Toward the Swiss Energy Transition: Challenges and Opportunities

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1 The energy transition

2 Current status, trends and challenges

3 Tackling the challenges

4 Pathways to 2050

- Flexibility

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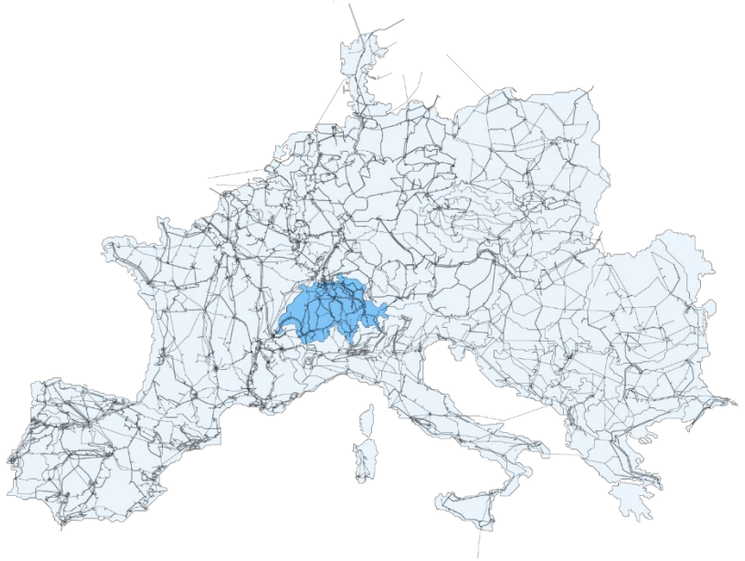
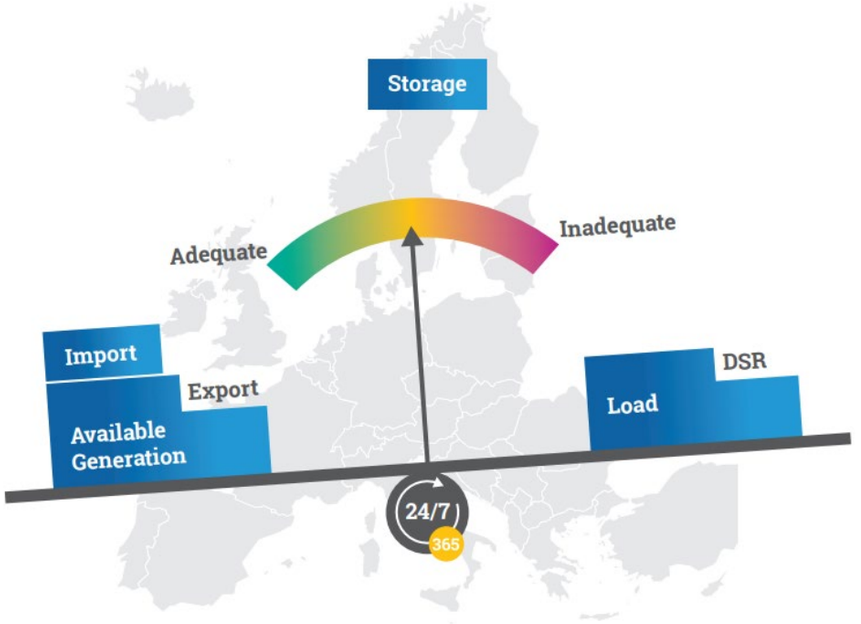
Electricity is a core societal need but a complex and unique commodity



- A complex interconnected system
- Power flows governed by physical laws and lines have flow limits

- Storage is not simple or cheap



- Maintain a balance between demand and supply at all times

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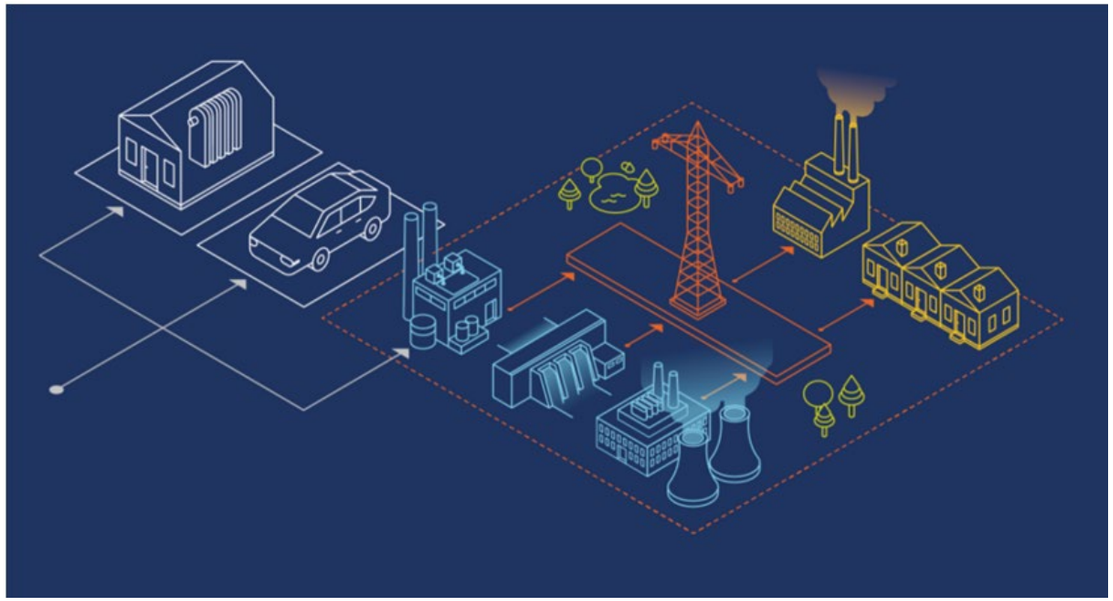
The Energy Transition: a paradigm shift in the way energy is supplied and consumed

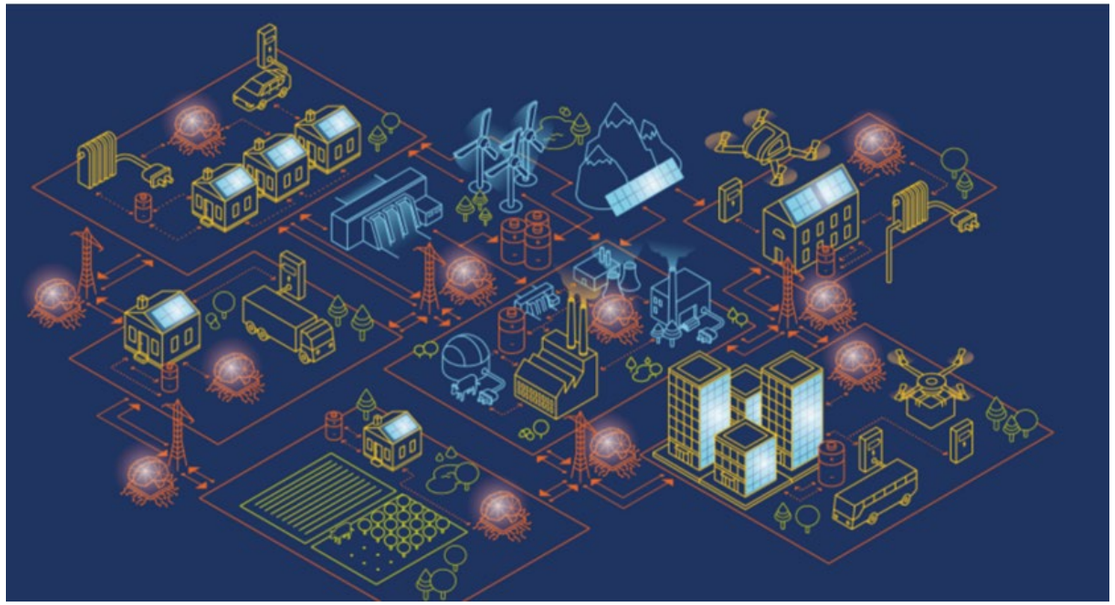
Net-zero emissions by 2050



Source: BKW

The recent past

- Centralized
- Large scale generation
- Predictable consumption



Source: BKW

The expected future

- Decentralisation & digitalisation
- Distributed local renewable generation
- Electrification of heating and transportation

Needed for Net-Zero

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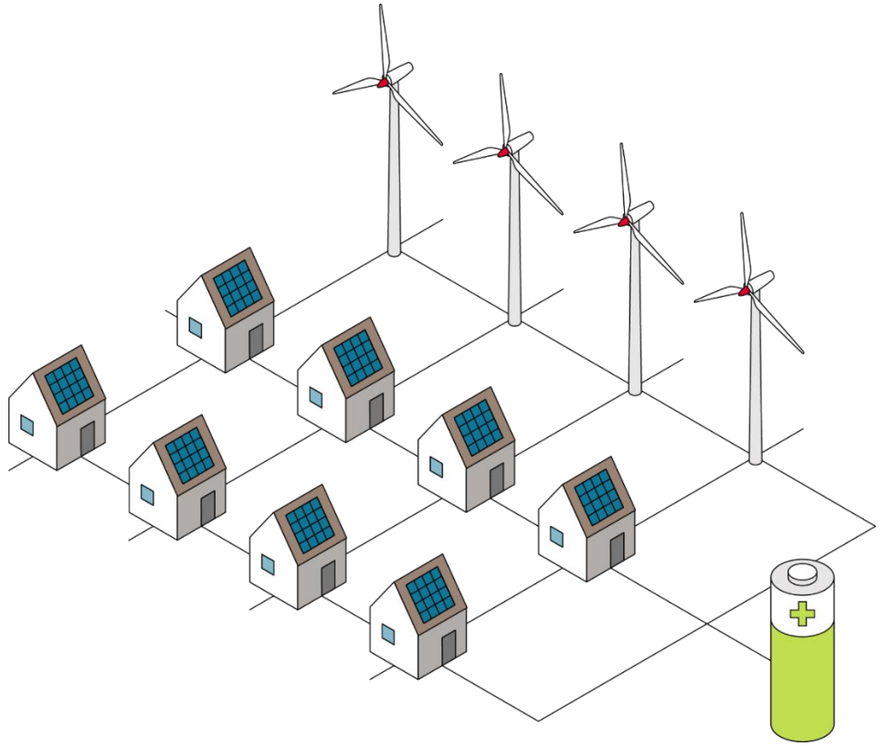
Switzerland’s goals: emissions and renewable electricity targets



1. Reduce emissions: Net-zero by 2050 → Electrification of EVs and HPs

2. Expansion of Renewables: 45 TWh → Rooftop PV

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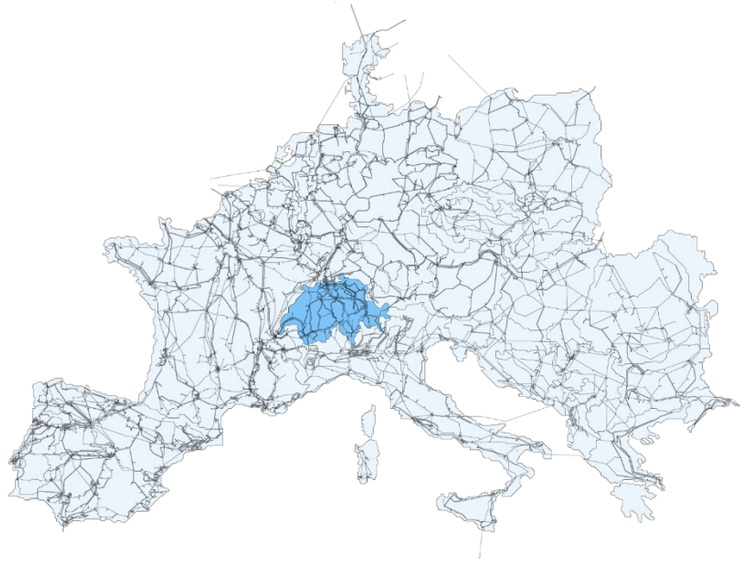
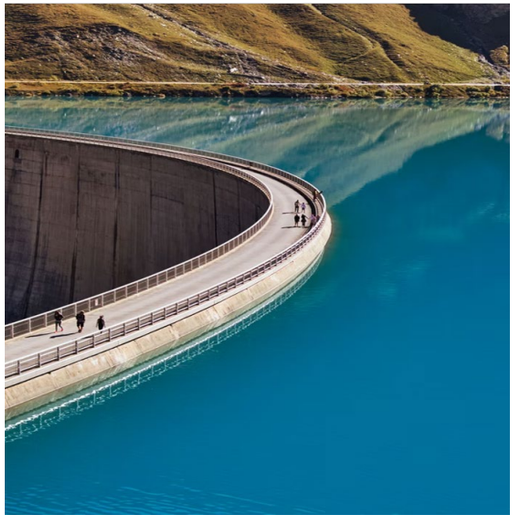
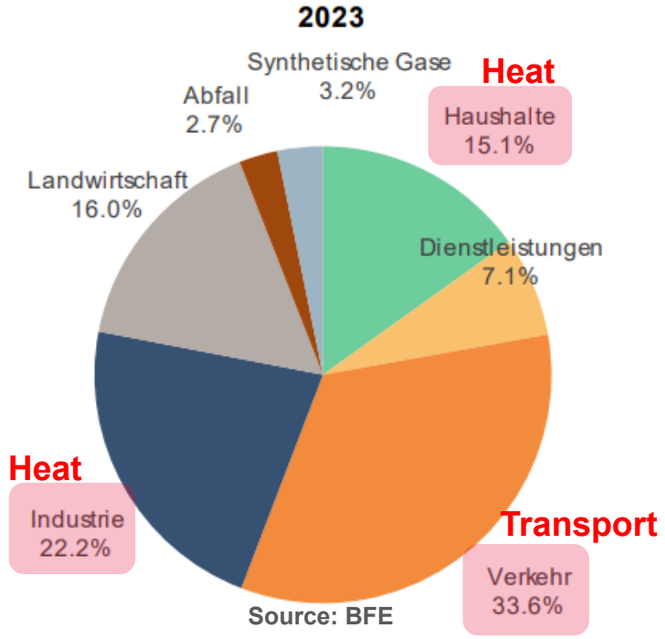
Characteristics of the current Swiss electricity (and wider energy) system



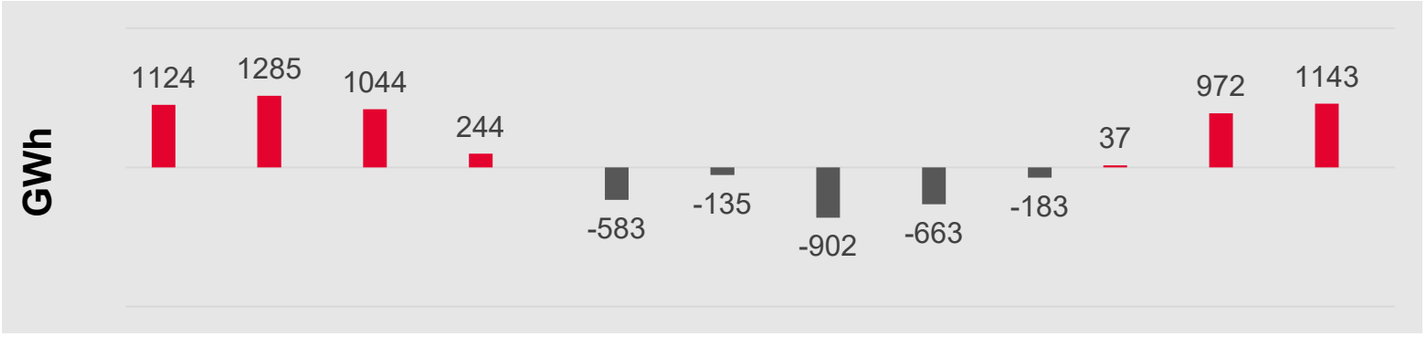
Interconnected to EU



Hydro dominant



32 Million tonne
CO2 Emissions



(Net imports): Seasonality of supply & demand

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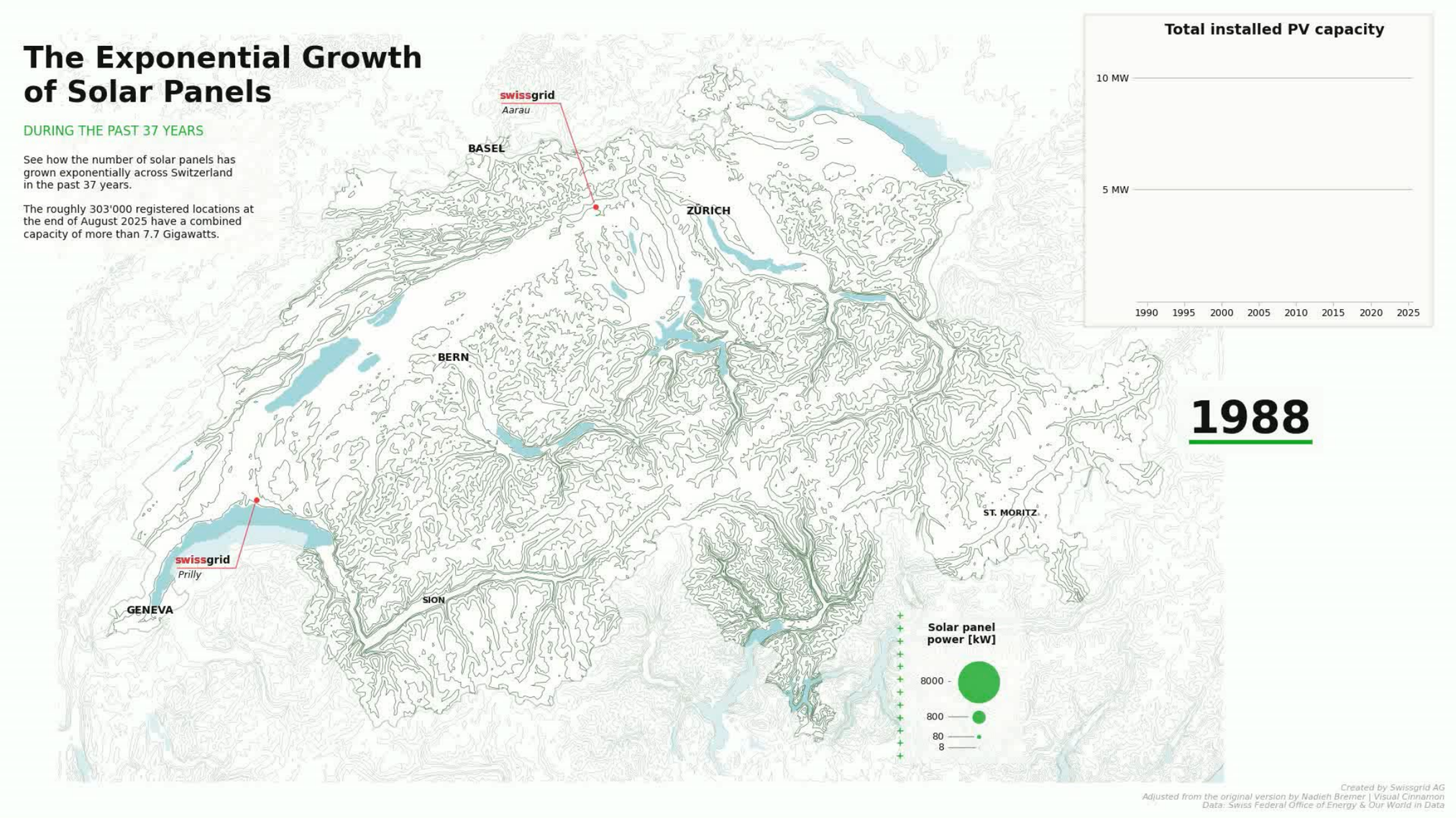
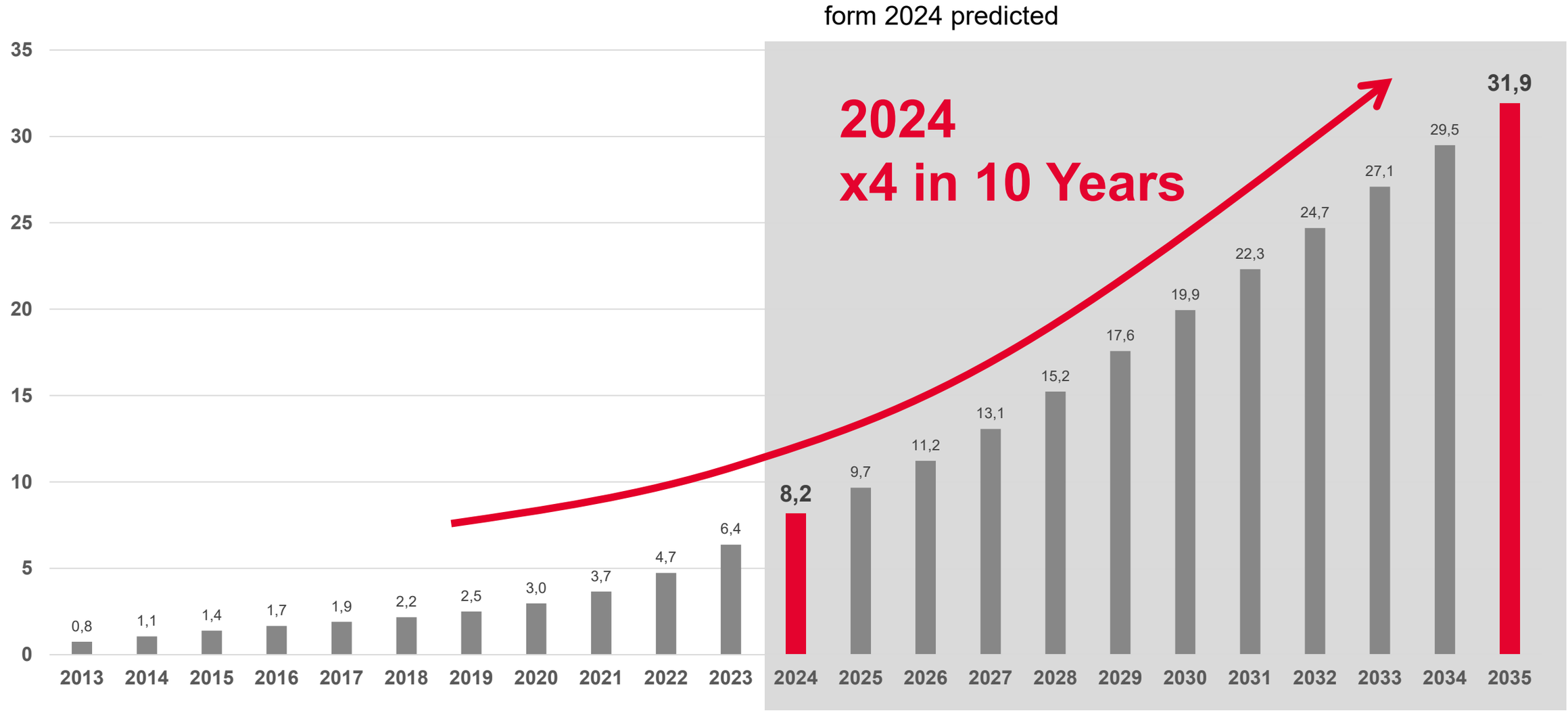
Trend #1: Growing rooftop PV installations



Trend #1: Expect PV expansion to continue

Cumulative installed PV capacity in Switzerland [GW]



Quelle: Bestand bis 2023: Statistik Sonnenenergie BFE
Zubau ab 2024: Swisssolar Solarmonitor Schweiz

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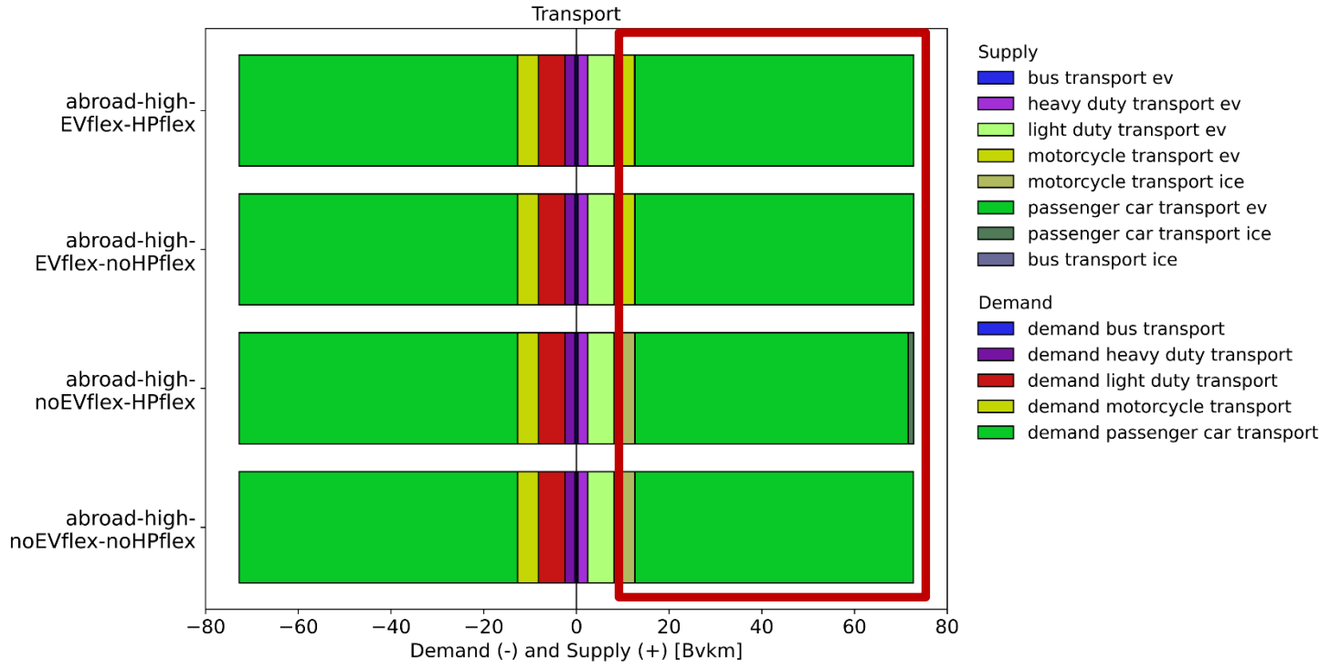
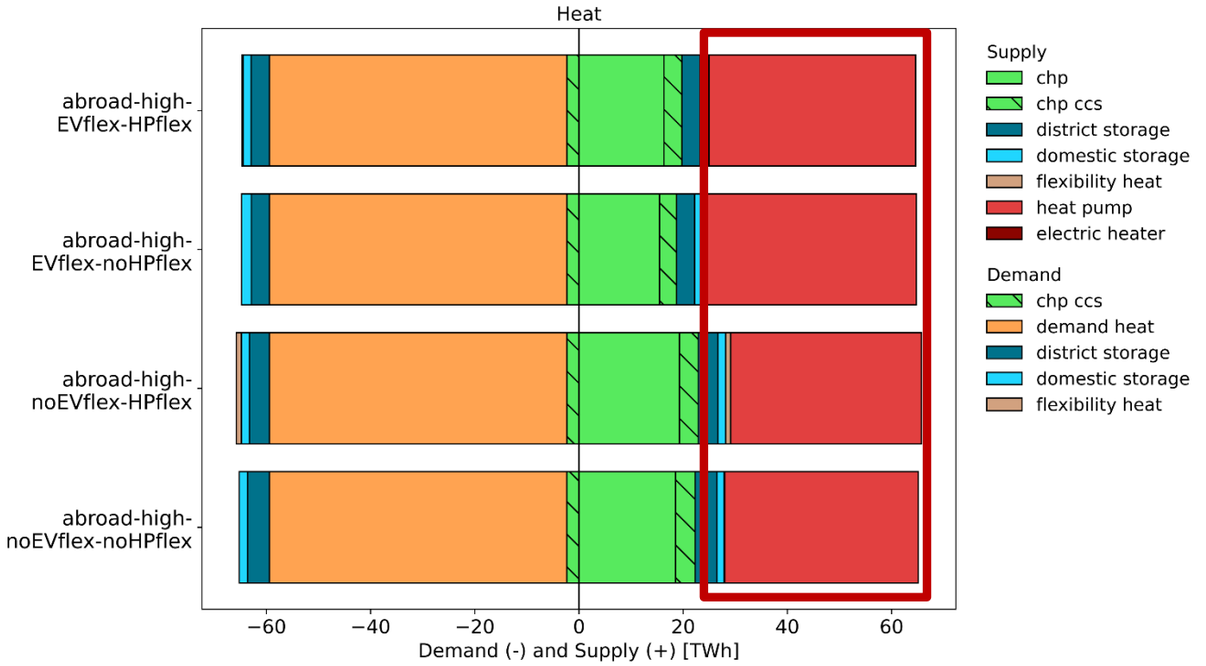
Trend #2: Electrification of heating and transportation sectors

Necessary to reach our decarbonization goals

2050 Swiss Scenarios – from SWEET PATHFNDR





Source: ETH Energy Science Center, Nexus-e webviewer, PATHFNDR Scenarios

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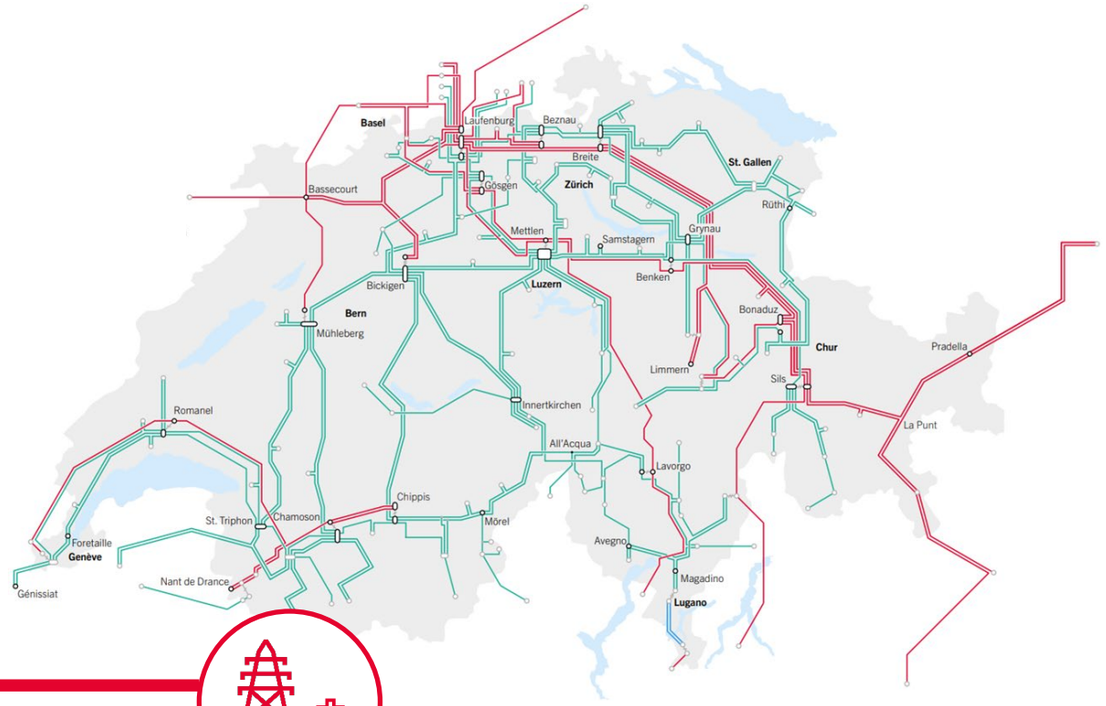
Key challenges



Grid expansion needs

- Peak flows in distribution networks driven by PV production
- Transmission network has more uncertainty and trading
- Potentially require massive investments

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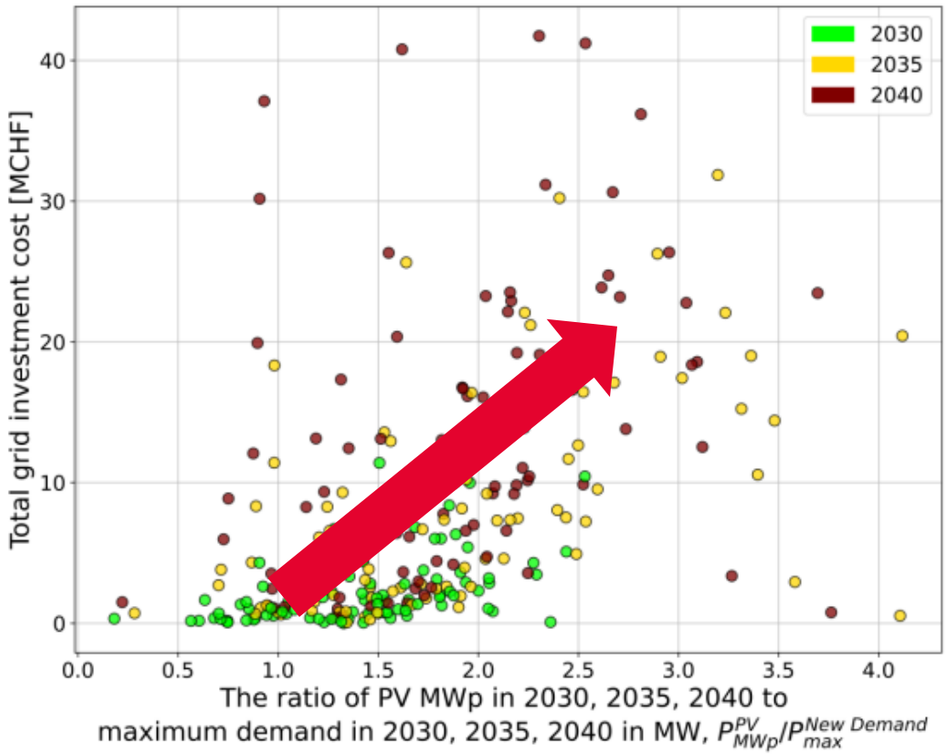
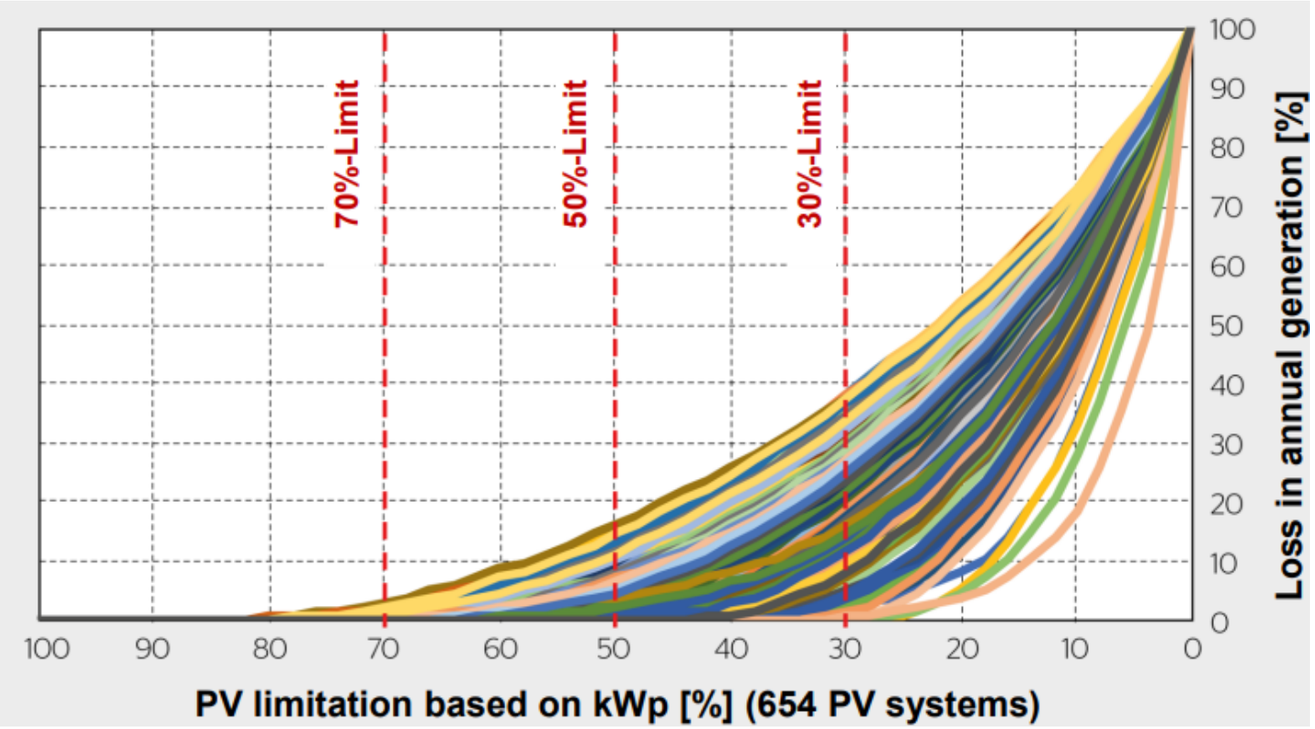
Peak grid flows are much higher & dominated by PV production

To safely operate, massive distribution grid reinforcement would be needed



Source: "End-user flexibilities for electrical distribution grid planning", ETH FEN, September 2025



Source: "Ohne Leistungsregelung von PV geht es nicht", Bulletin Electrosuisse, December 2024

Distribution grids must handle 4x peak flows, millions required in grid expansion for each region

Curtailing (throwing away) a little PV production could save a lot of €€

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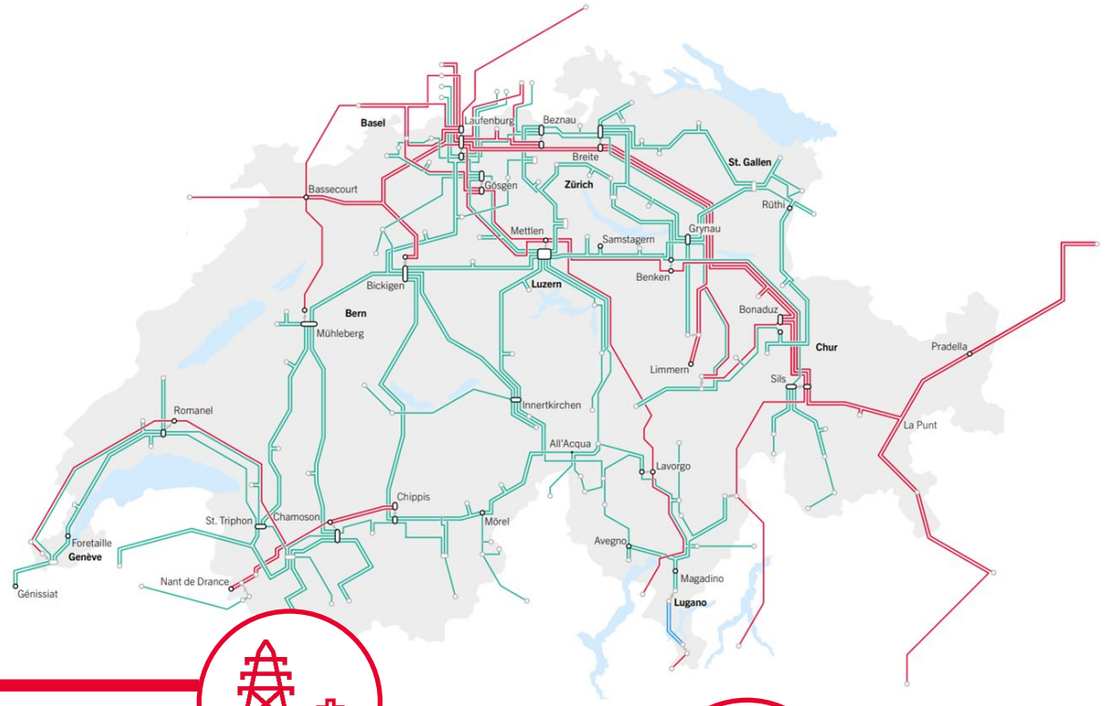
Key challenges



Grid expansion needs

- Peak flows in distribution networks driven by PV production
- Transmission network has more uncertainty and trading
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Increasing need for flexibility and control

- Weather dependent PV and Wind need to be accurately forecasted
- More sources of flexible production/demand needed to maintain balance and stability

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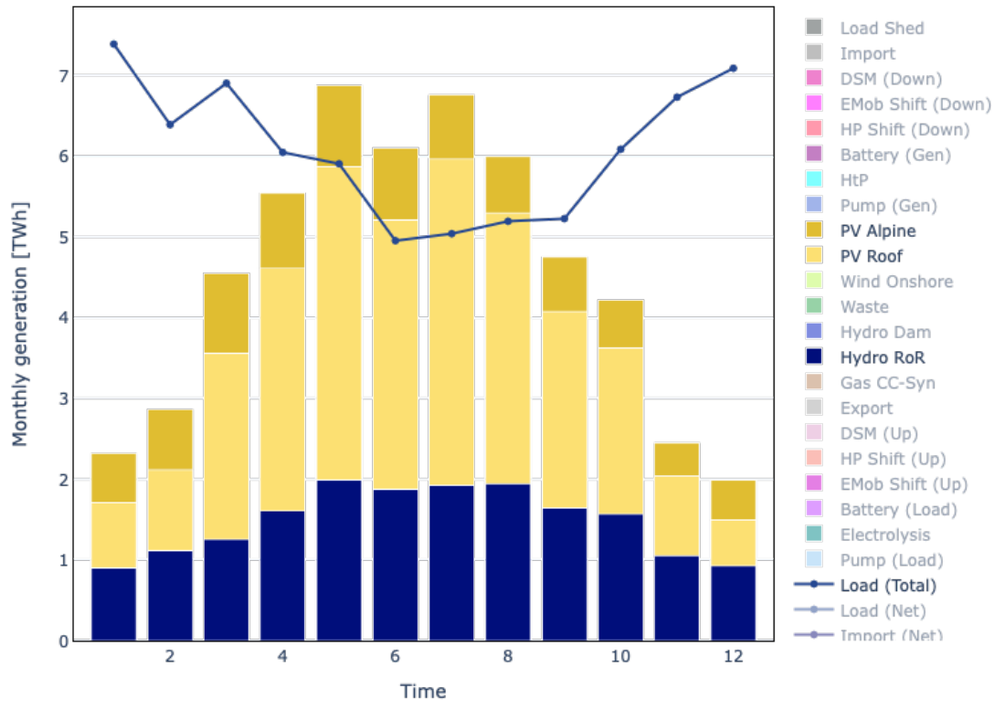
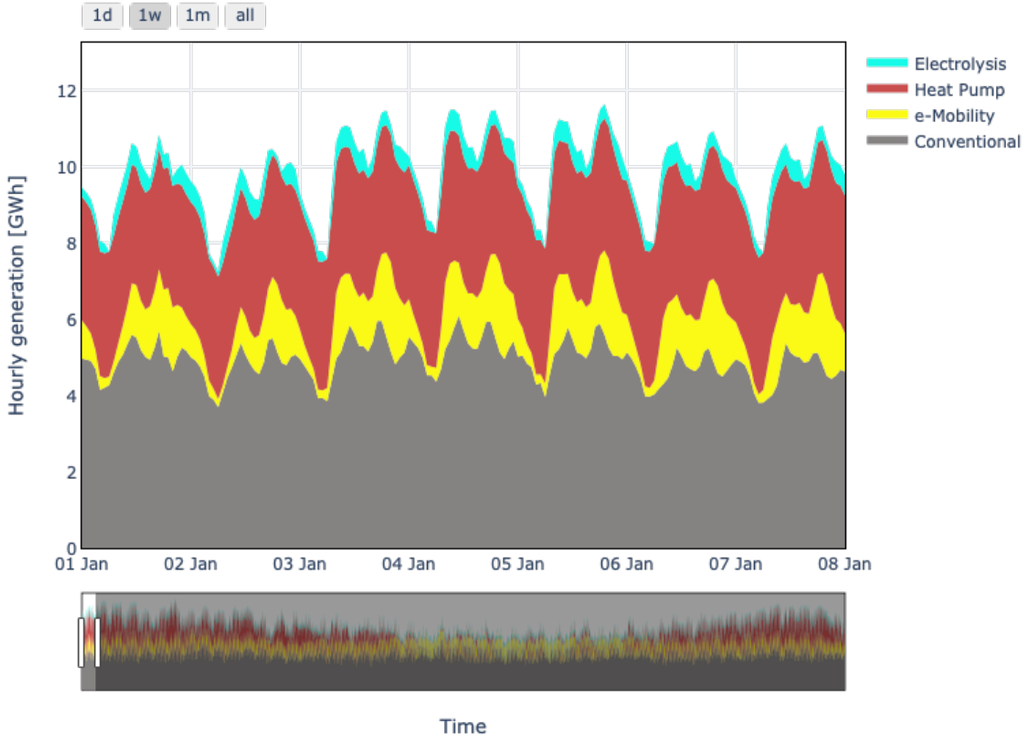
Fast flexible generators keep supply balanced in the long & short-term

Increasing weather-dependent supplies → greater need for new flexibility sources



Seasonal mismatch between demand and supply



A highly dynamic (volatile) electricity demand

Source: ETH Energy Science Center, Nexus-e webviewer, PATHFNDR Scenarios

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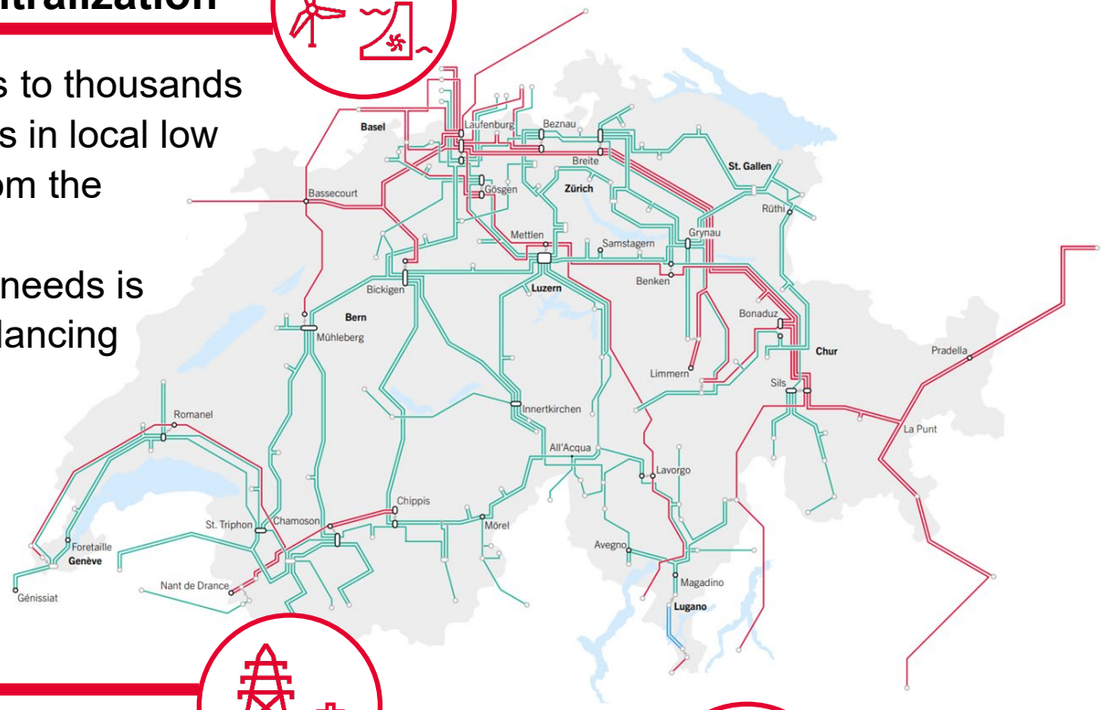
Key challenges

Coordination for decentralization

- From tens of generators to thousands
- Major electricity supplies in local low voltage grids, farther from the transmission network
- Diffusion of forecasting needs is leading to increased balancing activation and costs



Grid expansion needs

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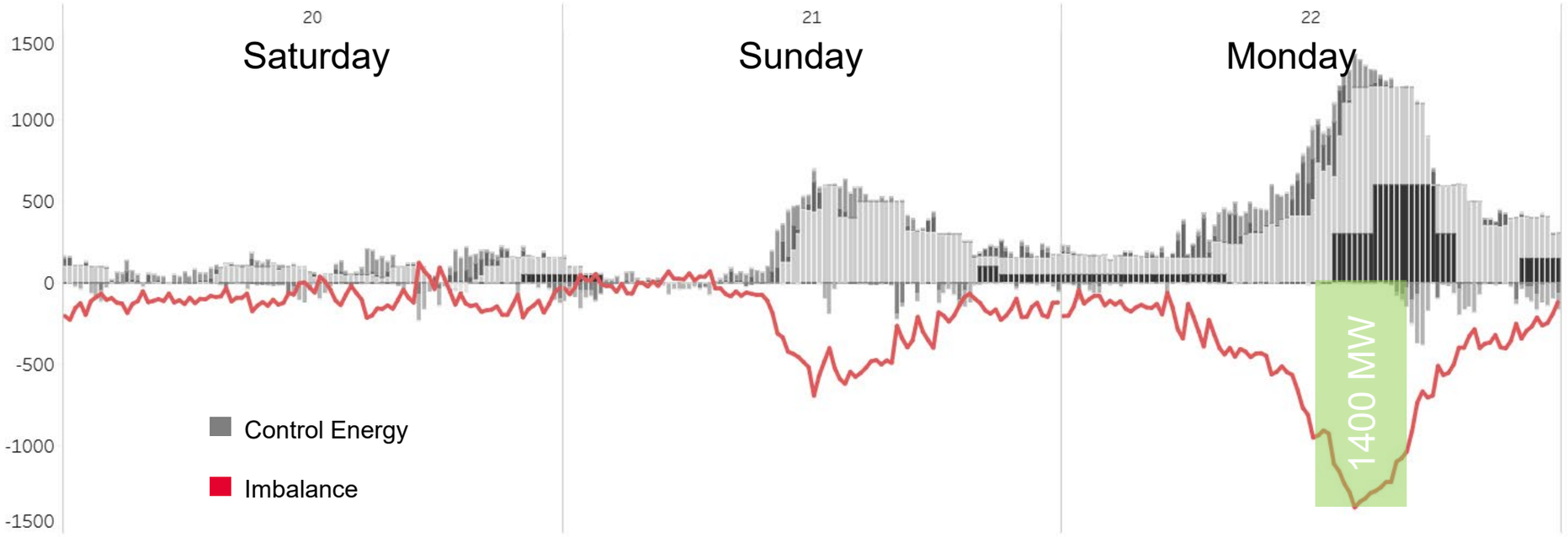
Poor short-term forecasts & schedules for PV

Increasing the use of balancing energy & associated costs

Significant imbalances occur more frequently **at weekends, on public holidays and on Mondays** in the **months of April to August** – coincidence?



Reason: bad forecast and not enough correction over the weekend

An **imbalance of 1,400 MW** with an installed PV capacity of 7 GW is a lot when you consider that Switzerland aims to have more than 30 GW of PV by 2040.

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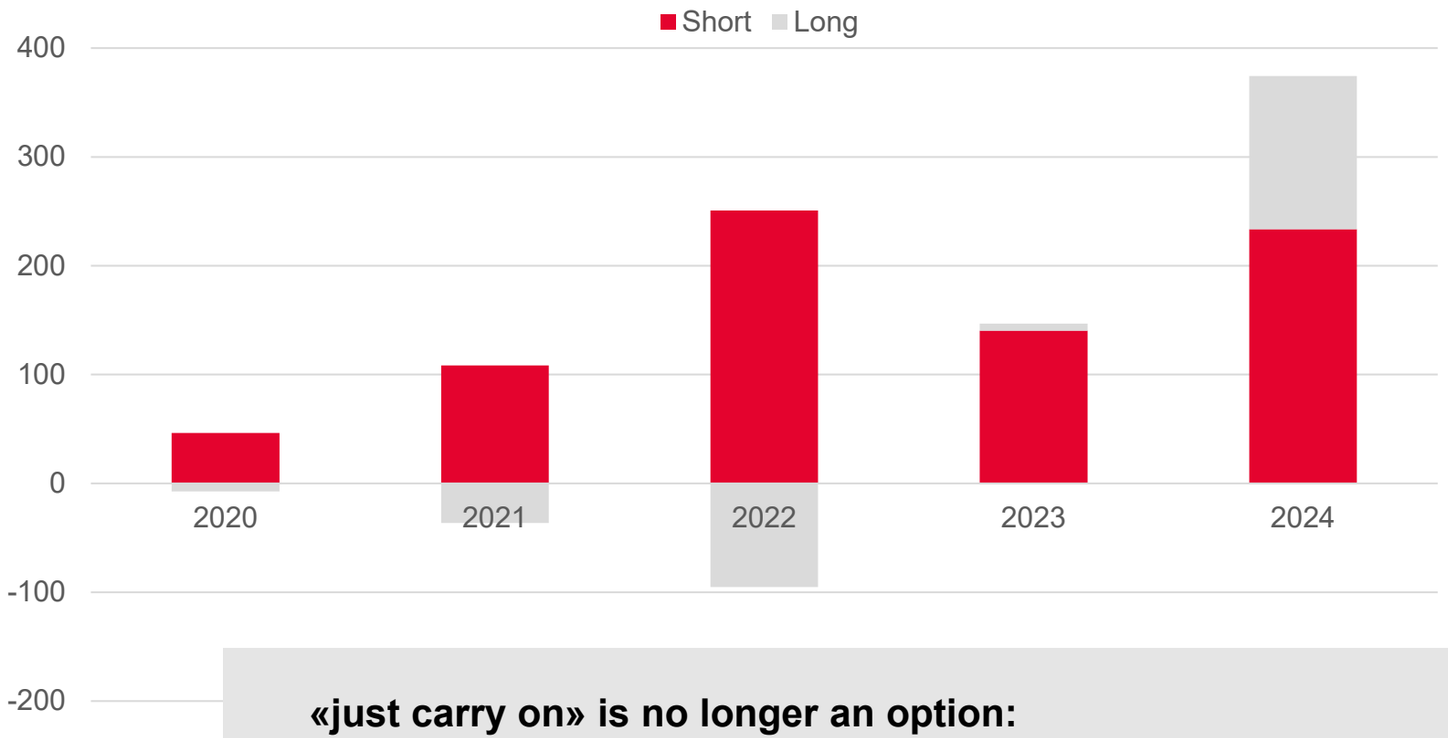
Costs for balancing energy are continuing to increase in recent yearsDevelopment of balancing energy costs [million CHF]



- Total balancing energy costs around CHF 374 million.
- CHF 264 million paid to suppliers for balancing energy
- The remaining CHF 110 million was used as surplus to reduce tariffs.

«just carry on» is no longer an option:

- Swissgrid: «Optimizer balancing energy» to automate TRE schedules
- Balance groups: obligation to forecast again in intraday and not just day-ahead
- Market model: implementation of a single price model for balancing energy by 2026
- Market expansion: giving balance groups the option of supporting open positions for the CA by 2026

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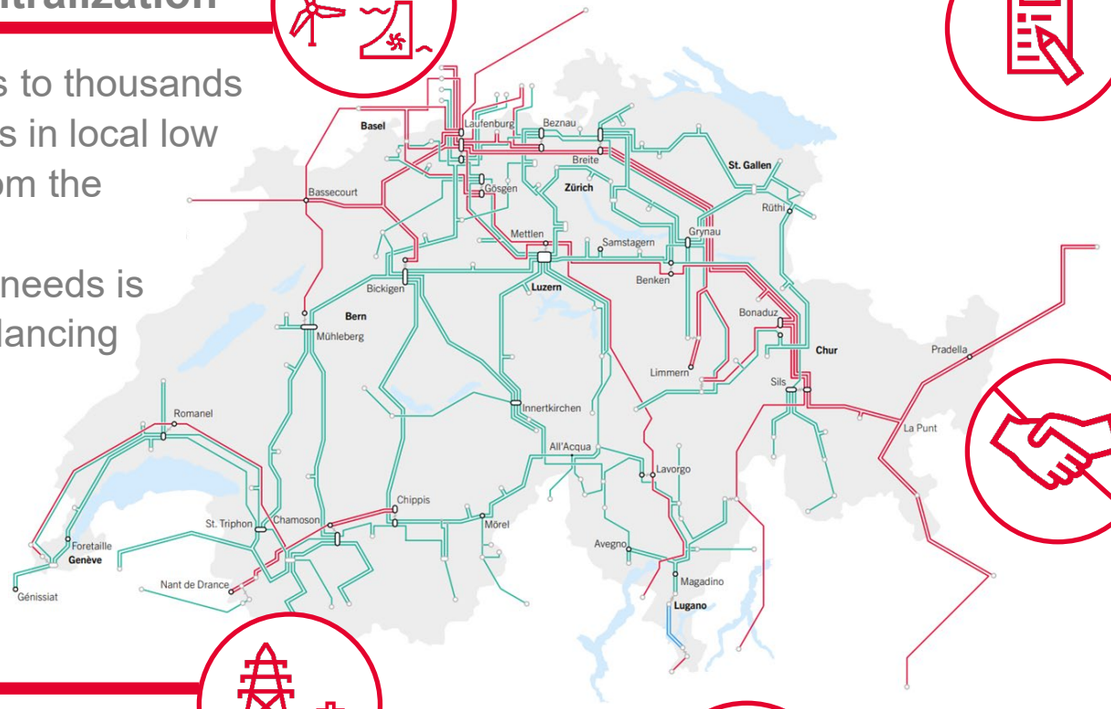

Grid expansion needs

- Peak flows in distribution networks driven by PV production
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Cost sharing withdrawal

- Prosumers who self-supply do not contribute toward socialized costs
- Higher burden for those who cannot produce locally

Lack of an EU electricity agreement

- Switzerland cannot contribute to the development of the EU electricity system

Increasing need for flexibility and control

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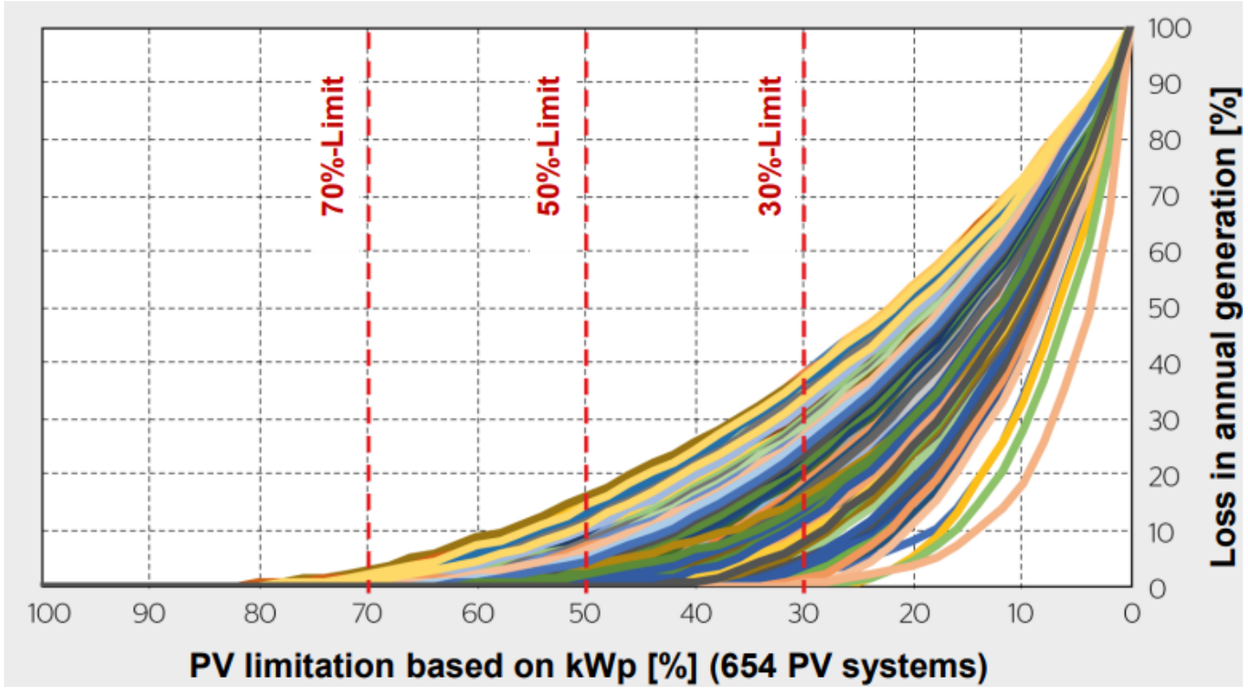
Challenge: peak PV flows in distribution grids

Operating assets in distribution grids in a ‘grid-friendly’ way can help



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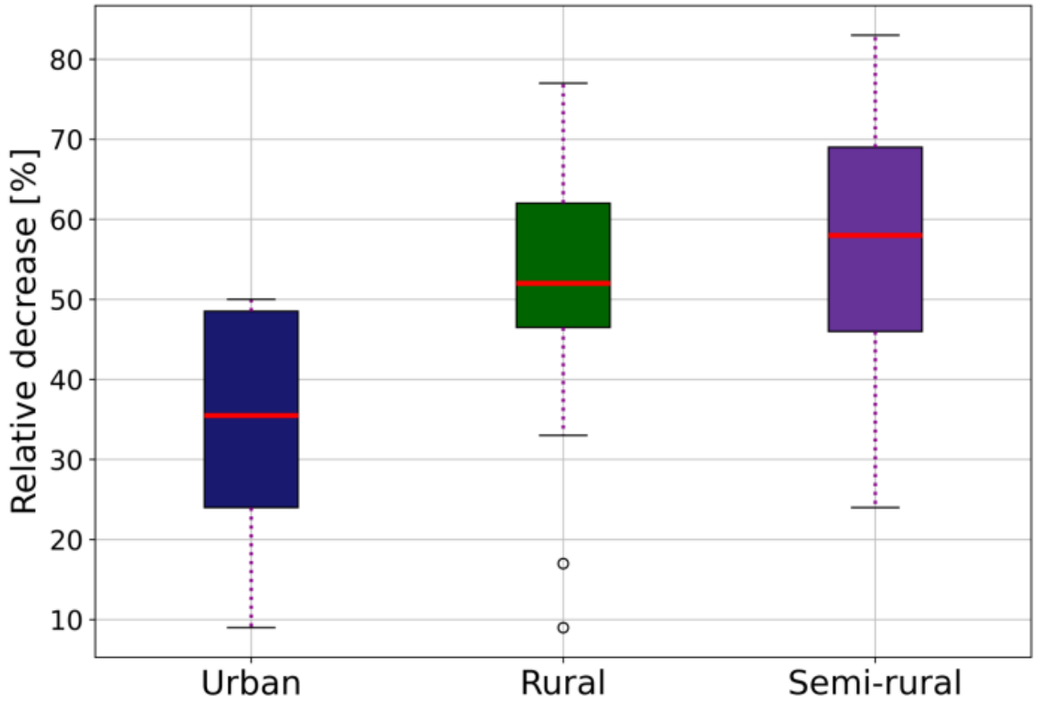

Source: “End-user flexibilities for electrical distribution grid planning”, ETH FEN, September 2025

Curtailing (throwing away) a little PV production could save a lot of €€

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Challenge: weather-dependent PV & wind require more flexibility & control

Enable the use of new/distributed sources of flexibility from EV and HP demand

TSO-DSO Coordination (TDC) at a glance

DER Owners

- ✓ Optimize assets
- ✓ Participate with minimal effort

Flexibility Service Providers

- ✓ Market DER flexibility

TDC

- ✓ Efficient, **market-based** allocation of flexibility
- ✓ Systematic TSO-DSO coordination respecting grid constraints

DSOs

- ✓ Access flexibility for peak load, voltage and congestion management
- ✓ Avoid issues due to flexibility activations for others
- ✓ Share cost

TSO

- ✓ Access flexibility for control energy and congestion management
- ✓ Share cost

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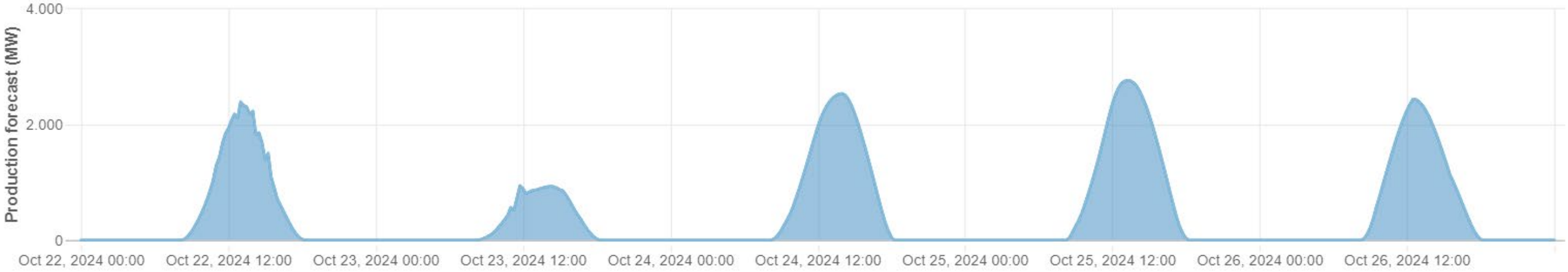
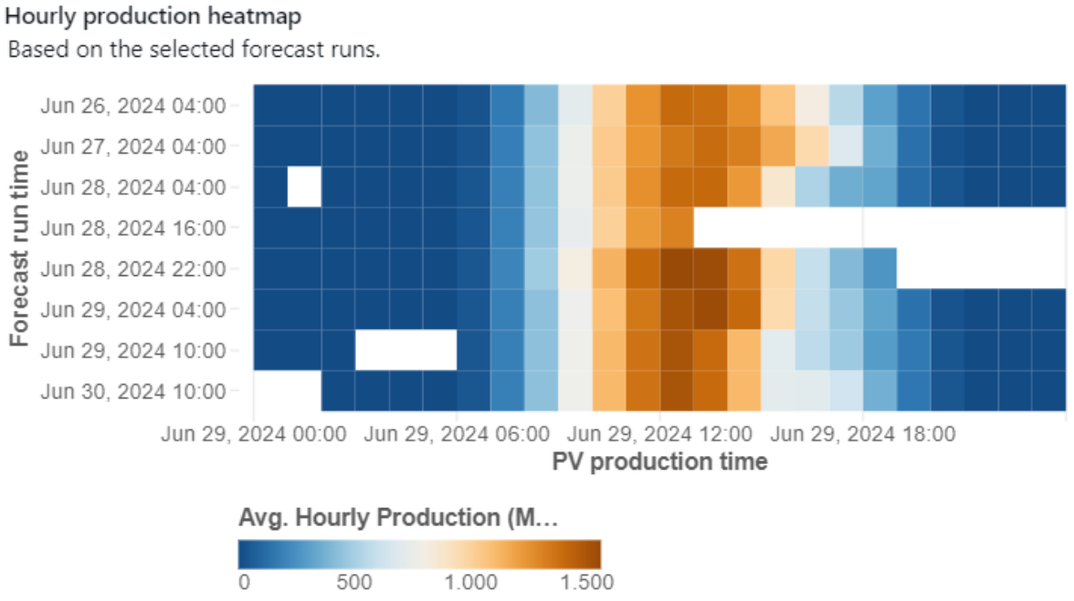
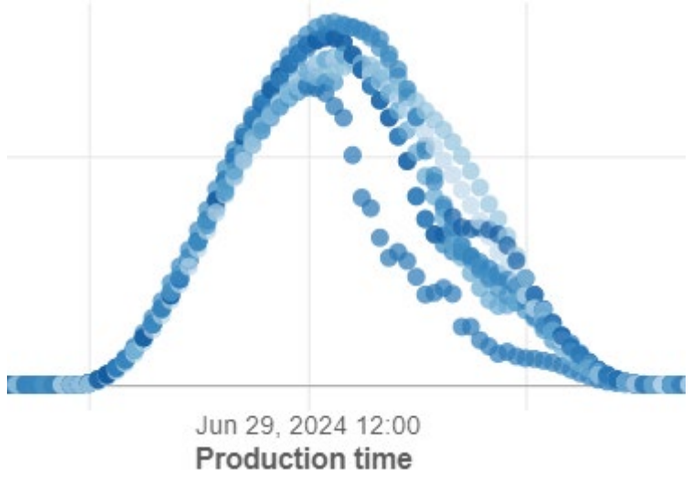
Challenge: weather-dependent PV & wind result in more activation of balance energy

Create better PV forecasts with data and machine learning







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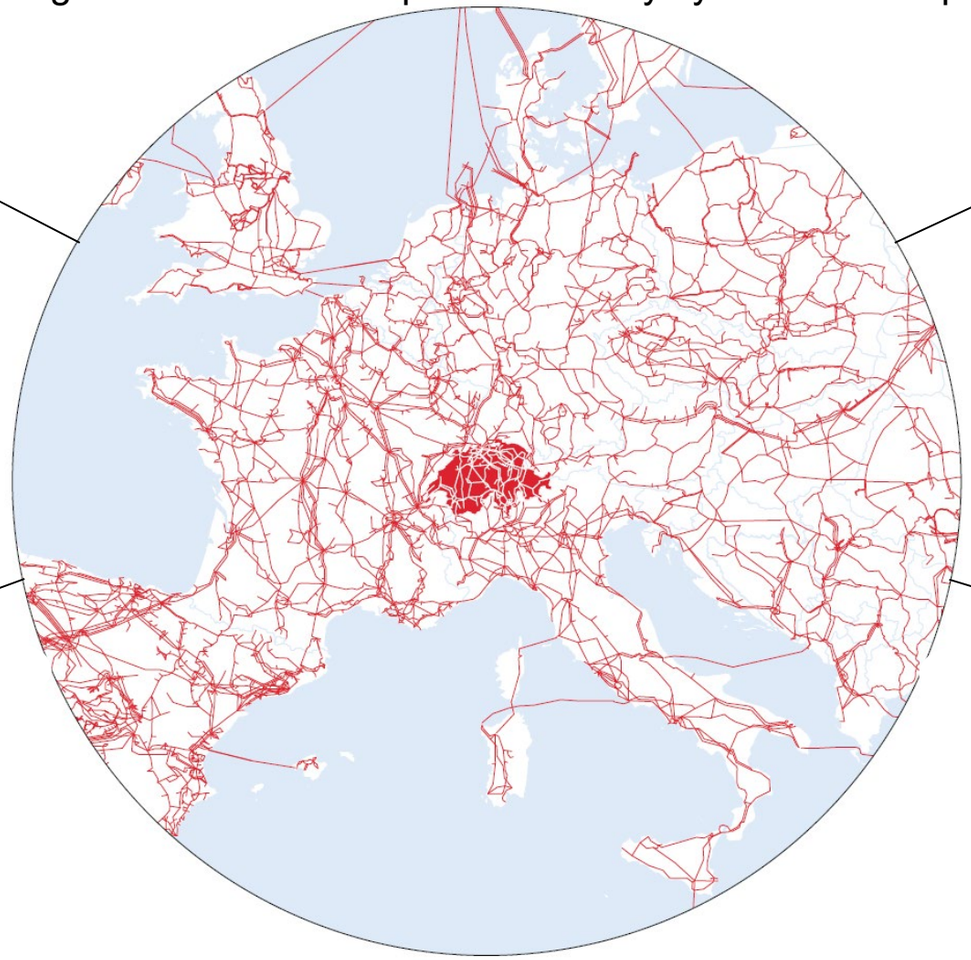
Challenge: Lack of an electricity agreement with EU

Clear communication about benefits, hope for the best but plan for the worst

According to **Article 89 of the Federal Constitution**, Switzerland shall endeavour to ensure a **safe, economic and environmentally sustainable energy supply**. Integration into the European electricity system is an important prerequisite for achieving this goal.



Grid stability

Participating in the EU's control energy platforms (TERRE, MARI, PICASSO), which are essential for grid security

Marketing opportunities

Making optimal use of flexible Swiss hydropower in the European power market and taking advantage of trading opportunities for the Swiss electricity industry

Importability

Ensuring the maximum possible import capacities

Right to participate

Obtaining a say in the EU bodies responsible for the electricity sector, thereby helping to shape future electricity market developments in Europe

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Challenge: successful long-term grid planning with many uncertainties

Enhance coordination at national and international levels for consistent broad scenarios and long-term data projections

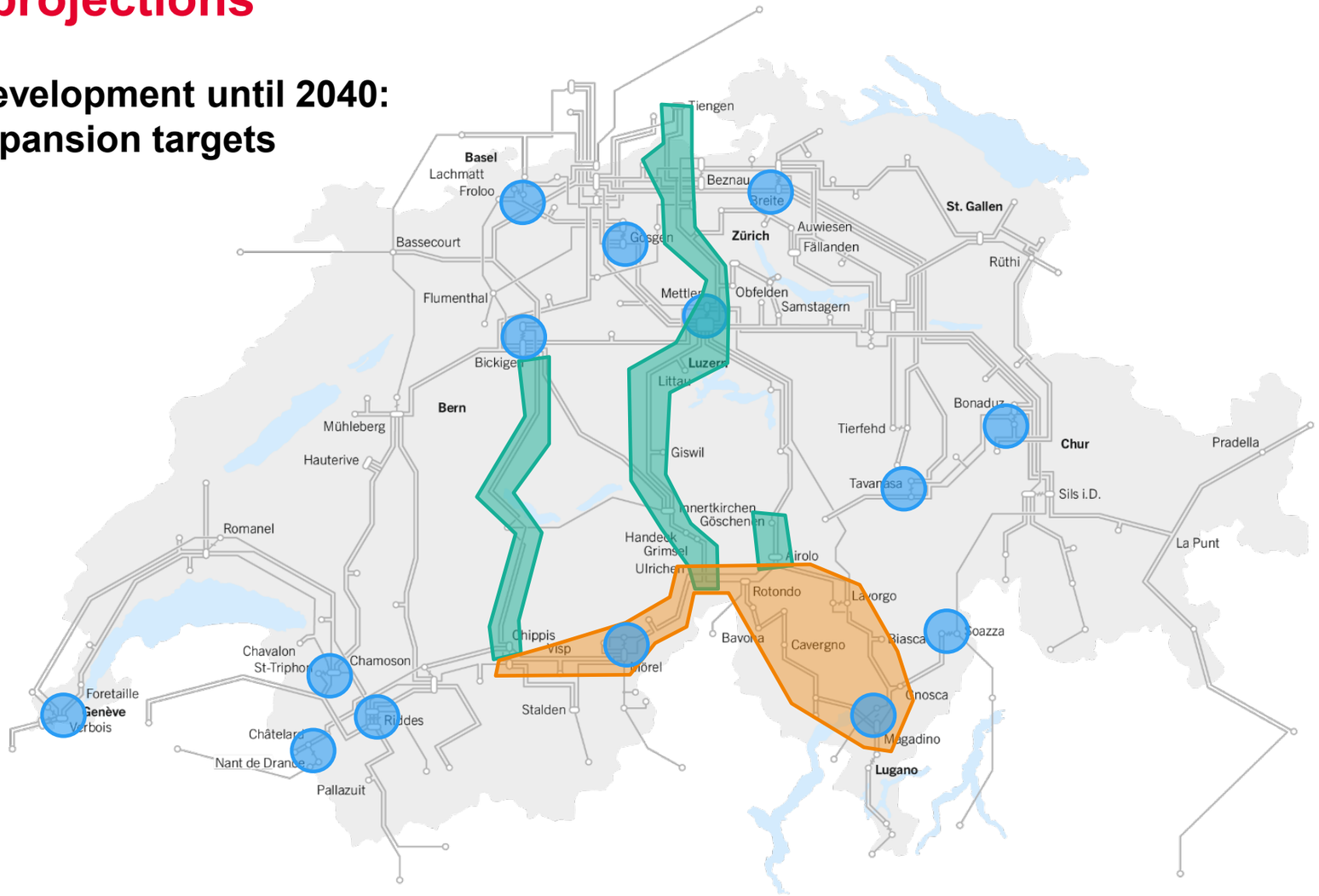
21 new controllable transformers:
Optimize current flows and transmission capacity

Strengthen North-South axis:
Better connection between storage power plants, consumers and producers at home and abroad

Strengthen the East-West axis and the connection to Ticino

Other projects serve to ensure security of supply, enable grid connection applications or relieve burden on the environment

Grid development until 2040:
Key expansion targets



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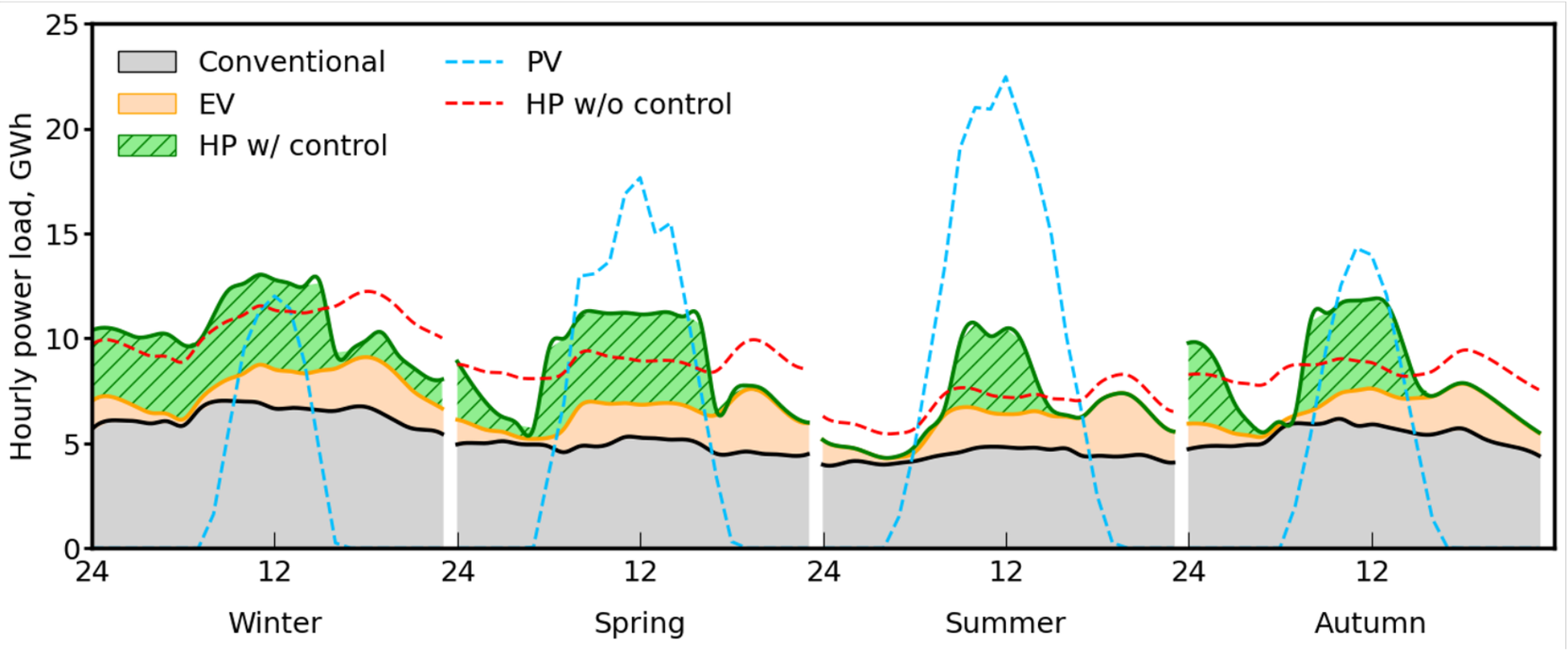
HP demand could shift to align with peak electricity generation (from PV)

*same is true for EV demand shifting

HP demand over one day each season



Shifting of HP into midday and away from evening

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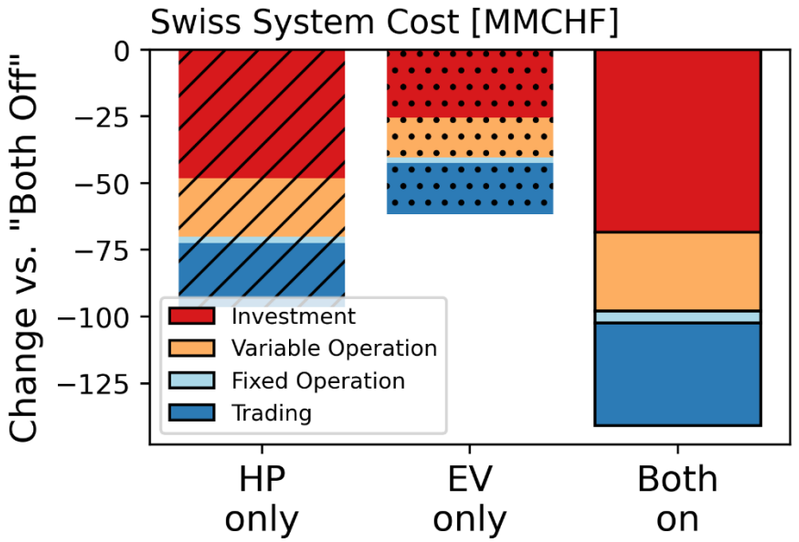
Flexibility from HP and EV can provide useful benefits

- **Electrification**: key trend to decarbonize
- **EV & HP Flexibility**: clear system benefits
- RES support
- Value to replace other flexibility options (H2, Syn-Gas, BESS, Import)
- Reduce system operating costs

Accumulation of Benefits

- Additionality / Saturation / Seasonal / Compliment



Investment savings

- Building less BESS and Syn-GasCC

Variable cost savings

- Operating less Syn-GasCC

Trading

- Reduce Import costs
- Increase Export revenues

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Thank you for your attention

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