Rialtas na hÉireann
Government of Ireland

Urban Transport Related Air Pollution (UTRAP Group) Final Report

January 2023

Contents

List of Acronyms

AQIH	Air Quality Index for Health
BC	Black Carbon
BEV	Battery Electric Vehicle
CARO	Climate Action Regional Office
CAS	Clean Air Strategy
CSO	Central Statistics Office
DCC	Dublin City Council
DECC	Department of the Environment, Climate and Communications
DFIN	Department of Finance
DHLGH	Department of Housing, Local Government and Heritage
DMS	Demand Management Study
DoH	Department of Health
DPER	Department of Public Expenditure and Reform
DPF	Diesel Particulate Filter
DoT	Department of Transport
EEA	European Environment Agency
EIAR	Environmental Impact Assessment Report
EPA	Environmental Protection Agency
EU	European Union
EV	Electric Vehicle
GDA	Greater Dublin Area
HDV	Heavy Duty Vehicle

HGV	Heavy Goods Vehicle
HSA	Health and Safety Authority
HSE	Health Service Executive
LA	Local Authority
LEV	Low Emission Vehicle
LEZ	Low Emission Zone
NECP	National Energy and Climate Plan
NMVOC	Non-Methane Volatile Organic Compounds
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxide(s)
NTA	National Transport Authority
O_3	Ozone
OELV	Occupational Exposure Limit Value
PHEV	Plug-in Hybrid Electric Vehicle
PM	Particulate Matter
PSO	Public Service Obligation
RSA	Road Safety Authority
SDCC	South Dublin County Council
SDG	Sustainable Development Goal
SDZ	Strategic Development Zone
SEAI	Sustainable Energy Authority of Ireland
SO_x	Sulphur Oxide(s)
TII	Transport Infrastructure Ireland
WHO	World Health Organisation

1. Background

This document provides an update to the interim UTRAP report, which was published on 26 March 2021. As published, the Interim Report presented a comprehensive and detailed overview of urban transport and the key elements contributing to transport-related air pollution in urban areas in Ireland to that date. It further demonstrated the work completed up to the point of its publication and set out the initial series of recommendations made by the Group.

The text of the Interim Report has been reviewed and updated to reflect related policy developments, and these are consolidated within this document and noted in the associated Synthesis Report.

The Synthesis Report reviews the structures underpinning the UTRAP Group and its work programme and charts a future path for optimising the Group's contribution to reducing transport-related air pollution. It reflects on the original objectives and Terms of Reference for the Group, how the Group's achievements align with these objectives, how and whether the continuation of the Group can add value to the process of addressing urban transport-related air pollution and identifies recommendations to further progress the work of the Group.

1.1. The UTRAP Group

Concern had been mounting that levels of NO_2 were approaching EU limit values in certain areas of Dublin. Work carried out by the EPA, including the Urban Environmental Indicators Report, served as an early warning of potential exceedances in EU limit values for NO_x. While air pollutant emissions levels in Ireland were generally below EU limits in 2018[1], concerns remained regarding rising levels of transport-related air pollution in certain urban areas. The Urban Environmental Indicators (UEI) report suggested that on certain heavily trafficked streets in Dublin, nitrogen dioxide (NO_2) levels were higher than previously indicated. NO_2 is an air pollutant that is strongly associated with traffic emissions and with older diesel vehicles in particular. The report indicated that at some locations (in Dublin city centre, on the M50 motorway and at the entrance and exit to the Port Tunnel), levels of NO_2 may have exceeded EU limit values.

The EPA Air Quality in Ireland 2020[2] report, published in September 2021, confirmed that there was an exceedance of the EU air quality legal limit value for NO_2 at one air quality monitoring station in Dublin in 2019. The exceedance was at the St. John's Road West station. An annual average concentration of 43µg/m³ was measured for 2019. This was above the EU annual limit value for NO_2 of 40ug/m³. The report concluded that the main contributors to this exceedance were emissions that were the result of heavy traffic in the vicinity of this monitoring station.

The Urban Transport-Related Air Pollution Working Group (UTRAP) was formed in autumn 2019, to consider and address rising concerns about the level of transport-generated air pollution in certain areas. The UTRAP Working Group included representatives from government departments and agencies and additional key stakeholders and was tasked with addressing the findings of the UEI report as they related to transport-related air pollution.

A full overview of the work of the group, its membership and its meetings are available for consultation online at Urban Transport-Related Air Pollution (UTRAP) Working Group.

1.2. The Interim and Final Reports

The Interim Report was developed to capture the first stage of work completed by the UTRAP group. It was also intended as a resource for future investigation and understanding of the issues and measures, drawing together in one place information and data specifically related to urban transport-related air pollution.

Its publication as an interim rather than final report reflected the group's decision to postpone publication of a final report until the completion of the Department of Transport's Five Cities Demand Management Study. While the group have not proposed any additional recommendations on foot of the Study, it welcomes the actions on demand management in the Department of Transport's Sustainable Mobility Policy[3], which was published in April 2022, and in the recently published Climate Action Plan 2023. The latter commits to the development, by the end of 2023, of a new National Demand Management Strategy.

The structure of this revised report broadly follows that of the original interim report, and many sections remain the same. However, each section was reviewed by the main stakeholders and updates were provided to ensure that this document reflects the most current assessment of the sector.

2. An Overview of Air Quality in Ireland

Key to addressing transport-related air pollution is gaining a better understanding of how urban transport, air quality and health currently intersect. This section includes (a) an overview of the public health impacts associated with air pollution in general, and with transport-derived pollution in particular; (b) the legislative and regulatory frameworks for air pollution monitoring and compliance in Ireland; and (c) an outline of air quality work ongoing in the Dublin region.

2.1. Transport-Related Air Pollution

In the case of transport, the air pollutant most directly associated with traffic in high-density urban contexts is nitrogen dioxide (NO_2). NO_2 exists in the environment as a gas and is formed by a reaction between ozone, other radicals, and nitrogen oxide (NO), which is emitted during combustion processes. Sources of NO include the burning of fossil fuel in vehicle engines and by stationary combustion sources, such as industry and home heating[4]. In towns and cities, where people are often close to traffic, vehicles are responsible for a significant portion of localised NO_2 levels. As NO_2 is a precursor to the formation of other pollutants, such as ground-level ozone (O_3) and secondary $PM_{2.5}$, vehicles also contribute to overall ambient levels of these pollutants. Vehicle engines also emit $PM_{2.5}$ directly, and brake and tyre wear also contribute to levels of PM_{10} in the air.

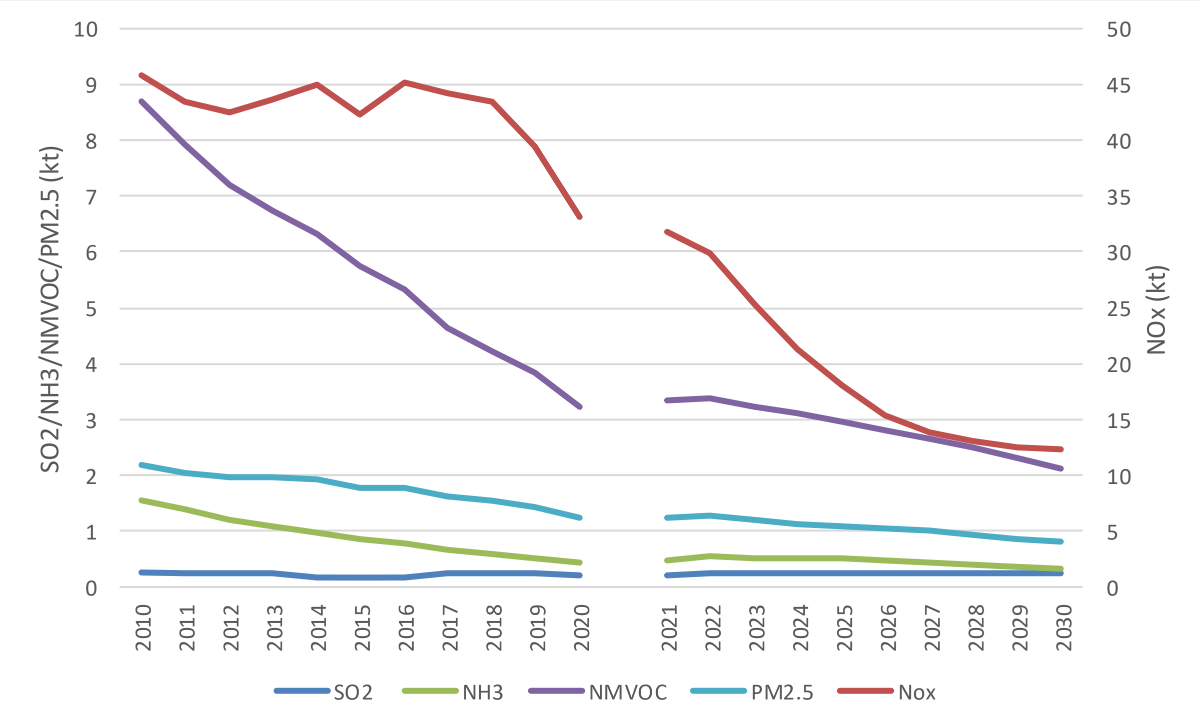
According to the European Environment Agency[5], levels of transport-derived air pollutant emissions significantly decreased between 1990 and 2017. In this period, levels of carbon monoxide (CO) and non-methane volatile organic compounds (NMVOC) emissions from transport reduced by up to 87% across the EU. Transport-derived sulphur oxides (SO_x) also reduced by c. 66%, during this period, while the levels of NO_x emitted by transport dropped by 40%. Since 2000, reductions in particulate matter emissions from transport have also been recorded (44% for $PM_{2.5}$ and 35% for PM_{10}).

Figure 1 demonstrates the changing levels in the five pollutants in relation to the transport sector between 2010 and 2020, and the projected levels from 2021 to 2030. Overall reported emissions have decreased to date and are expected to decline even further over the next ten years.

Figure 1 also demonstrates a significant decline in overall NO_x emissions in 2020 as a result of the Covid-19 travel restrictions. The impacts of existing policies and measures and those set out in the Climate Action Plan are expected to have a significant impact on overall NO_x

emission levels over the coming decade. The projected future decline is primarily attributed to a significant electrification of the national fleet and improvements in combustion engine design and emissions mitigation.

Figure 1 Changing levels in the five pollutants in the transport sector 2010 to 2020 and projected levels 2021 to 2030 (based on EPA IIR 2022)



The additional reductions observed to date can be linked to improved vehicle standards, particulate matter abatement technologies and Fuel Quality Directives, plus localised transport policies aimed at improving air quality.

These decreases have occurred in tandem with a rise in transport demand. This has meant that while the volume of pollutants emitted by individual vehicles has declined, emissions from transport have decreased by less than was anticipated over the last two decades, as more vehicles are on Ireland's roads[6]. Rising traffic levels also mean that where there are high levels of congestion, or where it is difficult for transport-derived air pollutants to disperse (such as in heavily built-up city streets), it is becoming increasingly challenging to maintain high standards of air quality for people nearby.

2.2. The Public Health Impacts of Air Pollution

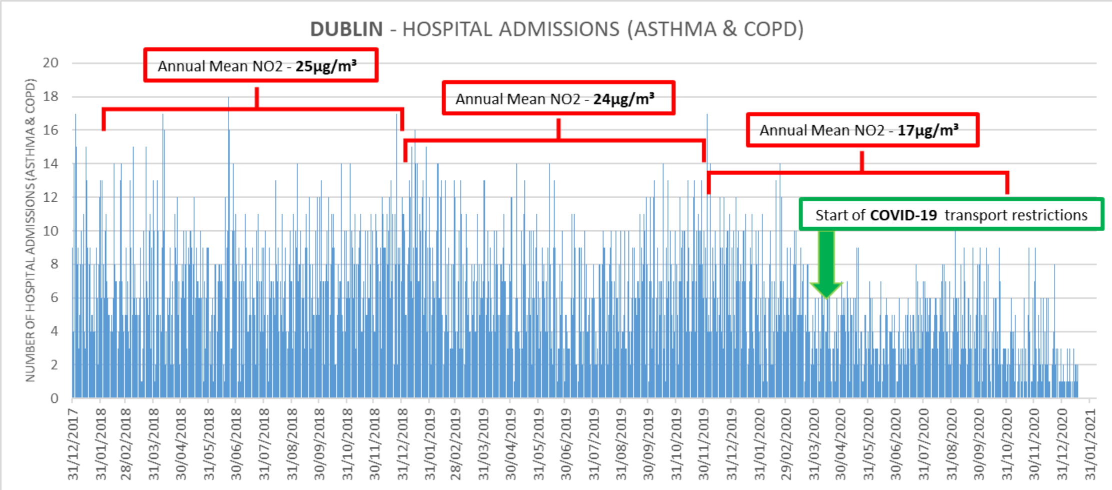
Internationally, air pollution has been acknowledged as a major public health concern. Air pollution is a significant cause of premature death and disease and is the single largest environmental health risk in Europe[7]. It has been reported to have a marked impact on the health of the European population, particularly in urban areas; and has also been shown to have comparable/greater impacts to human health than tobacco smoking and consumption of an unhealthy diet[8].

While the Environmental Protection Agency (EPA) has characterised Ireland's current air quality as good relative to other European Union (EU) Member States[9], it has also noted the existence of local issues and the growing challenge of maintaining this good air quality standard. This is consistent with wider European air quality patterns that show that although emissions of key ambient air pollutants and their concentrations have fallen significantly over the past two decades, localised poor air quality remains an issue in many areas. Recent reports from the EPA have shown that one of the main sources of ambient air pollutants in Ireland is the transport sector[10], with the term 'transport-related air pollution' (TRAP) used to describe such emissions[11][12]. In addition, estimates by the European Environmental Agency (EEA) have highlighted that these emissions continue to cause substantial impacts on the health and social care systems in many countries. These air pollutants include nitrogen dioxide and particulate matter.

Both short- and long-term exposure to air pollution can lead to a wide range of diseases, including stroke, chronic obstructive pulmonary disease (COPD), trachea, bronchus and lung cancers, aggravated asthma, and lower respiratory tract infections. The World Health Organization (WHO) provides evidence of links between air pollution and type 2 diabetes, obesity, systemic inflammation, Alzheimer's disease and dementia. Reports in the literature have also highlighted that chronic exposure can affect every organ in the body, complicating and exacerbating existing health conditions. In addition, work in Ireland has shown significant associations between TRAP and respiratory admissions, including COPD, as well as an association between the Air Quality Index for Health (AQIH) and overall respiratory hospital admissions[13].

In March 2020, the WHO declared a global pandemic following the emergence of the severe acute respiratory syndrome coronavirus 2 (SAR-CoV-2)[14]. Part of the mitigation measures implemented in Ireland included transport restrictions. Non-essential services were closed, people were asked to work from home, and travel was restricted to a two-kilometre radius from their home[15]. Compliance with these restrictions was estimated between 60 – 80% from April to November 2020, with vehicular traffic demonstrably reduced[16][17]. Similar restrictions were introduced internationally, and as a result, ambient air pollution concentrations (particularly NO_2) were noted to be reduced in a number of studies[18][19][20]. The trends in air pollution concentration seen as a result of COVID-19 mitigation measures have allowed for exploration of the relationship between air pollution and asthma. In Ireland, reports have shown that with this reduction in ambient air pollutants, there was an associated health co-benefit, i.e. a significant decrease in respiratory admissions to hospitals. (see Figure 2).

Figure 2: Daily numbers of respiratory admissions to hospitals between 2018 and 2021.



Although acknowledging that these restrictions were not sustainable or justifiable in the long-term, these recent studies have highlighted that experience has resulted in improvements in ambient air quality and also had a positive impact on human health outcomes[21]. These studies add to the existing evidence on the association between TRAP and asthma and suggest that the greatest impact on reducing transport-related emissions from road transport and allowing for improvement in Public Health outcomes is the co-implementation of a package of policy measures (i.e. transport and non-transport related interventions) designed according to requirements in Ireland.

The potential for poor air quality to cause adverse health effects and other environmental costs has been well documented, and, as noted by the European Environment Agency (EEA), the 'scale of policy actions undertaken in Europe to specifically address transport-related air pollution has increased over recent years, reflecting the important contribution that transport still makes to reducing air quality'[22].

Currently, EU air quality standards provide for a minimum level of health protection, but evidence from the World Health Organisation indicates that human health impacts occur at air pollution levels below the current EU ambient air quality limits.

2.3. The EPA Air Quality Index for Health (AQIH)

Air quality in Ireland generally compares favourably with other EU countries, and in general, pollution levels do not rise to levels at which people need to make significant changes to their habits to avoid exposure. However, there are often some concerning localised issues which arise. Additionally, we have seen the beneficial impacts of reducing air pollution, for example as a result of the introduction of 'Low Smoke Zones'[23] in relation to solid fuels and the travel restrictions implemented under the COVID-19 public health measures.

As the EPA's Urban Indicators Nitrogen Dioxide Report[24] indicates, local conditions (including climatological events and proximity to emissions sources) can lead to relatively high ambient air pollution levels in some areas. As set out above, these may result in negative public health impacts. To provide members of the public with information on air quality in their local areas, the EPA has developed the Air Quality Index for Health[25] (AQIH). The AQIH provides real-time information on the quality of air at a number of locations in Ireland, indicates whether or not this might have an effect on human health, and suggests actions that can be taken to avoid potential negative effects.

The AQIH does not distinguish between air pollutants or emission sources (i.e. it does not separate out different sources of air pollution) but it does map local air quality using a relative scale from 1 to 10 (where 1 is good and 10 is very poor).

2.4. Air Quality Legislative and Regulatory Framework in Ireland

The main national legislative provisions to address air pollution in Ireland were introduced under the Air Pollution Act 1987 and it remains the primary basis for national legislation in this country. This Act sets out the statutory definition of air pollution and contains a general obligation to prohibit pollution, along with powers to prevent it.

Over the years, the EU Commission has introduced legislation to ensure reduced emissions of air pollutants into the atmosphere and to limit maximum concentrations for pollutants in the ambient air that we breathe. These have been transposed into Irish legislation through a number of statutory instruments.

The Environment Protection Agency (EPA) is the designated competent authority for monitoring and assessing air quality in Ireland.

To comply with EU regulatory requirements, air quality is assessed by two distinct but complementary methodologies: (1) compilation of national emission inventories, and (2) monitoring of ambient air quality.

- **Emissions** are the overall atmospheric pollutants emitted from various sources across the economy, e.g. transport, agriculture, industry, power stations, waste and residential/commercial.
- **Ambient air quality** is the air in outdoor environments. Poor ambient air quality occurs when pollutants reach sufficiently high concentrations in a specific location to affect human health and/or the environment.

This report and the work of the UTRAP Group is primarily focused on those pollutant emissions that are associated with land transport in and around Irish cities, specifically those emitted by vehicular traffic and also by urban trains, which have a direct impact on our ambient air quality. The Group initially planned to include a consideration of port-related shipping emissions in its work programme but work in this area was temporarily halted due to the COVID-19 pandemic. Since the publication of the first Interim Report in March 2021, an EPA-funded air pollution source apportionment study for the Dublin Port area[26] by a research team from University College Cork has begun, and this will feed into future work by the Group.

2.4.1. National Emissions Regulations

Annual emissions of atmospheric pollutants are primarily regulated under the National Emissions Ceiling Directive (2016/2284/EU) (NECD). This puts an annual permitted cap or 'ceiling' on total annual emissions of five key pollutants:

- Nitrogen Oxides (NO_x)
- Sulphur Dioxide (SO_2)
- Volatile Organic Compounds (VOCs)
- Ammonia (NH_3)
- Fine Particular Matter ($PM_{2.5}$)

The NEC Directive also sets national reduction commitments for the five pollutants listed above. Of these pollutants, those most closely associated with urban transport are NO_x (particularly NO_2) and fine Particulate Matter ($PM_{2.5}$). Transport emissions also contribute to overall NMVOC levels and to a small percentage of national NH_3 emissions, although the bulk of both of these pollutants and of urban $PM_{2.5}$ emissions come from other sectors (e.g.

industry, agriculture and home heating). A National Inventory Report is published each year by the EPA[27] and gives a detailed account of all emissions.

The NEC Directive set emission reduction commitments for Ireland for 2020 and 2030 for NO_x, SO_2, NMVOC, NH_3, and $PM_{2.5}$, and these are shown in Table 1 below.

At a national level, recent analysis suggests that while ammonia and NMVOC targets will be very challenging to achieve, the 2030 NO_x reduction target will be met subject to the full implementation of Climate Action Plan targets, including electric vehicle targets[28].

Table 1: Emission Reduction Commitments under the NEC Directive

Pollutant	SO_2	NO_x	NH_3	NMVOC	$PM_{2.5}$
2020	65%	49%	1%	25%	18%
2030	85%	69%	5%	32%	41%

2.4.2. Ambient Air Quality Regulations

Ambient Air Quality legislation deals with the concentration of a pollutant at a specific place, at a specific time or over a specific period of time. The levels of pollution in ambient air are a result of the accumulation of local emissions released from multiple and various sources such as vehicle emissions or the burning of fossil fuels, in particular solid fuels such as coal, peat and wood in the home. Limits for ambient air quality are regulated under the Cleaner Air for Europe (CAFE) Directive (2008/50/EC).

Under the CAFE Directive, the annual mean limits are set for several pollutants as demonstrated in Table 2 below. In addition, the World Health Organisation (WHO) guidelines also set non-binding guideline values which are more stringent for some pollutants.

Table 2: Annual Limits for Ambient Air Pollution under CAFE Directive and WHO Guidelines

Pollutant	Averaging Time	EU Limit Values	2005 WHO Guidelines	2021 WHO Guidelines
$PM_{2.5}$, µg/m^3	Annual	25	10	5
	24-hour[a]	-	25	15
PM_{10}, µg/m^3	Annual	40	20	15
	24-hour[a]	50	50	45
O_3, µg/m^3	Peak season	-	-	60
	8-hour[a]	120	100	100
NO_2, µg/m^3	Annual	40	40	10
	24-hour[a]	200	-	25
SO_2, µg/m^3	24-hour[a]		20	40
CO, mg/m^3	24-hour[a]		-	4

As part of the European Green Deal, the EU is currently in the process of revising the EU limit values, to align them more closely with the recommendations of the WHO and to ensure improvements to overall EU legislation for clean air. Any relevant legislative changes to EU air quality directives will be reflected in the Irish legislative framework in due course.

In Ireland, the current annual average limit for Nitrogen Dioxide (NO_2) is 40µg/m^3. An hourly mean limit of 200µg/m^3 is also in place, which should not be exceeded more than 18 times a year in a specific location.

2.4.3. National Clean Air Strategy

The Department of the Environment, Climate and Communications (DECC) is currently finalising Ireland's first National Clean Air Strategy. The Strategy will provide the policy framework necessary to identify and promote the integrated measures and actions across Government that are required to reduce air pollution and promote cleaner air, while delivering on wider national objectives.

There are a number of national policy frameworks already in place which will also help to reduce pollutant emissions and improve air quality, and the recommendations from the UTRAP group will play a part in delivering improvements in our transport-related ambient air pollution. It is important that the synergies are maximised between this work and the Clean Air Strategy, with a view to achieving lasting reductions in the health and environmental impacts of air pollution in the most effective manner.

DECC held a public consultation on a draft Clean Air Strategy, which closed on 3 May 2022. The strategy is being reviewed in light of the responses received and also to consider subsequent policy developments. It is also important that the Strategy reflect the outcomes of the UTRAP reports and as such could not be completed until the work of UTRAP was finished and the final reports are published.

2.5. Local Authorities and Transport-Related Ambient Air Quality

Under the Air Pollution Act, 1987[29] local authorities are required to take the best practicable means to prevent or limit air pollution that could negatively impact on the environment and human health within their jurisdictions. This means that within the national legal air quality framework as outlined above, local authorities monitor and review air pollutant emissions arising from a range of air pollutant sources including machinery, plant, equipment, appliances, apparatus, buildings and other structures within the authority areas.

In the context of transport-related air pollutants, local authorities monitor nitrogen oxides (NO_x) in partnership with the EPA, as is currently the case in Dublin and Cork. In Ireland, under the provisions of the CAFE Directive, if a breach of the EU limit values for pollutants occurs, the local authority with responsibility for the area within which the breach occurs is legally required to prepare an Air Quality Action Plan. In such plans, authorities are required to set out measures to be implemented in order to address the causes of exceedance, and to ensure compliance with EU limit values within as short a timeframe as possible[30].

There have only been two exceedances of the EU NO_X limits since 2005. The first occurred in Dublin in 2009 and the four local city and county authorities compiled and submitted an Air Quality Action Plan in 2011[31]. In that report, the participation of key transport stakeholders was seen as vital to the success of efforts to resolve the exceedance. Proposed measures to address the NO_2 exceedance included implementation of national spatial planning and land-use strategies; public transport expansion and fleet replacement; and the implementation of fiscal and other policies to reduce congestion and encourage modal shift away from car use and towards active and sustainable travel[32].

The second observed exceedance occurred in 2019 and instigated the establishment of the UTRAP group. Again, the four Dublin local authorities were required to develop a new Air Quality Management plan for the Dublin region. The plan[33] was submitted to the European Commission in December 2021. No exceedance was observed in 2020 or 2021 and as at November, no exceedance was anticipated for 2022.

The four Dublin local authorities have also collectively joined the WHO, UN and World Bank-supported BreatheLife Network. The network links 70 cities and regions which have joined to demonstrate their commitment to bring air quality to safe levels by 2030, and to collaborate and share information on the clean air solutions that will help to achieve this goal as quickly as possible[34]. Sustainable transportation has been identified as a key plank of a Dublin-wide approach to air quality, and strategies adopted in this regard include the trialling of car-free shopping streets[35] as part of Dublin City Council's Covid-19 Mobility Strategy.

As part of wider suites of measures to address urban air pollution, key options for local authorities to address transport-related emissions include:

- Creation of Low Emission Zones (LEZ);
- Work with NTA and TII to improve public transport infrastructure;
- Promotion of modal shift towards active travel (walking & cycling);
- Smart management of traffic flows and volumes;
- Review of speed limits;

- Support the national transition to Electric Vehicles through working with stakeholders to ensure a future demand led roll-out of charging infrastructure;
- Develop and implement Tree Management & Green Infrastructure Plans;
- Provide guidance and support for the development of green infrastructure through the planning system.

3. An Overview of Transport in Ireland

In Ireland, due to our historically dispersed settlement pattern, low population densities and dependence on fossil fuels[36], the transport sector as a whole has a significant impact on national emission levels. In 2018, the transport sector accounted for 20.1% of the country's total CO_2 emissions[37] but contributed approximately 41% of Irish nitrogen oxide (NO_X) emissions in the same year[38]. However, in 2020, the transport sector accounted for 19% of the country's total CO_2 emissions[39] and for approximately 35% of nitrogen oxide (NO_X) emissions[40]. This drop in emissions is most likely the result of the reduced volumes of traffic on the Irish roads due to the impact of Covid restrictions on transport-related emissions, and the impact becomes clear when comparing the 2019 and 2020 climate and air pollution national emissions data. This is also seen in the EPA's 2022 ambient air quality report (which presents 2020 data).

3.1. Profile of the Irish Vehicle Fleet

The make-up of the Irish vehicle fleet plays a significant role in determining local ambient air pollution levels. Nationally, over 2.86 million vehicles were registered and taxed in Ireland at the end of December 2020, of which only 5% were privately-owned electric cars. However, figures published in June 2022 by the CSO[41] show the continued growth in the number of electric and plug-in hybrid vehicles licensed in Ireland. The data also showed that:

- In the first five months of 2022, 21% of all new cars licensed for the first time were electric or plug-in hybrid electric vehicles (PHEV);
- The number of new cars licensed in May 2022 fell by 217 (-3%) vehicles compared with May 2021;
- In the first five months of 2022, 26% of new private cars licensed were diesel, compared with 37% in the same period in 2021;
- There was a fall of 2,403 (-37%) used private cars licensed in May 2022 compared with May 2021.

Private passenger cars accounted for over three-quarters of the vehicles on the road in 2019 and 2020 and for almost three-quarters of the journeys that people made, either as drivers or as passengers, in 2019[42]. A detailed breakdown of the fleet is available at Transport - CSO - Central Statistics Office. While the number of cars registered in each county does not always reflect where each car is being driven, the greatest numbers of cars on the road were registered in counties with high urban populations. This pattern remained constant despite reduced vehicle purchase levels in 2020 and in 2021 associated with the wider impacts of Covid-19[43].

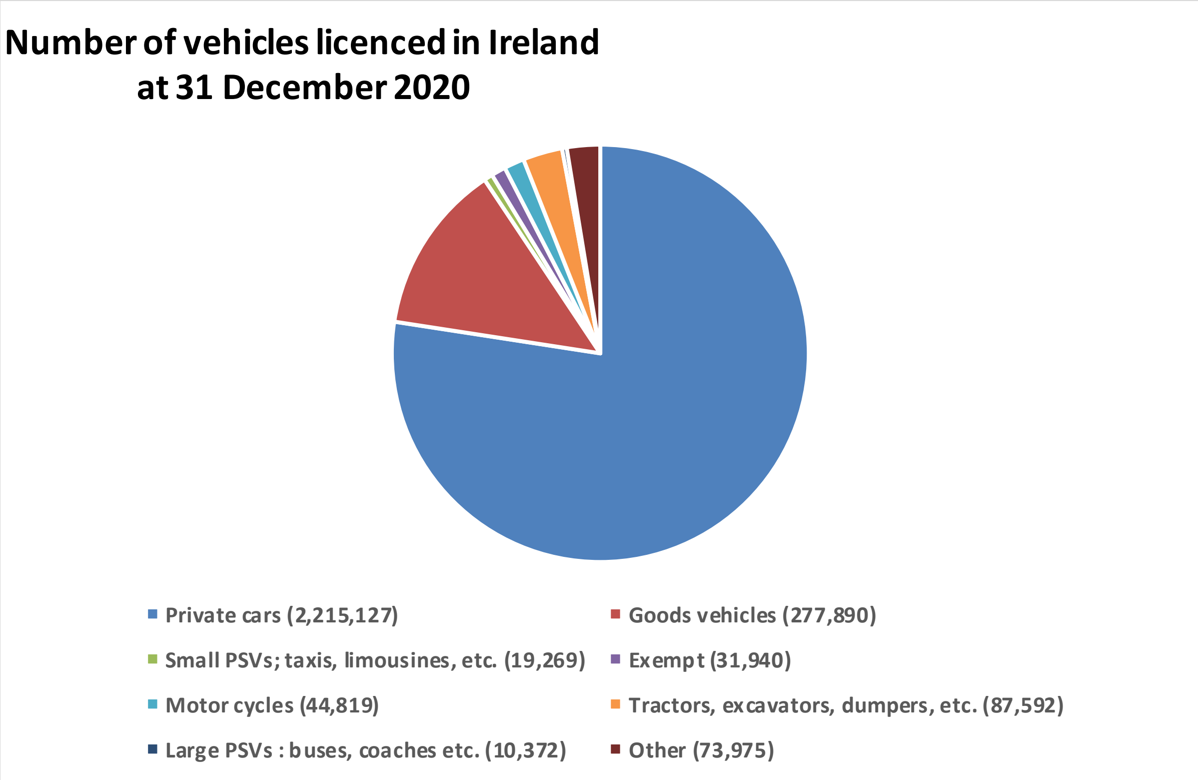


Table 3: Number of private cars taxed by county on 31 December 2020

County	Number of private cars taxed
Dublin	554,470
Cork	369,602
Galway	120,142
Rest of Ireland	1,270,913

By 2030, total transport-related carbon emissions must decrease by 50% compared to 2018 levels. As part of the sector's contribution to achieving this target, along with measures to reduce transport demand and increase sustainable mobility (walking, cycling, public transport, shared mobility), significant progress has been achieved in promoting the electrification of the public and private vehicle fleet including the establishment of Zero Emission Vehicles Ireland (ZEVI) in July 2022. ZEVI will lead on the delivery of the Ireland's ambitious targets to have an expected 30% of our private car fleet switched to electric vehicles by 2030 (i.e., our 845,000 private EV target) with considerable co-benefits for air quality in the transport sector.

3.1.1.Taxis and Small Public Service Vehicles

The Irish taxi fleet was impacted by Covid-19, as the numbers of Small Public Service Vehicles (SPSVs), which include taxis, hackneys and limousines, licenced in Ireland dropped by just over 15% between end 2020 and end 2021, reflecting the significant impact that changed Covid-19 travel patterns and transport restrictions had on the industry. However, the industry shows a similar pattern of increasing electric vehicle purchases as the private vehicle fleet.

The use of diesel in the fleet remains high and it remains the dominant fuel type, albeit trending downwards from 82% of the total number of licenced SPSVs at end 2020, to just under 80% by end December 2021. Statistics relating to the taxi fleet continue to show a similarly high concentration of vehicles in Dublin as is evident in the private passenger fleet: over half of the 18,083 vehicles in the national SPSV fleet were registered in the county at end 2021. Although not all operate there, the high numbers of taxi drivers licenced and certified (as having passed the 'Area Knowledge Test') in Dublin suggests that the Greater Dublin Area (GDA) is the primary focus of taxi operations at a national scale.

3.1.2.Heavy Goods Vehicles

Post-recession, there has also been a steady increase in the number of Heavy Goods Vehicles in the national vehicle fleet, and greater levels of road freight activity have been registered. It is predicted that this trend will accelerate in the coming decades, with future demand for freight expected to nearly double (*c.* 91%) in kilometre tonnes by 2050, surpassing the previous Celtic Tiger peak of freight activity in less than a decade. Vans and light trucks remain by far the most numerous types of goods vehicles on the road, even as heavier trucks (of over 12.5t unladen weight) continue to be responsible for hauling almost three-quarters of the goods transported on the Irish road network[44]. This is of potential significance to future freight emissions patterns in urban areas as the increased volume of home deliveries that was accelerated by pandemic travel restrictions is expected to increase in the coming decades, with projected shifts in purchasing patterns and in population growth[45]. In 2021, a total of 154.9 million tonnes of goods was transported by road. This represents an increase of 10% on the 2020 total but a decrease of 3% when compared with 2019. While freight transport patterns were impacted by Covid-19-related changes to people's buying habits as well as by global and European supply chains in 2020 and 2021, and the impacts of Brexit, the tonnage of goods transported by road nonetheless remained relatively constant[46].

3.1.3.Bus Fleet

Ireland's bus fleet shows a similar variability and diversity in terms of numbers, vehicle types and operating patterns. At the end of 2019, 11,424 miscellaneous minivans, buses and coaches were under taxation in Ireland and almost 100% of these were diesel-fuelled. At that time, a relatively small percentage of the vehicles under taxation (1,325 or 11.5%) were used to provide scheduled commercial bus services around the country, accounting for almost 9.3% of all public transport passenger journeys. As noted in a 2019 NTA bulletin:

> 'Commercial bus services cover large scale inter-city and interurban bus services which provide connections to and from the country's main towns, cities and airports; commuter services that bring passengers to employment and education; urban and suburban services; as well as rural services that generally link small towns and villages in rural areas[47].'

Once again, the GDA was a primary focus of operations, with almost 71% of these commercial bus services being offered in Dublin and adjoining counties.

By far the largest number of bus trips taken by passengers in Ireland is accommodated by transport services funded under the national Public Service Obligation (PSO) bus fleet. The Obligation is a way of making sure that socially necessary but commercially non-viable bus services are provided; some commercial services offered by transport operators would fall outside the PSO remit. PSO service providers include Dublin Bus, Bus Éireann and Go-Ahead, among others. In 2018, before the pandemic, 178 million passenger journeys were made on bus services alone. Of these, approximately 140 million passenger journeys were made on Dublin Bus services, while approximately 22.9 million journeys were made on the Bus Éireann urban and regional fleets. The total urban bus fleet operating in the five largest cities at the end of 2018 consisted of 1,322 single and double-decker buses[48].

The transition of this fleet away from diesel fuel standards is mandated by the National Development Plan (NDP), with a Government commitment to no longer buy fossil-fuel only buses from July 2019. Since end 2021, therefore, as part of the overall fleet transition, the Irish PSO city fleets now include a further 74 hybrid-electric buses delivered to Dublin Bus, and a further 61 hybrid-electric buses deployed by Bus Éireann on urban routes in Galway and Limerick[49]. A switch to low and zero tailpipe emission bus technologies in Irish towns as well as cities is also planned, for example the roll-out of a pilot full electric bus trial in Athlone by Bus Éireann in 2022.

As of 2021, this means that 15% of the CIÉ Group vehicle fleet (which includes Dublin Bus and Bus Éireann) are hybrid electric, up from just under 1% of the fleet in 2020[50], with a total of 233 hybrid buses in operation in mainly urban areas across the country in 2021. Additionally, as alternative fuels technologies for coaches develops, the NDP also commits the Government to continue the upgrading of the national coach fleet (operating on intercity and regional routes) to Euro VI diesel standard[51]. In 2021, as part of the replacement of approximately one in five vehicles in the Bus Éireann fleet, this included the introduction of 30 Euro VI diesel buses to serve commercial Expressway routes along the western seaboard[52].

Further developments in relation to the operation of bus services since the publication of the UTRAP Interim Report in 2021 include the launch of two of BusConnects phases in Dublin (Spines C and H, operating out of the Clontarf and Conyngham Road bus depots). This has led to increased bus frequencies along these routes.

The age profile of the PSO buses varies from city to city but has remained relatively constant since 2013 at an average of 6.6 years[53], reflecting a consistent fleet replacement trajectory and a current average PSO bus emissions standard of Euro VI.

Covid-19 transport restrictions and disruption had a significant impact on travel patterns and the operation of commercial bus services, with a disproportionately high drop-off in Greater Dublin Area (GDA) public bus travel between 2019 and 2021. The number of total annual passenger journeys on commercial bus services (including both GDA and non-GDA trips) fell from 30.52 million in 2019 to 9.43 million journeys in 2021, with the number of GDA trips falling from 21.68 million trips to 5.84 million trips over the two-year period, i.e., a reduction of nearly three-quarters in the numbers of journeys made in that time[54]. According to operators, as well as reduced numbers of people travelling due to transport restrictions, 2021 saw greater numbers of single journeys or once-off journeys on buses, the use of tickets sold in 2020, and higher levels of shorter local trips. While trip levels are once again rising, public transport use remains below 2019 levels[55], reflecting an overall reduction in transport journeys across the road network[56] and the continuing impact of remote working on transport demand across the working week[57].

3.1.4. Irish Rail

Irish Rail has also seen continued growth in passenger numbers since 2013, primarily due to the expanding national economy and supported by the extension of intercity and commuter services and the introduction of a ten-minute Dart light rail service in Dublin in 2018. Data published by the NTA[58] indicates that heavy rail intercity passenger journeys grew steadily between 2013 and 2019 (32.1%) before seeing a dramatic decrease in 2020, due to the impact of Covid-19 travel restrictions from March of that year. National rail services shrank by over 65% between 2019 and 2020, with a similar reduction of 64% on Dublin Dart and commuter rail services, and there was a decline of 60% in the use of light rail services (LUAS) in the same time period. Cork commuter services also showed a significant pandemic-related decline in passenger journeys between 2019 and 2020, with trip numbers declining by 45%. Since the end of 2021, passenger numbers have increased, but remain below 2019 levels and both heavy rail and light rail systems have seen a slower return of passenger numbers that public bus services. For example, in the week before Christmas 2021, rail journeys were at 55% of March 2019 pre-Covid levels, and in the week beginning 23 May 2021, were at 78% of the levels seen immediately prior to the introduction of Covid restrictions in March 2020[59].

This period has coincided with the ongoing programme of fleet renewal by Iarnród Éireann/Irish Rail, and 2021 saw the launch of that company's Intercity Railcar Hybrid Drive Trials to test the use of hybrid technology in its intercity rail fleet[60]. In the same year, Iarnród Éireann/Irish Rail also placed an order for up to 750 new electric rail carriages as part of the Dart+ expansion programme, which will replace existing diesel-fuelled services in the Greater Dublin Area in the coming decade. More recently, in November 2022, Government gave approval to Iarnrod Éireann to place an order for an additional 90 new battery-electric train carriages to also be used as part of the Dart+ programme, which – under the National Development Plan – will see the expansion of Dart services across three existing commuter routes to Drogheda, Maynooth and Hazelhatch.

3.2. Vehicle movements in and around Ireland's Cities

As indicated by the registration and public transport configurations described above, transport patterns in Ireland as a whole are not uniform. They reflect not just differences in population densities, but also the proximity of people's homes to public transport systems and the numbers and types of vehicles travelling along different roads at different times. The general pattern that emerges is that a higher number of vehicles on the road lead to higher levels of congestion, longer journey times and higher levels of vehicle emissions.

Therefore, while overall vehicle-related emissions levels on the national roads network reduced between 2018 and 2019 with further Covid-related reductions reported in 2020 (albeit with an uptick in 2021, while remaining below 2019 levels), places with higher-than-average congestion levels remain associated with higher air pollutant concentrations. This effect is offset by the higher percentage of newer and alternatively fuelled vehicles (e.g. electric cars) in urban areas relative to rural vehicle ownership patterns. The complex interaction between these factors is illustrated in a study presented by Transport Infrastructure Ireland, in which average annual NO_x emissions per vehicle per kilometre travelled were approximately 25% lower for light duty vehicles (cars and vans) and approximately 2% higher for Heavy Goods Vehicles or HGVs (lorries) in the Dublin urban area compared to those in a rural part of Tipperary[61].

The residual impact of Covid-19 on transport patterns means that although traffic levels across the road network have increased since the lifting of travel restrictions, they have not yet reached pre-Covid levels. On average, before the pandemic, journey lengths in the GDA were shorter than elsewhere in the country (9.5km per journey in 2019 as opposed to 15.3km in other regions) but the journeys themselves took longer[62], reflecting the growing challenges posed by traffic congestion in the region as a whole[63]. Increased traffic congestion levels have also been recorded and addressed in recent years in other cities, notably in both Cork (particularly on the N40 Southern Ring Road[64]) and Galway[65], contrasting with relatively low congestion levels on the rural road network in both counties[66].

On a daily basis, traffic congestion patterns mirror the movements of large numbers of people during the working week and into the weekend, as they routinely enter cities and towns to work, shop, socialise and carry children to and from school. While patterns altered during the COVID crisis, in recent years, peak periods on the national road network have extended outwards due to pressures of increased demand and congestion. In the morning, the peak period lasts between 6.30am and 9.30am, while in in the evening, the peak covers the period between 3.30pm and 6.30pm[67]. The return of greater numbers of people to workplaces and a reduction in the number of people working from home has meant increased morning peak hour demand across the road network. The proportion of activity in the period between the peak times – from 10am to 3pm – decreased slightly in 2021[68].

Not all people moving through Ireland's cities use cars and other vehicles to get around, however, with significant numbers of people entering and circulating within cities on foot or by bicycle[69]. In urban areas there is a consistently greater modal share for active travel in densely populated areas where travel by foot or bicycle were 2.3% and 0.6% higher respectively than at aggregate level[70]. These shares are likely to have trended upwards during and following on from Covid-19, as outdoor exercise rates and time spent outdoors increased together with wider travel restrictions. In a survey carried out in April to May 2022, for example, three out of ten respondents reported that they had taken up new outdoor activities since the start of Covid, with that number rising to four in ten respondents under 35 years of age. Of these, a higher number of people with families and people living in urban areas took up running and cycling than people living in smaller towns and villages[71].

This trend supports broader national policy directions, as the health, air quality, congestion, carbon emissions and cost benefits associated with cycling means that – along with walking – it has been built into transport decarbonisation and sustainable mobility plans as a key measure to address the effects of climate change and as part of the wider transition away from fossil-fuelled transport[72]. The National Sustainable Mobility Policy[73] also sets out a series of actions aligned with the Road Safety Strategy to prioritise the safety of walking and cycling, as well as to increase the provision of cycling infrastructure in the five cities. The provision of cycling infrastructure has also become an increasingly prominent part of metropolitan transport strategies for Ireland's cities, and of urban innovation projects[74].

Such measures are being implemented to address the fact that in Irish cities, greater numbers of people share space for longer periods at higher densities. This has obvious implications both for the levels of vehicular air pollutants emitted and for the health of those exposed to those pollutants. For example, in 2019, before the onset of the pandemic, the NTA's Canal Cordon count[75] indicated that over two mornings in November, at morning rush hour, an average of 46,388 cars, 4,292 taxis, 1,852 buses and 983 goods vehicles travelled inbound on these major arteries leading into Dublin city centre. During the same rush hour period, 24,691 people walked into the city, while a further 13,131 people cycled in. Footfall in Dublin city centre increased with the relaxing of travel restrictions, with a steady growth in the numbers of people walking into and around the city in 2021[76]. The numbers of cyclists dipped slightly in summer 2021, but showed steady upward growth after that, albeit not reaching pre-Covid levels.

Of these 2019 figures, the number of buses travelling into the city is of particular interest as it represents a significant portion of the overall national and urban bus fleet. Buses overall account for only 3.4% of Ireland's CO_2 transport emissions, but as they are disproportionately highly represented on the streets of Irish cities, they represent a potentially significant source of urban air pollutant emissions. This is reflected in and addressed by the public bus fleet transition commitments in National Development Plan and in the redesign of the existing urban bus networks through BusConnect. Both initiatives chart a clear trajectory towards the planned replacement of diesel-fuelled public buses with zero- and low-emission vehicles through large-scale framework bus purchasing contracts[77].

Overall, the volume of goods vehicles crossing the cordon remained relatively static between 2009 and 2019, when the last Canal Cordon Report was published. Over the longer period from 2006 to 2019 however, the number of goods vehicles crossing the cordon decreased by almost half. Most of that decrease (70%) occurred in the period 2006-2007 and coincided with the opening of the Dublin Port Tunnel in 2006 and the implementation of the HGV Management Strategy in 2007'[78]. This strategy involved banning 5+axle heavy duty trucks from driving within the city centre and was responsible for a welcome improvement in public safety and air quality in the city. The strategy demonstrated the effectiveness and co-benefits that can result from the use of targeted local measures to address interlinked air quality, congestion, and other transport-related issues. The strategy also demonstrates the necessity for considering negative trade-offs in the design of emission reduction measures. Subsequent studies suggested that, after the introduction of the 5+axle ban in Dublin, trucks travelled longer journeys on average, resulting in an overall rise in NO_2 emissions in the wider city area[79].

3.3. The M50 and Dublin Port Tunnel

The M50 motorway is a 40km long C-shaped orbital motorway with 15 junctions that circles the northern, western, and southern suburbs of Dublin, and that connects all of the national primary routes to the capital (Figure 3). It is a key national freight corridor, and it facilitates local, inter-urban and business as well as freight trips. It also performs several functions as a strategic national inter-urban corridor including direct linkage to Dublin Airport and Dublin Port through the Dublin Port Tunnel. In 2021, it was the most heavily trafficked length of road in the national network, and it is one of the key national traffic hotspots, with average numbers of 100,000 or more vehicles using it on a daily basis[80]. For comparison, this is approximately double the number of vehicles that used the heavily trafficked N40 in the Cork area every day in 2021. It should be noted that this recorded level is still less than the average value of 150,000 vehicles recorded in 2019. Total traffic volumes on the M50 and the Port Tunnel during the pandemic were significantly reduced due to the restrictions, however HGV volumes remained at similar levels to those recorded prior to the pandemic[81].

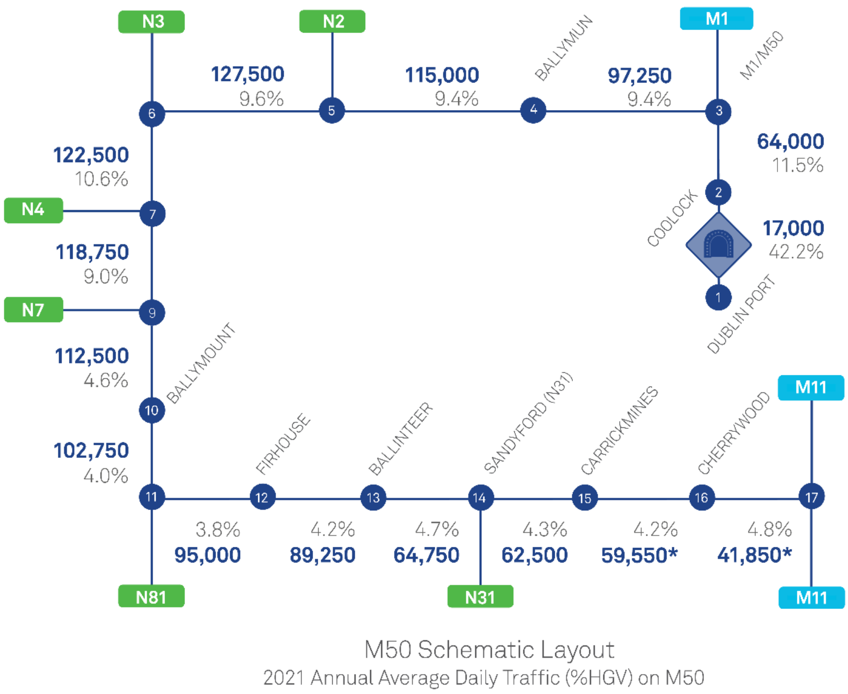
Responsibility for the safe and efficient operation of the M50, and of the wider national road network, lies with Transport Infrastructure Ireland (TII). Through its commitment to ensuring that Ireland's national road and light rail infrastructure is safe, sustainable and resilient[82], and as part of its environmental sustainability activities, TII operates a network of NO_2 and noise pollution monitors along the M50 (see Section 4.1.4). The following information is based on analysis of traffic and emission patterns collated by TII from monitoring data and from traffic count numbers and presented to the UTRAP group as part of its work programme.

3.3.1. Traffic Movements on the M50

Some 44% of trips taken on the M50 involve journeys of less than 20km (equating to approximately one to two junctions) with only 4% of trips involving travel along the entire length of the motorway from end to end (M1 to M11)[83]. The average M50 trip length is c. 12km. On a daily basis, the M50 accommodates an average of between 125,000 vehicles (post-Covid in 2021) and 150,000 vehicles (pre-Covid in 2019) on its busiest segment, which extends between the junctions with the M4 and M7 routes to the west and southwest of the city. The numbers of vehicles travelling on each segment of the motorway between the 15 junctions varies on a daily basis, with the lowest overall average percentage of trips occurring in the southernmost section (Junction 16 to M11). This pattern correlates with higher numbers of journeys taken by trucks on the northern to southwestern portions of the M50 in part due to the use of the Port Tunnel by trucks travelling to and from Dublin Port. In 2021, approximately 17,000 vehicles per day used the tunnel, of which 42% were Heavy Goods Vehicles (HGVs). Commuter journeys make up most of the trips taken on the southern sections of the motorway.

Pre-Covid, the annual traffic growth rate on the M50 averaged 5% per annum since 2013, however the growth rate had reduced in 2019. There were similar growth rates on the radial routes into Dublin. In the case of the Dublin Port Tunnel, traffic growth between 2017 and 2018 was 6%. The performance of the M50 is significantly impacted by the morning and evening commuting patterns on a typical working day, with peaks occurring between 6am to 10am and from 3pm to 6pm. This congestion has a consequential impact on vehicle performance and the levels of vehicle emissions. Analysis of key movements of M50 users (extracted from the National Transport Authority's Eastern Regional Model) shows an orbital pattern with very limited radial connections. This contrasts with the pattern of existing public transport trips and service routes, which predominantly extend radially from the city centre outwards.

Figure 3: Annual Average Daily Traffic (% Heavy Goods Vehicles) on M50 in 2021 (Source: TII)



3.3.2.Dublin Port and Tunnel

Prior to the outbreak of Covid-19, it was originally intended that the UTRAP group would also consider information on other transport infrastructure. The planned work programme was to include a review of preliminary data that was to be generated during the development of a proposed EPA/DoT co-funded study of the apportionment of air pollutant emissions from various sources (e.g., vehicular, maritime, industrial and other) in the vicinity of Dublin Port. Due to Covid-19, this project was postponed but it is now underway, and its results will feed into any future UTRAP Group considerations of possible transport-related impacts on air quality within the study area.

4. Air quality Monitoring, Modelling and Research

This chapter reviews existing national and local air quality monitoring and modelling networks. These networks provide the baseline evidence used to calculate ambient air pollutant levels across the county and at particular locations, and to assess the impact of measures introduced to reduce these levels. The close link between ambient NO_2 emissions and traffic means that tracking NO_2 as well as other traffic-related pollutants such as $PM_{2.5}$ is key to assessing the levels of emissions from the land transport sector and disaggregating these from emissions from other sources and sectors (e.g. home-heating, industry and agriculture). Data from research on identifying the profile of emissions from vehicles as well as on identifying traffic-specific pollutant emissions and levels also form the backdrop against which the effectiveness of existing and proposed mitigating measures can be assessed.

Contributors to the work of the Group in this area included stakeholders responsible for national and traffic emissions monitoring and modelling networks, including the EPA, NTA and TII. The Group reviewed the existing national air pollutant monitoring and modelling framework with a particular emphasis on the monitoring of NO_2 and considered:

- How the national network intersects with transport-specific air pollutant monitoring networks, what overlaps and gaps in information exist, and how these intersect with on-going research projects;
- How identified information gaps can be addressed;
- How to leverage existing networks to strengthen the collection of transport-specific data;
- Areas of potential future action; and
- How to increase stakeholder and public awareness of traffic-related pollution and its impacts so that citizens and stakeholders can take action to reduce those impacts.

Presented here is a summary overview of current land transport-related air quality monitoring and modelling networks and activities as presented to the UTRAP Group. Also contained are the Group's recommendations, which aim to address identified knowledge gaps and to strengthen future traffic-related emissions monitoring, modelling and research activities. The overall aim of these recommendations is to improve the identification and quantification of land-transport-derived emissions, and to strengthen the evidence base for assessing the effectiveness of existing and proposed measures to reduce these emissions.

4.1. Monitoring Networks and Activities

4.1.1. The National Ambient Air Quality Monitoring Network

The EPA is responsible for overall air quality monitoring within the State and manages the National Ambient Air Quality Monitoring Network as well as the roll-out of the National Ambient Air Quality Monitoring Programme (AAMP) 2017 - 2022[84]. The programme was built around three key pillars, namely:

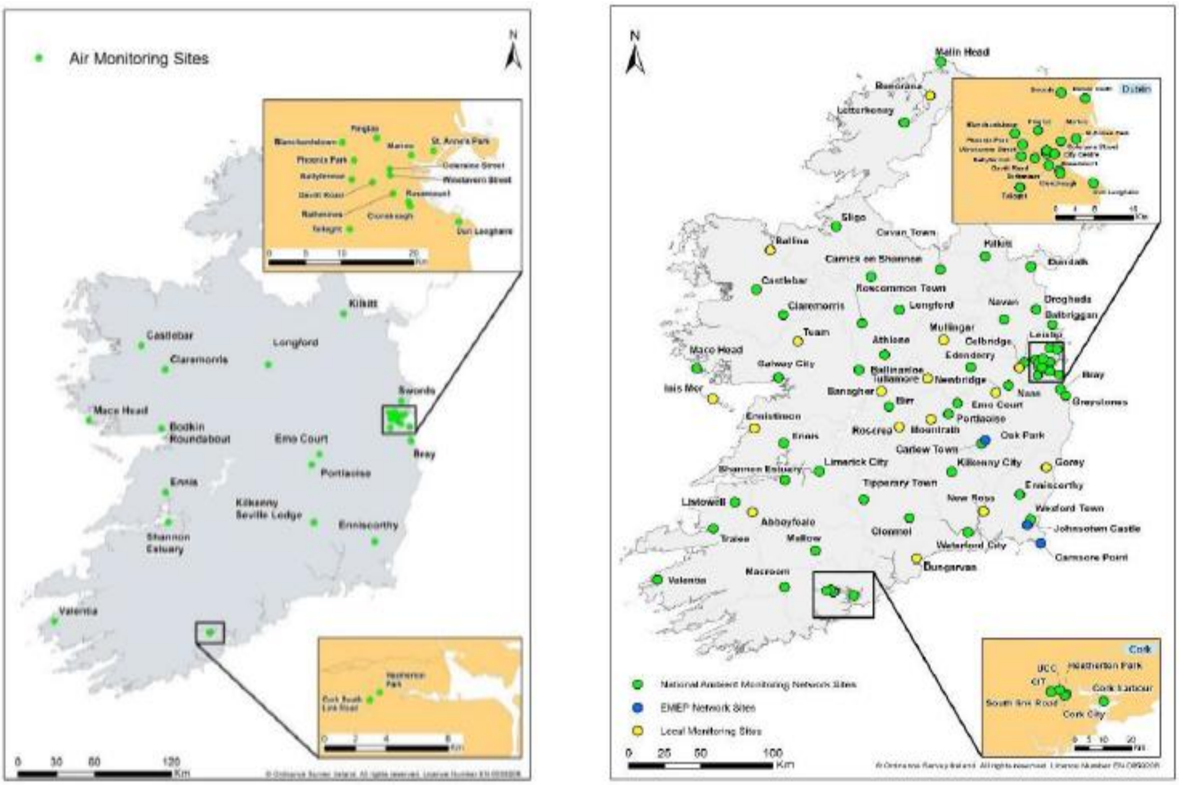
- A greatly expanded national monitoring network, providing enhanced real-time information to the public;
- Modelling and forecasting capability, to provide an ongoing air quality forecast to the public;
- Encouraging greater understanding and involvement of the public in air quality issues utilising citizen engagement and citizen science initiatives.

This network of monitoring stations is currently undergoing a significant upgrade which will expand the number of stations from 29 in 2017 to 116 (in early 2023). As of November 2022, 103 monitoring stations were operational across the country. The information collected at the stations is gathered in accordance with the requirements set out in EU air quality directives, which govern air quality standards in Ireland as outlined in Chapter 2. These directives also outline how ambient air quality is monitored, assessed and managed and they also require member states to designate "Zones" for the purpose of managing air quality.

For Ireland, four zones were defined in the Air Quality Standards Regulations (2011)[85]. Three of these zones cover Ireland's larger cities, with Dublin designated as Zone A, Cork as Zone B, a range of other cities and larger towns collectively designated as Zone C, and the remainder of the State outside of the cities (i.e. 'Rural Ireland') designated as Zone D[86]. The maps below (Figure 4) show the total number of stations in Ireland in 2016, prior to the new AAMP getting underway. Figure 4 also shows what will be the location of all stations once full roll-out of programme has been completed.

Once completed, significant clusters of monitors will be located in both Dublin and Cork, as well as in other Irish cities and towns. The programme also involves the upgrading of the original network of 29 stations to include real-time monitoring of PM under the provisions of the CAFE Directive. Additionally, in urban areas, 26 of the EPA-operated national monitoring stations include NO_2 monitors situated at traffic orientation sites, which collect information on localised NO_2 levels at particular sites within Ireland's cities.

Figure 4: Monitoring Stations pre AAMP and Stations following full roll-out of AAMP



The EPA also gathers additional information on traffic-related urban air pollutant levels in conjunction with local authorities in the largest Irish cities. Under this programme, non-permanent localised networks of NO_2 diffusion tubes were established in urban areas over a set timeframe between 2016 and 2022. Whilst the diffusion tube method is useful for gathering information on localised NO_2 concentrations, the results that they produce are 'indicative' rather than definitive. This means that they only give an estimate of longer-term average NO_2 concentrations rather than definitive information on NO_2 levels at specific times.

Table 4 Local Authority NO_2 Diffusion Tube Location Numbers

Year	Cork	Dublin	Fingal	Galway	Limerick	South Dublin	Waterford
2016	-	12	-	-	-	-	-
2017	-	25	-	-	10	-	-
2018	12	9	-	27	14	-	7
2019	14	13	-	25	14	-	7
2020	-	12	-	14	13	-	-
2021	-	10	-	10	12	10	9
2022	10	10	10	10	12	10	10

Five of the national networks monitoring stations installed across Cork City Council's functional area currently provide live, continuous air quality data, of which three collect information on NO_2 and O_3 levels[87]. Levels at these stations provide an indication of adjacent traffic-related air pollutant emissions levels, and broadly correlate with the volumes of traffic reported in the vicinity of the station.

While the indicative results of the NO_2 diffusion tubes provide a valuable picture of emissions levels in their vicinity over set periods of time, as CAFE Directive-compliant monitoring sites, the EPA fixed site network represents the most accurate data source for pollutant concentrations. Data collected at these sites is also used to identify the occurrence of EU air pollutant level exceedances. In 2019, one exceedance of the EU annual limit value for NO_2 was recorded at St John's Road West in Dublin[88]. All other concentrations observed at the remaining monitors located at national traffic orientation sites that recorded NO_2 data in that period were below the annual average EU limit values of 40µg. It should be noted, however, that not all of these monitors are located in urban areas.

The ongoing expansion of the EPA's NO_2 monitoring programme through the national air quality monitoring network in Ireland's cities, as well as the roll-out of EPA-supported local indicative NO_2 monitoring programmes, was therefore identified by the UTRAP group as being crucial to accurately gauging the extent of transport-related pollution. Results from these programmes together allow patterns of emissions to be established that can be related to data on national and urban vehicle fleet profiles. They also provide the baseline data through which the effectiveness of policy measures implemented to reduce urban transport-related air pollutant emissions can be assessed.

4.1.2. Localised Traffic-Related Air Quality Monitoring Networks and Activities

In addition to the national ambient air quality monitoring network operated by the EPA, other State agencies and some local authorities also engage in transport-focused air quality monitoring activities, which represent an additional source of information on NO_2 levels at particular points on Ireland's road network. In the case of road infrastructure-related monitoring, the backdrop to these activities was the publication in 2011 of the National Road Authority's *Guidelines for the treatment of air quality during the planning and construction of National Road Schemes*[89]. These guidelines were underpinned by a three-year post Environmental Impact Assessment (EIA) air quality study on major national roads. All new national roads are assessed in accordance with the guidelines and the 2011 Air Quality

Standards Regulations. Of the standards set out in the Regulations, those for NO_x, PM_{10} and $PM_{2.5}$ are considered to be most relevant for the assessment of national road schemes.

4.1.3. NTA Air Quality Monitoring

In advance of the roll-out of the BusConnects[90] project, which will improve and expand bus services in all our major cities, the NTA has analysed air quality impacts as part of the preparation of Environmental Impact Assessment Reports (EIAR) for the sixteen radial Core Bus Corridors (CBCs) planned for the Greater Dublin Area. These corridors generally follow the line of the major traffic arteries leading from Dublin's hinterland into the city centre. As part of this assessment, it was proposed that a baseline model for the current air quality conditions along each corridor would be established. To develop this baseline, in November 2019 the NTA's Environmental Impact Assessment Report (EIAR) team set up approximately 120 air NO_2 diffusion tube locations along all 16 CBCs. The timeframe for the operation of these monitors was six months, with monitors to be removed in May 2020. This meant that in some instances, where monitors were in operation post-March 2020, the last two months of monitoring data were considered by the EIA air quality assessment teams to be 'non typical', due to the sharp fall-off in traffic during those months due to Covid-19 traffic restrictions. This data was therefore not included in the baseline data set[91].

Figure 5: BusConnects core corridors

Monitor locations were chosen in consultation with all four Dublin local authorities, with 83 diffusion tube sites being placed within the Dublin City authority area, 8 in Fingal, 23 in South

County Dublin and 10 in Dún Laoghaire-Rathdown. As set out in the air quality assessment methodology developed as part of the overall EIA assessment approach for the radial corridors, the BusConnects air quality assessments were considered in terms of construction phase and operation phase air pollution impacts, considering the EU and national legislative frameworks as well as road construction air quality mitigation guidelines[92]. Indicative data gathered by the diffusion tube monitoring programme was also intended to validate models as well as indicate potential impacts on sensitive adjacent areas and communities.

For those radial corridor proposals submitted to or currently under consideration by An Bord Pleanála (e.g. Clongriffin to City Centre[93]; Belfield to Blackrock[94]; Blanchardstown to City Centre[95]; Ballymun/Finglas to Dublin City Centre[96]), monitored and modelled emissions levels are described in detail in the relevant EIAR air quality chapters. The BusConnects EIA air quality assessment reports therefore represent a useful snapshot of indicative emissions levels at intervals on some of the main Dublin traffic arteries in the immediate pre-Covid period. They also highlight several high-traffic diffusion tube monitoring locations where indicative NO_x values were found to approach (but not exceed) the EU limit values. Additional BusConnects EIAR air quality assessments submitted as part of ongoing and future radial corridor planning applications will therefore increase the availability of locally specific air quality information for particular urban routes as each is published in advance of implementation phases.

4.1.4. TII Air Quality Monitoring (M50 motorway, Dublin)

Since 2014, monitoring of NO_2, PM_{10} and $PM_{2.5}$ has been undertaken on the M50 by TII in accordance with An Bord Pleanála's approval to upgrade the M50, and as part of TII's commitment to ensure that the air quality of communities alongside transport infrastructure is not negatively impacted. TII significantly extended its NO_2 monitoring network in June 2018 in advance of the introduction of Variable Speed Limits and the delivery of M50 Traffic Flow Optimisation (MTFO) Project. The expansion of the network involved the establishment of 34 new monitoring stations at residential and leisure facility locations adjacent to the M50. In July 2019, two further monitoring stations were established. Like the NTA, air quality monitoring by TII involved recording indicative NO_2 concentrations at the monitoring stations using passive diffusion tube samplers. In addition to recording indicative information on NO_2 levels, TII has since 2014 also monitored PM at two locations on the M50 using real-time continuous nephelometers. These monitors were sited at the same locations as the two initial NO_2 monitoring stations: at the eastern quadrant of the N4/M50 interchange, and at the western quadrant of the Sandyford interchange.

TII reported to the UTRAP Group that in 2019, the average NO_2 concentrations measured at these 34 new monitoring stations ranged from 13.6 to 36.4µg/m^3. A comparison of NO_2 concentrations measured at the 34 new monitoring stations between June–December 2018 and June–December 2019 by TII showed a strong correlation between the measured concentrations for both monitoring periods. In 2020 the average NO_2 concentrations measured at the 36 monitoring stations ranged from 8.7 to 28.4µg/m^3 whilst in 2021, the average NO_2 concentrations measured at the 36 monitoring stations ranged from 10.0 to 30.3µg/m^3. Unsurprisingly, reduced traffic flows along the M50 due to pandemic restrictions resulted in concentrations measured which were, on average, lower than pre-Covid measured concentrations.

All annual values measured to date are below the annual average EU NO_2 limit value of 40µg/m^3. TII data, measured as part of this ongoing survey, along with overview of the TII environmental monitoring network can be viewed at Home | TII Monitoring Network

4.1.5. Dublin City Council Air Quality Monitoring

Dublin City Council monitors air quality at a number of locations around Dublin City and has also been involved in air monitoring activities on behalf of other local authorities in the Dublin area. The EPA now engages with the Dublin Local Authorities separately, as described above. The Dublin City monitoring locations have over time been integrated into the EPA national monitoring network, and in some cases, DCC and EPA monitors have been sited at the same location, where complementary monitoring activities are carried out. In the latter half of 2019, in response to increasing public demand for air quality information, a number of additional stand-alone indicative particulate matter monitoring stations were also established by the authority.

4.1.6. Dublin Port Air Quality Monitoring

One of the DCC air quality network monitors is of particular interest with respect of emissions in the vicinity of Dublin Port as it is located on Tolka Quay Road on the north side of the port, close to wider port transport operations. Dublin City Council drew the attention of the UTRAP Group to this air quality monitoring station and noted that the monitor is operated by the Council in collaboration with the Dublin Port Company. The Council also signalled its interest in establishing an analogous monitoring station on the southern side of Dublin Bay to compare air pollutant emissions in both locations.

Currently, while research[97] and PM monitoring at various locations across Dublin suggest the spread of sea-derived emissions such as sea salt across the city, the contribution of shipping to the overall air pollutant emissions profile of the city and wider port area is poorly understood. International research has indicated, however, that air pollutant emissions from shipping can have a significant impact on the air quality of coastal cities. At an international level, this has led to the implementation of international policies by the EU and International Maritime Organisation (IMO) to reduce pollutants associated with shipping fuels, particularly sulphur[98].

At a national level, the Tolka Quay Road monitor was established to capture data relating to overall air pollutant emissions levels in and around Dublin Port, where a significant knowledge gap exists. Given the high volumes of vehicular and maritime traffic in and around the port (which in 2019 catered for 9.4m gross tonnes of exports, nearly 2 million passengers and 158 cruise ships[99]), it is possible that port-related emissions are contributing to the elevated levels of NO_2 that have been recorded in the wider Amiens Street area.

Although the Tolka Road air quality station feeds data on NO_2 and sulphur dioxide (SO_2) into EPA bulletins[100], it was noted in the course of the UTRAP meeting that the ambient air quality monitors in the national and local networks do not distinguish between specific sources of air pollutant emissions (e.g. what percentage of identified emissions have been emitted by freight vehicles as opposed to berthed ships or other port-side transport infrastructure). There is a similar lack of information about the emissions profiles of Ireland's other ports, most of which lie in proximity to urban centres and towns. Prior to the Covid-19 crisis, a proposal had been made for an EPA/Department of Transport co-funded air pollutant emissions source-apportionment study to be carried out at Dublin Port. As proposed, the aim of the study was to establish the profile and also the sources of transport-related air pollutant emissions in the port area. With the onset of Covid-19 restrictions, the commissioning of this study was postponed.

Given the valuable information that such a study could provide on a potentially significant but poorly understood source of transport-related emissions at Dublin Port in particular and at other Irish ports, the UTRAP group recommended that this study be commissioned and carried out. Since the publication of the UTRAP Interim report, the study has commenced and is currently being undertaken by a collaborative research team from University College Cork and National University of Ireland Galway[101]. Air quality monitoring instrumentation was put in place in late 2021 and work on the project is ongoing.

4.1.7. PurpleAir PM Monitoring, Cork City Council

The UTRAP work programme also included a brief overview of the pilot PM air quality research study carried out in Cork city by Cork City Council and the Centre for Research into

Atmospheric Chemistry (CRAC) research group at University College Cork (UCC). The project involved the deployment of a number of air quality sensors from the PurpleAir Company, which use laser particle counters to provide real time measurement of $PM_{1.0}$, $PM_{2.5}$ and PM_{10}. Data from the air quality sensors is hosted by PurpleAir and provides live indicative air quality data to the public that can be accessed from the PurpleAir website[102]. While this study provided information on PM levels adjacent to the monitors, it did not allow the different emissions sources to be identified.

The data from these low-cost sensors must be interpreted with caution. The European Environment Agency in its report on using citizen science for assessing air quality[103] had noted that the results from these types of monitors obtained are only robust when humidity is in the range of 20-50% and particulate matter (PM_{10}) mass concentrations are below 20μg/m^3.They further noted that when humidity is very high, for example when it is foggy, the sensors can deliver incorrect values. The average humidity in Ireland is much higher than most other countries (typically 75-85%) and thus the PurpleAir maps can therefore give only a general indication of the geographical patterns of air quality in the city.

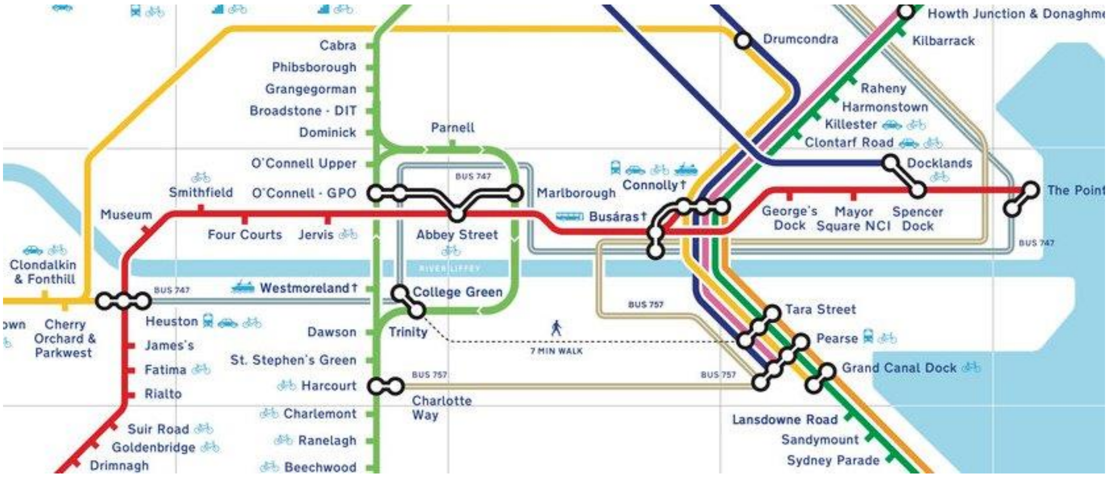
4.1.8. Air Quality Monitoring Activities at Dublin Terminal Railway Stations

Several locations in Dublin were identified in the 2019 EPA Urban Indicators Report as NO_2 air pollution hotspots, with emissions levels approaching or potentially exceeding EU limit values. One of the observations to emerge from the UTRAP Work Programme was the fact that three of the highest NO_2 concentration clusters identified in Dublin were broadly centred in the wider area of Dublin's three major urban terminal railway stations[104] which are highlighted in Figure 6.

All three stations (Connolly Station, Heuston Station and Pearse Station) are among the most frequented heavy rail stations in the country and were the three busiest rail stations in Ireland in terms of passenger boarding and alighting numbers in 2017, 2018[105] and in 2019[106]. In 2019, before the significant drop-off in numbers due to Covid-19, rail passenger numbers across the entire network had increased to peak levels as part of a trend that saw 6% per annum growth in the number of rail passengers every year since 2014[107].

Outside of Dublin, Cork's Kent/Ceannt Station is the only station in the top ten busiest stations, serving approximately 8,000 passengers a day.

Figure 6: Map of Urban Terminal Railway Stations



All three Dublin stations are also significant transport hubs, where heavy rail, public service vehicles such as taxis and buses, and passenger car networks intersect. As noted in UTRAP Meeting 4, studies in other European cities[108] have shown similarly high concentrations in the vicinity of rail stations.

In Ireland, the direct contribution of heavy rail train emissions to ambient air pollutant levels is generally poorly understood. The potential role of operational practices relating to the movement of trains within, and around urban terminal rail stations is also poorly understood. Additionally, although significant work and progress have been made over the last two decades by CIÉ and Iarnród Éireann to reduce emissions through fuel efficiency, maintenance and fleet replacement practices, the impact of these interventions has not been quantified in terms their impact on ambient air quality[109]. This lack of information represents a significant gap in understanding of the extent to which trains contribute to the build-up of transport-related air pollutants in Ireland's towns and cities. While the planned further electrification of rail services in the GDA through the extensive Dart+ expansion programme will benefit air quality in all three Dublin terminal rails stations, getting a better picture of potential heavy rail emissions at these locations remains an important consideration, particularly in light of planned residential and sustainable mobility developments in their wider areas[110].

To date, as described to the UTRAP Group, air quality programmes implemented by Iarnród Éireann/Irish Rail within Dublin's major terminal rail stations have been undertaken from an occupational health viewpoint. Their primary aim has been to assess and mitigate the potential exposure of station employees and rail passengers to air pollutant emissions within station buildings. For that reason, the results of the studies carried out to date within the stations are not directly comparable with national and local ambient air pollutant emission monitoring activities carried out by the EPA. The studies do, however, provide a general indication of the potential contribution of heavy rail to ambient NO_2 and PM levels in and around the terminal stations. The studies were also undertaken to address public concerns arising from visible air emissions build-up in the stations at peak times associated with the running of trains.

Three investigations were carried out at Connolly Station and two at Heuston Station between August 2018 and December 2019. The results of four of the five studies indicated that Occupational Exposure Limit Values for NO_2 and PM within both the stations were below the legally permitted thresholds. However, the NO_2 and PM study carried out at Connolly Station between August and October 2018 indicated that mean value exceedances for NO_2 were recorded within the station building on two of the platform walkways and at the entrance to the station concourse. On Amiens Street, the test showed mean average values below the annual limit value.

Based on the results of the Connolly Station study, as well as the identification of the knowledge gaps referenced above, the UTRAP Group proposed that collaboration and information sharing between rail and air quality stakeholders would be of benefit in identifying and quantifying the contribution of heavy rail to overall transport-related air pollutant emissions levels. While the focus of activities to date has been on the larger Dublin terminal stations, information derived from these stations may also have relevance for the operation of other urban terminal stations, such as those in Cork, Galway and Limerick.

4.2. Modelling Ambient Air Quality

While not currently a requirement under the CAFE Directive, modelling of ambient air quality allows the provision of information for locations between monitoring stations and supports the identification of the sources of poor-quality air. As part of the modelling pillar of the AAMP, the EPA in conjunction with Cambridge Environmental Research Consultants Ltd (CERC) carried out a modelled urban air quality assessment of Dublin City for 2015 and 2017. This assessment included the modelling of NO_2, PM_{10} and $PM_{2.5}$ concentrations. The outputs of this model in relation to NO_2 were published in the Urban Environmental Indicators report for Dublin.

4.2.1.EPA Modelling: Future Potential Outputs of the ADMS-Urban Model

As part of the UTRAP work programme, the EPA outlined the potential future information that the ADMS-Urban model was capable of capturing, and described potential future model runs. It was noted that a model could be run for the entire city for one year, with support from model application providers to ensure that the model set up is consistent. Also discussed was the potential modelling of specific streets, which could be completed within a relatively tight timeframe by the EPA, subject to the availability of resources and accurate input data. Discussion at the meeting also centred on the possibility of the EPA carrying out source apportionment studies for NO_2 using other models, such as the SHERPA emissions source app developed by the EU Joint Research Centre (JRC) and the EU Commission. Such studies could be completed internally by EPA, with the proviso that accurate traffic configuration information would be required in order to reflect the scenario being assessed. The EPA further reported that additional modelling assessments using newly developed air quality modelling tools and verification methodologies could also be used in conjunction with the existing local information where applicable.

In 2021 the EPA completed the first ambient air quality scenario modelling for Dublin in support of the Dublin Air Quality Plan[111] prepared by the four Dublin local authorities and submitted to the European Commission in December 2021.

4.2.2.Modelling of other Irish Cities

In its discussions, the UTRAP group also noted that the majority of projects relating to urban transport-related emissions monitoring and modelling focus on Dublin city and the Greater Dublin Area. A further strong recommendation to emerge from the group was that modelling for air pollutants be extended to other urban areas, outside of Dublin. This was proposed by the EPA as being of particular importance, given the increasing levels of traffic congestion recorded in a number of cities in Ireland. The EPA also noted the potential role that extended modelling activities could play in informing policy direction in this area, and in assessing the potential impact of any proposed policy changes regarding transport demand measures. In 2022 the EPA will receive the outputs from a nationwide model run by CERC, however the EPA does not have the capacity on an ongoing basis to perform modelling across the five cities in Ireland.

4.2.3. EU LIFE Emerald Project

In addition to examining the potential expansion of modelling to Irish cities other than Dublin, the UTRAP Group also discussed the EPA's work on the EU LIFE Emerald (Emissions ModElling and FoRecasting of Air in IreLanD) project which commenced in January 2021.

Among the proposed outcomes of the LIFE Emerald project proposal were a number of key products that will support the ongoing work in relation to reduce urban transport emissions, such as:

- A customised air quality dashboard;
- An operational 3-day ambient air quality forecasting system;
- Near real time (NRT) air quality maps to provide finer granularity in the information being disseminated to the public;
- Annual average high-resolution air pollutant maps providing detailed air pollution assessment, reliable health impacts, and meeting current/future (e-)reporting needs.

From a national policy perspective, the Group noted the potential value of annual average air pollution maps, which could be used to provide baseline snapshots of emissions at particular points in time. As other European countries have implemented similar models, the existence of a similar Irish mapping capacity could facilitate more direct comparisons of the impacts of air pollutant measures introduced in other jurisdictions.

4.2.4. Communication of Information on Transport-Related Air Pollution to the Public

A further broad theme that emerged from the work of the UTRAP Group on modelling and monitoring was the critical importance of raising public awareness of the nature and sources of air pollutant emissions. This importance related not solely to the significant negative health impacts of transport-related air pollution, but also to encouraging the inhabitants of Irish cities to move away from the use of private cars and towards more sustainable transport, such as walking and public transport. In this respect, communicating the impacts of transport-related air pollution dovetails with national sustainable mobility objectives[112], as well as illustrating the wider value of extensive and on-going investment and implementation of active travel and public transport infrastructure. It was noted that many of the monitoring projects presented to the Group had public information components, with the EPA[113], TII[114], Dublin City Council[115] and Cork City Council[116] all operating online air quality resources, such as maps or dashboards that are accessible to members of the public.

Through its Citizen Science programmes, the EPA also noted its status as a participant in a joint European Environment Agency (EEA) 'Cleanair@schools' project[117]. This project resulted in the installation of NO_2 diffusion tubes at the gates of 54 schools across the State in autumn 2019. The aim of the project was to encourage children and their parents to build an awareness of air pollutant emissions from cars and other vehicles, and to track changes in emissions levels, particularly at drop-off and collection times.

Local authorities and An Taisce have 'Active Schools' initiatives in operation which are proven to be a readymade framework for promoting a wide range of environmental initiatives including air quality.

Local authorities and An Taisce in particular noted the existence of keen interest in air quality-related issues among sectors of the Irish public, and the increasing presence of informal air quality monitoring activities by individual citizens. The role of such initiatives in supporting wider policy measures aimed at improving air quality and at promoting behavioural shift was discussed. From these discussions, the Group recommends examining how best to support the communication of accurate and effective information on transport-related air pollutant emissions to the wider public.

4.3. Transport-Related Air Pollutant Research Projects

The UTRAP work programme also included a brief overview of ongoing and recently completed traffic-related air quality projects. These projects were carried out under the auspices of a range of Irish research institutions and were funded by a range of sponsors, including the EPA and the Department of Transport. Eleven Ireland-specific research projects were referenced, of which four (Nos 1-4 in Table 5) examined the impacts of transport-related pollutant emissions operating at a broad social scale. Of the remaining research projects, three are concerned with mitigating air pollutant emissions associated with fuel use with a particular emphasis on the Heavy-Duty Vehicle (HDV) sector (Nos 5-7 in Table 5). The remaining projects (Nos 8-11 in Table 5) focus on measuring real-life emissions from a range of vehicles, including contributions from non-road vehicles.

As the work of the Group progressed, knowledge gaps emerged and in the recommendations of the Interim Report, two priority research areas were identified. These related to air quality in the Dublin Port area, and to air quality in the vicinity of urban railway stations, which are also major transport hubs. Research projects to examine both of these topics have begun and will provide valuable evidence of the degree to which transport-related activities at such sites contribute to urban air pollutant emissions in their wider environment.

Also referenced as part of the UTRAP Group review of research was the Department of Transport Five Cities Demand Management Study, the final report of which was published in November 2021. The significance of the report findings is briefly discussed in Chapter 6. The results of all of the research projects listed in Table 5 below will add to the evidence base upon which the Department of Transport and associated agencies will develop emissions reductions policy and measures. It should be noted that the below list is not exhaustive and that other research has been done in this area[118]; the below projects represent targeted and Irish-specific projects that focus on transport-related emissions and they are included in this report on that basis.

Table 5: Summary of recent and on-going Irish transport-emissions-focussed research[1] projects

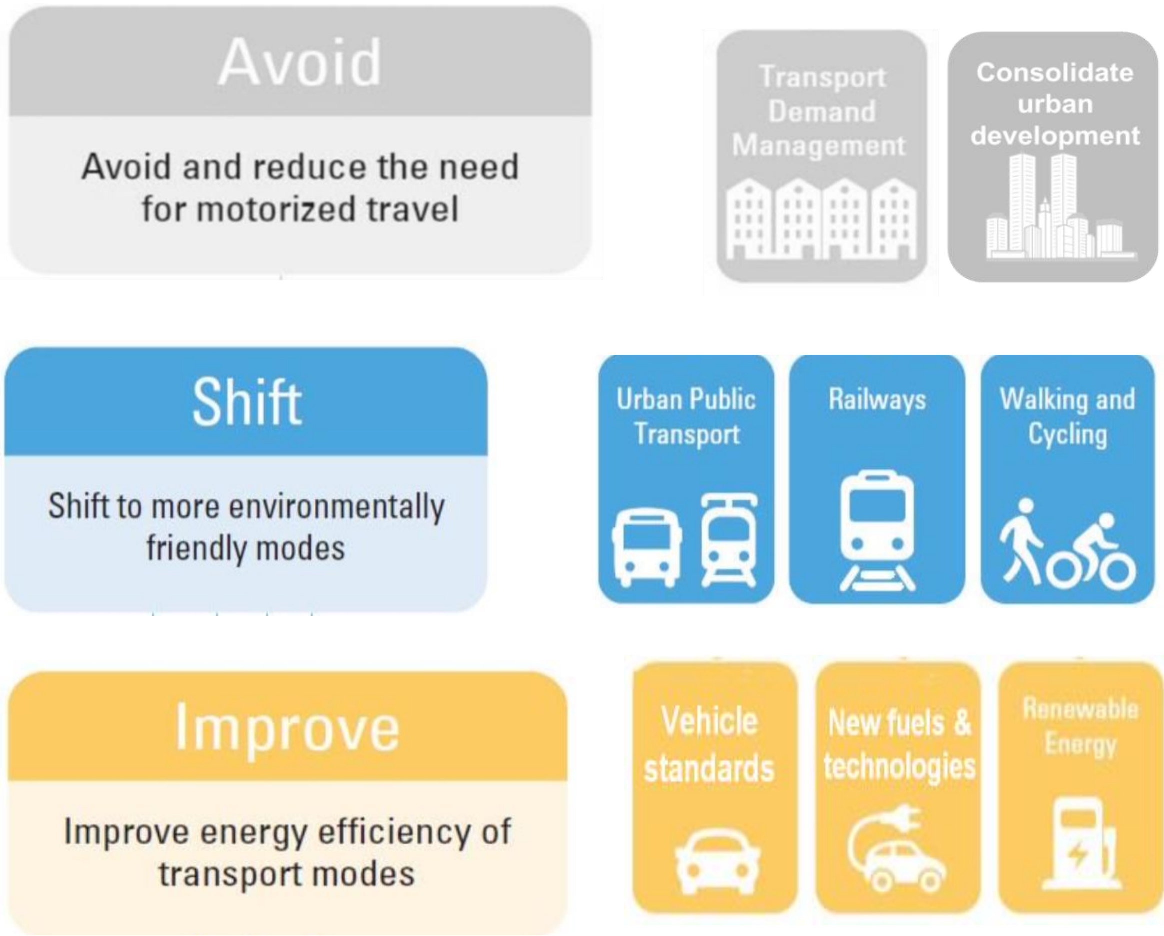
No.	Project name/ Acronym	Description/Full name of project	Project Leader/ Lead Author	Institution/ Funding authority	Status
1	Greening Transport Project	Greening transport	Brian Caulfield et al.	TCD/EPA	Completed
2	Impact of NO_2 on Health Project	Impact of NO_2 on health with particular emphasis on vulnerable groups	Margaret O'Mahony et al.	TCD/EPA	Completed
3	CON+AIR Project	Addressing **Con**flicts of Climate and **Air** Pollution	Eoin Ó Broin et al.	EPA	Completed.
4	DISTRACT Project	Mo**D**al **S**hif**T** **R**educe **C**arbon in **T**ransport	Sheila Convery et al.	TCD/SEAI/DoT	Completed
5	Mitigation of Irish HDV CO2 and/or air pollutant emissions	Desktop study to assess potential mitigation measures that would reduce CO_2 and/or air pollutant emissions from the existing Irish HDV fleet	Brian Ó Gallchóir	UCC/SEAI/DoT	Completed
6	MAP-HDV Project	**M**itigation of **Air Pollution** impacts of Irish **HDV**s	Bidisha Ghosh et al.	TCD/SEAI/DoT	Completed
7	Eco-HDV Project	Evaluating the impacts of adaptation of **eco**-driving training programmes in the Irish Heavy Duty Vehicles (**HDV)** fleet, including the freight sector	Brian Caulfield (Bidisha Ghosh)	TCD/EPA/DoT	Completed.
8	Particulate Matter from Diesel Vehicles Study	Particulate matter from diesel vehicles: emissions & exposure	Meabh Gallagher et al.	TCD/EPA	Completed
9	REDMAP	**R**oadside **E**missions in **D**ublin - **M**easurements **A**nd **P**rojections	Bidisha Ghosh et al.	TCD/EPA/DoT	Ongoing, first workshop was in April; 2022
10	EFFORT Project	**E**missions **F**rom **F**uel consumption associated with **O**ff **R**oad vehicles and o**t**her machinery	Eoin McGillicuddy	TU Dublin/EPA	Completed
11	Low Emission Bus Trial	Low Emission Bus Trial to inform future urban bus procurements	Byrne Ó Cléirigh for DTransport	DoT	Phase 1 and Phase 2 reports completed
12	Source Apportionment of Air Pollution in Dublin Port Area (PortAIR)	Study to ascertain the sources of air pollution in the Dublin Port area	John Wenger et al.	EPA	Work began in Q3 2021
13	StationAir	To examine the effects transport hubs in proximity to train stations in urban areas have on NOx emissions.	John Gallagher et al.	DoT/EPA	Work began in June 2022

[1] It is noted that this is not a comprehensive list of all transport related air pollution research projects

5. Reducing Emissions

In recent years, several measures have been implemented in Ireland and across Europe to reduce emissions from transport. While not all of these measures have been specific to air quality, they have had the added benefit of reducing transport-related air pollution. There are several ways to reduce emissions from transport and they can be broadly summarised by the "Avoid, Shift, Improve" model.

Figure 7: Overview of transport transition model



The work of the Group aimed to evaluate what has been done to date, identify gaps that exist and identify opportunities to reduce transport-related emissions. Areas considered included:

- European vehicle standards;
- Relevant vehicle taxation measures;
- The transition of the PSO public transport fleet;
- Critical infrastructure;
- The possible role of traffic demand management in reducing air pollution from transport.

Key transport actors engaged in work in this area that were invited to contribute to UTRAP Group discussions of these topics included the Road Safety Division of the Department of Transport; the Road Safety Authority (RSA); Córas Iompair Éireann (CIÉ), and Systra, which carried out the Five Cities Traffic Demand Management report on behalf of the Department of Transport.

5.1. Vehicle Standards

5.1.1. Euro Vehicle Emissions Standards

Emissions testing for vehicles form an important part of roadworthiness testing which aims primarily to enhance road safety. In 1992, the first European Union-wide emissions standards for light duty vehicles such as passenger cars – known as Euro 1 – were introduced. Since the introduction of Euro 1, the EU has continued to strengthen emissions standards for new vehicles to improve air quality. While the emissions standards apply to all internal combustion engine vehicles, different pollutant levels apply depending on whether the vehicle is petrol or diesel-powered. This is an important point to note when considering the composition of the Irish fleet, as approximately two-thirds of the vehicles on the Irish roads currently run on diesel[119]. Each successive version of European vehicle standards has set lower emissions limits, with Euro 5 and Euro 6 standards setting limits for emissions of atmospheric pollutants such as particulates and nitrogen oxides. The EU has also implemented an equivalent system of emissions standards for large commercial vehicles known as the EURO I to EURO VI series.

Euro 5 emissions limits came into effect for new vehicle types from September 2009 (and new vehicles from 1 January 2011), while Euro 6 emissions limits came into effect for new vehicle types from September 2014 (and new vehicles from September 2015). The main effect of Euro 5 was to reduce the emission of particulate matter from diesel cars from 25mg/km to 5mg/km, and accordingly the introduction of particle filters for diesel cars became widespread. Euro 6 limits mainly reduce the emissions of nitrogen oxide from diesel cars further, from 180mg/km to 80mg/km. Cumulatively, the implementation of Euro vehicle standards has resulted in significant reduction of the quantities of air pollutants that vehicles can emit, with Euro 6 standards reducing some air pollutant emissions by 96% relative to the Euro 1 standards established in 1992.

In the case of heavy-duty vehicles (HDVs), such as buses or trucks, the introduction of EURO VI standards – which have been in place since 31 December 2013 - represent a reduction of 77% for NOx limits and 50% for PM emissions compared to the previous 2008 limits (i.e. Euro V). The EURO VI standards for HDVs also set requirements for vehicles to be fitted with exhaust after-treatment systems that use consumable reagents to reduce air pollutant emissions. These systems allow for more stringent HDV standards than could be achieved through increased engine efficiency standards alone. The systems often involve injecting small quantities of ammonia-based or other Diesel Exhaust Fluid (DEF) into exhaust streams to reduce NOx emissions as part of selective catalytic reduction (SCR) processes[120].

In line with an increasing European policy focus on decarbonising road transport under the European Green Deal[121], the European Commission (EC) is also to propose more stringent air pollutant emissions standards for internal combustion-engine vehicles (ICEs) with a view to improving air quality, environment, and health outcomes [122]. These proposed new standards will be known as Euro 7 and EURO VII for light-duty vehicles (LDVs) and heavy-duty vehicles (HDVs) respectively. The European Commission completed a public consultation on the development of the new standards in 2020[123], and recently published a draft proposal[124]. In order to introduce up-to-date air pollutant emissions limits for vehicles, the EURO 7/VII proposals will aim to expand the scope of the current regulation to include pollutant emissions over the lifecycle of the vehicle and from non-tailpipe emissions. This will have the benefit of targeting the second-hand vehicle market and also bring EVs within the scope of the regulation.

Regulation (EC) No 715/2007 also sets the requirements for unrestricted access to vehicle repair information and in particular to information relating to on-board diagnostic (OBD) systems and their interaction with other vehicle systems. OBD systems play an important role in the control of vehicle emissions.

5.1.2. Ensuring Emission Standards

In September 2015, the United States Environmental Protection Agency (US EPA) formally reported that Volkswagen (VW) had violated US emissions standards. They reported that VW had installed illegal “defeat devices” in hundreds of thousands of engines in the United States since 2009. In Turbocharged Direct Injection (TDI) diesel vehicles, software was installed to allow emissions control to activate during laboratory testing. This had the effect of lowering the nitrogen oxide (NO_x) output to meet the required standards during type approval testing. Real driving emissions (RDE) were found to be up to 40 times the amount measured in the laboratory. The vehicles had engine control units that could switch from good fuel economy with high NO_x emissions to low-emission compliant mode when the vehicles system detected an emission test was being undertaken. This software was reported to be deployed in approximately eleven million diesel vehicles worldwide between 2009 and 2015. This is commonly referred to as the 'Dieselgate scandal'.

This has resulted in several improvements to the EU test process:

- The New European Driving Cycle was replaced by the Worldwide Harmonised Light Vehicle Test Procedure (WLTP), a more rigorous test for measuring pollutant levels, in September 2017;
- For light-duty vehicles, portable emission measurement systems (PEMS) equipment has now become an element of on-road testing under the Real-Driving Emissions (RDE) procedure; and
- Conformity factors, which provided a range within which emissions were considered acceptable, were introduced.

5.1.3. Diesel Particulate Filters (DPFs)

A DPF is a filter placed within the exhaust system of a diesel vehicle to remove particulate matter or remove soot from exhaust gases in the case of diesel vehicles. DPFs can become blocked by trapped soot and need to be emptied regularly to prevent blockage. Long journeys and correct fuel usage help to prevent DPF blockages. However, now that there are more people using diesel vehicles for short, urban journeys there is a worry that DPF issues are becoming more common. As a result, there is a worry that DPF removal, which is illegal[125], is becoming more commonplace. There is no evidence of widespread DPF removal and all of the discussion to date has been anecdotal.

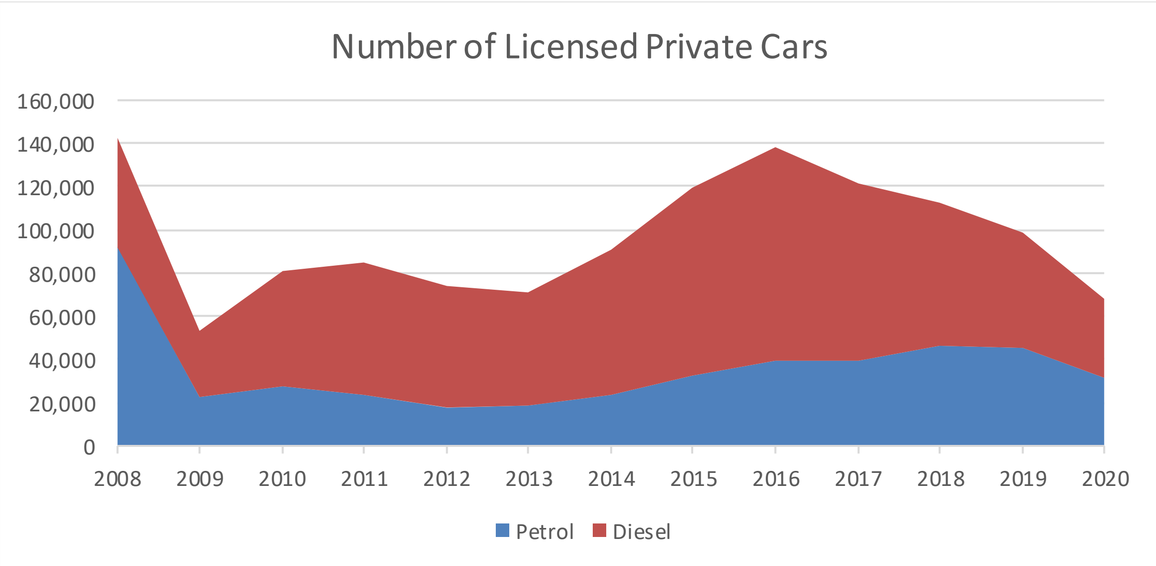
The Department of Transport has had initial conversations with the Road Safety Authority (RSA) on how the checking of DPF removal can be tested on a continuous, nationwide basis. While no firm actions have been agreed, discussions will continue between the Department and the RSA to address Recommendation 13 of the Interim Report.

5.2. The Tax System in Ireland as a tool for addressing Vehicle Emissions

The tax system, particularly taxes on fuels, can play a complementary role to regulation and wider public policies that support clean transport in addressing negative environmental impacts from road transport. Taxes on road vehicles can also support these wider environmental and public health objectives.

Ireland's VRT regime for cars is an emissions-based tax which is levied as a percentage of the open market selling price (OMSP) of a vehicle entering the State for the first time. The higher the CO_2 emissions of the vehicle, the higher the charge will be. Vehicle taxes which are solely CO_2-based have been criticised for their failure to recognise the specific contribution of other emissions such as NO_x and PM to air pollution and their impacts on public health and the environment. The introduction of CO_2-based VRT and motor tax regimes in 2008 initiated the dieselisation of the Irish car fleet. This is illustrated in the Figure 8 below[126].

Figure 8 Number of Licensed Private Cars 2008 - 2020



The increase in the share of diesel cars registrations between 2008 and 2011 was highly significant, and in more recent years the high volume of diesel car registrations has been sustained due to a sharp increase in used car imports to 2019, about 70 to 75% of which were diesel. However, imports have significantly decreased in 2020 and 2021[127].

5.2.1. Fiscal Measures Implemented to address Vehicle Emissions

In recognition of the environmental health costs caused by pollutants emitted in particularly high quantities by diesel vehicles, Budget 2019 saw an introduction of a 1% surcharge on all diesel vehicles. Due to the car value component of the VRT charging formula, this surcharge resulted in newer diesel cars paying more than cheaper imports even though the older imports were likely to emit higher levels of pollutants.

Budget 2020 replaced the 1% surcharge with a surcharge tied to NO_x emissions levels based on the "polluter pays" principle, where the greater the level of NO_x a car emits, the higher the surcharge. Budget 2021 adjusted the structure of the NOx surcharge, with the effect of adding €200 to high emission vehicles. The surcharge structure is set out on the Revenue website[128].

5.2.2. Impacts of Fiscal Measures Taken

The surcharge is structured to levy a modest charge on the newest vehicles complying with the latest vehicle standards. Most new petrol and well-performing diesel cars will have typical NOx emissions below 40mg/km and therefore are subject to a NOx charge of less than €200. Levels of NO_x emissions tend to be much higher among older cars, particularly diesel, which were not subject to more stringent Euro standard thresholds. As such, for an older diesel with 85mg/km NO_x, the surcharge added to the regular VRT will be €925. In general, the impact will be less severe on petrol-fuelled cars, as petrol engines are typically associated with lower NO_x emissions.

The introduction of the NO_x surcharge is designed to correct an imbalance in VRT where the focus was purely on CO_2 emissions. The environmental and public health impacts of other pollutants such as NO_x are now recognised in the tax code and duly charged. It is envisaged this will have a positive impact on incentivising cars which are less harmful to our environment and in reversing recent trends in the proliferation of used diesels imported from the UK.

Preliminary data from Revenue and SIMI suggests that the introduction of the NO_x VRT component is promoting a move towards cleaner, newer cars. The number of used diesel cars registered in Ireland rose in the first half of 2021 compared to the same period in 2020 (from 17,888 in 2020 to 23,303 in June 2021), consistent with the overall increase in vehicle purchases in that year as sales recovered from the impacts of Covid-19. The number of imported used cars remains below 2019 levels, with electric cars representing almost one-third (32%) of new car registrations to June 2021, compared to 18.7% in the first half of 2020[129].

It must be noted, however, that the impacts on the motor industry of Covid19, wider supply chain issues, and Brexit, make it difficult to gauge the impact of the NO_x charge in isolation. Since 2019 the overall share of diesel cars in the Irish market has been decreasing: from 58.53% in 2019, to 52.35% in 2020, to 39.76% for 2021. Used imports have also been decreasing year-on-year, down 57.1% in the first quarter of 2022 compared with the same period in 2019, before the NO_x surcharge commenced. Used diesels aged 6 to 9 years are down 72.7%. This suggests the NO_x charge can act as a successful deterrent to high NO_x

emission vehicles, but due to the factors mentioned above, more data and time will be required to fully gauge the impact.

5.3. Transition of the Public Transport Fleet

5.3.1. Background to Public Fleet Transition

The National Transport Authority (NTA) is responsible for the procurement of all Public Service Obligation (PSO) bus services and the rail fleet. In 2019, in line with the commitment in the *Project Ireland 2040: National Development Plan* and Action 85 of the Climate Action Plan 2019[130], the NTA has commenced the transition of the urban PSO bus fleet from diesel only vehicles to lower emission vehicles. This commitment was set out as Priority 3 of the NTA Statement of Strategy 2018-2022, which was to "acquire 300 low emission buses for the operation of subsidised bus service". Under the first phase of this transition, about 90 diesel-hybrid buses are now in operation on urban PSO bus routes. Under the NDP, by 2025 it is expected that over 50% of the urban PSO bus fleet will be converted from diesel to low and zero emission vehicles, with 30% of the bus fleet being zero emission. Additionally, the European Clean Vehicles Directive (EU) 2019/1161, which aims to promote clean and energy-efficient road transport. Ireland is committed to binding minimum targets for the procurement of clean and zero-emission vehicles procured by State bodies. The targets for buses are set out at Table 6 below.

Table 6: Targets for buses

	From 2 August 2021 – 31 December 2025	From 1 January 2026 to 31 December 2030
Clean Vehicles	45% of bus fleet procured during this period	65% of bus fleet procured during this period
Zero Emission Vehicles	One quarter of the 45% of Clean Vehicles	One half of the 65% of Clean Vehicles

5.3.1.1 Proposed Technology Pathway

Unlike for the passenger car sector, where electrification is expected to play a key decarbonising and emissions-reducing role, low- and zero-emissions heavy duty vehicle (HDV) technologies (including for buses) are at varying stages of development and commercial availability. For that reason, to ensure a clear and consistent pathway to the deployment of low- and zero-emission vehicle technologies over the next three years, the NTA will:

- Ensure that the diesel-electric hybrid buses purchased from 2020 onwards comply with the definition of Clean Vehicles;

- Undertake pilot studies zero emission buses, both electric and hydrogen, to assess technology readiness level[131];
- Assess infrastructure requirements for charging/refuelling at depot locations and determine lead-in times for bringing zero emission vehicles into full service;
- Procure single-deck electric buses for town services and commence deployment in 2021, with planned entry into service of electric bus fleet in Athlone by end 2022;
- Continue to monitor developments in new technologies and develop pilots and trials as appropriate to determine technology readiness levels;
- Following the above trials and pilots, determine the fleet investment programme for zero emission double-deck buses, providing sufficient time to meet minimum target requirements by 2025;
- Procure zero emission double-deck bus fleet starting in 2023;
- Deliver fuelling/charging infrastructure at depots.

5.3.1.2. Current Status of the Transition of the Public Bus Fleet

Since the publication of the UTRAP Interim Report in 2021, progress towards the transition of the public bus fleet to low- and zero-emission technologies has continued and includes:

- The placement of orders for 280 Hybrid Electric Buses, with 89 buses in service in Galway and Dublin;
- A framework agreement for the delivery of up to 200 single-deck electric buses has been put in place, with an initial order of 45 buses commencing delivery in 2022 to operate in Athlone and in Dublin[132];
- An order for 120 double-deck battery-operated electric buses was placed in June 2022, as part of a framework agreement that provides for the procurement of up to 800 such buses by 2025[133]. Of the 120 buses on order, 100 are destined for the Dublin PSO fleet, with the remaining 20 buses to be used by Bus Éireann in Limerick.

Three hydrogen fuel cell double-deck buses were procured for the purposes of a hydrogen pilot and entered into service in 2021[134], following an initial deployment trial carried out on Dublin and Cork suburban bus routes between November 2020 and August 2021[135]. The buses are currently being deployed on Bus Éireann passenger service routes in the GDA.

5.3.2. Transition of the Public Rail Fleet

The DART Expansion Programme is a key element of the transport strategy for the GDA. The initial elements of the programme comprise the provision of high-frequency electrified rail services on the Dublin commuter routes extending to Drogheda to the north, Maynooth and Celbridge to the west, and Greystones to the south.

Initial plans laid out in *Project Ireland 2040: National Development Plan* included the purchase of Diesel Electric Multiple Units (DEMU) to facilitate increased frequency of rail services in advance of electrification of the existing lines. Following an extensive fleet strategy study and given that it will take time to fully electrify the network, it has been determined that the appropriate fleet is a mixture Battery Electric Multiple Units (BEMU) and Electric Multiple Units (EMU).

Iarnrod Éireann has completed a pre-qualification process for a framework agreement for up to 600 BEMU/EMU units, with a tender competition for supply of the units announced in 2019. In 2021, a contract for up to 750 new rail carriages over a ten-year period was signed, with a first order for delivery of 95 carriages placed as part of this agreement[136]. This represents the largest ever order of rail fleet by Iarnród Éireann. In November 2022, agreement was received by Government for Iarnrod Éireann to place an order for an additional 90 new battery-electric train carriages under this framework. These new electric trains and carriages will be used in the GDA as part of the Dart+ programme, which – under the National Development Plan – will see the expansion of Dart services across three existing commuter routes to Drogheda, Maynooth and Hazelhatch. The adaptable nature of these carriages means there is also potential to use them at some stage in the future between Greystones and Wicklow and/or for the Cork Area Commuter Rail. The 10-year supply framework also permits the order of trains powered by traction battery to permit up to 50km operation in areas without overhead electrification thus facilitating an earlier move to carbon-free public transport pending electrification.

Iarnrod Éireann has carried out a pilot study to replace the existing diesel power train with a hybrid electric power train on their InterCity Railcars (ICRs). These hybrid power trains have the potential to reduce fuel consumption by up to 33% with associated reductions in emissions. Stage V engine components were being manufactured to facilitate Stage V engine trials (2 trains) in 2022, with the initial hybrid drive trial scheduled for the end of the year. Also planned is a feasibility study to determine the options and business case to repower the 2003-2005 era diesel commuter fleet of DMUs and to explore possible hybrid conversion. Additionally, a programme of work is underway to refurbish four generator vans operating on the Enterprise Intercity fleet with modern emissions friendly diesel generator sets. Two pairs of generators were refurbished in 2021 and are now in service, with refurbishment of the remaining sets expected to be completed in the near future[137].

5.3.2.2 Air Pollutant Emissions associated with Rail Stations

Air pollutant emissions in terminal stations - where diesel-powered intercity and commuter services currently begin and end - are addressed through established organisational energy efficiency practices, occupational air pollutant exposure considerations, ongoing reviews of driver practices and driver training, and through analyses of the feasibility of ventilation options for the historic station structures. Following on from recommendations made in the UTRAP Interim Report, the current knowledge gap relating to the potential contribution of rail emissions to overall ambient air pollution levels in the vicinity of rail stations will be addressed through the EPA and Department of Transport co-funded StationAir research project[138].

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5.4. Traffic and Demand Management of the M50 and Dublin Port Tunnel

In the National Roads Traffic Management Study (2011) some key measures were identified for the management of traffic on the M50, e.g. Variable Speed Limits (VSLs) and fiscal intervention (multi-point tolling). In the absence of fiscal intervention, it was recommended that a Public Transport Freight Toll, i.e. extension of the Dublin Port arrangements to the wider M50, be considered. Within the M50 Demand Management Study (2014)[139], proposals identified include:

- Fiscal Measures in the form of multi-point distance-based variable time tolling;
- Intelligent Transport Systems (ITS) / Traffic Control Measures in the form of VSL and Incident management;
- Traffic Control Centre.

In the case of the Dublin Port Tunnel, while no capacity issues have been identified within the tunnel itself, congestion can be experienced on the surrounding road network on the city side, which has the potential to negatively impact ambient air quality in the city. When such congestion occurs, vehicular access to the tunnel can be temporarily withdrawn as vehicle queueing in the tunnel is not permitted for safety reasons. Withdrawal of access shifts the standing traffic to the northside of the tunnel and further north and around the M50 depending on the severity of the incident. The impact of Brexit in relation to congestion in the environs of the Port will be assessed in due course.

As noted above, approximately 60% of the traffic travelling through the tunnel consists of passenger cars and private vehicles, with 40% consisting of HGVs. When designed, it was intended that the tunnel would primarily operate as a dedicated route for HGVs between the Port and the greater road network via the Coolock Lane Interchange (M50)[140] as part of a wider strategy to shift HGV traffic away from Dublin City Centre[141]. Through the provisions of the Dublin Tunnel Bye Laws, TII does not have any means to prioritise trucks and buses other than to discourage tunnel use by non-exempt vehicles by raising the applicable toll. Currently, non-exempt vehicles are subject to a €10 charge southbound during the morning peak and northbound during the evening peak, while the charge is €3 at other times.

5.4.1.Variable Speed Limits – M50 Traffic Flow Optimisation (MTFO)

Following the M50 Demand Management Study, TII is progressing the implementation of Variable Speed Limits (VSLs) on the M50. TII established the M50 Traffic Flow Optimisation (MTFO) Project to implement a variable speed limit regime on the M50 which will improve the operational efficiency of the motorway by smoothing traffic flow, improving journey time reliability and reducing the number of traffic collisions. This will be achieved through the setting of mandatory reduced speed limits which are most appropriate to the prevailing traffic conditions, using electronic speed limit signs displayed overhead each lane. MTFO is a part of the wider enhancing Motorway Operation Services (eMOS) project. The first phase of this project was implemented in 2021 and the scheme has been in operation from Junction 4 Ballymun to J9 Red Cow since May 2022.

The consequent smoother traffic flows that will result from the VSL regime will reduce the number of shockwaves and breakdowns in traffic flows that occur, thereby reducing increases in vehicle emissions. Speed management has in places (e.g. The Netherlands) been complemented by 'eco-driving' campaigns which educate the public on fuel-efficient forms of driving. TII is continuing to monitor concentrations of NO_2 at a range of residential sites near the M50.

5.4.2.Park & Ride Strategy

The Government's Climate Action Plan 2019[142], the National Mitigation Plan[143] and the NTA's Transport Strategy for the Greater Dublin Area[144] all highlight the need to reduce emissions from the transport sector via a range of measures including the development of a Park & Ride Strategy and eventual provision of associated facilities. In the Greater Dublin Area, Park & Ride has potential in terms of serving national roads users and also reducing, or slowing, the growth in demand for car travel on both the radial corridors (M1, M2, M3, M4, M7, M11) and the M50 but is part of a wider strategic demand management process.

In line with the Action 89 of the Climate Action Plan 2019, the NTA established a Park and Ride Development Office in February 2020. In 2021, the Park and Ride Development Office published a Park and Ride Strategy for the GDA, to feed into the revised Transport Strategy for the Greater Dublin Area[145]. Reports are also being developed for the regional cities of Cork, Limerick, Galway and Waterford with the expectation that these will be completed in 2022 to 2023. Park and Ride considerations have also been integrated into the development of the metropolitan area transport plans for the regional cities. The GDA Strategy identifies three categories of Park & Ride, including Strategic Park & Ride sites (proposed across 6 corridors), Local Park & Ride sites are also considered including upgrade of facilities at various existing Rail Stations and Mobility Hub Park & Ride sites. The strategy sets out timelines for implementation of strategic sites to 2026, in cooperation with transport infrastructure stakeholders and local authorities.

5.4.3. Air Pollution Barriers

Environmental noise barriers have effects on air quality without this being their original purpose. These barriers tend to lead to decreased pollution behind the barrier. Therefore, the 39km of environmental noise barrier along the M50 may also be considered to have air quality improvement capabilities. Trees and vegetation, in general, have been shown to have positive impacts on air quality. Leaves are capable of filtering out certain pollutants such as NO_2 and PM. While data is not currently available, it is anticipated that the significant planting along the M50 may play a role in mitigating air quality impacts from vehicle emissions, however it is also important that this is fully examined to ensure that air dispersion is not prevented due to canopy effects. A further study in relation to this approach may be of merit.

In addition to the beneficial effects of certain types of physical barriers, technologies have also been developed that seek to remove road traffic pollution from the air. However, these remain unproven. For example, substances which react with NO_2 have been applied to surfaces (e.g. noise barriers) in several countries including The Netherlands and the UK. However, the results of these initiatives remain inconclusive and everyday wear and tear can limit their effectiveness. The key difficulty with these initiatives is that only a small fraction of air ever comes into contact with the applied substances, meaning that the overall impact on air quality is often negligible.

5.4.4. Ireland's Road Haulage Strategy 2022 – 2031

On 15 December 2022, Ireland's Road Haulage Strategy 2022 – 2031 was published. This 10-year strategy is the first-ever government strategy dedicated to the haulage and road freight sector. The strategy consists of seven key themes with relevance for road haulage. Two of these themes, which have relevance to air quality, are sustainability and decarbonisation and integrated transport planning and intermodal transport. The strategy sets out short-term and medium-to long-term priorities under each theme to ensure the delivery of the policy objectives over the 10 years of the strategy.

As short-term priorities, actions targeting the support of alternatively-fuelled vehicles and exploring the feasibility of freight consolidation centres have been identified. In the medium-to long-term, the strategy highlights the need to continue exploring alternative fuel options, the use of taxation and supporting the Zero Emission Vehicles Ireland (ZEVI).

6. Demand Management Study

Given the critical role played by traffic congestion, commuter patterns and urban fleet profiles in determining concentrations of transport-related air pollutant emissions in cities and towns, the UTRAP work programme also included an outline review of traffic demand management in Ireland's five major cities: Dublin, Cork, Galway, Limerick and Waterford.

As noted above, the Dublin city air pollution hotspots coincide with locations at which various modes of urban traffic intersect. The EPA air quality modelling (as distinct from air pollutant monitoring) also indicated elevated levels of NO_2 on heavily trafficked urban streets, where dense urban fabric as well as local climatological conditions can prevent the dispersal of pollutants[146]. In recent years, increased travel demand has led to an increased number of vehicles on the streets of several cities, with the result that urban traffic congestion is increasingly recognised as a problem in Ireland. This problem is not specific to Irish cities, as traffic congestion is a problem globally and has been estimated to cost local and national economies in the EU in the region of €100 billion (or 1% of the EU's GDP) annually[147]. Traffic congestion is also associated with increased air pollutant emissions from vehicles[148], as increased numbers of cars on the roads taking longer to reach their destinations burn more fuel and are constantly accelerating/decelerating and idle for longer along particular routes.

In cities, congestion and its associated problems are generally addressed using traffic demand management measures, such as road pricing strategies and parking controls within city centres and suburban locations. A multi-faceted approach is required to identify the suite of options best suited to the particular needs of specific locations. Traffic demand measures may be complemented by a range of interventions aimed at making the alternative to car use more viable, such as enhanced public transport provision; home/remote working opportunities; improved walking and cycling facilities and networks within the urban areas and supports for shared mobility and low emission small public service vehicles (SPSVs).

In 2019, the Department of Transport, Tourism and Sport commissioned a study to consider the potential roles of congestion pricing, low-emission zones, parking policies and other demand management measures in reducing greenhouse gas emissions and improving air quality in five Irish cities. The study was commissioned in response to Action 81 of the Climate Action Plan 2019[149], which required the Department to:

> 'Develop a regulatory framework in low emission zones and parking pricing policies and provide local authorities with the power to restrict access to certain parts of a city

> or town to zero-emission vehicles only. Examine the role of demand management measures in Irish cities, including low emission zones and parking pricing policies.'

Representatives from the relevant local authorities and Climate Action Regional Offices (CAROs) sat on the Steering Group for this Study. Consequently, there was an overlap between the Study Steering Group and UTRAP Group membership, which maximised the alignment of the work carried out by both groups.

The study was published in two parts, with the final Phase 2 report including quantitative analysis and updated final recommendations[150]. It considered key demand management drivers in each city (e.g., congestion, air quality, climate considerations), each of which are given equal weight. It also reviewed international best practice on various demand management measures, having regard to minimising any negative impacts on the local economy, and any transport-related inequalities on vulnerable groups, and recommended the most appropriate responses for Dublin, Cork, Galway, Limerick and Waterford.

The Study collated and analysed data from a range of sources to establish the current make-up of vehicle fleets travelling into the centres of the five cities. It also modelled the impact of a range of potential measures on both congestion and emissions levels in each city. The collection of baseline Automatic Number Plate Recognition (ANPR) data on the vehicle fleet profiles of each city was completed in February 2020 prior to the imposition of Covid-19 travel restrictions. Where possible, ANPR monitors were placed close to existing EPA air quality monitors. Analysis was also undertaken to establish local traffic flow patterns as well as establishing the specific local profile of each city's vehicle fleet. Preliminary analysis was also carried out to examine potential Low Emission Vehicle (LEV) use patterns in Irish cities, as well as the profile of vehicles using critical infrastructure (such as the Dublin Port Tunnel).

One of the key findings that emerged from the study is that interactions between different traffic measures are complex, that their impact is cumulative, and that there is no silver bullet or one measure that will solve the problems facing our cities. The measures identified in the course of the study were grouped into two main tiers. Tier 1 measures are of such a scale that they would have wide-reaching, national benefits while Tier 2 measures would achieve certain (but not necessarily all) study objectives. Tier 2 measures were further broken down into National and City measures, while the measures in Tier 1 were classified as Transport Demand Management (TDM) Strategy Pillars.

Tier 1 measures range from Clean Air Zones and parking controls to national planning frameworks, providing evidence that tackling our climate objectives involves a whole-of-Government approach across multiple areas of action. As set out in the Study, some TDMs are likely to be more suited to some cities than others, while others are expected to work best in conjunction with one or more other measures. In some cases, one measure won't work if other measures are present, further showing the complexity involved in reducing traffic on our roads, and with it, reducing emissions.

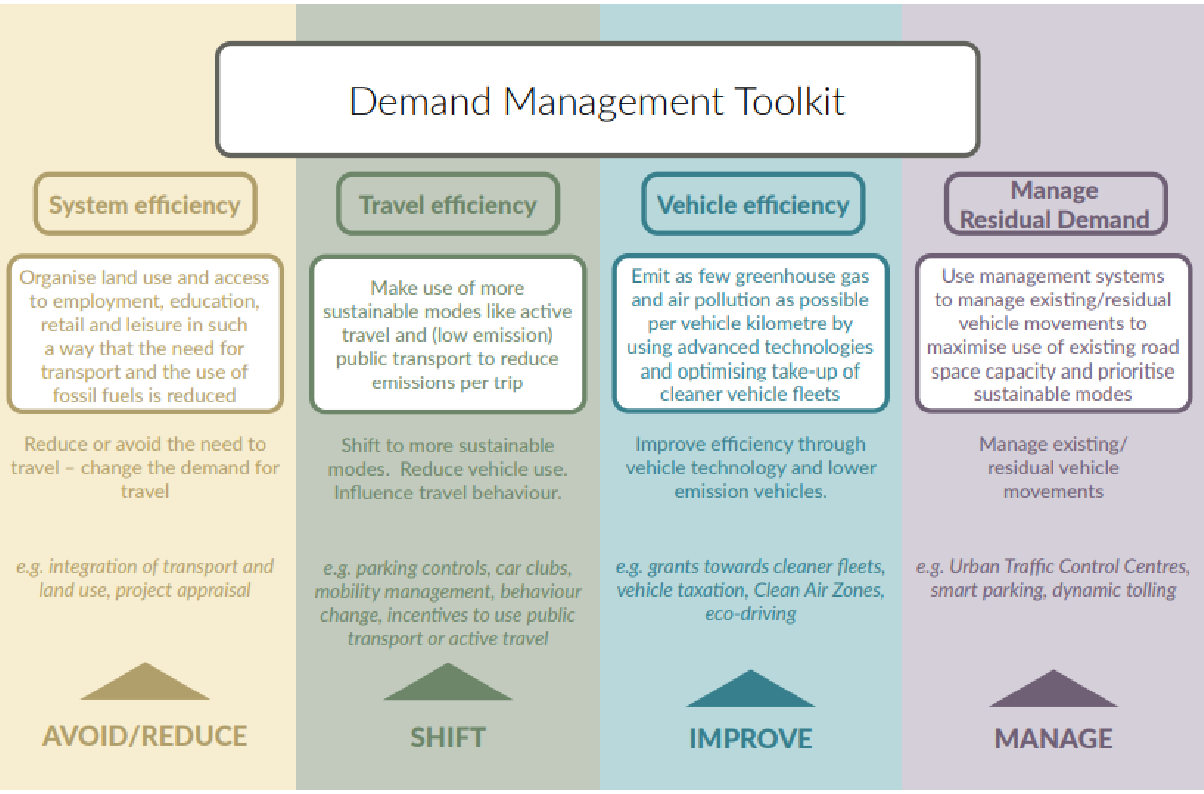
As mentioned earlier, the study did not specifically focus on air quality issues. It assessed measures across four criteria, each of which were assigned equal weight: air quality issues due to vehicular traffic; vehicular traffic congestion; reducing GHG emissions from traffic congestion; and improving the quality of the urban environment. The highest-ranking measures in the Tier 1 suite of 14 measures were those that offered benefits across multiple or all criteria, such as 15-minute neighbourhoods, enhancing the delivery of national planning frameworks and public parking controls. This multi-criteria approach meant that measures that were considered effective in tackling air quality concerns but negligible concerning the other criteria were not ranked as highly. Clean Air Zones for example scored poorly. While they have the potential to be very effective at improving air quality, their potential to reduce congestion and to improve the quality of the urban environment is more limited. As an example, a Clean Air Zone that allowed restricted access to Euro 6 and zero-emission vehicles only, or even just zero-emission vehicles, would improve air quality, but could still result in congestion, with knock-on negative impacts on the quality of the urban environment. In addition, with growing numbers of clean vehicles on our streets, even zero-emission-vehicle-focused Clean Air Zones would have the potential to create congestion, as low emission vehicle technologies replaced fossil-fuel vehicles on our streets.

The study recommended the development of a roadmap focussed on the four following processes:

- Avoid – System Efficiency (planning, parking controls);
- Shift – Travel Efficiency (modal shift);
- Improve – Vehicular Efficiency (improved vehicle standards, alternative fuels);
- Manage Residual Demand (smart parking, dynamic tolling).

While the study provided a blueprint, it is recognised that further work is needed to identify exactly what measures will suit each city and how they can and will be implemented. In this context, the National Transport Authority is leading on the development of a Demand Management Scheme for the Greater Dublin Area in line with Action 40 of the National Sustainable Mobility Policy. This action commits to developing and publishing a scheme in 2023.

Figure 9 Demand Management Toolkit



7. Conclusion

As set out in the introduction to this report, its main purpose is to present a current assessment of urban transport-related air pollution issues since the publication of the UTRAP Interim Report in March 2021 and the measures that are being undertaken to address these.

The Covid-19 pandemic has been the single most significant factor in contributing to changes in transport emissions levels in our cities since the publication of the first Interim Report. As noted in a recent European Environment Agency report on urban sustainability after the pandemic[151], despite its devastating health, societal and economic costs, Covid-19 has had a broadly positive impact on the sustainability of European cities. In many cities, travel restrictions resulted in reduced congestion and associated air pollutant emissions; greater public awareness of air quality and its health benefits; greater flexibility in the introduction of sustainable mobility measures, and increased interest in and use of urban green spaces. In Ireland, while traffic volumes are increasing across the urban and national road network post-Covid, changes to travel behaviour continue, reflecting ongoing working-from-home patterns, and increased active travel.

Against this backdrop, the planned transition of the national, private and public transport fleet to low- and zero-emission alternatives has continued, as have research actions to address knowledge gaps, and continuing improvements to the national air quality monitoring network and modelling capacity. Key sustainable mobility actions, with co-benefits for human health and urban environments as well as for reduced air pollutant emission levels have been identified, together with a pathway for their implementation through the delivery of 91 actions under the Department of Transport's Sustainable Mobility Policy by 2025. In addition, and within the same timeframe, the department recently launched a Pathfinder Programme of 35 projects that will demonstrate the benefits of sustainable mobility, including air quality co-benefits, to key stakeholders and communities. The publication of the Five Cities Traffic Demand Management Study has also established an important toolkit of measures for reducing traffic-related urban air pollution – and these will be integral to informing the development of a new National Demand Management Strategy in 2023 in line with the most recent Climate Action Plan.

In addition to the work being done under the Department of Transport's Sustainable Mobility Policy and Pathfinder Programme, Zero Emission Vehicles Ireland (ZEVI) was established in 2022. The mission of ZEVI is to support the uptake of zero emission vehicles and to coordinate the provision of charging infrastructure to meet the full range of needs for people and businesses across Ireland. This will have knock-on benefits for air quality and will aid Ireland in remaining below air quality limit thresholds.

Finally, the UTRAP Group have continued to make progress on the recommendations that were included in the 2021 Interim Report. Achievements to date, together with new recommendations on the optimal future configuration of the UTRAP Group to support the continued reduction of air pollutant emissions, can be found in the associated Synthesis Report.

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