Abstract of "Multi-Objective Optimization for Coordinated Routing and Charging: A Framework of Electric Vehicle Navigation Systems"

Navigation systems are helpful in finding the shortest route and avoiding traffic jam. Navigation systems of electric vehicles (EVs), due to the short driving range of EVs, shall consider the location of battery switching stations and charging posts, and can work with the energy management system (EMS) to recommend routes, estimate the arrival time, and predict the energy cost, battery depreciation, as well as the residual driving range.

This paper proposes a framework of navigation systems of EVs to recommend routes and charging that benefit the two sides involved, the individuals and the system. Generally, the concerns of the individuals include reducing the travel time and enhancing the energy efficiency, while the concerns on the system level include traffic jam alleviation of traffic systems and narrowing peak-valley difference of power systems. The route recommendation should base on the information of battery switching stations and charging posts, traffic conditions, security operations of power systems, and EVs' state of charge (SOC).

In this context, we first address a multi-objective optimization problem to show all Pareto optimal solutions in EV navigation systems that help satisfy the objectives. While there is usually no single solution that optimizes all the objective functions, we are searching for trade-offs between the multiple objectives. The concept of utility maximization is considered here as two separate utility functions are formulated for the system and the individuals to represent their preferences over the characteristics of a route. Once the utility functions are formulated, their indifference hypersurfaces are also formed in which all points on one indifference hypersurface have the same utility. The maximum utility of the two sides respectively can be found at the point of tangency of the indifference hypersurface with the Pareto frontier in the Euclidean space formed by different characteristics of routes. The two points are the trade-off solutions that separately maximize the utility of the two sides. A compromised solution for the individuals and the system can be found on the shortest path between the two points along the Pareto frontier.

Chongming Island in China has well-planned traffic networks with 6 main battery switching stations and 302 charging posts. We carry out numerical simulations on Chongming Island to evidence the effectiveness of the proposed framework. An overall map of battery switching stations and charging posts on Chongming Island is shown as below.

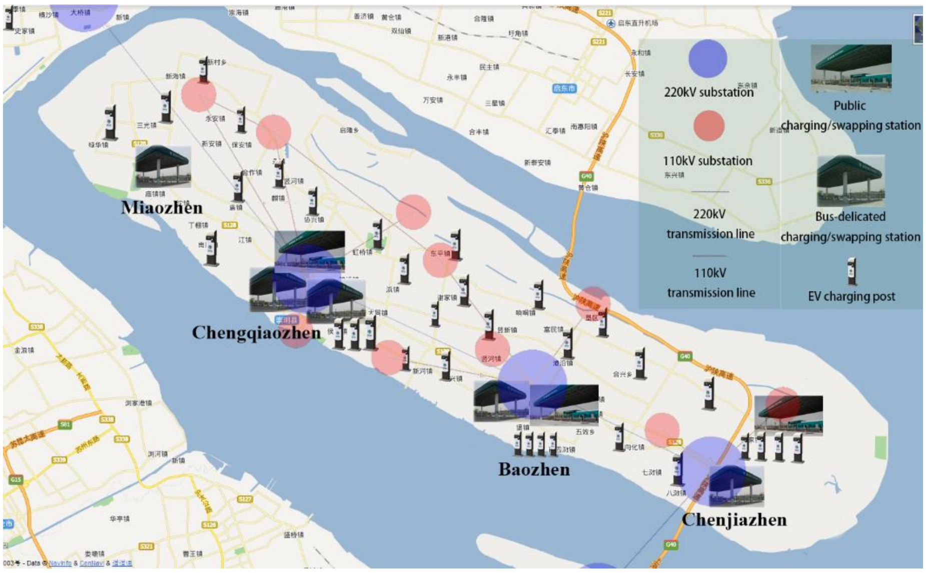

Fig. 1 Battery switching stations and charging posts on Chongming Island.