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Efficient Technologies and Systems for Mobility

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First insights from extending a Swiss energy system model with heterogeneous car consumer segments

Highlights:

- Socio-economic consumer segmentation is applied in the passenger transport sector of the Swiss TIMES Energy Systems Model (STEM).
- Effects of home office and online shopping in a climate ambitious scenario are tested in the new modelling framework.
- Preliminary results show not only a reduction in fuel consumption, but also differences in vehicle choice and usage.
- In further work, consumer segments will be enriched with behavioral attributes to achieve an improved proxy of real-world mobility decisions and the approach will be extended towards enabling endogenous modal shifts.

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1) Introduction

Background:
The transport sector needs a quick transition in order to achieve ambitious net-zero emission goals by 2050. Such a transition requires vehicle technological improvements along with changes in consumer behavior in a heterogeneous population, such as acceptance of such technologies, modal shifts and the need for mobility demand reductions.

Swiss TIMES Energy Systems Model (STEM):
The STEM is a tool for generating long-term energy system pathways based on cost-optimization. While including many techno-economic details, it represents limited socio-economics and consumer behavior.
In passenger transportation, STEM includes different transportation modes and range of vehicle technologies. However, mobility demand is modelled for one homogeneous consumer, which does not reflect diverse socio-economic backgrounds, mobility demands and ~~choice~~ preferences across the population.

2) Research questions & aims

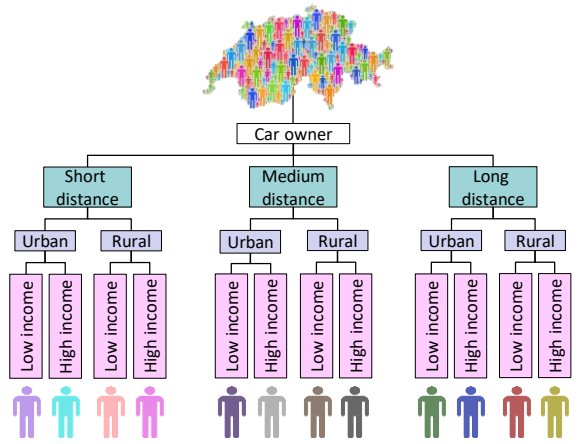
Research Questions:

- How to integrate consumer behavior in STEM to achieve a more realistic representation of mobility demand?
- Which attributes are most effective for representing consumer diversity in STEM?
- How to design tailored policy measures for achieving effective decarbonisation with minimum perceived negative influence for the overall society?

Aims:

1. *Substitute the homogenous consumer representation in STEM with heterogeneous consumer segments of the Swiss population.*
2. *Distinguish mobility-relevant socio-economic characteristics of the consumers to represent their car transport decision-making.*
3. *Implement cost- and non-cost related attributes for vehicle and modal choice of the consumers.*

3) Integrating consumer segmentation



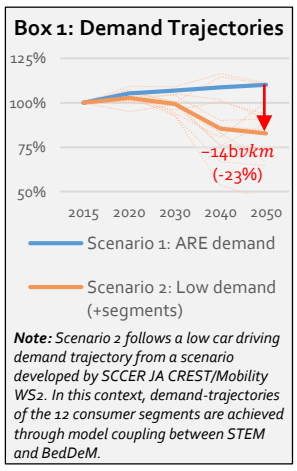
Individual attributes allow diverse decision-making preferences across consumer segments:

- Consumer specific demand trajectories
- Hourly driving patterns with on- and off-road timings
- Access to smaller/larger cars (proxy for income)
- Vehicle lifetimes (~ 1 / annual driving distance)
- Annual driving distance and vehicle survival probability decrease for older cars.

4) Results: Preliminary insights from integrated consumer segments in STEM

Scenarios: Climate-ambitious scenarios (CLI) that apply stringent CO_2 emission targets for 2030 and 2050, and aim for system-wide net-zero emissions by 2050. Scenario 1 follows the ARE demand patterns, while Scenario 2 foresees a reduced car driving demand due to a future with increasing home office and online shopping, assessed by the Behavioral-driven Demand Model (BedDeM) within the JA CREST Mobility (see Box 1).
Test case results are from STEM with heterogeneous consumer segments, but without applying any distinguishing behavioral preferences.
Insights: 23% decrease in car driving in 2050 reduces not only the fuel demand for cars (Figure 1), but also eases expensive mitigation measures in other energy sectors, such as a 4% lower energy demand for building insulation the residential sector. The reduced car demand in 2050 is mainly met by less usage of battery- and ICE gasoline cars (Figure 2).

Box 1: Demand Trajectories



Note: *Scenario 2 follows a low car driving demand trajectory from a scenario developed by SCCER JA CREST/Mobility WS2. In this context, demand-trajectories of the 12 consumer segments are achieved through model coupling between STEM and BedDeM.*

Figure 1: Car Fuel Consumption

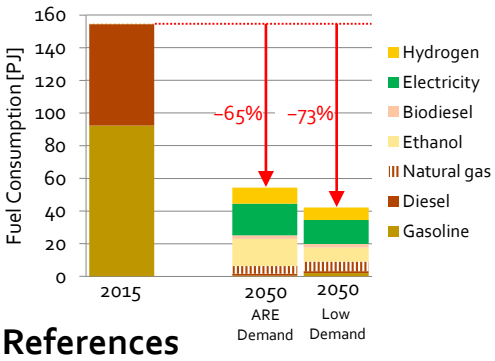
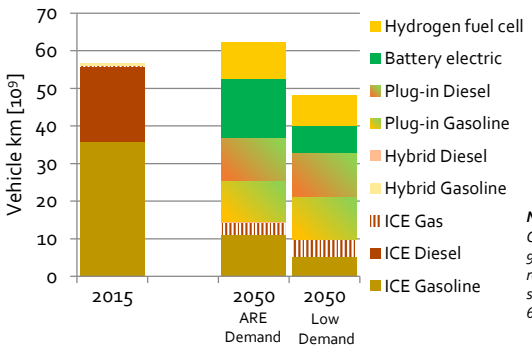


Figure 2: Vehicle km by car type



Note: *In the ARE Demand scenario, Gasoline and Diesel consist in 2050 to 97% of Ethanol and 65% of Biodiesel, respectively. In the Low Demand scenario, such shares are 80% and 66%, respectively.*

5) Conclusions & Outlook

Conclusions:
In STEM, 12 consumer segments are integrated, and the model is applied to assess the effects of home-office and online shopping. The lower demand leads not only to reduced fuel consumption, but also show differences in vehicle choice and usage across the consumer segments due to their diverse driving characteristics. Most importantly, the tested demand reduction in private car transport allows to ease expensive mitigation measures in other sectors of the Swiss energy system.

Outlook:
Future work will focus on implementing additional behavioral attributes for the consumer segments, such as travel money budgets, range anxiety, and E-charging availability/duration. This shall steer individual decision algorithms towards an improved proxy of real-world mobility behavior, lead to clearly distinguishable patterns, and allow for analyses on segment-level. Beyond this, the model shall be extended by enabling endogenous modal shifts for the consumers.

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Partners

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