Chapter 3
Air Quality

Air Quality

1. Introduction

Air is of critical importance to supporting life in all its forms. Natural events such as volcanoes, desert dust and forest fires and occurrences such as sea salt particles being carried in the wind have always affected the quality of the air we breathe. But day-to-day human activities have a greater impact on our atmosphere. Emissions from home heating, agriculture, transport and energy generation all contribute to poorer air quality throughout the year. Poor air quality has serious health implications both in the short term (e.g. causing temporary illnesses such as headaches, breathing difficulties or eye irritation) and in the long term (e.g. causing chronic illnesses such as asthma, reduced liver function and cardiovascular diseases). The latest estimates from the European Environment Agency (EEA) calculate that in excess of 1300 premature deaths occur in Ireland each year because of poor air quality (EEA, 2020a).

In addition to emissions from various sources of air pollution, meteorological conditions influence air quality. Owing to Ireland's geographical location as an island on the periphery of Europe, with prevailing winds from the south-west, it is less frequently affected by transboundary air pollution from its neighbours. Historically too, the absence of large cities and heavy industry in Ireland resulted in less pressure on air quality. However, data from the expanded National Ambient Air Quality Monitoring Programme, which is providing more comprehensive air quality information, indicate several areas of poorer air quality across the country (EPA, 2017). It is becoming increasingly clear that there are challenges to good air quality in both urban and rural areas that need to be addressed.

2. Air Quality Standards and Policy in Ireland

European Directives on Air Quality and Emissions

EU directives set baseline standards for monitoring air quality and reducing emissions in Ireland.

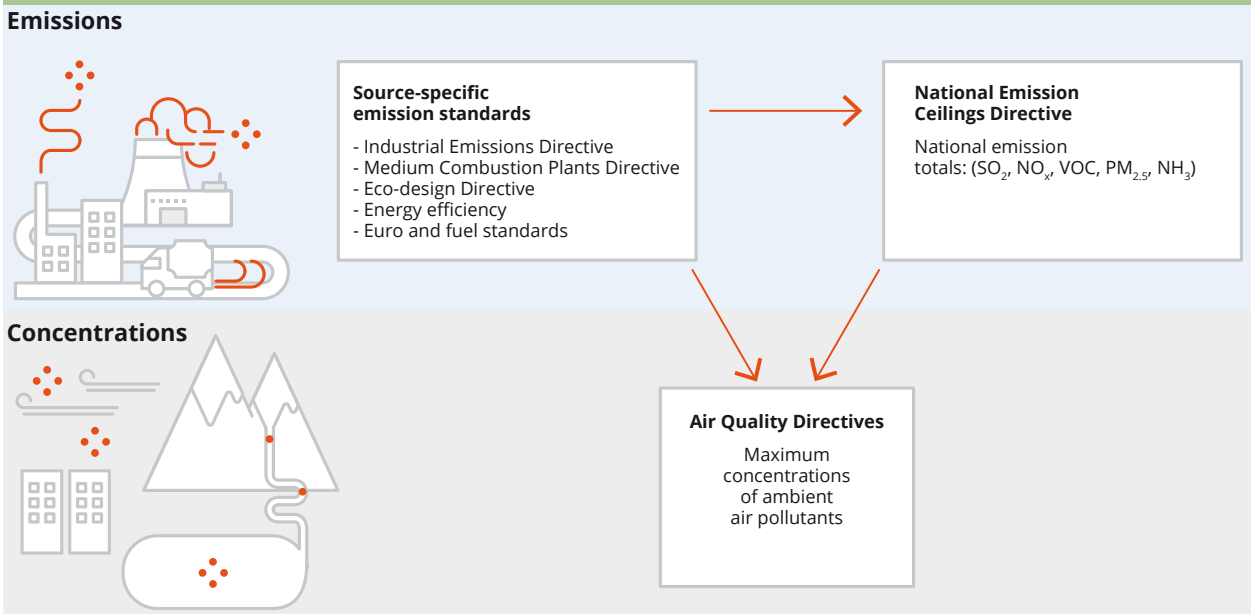
The framework for the European Union (EU) clean air policy, illustrated in Figure 3.1, has a three-pillar approach that aims to protect EU citizens from the adverse health effects of poor air quality, as well as protect ecosystems. The framework uses a combination of standards and directives to regulate sources of air pollutants, obtain commitments to reduce national emission quantities and set limit values for levels of air pollutants in ambient air. The Clean Air Programme for Europe, published by the EU in 2013, provided a comprehensive review of emissions-related elements (EC, 2013). As a result, new targets were put in place through updated emissions ceilings levels and provisions in a new directive governing medium combustion plants.

A new National Emission Ceilings (NEC) Directive (2016/2284/EU), which entered force on 31 December 2016, replaces earlier NEC directive (2001/81/EC) (EEA, 2020b). The NEC Directive, Annex II, set emissions reduction commitments for 2020 and 2030, based on a reduction from 2005 emissions, for the five main air pollutants (covered below). It also provided for the 2010 emission ceiling levels to remain applicable for Member States until the end of 2019. The NEC Directive transposes the reduction commitments for 2020 agreed by the EU and its Member States under the 2012 revised Gothenburg Protocol (UNECE, 2016a). The reduction commitments for 2030 are designed to reduce the health impacts of air pollution by half compared with 2005. The NEC Directive also requires that Member States, including Ireland, draw up a National Air Pollution Control Programme (NAPCP) to help implement air quality plans established under the Ambient Air Quality Directives (2008/50/EC and 2004/107/EC).

The Ambient Air Quality Directives set standards for 13 air quality pollutants that have an impact on human health and vegetation. When a Member State exceeds a limit value for a pollutant, it is required to prepare an air quality plan, which is also submitted to the European Commission. These plans must detail the measures that the Member State will take to bring the pollutant levels back under the limit value. A new air quality plan for Dublin will be required to address an exceedance of nitrogen dioxide limits in 2019.

The EU reviewed the effectiveness of the Ambient Air Quality Directives through a process of fitness checking and concluded that they have been partially effective in improving air quality and achieving air quality standards. Additional guidance or clarification of requirements in the directives could help to make monitoring, modelling and the provisions for plans and measures more effective and efficient (EC, 2019a).

Figure 3.1 EU clean air policy – the policy framework (Source: EEA, 2018)



NH_3, ammonia; NO_x, nitrogen oxides; $PM_{2.5}$, particulate matter; SO_2, sulphur dioxide; VOC, volatile organic compounds.

World Health Organization Guidelines on Air Quality

World Health Organization guideline values, which the EPA uses to assess air quality, are more stringent than EU ambient air quality legislative values.

The World Health Organization (WHO) first published guidance on the threshold limits for four air pollutants in 1987 (WHO, 2017). The guidance was produced based on accumulated scientific evidence and was designed to offer support in reducing the health impacts of air pollution. The guidelines have been reviewed several times, with the most recent version being completed in 2005 (WHO, 2006). In general, the guideline values recommended by the WHO are more stringent than the limits set in European legislation. The WHO is currently reviewing its air quality guidance in recognition of a much broader knowledge base regarding the adverse health effects related to short-term and long-term exposure to air pollutants (WHO, 2020).

Air Quality Policy in Ireland

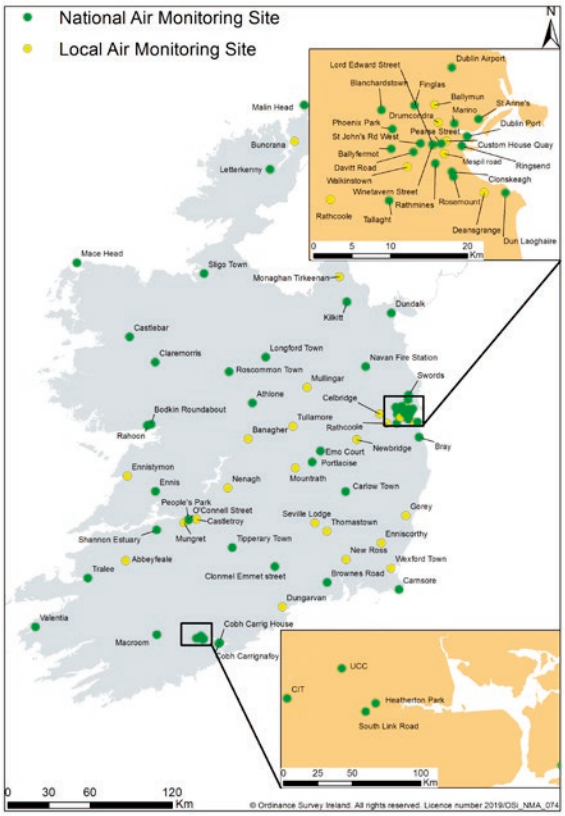
The Department of the Environment, Climate and Communications (DECC) has responsibility for ensuring that Ireland meets its air quality obligations under EU/international legislation and agreements. The Environmental Protection Agency (EPA) is the competent body for coordinating ambient air quality assessment. The DECC is preparing a National Clean Air Strategy (NCAS) as part of a wider NAPCP. The overall aim of the strategy will be the promotion of clean air policies to enhance and protect the quality of the air that we breathe (DCCAE, 2017). As part of the preparatory process, a Clean Air Dialogue with the European Commission, including numerous stakeholders, took place. Some of the recommendations from the Clean Air Dialogue include tackling road transport-related nitrogen oxide emissions, monitoring of ammonia emissions from agriculture and taking action on residential solid fuel use and shipping emissions (DCCAE, 2017).

Assessing Air Quality in Ireland

Data from the National Ambient Air Quality Monitoring Network are used for public information and reporting purposes.

Air pollution levels are assessed using specialised techniques and instruments at designated monitoring stations across the country. Figure 3.2 displays the national ambient air monitoring network. The stations collect air quality data for public information display (available at www.airquality.ie) and for assessment against both the European legal limit values and WHO guideline values. The data are reported to the EEA every hour. The network is managed by the EPA, in partnership with local authorities and other public bodies and third-level education institutions.

Figure 3.2 National Ambient Air Quality Monitoring Network in 2020 (Source: EPA)



National Ambient Air Quality Monitoring Programme 2017-2022

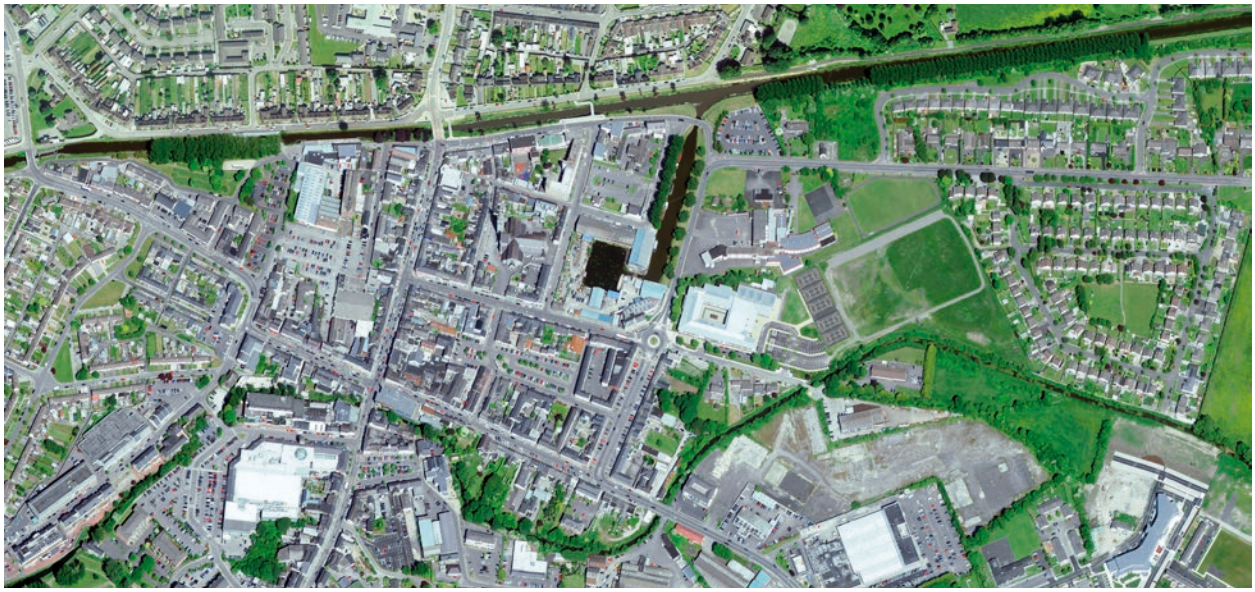
Following a review of ambient air quality monitoring in Ireland, the current national monitoring programme was launched at the end of 2017.

Following a review of ambient air quality monitoring in Ireland, a new national ambient air quality monitoring programme commenced at the end of 2017. The programme is providing more comprehensive, real-time, localised air quality information that is linked to public health advice. The programme involves a greatly expanded national monitoring network, supported by increased modelling capability to provide air quality information to the public. To date, the network has expanded from around 30 stations to more than 80, with a number of the existing stations upgraded to provide more real-time data. The EPA currently undertakes air quality monitoring, communicates these data to the public and reports data in compliance with the requirements of the Ambient Air Quality Directives. The programme also aims to involve the public through various citizen science initiatives to encourage greater public understanding of and involvement in air quality issues (Topic Box 3.1).

Topic Box 3.1 GLOBE Program

GLOBE[1] is an international science education programme running in more than 120 countries across the world. In Ireland, it is coordinated by the Environmental Education Unit of An Taisce in partnership with the EPA. Twice a year, students from schools across Ireland measure the air quality around their schools as part of the GLOBE Air Quality Campaigns. Students use diffusion tube samples to measure nitrogen dioxide – a principal pollutant from car exhaust emissions – at locations around their schools for one month. They then analyse the results and examine potential impacts on their health and wellbeing. Overall, the findings in Ireland have indicated generally good air quality. For most schools, the results ranged from 'excellent' to 'pretty good'. Nitrogen dioxide levels were higher for schools in major towns and cities than for schools in rural areas. Schools noted a deterioration in air quality at the school gate compared with more sheltered areas, such as school grounds.

1 https://www.globe.gov/web/ireland/home/overview-of-air-quality-campaign



Aerial image of Tullamore, Co. Offaly

3. Tracking Emissions of Transboundary Air Pollutants

The NEC Directive sets national emission reduction commitments for Member States and the EU for five important air pollutants: nitrogen oxides, non-methane volatile organic compounds (NMVOC), sulphur dioxide (SO_2), ammonia and fine particulate matter ($PM_{2.5}$). The position in Ireland concerning the requirements of the NEC Directive is as discussed below. An assessment of projected future emissions of these pollutants in 2020 and 2030 is provided, focusing on the 'With Additional Measures' scenario. This scenario includes the effect of Ireland's 2019 Climate Action Plan.

State of Progress for Limiting Transboundary Air Pollutants in Ireland

Nitrogen oxides (NO_x)

Overview: Nitrogen oxide emissions are linked to fuel combustion in transport, home heating and power stations and nitrogen (fertiliser and manures) in agriculture. Nitrogen oxide emissions contribute to acidification and eutrophication processes. Nitrogen dioxide, in particular, can have negative impacts on respiratory and cardiovascular health.

Progress against the emission ceiling target

Figure 3.3 shows nitrogen oxide emissions by sector before and after applying the flexibilities[2] as allowed under Article 5 of the NEC Directive. The figure shows that, even after applying the flexibilities, Ireland exceeded the emission ceiling of 65 kilotonnes in 2010 but was compliant in all subsequent years up to and including 2018. Current projections show Ireland's emissions exceeding the reduction commitment for 2020. Projections estimate compliance with the 2030 emission reduction ceiling on the basis of full implementation of the 2019 Climate Action Plan; however, further measures may be required to ensure compliance in 2030. Emissions of nitrogen oxides from manure management and agricultural soils are not within the scope of the NEC Directive for the purposes of complying with the reduction commitments applicable from 2020 onwards.

2 *The use of flexibilities is allowed under Article 5(1) of the NEC Directive (2016/2284/EU) as Ireland is non-compliant with national emission reduction commitments as a result of applying improved emission inventory methods updated in accordance with best scientific knowledge. The flexibility mechanism allows Member States to subtract emissions from new sources that have been included in the national inventory since the reduction commitments or ceilings were established or where the emission factors used to estimate emissions have changed significantly based on new science. Ireland's adjustments are reviewed under Article 10(3) of the NEC Directive.*

Figure 3.3 Total nitrogen oxide emissions with and without the use of flexibilities, and projected emission figures (Source: EPA)

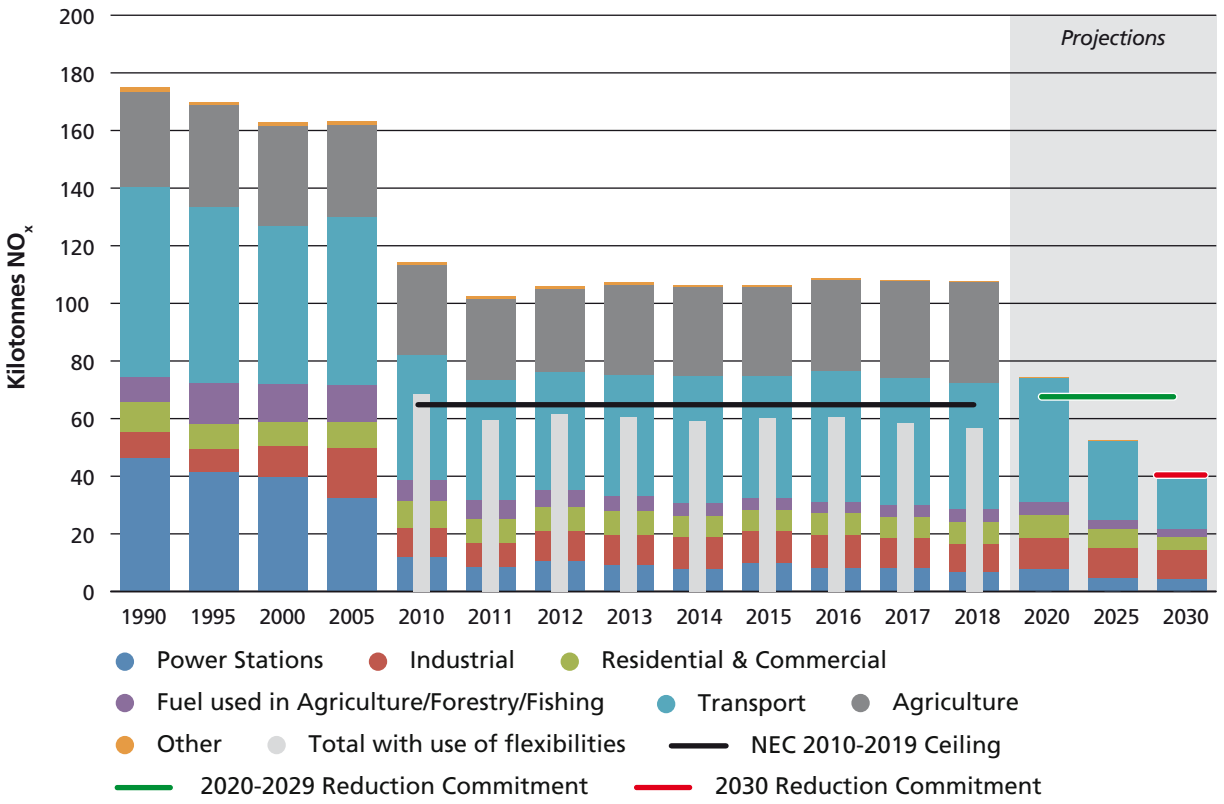


Figure 3.3 presents a scenario where the NOx emissions from manure management and agricultural soils (Agriculture) are excluded, as these sources were not included in the national inventory at the time the 2020 and 2030 reduction ceilings were established.

Key steps towards achieving the target

A reduction in the contribution of transport combustion sources (mainly exhaust emissions from road transport) will be crucial for Ireland to achieve its commitments under the NEC Directive. Transforming the transport system by promoting measures such as public transport use, walking and cycling can reduce dependency on cars. This, combined with an overall transition to low-emission fuel and renewable energy use in road transport, is needed to address nitrogen oxide emission concerns in transport. This will also assist in reducing greenhouse gas emissions in the transport sector.

Sulphur Dioxide (SO_2)

Overview: Sulphur dioxide emissions are transboundary emissions that can cause acid deposition, damaging ecosystems and vegetation. Sulphur dioxide emissions have significantly reduced in Ireland since 1990 and are linked to combustion processes that use sulphur containing fuel.

Progress against the emission ceiling target

Ireland achieved the 2010 emission ceiling of 42 kilotonnes in 2010 and all subsequent years up to and including 2018. Current projections estimate that Ireland will be compliant with the 2020 and 2030 reduction commitments.

Key steps towards achieving the target

Fuel switching in the power generation and industrial sectors has aided the achievement of Ireland's commitments on sulphur dioxide. Reductions in the sulphur content of fuel oil, gas oil, diesel and gasoline, and a decrease in coal and peat use for power generation and heating in Irish homes, should help to maintain this situation.

Non-methane Volatile Organic Compounds (NMVOC)

Overview: NMVOC emissions are linked to paint and solvent use, the production of food and beverages (spirits), transport and agriculture. NMVOCs can have a number of direct damaging impacts on human health and can also have indirect effects on health by contributing to the formation of ground-level ozone, which causes respiratory and cardiovascular problems.

Progress against the emission ceiling target

Figure 3.4 shows NMVOC emissions by sector for recent years and projected amounts for 2020 and 2030. Ireland's emission ceiling for NMVOC is 55 kilotonnes and this was exceeded in 2010. Ireland was compliant in all subsequent years up to and including 2018 after applying flexibilities, as allowed under the NEC Directive. Current projections estimate that Ireland's emissions may meet the reduction commitment for 2020. Emissions are projected to exceed the 2030 reduction commitment and further measures may be required to ensure compliance in 2030.

Key steps towards achieving the target

Future trends in NMVOC emissions depend largely on the results from the implementation of EU directives on solvent and product uses and the levels of spirit production, solid fuel combustion in the residential sector, and cattle numbers in the agriculture sector in Ireland. Emissions of NMVOCs from manure management and agricultural soils are not within the scope of the NEC Directive for the purposes of complying with the reduction commitments applicable from 2020 onwards.

Ammonia (NH_3)

Overview: The agriculture sector accounts for nearly all (99%) ammonia emissions in Ireland. Uniquely for the pollutants under the NEC Directive, ammonia emissions are increasing year on year. Ammonia emissions can lead to the formation of secondary particulate matter, acidification and eutrophication.

Figure 3.4 Total NMVOC emissions with and without the use of flexibilities, and projected emission figures (Source: EPA)

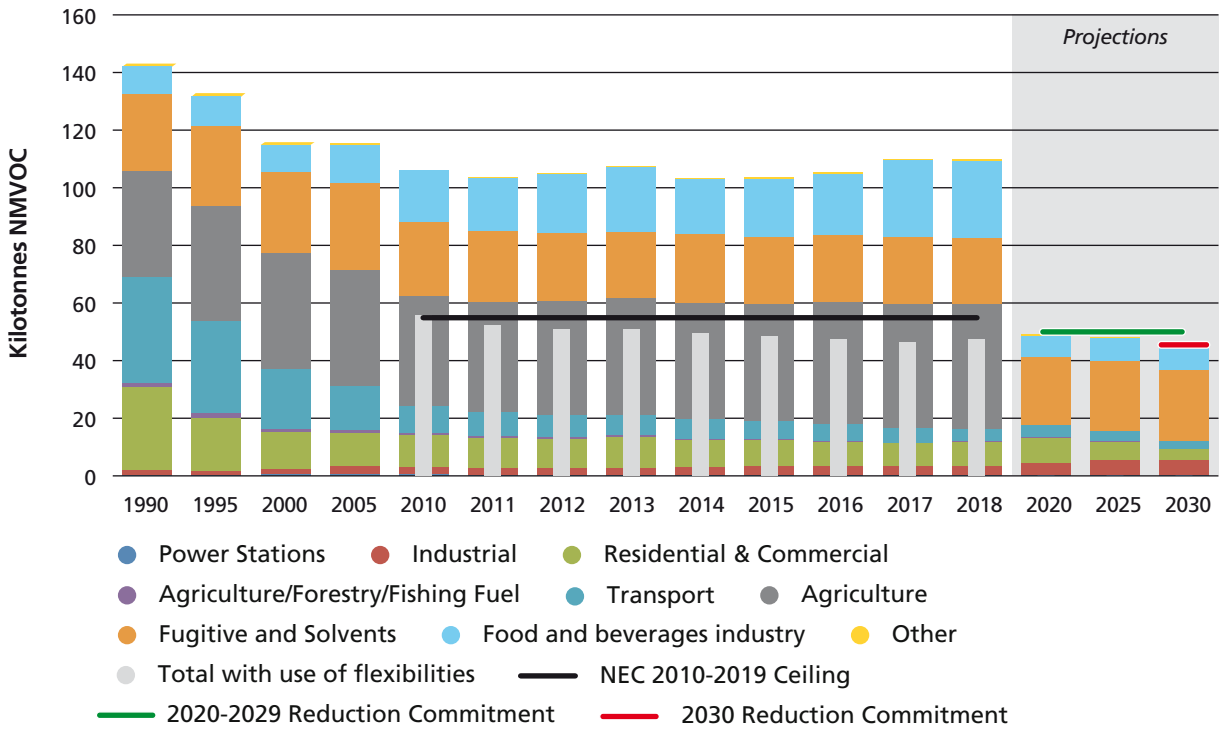


Fig 3.4 presents a scenario where the NMVOC emissions from spirit production (Food and beverages industry), manure management and agricultural soils (Agriculture) are excluded, as these sources were not included in the national inventory at the time the 2020 and 2030 reduction ceilings were established

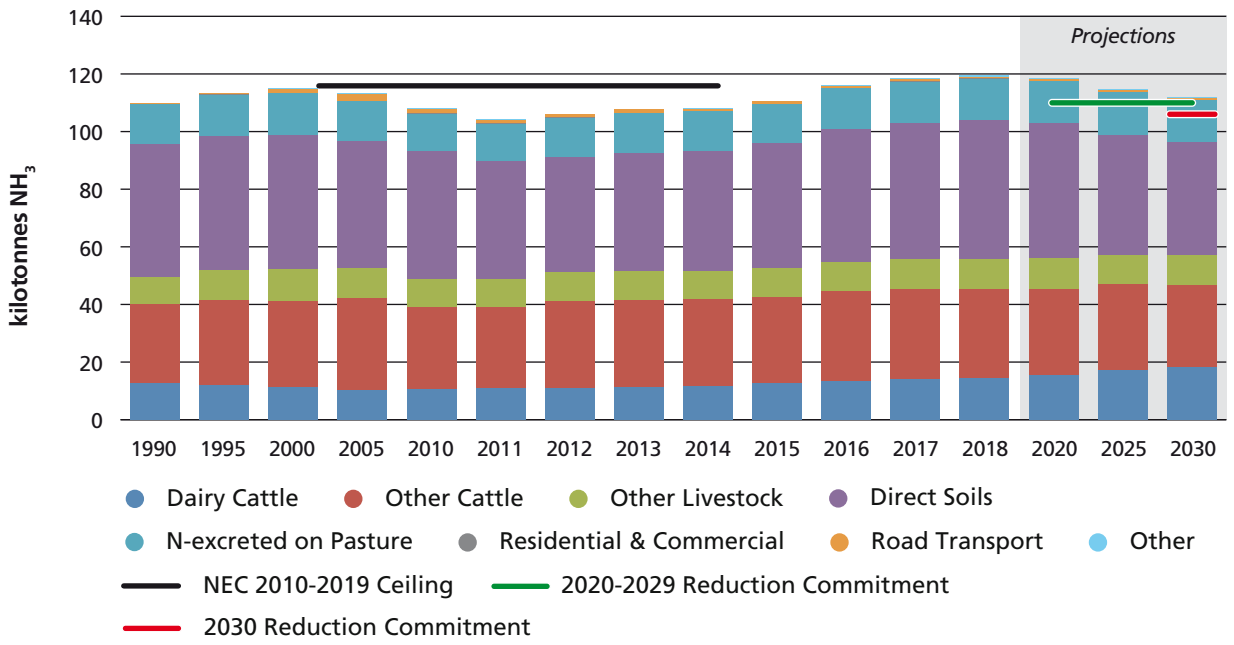
Progress against the emission ceiling target

Figure 3.5 shows ammonia emissions by sector. Ireland's national emission ceiling for ammonia under the NEC Directive is 116 kilotonnes, to be achieved by 2010 and in each year up to and including 2019. The emissions of ammonia complied with the 2010 NEC Directive ceiling for the years 2010-2015; however, Ireland exceeded the emission ceiling in the years 2016-2018. Current projections show Ireland's ammonia emissions exceeding the reduction commitments for 2020 and, without further measures, in 2030 and the intervening years.

Key steps towards achieving the target

The agriculture sector accounts for virtually all (99%) of ammonia emissions in Ireland. Limiting and reducing ammonia emissions in the future could be problematic given the strong performance of the agriculture sector, in line with the ambitious targets of Food Wise 2025 (DAFM, 2015) and the current discussions on the agri-food strategy to 2030. There is now an immediate requirement for focused implementation of abatement measures at the farm level. These measures include the use of low-emission manure-spreading techniques and the use of urea fertiliser products that include urease inhibitors. Furthermore, increases in nutrient use efficiencies at farm level through improvements in soil fertility and soil pH levels should lead to the more optimum use of manures and synthetic fertilisers.

Figure 3.5 Total ammonia emissions and projected emission figures (Source: EPA)



Particulate matter ($PM_{2.5}$)

Overview: Particulate matter ($PM_{2.5}$) emissions are linked to the combustion of fuels in the residential sector, road transport, construction works and industry.

In addition, particulate matter can be formed from reactions between different pollutant gases. Fine particulate matter, $PM_{2.5}$, is associated with significant negative impacts on human health, including acute and chronic respiratory illnesses and cardiovascular diseases (Kim *et al.*, 2017).

Progress against the emission ceiling target

The NEC Directive sets out new national emission reduction commitments for $PM_{2.5}$ that are applicable from 2020 to 2029 and from 2030 onwards. These new reduction commitments are relative to the emissions in 2005.

Key steps towards achieving the target

Future trends in $PM_{2.5}$ emissions depend largely on solid fuel combustion in the residential sector. Current projections estimate that Ireland will be compliant with 2020 and 2030 reduction commitments.

4. Air Pollutants Monitored in the National Ambient Air Quality Monitoring Network

The EPA and partner bodies assess a range of air pollutants as part of the Irish air quality monitoring network.

The EPA and partner bodies use data from the National Ambient Air Quality Monitoring Network to assess levels of air pollutants. These include nitrogen oxides, sulphur dioxide, carbon monoxide, ground-level ozone, particulate matter (PM_{10} and $PM_{2.5}$), benzene, heavy metals and polycyclic aromatic hydrocarbons (PAH). Across Europe, the most problematic pollutants have consistently been particulate matter, nitrogen oxides and ozone but, recently, PAHs have also been identified as pollutants of concern. The following section details the assessments of monitoring results for these four pollutants in Ireland.

Particulate Matter

Particulate matter in air consists of very small particles that have a very big impact on health.

Particulate matter is a mixture of very small solid or liquid particles suspended in air. Primary particulate matter is emitted directly into the atmosphere from natural and human activities, while secondary particulate matter is formed in the atmosphere from precursor compounds.

Particulate matter is usually referred to as PM with a number after it to show how small the particles are. The EPA monitors two types of PM, namely PM_{10} and $PM_{2.5}$, and compares levels with limit values in the CAFE (Clean Air for Europe) Directive (2008/50/EC) and WHO guidelines. PM_{10} means that the particulate matter is 10 microns or less in diameter, 1/10th the width of an average human hair. $PM_{2.5}$ signifies particulate matter of 2.5 microns or less in diameter – 1/40th the width of an average human hair.

While PM_{10} particles can penetrate and lodge deep inside the lungs, $PM_{2.5}$ is even more health-damaging. These fine particles can penetrate the lungs and enter the blood system. Long-term exposure to particulate matter contributes to the risk of developing cardiovascular and respiratory diseases, as well as lung cancer (WHO, 2018).

In Ireland the dominant sources of particulate matter from human activities are:

- solid fuels used in home heating in winter
- the transport sector
- agricultural activities, particularly the formation of secondary particulate matter from nitrogen use.

Figure 3.6 illustrates the annual mean levels of PM_{10} in Ireland from 2009 to 2019. The annual averages were well within the annual limit value of the EU standard. However, in recent years there have been breaches of the WHO annual guideline value of 20 µg/m^3, including in Zone C (towns > 15,000 inhabitants) for 2014. Concentrations at the suburban background monitoring site in Rathmines (Zone A background on the graph) – which is influenced by a variety of sources, including residential heating – were in the range of 13-17 µg/m^3 over the period, which is below the WHO guideline value. At both traffic monitoring sites in Cork and Dublin, the concentrations of PM_{10} have slightly decreased, possibly because of reduced emissions from newer vehicles. For the most recent year, 2019, PM_{10} was monitored at 30 sites. While there were no exceedances of the EU limit value (annual or daily), the WHO air quality daily guideline value of 50 µg/m^3 was exceeded at 14 monitoring stations (EPA, 2020). The WHO annual guideline value of 20 µg/m^3 was not breached.

Figure 3.7 displays annual mean levels of $PM_{2.5}$ from 2009 to 2019. Levels of $PM_{2.5}$ have been in exceedance of the WHO air quality guideline value at all monitoring locations since 2009. In 2019, both Dublin (Zone A) and Ennis (Zone C) exceeded the WHO air quality guideline value (Topic Box 3.2). The highest concentrations were measured in large towns of > 15,000 inhabitants (Zone C) and rural locations (Zone D) when compared with both Cork and Dublin. In 2019, $PM_{2.5}$ was monitored at 30 stations. There were no exceedances of the EU annual limit value. However, the WHO air quality guideline annual value of 10 µg/m^3 was exceeded at ten monitoring stations. The WHO air quality daily guideline value of 25 µg/m^3 was exceeded at 25 monitoring stations. Numerous transboundary particulate matter events were measured in spring 2019.

Figure 3.6 Annual mean levels of PM_{10} from 2009 to 2019 (Source: EPA)

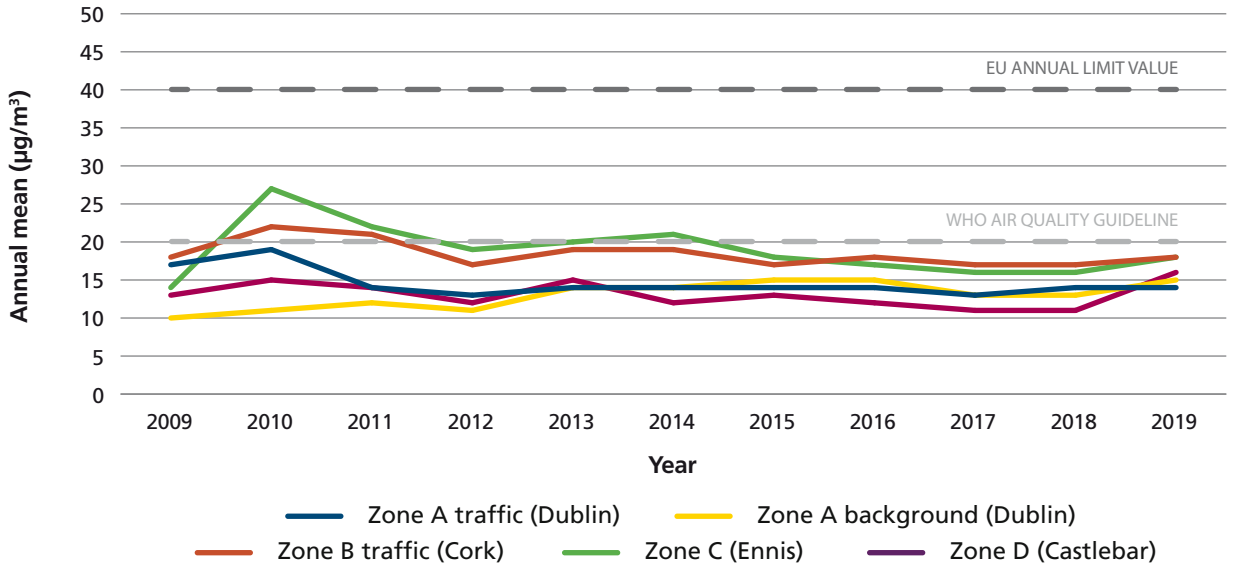
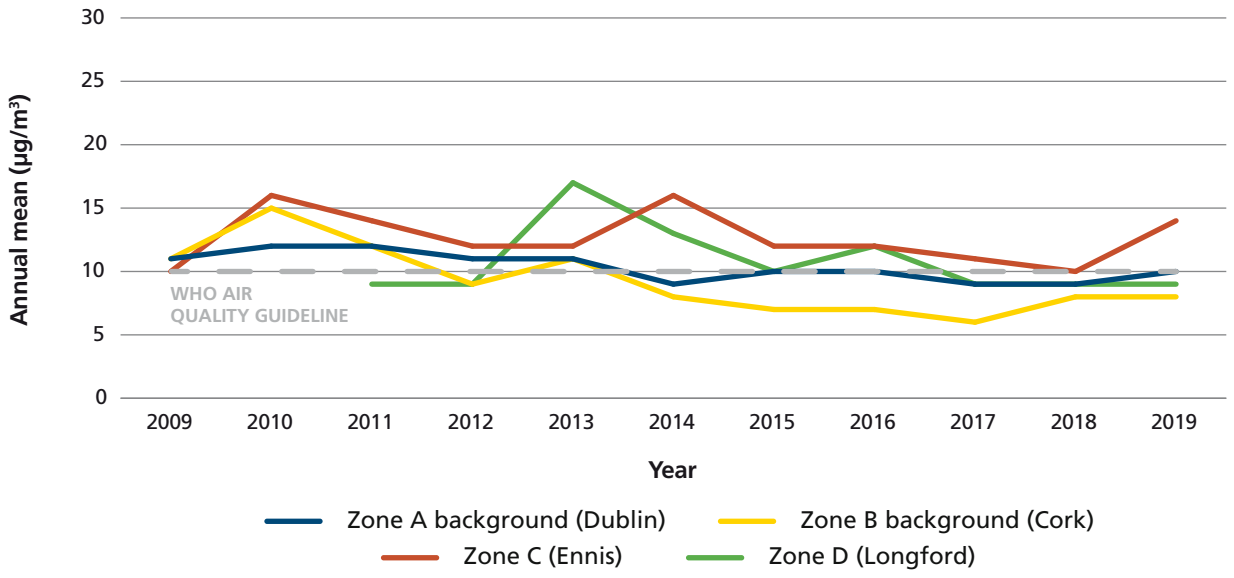


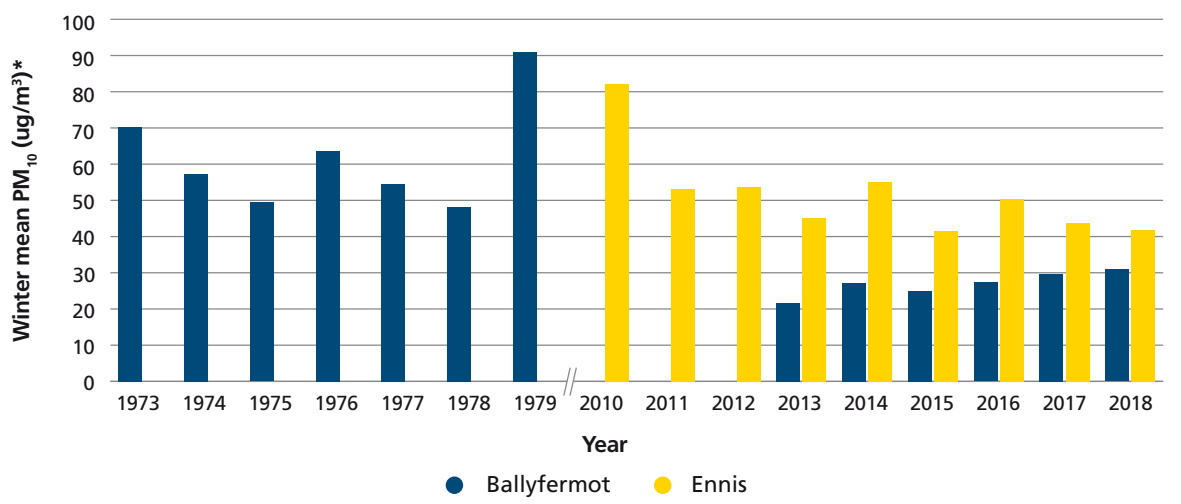
Figure 3.7 Annual mean levels of $PM_{2.5}$ from 2009 to 2019 (Source: EPA)



Topic Box 3.2 PM_{10} Levels during the Winter in Ballyfermot and Ennis

Figure 3.8 shows approximate levels of PM_{10} in Ballyfermot, Dublin, in the 1970s (these have been derived from black smoke measurements – AFF, 1981; Heal and Beverland, 2017), along with direct PM_{10} measurements from 2010 to 2018 during the winter at Ballyfermot and Ennis. Both areas have smoky coal bans in place; the ban in Ballyfermot was introduced as part of the Dublin area ban in 1990, while the ban in Ennis was introduced in 2011. Both areas also have access to the national gas network. Currently there are 41 smoky coal ban specified areas nationally. This includes an additional 13 areas added from 1 September 2020. As can be seen from the graph, while the ban is effective in reducing concentrations of PM_{10} in both areas, Ballyfermot experienced a greater overall improvement. This may reflect the difficulties in enforcing a ban in a smaller town when residents do not have to travel far to purchase smoky fuel from outside the ban area, compared with enforcing it in a large urban area such as Dublin (Goodman *et al.*, 2015).

Figure 3.8 Actual and estimated concentrations of PM_{10} in Ballyfermot and Ennis (Source: EPA)



* *Average black smoke concentrations from 1973 to 1979 have been adjusted by a factor of 1.3 to provide estimates of PM_{10} levels (Heal and Beverland, 2017).*

Nitrogen Oxides

Nitrogen oxides are gaseous pollutants associated with traffic exhaust emissions.

Nitrogen oxides include the gases nitrogen oxide (NO) and nitrogen dioxide (NO_2). Both pollutants are emitted to ambient air when petrol or diesel is burned in internal combustion engines. Nitrogen dioxide is more important from an ambient air quality perspective because of its increased impact on cardiovascular and respiratory health (EEA, 2014).

Internationally, epidemiological studies have shown that symptoms of bronchitis in asthmatic children increase in association with long-term exposure to nitrogen dioxide. In Ireland, research has shown an association between levels of nitrogen dioxide and rates of asthma in older adults (ESRI, 2020). Reduced lung function growth is also linked to nitrogen dioxide at concentrations currently measured in cities in Europe and North America (WHO, 2018).

In terms of ambient air quality, the main source of nitrogen oxides in Ireland is road transport. Diesel vehicles produce more nitrogen oxides than petrol vehicles, particularly older diesels vehicles. Other sources of nitrogen oxides in Ireland include non-road mobile machinery, for example heavy plant machinery, agricultural machinery, industry including energy production, and construction activities.

Measurements indicated an exceedance of the nitrogen dioxide EU limit value at one of the monitoring locations in Dublin during 2019.

Figure 3.9 details the annual average concentrations of nitrogen dioxide across the country from 2009 to 2019. Levels of nitrogen dioxide from transport decreased from 2009 to 2012; this may have been a result of decreased economic activity and favourable meteorological conditions. The highest nitrogen dioxide levels currently are associated with urban areas with the heaviest traffic. Two new air monitoring stations focusing on emissions from road traffic were installed in Dublin in 2018 (St John's Road West near Heuston Railway Station) and 2019 (Pearse Street) (Topic Box 3.3). The annual average nitrogen dioxide level at the St John's Road West site was 43 µg/m^3 – an 8 per cent exceedance of the nitrogen dioxide EU limit value of 40 µg/m^3 in Dublin for 2019 (EPA, 2020). Levels of nitrogen dioxide in other zones were below the EU limit value at the locations monitored. Under EU legislation, an Air Quality Action Plan is required from local authorities in the Dublin area to outline measures to reduce levels. As part of this process, the DECC and Department of Transport, Tourism and Sport have established the Urban Transport-Related Air Pollution Steering Group to address nitrogen dioxide and other traffic-related air pollution in Dublin.

Figure 3.9 Annual mean nitrogen dioxide concentrations from 2009 to 2019 (Source: EPA)

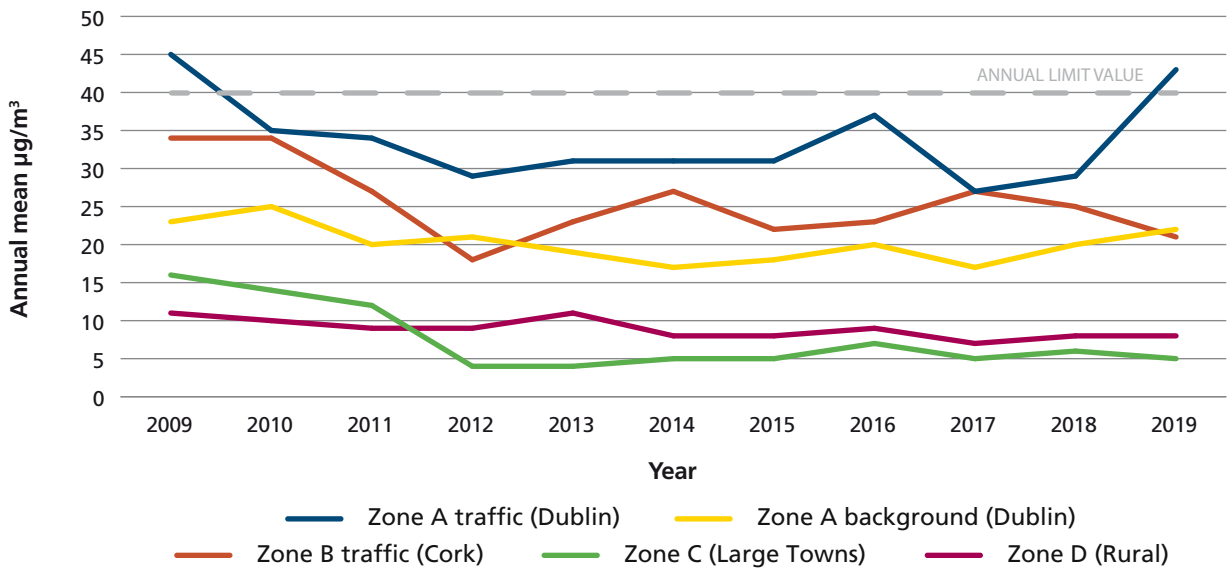


Figure 3.10 Modelled annual average nitrogen dioxide concentrations in Dublin for 2017

Topic Box 3.3 Modelling Air Quality in Dublin

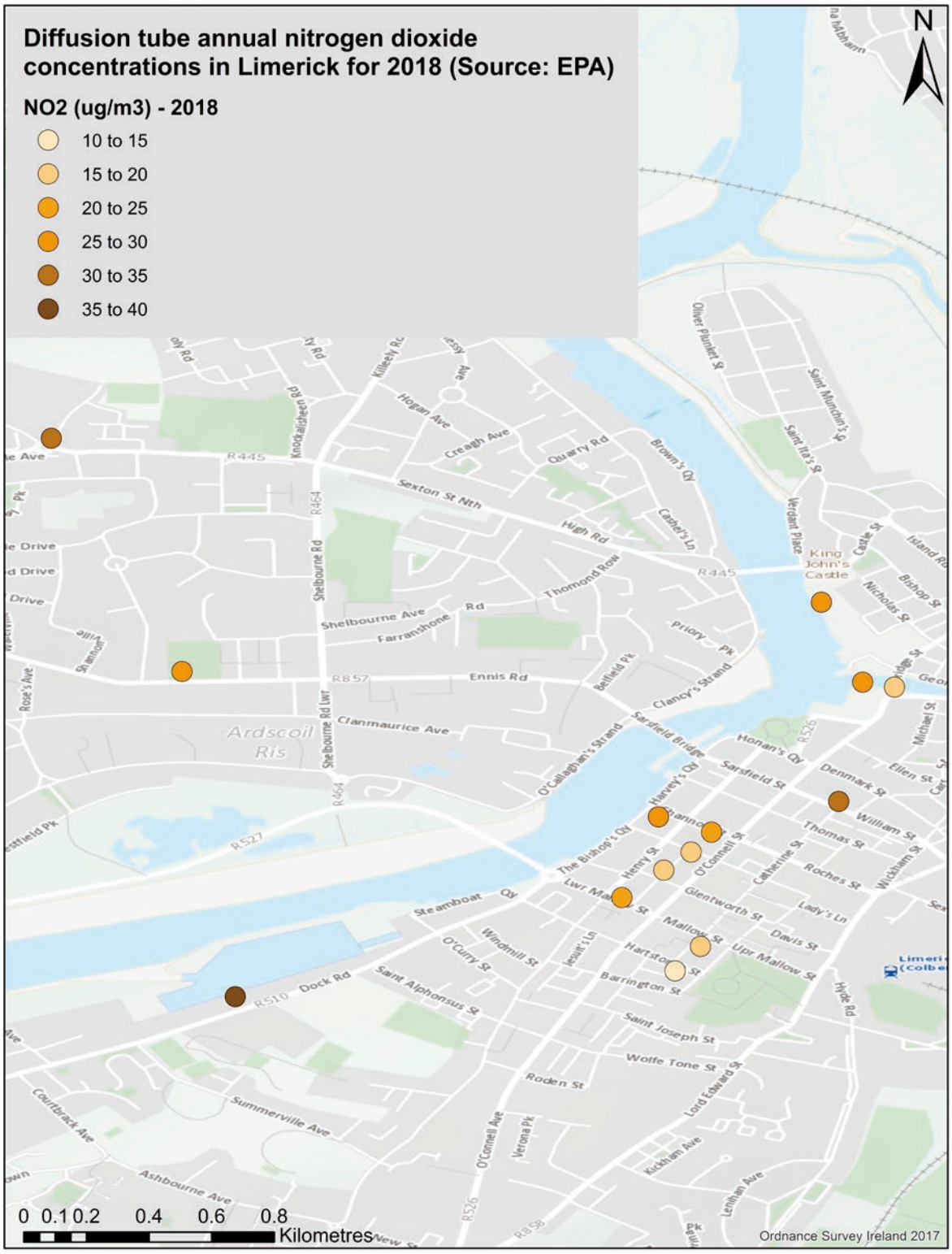
In 2019, the EPA released a report entitled *Urban Environmental Indicators: Nitrogen Dioxide Levels in Dublin*, which detailed modelled concentrations of nitrogen dioxide beyond monitoring stations (EPA, 2019a). The report found that based on air quality indicative monitoring and modelling predictions many areas across Dublin, in particular those close to busy roads, were above the EU nitrogen dioxide annual limit value of 40 µg/m^3. The modelled concentrations of nitrogen dioxide were highest around the M50 motorway, along certain city centre streets, and around the entrance and exit of the Dublin Port tunnel. Away from busy roads, the modelling showed that levels of nitrogen dioxide are low. The modelled predictions have since been used, along with indicative measurements, to aid the siting of new monitoring stations such as those at the Pearse Street and St John's Road West sites. Figure 3.10 shows the modelled annual average nitrogen dioxide levels across Dublin.

Nitrogen Dioxide Diffusion Tube Results in Other Cities

Since 2017, the EPA, in partnership with local authorities in Dublin, Cork, Limerick, Galway and Waterford, has been monitoring indicative nitrogen dioxide levels using passive diffusion tubes. Diffusion tubes allow measurements to be obtained at additional locations beyond the permanent monitoring network. Figure 3.11 shows the indicative annual nitrogen dioxide levels from diffusion tubes around Limerick City. These studies have enabled areas of high nitrogen dioxide concentrations, associated with heavily trafficked roads, to be identified. Information for other cities and years are available on the EPA website at www.airquality.ie.

The air quality situation in 2020 has changed significantly as a result of restrictions on people's movement in response to the coronavirus (COVID-19) pandemic, especially during the period of 'full lockdown'. There is clear evidence that there was a decrease in air pollution, particularly towards the end of March and beginning of April 2020, which coincided with the introduction of restrictions on movement. The EPA has been assessing monthly concentrations of nitrogen dioxide and comparing them with the corresponding period in previous years. Owing to a strong association with road transport, nitrogen dioxide levels have been affected to the greatest extent, with decreases of up to 50 per cent compared with previous years. The largest decreases were observed at urban traffic monitoring stations in the National Ambient Air Quality Monitoring Network.

Figure 3.11 Diffusion tube annual nitrogen dioxide concentrations in Limerick for 2018 (Source: EPA)



Ozone

Ground-level ozone is formed when other air pollutants chemically react in the presence of strong sunlight.

Ground-level ozone is formed as a secondary pollutant from the chemical reaction of nitrogen oxides, carbon monoxide and volatile organic compounds in the presence of sunlight. Ozone concentrations tend to be highest in spring and summer. Ozone is a greenhouse gas that affects our climate.

Ozone can be present at ground level because of downwards movement from the ozone-rich stratosphere, where it occurs naturally and plays an important role in absorbing harmful ultraviolet radiation. Ozone is readily transported to Ireland from Atlantic and European regions as a result of the natural movement of air masses. Ground-level ozone is reduced through reactions with traffic-emitted pollutants; therefore, levels of ozone are higher in rural areas than in urban areas.

Elevated concentrations of ozone can decrease lung function. It can also aggravate respiratory ailments in sensitive individuals such as those with asthma and lung disease (EEA, 2014). Normally, elevated concentrations of ground-level ozone in Ireland are caused by transboundary ozone from continental Europe.

Ozone concentrations measured as 8-hour averages in Ireland for the period 2008-2018 show levels well below the maximum allowed number of exceedances per year (25 occurrences). In 2018, Valentia Observatory had the maximum number of exceedances in the network, at six. However, shorter-term ozone episodes do occur. During 2018, a hot and sunny spell of weather from 22 to 30 June led to an increase in ozone concentrations across the country (EPA, 2019b). The highest concentrations from the ozone monitoring network were observed at the rural background site in Kilkitt, County Monaghan, on 28 June 2018. During this episode, the concentrations reached ≈170 µg/m^3. Had they reached 180 µg/m^3, a public information alert would have been triggered to inform the public of the health impacts of elevated (raised) ozone concentrations.

This episode shows that ground-level ozone could be a potential problem pollutant in Ireland if suitable weather conditions are experienced again in the future.

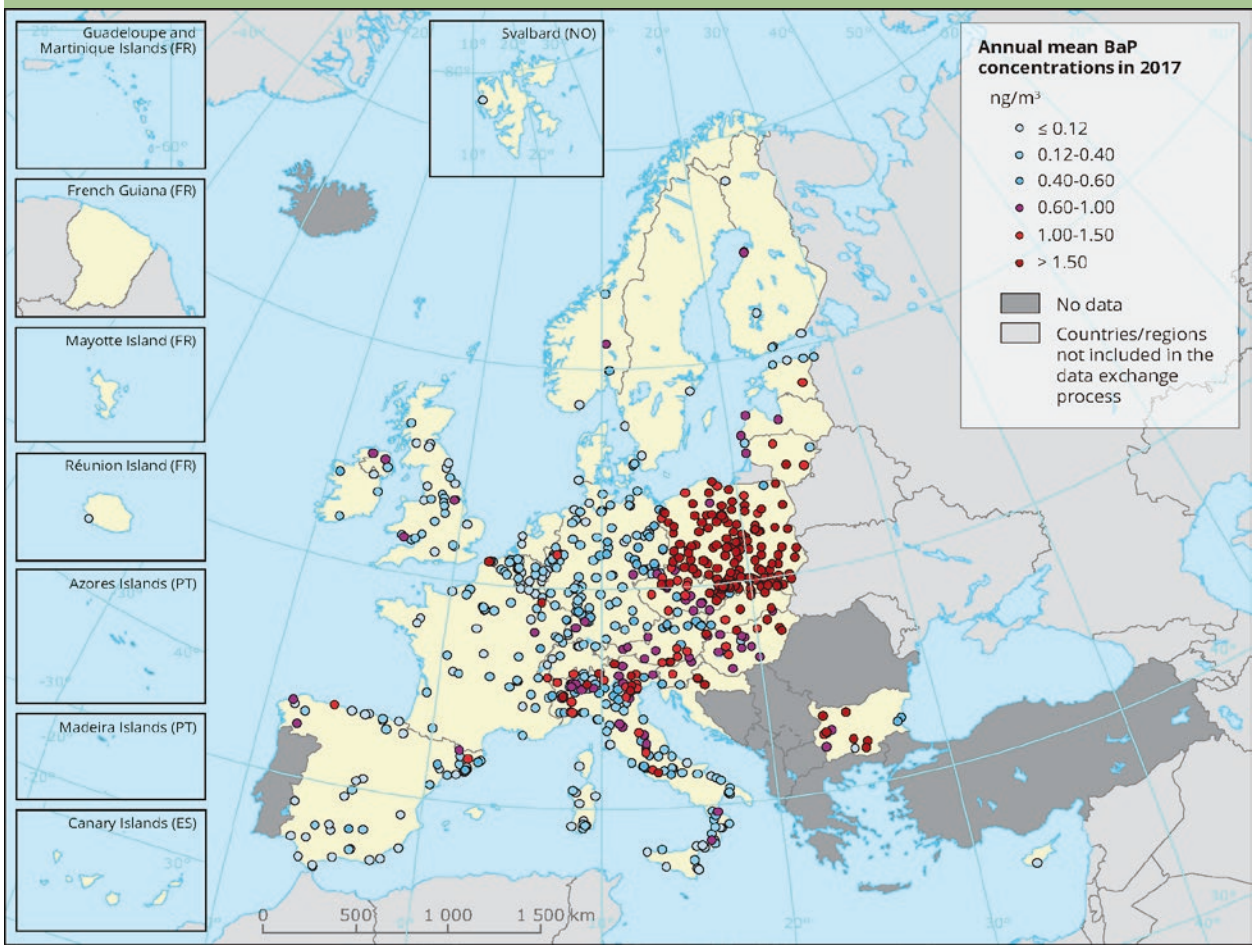
Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons are complex chemical compounds formed through the burning of solid fuel.

Polycyclic aromatic hydrocarbons (PAH) are chemical compounds that consist of two or more fused aromatic rings made entirely from carbon and hydrogen. Sources of PAH include industry, traffic emissions and the domestic use of solid fuels such as peat, wood and coal. Long-term exposure to low levels of PAH may cause several diseases, including cancer (EEA, 2014). PAH, in the form of the compound benzo[a]pyrene (BaP), were first monitored in Ireland in 2009 at five monitoring stations. In 2018, levels at three of the four monitoring stations were above the EEA reference value (0.1 ng/m^3) but below the EU target value (1 ng/m^3). Figure 3.12 details annual mean concentrations of BaP across Europe in 2017 (EEA, 2019). Reductions in emissions from the domestic use of solid fuel are required to reduce ambient levels of PAH. Previous EPA research studies on levels of PAH in various towns throughout Ireland have highlighted elevated levels during the heating season in particular (Goodman *et al.*, 2015).

Air monitoring station, Carrick-on-Shannon, Co. Leitrim, installed in September 2020.

Figure 3.12 Annual mean concentrations of benzo[a]pyrene (BaP) in 2017 (Source: EEA)



5. Outlook for Air Quality in Ireland

Tackling the sources of nitrogen dioxide and particulate matter is the key challenge in our cities and countryside.

While air quality in Ireland has been considered to be generally good, new evidence from increased monitoring and modelling, coupled with new research on the health impacts at lower levels of exposure to particulate matter, raises questions about that status.

Emissions from solid fuel use (coal, peat and wet wood) continue to contribute to localised high levels of particulate matter and PAH during the heating season. The most recent year's data for particulate matter show exceedances of the WHO guideline values throughout the country. There is a need to reduce the use of wet or green wood (i.e. wood that has not been either seasoned for a long period or dried). The level of harmful particulate emissions from such wood is almost four times higher than that for seasoned or dried wood. Having a standard to control the quality of wood for sale would support this reduction in use of wet or green wood.

Levels of nitrogen dioxide are expected to remain above the EU annual limit at several locations close to busy roads in Dublin. A monitored exceedance from the new Dublin city centre monitoring site at St John's Road West for 2019 confirms previous report findings of elevated nitrogen dioxide levels (EPA, 2020). Actions to tackle the key sources of road transport pollution are required to improve the current situation.

Planned actions as part of the National Clean Air Strategy, the National Air Pollution Control Programme, the Climate Action Plan and local air quality plans at a city level are designed to improve air quality for everyone (EC, 2019b). To tackle localised air quality impacts, further regulation of solid and biomass fuel (i.e. coal, peat, wet wood) is required in the area of residential home heating. The promotion of affordable alternatives in terms of home heating upgrades and public transport should be continued. At a European level, the planned implementation of the Ecodesign Directive (2009/125/EC) for domestic stoves will have a positive impact and will need to be implemented into Irish legislation by 2021.

6. Air Quality Research in Ireland

Since 2016, the EPA has invested €3.3 million in 17 new research projects in the air evidence area.

The EPA has funded 17 new research projects relevant to the air area since 2016; a commitment of €3.3 million. Air Science is a theme under the Climate Research Pillar of the EPA Research Programme 2014-2020 (a selected example is given in Topic Box 3.4). EPA-funded research projects[3] include research on:

- addressing conflicts of climate and air pollution policy
- residential solid fuel use in Ireland
- eco-driving
- effects of air pollution on terrestrial ecosystems.

Topic Box 3.4 AEROSOURCE Research Project

Evidence from the UK (Defra, 2017) suggests that the contribution of wood burning to $PM_{2.5}$ levels is increasing across both urban and rural areas. This in turn is leading to increased population exposure to particulate matter pollution. From an Irish research point of view, the evidence to date provided from the EPA-funded AEROSOURCE project (EPA, 2019b) suggests that there is a considerable contribution to particulate matter from residential solid fuel use in Dublin.

This research work, which is being conducted by the National University of Ireland Galway, involves examining the various sources that contribute to poor air quality, in particular those sectors that contribute to particulate matter levels. The process, known as source apportionment, involves the use of advanced measurement and assessment techniques to estimate the various source contributions at representative rural and urban locations. The outputs from this research will give a greater understanding of the dominant sources of particulate matter air pollution in Ireland. This will provide Irish policymakers with evidence that can be used to tackle the problem of particulate matter in a more focused manner.

3 *More information on these projects is available from http://www.epa.ie/researchandeducation/research/. Air-related EPA research reports are available on the EPA website: http://www.epa.ie/pubs/reports/research/air/.*

7. Conclusions

Air Quality and Health

Air pollution is the single largest environmental health risk in Europe (EEA, 2020c). Latest figures for Ireland from the EEA attribute in excess of 1300 premature deaths annually to poor air quality. New evidence suggests that there are more extensive air quality issues than previously thought. It is now time to tackle the three key issues that have a negative impact on air quality in Ireland: emissions from the burning of solid fuels in our homes, transport emissions from vehicles in urban areas and ammonia emissions from agriculture.

Monitoring

As a result of the provision of additional data from the National Ambient Air Quality Monitoring Programme, a wider assessment of the state of Ireland's air quality continues to take place. Additional monitoring and modelling assessments are confirming previous EPA early warnings about higher-than-acceptable levels of nitrogen dioxide in our cities, particulate matter levels throughout the country, and ozone during summer time. To have a positive impact on air quality, responses at individual, local, national and EU levels are required.

Events linked to the impacts of transboundary air pollution on the Irish air mass continue to occur on an annual basis. Of concern from a transboundary point of view are continental ozone and particulate matter events, which occur most often during spring and summer. Cohesive EU-level coordinated action is required to tackle the issue of ozone levels throughout the EU.

Nitrogen dioxide

With regard to nitrogen dioxide levels in our cities and towns, action is required to reduce levels in Dublin to comply with the EU limit value. Additional indicative diffusion tube campaigns on nitrogen dioxide levels in other Irish cities indicate some areas of elevated concentrations close to busy streets. To reduce levels of nitrogen dioxide, local authorities will prepare and implement an air quality plan for Dublin. Measures could include those used in other European cities, such as promoting the use of public transport, cycling and walking, and restricting more polluting vehicles from central areas. The announcement that Dublin has become the first Irish city to sign up to the WHO Breathe Life campaign, which entails making a commitment to meeting the WHO guideline values by 2030 (Breathe Life, 2020), is a positive step.

Particulate Matter

Particulate matter levels are a concern countrywide. All solid fuels (e.g. coal, peat and wood) produce fine particulate matter emissions. Fine particulate matter in our air has well-established impacts on respiratory and cardiovascular health. This is particularly problematic in or near towns and cities because of the cumulative effects of multiple sources of the pollutant and the large numbers of people exposed.

Home Heating

People are encouraged to think twice about using an open fire or a solid fuel stove unless they have no other form of heating available. For stoves and biomass boilers, emissions levels can vary depending on the quality of the installation, the choice of fuel, how well the stove/boiler is maintained and the way it is used.

Moving to cleaner ways of heating our homes will significantly improve air quality in our towns and cities. Air quality considerations need to be integrated into planning decisions at national and local levels. This includes considering healthier home heating options at the design stage for new homes and large-scale home renovations, as well as considering transport options when planning large housing developments. The EPA infographic *heating your home and its impact on air quality and health* from the 2019 air quality report outlines the spectrum of home heating choices. Any move along the spectrum towards cleaner choices will reduce air pollution in your local area and will also reduce the linked negative health impacts.[4]

Ammonia Emissions from Agriculture

From an emissions perspective, ammonia emissions from agriculture require immediate attention. Projections for future years up to 2030 show Ireland exceeding the reduction commitments for every year if further measures are not put in place. This presents a major challenge considering the agriculture and food sector's strong performance and ambition. There is a need for abatement measures to be adopted at the farm level for progress to be made.

Awareness

Continued education, public information and awareness raising are required to inform the public about air quality and its link to health impacts. Continued engagement with local communities through citizen science initiatives such as the GLOBE Programme can help to raise awareness of local air quality issues (EPA, 2020).

Integrated Solutions

Many air pollutant sources have an impact on both air quality and greenhouse gas emissions. Actions to mitigate climate change need to consider impacts on air quality and vice versa, so that we avoid unintended consequences. Actions should also link with measures to mitigate noise pollution from transport sources. There is no 'one size fits all' solution: for example, what works in rural areas may not work in urban areas. We need integrated approaches to meeting Ireland's climate targets and protecting its air quality. The National Clean Air Strategy as part of the National Air Pollution Control Programme which was first announced in 2017, should also include positive actions for climate change. The government's 2019 Climate Action Plan will also have co-benefits for air quality across a number of sectors, including residential heating and transport. Examples of planned actions include promotion of electric vehicles and upgrades to housing with improved insulation and cleaner modes of home heating. As a country we should have the ambition to adopt the WHO air quality guideline values as national air quality standards. This would provide for a higher level of public health protection and cleaner air for all. A nationwide smoky coal ban would allow the benefits of improved air quality to be experienced by all. At a European level, the implementation of the Zero-Pollution Action Plan, expected to be published in 2021, and the promotion of sustainable and smart mobility plans as part of the EU Green Deal, should have positive effects for Ireland provided that there are clear implementation pathways.

Air Quality Research

Continued research into the ever-evolving situation regarding air quality is necessary. Recently funded projects looking at additional emissions sources such as shipping and real-world traffic emissions and the impacts of agriculture on air quality are ongoing. The findings of this research will be needed to inform effective policy responses to the challenges in these areas.

4 https://www.epa.ie/pubs/reports/air/quality/Air%20Quality%20In%20Ireland%202019.pdf

Chapter Highlights for Air Quality

Monitoring and research show that Ireland has air quality issues that need to be resolved. Poor air quality has implications for public health. Identified solutions need to be implemented for the causes of poor air quality, which mainly relate to the residential use of solid fuels for home heating, emissions from transport, especially from diesel and petrol engine passenger cars, and ammonia-related emissions from livestock farming.

Using home heating choices that reduce air emissions, along with improved standards for the quality of solid fuel available, will help to minimise local air quality impacts. Reducing our reliance on diesel- and petrol-fuelled passenger cars and the adoption of best practices to reduce agricultural ammonia emissions on farms will have co-benefits for air quality, the climate, human health and biodiversity. In addition, the implementation of the commitments in the government's Climate Action Plan will have co-benefits for air quality.

The need for a National Clean Air Strategy supported by WHO standards is more pressing than ever. The publication and roll-out of actions as part of the National Clean Air Strategy will be a necessity. The adoption of the WHO guideline values as national air quality standards would provide for a higher level of public health protection.

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