Should the focus be on broader policy goals or on specific technology targets? – A case study scoping on the Swiss transportation sector

ETSAP semi-annual workshop, Madrid, Spain
17-18 November 2016
Outline

• Overview of the Swiss energy system
• Swiss TIMES energy system model (STEM)
• Scenarios and results
• Conclusions and outlook
Overview of the Swiss energy system


• Energy expenditure: CHF 26.36 Billion (4.1% of GDP)
• Energy import: CHF 6.2 Billion (2.4% of import expenditures)
• Energy import dependency: 75.4%
Overview of the Swiss energy system

Electricity generation mix (2015)

- Nuclear: 35%
- Hydro - Run of river: 26%
- Hydro - Storage dam: 32%
- Other: 7%
- Waste: 4%
- Solar PV: 1.32%
- Wind: 0.16%
- Gas: 0.83%
- Landfill gas: 0.46%
- Wood: 0.45%
- Oil: 0.05%
The Swiss energy strategy 2050

**CO₂ emissions reductions in 2050 from 2010 level**

- Business as usual (WWB): 19 - 29%
- Policy Measures (POM): 37-50%
- New Energy Policy (NEP): 60-67%

**Underlying demand drivers are same for all the scenarios!!**

---

**With centralised natural gas power plants**

**Without centralised natural gas power plants**
The Swiss energy strategy 2050

- 25 – 60% transport sector energy demand reduction by 2050 from 2010 level
- 30-40% electric cars by 2050
What are ultimate objectives of our scenarios?

- **To assess broader policy objectives**
  - Decarbonisation of the entire energy system (60-80%)
  - Transport (or sectoral) energy, CO₂ emission reduction targets in the energy strategy?

- **To assess specific technology objectives**
  - To meet e-mobility targets in the energy strategy
  - Certain fleet level CO₂ targets on g-CO₂/km basis
A whole energy system model of Switzerland in an (cost) optimization framework

- Primary energy supply to end use (all end-use sectors with sub-sector details, detail electricity and fuel supply modules, CO₂ emission tracking, taxes, etc.)
• A whole energy system model of Switzerland.
• Long time horizon (2010–2100) & an hourly time resolution for typical days.
• Transparent and well documented model input data and assumptions.
• Peer reviewed publications.
Transportation module
• 10 modes of demand (e.g. car, buses, trucks)
• 4 market segments for cars (<60kW, 60-100kW, 100-140kW, >140kW) by fuel and drivetrain
• Simplified fuel distribution network
• Transportation fuel taxes
• Endogenous charging of electric cars
Scenario definition

• **Base**
  – Travel demands from Swiss Energy Strategy 2050
  – Nuclear phase-out and option for new gas power plants
  – Annual self-sufficiency in electricity supply

• **Transport CO₂ emission mitigation**
  – 40% CO₂ emission reduction from 2010 level in *transport sector* as in the POM scenario (*T-40*)
  – *T-60* (as in NEP scenario)

• **Energy system-wide CO₂ mitigation**
  – Whole energy system-wide CO₂ emission reduction of 60% by 2050 from 2010 level as in the NEP scenario variant C (*S-60*)
  – NEP scenario variant RES – i.e. 67% total reduction (or 80% in domestic CO₂ emission) or (*S-67*)
Car fleet technology and tailpipe CO2

- ICE → hybrid (small size)
- ICE → diesel (long range)
• **Fuel** $\rightarrow$ 40% reduction in fuel from 2010 level
• **CO$_2$** $\rightarrow$ 53% CO$_2$ emission reduction from 2010 level
Car fleet: Technology

Transport **sectoral** cap $\rightarrow$ plug-in hybrid & biodiesel

**System-wide** cap $\rightarrow$ Battery electric and gas hybrid
Transport sectoral cap $\Rightarrow$ Electricity demand increase
System-wide cap $\Rightarrow$ Electricity demand declines
Electricity supply and demand in 2050

**Base scenario**

- **Winter weekdays**
  - **Demand**
  - **Marginal cost electricity**
  - **Battery electric vehicles**
  - **Gasoline hybrid car**

- **Summer weekdays**
  - **Demand**
  - **Marginal cost electricity**
  - **Battery electric vehicles**
  - **Gasoline hybrid car**

**Charts**

- **BAU: SUM-WD (2050)**
- **Export: BAU: SUM-WD (2050)**
- **BAU: WIN-WD (2050)**
- **Export: BAU: WIN-WD (2050)**
Transport sector CO₂ emission targets shift the emissions to electricity and industry.
• Net emissions are higher than tailpipe emission
• Still e-mobility contributes to net reduction
• There is no linear relation between electricity demands and load profile
Electricity demands and load curves in 2050

Electricity (TWh) vs. peak (GW) demand in 2050

Change relative to 2010

-40% -30% -20% -10% 0% 10% 20% 30% 40%


- Electricity
- Summer peak
- Winter peak
Conclusions

• E-mobility can decarbonise car fleet and contributes to net reduction in CO₂ emissions.

• Transport specific CO₂ target does not result in net system-wide 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 the low-carbon target, including signals for continued expansion of generation from renewable energy.

• 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).
Outlook

• How to enhance mobility representation in STEM
  – Range and size → are they independent?
  – Short vs. long range cars
  – Big vs. small cars
  – Further disaggregation → How to avoid computational time?
• How to address non-cost driver / barriers
  – Battery charging time and infrastructure
• Modal shift
  – Refining demands from vehicle (vkm) to personal (pkm)
  – Is there a way to control domination of specific modes (other than user constraints)?
• Storage
  – Is vehicle to grid reality?
Wir schaffen Wissen – heute für morgen

Thank you!