The Hong Kong University of Science and Technology

Dept of Information Systems, Business Statistics and Operations Management

Dept of Industrial Engineering & Decision Analytics

Joint Seminar Announcement

Scaling Up Battery Swapping Services in Cities: A Joint Location and Repairable-Inventory Model

by

Dr Wei Qi

Associate Professor of Operations Management

McGill University

Date : **23 July 2021 (Friday)**

Time : **9:00 - 10:15 AM**

Zoom ID : **943 8935 2374 (passcode 227609)**

Abstract: Battery swapping for electric vehicle refueling is reviving and thriving. Despite a captivating sustainable future where swapping batteries will be as convenient as refueling gas today, a tension is mounting in practice (beyond the traditional "range anxiety" issue): On one hand, it is desirable to maximize battery proximity and availability to customers. On the other hand, power grids for charging depleted batteries are not accessible everywhere. To reconcile this tension, some cities are embracing an emerging infrastructure network: Decentralized swapping stations replenish charged batteries from centralized charging stations. It remains unclear how to design such a network, or whether transitioning into this paradigm will save batteries which are environmentally detrimental. In this paper, we model this new urban infrastructure network. This task is complicated by non-Poisson swaps (observed from real data), and by the intertwined stochastic operations of swapping, charging, stocking and circulating batteries among swapping and charging stations. We show that these complexities can be captured by analytical models. We next propose a new location-inventory model for citywide deployment of hub charging stations, which jointly determines the location, allocation and reorder quantity decisions with a non-convex non-concave objective function. We solve this problem exactly and efficiently by exploiting the hidden submodularity and combining constraint-generation and parameter-search techniques. Even for solving convexified problems, our algorithm brings a speedup of at least three orders of magnitude relative to Gurobi solver. The major insight is twofold: Centralizing battery charging may harm cost-efficiency and battery asset-lightness; however, this finding is reversed if foreseeing that decentralized charging will have limited access to grids permitting fast charging. We also identify planning and operational flexibilities brought by centralized charging. In a broader sense, this work deepens our understanding about how mobility and energy are coupled in future smart cities.

Bio: Dr Wei Qi is an Associate Professor in Operations Management at the Desautels Faculty of Management at McGill University. He is also a faculty advisor of the China's Energy Group at the Lawrence Berkeley National Laboratory. His work has contributed to smart city operations concerning urban energy, mobility and retail logistics. Dr Qi is leading multiple internationally funded research projects, such as Fonds Québécois de la Recherche sur la Société et la Culture (FRQSC) - National Science Foundation of China (NSFC) Research Program on Smart Cities and Big Data. His research has been published in *Operations Research, Manufacturing & Service Operations Management*, and *Production and Operations Management*. His cross-disciplinary research has also appeared in the first-tier systems engineering journals such as IEEE Transactions on Power Systems and IEEE Transactions on Smart Gird. Dr Qi earned a Ph.D. from UC Berkeley, an M.S. from UCLA and a B.E. from Zhejiang University, China.

All interested are welcome!

Enquiries: Dept of ISOM