Irish Climate Policy Evaluation Project

EPA Research Project 2017-CCRP-DS.12

Evaluation of climate change mitigation policies in Ireland's transport sector

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1. Introduction

The Irish Climate Policy Evaluation (ICPE) project was funded by the EPA (2017-CCRP-DS.12). The aim of the project was to undertake an *ex post* evaluation of Ireland's policy response to climate change across all sectors since 1996. As an exercise in ex post evaluation, the ICPE project focused on policies and measures already in place at the commencement of the project. Our first ports of call were the NMP, the NAF and data submitted by Ireland under the EU's Monitoring Mechanism Regulation [(EU) No. 525/2013/EU], which requires Member States to report on policies and measures they have adopted to reduce GHG emissions and adapt to climate change. Those policies listed as planned or implemented only in 2017 or 2018 in the NMP were excluded from our analysis. Moreover, policies and measures announced as part of the National Development Plan or the Climate Action Plan fell outside the scope of our analysis.

The project technical description called for an evaluation of "effectiveness, efficiency, coherence and relevance. The evaluation framework utilised should align with standard evaluation criteria and procedures used in ex-post evaluations of EU policies". Accordingly, the ICPE project incorporated the standard criteria of effectiveness, efficiency, coherence and relevance, but, importantly, added two additional criteria: "governance" and "distributional impact". Because of the diverse set of criteria that spans both process and outcome dimensions, the project drew on a diverse set of qualitative and quantitative data and sought to triangulate from multiple sources where possible.

We divided our research into five sectoral work packages. For each of the five work packages, our research commenced with a comprehensive mapping exercise drawing on a wide range of data sources. This was used to produce a sectoral overview that detailed policies in place and undertook an initial evaluation according to the six criteria above. This overview was then presented at a workshop of invited sectoral stakeholders: policymakers from across relevant government departments and public bodies, business, civil society and academia. Input and feedback were sought at these workshops on the research to date as well as on areas suitable for further research.

This document presents the findings of our research on climate change mitigation policies in the transport sector. Section 2 provides a broad overview of the sector in terms of emissions trends and sources within the sector, and also places Ireland in comparative perspective. Section 3 presents existing climate change mitigation actions and measures in the transport sector, classifying them according the instrument type. Section 4 provides a sector-wide evaluation of the actions and measures against six evaluation criteria: effectiveness, efficiency, coherence, relevance, distributional impact, and governance. Section 5 presents a case study evaluation of the suite of supports for deployment of electric vehicles. Finally, Section 6 concludes by developing recommendations based on the evaluations conducted.

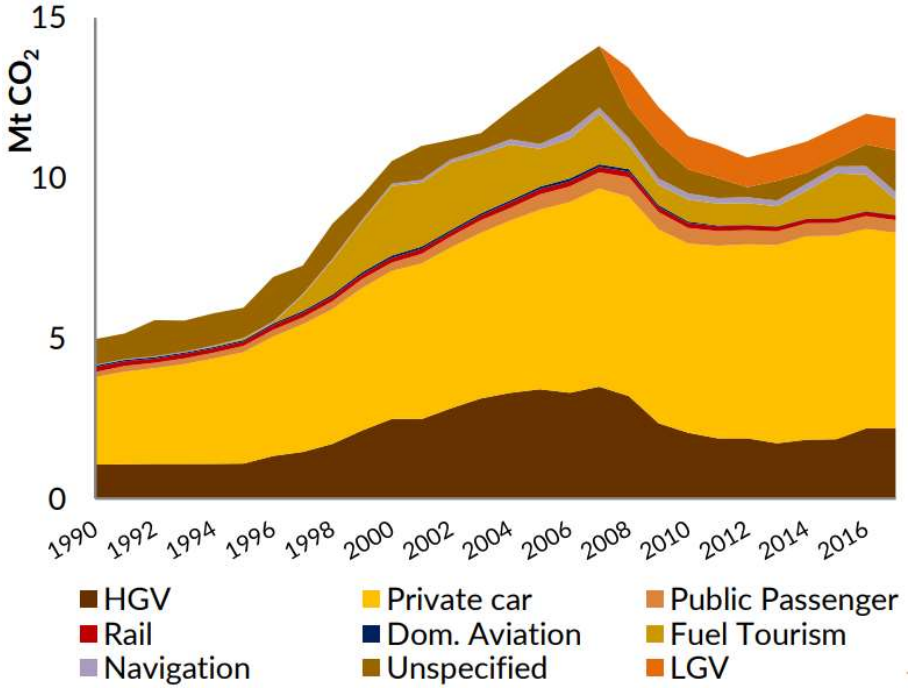
2. Sectoral overview

Between 1990 and 2018, greenhouse gas emissions (GHGs) from transport increased by 137.1 percent—more than any other sector in the national inventory—with emissions from road transport increasing by 143.4 percent. Emissions from transport peaked in 2007 at 14,406 MtCO2eq, 180 percent above 1990 levels. Following a sharp decline during the economic crisis, emissions increased each year for the four years between 2012 and 2016. Emissions were largely flat over the subsequent two years (EPA 2019b).

Under the EPA's "With Existing Measures" scenario, transport emissions are projected to increase by 8 percent over the period 2018–2020, and by 11 percent over the period 2018–2030. Under the "With Additional Measures" scenario, transport emissions are projected to increase by 6 percent over the period to 2020, and by 1 percent over the period to 2030 (EPA 2019a). From a policy perspective, tackling transport emissions is critical because transport falls within the scope of Ireland's EU Effort Sharing target.

In terms of the sectoral distribution of emissions, road transport accounts for the majority of CO_2 emissions from the transport sector (DTTAS 2019). Within this, private car use accounted for 51% in 2017, while goods vehicles accounted for 27%. Fuel tourism is another significant contributor to sectoral CO_2 emissions. 10% of Ireland's transport emissions in 2016 were accounted for by fuel purchased in the jurisdiction but consumed elsewhere, mostly in Northern Ireland (DTTAS 2018c). Figure 1 shows the composition of Ireland's transport CO_2 emissions over time. It illustrates the cyclical nature of transport emissions, reflecting the fact that emissions from this sector remain strongly coupled with economic growth.

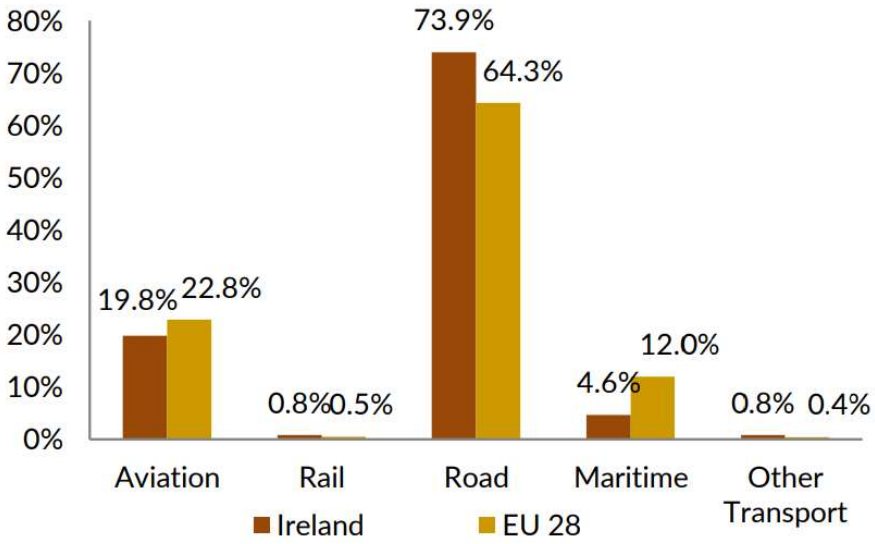
Figure 1: Transport CO2 emissions by mode, 1990–2017



Source: DTTAS (2019)

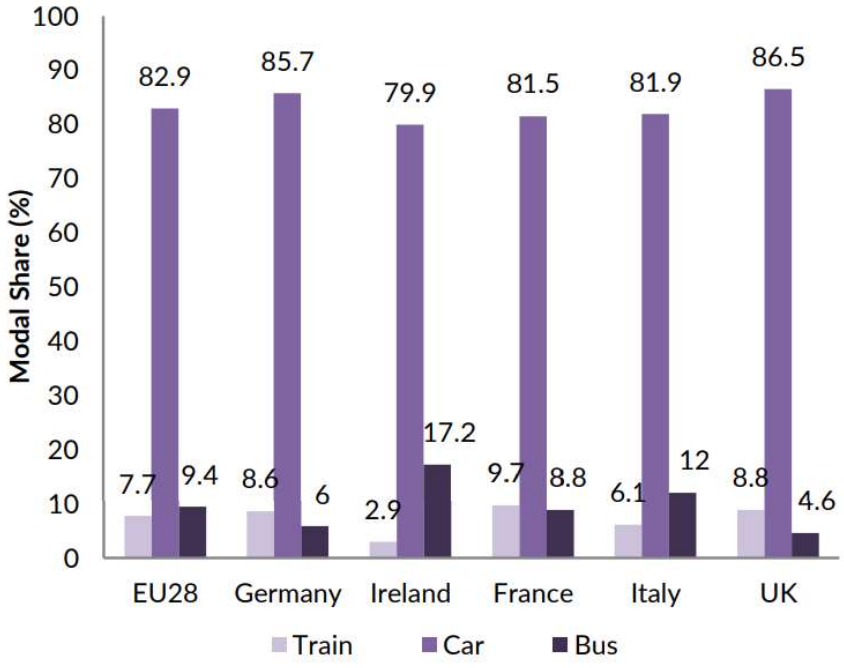
In a comparative European perspective, Ireland's CO_2 emissions from transport have grown much faster than the EU28 average since 1990. EU28 transport emissions (including aviation but excluding international shipping) grew by 28% between 1990 and 2017, whereas Ireland's transport emissions grew by 149% over the same period (EEA 2019). This was driven by Ireland's strong economic growth between 1990 and 2007. It is also important to note that Ireland's return to growth in transport emissions since the crisis mirrors a wider EU trend. Since 2013, EU28 transport emissions have been increasing as well (EEA 2019).

Figure 2: Emissions share by transport sector, Ireland and EU28, 2017



Source: DTTAS (2019)

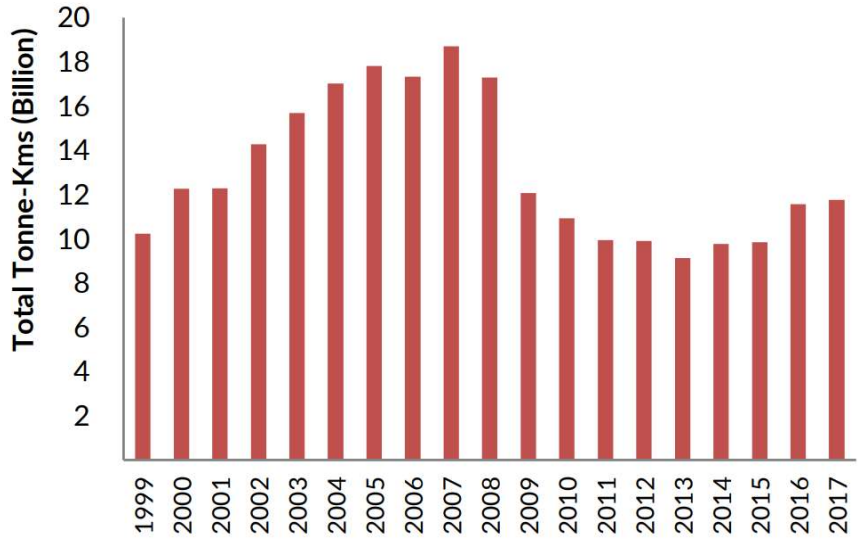
Figure 3: Land transport passenger-km modal share, 2016



Source: DTTAS (2019)

Figure 2 shows the breakdown of transport emissions in Ireland compared to the EU28 in 2017. It shows Ireland's road-based emissions as a share of total transport emissions, at 74 percent, are a higher share of than the EU28 average of 64 percent. Figure 3 provides a comparative European perspective on land transport passenger km by modal share. This shows that Ireland's share of land transport passenger km by car (80 percent) is broadly in line with the EU28 average. It also shows that rail is significantly lower, but bus is significantly higher, than the EU28 average.

Figure 4: Total road freight tonne km, 1999–2017



Source: DTTAS (2019)

As discussed above, goods vehicles (HGV and LGV) accounted for 27 percent of Ireland's transport emissions in 2017. Figure 4 shows total road freight measured in tonne km since 1999. Not surprisingly, the trend closely follows the economic cycle. Of particular note, there was a 17% increase between 2015 and 2016, though overall the figure remains well below the peak of 2007 (DTTAS 2019).

Aviation and maritime emissions are not a central focus of this study due to the fact that these emissions sources are dealt with through other European and/or global policy mechanisms. Emissions from aviation within the EEA are covered under the EU Emissions Trading Scheme (ETS), while other international aviation emissions are covered under a recent global agreement concluded within the framework of International Civil Aviation Organization. Maritime emissions are being addressed within a process under the auspices of the International Maritime Organization.

3. Actions and measures in place

Ireland has committed to a decarbonisation target of 80 percent, relative to 1990 levels, by 2050 across electricity generation, the built environment and transport, and an approach to carbon neutrality in the agriculture and land use sector (Government of Ireland and Department

of Communications 2014). The vision for the sector, as defined in the National Mitigation Plan (DCCAE 2017b, 94), is as follows:

> Moving to a low carbon society represents a significant challenge for Ireland's expanding transport sector where the use of fossil fuels is firmly embedded in driving culture. To address the challenge of transitioning from conventionally fuelled vehicles to alternative fuels and technologies an ambitious national target was established whereby all new cars sold in Ireland will be zero carbon emission or zero emission-capable by 2030 as well as many of our public transport buses and rail lines. The ultimate aim is to decarbonise the national passenger car fleet by 2050 and increase the use of alternative fuels in the freight sector.

Smarter Travel—A Sustainable Transport Future is the most recent overarching government transport policy document (DTTAS 2009). Published in 2009, it set out a vision for transport to 2020 centred on the following key goals: (i) to reduce overall travel demand; (ii) to maximise the efficiency of the transport network; (iii) to reduce reliance on fossil fuels; (iv) to reduce transport emissions; and (v) to improve accessibility to transport.

The *Smarter Travel* strategy set several quantitative targets to be met by 2020, including: total share of car commuting would decline from 65% to 45%; alternative modes such as walking, cycling and public transport would rise to 55%; total kilometres travelled by the car fleet in 2020 would not increase significantly; and GHG emissions from transport would be reduced relative to 2005. The most recent data indicate that, of these four targets, the only one that may be met is the GHG emission target, though it is too early to say with certainty. The economic crisis, which was not fully foreseen at the time of publication of the strategy, severely constrained investment in the transport sector in the period since 2009.

Table 1: Types of policy instruments reported in EEA PaMs database[1]

Type of instrument	Number of instruments	Target group
Regulatory	3	Various
Economic or fiscal	4	Private Sector (SMEs) and individuals
Information/ Education	2	Private Sector (SMEs) and individuals

Source: EEA Policies and Measures database

[1] We have combined legislative with regulatory and financial includes both economic and fiscal incentives. Because of the backward-looking nature of this project, we exclude instruments listed in the PaMs database as "planned". We have also excluded from the table above one instrument dealing with aviation, because this is outside the immediate scope of this project.

Ireland reports on climate change policies and measures on a biannual basis under the EU Greenhouse Gas Monitoring Mechanism Regulation (MMR)(525/2013). Table 1 above provides overview information on policies and measures listed according to type of instrument and target group. Under the MMR requirements, member states are required to report on *ex post* policy impacts as well as realised costs and benefits of policies and measures "where available". In common with a majority of member states, Ireland has not reported this data for any PaMs reported under the MMR (European Environment Agency 2018, 27).

The rest of this section provides a narrative overview of existing policies and measures to mitigate climate change in the transport sector. It draws on a variety of sources, including the National Mitigation Plan (DCCAE 2017b) and the 4th National Energy Efficiency Action Plan (DCCAE 2017a).

3.1 Regulation

The principal regulatory measures employed in the transport sector include EU regulations that govern average emission performance of vehicles and the Biofuels Obligation Scheme.

EU Regulation 443/2009 set CO_2 emission performance standards for new passenger cars. The regulation stipulated that, by 2015, the average CO_2 emissions for all new passenger cars registered in the EU would be less than 130g CO_2/km. It further stipulated that, by 2021, average fleet emissions for new cars should not exceed 95g CO_2/km. These 2015 and 2021 targets represent reductions of 21% and 42% with respect to the 2007 new passenger car fleet average emissions. Under EU Regulation 510/2011, standards have also been put in place for new light commercial vehicle fleets. This regulation set average fleet emission limits of 175g CO_2/km by 2017 and 147g CO_2/km by 2021. This latter target is 19% less than the 2012 average. In April 2019 the Council of Ministers and European Parliament agreed new CO2 emission standards for vehicles for the period to 2030. Under these new standards, emissions from new cars are required to be 37.5 percent lower than 2021 levels by 2030, and emissions from new vans are required to be 31 percent lower (European Commission 2019).

As a result of the "Dieselgate" scandal, a new system of vehicle testing, the Worldwide Harmonised Light Vehicles Test Procedure, is due to be introduced in the near future. Recent research by the European Commission suggests that, on average, CO_2 values for passenger cards will increase by 21%, but that lower emitting cars are expected to increase by up to 41% whereas the highest emitting cars are not expected to increase significantly (Tax Strategy Group 2018).

The Biofuels Obligation Scheme (BOS) aims to progressively increase the share of biofuels in the fuel mix over time. Under Article 3 of the Renewable Energy Directive (2009/28/EC), member states are required to "ensure that the share of energy from renewable sources in all forms of transport in 2020 is at least 10% of the final consumption of energy in transport". The Energy (Biofuel Obligation and Miscellaneous Provisions) Act 2010 underpins the BOS, which is administered by the National Oil Reserves Agency (NORA). The Scheme requires that road transport fuel suppliers must ensure that biofuels represent a certain percentage of the

motor fuel they place on the market. Fuel suppliers receive one certificate for each litre of biofuel placed on the market, and two certificates if the biofuel is produced from sustainable materials such as biodegradable waste, residue, non-food cellulosic material, ligno-cellulosic material, or algae. The obligation was increased on 1 January 2019 from 8.695 percent to 11.111 percent by volume.

A policy statement published by DCCAE in April 2018 signalled the Government's intention to continue the Biofuels Obligation Scheme until at least 2030, with progressive increases in the level of obligation (DCCAE 2018). The Policy Statement also committed to updating the relevant legislation in line with EU developments, including the Indirect Land Use Change Directive and the recast Renewable Energy Directive.

3.2 Economic and fiscal instruments

A range of economic and fiscal instruments are employed in the transport sector to facilitate low carbon transition, including the carbon tax, preferential treatment of lower emission vehicles through the VRT and motor tax regimes, and supports for electric vehicles (see section 5 for a fuller discussion).

The Carbon Tax was introduced in December 2009 and aims to disincentivise high-emitting activities through a price mechanism. Initially it applied only to motor fuels. In 2010 it was extended to other non-solid fuels, and was extended to solid fuels in 2013 and 2014. It applies to emissions from burning petrol, auto-diesel, kerosene, marked gas oil, liquid petroleum gas, fuel oil, natural gas and solid fuels, including peat and coal, but does not apply to the ETS sector. As such, it is a cross-cutting policy instrument that applies to the transport sector as well as other sectors of the economy. The Carbon Tax was increased in Budget 2020 from €20 per tonne of CO_2 to €26 per tonne. The Carbon Tax constitutes a relatively small share of the overall excise rate applied to petrol and diesel (Tax Strategy Group 2018).

Consumers are disincentivised from high-emitting transport through the Vehicle Registration Tax (VRT) and Motor Tax regimes. These were reconfigured in 2008 to support reducing CO_2 emissions. The (VRT) rate applicable to new cars registered on or after 1 July 2008 was changed from engine capacity to CO_2 emissions. A seven-band system—A to G—was introduced. In 2013, this banding system was revised, splitting A (1–120g CO_2/km) into four bands and B (121–140g CO_2/km) into two bands (DCCAE 2017a, 50). Since 2008, Motor Tax is also charged according to CO_2 emissions rather than engine capacity.

Budget 2019 introduced a 1 percent surcharge on VRT to be levied on all new diesel cars, as well as diesel cars imported into the country. Budget 2020 replaced this 1 percent levy with a NO_X emissions based charge from January 2020. This is levied at €5 per mg/km for the first 60mg/km, €15 per mg/km for the next 20mg/km, and €25 per mg/km above 80mg/km. The NOx charge is capped at a maximum of €4,850 for diesel vehicles and €600 for other vehicles.

Consumers are incentivised in the purchase of EVs through grants as well as favourable treatment through the VRT and Motor Tax regimes. The EV Grant Scheme, administered by

SEAI, provides consumers with a grant of up to €5000 towards purchase of a new EV. EVs also qualify for €5000 relief from VRT. Additionally, ESB committed to installing free home charge points for the purchasers of new EVs that qualified for the SEAI grant for EVs. This scheme involved the installation of 2,300 home chargers, and concluded at the end of 2017. Since the beginning of 2018, SEAI is responsible for administering a grant of up to €600 available to home owners to install a home charging point.

There are also financial incentives for businesses to purchase lower emission vehicles. The Accelerated Capital Allowance (ACA) is a tax incentive scheme that promotes investment in energy efficient products & equipment, and specifies technical standards to be met by products eligible for ACA. The scheme allows for the write off of the capital cost in year 1 rather than over the standard 8 year period (Tax Strategy Group 2018). The Finance Act 2013 added natural gas vehicles and associated equipment and natural gas vehicle conversions to the ACA Scheme for Energy Efficient Equipment.

3.3 Information and education

A range of programmes have been established to promote low carbon and sustainable travel through education programmes. These include the Green School Travel programme, the Smarter Travel Workplaces Programme, and the Smarter Travel Campus programme. Other initiatives such as the Smarter Travel Areas pilot programme include an education/behaviour change component as part of the overall programme, though most of the funding was targeted at infrastructure investment (Aecom 2015).

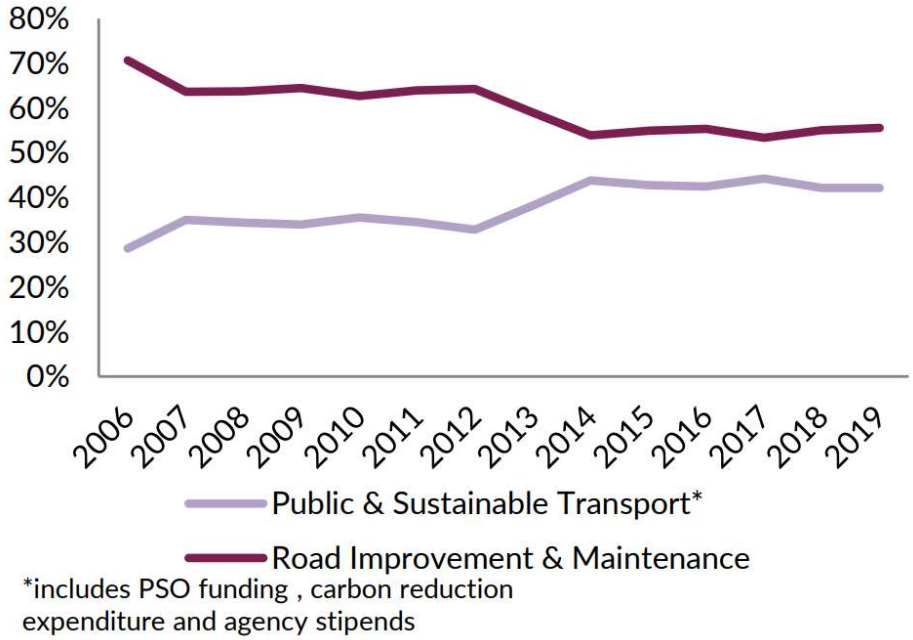
The Green School Travel Programme has been in existence since 2008. Travel is one theme in the wider Green Schools programme, which is run by An Taisce in conjunction with local authorities. The travel theme is funded by DTTAS, with funding provided by NTA to An Taisce. Average annual expenditure between 2008 and 2012 was €1.7 million. The aim of the programme is to achieve and sustain a shift from reliance on private car for school transport, as well as to increase the reach and scope of the programme (DTTAS 2015a).

The Smarter Travel Workplaces Programme is operated by the NTA on behalf of DTTAS. The Programme has projects in 125 of the largest workplaces in Ireland, including companies such as the ESB, Dell, Pfizer and major universities and hospitals. The Programme involves the development of a Workplace Travel Plan for an organisation, which is a package of measures aimed at supporting sustainable travel for work-related journeys. This Plan comprises actions to promote sustainable modes of commuting including walking, cycling, public transport, car-sharing, the use of technology instead of travel, and flexible working practices. Within the framework of the Smarter Travel Workplaces Programme, the Smarter Travel Campus Programme engages with third level institutions sustainable and cost-effective travel habits among students, employees and visitors.

3.4 Investment

Between 2005 and 2019, roads expenditure accounted for an average of 60% of DTTAS expenditure on land transport, with public accounting for 37%. This gap has narrowed in recent years as show in Figure 5, but this took place in a context of a sharp decline in overall expenditure on land transport (Figure 6). In 2018 the spending allocation is made up of 55% on roads and 42% public transport and the PSOs (DTTAS 2019, 4). Figure 6 shows that, with the exception of a few years in the early to mid-2000s, Ireland's expenditure on land transport has been below the OECD average in terms of share of GDP (DTTAS 2018c).

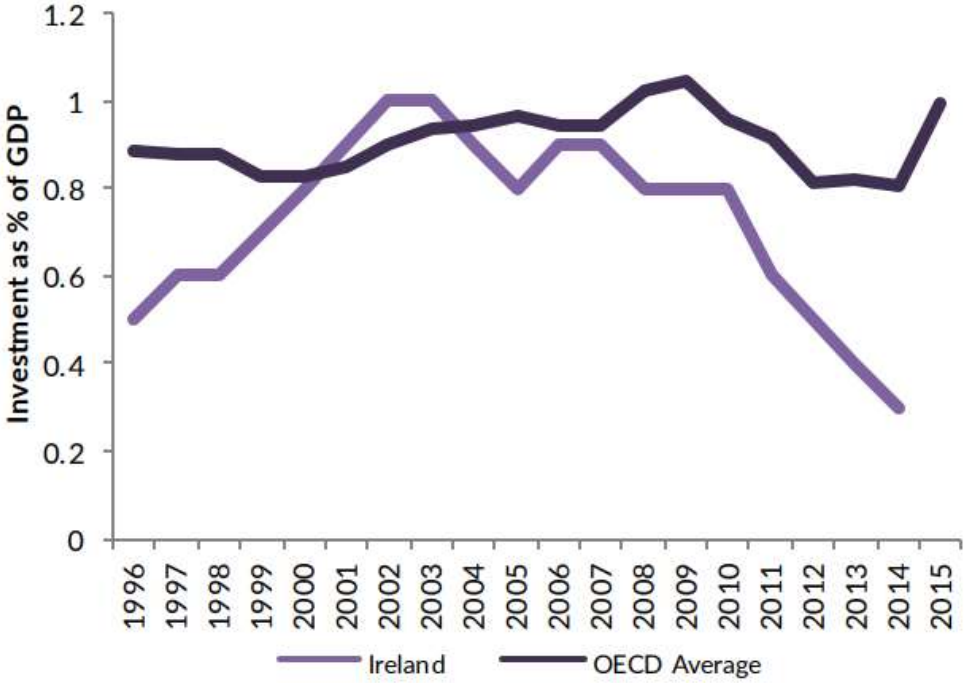
Figure 5: Share of gross DTTAS land transport expenditure, 2006–2019



Source: DTTAS (2019)

The Government's Strategic Investment Framework for Land Transport, *Investing in our Transport Future*, estimates the "steady state" level of funding required to maintain existing transport infrastructure at €1.6 billion per annum. It argues that capital investment in land transport should be restored to and maintained at 1.1–1.15% if GDP per annum, but also notes that "significant additional investment in transport infrastructure identified as necessary to meet the transport sector's share of Ireland's carbon reduction commitments and adapt to new climate conditions would require a review of this target" (DTTAS 2015b, 24). The Strategy sets out three priorities to guide investment: (i) achieving steady state maintenance; (ii) addressing urban congestion; and (iii) maximising the contribution of land transport networks to national development. It is notable that consideration of climate change is often implicit rather than explicit in this strategy.

Figure 6: Investment in inland transport infrastructure as % of GDP, 1996–2015



Source: DTTAS (2018c, p 8)

The impacts of the crisis constrained investment in transport infrastructure in recent years, though there have been some investment projects. The Luas Cross City project commenced in June 2013 and was completed in 2017, at a cost of €368 million. The Smarter Travel Areas pilot investment programme was launched in 2012 with the objective of piloting a range of sustainable travel measures aimed at promoting modal shift from private car to sustainable transport modes such as walking and cycling. Following a competitive bidding process, three demonstration towns/cities were selected: Limerick, Dungarvan and Westport. The pilot investment programme ran from 2012 to 2016 and involved expenditure of €21.2 million across the three demonstration locations. In all three cases a majority of the funding was spent on infrastructure development, with the remainder spent on behavioural change initiatives, though the balance between these priorities varied across the cases. *Ex post* evaluation was included in the programme design, and Aecom, a consultancy, was commissioned to undertake the evaluation. An interim evaluation was published in 2015 (Aecom 2015), and a final evaluation was published in November 2019 (Aecom 2019).

With respect to the charging infrastructure for electric vehicles, ESB has rolled out a national charging infrastructure through its "ecars" programme. There are 1,110 public charge points installed across the island of Ireland, which includes 300 charging points in Northern Ireland. Additionally, there are more than 70 fast chargers in the Republic of Ireland, primarily installed at service stations to facilitate longer journeys between major towns and cities (ESB 2018a). Additionally, ESB committed to installing free home charge points for the purchasers of new EVs (see section 3.2 above). This scheme involved the installation of 2,300 home chargers, and concluded at the end of 2017. The *National Policy Framework on Alternative Fuels*

Infrastructure for Transport in Ireland - 2017 to 2030 indicates that the existing charging infrastructure is considered adequate for a projected 20,000 EVs by 2020, and that any deployment of additional infrastructure should be driven by market demand (DTTAS 2017a). A Green Public Transport Fund of €2.5 million was established in 2017 to support pilot demonstrations of emerging low emission technologies, particularly buses and also focusing on taxis (DCCAE 2017a, 52). In October 2019, ESB announced the introduction of pricing for electricity delivered through the public charging network on a phased basis, commencing in November 2019 (ESB 2019).

4. Evaluation of climate mitigation policies in the transport sector

The EPA Project Technical Description stipulates an evaluation of "effectiveness, efficiency, coherence and relevance. The evaluation framework utilised should align with standard evaluation criteria and procedures used in ex-post evaluations of EU policies". The project builds on these guidelines by using an evaluation framework that incorporate the Effectiveness, Efficiency, Coherence and Relevance criteria, but also adds two additional criteria: "Governance" and "Distributional impact". The discussion below provides an initial, high-level evaluation of Ireland's climate change mitigation policies in the transport sector according to these criteria.

4.1 Effectiveness

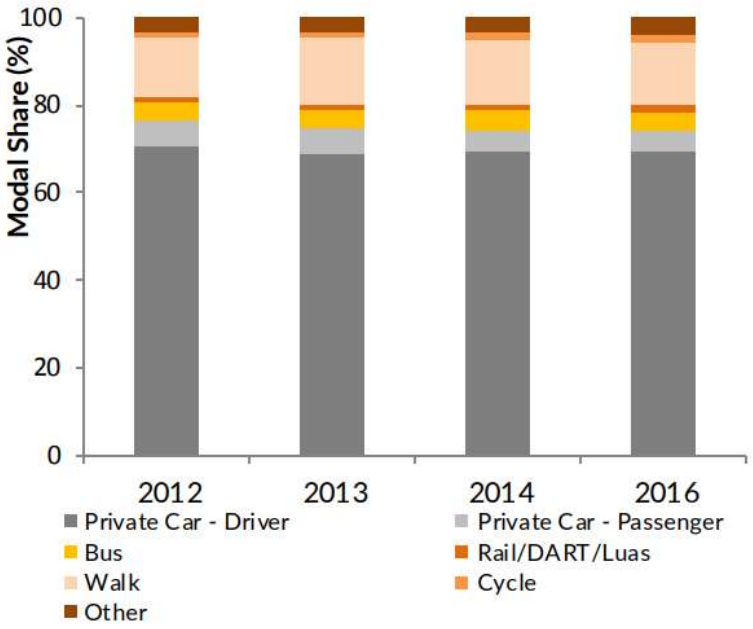
Measuring effectiveness of policy interventions at a sectoral level poses conceptual and methodological challenges. First, what should be the metric of success? In the case of climate change mitigation measures, it seems reasonable to adopt as the ultimate measure of success a reduction in greenhouse gas emissions, though we could also assess effectiveness in respect of intermediate goals, such as for example modal shift. Second, it is not clear against what benchmark effectiveness should be assessed. This would not be a problem if there existed a sectoral pathway towards the 2050. Although the National Policy Position sets a decarbonisation goal of 80% by 2050 relative to 1990 levels, it does not establish a pathway towards achievement of that goal, as the Climate Change Advisory Council has noted (CCAC 2018). Such a pathway might, for example, set intermediate 5 or 10 year sectoral goals. The 2019 Climate Action Plan (DCCAE 2019) committed to introduction of carbon budgeting as part of a substantial revision to the 2015 Climate Action and Low Carbon Development Act. In January 2020 the General Scheme of the Climate Action Amendment Bill was published (DCCAE 2020), but the Dáil was dissolved two days after its publication.

Absent a sectoral emissions pathway, it is difficult to know against which benchmark to assess the effectiveness of policies in the transport sector. The absence of clarity regarding the overall benchmark for progress is compounded by the difficulty of establishing a robust counterfactual scenario—i.e., what would have happened to GHG emissions in the transport sector absent any policy intervention. This is challenging even at the level of individual policies, but it is particularly so if an evaluation is conducted at a sectoral level. What is not in doubt, however, is that GHG emissions in the transport sector have risen significantly over the period since 1990, that they have continued to rise as the economy has recovered over recent years, and that

a continuation of this trend is, on any reasonable assessment, incompatible with the National Policy Position on climate change.

O'Mahony et al. (2012) undertook a decomposition analysis of emission trends in the transport sector (along with other sectors). They report that, over the period 1990–2007, that the scale effect is the dominant driver of the overall growth in transport emissions, but that increasing energy intensity of private cars was also a significant driver. Note that this is prior to the recalibration of the VRT and motor tax regimes. They report that increasing engine size and decreasing occupancy rates drove this increase in energy intensity per passenger-km. Regarding road freight, they find that a scale effect combined with a structural share effect to drive emissions: incremental increases in freight were handled by road rather than rail, and there was also a modal shift towards road in existing freight. Growth in rail emissions was the only transport sector in their analysis that fell within the Kyoto target of +13%. Growth was driven by a scale effect that was limited by significant efficiency improvements over the period.

Figure 7: Modal share of all journeys, 2012–2016



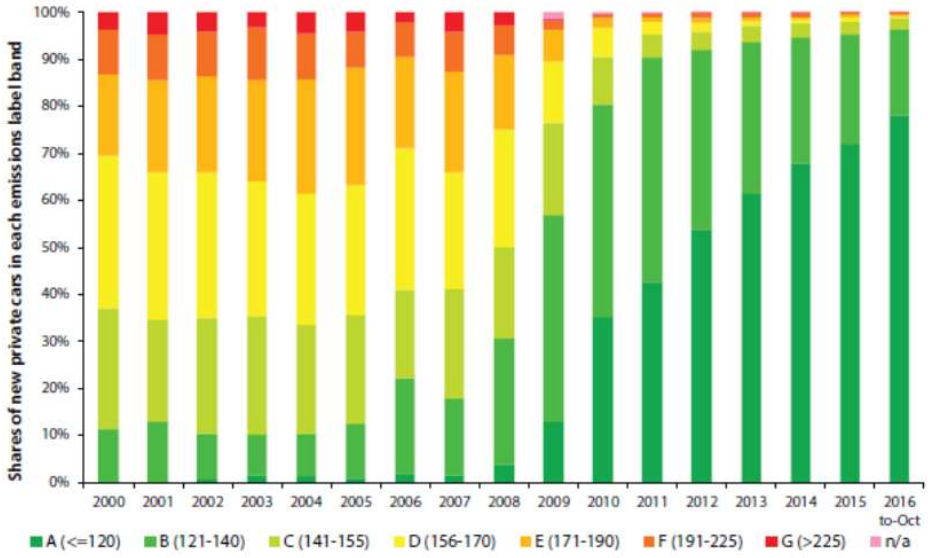
Source: DTTAS (2018c)

Drilling down, we can attempt to evaluate the effectiveness of policies against an intermediate policy goal, such as modal shift. Figure 7 shows the modal share for all passenger transport over the period 2012–2016. Overall the patterns are stable over this time period with a heavy dominance of private car based transport, though there has been a slight decline in the share of private car - driver, from 70.4% in 2012 to 69.4% in 2016. Walking remains the second most popular mode of transport at 14.6% of all journeys in 2016, while cycling has increased slightly from 1.2% in 2012 to 1.7% in 2016 (DTTAS 2018c). However, these data need to be viewed against the backdrop of a growing economy, such that car use may actually be increasing in absolute terms.

Within Dublin, there has been more noticeable modal shift, particularly in the recent past. The Canal Cordon Report shows that over the period 2006–2017, cars as a percentage of total person trips crossing the Dublin canals between 07:00 and 10:00 has decreased from 37.1% to 29.2%. Public transport has increased slightly from 49.4% to 50.7%, with Luas accounting for almost the entire increase. Both walking and cycling have increased. Walking increased from 8.3% to 11.8%, while cycling increased from 2.3% to 5.9% (NTA and Dublin City Council 2018).

An alternative intermediate policy goal is the share of renewable energy in the transport sector. Under the Renewable Energy Directive, the state has a target for the transport sector of 10 percent of energy consumption to come from renewable sources by 2020. The Biofuels Obligation Scheme has been effective in displacing a limited quantity of fossil fuels in the transport. As reported in Ireland's NREAP Fourth Progress Report (DCCAE 2017c), 128,240 ktoe of sustainable biofuels were consumed in 2015, and 119,148 in 2016. This equates to a share of energy from renewable sources in the transport sector of 5.7% in 2015 and 5.0% in 2016. The estimated GHG emission savings from the use of renewable energy in transport is 263,885 t CO_2eq in 2015 and 238,091 t CO_2eq in 2016.

Figure 8: Shares of new private cars in each emissions label band, 2000–2016



Source: DCCAE (2017a, p 50)

We can also assess the effectiveness of measures to incentivise uptake of lower carbon vehicles. Figure 8 illustrates the impact that the recalibration of the VRT and Motor Tax regimes had on new private car sales. The period up from 2000 to 2007 shows no discernible pattern. With the recalibration of VRT and Motor Tax towards CO_2 emissions rather than engine capacity, we see a very pronounced shift in consumer behaviour. Of course, we cannot know with precise certainty what would have happened to consumer behaviour absent this change, but we can reasonably assume that the policy change had a significant impact.

A small number of ex post analyses have been conducted and published with respect to particular policy interventions, including the Smart Travel Towns investment programme and the Green School Travel programme (Aecom 2015, 2019; DTTAS 2015a).

4.2 Efficiency

Efficiency seeks to capture some measure of the cost of policy interventions, asking whether outcomes achieved through an intervention could have been achieved through less costly means. Other things being equal and with limited resources, policymakers should aim for less costly interventions. However, an overly narrow focus on least cost decarbonisation may unnecessarily constrain the range of available policy options, and decarbonisation at "reasonable" or "acceptable" cost may correspondingly widen the scope for policy interventions, though of such concepts would need to be operationalised carefully (Torney 2018).

Efficiency is an evaluation criterion that can more easily be applied to individual policy measures rather than to a sector as a whole. When evaluating a specific policy instrument, it is easier to quantify the effects and costs of the policy, though challenges can arise in this respect. Uncertainty can make economic evaluation through standard cost-benefit analysis challenging (Bullock et al. 2015). Many environmental outcomes are not valued by markets, and it can be difficult to capture co-benefits. This can be overcome through a range of valuation methods, such as willingness-to-pay and willingness-to-accept, and others, but all of these approaches pose their own difficulties (Bullock et al. 2015). Choosing an appropriate shadow price of carbon and discount rate are also fraught with challenges. In an Irish context, the shadow price of carbon and discount rate are currently under review by the Department of Public Expenditure and Reform. An alternative is to use cost-effectiveness analysis, which can be preferable to cost-benefit analysis because it estimates the cost per unit of outcome and does not require economic valuation of non-market benefits (IPCC 2014).

Linking to the discussion above, an absence of a robust counterfactual scenario will inhibit an assessment of efficiency. If we do not know what the impact of a policy was, then we cannot estimate the cost per unit of outcome achieved, since we do not know the outcome. If it were possible to quantify the effects and costs of the range of policies implemented in the transport sector, then we could develop a sector-wide assessment of the relative efficiency of different measures within the overall policy mix. However, that task is outside of the scope of the current project, though it could be undertaken in future research. As a result of these constraints and challenges, the efficiency criterion will be assessed primarily in the context of the "deep dive" evaluation of a single policy measure, discussed in Section 5 below.

4.3 Relevance and coherence

The relevance criterion asks to what extent the overall goals of a policy intervention are still valid, whether specific objectives contribute to these overall goals, and how well adapted a policy intervention is to subsequent technological or scientific advances. The coherence criterion has two dimensions. First, is a policy intervention internally coherent, or do different

elements of the intervention pull in different directions? Second, is a policy coherent with other policies that may have similar or different objectives?

Assessing relevance with respect to climate change mitigation policies in the transport sector is particularly pertinent for two reasons. First, the climate policy landscape is evolving at pace. Policies that were enacted in the 1990s or 2000s, for example, were conceived of when the overall goals policy were different. The overall range of quantitative emission reduction targets for developed countries have become more stringent over time, and Ireland's National Policy Position on climate change setting out targets for 2050 dates only from 2014 (Government of Ireland and Department of Communications 2014). Second, transport is a sector characterised by significant infrastructural investment requirements and whose technology profile is evolving rapidly. In such a context, policies risk locking in technology that will become outdated quickly.

Building on the discussion above regarding effectiveness, it is clear that the current suite of policies is insufficient to deliver decarbonisation consistent with the transition outlined in the National Policy Position, i.e., 80% decarbonisation of transport by 2050. This disconnect between the existing policy mix and the overall policy goal agreed by Government could be thought of as a failure of relevance, i.e., that the policy mix has not kept pace with the evolution of the overall decarbonisation goal. However, the elaboration of specific and measurable targets for modal share, vehicle numbers and GHG emissions from transport set out in the *Smarter Travel* strategy in 2009 (DTTAS 2009) suggest that already nearly a decade ago there was a relatively clear vision of the broader goal for the sector.

Another notable feature of the suite of climate mitigation policies in the transport sector from the perspective of relevance is their predominant focus on passenger transport (see Figure 1 above). While passenger transport accounts for a majority of GHG emissions from the sector, the freight transport sector has grown once again during the recovery, and emissions from freight transport increased by 7.5% in 2016, though with some evidence of a minor decoupling of emissions (CCAC 2018, 31). Although some policy measures, such as the Biofuels Obligation Scheme, apply equally to passenger and freight, the relevance of the overall policy mix could be enhanced by a greater focus on this sector.

With regard to coherence, there is a now well-documented tension between climate change and air quality objectives in terms of the incentivisation of diesel fuelled cars. Although thought to be more efficient in terms of CO_2 emissions, diesel fuelled cars emit more air pollution—and in fact the "dieselgate" scandal revealed that in many cases diesel fuelled cars were not as CO_2-efficient as was once thought. Other jurisdictions have moved to equalise excise rates on diesel and petrol, and in some case to disincentivise or even ban diesel cars in cities on air pollution grounds, but excise rates remain differentiated in Ireland. Equalisation of excise rates in the UK combined with moves to reduce the number of diesel vehicles in London through congestion charging have led to an increase in imports of second hand diesel vehicles into Ireland (Tax Strategy Group 2018).

Increasing use of biofuels in the transport sector may also lead to incoherence between climate mitigation and other policy goals such as biodiversity protection food production, if not managed carefully. Ireland's NREAP Fourth Progress Report reports that, in 2015–16, all feedstocks for domestic biofuels were waste and residues, i.e., used cooking oil and tallow, and that "Domestic production of biofuels has produced no detectable impacts in terms of biodiversity, water resources, water quality or soil quality in Ireland in 2015 or 2016" (DCCAE 2017c, 42).

Incoherence can also result from climate change consequences of non-climate policies. Research by Morgenroth et al. (2018) has shown that many non-environmental fiscal instruments in Ireland sought to identify the environmental impact of existing and potential fiscal instruments in Ireland. They found that 98 out of 142 measures reviewed had an impact on greenhouse gas emissions, of which 57 were positive impacts and 41 were negative impacts.

A further source of policy incoherence relates to the interaction between transport and land use policies. A number of policy documents point to the importance of prioritising higher density urban development in order to make public transport and also walking and cycling more efficient and attractive, including the Smarter Travel Strategy, the National Mitigation Plan, and the NREAP (DCCAE 2017c, 2017b; DTTAS 2009). Past spatial planning decisions concerning the location of housing, commercial premises and public amenities such as schools has strongly constrained the potential for low carbon and sustainable transport modes.

4.4 Distributional Impacts

According to data from the CSO Household Budget Survey (CSO 2017), in 2015–16 transport constituted the third largest element of weekly household budget (14.9%), after "miscellaneous goods, services and other expenditure" (33.6%) and housing (19.6%), and marginally higher than food (14.7%). The share of transport expenditure has been very stable over time since 1980, even as household incomes have fluctuated significantly over the period. Over the entire period from 1980 to 2015–16, transport's share never fell below 13.6% or above 16.4% of household budget. Between 2009–10 and 2015–16, expenditure on transport increased from €116.31 to €124.39. This was driven primarily by increase in car purchases, which rose from €30.25 to €44.43 over the time period. Excluding car purchases, household transport expenditure decreased by 7.1%, with expenditure on petrol/diesel decreasing by 6.3%.

Across the income spectrum, there is relative consistency in terms of expenditure on transport. In 2015–16, the richest quintile spent the smallest proportion of household income on transport (12.3%) and the poorest quintile spent the next smallest proportion on transport (14.5%). The middle quintile spent the highest proportion (16.6%)(CSO 2017).

Transport demand is relatively price inelastic, particularly where people live long distances from their place of work or education and in areas that are poorly served by public transport. The construction of new public transport infrastructure such as the Luas elevates property prices, exacerbating patterns of exclusion from good quality public transport for those on lower incomes.

In this context, transport demand management policies have distributional consequences. Ex-ante research on a carbon tax concluded that those on middle incomes would be most impacted by a carbon tax because transport fuel as a share of disposable income was highest for this group (Scott and Eakins (2004) cited in Convery, Dunne, and Joyce 2013, 26). At the time of introduction of the carbon tax in 2009, complementary supports were used to assist with additional expenses, including the Better Energy Homes Scheme as well as, most significantly from a distributional point of view, the Better Energy Warmer Homes Scheme that targets those suffering fuel poverty. The National Fuel Allowance Scheme was also extended in 2009 in advance of the introduction of the carbon tax (Convery, Dunne, and Joyce 2013; Tax Strategy Group 2018). However, it appears that no similar measures were introduced to deal with equity issues associated with the carbon tax in the transport sector.

4.5 Governance

Governance institutions are key enabling factors for decarbonisation across economy and society. The literature on governance of low carbon transition points to the importance of both bottom-up innovation and experimentation and top down direction from central government in creating change (Fankhauser, Averchenkova, and Finnegan 2018; NESC 2019; Ostrom 2010; Sabel and Victor 2017). Previous contributions have noted the distinctive characteristics of the transport sector that pose challenges for achieving a low carbon transition. A forum convened by the National Economic and Social Council in November 2015 identified the institutional environment as a key enabler of decarbonisation of the transport sector (NESC 2015). In particular, the forum identified: (i) a need for more stakeholder engagement; (ii) a need for better links across and beyond government departments, including with local authorities; (iii) a tension between short term and long term concerns and priorities; and (iv) that governance approaches need to recognise the many distinctive features of the transport sector.

A parallel research project to the ICPE project, commissioned by NESC and undertaken by the ICPE Principal Investigator along with Dr. Laura Devaney, explored the governance context of low carbon transition in the Irish transport sector (Devaney and Torney 2019). On the basis of interviews with key stakeholders as well as desk-based research, this project identified three key themes. The first concerned how the transport system operates, with complexities inherent in the sector. This includes tensions between public and private, rural and urban, and the role of special interests as well as complex external interactions with broader policy objectives and systems, including planning, health and education. The second key theme concerned the drivers of the transport system. Contestation between institutional priorities has shaped the development of a carbon intensive transport system to date. Low carbon transition has yet to be embedded within these priorities, and there is disagreement over what low carbon transition might entail and across transport sub-sectors. The third key theme identified a governance landscape that is characterised by significant fragmentation, which has constrained progress in transitioning to a low carbon transport system.

5. Case study evaluation: Support for deployment of Electric Vehicles

Electric vehicles (EVs)—taken here to encompass battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) but not conventional hybrids—can potentially contribute significantly to decarbonisation of passenger transport, provided that the electricity system powering them is decarbonised. Furthermore, by reducing emissions of NOX and particulate matter, EVs can contribute significantly to improving air quality and health outcomes in urban areas. At present, electricity is not generally considered suitable for propulsion of HGVs, but some cities are switching to fully electric buses, and Shenzhen recently became the first city in the world with a fully electric bus fleet (Keegan 2019). However, this case study will be limited to focus on incentivisation of EVs for passenger transport.

Research on factors affecting the uptake of EVs has focused on both technology and consumer characteristics. Relevant technology characteristics include battery specifications, noise, emissions, practicality/reliability, and design. Relevant consumer characteristics include lifestyle orientations, social norms, environmental beliefs, and socio-economic characteristics. Although, consumer characteristics have generally been found to be less important than technological aspects, research has found that men, young or middle-aged, educated, affluent, and persons from multi-car households are more likely to purchase an EV (Bjerkan, Nørbech, and Nordtømme 2016).

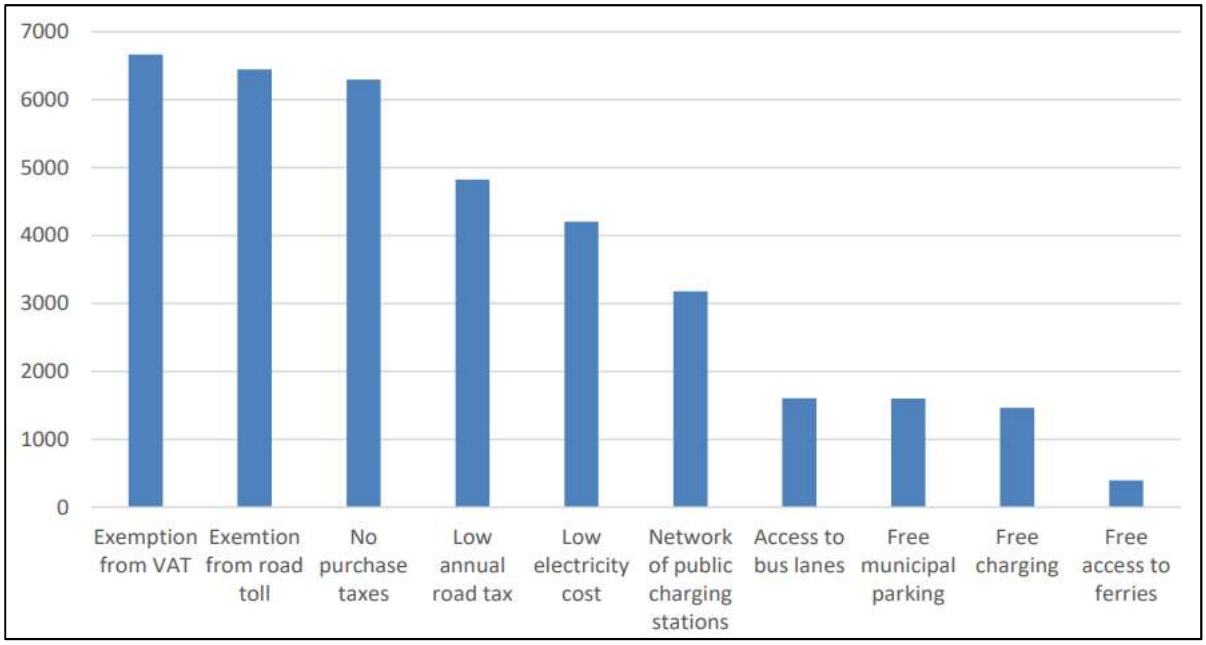
Norway is frequently held up as an exemplar of EV deployment. In 2019, 42% of all new passenger cars purchased were fully electric BEVs, up from 31% in 2018 and 21% in 2017 (Holter 2020). Norway's exemplary position has been driven by early and comprehensive policy interventions targeting that focused on both financial incentives as well as ease of use factors (Steinbacher, Goes, and Jörling 2018). Indeed, some of Norway's EV incentives date from 1990 (Figenbaum 2017).

It was not until the current decade that deployment of EVs significantly accelerated in Norway. This has been driven by very attractive incentives. The purchase cost of EVs is reduced through a combination of exemption from registration tax and VAT. The operating cost is reduced through low annual road tax, reduced company car tax, no or reduced tolls on roads and ferries, and free municipal parking and access to bus lanes at the discretion of local municipalities. The result is that the total cost of ownership for EVs in Norway is lower than internal combustion engines (Steinbacher, Goes, and Jörling 2018). Another important factor has been the development of public charging infrastructure. As of August 2018, there were 11,200 charging points and 2300 charging stations, including 700 fast charging/semi-fast charging stations throughout the country (Nørbech 2018).

Figure 9, based on data from the Norwegian EV Associations annual EV owners survey, show that price considerations are the most important determining factors in Norwegian consumers' purchases of EVs. Research on the Norwegian case has found purchase cost reduction to be the strongest incentive in promoting BEV adoption (Bjerkan, Nørbech, and Nordtømme 2016). Other research by Mersky et al. (2016) examined variation in BEV sales at the regional and municipal level in Norway and found that access to charging infrastructure, being adjacent to

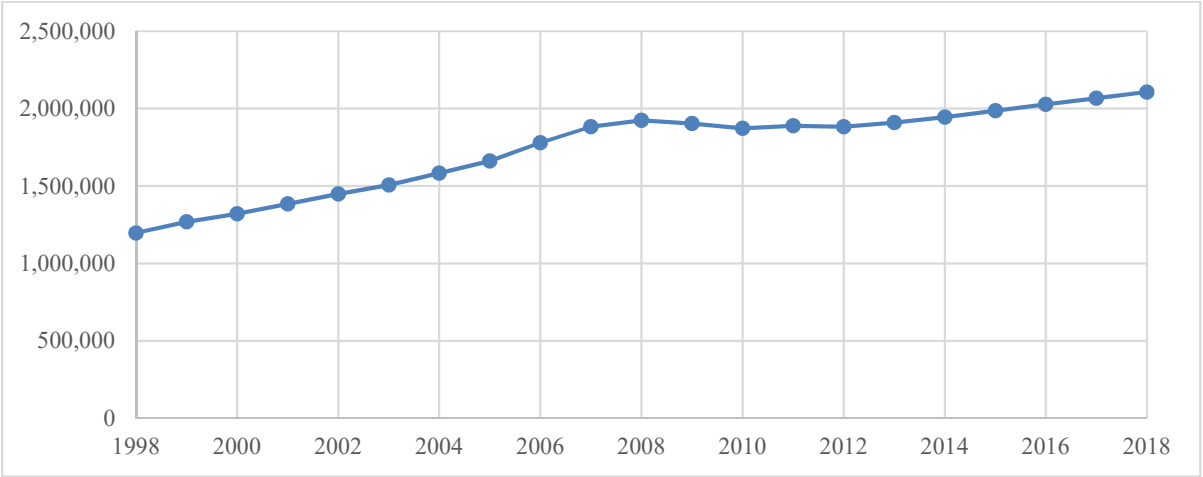
major cities, and regional incomes had the greatest predictive power for the growth of BEV sales.

Figure 9: Most important EV incentives according to Norwegian EV owners



Source: Haugneland et al. (2017, 3)

Figure 10: Number of private cars licenced in Ireland, 1997–2018

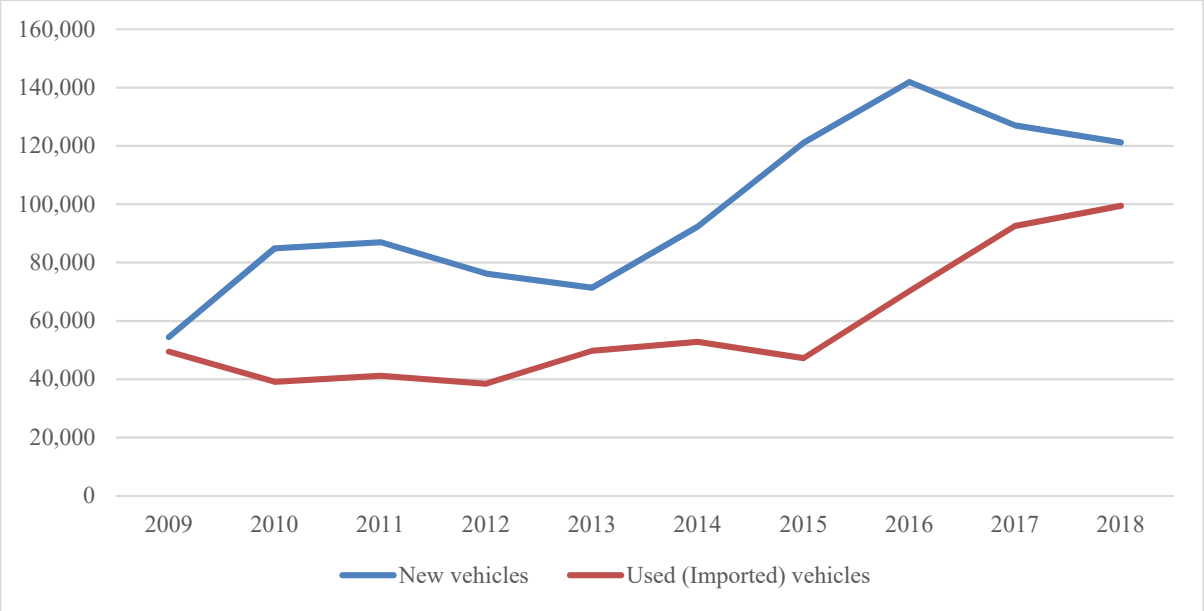


Source: CSO (2019)

Before considering the incentives for EVs in Ireland and their evaluation, it is useful to paint the overall picture of the sector. At the end of 2018, the latest year for which full statistics are currently available, there were 2,106,369 private cars and 21,433 small public services vehicles (i.e., taxis, hackneys and limousines) licenced in Ireland (CSO 2019). Figure 10 shows the trend since 1998 in the number of licenced private cars in Ireland, showing that the trend is broadly coupled with economic cycles.

Figure 11 illustrates the trend over the past decade in licencing of new and used (imported) private cars. This again shows a cyclical trend, with significant growth in licencing of new private cars during the period 2013–2016. Another interesting trend is the strong growth in licencing of imported used cars in 2016–2018, and a decline in new car licencing in 2017 and 2018. Used cars are imported overwhelmingly from the UK (96% in 2016 and 97% in 2017), and this recent trend is most likely attributable to tighter regulations on diesel cars in the UK and the impact of Brexit on the currency exchange rate, making UK imports more attractive.

Figure 11: Private cars licenced for the first time in Ireland, 2009–2018



Source: CSO (2019)

5.1 Overview of incentives to promote EVs in Ireland

Ireland is relatively well suited to EVs. The greatest distance between any two Irish cities is 265km (Dublin to Cork). Ireland has a single electricity network company, ESB Networks, and a relatively large proportion of the population have off-street parking facilities at their place of residence.

In 2009, the *Smarter Travel* strategy set the following target for take-up of EVs: "We will provide further incentives to encourage a switch to electric vehicle technology with the aim of achieving 10% market penetration by 2020" (DTTAS 2009, 52), equivalent to approximately 200,000 vehicles. This target was revised to 50,000 in Ireland's 3rd National Energy Efficiency Action Plan (NEEAP), published in 2014 (DCCAE 2014). At the end of 2016, only approximately 2,000 EVs were on the road. The target was revised downwards once again to 20,000 in 2017 (DTTAS 2017a). Forecasts contained in the *National Policy Framework for Alternative Fuel Infrastructure for Transport* projects that EV passenger car numbers will reach 250,000 by 2025 and 800,000 by 2030 (DTTAS 2017a). In February 2018, as part of Project Ireland 2040, the government announced a commitment that no new non-zero emission vehicles would be sold after 2030 in Ireland, and that NCT certificates would not be issued for

non-zero emission cars after 2045 (Government of Ireland 2018), and the 2019 Climate Action Plan projected that , by 2030, there would be 840,000 passenger EVs in Ireland (DCCAE 2019).

A range of measures have been put in place to incentivise the take up of EVs in the passenger transport sector. ESB has developed a national charging infrastructure through its "eCars" programme, established in 2010. In 2014, the Commission for Energy Regulation (now the Commission for Regulation of Utilities) approved funding of €25 million, sourced through a levy on electricity customers' bills, for ESB Networks to carry out a pilot trial on the effects of EVs on the distribution system (CER 2014). ESB Networks developed the public EV charging network using this funding along with €6 million of its own resources and EU funding, which brought the project to an estimated €40 million in total. In October 2017, the Commission for Regulation of Utilities stipulated that the public charging infrastructure developed by ESB Networks "should not be added to the ESBN RAB [regulated asset base] and the assets should either be sold or maintained by ESBN on a commercial basis", but that "the assets should remain in ESBN's ownership for a transitional period" (CRU 2017).

There are 1,110 public charge points installed across the island of Ireland, which includes 300 charging points in Northern Ireland. Additionally, there are more than 70 fast chargers in the Republic of Ireland, primarily installed at service stations to facilitate longer journeys between major towns and cities. Additionally, ESB committed to installing free home charge points for the purchasers of new EVs. This scheme involved the installation of 2,300 home chargers, and concluded at the end of 2017. In its place, Budget 2018 introduced a grant of up to €600 for installation of home chargers. Following on from the CRU decision of October 2017, ESB has announced that it will introduce fees for public charging in Q2 of 2019.

The *National Policy Framework on Alternative Fuels Infrastructure for Transport in Ireland—2017 to 2030* stated that the existing charging infrastructure is considered adequate for a projected 20,000 EVs by 2020, and that any deployment of additional infrastructure should be driven by market demand (DTTAS 2017a). Nonetheless, in its first funding round under the Climate Action Fund, announced in November 2018, the government provided €10 million to ESB eCars to install over one hundred high powered (150kW) chargers at key locations on the national road network, and to replace one hundred 50kW fast chargers and refurbish up to 200 standard (22kW) chargers (ESB 2018).

Financial incentives for BEVs and conventional hybrids were first introduced in the Finance Act 2008 in the form of relief from Vehicle Registration Tax (VRT). The Finance Act 2010 extended this relief to PHEVs. VRT relief is provided up to €5,000 for BEVs, up to €2,500 for PHEVs, and up to €1,500 for conventional hybrids. At present, the VRT relief for BEVs is committed until the end of 2021, while the relief for PHEVs and conventional hybrids is committed until the end of 2020. BEVs also qualify for the lowest tax band of motor tax (€120), while a PHEV is typically taxed at €170 per annum.

A purchase grant of up to €5,000 is available for both BEVs and PHEVs (it is not available for conventional hybrids), administered by SEAI and applied through the motor dealer. The value

of the grant is dependent on the list price of the EV, with the maximum €5,000 grant available for EVs with a list price of €20,000 or higher.

Businesses are also incentivised to purchase EVs. BEVs and PHEVs and associated recharging infrastructure are incentivised through the Accelerated Capital Allowance scheme. This allows businesses to write down the cost of such equipment in the year of purchase rather than over the standard 8 year period. Budget 2018 introduced a 0% rate of Benefit in Kind (BIK) for BEVs, though not for PHEVs. This was extended in Budget 2019 for a further three years, but with a cap of €50,000 imposed.

In February 2018, a new grant scheme was introduced to incentivise EVs for use as small public service vehicles (SPSVs), i.e., taxis, hackneys and limousines. In 2017 there were 21,345 SPSVs licenced in Ireland, up to 50% of which were located in Dublin. The scheme, administered by the NTA and funded by the Green Public Transport Fund, provided a grant of up to €7,000 towards purchase of a BEV, and up to €3,500 for a PHEV. Total funding available for the SPSV scheme was €500,000 (DTTAS 2018a). In Budget 2019, the grant levels were increased to a maximum of €10,000 for BEVs and €5,000 for PHEVs (NTA 2019).

In terms of other supports, discounted tolling was announced in Budget 2018 and introduced in summer 2018. BEVs receive a 50% discount on tolls while PHEVs receive a 25% discount. Conventional hybrids are not included in the scheme. The benefit is capped at €500 per year for private vehicles and €1,000 per year for commercial vehicles. Higher discount rates of 75% for BEVs and 50% for PHEVs are available on the M50 motorway during off-peak travel periods in order to assist with demand management efforts. Also for demand management purposes, the toll discount only applies to the Dublin Port Tunnel during off-peak periods (DTTAS 2018b).

Finally, a public awareness scheme was launched by SEAI on 18 April 2018. It is to run for a period of 3 years and includes a national public awareness campaign, a public driver experience roadshow, public sector and commercial fleet trials, and potential supports for car sharing schemes.

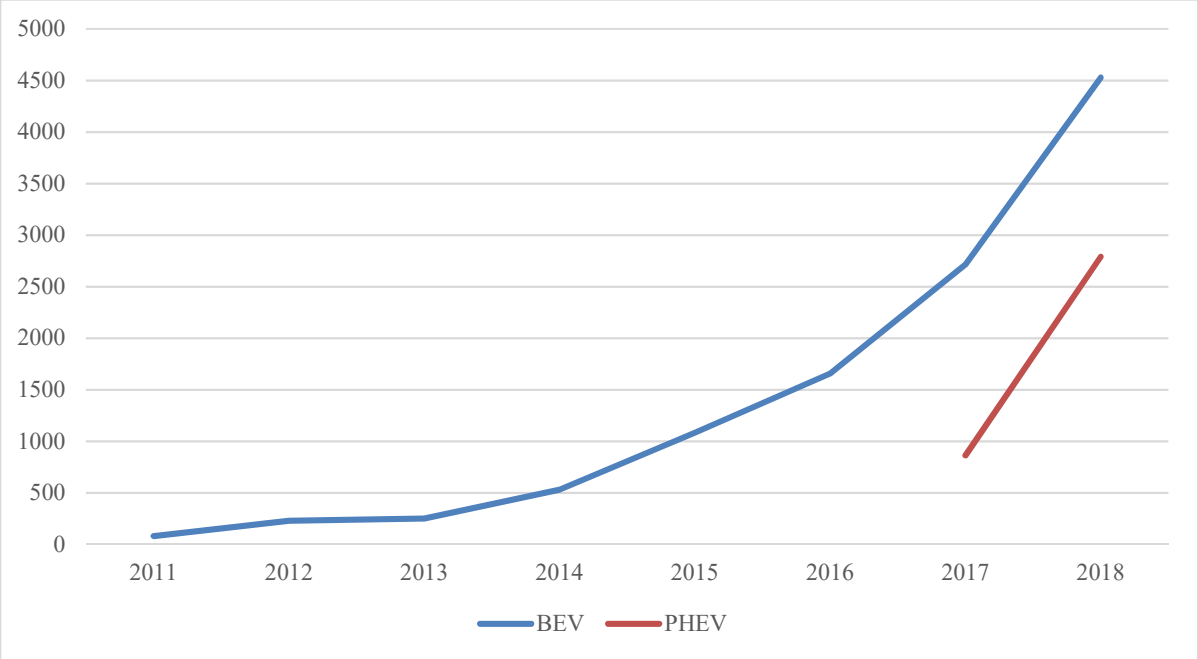
Having outlined the range of incentives offered in Ireland for EVs, the rest of this case study provides an evaluation of these incentives according to the criteria set out above, namely effectiveness, efficiency, coherence, relevance, governance, and distributional impact. Some of these are easier to evaluate than others, including due to data limitations. These challenges are noted below.

5.2 Effectiveness

In order to measure the effectiveness of the suite of incentives outlined above, we need to determine the outcome of interest and a plausible counterfactual. The proximate outcome of interest is the number of EVs licenced in Ireland. Figure 12 shows the total number of EVs licenced at the end of each year from 2011 to 2019. Note that data for PHEVs was recorded only in the 2017 edition of the *Irish Bulletin of Vehicle and Driver Statistics* from which the

data are drawn. This shows that there has been a steady trend upwards since 2013. At the end of 2018, the latest year for which the data have been published, there were a total of 7,318 EVs licenced in Ireland (4,528 BEVs and 2,790 PHEVs).

Figure 12: Total BEV and PHEV private cars licenced in Ireland, 2011–2018



Source: *Irish Bulletin of Vehicle and Driver Statistics*, 2011–2018

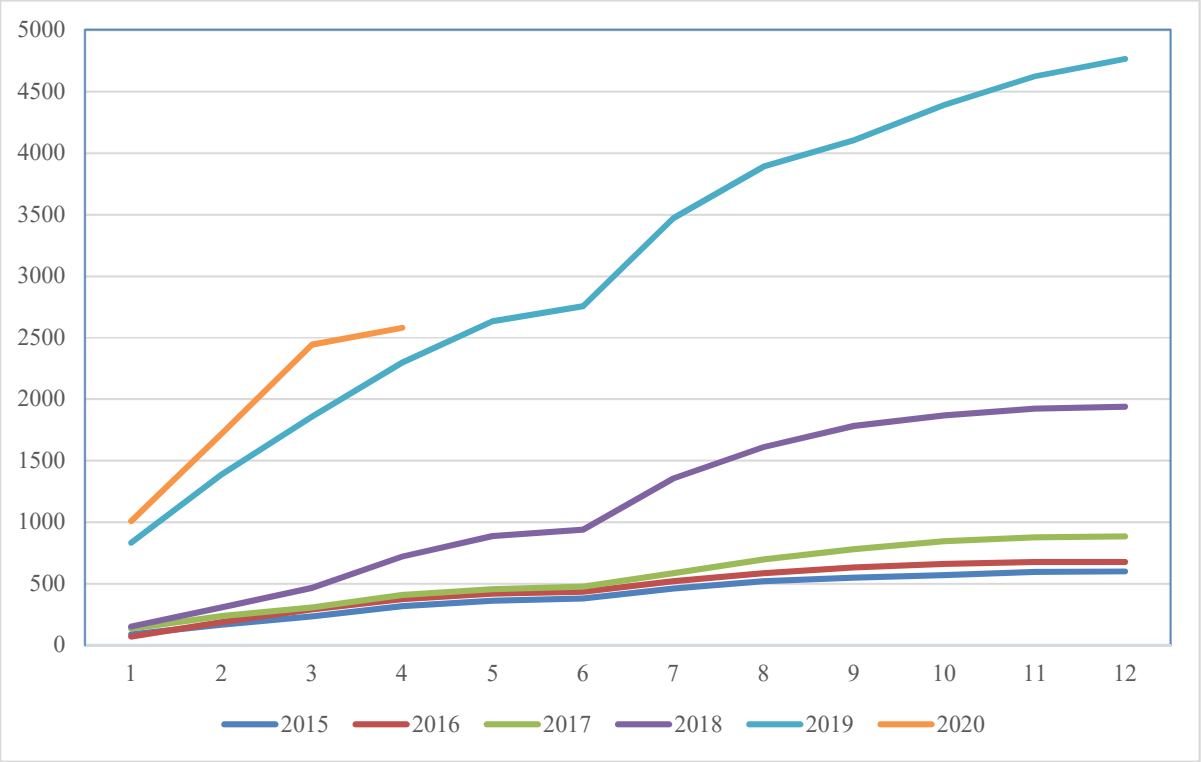
Note: Data for PHEVs was recorded only from the 2017 edition onwards.

Attributing causality to the policy measure(s) under evaluation is a standard concern of policy evaluators. This requires a plausible counterfactual to be defined. Within the scope of this evaluation, it has not been possible to estimate the likely trend in EV sales absent the incentives. For the years 2015–2017, the level new private car licences is a very small proportion of overall vehicle licences (0.5% of total in 2015 and 2016, and 0.7% of total in 2017).

Figure 13 shows an appreciable change in 2018 relative to previous years and an even larger increase in 2019, with 2020 higher again, though the Covid-19 pandemic is expected to constrain new car sales for the rest of the year. This may have been driven by a range of factors, including changes to the incentive regime, technological improvements, or changing consumer preferences, for example. It has not been possible within this study to disaggregate the relative importance of each of these factors, but it is useful to discuss each briefly.

The principal policy changes in 2018 were the introduction of 0% BIK for BEVs in Budget 2018 (extended in Budget 2019 for a period of 3 years) and the introduction of reduced tolls for BEVs and PHEVs. It was the view of several stakeholders that the BIK incentive had a significant effect on EV sales in 2018. However, it should be noted that the BIK incentive applies to BEVs only.

Figure 13: Cumulative monthly EV (BEV+PHEV) private car new licences, 2015–2020



Source: CSO Statbank

Note: Data for 2020 are January–April only.

2018 also saw the introduction of the SEAI's public engagement programme in April of that year. In the absence of customer surveys it is not possible to attribute causality directly to the programme, but it is noteworthy that EV sales in April 2018 were 60% higher than the previous month, and sales for the July–September period were 82% higher than the January–March period. The range of EVs on the market has also increased significantly over recent years. Compared with just 2 models available in 2011 when the VRT and purchase grants were introduced, there are now 40 models (BEV and PHEV) available on the Irish market. The significant increase between 2018 and 2019 cannot be accounted for by changes in the incentive regime, since these were broadly consistent over the two years. It is likely that greater consumer range, declining cost, and greater consumer awareness are important factors. Further research ought to be undertaken to investigate the relative importance of these various factors.

Effectiveness can also be measured against the ultimate objective of decarbonisation and meeting Ireland's renewable energy targets for the transport sector under the renewable Energy Directive. In respect of decarbonisation, a shift to electric vehicles will only reduce emissions if the electricity source is decarbonised first or in parallel (Barkenbus 2017). Investment and progression in Irish renewable energy generation and storage will thus be essential if electrification is to contribute to low carbon transition aims. Currently, it is estimated that a BEV charging from the national grid in Ireland has emissions of approximately 80g/km, which is roughly equivalent to a conventional hybrid car. However, co-benefits of BEVs include that

they emit no local pollutants and are up to three times as energy efficient as Internal Combustion Engine cars (Figenbaum 2017).

5.3 Efficiency

The total cost the SEAI EV purchase grants to the end of July 2019 was €39.1 million. The cost of the EV Home Charger Grant scheme, launched in January 2018 and run by SEAI as well, was €1.37 million up to June 2019. The Department of Finance has estimated the total cost, in terms of lost revenue, of the VRT relief offered to BEVs and PHEVs from its introduction until April 2019 at €88.4 million (Kevaney 2019).

In addition, ESB Networks spent approximately €40 million on the first round of public infrastructure, though this did not come from the public exchequer but rather from a levy on customer electricity bills (€25 million) along with €6 million investment from ESB and EU funding. Furthermore, as discussed above the government provided €10 million in funding from the first round of the Climate Action Fund to ESB Networks for further development and refurbishment of the public charging infrastructure.

As discussed above, it is outside the scope of this study to estimate the specific contribution of each individual incentive and therefore each incentive's cost effectiveness. However, given the relatively low number of EVs currently deployed, it is reasonable to conclude that this represents a comparatively expensive means of decarbonisation.

The same can be said of the cost effectiveness of the current set of incentives in contributing to achievement of Ireland's target under the Renewable Energy Directive. According to an Energy Ireland report, deployment of 50,000 EVs would contribute less than 0.5% to Ireland's RES target (cited in Houses of the Oireachtas 2018). It is estimated that Ireland will be required to pay €100–€150 million per percent it falls short of the 16% RES target. Using these figures, the break-even point for EV incentivisation per vehicle averages at €1,250, significantly lower than the cost of the incentivisation per vehicle.

However, the above calculations do not account for the co-benefits of cleaner air resulting from increased take-up on EVs, particularly BEVs and particularly in urban areas. Further research would be needed to take such co-benefits properly into account. Moreover, the calculations do not make explicit the difference between fixed and variable costs of incentives. With the current level of deployment, the cost of the public charging infrastructure is very high per EV on the road. The public charging infrastructure will need to be expanded as deployment ramps up, but the per-vehicle cost of the public charging infrastructure will nonetheless decline over time.

There is potential to make the cost of current or expanded incentives revenue neutral by either increasing the rate of excise on fossil fuels or by increases in other areas of the income tax system. However, this would have distributional consequences and, in light of recent developments including the "yellow vest" protests in France, may not be considered politically expedient.

5.4 Coherence

The evaluation criterion of coherence can be subdivided into internal and external coherence. The suite of measures developed over the past decade does not obviously suffer from a lack of internal coherence. Different individual incentives cannot be said to be at odds or significantly in tension with each other. The range of measures that have been implemented have sought to deal with the spectrum of barriers to deployment that could be addressed within Ireland, including price (both purchase and running costs), range anxiety (through build out of public charging network and home chargers), and consumer preferences and knowledge (through a public information campaign run by SEAI). That is not to say that more could not be done, but the suite of measures is relatively broad-ranging and internally coherent.

There are perhaps more significant challenges in terms of external coherence, that is, how coherent the suite of measures to promote EVs is with broader transport and climate change mitigation policies. Although EVs represent a potential low carbon transport solution (though only if the electricity system is decarbonised (Barkenbus 2017)), they can continue to contribute to urban congestion, dispersed settlement patterns, sedentary lifestyles, competition for urban space, and single vehicle occupancy preferences (Brueckner 2018). Pursuing EV deployment as a principal climate mitigation goal in the transport sector, as the National Mitigation Plan (DCCAE 2017b) and Climate Action Plan (DCCAE 2019) suggest, focuses on only the third of the pillars of the "Avoid, Shift, Improve" framework (EEA 2016; Stucki 2015). This framework suggests that our primary goal should be to reduce the need for travel through better spatial planning, followed by modal shift to more sustainable modes such as cycling, walking, and public transport. EVs fall within the third, "improve" pillar.

A further source of concern is the negative social impacts that may arise in sourcing elements for the creation of EV batteries (e.g. with rises in child labour reported in mines in the Congo in the search for cobalt (Peyton 2018)), and in the disposal of batteries after their useful life. GHG emissions from the raw material and production phases are typically higher for a BEV than for its Internal Combustion Engine equivalent, but over the whole lifecycle a BEV is typically more GHG efficient, though this depends on the source of the electricity used to fuel the BEV (EEA 2018).

5.5 Relevance

Relevance captures the degree to which a measure remains relevant to possibly changing circumstances. It took some time for the full suite of measures to be developed and implemented. It could perhaps be argued that a more comprehensive—and therefore relevant—suite of measures could have been put in place earlier. However, if we look internationally at deployment rates there are reasons to believe that a more comprehensive suite of measures implemented at an earlier point in time, perhaps in the early- to mid-2010s, would not have done much to facilitate more rapid take-up, which was most likely partly constrained by lack of consumer choice in the EV market.

Looking forward, different challenges of relevance are likely to manifest themselves in the coming years. As innovation in battery technology continues to drive down the costs of EVs, the need for incentives that reduce purchase cost and operating cost will need to be adjusted. DTTAS (DTTAS 2017b) projected the annual cost of the set of incentives existing in 2017 (i.e., VRT relief, purchase grant, home charger, and fuel excise foregone) out to 2030 under both "EV low growth" and "EV high growth" scenarios. By 2030, the annual cost in both scenarios is over €1.4 billion, which is unsustainable. As the scale of EV purchases increases and the list price of EVs falls, the suite of incentives will no longer be relevant for these changed circumstances and will need to be adjusted.

The point at which incentives are adjusted or eliminated will need to be chosen with care, and it will be important to give an adequate and timely signal in advance about the future trajectory of incentives, particularly around supports such as motor tax, charging for electricity, and reduced tolls that affect the operating as opposed to purchase costs. Given the significant but uncertain pace of technological innovation, setting out a definite timeframe for reduction of subsidies could be challenging. In this regard, it may be advisable to adopt the Norwegian approach of committing to retaining the package of incentives until a numerical threshold of licenced EVs is passed, though in fact in the Norwegian case parliament decided to extend the incentives even once the 50,000 threshold was passed (Steinbacher, Goes, and Jörling 2018).

A further challenge of relevance concerns the charging infrastructure. The *National Policy Framework on Alternative Fuels Infrastructure for Transport in Ireland* (DTTAS 2017a) took the view that the current public charging infrastructure is sufficient for deployment of 20,000 EVs, the current target for 2020. If current trends continue, it appears that the 20,000 target may be reached in 2020 and significantly exceeded thereafter. Further development of the public charging network will be important, and some of the existing public charging infrastructure is now in need of refurbishment. In this regard, the decision of government in November 2018 to commit €10 million in funding to ESB Networks for further development of the public charging infrastructure is a welcome development.

5.6 Governance

Governance of measures to incentivise EVs has functioned largely effectively. In the broader arena of climate change mitigation and transport, the key government departments are the Department of Transport, Tourism and Sport and the Department of Communications, Climate Action and Environment. Within this policy space, DTTAS is responsible for policy development related to mode share, and DCCAE is responsible for policy development related to transport fuels as well as electricity generation, and vehicles are a joint responsibility. A range of other actors are involved, including SEAI as implementing agency for the EV purchase grants and the public engagement programme, the National Transport Agency as implementing agency for the SPSV scheme, and ESB as the actor responsible for development of public charging infrastructure, while the Department of Finance has responsibility for fiscal policy and the Department of Public Expenditure and Reform has oversight of public spending. Furthermore, local authorities are responsible for decisions around charging for parking at public charging points and other matters. In short, the governance landscape is complex.

To overcome the challenges associated with this complexity, an LEV Taskforce was formed on foot of the commitment in the 2016 Programme for Government to make Ireland a leader in EV deployment. Its objective is to "Present a range of measures and options that will assist in accelerating the deployment of LEVs in Ireland" (LEV Taskforce 2018). It is chaired jointly by DTTAS and DCCAE, and includes representatives across the public sector including all of the actors mentioned in the previous paragraph. It has also conducted consultations with a wide range of industry, stakeholder and representative groups during the course of its work to date.

The LEV Taskforce consists of three working groups, dealing respectively with: (i) market growth stimuli, visibility and public leadership (ii) infrastructure, regulation, pricing; (iii) legislation and building regulations. According to participants in the Taskforce, it has helped to develop joined up thinking on key policy issues and has been particularly useful in bringing in the wider range of governance actors that have a role in this policy space. Its recommendations on further incentives were broadly enacted in Budget 2018. It was also noted, however, that its work on EVs was more straightforward because it was relatively clear to participants what the challenges were and what needed to be done to overcome them. This contrasts with the Taskforce's work on alternative fuels, where there is less clarity on future pathways and policy options.

5.7 Distributional impacts

Measures to mitigate climate change are likely to differentially impact upon different sectors of society, both positively and negatively. Such concerns have come to the fore in recent years internationally and in Ireland. They became particularly prominent in late 2018 with the "yellow vest" movement in France, the proximate aim of which was to protest against the imposition of higher fuel costs resulting from a carbon tax.

Measures to support the deployment of EVs are particularly prone to concerns over distributional impacts for a number of reasons. First, while there remains a price differential between the subsidised price of EVs and conventional ICE vehicles, it is likely that only richer consumers will be able to afford them. Second, the purchase grant, VRT relief and other fiscal incentives for EVs are paid out of general exchequer financing, meaning that all tax payers are funding subsidies for richer consumers. Third and related, many consumers purchase second hand rather than new cars. Until there is a significant second hand market for EVs, public funding for EV supports will benefit those who are better off. Data on socioeconomic status of EV owners in Ireland is not available, but research on the Norwegian case has indicated that EVs have been predominantly adopted by those with higher income and higher education, who live in large households in urban areas that own more than one car (Figenbaum 2017).

Concerns over distributional consequences of policy may limit the political feasibility of using fiscal measures to make ICE vehicles relatively more expensive than EVs. However, until the purchase price of EVs falls below ICE vehicles (either with or without subsidy), poorer consumers are likely to remain locked in to ICE vehicles. In these circumstances, increasing the operating costs of ICE vehicles will serve to increase the burden on poorer consumers rather than incentivising them to purchase EVs.

In the coming years it will be important to invest further in the public charging infrastructure. This will be less problematic from a distributional impact perspective as well. Although it will in the immediate term benefit only EV owners who are likely to be better off, it is to be hoped that the infrastructure will endure to benefit a wider proportion of the population who are able to purchase EVs once they reach cost parity with ICE vehicles, which according to some projections is likely to occur in the mid-2020s (Bloomberg 2018).

6. Recommendations

6.1 Sector-wide recommendations

At a sector-wide level, the actions and measures currently in place ought to be strengthened considerably in order to deliver low carbon transition in the transport sector. Further actions and measures, and their evaluation, would benefit from the following:

- **Low carbon transport vision:** A first key step is to elaborate a low carbon transport vision that aligns fully with best international practice, including fully embedding the "Avoid, Shift, Improve" hierarchy of policy goals (EEA 2016). Given stark warnings from climate science (IPCC 2018), Ireland's transport vision ought to promote a zero carbon transport future.

- **Top-down direction from government:** High-level signalling from government is critical to facilitating transition. It provides certainty to investors and confidence to society. This includes leadership from the Department of Transport, Tourism and Sport to guide the plethora of transport institutions that operate under its remit. It should be underpinned by a whole-of-government approach and enhanced policy coordination that prioritises climate action and mandates responsibilities.

- **Bottom-up experimentation and peer learning:** Peer learning between Irish villages, towns and cities will be imperative to scale up innovative low carbon transport solutions. This would introduce a much-needed level of reflexivity into the system and allow low carbon transport innovations to be tested, compared and revised accordingly in local conditions. Dedicated resources, communication channels and engagement fora will be important for success.

6.2 Recommendations for Electric Vehicles deployment support measures

The range of measures to support EV deployment has been expanded significantly over recent years. Sales of EVs have increased significantly over the past two years, though starting from an exceptionally low base. In order to facilitate further deployment of EVs, the following measures ought to be considered:

- **Continued investment in public charging infrastructure:** According to the *National Policy Framework on Alternative Fuels Infrastructure for* Transport, the current public charging infrastructure is sufficient for deployment of 20,000 EVs, the current target for

2020. Further development of the public charging network will be important, and some of the existing public charging infrastructure is now in need of refurbishment. Doing so would serve to ease lingering consumer concerns around range anxiety. Investing in the public charging infrastructure should constitute a significant focus of future efforts to incentivise EV deployment. Doing so also has the benefit of being less regressive than direct purchase grants and subsidies, since public charging infrastructure should, in time, be of benefit to a wider range of consumers once the price of EVs declines further and they become available to a more diverse set of consumers.

- **Roadmap for phase-out of EV supports:** Given cost projections for the current suite of incentives to 2030 run to more than €1 billion per annum, it is clear that incentives will need to be phased out over time. In order to provide certainty to consumers, government should provide a roadmap including timeline for phase out of EV supports. Given the inherently uncertain nature of the speed of technological development and cost reductions, providing specific commitments would be difficult. Instead, commitment could be given to phase out incentives once specified numerical thresholds (e.g., 20,000, 50,000, etc.) are reached. Such a commitment was given in the Norwegian case, though parliament subsequently decided to continue the incentives even though the target of 50,000 had been reached. Providing a clear roadmap will be particularly important for those incentives that reduce operating as opposed to purchase cost of EVs, since consumers will make purchase decisions based on expectations of operating costs over the lifetime of the car.

- **EV supports as part of a broader transport transition that emphasises modal shift:** EVs provide one part of the low carbon transport puzzle. Once concerns around range anxiety are addressed, EVs will be particularly suited to those who live in rural or suburban settings that are less amenable to public transport, cycling, or walking. Yet, in urban settings EVs are likely to lock in further car dependency, exacerbate congestion, and promote sedentary lifestyles. Policy supports for EV deployment should be seen as one part of a broader approach to low carbon and sustainable transport that emphasises reduction of the need for travel through better spatial planning and modal shift.

- **More and better data on drivers of EV ownership:** As deployment of EVs progresses, it would be useful to gather more and better data on the factors driving consumers to invest in EVs. This data could be gathered through a regular consumer survey as is the case in Norway, and could perhaps be undertaken with the assistance of the Irish EV Owners' Association. Understanding better what motivates consumers to purchase an EV will allow for more comprehensive evaluation of the existing suite of supports, and ultimately the crafting of more effective and efficient supports in the future.

References

Aecom. 2015. *Ex-Post Evaluation of Smarter Travel Areas – Interim Report 2015*. Dublin: Aecom.

———. 2019. *Ex-Post Evaluation of Smarter Travel Areas – Final Report 2018*. Dublin: Aecom.

Barkenbus, Jack. 2017. "Electric Vehicles: Climate Saviors, or Not?" *Issues in Science and Technology* 33(2).

Bjerkan, Kristin Ystmark, Tom E. Nørbech, and Marianne Elvsaas Nordtømme. 2016. "Incentives for Promoting Battery Electric Vehicle (BEV) Adoption in Norway." *Transportation Research Part D: Transport and Environment* 43: 169–180.

Bloomberg. 2018. "Electric Cars May Be Cheaper Than Gas Guzzlers in Seven Years." *22 March*. https://www.bloomberg.com/news/articles/2018-03-22/electric-cars-may-be-cheaper-than-gas-guzzlers-in-seven-years.

Brueckner, Martin. 2018. "Why the Electric Vehicle Revolution Will Bring Problems of Its Own." *The Conversation*. https://phys.org/news/2018-04-electric-vehicle-revolution-problems.html.

Bullock, Craig, Rowan Fealy, J. Peter Clinch, and Robert O'Shea. 2015. *ADAPT: Quantifying the Costs and Benefits Associated with Climate Change Risks and Adaptation*. Wexford: Environmental Protection Agency.

CCAC. 2018. *Annual Review 2018*. Dublin: Climate Change Advisory Council.

CER. 2014. "Decision on ESB Networks Electric Vehicle Pilot, Decision Paper CER/14/057." https://www.cru.ie/wp-content/uploads/2014/07/cer14057-Decision-on-ESB-Networks-Electric-Vehicle-Pilot.pdf.

Convery, Frank J., Louise Dunne, and Deirdre Joyce. 2013. "Ireland's Carbon Tax and the Fiscal Crisis: Issues in Fiscal Adjustment, Environmental Effectiveness, Competitiveness, Leakage and Equity Implications." *OECD Environment Working Papers* 59.

CRU. 2017. "ESBN Electric Vehicle Pilot & Associated Assets, Decision Paper CRU17283." https://www.cru.ie/wp-content/uploads/2017/10/CRU17283-Decision-paper-on-ESBN-Electric-Vehicle-Pilot-Associated-Assets.pdf.

CSO. 2017. "Household Budget Survey 2015-2016."

———. 2019. "Transport Omnibus 2018." *Central Statistics Office*. https://www.cso.ie/en/releasesandpublications/ep/p-tranom/transportomnibus2018/vehiclelicensingandregistrations/.

DCCAE. 2014. *National Energy Efficiency Action Plan for Ireland, 2014*. Dublin: Department of Communications, Climate Action and Environment.

———. 2017a. *National Energy Efficiency Action Plan for Ireland # 4, 2017-2020*. Dublin: Department of Communications, Climate Action and Environment.

———. 2017b. *National Mitigation Plan*. Dublin: Department of Communications, Climate Action and Environment.

———. 2017c. *National Renewable Energy Action Plan: Fourth Progress Report*. Dublin: Department of Communications, Climate Action and Environment.

———. 2018. *Biofuels Obligation Scheme Policy Statement April 2018*. Dublin: Department of Communications, Climate Action and Environment.

———. 2019. *Climate Action Plan to Tackle Climate Breakdown*. Dublin: Department of Communications, Climate Action and Environment.

———. 2020. "General Scheme Climate Action Amendment Bill." https://dccae.gov.ie/en-ie/climate-action/legislation/Pages/General-Scheme-Climate-Action-Amendment-Bill.aspx (February 25, 2020).

Devaney, Laura, and Diarmuid Torney. 2019. *Advancing the Low Carbon Transition in Irish Transport*. Dublin: National Economic and Social Council.

DTTAS. 2009. *Smarter Travel—A Sustainable Transport Future*. Dublin: Department of Transport, Tourism and Sport.

———. 2015a. *Focused Policy Assessment: Green-Schools Travel Programme*. Dublin: Department of Transport, Tourism and Sport.

———. 2015b. *Investing in Our Transport Future: Strategic Investment Framework for Land Transport*. Dublin: Department of Transport, Tourism and Sport.

———. 2017a. *National Policy Framework on Alternative Fuels Infrastructure for Transport in Ireland - 2017 to 2030*. Dublin: Department of Transport, Tourism and Sport.

———. 2017b. *Review of Ecisting Electric Vehicle Support Mechanisms*. Dublin: Department of Transport, Tourism and Sport.

———. 2018a. "Minister Ross Launches New €500,000 Fund to Help SPSV Drivers Move to Electric Vehicles." http://www.dttas.ie/press-releases/2018/minister-ross-launches-new-%E2%82%AC500000-fund-help-spsv-drivers-move-electric-vehicles.

———. 2018b. "Reduced Toll Fares for Electric Vehicles." http://www.dttas.ie/press-releases/2018/reduced-toll-fares-electric-vehicles.

———. 2018c. *Transport Trends: An Overview of Ireland's Transport Sector 2018*. Dublin: Department of Transport, Tourism and Sport.

———. 2019. *Transport Trends 2019: An Overview of Ireland's Transport Sector*. Dublin: Department of Transport, Tourism and Sport.

EEA. 2016. *Transitions towards a More Sustainable Mobility System, TERM 2016: Transport Indicators Tracking Progress towards Environmental Targets in Europe*. Copenhagen: European Environment Agency.

———. 2018. *Electric Vehicles from Life Cycle and Circular Economy Perspectives TERM 2018: Transport and Environment Reporting Mechanism (TERM) Report*. Copenhagen: European Environment Agency.

———. 2019. "Greenhouse Gas Emissions from Transport in Europe." https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases/transport-emissions-of-greenhouse-gases-12 (March 6, 2020).

EPA. 2019a. *Ireland's Greenhouse Gas Emissions Projections, 2018–2040*. Wexford: Environmental Protection Agency.

———. 2019b. *Ireland's Provisional Greenhouse Gas Emissions, 1990-2018*. Wexford: Environmental Protection Agency.

ESB. 2018. "ESB Welcomes Climate Action Fund Support to Develop High-Power EV Charging Network." https://www.esb.ie/tns/press-centre/2018/2018/11/28/esb-welcomes-climate-action-fund-support-to-develop-a-national-high-power-ev-charging-network-for-ireland.

———. 2019. "ESB Ecars Introduce Pricing to Support EV Network Expansion."

European Commission. 2019. "Clean Mobility: New CO2 Emission Standards for Cars and Vans Adopted." https://ec.europa.eu/clima/news/clean-mobility-new-co2-emission-standards-cars-and-vans-adopted_en (March 6, 2020).

European Environment Agency. 2018. *National Policies and Measures on Climate Change Mitigation in Europe in 2017*. Copenhagen: European Environment Agency.

Fankhauser, Sam, Alina Averchenkova, and Jared Finnegan. 2018. *10 Years of the UK Climate Change Act*. London: Grantham Research Institute on Climate Change and the Environment.

Figenbaum, Erik. 2017. "Perspectives on Norway's Supercharged Electric Vehicle Policy." *Environmental Innovation and Societal Transitions* 25: 14–34.

Government of Ireland. 2018. *Investing in the Transition to a Low-Carbon and Climate-Resilient Society, 2018–2027*. Dublin: Government of Ireland.

Government of Ireland, and Climate Action & Environment Department of Communications. 2014. *Climate Action and Low-Carbon Development: National Policy Position Ireland*.

Haugneland, Petter, Erik Lorentzen, Christina Bu, and Espen Hauge. 2017. "Put a Price on Carbon to Fund EV Incentives: Norwegian EV Policy Success." *EVS30 Symposium Stuttgart, 9–11 October*. https://wpstatic.idium.no/elbil.no/2016/08/EVS30-Norwegian-EV-policy-paper.pdf.

Holter, Michael. 2020. "Tesla Record Pushes Norway's Share of Electric Car Sales to 42%." *Bloomberg Technology*. https://www.bloomberg.com/news/articles/2020-01-03/tesla-record-pushes-norway-s-share-of-electric-car-sales-to-42.

IPCC. 2014. *Climate Change 2014: Mitigation of Climate Change*. Geneva: Intergovernmental Panel on Climate Change.

———. 2018. *Global Warming of 1.5 °C*. Geneva: Intergovernmental Panel on Climate Change.

Keegan, Matthew. 2019. "Shenzhen's Silent Revolution: World's First Fully Electric Bus Fleet Quietens Chinese Megacity." *The Guardian, 12 December*. https://www.theguardian.com/cities/2018/dec/12/silence-shenzhen-world-first-electric-bus-fleet.

Kevaney, Laura. 2019. *Spending Review 2019: Incentives for Personal Electric Vehicle Purchase*. Dublin: Department of Public Expenditure and Reform.

LEV Taskforce. 2018. *Low Emission Vehicle Taskforce Progress Report, September 2018*. Dublin: Governmant of Ireland.

Mersky, Avi Chaim, Frances Sprei, Constantine Samaras, and Zhen (Sean) Qian. 2016. "Effectiveness of Incentives on Electric Vehicle Adoption in Norway." *Transportation Research Part D: Transport and Environment* 46: 56–68.

Morgenroth, Edgar, Martin Murphy, and Kyle Moore. 2018. *The Environmental Impacts of Fiscal Instruments*. Dublin: Economic and Social Research Institute.

NESC. 2015. *NESC Forum: Opportunities & Challenges for Climate Mitigation in the Irish Transport Sector*. Dublin: National Economic and Social Council.

———. 2019. *Climate-Change Policy: Getting the Process Right*. Dublin: National Economic and Social Council.

Nørbech, Tom E. 2018. "The Norwegian Electromobility Succes." *Presentation to Initiative seminar on Electromobility at Chalmers University, September 2018*. https://www.chalmers.se/SiteCollectionDocuments/Transport/Noerbech_The%20Norwegian%20Electromobility%20Success.pdf.

NTA. 2019. “Increased Purchase Grants for Electric SPSVs in 2020.” *National Transport Authority*. https://www.nationaltransport.ie/bus-forms/increased-purchase-grants-for-electric-spsvs-in-2020/.

O’Mahony, Tadhg, Peng Zhou, and John Sweeney. 2012. “The Driving Forces of Change in Energy-Related CO2 Emissions in Ireland: A Multi-Sectoral Decomposition from 1990 to 2007.” *Energy Policy* 44: 256–67.

Ostrom, Elinor. 2010. “Polycentric Systems for Coping with Collective Action and Global Environmental Change.” *Global Environmental Change* 20(4): 550–57.

Peyton, Nellie. 2018. “Electric Car Demand Fuelling Rise in Child Labour in DR Congo – Campaigners.” *Reuters*. http://www.mining.com/web/electric-car-demand-fuelling-rise-child-labour-dr-congo-campaigners/.

Sabel, Charles F., and David G. Victor. 2017. *Making the Paris Process More Effective: A New Approach to Policy Coordination on Global Climate Change*. Muscatine, IA: The Stanley Foundation.

Steinbacher, Karoline, Minke Goes, and Korinna Jörling. 2018. *Incentives for Electric Vehicles in Norway*. Berlin: Adelphi & Ecofys.

Stucki, Martin. 2015. “Policies for Sustainable Accessibility and Mobility in Urban Areas of Africa.” *Africa Transport Policy Programme*. https://www.ssatp.org/sites/ssatp/files/publications/SSATPWP106-Urban%20Mobility_IO.pdf.

Tax Strategy Group. 2018. *Energy and Environmental Taxes*. Dublin: Department of Finance.

Torney, Diarmuid. 2018. *Enabling Decarbonisation: A Study of Energy Sector Governance in Ireland*. Wexford: Environmental Protection Agency.

Appendix I: Actions and Measures listed in National Mitigation Plan

Mitigation actions	Mitigation measures
Completion of the Luas Cross City integrated light rail network	T1 - Public Transport Investment - The quality, capacity, cost and accessibility of public transport are critically important in the context of delivering a sustainable transport sector. Transport climate emission reduction efforts must be reinforced by continued investment in public transport capacity increases and quality improvements to secure high levels of modal shift.[2]
Support Government funding commitments to rail and bus improvements, including completion of the City Centre Re-signalling Programme and investment in the bus fleet and bus priority measures	
Electrification of the Northern DART Line to extend the DART to Balbriggan.	
Investment in infrastructure and behavioural change interventions to encourage and support a shift to sustainable modes of transpor	T2 - Smarter Travel Initiative Investment - DTTAS is focused on the promotion of sustainable means of transport – walking, cycling and public transport – through the provision of funding for infrastructure as well as funding for behavioural change programmes to encourage the use of more sustainable transport modes.[3]
Maintain a grant scheme for electric vehicles. Support levels to be reviewed annually	T3 - Low Emission Vehicle (LEV) Incentivisation - Maintain a grant scheme for electric vehicles. Support levels to be reviewed annually.
Deployment of 14 CNG refuelling stations and a renewable gas injection facility	
Broaden the ACA tax incentive for companies to encourage investment in refuelling infrastructure and equipment for natural gas, both CNG and LNG	
Maintain under continuous review the use of the VRT/Motor Tax system in incentivising the uptake of lower emission technologies	T4 - Taxation Policy Vehicle Registration Tax and Annual Motor Tax rebalancing - Increase the number of passenger cars with lower CO2 emissions
Continue to encourage the adoption of natural gas as a cleaner transport fuel by maintaining the excise rate applied at the minimum rate allowable under the Energy Tax Directive	
Continue to optimise current energy efficiency actions in place in the area of public transport	T5 - Public Transport Energy Efficiency - Modal shift to public transport or non-motorized transport; improved behaviour; improved transport infrastructure
Sustain the current Biofuels Obligation Scheme to ensure that biofuels continue to	T6 - Biofuels Obligation Scheme - Low carbon fuels

[2] In 2016, €355m was invested in public transport and sustainable transport infrastructure, €249m was allocated to fund the operation of public transport and rural services; enhancing the capacity and quality of public transport to ensure that – where feasible - our increased transport demand is met by greener public transport (over €400m will be invested in public transport infrastructure in 2018 with a 4 year capital envelope of €2.7bn);

[3] €13.5m was spent on smarter travel projects and greenway

be an increasing part of the road transport fuel mix	
Implement the National Policy Framework on Alternative Fuels Infrastructure for Transport: 2017-2030	
Publish a new Public Transport Policy Statement.	
Publish a review of the National Cycle Policy Framework	
Review the Smarter Travel Policy	
Publish the Greenway Strategy	
Draft a comprehensive National Strategy on ITS	
NPF to secure better integration of land use and transport planning to reduce travel demand and encourage more sustainable modes of travel (walking, cycling, and public transport) as well as more efficient and cleaner transport.	
	T12 - Aviation Efficiency - Policy/regulation
	T13- EU CO2 Cars/Vans Regulation - effiency improvements of vehicles
Continued development and implementation of sectoral energy saving projects	
Continue support for the International Transport Forum's (ITF) Decarbonising Transport Worldwide research and modelling project	
Undertake and fund climate change and air quality research and analysis within the Irish transport sector	
Investment in improved and additional public transport capacity	
Utilisation of the Green Public Transport Fund to support the uptake of low carbon, energy efficient technologies within the public transport sector.	
Examine the expansion of existing support schemes.	
Establish a Behavioural Economics Working Group to consider behavioural change.	
Recommend incentives and optimal regulatory framework for early adoption of LEV technology	T18 - Further Low Emission Vehicle (LEV) Incentivisation
Conduct a review of vehicle and fuel taxation measures within the context of evolving technology development and	T19 - Taxation Policy Development – Motor Tax (Cars)

need to chart a sustainable pathway to the decarbonisation of transport by 2050.	
Conduct a public consultation on progressively increasing the biofuel obligation rate by 2020.	T21 - Biofuels Obligation Scheme Development
Consider the introduction of a grant scheme to encourage eco-driving for HGVs and buses.	T22 - Eco-Driving
	T24 - Reduction of Top Speed Limits on Motorways