REGIONAL MODELLING SYSTEM

Climate Action Plan Phase 3

Modelling Executive Summary

Technical Report

Údarás Náisiúnta Iompair
National Transport Authority

Project Ireland 2040
Building Ireland's Future

Contents

Figures

Tables

1 Introduction

1.1 Overview

In February 2021, the National Transport Authority (NTA) and Department of Transport (DoT) commissioned Jacobs and SYSTRA to undertake detailed transport modelling and appraisal to support the development of the Climate Action Plan (CAP21) and the emerging Climate Action Plan 2023 (CAP23). The modelling and appraisal were undertaken over three phases and used the NTA's Regional Modelling System (RMS) and purpose-built modelling tools.

Phases 1 and 2 of the modelling informed CAP21 considerations on transport policy measures that reduce carbon emissions. Phase 1 consisted of a preliminary high-level assessment of measures that could lead to a targeted 51%[1] reduction in transport-related carbon emissions. Phase 2 elaborated on this initial study by applying more advanced modelling tools and expanding upon a subset of measures related to behavioural changes.

Building on this work, the Phase 3 modelling completes Action 301 of CAP21 to devise a pathway capable of achieving transport sector carbon emissions reduction of 50% by 2030 and has informed the Department of Transport's inputs to development of the CAP23 Transport chapter, identifying a group of additional possible measures, herein referred to as the 'Pathway'. The measures consist of transport schemes, policies and interventions specific to the modelling that have been considered under the following three broad packages:

- 'Fleet Improvements';
- 'Biofuel'; and
- 'Behavioural Change Measures'.

This report provides an overview of the modelling process, a description of the Pathway measures, an assessment of the Pathway, and outcomes of the emerging CAP23 work.

The modelling assumptions and measures that collectively form the Pathway are not agreed policy measures. The modelling framework described simulates many of the interventions in terms of delivering behavioural change as a function of the relative attractiveness of car versus other modes, specifically in terms of generalised cost (the combined cost of actual and perceived costs). While the modelling provides a high degree of specificity in terms of the impacts from a carbon emissions perspective, it does not provide detailed design of the specific interventions or policies involved. CAP23 includes further actions in respect of progressing detailed policy development and scheme design.

[1] Note that this refers to the target set for the economy prior to the adoption of the sectoral emissions ceilings.

1.2 Climate Action Policy

The Climate Action and Low Carbon Development (Amendment) Act 2021 committed Ireland to a legally binding target of net-zero greenhouse gas (GHG) emissions by 2050, and a 51% reduction of GHG emissions by 2030 from a 2018 baseline. These targets are a key pillar of the Programme for Government.

In November 2021, the Government launched CAP21[2], an ambitious plan to put Ireland on a more sustainable path by cutting emissions, creating a cleaner, greener economy and society and to protect the country from the devastating consequences of climate change. CAP21 defined the actions needed to deliver on our climate targets, for which an indicative range of 42-50% transport sector carbon emissions reductions were given in CAP21.

The key milestones of the adoption of the aforementioned emissions ceilings prescribed by the Climate Action and Low Carbon Development (Amendment) Act 2021 were as follows:

- April 2022 – Formal adoption of the carbon budget programme proposed by the Climate Change Advisory Council by the Houses of the Oireachtas. These carbon budgets set out for the first time legally binding limits on the emissions (measured in tonnes of CO2 equivalent), that may be emitted during a specific time period, and comprise three 5-year budgets (295 $MtCO_2eq.$ over the 2021-2025, 200 $MtCO_2eq.$ over 2026-2030, and a provisional budget of 151 $MtCO_2eq.$ for 2031-2035).
- July 2022 – Government established sectoral emission ceilings for relevant sectors of the economy. These legally-binding ceilings set out the maximum amount of emissions that are permitted during a carbon budget period for relevant sectors of the economy. Under these sectoral emission ceilings, the transport sector is obligated to achieve a 50% reduction in emissions by 2030 (relative to a 2018 baseline), and to do so in a manner that is consistent with a sectoral emissions ceiling of 54 $MtCO_2eq.$ over 2021-2025, and a sectoral emissions ceiling of 37 $MtCO_2eq.$ over 2026-2030 (the budgets equate to an annual reduction in greenhouse gases of 20% and 50% in 2025 and 2030 respectively).

The Climate Action and Low Carbon Development (Amendment) Act 2021 also requires that the government prepare annual updates of the Climate Action Plan, which must set out actions that will be taken in order to:

- Ensure the achievement of 2030 legally binding targets;
- Prepare for climate neutrality no later than 2050; and
- Make Ireland a leader in responding to climate change.

In line with this provision, CAP23 was published in December 2022 and sets out a strong focus on the need for accelerated implementation and delivery. Alongside the CAP23, an

[2] The Climate Action Plan 2021 was published on 4th November 2021: https://www.gov.ie/en/publication/6223e-climate-action-plan-2021/.

accompanying Annex of Actions will assign clear lines of responsibility for delivery and including actions with specific timelines and steps needed to achieve each action. This modelling work has informed the targets set out in CAP23, and has been informed by stakeholder workshops and the consideration of successful approaches in other countries which could be adapted for implementation in Ireland.

1.3 Transport Sector Emissions in Ireland (2018-2030)

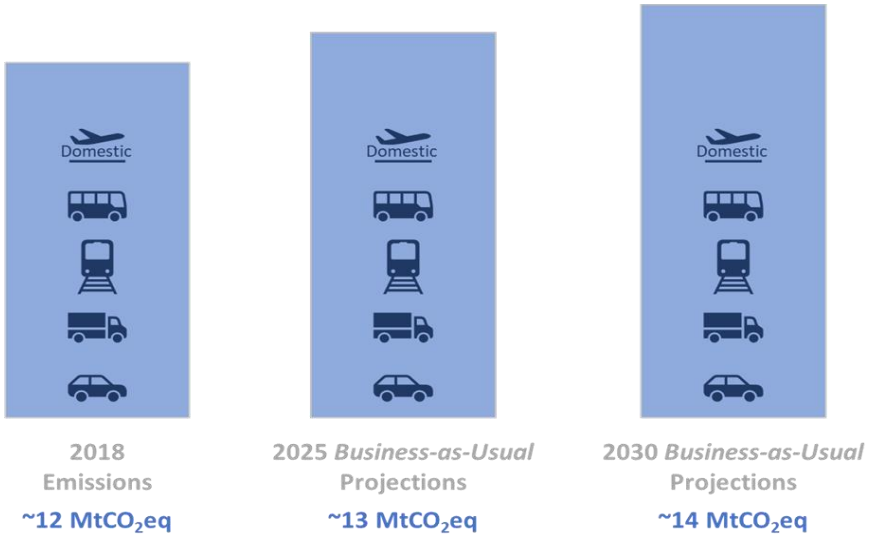
Transport sector GHG emissions (mainly carbon dioxide CO_2) are largely generated by the use of internal combustion engines (ICEs) in vehicles. These emissions are referred to as 'carbon emissions', or 'carbon dioxide equivalent emissions' measured in megatonnes (Mt) of CO_2 or $MtCO_2eq$.

In Ireland, the transport sector is one of the largest emitters of carbon dioxide, accounting for around 12 $MtCO_2eq$. in 2018, or approximately 20% of all of Ireland's carbon emissions output. Analysis of the 2017 household survey data using the National Household Travel Survey (NHTS) Modelling Tool shows that 95% of emissions in that sector are from road: a combination of passenger cars, freight and public transport. Therefore, to achieve a reduction in emissions in this area, a significant change to our road transport fleet and a change in our road usage habits is required[3].

As shown in Figure 1 below, modelled projections indicate that increased transport activity levels will lead to an increase in carbon emissions to approximately 13 $MtCO_2eq$. and 14 $MtCO_2eq$. by 2025 and 2030 respectively, representing an increase of approximately 8% and 15% above 2018 levels[4] respectively. This package is referred to as the 'Business-as-Usual' forecast in the remainder of this report.

[3] Emissions from international aviation do not form part of the national emissions inventory and are therefore outside the scope of this work.
[4] Emissions generated by car and goods vehicles operating on the road network in 2018 account for 50% and 18% respectively. In 2030, the estimated emissions generated by these car and goods vehicles accounts for 50% and 21% respectively.

Figure 1 Carbon Emissions 2018 – 2030



Under the now established sectoral emissions ceiling commitments, by 2030, total transport-related carbon emissions must decrease by 50% compared to 2018 levels, which results in a target of approximately 6 $MtCO_2eq$.

1.4 Structure of Report

The remainder of this report is structured as follows:

- Chapter 2: Modelling Process Summary;
- Chapter 3: Pathway Measures;
- Chapter 4: Pathway Assessment; and
- Chapter 5: Pathway Outcomes and Conclusions.

2 Modelling Process Summary

2.1 Pathway and Measures

The modelling and appraisal work has led to the identification of the Pathway and consists of packages of measures that could deliver a 50% reduction in carbon emissions by the year 2030. The grouping of the Pathway measures was based on tiers outlined in work undertaken by McKinsey in April 2022[5] in support of the Climate Action Plan 2021, and the groupings align with policies, such as the National Sustainable Mobility Policy (April 2022), which prioritise sustainable modes.

The carbon emissions reduction Pathway considers three packages of measures, which are applied to the 'Business-as-Usual' forecasts. The 'Business-as-Usual' forecasts include the demographic traffic growth between 2018 and the forecast years (2025 and 2030), which will result in increased emissions without additional interventions. The three packages, which all aim to reduce emissions from the 2025 and 2030 'Business-as-Usual' forecasts, are:

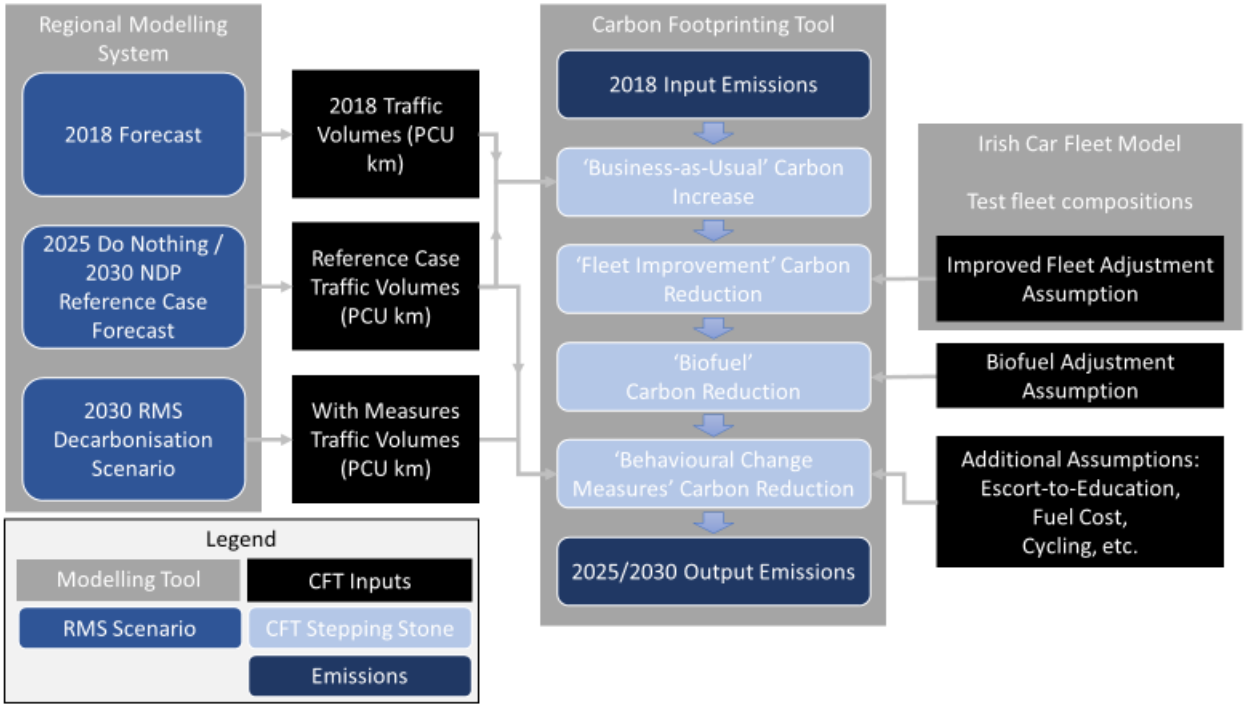
- ***'Fleet Improvements'***: this package includes measures aimed at reducing emissions per kilometre (km) through changes to the fleet. This is largely as a result of electrification, but the impact of other vehicle technologies is also considered;
- ***'Biofuels'***: this package includes the Renewable Transport Fuel Obligation (RTFO), which requires minimum adoption of biofuels and would result in reduced emissions per km; and
- ***'Behavioural Change Measures'***: unlike the other two packages, the measures in this package are aimed at travel demand management (i.e., lowering emissions by reducing the total km travelled by private car, either through modal shift, or by reducing the need to travel). These measures also include the consideration of National Road Network (NRN) speed limit reductions evaluated by Transport Infrastructure Ireland aimed at reducing emissions per km, as well as measures to address fuel tourism i.e., vehicle owners who travel across the border from Northern Ireland to take advantage of fuel price differentials.

[5] Government of Ireland, Department of The Environment, Climate and Communications, Summary of Analysis to Support Preparation of the Sectoral Emissions Ceilings, 2022

2.2 Modelling Tools

The Carbon Footprinting Tool (CFT) and the Irish Car Fleet Model were used throughout all three assessment phases, as outlined in Section 1.1, and the NTA's Regional Modelling System (RMS) was used in Phases 2 and 3. The interaction process between these tools is presented graphically in Figure 2 while the tools themselves are discussed below.

Figure 2 Phase 3 - Overview of the Model Interaction Process



2.2.1 Carbon Footprinting Tool

The CFT estimates the overall percentage reduction in carbon emissions from each transport-related measure and applies these sequentially to the 2025 and 2030 'Business-as-Usual' carbon emissions estimates. The outputs from the CFT can then be compared to the 2018 baseline level to determine how well the package of measures performs against the emissions reduction target. Note that the current version of the CFT does not attempt to predict the emissions in the intermediate years.

2.2.2 Irish Car Fleet Model

An Irish Car Fleet Model was used to assess the impact of new vehicle technologies on carbon emissions. The model is based on the 2019 Irish car fleet inventory and predicts how the proportion of fuel types (petrol, diesel, hybrid or electric) within the fleet will change over time. Its forecasts are based on observed Irish scrappage rates by age and fuel type and predictions for new registrations and second-hand imports (primarily from the UK). Fleet forecasts, and the associated carbon emissions, also include assumptions on the ongoing replacement of older ICE vehicles with new EURO 6 models.

2.2.3 National Household Travel Survey Modelling Tool

The National Household Travel Survey (NHTS) Modelling Tool is a spreadsheet model of travel choice which considers the travel cost of each mode in order to estimate a resultant country-wide modal split.

This tool was used to evaluate the response of behavioural change measures in Phase 1, and its function was replaced by the more comprehensive RMS in subsequent phases.

2.2.4 Regional Modelling System

The NTA's RMS was used in both Phases 2 and 3 as the primary tool to assess demand management measures such as parking constraint, congestion charging and car-free urban centres. The RMS includes a National Demand Forecasting Model (NDFM) and five Regional Models.

The NDFM forecasts the overall travel demand over a 24-hour period, which is then used as an input by the five Regional Models.

The five Regional Models cover the entirety of Ireland and are a set of multi-modal demand models, which are focussed on the following areas:

- Dublin, represented by the East Regional Model (ERM);
- Cork, represented by the South West Regional Model (SWRM);
- Limerick, represented by the Mid West Regional Model (MWRM);
- Galway, represented by the West Regional Model (WRM); and
- Waterford represented by the South East Regional Model (SERM).

The purpose of the five Regional Models is to forecast changes in transport demand and travel choices, as well as to provide estimates of vehicle and person volumes on the road and public transport networks. The Regional Models also produce several other useful indicators, such as total vehicle km travelled and associated tailpipe emissions.

For Phase 3, a series of forecast scenarios were prepared within the RMS, allowing vehicle km growth to be estimated. Vehicle km was the primary input into the CFT for estimating carbon emissions. The following RMS scenarios were used:

- 2018 'Do Nothing' scenario, which includes only planning demographic (i.e., population and employment) growth;
- 2025 'Do Nothing' scenario, which includes only demographic growth;
- 2030 'National Development Plan (NDP) Reference Case' scenario which includes demographic growth in addition to a number of transport schemes which are expected to be delivered by 2030 according to the 2018 NDP; and
- 2030 RMS Decarbonisation Scenario (RMSDS) which builds upon the 2030 'NDP Reference Case' scenario and includes further mitigation measures as highlighted in Section 2.3.2.

2.3 Modelling Approach

The three modelling assessment phases are described below.

2.3.1 Phases 1 and 2 Modelling

The modelling undertaken in Phase 1 assessed high-level policy interventions that could deliver the required reduction in emissions. The NHTS Modelling Tool was used in this stage.

The Phase 2 modelling replaced the NHTS Modelling Tool with the NTA's RMS. This permitted a more detailed assessment of the Phase 1 outcomes and allowed a more robust estimation of the impacts of individual measures.

2.3.2 Phase 3 Modelling

The key components of the Phase 3 modelling and appraisal process are summarised in Figure 3. The process involved the following modelling and assessment steps.

1. Refresh of Previous Modelling

This stage improved the RMS relative to the previous Phase 2 modelling, by refining the initial assumptions. The outcome of these improvements was a 2030 RMS Decarbonisation Scenario (RMSDS) which included measures that could be represented explicitly within the RMS. The Phase 3 modelling objectives were to:

- Bridge the gap in carbon emissions reduction from the previous Phase 2 modelling;
- Include additional years to tie in with budget cycles (2025); and
- Assess the final package of measures that contribute to a 50% reduction in GHG emissions within Ireland's transport sector by 2030.

2. Explorative Modelling

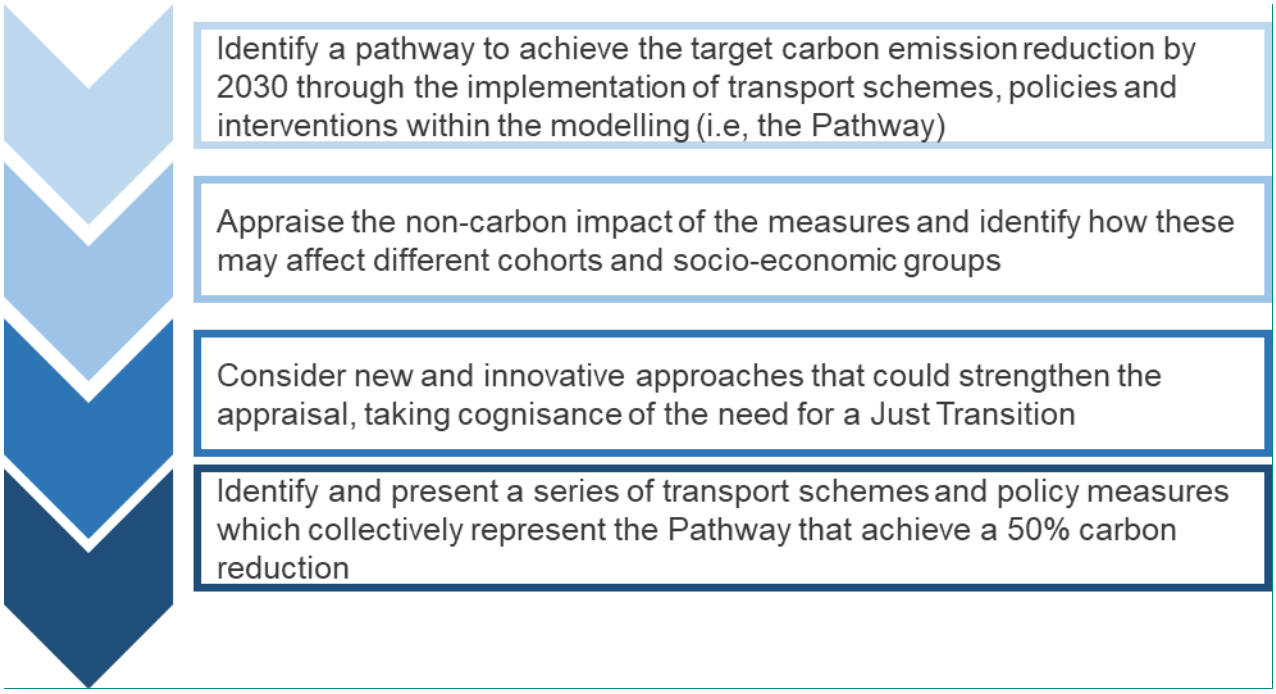
The outcome of this stage was to establish the likely impacts resulting from a range of potential measures.

For those measures tested in the RMS, a final combined forecast scenario was created, the 2030 RMSDS. This was used to establish the potential traffic impacts of all modelled measures. For measures that could not be modelled within the RMS, a set of assumptions were produced using other modelling tools. The impacts of both sets of measures were considered collectively in the CFT in the following stage.

3. 2025 and 2030 Emissions Pathway Modelling

The full emissions Pathway was modelled in the CFT, by applying the impact from packages of measures to the 'Business-as-Usual' forecasts.

Figure 3 Phase 3 Process Summary



3 Pathway Measures

3.1 Overview

The Pathway consists of packages of measures that are predicted to achieve the 50% reduction in transport sector carbon emissions.

These packages are applied to the ‘Business-as-Usual’ forecasts in the following order and are described as:

- ‘Fleet Improvement’, which considers both improvements to ICE vehicles but also the dedicated shift to electric and sustainable power sources;
- ‘Biofuel’, which reflects the impact of increased biofuel usage; and
- ‘Behavioural Change Measures’, a series of measures related to behavioural change.

As noted in the previous chapter, the CFT utilises assumptions from a number of sources including the RMS and Irish Car Fleet Model in order to provide emissions projections for each package and for the two forecast years (2025 and 2030).

3.2 Business-as-Usual Forecasts

The ‘Business-as-Usual’ forecast represents what is expected to happen without any intervention as part of CAP23, while accounting for projected demographic growth to 2030, and therefore presents a worst-case scenario.

This ‘Business-as-Usual’ emissions projection is extrapolated from the percentage change in vehicle km, as forecast by the RMS for the two modelled years. In both cases, the 2018 ‘Do Nothing’ scenario is used as the baseline from which growth is calculated, and the 2025 ‘Do Nothing’ and 2030 ‘NDP Reference Case’ scenarios are used to provide the forecast values.

3.3 Fleet Improvement

‘Fleet Improvement’ covers two key aspects: the ongoing technological advances in fuel consumption which will introduce improvements to carbon emissions and a transition to Electric Vehicles (EVs) which is considered the most impactful measure in terms of emissions.

The carbon emissions reductions associated with improvements to the private car fleet are predicted using the Irish Car Fleet Model.

The carbon emissions reductions associated with improvements to the non-private vehicles (including goods vehicles, bus and rail) are based on assumptions inputted into CFT.

3.4 Biofuels

Biofuels are a form of renewable energy derived from biomass which can be used as a substitute for fossil fuels, thereby reducing carbon emissions from the car, LGV and HGV fleet.

The Renewable Transport Fuel Obligation requires fuel suppliers and large oil consumers to ensure that renewable transport fuels such as biofuels make up a certain proportion of the fuel used in the road transport sector. The 2022 renewable transport fuel obligation rate is 13% by volume (i.e., not less than 13 litres in every 100 litres of road transport fuel is biofuel). This share will increase on an indicative trajectory out to 2030.

The current E5 and B7 blends (as seen on petrol pump labels), mean up to 5% bioethanol in petrol and up to 7% biodiesel in diesel. The CAP21 Action is for these proportions to rise over time from the current E5/B7 to E10/B12 by 2025 and E10/B20 by 2030.

3.5 Behavioural Change Measures

The RMS is the most appropriate tool for evaluating a wide range of behavioural change measures which could affect different aspects of travel such as journey time and cost (e.g., fares and tolls).

Two scenarios were considered, the 2030 ‘NDP Reference Case’ and 2030 RMS Decarbonisation Scenario (RMSDS), and comparison of their traffic projections (vehicle km) allows the overall change in traffic levels to be applied within the CFT. No similar RMS CAP23 scenario is available for 2025. However, further assumptions, most notably changes to fossil fuel cost[6], are included within the CFT to obtain a 2025 forecast.

Based on evidence that demand management and behavioural change have been successful elsewhere (as shown in the DoT's ‘Five Cities Demand Management’ study[7]), the behavioural change measures which will be most effective in delivering the required reduction in carbon emissions include:

- Demand Management measures to reduce car usage and promote sustainable transport usage, such as:
  - Car-free urban centres;
  - Congestion charging;
  - Parking constraint;
  - Improve public transport service interchange; and

[6] Although fossil fuel cost changes have been accounted for in the 2030 RMSDS scenario, within the CFT they are taken out based on fuel elasticities so that they can be adjusted completely within the CFT without being reliant on a new RMS scenario being prepared

[7] gov.ie - Department of Transport publishes ‘Five Cities Demand Management’ Research Report (www.gov.ie)

    - Reduce public transport fares.
- Increased working from home or public awareness campaigns to encourage reduced trip frequency;
- Increase fossil fuel cost;
- Higher levels of cycling; and
- Elimination of fuel tourism.

It is assumed that some of the carbon emissions reduction relative to 2018 will be achieved by lower levels of home-to-work trip making, on the basis that working from home has become more routine for many workers since the COVID-19 pandemic.

The frequency of trip-making within the model is determined by trip rates which vary by journey purpose. In Phase 3, 2030 trip rates are adjusted according to the NTA's *Alternative Future Scenario for Travel Demand*[8] study, which includes the assumptions in the forecast trip rates outlined in Table 2 in Section 4.5.1.

These adjustments have been applied in the 2025 modelling. However, to take account of the shorter time available to implement the relevant behavioural change policies, the adjustments were reduced by a factor of two.

Speed limit reductions have the potential to reduce carbon emissions as ICE vehicles will be less efficient (i.e., have higher fuel consumption per kilometre) at higher speeds. This enters the CFT as a simple assumption which is noted in Section 4.5.2.

The elimination of fuel tourism (i.e., fuel purchased in Ireland being consumed in Northern Ireland) arises as a result of removing price differences that result in this behaviour.

[8] https://www.nationaltransport.ie/wp-content/uploads/2021/03/Alternative-Scenario-Development-Note-v-6.1_Final.pdf

4 Pathway Assessment

4.1 Overview

This chapter summarises the modelling of the measures outlined previously in Chapter 3, with a description of the relevant inputs and assumptions for each measure. Where relevant, the associated level of change required to achieve an appropriate level of carbon emissions reduction is also defined. The carbon emissions reductions achieved by each measure is summarised later in Chapter 5, Pathway Outcomes and Conclusions.

Each group of measures is assessed using the modelling tools presented in Section 2.2, and the output of each individual assessment is fed into the CFT, as illustrated in Figure 2.

4.2 Business-as-Usual Forecasts

As mentioned in Section 3.2, 'Business-as-Usual' forecasts represent what is expected to happen if CAP23 is not implemented (i.e., without any further interventions). This, therefore, presents a worst-case scenario based on traffic projections produced by the RMS. As shown in Table 1, significant increases are expected in traffic in both forecast years which are reflective of the underlying demographic growth in population and employment.

Table 1 'Business-as-Usual' Projections of Vehicle km and Demographic Growth

Metric	2025 'Do Nothing'	2030 'NDP Reference Case'
Total car km growth (from 2018)	3%	12%
Total goods km growth (from 2018)	16%	26%
Population growth (from 2018)	6%	10%
Employment growth (from 2018)	11%	18%

Growth in traffic is not solely tied to demographic growth as highlighted by the differences in projections, as the RMS forecasts changes in travel behaviour (for example, in response to including increased congestion).

There are also regional variations in the projections. For example, while a 12% overall increase in car km is expected nationally by 2030 (as shown above), there is a smaller increase of just 7% in the eastern (Dublin) region, while car km travelled in the rest of the country increases by 17%. Similarly, the increase in goods vehicle km travelled is predicted to be 32% and 23% in the eastern (Dublin) region and the rest of the country respectively.

'Business-as-Usual' forecasts also take into consideration the impact from a number of sustainable mode schemes including BusConnects and additional cycle infrastructure.

These are assumed to be fundamental to CAP23 and are considered as committed development. These measures provide viable travel alternatives to the car and are necessary to facilitate the attempts of demand management measures to reduce car usage.

4.3 Fleet Improvements

Improvements to the car fleet were assessed using the Irish Car Fleet Model, with separate processes used for the non-car (goods vehicles, bus, and rail) fleets.

4.3.1 Car Fleet

Growth in the car fleet was assessed through analysis of Ireland's car fleet over recent years which shows that approximately 183,000 private cars are added each year (140,000 new and 43,000 second-hand imports), resulting in a 6.4% growth in the total 'on-the-road' car fleet by 2030. The take-up rate of EVs within the fleet heavily influences emission reductions. Several scenarios were modelled which all assumed that 100% of future vehicle sales would be electric by a given year. The Pathway assumes EVs to comprise 100% of new car sales by 2029 (80% battery electric cars, 20% plug-in hybrids). With this uptake profile, the transport modelling estimates there would be around 960,000 plug-in electric cars (712,000 BEVs; 248,000 PHEVs) on the road by 2030[9] which represents approximately a 30% BEV share of the fleet in 2030.

Along with other metrics, projected growth in EV adoption will need to be monitored and calibrated continuously, noting that modelled estimates do not take into account the impact of the Covid-19 pandemic on vehicle registration rates and the potential reduction in second-hand imports.

4.3.2 Goods Vehicles

A fleet model for goods vehicles, similar to that developed for private cars, was not available for this study. Instead, the Pathway was informed by applying a set of agreed assumptions regarding the reduction of emissions in light and heavy goods vehicle types. These assumptions, which were arrived at following consideration of the comparable Sustainable Energy Authority of Ireland forecasts[10] and a review of Environmental Protection Agency projections[11], were:

[9] Source: The Irish Car Fleet Model developed by the NTA & DoT, last updated 16 January 2022
[10] Energy In Ireland | Key Publications | SEAI
[11] Monitoring & Assessment: Climate Change: Air emissions Publications | Environmental Protection Agency (epa.ie)

- From 2019 to 2030, light goods vehicle[12] (LGV) electrification and/or fuel blend improvements will deliver half of the percentage emission reductions achieved in private cars factors, or a 20% emissions reduction relative to the 2018 value, due to the higher number of vehicle kilometres in the future years; and
- Ireland has recently become a signatory to the Global Memorandum of Understanding on Zero-Emission Medium and Heavy-Duty Vehicles (MHDVs) at COP27, which sets a target of 30% of new MHDV registrations to be zero-emission by 2030. The number of vehicle kilometres is predicted to increase in future years and significant penetration of zero-emissions trucks is not expected until the latter part of the decade and subsequent carbon budget periods. However, general improvements in the fuel efficiency of Ireland's heavy goods vehicle[13] (HGV) fleet between now and 2030 are predicted to reduce carbon emissions per km by 10%, relative to the 2019 observed fuel consumption.

4.3.3 Bus and Rail Fleet

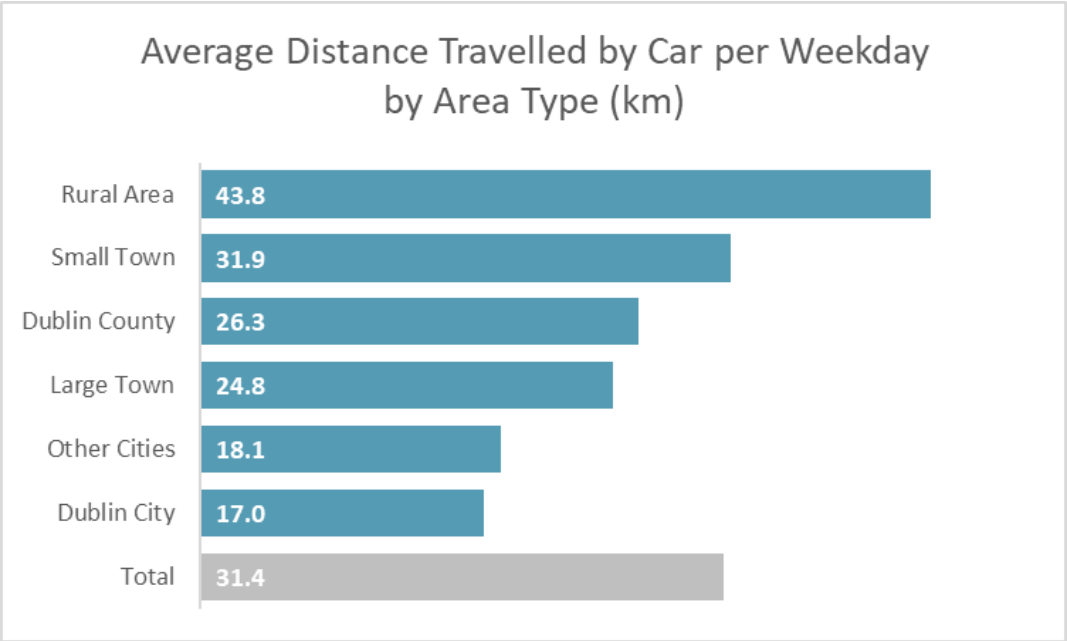
For the public transport fleet, the Pathway includes an assumption that both the bus and rail fleet will be electrified in the future, resulting in a reduction in carbon emissions. The rate at which Ireland's public transport fleet will be replaced by zero-emission vehicles is assumed to be in line with the current policy for Public Service Obligation services. It is expected that public transport electrification and vehicle technology can achieve 0.17 $MtCO_2eq.$ and 0.38 $MtCO_2eq.$ of reduction in carbon emissions in 2025 and 2030, respectively. However, further work will be required to account for demographic growth and the expected increases in levels of service required to meet the net 50% emissions abatement target for the sector.

4.3.4 Targeted Electric Vehicle Uptake

It is widely recognised that people who reside in different geographies will have varying dependence on cars and may use their car for longer journeys on average. Analysis of the average distances travelled per vehicle as shown in Figure 4 illustrate that trend. This analysis highlights that promoting a shift to electric vehicles in particular areas can potentially be a more effective policy than a blanket incentive and could therefore maximise the impact of the fleet electrification (discussed previously in Section 4.3.1).

[12] Light Goods Vehicles consist of vans and small trucks
[13] Heavy Goods Vehicles consist of articulated and multi-axle trucks

Figure 4 Average Personal Car Trip Length by Area Type (km)



While recognising that the initial cost of ownership is likely to be currently the largest impediment to owning an electric vehicle, and that the majority of new vehicles are purchased in urban areas, possible approaches to improve ownership in rural areas include:

- Low-interest loans exclusive to electric vehicles;
- Improved charging facilities (to overcome the perceived lack of range and inconvenience of out-of-home charging); and
- Development of a second hand EV purchase grant, once a second-hand market is established.

4.4 Biofuel

Biofuels are currently used in the transport sector and thus are included in the 'Business-as-Usual' forecast. Without intervention, diesel/biodiesel blends are assumed to remain at 7% until 2030, and the bioethanol proportion in petrol remains at 5%. The Pathway requires diesel/biofuel blends to increase to 12% by 2025 and 20% by 2030, and petrol/ethanol blends to increase to 10% by 2025 and stay there until 2030.

4.5 Behavioural Change Measures

This section details the proposed behavioural change measures, some of which were modelled in the RMS or supporting tools. In all cases, the CFT was used to assess their contribution to the Pathway through carbon emissions reductions. Note that this represents just one potential combination of measures that could be used to achieve emission reductions.

All behavioural change measures that could be represented in the RMS were modelled to identify their impact on vehicle km (and therefore carbon emission savings). These measures are discussed in Sections 4.5.1 to 4.5.6 below. The measures modelled in Phase 3 did not consider location or population-specific impacts, and it should be noted that local variations in the level and scale of the measures may achieve the same level of overall emission reduction but with less impact on certain communities or groups. Therefore, detailed testing and local consultation are recommended before implementing measures in local, regional, or national plans.

In addition to those measures modelled explicitly in the RMS, there are a number of further measures that were proposed as part of Explorative Modelling (Section 2.3.2). While not included in the RMS they can nevertheless help in delivering carbon reduction and are included in the CFT as part of the Pathway. These measures are described in Sections 4.5.2 to 4.5.6.

4.5.1 Demand Management Measures

The 2030 RMS Decarbonisation Scenario (RMSDS) scenario consists of a range of measures and assumptions as shown below in Table 2.

Table 2 2030 RMSDS Inputs/Assumptions

Measure	Inputs/Assumption
Increased working from home/public awareness campaigns	Increased working from home and the impact of public awareness campaigns have been included in the Pathway. This measure leads to changes in trip rates, which are both a driving force capable of reducing carbon emissions as well as being a potential outcome from other mitigations. Trip rates are recognised to be lower than they were in 2018 due to the long-term response to the COVID-19 pandemic, but there is still a requirement to ensure that they stay low and even reduce over time as part of CAP23. The changes to trip rates assumed here in 2030 are: ▪ White collar commute trip rate reduced by 25%; ▪ Food shopping trip rate increased by 10%; and ▪ Employers' business trip rate reduced by 20%.
Reduce Car Ownership	Car ownership can be shown to have a large impact on whether a car was available for a trip and therefore would have been used, hence has a direct consequence on carbon emissions. With some of the other mitigations (through public transport services improvements such as BusConnects, fare reductions, car-free centres, increased levels of working-from-home and increased parking charges/fuel costs) it is also recognised that the overall cost and convenience of owning a car could change as a result, and therefore car ownership

Measure	Inputs/Assumption
	might vary in response to these mitigations. Estimates of the potential changes that might be expected and required have been made in Phase 3 and the following reductions in car ownership by area type were adopted: ■ -14% in Dublin City; ■ -10% in Other Cities; ■ -5% in Large Towns; ■ -5% in Small Towns; ■ -4% in Dublin County; and ■ -1% in Rural Areas.
Car-Free Urban Centres	Introduce and extend car-free areas in the five urban centres (Cork, Dublin, Galway, Limerick, and Waterford) to reduce road space for cars and increase capacity for other modes.
Congestion Charging	€10 charge per inbound trip all day, crossing a city centre cordon in the five cities (i.e., Cork, Dublin, Galway, Limerick, and Waterford).
Increase Fossil Fuel Cost	A real increase of 65% in the pump price of petrol and diesel between 2018 and 2030. Note that around 30% of the car fleet is predicted to be battery electric by 2030 and so will not be affected by this fuel price increase.
Parking Constraint	Removal of free workplace parking spaces from the five major cities. A 400% increase from 2016 parking charges and a minimum charge of €5/hr introduced in all urban areas.
Improve Public Transport Service Interchange	Perceived wait-times for public transport reduced by 66% and capacity increased to remove all on-board crowding. (Note that additional work will be needed to estimate the number of additional public transport vehicles and staff required to deliver this enhanced public transport service offer).
Reduce Public Transport Fares	A 50% (real) reduction in fares from the 2018 baseline[14].

[14] This would require approximately a 37% real reduction further to the 2022 baseline 20% average fares reduction that was introduced as a cost-of-living measure.

The carbon emissions reductions from the 2030 RMSDS measures outlined above, and their contribution towards the Pathway, are provided in Chapter 5, Pathway Outcomes.

4.5.2 National Road Network Speed Limits

Transport Infrastructure Ireland (TII) released the *Impact of National Road Speed Limit Reductions on Greenhouse Gas Emissions*[15] study in March 2022, which assessed a range of speed limit reduction scenarios (10 kph, 20 kph, or 30 kph) on different classifications of road to understand their potential impact on GHG emissions.

The CAP23 modelling reflected a 20 kph reduction in NRN speed limits, which TII's study predicted could deliver a 0.214 MtCO2eq. reduction in GHG emissions relative to the 2018 baseline.

The NTA and TII continue to explore the impact of NRN speed limit reductions on GHG emissions and traffic safety.

4.5.3 Cycling

The Pathway assumes that cycling levels can double from their 2018 levels by 2030 and, based on an analysis of the NHTS, it has been estimated that doubling non-leisure-activity cycling trips will result in an additional 10% increase in overall walk and cycle trips and a 7% increase in overall sustainable trips (walk, cycle, and PT). Potential measures that can achieve this include:

- Fully implementing safe and connected cycle networks throughout the country, in line with national and regional cycle plans and the National Cycle Manual;
- Increasing use of cycle by part-time workers;
- Promoting cycle use for trips where a car is available; and
- Facilitating household cycle availability through purchase schemes, cycle parking and storage provision, and promotional campaigns.

Other additional measures that could support a large uplift in cycling include:

- A combination of fiscal measures designed to increase cycle ownership;
- Incentives to promote electric bike and cargo bike use as alternatives to private car ownership;
- Bike-to-work incentives;
- Improved bike storage facilities;
- Hearts & Minds campaigns;
- Prescription cycling (i.e., to explicitly tackle ill-health associated with lack of physical activity); and

[15] Impact of National Road Speed Limit Reductions on Greenhouse Gas Emissions: https://www.tii.ie/tii-library/strategic-planning/transport-research-and-information-notes(trins)/Impact-of-National-Road-Speed-Limit-Reductions-on-Greenhouse-Gas-Emissions.pdf

- Expansion of the segregated cycle network.

The resulting increase in cycle ownership and/or proficiency will then further reduce the barrier to cycling, even when the cost of the individual cycling trip (relative to car use) does not change. Increases in cycling numbers will also likely to result in a further positive feedback response, due to the perceived 'safety in numbers' effect from the increased visibility of cyclists.

4.5.4 Escort-to-Education

The carbon emissions associated with trips escorting students to education was calculated as 4.6% of personal car emissions, and therefore highlighted as a potential focus for mitigation. A desktop study was undertaken in Phase 3 to understand potential reductions obtainable through reducing primary-level escort-to-education trips, which could be achieved through:

- An assumed response to other measures, particularly additional costs to road such as fuel cost and congestion charging, etc.;
- Potential expansion of the Department of Education's School Transport Scheme (currently under review), or improved routing of PT services where necessary to offer a viable alternative for education trips;
- Additional consideration of alternative timings to better suit modern lifestyles for collection / drop-off of children;
- Expansion of the Safe Routes to School Programme (launched March 2021), and potentially introducing charging, restricted parking, or other measures to impede personal school drop-offs;
- Introduce a requirement for children to attend their catchment school;
- New walk-to-school routes for local children with supervised pickup; and
- A targeted Hearts & Minds campaign which will communicate the importance of removing road trips to parents.

The analysis targeted a 30% reduction in primary level escort-to-education car trips as part of CAP23.

4.5.5 Improving Rural Connectivity

One of the key constraints to reducing emissions, identified in the modelling, was the requirement to have a viable alternative to traveling by car where the trip was still necessary. For short-distance trips, shifting to walking is a plausible response. However, for longer-distance trips, a competitive public transport option becomes more of a requirement to shift travellers out of cars.

A number of public transport schemes have already been assumed in the modelling within the 'Business-as-Usual' forecast (e.g., BusConnects), and these are critical in providing an alternative to allow people to use their cars less frequently. However, these schemes are largely focussed on urban areas and do not deliver the same level of improvements for rural residents. Schemes such as Connecting Ireland are focussed on improving mobility in rural areas but were not included in the RMS as they are still in an early design phase.

Nonetheless, these schemes would be considered capable of further reducing carbon as part of a wider set of mitigations.

4.5.6 Fuel Tourism

It is assumed that fuel tourism (i.e., fuel purchased in Ireland being consumed in Northern Ireland) is eliminated as a result of removing price differences that result in this behaviour.

5 Pathway Outcomes and Conclusions

5.1 Overview

This chapter summarises the predicted Pathway outcomes in terms of overall carbon reduction and the contribution made by each package i.e., 'Fleet Improvements', 'Biofuels', and 'Behavioural Change Measures'. Following the introduction of the Sectoral Emission Ceiling budgets in July 2022, the Government confirmed the transport sector is obligated to achieve a 50% reduction in emissions by 2030 (relative to a 2018 baseline), and to do so in a manner that is consistent with a sectoral emissions ceiling of 54 MtCO2eq. over 2021-2025, and a sectoral emissions ceiling of 37 MtCO2eq. over 2026-2030. The budgets equate to a reduction in annual greenhouse gases of 20% and 50% in 2025 and 2030 respectively. The primary focus of the study was to develop the Pathway to meet the updated 2030 target value, but it was also necessary to assess the Pathway against the 2025 target value.

The chapter concludes with a review of how trip making (i.e., total trips and mode shares) is predicted to change as a result of implementing the Pathway for 2030 and the interim year of 2025.

5.2 2030 Pathway Modelling

The Pathway to 50% carbon emissions reduction by 2030, which is made up of all the measures discussed above, has been assessed in the CFT. This tool has been used to combine assumptions and demonstrate the impact of measures on carbon emissions. All emissions reductions presented in this chapter are an output of the CFT.

5.2.1 Fleet Improvements

The Pathway identified improvements in technology and electrification of the fleet, which will result in the following reductions in carbon emissions:

- 44% fewer carbon emissions per km from private cars (between 2018 and 2030) (including 4% from the targeted uptake of electric cars);
- 20% fewer LGV emissions per km;
- 10% fewer HGV emissions per km;
- 20% fewer emissions for domestic aviation;
- 80% fewer emissions from road-based PT; and
- 50% fewer emissions from trains.

The predicted overall reduction in carbon emissions due to improved vehicle technology, including electrification, is **4.7** $MtCO_2eq$. by 2030, which is 39% of the total 2018 emissions.

5.2.2 Biofuels

Increasing the amount of biofuel in diesel and petrol is predicted to reduce carbon emissions by **1.1** $MtCO_2eq$. by 2030, or 9% relative to 2018 emission levels.

5.2.3 Behavioural Change Measures

Behavioural change measures (outlined above in Section 4.5) will be key measures in the Pathway and are estimated to reduce all fossil-fuelled car use by 29% in 2030. Carbon emissions from road traffic will accordingly be reduced by **1.70** $MtCO_2eq$. (excluding fuel tourism).

This includes reductions of:

- 1.05 $MtCO_2eq$ of car-based emissions from the behavioural changes modelled in the RMS (including the increased fuel price);
- 0.42 $MtCO_2eq$ from goods vehicle operator responses to the higher fuel prices;
- 0.04 $MtCO_2eq$. associated with the additional 100% increase in cycling;
- 0.01 $MtCO_2eq$. associated with a reduction in escort-to-education trips;
- 0.01 $MtCO_2eq$. associated with improving rural connectivity;
- 0.14[16] $MtCO_2eq$. associated with lowering the speed limits on the National Road Network; and
- 0.03 $MtCO_2eq$. associated with long-distance inter-regional travel responses (which are not captured by the individual regional models in the RMS).

The committed changes to fuel price, changes in biofuel blends, and increased prevalence of EVs are predicted to reduce fuel-tourism-related carbon emissions from **0.55** $MtCO_2eq$. in 2018 to **0.41** $MtCO_2eq$. in 2030. The further increase in pump prices arising from the behavioural change measures is assumed to remove the remaining 0.41 $MtCO_2eq$. fuel tourism emissions in 2030.

It is assumed that fuel price increases will not create a significant reverse 'fuel tourism benefit' (i.e., Irish drivers filling their vehicles with UK fuel).

5.3 2030 Pathway Outcome

5.3.1 Carbon Emissions Reduction

All of the packages – ‘Fleet Improvements’, ‘Biofuels’, and ‘Behavioural Change Measures’ – would need to be in place to achieve the total emissions reductions necessary to meet the 50% target in 2030. The Pathway outcomes are summarised in Table 3 and presented graphically in Figure 5.

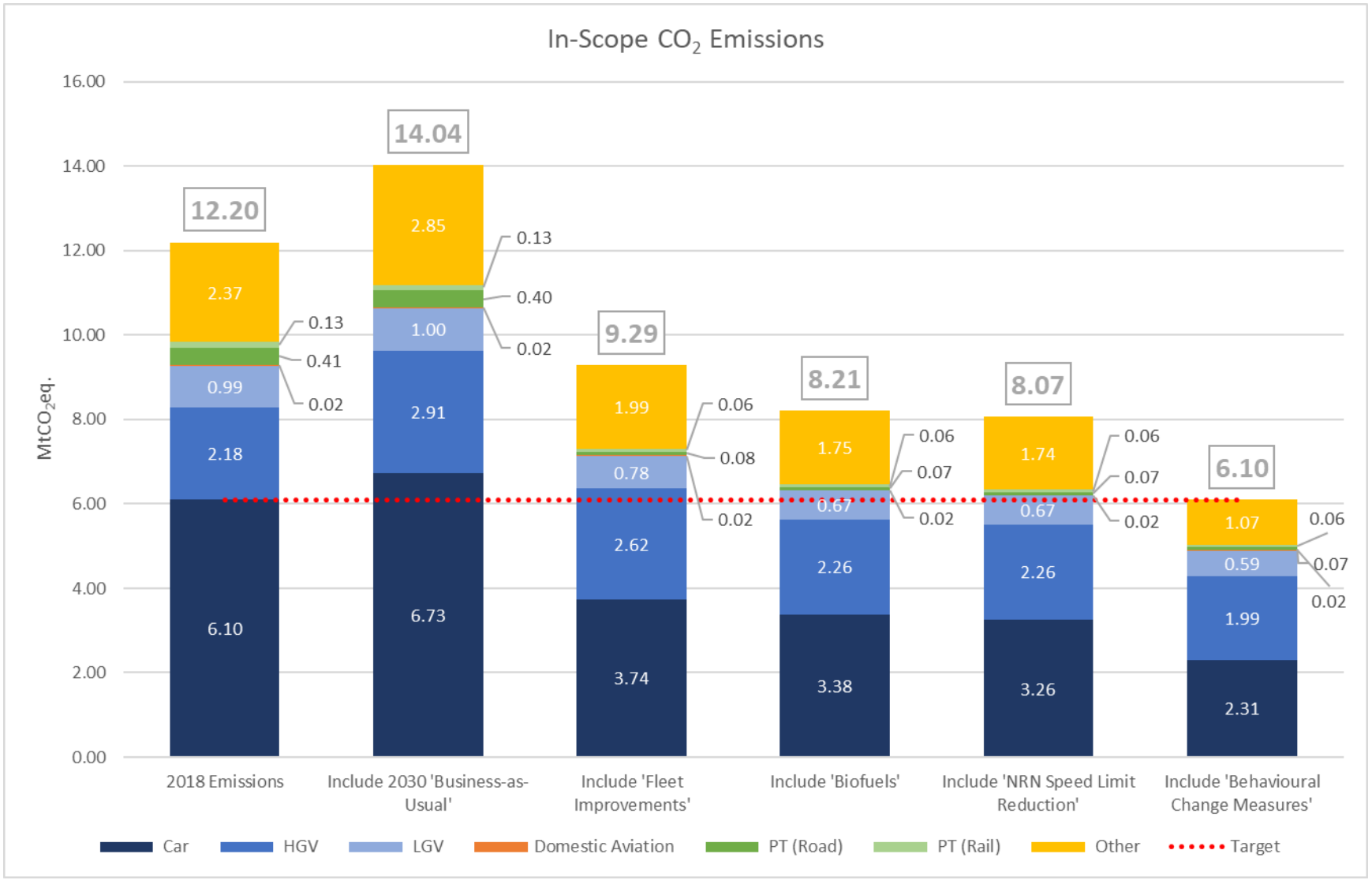
It is noted that only domestic aviation was considered within the transport element of the CAP and is assumed to be unresponsive to any of the measures proposed, hence does not vary throughout the results below.

[16] This has reduced from the 0.214 $MtCO_2eq$. quoted in Section 4.5.2 as the impact of ‘Fleet Improvements’ and ‘Biofuels’ have previously been applied

Table 3 Predicted Reduction in Carbon Emissions 2018-2030 (Pathway to 50% in 2030)

Description	Total Carbon ($MtCO_2eq.$)	Step Increment ($MtCO_2eq.$)	% of 2018 CO_2
2018 Emissions	12.20	-	-
Include 2030 'Business-as-Usual'	14.04	1.84	15%
Include 'Fleet Improvements'	9.29	-4.75	-24%
Include 'Biofuels'	8.21	-1.08	-33%
Include 'NRN Speed Limit Reduction'	8.07	-0.14	-34%
Include 'Behavioural Change Measures'	6.10	-1.97	**-50%**

Figure 5 Predicted Reduction in Carbon Emissions 2018-2030 (Pathway to 50% in 2030)



5.3.2 Trip Making

The Pathway measures outlined above also have an impact on the number of trips and mode share. These changes can be predicted by the modelling and are shown below in Table 4. This indicates that there will need to be a 48% increase in active trips, a more-than-doubling of PT trips (132% increase), and a 24% reduction in cars trips (note that this includes demographics growth, resulting in an overall increase in trips).

Table 4 Daily Journeys and Mode Share 2018 vs Pathway to 50% (in 2030)

	Daily Journeys				Mode Share		
RMS Scenario	**Road**	**PT**	**Active**	**Total**	**Road**	**PT**	**Active**
2018 'Do Nothing'	**9.49m**	**1.09m**	**2.63m**	**13.22m**	**72%**	**8%**	**20%**
2030 RMSDS	7.20m	2.53m	3.89m	13.62m	53%	19%	28%
Forecast Change	-2.29m	+1.44m	+1.26m	+0.40m			
% Change from 2018	-24.1%	+131.7%	+47.7%	+3.1%			

5.4 2025 Pathway Outcome

5.4.1 Carbon Emissions Reduction

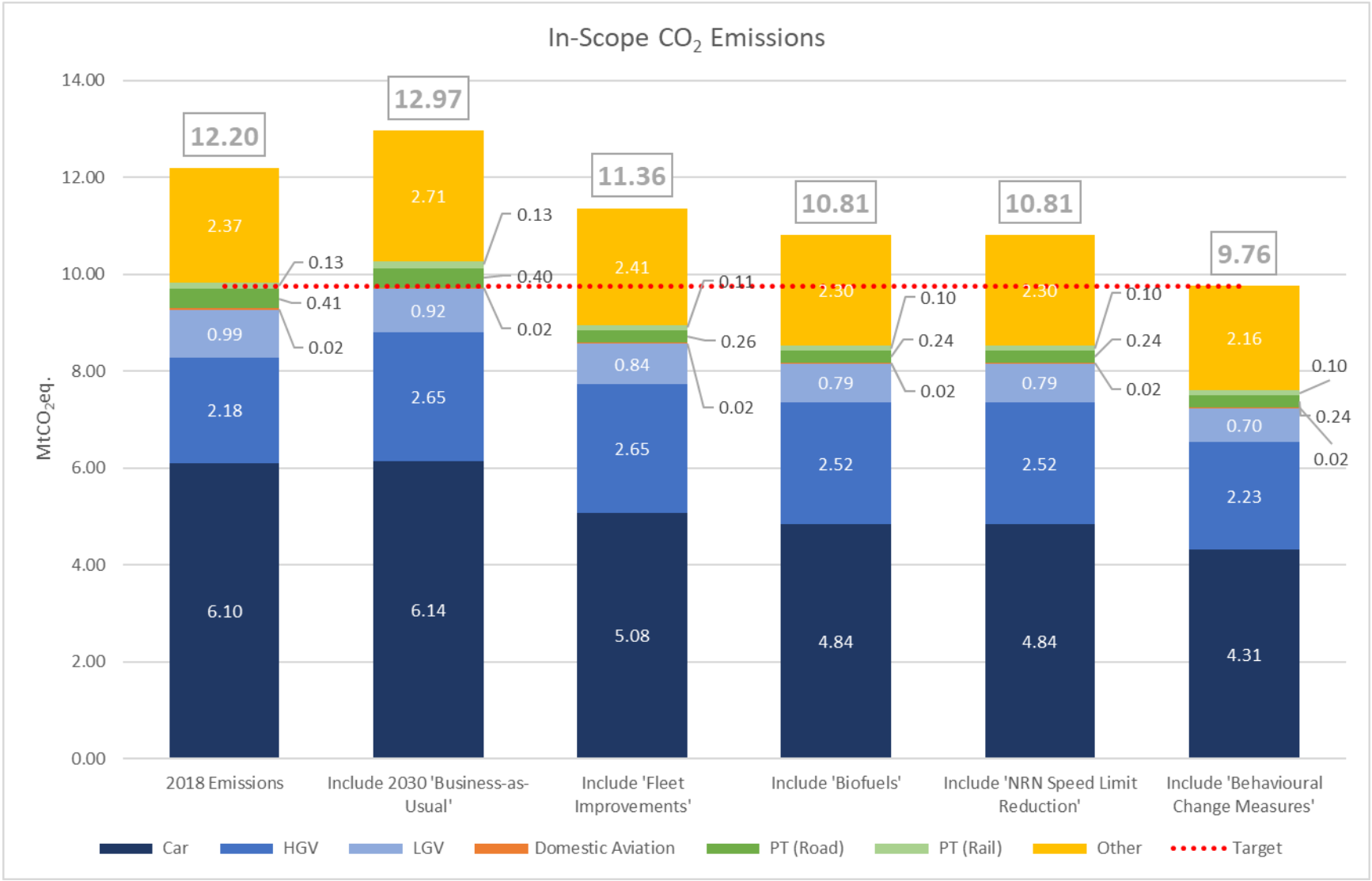
The sectoral emissions ceiling of 54 MtCO2eq. over the period 2021-2025 equates to a target 20% reduction, relative to 2018, in GHG emissions for the intermediate year 2025, i.e., 2.4 $MtCO_2eq$.

From the Phase 3 modelling, the estimated net effect of the Pathway in reducing 2025 carbon emissions is summarised in Table 5 and Figure 6.

Table 5 Predicted Reduction in Carbon Emissions 2018-2025 (Pathway to 50% in 2030)

Description	**Total Carbon ($MtCO_2eq.$)**	**Step Increment ($MtCO_2eq.$)**	**% of 2018 CO_2**
2018 Emissions	12.20	-	-
Include 2025 'Business-as-Usual'	12.97	0.77	6%
Include 'Fleet Improvements'	11.36	-1.60	-7%
Include 'Biofuels'	10.81	-0.55	-11%
Include 'NRN Speed Limit Reduction'	10.81	0.00	-11%
With 'Behavioural Change Measures'	9.76	-1.05	**-20%**

Figure 6 Predicted Reduction in Carbon Emissions 2018-2025 (Pathway to 50% in 2030)



Many of the measures required to achieve the necessary carbon reductions by 2030 are under development but will not be delivered until the latter half of this decade. This includes large-scale uptake of EVs within 'Fleet Improvements', NRN speed limit reductions[17], and the majority of measures that are categorised in 'Behavioural Change Measures' (public transport infrastructure, demand management schemes, and the full impact of public awareness campaigns and working from home).

The National Sustainable Mobility Policy (SMP) Pathfinder Programme[18] was launched in October 2022 and includes 35 projects and activities in 19 counties which are additional to the Pathway to help meet 2025 targets. Many of the projects will incorporate aspects of road space reallocation, shared mobility, rural community-based transport solutions, behavioural change and communications. Among the outputs to be achieved will be improved cycling infrastructure, electrification of bus services, and a refocus on active travel modes in line with the '10-minute town' concept. The SMP Delivery Team will oversee the implementation of the pathfinder projects – all of which must be completed by 2025.

The modelling acknowledges that implementation of measures will be slower up to 2025; therefore, a 65% increase (in real terms) in fuel cost was modelled to achieve the recommended target reduction of 2.4 $MtCO_2eq$. relative to the 2018 baseline. However, the SMP Pathway Programme and other interventions were not considered in the modelling. These proposed projects are anticipated to deliver carbon emissions reductions. Therefore, the final 0.7 $MtCO_2eq$. step increment reduction in carbon emissions may be achieved through the incorporation of additional projects. As a result, the incremental increase in fuel cost could be lower than assumed in the transport modelling.

5.4.2 Trip Making

The measures outlined above for the Pathway in 2025 also have an impact on the number of trips and mode share, as shown below in Table 6. This indicates that there will be an associated 4% increase in active trips, a 2% increase in PT trips, and a 3% increase in car trips (with an overall increase in trips driven by demographic growth).

Note that the RMS does not consider the committed 40% fuel cost increase and the impact that this will have on the number of predicted daily journeys and mode share (the carbon emission estimates in the previous section do take this into account).

[17] Note that the NRN speed limit reductions were not applied as part of the 2025 Pathway modelling. It was assumed these will not be in place by 2025. Therefore, the results in Figure 6 indicate no change from the application of the biofuels measure.

[18] https://www.gov.ie/en/publication/143e3-pathfinder-programme/

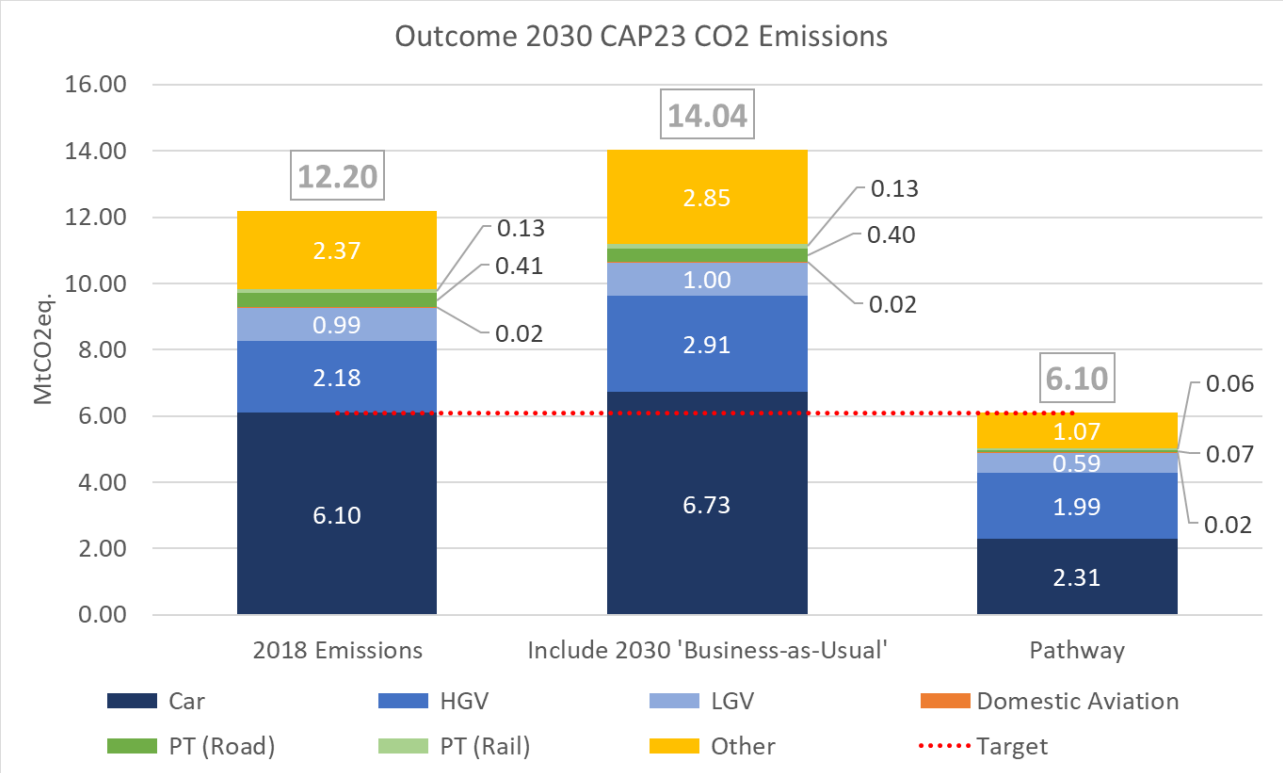
Table 6 Daily Journeys, Mode Share 2018 vs Pathway to 50% (in 2025)

	Daily Journeys				Mode Share		
RMS Scenario	**Road**	**PT**	**Active**	**Total**	**Road**	**PT**	**Active**
2018 'Do Nothing'	**9.49m**	**1.09m**	**2.63m**	**13.22m**	**72%**	**8%**	**20%**
2025 'Do Nothing'[19]	9.76m	1.12m	2.77m	13.62m	72%	8%	20%
Forecast Change	+0.27m	+0.03m	+0.11m	+0.41m			
% Change from 2018	+2.8%	+2.4%	+4.3%	+3.1%			

5.5 Conclusion

The Phase 3 modelling shows that there is a Pathway to reduce emissions by 50% in 2030, as shown below in Figure 7.

Figure 7 Outcome Carbon Emissions 2018 – 2030



[19] No RMS CAP21 scenario is available for 2025 and only a 'Do Nothing' forecast has been prepared, which is limited to demographic growth.

This Pathway is multi-faceted and requires a combination of fleet improvements (including electrification) and greater use of alternative fuels such as biofuels. It also requires change to how, why, and where we travel. People, businesses, transport suppliers, and governments can all contribute to changing these patterns of behaviour. Government policies will focus on the level of change, rate of change, and type of change to influence travel decisions and transport patterns.

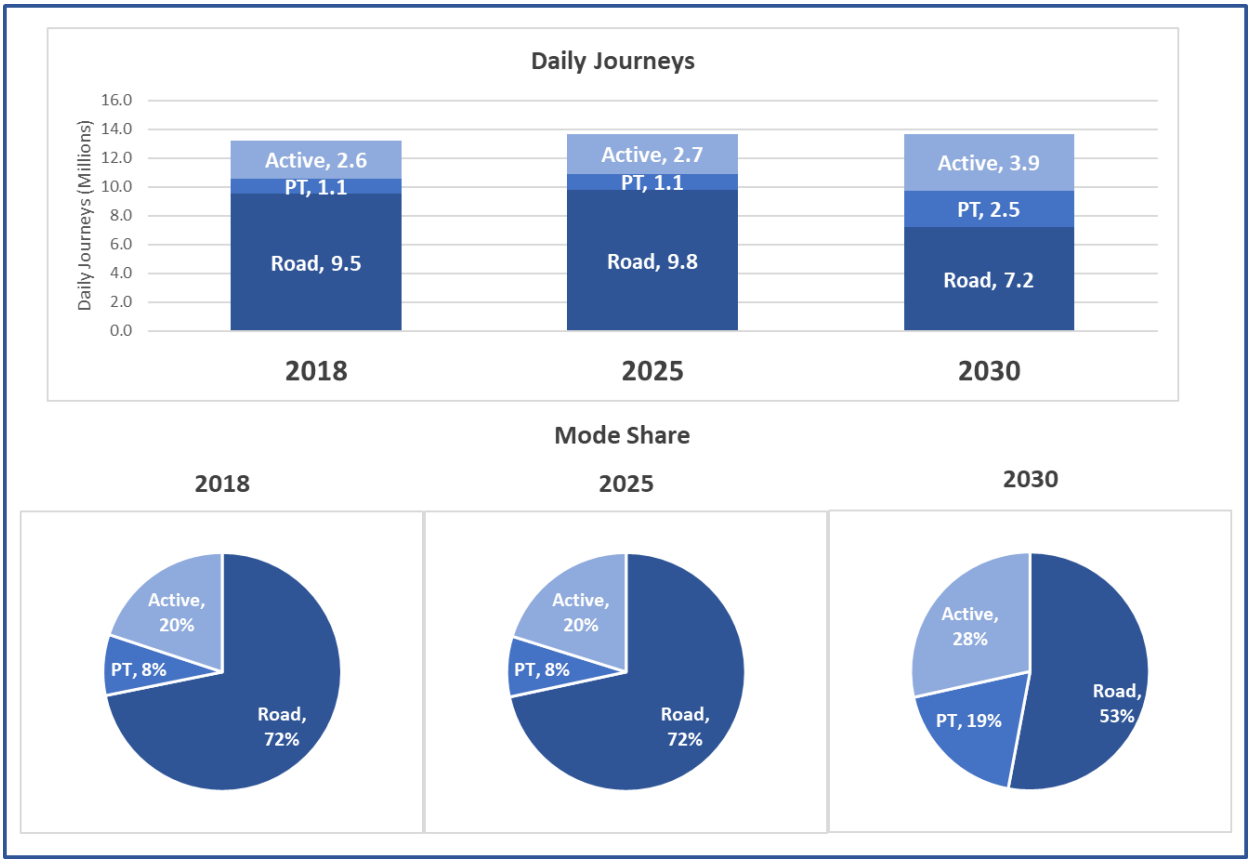
Travel using fossil-fuelled cars must be dramatically reduced to meet the carbon emissions target through a significant number of people choosing to take fewer car journeys and using alternative modes, along with a greater use of electric vehicles.

Based on the analysis conducted for the emerging CAP23, increasing the cost of ICE car use is the most effective way to reduce car trip-making. However, the implementation of other behavioural change measures to provide alternative means of travel and encourage the use of more-sustainable modes of transportation, is also important. Within the proposed Pathway, such measures are assumed to be implemented in combination.

As part of the proposed package of behavioural change measures, there is a strong focus on improving the level of service by walking, cycling, and public transport as a means of encouraging the necessary shift away from private, fossil-fuelled car trips.

The impact of the Pathway measures on the number of daily journeys travelled and on mode share can be seen below in Figure 8. Overall, the Pathway measures will have the effect of reducing daily car journeys and significantly increasing active and public transport trips. This will lead to around a 20% drop in car mode share by 2030.

Figure 8 Daily Journeys & Mode Share 2018, 2025 and 2030 Pathway to 50%



Abbreviations and Acronyms

Key abbreviations and acronyms used through the Climate Action Plan assessments are defined as follows:

- **BEV** - Battery electric vehicles;
- **CFT** – Carbon Footprinting Tool;
- **DoT** – Department of Transport;
- **EPA** - Environmental Protection Agency;
- **EV** – Electric road vehicles;
- **ICE** – Internal Combustion Engine;
- **GHG** – Greenhouse Gases;
- **HGV** – Heavy goods vehicle, consisting of both fixed and articulated vehicles;
- **km** – kilometre;
- **LGV** – Light goods vehicle;
- **MtCO_2eq.** – Megatonnes of Carbon Dioxide and equivalent other gases;
- **NTA** – National Transport Authority;
- **PHEV** - Plug-in hybrid electric vehicles;
- **RMS** – Regional Modelling System;
- **RMSDS** – Regional Modelling System Decarbonisation Scenario; and
- **SEAI** - Sustainable Energy Authority of Ireland.

Definitions

Key terms used through the Climate Action Plan assessments are defined as follows:

- **Measure(s)** – Item(s) tested in the modelling for their effectiveness in terms of achieving car km travelled and/or emissions reductions, primarily with respect to the Behavioural Change emissions package;
- **Package –** A collection of measures modelled together in the Carbon Footprinting Tool. There are three packages: ‘Fleet Improvements’; ‘Biofuels’; and ‘Behavioural Change Measures’;
- **Pathway** –Term used to denote the set of measures that aim to achieve the transport system decarbonisation objective, hierarchically built up from the proposed measures;
- **Scenario** – This term is used to refer to a Regional Modelling System run that is composed of a specific set of assumptions in terms of demand (planning data, etc.) and supply (networks); and
- **Just Transition** – Transition to climate neutrality that puts people first, and pays attention to the regions, industries and workers who will face the greatest challenges.

The term ‘Electric Vehicle’ (EV) collectively refers to different types of vehicle that can be powered by an electric motor, drawing power from a battery. Given the importance of electric vehicles within the assessment of fleet improvements on carbon emission reductions, the following terminology has been adopted throughout this report:

An Electric Vehicle in this report is defined as a vehicle that uses one or more electric motors for propulsion. These come in multiple forms, including:

- **Battery Electric Vehicle (BEV)**, which operate solely off a battery and have no Internal Combustion Engine (ICE);
- **Plug-in Hybrid Electric Vehicle (PHEV)**, which can run on either a battery or an ICE, but critically the battery can be charged via a cable (plugged in); and
- **‘Other’**, including mild hybrids and full hybrids which cannot be charged via a cable

The term ‘Plug-in Electric Vehicle’ includes BEVs and PHEVs, but excludes the ‘other’ category.

Údarás
Náisiúnta Iompair
National **Transport** Authority

National Transport Authority
Dún Scéine
Harcourt Lane
Dublin 2

Údarás Náisúnta Iompair
Dún Scéine
Lána Fhearchair
Baile Átha Cliath 2

Tel: +353 1 879 8300
Fax: +353 1 879 8333

www.nationaltransport.ie

Project Ireland 2040
Building Ireland's Future

No. XXXXXXXX