

Modeling wind energy imbalance risk in medium-term generation planning models: a methodological proposal for large scale applications

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Abstract-

Wind power is one of the most important renewable energy sources worldwide. However, integrating these technologies in electricity markets faces challenges due to the intermittent wind speed, resulting in potential imbalances within power grids and subsequent inefficiencies. Traditional approaches for modeling the uncertainty simulate fixed wind power values in operational and planning models, which work well for the short term but are inadequate for medium-term decision-making due to lower forecasting accuracy and the inability to differentiate the imbalance risk faced in each simulated value. This paper proposes a novel methodology for incorporating wind energy imbalance risk into medium-term generation planning models. For this, we first simulate realistic wind power scenarios and perform a fitting distribution process to characterize the hourly wind power behavior. Then, we model the imbalance risk using quadratic-uncertainty cost functions for each simulated value. Subsequently, we conduct a temporal aggregation to reduce the computational burden, preserving the conceptual framework of the imbalance risk modeling. Finally, we propose a medium-term generation planning model that includes the imbalance risk model and the temporal aggregation strategy. Our approach is evaluated in a real-size case study formed by Spain, Portugal, and France's electricity markets, demonstrating accurate wind power imbalance risk modeling and lowered planning costs.

Index Terms- Generation planning; Imbalance risk; Real-size power systems modeling; Temporal aggregation; Wind energy forecasting

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