Guest editorial: Special Issue on Electric Vehicles and Their Integration with Power Grid

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Decarbonization of transport via replacing fossil fueled vehicles with electric ones, has been recognized worldwide as a key measure to tackle the challenges of climate change and environmental pollution due to green house gas emissions. Electric vehicles (EVs), which are considered by many governments as strategic industry of national importance, have seen rapid development and breakthroughs in battery and vehicle technologies over the past few years. This, coupled with preferential state EV purchasing incentives, likely results in accelerated deployment of EVs over the next few years. However, the mass rollout of EVs will pose a significant challenge to the secure and efficient operation of power systems due to temporal and spatial characteristics of EV charging load. On the other hand, the development of EVs can bring many benefits to power system operations as EVs with vehicle to grid (V2G) technologies could participate in power system balancing and reserve operations, peaking shifting as well as increasing system's ability to integrate high penetration of renewable power. Therefore, it is important to plan and build the suitable infrastructure, and to manage the integration of EVs to ensure future power systems operate more reliably, more flexibly, and more economically, by coordinating actions of all temporally and spatially distributed actors of different natures, with due considerations to the constraints, and uncertainties imposed upon them by highly complex external environments.

This special issue contains fifteen original papers to address various issues relating to the EV battery management and grid integration of EVs. Papers included in this special issue are summarized below.

Yusheng XUE, Juai WU et al presented an experimental economics based method to analyse EV purchasing behaviours from a limited set of collected customer questionnaires. By using multi-agent and Monte Carlo simulation techniques, potential customer EV purchasing behaviours and patterns can be properly modeled and validated by the results acquired from the questionnaires. Chunlin GUO and Ching CHUEN investigated key barriers and promotion mechanisms to the development of EVs considering whole system approaches.

Mingfei BAN and Jilai YU developed a procedural method to model EV charging load by aggregating EV drivers into different clusters according to driving patterns and regularity of driver behaviours. Zhaoxi LIU, Qiuwei WU et al proposed a statistical process based method to analyze potential EV driving patterns, using the National Transport Survey data to group drivers' behaviour. The method was applied to the analysis of driving patterns in Nordic region. Mingming LIU, Paul MCNAMARA et al presented a mathematical framework for modeling EV charging load under different charging scenarios, and the models developed are suitable for use in centralized and decentralized optimal charging control.

Jian MENG, Yunfei MU et al developed a dynamic frequency control strategy for the participation of EVs in the system frequency regulation, taking into account the comfort levels of vehicle owners. Wuhua LI, Chi XU et al proposed a coordinated dual droop frequency control strategy for hybrid EV energy management whereby integrated supercapacitor and battery systems are dynamically controlled to absorb high and low

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frequency power fluctuations respectively. Changsong CHEN and Shanxu DUAN considered the impact of different EV charging and discharging modes in microgrid economic operation and further developed a microgrid economic scheduling model considering the integration of plug-in hybrid EVs. Hong LIU, Pingliang ZENG et al presented a controlled EV charging strategy to optimize grid peak-valley load difference, taking into consideration of stochastic wind and PV power outputs. A two-stage peak-valley price model was proposed for controlled EV charging. Aoife FOLEY and Brian Ó GALLACHÓIR explored the impact of EV rollout using traditional dynamic generation scheduling and expansion tool that minimizes the generation cost and also emissions. The method was applied to the 2020 EV rollout and electricity scenario in Republic of Ireland and Northern Ireland. Mahdi KIAEE, Andrew CRUDEN et al developed a Matlab based V2G simulator to investigate the potential cost savings of integrating EVs in V2G schemes, taking into consideration of electricity network constraints. A novel control algorithm was proposed to take the advantages of the price difference of selling and buying electricity. They showed that the proposed control strategy with V2G scheme can reduce the charging cost by 13.6%. when it was applied to the IEEE 30 network.

Xiaohu XU, Liangzhong YAO et al presented an overall architecture and mechanism of smart EV battery charging and swapping operation service network based on internet of things, including terminal devices, station management layer, and management center layer. The performance of charging behaviours of electric taxis in the fast charging stations using Queuing theory is investigated. Jiuqing CAI, Changsong CHEN et al proposed a centralized control scheme that coordinates the parallel operations of power conditioning systems (PCS) for the integration of EVs in a charging-discharging and storage station. A novel seamless transfer strategy is designed to allow PCS transitions between the V2G mode and the standalone mode. Francesco Paolo DEFLORIO, Luca CASTELLO et al developed a method for analyzing the performance of wireless inductive charging of EVs while driving from both traffic and energy perspectives.

Zhiguo LEI, Chengning ZHANG et al examined the charging and discharging performance of lithium-ion battery under low temperature conditions and showed that heating battery pack with a wide-line metal film can significantly improve the performance of batteries under -40℃.

In summary, these fifteen papers serve as an introduction to the recent development in addressing various challenging issues in EVs and their integration with the utility grid penetrated with a significant level of renewables. It is hoped that this issue will serve as a catalyst for future research aimed at tackling complex problems decarbonizing the whole energy system from head to tail. We would like to take this opportunity to thank all authors for contributing their innovative and original work to this special issue, and all reviewers for their great efforts and their rigorous approach in reviewing these papers to improve the overall quality. We also like to express our gratitude to the Editor-in-Chief, Prof Yusheng XUE and deputy Editor-in-Chief, Prof Kit Po WONG for initiating this special issue and offering continual support. Finally, we would like to thank the National Natural Science Foundation of China for providing financial support to this special issue.