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

**ETSAP Semi-Annual meeting, Freiburg, Germany, 23-24 May 2022**

# Outline

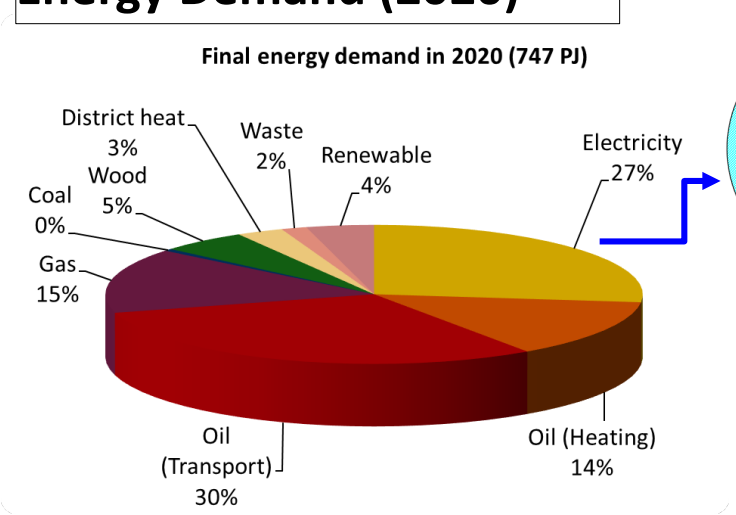
- Background
- STEM model & Scenarios
- Results
  - Final energy and $CO_2$ emissions
  - Vehicle fleet developments
  - Electricity and hydrogen supply
  - Cost of energy transition
- Concluding remarks

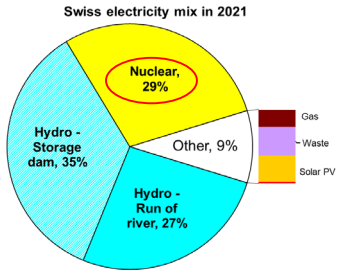
# Background: Swiss energy system

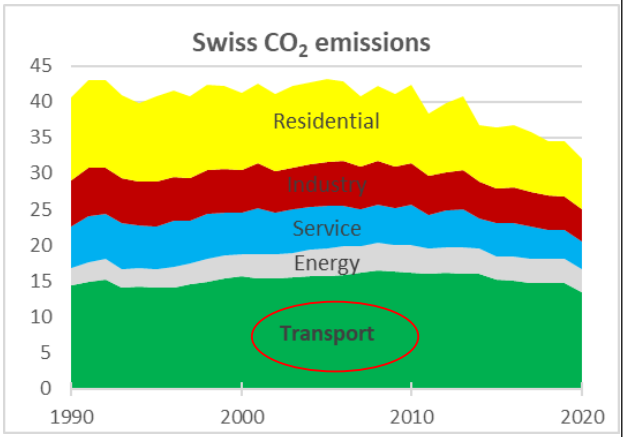
## Energy Economy (2020)

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

## Energy Demand (2020)

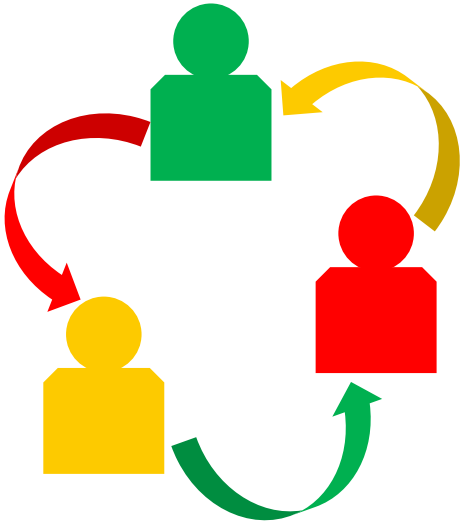


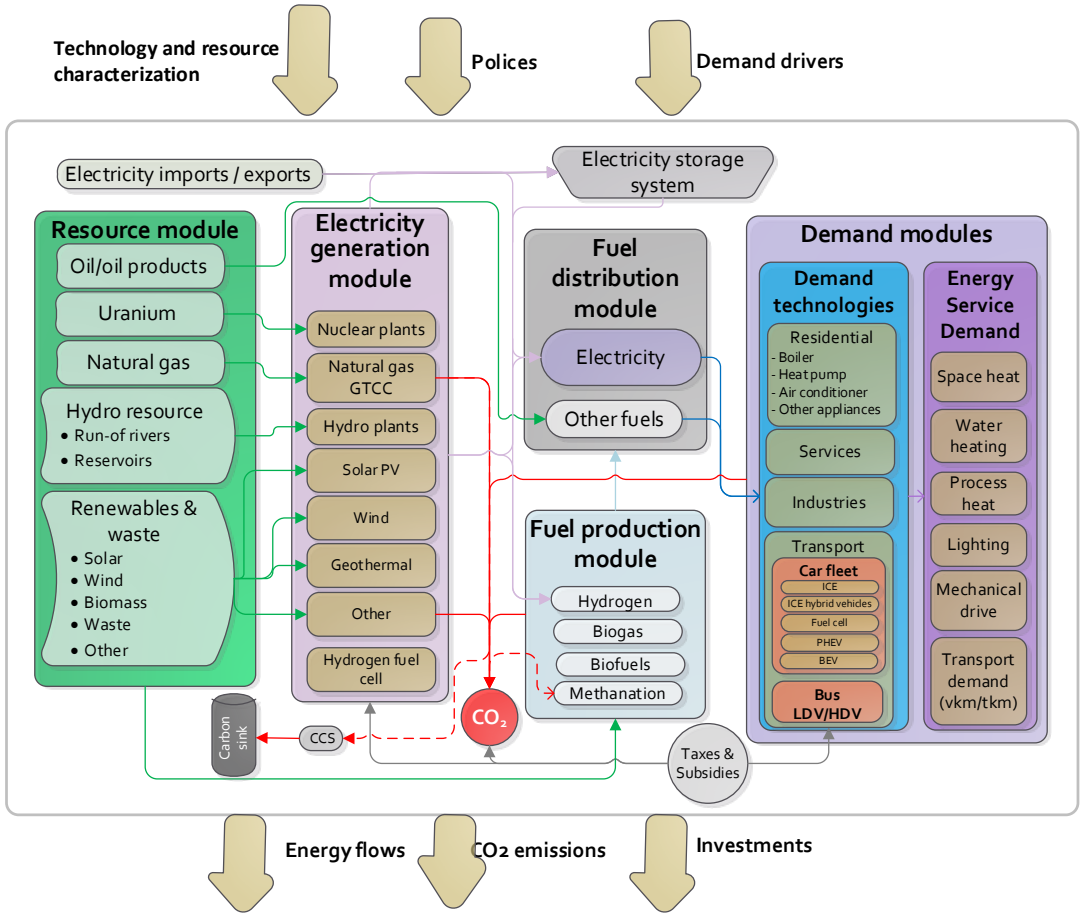



# Background

- Swiss government set a goal to reach ***net-zero emission*** by 2050.
- Often zero emission vehicles refer to zero ***tailpipe*** $CO_2$ 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

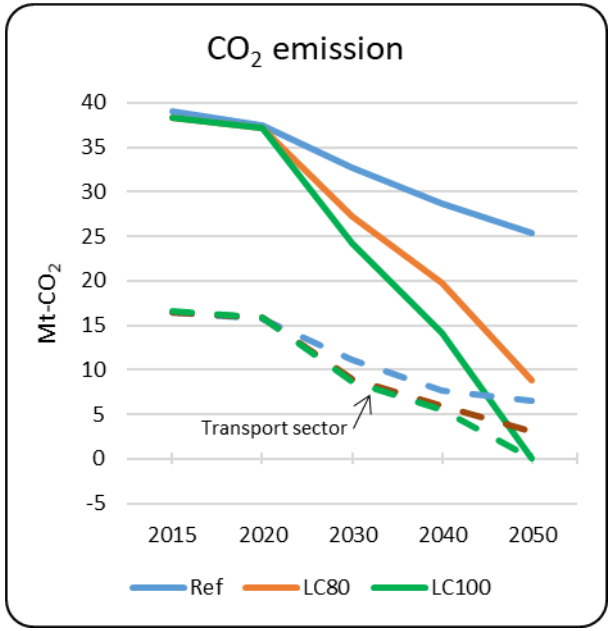
**LC100 (Net-zero emissions)**

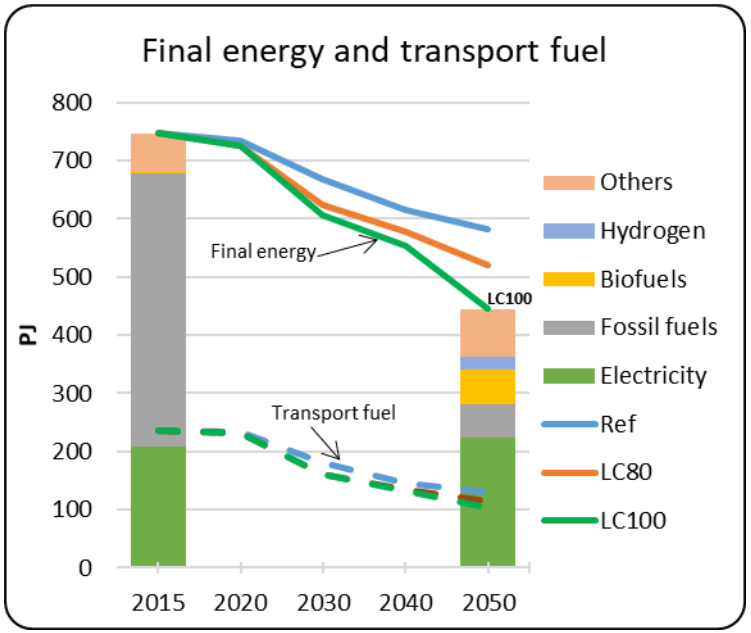
- Net Zero $CO_2$ emissions in 2050
- Vehicle $CO_2$ standards & Building standards
- CCS/NET technologies are available

**LC80 (Ambitious climate policy)**

- 80% $CO_2$ emission reduction by 2050

# Final energy and $CO_2$ emissions



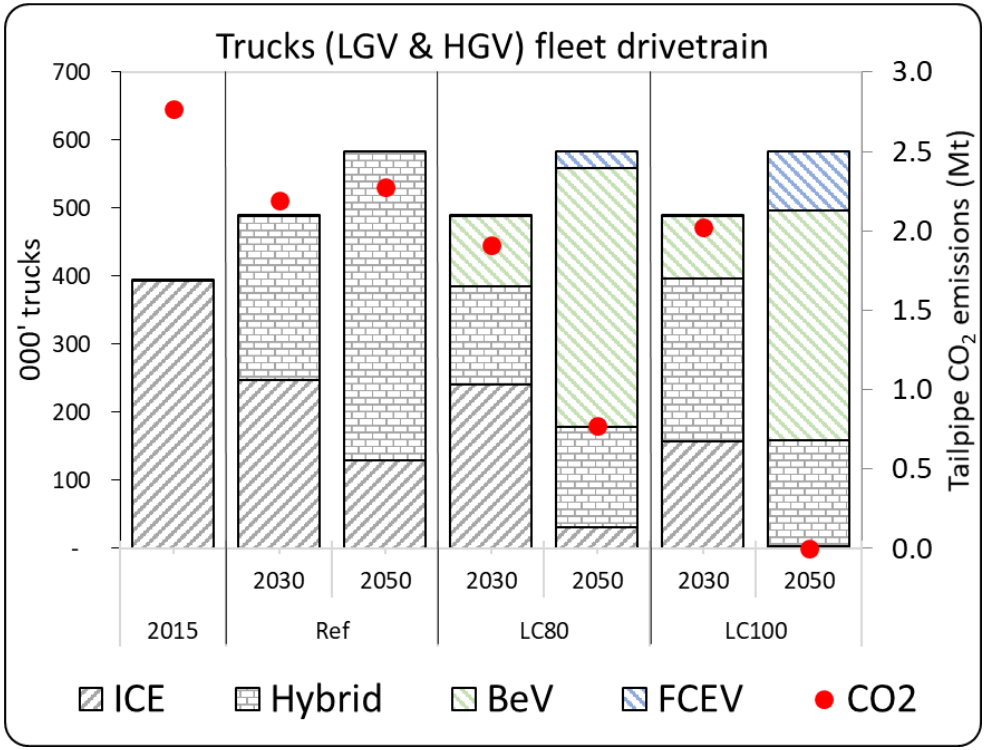




$CO_2$ emissions in transport sector* reduce by ***60% in Ref*** scenario and ~81-100% in the climate scenarios

* Excluding international aviation

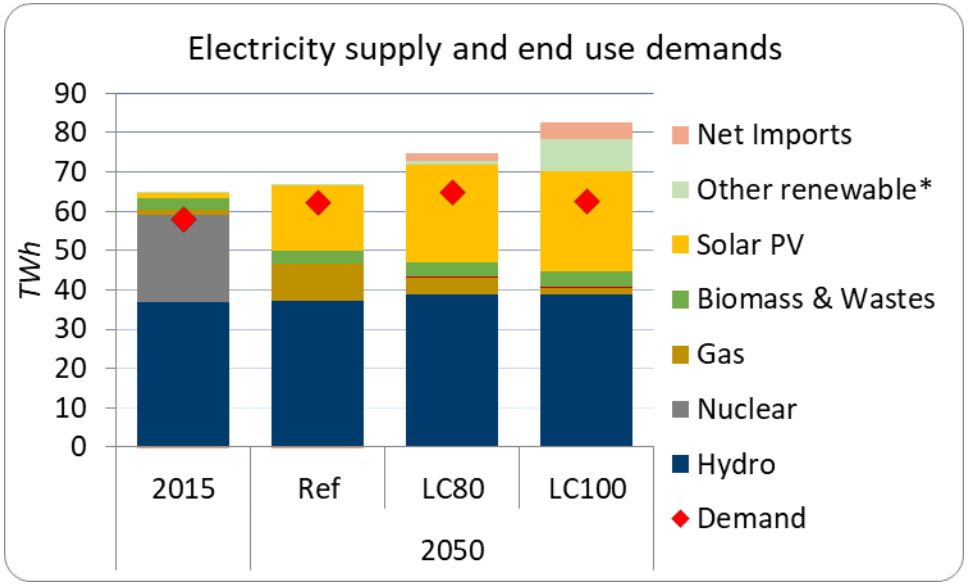
- Per capita energy demand declines by 38-45% in 2050
- Zero carbon energy carriers dominate
- Energy system retains fossil fuels, $CO_2$ emissions from which are offset by negative emission technologies

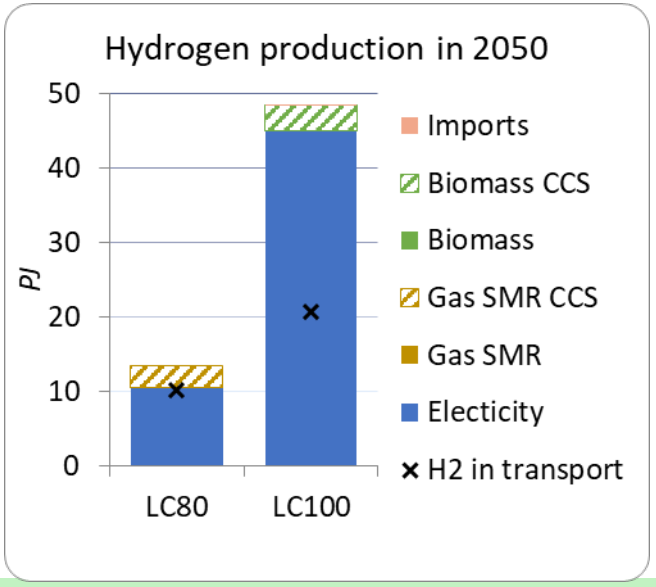
# Transport sector – Truck fleet transition




- 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

# Electricity and hydrogen supply

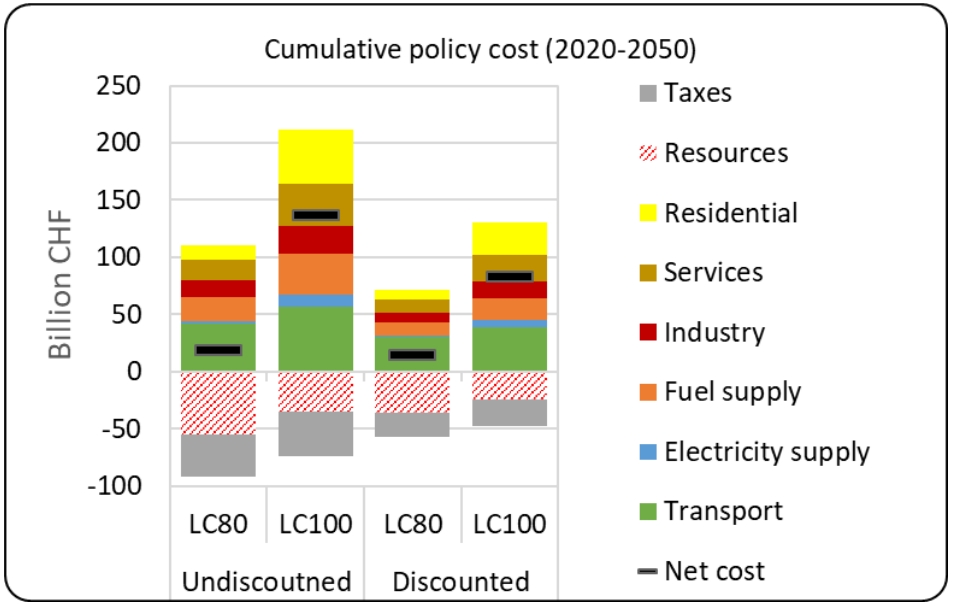


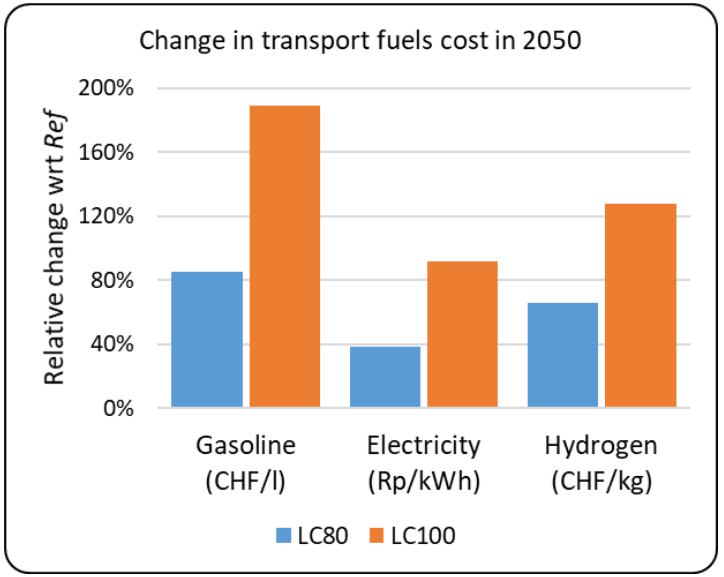




- ***Direct electrification*** in transport sector requires an additional electricity demand of ***~ 7-11 TWh*** by 2050.
- ***Hydrogen & synthetic fuels*** are also produced from electricity – additional 15 TWh in 2050 for transport.

- Biomass-based hydrogen production is necessary under net-zero $CO_2$ emission regime.
- Car fleet consume the highest share of hydrogen while share of fuel cell vehicles is the highest in freight vehicles

# Cost of energy transition




- Cumulative discounted cost of the climate scenarios are ~ ***CHF$_{2020}$ 14*** & ***82 Billion*** compared to *Ref*.
- Additional vehicle (investment) cost in transport is about ***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.

# Concluding remarks

- 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***.

Reference: *Kannan R, Panos E, Hirschberg S, Kober T, A net-zero Swiss energy system by 2050: technological and policy options for the transition of the transportation sector, Futures & Foresight Science. 2022. https://doi.org/10.1002/ffo2.126*

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# Wir schaffen Wissen – heute für morgen

## Thank you

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