

# **The impact of flexible resources on the resource adequacy in electricity markets**

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## **Overview:**

Electricity markets are different from other types of energy markets by their unique characteristics such as fairly inelastic demand, wide seasonal variations, and limited storage capability. As suppliers in an electricity market are required to offer into the market based on their short-term marginal cost due to competitive pressures, it is difficult for some suppliers with high marginal cost such as natural gas-fired plants, to recover their fixed capital costs. Also, current electricity prices in European and US electricity markets do not go high enough for the exiting peaking plants to be able to recover their fixed costs. This issue of revenue insufficiency resulted in lower investment incentives in some electricity markets which can lead to a resource inadequacy problem. A well-functioning energy market should be able to provide cost recovery for all types of generators to ensure a sustainable level of resource adequacy in the system.

## **Research Question:**

In the literature, different solutions were proposed to tackle the resource inadequacy problem. Proposed solutions include bilateral contracts approved by regulatory bodies, market power exercise, and addition of capacity market to the wholesale market design. In this work, we investigate the resource inadequacy problem by considering the demand response (DR) and storage resources as flexible resources. In this paper, we try to answer the key question of how the flexibility provided by demand response and storage resources in the market could mitigate the resource inadequacy issue in electricity markets. With that objective, we develop a probabilistic framework by modeling the uncertainty in both generation and demand sides of the market. Then, we implement a Monte Carlo analysis to examine all possible economic and reliability outcomes.

## **Methodology:**

System dynamics is an approach suitable for studying the causal effects of the interactions within the components of a system in time. In our work, a system dynamics approach is used to understand the dynamics of different interactions among the energy market components such as supply, demand, market price, profitability, and investment decisions. We evaluate the hourly prices and profits for all producers,

the optimal installed capacity, investment decisions, and profitability of newly installed capacity resources. As a case study, German electricity market with perfect competition is used as the main structure of the simulated market.

**Results:**

The results in this work shows that in the future electricity markets with significant generation share by renewable resources, the value of flexibility provided by DR and storage resources will play a major role to alleviate the resource inadequacy problem. By increasing the demand response penetration from 0% to 4% of peak load, the economically optimal reserve margin drops from 6.5% to 3%. Besides, the total resource adequacy-related costs decrease from €353 Million to €70 Million (approximately 80% reduction in total costs). However, the total costs of the systems could vary by the dispatch price and capital costs of demand response resources.

**Conclusion:**

It is concluded that both energy and capacity markets need higher level of flexibility or flexible resources to provide a sustainable level of resource adequacy to the electricity market and hence ensure reliability of the power system. The higher available capacity of flexible resources results economical and more efficient integration of intermittent renewables into the market.