Simulation-Based Electric Vehicle Charging Station Admission Control and Scheduling Model for Urban Traffic Network

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Abstract. Electric vehicle (EV) has become an important mode of urban transportation with increasing environmental concern. However, operating EVs as a main urban transportation mode faces a challenge in charging the vehicle battery. Therefore, admission control and scheduling at EV charging stations considering the real traffic network should be studied to operate a more efficient transportation system using electric vehicles. This study proposes a simulation-based EV charging station admission control and scheduling model. Firstly, a traffic fluid model is proposed to reflect topological characteristics and flow complexity in real traffic conditions. The real-time EV arrival rate is estimated through parameters such as the number of vehicles, vehicle velocity, and other factors. Secondly, the admission of EV charging is restricted by the waiting time limit. Finally, EVs charging schedule is developed through simulation. Sensitivity analysis is conducted for the evaluation of charging station performance according to decline rate and total revenue. Factors such as EV arrival pattern, charging station infrastructures, and waiting time limit are investigated. It is shown when waiting time exceeds a certain level, there is an indication of system breakdown. In addition, the impact of traffic networks on charging station performance and the EV decline rate is also analyzed. Scenarios indicating diverse traffic networks in downtown and suburb area are developed to reflect urban traffic conditions. In consideration of urban traffic congestion, we conduct an experiment considering peak and off-peak hours. The result shows that the urban traffic network is of vital importance in charging station performance. When flow complexity is accurately measured and reflected, the EV decline rate can be effectively controlled resulting in a total revenue increase. Finally, renewable energy sources are integrated into coordination with charging station operation to enhance model robustness and flexibility in sustainable energy management. For instance, wind, solar and hydro energy generation and storage profiles are collected and applied. It is validated that the proposed model possesses strong adaption with renewable energy applications.

Keywords: Electric vehicle, Charging station admission control, Charging scheduling, Simulation-based optimization