UNIVERSITÄT DUISBURG ESSEN

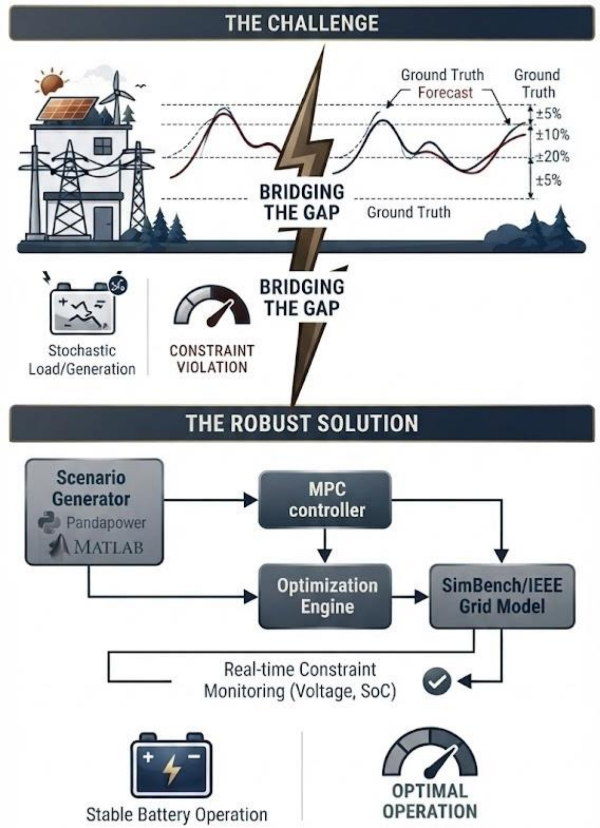
Offen im Denken

Fachgebiet für Elektrische Energiesysteme (EES)

Robust Model Predictive Control for Battery Energy Storage Systems under Forecast Uncertainty

The integration of decentralized energy resources and the intermittent nature of modern power grids have rendered real-time balancing and system stability more critical than ever. In the context of microgrid and distribution system operation, the management of Battery Energy Storage Systems (BESS) serves as the core physical engine for mitigating voltage fluctuations and demand spikes. However, most control strategies rely on deterministic assumptions that fail to account for the stochastic nature of load and generation forecasts. These strategies are highly sensitive to forecast errors, often struggling with suboptimal battery cycling or failing to maintain strict grid operational constraints under dynamic conditions.

The aim of the thesis is the analysis and verification of a robust, grid-aware Model Predictive Control (MPC) framework to facilitate the systematic operation of Battery Energy Storage Systems (BESS) under varying degrees of forecast uncertainty. The research investigates how MPC strategies respond to physical constraints—such as voltage bands and State of Charge (SoC) limits—and varying levels of forecast errors. By employing a simulation environment, this study integrates optimization-based control to monitor system stability, perform performance analysis against a deterministic MPC baseline, and verify that all dispatch schedules adhere to predefined electrical constraints. Ultimately, this work should provide a validated, simulation-based control tool that demonstrates the application of computational rigor to the complex task of grid-aware energy management.



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