

Modelling local vehicle stock dynamics in the decarbonization of the passenger car sector

6

Antonia GOLAB⁽¹⁾, Sebastian ZWICKL-BERNHARD^(1,2), Marcus OTTI⁽¹⁾, Hans AUER^(1, 2)

⁽¹⁾ Energy Economy Group (EEG), Technische Universität Wien, ⁽²⁾ Department of Industrial Economics and Technology Management, The Norwegian University of Science and Technology

Motivation

Large-scale energy system models often overlook the behavioral aspects of transport sector decarbonization [1]. Furthermore, they fail to account for the transition of drivetrain technologies in vehicle fleets. As a result, the uptake of battery-electric vehicles, which depends on customer purchase behavior, is disregarded. Consequently, these models tend to overestimate the speed of the transition to an electrified passenger car fleet. This work aims to address this issue by focusing on a granular case study and modeling vehicle uptake based on different travel purposes and consumer groups.

Methodology

A linear optimization model is developed to simulate the transition of the passenger car fleet while incorporating the modal shift to public transport. The objective function includes the following cost components: investment costs for the vehicle fleet, fueling costs, intangible costs, and costs associated with public transport.

$$\underset{x}{\text{minimize}} z = C^{\text{vehicle stock, total}} + C^{\text{fueling, total}} + C^{\text{intangible}} + C^{\text{public transport}}$$

Intangible costs refer here to “non-monetary” costs that influence the decision in the technology and mode choice. It is connected to the level of service a mode or type of vehicle provides in terms of time efficiency and perceived value of time, which varies by income class. By imposing constraints on the monetary budget of different consumer groups.

The model is applied to the Basque Country, a federal state in the North of Spain. Three subregions of this region are modeled and routes in the urban versus rural area are differentiated, further also by their purpose. For this origin-destination data is used [2]. This data is open-source and available at NUTS-3 level in all regions of the European Union.

Preliminary results and conclusions

Preliminary results from this analysis reveal significant differences in the uptake of electric vehicles across consumer groups (see Figure 1). Two key observations emerge:

- The uptake of battery-electric vehicles in the upcoming years is particularly fast in income classes with high purchase power, while those with less purchase power rather transition to the public travel transport mode.
- Fossil-fueled passenger cars are still present until the end of the optimization horizon, 2050. These vehicles are mostly allocated to households in rural areas with low incomes. This is mostly driven by a more limited budget and low availability of public transport.

These serve as indications that energy system models need to consider this impedance in their input parameters; policy-wise, this shows significant levers for removing fossil-fueled cars from the system by restricting their lifetimes and, further, that low-income groups in rural areas need particular support schemes to reduce the financial effect of the transition.

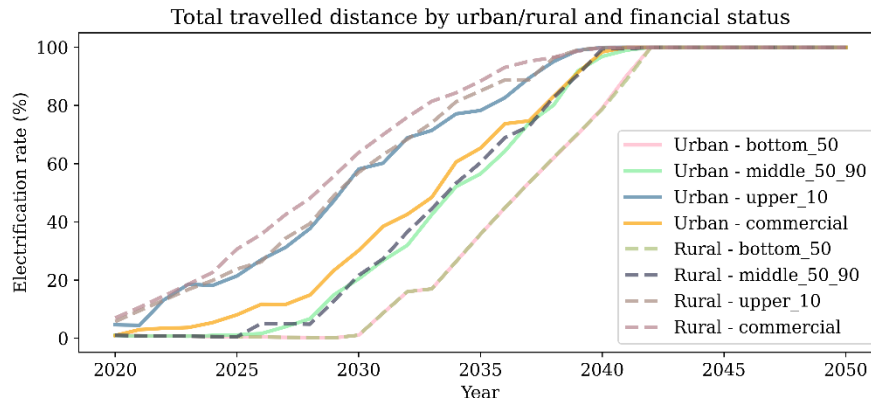


Figure 1: Electrification of passenger car by income class and allocation of housing (rural vs. urban).

Literatur

- [1] Tattini, J., Ramea, K., Gargiulo, M., Yang, C., Mulholland, E., Yeh, S., & Karlsson, K. (2018). Improving the representation of modal choice into bottom-up optimization energy system models – The MoCho-TIMES model. *Applied Energy*, 212, 265–282. <https://doi.org/10.1016/j.apenergy.2017.12.050>
- [2] Speth, D., Sauter, V., Plötz, P., & Signer, T. (2021). Synthetic European road freight transport flow data based on ETISplus (Version 1) [Data set]. Mendeley Data. <https://doi.org/10.17632/py2zkrb65h.1>