Capacity Area B2 Topic 3.2 Deliverable 2

Analytical results of integrated mobility scenarios

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In the framework of SCCER Mobility and its associated Joint Activities, a variety of scenarios for the future evolution of the Swiss transport sector have been generated. The transport sector is modelled as a part of the whole Swiss energy system and the scenarios span over different ambition levels for climate change mitigation. Besides a reference scenario that assumes moderate climate objectives reflecting current trends, we analyze an ambitious CO_2 emissions reduction scenario of 80% by 2050 compared to 1990 and a scenario aiming at net-zero CO_2 emissions by 2050 (excluding emissions from international aviation, land-use and forestry). The scenarios are assessed using PSI's Swiss TIMES Energy Systems Model (STEM) and represent least-cost energy system transformation pathways over the next three decades under different boundary conditions and the assumed policy targets. The multiple interdependencies between different technologies and actors in the whole energy system are accounted for. Apart from moderate to extreme reductions of CO_2 emissions all scenarios exhibit very high efficiency improvements, which are highest in the case of most stringent climate goals. Some of the main insights from scenario analysis are summarized below.

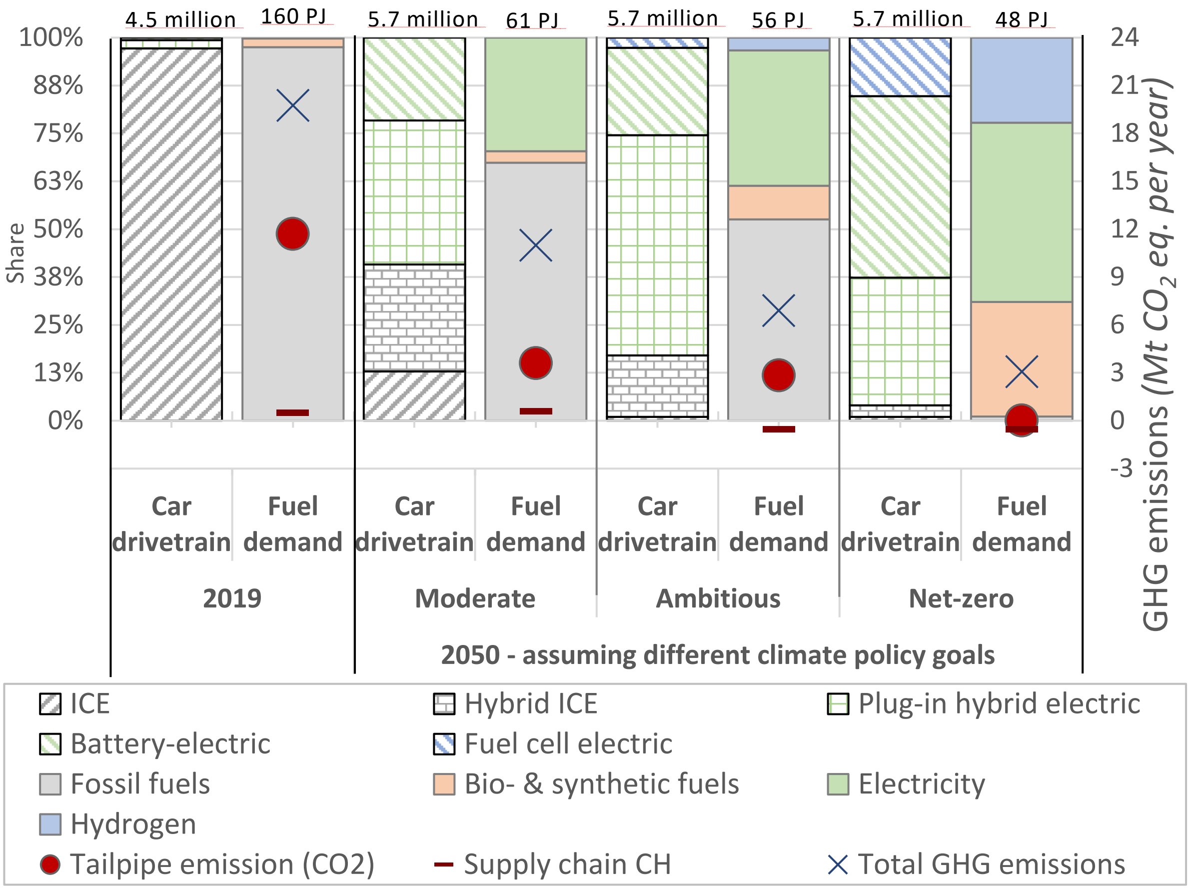
Electric cars are evolving as a cost-efficient mobility option even if climate change mitigation would not be the primary priority. The path to very extensive electrification goes in the middle term through quite strong expansion of hybrid vehicles. If the assumed purchase cost reductions, substantial improvements of driving range and charging time will be achieved, and fossil fuels prices will continue to increase in the long term, electrification of the car fleet primarily by means of Battery Electric Vehicles (BEV) and Plug-in Hybrid Electric Vehicles (PHEV), ramps up around 2030 and beyond. With ambitious climate goals, at least 80% of cars in 2050 would be predominantly based on battery and hydrogen electric drives. Achieving net-zero CO_2 emissions by 2050 additionally requires that the remaining PHEV use biofuels or synthetic fuels produced with Carbon Capture and Storage (CCS), which results in direct net emissions from the car fleet becoming at least carbon neutral. Depending on the ambition in climate mitigation the car fleet alone requires about 5-9 TWh of electricity which in 2050 would be dominated by renewable energy sources. The figure shows the scenario-dependent evolution of the Swiss car fleet until 2050.

Hybridization of buses, Light Duty Vehicles (LDV) and trucks emerges as a competitive option also without stringent climate change mitigation measures. Unlike for cars, extensive electrification of trucks beyond hybridization is more expensive because of high energy densities needed for batteries and longer annual mileages. This calls for ambitious climate policy measures. Under such conditions LDV and urban buses become extensively electrified. Major deployment of electric trucks occurs only when stringent emission performance or fuel efficiency standards are enforced, or carbon taxes are levied on transport fossil fuels, or battery costs can be pushed below currently projected costs. To achieve the ambitious climate goals, a part of the medium size trucks become battery electric due to their lower payload and short haul trips. In the net zero emission scenario hydrogen provides significant contributions in all segments mentioned above.

Heavy duty trucks turn to hybrid internal combustion trucks powered by biofuels and imported synthetic fuels (Power to Liquid). Uptake of fuel cell trucks occurs when emissions or efficiency standards are in place or if most ambitious climate goals are to be achieved for heavy duty road-transport segments where direct electrification is limited or impracticable.

The transport sector is a major driver for the deployment of hydrogen in the energy sector in the long-term. Demand for hydrogen as clean transport fuel is an important driver for the deployment of renewable-based hydrogen production. Reducing the energy system-wide CO_2 emissions by 80% in 2050 would result in a hydrogen share of about 10% of the whole transport sector's fuel consumption. The share of hydrogen would double if a net-zero emission goal is to be achieved by 2050. Compared to other sectors, transport applications consume more than three quarters of the hydrogen across the different climate scenarios analyzed. The technologies for producing hydrogen, include electrolyzers, fed with electricity from renewable sources. Also biomass-based hydrogen production is necessary under net-zero CO_2 emission regime.

The assessment of national long-term climate goals from a holistic system perspective, provides evidence of the interdependencies between climate change mitigation actions within the different sectors of the energy system and the necessity of cross-sectoral coordination. In order to effectively achieve the national climate goals, the sectoral potentials and costs to mitigate emissions need to be taken into consideration when designing sectoral policies. As such, the car sector provides a significant reduction potential in the long-term via electric vehicles that are at a more advanced technology readiness level compared to some mitigation technologies in other sectors, which, for instance, rely on the transportation and sequestration of CO_2. Therefore, the deployment and coordination of mature mitigation options (e.g. electric passenger cars, heat pumps) and disruptive end-user innovations (e.g. car sharing, smart homes) should be prioritized and supported, followed by adequate incentives for increasing the technology readiness of CCS technologies in electricity and hydrogen production, in order to cost-efficiently achieve net-zero emissions by 2050.



The figure shows the composition of the Swiss car fleets by drivetrains and corresponding fuels in year 2019 and for three scenarios for the year 2050. Furthermore, the Greenhouse Gas (GHG) emissions from the fleets are provided based on coupling the STEM model with Life Cycle Assessment (LCA) and the global system model REMIND. The bars indicate the share of number of cars having specific drivetrains and the car fleets' fuel shares. The markers show the GHG emissions from different sources, *i.e.* from the tailpipe and from the supply chains in Switzerland, which together with related emissions abroad add up to the total GHG emissions. In this way apart from the direct emissions from the car also the indirect emissions from the fuel supply chain, car manufacturing, maintenance and disposal as well as infrastructure are accounted for.