CASE STUDY 7

Indirect impacts

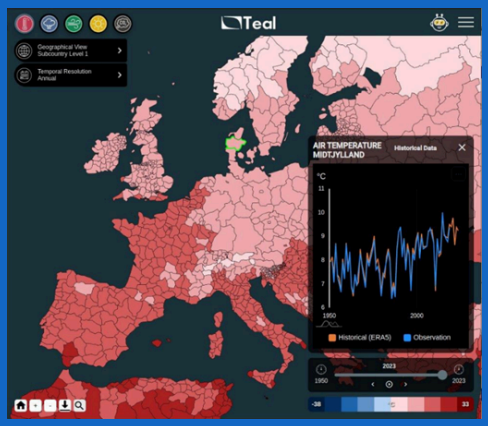
CrossEU

Europe

Context

Across Europe's tightly linked power networks, intensifying climate extremes, from heatwaves and prolonged droughts to periods of sparse wind, are putting unprecedented strain on both electricity supply and demand. Events such as the July–August 2022 heatwave and the late-2021 wind drought serve as benchmarks, anchoring our analysis in ERA5 reanalysis and bias-corrected CMIP6 projections. By tracing these phenomena at national and sub-national (NUTS) levels throughout the EU, we chart how often, and in which regions, compound supply-demand stresses may recur under a range of SSP scenarios, thereby assembling a comprehensive climate-forcing dataset for further modelling.

Feeding this enriched dataset into the plan4res framework unlocks three complementary views of future power-system performance. First, we appraise seasonal reservoir management; next, we simulate day-to-day operations via unit-commitment; and finally, we explore long-term capacity expansion. These analyses expose regional vulnerabilities and risk profiles: how often and how long supply shortfalls may occur, the likelihood and severity of non-served energy events, the volatility and spike-risk in marginal power and ancillary-service costs, and the potential for cross-border import dependencies under stress.



Example from the current public Teal Tool version that will be tailored to fit the needs of EDF acting as end-user

Climate Change Hotspots (CCH)

Hotspot: Europe (France)

- For this case study the focus is on France in the context of the European electricity system with a focus on how climate change will influence the role of renewable energy in the electricity systems. This focus is chosen, e.g., because in a broader European context France already has an energy production with a significant contribution of renewable energy, and experiences from France then provides valuable results for other member states to achieve ambitious decarbonization goals. While France is the main focus, energy indicators have been calculated throughout all the European domain and aggregated at different NUTS levels.

Objectives

- To analyse the trend in and quantify the impacts of concurrent heatwaves, droughts and wind droughts on electricity production and demand.
- To (partly) estimate (part of) the cost of necessary operational adjustments and investments in mitigation and adaptation strategies for a renewable-dominated system under different climatic and socioeconomic scenarios.
- To analyse the dispersion of the marginal costs of electricity, and the risks of non-served energy events linked to the meteorological scenarios.

Methods

We start by characterizing climatological events in ERA5 to set day-and-hour thresholds, then bias-correct several high-resolution CMIP6 models across SSP1-2.6 through SSP5-8.5 and downscale each to hourly 0.25°×0.25° grids to produce renewable generation and demand profiles following the C3S Energy methodology. Those series drive plan4res in three steps: first computing Bellman values for seasonal hydro management, next running hourly unit-commitment simulations, and finally optimizing long-term capacity expansion; so that by comparing reference and extreme-event runs we can quantify regional non-served energy risks, shifts in operating and investment costs, marginal-price volatility, and cross-border reliance.

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