Resource Adequacy through Operating Reserve Demand Curves: Design Options and their Impact on the Market Equilibrium

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Operating reserve demand curves (ORDCs) have become part of the electricity market design in several countries and power systems. They aim at improving the security of supply through enhanced peak prices that occur already when the system is running low on operating reserves, before an actual shortfall has to occur. Their suitability to achieve resource adequacy in the context of decarbonization has, however, been questioned, as previous research suggests that the ORDC's effect on prices would be thwarted by the merit order effect, caused by the deployment of variable renewable generation with zero marginal costs, such as wind and solar power.

The goal of this study is therefore to perform a thorough investigation whether resource adequacy can be steered through ORDCs, with a special focus on the interaction with the deployment of renewables. To this aim, we apply a balancing model, which models the occurrence of system imbalances based on generation and load timeseries, coupled with a stylized investment model that models the long-term equilibrium under perfect competition. This set up is used to investigate the market equilibrium at different stages of decarbonization, up to a renewable penetration above 80%. We apply different ORDC configurations to investigate their effect on the capacity mix and, ultimately, the system's reliability.

Our results suggest that ORDCs can be configured to achieve any reliability standard, up to perfect reliability. This can partially be attributed to the fact that the ORDC parameters reflect the level of uncertainty within the grid, leading to earlier price increases as supply gets more volatile due to renewable deployment. The associated cost increase we observed in our case study was between 2.5 and 5.4 EUR/MWh, suggesting that ORDCs can be a cost-effective instrument to maintain resource adequacy.

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