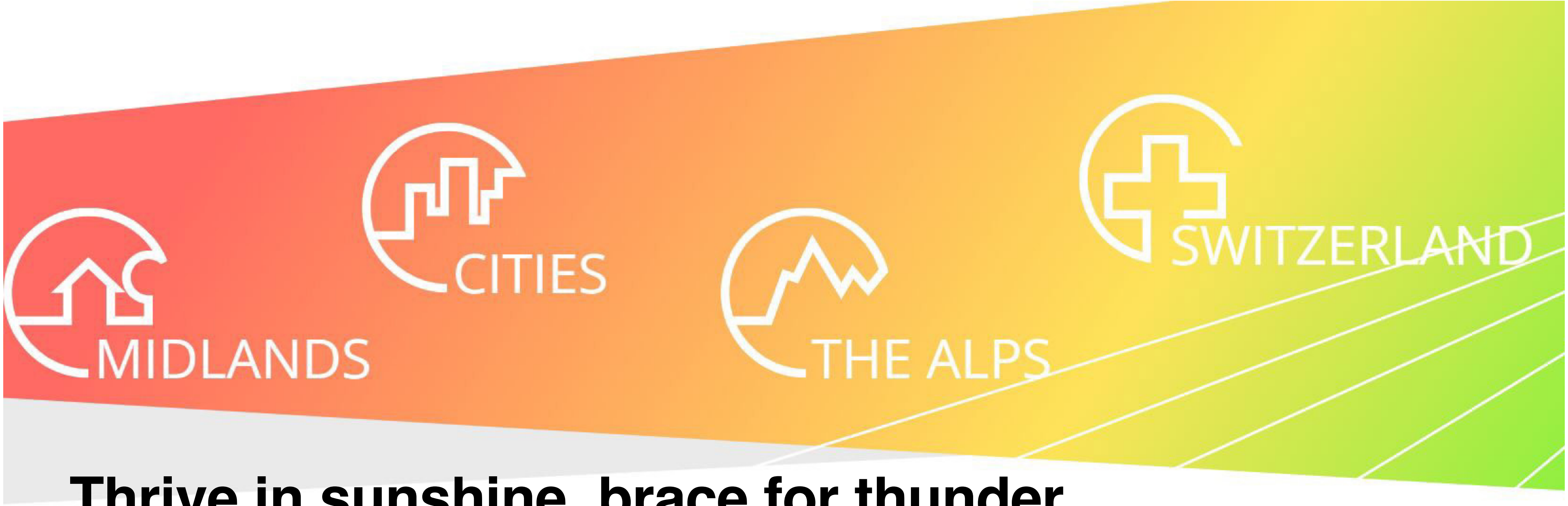


Thrive in sunshine, brace for thunder

Least-cost robust power system investments under political shocks

Ali Darudi, Ingmar Schlecht CEE ZHAW – Jonas Savelsberg ETH

31.01.2025 – Energieforschungsgespräche Disentis 2025

sweet swiss energy research for the energy transition
EDGE

EDGE is a consortium sponsored by the Swiss Federal Office of Energy's SWEET programme and coordinated jointly by UNIGE and EPFL

System Adequacy: efficiency & robustness

- Traditional energy planning focuses on either normal conditions or extreme shocks.
- If optimized only for normal years, it fail in crises.
  - lost load that was avoidable with some small extra investment.
- If optimized only for shocks, excessive investment costs.
  - High Capex overestimate the period in which it recovers its costs.
- What should the goal of power system design be—optimizing for normal years or ensuring resilience during shock years? Why not both?

Liquid Fuel Storage: less explored option

- Existing liquid fuel storage in CH:
  - Federal Act on National Economic Supply:
    - 3-4.5 months of gasoline, diesel oil, heating oil, aviation fuel to be stored in CH
    - Total tank capacity: 6,6 million m³ (max 24 TWh of electricity)
  - Possibly underutilized liquid storage reserve in the future
    - No initial investment cost for existing storages (adjustment and maintenance costs)

Source: Wikipedia

Research Question

- How should power systems be designed to remain cost-effective while ensuring resilience to trade capacity and fuel import shocks?
  - What is the optimal technology mix under different shock frequencies and severities?

- Approach:
  - FEM dispatch and investment model of power system (numerical modelling)
  - Simultaneously solving several shock and normal scenarios

- Goal: showcase the idea, not the exact numbers

FEM (Future Electricity Market)

- Techno-economic model for simulating investment, dispatch, and trade
- Objective: Minimizes total system costs while meeting constraints
  - Lost load cost of CHF10 K/MWh
- Outputs: Optimal capacity mix, generation profiles, etc.
- Temporal and Spatial Focus:
  - Hourly resolution over one year, 2050
  - Investments solely for CH

FEM (Future Electricity Market)

- Mix to invest
  - Renewables: PV & Wind (with limit)
  - Conventional technologies: gas-fired, nuclear, liquid fuel plants …
  - “Green” conventional: gas-fired plants with green fuel or CCS
  - Storage: batteries and hydrogen

- Limitation
  - Perfect foresight

FEM goes robust - Shock Scenarios

A shock is defined by:

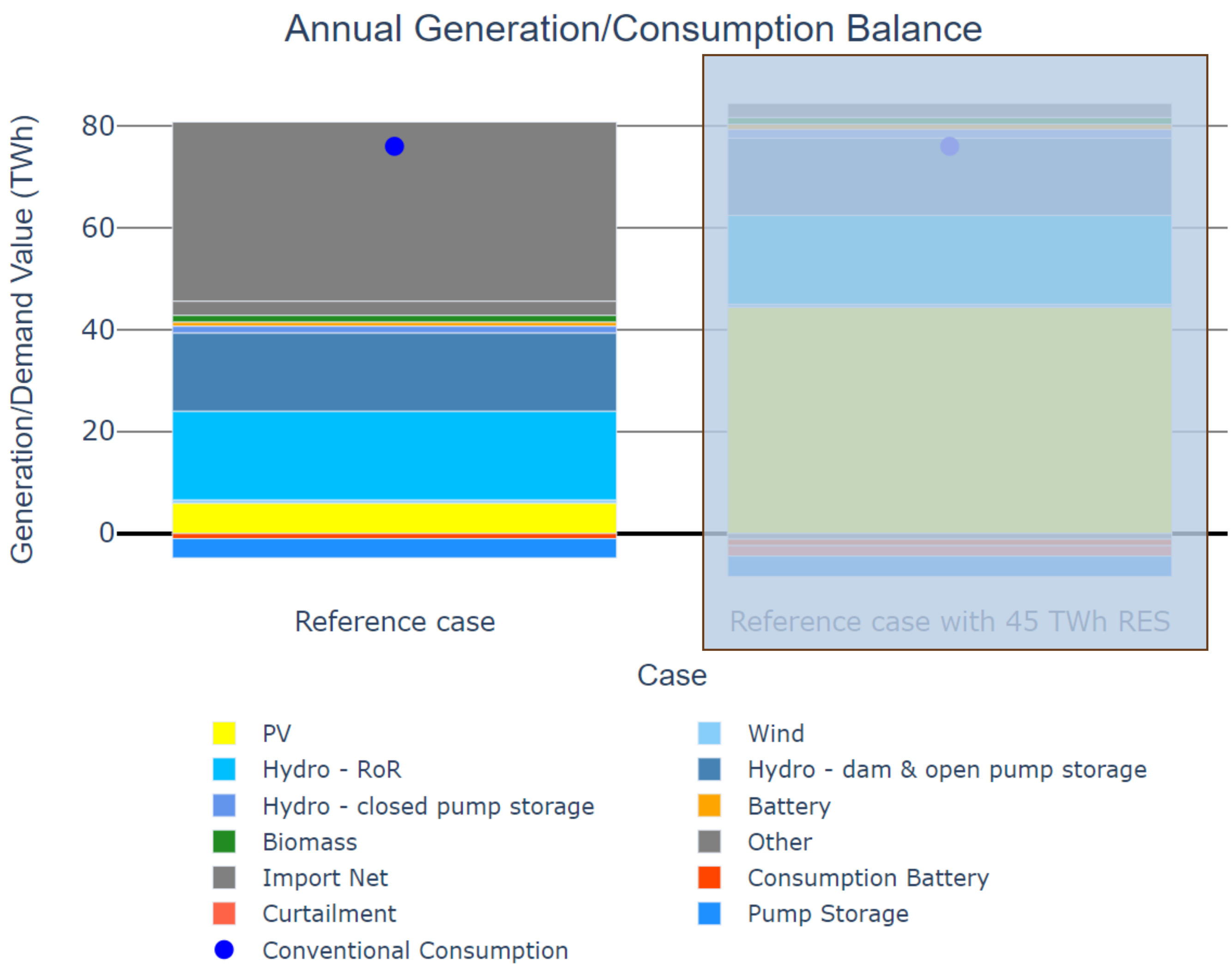
- Severity:
  - Full year with trade reduction (NTC reduction of 100%, 90%, 75%, 70%)
- Frequency:
  - Occurs one year every 1000, 100, 10, 5, or 2 years

Model Objective:

- Minimize total expected system cost:

Reference cases

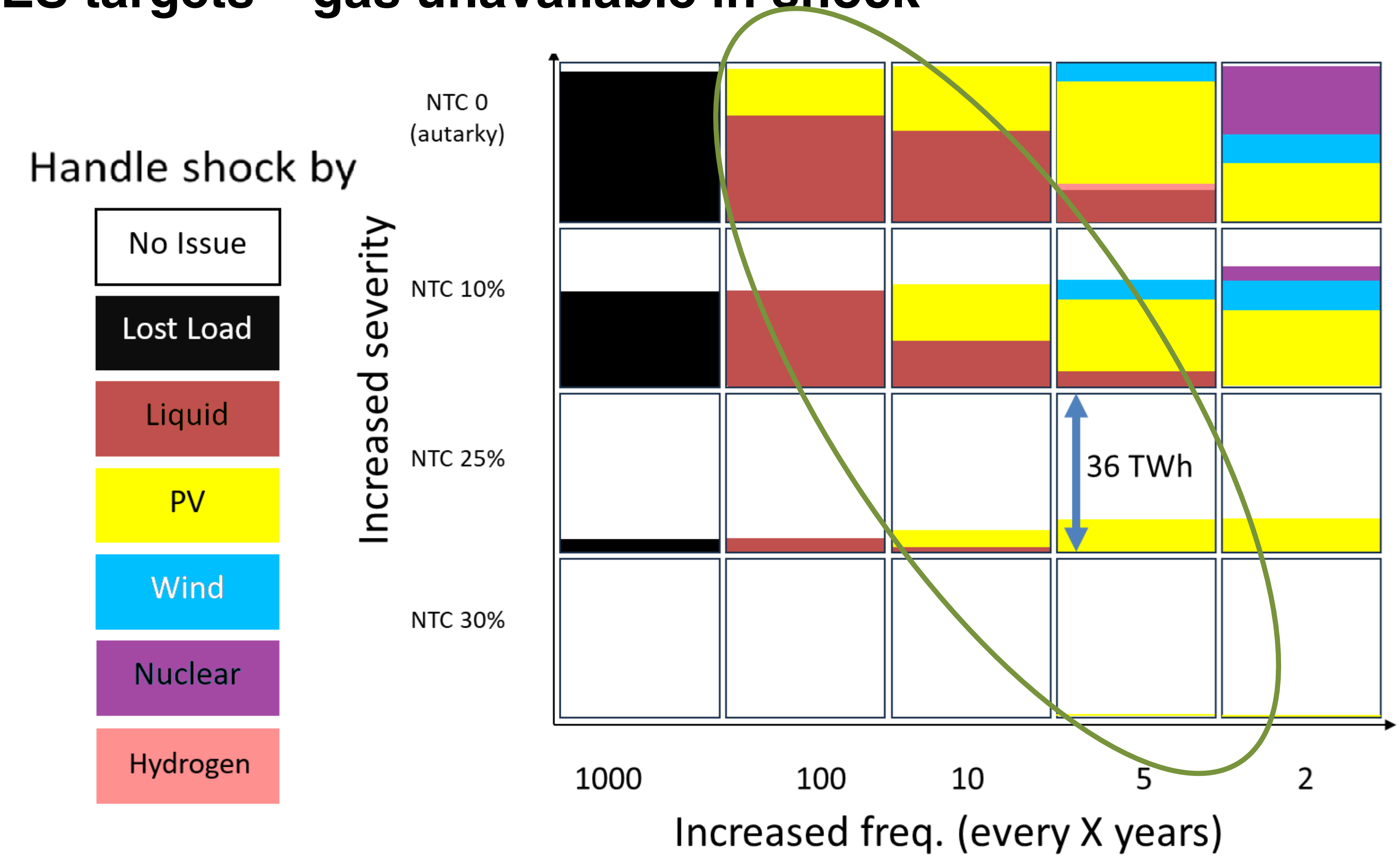
(no shocks, never)



Robust systems results …

- ***Increase*** in annual “generation” values (TWh) for different technologies (+lost load)
    - *Compared* to a reference cases
- Only the shock year
    - Not normal dispatch

No RES targets – gas unavailable in shock



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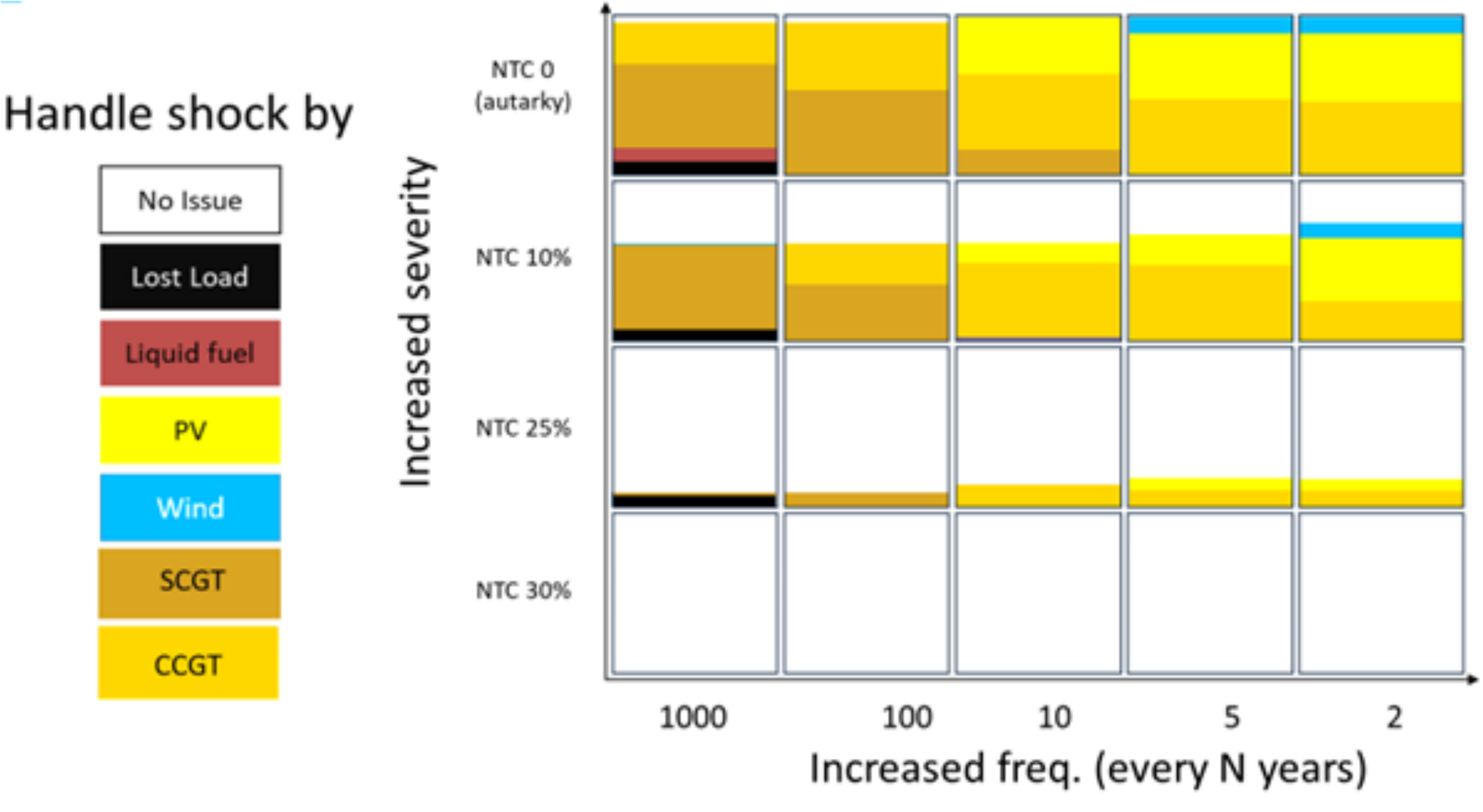

Conclusion

Technology analysis:

- **Liquid Fuel and gas**: Key for rare, extreme shocks due to low CAPEX.
- **Renewables**: Preferred as shock frequency increases.
- **Nuclear**: Only viable in extreme, frequent shocks (electricity and gas autarky).
- **Hydrogen storage**: Minor role, mainly in high-RES, no-gas scenarios.

Conclusion

- **Robust planning:** importance of balancing cost-efficiency with system resilience to ensure robust energy planning, capable of **thriving in normal conditions** whilst **bracing for stressed** conditions.

Future steps

- Gather opinion about the shock:
  - Against what shock are we going to get insurance?
- Consumer energy reduction incentives?
  - Introducing a merit order of lost load
- How to incentivize investment in the target mix?
- Analysis from the perspective of various stakeholders.

Questions? Recommendations?

Ali Darudi
ZHAW
Ali.darudi@zhaw.ch

Jonas Savelsberg
ETH
jonas.savelsberg@esc.ethz.ch

Ingmar Schlecht
ZHAW
Ingmar.Schlecht@zhaw.ch

zh aw

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Stresstests für das Schweizer Stromsystem

Forschende der ETH Zürich und der ZHAW Winterthur simulieren in einer neuen Studie, wie das zukünftige Schweizer Stromsystem aufgestellt sein könnte, um einen drastischen Einbruch der Gas- und Stromimporte zu verkraften. Damit wollen sie einen Beitrag zur Diskussion um die Versorgungssicherheit der Schweiz leisten.

Dienstag, 14. Januar 2025

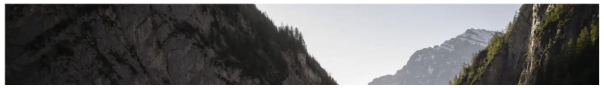
NZZ

Stresstest der ETH: Könnte das Schweizer Stromsystem einen drastischen Einbruch der Importe verkraften?

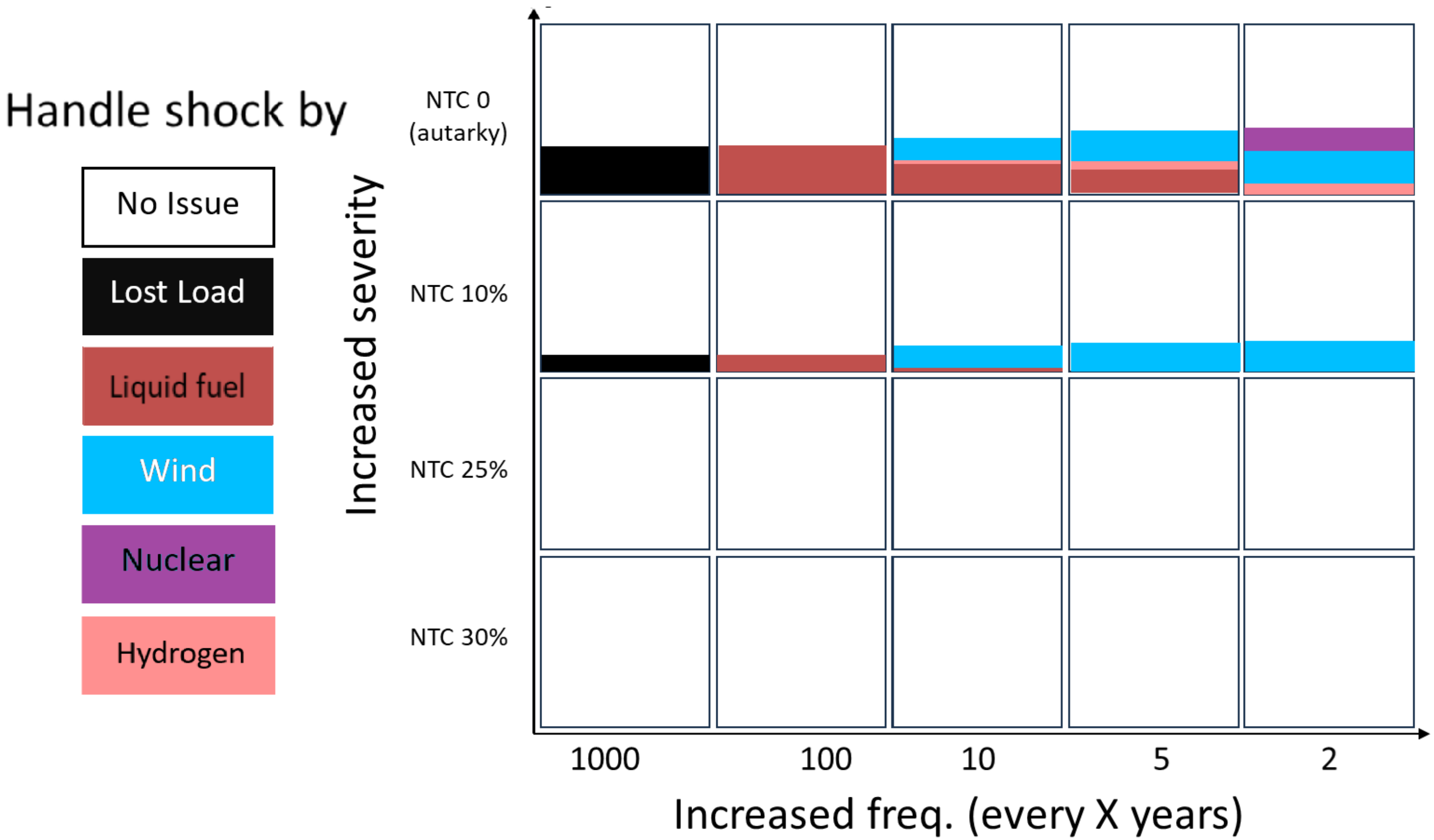
Die Energieversorgung der Schweiz ist dank den Stauseen in den Alpen erstaunlich gut gegen externe Schocks gewappnet.

David Vonplon
15.01.2025, 05.30 Uhr 3 min

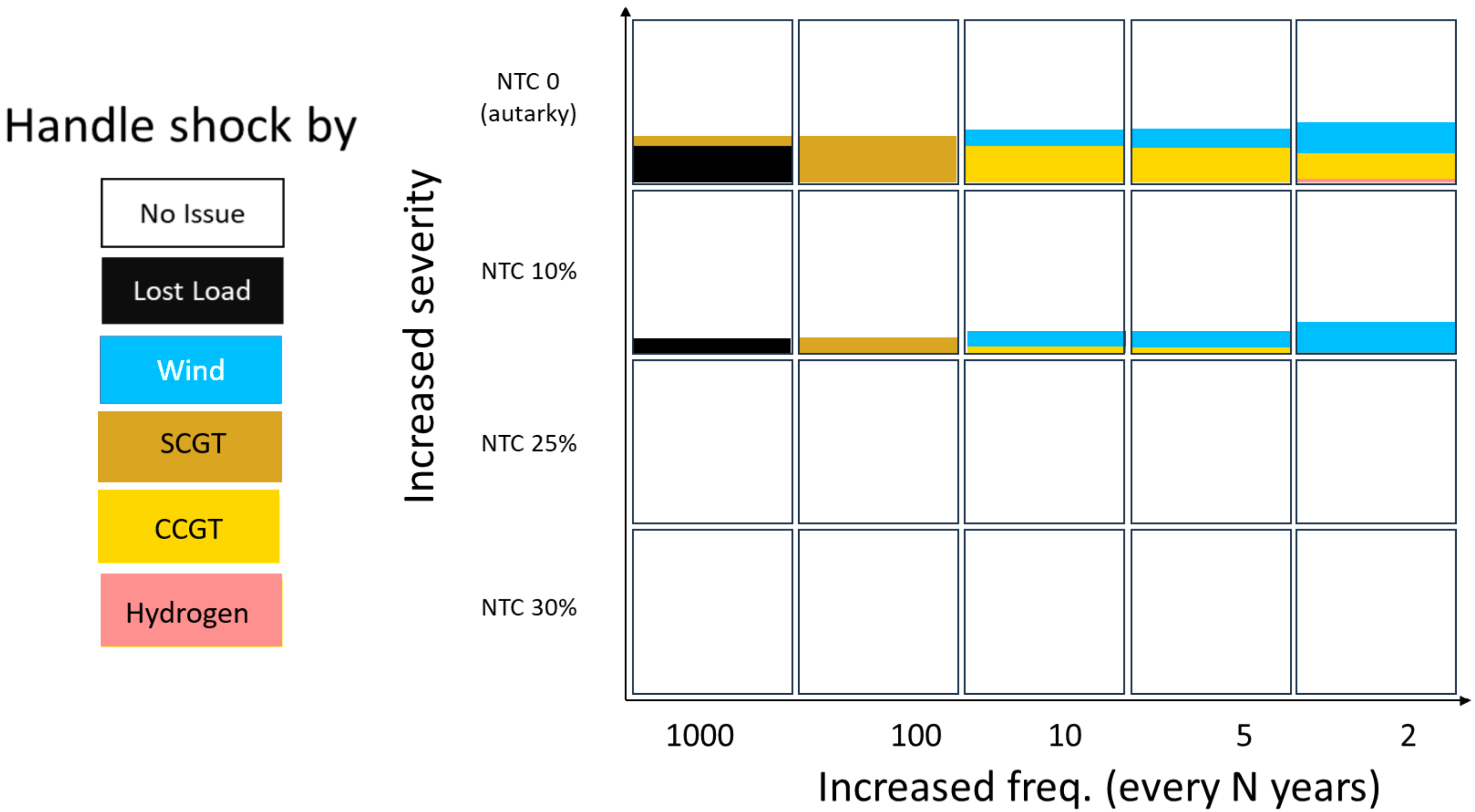
Hören Merken Drucken Teilen



RES targets – gas unavailable in shock



RES targets – gas available in shock



RFEM – Objective function

Investment cost: scenario independent

$$\text{Minimize:} \quad \sum_{p \in P_{\text{allinv}}} \left(\text{investment\_genmax\_slp}_p \times \text{gen\_max}_p + \text{investment\_enmax\_slp}_p \times \text{en\_max}_p \right)$$

$$+ \sum_{\text{scen} \in \text{Scenarios}} \text{weight}_{\text{scen}} \times \Bigg[\sum_{p \in P_{\text{gen}}} \sum_{t \in T} \left(\text{operation\_slp}_{p,\text{scen}} \times \text{gen}_{p,t,\text{scen}} + \text{operation\_qdr}_{p,\text{scen}} \times \text{gen}^2_{p,t,\text{scen}} \right)$$

$$+ \sum_{\sum_{t \in T}} \text{lostload}_{t,\text{scen}} \times \text{lostload\_cost}_c \Bigg]$$

Operation costs: scenario weighted