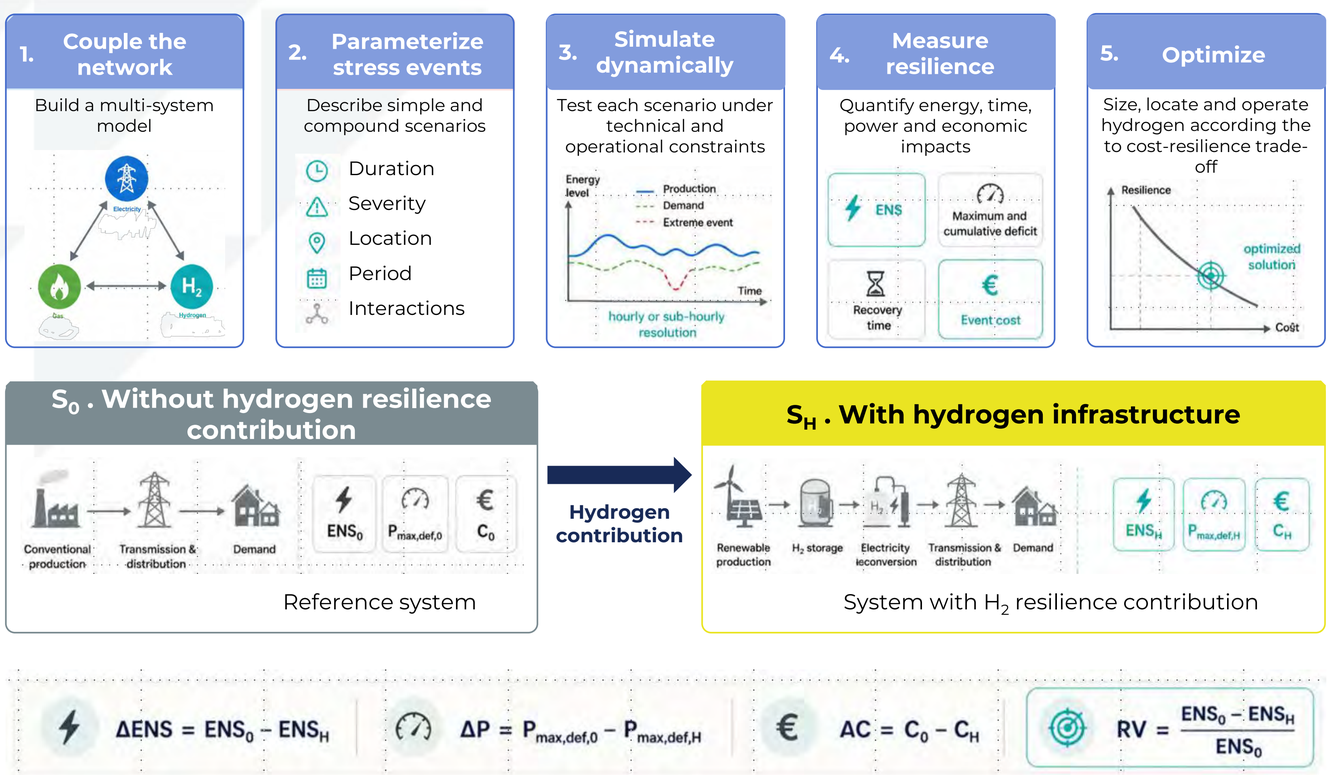
Scenario-Based Assessment and Optimisation of Hydrogen Resilience Value Under Stress Events

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Climate change increases risks to renewable and hydrogen-integrated energy systems through compound extreme events. This research develops a climate-aware model to simulate such scenarios, quantify hydrogen's resilience value, and optimise its operation. The framework combines climate data, hydrogen technologies, resilience indicators, and AI-based control to support resilient energy-system planning.

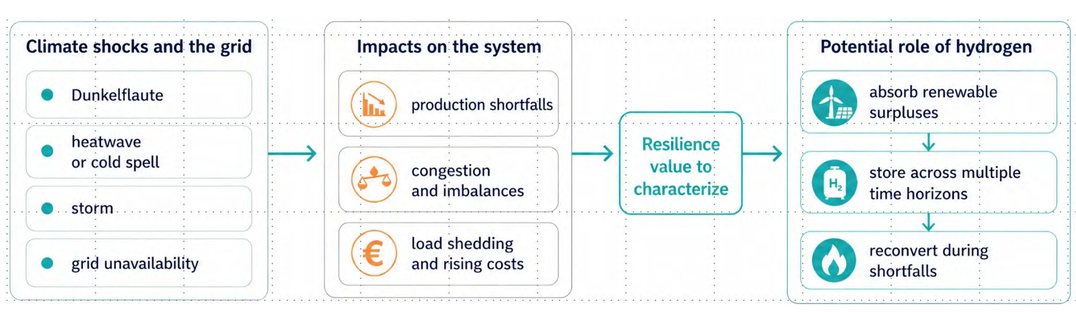


Problem Statement

The increasing penetration of variable renewable energy sources is essential for decarbonizing energy systems but also increases their exposure to weather variability and climate extremes. Such events can lead to supply deficits, supply-demand imbalances, curtailment or load shedding, and increased system costs.

Current resilience assessments often rely on qualitative scenario-based analyses, while systematic methods for quantifying the impact of extreme events accounting for their duration, severity, location, and interactions remain limited. There is therefore a need to better link the characteristics of extreme events to their impacts on energy security, supply continuity, and system costs.

Green hydrogen could provide a valuable source of flexibility and resilience by enabling excess renewable electricity to be stored over extended periods and subsequently used when renewable resources are insufficient. However, its specific value as a resilience resource against extreme events remains insufficiently characterized.



Research objective

Develop a dynamic framework for the integrated electricity–gas–hydrogen energy system to simulate and quantify the impacts of individual and compound extreme climate events, evaluate the contribution and economic value of hydrogen infrastructure to system and consumer resilience and optimize its operation.

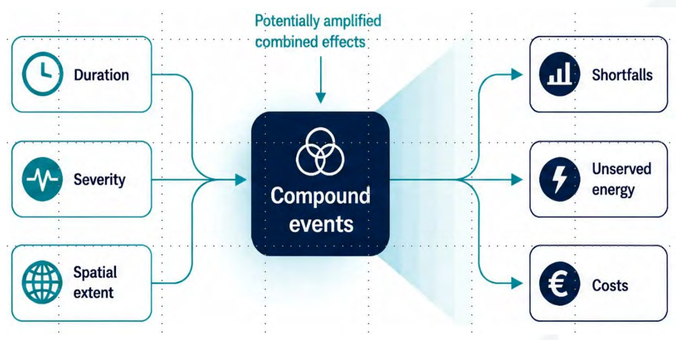
Methods

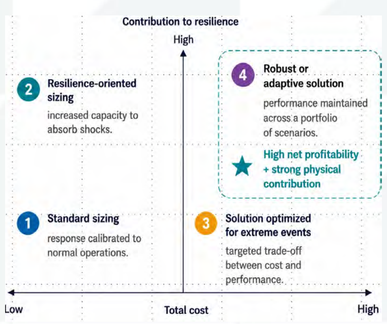
Using several dimensions: duration, severity, location, period, and interactions allows to investigate how changing these dimensions changes the impact on the energy system.

The **resilience value** of hydrogen is defined as the reduction in costs, unserved energy, power deficits, or service interruption duration achieved by adding hydrogen capacity, expressed in monetary terms.

Expected Results

- Reproducible framework linking event attributes to resilience outcomes
- Response surfaces: H_2 value vs. event duration, severity, location
- Storage/reconversion thresholds with diminishing resilience returns
- Robust configurations balancing investment and resilience





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