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Title: Assessment of generation adequacy of the European power system during natural gas shortages

Motivation and research question

The Russian invasion of Ukraine and reductions in gas supply affect the security of supply of the European power system. Consequently, the need for flexibilities and dispatchable power plants to ensure generation adequacy increases [4].

Generation adequacy refers to sufficient installed generation capacity to supply the demand and various approaches, both deterministic and probabilistic ones, have been in use so far for its assessment [2]. However, the uncertainty of the availability of dispatchable power plants on generation adequacy has not been investigated thoroughly. In this paper, we analyze generation adequacy in central western Europe during winter 2022/2023 and 2023/2024 using a multivariate probabilistic approach simulating notably the availability of dispatchable power plants.

Methodical approach

The general approach for generation adequacy assessment combines a stochastic characterization and subsequent Monte-Carlo simulation of uncertainties in the power system:

A. Infeed from renewable energy sources:
   - A.1. Onshore and offshore wind turbines
   - A.2. Photovoltaic plants
   - A.3. Run-of-river power plants

B. Temperature-dependent demand

C. Available capacity of thermal power plants

D. Storage operation under consideration of limited energy content

According to Figure 1, the approach can be divided into five steps: (I) A vector autoregressive model is used to simulate renewable infeeds (A) and demand (B) considering regional and temporal dependencies such as fundamental effects determined in a prior quantile regression based on historical data. (II) On the basis of empirical data of [3], a non-homogenous semi-Markov model simulates availabilities of thermal power plants (C) considering planned and forced unit-wise non-availabilities and reflecting seasonal effects on non-availabilities. Further, we consider restrictions regarding availabilities (C) due to heat obligations making using of a simplified heat dispatch model [4]. (III) Storage operation (D) is determined in a least-squares Monte-Carlo model using the simulations of (I) and (II) [5]. In (IV), cross-regional exchanges of critical simulations are optimized according to net transfer capacities. In (V), we use the (possibly negative) remaining capacity per time step to calculate the expected energy not served (EENS) and loss of load expectation (LOLE). These are then used as key indicators for generation adequacy.

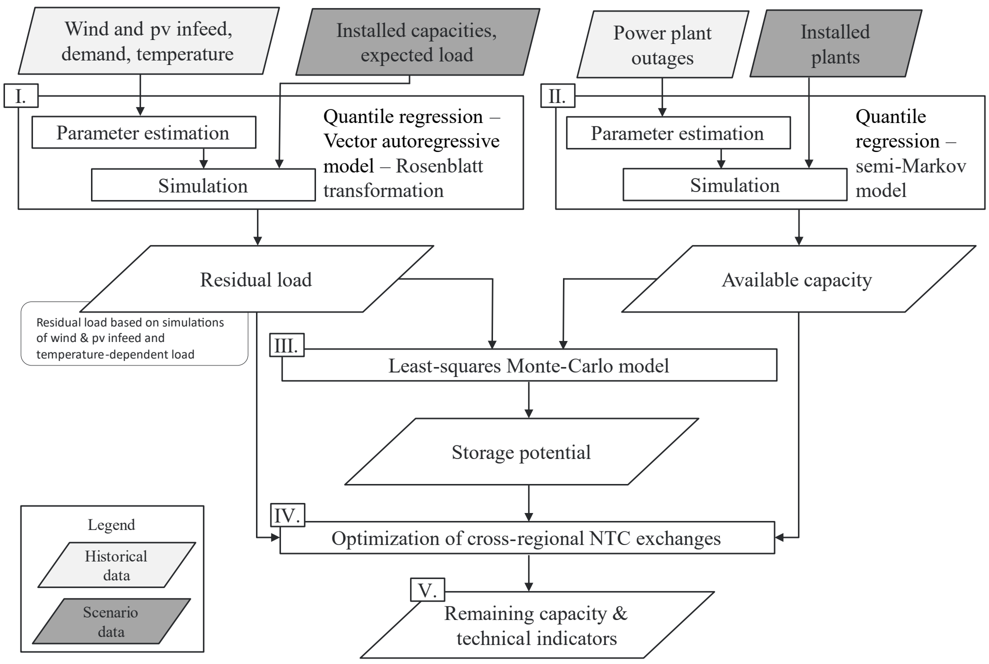

Figure 1: General Approach

Results and conclusion

Preliminary results of a case study on Germany and neighboring countries plus United Kingdom show that the generation adequacy situation during winter 2022/2023 is critical but manageable. Short and forced outages of dispatchable power plants result in unmet demand which is quantified in expected energy not served (EENS). Based on the use of a preliminary deterministic model of storage operation, we find that storages contribute to reduce the EENS and thus improve the level of generation adequacy. Cross-regional exchanges further significantly cut the EENS, enhancing the overall level of generation adequacy. In particular, Austria, Switzerland and France benefit from power imports in critical situations. However, a low planned availability of nuclear power plants in France and restricted gas supply for power generation in gas power plants add further stress to the power system.

These preliminary results already suggest that simulating the availability of dispatchable power plants with comprehensive models provides further insights for assessing generation adequacy. Further work needs to be done to integrate a consistent stochastic dynamic programming approach as described above to determine the storage potential considering uncertainties.

Literature

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