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Optimal Scheduling Methods for Distributed Energy Storage Systems in Electric Vehicle Charging Networks

With the rapid development and widespread adoption of electric vehicles (EVs), load fluctuations in urban charging networks have become increasingly prominent, posing significant challenges to grid stability and operational economy. EV charging is characterized by high randomness and peak-valley load concentration, which, if not properly managed, may lead to local grid overload, voltage fluctuations, and increased power system operating costs. To mitigate these issues, distributed energy storage systems (DESS) have emerged as a promising solution in EV charging networks. DESS can not only smooth charging load fluctuations but also provide critical support in power dispatch, energy trading, and ancillary services, enhancing the flexibility and reliability of the charging network.

Optimal scheduling strategies are crucial for efficient DESS operation. Effective methods must consider multiple objectives, including minimizing system operating costs, reducing peak load, improving storage utilization, and supporting renewable energy integration, while ensuring grid safety, meeting charging demands, and satisfying storage constraints. To achieve this, researchers typically employ mathematical modeling, optimization algorithms, and simulation techniques to plan storage capacity, charging/discharging schedules, and power allocation in the network. Properly designed scheduling strategies can alleviate grid stress and improve overall energy efficiency and economic performance, supporting the development of smart grids and sustainable transportation systems.

This study aims to propose an optimal scheduling method for distributed energy storage systems in electric vehicle charging networks. The research focuses on load forecasting, storage modeling, constraint analysis, and multi-objective optimization algorithm design. Through case studies and performance evaluation, the effectiveness of the proposed method in reducing grid operating costs, peak shaving and valley filling, and improving storage utilization will be assessed. The results are expected to provide theoretical guidance and technical support for planning and managing urban EV charging networks, contributing to a low-carbon, intelligent, and sustainable transportation energy system.