The role of hydropower in renewable-rich energy systems under climate change

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Introduction and motivation

Larger share of power supply from variable renewable sources and electrification of end uses

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Critical role of hydropower to decarbonize the energy system and enhance its flexibility

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Potential impacts of climate change on hydropower generation and management

Workflow to generate time series of weather- and climate-dependent energy variables

Input data (~ 3 TB)

Meteorological variables
- Wind speed
- Solar radiation
- Temperature
- Runoff

Datasets
- ERA5 (1940-2022)
- EURO-CORDEX (2010-2100)

Other geospatial data
- Population density
- Terrain roughness
- Terrain elevation
- Protected areas
- Land use

Conversion and aggregation

Regridding of projected climate data

Conversion of meteorological variables to power supply and demand
- Atlite
- Established literature

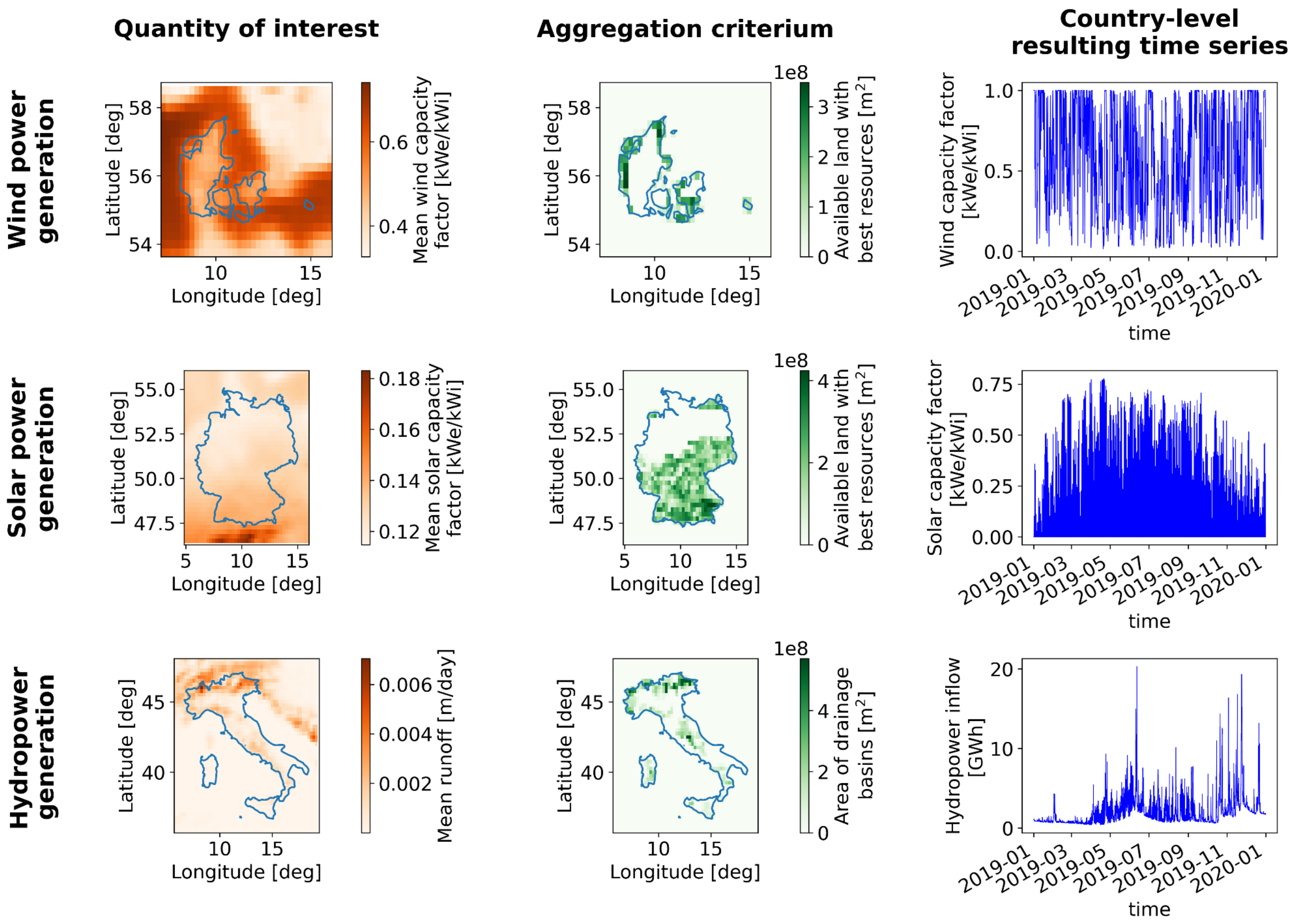
Aggregation
- Grid cells with top 25% resources
- Drainage basins
- Population density

Calibration with publicly available data
- ENTSO-E
- Eurostat

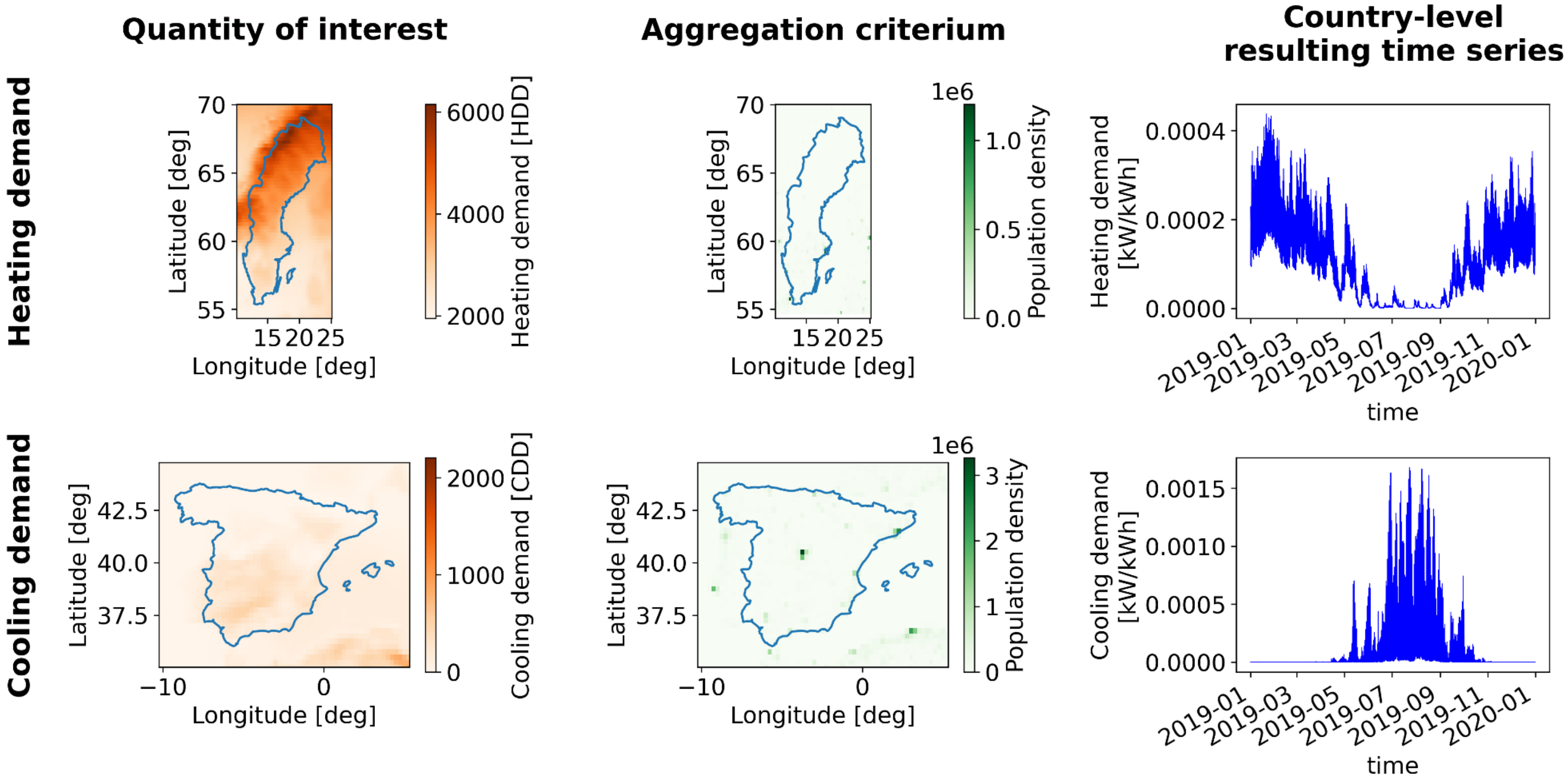
Output data (~ 25 GB)

Country-level time series
- Offshore wind capacity factor
- Onshore wind capacity factor
- Solar photovoltaics capacity factor
- Hydropower inflow
- Heating demand
- Cooling demand

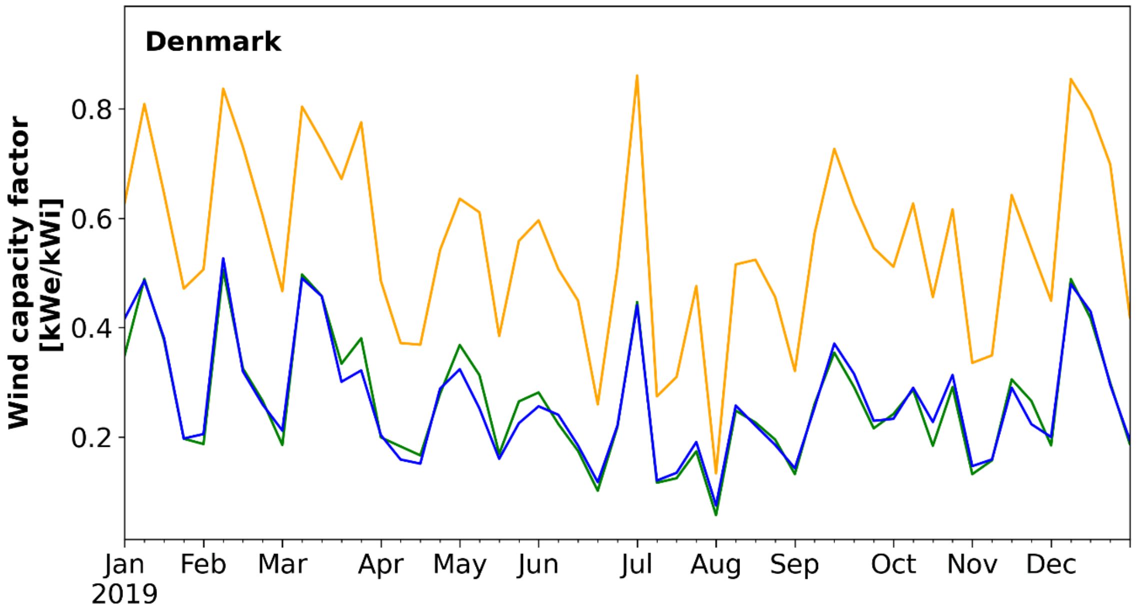
Conversion and aggregation of meteorological variables – Supply

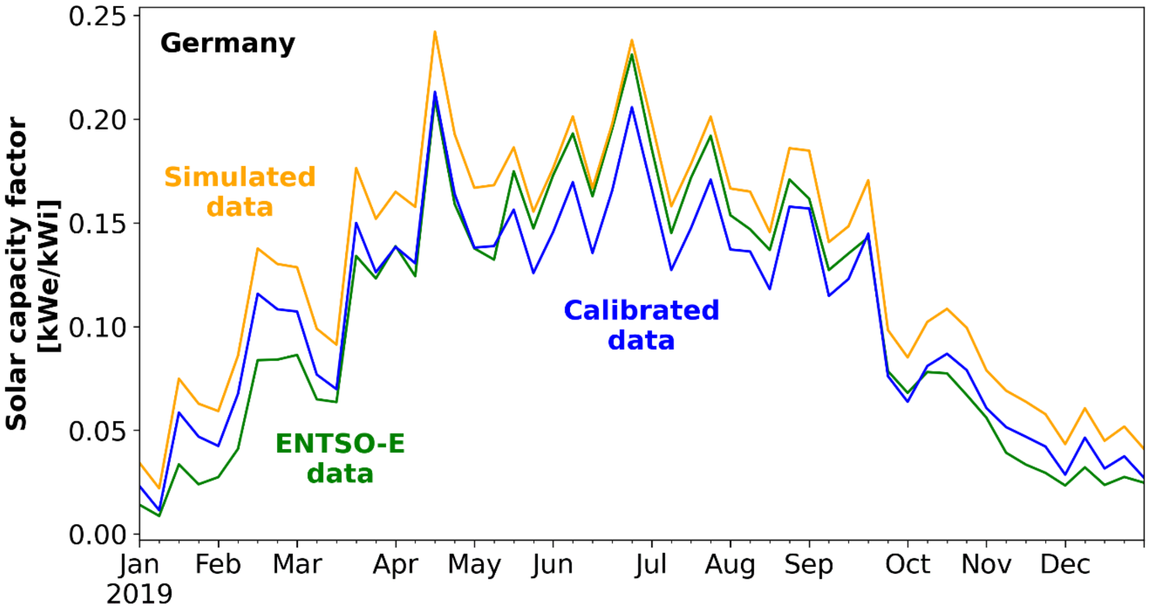


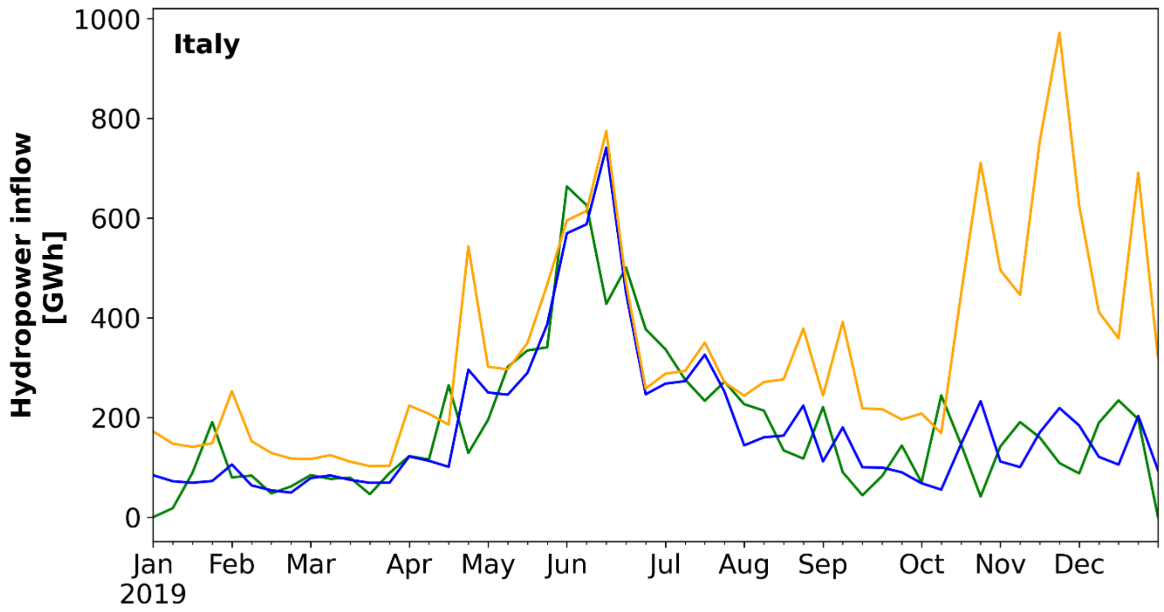
Conversion and aggregation of meteorological variables – Demand



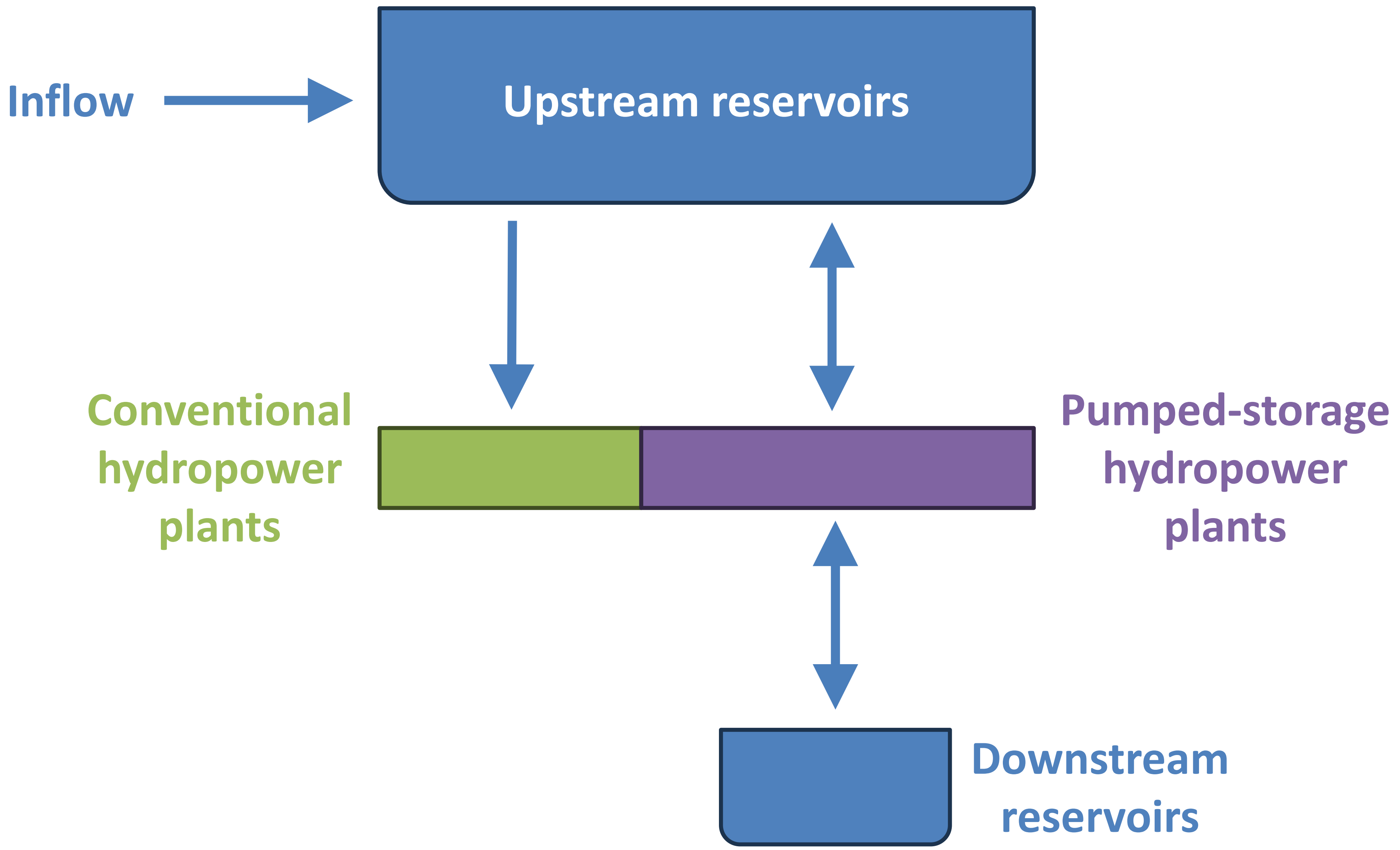
Calibration of the time series of energy variables



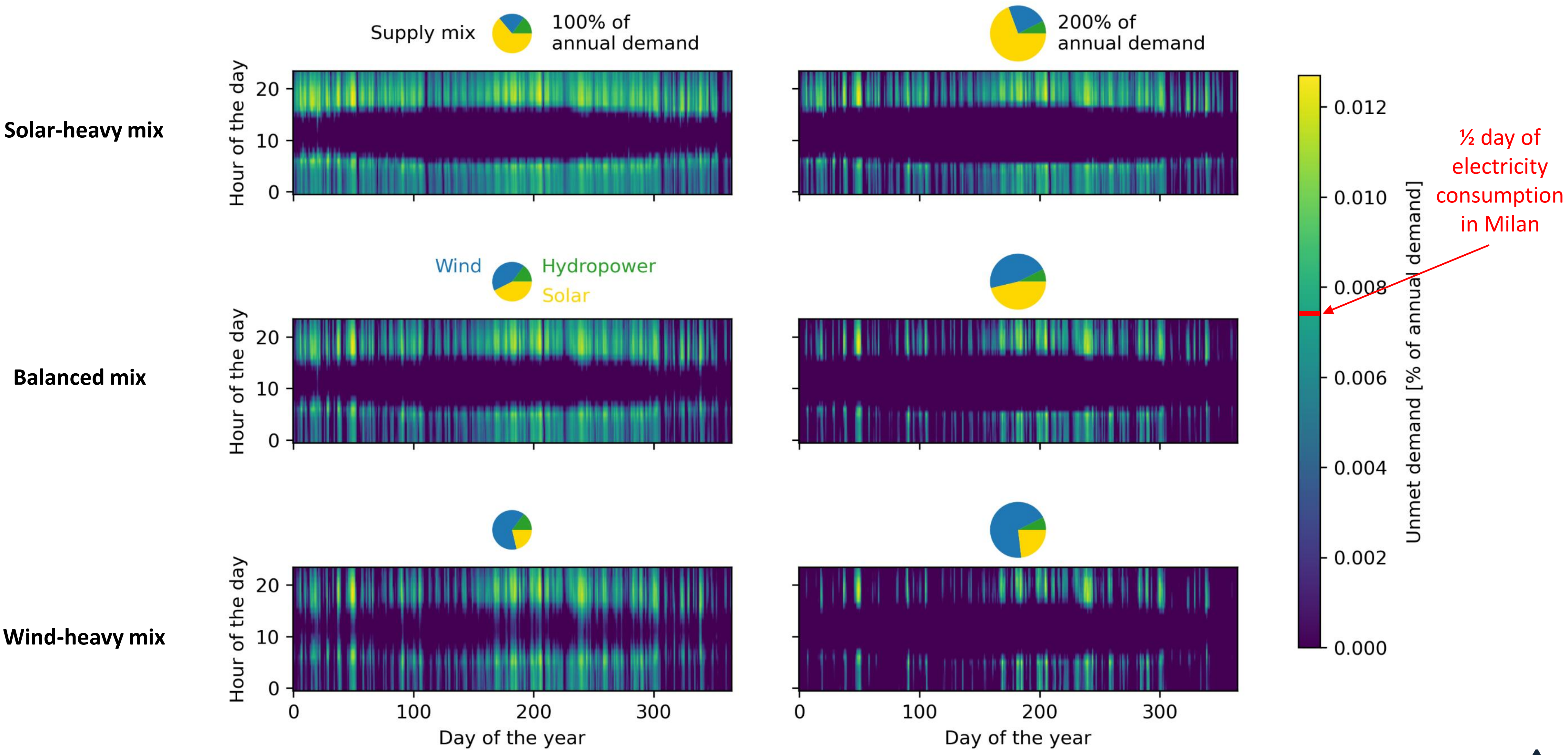




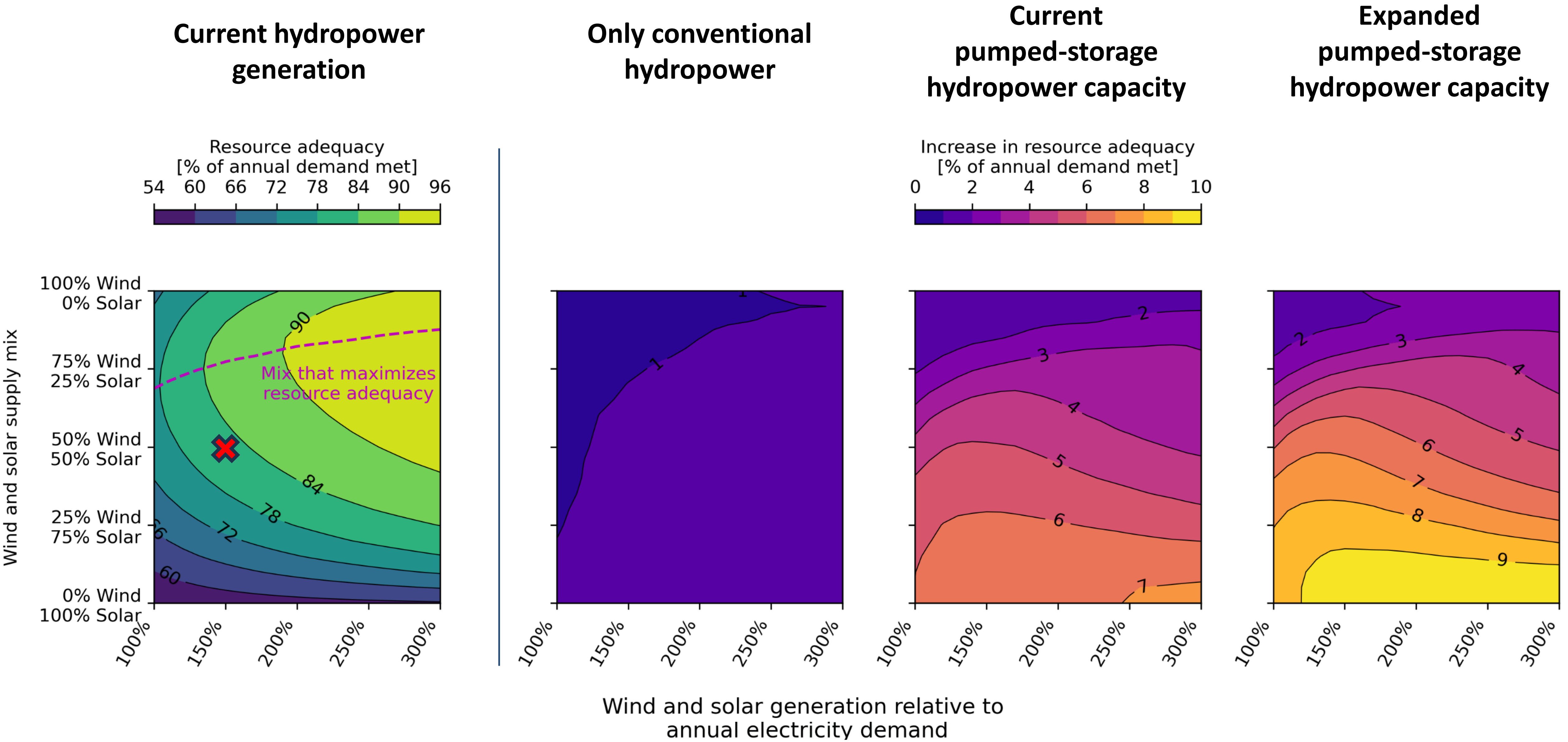
Hydropower generation



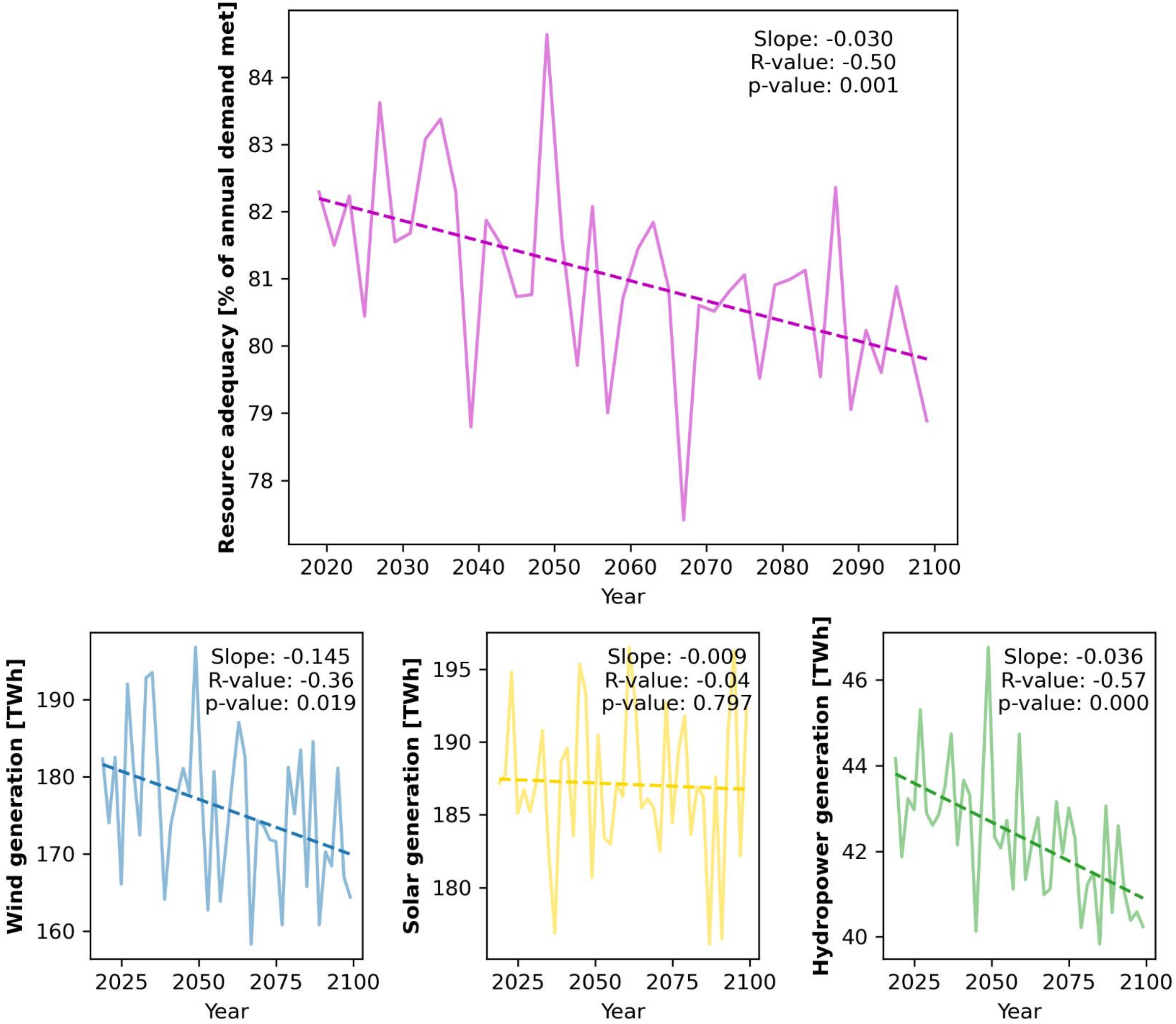
Unmet demand in 6 different cases of supply mix



Resource adequacy with different hydropower scenarios



Resource adequacy with a changing climate



Main takeaways

Wind-heavy supply mixes exhibit better resource adequacy

Changes in hydropower management and expansion of pumped-storage capacity can improve resource adequacy

Climate change and weather variability will substantially impact resource adequacy

Future work

Extend the analysis to other countries and climate projections

Include changes in power demand and evaluate impacts of climate and socio-economic factors

Evaluate the feasibility of changes in hydropower management for better adaptation

Thanks

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GRINS

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