Long term Swiss Mobility Energy Scenarios – An integrated energy systems approach

The goal of «Energy Economic Modelling» in the Capacity Area B2.3 is to carry out integrated analysis of the Swiss transportation system and other energy sectors. This is achieved by ***whole energy system approach*** with 1) high level of ***technology detail*** to identify future energy pathways; 2) ***long time horizon*** to account for long-term goals and long lifetimes of energy-related infrastructure; and 3) ***high temporal resolution***. We account for intra annual variations in supply and demand, which is critical for evaluating the deployment of intermittent renewables, electrification of transportation and heating, and an emerging need for storage. We undertake what-if type ***scenarios analysis*** to understand long term transition of the Swiss mobility to meet the goals of the 2050 Swiss Energy Strategy.

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Swiss TIMES Energy System Model (STEM)

STEM is a whole energy system model of Switzerland with a time horizon of 2010-2100 and an hourly resolution (Figure 1). It optimises (minimise cost) technology and fuel mix to meet exogenously given energy services demands (e.g. personal (vehicle kilometre) and freight (tonne kilometre) transport) based on competing energy 'pathways'.

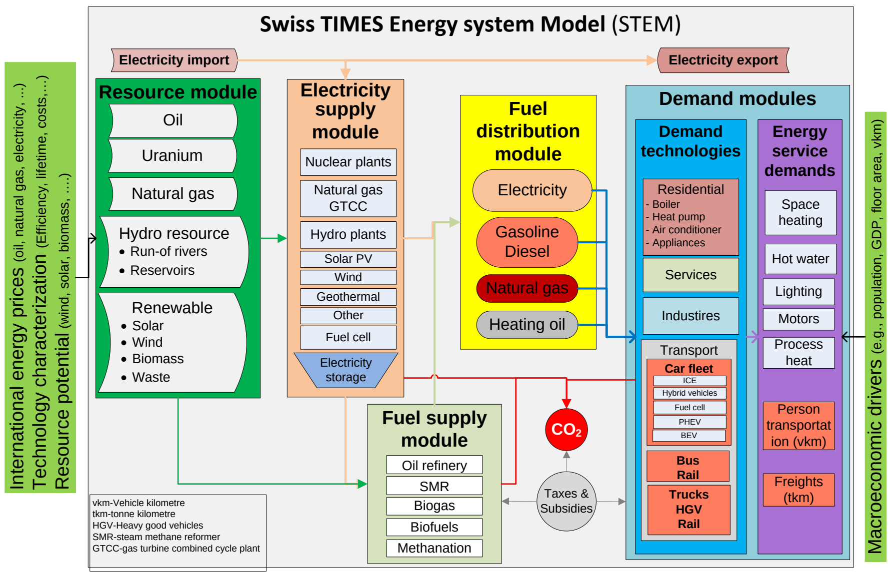

Figure 1: Framework of Swiss TIMES Energy Systems Model

The **transport sector** covers ten modes (e.g. cars, buses, rails, and trucks) and range of existing / future vehicle technologies with a diverse drivetrains /fuels. It includes pure battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), charging of which is possible when the cars are not on road.

Energy scenarios

Base scenario includes transport demands from the SES2050, nuclear phase out and self-sufficiency (i.e. no net import) in annual electricity supply.
Two transport emission reduction scenarios to meet the **transport sector CO2 emissions** in POM (***T40***) and NEP (***T60***) scenarios of the SES2050.
Two **low carbon energy system scenarios** similar to the NEP scenario of the SES2050 – a 22% reduction in CO2 by 2020 and 60% (***S60***) or 67% (***S67***) by 2050 relative to 2010 (and including emissions from international aviation).

Cars fleet and electricity supply

In *Base* scenario, existing gasoline ICE cars are replaced by hybrid cars due to increasing energy price. Average CO2 emission of car fleet decline from 208 g-CO2/km in 2010 to 98 g-CO2/km by 2050.

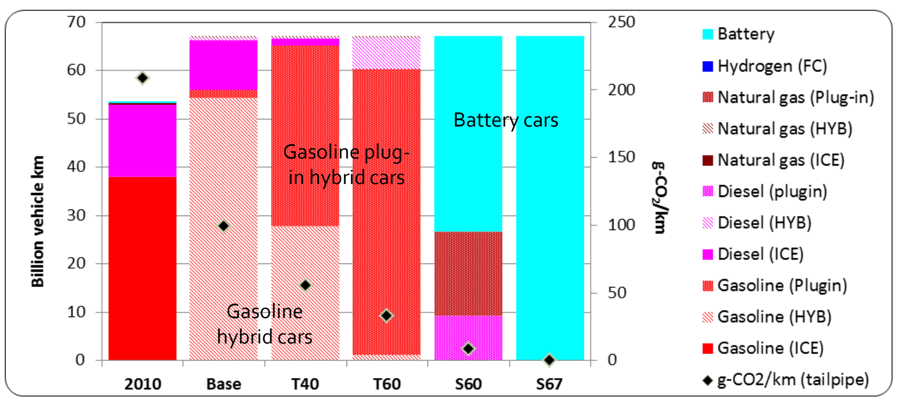

Figure 2: Car fleet and tailpipe CO2 emissions in 2050

To meet the transport only emission target (*T40* and *T60* in Fig 2), PHEV car penetrate the market whereas the system wide CO2 target strongly promotes pure electric cars. Some non-car transportation (bus, trucks) shift to hydrogen and biodiesel.
Electrification (e.g. e-mobility) result in continuous growth in electricity demands (60 TWh in 2010 to 70-80 TWh in 2050) (see Fig. 3).

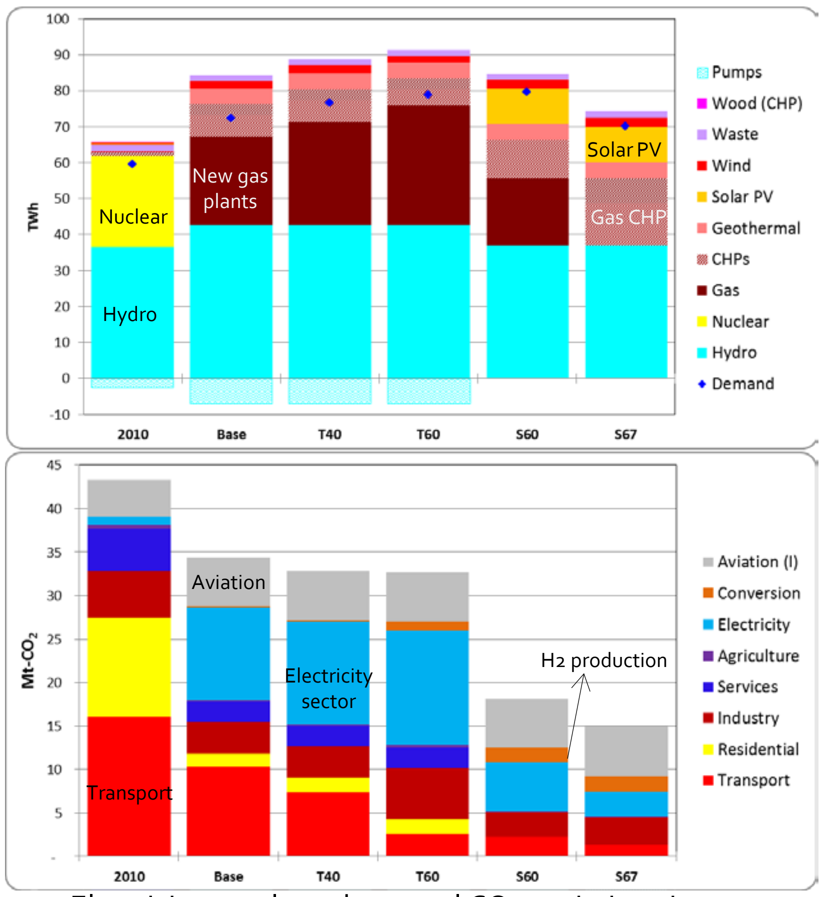

Figure 3: Electricity supply and sectoral CO2 emissions in 2050

CO2 emissions and costs

In *Base* scenario, CO2 emissions in 2050 reduce by 30%. E-mobility 'shifts' the CO2 emissions to the electricity sector due to gas power plant (see Fig 3). Compared to the *Base* scenario, additional cumulative (2015-2050) costs of the scenarios are between CHF 16-152 billion for mobility sector CO2 mitigation and CHF 44-614 billion for system wide CO2 mitigation.

Conclusions

- E-mobility can decarbonise car fleet and contributes to net reduction in CO2 emissions.
- Transport specific CO2 target does not result in net reduction in CO2 emissions, instead it leads to carbon leakage to other sectors.
- Given the phase out of nuclear generation, clear policy for electricity sector is required to ensure that capacity is built to achieve low-carbon target, including signals for continued expansion of renewable generation.
- It is essential to ensure consistency between policies on electricity and end-use sectors (e.g. promotion of e-mobility and expansion of new centralised power plants).

Reference

R. Kannan and H. Turton (2016) Interplay between electricity and transport sectors – Integrating the Swiss car fleet and electricity system, *Transportation Research Part A: Policy and Practice* (submitted).