

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 Teagasc 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.

⁴ <http://www.agriculture.gov.ie/farmerschemespayments/crosscompliance/>

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 6.8.

Emissions of NO_x, SO₂, NMVOC, CO and particles from this small source are not estimated and are therefore reported as “NE”.

Table 6.8 Time Series of Emissions from the Open Burning of Farm Plastics

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
PCDD/F (g-I-TEQ)	0.94	1.10	0.65	0.23	1.15	0.39	0.28	0.45	0.49	0.46	0.50	0.59	0.83	0.48	0.45
PCBs (kg)	1.59	1.86	1.11	0.39	1.96	0.67	0.48	0.77	0.84	0.78	0.84	1.01	1.41	0.82	0.76
B[a]p (kg)	0.28	0.33	0.20	0.07	0.34	0.12	0.08	0.13	0.15	0.14	0.15	0.18	0.25	0.14	0.13
B[b]F (kg)	1.26	1.48	0.88	0.31	1.55	0.53	0.38	0.61	0.67	0.62	0.67	0.80	1.12	0.65	0.60
B[k]F (kg)	1.26	1.48	0.88	0.31	1.55	0.53	0.38	0.61	0.67	0.62	0.67	0.80	1.12	0.65	0.60

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/m³ 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, PM₁₀ and PM_{2.5}. Each of these combustion sources is described in the following sections. The activity data associated with each type of fire is shown in Table 6.9.

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 6.9).

Table 6.9 Time Series of activity data from Accidental Fires from Vehicles and Buildings

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Vehicle fires	4130	4130	7749	4907	4534	2937	1609	1637	2681	1607	2137	2667	2316	1885	1827
Building fires-detached	1344	1344	1344	1263	1671	1306	800	770	1392	621	860	1099	946	989	828
Building fires-undetached	2015	2015	2015	1894	2506	1959	1200	1155	2088	931	1290	1649	1420	1484	1243
Apartment fires	426	426	426	470	245	246	242	214	240	192	211	229	209	217	204
Industrial fires	508	508	508	433	453	343	270	288	458	234	317	400	386	284	318

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 other 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, PM₁₀ and PM_{2.5}, 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 2000–2021 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 1990–2021 time series are presented in Table 6.10. Emission factors are compiled in Table F.2 of Annex F. Ireland has included estimates of TSP, PM₁₀ and PM_{2.5} emissions in this using the emission factors from the Inventory Guidebook (EMEP/EEA, 2019).

Table 6.10 Time Series of Emissions from Accidental Fires from Vehicles and Buildings

Year	1990	1995	2000	2005	2010	2014	2015	2016	2017	2018	2019	2020	2021
PCDD/F (g-I-TEQ)	5.33	5.33	3.87	3.39	4.28	1.93	3.46	1.59	2.19	2.78	2.40	2.45	2.08
PCBs (kg)	6.37	6.37	4.14	3.82	5.00	2.30	4.13	1.86	2.57	3.28	2.82	2.94	2.47
B[a]p (kg)	1.5E-05	1.5E-05	9.7E-06	9.0E-06	1.2E-05	5.4E-06	9.7E-06	4.4E-06	6.0E-06	7.7E-06	6.6E-06	6.9E-06	5.8E-06
B[b]F (kg)	2.4E-05	2.4E-05	1.5E-05	1.4E-05	1.9E-05	8.6E-06	1.5E-05	6.9E-06	9.6E-06	1.2E-05	1.1E-05	1.1E-05	9.2E-06
B[k]F (kg)	8.4E-06	8.4E-06	5.4E-06	5.0E-06	6.6E-06	3.0E-06	5.4E-06	2.4E-06	3.4E-06	4.3E-06	3.7E-06	3.9E-06	3.2E-06
I(123-cd)P (kg)	1.6E-05	1.6E-05	1.1E-05	9.7E-06	1.3E-05	5.9E-06	1.1E-05	4.7E-06	6.6E-06	8.4E-06	7.2E-06	7.5E-06	6.3E-06
TSP (kt)	0.36	0.36	0.37	0.34	0.43	0.20	0.36	0.17	0.23	0.29	0.25	0.26	0.22
PM10 (kt)	0.36	0.36	0.37	0.34	0.43	0.20	0.36	0.17	0.23	0.29	0.25	0.26	0.22
PM2.5 (kt)	0.36	0.36	0.37	0.34	0.43	0.20	0.36	0.17	0.23	0.29	0.25	0.26	0.22

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,)), with data calculated for other years using waste statistical data (<http://www.epa.ie/nationalwastestatistics>). “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 2004–2021, 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 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 1990–2021 time series are presented in Table 6.11.

Table 6.11 Time Series of Emissions from Other Waste Burning

Year	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
PCDD/F (g-I-TEQ)	1.15	1.29	1.72	2.24	0.72	0.70	0.66	0.63	0.63	0.63	0.63	0.64	0.64	0.64	0.65
PCBs (kg)	7.73	9.46	14.75	21.21	1.43	1.15	0.70	0.24	0.24	0.25	0.25	0.26	0.27	0.18	0.24
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	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	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	0.01
I(123-cd)P (kg)	0.82	0.83	0.85	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

6.7 Recalculations in the Waste Sector

There were no significant recalculations in the waste sector as can be seen in Table 6.12

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.

National inventory experts are currently investigating the relevant sources of information with respect to 5B2 Anaerobic digestion which is very much in its infancy in Ireland and will include estimates of emissions for the relevant pollutants as and when sufficient activity data and knowledge of feedstocks is gathered. It is envisaged that the likely level of emissions from this category will be of the order of tonnes of NH₃ and thus negligible. There is no further update on this category in this submission. In practice there is a small number of test/pilot digesters in Ireland. However, there is no regulation regarding the collection of data in respect of the feedstocks of these digesters. The inventory agency is working with the Department of Agriculture, Food and Marine to get this information. The activity data issue relates primarily to feedstocks that are not classified as wastes and do not have waste codes, mainly animal manures/slurries and crop residues or grass inputs. We have managed to collect the food wastes input data, but to estimate emissions from this category requires the animal manure amounts, otherwise a double count of emissions would occur in agriculture. It seems that the manure/slurry and cellulose material input is much greater than the food waste.

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

Table 6.12 Recalculations for Waste 1990–2020

NFR Category	Pollutant	Unit	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022															
5A Solid waste disposal on land	NMVOC	kt	1.01	0.80	0.64	0.18	0.19	0.29	0.41	0.46	0.47	0.45	0.44	0.43	0.42
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
5A Solid waste disposal on land	PM ₁₀	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
5A Solid waste disposal on land	PM _{2.5}	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
5A Solid waste disposal on land	Hg	t	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-I-TEQ	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5A Solid waste disposal on land	PCBs	kg	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Submission 2023															
5A Solid waste disposal on land	NMVOC	kt	1.01	0.80	0.64	0.18	0.19	0.29	0.41	0.46	0.47	0.45	0.44	0.42	0.42
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
5A Solid waste disposal on land	PM ₁₀	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
5A Solid waste disposal on land	PM _{2.5}	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
5A Solid waste disposal on land	Hg	t	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-I-TEQ	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5A Solid waste disposal on land	PCBs	kg	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
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%	-1.3%
5A Solid waste disposal on land	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%
5A Solid waste disposal on land	PM ₁₀	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5A Solid waste disposal on land	PM _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	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%	0.3%	0.0%	0.2%	0.5%	0.8%	1.1%	0.0%	0.6%	1.5%	0.5%	-0.1%
5A Solid waste disposal on land	PCDD/F	%	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
5A Solid waste disposal on land	PCBs	%	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

NFR Category	Pollutant	Unit	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022															
5B Biological treatment of waste - Composting	NH ₃	kt	NO	NO	0.07	0.07	0.06	0.06	0.06	0.06	0.05	0.06	0.06	0.06	0.06
5B Biological treatment of waste - Composting	CO	kt	NO	NO	0.15	0.16	0.14	0.15	0.13	0.13	0.13	0.14	0.14	0.15	0.15
Submission 2023															
5B Biological treatment of waste - Composting	NH ₃	kt	NO	NO	0.07	0.07	0.06	0.06	0.06	0.06	0.05	0.06	0.06	0.06	0.06
5B Biological treatment of waste - Composting	CO	kt	NO	NO	0.15	0.16	0.14	0.15	0.13	0.13	0.13	0.14	0.14	0.15	0.14
% Change in Emission															
5B Biological treatment of waste - Composting	NH ₃	%	NO	NO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-4.6%
5B Biological treatment of waste - Composting	CO	%	NO	NO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-4.6%

NFR Category	Pollutant	Unit	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022															
5C Waste Incineration	NO _x	kt	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
5C Waste Incineration	NMVOG	kt	0.20	0.15	0.27	0.13	0.11	0.11	0.10	0.10	0.06	0.06	0.05	0.07	0.07
5C Waste Incineration	SO ₂	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
5C Waste Incineration	TSP	kt	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 ₁₀	kt	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 _{2.5}	kt	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	0.00	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	0.03	0.05	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
5C Waste Incineration	Hg	t	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	2.62	0.73	0.25	1.16	0.40	0.29	0.46	0.51	0.48	1.10	1.90	1.18	0.50
5C Waste Incineration	PCBs	kg	1.95	1.15	0.42	1.97	0.68	0.49	0.78	0.85	0.79	0.85	1.02	1.42	0.83
5C Waste Incineration	HCB	t	0.05	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.01	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
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
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
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
Submission 2023															
5C Waste Incineration	NO _x	kt	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.02
5C Waste Incineration	NMVOG	kt	0.20	0.15	0.27	0.13	0.11	0.11	0.10	0.10	0.06	0.06	0.05	0.07	0.07
5C Waste Incineration	SO ₂	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
5C Waste Incineration	TSP	kt	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 ₁₀	kt	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 _{2.5}	kt	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	0.00	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	0.03	0.05	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
5C Waste Incineration	Hg	t	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	2.62	0.73	0.25	1.16	0.40	0.29	0.46	0.51	0.48	1.10	1.90	1.18	0.50
5C Waste Incineration	PCBs	kg	1.95	1.15	0.42	1.97	0.68	0.49	0.78	0.85	0.79	0.85	1.02	1.42	0.83
5C Waste Incineration	HCB	t	0.05	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.01	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
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
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
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
% Change in Emission															
5C Waste Incineration	NO _x	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.2%
5C Waste Incineration	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%	6.0%
5C Waste Incineration	SO ₂	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.9%
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%	1.3%

NFR Category	Pollutant	Unit	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020
5C Waste Incineration	PM ₁₀	%	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%
5C Waste Incineration	PM _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%
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%	5.7%
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%	5.9%
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%	0.2%
5C Waste Incineration	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%	0.0%
5C Waste Incineration	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%	0.0%
5C Waste Incineration	HCB	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.7%
5C Waste Incineration	B[a]P	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
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%	0.1%
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%	0.1%
5C Waste Incineration	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%

NFR Category	Pollutant	Unit	1995	2000	2005	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020
Submission 2022															
5E Other Waste	TSP		0.36	0.37	0.34	0.43	0.34	0.21	0.20	0.36	0.17	0.23	0.29	0.25	0.26
5E Other Waste	PM ₁₀		0.36	0.37	0.34	0.43	0.34	0.21	0.20	0.36	0.17	0.23	0.29	0.25	0.26
5E Other Waste	PM _{2.5}		0.36	0.37	0.34	0.43	0.34	0.21	0.20	0.36	0.17	0.23	0.29	0.25	0.26
5E Other Waste	PCDD/F	g-l-TEQ	6.43	5.59	5.63	5.01	3.99	2.66	2.55	4.08	2.22	2.82	3.42	3.04	3.10
5E Other Waste	PCBs	kg	15.58	18.89	25.04	6.43	5.04	3.09	2.54	4.38	2.11	2.82	3.54	3.09	3.19
5E Other Waste	B[a]P	t	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	0.03	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	0.02	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
Submission 2023															
5E Other Waste	TSP		0.36	0.37	0.34	0.43	0.34	0.21	0.20	0.36	0.17	0.23	0.29	0.25	0.26
5E Other Waste	PM ₁₀		0.36	0.37	0.34	0.43	0.34	0.21	0.20	0.36	0.17	0.23	0.29	0.25	0.26
5E Other Waste	PM _{2.5}		0.36	0.37	0.34	0.43	0.34	0.21	0.20	0.36	0.17	0.23	0.29	0.25	0.26
5E Other Waste	PCDD/F	g-l-TEQ	6.62	5.59	5.63	5.01	3.99	2.66	2.56	4.08	2.22	2.82	3.42	3.04	3.10
5E Other Waste	PCBs	kg	15.83	18.89	25.04	6.43	5.04	3.09	2.54	4.38	2.11	2.82	3.54	3.09	3.12
5E Other Waste	B[a]P	t	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	0.03	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	0.02	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
% Change in Emission															
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%
5E Other Waste	PM ₁₀	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5E Other Waste	PM _{2.5}	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5E Other Waste	PCDD/F	%	3.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.2%	-0.1%	0.0%	0.2%	0.0%	-0.2%
5E Other Waste	PCBs	%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-2.4%
5E Other Waste	B[a]P	%	0.0%	0.0%	0.0%	0.0%	0.2%	0.5%	0.8%	1.1%	-0.5%	0.2%	1.0%	0.0%	-0.1%
5E Other Waste	B[b]F	%	0.0%	0.0%	0.0%	0.0%	0.2%	0.5%	0.8%	1.1%	-0.5%	0.2%	1.0%	0.0%	-0.4%
5E Other Waste	B[k]F	%	0.0%	0.0%	0.0%	0.0%	0.2%	0.4%	0.7%	1.1%	-0.4%	0.2%	1.0%	0.0%	-1.1%
5E Other Waste	I[123-cd]P	%	0.1%	0.0%	0.0%	0.0%	0.2%	0.5%	0.8%	1.1%	-0.5%	0.2%	1.0%	0.0%	0.0%

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 reporting requirements are identical.

The development of a high-resolution model for distribution of emissions was part of a 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

GNFR
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
'MEMO' ITEMS - NOT TO BE INCLUDED IN NATIONAL TOTALS
O_AviCruise
P_IntShipping
z_Memo
N_Natural

Table 7.2. Correspondence list for GNFR and NFR categories

NFR	NFR name	GNFR
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
1A3aii(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
1A3dii	National navigation (shipping)	G_Shipping

NFR	NFR name	GNFR
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
2H3	Other industrial processes	B_Industry

NFR	NFR name	GNFR
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
'MEMO' ITEMS - NOT TO BE INCLUDED IN NATIONAL TOTALS		
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 2019 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 2019 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

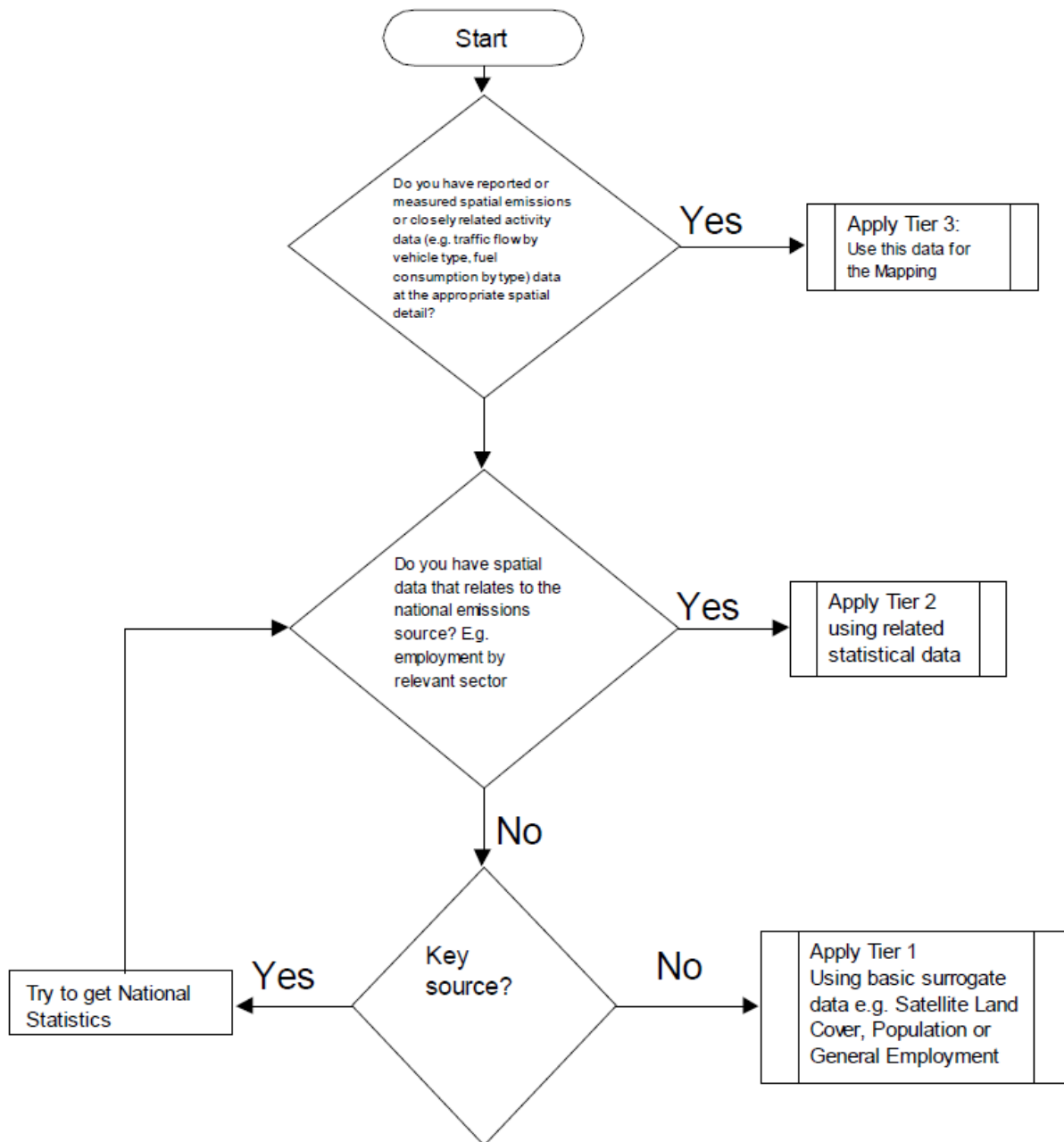


Figure 7.1 General decision tree for emissions mapping (EMEP/EEA 2019)

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 accurately, 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 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).

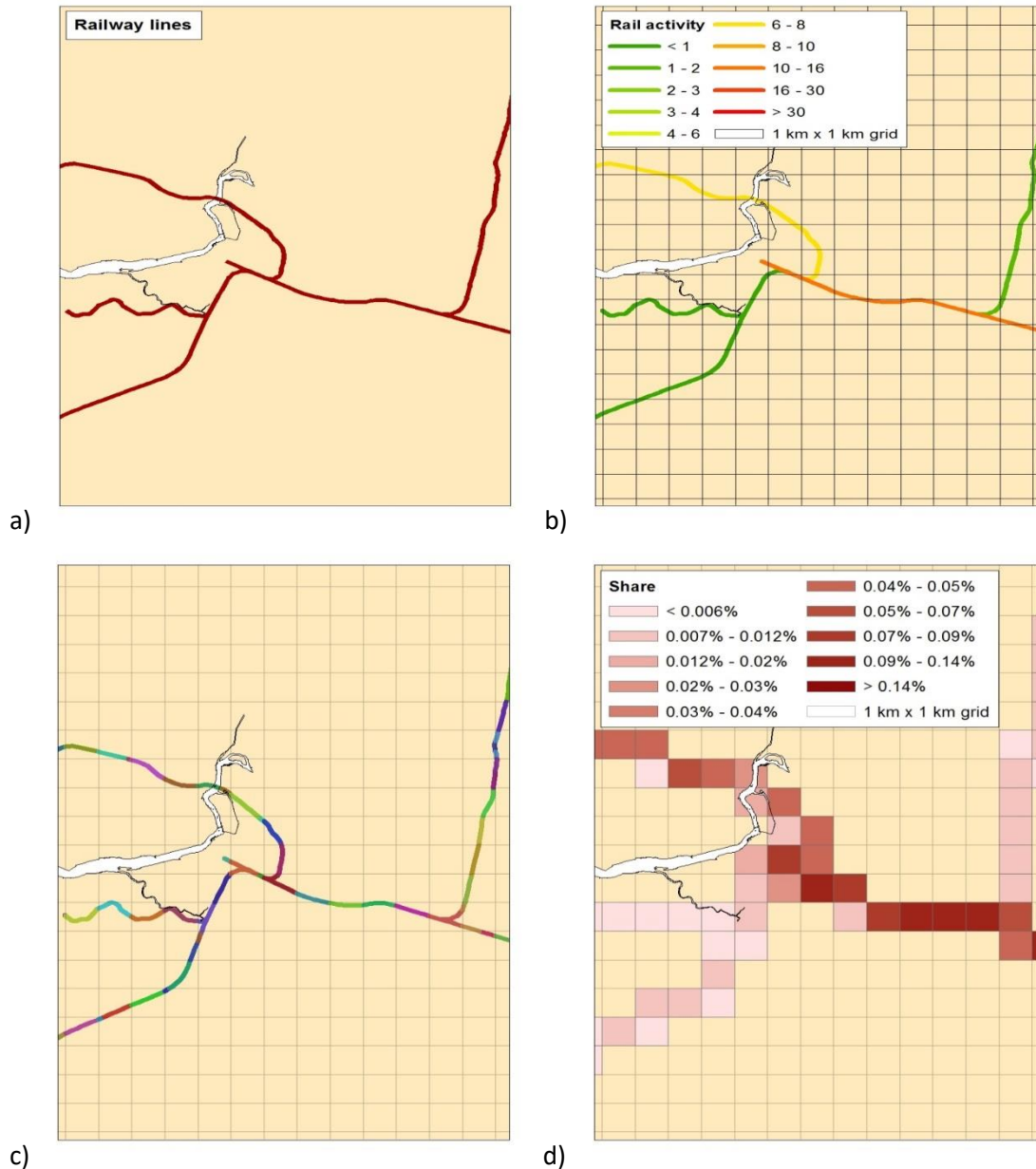


Figure 7.2 Example of GeoKey preparation

The emission mapping is made using an orthogonal grid with a resolution of 1 km x 1 km in the Irish projection TM65 (EPSG 29902). 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 NR. 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 NR 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.

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 the major 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).

This is considered tier 1/2 methodologies.

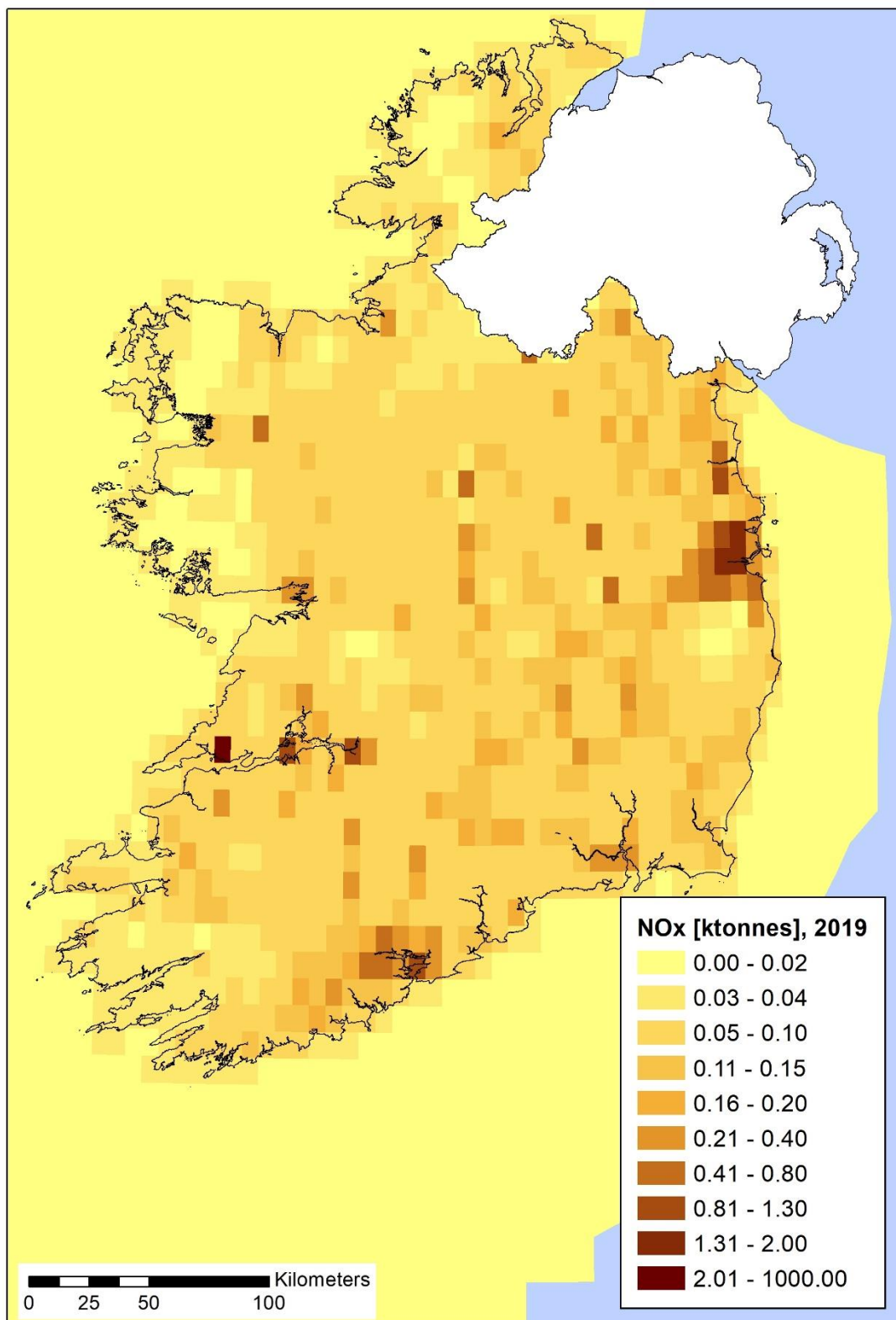
7.3.14 International navigation (GNFR P_IntShipping)

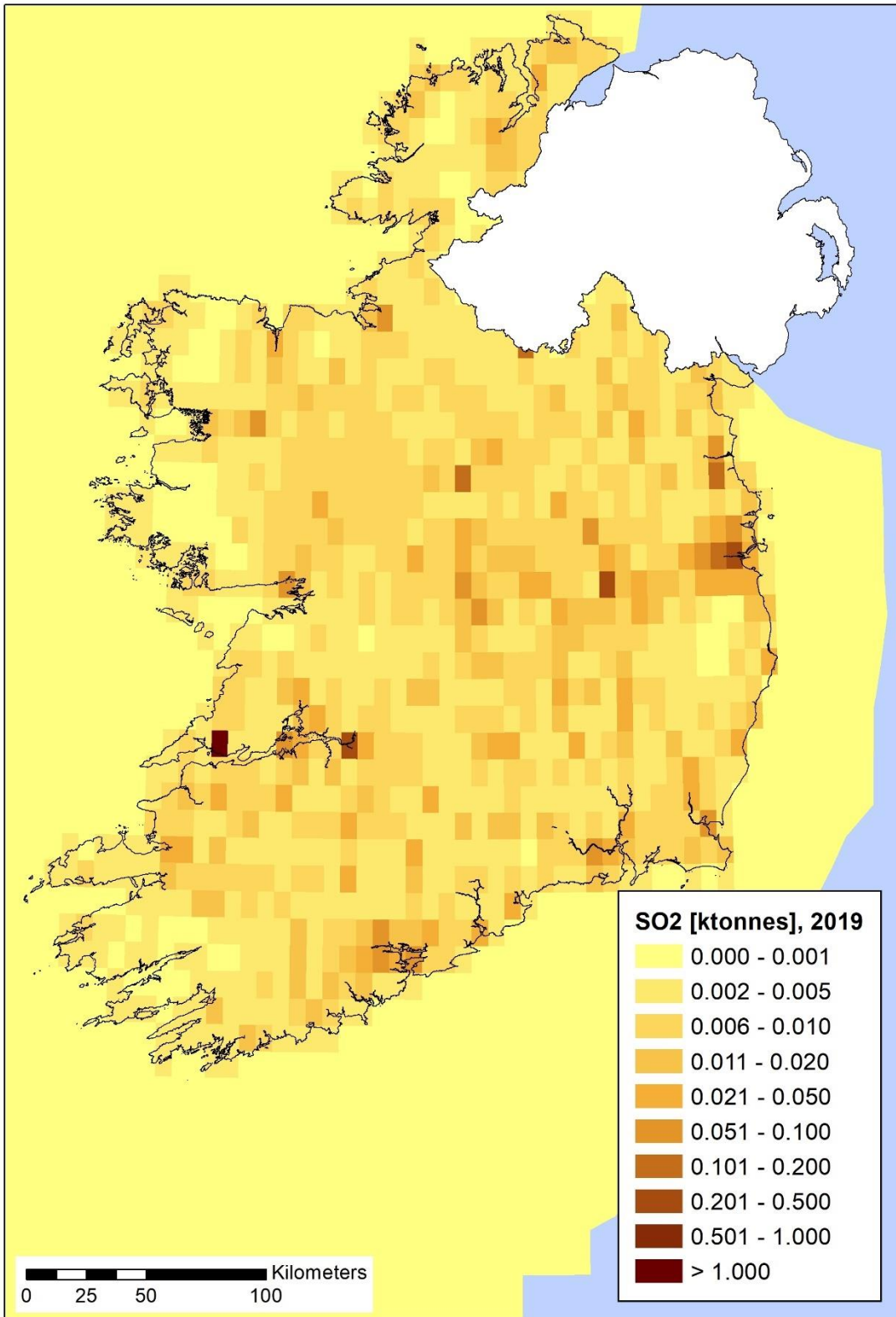
Emissions from international navigation will largely occur outside the Irish territory, but for the purposes of the submission, emissions are allocated evenly across the sea area outlined by the Irish Exclusive Economic Zone (EEZ).

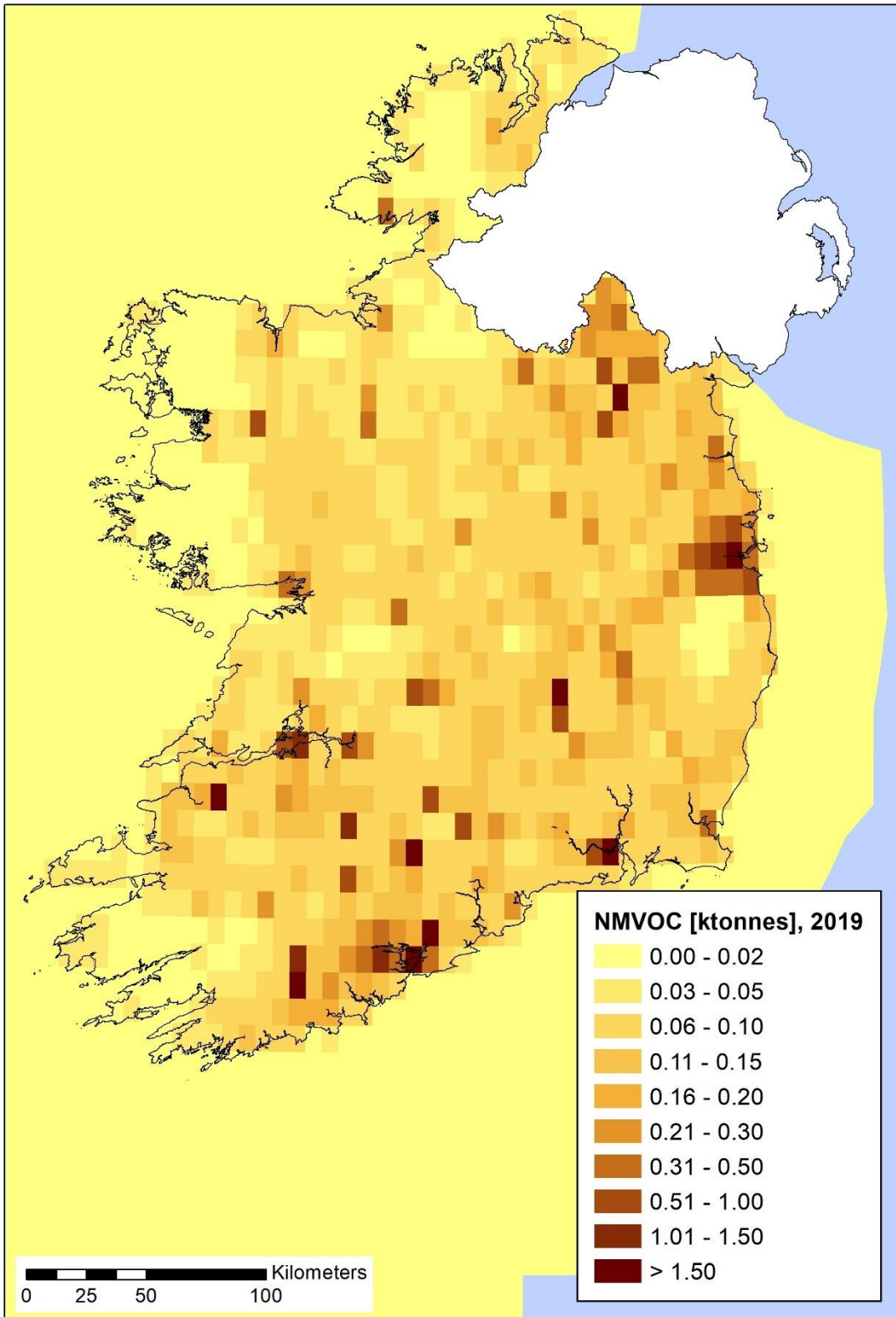
This approach is a tier 1 method.

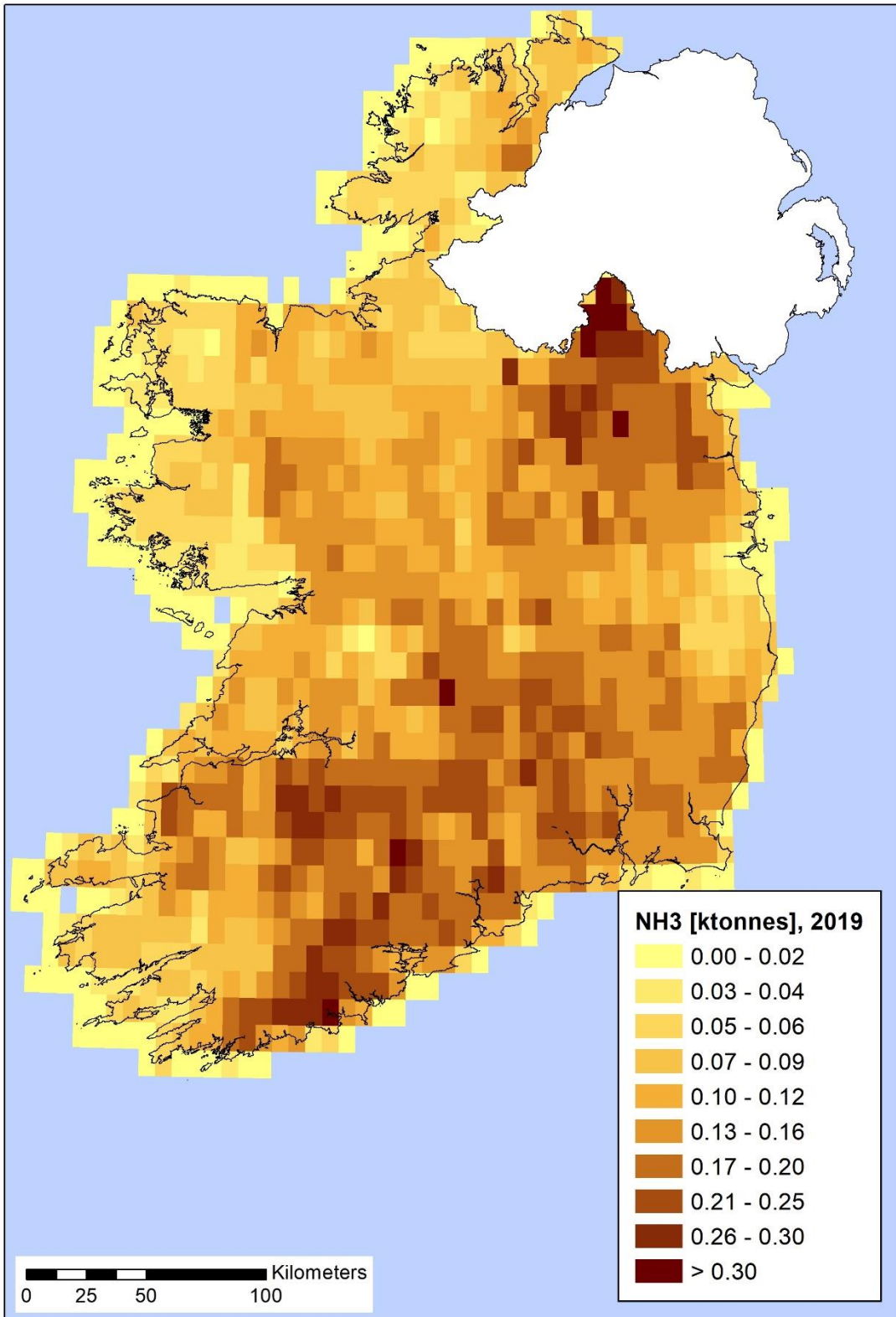
7.4 National total emission mapped by the EMEP 0.1 degree x 0.1 degree grid

Figure 7.3 a-e present the mapped national total emissions for NO_x, SO₂, NMVOC, NH₃, and PM_{2.5} in Ireland by EMEP 0.1 x 0.1 degree grid.









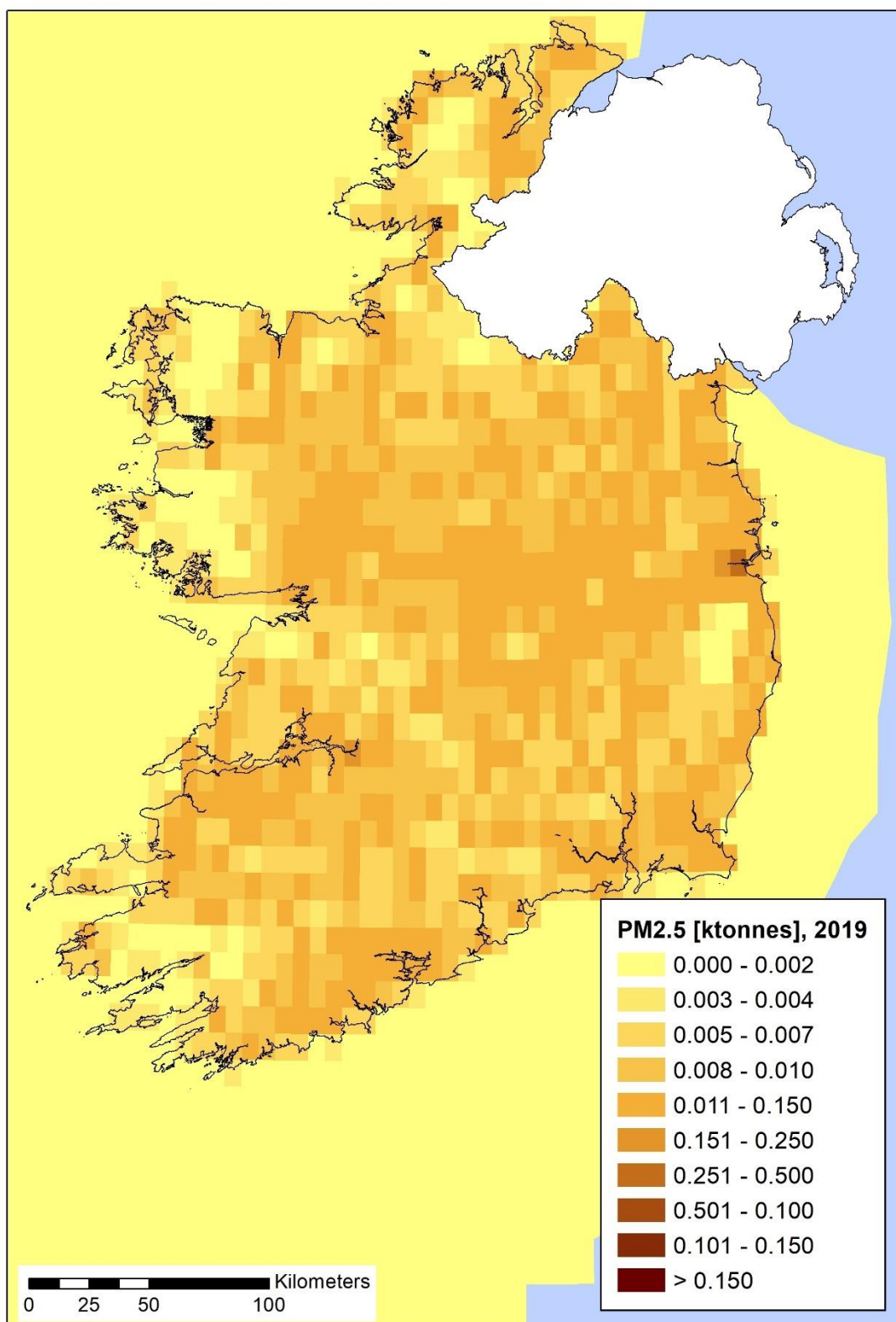


Figure 7.3 National Total Emissions in 2015 for a) NO_x, b) SO₂, c) NMVOC, d) NH₃, and e) PM_{2.5}

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 Governance of the Energy Union and Climate Action Regulation (EU) 2018/1999. In this section an overview of the emission projections is discussed.

Section 8.2 describes emission commitments for 2025 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 present 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 (EU) 2016/2284 requires biennial reporting from 2017 of projected emissions for SO₂, NO_x, NH₃, NMVOC, PM_{2.5} and, if available, Black Carbon (BC) covering projection years 2020, 2025, 2030 and, where available, 2040 and 2050. 2023 is a mandatory reporting year.

The CLRTAP guidelines for reporting emissions projections 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 SO₂, NO_x, NH₃, NMVOC, PM_{2.5} and BC under Directive (EU) 2016/2284 utilising the updated 2023 reporting template contained within annex IV of the Guidelines for Reporting Emissions and Projections Data under the CLRTAP⁵.

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 commitments for the period 2021-2030: NO_x, SO₂, NMVOC, NH₃ and PM_{2.5}.

⁵ [Reporting instructions \(ceip.at\)](https://ceip.at)

8.2 Emission Reduction Commitments 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 2016⁶, Directive (EU) 2016/2284. Emission reduction commitments have been set for Ireland for 2020 and 2030 for NO_x, SO_x, NMVOC, NH₃, and PM_{2.5}. Table 8.1 details the emission reduction commitments in place for each pollutant for 2020 and 2030 for Ireland under Directive (EU) 2016/2284.

Table 8.1. Emission Reduction Commitments for 2020 and 2030 (expressed as a percentage reduction on 2005 levels)

Pollutant	SO ₂	NO _x	NH ₃	NMVOC	PM _{2.5}
2020	65%	49%	1%	25%	18%
2030	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 2023 emissions projections were prepared by Sustainable Energy Authority of Ireland (SEAI) in conjunction with the Economic and Social Research Institute (ESRI). The ESRI produce energy demand projections using the I3E model (Ireland Environment, Energy and Economy model)⁷.
- Agricultural projections provided by Teagasc (Agriculture and Food Development Authority) in February 2023 which consider the impact of Food Wise 2025⁸, Food Vision 2030⁹ and the impacts of the Brexit related Trade and Cooperation Agreement (TCA) reached between the EU for the agriculture sector.

SEAI compile two energy projections scenarios, which are used in national emission projections:

- The *Baseline or With Existing Measures* (WEM) energy projections project 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 2021, the latest inventory year. It includes progress in the implementation of policies and measures as set out in Ireland's National Renewable Energy Action Plan (NREAP), National Energy Efficiency Action Plan (NEEAP) and the National Development Plan 2018-2027 and the 2019 and 2021 Climate Action Plans¹⁰. Only those Climate Action Plan (CAP) 2021 measures that are considered to be "implemented" or "adopted", using the official terminology, are included in the WEM scenario and it does not include measures from the 2023 Climate Action Plan.

⁶ 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

⁷ <https://www.esri.ie/current-research/the-i3e-model>

⁸ <http://www.agriculture.gov.ie/foodwise2025/>

⁹ [gov.ie](http://www.gov.ie) - Food Vision 2030 - A World Leader in Sustainable Food Systems (www.gov.ie)

¹⁰ [gov.ie](http://www.gov.ie) - Climate Action Plan 2021 (www.gov.ie)

- The *Advanced or With Additional Measures* (WAM) energy projections present an alternative view of future energy demand that accounts for further implementation of the *With Existing Measures* scenario in addition to the implementation of planned government policies and measures in Ireland's 2021 Climate Action Plan¹¹. For all sectors except Agriculture and LULUCF the WAM scenario is made up of policies and measures as set out in CAP 2021. For agriculture and LULUCF some CAP 2023 policies and measures are also used.

For the energy demand projections, the Economic and Social Research Institute (ESRI) used the I3E model¹². The I3E model is an intertemporal computable general equilibrium (CGE) model, which reproduces the structure of the Irish economy in its entirety, including productive sectors, households, and the government, among others.

Main scenario and sensitivity scenarios

Typically, SEAI request the development of two projections from the I3E, reflecting high and low-price scenarios. One price scenario is used for the main scenario, and the other is usually used as a sensitivity analysis. The 2022 I3E High-price scenario is being used as the basis for the main scenario for the 2022 National Energy Projections.

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. This pathway now includes a carbon tax that increases to €100 per tonne by 2030.

Fossil Fuel Prices

Future international fossil fuel prices are given as input to the I3E model. Recent volatility in energy prices owing to economic impacts from the war in Ukraine and the global recovery from the COVID-19 pandemic, have increased the likelihood of near-term sustained higher prices and intensified uncertainty around longer-term future fuel prices. In Spring 2022 the European Commission consulted with experts from member states and supplied recommended harmonised trajectories for oil, gas and coal import prices that combine a near-term trend reflecting recent data up to 2025 and a linear interpolation to a long-term trajectory derived from EU Reference Scenario 2020. 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

¹¹ <https://www.gov.ie/en/publication/6223e-climate-action-plan-2021/>

¹² <https://www.esri.ie/current-research/the-i3e-model>

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 €41.00 a tonne in 2022. Both WEM and WAM scenarios include a varying Irish carbon tax that reaches €100 per tonne by 2030 and a varying EU ETS price that increases annually to €80 per tonne by 2030 and €160 per tonne by 2050.

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* or WEM 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 2021 but which are considered too recent to be detectable in any time-series analysis. The *Advanced* or WAM energy projections builds on the *Baseline* projections with adjustments made to account for implementation of additional policies and measures outlined in Ireland’s 2021 and 2023 Climate Action Plans⁶.

The model input assumptions for the latest SEAI Energy Projections were delayed, due primarily to difficulties in reconciling the economy and price developments apparent from the latest actual data with the expectations of the I3E model. Assumptions were finalised in quarter 1 of 2023. 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. COSMO, I3E, Plexos Integrated Energy Model, SEAI’s National Energy Modelling Framework, SEAI BioHeat Model and the FAPRI Ireland model) are included in the 2022 submission made under made under Article 18 (4) of the Governance Regulation of the Energy Union and Climate Action (EU) 2018/1999. This is available in the relevant 2023 submission folder at the following link:

<https://reportnet.europa.eu/public/dataflows>

Table 8.2. Key assumptions underpinning the energy projections

	2022	2023-2025	2026-2030
Average Annual % Growth Rate			
GDP	-3.8	3.4	3.3
GNP	2.5	3.4	3.2
	2022	2025	2030
Housing Stock ('000)	1,913	1,998	2,168
Population ('000)	4,933	5,052	5,257
EUETS: Carbon €/tCO₂	75	80	80
Carbon tax €/tCO₂	41	63.5	100
Coal €/toe	127	128	130
Oil €/toe	643	643	643
Gas €/toe	1391	554	473
Peat €/toe	25	25	25

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 the emission commitment set for 2030. The year 2025 is also discussed to give an indication of trends to 2030. The WAM scenario is then considered in more detail. The 1990-2021 inventory was used as the baseline historic inventory for the emissions projections. Figures in the following sections include historic and projected air pollutant emission estimates from 1990-2030 for both the WM and WAM scenarios. A linear reduction pathway (Article 4 (2) Directive (EU) 2016/2284) between the 2020 and 2030 emission reduction commitment (ERC) for each pollutant is also presented. Tables in the following sections present projected emission estimates up to and including 2030 under both the WM and WAM scenarios. The 2005 emission levels are also provided for context in terms of the base year under the emission reduction commitments.

8.4.1 Sulphur Dioxide (SO₂)

Emission projections for SO₂ for the WM and WAM scenarios are presented in Figure 8.1. The emission reduction pathway between the ERCs for 2020 and 2030 is also presented. The emission projections predict compliance throughout the projected period. Key sources of SO₂ emissions in the projections include emissions from residential, commercial and industry. Emissions from electricity generation are projected to significantly reduce with the proposed closure of Ireland's only coal fired electricity generation plant in 2025.

Total SO₂ emissions under the WM scenario are projected to be 4.7 kt (91.4 per cent below 2005 levels) in 2030. Total SO₂ emissions are projected to be 5.4 kt (92.4 per cent below 2005 levels) in 2030 under the WAM scenario. The ERC for SO₂ for 2030 is an 85 per cent reduction on 2005 emission levels. It is therefore projected that under both scenarios the ERC for 2030 will be complied with.

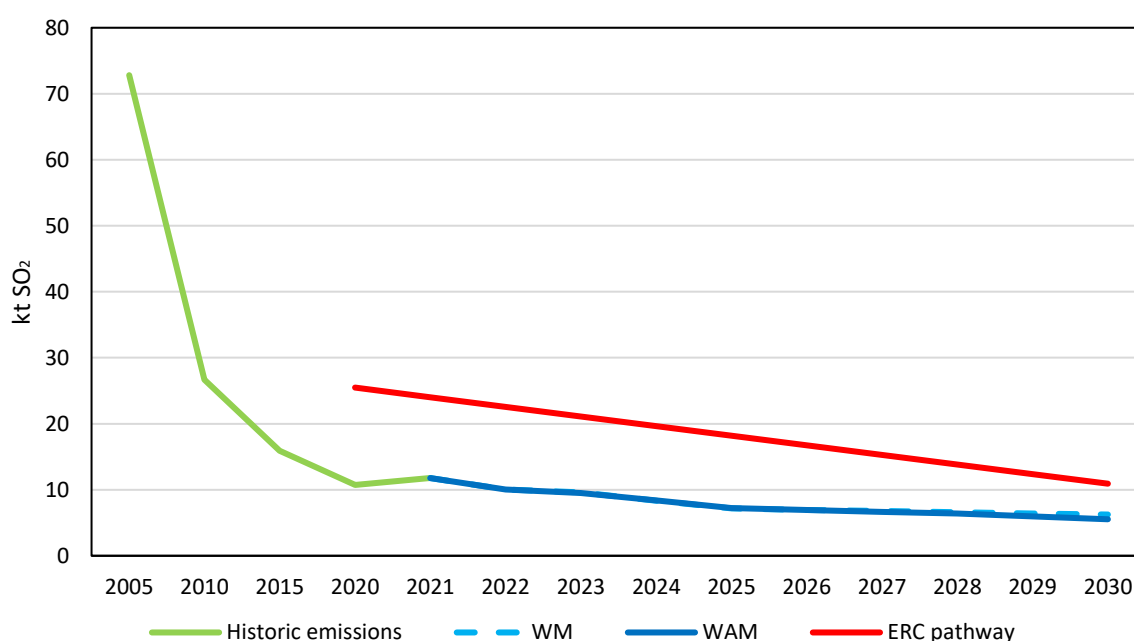


Figure 8.1 SO₂ Emission Projections for the With Existing Measures and With Additional Measures Scenarios

SO₂ emissions under the WAM scenario by source sector are presented in Figure 8.2. Emissions from Public Electricity and Heat Production (1A1a) contribute approximately 26.0 per cent and 11.4 per cent of national total emissions of SO₂ in 2021 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 59.5 per cent and 64.9 per cent of emissions in 2020 and 2030 respectively.

Table 8.3 presents the projected Emissions of SO₂ under the WM and WAM by sector over the period 2005 to 2030.

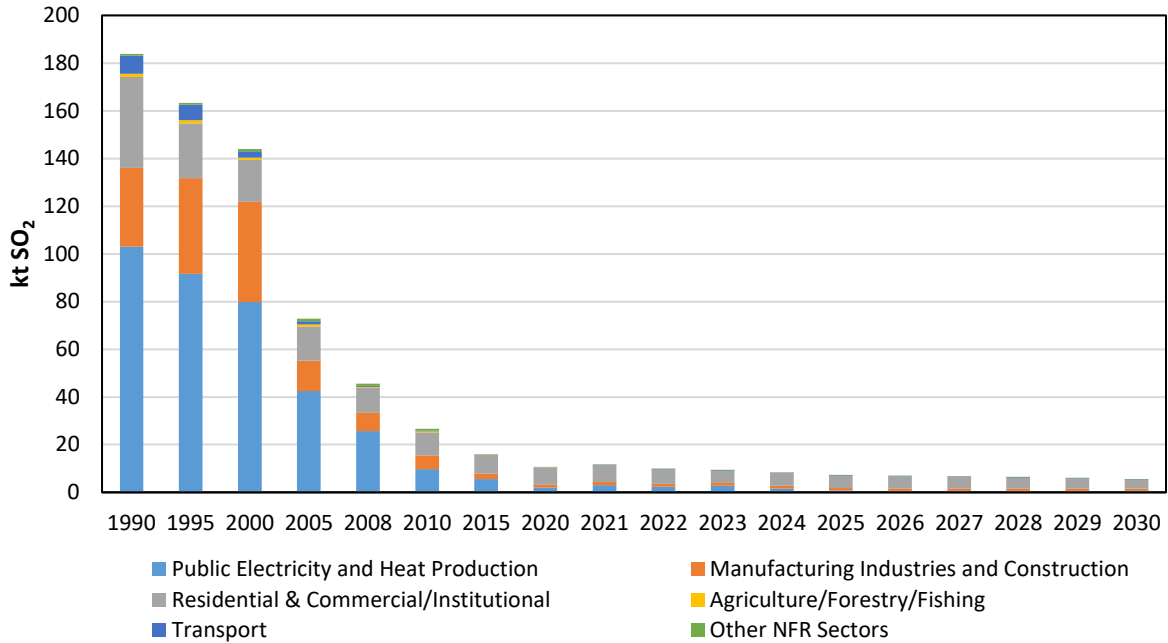


Figure 8.2 SO₂ Emission Projections for the With Additional Measures Scenario by Source Sector

Table 8.3. Projected Emissions of SO₂ under the With Measures and With Additional Measures Scenarios (kt)

With Measures scenario				
	2005	2021	2025	2030
Public Electricity and Heat Production	42.5	3.1	0.7	0.6
Manufacturing Industries and Construction	12.7	1.3	1.1	1.0
Residential & Commercial/Institutional	14.3	7.0	5.0	4.3
Agriculture/Forestry/Fishing	0.9	0.0	0.0	0.0
Transport	1.4	0.2	0.3	0.3
Other NFR Sectors	1.1	0.2	0.0	0.0
TOTAL	72.8	11.8	7.2	6.2
With Additional Measures scenario				
Public Electricity and Heat Production			0.7	0.6
Manufacturing Industries and Construction			1.1	1.0
Residential & Commercial/Institutional			5.1	3.6
Agriculture/Forestry/Fishing			0.0	0.0
Transport			0.3	0.3
Other NFR Sectors			0.0	0.0
TOTAL			7.2	5.5

8.4.2 Nitrogen Oxides (NO_x)

Emission projections for NO_x for the WM and WAM scenarios are presented in Figure 8.3. The emission reduction pathway between the ERCs for 2020 and 2030 is 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 the ERCs for 2020 and 2030. The WM emissions and WAM emissions (in addition to 2020 and 2030 emission reduction pathway) displayed in Figure 8.3 excludes emissions from these categories (3B and 3D)

Emission projections predict compliance with the ERC for 2030 under the WEM and WAM scenarios. Emissions from transport is the largest contributor to NO_x emissions.

Total NO_x (excluding categories 3B and 3D) emissions under the WM scenario are projected to be 37.1 kt (72.3 per cent below 2005 levels) in 2030. Total NO_x (excluding categories 3B and 3D) emissions are projected to be 34.5 kt (74.2 per cent below 2005 levels) in 2030 under the WAM scenario. The ERC for NO_x for 2030 is a 69 per cent reduction on 2005 emission levels. It is therefore projected that under both scenarios the ERC for 2030 will be complied with.

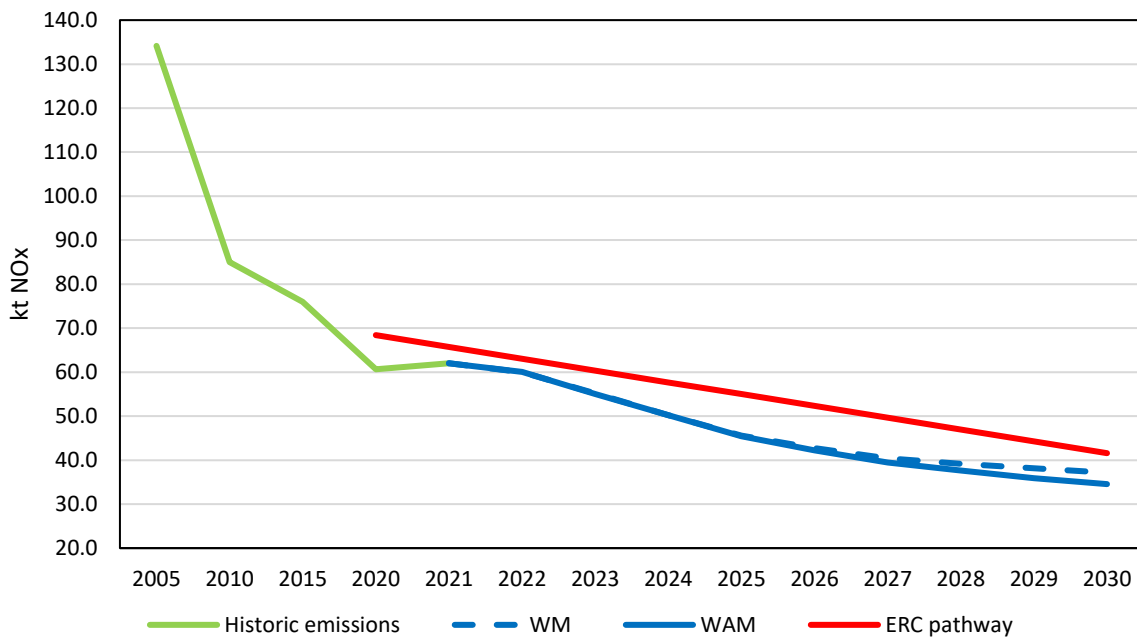


Figure 8.3 NO_x Emission Projections for the With Measures and With Additional Measures Scenarios

Figure 8.4 presents the total NO_x 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 53.5 per cent and 45.9 per cent share of emissions in 2021 and 2030 respectively.

Table 8.4 presents the projected emissions of NO_x under the WM and WAM by sector over the period 2005 to 2030.

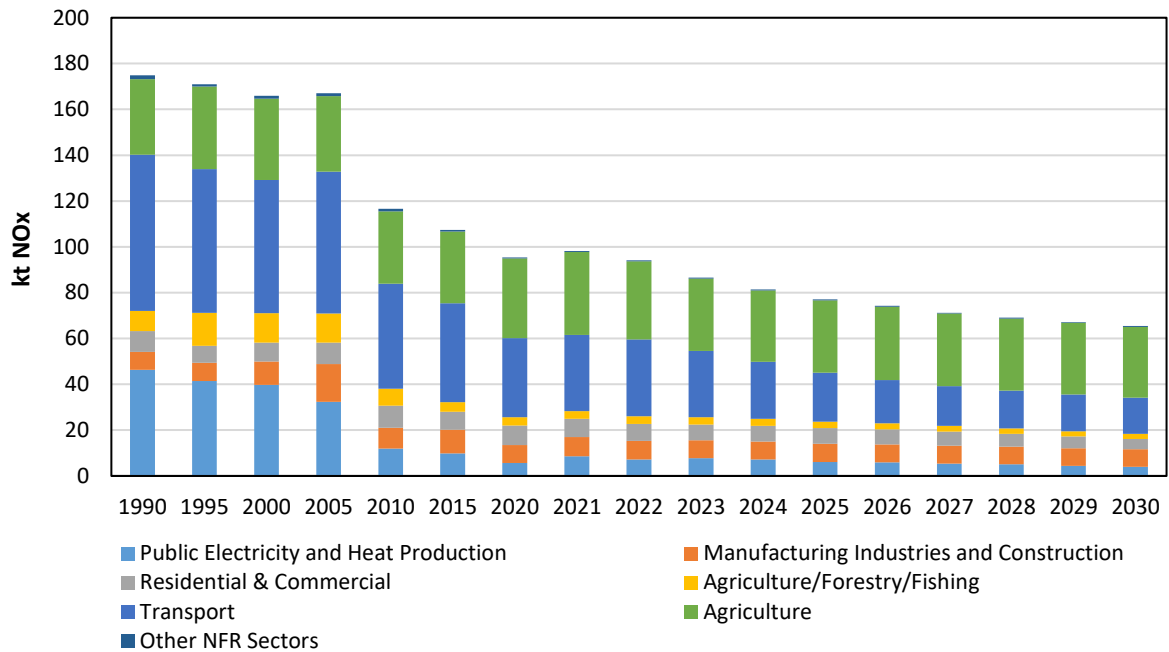


Figure 8.4 NO_x Emission Projections for the With Additional Measures Scenario by Source Sector

Table 8.4. Projected Emissions of NO_x under the With Measures and With Additional Measures Scenarios (kt)

With Measures scenario				
	2005	2021	2025	2030
Public Electricity and Heat Production	32.4	8.5	6.2	4.4
Manufacturing Industries and Construction	16.4	8.4	7.9	7.8
Residential & Commercial	9.3	8.0	6.8	5.8
Agriculture/Forestry/Fishing	12.8	3.4	2.9	2.2
Transport	62.0	33.2	21.5	16.6
Agriculture	32.9	36.2	31.8	33.1
Other NFR Sectors	1.3	0.5	0.3	0.3
TOTAL	167.1	98.2	77.4	70.3
With Additional Measures scenario				
Public Electricity and Heat Production			6.1	3.9
Manufacturing Industries and Construction			7.9	7.7
Residential & Commercial			6.8	4.5
Agriculture/Forestry/Fishing			2.8	2.2
Transport			21.5	15.9
Agriculture ¹⁴			31.6	30.9
Other NFR Sectors			0.3	0.3
TOTAL			77.0	65.4

8.4.3 Ammonia (NH₃)

Figure 8.5 presents the emission projections for NH₃ for the WM and WAM scenarios. The emission reduction pathway between the ERCs for 2020 and 2030 is also presented. Overall the Ammonia emission projections predict compliance with the 2030 ERC under both the WM and WAM scenarios. Ireland is not compliant with the ERC for 2020, however it is projected that compliance will be achieved in 2023 under both scenarios and that emission levels under both scenarios follow a pathway to compliance with the 2030 ERC.

Total NH₃ emissions under the WM scenario are projected to be 114.1 kt (5.0 per cent below 2005 levels) in 2030. Total NH₃ emissions are projected to be 113.1 kt (5.9 per cent below 2005 levels) in 2030 under the WAM scenario. The ERC for NH₃ for 2030 is a 5 per cent reduction on 2005 emission levels. It is therefore projected that under both scenarios the ERC for 2030 will be complied with.

Compliance with emission reduction targets is a challenge for the agricultural sector, however there have been some encouraging signs of uptake of abatement measures in the sector which are further described in Chapter 5.

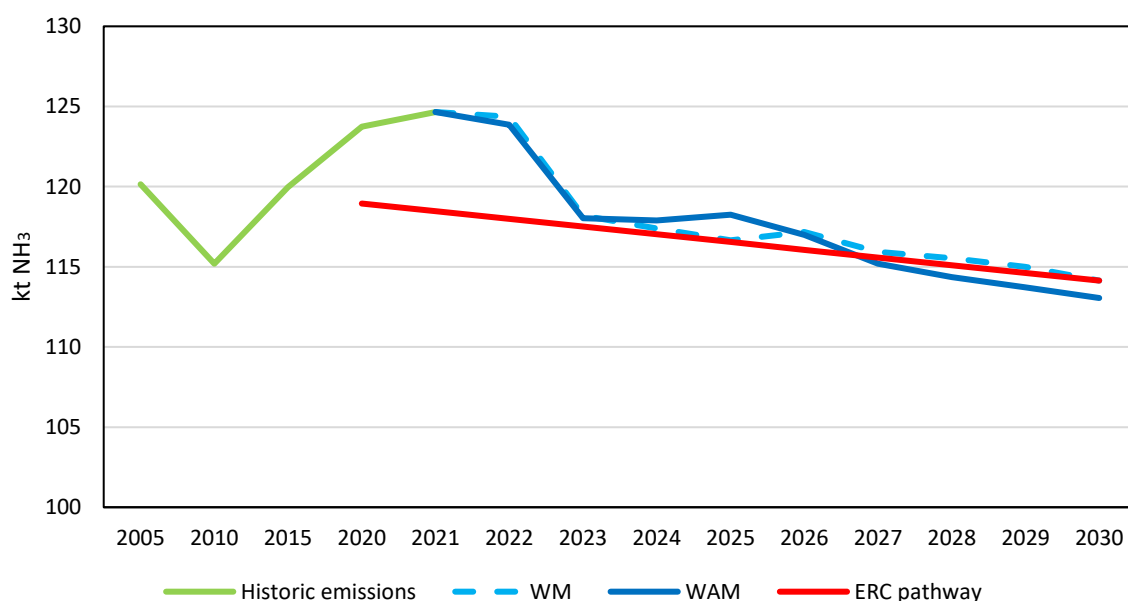


Figure 8.5 NH₃ Emission Projections for the With Measures and With Additional Measures Scenarios

The reduction in the WAM scenario compared to the WM scenario over the period 2021-2030 is attributable to the additional measures (over and above those in WEM scenario) that are included in the most recent Teagasc Marginal Abatement Cost Curve¹³, and the Department of Agriculture, Food and the Marine National Climate and Air Roadmap for the Agriculture Sector “AgClimate”¹⁴. Key measures are discussed in section 8.13.

¹³ <https://www.teagasc.ie/news--events/news/2020/reduce-ammonia-emissions.php>
<https://www.teagasc.ie/media/website/publications/2018/An-Analysis-of-Abatement-Potential-of-Greenhouse-Gas-Emissions-in-Irish-Agriculture-2021-2030.pdf>

¹⁴ <https://www.gov.ie/en/publication/07fbc-ag-climate-a-roadmap-towards-climate-neutrality/>

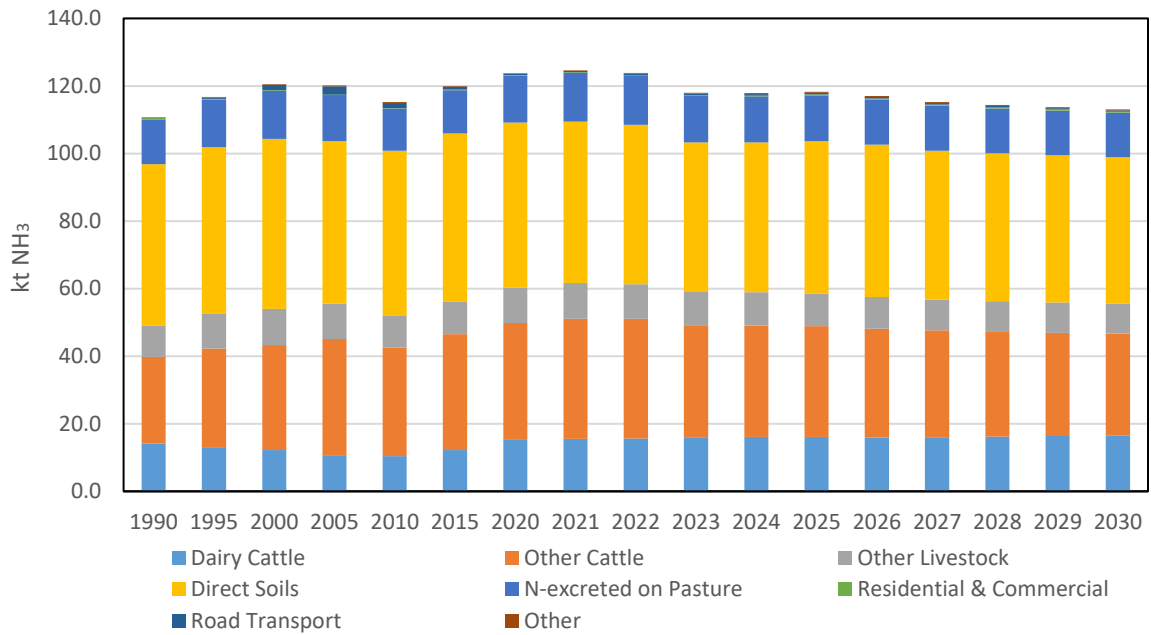


Figure 8.6 NH₃ Emission Projections for the With Additional Measures Scenario by Source Sector

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 2005 to 2030.

Table 8.5. Projected Emissions of NH₃ under the With Measures and With Additional Measures Scenarios (kt)

With Measures Scenario				
	2005	2021	2025	2030
Dairy Cattle	10.7	15.5	16.4	17.2
Other Cattle	34.4	35.6	33.3	31.0
Other Livestock	10.4	10.6	10.5	10.5
Direct Soils	48.2	47.8	41.4	40.6
N-excreted on Pasture	13.7	14.4	13.9	13.6
Residential & Commercial	0.1	0.1	0.3	0.3
Road Transport	2.5	0.4	0.5	0.5
Other	0.2	0.2	0.2	0.3
Total	120.1	124.7	116.6	114.1
With Additional Measures Scenario				
Dairy Cattle			16.1	16.6
Other Cattle			32.8	30.2
Other Livestock			9.6	8.8
Direct Soils			45.3	43.4
N-excreted on Pasture			13.5	13.1
Residential & Commercial			0.2	0.3
Road Transport			0.5	0.4
Other			0.3	0.3
Total			118.2	113.1

8.4.4 Non-Methane Volatile Organic Compounds (NMVOCs)

Emission projections for NMVOC for the WM and WAM scenarios are presented in Figure 8.7. The emission reduction pathway between the ERCs for the 2020 and 2030 is also presented.

Article 4 (3) of the Directive (EU) 2016/2284 provides that emissions of NMVOCs from categories 3B (manure management) and 3D (agricultural soils) are not accounted for the purpose of complying with the ERCs for 2020 and 2030. The WM and WAM emission estimates (in addition to 2020 and 2030 emission reduction pathway) displayed in Figure 8.3 excludes emissions from these categories (3B and 3D).

Emission projections predict non compliance for the ERC for 2030 under both the WM and WAM scenarios. Additionally, as outlined in chapter 9 the ERC for 2020 is not complied with. However, Ireland has applied for an adjustment (in relation to 2H2 Spirit production) as allowed under Article 5 and Part 4 of Annex IV of the Directive (EU) 2016/2284 for 2020. When this adjustment is taken into account the ERC for 2020 is complied with. Figure 8.8 presents NMVOC emissions to 2030 if the same adjustment process was applied for 2030.

Total NMVOC (excluding categories 3B and 3D) emissions under the WM scenario are projected to be 80.7 kt (4.7 per cent above 2005) in 2030. Total NMVOC (excluding categories 3B and 3D) emissions are projected to be 78.4 kt (1.7 per cent above 2005) in 2030 under the WAM scenario. The ERC for NMVOC for 2030 is a 32 per cent reduction on 2005 emission levels. It is therefore projected that under both scenarios the ERC for 2030 will not be complied with.

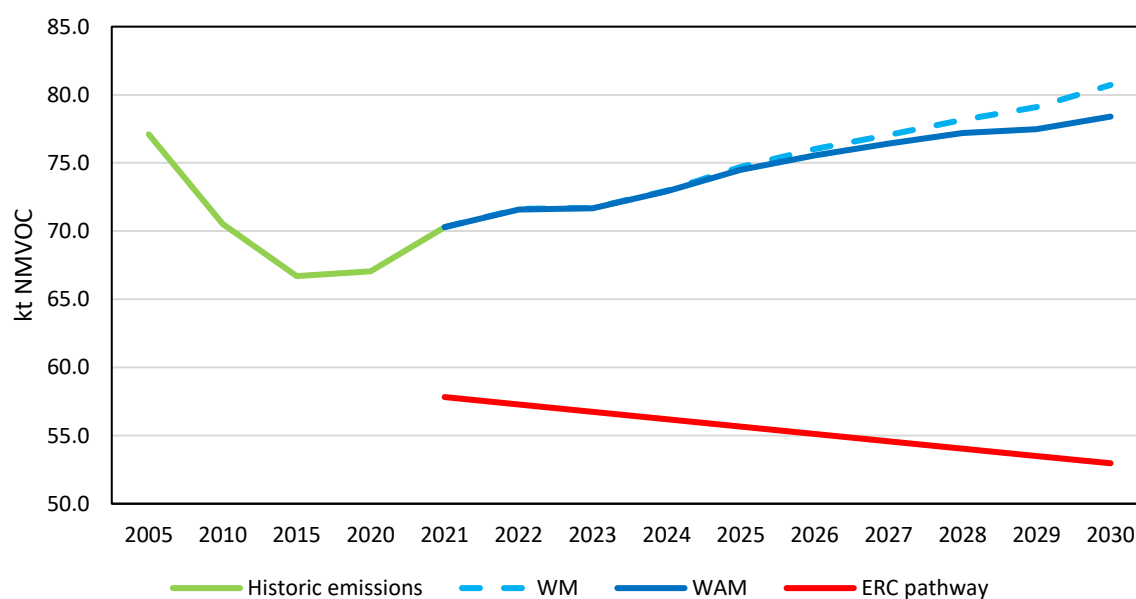


Figure 8.7 NMVOC Emission Projections for the With Existing Measures and With Additional Measures Scenarios¹⁵

¹⁵ 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)

With respect to Figure 8.8, total NMVOC emissions (excluding categories 3B and 3D and category 2H2 spirit production) under the WM scenario are projected to be 47.3 kt (31.2 per cent below 2005) in 2030. Total NMVOC emissions (excluding categories 3B and 3D and category 2H2 spirit production) under the WAM scenario are projected to be 44.9 kt (34.6 per cent below 2005). The ERC for NMVOC for 2030 is a 32 per cent reduction on 2005 emission levels. It is therefore projected that in this circumstance the ERC for 2030 will be complied with under the WAM scenario and not complied with under the WM scenario.

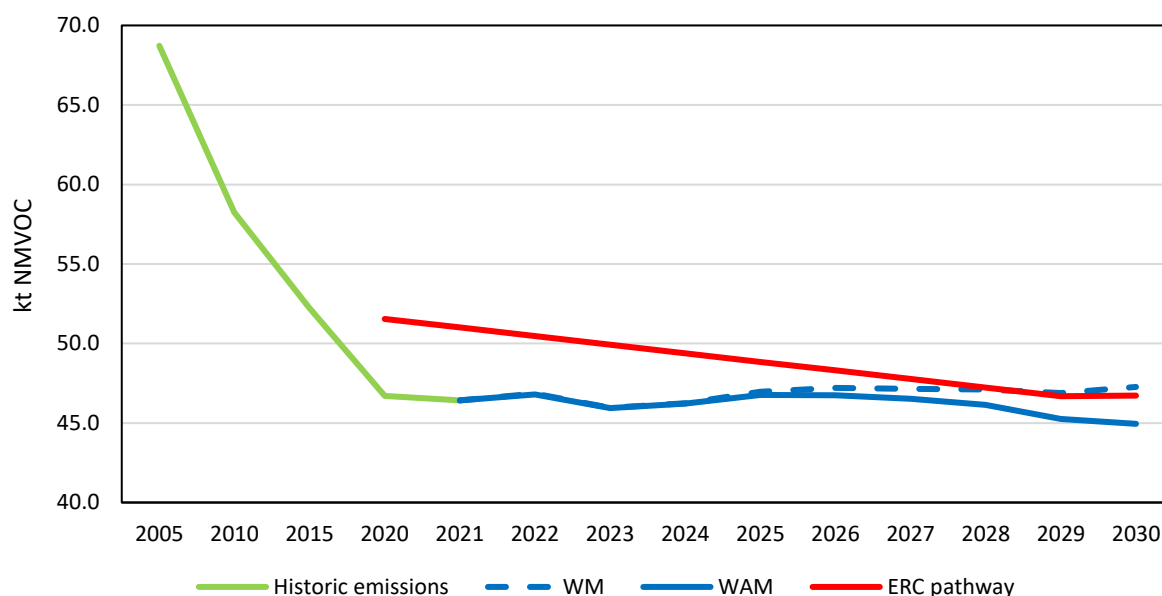


Figure 8.8 NMVOC Emission Projections for the With Measures and With Additional Measures Scenarios where an adjustment is applied for category 2H2 Spirit production¹⁶

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 emissions account for 28.6 per cent and 29.1 per cent of the total under the WM and WAM scenarios, respectively in 2030. Food and Beverage production accounts for 49.6 per cent and 51.1 per cent of emissions in 2030 under the WM and WAM scenarios, respectively.

Projected emissions across the time series show an increase in both scenarios 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 emissions under the WM and WAM by sector over the period 2005 to 2030.

¹⁶ 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 2H2 (Spirits production)

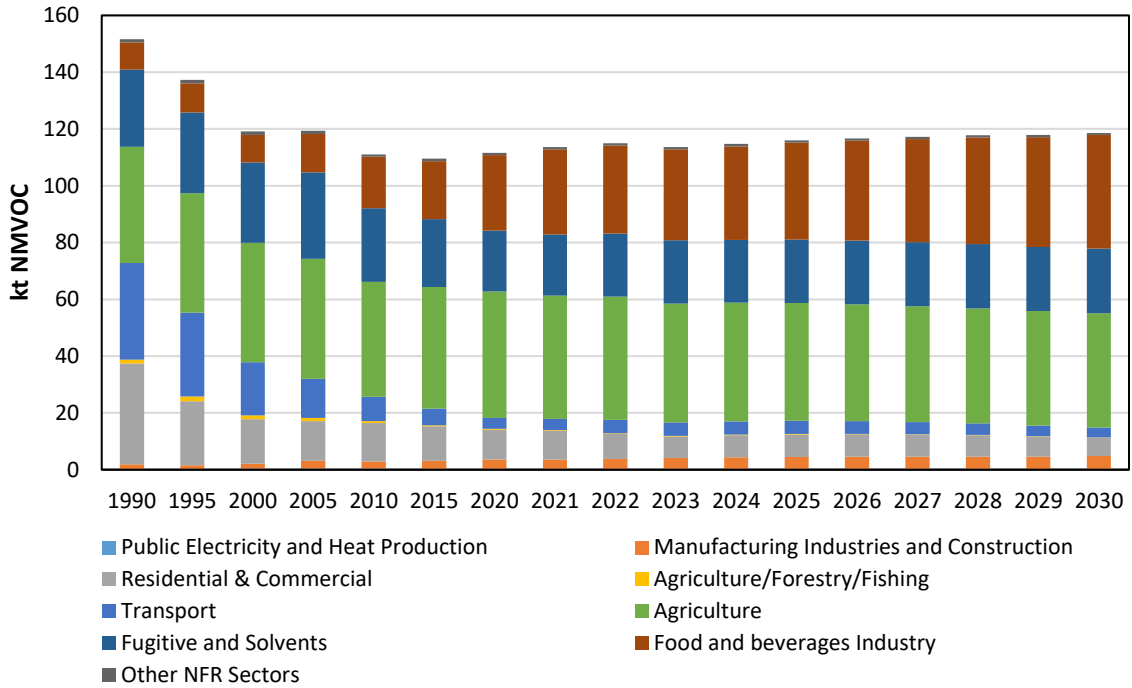


Figure 8.9 NMVOC Emission Projections for the With Additional Measures Scenario by Source Sector

Table 8.6. Projected Emissions of NMVOC under the With Measures and With Additional Measures Scenarios (kt)

With Measures Scenario				
	2005	2021	2025	2030
Public Electricity and Heat Production	0.4	0.3	0.4	0.2
Manufacturing Industries and Construction	2.7	3.3	3.9	4.6
Residential & Commercial	14.0	10.1	8.1	7.7
Agriculture/Forestry/Fishing	1.1	0.2	0.2	0.1
Transport	13.8	4.0	4.8	4.4
Agriculture ¹¹	42.3	43.4	42.3	41.3
Fugitive and Solvents	30.4	21.5	22.5	23.1
Food and beverages Industry	13.5	30.0	34.1	40.0
Other NFR Sectors	1.2	0.8	0.8	0.7
Total	119.4	113.7	117.0	122.0
With Additional Measures Scenario				
Public Electricity and Heat Production			0.3	0.2
Manufacturing Industries and Construction			4.1	4.6
Residential & Commercial			7.9	6.5
Agriculture/Forestry/Fishing			0.2	0.1
Transport			4.6	3.5
Agriculture ¹¹			41.5	40.2
Fugitive and Solvents			22.4	22.8
Food and beverages Industry ¹²			34.1	40.0
Other NFR Sectors			0.9	0.7
Total			116.0	118.6

8.4.5 Particulate Matter < 2.5 µm in diameter (PM_{2.5})

Emission projections for PM_{2.5} for the WM and WAM scenarios are presented in Figure 8.10. The emission reduction pathway between the ERCs for the 2020 and 2030 is also presented.

Emissions from Residential and Commercial combined are the largest contribution to the projected emissions.

Total PM_{2.5} emissions under the WM scenario are projected to be 11.8 kt (37.1 per cent below 2005 levels) in 2030. Total PM_{2.5} emissions are projected to be 11.0 kt (1.1 per cent below 2005 levels) in 2030 under the WAM scenario. The ERC for PM_{2.5} for 2030 is a 41 per cent reduction on 2005 emission levels. It is therefore projected that in this circumstance the ERC for 2030 will be complied with under the WAM scenario and not complied with under the WM scenario.

Table 8.7 presents the projected PM_{2.5} emissions under the WM and WAM by sector over the period 2005 to 2030.

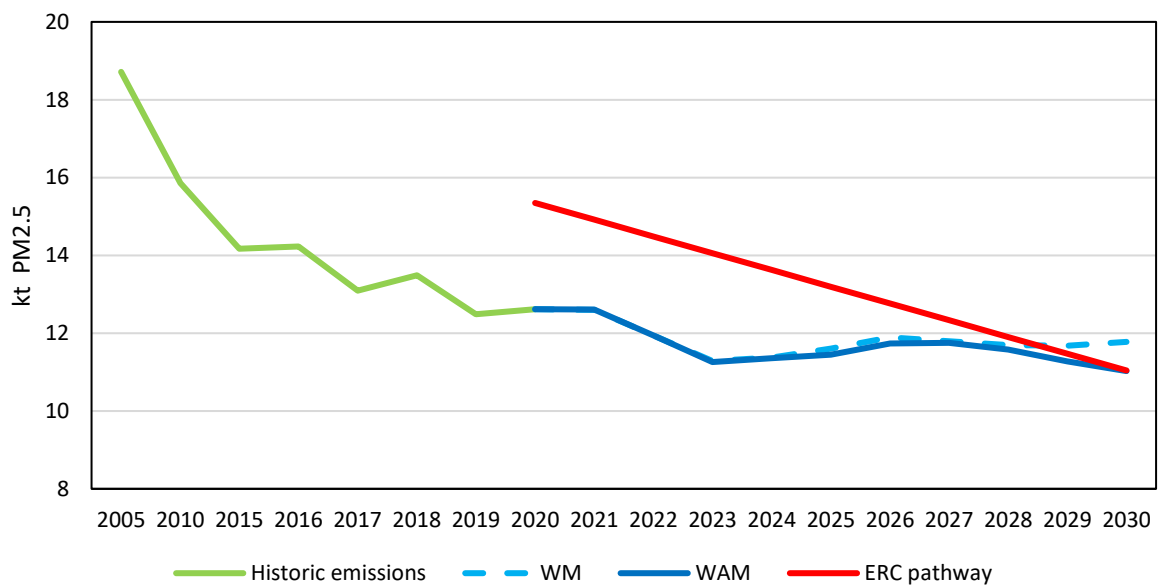


Figure 8.10 PM_{2.5} Emission Projections for the With Measures and With Additional Measures Scenarios

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.

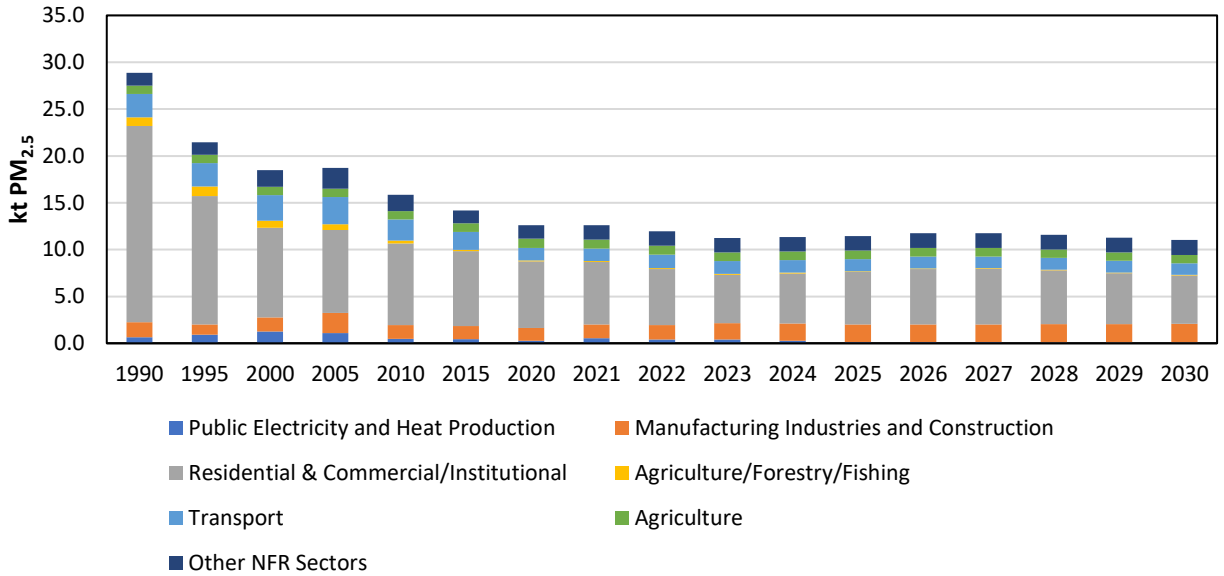


Figure 8.11 PM_{2.5} Emission Projections for the With Additional Measures Scenario by Source Sector

Table 8.7. Projected Emissions of PM_{2.5} under the With Measures and With Additional Measures Scenarios (kt)

With Measures scenario				
	2005	2021	2025	2030
Public Electricity and Heat Production	1.1	0.5	0.2	0.1
Manufacturing Industries and Construction	2.2	1.5	1.7	2.0
Residential & Commercial/Institutional	8.8	6.7	5.8	5.8
Agriculture/Forestry/Fishing	0.6	0.1	0.1	0.1
Transport	2.9	1.3	1.3	1.3
Agriculture	0.9	1.0	0.9	0.9
Other NFR Sectors	2.2	1.5	1.5	1.6
TOTAL	18.7	12.6	11.6	11.8
With Additional Measures scenario				
Public Electricity and Heat Production			0.1	0.1
Manufacturing Industries and Construction			1.9	2.0
Residential & Commercial/Institutional			5.6	5.1
Agriculture/Forestry/Fishing			0.1	0.1
Transport			1.3	1.2
Agriculture			0.9	0.9
Other NFR Sectors			1.6	1.6
TOTAL			11.4	11.0

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 reached approximately 22.4 per cent of electricity consumption from renewable energy by 2021. Renewable electricity generation capacity is dominated by wind. In 2030 it is estimated that renewable energy generation increases to approximately 70 per cent of electricity consumption (as stated in the 2019 Climate Action Plan).

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)/REFIT3¹⁷) and maximum levels of peat likely to be permitted under planning permission.

In the assumptions underpinning both the baseline and advanced scenarios, one peat station is eligible for REFIT3 30 per cent biomass cofiring up to the end of 2030. However, it only has planning permission to the end of 2023 and therefore, only operates to the end of 2023 with 30 per cent cofiring.

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 which started in 2019.

In the *Advanced* energy projection (and therefore the *With Additional Measures* emissions scenario) for 2030 it is estimated that renewable energy generation increases to approximately 80 per cent of electricity consumption (as stated in the 2021 Climate Action Plan). This is mainly a result of additional expansion in wind energy and Solar PV.

In terms of inter-connection, both scenarios assume that the Greenlink 500MW interconnector to the UK to come on stream in 2025 and the Celtic 700MW interconnector to France to comes on stream in 2027. The North South tie-line provides 300 MW by the end of 2025 with 1500 MW being provided from 2026 onwards.

Emission factors for NO_x and SO₂ predominantly are based on those used for the year 2021 in the national inventory (1990-2021). 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).

¹⁷<https://www.dccae.gov.ie/en-ie/energy/topics/Renewable-Energy/electricity/renewable-electricity-supports/refit/Pages/REFIT-3.aspx>

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 2021 SO₂ inventory emission factor for oil is assumed for all future years.

NMVOC and PM_{2.5} 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 2021 value utilised in the national inventory (1990-2021).

8.5.1 Oil and Gas Refining and Solid Fuel Manufacturing (NFR 1A1b and 1A1c)

Projected NO_x, SO₂, NMVOC and PM_{2.5} 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_x, SO₂, NMVOC, NH₃ and PM_{2.5} 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_x and SO₂ from the combustion of coal, natural gas and petroleum coke are based on the weighted average emission factor for all fuels across the sub sectors 1A2a – 1A2g from the values used in the inventory.

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 *WAM* scenario includes an extension of the above polices 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_x, SO₂, NMVOC, NH₃ and PM_{2.5} 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 and navigation will remain constant at 2021 levels for each year out to 2030.

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_x, SO₂, NMVOC and PM_{2.5} emission projections from aviation are estimated using the 2021 inventory and also projected data, where available, related to aircraft movements as provided to the EPA by the relevant airport authorities. Emissions associated with all LTO (landing and take-off) cycles are calculated. It is assumed that NO_x, SO₂, NMVOC and PM_{2.5} emission factors remain constant for all projected years at the 2021 value utilised in the national inventory (1990-2021)

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, 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 Baseline energy projection a statutory target at 12.359 per cent (i.e. 11% per cent by volume) from 1 January 2020 under the Biofuels Obligation Scheme is assumed. For the Advanced energy projection, the blending levels are to reach E10 and B20 on average by 2030.

In terms of Electric Vehicles, the baseline energy projection assumes approximately 541,899 Electric Vehicles on the road by 2030 (includes 363,076 Passenger Battery Electric Vehicles, 178,823 Plug in Hybrid Electric Vehicles and 14,645 electric vans). The Advanced Scenario assumes 944,600 Electric Vehicles on the road by 2030 (includes 661,600 Passenger Battery Electric Vehicles, 183,000 Plug in Hybrid Electric Vehicles and 95,000 electric vans).

8.7.3 Rail (NFR 1A3c)

NO_x, SO₂, NMVOC, NH₃ and PM_{2.5} emission projections from rail transport are estimated. It is assumed that fuel use in the sector will remain constant at 2021 levels for each year out to 2030. It is also assumed that NO_x, SO₂, NMVOC, NH₃ PM_{2.5} emission factors remain the same as in the 2021 national inventory.

8.7.4 Navigation (NFR 1A3d)

NO_x, SO₂, NMVOC, NH₃ and PM_{2.5} emission projections from navigation are estimated. Gasoil/diesel consumption in in-land navigation is assumed to remain constant at the 2021 level out to 2030. NO_x, SO₂, NMVOC, NH₃ and PM_{2.5} emission factors are assumed to remain constant at the 2021 level.

8.7.5 Gas Transmission (NFR 1A3e)

Emission projections for NO_x, SO₂, NMVOC, and PM_{2.5} 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_x, SO₂, NMVOC and PM_{2.5} emission factors remain constant at the 2021 level.

8.8 Residential and Commercial/Institutional (NFR 1A4)

8.8.1 Commercial/Institutional (NFR 1A4a)

Projected NO_x, SO₂, NMVOC, NH₃ and PM_{2.5} emissions are based on SEAI's *Baseline* and *Advanced* energy projections and are therefore estimated for both the WEM 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_x, SO₂, NMVOC, NH₃ and PM_{2.5} are estimated. It is assumed that NO_x, SO₂, NMVOC, NH₃ and PM_{2.5} emission factors remain constant at the 2021 level.

The following policies and measures are included in the 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 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_x, SO₂, NMVOC, NH₃ and PM_{2.5} 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_x, SO₂, NMVOC, NH₃ and PM_{2.5} are estimated. It is assumed that NO_x, SO₂, NMVOC, NH₃ and PM_{2.5} emission factors remain constant at 2021 levels.

The following policies and measures are included in the 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
- Better Energy Finance
- Solar Pilot scheme

The 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
- Better Energy Finance
- Solar Pilot Scheme

8.9 Combustion in Agriculture and Fishing (NFR 1A4c)

Projected emissions of NO_x, SO₂, NMVOC, NH₃ and PM_{2.5} 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. For mobile combustion the same modelling approach is used as in the national inventory which takes into account the relevant Tier legislation as it affects the age structure mobile agricultural machinery. For stationary combustion in agriculture and combustion in fishing, NO_x, SO₂, NMVOC, NH₃ and PM_{2.5} emission factors remain constant at 2021 levels.

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 *Baseline* and *Advanced* energy scenarios (and therefore WEM and WAM scenarios), there is a varying carbon tax that reaches €100 per tonne by 2030.
- In terms of renewable heat, both the WM and WAM scenario assumes 1,600GWh of additional renewable heat (up to 2027) supported under the Support Scheme for Renewable Heat (SSRH)¹⁸.
- 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 680,000 existing residential oil boilers, gas boilers and electric heaters are replaced with heat pumps. District heating is also assumed to be deployed (growth to 2.7 TWh by 2030).
- Under the WAM scenario, a total of 1,600GWh of biogas use across the heat and transport sectors by 2030 is assumed.

8.10 Fugitive emissions (NFR 1B)

Projected NMVOCs emissions from category 1B are estimated from three sources, Refining of oil products, Distribution of Oil Products and transmission and distribution of natural gas. Refinery NMVOC emissions are projected using the latest inventory year refinery NMVOC emissions and using the projected trend in CO₂ emissions from the refinery over the projected period as a proxy. Emissions from distribution of oil products are estimated by projecting the trend in imported petrol/gasoline using the latest inventory year imported petrol/gasoline and using the total projected transport petrol that is available from the energy forecasts for each of the scenarios (WM and WAM). The total projected transport petrol that is available from the energy forecasts have been revised downwards since the previous projections submission. The latest inventory emission factors and abatement efficiencies are also used to produce the projected emission estimates. NMVOC from the transmission and distribution of natural gas is projected using the latest inventory year fugitive releases reported by Bord Gais Eireann and projected trend in CO₂ emissions from gas transmission and distribution over

¹⁸ <https://www.seai.ie/business-and-public-sector/business-grants-and-supports/support-scheme-renewable-heat/>

the projected period. The percentage NMVOC in natural gas is taken from gas analysis reports for the current inventory year and flatlined for the projected years. PM_{2.5} emissions from category 1B are projected for coal storage and coal handling. Projections for coal storage are flatlined from the latest inventory year which is based on the area of coal storage and relevant emission factor that is used for the latest inventory year. Projections for coal handling is based on the projected coal used for electricity generation and applying the emission factor that is used in the latest inventory.

8.11 Mineral Products (NFR 2A), Chemical industry (NFR 2B), Metal Industry (NFR 2C)

Emission of air pollutants (e.g. NO_x and SO₂ 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. 2.A.1 Cement Production, emissions are generally reported under NFR Category 1A2f (Non-metallic minerals) and notation keys IE and NA are reported under 2A1 for these pollutants NO_x, SO₂, NMVOC and NH₃, only particulates are projected for 2.A.1. Sector 2.A.2 Lime Production all emissions from lime production are assumed to be included in those reported within Sector 1A2f and the notation key IE (Include elsewhere) is used for 2A2 with the exception of particulates which are projected for lime production, 2.A.3 Glass Production- 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 projected as 'NO' (not occurring), 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 and 2.A.6 Other mineral products (Bricks and ceramics and Asphalt production) do not have NO_x, SO₂ or NH₃ emissions associated with them, only particulates are projected for these subcategories.

The chemical industry NFR category 2.B 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_x emissions from Nitric Acid Production for the years 1990-2002 after which the plant was closed therefore no emissions are reported for projected years.

2.C Metal production the following subcategories are reported; 2C1 Iron and 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; 2C2 Ferroalloys Production –Ireland has a single operating facility from 2014 onwards no NO_x, SO₂ or NH₃ emissions occur from this facility; 2C3 Aluminium Production – Ireland is an important producer of alumina at one large plant using the Bayer process (extraction of Al₂O₃ using NaOH). The production of alumina using the Bayer process does not give rise to significant emissions and therefore process emissions are not estimated for this source; 2C5 Lead production – 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 and are reported as NO since 2009 therefore emissions from these categories are not projected.

8.12 Non-Energy Products from Fuels and Non-Energy Products from Fuels and Solvent Use (NFR 2D) and NFR 2H, I, J,K,L

Emissions projections of NMVOCs from solvent use and other products are estimated. Population growth is used to project emissions out to 2030 with the 2021 inventory used as a starting point.

Projected emissions for NFR category 2.H; 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. These activities do not have NO_x, SO₂ or NH₃ emissions associated with them. Emissions projections of NMVOCs are reported for this category. For subcategory Spirits emissions are projected using the whiskey industry projected growth figures out to 2032 and information from CSO on the proportion of spirit production for whiskey. The global whiskey market is projected to expand steadily during the forecast period 2022-2032 and this is reflected in a 5 per cent annual increase in spirit production for the whiskey market.

2.I Wood processing, as stated in the EMEP/EEA 2019 guidebook this source category is only important for particulate emissions.

2.J Production of POPs as stated in the EMEP/EEA 2019 guidebook this source category is not significant, since the contribution to the total national emissions is less than 1 % of the national emissions of any pollutant, these are not occurring in Ireland and projected emissions are not reported for this category.

2K Consumption of POPs and Heavy metals no emissions occur in this subcategory in Ireland and projected emissions are not reported.

2L Other production, consumption, storage, transportation or handling of bulk products 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, therefore no NO_x, SO₂ or NH₃ or PM_{2.5} projected emissions are associated with these activities.

8.13 Agriculture (NFR 3)

The Agriculture sector is the largest source of NH₃ emissions in Ireland. Projected estimates of NH₃ 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 Q1 2023 in order to prepare agricultural emission projections. This includes proposed national herd, crop areas and fertilizer use. It assumes that agricultural policy continues as currently agreed and that the Brexit related Trade and Cooperation Agreement (TCA) reached between the EU and the UK governs UK-EU trade over the projection period. It is further assumed that no new bilateral trade agreements are entered into by either the EU or UK which offers other third countries preferential market access to EU and UK markets.

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”¹⁹ 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.

The majority of the data supplied to the EPA is disaggregated at the level of that used in inventory estimates.

Under WM and WAM scenario dairy cow numbers are projected to increase reflecting the continuing profitability of dairy production in Ireland. Dairy cow numbers in 2030 reach 1.69 million. This represent a 8.8 per cent increase relative to 2021. 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 0.63 million. This represents a 30.9 per cent decrease relative to 2021. The total cattle herd in 2030 are projected to be 6.8 million. This represents a 6.9 per cent decrease relative to 2021.

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 399,161 tonnes which is similar to total use in 2021.

Irish ewe and total sheep numbers are projected to decrease slightly over the period to 2030. By 2030 total Irish sheep numbers are projected to decrease to 4.66 m. This represents a 12.6 per cent decrease relative to 2021. The projected decline in sheep production reflects the projected evolution of sheep prices on world and EU markets as global growth in the supply of meat (beef, sheep, pig and poultry meat) is expected to outpace growth in demand. As a result, the total volume of pig and poultry output is also projected to decrease. The total crop land area is projected to contract due to the higher level of profits per hectare in grassland farming (dairying) compared to tillage. By 2030, the total cereal area harvested in Ireland is projected to decrease to 271,830 hectares. This represents a 6.0 per cent decrease relative to 2021.

¹⁹ 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 WM scenario assumes mitigation over the period 2022-2030 attributable to some of the measures that are included in the Teagasc Marginal Abatement Cost Curve²⁰, and the DAFM Roadmap towards Climate Neutrality “AgClimatise”²¹. Legislation levers (namely Nitrates Directive Action Plan) are in place to deliver the following key measures under the WM scenario which are low emission slurry spreading for cattle slurry, reduced nitrogen fertiliser use (due to increased liming of soils to correct soil fertility issues), and a reduction in crude protein in dairy cow diets. The WAM scenario on the other hand includes a reduction in the crude protein content of pig diets, covering of uncovered slurry stores for both cattle and pigs, slurry acidification in store, low emission slurry spreading for pigs, drying of poultry manure, a ban on straight urea fertiliser, replacement of straight urea and part replacement of CAN/NPK type fertiliser products with inhibited urea and a total fertiliser sales target of 300,000 tonnes in 2030.

Projected emissions of NMVOC and PM_{2.5} from manure management are estimated using the same approaches and methodologies as the national inventory. Projected activity data that is utilized for NH₃ emission projections is also used to estimate projected emissions of NMVOC and PM_{2.5} for the Agriculture sector.

8.14 Waste (NFR 5)

Air pollutant emission projections in the form of NO_x, SO₂, NMVOC, NH₃ and PM_{2.5} are estimated for the waste sector. Non-methane volatile organic compounds are estimated from landfill gas production, whilst NO_x, SO₂ and PM_{2.5} emissions are estimated from the incineration of industrial waste and from cremation. NH₃ emissions are estimated from composting. PM_{2.5} 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⁻³ NMVOC/m³ landfill gas is used in projected emission estimates. Ireland has met all Landfill Directive²² 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_x, SO₂, NMVOC and PM_{2.5} at these facilities will remain constant at the 2020 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 1999-2021 activity level.

²⁰ <https://www.teagasc.ie/media/website/publications/2020/NH3-Ammonia-MACC.pdf>

²¹ <https://www.gov.ie/en/publication/07fbc-ag-climatise-a-roadmap-towards-climate-neutrality/>

²² Council Directive 1999/31/EC on the landfill of waste

Chapter Nine

Adjusted annual national emission inventories

9.1 Meeting the Requirements for an Adjustment in the period 2020 to 2030

9.1.1 Emission Reduction Commitments

The amended Gothenburg Protocol and National Emission reduction Commitments Directive (Directive (EU) 2016/2284) requires parties to demonstrate compliance with emission reduction commitments (ERCs) for 2020 onwards using 2005 as a baseline on which ERCs are based. This is a different approach to the concept of emission ceilings for the period 2010 to 2019 as outlined in the Gothenburg Protocol and Directive 2001/81/EC. As a result, different considerations apply to the demonstration of compliance with emission reduction commitments.

Article 5(1) Directive (EU) 2016/2284 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.

Parties who wish to use adjustments to demonstrate compliance with ERCs cannot use existing inventory adjustments accepted with respect to emissions ceilings (for the period 2010-2019) to demonstrate compliance with ERCs. This is primarily for the following reasons:

- The reference version of the EMEP/EEA Guidebook (that is used to determine the scientific knowledge and understanding when the ERCs were set) is 2009 and as a result, it is likely that the validity and quantification of most adjustments will have changed.
- The calculations that are required for an adjustment with respect to ERCs require consideration, and reporting, of information relating to emissions in 2005 as well as 2020 onwards. Previously accepted adjustments do not provide this information.
- A valid adjustment under ERC might involve revising down the emissions in the compliance year in question, or it might involve revising up the emissions in 2005 to change non-compliance into compliance. However, in many cases it is likely that both years would need to be revised to capture relevant changes that impact across the entire time series, and the magnitude and direction of the revisions will determine whether the net effect would bring a Party into compliance and is therefore considered eligible for an adjustment application.
- Article 4 of Directive (EU) 2016/2284 states that emissions of NMVOCs and NO_x from activities falling under the NFR sectors 3B (manure management) and 3D (agricultural soils) are not accounted for the purpose of complying with ERCs as set out in the directive.

Table 9.1 provides details of the emission values in this submission for the years 2005 and 2021, the required emission reduction commitments under Directive (EU) 2016/2284 and the percentage reduction in emission levels for all five pollutants covered (NO_x, SO₂, NMVOC, NH₃ and PM_{2.5}). For the pollutants NO_x and NMVOC, emission from the NFR sectors 3B and 3D are not included in the compliance assessment.

Table 9.1 Summary of National Emissions in 2005 and 2021, the ERCs for 2020-2030 and actual emission reduction

	2005	2021
NO_x (kt)*	134.144	62.017
ERC (%)		-49%
Actual reduction in emissions (%)		-53.8%
SO₂ (kt)	72.813	11.768
ERC (%)		-65%
Actual reduction in emissions (%)		-85.3%
NMVOC (kt)*	68.723	46.421
ERC (%)		-25%
Actual reduction in emissions (%)		-32.5%
NH₃ (kt)	120.148	124.654
ERC (%)		-1%
Actual reduction in emissions (%)		3.8%**
PM_{2.5} (kt)	18.715	12.599
ERC (%)		-18%
Actual reduction in emissions (%)		-32.7%

* Emissions of NMVOCs and NO_x from activities falling under the NFR sectors 3B (manure management) and 3D (agricultural soils) are not accounted for the purpose of complying with ERCs

** Emission reduction commitment has not been met

The data presented in Table 9.1 shows that Ireland is non-compliant with the ERCs for 2020 for the pollutant NH₃. For NMVOC, an adjustment application accompanies this submission and is detailed in the following section. With respect to non-compliance for NH₃, the non-compliance does not meet the criteria for an adjustment and is the direct result of increased agricultural activity.

9.1.2 NMVOC Adjustment Application

Ireland considers that non-compliance with the ERC for 2020 for NMVOC is as a result of the inclusion of a new source of emissions, which was not include in the national inventory when ERC targets were set.

NMVOC emissions from the food and beverage industry were not included in Ireland's national emissions inventory submission in 2012, 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, 2019), 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 9.2. On the basis of the data presented in Table 9.2, NMVOC emissions are in compliance with the emission reduction commitment when the adjustment is taken into account.

Table 9.2. Adjustments for emissions from the Food and Beverage Industry (NMVOC)

	2005	2021
NMVOC (kt)	77.100	70.295
ERC (%)		-25%
Actual reduction in emissions (%)		-8.8%
Adjustment (kt)	-8.376	-23.874
Adjusted NMVOC (kt)	68.723	46.421
Adjusted reduction in emissions (%)		-32.5%

Glossary

Annex 1 Parties	Countries listed in Annex I to the United Nations Framework Convention on Climate Change
Base year	The year or period under the Kyoto Protocol on which quantified emission limitation or reduction commitments in the commitment period are based.
BOD	Biochemical Oxygen Demand
CARBWARE	A forest model to calculate carbon stock change and growth increment for Irish forests
CFCs	Chlorofluorocarbons
CH₄	Methane
CHP	Combined Heat and Power.
CMMS	Cattle Movement and Monitoring System
CO	Carbon Monoxide
CO₂	Carbon Dioxide
CO₂ equivalent	The equivalent mass as CO ₂ of other greenhouse gases converted on the basis of their global warming potential (GWP)
COFORD	National Council for Forest Research and Development
Commitment Period	The years 2008 to 2012 (first CP) or 2013 to 2020 (second CP) inclusive for which quantified emission limitation or reduction commitments are established under the Kyoto Protocol
COP	Conference of the Parties
CORINAIR	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.
CRF	Common Reporting Format
DAF	Department of Agriculture and Food
DAFM	Department of Agriculture, Food and the Marine
DCCA	Department of Communications, Climate Action and Environment
DCENR	Department of Communications, Energy and Natural Resources
DEHLG	Department of Environment Heritage and Local Government
DNDC	DeNitrification-DeComposition, is a computer simulation model of carbon and nitrogen biogeochemistry in agri-ecosystems
EMEP	European Monitoring and Evaluation Programme, a co-operative programme for monitoring and evaluation of the long-range transmissions of air pollutants in Europe
Emission	(of a greenhouse gas). The release of greenhouse gases into the atmosphere.
Enteric Fermentation	The digestive process in ruminant animals (e.g cattle and sheep) where bacteria convert the feed to a usable form of energy for the animal, producing CH ₄ as a by product
EUROSTAT	Statistical Agency of the European Union
FAO	Food and Agriculture Organisation of the United Nations
FFS	Farm Facilities Survey
FIPS	Forest Inventory and Planning System
Fluorinated Gases	HFCs, PFCs, SF ₆ and NF ₃

Fossil Fuel	Peat, coal, oil and natural gas and associated derivatives
FTA	Fraction of BOD in sludge that degrades anaerobically
GDP	Gross Domestic Product
Gg	Gigagram (10 ⁹ g) = kilo tonne = 1,000 tonnes
Greenhouse Gas	A gas in the atmosphere that allows solar radiation through to the earth's surface, but traps some of the heat radiated back from the earth's surface
GWP	The cumulative warming over a specified time period, e.g. 100 years, resulting from a unit mass of a greenhouse gas emitted at the beginning of that time period, expressed relative to an absolute GWP of 1 for CO ₂
HCFCs	Hydrochlorofluorocarbon
HFCs	Hydrofluorocarbons
HGV	Heavy Goods Vehicle
IEA	International Energy Agency
IEF	Implied Emission Factor
IPC	Integrated Pollution Control
IPCC	Intergovernmental Panel on Climate Change
IUCC	Information Unit on Climate Change
kt	kilo tonne (1,000 tonnes)
Kyoto Protocol	The Protocol to the UNFCCC adopted by Decision 1/CP.3 under which industrialised countries agreed to reduce their combined greenhouse gas emissions in 1990 by at least 5 per cent by the period 2008-2012
LTO	Landing and Take-off cycle
MMS	Manure Management System
Montreal Protocol	Protocol on substances that deplete the ozone layer
Mt	million tonnes or mega tonnes
N₂O	Nitrous Oxide
NBP	Net Biome Productivity
NEE	Net Ecosystem Exchange
NF₃	Nitrogen trifluoride
NIR	National Inventory Report
NMVOC	Non Methane Volatile Organic Compounds
NO_x	Nitrogen Oxides
NRA	National Roads Authority
OSPAR	Oslo and Paris Convention for the Protection of the Marine Environment
PFCs	Perfluorocarbons
SBSTA	Subsidiary Body for Scientific and Technological Advice
SEAI	Sustainable Energy Authority of Ireland
SF₆	Sulphur Hexafluoride
Sink	The reservoir or pool in which sequestered carbon is stored; the process of sequestration
SO₂	Sulphur Dioxide
Teagasc	Irish Agriculture and Food Development Authority
TPER	Total Primary Energy Requirement
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile Organic Compounds

References

- Adams, M., Wagner, A., Goodwin, J., O’Leary, E., Creedon, M., McHugh, M and Gibson, C. (2005). Compiling Emission Inventories of HFCs, PFCs and SF6 for inclusion in Ireland’s greenhouse gas submissions to the EU under Decision 280/2004/EC under the United National Framework Convention on Climate Change. Netcen/ ED48411/R1, AEA Technology UK.
- AEA. (2011). HFC consumption and emissions forecasting. Containing an update to the June 2008 HFC projections. Report to Defra.
- Alam M S, Duffy P, Hyde B, McNabola A. (2017). Improvement in the estimation and back-extrapolation of CO2 emissions from the Irish road transport sector using a bottom-up data modelling approach, Transportation Research Part D: Transport and Environment 56, pp18-32.
- Baesens, B., van Gestel, T., Viaene, S., Stepanova, M. Suykens, J. and Van-thienen, J. (2003). Benchmarking state-of-the-art classification algorithms for credit scoring. Journal of the Operational Research Society, 54:p 627-635.
- Barry, S. and O’Regan, B. (2016). FS-2 Activity data for emissions of Non-methane VOC Fellowship 1990-2014: Project Code 2012-CCRP-FS.8, EPA Research Report (In Press).
- Benanti, G., Saunders, M., Tobin, B, Osborne, B 2014. Contrasting impacts of afforestation on nitrous oxide and methane emissions. Agricultural and Forest Meteorology 198–199 (82–93)
- Bigler, C. and Bugmann, H. (2004). Predicting the time of tree death using dendrochronological data. Ecological Applications, 14(3): p902-914..
- Black K (2016) Description, calibration and validation of the CARBWARE single tree-based stand simulator. Forestry 86 (1):55-68 doi: 10.1093/forestry/cpv033
- Black, K, Creamer, R.E., Xenakis G., and Cook, S. 2014. Improving the YASSO forest soil carbon model using spatial data and geostatistical approaches. *Geoderma* 232-234:487-499
- Black, K., Hendrick, E., Gallagher., G.,Farrington, P., (2012). Establishment of Irelands projected reference level for Forest Management for the period 2013-2020 under Article 3.4 of the Kyoto Protocol. Irish Forestry 69: p7-33.
- Black, K., Tobin, B., Saiz, G., Byrne, K. and Osbourne, B. (2004). Improved estimates of biomass expansion factors for Sitka spruce. Irish Forestry 61: p50–65.
- Black, K.G., O’Brien, P., Redmond, J., Barrett, F. and Twomey M. (2009a). The extent of peatland afforestation in Ireland. Irish Forestry 65, p61-71.
- Bond-Lamberty et al., 2008. Decomposition and Fragmentation of Coarse Woody Debris: Re-visiting a Boreal Black Spruce Chronosequence Ecosystems (2008) 11: 831–840
- Bossard, M., Feranec, J. and Otahel, J. (2000). CORINE land cover technical guide – Addendum, 2000. Technical Report No. 40, EEA.
- Boudewyn, P. Song, X. Magnussen, S. and Gillis, M.D. 2007. Model-based, volume-to-biomass conversion for forested and vegetated land in Canada. Natural Resources Canada • Canadian Forest Service Pacific Forestry Centre • Victoria, British Columbia Information Report • BC-X-411

- Boyle, O. C., (1987). National Database on Waste. An Foras Forbartha, Dublin.
- Buckley, C., Moran, B., and Donnellan, T. (2023). Teagasc national farm survey - A report on bovine manure management, application and storage practices in Ireland 2017 to 2021. Agricultural Economics & Farm Surveys Department, Teagasc. <https://www.teagasc.ie/publications/2023/a-report-on-bovine-manure-management-application-and-storage-practices-in-ireland-2017-to-2021.php>
- Burke, F., O'Donovan, M.A., Murphy, J.J., O'Mara, F.P. and Mulligan, F.J. (2008). Effect of pasture allowance and supplementation with maize silage and concentrates differing in crude protein concentration on milk production and nitrogen excretion by dairy cows. *Livestock Production Science* 2008; 114: 325-335.
- Büttner, G., Feranec, J., Jaffrain, G., Mari, L., Maucha, G. and Soukup, T. (2004). The CORINE land cover 2000 project. In Reuter, R. (Ed.), *EARSeL eProceedings* 3(3). Paris (EARSeL), pp. 331–346. CEC. 1993. CORINE Land Cover Technical Guide. European Union, Directorate-Environment, Luxembourg.
- Byrne, K.A. and Farrell, E.P. 2005. The effect of afforestation on soil carbon dioxide emissions in blanket peatland in Ireland. *Forestry*, 78, 217-227. doi:210.1093/forestry/cpi1020.
- Byrne, K.A. and Kiely, G. (2006). Partitioning of respiration in an intensely managed grassland. *Plant and Soil* 282:p 281–289.
- Carey, P., Carty, G., Crowe, M., and Rudden, P.J. (1996). National Waste Database Report 1998, Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.
- CEC-Commission of the European Communities, (2004). Commission Decision 2004/156/EC of 29/01/2004 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC. O.J. L59, 26 February 2004.
- CEC-Council of the European Communities, (1991). Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources O.J. L167.
- CEC-Council of the European Communities, (1999). Council Directive 99/13/EC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations. O.J. L85, 29 March 1999.
- CER- Commission for Energy Regulation, (2006) Gas Capacity Statement 2006
- CER- Commission for Energy Regulation, (2007) Gas Capacity Statement 2007
- CEU-Council of the European Union, (1999). Council Directive 1999/31/EC on the landfill of waste. O.J. L182, July 1999.
- Collins, C., Le Bolloch, O. and Meaney, B. (2005). National Waste Report 2004. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.
- Collins, C., Meaney, B., Nolan, K., Maher, H. and Corish, C. (2004b). National Waste Database Interim Report 2003. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.
- Collins, C., Meaney, B., Nolan, K., Maher, H. and Murphy, D. (2004a). National Waste Database Interim Report 2002. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

Connolly, J., Holden, N., (2009). Identification, Mapping, Assessment and Quantification of the Effects of Disturbance on the Peat Soil Carbon Stock in Ireland. https://www.epa.ie/publications/research/land-use-soils-and-transport/STRIVE_98_web.pdf

Cossu, R., Andreottola, G. and Muntoni, A., (1996). Modelling Landfill Gas Production. In Landfilling of Waste Biogas. Edited by T. H. Christensen, R. Cossu and R. Stegman. E and FN Spon, London.

Crowe, M., Fanning, A., Nolan, K., Carty, G. and Howley, D. (2000). National Waste Database Report 1998, Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

Crowley, A. M. (2001). Prediction of net energy requirements of beef cattle. M.Agr.Sc. Thesis, National University of Ireland, University College Dublin, November 2001, p145.

Crowley, A. M., Keane, M.G., Agabriel, J. and O'Mara F. P. (2002). Prediction of net energy requirements of beef cattle. Proceedings of Agricultural Research Forum, 11 and 12 March 2002, Tullamore, p 19.

Cruickshank, M.M. and Tomlinson, R.W. (1996). Application of CORINE Land Cover Methodology to the U.K.-Some Issues Raised from Northern Ireland. Global Ecology and Biogeography Letters 5 (4/5) Remote Sensing and GIS in the Service of Ecology and Biogeography: A Series of Case Studies.

Cruickshank, M.M., Tomlinson, R.W. and Trew, S. (2000). Application of CORINE land-cover mapping to estimate the carbon stored in the vegetation of Ireland. Journal of Environmental Management, 58, p269-287.

CSO- Central Statistics Office.(2009-2012). Transport Omnibus 2009-2010 and 2011. 2010 and 2012; Available at: <https://www.cso.ie/en/statistics/transport/archive/>

CSO-Central Statistics Office (2016) Population census 2016 Chapter 9 Housing; Available at https://www.cso.ie/en/media/csoie/releasespublications/documents/population/2017/Chapter_9_Housing.pdf

CTC-Clean Technology Centre, (2005). NMVOC Inventory for Ireland (SNAP Sector 6 Solvent and Other Product Use). Report to the Environmental Protection Agency.

DAFF-Department of Agriculture, Fisheries and Food, (2004). CMMS Statistics Report 2003. Department of Agriculture and Food, Dublin; Available at: [CMMS report 2003](#)

DAFF-Department of Agriculture, Fisheries and Food, (2005). CMMS Statistics Report 2004. Department of Agriculture and Food, Dublin; Available at: [CMMS Report 2004](#)

DAFF-Department of Agriculture, Fisheries and Food, (2006). CMMS Statistics Report 2005. Department of Agriculture and Food, Dublin; Available at: [CMMS Report 2005](#)

DAFF-Department of Agriculture, Fisheries and Food, (2007). CMMS Statistics Report 2006. Department of Agriculture and Food, Dublin; Available at: [CMMS Report 2006](#)

DAFF-Department of Agriculture, Fisheries and Food, (2008). CMMS Statistics Report 2007. Department of Agriculture and Food, Dublin; Available at: [CMMS Report 2007](#)

DAFF-Department of Agriculture, Fisheries and Food, (2009). AIM Bovine Statistics Report 2008. Department of Agriculture and Food, Dublin; Available at: [AIM Report 2008](#)

DAFF-Department of Agriculture, Fisheries and Food, (2010). AIM Bovine Statistics Report 2009. Department of Agriculture and Food, Dublin; Available at: [AIM Report 2009](#)

DAFM-Department of Agriculture, Food and the Marine, (2011). AIM Bovine Statistics Report 2010. Department of Agriculture, Food and the Marine, Dublin; Available at: [AIM Report 2010](#)

DAFM-Department of Agriculture, Food and the Marine, (2012). AIM Bovine Statistics Report 2011. Department of Agriculture, Food and the Marine, Dublin; Available at: [AIM Report 2011](#)

DAFM-Department of Agriculture, Food and the Marine, (2013). AIM Bovine Statistics Report 2012. Department of Agriculture, Food and the Marine, Dublin; Available at: [AIM Report 2012](#)

DAFM-Department of Agriculture, Food and the Marine (2014). AIM Bovine Statistics Report 2013. Department of Agriculture, Food and the Marine, Dublin; Available at: [AIM Report 2013](#)

DAFM-Department of Agriculture, Food and the Marine (2015). AIM Bovine Statistics Report 2014. Department of Agriculture, Food and the Marine, Dublin; Available at: [AIM Report 2014](#)

DAFM-Department of Agriculture, Food and the Marine (2016). AIM Bovine Statistics Report 2015. Department of Agriculture, Food and the Marine, Dublin; Available at: [AIM Report 2015](#)

DAFM-Department of Agriculture, Food and the Marine (2017). AIM Bovine Statistics Report 2016. Department of Agriculture, Food and the Marine, Dublin; Available at: [AIM Report 2016](#)

DAFM-Department of Agriculture, Food and the Marine (2018). AIM Bovine Statistics Report 2017. Department of Agriculture, Food and the Marine, Dublin; Available at: [AIM Report 2017](#)

DAFM-Department of Agriculture, Food and the Marine (2019). AIM Bovine Statistics Report 2018. Department of Agriculture, Food and the Marine, Dublin; Available at: [AIM Report 2018](#)

DAFM-Department of Agriculture, Food and the Marine (2020). AIM Bovine Statistics Report 2019. Department of Agriculture, Food and the Marine, Dublin; Available at: [AIM Report 2019](#)

DAFM-Department of Agriculture, Food and the Marine (2020), Industry survey on the crude protein content in compound animal feeds. Department of Agriculture, Food and the Marine, Dublin.

Davis, M. and Condron, L. (2002). Impact of grasslands afforestation on soil carbon in New Zealand: a review of paired-site studies. Australian Journal of Soil Research 40, 675-690.

DECLG-Department of the Environment, Community and Local Government, (2015). Climate Action And Low Carbon Development Act 2015; Available at: <http://www.irishstatutebook.ie/eli/2015/act/46/enacted/en/pdf>

DEHLG-Department of the Environment Heritage and Local Government, (2005). European Communities(Good Agricultural Practice for Protection of Waters) Regulations 2005. SI No 788 of 2005. Government Publications Office, Dublin.

DEHLG-Department of the Environment Heritage and Local Government, (2006). European Communities(Good Agricultural Practice for Protection of Waters) Regulations 2006. SI No 378 of 2006. Government Publications Office, Dublin.

DEHLG-Department of the Environment Heritage and Local Government, (2007). Limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints, varnishes and vehicle refinishing products regulations 2007. S.I. No. 199 of 2007. Government Publications Office, Dublin.

DEHLG-Department of the Environment Heritage and Local Government, (2008). Waste Management (Certification of Historic Unlicensed Waste Disposal and Recovery Activity) Regulations 2008. S.I. No. 524 of 2008. Government Publications Office, Dublin.

DEHLG-Department of the Environment Heritage and Local Government, (2009). European Communities(Good Agricultural Practice for Protection of Waters) Regulations 2009. SI No 101 of 2009. Government Publications Office, Dublin.

DEHLG-Department of the Environment Heritage and Local Government, (2010). European Communities(Good Agricultural Practice for Protection of Waters) Regulations 2010. SI No 610 of 2010. Government Publications Office, Dublin.

Del Prado, A., Brown, L., Schulte, R., Ryan, M. and Scholefield. (2006). Principles of development of a mass balance N cycle model for temperate grasslands: an Irish case study *Nutrient Cycling in Agroecosystems* (2006) 74: p 115–131.

DELG-Department of the Environment and Local Government, (1997). Sustainable Development. A Strategy for Ireland. Department of the Environment and Local Government, Custom House, Dublin.

DELG-Department of the Environment and Local Government, (1998). A Policy Statement. Waste Management. Changing our Ways. Department of the Environment and Local Government, Custom House, Dublin.

DeLong, E. R. , DeLong, D. M. and Clarke-Pearson D. L. (1988). Comparing the areas under two or more correlated receiver operating characteristic curves: A nonparametric approach. *Biometrics*, 44: p837-845.

DHPLG-Department of Housing, Planning and Local Government (2017). European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2017. SI No 605 of 2017. Government Publications Office, Dublin.

DHPLG-Department of Housing, Planning and Local Government (2018). European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2018. SI No 65 of 2018. Government Publications Office, Dublin.

DOE- Department of the Environment, (1997). IRELAND: Second National Communication under the UN Framework Convention on Climate Change. Department of the Environment, Custom House, Dublin.

DOE, DELG, DEHLG, DOT, DOTTS (1990 to 2014), Irish Bulletin of Vehicle and Driver Statistics (27 reports).

DOE-Department of the Environment, (1992). The Environmental Protection Agency Act, 1992. SI No 7 of 1992. Department of the Environment, Custom House, Dublin.

DOE-Department of the Environment, (1994). Recycling for Ireland. A Strategy for Recycling Domestic and Commercial Waste. Department of the Environment, Custom House, Dublin.

Duffy, P., Hyde, B., Hanley, E., Dore, C., O'Brien, P., Cotter, E. and Black, K. (2011). Ireland National Inventory Report 2011. Greenhouse Gas Emissions 1990-2009. Reported to the United Nations Framework Convention on Climate Change. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

Duffy, P., Hyde, B., Ryan, A.M. and Murphy, J. (2021). Ireland Informative Inventory Report 2021. Air pollutant emissions in Ireland 1990-2019. Reported to the secretariat of the UNECE convention on long-range transboundary air pollution and to the European Union. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

EC- European Commission (2013a). Commission Decision 2013/162/EU on determining Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC of the European Parliament and of the Council.

EC- European Commission (2013b). Commission Implementing Decision 2013/634/EU on the adjustments to Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC of the European Parliament and of the Council.

EC-European Commission (2020). Report from the Commission on the availability of hydrofluorocarbons on the Union Market (8842 final).

Edwards, P.N., and Christie, J.M. (1981). Yield models for forest management. Forestry Commission Booklet No. 48. HMSO, London.

EMEP/EEA (2013). EMEP/EEA air pollutant emission inventory guidebook 2016. Technical guidance to prepare national emission inventories. EEA Technical report No 12/2013. Publications Office of the European Union, Luxembourg.

EMEP/EEA (2016). EMEP/EEA air pollutant emission inventory guidebook 2016. Technical guidance to prepare national emission inventories. EEA report No 21/2016. Publications Office of the European Union, Luxembourg.

EMEP/EEA (2019). EMEP/EEA air pollutant emission inventory guidebook 2019. Technical guidance to prepare national emission inventories. EEA report No 13/2019. Publications Office of the European Union, Luxembourg.

EP- European Parliament and CEU-Council of the European Union (2009b). Directive 2009/30/EC amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EC.

EP- European Parliament and CEU-Council of the European Union (2013). Regulation of the European Parliament and of the Council No. 525/2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC

EP- European Parliament and CEU-Council of the European Union, (2001). Directive 2001/81/EC of 23 October 2001 on national emissions ceilings for certain atmospheric pollutants. O.J. L309, 27 November 2001.

EP- European Parliament and CEU-Council of the European Union, (2003). Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC. O.J. L275, 25 October 2003.

EP- European Parliament and CEU-Council of the European Union, (2004a). Decision 280/2004/EC of the European Parliament and of the Council concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol. O.J. L49, 19 February 2004.

EP- European Parliament and CEU-Council of the European Union, (2004b). Directive 2004/42/CE on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC. O.J. L143, 30 April 2004.

EP- European Parliament and CEU-Council of the European Union, (2009a). Decision No. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020.

ERL-Environmental Resources Limited, (1993). Towards a Recycling Strategy for Ireland. Department of the Environment, Custom House, Dublin.

EU- European Union (2015a). Council Decision EU 2015/1339 on the conclusion, on behalf of the European Union, of the Doha Amendment to the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfilment of commitments thereunder.

EU- European Union (2015b). Council Decision EU 2015/1340 on the conclusion, on behalf of the European Union, of the Agreement between the European Union and its Member States, of the one part, and Iceland, of the other part, concerning Iceland's participation in the joint fulfilment of commitments of the European Union, its Member States and Iceland for the second commitment period of the Kyoto Protocol to the United Nations Framework Convention on Climate Change.

European Semiconductor Industry Association (2011). PFC Voluntary Agreement Final Report, 2011

Eurocontrol, (2016). EUROCONTROL method for estimating aviation fuel burnt and emissions in the framework of the EMEP/EEA air pollutant emission inventory guidebook 2016
<https://www.eurocontrol.int/publication/eurocontrol-method-estimating-aviation-fuel-burnt-and-emissions>

Farrelly, N., NiDhubhain, A., Nieuwenhuis, M., (2011). Productivity models for Sitka spruce in Ireland based on GIS data and readily accessible site quality factors. Irish Forestry68: 6-23.

FDA (Forest Development association). 2007. Irish Thinning Protocol. - A complete step by step guide to the requirements and implementation of thinning systems in Ireland. Funded by the Forest Service of the Department of Agriculture and Food.

Fealy, R., and Green, S., (2009). Teagasc-EPA Soils and Subsoils Mapping Project, Final report.EPA, 2009

Fealy, R., Loftus, M. and Meehan, G. (2006). EPA Soil and Subsoil Mapping Project: Summary, Methodology, Description for Subsoils, Land Cover, Habitat and Soils Mapping/Modelling. EPA project report, Environmental Protection Agency, Johnstown Castle, Wexford.

Fehily Timoney and Company, (1985). Code of Good Practice for the Use of Biosolids in Agriculture. Guidelines for Farmers. Department of Environment and Local Government, Dublin.

Finn, J. et al, (2001). Estimation of Emissions of Non-Methane Volatile Organic Compounds from SNAP Sector 6: Solvent and Other Product Use for Ireland in 1998. Prepared for the Environmental

Protection Agency by the Clean Technology Centre, Cork Institute of Technology. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

Fogarty, G., Coggins, K and Gallagher, G., (1999). Forest Inventory and Planning System (FIPS). Irish Timber Growers Association Forestry Yearbook 2000. ITGA, Dublin.

Forestry Act 2014. Act Number 31 of 2014.

<http://www.irishstatutebook.ie/eli/2014/act/31/enacted/en/pdf>

Forest Service, (2000). Department of the Marine and Natural Resources Forestry Statistics. Internal publication.

Forestry Scheme Manual (2003). Forest Service, Department of Agriculture Food and the Marine. Dublin.

FSAI (Food Safety Authority of Ireland), (1999). Recommended Dietary Allowances for Ireland. Food Safety Authority of Ireland, Dublin. <http://www.fsai.ie/>

Gardiner, M. J. and Radford, T., (1980). Soil Associations of Ireland and their Land Use Potential. Explanatory Bulletin to Soil Map of Ireland 1980, Soil Survey Bulletin No 36, An Foras Taluntais, Dublin.

Gkatzoflias D. (Emisia S.A.), C. Kouridis (Emisia S.A.), L. Ntziachristos (LAT/AUTH), Z. Samaras (LAT/AUTH). (2012). COPERT 4 Computer programme to calculate emissions from road transport. User manual (version 9.0).

Gkatzoflias D., Kouridis C., Ntziachristos L. and Samaras Z., (2007). Copert 4. Computer programme to calculate emissions from road transport. Laboratory of Applied Thermodynamics, Mechanical Engineering Department, Aristotle University Thessaloniki.

Goodwin J., Gschrey B. and Salisbury E., (2013), Emission Inventories for HFCs, PFCs and SF6 for inclusion in Ireland's submission to the EU under Decision 280/2004/EC and the United Nations Framework Convention on Climate Change

Grassi, G., Pilli, R., House, J., Federici, S., & Kurz, W. A. 2018. Science-based approach for credible accounting of mitigation in managed forests. Carbon balance and management, 13(1), 8.

Hamilton, G.J. (1975). Forest Mensuration Handbook. Forestry Commission Booklet 39, HMSO, London.

Hargreaves, K., Milne, R. and Cannell, M.G.R. (2003). Carbon balance of afforested peatland in Scotland. Forestry, 76, p 299-317.

Harty, M.A., Forrestal, P.J., Watson, C.J., McGeough, K.L., Carolan, R., Elliot, C., Krol, D., Laughlin, R.J., Richards, K.G. and Lanigan, G.J. (2016). Reducing nitrous oxide emissions by changing N fertiliser use from calcium ammonium nitrate (CAN) to urea based formulations. Science of the Total Environment 563-564; 576--586

Hawkins M and Black K. (2012). Validating generalised diameter-height models for several species and heterogeneous crop structures. Irish Forestry 69: p58.73

Hazeu, G.W. and De Wit, A.J.W. (2004). CORINE land cover database of the Netherlands: monitoring land cover changes between 1986 and 2000. EARSeL eProceedings 3 (3). Paris (EARSeL)

Hyde, B., Carton, O.T. and Murphy, W.E. (2008). Farm Facilities Survey – Ireland 2003. Report prepared for the Department of Agriculture by Teagasc, Johnstown Castle, Co. Wexford. P1-150

ICRL, (1990). Notes on the development and after-use of landfill sites. Guidance Note 17/78. Eight Edition, December, 1990. Interdepartmental Committee on the Redevelopment of Contaminated Land.

INRA, (1989). Ruminant Nutrition. Recommended Allowances and Feed Tables. R. Jarrige, Ed. John Libbey Eurotext, London and Paris.

IPCC-Intergovernmental Panel on Climate Change, (1997). Revised 1996 Guidelines for National Greenhouse Gas Inventories. OECD, Paris.

IPCC-Intergovernmental Panel on Climate Change, (2000). IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. IGES (Institute for Global Environmental Strategies), Kanagawa, Japan.

IPCC-Intergovernmental Panel on Climate Change, (2003). Good Practice Guidance for Land Use, Land-Use Change and Forestry. IGES (Institute for Global Environmental Strategies), Kanagawa, Japan.

IUCC-Information Unit on Climate Change, (1998). The Kyoto Protocol to the Framework Convention on Climate Change. UNEP, Geneva.

Jovani-Sancho, A. J., Cummins, T., Byrne, K.A. 2018. Soil respiration partitioning in afforested temperate peatlands. *Biogeochemistry* 141:1–21

Khalil, M.I., Kiely, G., O'Brien, P. and Müller, C. (2013) Organic carbon stocks in agricultural soils in Ireland using combined empirical and GIS approaches. *Geoderma*, 193-194: p 222–235.

Kiely G., Xu X., Hsieh C.-I, Leahy P., Sottocornola M., Laine A., Mishurov M., Albertson J., Katul G., Oren R. and O. Carton (2009). CELTICFLUX: Measurement and Modeling of GHG Fluxes from Grasslands and a Peatland in Ireland *AsiaFlux Newsletter* No 28, March 2009.

Krol, D.J., Carolan, R., Minet, E., McGeough, K.L., Watson, C.J., Forrester, P.J., Lanigan, G.J. and Richards, K.G. (2016). Improving and disaggregating N₂O emission factors for ruminant excreta on temperate pasture soil. *Science of the Total Environment* 568; 327-338.

Kull, S.J.; Morken, S.; Smyth, C.E.; Fellows, M. 2016. Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3): Archive Index Database Table and Parameter Descriptions. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta.

Kurtz, W.A., Dymond, C.C., White, T.M., Stinson, G., Shaw, C.H., Rampley, G.J., Smyth, C., Simpson, B.N., Neilson, E.T., Trofymow, J.A., Metsaranta, J., and Apps, M.J. 2009. CBM-CFS3: a model of carbon-dynamics in forestry and land- use change implementing IPCC standards. *Ecol. Model.* 220(4): 480–504. doi 10.1016/j.ecolmodel.2008.10.018.

Le Bolloch, Meaney, B., Cope, J and Doyle, M., (2006). National Waste Report 2005: Data Update. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

Le Bolloch, O., Cope, J., Kurz, I., Meaney, B. and Higgins, T. (2009). National Waste Report 2007. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

Le Bolloch, O., Cope, J., Meaney, B and Kurz, I., (2007). National Waste Report 2006. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

Li, C., Frohling, S. and Harriss, R. (1994). Modelling carbon biogeochemistry in agricultural soils. *Global Biogeochemical Cycles*, 8, 237-254.

Li, Z., Kurtz, W.A., Apps, M.J., Beukema, S.J., 2003. Belowground dynamics in the Carbon Budget: recent improvements and implications for the estimation of NPP and NEP. *Can. J. For. Res.* 33, 126–136.

Li, C., Narayanan, V. and Harriss, R.C. (1996). Model estimates of nitrous oxide emissions from agricultural lands in the United States. *Global Biogeochemical Cycles* 10, 297-306.

Liski, J., Palosuo, T., Peltoniemi, N., Sievänen, R. (2005) Carbon and decomposition model Yasso for forest soils. *Ecological Modelling*: 189 168–182.

Loftus, M., Bulfin, M., Farrelly, N., Fealy, R., Green, S., Meehan, R. and T. Radford., 2002. The Irish Forest Soils project and its potential contribution to the assessment of biodiversity. *Proceedings of the Royal Irish Academy*, 102B (3), 151-165.

Luyssaert, S., Inglima, I., Jung, M., Richardson, A.D., Reichstein, M., Papale, D., Piao, S.L., Schulze, E.D., Wingate, L., Matteucci, G., Aragao, L., Aubinet, M., Beer, C., Bernhofer, C., Black, K.G., Bonal, D., Bonnefond, J.M., Chambers, J., Ciais, P., Cook, B., Davis, K.J., Dolman, J., Gielen, B., Goudlen, M., Grace, J., Granier, A., Grelle, A., Griffis, T., Grünwald, Guidolotti, G., Hanson, P.J., Harding, R., Hollinger, D.Y., Hutya, L.R., Kolari, P., Kruijt, B., Kutsch, W., Lagergren, F., Laurila, T., Law, B.E., Le Maire, G., Lindroth, A., Loustau, D., Malhi, Y., Mateus, J., Migliavacca, M., Misson, L., Montagnani, L., Moncrieff, J., Moors, E., Munger, J.W., Nikinmaa, E., Ollinger, V., Pita, G., Rebmann, C., Roupsard, O., Saigusa, N., Sanz, M.J., Seufert, G., Sierra, C., Smith, M.L., Tang, J., Valentini, R., Vesala, T. and Janssens, I.A. (2007). CO₂ balance of boreal, temperate, and tropical forests derived from a global database. *Global Change Biology* 13 (12), 2509-2537.

Marcogaz: Technical Association of the European Natural Gas Industry (2019). Assessment of methane emissions for gas Transmission and Distribution system operators, WG_ME-485.

Matthias Peichl, Paul Leahy, and Gerard Kiely (2011). Six-year Stable Annual Uptake of Carbon Dioxide in Intensively Managed Humid Temperate Grassland Ecosystems 14: p112–126 doi:10.1007/s10021-010-9398-2.

McCooles, F., Derham, J., Kurz, I and McDonagh, M. (2011). National Waste Report 2009. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

McCooles, F., Derham, J., Kurz, I. and Higgins, T. (2009). National Waste Report 2008. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

McCooles, F., Kurz, I., McDonagh, M. and O'Neill, D. (2013). National Waste Report 2011. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

McCooles, F., Kurz, I., McDonagh, M., Derham, J., O'Neill, D. (2012). National Waste Report 2010. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

McGoff, N.M., Eaton, J.M., Byrne, K., Leahy, P. and Kiely, G. (2007). Measurement of soil carbon stocks in Irish soils. British Ecological Society Annual Meeting, September 10-12, University of Glasgow, UK.

McInnes, G. (ed.), (1996). CORINAIR/EMEP Atmospheric Emission Inventory Guidebook. First Edition. European Environment Agency, Copenhagen.

MCOS - M C O'Sullivan & Co. Ltd, (1994). Report on Solid Waste Recycling (Packaging). Department of the Environment, Custom House, Dublin.

Meaney, B., Collins, C., Nolan, K., Cahill, E., Delaney, J., Murray, B., Healy, J. and Carty, G. (2003). National Waste Database Report 2001, Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

Monaghan, S., Smith, D., Wall, B. and O'Leary, G. (2009). Urban Waste Water Discharges in Ireland for Population Equivalents Greater than 500 Persons. A Report for the years 2006 and 2007. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

Monteith J.L., 2002. Fundamental equations for growth in uniform stands of vegetation. *Agricultural and Forest Meteorology* 104: 5–11.

Mulqueen et al., (1999). *Forest Drainage Engineering: A design Manual*. COFORD, Dublin

NEUT-Working Group on Nutrients and Eutrophication under the OSPAR Convention, (1999). *Screening Procedure for Irish Coastal Waters with Regard to Eutrophication Status*.

NFI- National Forest Inventory (2007a). *National Forest Inventory - Republic of Ireland - Results*. Forest Service, Department of Agriculture, Fisheries and Food, Johnstown Castle Estate, Co Wexford.

NFI- National Forest Inventory (2007b). *National Forest Inventory - Republic of Ireland - Methodology*. Forest Service, Department of Agriculture, Fisheries and Food, Johnstown Castle Estate, Co Wexford.

O'Brien, P. (2007). *Data Analysis and Estimation of Greenhouse Gas Emissions and Removals for the IPCC Sector Land Use Land-Use Change and Forestry in Ireland*. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland (in preparation).

O' Brien, D. and Shalloo, L. (2019), *A review of livestock methane emission factors*. Report prepared by Teagasc for the Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

O'Doherty, S. and McCulloch, A. (2002). *Emission Inventories of HFC, PFC and SF6*. RTDI Project L.S.-5.1.3(a) Final Report. Environmental Protection Agency, Johnstown Castle, Wexford.

O'Leary, E., (2002). *Emission Inventories for HFCs, PFCs and SF6 for Ireland 1995-2000*. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

O'Leary, E., Finn, J. and Cunningham, D., (2002). *Emission Inventories for HFCs, PFCs and SF6 for Ireland 1998*. RTDI Project L.S.-5.1.3(b) Final Report. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

O'Leary, G. and Carty, G. *Urban Waste Water Discharges in Ireland (1998)*. A Report for the years 1996 and 1997. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

O'Leary, G., Fanning, A. and Carty, G. (2000). *Urban Waste Water Discharges in Ireland*. A Report for the years 1998 and 1999.

O'Leary, G., Meaney, B. and Carty, G. (1997). *Urban Waste Water Discharges in Ireland*. A report for the years 1994 and 1995. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

O'Mara, F., (2006). *Development of Emission Factors for the Irish Cattle Herd*. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

O'Mara, F., Caffrey, P. J., and Drennan, M. J., (1997). *Net energy values of grass silage determined from comparative feeding trials*. *Irish Journal of Agricultural and Food Research*, 36, p110.

O’Rielly, C., Hasslacher, D., Murphy, W., Hendrick, E., Ward, D., Sheridan., J., Kelleher, D. and Gardiner, J. (1997). Christmas tree growing in Ireland. A sectoral report outlining the opportunities and problems. Council for Forest Research and Development.

Ordnance Survey Ireland (2005). Ortho Photography. <https://www.osi.ie/products/professional-mapping/osi-aerial-imagery/>

Pastramas, N.; Samaras, Ch.; Mellios, G.; Ntziachristos, L. (2014). Update of the Air Emissions Inventory Guidebook - Road Transport 2014 Update.

Peichl, M., Leahy, P. and Kiely, G. (2011). Six year stable annual uptake of carbon dioxide in intensively managed humid temperate grassland. *Ecosystems* 14, 122-126.

Petros, K., Ntziachristos, L., Mellios, G. (2012). Description of new elements in COPERT 4 v10.0.

Phillips, H. (2011). All-Ireland Roundwood Production Forecast 2011-2028. COFORD, Department of Agriculture, Fisheries and Food, Dublin.

Pilli R, Grassi G, Kurz WA, Smyth CE, Blujdea V. Application of the CBM-CFS3 model to estimate Italy’s forest carbon budget, 1995–2020. *Ecol Modell.* 2013;266(1):144–171. doi: 10.1016/j.ecolmodel.2013.07.007.

Pilli R, Grassi G, Kurz WA, Viñas RA, Guerrero NH. Modelling forest carbon stock changes as affected by harvest and natural disturbances. I. Comparison with countries’ estimates for forest management. *Carbon Balance Manag.* 2016;11(1):5. doi: 10.1186/s13021-016-0047-8.

Purcell, T. (1979). Inventory of Private Woodlands – 1973. Forest and Wildlife Service, Dublin.

Richards, K.G., Fenton, O., Khalil, M.I., Haria, A.H., Humphreys, J., Doody, D., Moels, R., Morgan, G. and Jordan, P. (2009). Good water status: The integration of sustainable grassland production and water resources in Ireland. *Tearmann: Irish journal of agri-environmental research*, 7, p143-160.

Richardson, S. (ed), (1999). CORINAIR/EMEP Atmospheric Emission Inventory Guidebook. Second Edition. European Environment Agency, Copenhagen.

Roche, L., Forrestal, P.J., Lanigan, G.J., Richards, K.G., Shaw, L.J. and Wall, D.P. Impact of fertiliser nitrogen formulation, and N stabilisers on nitrous oxide emissions in spring barley. *Agricultural, Ecosystems and Environment* 233; 229-237.

RSA- Road Safety Authority (2006). Survey of Free Speed 2006: Urban and Rural, Research Department.

RSA- Road Safety Authority (2007). Survey of Free Speed 2007: Urban and Rural, Research Department.

RSA- Road Safety Authority (2008). Free speed survey 2008 (Urban and Rural), Research Department.

RSA- Road Safety Authority (2011). Free speed survey 2011 (Urban and Rural), Research Department.

Ryan, M. Brophy, C., Connolly, J., McNamara, K. and Carton, O.T. (2006). Monitoring of nitrogen leaching on a dairy farm during four drainage seasons. *Irish Journal of Agricultural and Food Research* 45: p115–134.

SBSTA -Subsidiary Body for Scientific and Technological Advice, (1999). Guidelines for the Preparation of National Communications by Parties included in Annex I to the Convention. Part I: UNFCCC Reporting Guidelines on Annual Inventories. FCCC/SBSTA/1999/6/Add.1. UNFCCC Secretariat, Bonn.

SBSTA-Subsidiary Body for Scientific and Technological Advice, (2002). Guidelines for the Preparation of National Communications by Parties included in Annex I to the Convention. Part I: UNFCCC Reporting Guidelines on Annual Inventories. FCCC/SBSTA/2002/L.5/Add.1, UNFCCC Secretariat, Bonn.

Schwarz, W.; Gschrey, B.; Kimmel, T.; Stöbener, S. (2012). Inventarermittlung der F-Gase 2012 - Daten von HFKW, FKW und SF6 für die nationale Emissionsberichterstattung gemäß Klimarahmenkonvention für das Berichtsjahr. Commissioned by Umweltbundesamt (German EPA).

Sing, T., Sander, O. Beerenwinkel, N. and Lengauer, T. (2005). ROCr: Visualizing classifier performance in R. *Bioinformatics*, 21(20): p3940-3941.

Smith, D., O'Neill, N., Doris, Y. and Moriarty, J., (2004). Urban Waste Water Discharges in Ireland. A Report for the Years 2002/2003. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

Smith, D., O'Neill, N., Wall, B and Crowe, M. (2007). Urban Waste Water Discharges in Ireland. A Report for the years 2004 and 2005. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

Smith, D., O'Neill, N., Clinton, F. and Crowe, M. (2003). Urban Waste Water Discharges in Ireland. A Report for the years 2000 and 2001. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

Stange, F., Butterbach-Bahl, H., Papen, H. 2000. A process-oriented model of N₂O and NO emissions from forest soils 2. Sensitivity analysis and validation. *JOURNAL OF GEOPHYSICAL RESEARCH*, VOL. 105, NO. D4, PAGES 4385–4398

Thistlethwaite, G., Baggott, S. L. and Goodwin, J., (2005). National Inventory System Scoping Report for the Greenhouse Gas Emission Inventory in Ireland. AEAT/ENV/R/1990 Issue 1, NETCEN, UK.

Tobin, B., Black, K., Osborne, B. (2006). Assessment of allometric algorithms for estimating leaf biomass, leaf area index and litter fall in different aged Sitka spruce forests. *Forestry* 79: p453-465

Tomlinson, R.W., Cruickshank, M.M., Cruickshank, J.G., Mallon, G., McStravick, A., Byrne, K., Collins, J., O'Toole, P., Farrell, E., Cunningham, D., Milne, R. and Walsh, M. (2005). Impact of land use and land-use change on carbon emission/fixation. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland.

UN- United Nations, (2007). Report of the individual review of the greenhouse gas inventory of Ireland, Available at: <http://unfccc.int/resource/docs/2007/arr/irl.pdf>

UNECE-United Nations Economic Commission for Europe (1999). Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution to Abate Acidification, Eutrophication and Ground Level Ozone. UNECE Secretariat, Geneva.

UNFCCC-United Nations Framework Convention on Climate Change, (2014). Report of the individual review of the annual submission of Ireland submitted in 2013. FCCC/ARR/2013/IRL (In-country review, Ireland).

UNFCCC-United Nations Framework Convention on Climate Change, (2015). Report of the individual review of the annual submission of Ireland submitted in 2014.FCCC/ARR/2014/IRL (UN Secretariat, Bonn).

UNFCCC-United Nations Framework Convention on Climate Change, (2014). Decision 24/CP.19 Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention

UNFCCC-United Nations Framework Convention on Climate Change, (2013). 1/CMP.8 Amendment to the Kyoto Protocol pursuant to its Article 3, paragraph 9 (the Doha Amendment)

Waldchen et al 2013. The influence of changes in forest management over the past 200 years on present soil organic carbon stocks. *Forest Ecology and Management* 289(1):243–254.

WB -World Bank. World Development Indicators (Ireland), (2013); Available at: <http://data.worldbank.org/country/ireland>.

Wilson, D., Wilson, F.R., Farrell, C., Bullock, C. and Müller, C. (2012). *Carbon Restore – The Potential of Restored Irish Peatlands for Carbon Uptake and Storage*. CCRP Report Series No.15. Environmental Protection Agency, Johnstown Castle, Wexford, Ireland

Yamulki, S., Anderson, R., Peace, A. and Morison, J.I.L. (2013) Soil CO₂, CH₄ and N₂O fluxes from an afforested lowland raised peatbog in Scotland: implications for drainage and restoration. *Biogeosciences* 10: p1051-1065.

Yan, T., Agnew, R. E., Gordon, F. J. and Porter, M. G. (2000). Prediction of methane energy output in dairy and beef cattle offered grass silage-based diets. *Livestock Production Science*, 64: p 253-263.

Annex A to H

(click on hyperlinks below to view relevant Annex or navigate to <https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/irelands-unece-submissions-2023.php>)

Annex A	A.2 Key Category Analysis 2021
Annex B	A.3 Fuel Tourism in Road Transport and Nitrogen Oxides Emissions Based on Fuels Used
Annex C	Expanded Energy Balance Sheet for 2021
Annex D	Emission Factors for Energy (NFR 1)
Annex E	Emission Factors for Industrial Processes (NFR 2)
Annex F	Emission Factors for Agricultural Activity Data and Emission Factors (NFR 3)
Annex G	Emission Factors for Waste (NFR 5)
Annex H	Uncertainty Analysis
	2022 NECD Review findings and responses

Annex H
2022 NECD Review findings and responses

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-1A3bvi-2022-0001	1A3bvi Road Transport: Automobile Tyre and Brake Wear, PM10, 1990-2020	For category 1A3bvi Road Transport: Automobile Tyre and Brake Wear and PM10 for all years, the TERT noted, with reference to NFR tables that PM10 emissions were lower than PM2.5 emissions. In response to a question raised during the review, Ireland explained that there was a transcription error in the NFR table for PM10. Ireland provided a revised estimate for all years and stated that it will be included in the 2023 submission. The TERT agreed with the revised estimate provided by Ireland. The TERT recommends that Ireland include the revised estimate in its 2023 NFR tables and IIR submission.	RE	-	-
IE-1A2-2022-0001	1A2 Stationary Combustion in Manufacturing Industries and Construction, NH3, 2020	For 1A2 Stationary Combustion in Manufacturing Industries and Construction (the issue relates to source categories 1A2b, 1A2c and 1A2d) and NH3 and year 2020 the TERT noted that there is a lack of transparency regarding the use of the notation key 'IE' which is inconsistent with other years. Additionally, the TERT notes for the sources sectors 1A2a-f that there is a lack of transparency regarding the use of the notation key 'NO' in several years. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Ireland explained with regards 1A2b, 1A2c and 1A2d and NH3 and the use of 'IE' in year 2020 that the notation key for 2020 should be brought in line with other years and that this will be corrected in the next submission. With regards to the source categories 1A2a-f and NH3 and the use of 'NO' in several years Ireland explained that it will review the use of 'NO' and include an explanation in the next submission. The TERT recommends that Ireland review the use of notation keys and corrects them where appropriate in the next submission.	-	-	-

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-1A3ai(i)-2021-0001	1A3ai(i) International Aviation LTO (Civil), PM10, 2019	For category 1A3ai(i) International Aviation LTO (Civil) and PM10 for 2019, the TERT noted, with reference to the NFR tables and IIR pages 50-51, that there is a lack of transparency regarding the trend of PM10 implied emission factor for the year 2019. The 2019 IEF is 1.43 g/GJ whilst the 2018 IEF is 2.18 g/GJ and the 2020 IEF is 2.15 g/GJ, and the 2005-2020 timeseries IEFs are between 2.64 and 2.14 g/GJ. This 2019 IEF is not in the trend. This was raised during the 2021 NECD inventory review. In response to a question raised during the review, Ireland explained that PM emissions are from EUROCONTROL AEM Model, and that Ireland has asked many times for further detail in relation to the revisions made, specifically in relation to the changes made at the level of emission estimation (i.e. airport pairs), however no response has been forthcoming. Ireland will endeavour to follow up on this issue with EUROCONTROL again prior to the next annual submission and report on any revisions made. The TERT recommends again that Ireland check the entire time series emissions from and with EUROCONTROL at each submission to report a consistent emissions time series.	-	-	-
IE-1A3aii(i)-2021-0001	1A3aii(i) Domestic Aviation LTO (Civil), Pb, 1990-2018	For 1A3aii(i) Domestic Aviation LTO (Civil) and Pb for all years, the TERT noted that there is a lack of transparency regarding recalculation explanations in the IIR. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Ireland explained that the Pb EF for aviation gasoline was changed from using a gasoline EF from road transport to the '2019 EMEP/EEA Guidebook, 1A3a, Appendix B: 'A value of 0.56 g lead per litre gasoline should be used as the default value if there is an absence of better information'. The new EF is 16.64 kg/TJ for gasoline based on a density of 0.56 g/litre. The TERT recommends that Ireland includes a clear explanation in its next IIR submissions, e.g. by ensuring that all NFR categories where emissions have been recalculated are addressed in the recalculations chapter.	No	Ireland has explained all recalculations in the relevant recalculations sections of each Chapter	Section 3.11, 4.8, 5.6 and 6.7

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-1A5a-2022-0001	1A5a Other, Stationary (Including Military), NH3, 1990-2020	For 1A5a Other, Stationary (Including Military), and NH3 for all years, the TERT noted that there is a lack of transparency regarding the use of the notation key 'NE' whilst in the IIR for this source category it is stated that it's included in source category 1A4a. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Ireland explained that the wrong notation key is used in the NFR and that this will be changed to 'IE'. The TERT recommends that Ireland in the next submission changes the notation key to bring it in line with the explanation on this source category in the IIR.	-	-	-
IE-2-2022-0002	2 Industry, NA, 1990-2020	For several subcategories within 2 Industry and all years, the TERT noted that there is a lack of transparency regarding the use of notation keys. The TERT identified three distinct instances where the current use of notation keys is not in line with the guidelines: (1) For activities not indicated in the IIR to exist, the notation keys for all pollutants should be 'NO', e.g. 2B1 Ammonia Production, 2B3 Adipic Acid Production, 2B5 Carbide Production and 2B6 Titanium Dioxide Production; (2) For activities occurring according to the IIR and reported under 2A6 Other Mineral Products and 2K Consumption of POPs and Heavy Metals (e.g. electrical and scientific equipment), the 'NO' notation key cannot be used for single pollutants when the activity occurs, and, (3) For those years that 2A3 Glass Production did not occur, the notation keys used for all pollutants should be 'NO'. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Ireland stated that they will review the use of notation keys for the aforementioned categories and provide appropriate text in the IIR of its next annual submission. The TERT recommends that Ireland change the notation keys to follow the definitions and to provide the related explanations in the IIR in the next submission.	No	1. Notation key for 2B1, 2B3, 2B5 and 2B6 updated to NO. 2. Notation key for 2A6 and 2K has been updated for single pollutants to NA. 3. The notation key for 2A3 for years where production did not occur has been changed to NO	-

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-2-2022-0001	2 Industry, NA, 1990-2020	<p>For many subcategories within industrial processes and all years, the TERT noted that there is a lack of transparency regarding the use of notation keys. The TERT noted that there is a lack of transparency regarding whether all sources occur or not in Ireland as the different pollutants from the same source are reported using the notation keys 'NO', 'NA' and 'IE' without any numerical estimates nor explanations in the IIR. The categories concerned are: 2B2 Nitric Acid Production, 2B7 Soda Ash Production, 2B10a Chemical Industry: Other, 2B10b Storage, Handling and Transport of chemical products, 2C7a Copper Production, 2H1 Pulp and Paper Industry, 2H3 Other Industrial Processes, 2I Wood Processing, and 2J Production of POPs. On the other hand, e.g. for NFR 2C2 Ferroalloys Production, 2C7c Other Metal Production the notation key 'NO' (not occurring) has been used for some pollutants, while emissions are reported for other pollutants. Regarding 2C4 Magnesium Production the notation key 'NO' has been used correctly across all pollutants indicating the activity does not occur. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Ireland stated that they will review the use of notation keys and ensure 'NO' is reserved for activities that do not occur in the country, the notation key for pollutants not relevant to the activity shall be reported as 'NA' and those not estimated as 'NE' - in line with the Reporting Guidelines. The TERT recommends Ireland change notation keys as appropriate to follow the definitions in the next submission.</p>		<p>NK for 2B2, 1990-2002 changed to "NA" for single pollutants where the activity occurs and "NO" for those years that it did not occur 2B7 changed from "NA" to "NO", NK for 2B10a changed to "NA" for single pollutants which are not applicable, NK for 2B10a remains as "NO" emissions in this activity are not occurring. NK for 2C7a 1990-2006 "NA" for single pollutants where the activity occurs and "NO" for those years that it did not occur. 2H1 Nk remains as "NO" emissions in this activity are not occurring. 2H3, 2I and 2J NK "NO" is used as emissions in this activity are not occurring. 2C2 NA used for single pollutants where activity occurs and EF is not available, NO used for HCB after 1996 as there was a European ban on HCB imposed in this year. 2C7c NK changed to NA for single pollutants where activity occurs and EF not available.</p>	
IE-2A1-2022-0001	2A1 Cement Production, PM2.5, PM10, 1990-2020	<p>For 2A1 Cement Production and pollutants PM10 and PM2.5 for all years, the TERT noted that there may be an under-estimate of emissions related to reporting 'NE' for particle emissions while the 2019 EMEP/EEA Guidebook provides a Tier 1 method. In response to a question raised during the review, Ireland provided a revised estimate using the 2019 EMEP/EEA Guidebook Chapter 2A1 Cement Production Table 3.1 Tier 1 EFs for particulates and informed the TERT that these estimates will be included in the 2023 submission. The TERT agreed with the revised estimate provided by Ireland. The TERT recommends that Ireland include the revised estimate in its 2023 NFR and IIR submission.</p>	RE	Revised estimate is included in 2023 submission.	Chap 4, section 4.2.1

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-2A2-2022-0001	2A2 Lime Production, PM2.5, PM10, BC, TSP, 1990-2020	For 2A2 Lime Production and particulate matter for all years, the TERT noted that there may be an under-estimate of emissions related to reporting 'NA' for PM2.5, PM10, TSP and BC emissions while the 2019 EMEP/EEA Guidebook provides methods for these process-related emissions. In response to a question raised during the review, Ireland provided a revised estimate based on the use of 2019 EMEP/EEA Guidebook Tier 2 controlled emission factors Table 3.3 Chapter 2A2 Lime Production and stated that the use of controlled emission factors is justified as facilities have BAT abatement techniques in use to minimise/prevent diffuse dust emission from dusty operations, bulk storage areas and other operations. The TERT agreed with the revised estimate provided by Ireland. The TERT recommends that Ireland include the revised estimate in its 2023 NFR and IIR submission.	RE	Revised estimate is included in 2023 submission.	Chap 4, section 4.2.2

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-2A5a-2022-0001	2A5a Quarrying and Mining of Minerals Other Than Coal, PM2.5, PM10, TSP, 1990-2020	<p>The TERT noted with reference to category 2A5a Quarrying and Mining of Minerals Other Than Coal and particulate matter for all years and IIR 2022 (p. 77) that a Tier 1 method is used for a key category. The TERT is of the view that the use of a Tier 2 or Tier 3 method could be possible if Ireland could use data from the mining companies. In response to a question raised during the review, Ireland explained that the Tier 2 methodology was reviewed previously and the level of detail of data required is not available, so Ireland will continue to use the Tier 1 method to estimate emissions from this source. The TERT notes that this finding could be related to an over/under-estimate of emissions with an impact on total emissions that is above the threshold of significance. Ireland has not provided a revised estimate which has been accepted by the TERT. It is currently not possible for the TERT to provide a numerical emissions estimate with an adequate level of certainty as the TERT has no activity data available. Therefore, this issue is flagged as a recommendation only, however the TERT strongly recommends that Ireland develop a Tier 2/Tier 3 method for PM2.5, PM10 and TSP emissions from NFR 2A5a Quarrying and Mining of Minerals Other Than Coal for inclusion in next years' inventory submission. The TERT recommends that Ireland either (1) use TSP reported by the plants according to their environmental permits and then use fraction factors to quantify PM10 and PM2.5 emissions, or, (2) develop a country specific method in cooperation with mining companies, or, (3) collect the data needed in the Guidebook calculation sheet for a Tier 2 methodology, and report the revised emissions with the related documentation in the IIR in the next submission.</p>	no	<p>Ireland has reviewed the Tier 2 methodology and determined the level of detail of data required is not available as the number and types of quarries in addition to mines makes moving to a Tier 2 impossible. The recommendation mentions mining companies, however as stated in our answer during the review, it is not possible for Ireland to source the data required to estimate these emissions using a Tier 2 method, nor is it appropriate to apply the Tier 2 model using the context of a different country such as that on which the model has been developed. Ireland does not have information on the type of processing occurring on quarries, internal transport movements, drilling and blasting activity, material handling, stockpile sizes, abatement technologies used or annual output of quarries. Ireland does not have this data available for any mining and quarry sites which would be numerous, of varying sizes and mainly under private ownership (and not owned by large companies) and will continue to use the Tier 1 method to estimate emissions from this source.</p>	Chapter 4, Section 4.1.1

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-2C5-2022-0001	2C5 Lead Production, SO ₂ , PM _{2.5} , Cd, Hg, Pb, PM ₁₀ , 1990-2009	<p>For 2C5 Lead Production and particulate matter, heavy metals and SO₂ for 1990-2009, the TERT noted that there may be an under-estimation of emissions because no emissions are reported except for Pb for the years 1990-2009, while the 2019 EMEP/EEA Guidebook provides default EFs for particles, heavy metals, SOX and POPs. The IIR 2022 section 4.4.4 is not clear on whether the provided Pb emissions are from lead mining (which should be, and also seem to be, reported under NFR 2A5a) or from lead production (2C5) when there is reference to 'facility' rather than 'mining'. In response to a question raised during the review Ireland explained that as stated in the IIR estimates, facility level lead emissions have been obtained from annual environmental reports and PRTR data, and this facility reporting is a metal processing facility which carries out secondary lead production and processes lead and lead alloys from scrap lead. Abatement using bag filters is in place in this facility and no fugitive releases of lead have been reported since 2009. Ireland will review the reporting of PM emissions and notation keys used and correct as appropriate for the 2023 submission. Ireland will also include more transparent information on source of emissions in the IIR 2023. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Ireland estimate and report emissions of relevant pollutants in accordance with the 2019 EMEP/EEA Guidebook or provide justification for why these emissions are not applicable under Irish conditions. Furthermore, the TERT recommends that Ireland improve the information in the IIR on the process, abatement equipment and related emissions.</p>	No	Explanation included in IIR 2023. NK for 2C5, 1990-2009 changed to "NA" for single pollutants where the activity occurs and the pollutants are not reported by the facility.	Chapter 4, Section 4.4.4

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-2C7a-2022-0001	2C7a Copper Production, SO ₂ , PM _{2.5} , PM ₁₀ , 1990-2006	<p>The TERT notes that for category 2C7a Copper Production no emissions are reported for the years and pollutants: SOX (1990-2006); PM_{2.5} (1990-2006); PM₁₀ (1990-2006), and that there may be an under-estimation of emissions. The TERT would expect emissions to be reported for these pollutants because emissions of other pollutants have been reported for this category and there are default Tier 1 EFs in the 2019 EMEP/EEA Guidebook. Please also note, that the notation key 'NO' that is used for this category throughout the NFR tables is reserved to activities that do not occur in the country. While according to the 2022 IIR this activity occurred, the notation key for pollutants not relevant to the activity shall be reported as 'NA' and those not estimated as 'NE'- in line with the Reporting Guidelines (available on CEIP website). In response to a question raised during the review, Ireland responded that the emissions reported in 2C7a Copper Production (Cu emissions only) were taken from the annual reporting of monitoring results from a licenced facility that granulates copper cables. Installation of abatement equipment resulted in all emissions to air falling below detection limits, hence reporting of Cu ceased in 2007. As no roasting, smelting, converting, refining or electro-refining of copper is carried out at this facility, the emissions associated with Primary and Secondary copper production are not occurring. The TERT recommend Ireland to (1) change the notation key 'NO' to a notation key following the definitions in Reporting Guidelines paragraph 12 to reflect the existence of activities and emissions through the historical years and to include the related explanation in the IIR; and to (2) include the information given in their response about development of abatement technologies and their impact on emissions in the IIR to increase the transparency of reporting in the next submission.</p>	No	NK for changed to "NA" for single pollutants where the activity occurs but these pollutatnts are not emitted and "NO" for those years that it did not occur. Explanation of reporting included in IIR 2023	Chapter 4, section 4.4.5

IE-2C7d-2022-0001	2C7d Storage, Handling and Transport of Metal Products , PM2.5, PM10, TSP, 2000-2010	<p>For 2C7d Storage, Handling and Transport of Metal Products and particulate matter for 2000-2010, the TERT noted that there is a lack of transparency regarding the emission levels presented in Table 4.12 because categories 2C7a and 2C7b are reported as 'NO' while only notation keys are reported for 2C7d, and the values reported for 2C7c do not match those in the IIR table. For NFR 2C7d particles are reported as 'NE' while methods exist in the 2019 EMEP/EEA Guidebook (albeit only for iron ore). The IIR does not provide any AD for NFR 2C7 categories. This does not relate to an over- or underestimate of emissions. In response to a question raised during the review, Ireland explained that the emissions reported in 2C7 were taken from the annual reporting of monitoring results from licenced facilities which, as stated in the IIR, manufacture wire, galvanise metal and manufacture refined or secondary metal products e.g. metal plating or casting. Plant production data has not been provided by the facilities and this has proved difficult to obtain, so reported emissions under AER and PRTR are used to estimate emissions in 2C7. Installation of abatement equipment resulted in some emissions to air falling below detection limits, hence reporting of various metals ceases for some facilities in certain years. In 2C7a no roasting, smelting, converting, refining or electro-refining of copper is carried out, so the emissions associated with Primary and Secondary copper production are not occurring. 2C7b Nickel Production is not occurring so emissions are reported as 'NO'. Table 4.12 does not report heavy metal emissions by sub sector 2C7a-2C7d but rather by heavy metal species. In the case of 2C7c, Cu is reported from metal plating facilities until 2008, table 4.12 gives total Cu emissions reported under 2C7 which includes those reported under 2C7a and 2C7c which is why the IIR does not match 2C7c emission values. No Iron and Steel Production occurred in Ireland after 2001, for years 2000-2010 storage, handling and transport of Iron ore was not occurring, the use of notation key 'NE' will be reviewed for sector 2C7d for the 2023 submission. The TERT recommends that Ireland in the next IIR submission document the history of existence of the different metal industries in line with the information provided during the review. Furthermore, the TERT recommends that Ireland check the consistency between IIR table 4.2 and the NFR.</p>	no	Explanation in IIR updated and notation keys reviewed as per response to IE-2C7a-2022-0001	Chapter 4, section 4.4.5
-------------------	--	--	----	--	--------------------------

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-2D-2022-0001	2D Non Energy Products From Fuels and Solvent Uses, NMVOC, 1990-2020	<p>For 2D3a Domestic Solvent Use Including Fungicides, 2D3c Asphalt Roofing, 2D3d Coating Applications, 2D3g Chemical Products, 2D3h Printing, the TERT noted that there is a lack of transparency regarding the activity data used. 2D3a Domestic Solvent Use Including Fungicides: Ireland explained a Tier 2 method was implemented which uses population data obtained from the C.S.O and per capita emission factors for product use from the 2019 EMEP/EEA Guidebook. However, the TERT noted that this approach is not in line with the decision tree as 2D3a is a key category. The Tier 2b methodology requires the use of EF from Table 3.4 Tier 2 NMVOC emission factors for source category 2D3a Domestic Solvent Use Including Fungicides for different products and product types of the 2019 EMEP/EEA Guidebook (chapter 2D3a Domestic Solvent Use Including Fungicides, page 16). Only to complete the emissions estimates for 2D3a, the EF of Table 3.5 Tier 2 NMVOC emission factors can be used. The TERT recommends that Ireland provides an estimate for NMVOC based on the guidance in the 2019 EMEP/EEA Guidebook in the next submission. For 2D3c Asphalt Roofing, 2D3d Coating Applications, 2D3g Chemical Products, 2D3h Printing, the TERT noted that there is a lack of transparency regarding the activity data used. This does not relate to an over- or under-estimate of emissions. Furthermore, Ireland explained that 2D3c Asphalt Roofing does not occur in Ireland. The TERT recommends that Ireland uses for both emissions and activity data the notation key 'NO' (not occurring) in the next submission and includes documentation for the lack of asphalt roofing in Ireland in the IIR. 2D3d Coating Applications, 2D3g Chemical Products and 2D3h Printing: Ireland explained that due to the variation in sources of AD, AD could not be provided in the NFR. The TERT recommends that Ireland provide detailed information on the activity data used including time series in the IIR.</p>	no	<p>Ireland does not have the product statistics required to use the Tier 2 EF's in Table 3.4 (g/kg product) for the various products and product types and hence used the emission factors in table 3.5 which are per capita EF's. Ireland has included the notation key NO for 2D3c asphalt roofing activity data and emissions and has explained in the IIR section 4.11 why this does not occur. An explanation of AD for 2D3d Coating Applications has been included in the IIR for several years in sections 4.5.3.1 to 4.5.3.6. Activity data for 2D3g Chemical Products is described in sections 4.5.5.1 to 4.5.5.8 and in most cases emissions data are sourced from PRTR and AER reporting. The activity data for 2D3h Printing was described in section 4.5.6 of the IIR. These descriptions are included in the IIR 2023.</p>	<p>Sections 4.5.3.1-4.5.3.6, 4.5.5.1 - 4.5.5.8 and section 4.1.1</p>

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-2H2-2022-0003	2H2 Food and Beverages Industry, NMVOC, 1990-2020	<p>For 2H2 Food and Beverages Industry and NMVOC for all years, the TERT noted that there was a lack of transparency regarding the activity data used to estimate emissions. Specifically, the TERT was unsure on whether emissions from animal rendering, cakes, biscuits, margarine and solid cooking oil manufacture were included. In response to a question raised during the review Ireland clarified that 2H2 Food and Beverages Industry includes emissions from animal rendering as well as production of cakes and biscuits. Ireland noted that the statement 'Emissions from cakes are not included in this estimate as no activity data is available' in the IIR section 4.5.8 was incorrect and would be deleted in the 2023 submission. Ireland further stated that attempts would be made to find a suitable source of activity data for margarine and solid cooking oils manufacture and will report on progress in the 2023 submission. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Ireland estimate and report the missing emissions in the next submission. Furthermore, the TERT recommends that Ireland clearly document in the next IIR submission the activities that are included within the category of 2H2 and any omissions of activities where there are default emission factors in the 2019 EMEP/EEA Guidebook.</p>	no	The IIR 2023 was updated and Ireland is attempting to source AD for margarine and solid cooking oils manufacture	section 4.5.8, 4.5.8.1, 4.5.8.4,

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-2H2-2022-0002	2H2 Food and Beverages Industry, PM10, PM2.5, TSP, BC, 2000-2020	<p>The TERT noted with reference to NFR 2H2 Food and Beverages Industry and IIR Chapter 4.5 that there may be an under-estimate of emissions. This under-estimate does not have an impact on total emissions that is above the threshold of significance. The TERT notes that this issue may be caused by not estimating PM10 emissions from handling of agricultural products while the 2019 EMEP/EEA Guidebook provides the EF (Table 3-10). The TERT also notes that for PM2.5, TSP and BC emissions the notation key 'NO' (not occurring) is reported, while no emissions are expected. To the questions on the issue Ireland responded that emissions from the handling of agricultural products in category 2H2 relates to just one part of the different processes/technologies, which occurs in the food and beverage industry. Ireland utilises the default Tier 2 emission factors from Table 3-28 on the basis that activity data statistics are available. Table 3-28 does not include emission factors for PM10, PM2.5, TSP, BC. In fact, the text at the top of page 21 of Chapter 2H2 states that the default Tier 2 emission factors are expected to be more useful than the background emission factors because of the availability of activity data statistics. However, the inventory agency will investigate whether information /activity data can be gathered directly from the food and beverage industry to apply the background emission factors. The TERT recommends Ireland to use the Tier 1 EF provided in Table 3-10 Chapter 2H2 of the 2019 EMEP/EEA Guidebook to estimate the missing PM10 emissions from handling of agricultural products as no higher Tier EFs are available for the source in the next submission. The TERT also recommends Ireland to change the notation keys 'NO' reported for PM2.5, TSP and BC emissions to follow the definitions in Reporting Guidelines paragraph 12, as this category occurs in Ireland, in the next submission.</p>	no	-	-

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-3-2022-0001	3Da2a Animal Manure Applied to Soils, NH3, 2018-2020	For 3Da2a Animal Manure Applied to Soils and NH3 for 2018-2020, the TERT noted that there is a lack of transparency regarding data for the use of low emission spreading techniques. From 2018-2020 a significant decrease in NH3 emissions from application of animal manure on soils is seen, and regarding the use of low emission spreading techniques refers to Teagasc, 2020 (also pers.comm.) (IIR p. 120). However, it was not clear for the TERT how the use of low emission technologies is estimated for 2018-2020. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Ireland provided a link to the report documenting application techniques until 2018 and explained that for 2019 and 2020, the information was received from Teagasc and the data was not yet published. Ireland also explained the background for the changes, where the driver has been the Nitrates Action Plan. Ireland further informed the TERT that an updated report containing the latest data had been commissioned and is expected in 2022. The TERT notes that information leading to a substantive decrease in emissions should be better documented than through personal communication. The TERT recommends that Ireland provide more information in the IIR on the data used regarding manure application practices through the time series with references to the relevant publications in the next IIR submission.	No	Ireland has provided further information on the source of LESS spreading of manures in the IIR 2023	Chapter 5, section 5.3.2
IE-3B1a-2022-0001	3B1a Manure Management - Dairy Cattle, PM2.5, PM10, 1990-2020	For 3B1a Manure Management - Dairy Cattle, PM emissions for all years, the TERT noted that Ireland in the IIR in Section 5.2.1 page 121 explained that "Emissions of TSP, PM10 and PM2.5 are estimated using a Tier 1 emission factor split by cattle type and housing category (slurry/solid housing)", which is not consistent with information given in IIR Table E.7. Furthermore, PM10 emissions are a key source and therefore it is good practice to use more detailed data if available (distinction between liquid and solid manure. In response to a question raised during the review Ireland responded that they will examine the emission factors presented in Table A1.7 of the 2019 EMEP/EEA Guidebook in conjunction with animal weights in Ireland and include revised emissions estimates for particulate matter emissions in the next submission. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Ireland proceed as outlined with examining and as applicable implementing the revised methodology in the 2023 submission.	No	Not yet complete, we will continue this work and include in the next submission as applicable.	-

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-3Da1-2022-0001	3Da1 Inorganic N-Fertilizers, PM2.5, PM10, TSP, 1990-2020	For 3Da1 Inorganic N-fertilizers, PM emissions for years 1990-2020, the TERT noted that there may be an over/under-estimate of emissions, since emissions are estimated using a Tier 1 methodology for a key category. In response to a question raised during the review, Ireland provided a revised estimate for PM from field operations for all years using the Tier 2 methodology in the 2019 EMEP/EEA Guidebook. Ireland stated that it will be included in the next submission (reallocated to category 3Dc). The TERT agreed with the revised estimate provided by Ireland. The TERT recommends that Ireland include the revised estimate in its 2023 NFR and IIR submission.	RE	Revised estimate is included in 2023 submission For PM2.5 and PM10 and reallocated to category 3Dc. Notation key NA used for TSP for 3Dc as no EF in 2019 guidebook chapter 3D tables 3.5-3.8	Annex 1
IE-3B4h-2022-0001	3B4h Manure Management - Other Animals, NOX, 1990-2020	For category 3B4h Manure Management - Other Animals and NOX for all years, the TERT noted that the implied emission factor reduced by nearly half from 2010 to 2011. In response to a question raised during the review Ireland explained that this decreasing in IEF is due to change of AWMS used for mink which are included in 3B4h. From 2011 onwards, 48% are housed in solid manure-based housing and 52% in liquid-based housing systems. Ireland confirmed that information on AWMS for mink will be included in next submission. The TERT recommends that Ireland include information in the IIR regarding the AWMS for mink production, and information on the NOX emission factor used for liquid and solid mink manure in the next submission.	No	Explanation included in IIR 2023	Chapter 5, Section 5.2.5

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-3Da2a-2022-0001	3 Agriculture, NMVOC, 1990-2020	For category 3Da2a Animal Manure Applied to Soils and 3Da3 Urine and Dung Deposited by Grazing Animals and NMVOC for all years, the TERT noted the notation key 'NE' is used for these categories, while emissions estimates are expected, because emission from livestock production is based on a Tier 2 approach. In response to a question raised during the review, Ireland explained that either the notation key will be changed to 'IE' or the NMVOC emission associated with these categories will be reallocated from 3B. The TERT noted that the issue is related to allocation of emissions. The TERT recommends that Ireland report NMVOC emission from livestock production split in category 3B, 3Da2a and 3Da3 in the next submission.	No	Emissions of NMVOC from 3Da2a and 3Da3 are estimated based on the Tier 2 approach and have been reported along with emissions from manure management in NFR 3B. The notation key included elsewhere (IE) is used for NMVOC for 3Da2a and 3Da3.	Chap 5, section 5.3.2 and 5.3.4
IE-3Dd-2022-0002	3Dd Off-Farm Storage, Handling and Transport of Bulk Agricultural Products, PM2.5, PM10, TSP, 1990-2020	For 3Dd Off-Farm Storage, Handling and Transport of Bulk Agricultural Products and particulate matter for all years, the TERT noted that there is a lack of transparency regarding the emission factor used and the emission calculations, and it was not possible based on the information contained in the IIR with annexes for the TERT to reproduce the calculation. This was further complicated by two different activities being included, i.e. emissions from field operations and from handling of mineral fertiliser. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Ireland provided a link to the reference for the emission factors used for handling of mineral fertilisers and clarified that the emission factor units are grams per tonne fertiliser rather than kg/ha as presented in IIR Annex E.8 and that this will be corrected for the next submission. The TERT notes that handling, storage and transport of mineral fertiliser (originally SNAP 040415) is considered part of the NFR category of 2B10b Storage, handling and transport of chemical products. The TERT recommends that Ireland reallocate the emissions from handling, storage and transport of mineral fertiliser to 2B10b in the next submission.	no	reallocated fertiliser emissions reporting from 3Dd to 2B10b	Annex 1

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-5A-2022-0001	5A Biological Treatment of Waste - Solid Waste Disposal on Land, PM2.5, PM10, 1990-2020	For 5A Biological Treatment of Waste - Solid Waste Disposal on Land, PM10 and PM2.5 for all years, the TERT noted that activity data used by Ireland does not include all amounts of mineral waste handled. Indeed, the 2022 IIR (p122) states that AD is “annual MSW”. In response to a question raised during the review Ireland confirmed that the activity data used is the annual MSW landfilled and that inert waste such as construction and demolition waste are not included in the calculation. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Ireland estimate PM emissions including inert waste and report the results and conclusion of its investigations in the next annual submission.	No	-	-
IE-5B1-2022-0001	5B1 Biological Treatment of Waste - Composting, NH3, 1990-2020	For 5B1 Biological Treatment of Waste - Composting and NH3 for all years, the TERT noted that there is a lack of transparency regarding waste composting activities. It is noted in the IIR p140 that Tier 2 emission factors in the 2019 EMEP/EEA Guidebook of 0.66 kg/Mg waste is used by Ireland. However, the IEF calculated by the TERT result to 0.24 kg/Mg (value noted for Tier 1 approach in the 2019 EMEP/EEA Guidebook). This does not relate to an over- or underestimate of emissions. In response to a question raised during the review, Ireland explained that the emission factor used is 0.24 kg/Mg. The TERT recommends that Ireland correct the emission factor value indicated in the IIR in the next submission.	No	-	-
IE-5B2-2019-0001	5B2 Biological Treatment of Waste - Anaerobic Digestion at Biogas Facilities, NH3, 2000-2020	For 5B2 Biological Treatment of Waste - Anaerobic Digestion at Biogas Facilities and NH3, the TERT noted NH3 emissions have been reported 'not occurring'. This was raised during the 2019, 2020 and 2021 NECD inventory reviews. The 2022 review noted that the IIR states that Ireland will continue to review emission estimates for this sector in light of any new information that may become available for future submissions. The TERT reiterates the recommendation that Ireland estimate and report emissions.	no	-	-

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-5C2-2021-0001	5C2 Open Burning of Waste, PM10, CO, BC, 1990-2020	<p>For 5C2 Open Burning of Waste and all pollutants for all years, the TERT noted that it is not justified in the IIR that the activity does not occur and has never occurred in Ireland. This was raised during the 2021 NECD inventory review. Ireland added information in the IIR p144 that Ireland considers that 'there is no emission as a result of requirements imposed on farmers who are in receipt of payments under the Common Agricultural Policy and national agri-environmental schemes and consequently emission estimates from these sources should be reported as 'NO' (not occurring). However, the year of the legislation implementation is not provided in the IIR. In response to a question raised during the review, Ireland provided the different legislations which refer to burning of agricultural waste and where references are made to 'a wood' or 'forestry plantation' or 'vegetation' or 'straw' or 'substance' or 'waste': Wildlife Act, 1976; Wildlife (Amendment) Act, 2000; Birds and Habitats Directive; Air Pollution Act, 1987; The Safety, Health and Welfare at Work Act, 2005 and Safety, Health and Welfare at Work (General Application) Regulations, 2007; Forestry Act, 1946; Waste Management Act, 1996; Waste Management Act, 2008; SI No. 286 of 2009 – Waste Management Regulations; Fire Services Act, 1981; Fire Services Act, 2003; Criminal Damages Act, 1991. Furthermore, the TERT noted an inconsistency between information provided in the IIR ('NO' as notation key) and the notation key reported in the NFR table ('NE'). During the review, Ireland explained that corrections will be made concerning notation keys used and reporting updated as necessary in its next annual submission including providing revised text in the IIR. The TERT recommends that Ireland include references to the different legislation provided during the review in the 2023 IIR for more transparency.</p>	no	-	-

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
IE-5D1-2022-0002	5D1 Domestic Wastewater Handling, NH3, 1990-2020	For 5D1 Domestic Wastewater Handling and NH3 for all years, the TERT noted that there is a lack of transparency regarding emissions from dry toilets (including latrines) which are not reported in the inventory (the notation key 'NE' is used in the NFR tables). There is no information about this activity in the IIR. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Ireland confirmed that latrines are not a wastewater treatment system that is currently in use in Ireland and thus no emissions are reported associated with their use. The TERT recommends that Ireland provide this information in the IIR and report the appropriate notation key 'NA'.	no	-	-
IE-5D1-2022-0001	5D1 Domestic Wastewater Handling, NMVOC, 1990-2020	For 5D1 Domestic Wastewater Handling and NMVOC for all years, the TERT noted that there is a lack of transparency regarding activity data used and reported emissions. Indeed, in the IIR p145 Ireland considers 'emissions from this source as negligible and 'NE' is reported for this source'. However, NFR tables include NMVOC emission data for this subcategory (e.g. 5.4 t in 2020) but there is no information about activity data and emission factor used in the IIR. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Ireland provided activity data and emission factor used in the calculation. The TERT recommends that Ireland provide these data in the IIR in the next submission.	no	-	-
IE-5D2-2022-0001	5D2 Industrial Wastewater Handling, NMVOC, 1990-2020	For 5D2 Industrial Wastewater Handling and NMVOC for all years, the TERT noted that there is a lack of transparency regarding activity used. Indeed, there is no information in the IIR about this category and notation key 'IE' is used in NFR tables. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Ireland explained that industrial wastewater handling is included in category 5D1 Domestic Wastewater Handling. The TERT recommends that Ireland provide this explanation in the IIR and the activity data used in the next submission.	no	-	-
IE-5E-2022-0001	5E Other Waste, PM2.5, PM10, 1990-2020	For 5E Other Waste and PM2.5 and PM10 for all years, the TERT noted emissions estimated from activity data provided in the IIR of Ireland were different than reported emissions in the NFR table. In response to a question raised during the review, Ireland noted that activity data identified in the Table 6.9 of the IIR were wrong. During the review, Ireland provided figures used in the calculation distinguishing the type of building fires. The TERT recommends that	no	-	-

Sector/ID	NFR, Pollutant(s), Year(s)	Recommendation	Revised Estimate or Potential Technical Correction	Party response	IIR Section
		Ireland correct the values presented in the Table 6.9 of the IIR in the next submission.			

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL

Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaoil a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaoil a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maíthe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.

Eolas: Soláthraimid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithé agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.

Tacaíocht: Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaoil atá glan, táirgiúil agus cosanta go maíthe, agus le hiompar a chuirfidh le comhshaoil inbhuanaithe.

Ár bhFreagrachtaí

Ceadúnú

Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaoil:

- saoráidí dramhaíola (*m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistriúcháin dramhaíola*);
- gníomhaíochtaí tionsclaíoch ar scála mór (*m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta*);
- an diantalmhaíocht (*m.sh. muca, éanlaith*);
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaíthe (OGM);
- foinsí radaíochta ianúcháin (*m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíoch*);
- áiseanna móra stórála peitрил;
- scardadh dramhuisece;
- gníomhaíochtaí dumpála ar farráige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhírú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaoil.

Bainistíocht Uisce

- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uisce idirchriosacha agus cósta na hÉireann, agus screamhuisecí; leibhéal uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaoil

- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil (*m.sh. tuairisciú tréimhsúil ar staid Chomhshaoil na hÉireann agus Tuarascálacha ar Tháscairí*).

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn

- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis ceaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil

- Taighde comhshaoil a chistiú chun brúnna a shainiú, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta

- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaoil in Éirinn (*m.sh. mórphleananna forbartha*).

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéal radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas

- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaoil ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaoil (*m.sh. Timpeall an Tí, léarscáileanna radóin*).
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosaint agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta

- Feasacht comhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlach a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an ghníomhaíocht á bainistiú ag Bord Iánaimeartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:

- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair inní agus le comhairle a chur ar an mBord.



Headquarters
PO Box 3000, Johnstown Castle Estate
County Wexford, Y35 W821, Ireland
Bosca Poist 3000, Eastát Chaisleán Bhaile Sheáin
Contae Loch Garman, Y35 W821, Éire

T: +353 53 9160600
F: +353 53 9160699
E: info@epa.ie
W: www.epa.ie
Lo Call: 1890 33 55 99

EPA Regional Inspectorate Dublin
McCumiskey House
Richview
Clonskeagh Road
Dublin 14
D14 YR62
Tel: 01-268 0100
Fax: 01-268 0199

EPA Regional Inspectorate Cork
Inniscarra
Co. Cork
P31 VX59
Tel: 021-4875540
Fax: 021-4875545

EPA Regional Inspectorate Castlebar
John Moore Road
Castlebar
Co. Mayo
F23 KT91
Tel: 094-9048400
Fax: 094-9021934

EPA Regional Inspectorate Kilkenny
Seville Lodge
Callan Road
Kilkenny
R95 ED28
Tel: 056-7796700
Fax: 056-7796798

EPA Regional Inspectorate Monaghan
The Glen
Monaghan
H18 YT02
Tel: 047-77600
Fax: 047-84987

E: info@epa.ie
W: www.epa.ie
LoCall: 1890 33 55 99

