Low-emission mobility & transport

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1 Introduction

Transport accounts for about 25% of Europe's greenhouse gas (GHG) emissions in 2015 and the emissions mainly stem from road transport fuel. Main strategies to reduce GHG emission from transport include (1) the reduction of transport demand, (2) a shift in transport modes to those with higher energy efficiency and lower GHG emissions, (3) an increase in vehicle technology and efficiency, as well as (4) a switch to low-carbon fuels such as biofuels or renewables.

In most mitigation scenarios (especially global IAM scenarios), reductions are mostly achieved through fuel switching and further enhancements in energy efficiency. Creutzig et al. (2015) argue that limiting demand growth by shifting to modes that are more efficient and reducing the distance travelled has limited application in global IAM scenarios and emissions could be further reduced than currently suggested.

The aim of the present technical note is to discuss current practices in modelling policies for a transition towards low-carbon transport. We discuss the examples of fuel switch in road transport and travel demand modelling. We close with a few comments on policy modelling and best practices in general.

2 Fuel choice modelling

Low-emission or zero-emission vehicles both in passenger and freight transport are crucial for GHG mitigation in transport. The discussion is presently dominated by passenger cars and plug-in electric vehicles (PEVs). These are battery electric vehicles (BEVs) which have a battery for energy storage and an electric motor for propulsion as well as plug-in hybrid electric vehicles (PHEVs) which can use both a combustion engine and an electric motor for propulsion. Fuel-cell electric vehicles (FCEVs) that use hydrogen for energy storage and convert that to electricity using a fuel cell are another option.

Supported by:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
based on a decision of the German Bundestag
European Climate Initiative EUKI
STIFTUNG MERCATOR

Project partners:
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This project is part of the European Climate Initiative (EUKI) of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

These three represent options that reduce technically GHG emissions from road transport if renewable energies are used for recharging and are widely accepted as future propulsion technologies both for passenger cars and light and heavy-duty vehicles. However, key questions for policy makers are (1) the speed of their future market diffusion and (2) how to accelerate this market diffusion. For modellers, this translates into the question of many individual future purchase decisions and policies that affect these purchase decisions.

To set-up a model for the market diffusion of future fuel technologies, the modeller has to make several important choices:

1. Which technologies to include? For example, many diffusion models on PEVs ignore natural gas vehicles or FCEVs.

2. How to model purchase decisions? Common approach in the literature are logit-based models, agent-based models or hybrid models with many different parameters entering the decision algorithm.

3. The geographical or market coverage: If only a local market, such as one country, is covered, many parameters such as battery prices will be exogenous.

4. How much charging infrastructure will be provided and by whom? Should it be part of the model or exogenous? This seems not as urgent for passenger cars where many drivers in Europe own houses and could easily recharge at home, but is an important issue for trolley trucks that can only be operated with an infrastructure and at best had a trans-European infrastructure.

Apart from these very fundamental decisions, assumptions about future energy prices, technology costs, and many individual parameters have to be made.

Highly detailed purchase decision and market diffusion models seem to cover many aspects of reality. Yet, in practice, many aspects of purchase decisions are not well understood or sufficient data is unavailable. A problem that seems unsolvable is that we can only collect data about the present and the past: We simply do not know what future buyers will think of PEVs and how they evaluate various aspects of this technology and if they behave differently in the future.

3 Travel demand modelling

There is a long tradition of travel-demand modelling, mostly in the context of infrastructure planning. Travel demand models have evolved from macro-level strategic models to classical four-step models and further to activity-based modelling. Classical four-step models are trip-based and consist of four steps: trip generation, trip distribution, mode choice and route assignment. Over the last decades, activity-based models have gained more and more importance. In activity-based models, travel demand is derived from the activities that individuals need or wish to perform rather than focussing on trips. State-of-the-art activity-based travel demand models can deliver detailed and good analysis of travel behaviour and are sensitive to a broader range of planning strategies and policies. For example, they allow substitution between travel and non-travel means of meeting personal and household needs; and they are able to capture the effect of urban form, congestion and activity opportunities on travel demand. Recently, there have been attempts to improve modelling results by integrating big data resources (Toole et al. 2015). On the other hand, complex activity-based models require high level of data input and generally more care by users. Thus, those models are mostly used on regional or city-level. Most models used in the policy context (e.g. the “Primes” model used by the European Commission) operate on a higher aggregated level.

Even if travel demand models are able to accurately explain current travel behaviour and to make short-term predictions on the influences of policy instruments, this is not always true for the long-term perspective. Main limitations when using travel demand models for long-term scenarios are that usually no changes in user preferences, attitudes or travel behaviour are assumed. Predicting the effect of future trends, e.g. autonomous vehicles or a high level of digitalisation, is difficult or related to a high level of uncertainty.

4 Modelling policies in transport

Policies in transport are often categorized in three types: monetary policies, regulation and information. For transport, a fourth category seems to be useful, i.e. infrastructure and urban planning. Depending on the choice of the model, these types of policies can be easy or very difficult to implement:

- For example, many models base the vehicle purchase decision on the total costs of ownership of a vehicle. Accordingly, financial incentives addressing vehicle prices or operation costs are easy to integrate. Here, most difficulties lie in evaluating the impact of certain monetary policies and the differentiation of incentives that are effective at purchase or during the use phase.
- Only a few models cover regulations, e.g. the CO_2 regulation for new vehicle purchase in the EU or the CAFE standard in the US, in full. This lies in the nature of models that are often designed to model the purchase decision of vehicles, yet the vehicle supply is often out of scope or too difficult to describe.
- Even more rarely covered in models are information campaigns. The difficulty here is to quantify the effect of such campaigns on users or society as a whole.
- Lastly, the aspect of infrastructure and urban planning is addressed and somehow integrated in many models, especially when charging infrastructure for PEVs is discussed. However, long-term aspects, e.g. placing companies close to communities so commuting is shorter or the installation of a new railway connection, are often neglected.

To the authors' point of view, there is a need for (1) more studies about the effect and quantification of regulation and information campaigns on users and (2) a better integration of these aspects into models. An integration of infrastructure and urban planning depends on the scope of the study and might sometimes better by evaluated without complex modelling.

Modelling real-world policies can be a tough task. Modellers often face a lack of detailed information on policies and their consequences, and integrating real-world policies into a model often needs many assumptions – especially if the model was not designed for this purpose. Furthermore, when comparing ex-ante modelling and ex-post results, it often becomes clear that unexpected user behaviour, loopholes in regulations or changes in underlying trends can result in a gap between modelled and observed policy outcome. Givoni et al. (2012) state that a complex model is not always needed to achieve better results in a decision-making process. What is more important is to ask the right questions; develop models that answer those questions. There is a gap between what can be considered good, or the best model from a modelling perspective and what can be considered the most useful, or useful from a policy perspective.

The following gives a few short comments on potential issues in modelling in general and in modelling policies in particular.

Modelling for insights – not for numbers. (Hamming 1962, Geffrion 1976 and Huntington et al. 1982) Simulations and Models help to understand complex systems – there are not accurate representations of the world and should thus always be interpreted with care. In the discussion and interpretation of model results, one should rather seek a general understanding and general conclusions instead of specific numbers. The focus of this understanding concerns the system and its behaviour; conclusion should focus on that.

All models are wrong but some are useful. (George Box) All models are clear simplifications and approximations of reality. Accordingly, model results come with the uncertainty. Quite often, the modeller knows the uncertainties, but they need to be communicated as well. Thus, always state your model results with confidence intervals, error bars or sensitivity analysis. Focus on robust findings in your results and conclusions.

Predictions are difficult – in particular about the future. (Niels Bohr) Many important factors in modelling future energy systems are highly uncertain and unpredictable. However, one should validate the model results as much as possible on existing historical data. This helpful to improve the model and learn about the range of applicability of the model. Furthermore, one can easily acknowledge that many simulations are not predictions but tools to understand systems and help informed decision-making.

5 Communicating modelling results for low emission mobility

Good communication of modelling results is highly important in order to avoid false conclusions. Scenarios in transport are often more complex than for example in the power sector. It is important to break down possible strategies in order to inform decision makers about the “building blocks” for low emission transport. In the context of transport, it is especially important to inform policy makers about the contribution of both sufficiency and efficiency strategies. Furthermore, it is important to not only focus on decarbonisation but to take into account a broader perspective trying to include distributional effects (e.g. how does electromobility affect second-hand car owners?), employment effects, and other sustainability issues (e.g. pollution & noise are important drivers of change in most cities). Some suggestions for best practices for better communication of modelling results from the transport sector are:

Where assumptions are necessary, consider worst case and not only best case to avoid overestimating policy impact. For example, ex-ante modelling of the effect of EU regulation 443/2009 on the CO_2 emissions of passenger cars resulted in high outcome estimates. In reality, the real-world gap between official CO_2 test values and real-world driving increased drastically and resulted in CO_2 reduction being much lower than previous estimates suggested. Consequently, when modelling the effect of the post-2020 regulation, the possibility of a further increase in the real-world gap or other loopholes (e.g. WLTP – NEDC conversion factor) should be taken into account. "Worst-case assumptions" become even more important in the context of ambitious climate targets (national targets, effort-sharing regulation), because overestimating the impact of adopted and planned policies will ultimately result in missed targets.

Specify policies as clearly as possible to avoid mis-interpretation of results by policymakers. Low-emission mobility strategies are sometimes stated on a very qualitative or abstract level. For example, policymakers might agree to „support cycling", and modellers are asked to quantify the impact of "cycling support". In order to be able to quantify the impact of "cycling support", assumptions are necessary – and these assumptions should be communicated clearly afterwards by specifying the policy instrument (e.g. „From 2020-2030, invest additional 10 Euro per capita and year into cycling infrastructure").

Consider uncertainties by giving a range of possible outcomes depending on uncertain parameters. Policymakers sometimes ask for simplicity and "one number" (e.g. the GHG mitigation effect of a policy instrument). Nevertheless, sensitivity analysis of modelling results often shows that results are dependent on uncertain parameters. In order to avoid the impression of high predictability and low uncertainty, it seems often better to give results such as „GHG-reduction 2-3 Mt" instead of „GHG-reduction 2,54 Mt".

6 Further reading/ publications

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