Optimization of Microgrid Operations with Multi-Time Scale and Event-Driven Control Techniques

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Abstract. This paper presents a hybrid control approach that integrates multi-time scale optimization and event-driven techniques to improve the efficiency and reliability of microgrid operations. By coordinating control decisions across short, medium, and long time horizons while triggering updates based on system events, the proposed strategy ensures both high performance and reduced computational complexity. The study applies the method to a microgrid environment with diverse energy resources and validates its effectiveness through comprehensive simulations that highlight better energy management and operational stability compared to traditional control methods.

Keywords: Microgrid Optimization, Event-Driven Control, Multi-Time Scale Management, Distributed Energy Resources, Control Systems, Adaptive Optimization

Introduction:
Microgrids have gained considerable attention as a flexible solution for integrating distributed energy resources (DERs) and enhancing the sustainability of local energy systems. They offer the ability to operate autonomously and provide reliable energy supply even during grid disruptions. However, the increased complexity of microgrids, driven by the integration of various DERs and dynamic load profiles, necessitates advanced control solutions capable of optimizing performance while maintaining system stability.

Control strategies for microgrids must address the varied time scales inherent in their operations. For instance, real-time control is needed to handle fluctuations in load and generation, whereas longer time scales are relevant for optimizing energy storage utilization, demand response, and scheduling. Multi-time scale control frameworks have been proposed to manage these layered decision processes, but traditional approaches often involve continuous updates, leading to high computational overhead.

To mitigate these challenges, event-driven control techniques are employed in this paper, where control actions are triggered only when significant events occur, such as changes in load demand or renewable generation output. This reduces the need for constant monitoring and control, improving both computational efficiency and system responsiveness. The paper details the development and implementation of this hybrid approach and demonstrates its advantages through simulation studies on a microgrid model with varying operational conditions.