RESILIENCE MONITORING OF FUTURE SECTOR-COUPLED ENERGY SYSTEMS

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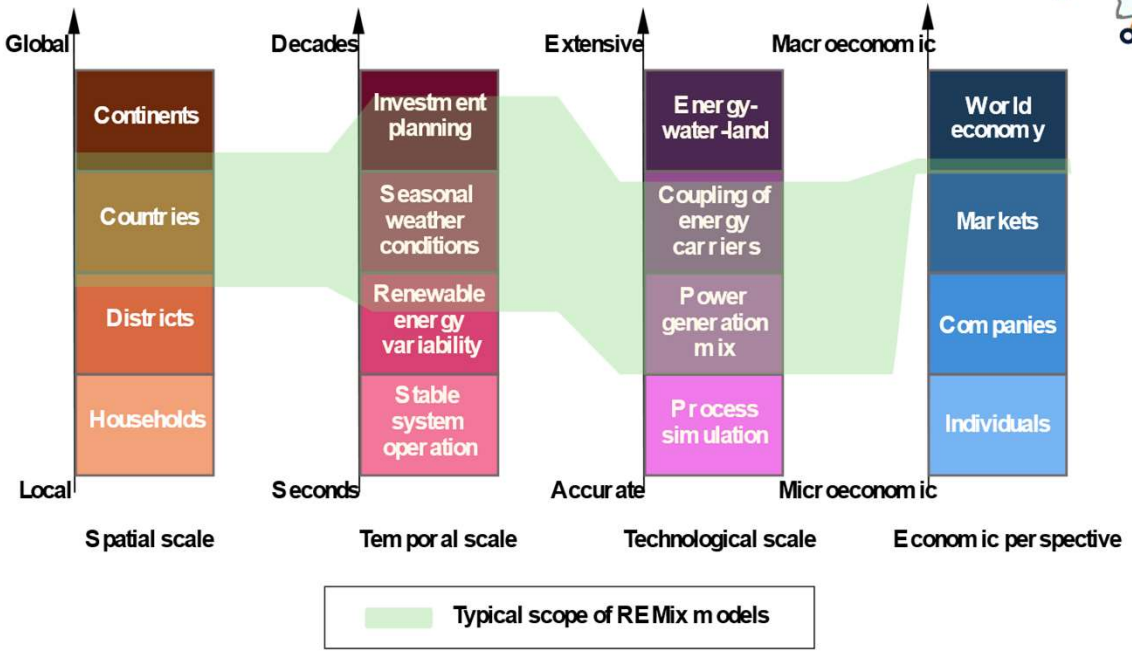
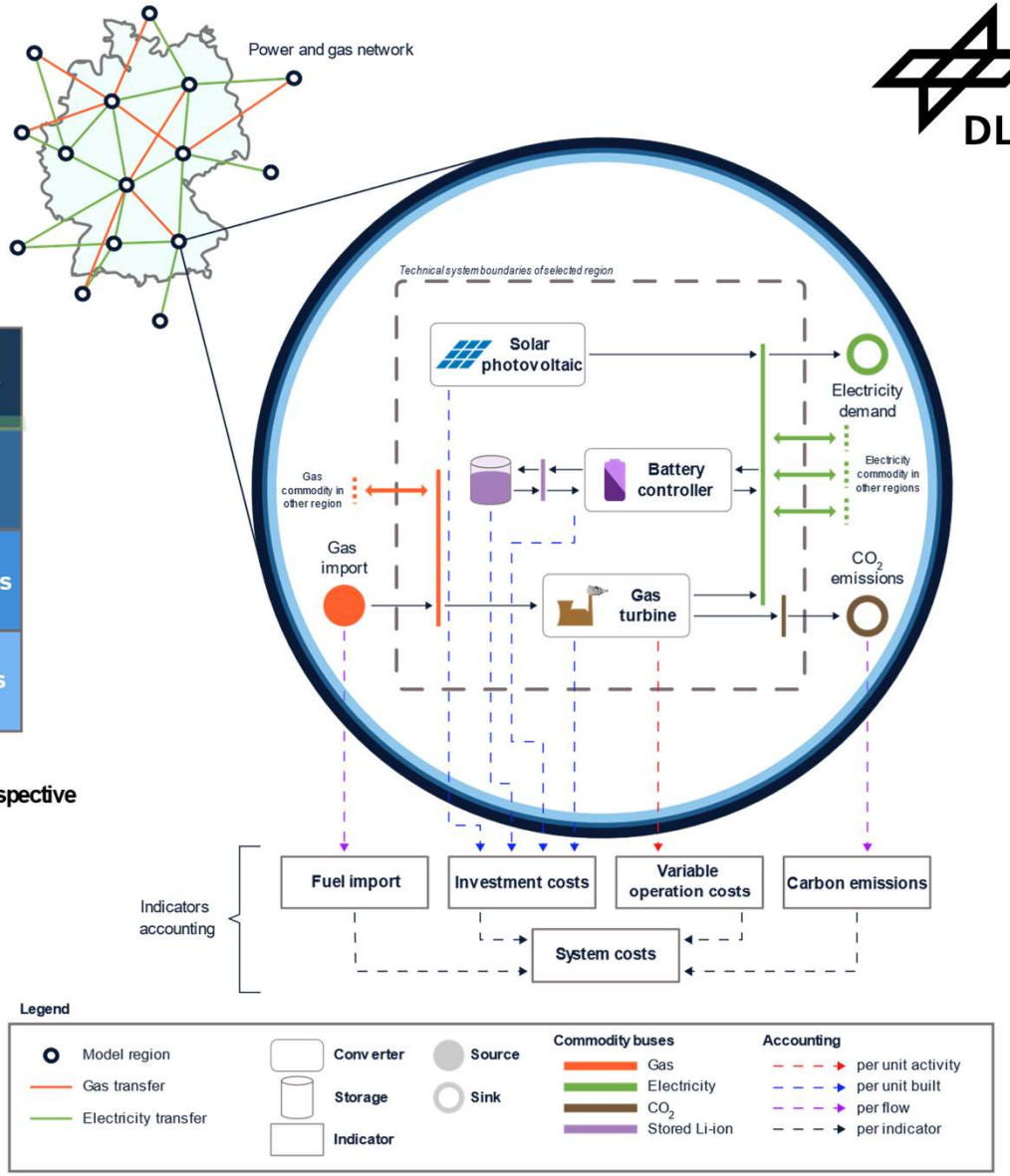
Context: Part 1

Energy system optimisation





Check out the open source REMix framework here :

Code

Documentation

Context: Part 2

Approach for resilience monitoring

Context
Scenarios

Stress Cases

Energy systems optimisation

Comparative metrics / indicators

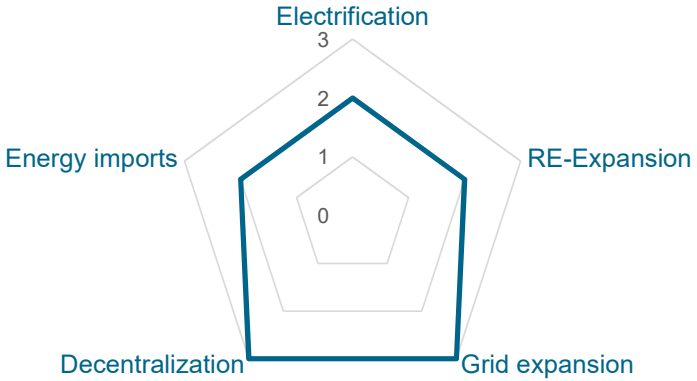
HOW IS IT DONE?

Context Scenarios*

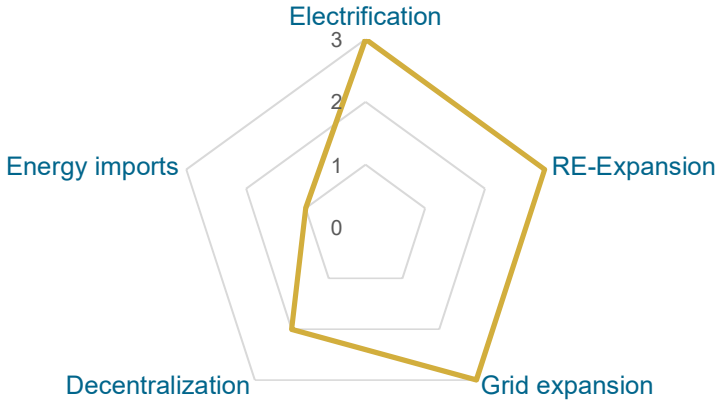
Descriptors

- Electrification
- RE-Expansion
- Grid expansion
- Decentralization
- Energy imports

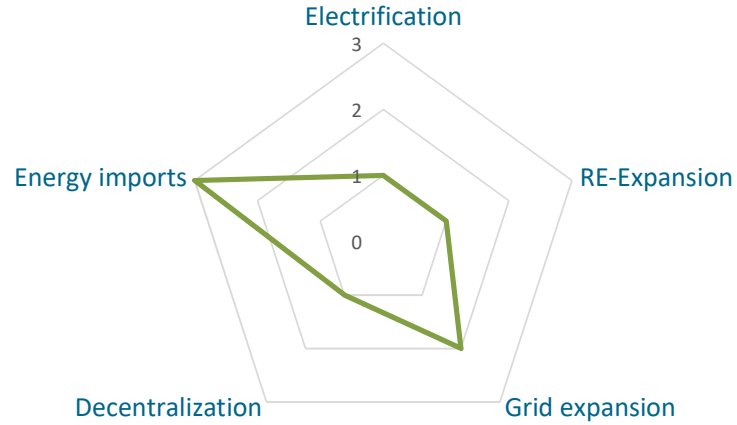
Mix-Decentral



Elec-HighRE

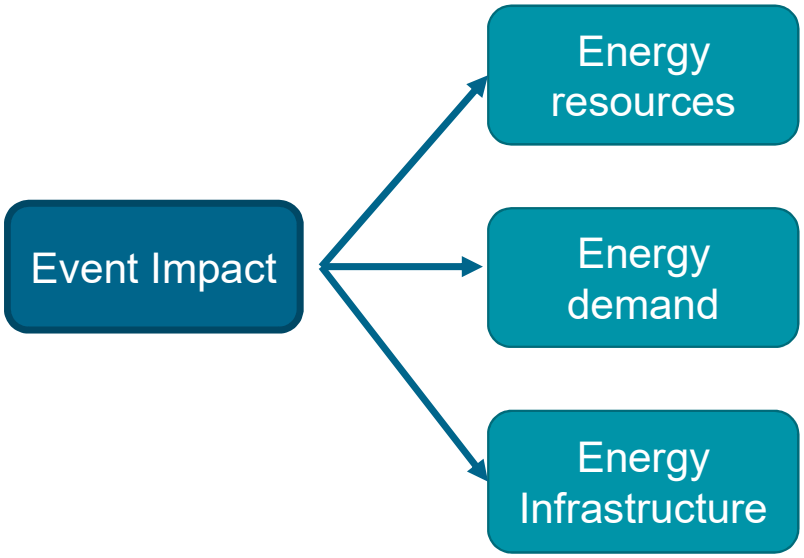


H2-Import



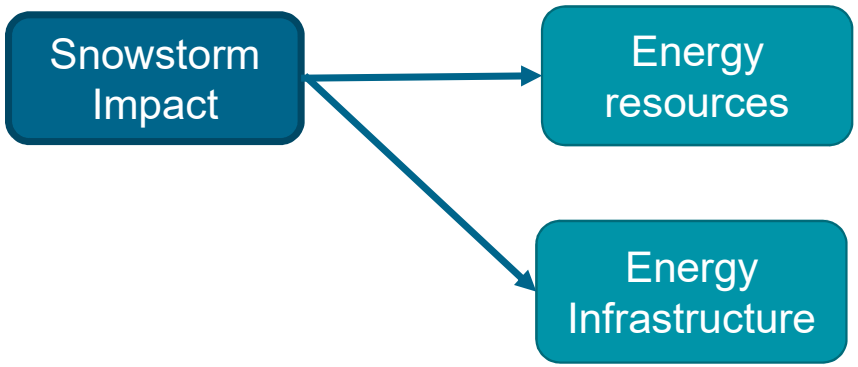
* Formulated by ZIRIUS, applied by us

Stress cases: extreme event impact



- *e.g. low solar and wind profiles*
- *e.g. rise in electricity demand during a heat wave*
- *e.g. disruption of power transmission due to storms*

Stress cases: extreme event impact



- *limited solar resource availability*

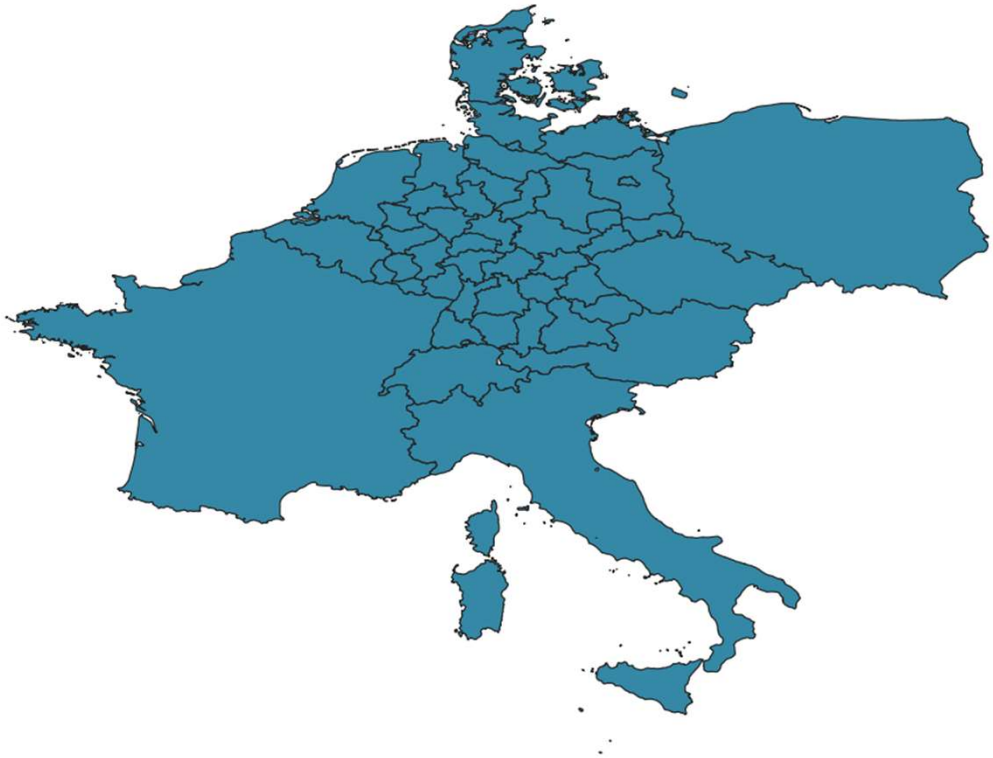
- *Offshore and onshore wind turbines shut down due to extreme wind speed*
- *Offshore wind turbines shut down due to frost*
- *Transmission line outages*

- *limited solar and wind resource availability*

Energy system modelling

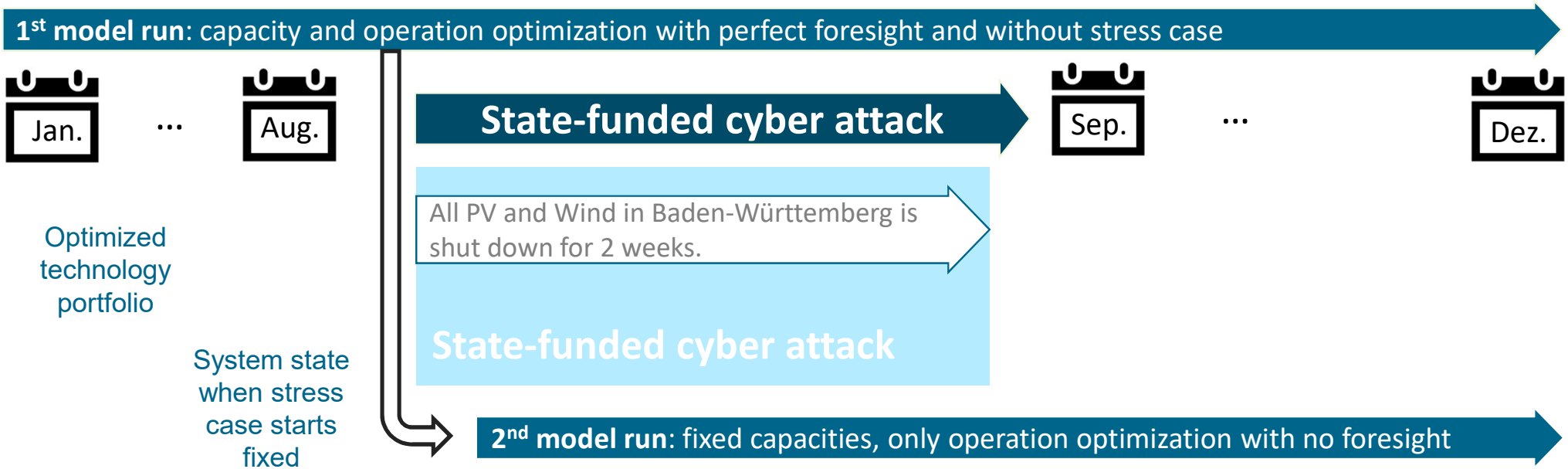
REMix model scope

- **Spatial**: DE (NUTS2), neighbouring countries (NUTS0)
- **Temporal**: 2050
- **Technological:**
  - Electricity and gas networks
  - Electricity + heating + H_2/CH_4
  - + flexible battery vehicles, demand response (Germany)
  - Brown-field optimisation

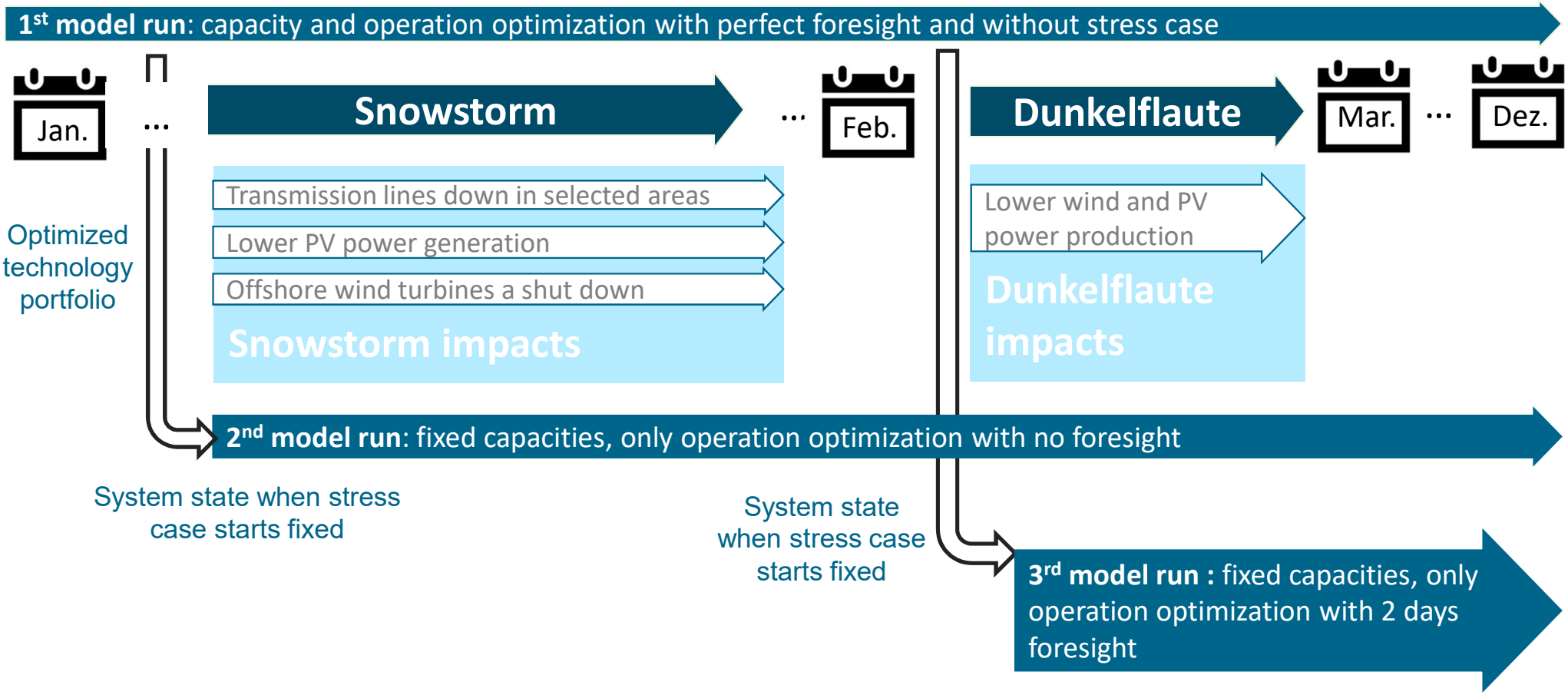


Stress case as exogenous input to REMix - time profiles of outages

Stress case impact and storyline: State-funded cyber attack



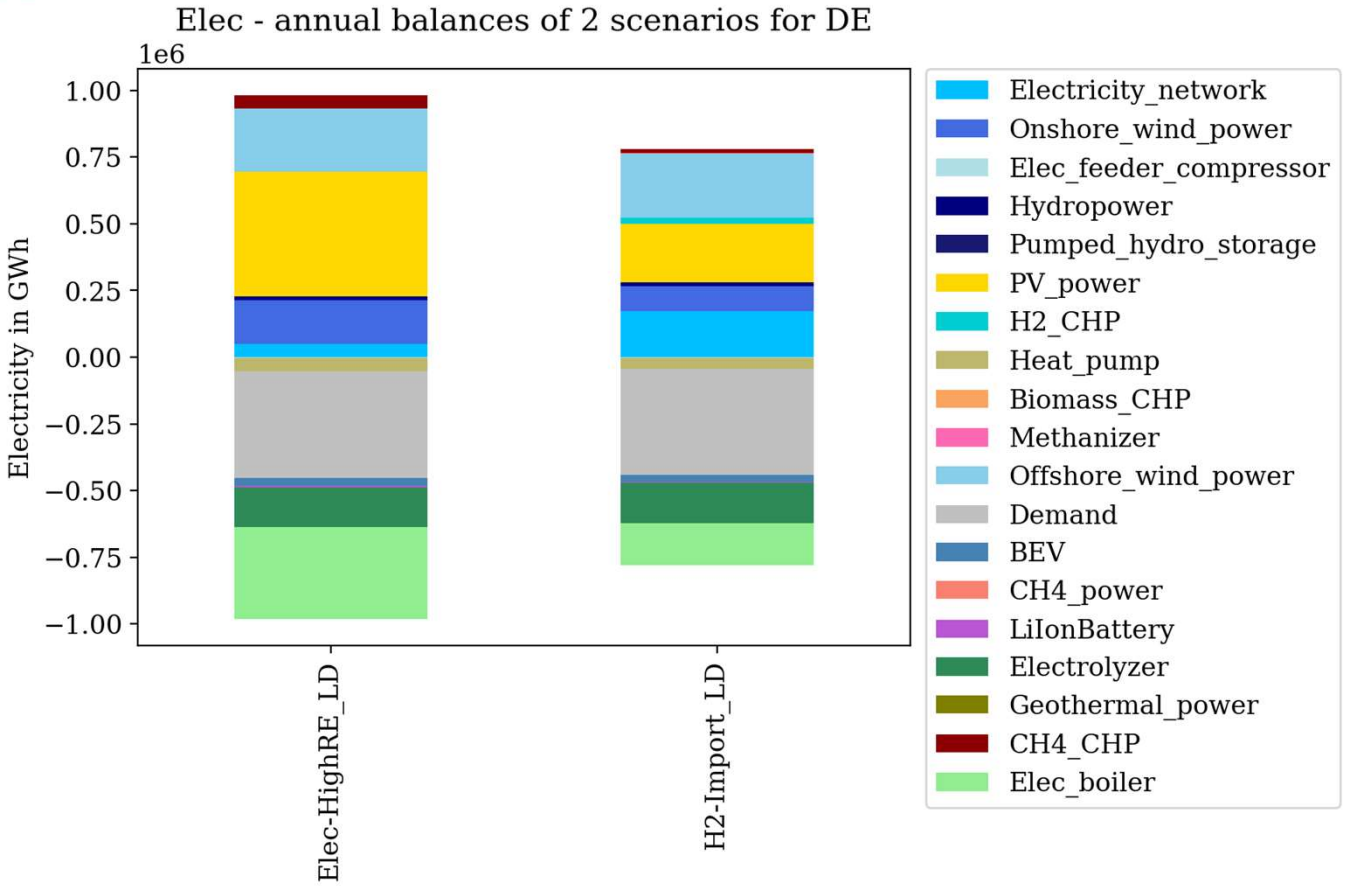
Stress case impact and storyline: Snowstorm and dunkelflaute



RESULTS AND OUTLOOK

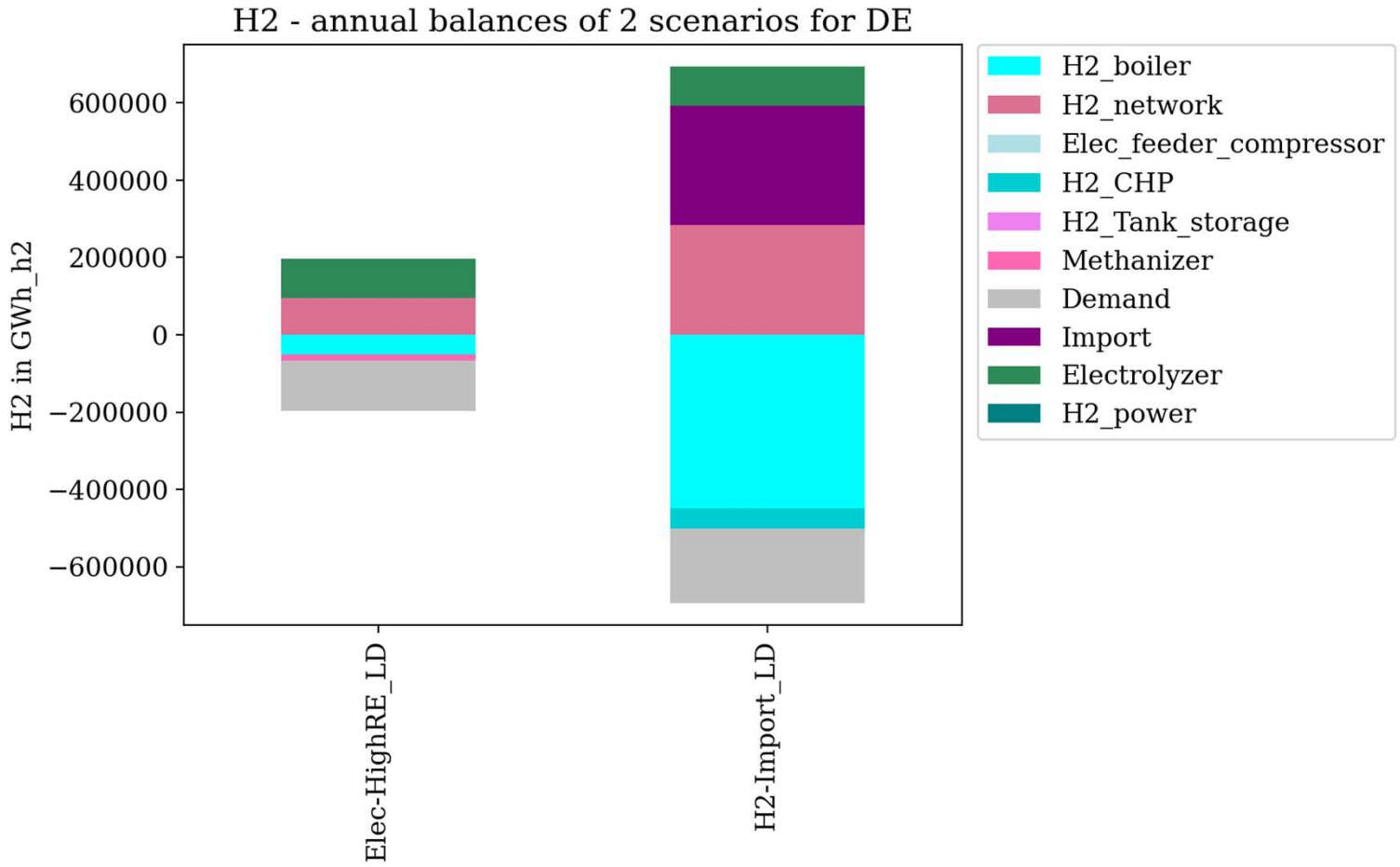
Energy System Design

Germany 2050



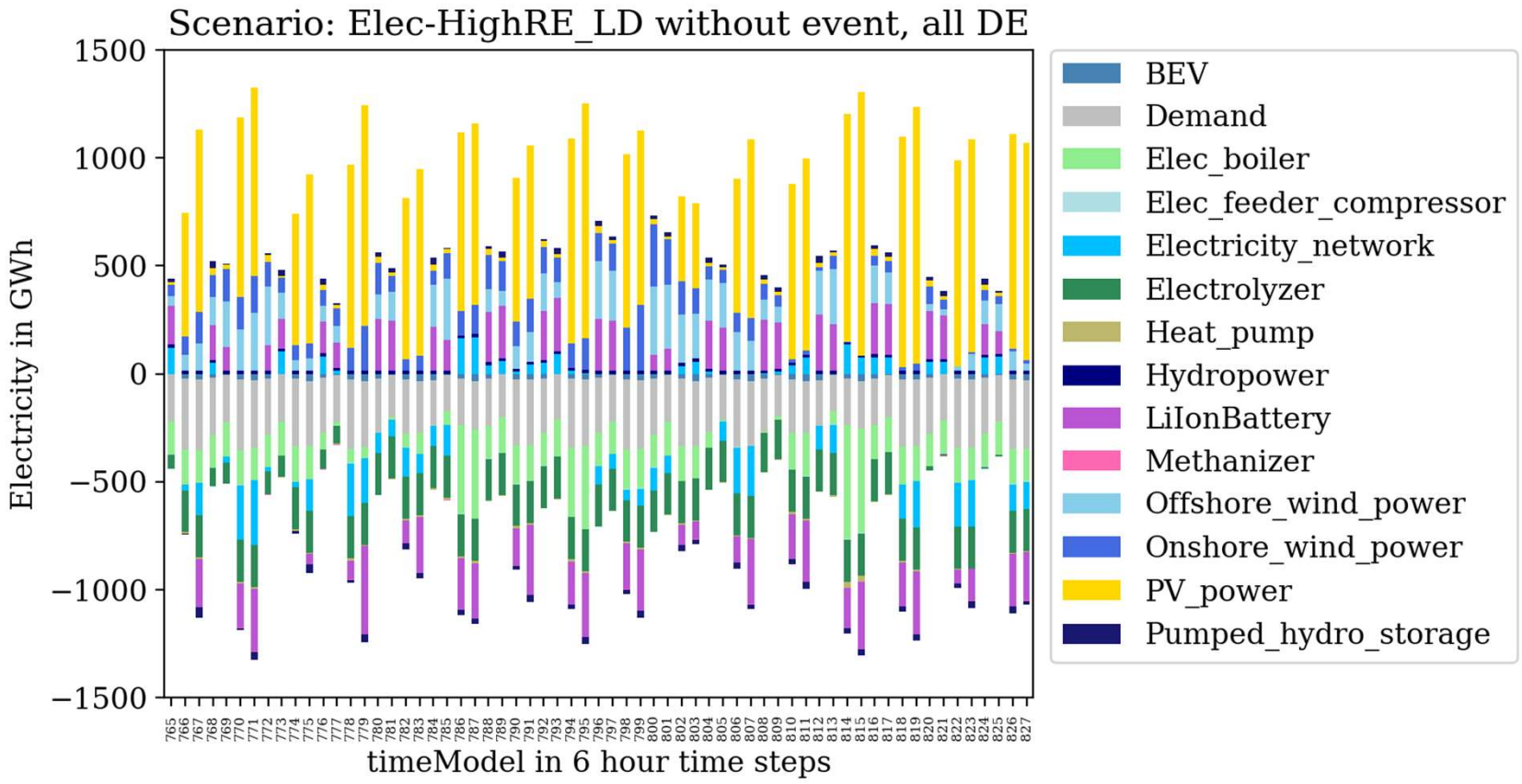
Energy System Design

Germany 2050



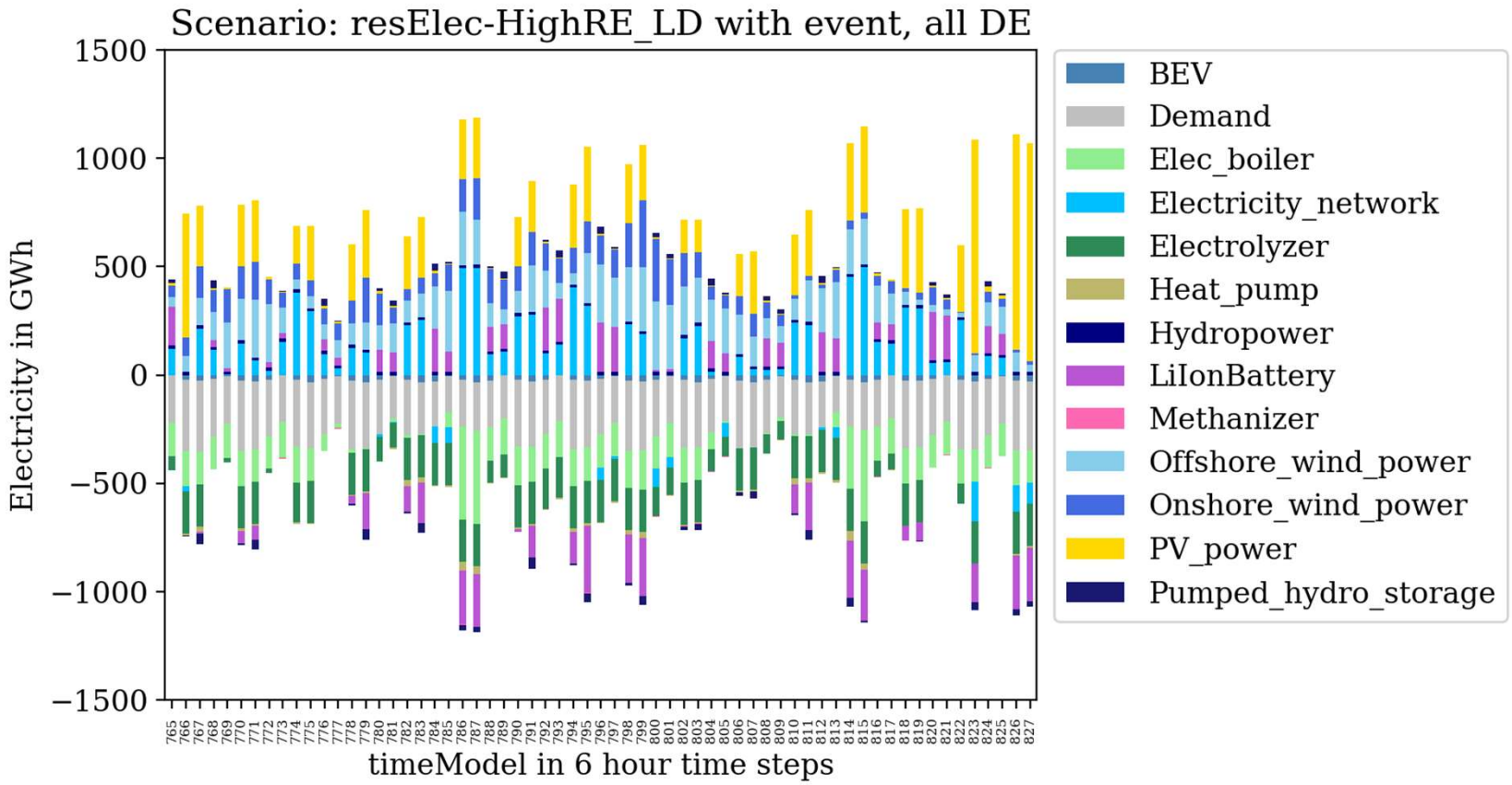
Scenario Elec-HighRE at the time of state-funded cyber attack

11th Aug – 24th Aug



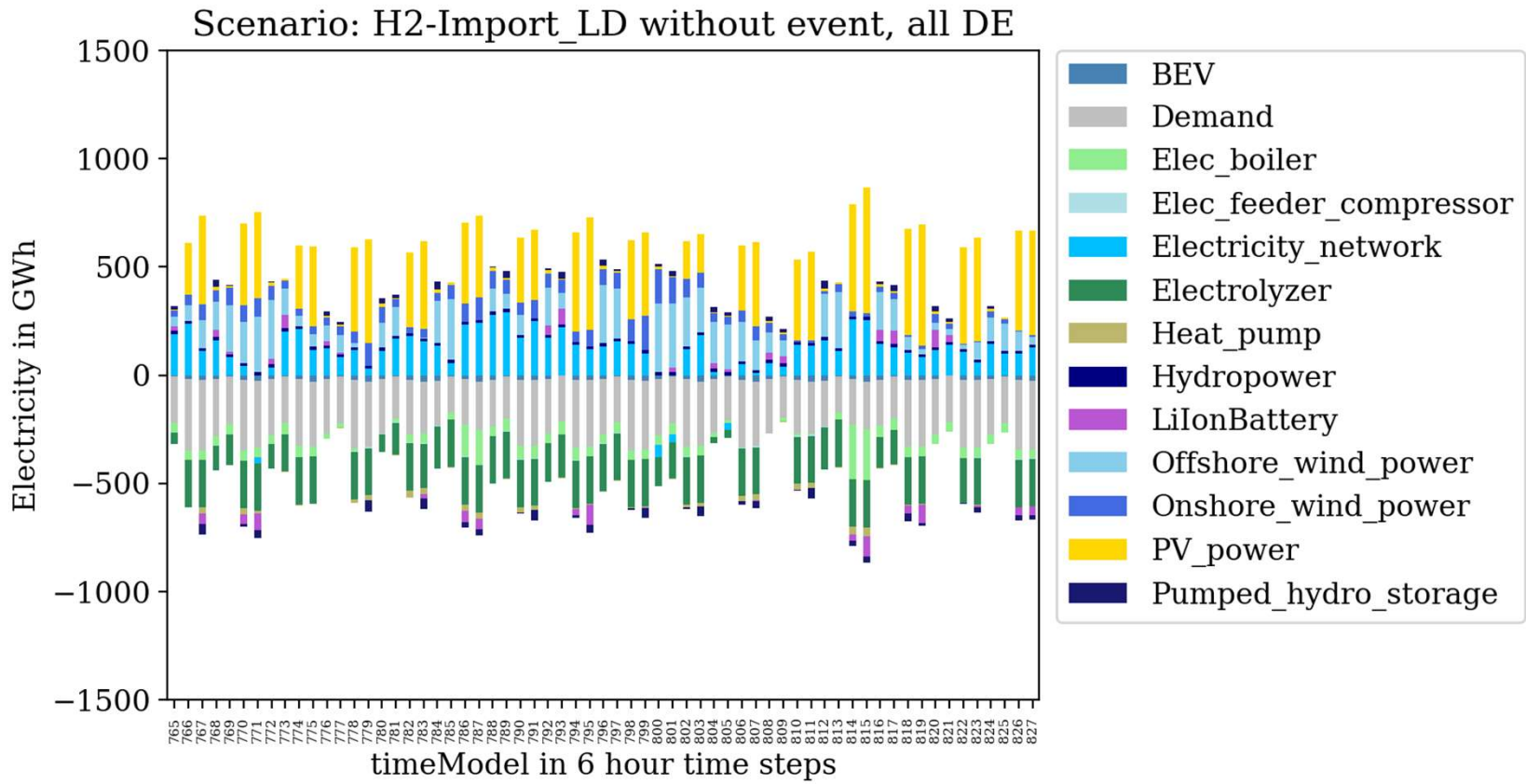
State-funded cyber attack – scenario Elec-HighRE

11th Aug – 24th Aug
- event impacting ~253 GW of PV capacity in DE



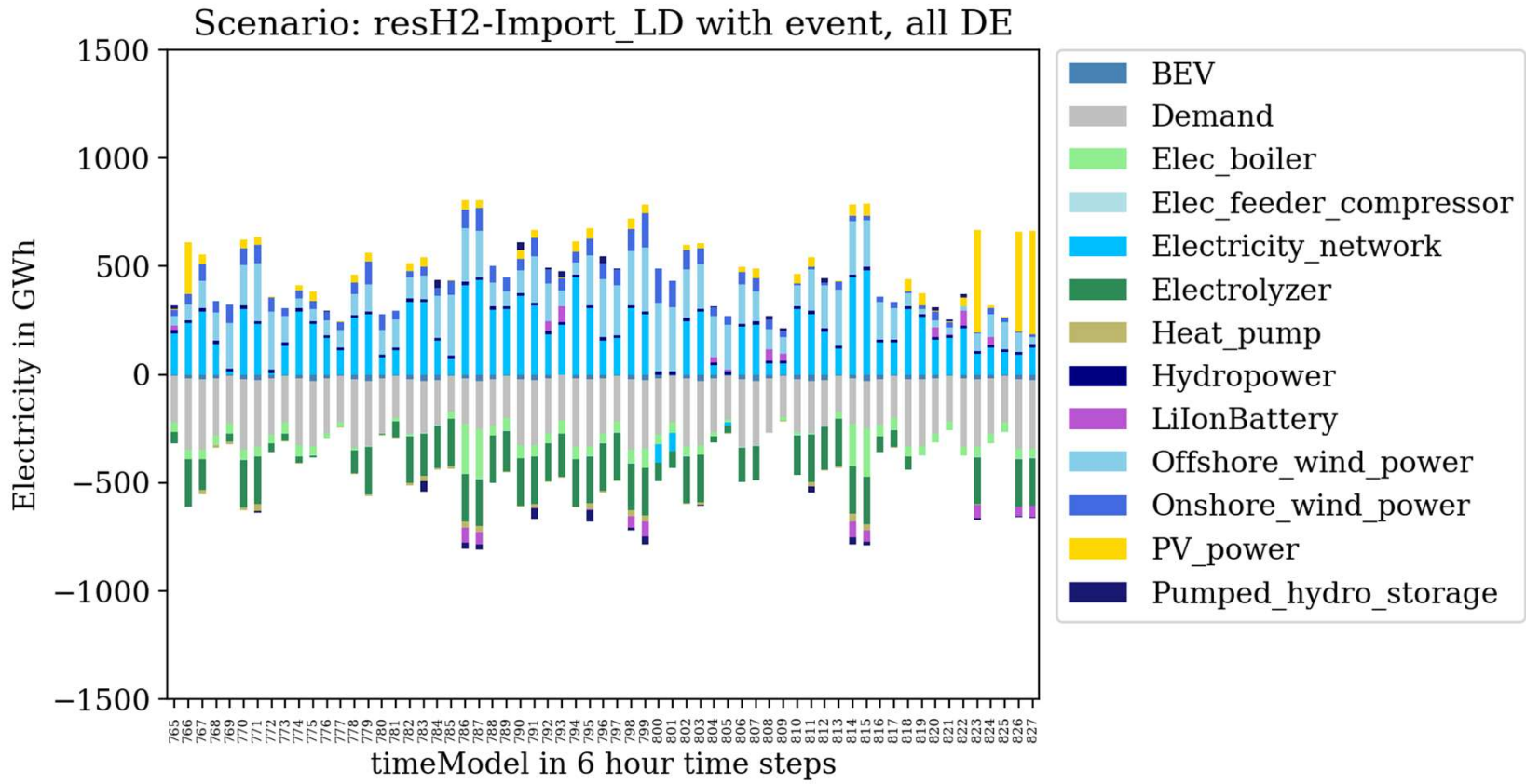
Scenario H_2-Import at the time of state-funded cyber attack

11th Aug – 24th Aug



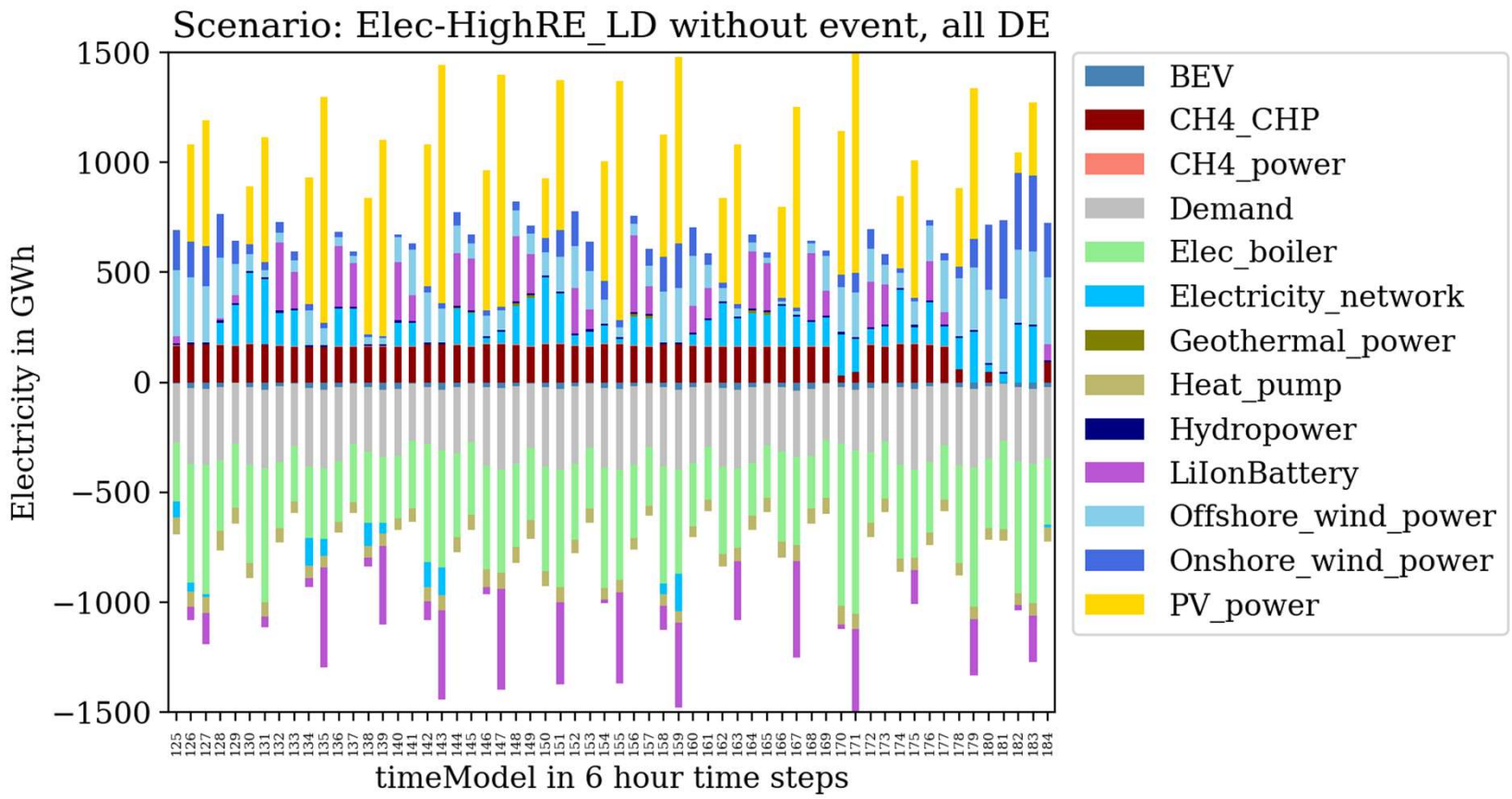
State-funded cyber attack – scenario H_2-Import

11th Aug – 24th Aug
- event impacting ~159 GW of PV capacity in DE



Scenario Elec-HighRE at the time of dunkelflaute

01st Feb– 15th Feb



Dunkelflaute – scenario Elec-HighRE

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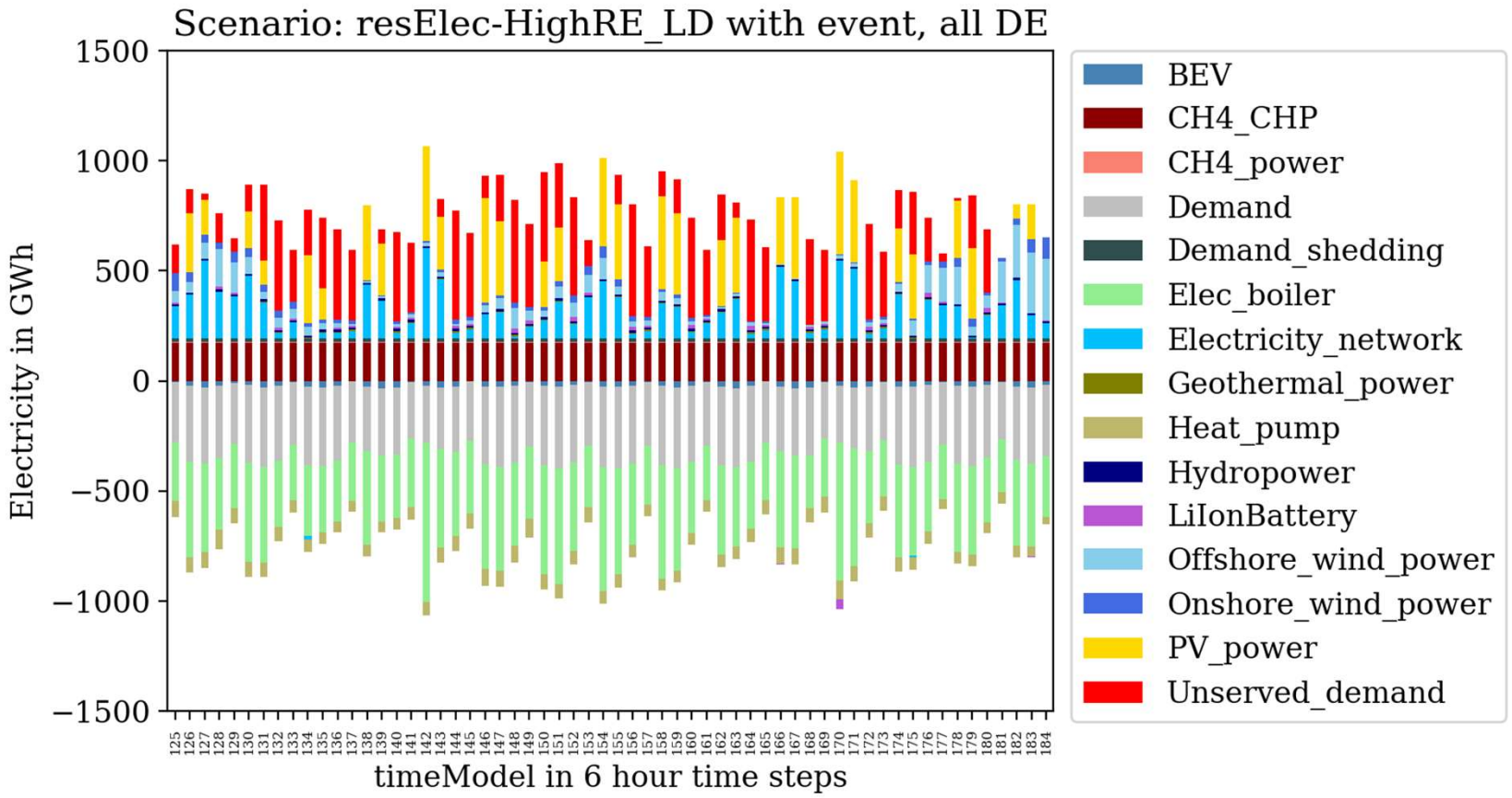

Scenario H_2-Import at the time of dunkelflaute

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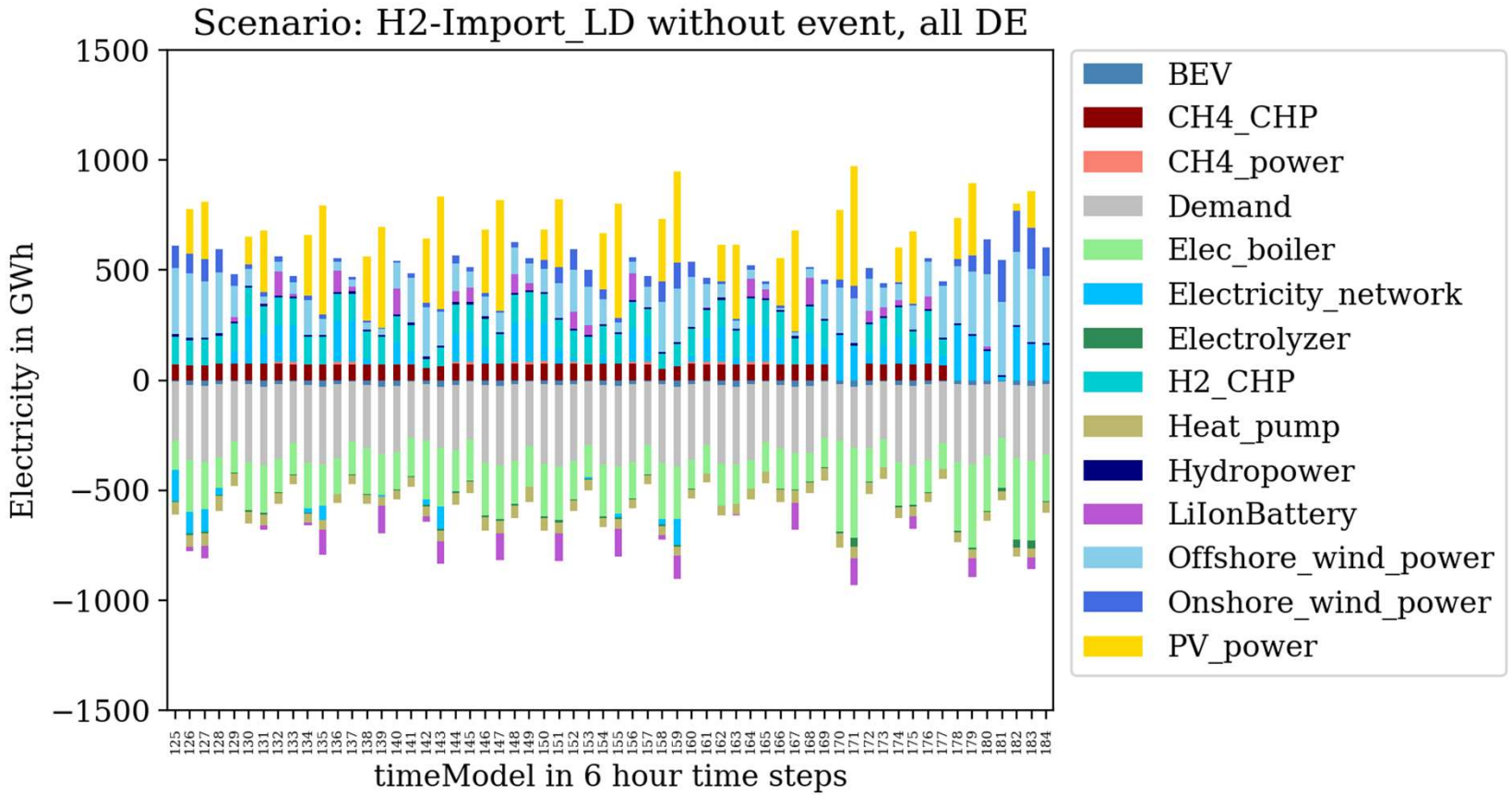

Dunkelflaute – scenario H_2-Import

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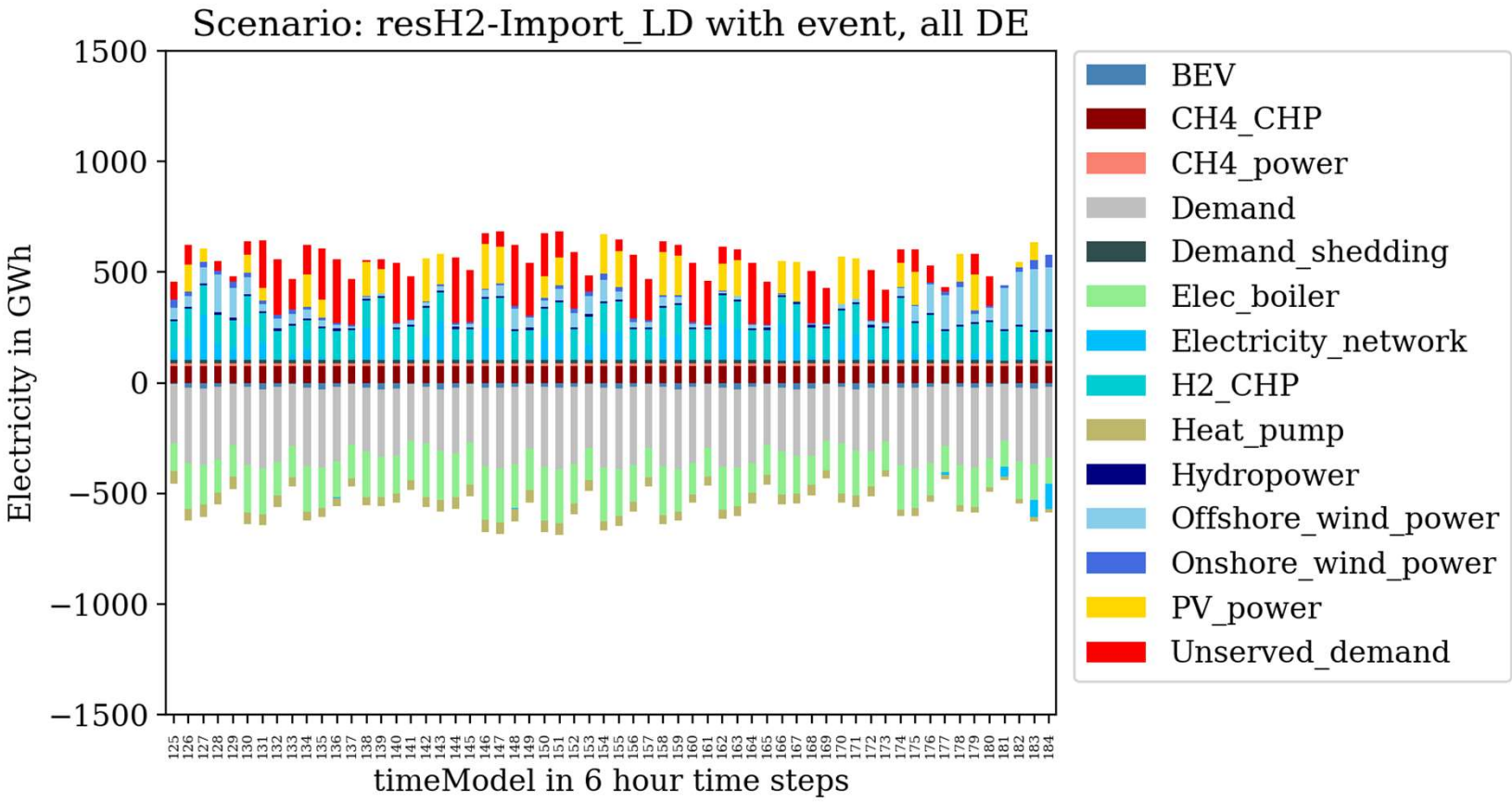

What can we deduce from our tests so far?

- Widespread weather events risk supply security drastically
- Loss of power generation capacity is more severe than loss of transfer capacity
- Extreme weather events have higher impact in scenarios with higher electrification
- Decentralised options fail to offer security in the case of large and long-lasting extreme events like a dunkelflaute
- Fallback options to revive security:
  - More back-up power generators (gas turbines, nuclear power, hydropower, ..)
  - Demand-shedding/hybridisation in industry sector (including electric boilers)
  - Wider network infrastructure (e.g. across the EU)

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