ENV-421
Project Kick-Off

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Project

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This week

Agenda

	Week 2	Week 4	Week 7	Week 9
Lectures	Energy System Fundamentals	Energy Conversion Technologies	Technologies' Impacts	Climate Impact on Energies
Applications & Excercises	The Swiss Energy System Evolution & Perspectives	Efficiencies & Classification	Conference *Is it all about renewable energies?* Closing the Balance & Defining Compromises	*Powerplay Game*

Project: Addressing Contemporary Challenges to the Swiss system
Energy-independent and carbon-neutral Switzerland 2050

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Addressing contemporary challenges

The project

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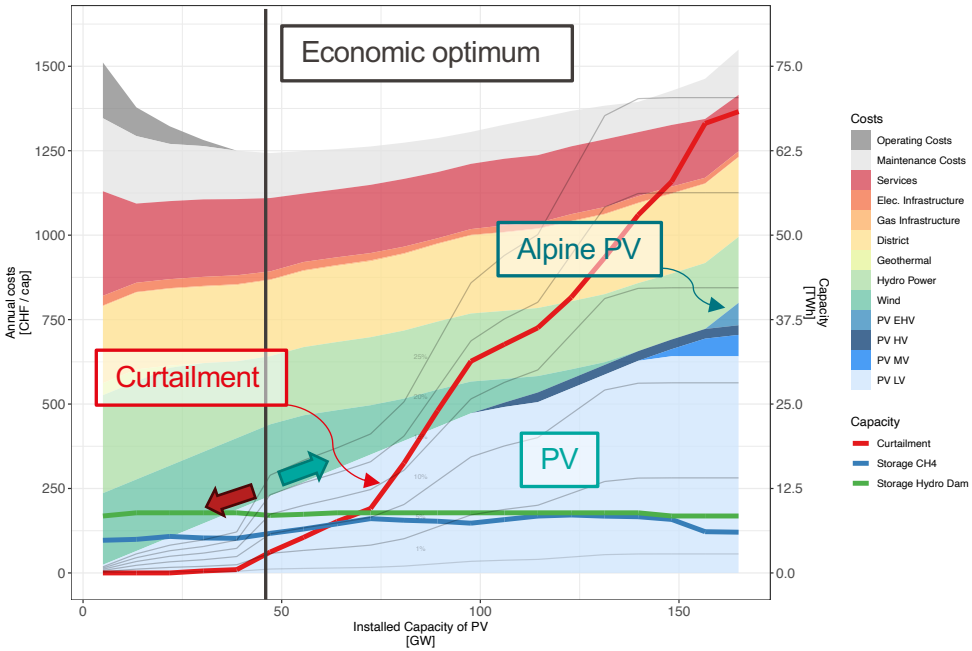
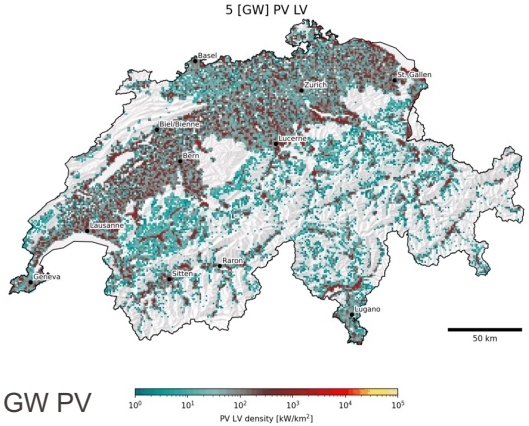
Wind-PV tradeoff *& self-consumption*

The transition towards a decentralized system



Evolution of energy system costs composition and storage capacities of the Swiss energy system



Animation of the geographic PV installation Evolution density

- Minimum Cost:
  20 GW Wind & **37** GW PV
  - PV: Limitation by the LV grid but more (37 GW)
  - Wind: installation to its maximum potential (20 GW)
- PV ↘
  - Wind at maximum
  - Compensation by biomass resources
    0-15% biomass potential
  - Methane storage via power-to-methane (4.3-6.1 TWh)
- PV ↗
  - Wind reduction
  - Seasonal dephasing
  - Methane storage via power-to-methane (6.1-8.8 TWh)

PV installation parametrization.
The transparent lines represent the annual PV-LV production fractions, allowing us to compare them with the curtailment depending on the installed PV capacity. The case study represents the economic optimization of a neutral (no net emission) and independent (no import) Swiss energy system in 2050 for a population of 10 Million.

Schnidrig et al. 2024, *Power to the People: Envisioning Decentralized Energy Landscapes - Synergies of Centralized and Decentralized Energy Models through Unveiling the Role of Districts and Self Consumption, Energies*

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What about the grid?

PV deployment and grid reinforcement in the transition towards a decentralized system

Urban areas:

- Limited PV deployment
  50-250 kW/km^2
- Reinforcement due to electrification of heating sector
  5-21 MW km / km^2

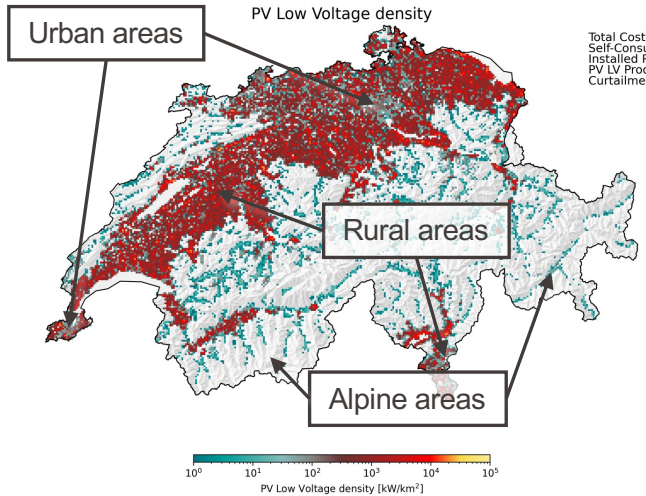
Rural areas:

- High PV deployment
  1-50 MW/km^2
- Self-consumption & Export to urban
- Low reinforcement due to lower energy demands
  0-0.5 MW km / km^2

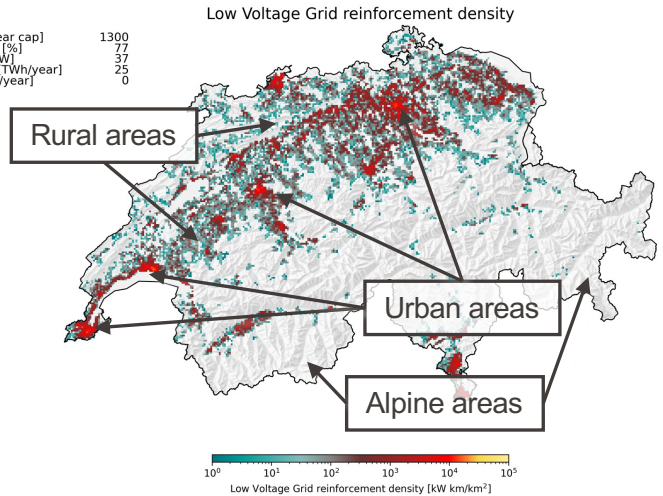
Alpine areas:

- PV deployment to maximise self-consumption
  15-100 kW km / km^2
- No export
- No reinforcements needed

Minimal Cost corresponding to deploying 37 [GW] PV LV



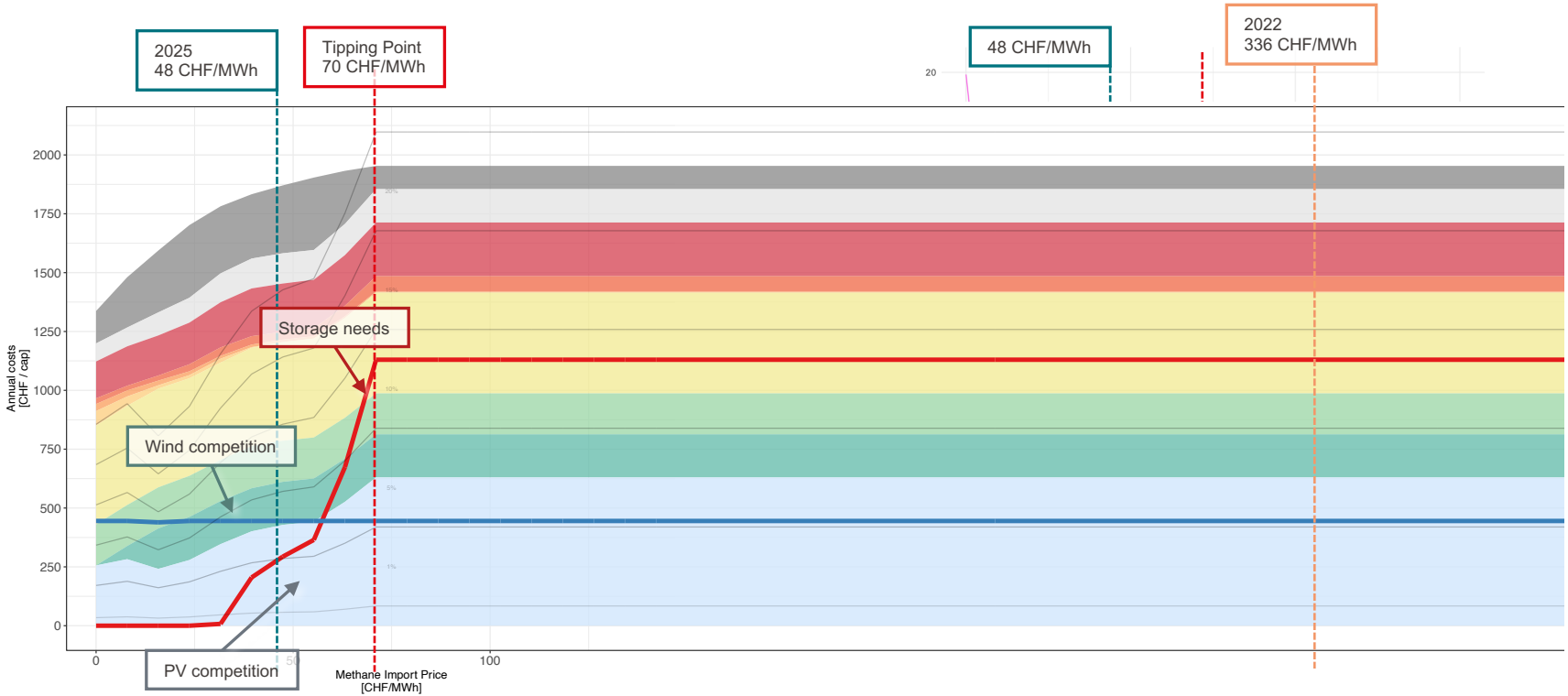
Total Cost [CHF/year cap]	1300
Self-Consumption [%]	77
Installed PV LV [GW]	37
PV LV Production [TWh/year]	25
Curtailment [TWh/year]	0



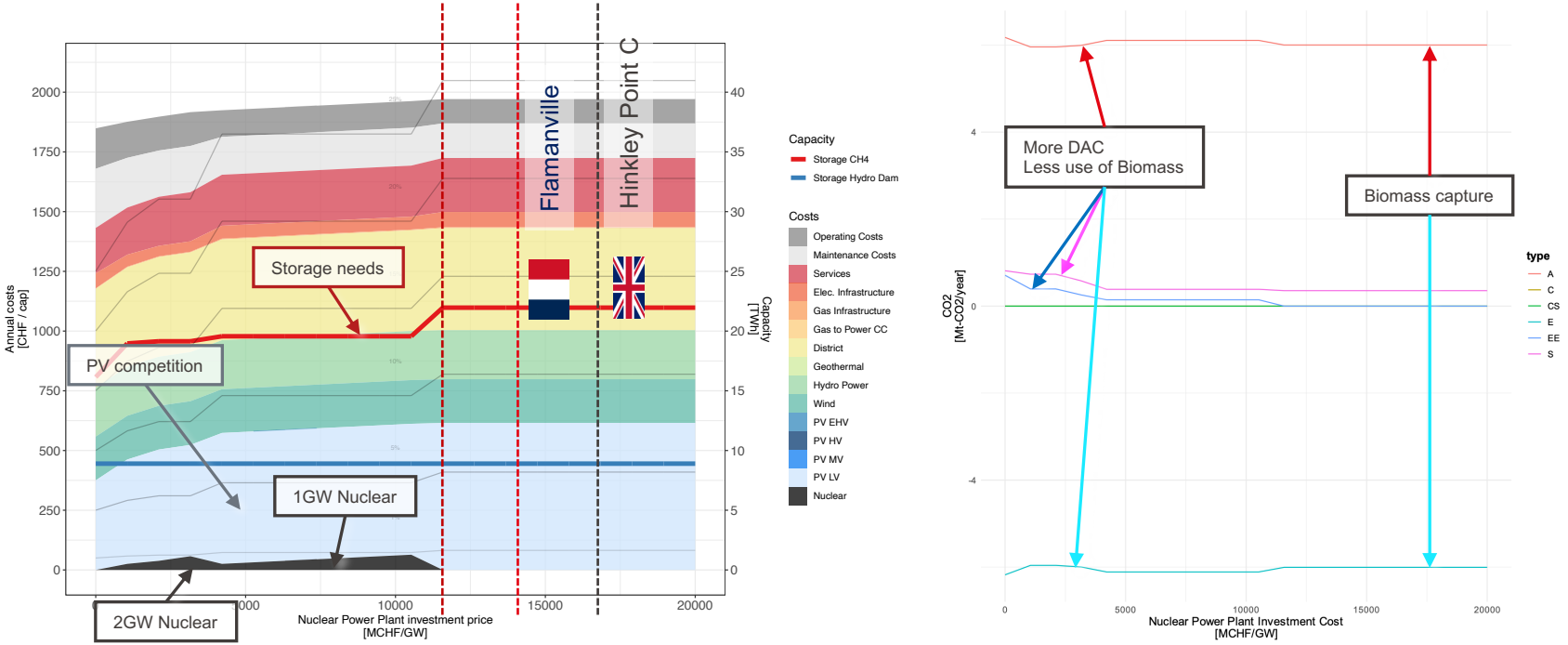
Geographical deployment of LV PV and respective grid reinforcement in CH 2050.
Case study of the economic optimization of a neutral (no net emissions) and independent (no imports) Swiss energy system in 2050.
Cost minimization

Schnidrig et al. 2024, *Power to the People: Envisioning Decentralized Energy Landscapes - Synergies of Centralized and Decentralized Energy Models through Unveiling the Role of Districts and Self Consumption, Energies*

Independence of Switzerland
Critical price of methane import price



Independence of Switzerland
Critical price of nuclear power plants



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Une énergie suisse et décarbonnée d'ici à 2050 ? L'HES-SO et l'EPFL amènent leur éclairage...

Swiss and decarbonized Swiss Energy by 2050? The HES-So and EPFL enlighten the question

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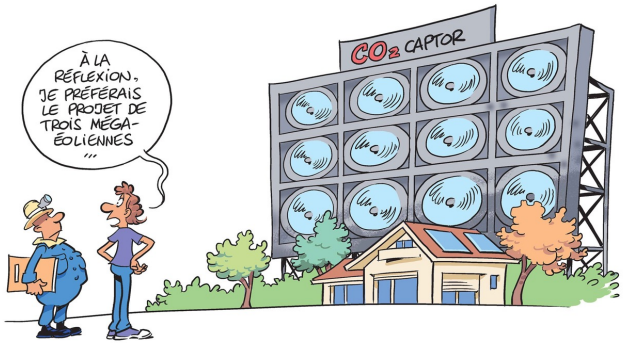
Addressing contemporary challenges

The project

You are member of the federal council



- **Objectives** :

  In groups of seven, develop an energy system for Switzerland using **EnergyScope**.

- **Scenario** :
  - Each group represents the Swiss Federal Council (five members).
  - Each member is responsible for a specific ministry and defends the interests of that sector.
- **Final Result**:
  - he group must reach a consensus on a national energy system, accounting for the necessary trade-offs.
  - Present the solution in **1 poster**, and discuss the **compromises** made.

The Federal Council

Minister of Energy

- Calibration of EnergyScope model to Swiss-specific data sets and boundary conditions.
- Reconciliation of sectoral demands (industry, residential, transport) within generation and storage limits.
- Preservation of model transparency to facilitate informed decision-making.
- Mediation of conflicting technical objectives to drive group consensus

Minister of Environment

- Quantification of ecosystem externalities (habitat loss, water stress, landscapescapes).
- Preservation of biodiversity under scenarios of infrastructure expansion.
- Design and evaluation of mitigation measures to meet national and international environmental standards.
- Integration of cumulative ecological impacts into system-level trade-off analyses.

Minister of Foreign Affairs

- Evaluation of import-dependency risks under geopolitical and supply-security scenarios.
- Diversification of energy sourcing portfolios to enhance resilience.
- Negotiation of cross-border energy trade agreements and regulatory harmonisation.
- Balancing strategic autonomy with integration into European and global energy markets..

Beat me

Benevolent Dictator

Minister of internal affairs

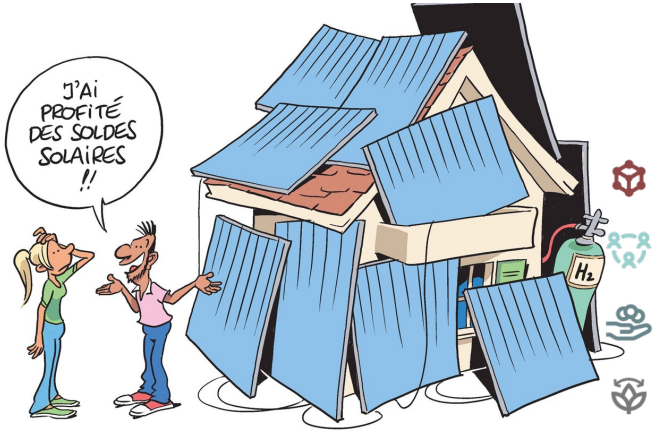
- Analysis of demographic trends and regional population distributions to identify differential impacts of energy policies.
- Assessment of public-health externalities, including air-quality changes, noise pollution and thermal stress.
- Evaluation of social acceptance and equity implications through stakeholder surveys and behavioural studies.
- Design of inclusive engagement strategies to foster transparent communication and build trust among diverse communities.
- Identification of vulnerable groups and formulation of measures to mitigate disproportionate burdens on at-risk populations.

Minister of Economy

- Comprehensive assessment of capital expenditures, operational costs and levelised cost of energy (LCOE) across technology options.
- Optimization of resource allocation under budgetary and financing constraints.
- Projection of long-term economic viability, including sensitivity to fuel-price volatility and carbon pricing.
- Structuring of incentive mechanisms (tariffs, subsidies) to balance cost-recovery and affordability.

Points to discuss

- **Energy efficiency:**
  What measures can be implemented to reduce energy consumption?
- **Resource selection:**
  Which energy sources should be prioritised (renewables, nuclear, fossil)?
- **Energy import:**
  Should Switzerland import energy or strive for self-sufficiency?
- **Emissions:**
  What actions are required to lower emissions? Should carbon neutrality be pursued?
- **Costs:**
  What is the total cost of the system and how will it be allocated?
- **Environment:**
  What impact will the system have on biodiversity and the broader environment?
- **Social acceptance:**
  How will decisions affect citizens' daily lives and public health?



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How to proceed

- Tool: env421.epfl.ch/project/ (VPN needed)
- Scenario Creation with Myopic vision
  1. Technoeconomic assessment
  2. Environmental Assessment
  3. Climate Change resilience
- All steps necessary to finalize the scenario
- Sharing/Exporting/Importing Scenarios
- Guiding questions

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How to “Win"

- Presentation and submission of 1 Poster in Week 14
- Explain and illustrate your choices and compromises
- Show the path of “thought” and illustrate the interactions of the Ministers

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