Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

Ireland's Air Pollutant Emissions

1990-2030

May 2024

Contents

ISBN: 978-1-80009-167-2

KEY FINDINGS

Assessment of targets	Although ammonia (NH_3) emissions in 2022 were 1% below 2021 levels, Ireland has exceeded its emission reduction commitment for a third year in succession[1]. Implementation of key abatement measures, such as the increased uptake of low emission slurry spreading techniques and decreased use of nitrogen fertilisers in combination with increased use of inhibited urea, are reducing ammonia emissions. However, compliance with 2030 reduction commitments will only be achieved through comprehensive implementation of the full suite of abatement measures.
	Emissions of non-methane volatile organic compounds exceeded the 2020-2029 emission reduction commitment in 2022 due to use of better scientific data which was unavailable when the emission reduction commitments were set. Ireland is adjusting the emissions of non-methane volatile organic compounds to achieve compliance, as allowed under Article 5(1) of Directive (EU) 2016/2284.
	Ireland is compliant with current and future emission reduction commitments for sulphur dioxide (SO_2), nitrogen oxides (NO_x) and fine particulate matter ($PM_{2.5}$)
Main drivers	Nitrogen oxide (NO_x) emissions decreased in 2022 driven largely by a decrease in the use of fuel oil and coal in electricity generation following an increase in the use of these fuels in 2021. The use of cleaner vehicles meant that transport NO_x emissions remained similar to 2022 despite continued increase in activity following the lifting of pandemic restrictions.
	Overall fine particulate matter ($PM_{2.5}$) emissions reduced in 2022 and continue to meet the emission reduction commitment. Reduced combustion of fossil fuels for heating in the residential sector was the main reason due to milder winter conditions than 2021.
	Reduced non-methane volatile organic compound emissions (down by 1% in 2022 vs 2021) were driven largely by reduced combustion of fossil fuels in the residential sector. Continued expansion in spirit production in the food and beverages industry, however partly offset the impact of this reduction in emissions.
	Increased bovine population and increased nitrogen fertiliser use since the removal of milk quotas in 2015 are the main drivers of non-compliance in 2020, 2021 and 2022 for ammonia emissions. Increased use of low emission slurry spreading to 59 per cent of all cattle slurry and increased use of inhibited urea fertiliser (increased by 52.3 percent compared to 2021 levels) have reduced emissions but not to the point of compliance.
	In addition to the five key air pollutants for which emission reduction commitments apply, this report also highlights the emissions trends for other pollutants such as carbon monoxide, lead, dioxins, Heavy Metals and Polycyclic Aromatic Hydrocarbons (PAHs). Emissions of most of these pollutants have greatly decreased since 1990 because of measures such as banning leaded fuel, catalytic converters and the move away from solid fuel for residential heating.
Future outlook	Mitigation measures to achieve compliance with emission reduction commitments out to 2030 are outlined in the National Air Pollution Control Programme (NAPCP) and Clean Air Strategy and include measures specifically to tackle air pollutants as well as greenhouse gas emission mitigation measures that have air pollutant emission co-benefits. A second NAPCP is currently being finalised.
	The 2030 emission reduction commitments for nitrogen oxides requires full implementation of the measures in the NAPCP, Clean Air Strategy and Climate Action Plan measures which include accelerated electrification of the transport sector, replacement of fossil fuels in the residential sector with electrification of heat (heat pumps) and roll out of proposed district heating projects.
	Measures are required to mitigate increasing NMVOC emissions from a growing spirit production sector. In addition, further research is necessary on the broader range of NMVOC sources where emissions growth has historically been coupled with population growth.
	Meeting the 2030 emission reduction commitment for ammonia is dependent on fully executing all known ammonia abatement measures at the farm level, as outlined in the AgClimatise plan, Teagasc Marginal Abatement Cost Curves, 2023 and 2024 Climate Action plans, and current revision of the NAPCP. Failure to do so, alongside activity expansion beyond projections, risks failing to achieve the 2030 emission reduction commitment.
	A narrow compliance margin with the 2030 emission reduction commitment continues to be projected for fine Particulate matter ($PM_{2.5}$) emissions. Sustained transition away from solid fuels for residential heating is required to minimise $PM_{2.5}$ emissions and address air quality issues in towns and villages.

1 https://ec.europa.eu/commission/presscorner/detail/en/inf_23_5380

1. Introduction

This report provides details of emissions of air pollutants in Ireland in the period 1990 to 2022 and projected emissions of these pollutants for 2030. The information used to compile this report is sourced from many Agencies and Government Departments, as well as from Annual Environmental Reports submitted by industry and waste management activities licensed by the EPA. The EPA has calculated emissions using the methodologies described in EU[2] and UN[3] reporting guidelines to comply with the annual reporting requirements of the Convention on Long Range Transboundary Air Pollution (CLRTAP) and the National Emission reduction Commitments Directive (NECD).

The Revised Gothenburg Protocol to abate Acidification, Eutrophication and Ground-level Ozone was adopted in May 2012. The Protocol set national emission reduction commitments for 2020 and beyond for five pollutants: sulphur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOCs), ammonia (NH_3) and particulate matter < 2.5 µm ($PM_{2.5}$). The EU has implemented its provisions via the National Emission reduction Commitments Directive (Directive (EU) 2016/2284)[4], setting out emission reduction commitments for these five air pollutants.

This report provides emission projections for these air pollutants to give an indication of the likelihood of compliance with future emission reduction commitments. A summary of emission trends in air pollutants for which there are no emission reduction commitments under Directive (EU) 2016/2284 is also presented in section 4.

2 https://www.eea.europa.eu/publications/emep-eea-guidebook-2023

3 https://unece.org/DAM/env/documents/2013/air/eb/ece.eb.air.125_E_ODS.pdf

4 Transposed into Irish law via S.I. No. 232/2018.

2. National Emission Reduction Commitments

The five air pollutants for which emission reduction commitments are set affect the environment and human health in different ways. SO_2, NO_x and NH_3 are primarily associated with acid deposition leading to toxicity of soils and waters[5]. The EPA water quality reports highlight many of the same drivers for Nitrate pollution as this report highlights for ammonia emissions. Ammonia is also responsible for secondary particulate matter formation and nitrogen oxides are precursors to tropospheric (ground level) Ozone formation. Fine Particulate Matter, tropospheric Ozone, NO_x and NMVOCs directly impact human health, especially in higher concentrations in urban areas. The European Environment Agency[6] estimates there are approximately 1,600 premature deaths in Ireland every year due to poor air quality. The EPA, working with local authorities and other public bodies, has established 115 air monitoring stations and monitoring data from these stations are available in real time. The EPA's annual Air Quality in Ireland Report presents the key findings from these stations[7].

The National Emission reduction Commitments Directive (Directive (EU) 2016/2284) on the reduction of national emissions of certain atmospheric pollutants, harmonises the reporting obligations to the European Union under the Convention on Long Range Transboundary Air Pollution (CLRTAP) and details emission reduction commitments for the above-mentioned air pollutants for 2020 and 2030. A full outline of the reporting obligations and submission deadlines are outlined in Article 8 and Annex I of Directive (EU) 2016/2284[8].

The emission reduction commitment for Ireland for 2020 and 2030 are as follows and are set as percentage reductions on 2005 emission levels:

	2020	2030
Sulphur Dioxide (SO_2)	-65%	-85%
Nitrogen Oxides (NO_x)	-49%	-69%
Ammonia (NH_3)	-1%	-5%
Non-Methane Volatile Organic Compounds (NMVOCs)	-25%	-32%
Particulate Matter < 2.5 µm ($PM_{2.5}$)	-18%	-41%

Additionally, emissions in 2025 should follow a linear reduction trajectory between the levels defined by the emission reduction commitments in 2020 and 2030.

2.1 Compliance with National Emission Reduction Commitments

Current emission reduction commitments

The current emission reduction commitments to which Ireland must comply under Directive (EU) 2016/2284, are set out in Table 1 along with the latest emission estimates for 2022. Emission reduction commitments are based on percentage reductions compared to 2005 emission levels. As the reductions are relative to a base year (2005), the absolute value of allowed emissions will continue to vary as emission estimates are revised and updated.

5 https://www.epa.ie/publications/research/air/research-390-nitrogensulfur-critical-loads-assessment-of-the-impacts-of-air-pollution-on-habitats.php

6 Health Impacts of air pollution in Europe 2022. European Environment Agency. https://www.eea.europa.eu/publications/air-quality-in-europe-2022/health-impacts-of-air-pollution

7 https://www.epa.ie/publications/monitoring--assessment/air/Air_Quality_Report_22_v8v2.pdf

8 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.

The findings of the EPA's assessment of Ireland's air pollutant emissions for 2022 are set out in Table 1 and show that:

- Ireland complied with the SO_2, NO_x and $PM_{2.5}$ emission reduction commitments for 2022.
- Ireland did not comply with its emission reduction commitments for NH_3 and NMVOC for 2022.
- Emissions of NMVOC reduced by only 13.0 per cent compared to the required 25 per cent emission reduction commitment.
- Emissions of NH_3 increased by 3.0 per cent compared to the required 1 per cent emission reduction commitment.

Table 1. Actual emissions for 2005 and 2022 and Emission reduction commitments for 2020 for NEC relevant pollutants for 2022 compared to 2005

	2005	2022
Nitrogen Oxides (NO_x) (kt)	133.723	59.024
Emission reduction commitment for 2020 (%)		-49%
Actual reduction in emissions 2022 (%)		-55.9%
Sulphur Dioxide (SO_2) (kt)	74.253	9.453
Emission reduction commitment for 2020 (%)		-65%
Actual reduction in emissions 2022 (%)		-87.3%
Non-Methane Volatile Organic Compounds (NMVOC) (kt)	76.71	66.75
Emission reduction commitment 2020 (%)		-25%
Actual reduction in emissions 2022 (%)		-13.0%*
Ammonia (NH_3) (kt)	124.883	128.636
Emission reduction commitment for 2020 (%)		-1%
Actual reduction in emissions 2022 (%)		+ 3.0%*
Fine Particulate Matter ($PM_{2.5}$) (kt)	18.644	10.704
Emission reduction commitment 2020 (%)		-18%
Actual reduction in emissions 2022 (%)		-42.6%

* Data in red highlights where the 2020 emission reduction commitments have not been complied with.

Directive (EU) 2016/2284 has a flexibility mechanism that allows Member States to make an adjustment to their national inventory estimates for compliance purposes. This is allowed where non-compliance with national emission reduction commitments would result from applying improved emission inventory methods that have been updated in accordance with scientific knowledge. This flexibility applies to the five key pollutants and is available to all Member States, ensuring that countries are not penalised for updating estimates with information that could not have been foreseen when the emission reduction commitments were agreed in 2012.

Emissions of NO_x and NMVOCs from manure management and agricultural soils are not accounted for the purpose of compliance assessment (Article 4 (3) Directive (EU) 2016/2284).

Ireland is non-compliant with national emission reduction commitments for NMVOCs for 2022 as a result of applying improved emission inventory methods which consists of using more up-to-date emission factors and recognising new sources of emissions. As a result, and in accordance with Directive 2016/2284, Ireland is allowed to utilise the prescribed flexibility mechanism.

Adjusted total emissions for NMVOC are presented in Table 2. When the adjustment is considered, Ireland is compliant with the emission reduction commitment for NMVOC for 2020, 2021 and 2022. Detailed information relating to the use of the flexibility mechanism is outlined in Ireland's Informative Inventory Report 2024[9].

Table 2. Adjusted emission estimates for NMVOCs*

	2005	2022
NMVOC (kt)	76.71	66.751
2020 Emission reduction commitment (%)		-25%
Actual reduction in emissions (%)		-13.0%*
Adjustment (kt)	-8.376	-24.735
Adjusted NMVOC (kt)	68.337	42.016
Adjusted reduction in emissions (%)		-38.5%

* Data in red highlights where emission reduction commitment has not been complied with

As the non-compliance for NH_3 has not been attributed to improved inventory methods and is as a direct result of increased agricultural activity, the criteria for use of the flexibility mechanism does not apply in this case.

Future emission reduction commitments

Ireland must implement significant mitigation measures to achieve compliance with emission reduction commitments out to 2030 as outlined in the National Air Pollution Control Programme (NAPCP) and the Clean Air Strategy[10]. Table 3 sets out the latest estimated values for the reduction commitments in 2030 along with projected emissions under two scenarios, *With Existing Measures* (WEM) and *With Additional Measures (WAM)*.

The WEM scenario assumes that no future policy actions are taken beyond those already implemented by the end of 2022, the latest inventory year.

The WAM scenario provides an alternative scenario which includes additional planned policies and measures beyond 2022, such as the effect of Ireland's Climate Action Plans (2021, 2023 and 2024) which sets out a major programme of policies and measures aimed to help Ireland achieve its decarbonisation goals. It also includes the effect of full implementation of AgClimatise[11] which is the roadmap for the agriculture sector towards climate neutrality and the latest Teagasc Marginal Abatement Cost Curve for NH_3 emissions from the agriculture sector[12]. Furthermore, the Government submitted to the EU a National Air Pollution Control Plan[13] in 2021 to meet the 2030 emission reduction commitments as assigned by Directive 2016/2284, and

9 https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/irelands-unece-submissions-2024.php

10 https://assets.gov.ie/255392/efe212df-d9a7-4831-a887-bea2703e2c64.pdf

11 gov - Ag Climatise - A Roadmap towards Climate Neutrality (www.gov.ie)

12 https://www.teagasc.ie/publications/2023/macc-2023.php

13 https://www.gov.ie/en/publication/23bdb-national-air-pollution-control-programme-napcp/

an updated Plan will be published in 2024[14] which includes further additional measures to reduce ammonia emissions from agriculture over and above those previously identified.

Often similar measures exist in both scenarios, for example Low Emission Slurry Spreading or the uptake of Electric Vehicles. For both of these measures the WEM scenario represents a projected uptake of the technology that is consistent with actions already in place and committed to whereas the WAM scenario reflects a higher level of ambition as expressed in Government plans. The Clean Air Strategy[15] includes many of the measures included in the WAM scenario.

As summarised in Table 3, compliance with the Emission Reduction Commitments (ERCs) for 2030 for SO_2, NO_x, NH_3 and $PM_{2.5}$ is projected based on the continued adoption of measures in the WEM scenario. Further reductions are then seen with adoption of planned polices and measures under the WAM scenario.

Initially, ammonia emissions are projected to be non-compliant but, with the adoption of abatement measures, emissions of this pollutant are forecast to become compliant in 2023 under the WAM scenario. It should be noted however that ammonia emissions are projected to be above the required linear trajectory between 2020 and 2030. In addition, under the WAM scenario, NH_3 emissions are forecast to be compliant with the 2030 ERC. If emissions of NH_3 were to increase over and above those forecasted, it will put the compliance with reduction commitments at risk and further measures may be required.

For NMVOC emissions, compliance is not achieved in either scenario without the inclusion of an adjustment under the flexibility mechanism in Directive (EU) 2016/2284.

Table 3. Actual emissions for 2022, projected emissions for 2025 and 2030 and reduction commitments for NEC relevant pollutants

Pollutant	Emissions (kilotonnes)			2020-2029 and 2030 Reduction Commitments (% reduction compared with 2005 levels) based on latest inventory estimates	
	2022	2025	2030	2020-2029	2030
Total SO_2 *WEM*	9.45	8.24	7.11	**25.99**	**11.14**
Total SO_2 *WAM*	9.45	8.24	6.78	-65%	-85%
Total NO_x *WEM**	59.02	42.93	33.94	**68.20**	**41.45**
Total NO_x *WAM**	59.02	42.93	30.65	-49%	-69%
Total NMVOC *WEM**	66.75	70.59	76.29	**57.54**	**52.17**
Total NMVOC *WAM**	66.75	70.57	74.63	-25%	-32%
Adjusted NMVOC *WEM**	42.02	42.91	42.91	**51.25**	**46.47**
Adjusted NMVOC *WAM**	42.02	42.89	41.25	-25%	-32%
Total NH_3 *WEM*	128.64	124.07	121.19	**123.63**	**118.64**
Total NH_3 *WAM*	128.64	119.12	112.56	-1%	-5%
Total $PM_{2.5}$ *WEM*	10.70	10.33	10.10	**15.29**	**11.00**
Total $PM_{2.5}$ *WAM*	10.70	10.32	9.62	-18%	-41%

* Article 4 (3) of the National Emission reduction Commitments Directive provides that emissions of NO_x and NMVOC from categories 3B (manure management) and 3D (agricultural soils) are not accounted for the purpose of complying with 2020 and 2030 emission reduction commitments.

14 https://www.gov.ie/en/consultation/d1ac8-consultation-on-the-national-air-pollution-control-programme-napcp/

15 https://www.gov.ie/en/publication/927e0-clean-air-strategy/

Section 3 of this report provides insights to current and historic trends of the five pollutants for which emission reduction commitments are in place for 2020 and 2030. It also provides an assessment of projected future emissions in 2030 of these pollutants, focusing on the With Additional Measures scenario.

Other pollutants

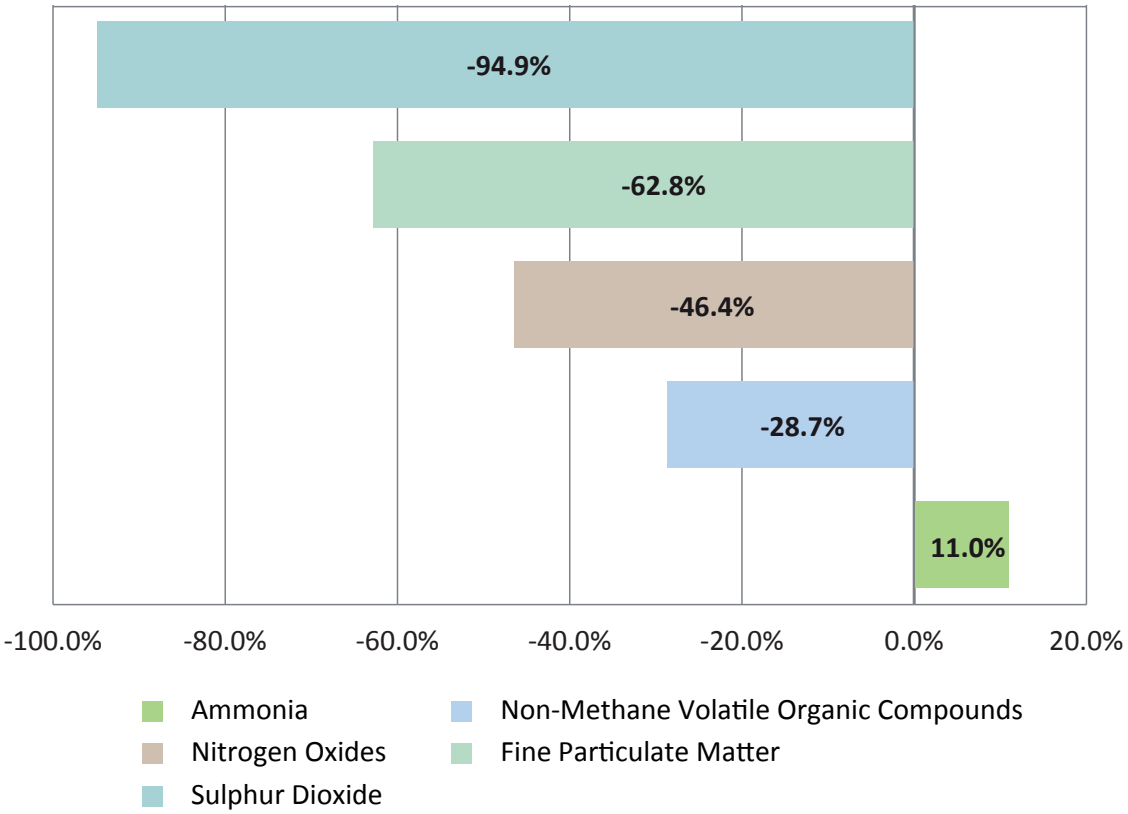
A large number of other pollutants for which no emission reduction commitments exist under Directive 2016/2284 are also reported on annually by the EPA. The general trend with these pollutants is downward, largely as a result of fuel switching from coal and peat to natural gas and kerosene in the residential sector, penetration of renewables for electricity generation and reductions in the quantities of coal and peat combusted for electricity generation. Changes in the age structure of the national vehicle fleet have also had a positive impact. Further detail on these pollutants is presented in section 4. Detailed information on these pollutants is also provided in Ireland's Informative Inventory Report 2024[16].

16 https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/irelands-unece-submissions-2024.php

3. Key Air Pollutants under the National Emission reduction Commitments Directive

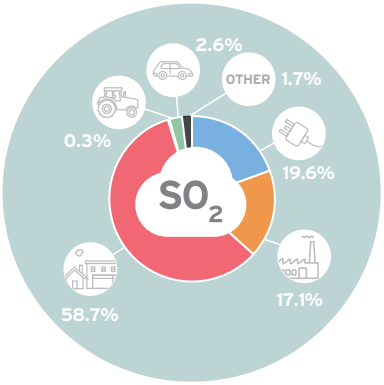
Ireland has seen large reductions in the emissions of all but one of these pollutants over the last thirty years as can clearly be seen in Figure 1 below. Despite this progress, challenges still remain to maintain decreasing trends in the face of increasing economic activity, particularly in relation to emissions from Transport, Agriculture and combustion of fossil fuels in industry. Future expansion of these sectors can result in increased emissions of all the key pollutants in the absence of decoupling, such as has occurred with emissions of sulphur dioxide from electricity generation.

Figure 1: Percentage change in key NECD Air Pollutants 1990-2022



3.1 Sulphur Dioxide (SO_2)

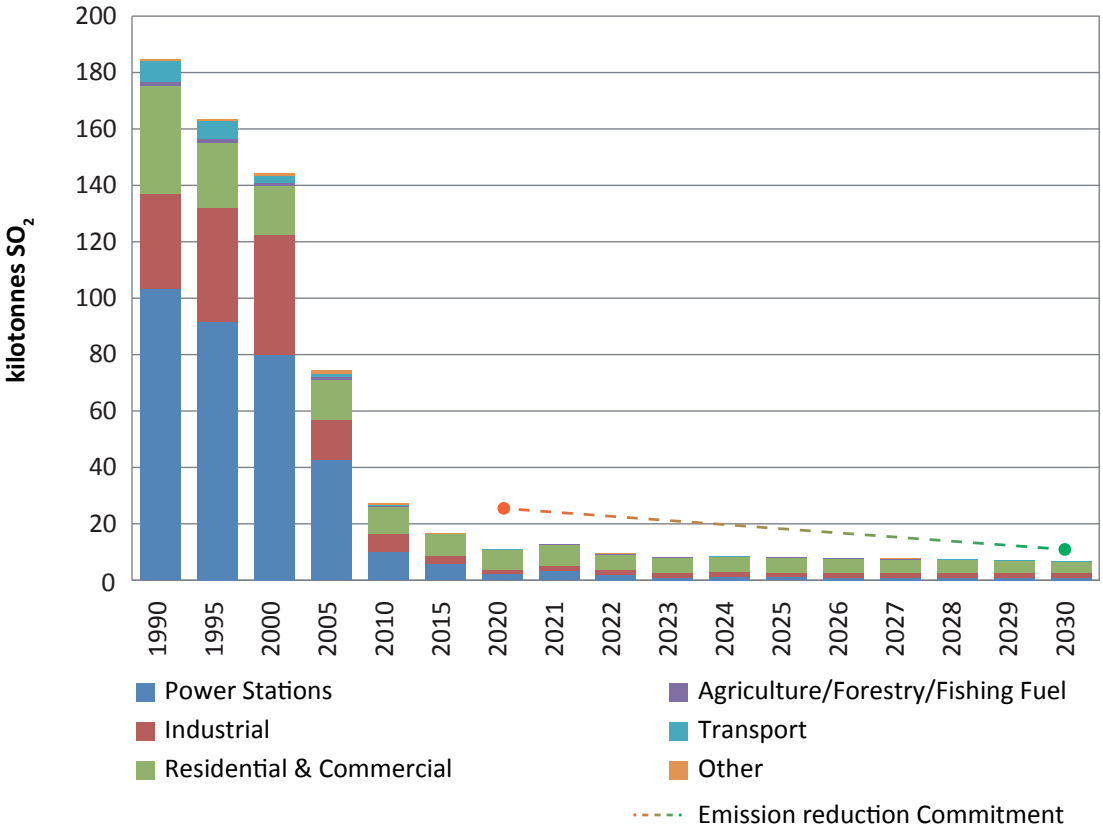
Sulphur dioxide (SO_2) is the major precursor to acid deposition, which is associated with the acidification of soils and surface waters and the accelerated corrosion of buildings and monuments. Emissions of SO_2 are derived from the sulphur in fossil fuels such as coal and oil used in combustion activities.



National Emission Reduction Commitments

Ireland's national emission reduction commitment for SO_2 under the NEC Directive is a 65% reduction on 2005 levels to be achieved for 2020 and an 85% reduction to be achieved for 2030. (Figure 2). Emissions have reduced by 87.3 per cent in the period 2005-2022 and therefore Ireland remains in compliance with the emission reduction commitment for 2020.

Figure 2: Trend in SO_2 emissions 1990-2030 (WAM) and emission reduction commitments 2020-2030



Current and future trends in SO_2 emissions

Total national emissions of SO_2 were 26.9 per cent lower in 2022 compared to 2021 mainly as a result of a reduction in both coal and fuel oil use in electricity generation. Power stations and combustion of fossil fuels in residential and commercial sectors for heating are the two principal sources of SO_2 emissions, contributing

19.6 and 58.7 per cent, respectively to the total in 2022. Combustion sources in the industrial sector accounted for 17.1 per cent in 2022. Decreases in emissions were seen in power stations, manufacturing industry and construction sectors in 2022. Emissions in the residential and commercial sectors decreased by 27.4 per cent, reflecting decreased home heating due to the 4.6% less heating degree days[17] in 2022 than in 2021 and continued fuel switching from solid and liquid fuels to natural gas and renewables.

In terms of the outlook for 2030, the emission projections predict compliance with the 2030 emission reduction commitment which require an 85 per cent reduction on 2005 levels. It is projected that in 2030 emissions will be 90.9 per cent below those in 2005. Key sources of projected SO_2 emissions, similar to current trends, include fossil fuel combustion for electricity generation in power stations and emissions from fuel combustion within the residential, commercial and manufacturing industry and construction sectors. Projected emission reductions are provided in Table 4.

Table 4. Projected SO_2 emission reduction in 2025 and 2030 compared to 2005

Projected SO_2 emissions	2025	2030
With Additional Measures Scenario (%)	-88.9	-90.9
Emission Reduction Commitment (%)	-65.0	-85.0

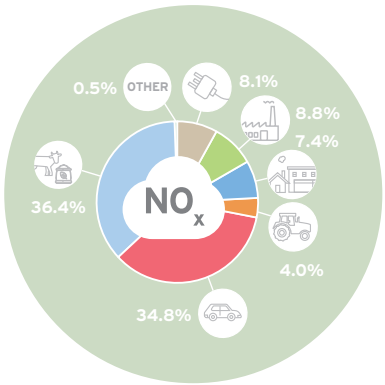
Historic SO_2 Emissions

Sulphur dioxide emissions in Ireland reduced considerably between 1990 and 2022. The latest estimates indicate a decrease of 94.9 per cent from 184.8 kt in 1990 to 9.5 kt in 2022. Emissions from Power stations and combustion in residential and commercial sectors decreased by 98.2 per cent and 85.5 per cent respectively since 1990. The emissions from industrial sources decreased by 95.3 per cent from 1990 while the emissions in the transport sector decreased by 96.8 per cent. These large reductions reflect significant switching from the use of oil and solid fuels to natural gas, reduced sulphur content in coal and oil and implementation of abatement measures in electricity generation to meet emission limit values. Increased use of renewables rather than combustion of fossil fuels to meet increased electricity demand also contributes to this trend. Emissions from transport have decreased by 96.8 per cent as a result of reduced sulphur content of fuels.

The remainder of SO_2 emissions are from combustion in oil refining, and combustion of fuels in agriculture, forestry, fishing. Emissions in these sectors decreased by 73.6 per cent and 97.6 per cent, respectively since 1990.

3.2 Nitrogen Oxides (NO_x)

Emissions of nitrogen oxides (NOx) contribute to acidification of soils and surface waters, ground level ozone formation and excess nitrogen or saturation in terrestrial ecosystems. Agriculture (as a result of both organic and synthetic nitrogen use) and fossil fuel combustion in power generation and transport are the principal sources.

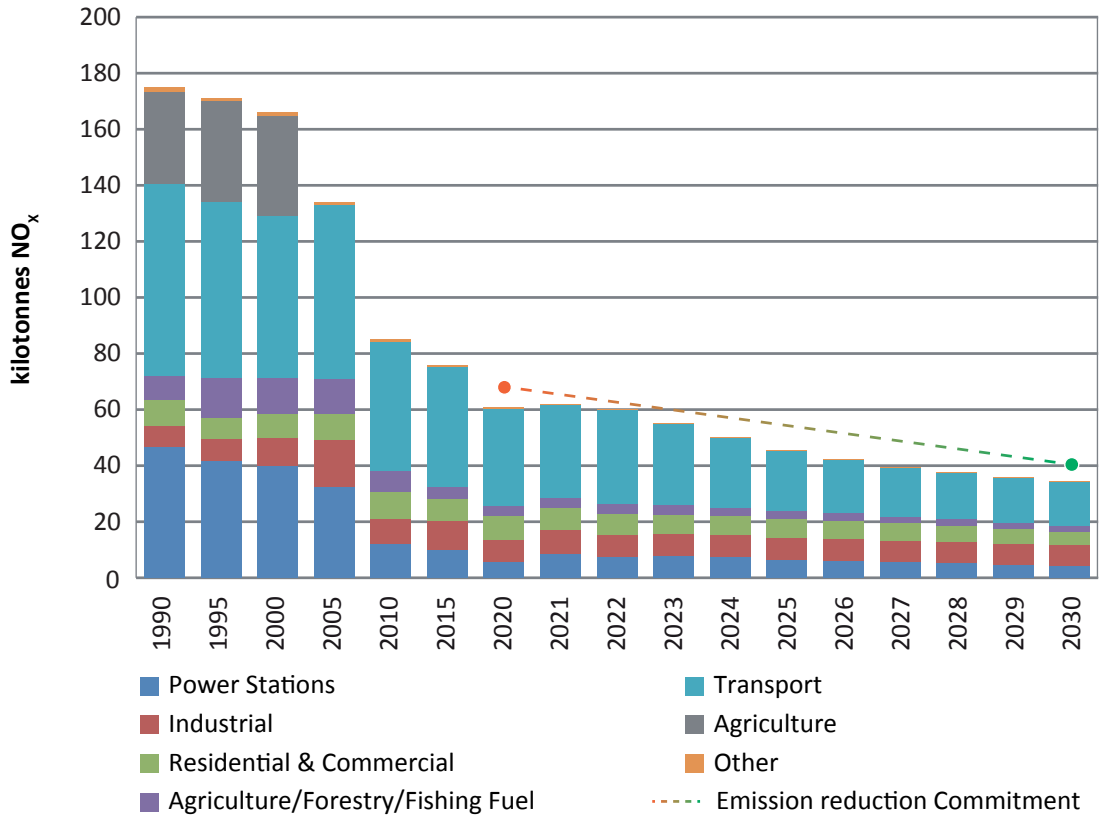


17 Degree days are a measure of the heating or cooling requirement on a given day with reference to a level where neither is required (typically 15.5°C). The number of degree days in a year is a strong indicator of the annual Residential energy demand.

National Emission Reduction Commitments

Ireland's national emission reduction commitment for NO_x for 2020 under the NECD was a 49 per cent reduction compared to a 2005 baseline level. Article 4 (3) of Directive (EU) 2016/2284 states that emissions from manure management and agricultural soils are not accounted for the purpose of compliance assessment. On that basis emissions have reduced by 55.9 per cent in the period 2005-2022 and therefore Ireland remains in compliance with the emission reduction commitment for 2020 (Figure 3).

Figure 3: Trend in NO_x emissions 1990-2030 (WAM) and emission reduction commitments 2020-2030



Current and future trends in NO_x emissions

The latest estimate is that in total 92.84 kt of NO_x was emitted in 2022, including Agriculture emissions from manure management and agricultural soils that are not accounted for the purpose of the NECD compliance assessment under Article 4 (3) of Directive (EU) 2016/2284. Emissions of NO_x decreased by 4.1 per cent in 2022 compared to 2021, primarily as a result of decreased emissions from power stations due to less coal and fuel oil being used. There were also smaller decreases in emissions from manufacturing industry and construction as a result in less combustion of fossil fuels, and in the agriculture sectors as a result of decreased fertilizer use in 2022. The agriculture sector, which consists of emissions from synthetic fertiliser application and emissions from urine and dung deposited by grazing animals, contributed approximately 36.4 per cent of the 2022 total. Transport (of which road transport is the main contributor), is the second biggest source of NO_x contributing approximately 34.8 per cent of the 2022 total. The industrial, power generation and residential/commercial sectors are the other main sources of NO_x emissions, with contributions of 8.8 per cent, 8.1 per cent and 7.4 per cent, respectively in 2022. The remainder of NO_x

emissions arise from combustion in the agriculture and other (refining and storage, solid fuel manufacture, fugitive emissions and waste) sectors, which together produced around 4.5 per cent of the total in 2022.

Total NO_x emissions in 2022, and projections for all subsequent years to 2030, are compliant with emission reduction commitments.

Table 5. Projected NO_x emission reduction in 2025 and 2030 compared to 2005

	2025	2030
With Additional Measures Scenario (%)	-67.9	-77.1
Emission Reduction Commitment (%)	-49.0	-69.0

Historic NO_x Emissions

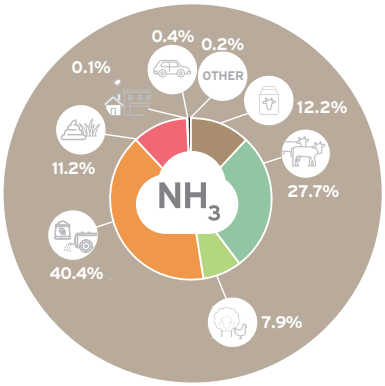
NO_x emissions in Ireland have decreased by 46.4 per cent between 1990 and 2022 and emissions have decreased by 53.37 kt, or 36.5 per cent since 2008. This reduction was achieved due to improved abatement in Moneypoint power plant, reduced demand for clinker/cement and a reduction in emissions from road transportation. The application of low-NO_x burner technology in several major power stations and the increased use of natural gas have reduced NOx emissions from electricity generation by 83.9 per cent on 1990 levels, even though electricity total final consumption has increased by 159.2 per cent over the same period. Emissions of NO_x from the coal-fired power plant at Moneypoint have decreased by 95.7 per cent between 1990 and 2022.

Road transport has seen a decline in emissions of 25.6 kt, or 44.2 per cent, between 2008 and 2022 due to the economic recession initially and in later years improvements in vehicle technologies. The effects of Covid-19 restrictions had a significant impact in 2020 and 2021.

The NO_x figures for transport reported here are based on fuel used and not fuel sold, and therefore take into account fuel tourism. This means that the impact on emissions of fuel sold in the Republic of Ireland for consumption across the border in Northern Ireland is removed as allowed for under the *Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution*[18], paragraph 23. It is estimated that fuel tourism accounted for 1.6 kt of NOx in 2022.

3.3 Ammonia (NH_3)

Ammonia (NH_3) emissions to air are associated with nitrogen deposition, acid rain and the formation of secondary particulate matter. The agriculture sector accounts for virtually all (99.4 per cent) of ammonia emissions in Ireland. Grasslands ultimately receive the bulk of the 41 million tonnes (Mt) of animal manures (equivalent to 566,826 tonnes of nitrogen) produced in Ireland along with nitrogen fertilisers which amounted to 343,193 tonnes (as nutrient nitrogen) in 2022. A proportion of the nitrogen in these inputs is volatilised into the air as ammonia. Emission factors for NH_3 were updated in line with the latest version (2023) of the EMEP/EEA emission inventory guidebook[2] for fertiliser application but as this change is applied across the 1990-2022 timeseries it does not impact compliance against percentage reduction targets.

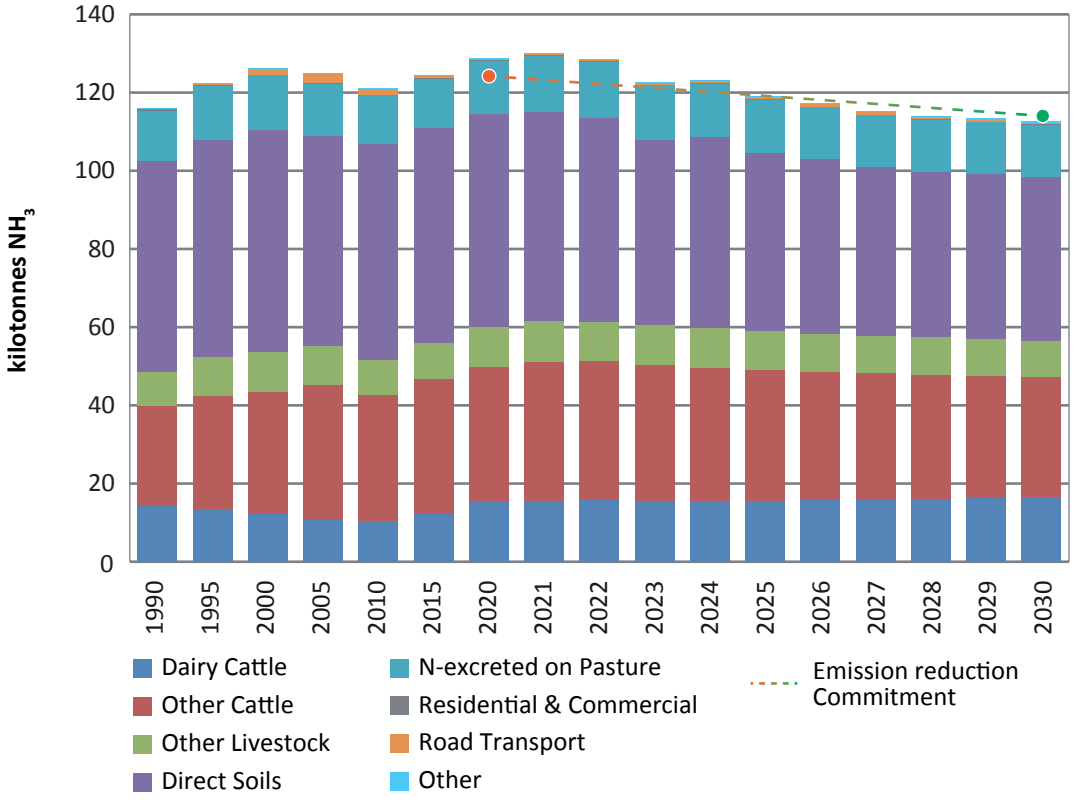


18 Paragraph 23, https://unece.org/DAM/env/documents/2013/air/eb/ece.eb.air.125_E_ODS.pdf

National Emission Reduction Commitments

Ireland's national emission reduction commitment for NH_3 for 2020 under the NECD was a 1 per cent reduction compared to a 2005 baseline level. As emissions in 2020, 2021 and 2022 were 3.2, 4.2 and 3.0 per cent higher, respectively, than in 2005, Ireland is non-compliant with the emission reduction commitment for 2020 to 2029 (Figure 4). As a result of Ireland's non-compliance with the 2020 emission reduction commitment the European Commission in January 2023 served Ireland with an infringement notice and reasoned opinion in November for non-compliance with the NECD[19]. As shown in figure 4 emissions (due to increased bovine population and increased nitrogen fertiliser use) since the removal of milk quotas in 2015 is the main driver of non-compliance in 2020, 2021 and 2022.

Figure 4: Trend in NH_3 emissions 1990-2030 (WAM) and emission reduction commitments 2020-2030



Current and future trends in NH_3 emissions

The emissions in 2022 were 12.72 kt or 11.0 per cent higher than emissions in 1990. Emissions in 2022 were 1.1 per cent lower than those in 2021, mainly as a result of decreased pig (down 5.9 per cent) and poultry (2.0 per cent) populations and increased use of low emission slurry spreading to 59 per cent of all cattle slurry and inhibited urea fertiliser increased by 52.3 percent compared to 2021 levels.

Livestock and poultry

Emissions arising from an increase of 0.5 per cent in the total cattle herd (0.9 per cent increase in dairy cow numbers) and 4.2 per cent increase in the sheep flock were offset by a 5.9 per cent decrease in pig numbers and 2.0 per cent decrease in poultry.

19 https://ec.europa.eu/commission/presscorner/detail/EN/inf_23_142, https://ec.europa.eu/commission/presscorner/detail/en/inf_23_5380

Manure management

Animal manures produce about 90 per cent of ammonia emissions in agriculture in 2022. It is estimated that approximately 16.9 per cent of the nitrogen in animal manures is lost to the atmosphere annually as NH_3. In 2022, 59 per cent of cattle slurry was applied using low emission techniques (48 per cent in 2021). Over 6 kt NH_3 were mitigated in 2022 as a result of the use of low emission slurry spreading techniques for cattle slurry.

Under the With Existing Measures and With Additional Measures scenario, it is projected that low emission slurry spreading techniques continue to grow in use with 90 per cent of all cattle slurry applied with these techniques by 2027 (as per AgClimatise) and 100 per cent of pig slurry from 2023 onwards (as required under the Nitrates Action Plan).

Nitrogen fertiliser

14 per cent of national ammonia emissions arise from the use of nitrogen fertiliser. It is estimated that 4 per cent of nitrogen contained in chemical fertilisers is lost to the atmosphere annually as NH_3. Fertiliser nitrogen sales reduced by 14 per cent in 2022 to 343,193 tonnes (as nutrient nitrogen) following a 5 per cent increase in 2021. However, overall, emissions from fertilisers increased by 5 per cent as a result of a 30 per cent increase in the use of straight urea (52,823 t in 2022). Although inhibited urea sales increased by 52 per cent (31,282 t in 2022), it was not enough to counteract the increase in emissions from straight urea.

Inhibited urea[20] was introduced on the market in Ireland in 2015 and accounted for 9 percent of total nitrogen (as nutrient) fertiliser sold in 2022 and 37 per cent of urea products sold. These products have a much lower emission factor than that straight urea.

Additionally, the fertiliser replacement value of increased use of lime to address soil fertility and enhanced nutrient use efficiency is also included. These measures are outlined in the Teagasc NH_3 MACC[12], the DAFM AgClimatise[11] documents and the revised National Air Pollution Control Programme.

With Additional Measures

The With Additional Measures scenario includes the following measures: a reduction in crude protein content of concentrates fed to pigs and cattle, cattle and pig slurry amendments, covering of slurry stores, drying of poultry manure, reduced slaughter age for cattle, reduced age of beef (suckler) cows at first calving, replacement of calcium ammonium nitrate (CAN) and CAN based compounds with inhibited urea products and target nitrogen fertiliser application of 300,000 tonnes in 2030, and a limit on straight urea sales to 20,000 t pa from 2025. These measures are outlined in the Teagasc NH_3 MACC and the DAFM AgClimatise documents and the revised National Air Pollution Control Programme.

Achievement of the 2030 Emission reduction Commitment is projected under the With Additional Measures scenario but not the With Existing Measures scenario. This reinforces that, achieving the adoption of these measures in full is necessary for compliance and will require significant policy levers.

Table 6: Projected NH3 emission reduction in 2025 and 2030 compared to 2005

Projected NH_3 emissions	2025	2030
With Additional Measures Scenario (%)	-4.6	-9.9
Emission Reduction Commitment (%)	-1.0	-5.0

20 https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/2024_03_27_FAQresearchInventories.pdf

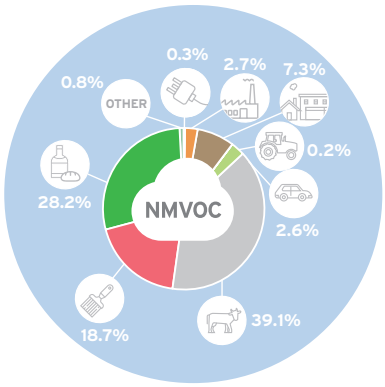
Historic NH_3 Emissions

The NH_3 emissions trend is largely determined by the cattle population and showed a steady increase up to 134.2 kt in 1998. There was some decline in the populations of cattle and sheep after 1998, as well as a decrease in fertiliser use, which contributed to a decrease in NH_3 emissions in the period 2000 to 2011.

Subsequently, increases in cattle numbers and fertiliser use have seen NH_3 emissions increase especially in response to the removal of milk quotas in 2015. NH_3 emissions increased up to 2018 to 142.2 kt, the highest emissions across the timeseries (response to significant drought conditions in 2018 and increase nitrogen fertiliser and concentrate feeding to bovines). Road transport produces a small proportion of emissions of ammonia (< 1 per cent) mainly from petrol passenger cars with three-way catalysts.

3.4 Non-Methane Volatile Organic Compound (NMVOC) emissions

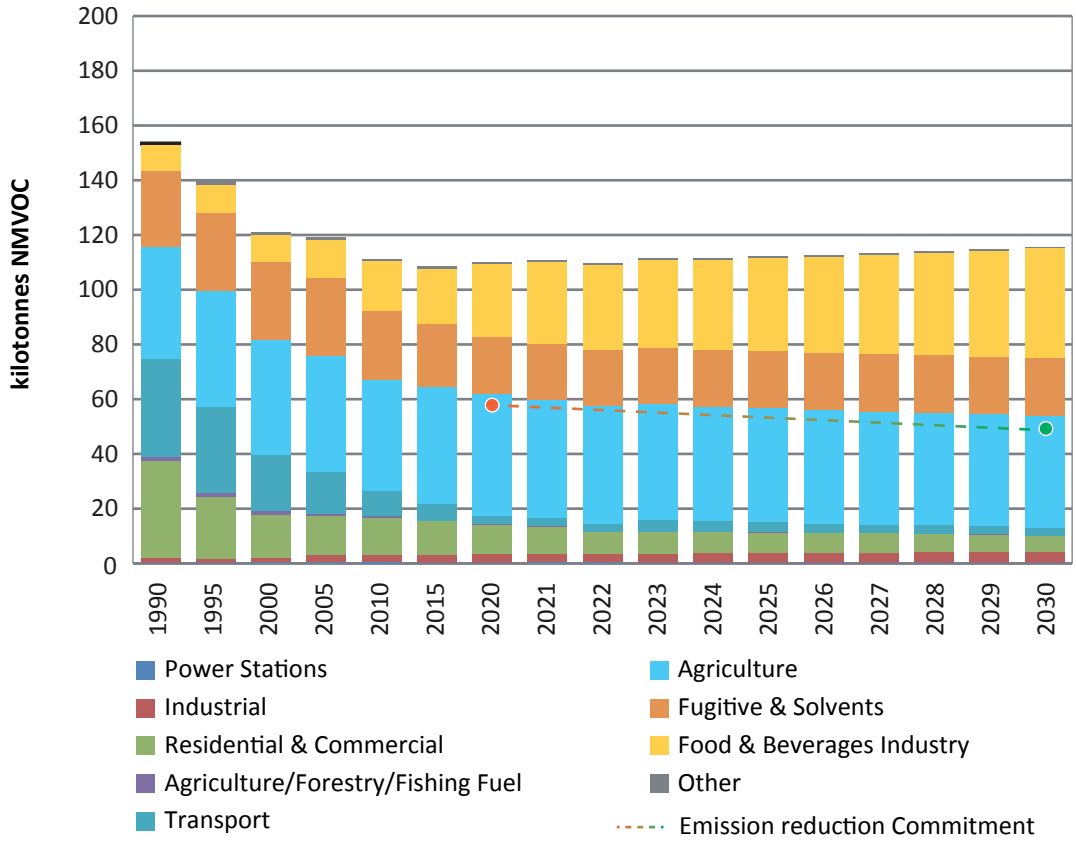
Non-methane volatile organic compounds (NMVOC) are emitted as gases by a wide array of products including paints, paint strippers, glues, cleaning agents and adhesives. They also arise as a product of incomplete combustion of fuels, from the storage and handling of animal manure and fertilisers in agriculture, and from the food and beverages industry.



National Emission Reduction Commitments

Ireland's national emission reduction commitment for NMVOC for 2020 under the NECD was a 25 per cent reduction compared to a 2005 baseline level. As per Article 4 (3) of the NECD, emissions from manure management and agricultural soils are not accounted for the purpose of compliance targets. When this is taken into account emissions have reduced by 13.0 per cent in the period 2005-2022 and therefore Ireland is non-compliant with the emission reduction commitment for 2020 (Figure 5).

Figure 5: Trend in NMVOC emissions 1990-2030 (WAM) and emission reduction commitments 2020-2030



As a result of applying improved emission inventory methods updated in accordance with better scientific knowledge, Ireland is technically non-compliant with its national emission reduction commitment for NMVOC. However, as allowed under Article 5(1) of Directive 2016/2284 in accordance with Part 4 of Annex IV, Ireland has applied an adjustment to the NMVOC emission inventory . This adjustment relates to the inclusion of emissions from spirit production in the food and beverage industry category. When this flexibility is taken into account emissions in 2022 are 38.5 per cent below 2005 levels bringing Ireland into compliance with its emission reduction commitment.

Current and future trends in NMVOC emissions

The main sources of NMVOC emissions in Ireland are from manure management in agriculture, solvent use and fugitive emissions and the food and beverages industry. These sources produced 39.1 per cent, 18.7 per cent and 28.2 per cent, respectively of the annual total in 2022. Emissions in 2022 were 1.0 per cent below those in 2021, mainly driven by 20.9 per cent decrease in emissions from the combined residential and commercial sectors.

Emissions from combustion of fossil fuels across all sectors; power stations, industrial, residential, commercial and agriculture accounted for 10.5 per cent of national total NMVOC emissions in 2022. Transport emissions accounted for 2.6 per cent of national total emissions of NMVOC, mainly from exhaust and fugitive releases from gasoline vehicles.

Total NMVOC emissions under the WAM scenario are projected to be 2.7 per cent below 2005 levels in 2030. The emission reduction commitment for 2030 is a reduction of 32 per cent on 2005 emission levels (Table 7). The emission projections thus predict non-compliance with the 2030 emission reduction commitment. Key drivers in emissions over the projected period include solvents and other product use, and emissions from food and beverages industry.

Table 7 also presents a scenario where the NMVOC emissions from source category 2.H (spirit production) are excluded, as this source was not included in the national inventory at the time the 2020 and 2030 emission reduction commitments were established. Emissions in 2030 are projected in this case to be 39.6 per cent below emission levels in 2005. The emission reduction commitment for 2030 is a 32 per cent reduction, thus compliance with the emission reduction commitment is projected when the flexibility outlined in Article 5(1) of Directive 2016/2284 in accordance with Part 4 of Annex IV is applied.

Table 7. Projected NMVOC emission reduction in 2025 and 2030 and associated emission reduction commitments compared to 2005

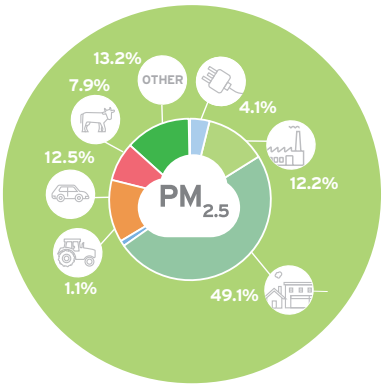
Projected NMVOC emissions	2025	2030
(excluding emissions from agricultural categories 3B and 3D)		
With Additional Measures Scenario (%)	-8.0	-2.7
Emission Reduction Commitment (%)	-25.0	-32.0
(excluding emissions from agricultural categories 3B and 3D and source category 2.H (spirit production)		
With Additional Measures Scenario (%)	-37.2	-39.6
Emission Reduction Commitment (%)	-25.0	-32.0

Historic NMVOC Emissions

Reductions corresponding to 28.7 per cent of NMVOC emissions have been achieved from 1990 to 2022. Technological controls for NMVOCs in motor vehicles, which have led to a significant reduction in emissions from road transport, have largely been responsible for the decrease in overall emissions along with reduced use of coal and peat as a source of heating in the residential sector. On the other hand, emissions from the agriculture sector have increased by 4.7 per cent since 1990. Emissions from the food and beverage industry, mainly spirit production have increased by 221.8 per cent over the same period.

3.5 Fine Particulate matter ($PM_{2.5}$) emissions

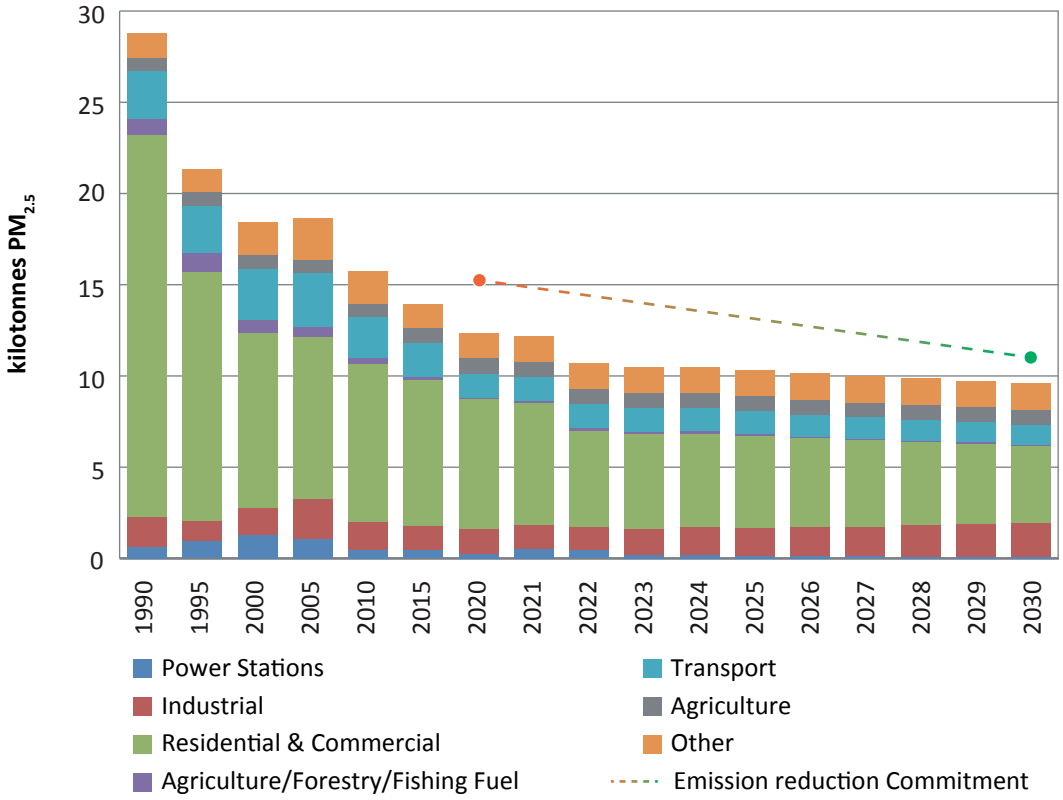
There are many sources of particulate matter (dust) including vehicle exhaust emissions, soil and road surfaces, construction works and industrial emissions. Particulate matter can be formed from reactions between different pollutant gases. Small particles can penetrate the lungs and cause damage. These are known as PM_{10} (diameter less than 10µm) and $PM_{2.5}$ (diameter less than 2.5µm). $PM_{2.5}$ is a better indicator of anthropogenic (man- made) emissions. Fine particulate matter $PM_{2.5}$ is responsible for significant negative impacts on human health.



National Emission Reduction Commitments

Ireland's national emission reduction commitment for $PM_{2.5}$ for 2020 under the NECD was an 18 per cent reduction compared to a 2005 baseline level. Emissions have decreased by 42.6 per cent in the period 2005-2022 and therefore Ireland remains in compliance with the emission reduction commitment for 2020. (Figure 6).

Figure 6: Trend in $PM_{2.5}$ emissions 1990-2030 (WAM) and emission reduction commitments 2020-2030



Current and future trends in $PM_{2.5}$ Emissions

Emissions in 2022 were 12.0 per cent below those in 2021. The main sources of $PM_{2.5}$ emissions in Ireland are from combustion of fossil fuels in the residential & commercial heating, manufacturing industries and construction sectors which produced 49.1 per cent and 12.2 per cent of the annual total, respectively in 2022. $PM_{2.5}$ emissions in the Other sectors account for 13.2 per cent of the total in 2022. These emissions arise from Manufacture of solid fuels, oil refining/storage sectors, coal mining and handling, quarrying and mining of minerals other than coal, construction and demolition, storage, handling and transport of mineral products, road paving with asphalt, fireworks, use of tobacco, storage handling and transport of agricultural products and accidental vehicle and building fires.

Transport was responsible for a 12.5 per cent share to the national total in 2022. Emissions from Agriculture arise from Manure Management and Inorganic Nitrogen fertilisers, together accounting for 7.9 per cent of the national total in 2022. Emissions from public electricity and heat production accounted for 4.1 per cent of the total.

It must be noted that while national emission levels are in compliance with the emission reduction commitment, localised air quality issues exist. Particulate matter levels recorded at ambient monitoring stations continue to be a concern in villages, towns and cities. Monitored levels of particulate matter were above the annual World Health Organisation air quality guidelines at 76 of 79 monitoring stations in 2022. Continued reductions in solid fuel burning for residential heating is necessary to continue the reduction in particulate matter emissions and associated particulate matter concentrations in ambient air. Additionally, research is underway to better understand emissions of particulate matter from the combustion of fuels in the residential sector and the contribution of agriculture to particulate matter.

Total $PM_{2.5}$ emissions under the With Additional Measures scenario are projected to be 48.4 per cent below 2005 levels in 2030 (Table 8). The emission reduction commitment for 2030 is a 41.0 per cent reduction. It is therefore projected that Ireland will be in compliance with its emission reduction commitment for $PM_{2.5}$ in 2030 under this scenario. Key contributors to emissions over the projected period include the combustion of fossil fuels in the Residential, Commercial and Manufacturing Industry sectors.

Table 8. Projected $PM_{2.5}$ emission reduction and emission reduction commitments

Projected $PM_{2.5}$ emissions	2025	2030
With Additional Measures Scenario (%)	-44.6	-48.4
Emission Reduction Commitment (%)	-18.0	-41.0

Historic $PM_{2.5}$ Emissions

Total $PM_{2.5}$ emissions in 2022, at 10.7 kt, show a reduction of 62.8 per cent since 1990. Reduced use of coal and peat in the residential & commercial sectors, with increased use of gasoil, kerosene and natural gas has resulted in 74.9 per cent lower emissions between 1990 and 2022 in those combined sectors.

Agriculture emissions have increased by 12.7 per cent from their 1990 level largely as a result of the increased cattle herd. Emissions from Transport sector, dominated by Road Transport have been decreasing since 2005, with a 48.3 per cent reduction between 1990 and 2022. This was largely due to technological advances and the age structure of the national fleet (whereby in recent times an increasing proportion of the fleet is newer vehicles), which has in turn been offset somewhat by increases in vehicle numbers over the time series.

4. Air Pollutants with no NEC Directive emission reduction commitment

The reporting obligations outlined in Article 8 and Annex I of the Directive (EU) 2016/2284 also include the mandatory reporting of emissions to air of carbon monoxide, cadmium, mercury, lead, polycyclic aromatic hydrocarbons, dioxins and furans, polychlorinated biphenyls (PCB), hexachlorobenzene, coarse particulate matter < 10µm and black carbon. Voluntary reporting of annual emissions of arsenic, chromium, copper, nickel, selenium, Zinc and total suspended particulates (TSP) is also undertaken. Emission reduction commitments are not set for any of the aforementioned pollutants in the Directive.

A brief overview of the pollutants involved and the trend in emissions of these pollutants over time is presented below. A summary table (Table 9) indicates the relative importance of each sector to emissions of each air pollutant. If a sector is the largest source of a pollutant, this is indicated in the second column, followed in the third column by other air pollutants for which the sector is a significant source.

Table 9. Sectoral sources of Pollutants

Sector	Largest source	Significant source
Transport	Cu, Pb, Cr, Zn	CO, PM_{10}, TSP, BC, As, Hg
Power Stations	Ni	CO, PM_{10}, TSP, Cd, Hg, As, Cr, Se
Combustion in manufacturing industries	Cd, Hg	PM_{10}, BC, Cr, Ni, Zn
Industrial Processes	TSP	PM_{10}, BC, Cd, Zn
Residential and Commercial Combustion	CO, PM_{10}, BC, Se, Dioxins, PAH	TSP, Pb, Cd, Hg, Ni, Zn, PCB
Agriculture	HCB	PM_{10}
Industrial waste incineration	As	Cr
Solid waste disposal (landfills)		Hg
Vehicle and building fires and waste burning	PCB	Dioxins

Carbon monoxide (CO) emissions continue to decline, driven by major reductions due to three-way catalysts in gasoline vehicles in Road Transport, and a large decrease in the use of solid fuels for space heating in the Residential sector. National total CO emissions have reduced by 82.4 per cent over the period 1990 to 2022.

Emissions of *coarse particulate matter* (PM_{10}) have reduced by 45.1 per cent since 1990. The main determinant of the trend in PM_{10} emissions is the combined total emissions from a wide range of sources including road paving with asphalt, quarrying, construction and demolition and the manufacture of products such as cement which contribute a 39.4 per cent share of the national total, and combustion in the Residential and Commercial/Institutional sectors combined with 25.3 per cent share of the total in 2022. Total suspended particulate (TSP) emissions have decreased by 22.4 per cent, since 1990. Total suspended particulates emissions are driven by a wide range of sources similar to PM_{10}. *Black Carbon* (BC) emissions have decreased by 68.3 per cent, between 1990 and 2022. The main driver of the BC trend is the Residential and Commercial/Institutional sectors combined with a 35.7 per cent share of the total in 2022.

Over the period 1990–2022, total national *lead* (Pb) emissions have decreased by 95.8 per cent with the Pb emissions trend largely determined by the Road Transport sector. There was a marked decrease between 1999 and 2005 when the lead content of petrol was reduced. Combustion of fuels in the Transport sector is the largest source of Pb in 2022 accounting for 70.1 per cent of the national total.

Total national emissions of *cadmium* (Cd) have decreased by 56.4 per cent. Emissions of Cd are largely determined by combustion of fuels in the Manufacturing Industries and Construction sector, specifically combustion sources in Non-Ferrous Metals.

Total national emissions of *mercury* (Hg) have decreased by 60.3 per cent between 1990 and 2022. Emissions from Manufacturing Industries and Construction are the largest source of Hg. Emissions from the Residential and Commercial/Institutional and Public Electricity and Heat Production sectors are also an important source of Hg.

Emissions of *arsenic* (As) are largely dominated by incineration of hazardous and clinical wastes and crematoria. In the past Public Electricity and Heat Production was the largest however both a reduction in coal and peat power generation and move towards cleaner fuels has reduced its contribution substantially.

Emissions of *chromium* (Cr) have decreased by 33.6 per cent between 1990 and 2022. Transport, fuel combustion in the Manufacturing Industries and Construction sectors and Waste Incineration are the main sources.

Total *copper* (Cu) emissions in Ireland were steadily increasing over the 1990–2008 period and have been steadily decreasing since. Total emissions in 2022 were 8.1 per cent lower than in their peak in 2008 but they are 105.3 per cent higher than in 1990. Transport and industrial processes are the main sources.

National total emission estimates of *nickel* (Ni) were steadily increasing over the 1990–1999 period and have been generally decreasing from 1999 onwards. The main contributor to the trend is combustion of fuels in the Public Electricity and Heat Production, Residential and Commercial/Institutional and Manufacturing Industries and Construction sectors. Total emissions in 2022 were 69.1 per cent below the 1990 level.

The main contributor to national *selenium* (Se) emissions has been fuel combustion in the Residential and Commercial/Institutional sectors which combined accounted for 62.3 per cent of selenium emissions in 2022. Emissions of Se were 75.4 per cent lower in 2022 compared to 1990.

National total emissions of *zinc* (Zn) have fallen by 52.3 per cent between 1990 and 2022. In the 1990–2001 period, the main determinant of the trend in zinc emissions was Metal Production. Since the closure of Ireland's only steel plant in 2001, fuel combustion in the Transport and Residential and Commercial/ Institutional and Manufacturing Industries and Construction and Public Electricity and Heat Production sectors are the largest sources.

Dioxin and *furan* emission levels decreased having reduced by 68.3 per cent between 1990 and 2022. The main contributors to national emissions are the combined Residential and Commercial/Institutional sectors, with a 67.9 per cent share of total emissions in 2022.

Hexachlorobenzene (HCB) emissions from secondary aluminium processing were the largest source of HCB emissions in Ireland up to 1996 after which the use of hexachloroethane (HCB being a contaminant of such gases) based cover gases was banned. Since then the use of pesticides (in which HCB is a contaminant) in agriculture is the largest source accounting for 83.8 per cent of national emissions in 2022.

Emissions of *polychlorinated biphenyls* (PCBs) have decreased by 85.4 per cent between 1990 and 2022. Emissions from the Waste sector, specifically vehicle and building fires and other burning such as bonfires and household waste are the largest sources in 2022.

Polycyclic Aromatic Hydrocarbon (PAHs) emissions, which include emissions of *benzo[a]pyrene*, *benzo[b] fluoranthene*, *benzo[k]fluoranthene*, and *indeno[1,2,3-cd]pyrene*, are dominated by combustion in the Residential and Commercial/Institutional sectors. Declines in the use of coal and sod peat have led to reduced emissions from these sectors across the timeseries 1990-2022.

Appendix – Emissions of key NEC Directive Air Pollutants, 1990-2022

	SO_2	NO_x	NMVOC	NH_3	$PM_{2.5}$
	kilotonnes				
1990	184.779	173.246	153.908	115.912	28.786
1991	184.316	173.933	153.506	117.876	28.539
1992	171.645	181.773	148.497	120.853	25.109
1993	162.736	173.971	145.736	120.195	24.761
1994	177.380	171.245	141.452	121.586	22.696
1995	163.465	169.436	139.437	122.435	21.358
1996	150.621	174.044	140.392	126.595	21.937
1997	168.870	164.489	135.962	129.180	20.083
1998	178.912	168.536	137.081	134.210	21.139
1999	161.111	166.825	127.769	132.228	18.191
2000	144.282	165.123	121.111	126.179	18.420
2001	142.297	165.687	121.499	125.720	18.381
2002	106.656	157.786	121.575	126.108	17.627
2003	82.839	159.313	120.346	126.436	17.597
2004	73.482	162.363	119.993	123.245	17.866
2005	74.253	166.164	119.142	124.883	18.644
2006	61.993	161.389	117.421	126.214	18.156
2007	56.134	155.760	116.785	119.292	17.556
2008	46.546	146.207	115.178	121.532	17.430
2009	33.339	122.412	120.637	122.231	16.575
2010	27.417	115.949	111.055	121.053	15.713
2011	25.454	104.225	107.537	115.996	13.881
2012	24.098	106.768	108.483	121.410	13.806
2013	24.111	107.980	110.354	122.893	14.160
2014	18.114	106.280	107.245	119.139	13.602
2015	16.571	106.411	108.588	124.582	13.964
2016	15.914	108.613	110.347	130.199	14.022
2017	15.185	108.185	113.667	134.976	12.897
2018	14.285	109.487	113.511	142.243	13.286
2019	11.309	100.649	112.960	131.299	12.266
2020	11.018	94.474	109.928	128.864	12.356
2021	12.935	96.777	110.778	130.094	12.167
2022	9.453	92.837	109.685	128.636	10.703


epa
Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil