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On Track or Not? Why Modelling Low Carbon Policy Pathways for Passenger Transport in Ireland Matters

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Abstract

Passenger transport emissions are currently responsible for 10% of all greenhouse gas emissions in Ireland.[8] Not only is the share of emissions from passenger transport significant at 10%, but also the quantity of carbon dioxide emissions from passenger transport has been growing. The majority of passenger transport emissions come from private car transport, it being responsible for 90% of all passenger transport emissions in Ireland.[19] Past policies to reduce the net emissions from passenger transport, such as manufacturer-based European-wide emissions and efficiency standards for private cars[5,6] have had limited success, with increases in activity from passenger transport and people travelling further and more often by car counterbalancing improvements in car fuel performance.[12] In recent years, the focus has shifted from improving and electrifying cars as a means to decarbonization of passenger transport to a broader range of measures to reduce emissions from passenger transport, including reducing the need for travel in the first place and encouraging a shift to walking, cycling or modes of mass/public transportation.[11,14,15,21,24] We discuss the global climate imperative for passenger transport decarbonization, the policy frameworks established to facilitate this, and the energy systems models we develop here in UCC to monitor current and plan future passenger transport decarbonization.

Keywords: transport emissions, passenger transport, modal shift, energy policy, low carbon transitions.

All models are wrong - but some are useful

— *George E.P. Box*

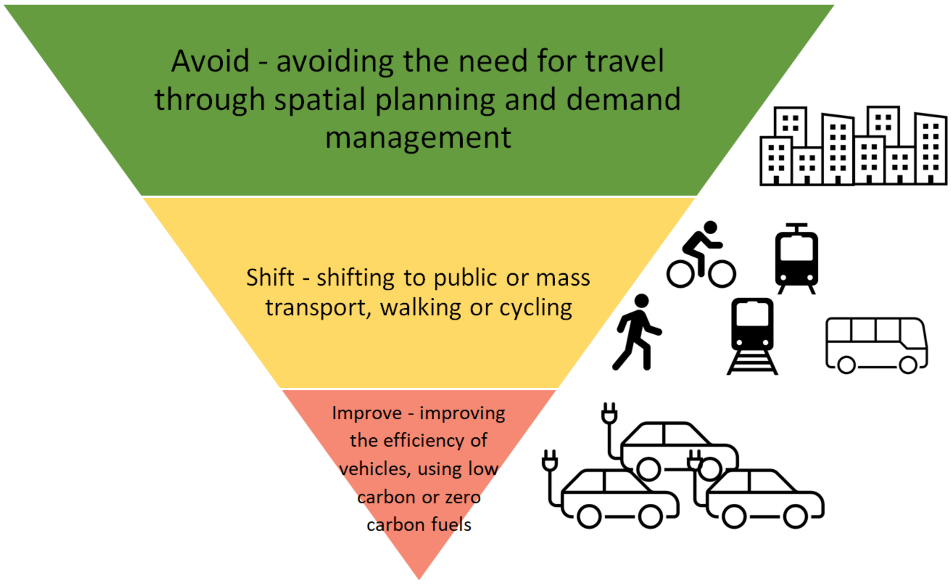

Figure 1: The hierarchy of transport sustainability in the avoid-shift-improve framework (Adapted from the EPA[9])

Avoid-Shift-Improve framework for passenger transport

Only in recent history are we prioritising the absolute reduction of carbon dioxide emission in passenger transport design. The transport policy design principle to emerge, having first been mentioned in the 1990s is the Avoid-Shift-Improve framework. This framework was adopted by the Intergovernmental Panel of Climate Change, the Environmental Protection Agency in Ireland, and the Department of Transport in Ireland.[7, 13, 18] It is summarized as a hierarchy of importance of ways to reduce carbon dioxide emissions from passenger transport as shown in Figure 1.

Ireland's Climate Action Plan

In response to Ireland's Climate targets, the Irish Government published its Climate Action Plan to tackle Climate Breakdown. The policy document sets out targets for infrastructure projects and technologies that can help Ireland achieve its carbon dioxide emissions targets. Overall Ireland has set a target of 51% reduction in carbon dioxide emissions by 2030 compared to 2018, and this commitment to carbon dioxide reductions is enshrined in Irish law through the Climate Action Bill.[1] Equally importantly, Ireland has two sets of carbon budgets (2021-2025 & 2026-2030) which set legally enforceable limits on the level of GHG emissions during these time periods. The Climate Action Plan has over 490 targets set out in the areas of emissions from homes, small businesses, big industry, agriculture, the transport of goods and as is the topic of this article – passenger transport. These targets in the Climate Action Plan help shape the goals, funding allocations and progress tracking in the Departments of Climate Action, Transport, Housing, Planning and Finance. For the passenger transport sector, the Climate Action Plan, while it does not specifically reference the Avoid-Shift-Improve framework, many of the actions can be linked to the principals of the framework. An overview of the key passenger transport targets from the Climate Action Plan and how they relate to the Avoid-Shift-Improve framework is shown in Figure 2.

Passenger Transport in the Climate Action Plan

To estimate the possible emissions reductions from each of these passenger transport policy measures, and what the uptake of the policy targets up to 2030 might mean for electricity consumption and fossil fuel consumption we put together multiple data sources, past academic technology stock models and software programs together to calculate carbon dioxide emissions. We refer to this as "Energy Systems Modelling" which will be discussed in the next section.

Energy Systems Modelling

All models are wrong, but some are useful. We subject reality to mathematical representations with models, and these are grossly simplified. Scientists select input characteristics and calculation processes, called "parameters" as the most important measurements and sums to include when building a calculation which pieces together how much carbon dioxide emissions we have from the passenger transport system, and where these emissions come from. Models can be particularly useful to identify the relative impact of one emissions reduction measure when compared to another. Energy systems modelling is a means of accounting for past, present, and future energy consumptions of a region. These regions generally range from towns up to global energy systems models. Passenger Transport is just one piece of the energy system that energy systems models look at. There are main kinds of the energy systems models that the Energy Policy and Modelling Group in Ireland look at are:

Simulation modelling

Simulation models develop scenarios based on adjustments to a reference "business as usual" projection into the future, spanning between 10 – 80 years into the future. Inputs in simulation models can be tweaked and can handle variability in ways that optimization models are not as suited for. Simulation models are exploratory in nature. The Energy Policy and Modelling Group here in UCC develops and maintains the *LEAP Ireland model*.[16,23]

Optimization Modelling

Energy Systems Optimization Models (ESOMs) - ESOMs explore what fuel types could be required to meet a calculated energy demand for a given region. The Energy Policy and Modelling Group here in UCC develops and maintains the *TIMES Ireland model*.[10] These optimization models are used to determine the optimal design for an energy system. Optimization models provide sharper decision support by providing a single, or a handful of "best" fuel mixes and choices. Optimization models work best with clearly defined mathematical relationships.

Action under the Climate Action Plan 2021	Avoid-Shift-Improve?
Action 231: Continue the improvement and expansion of the Active Travel and Greenway Network	Shift
Action 232: Develop a coherent and connected National Cycle Network Strategy	Shift
Action 233: Construct an additional 1,000km of cycling and walking infrastructure	Shift
Action 234: Encourage an increased level of modal shift towards Active Travel (walking and cycling) and away from private car use	Shift
Action 235: Accelerate sustainable mobility plans for schools	Shift
Action 236: Legislate to improve the Active Travel environment in urban centres	Shift
Action 237: Enable use of e-scooters and e-bikes	Shift Improve
Action 239: Commence delivery of BusConnects Network Redesign Dublin	Shift
Action 240: Commence delivery of BusConnects Network Redesign in Cork, Galway, Limerick & Waterford	Shift
Action 241: Commence delivery of BusConnects Core Bus Corridor Infrastructure Works	Shift
Action 245: Implement an enhanced rural transport system through delivery of Connecting Ireland Rural Mobility Plan	Shift
Action 246: Commence delivery of DART+ Programme and continue heavy rail fleet investment	Shift
Action 247: Commence delivery of MetroLink	Shift
Action 248: Introduce National Youth Travel Card on a phased basis	Shift
Action 249: Expand Smarter Travel Workplaces Programme	Avoid Shift
Action 250: Examine the role of demand management measures in Irish cities, including low emission zones and parking pricing policies	Avoid Shift
Action 252: Continue rollout of variable speed limits/dynamic traffic management infrastructure on the M50 Motorway to increase safety and reduce congestion	Avoid Shift
Action 253: Conduct review of Community Car Scheme	Avoid
Action 255: Balance better movement priorities within urban areas to transition the built environment and public domain from one that is "vehicle centred" to being "people centred" to align with the goal of net zero by 2050	Avoid Shift
Action 257: Review and, if necessary, develop a regulatory framework for low-emission zones	Avoid Shift
Action 258: Advance Demand Management Measures	Avoid
Action 259: Explore potential of road-user charging measures through the Better Road User Charging Evaluation (BRUCE) study	Avoid

Figure 2: Overview of the passenger transport centred actions under the Climate Action Plan 2021,[2] and their categorization under the Avoid-Shift-Improve framework

Hybrid models

Often modellers blend the two kinds of models together and use a combination of both optimization and simulation modelling to calibrate the models to one another. For example, in Mulholland et al.[17] a past version of the *TIMES Ireland* model was soft linked with the *LEAP Ireland* simulation model, and this was used in an iterative way to validate, and trouble shoot some of the results produced by each of the models. Sector specific models, such as the *PLEXOS Ireland* model developed here at UCC provide time-sliced and merit-based generation data for the electricity sector in Ireland which in turn serves as a soft-linked input for the Irish simulation (*LEAP Ireland*) and optimization (*TIMES Ireland*) models. In other instances, hard links to models are used, as the outputs from one model is used as an input to another model. For examples, the bottom-up car stock simulation model, the *Irish Car Stock Model* which produced emissions and vehicle kilometre calculations from cars in Ireland was hard linked to the *Irish Passenger Transport Emissions and Mobility (IPTEM)* model which produced passenger transport emissions calculations for all modes of passenger transport in Ireland.

Synergies and Antagonisms in policies

Policies do not operate in isolation. Therefore, modelling multiple policies, interactions and ongoings at once can help understand how different technologies, behaviours and policies work together. For example, calculating the impact of what electrifying all public transport in Ireland will have a greater impact if there is an accompanying modal shift from car use to public transport in the first place. The additional passenger transport demand may also make the electrification of public transport harder, as there would hypothetically be more public transport vehicles on the road and rail services to meet this increased demand. Energy Systems models can improve the assumptions, increase the number of input parameters and grow in size to capture more and more of these dynamic effects OR they can limit the number of parameters which in turn can make model maintenance, model sharing, and model use for policy questions faster and more responsive. Maintaining the balance between detail, data availability and speed when answering tough policy questions from the public, community groups and policy makers is one of the key challenges that energy systems modellers manage throughout their work. Previous work has stressed that electric vehicles alone are not enough to meet our ambitious climate targets, and that a broad range of policies – not just targets based on electric vehicle uptake – is required to meet our overall emissions reductions targets.[11,20,22] Uptake of electric vehicles has proven to be slower than a target consistent trajectory, despite annual sales of electric vehicles breaking records year-on-year. The scale of the change required is much greater than what is currently being met or seen, thus a multi-faceted strategy is required to reduce the risk of a single policy failure – not putting all the policy "eggs" in one basket and diversifying the ways in which we decarbonize transport is essential as we strive to meet these very ambitious climate policy targets.

Best practice in Passenger Transport Energy Systems Modelling to inform Climate Policy

Through our modelling activities in the passenger transport sector, we have developed the *IPTEM* model[19] that develops a picture of passenger transport emissions and demand by trip-purpose, mode type and trip distance. Passenger transport information such as this is helpful in informing demand reduction and modal shift scenarios in both the simulation models and optimization models we develop in the Energy Policy and Modelling Group.[10,16] The *Irish Car Stock Model*, and private vehicle stock, emissions and activity information is openly available.[4] Thus far, with the CAPACITY project, we have provided information to policy makers on walking and cycling targets, electric vehicles, working from home and transport in general.[3] An overview of the sources of passenger transport demand in Ireland, one of the insights from the *IPTEM* model is shown in Figure 3.

By engaging with and referring to policy documents, policy makers and academic literature throughout the energy systems modelling development process, we can, and have, produced instructive low carbon pathways and projections for how we could achieve our ambitious emissions reductions targets.

Conclusion

Energy Systems models are helpful tools to highlight the emerging pathways to a low carbon future in the passenger transport sector. By engaging with and referring to policy documents, policy makers and academic literature throughout the energy systems modelling development process, we can and have produced instructive low carbon pathways and projections for how we could achieve our ambitious emissions reductions targets. In this article we have discussed how simulation models could highlight low carbon emissions pathways using policy frameworks from the Intergovernmental Panel on Climate Change (IPCC). We also discuss how these simulation models have informed carbon Irish Climate Policy in the past, and matters relating to the synergies and antagonisms that simulation modelling reveals in low carbon passenger transport modelling.

Future work

Future work looks to make the documentation behind the *LEAP Ireland* model openly available for anyone to use. A broad-based study on the role of the Avoid-Shift-Improve framework using bottom-up passenger transport model in Ireland based on the historical calculations from the *IPTEM* model[19] will investigate what the impact of different transport policies could have on passenger transport emissions up to 2030, and the implications of the transition and targets on our carbon budget between now and 2030.

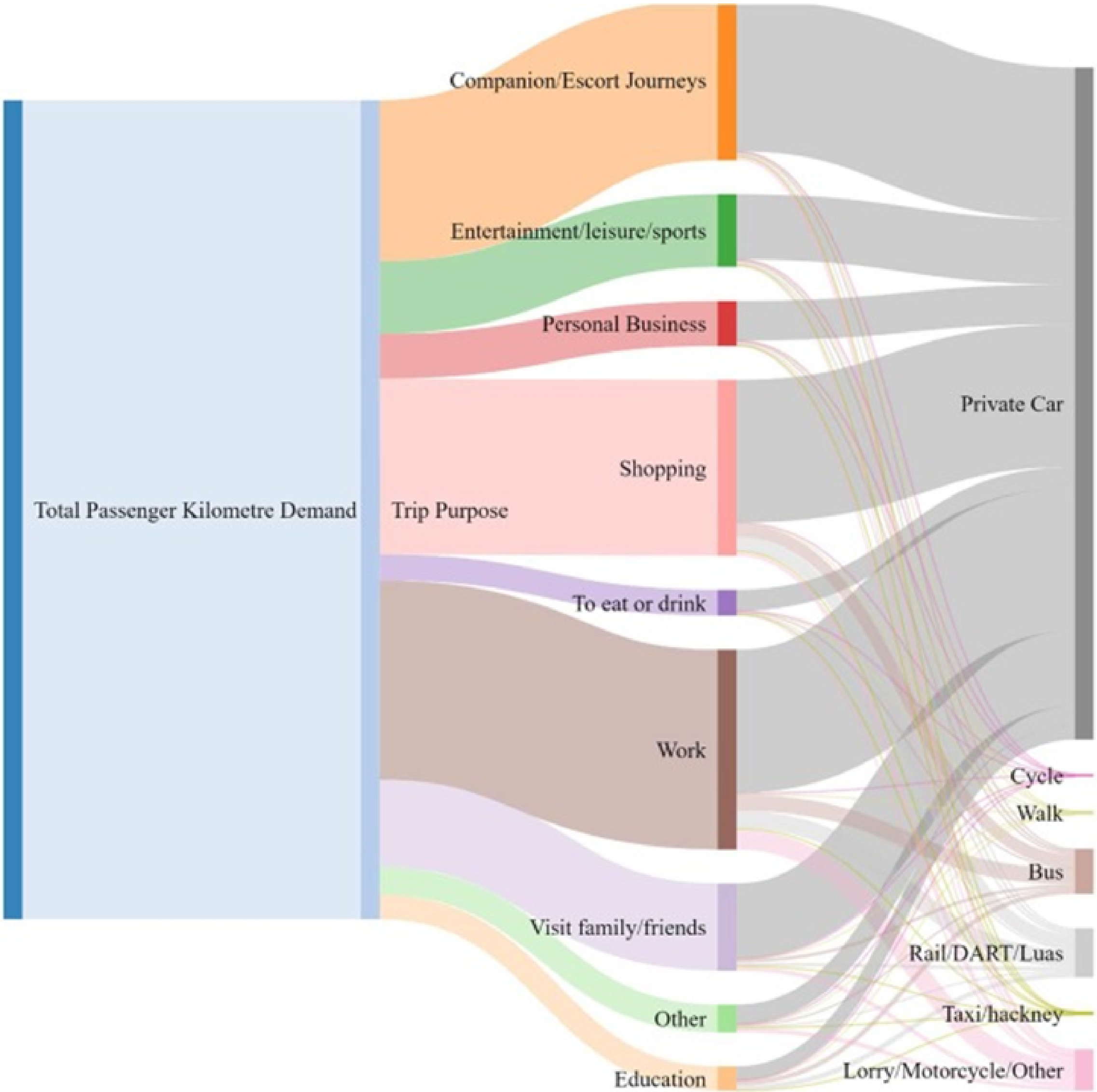

Figure 3: Passenger Kilometre demand by trip purpose and mode for Ireland in 2019[19]

Declaration of interest

The author has no conflicts of interest to declare. All ethical guidelines relating to the research and publication process were adhered to throughout this study.

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