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Policy Pathways and Flexibility for Switzerland's Net-Zero Transition

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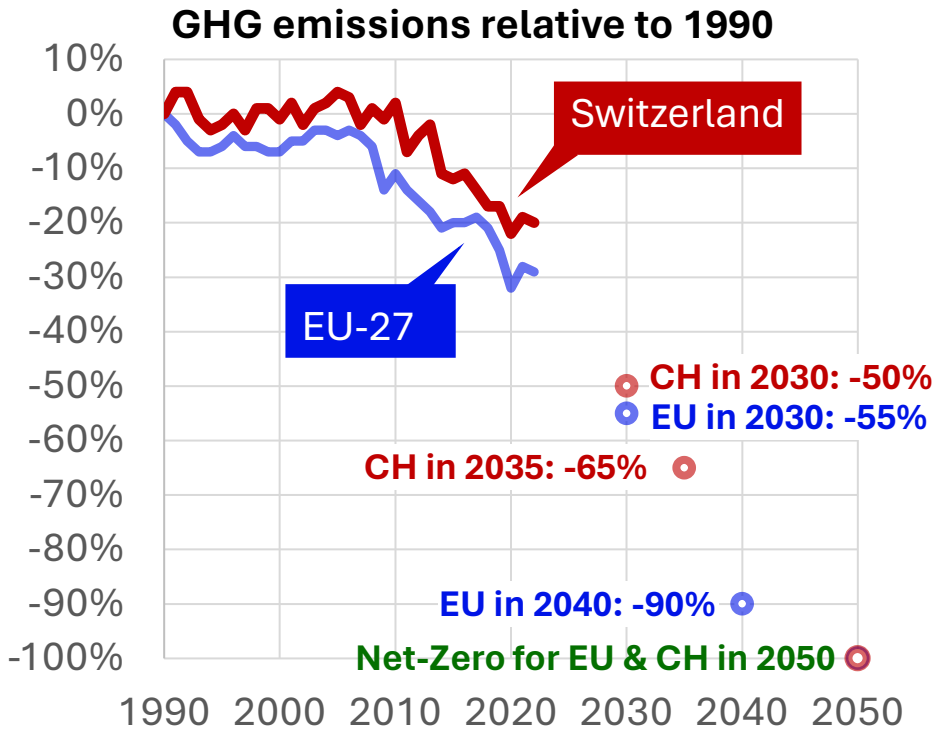
Swiss energy transition does not happen in isolation from the EU Green Deal

EU & CH emissions cuts accelerate sharply after 2030, shaping Swiss energy prices & imports (and technology costs)

Objectives of the POLIZERO Project:

- Quantify Switzerland's transition to Net-Zero under EU interdependencies
- Identify effective policy options for the Swiss Energy and Climate Strategies
- Design adaptive policy pathways under uncertainty to deliver the Swiss Energy and Climate Targets



Up to 20% of Swiss emissions reductions in 2010-2020 may stem from EU-CH spillovers:

→ Policy Diffusion & Harmonization
→ EU-ETS Linkage
→ Infrastructure & Trade Interdependence
→ Technology and Innovation Spillovers

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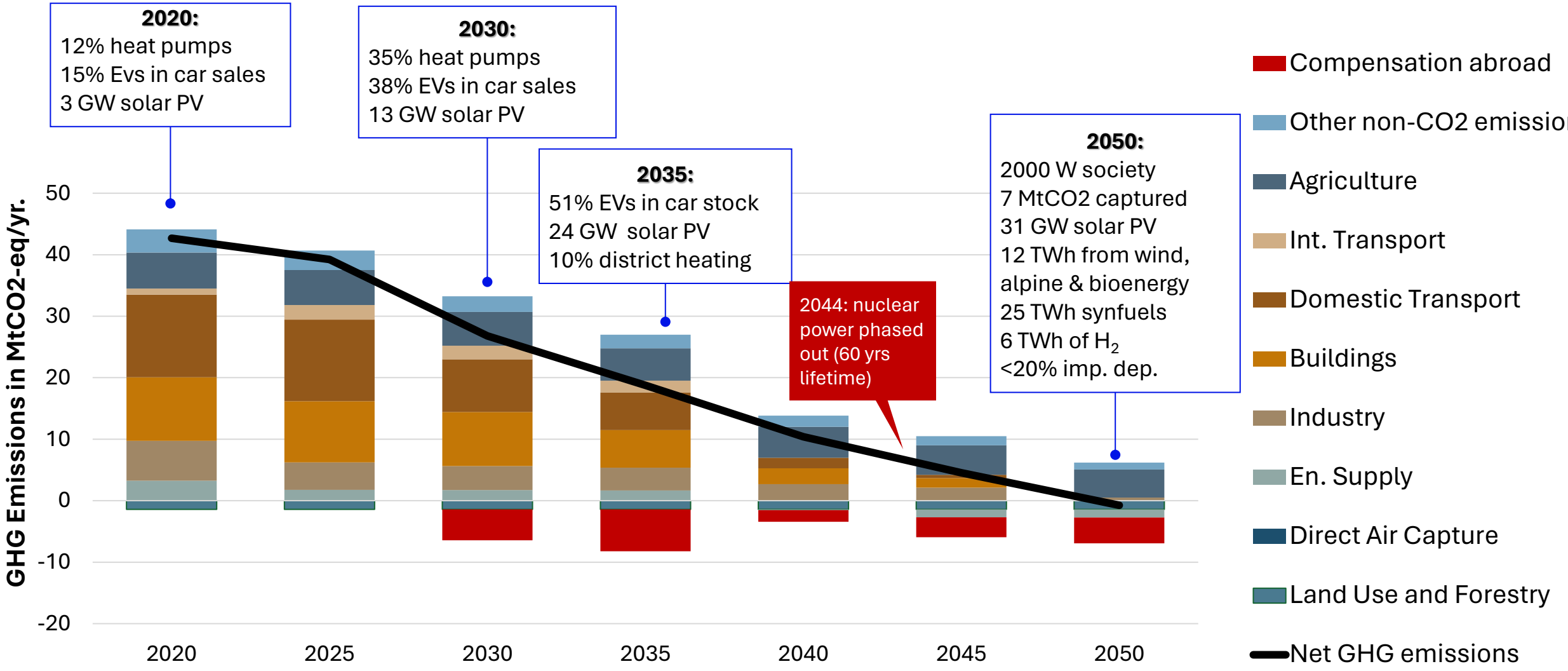
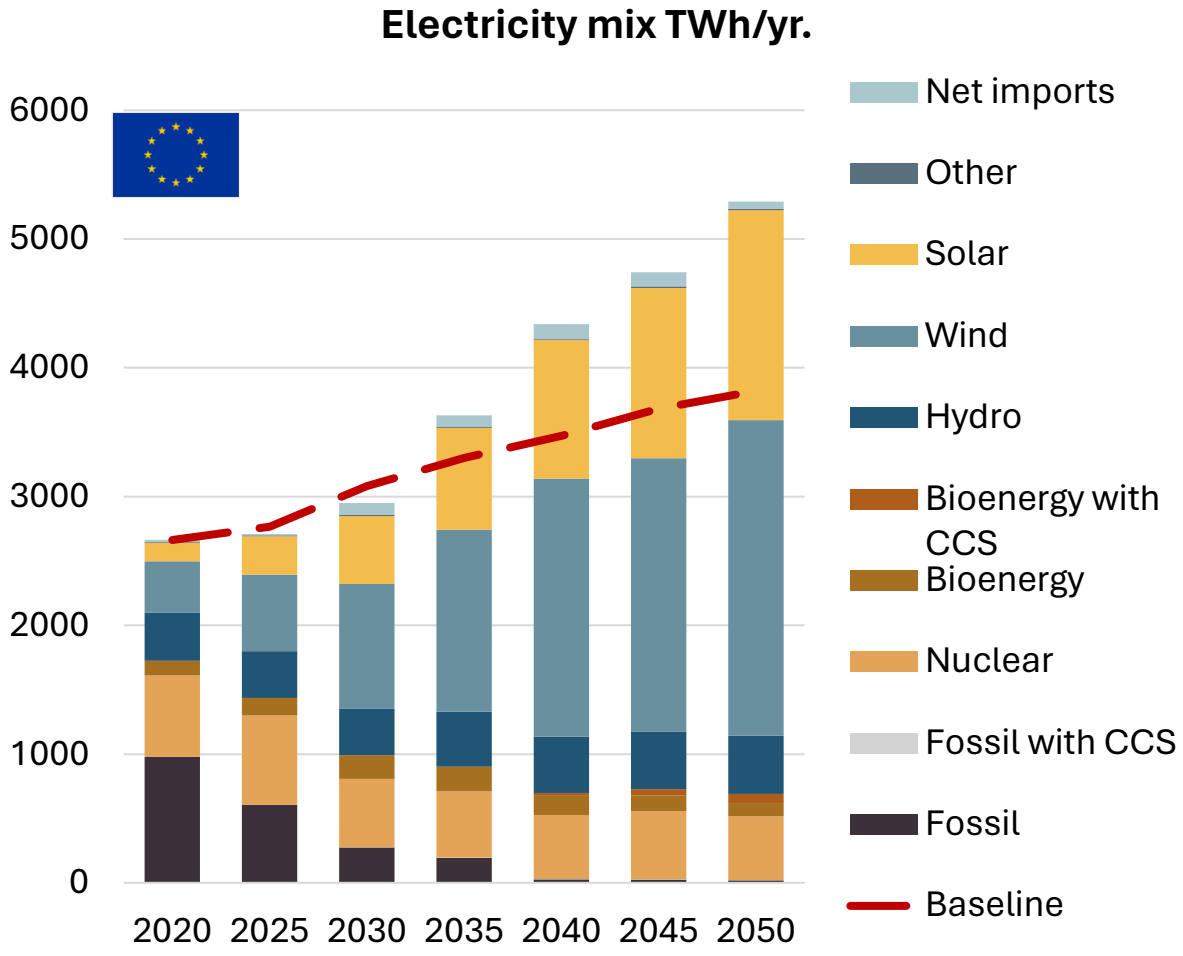
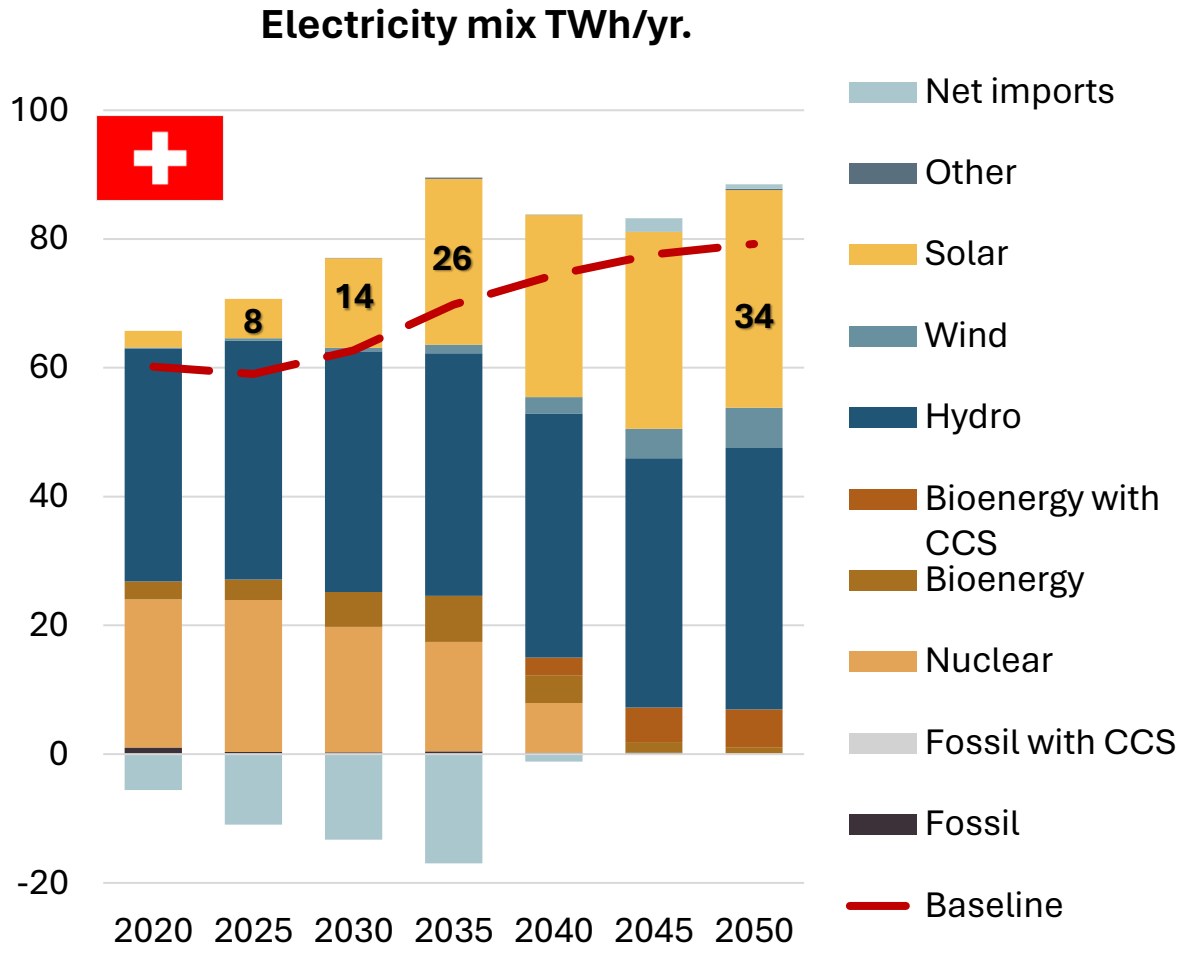
Quantifying Switzerland's Pathway to Net-Zero under the Energy & Climate Strategy (JRC-EU-TIMES energy system model of PSI)



Panos E., et al. (2025)

2025-2035: renewable build-up needs to take off to meet the increased electrification of heating and mobility

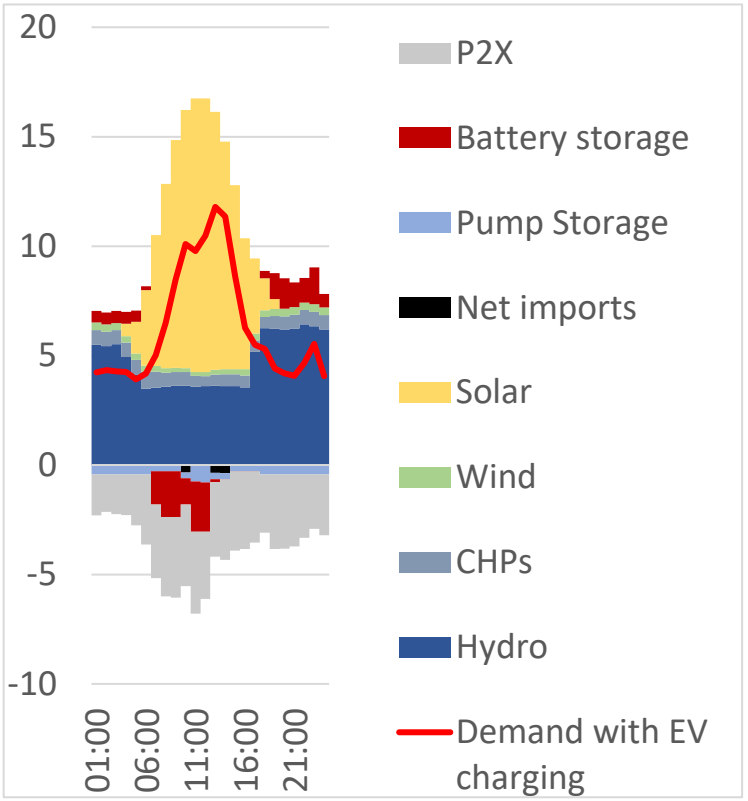




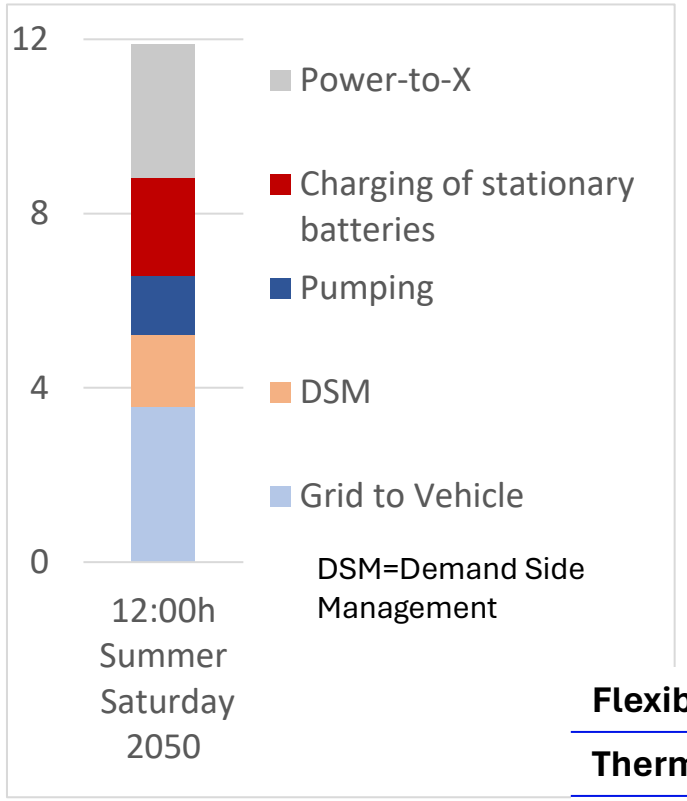
Panos E., et al. (2025)

Flexibility from all actors needs to be in a coordinated way

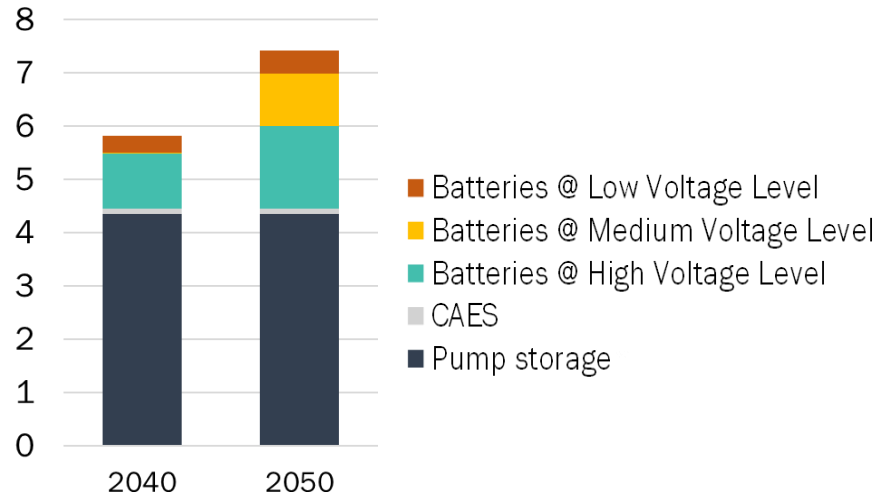
Electricity profile in GWh/h
Summer Saturday 2050



Flexibility deployment
options in GW at 12:00 in 2050



Needs in electricity storage capacity (stationary, excluding embedded storage and EVs) in GW/yr.



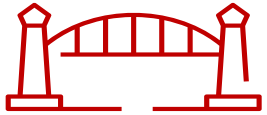
Sector coupling flexibilities

Flexibility	Capacity in 2050
Thermal Storage (short-term)	5.8 GW (35 GWh)
Thermal Storage (Seasonal)	1.4 TWh
Gas/H2 Storage (Seasonal)	1.4 TWh
Vehicle-to-Grid (V2G) in 2050	output to grid 0.5 TWh
aFRR+ demand in 2050	+45% from 2020 (624 MW)

Panos E., et al. (2023)

Delivering the Swiss Net-Zero transition
Stakeholder insights → Policy package design for pathway analysis

What matters to Swiss actors



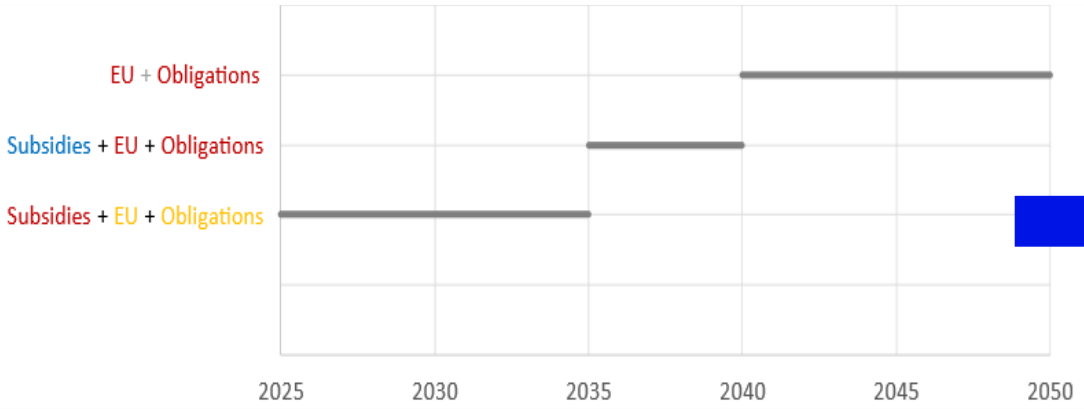
- **EU integration:** ETS, ETS2, energy agreements, regulatory alignment
- **Technology-neutral support:** avoid bans and technology exclusion
- **Simpler regulations:** reduce permit times for construction & operation
- **Technology vs behavioural switch:** technology switching in the short term; behavioural change in the long term
- **Concerns:** energy security, environmental protection, distributional impacts, hard-to-abate sectors

Policy packages: 4 philosophies x 3 intensities

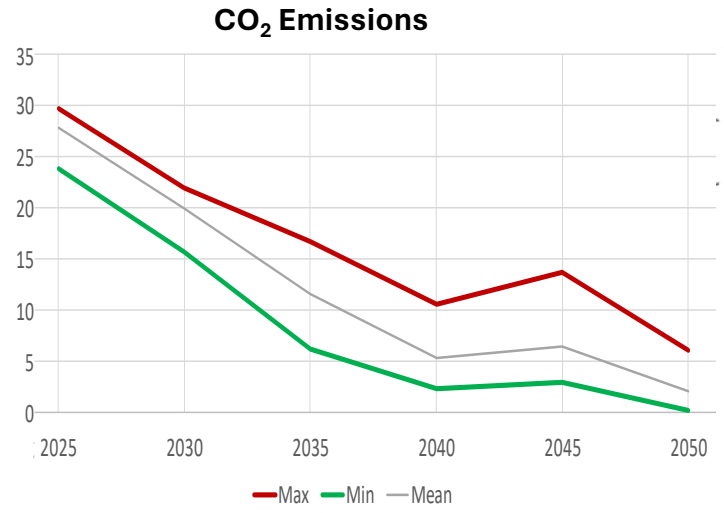
- **Subsidies (20-60% of CAPEX):** renewables, clean heating, green H_2, industrial clean tech, alt-fuel infrastructure
- **Levies (120 – 800 CHF/tCO2):** heating fuels, motor & aviation fuels, CO_2-based vehicle tax
- **EU harmonisation:** ETS, ETS2, post-2030 vehicle emissions standards, grid subsidies for CO_2 & H_2
- **Obligations:** CO_2 building standards, minimum PV, charging infrastructure, industrial CO_2 budgets, fossil heating phase-out

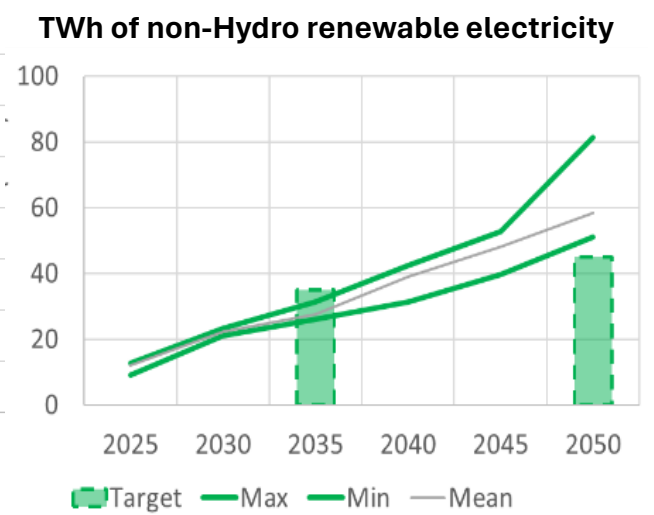
Panos E., et al. (2025)

Insights from the policy exploration: Policy Pathway 1



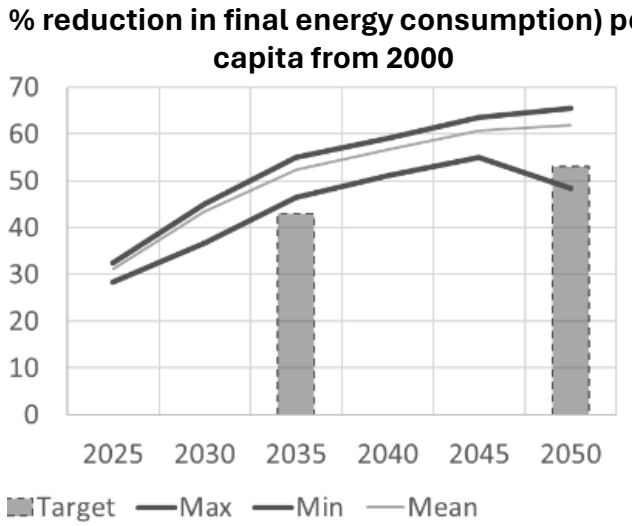
Blue: policies are implemented at low intensity
Yellow: policies are implemented at medium intensity
Red: policies are implemented at high intensity

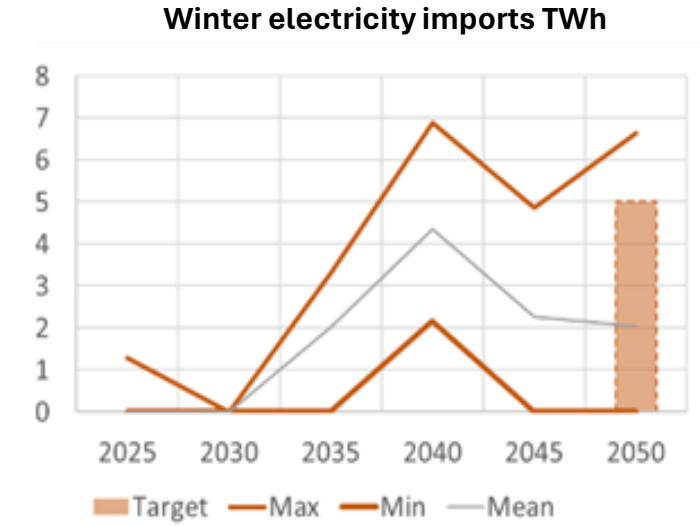




- Acceleration of transition until 2040 driven by the ETS2 in buildings and transport
- Slow down in emissions cuts after 2040 as additional reductions need to be achieved in hard-to-abate sectors

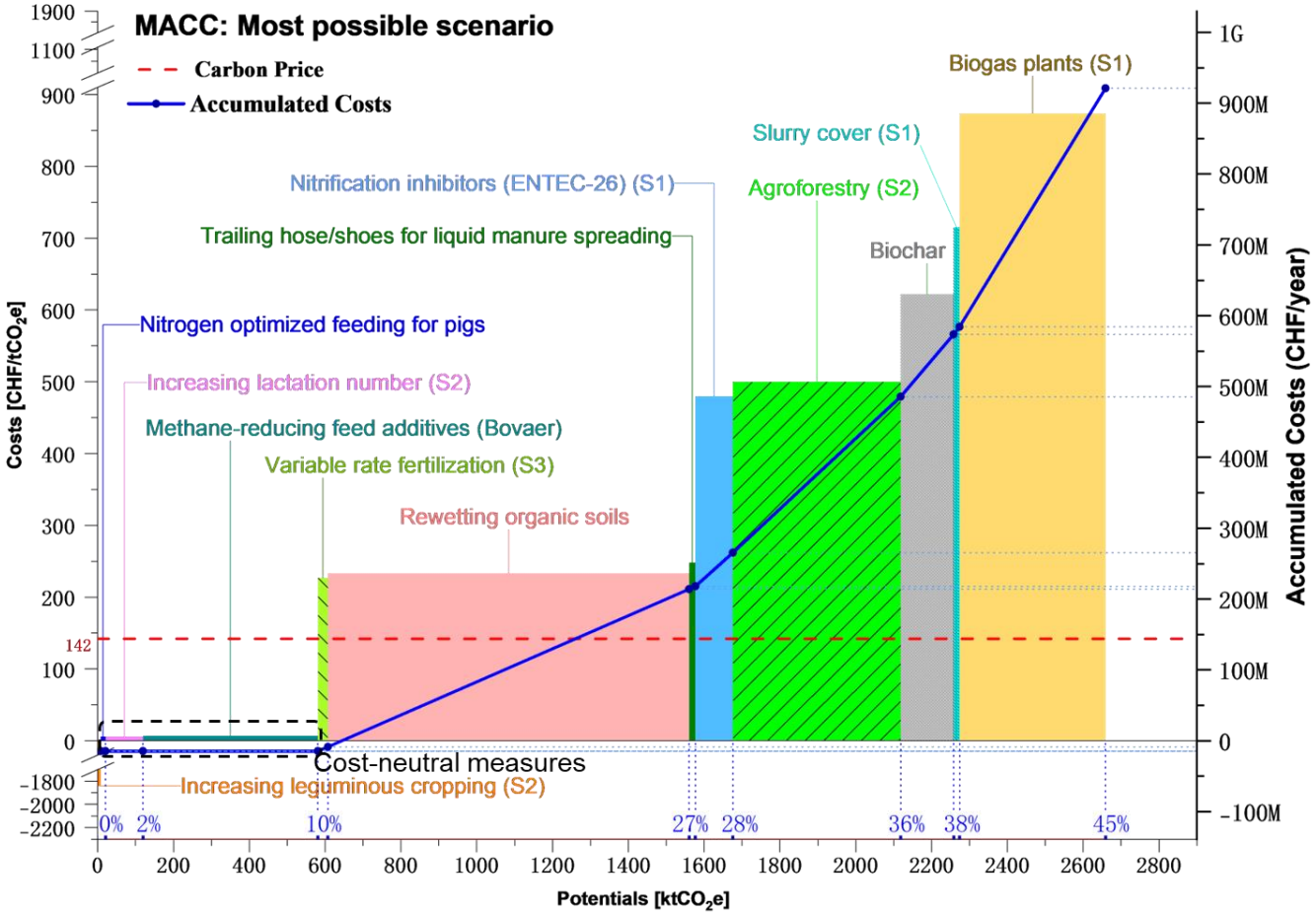
- Critical contexts: failure when imported synfuels less than 5 PJ, bioenergy potential needs to be 110 PJ, imported price of gasoline > 0.3 CHF/lt, imported price of gas >10 EUR/MWh





Panos E., et al. (2025)

Extending Policy Pathways Beyond Energy: Mitigation Options for Switzerland's Agricultural Emissions

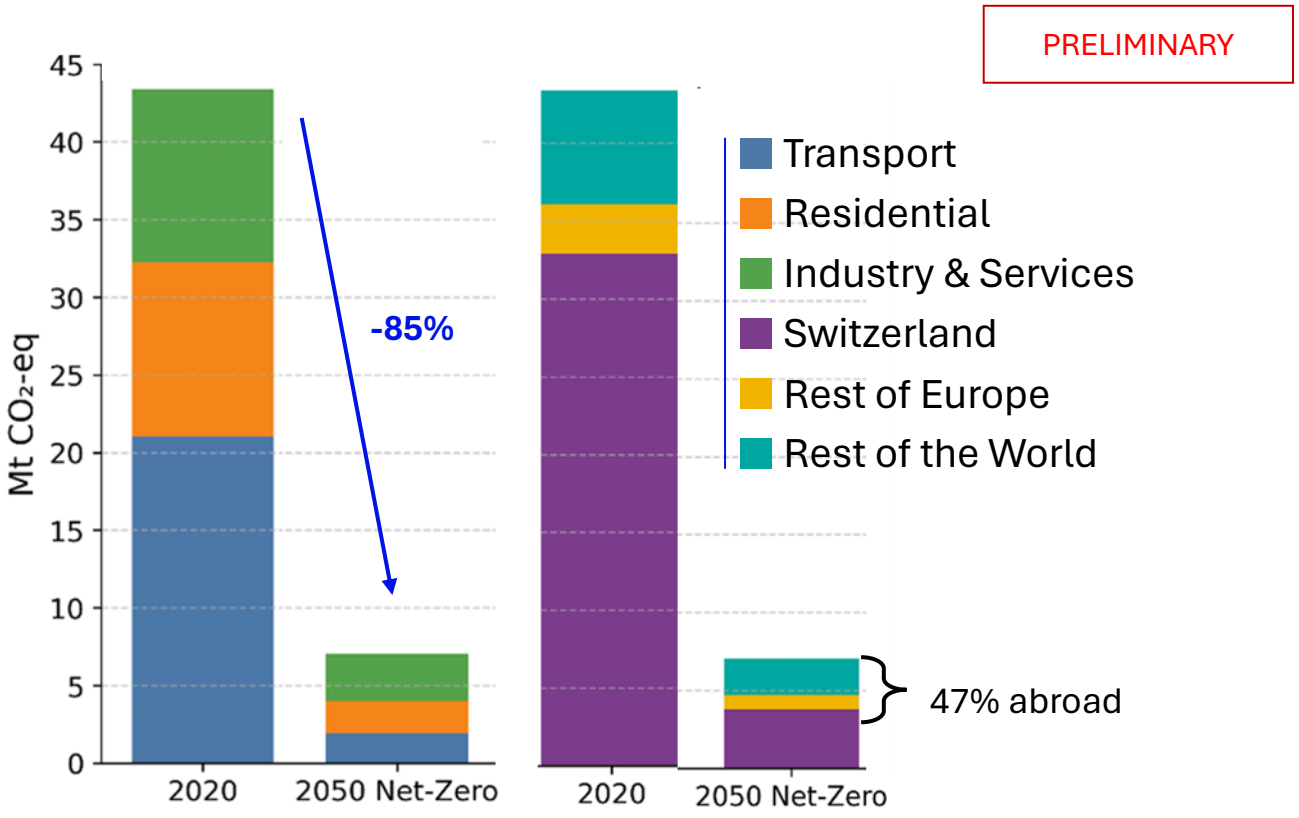


(Hao., et al. (2025)

- Around 10% emission reduction is cost-neutral, but uptake is low due to:
  - lack of information and advisory support
  - administrative hurdles/behavioural inertia
  - perceived risks to productivity
- Achieving ~40% reduction requires ~900 million CHF/year.
  - For comparison: Swiss farmers receive 2.8 billion CHF/year in direct payments.
- Most promising near-term measure: methane-reducing feed additive Bovaer.
- Large-potential but higher-cost options: rewetting organic soils, agroforestry, biogas plants (200–900 CHF/tCO_2e).

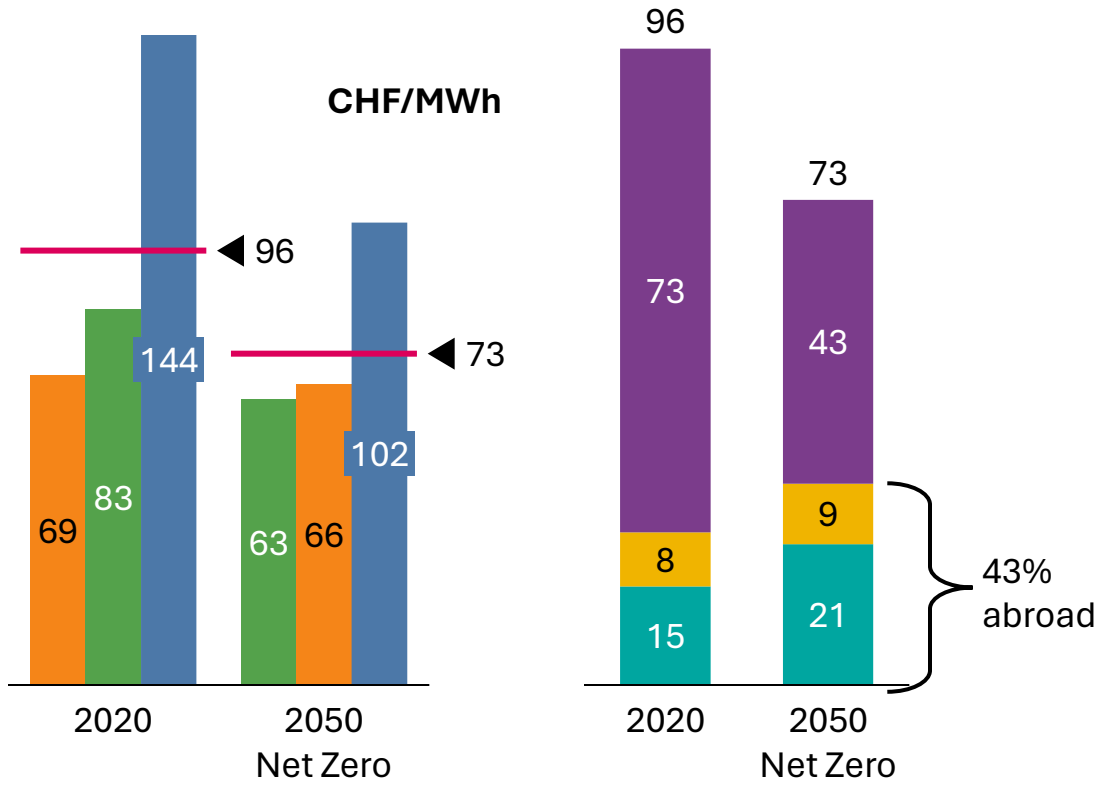
Accounting for Externalities in Energy Policy Design: The Hidden Costs of the Swiss Climate Goals

Life-cycle emissions from Swiss energy demand sectors

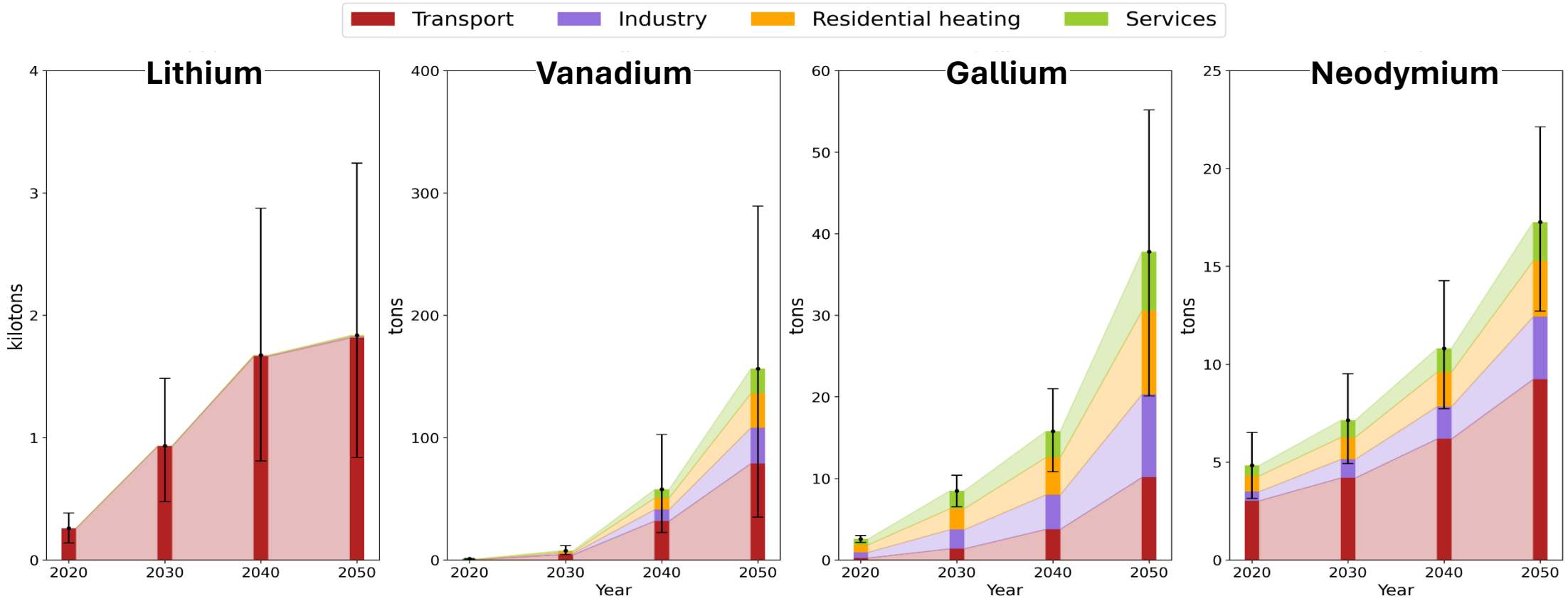


(Uribe., et al. (2025)

External cost intensity in CHF/MWh due to mortality and morbidity from climate change and PM 2.5 formation attributable to the net-zero transition of the Swiss energy demand sectors



Outreach: Critical raw materials for the Swiss net-zero transition



- Li-Ion **EV batteries**
- Uncertainty due to the different battery chemistries used

- Vanadium **Redox Flow batteries**
- Trade-off between Lithium and Vanadium depending stationary storage choice

- **Solar PV panels**
- Strategic choice of the panel type: CIGS, GaAs, CdTe, c-Si

- Permanent magnets in **Wind Turbines**

Hahn et al. (2025)

Conclusions for Switzerland’s Energy Transition

2025–2035: The decisive decade

- Rapid replacement of cars, boilers and industrial equipment
- Accelerate solar PV & expand district heating to ~10%
- Secure International agreements for low-carbon fuels & CO_2 compensation

2035–2050: Infrastructure scale-up

- Integrate sustainable fuels (90 PJ), hydrogen (~6 TWh), and CCS/CCUTS (6–10 Mt CO_2/yr)
- Large heat pumps supply ≥1/3 of district heat
- Add winter supply (~6 TWh) from wind, alpine solar & bioenergy

Cross-cutting system impacts

- Life-cycle emissions fall ~85% in Net-Zero from 2020; external cost intensity by ~25%
- ~47% of remaining externalities arise abroad (supply chains)
- Critical raw materials shape technology choices
- Agriculture offers low-cost cuts (~10%), but 40% cuts require ~900 MCHF/yr

Policy Design & Implications for Delivering Net-Zero

A balanced policy mix is essential

- Subsidies enable early uptake, but obligations secure post-2035 emissions cuts
- Levies are effective in buildings; transport reacts mainly to EU standards

EU alignment improves Swiss policy effectiveness

- ETS/ETS2/ vehicle standards create positive spillovers for CH
- Harmonisation improves investment certainty & ensures quantity-based targets

Internalise externalities & manage global impacts

- Apply CBAM-type rules, clean-supply-chain requirements & low-external-cost procurement

Include agriculture in the policy mix for the Swiss net-zero transition

- Lift information, admin, and behavioural barriers to unlock low-cost reductions (~10% of current GHG emissions)
- Align agricultural policy instruments by re-directing part of existing direct payments towards mitigation measures

Timing is critical

- Early standards prevent lock-ins and reduce CRM pressure
- Delays push CH toward expensive last-minute DAC/BECCS solutions

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My thanks go to:

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My colleagues at Energy Economics Group and Laboratory for Energy Systems Analysis

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Energy Economics

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Integrating Stakeholders, EU-CH Energy System Modelling and Adaptive Pathways to Assess Switzerland's Transition