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Entitled

COORDINATED LOCATION AND CAPACITY PLANNING OF FAST CHARGING STATIONS FOR ELECTRIC VEHICLES USING MULTI OBJECTIVE APPROACH

by

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Abstract

With the growing concerns on the energy depletion and CO_2 emissions, electric vehicles (EVs) have marked a new paradigm in the transport sector. Installation of publicly accessible charging stations (CS), namely fast CSs are crucial for the large-scale deployment of EVs. However, randomly placing CSs without prior research affect EV owners, CS operators and grid operators. For instance, the location and size of charging stations affect the accessibility and convenience of EV users since users prefer stations that are easier to access without much traffic congestion in road network. At the same time station should offer good service quality as the waiting time at stations is high compared to refuelling at gasoline stations, which eventually annoys EV drivers. Thus, CSs should have appropriate charging facilities to satisfy the charging demand of users. However, increasing the station capacity by building a greater number of chargers to satisfy the charging demands will subsequently increase the station costs. Furthermore, establishment of new charging stations impair the power grid functioning owing to the unpredictable charging behaviour of EVs. The power grid issues associated with EV charging are demand-supply unbalance, voltage fluctuation, and power loss. The above-mentioned characteristics of charging stations makes choosing the location and size of charging stations both intriguing and challenging research topic. Furthermore, charging station placement is irreversible due to the high cost of construction. Therefore, the thesis focuses on charging station location and capacity planning for EVs considering EV owner's benefits, distribution network safety and station related economy.The contributions of this project are in three-folds. Firstly, a location and capacity planning model for fast charging stations is proposed that addresses multiple aspects, such as the convenience of EV users, station operator economy, distribution networks impact and environmental impact simultaneously. Further a queuing algorithm to determine the CS capacity is developed which is beneficial for EV users as well as improving the efficiency of CSs, leading to minimum waiting time and maximum CS utilization. The conventional optimization methods have their limits in resolving the charging station location problem since the objective functions are inherently conflicting and competing. Hence the second contribution of this study is the development of a Pareto dominance based binary version of the atom search optimization (ASO) algorithm. The proposed method uses quantum operations to binarize the algorithm and achieve a higher convergence rate than the existing binary ASO algorithm. Additionally, a modified atom selection function is used to improve the searching capability of the ASO algorithm. It is expected that the modified function efficiently guides the atom particles to search the global optimum and thus enhances the global optimization capability of ASO. The efficiency of the proposed quantum atom search optimization algorithm is tested using both benchmark functions and by solving charging station location problem. Thirdly, a multi-level charging system that allows EV users to specify their charging needs and provide them charging at the best charging rate possible is developed. The proposed system allows the EV user to select the charging rate based on the user priority for battery lifetime and recharging time. Further, the proposed charging method is integrated to the location and capacity planning model in order to evaluate the benefits of combining charging characteristics with location planning. Finally, the proposed charging station location and capacity model is validated on real UAE road network.

Keywords: Electric vehicle, Fast charging station, Location and capacity, Multi-level charging, Optimization, Queuing