What does a net-zero emission goal imply for the Swiss transportation sector?
Outline

• Background
• STEM model & Scenarios
• Results
  – Final energy and CO₂ emissions
  – Vehicle fleet developments
  – Electricity and hydrogen supply
  – Cost of energy transition
• Concluding remarks
Background: Swiss energy system

Energy Economy (2020)
- End-user energy expenditure: CHF 22 Billion (3.1% of GDP)
- Energy import dependency: 72%

Energy Demand (2020)

Final energy demand in 2020 (747 PJ)
- Oil (Transport): 30%
- Oil (Heating): 14%
- Gas: 15%
- Coal: 0%
- District heat: 3%
- Wood: 5%
- Waste: 2%
- Renewable: 4%
- Electricity: 27%

Swiss electricity mix in 2021
- Nuclear: 29%
- Hydro - Run of river: 27%
- Other: 9%
- Hydro - Storage dam: 35%
- Gas: 10%
- Waste: 1%

Swiss CO₂ emissions
- Residential
- Industry
- Service
- Energy
- Transport
Swiss government set a goal to reach **net-zero emission** by 2050.

Often zero emission vehicles refer to zero **tailpipe** \(\text{CO}_2\) emission – _emissions associated with fuel supply are hardly addressed!_

It is paramount to ensure that **emission are not shifted** to elsewhere, i.e., the production of electricity, hydrogen, bio-/synthetic fuels should not entail additional emissions in the energy system.

Transport sector must be considered in the context of the **whole energy system**— buildings, vehicles, industries, and energy conversion.
Swiss TIMES Energy Systems Model (STEM)

- Whole energy system model with **full sector coupling**
- Long time horizon & hourly time steps
- Electric grid topology & ancillary services
- Extensive new and emerging technological options
- Cost optimization for entire time series (i.e. energy transition pathways)
Scenarios

Ref (Moderate climate)
- A business as usual outlook
- Frozen existing (2019) policies
- Mobility demands from Swiss Transport Outlook 2050
- Nuclear phase out

LC100 (Net-zero emissions)
- Net Zero CO₂ emissions in 2050
- Vehicle CO₂ standards & Building standards
- CCS/NET technologies are available

LC80 (Ambitious climate policy)
- 80% CO₂ emission reduction by 2050
Per capita energy demand declines by 38-45% in 2050
- Zero carbon energy carriers dominate
- Energy system retains fossil fuels, CO₂ emissions from which are offset by negative emission technologies

CO₂ emissions in transport sector* reduce by 60% in Ref scenario and ~81-100% in the climate scenarios

* Excluding international aviation
Transport sector – Truck fleet transition

- Only light duty trucks become extensively (80%) electrified
- < 15% of HGV fleet is electrified – because of high battery costs/payload
- In HGV segment, 70% of the vehicles in 2050 are hybrid but driven with bio-/synthetic fuels
- Fleet is fully decarbonized
• **Direct electrification** in transport sector requires an additional electricity demand of ~ 7-11 TWh by 2050.
• **Hydrogen & synthetic fuels** are also produced from electricity – additional 15 TWh in 2050 for transport.

• Biomass-based hydrogen production is necessary under net-zero CO₂ emission regime.
• Car fleet consume the highest share of hydrogen while share of fuel cell vehicles is the highest in freight vehicles.
• Cumulative discounted cost of the climate scenarios are \( \text{CHF}_{2020} \ 14 \ 82 \text{ Billion} \) compared to Ref.
• Additional vehicle (investment) cost in transport is about \( \text{CHF 30-38 billion} \)
• Reduction in fossil fuel costs and fuel taxes

Marginal cost of fuels increase very significantly between \( LC80 \) & \( LC100 \) scenarios. The higher gasoline/Syn fuel cost reflects the high carbon price and expensive import prices.
• As such there is no silver bullet to reach the net-zero carbon goal
• The sector dynamically evolves till 2050
  – Small/medium size electric cars are evolving while fuel cell vehicles are emerging in big size car segment
  – Hybridization of buses and trucks become competitive. They are propelled with bio- and synthetic fuels.
• Transport sector is a major driver for the deployment of hydrogen and renewable-based hydrogen production.
• Energy system relies on CCS and negative emission technologies
• Future energy system will be highly dependent on electricity. Any outage in electricity supply could bring the life to standstill because neither buildings nor mobility can be powered. The key aspect to look at is supply security.

Thank you

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