Guest editorial: special section on energy storage systems and operational flexibility in power systems

Shengwei MEI[1], Liangzhong YAO[2]

The energy storage system (ESS) is becoming an important component in power systems to mitigate the adverse impact of intermittent renewable energy resources and improve power grid reliability and efficiency. However, storage devices driven by different technologies can have specific grid impacts. This special section is dedicated to reflecting the latest progress and technologies in ESS, focusing on the key issues in operation, control, reliability impact and market value of multi-type grid-scale energy storage devices. There are 12 papers presented in this special section, 1 of which reviews challenges and progresses of ESS technology, 5 of which discuss the battery energy storage (BES); 2 of which are centered on compressed air energy storage (CAES), 2 of which focus on pumped hydro storage (PHS); 2 of which study the market issue with ESS.

1) Liangzhong YAO, Bo YANG, Hongfen CUI et al survey the latest progresses in various energy storage technologies, in terms of scale, efficiency, lifespan, cost and applications, taking into consideration their grid impacts, review the application scenarios of energy storage technologies, and forecast the prospect of global energy storage market.

2) Zao TANG, Youbo LIU, Junyong LIU et al propose a multi-stage sizing model for utility-scale BESS to optimize the BES development strategies in distribution networks with increasing penetration levels of rooftop photovoltaic panels. Xiangjun LI, Liangzhong YAO, and Dong HUI discuss the optimal control and management of large-scale battery energy storage system to mitigate the fluctuation and intermittence of renewable generations. Ying WANG, Zhi ZHOU, Audun BOTTERUD et al propose a mixed integer linear programming model for stochastic coordinated operation of wind-battery energy storage system with battery degradation. Xiangyu KONG, Linquan BAI, Qinran HU et al present a day-ahead optimal scheduling method for a grid-connected microgrid, in which the total operating cost is minimized subject to the required cold, heat, and electricity demands. Mingjun LIU, Wenyuan LI, Juan YU et al present a method for reliability evaluation of a hybrid generation system of wind and tidal powers with BES.

3) CAES is regarded as an effective approach to implement power load shifting and mitigate renewable energy uncertainty. Laijun CHEN, Tianwen ZHENG, Shengwei MEI et al demonstrate the fundamental principles, classifications, and operation modes of CAES, review the research progresses of CAES, and summarize the application prospects of CAES in smart grid and energy internet and further research directions. Rui LI, Laijun CHEN, Tiejiang YUAN et al propose a CAES based micro energy internet architecture without carbon emission, and further study the optimal energy flow and economic operation problems.

4) PHS is a mature technology and acknowledged as the best option for large scale storage. Aagje J.H. van MEERWIJK, René M.J. BENDERS, Alejandro DAVILA- MARTINEZ, et al investigate the potential of using PHS in Switzerland to support Germany power system, while taking into account the intermittency of

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(✉)Shengwei MEI
meishengwei@mail.tsinghua.edu.cn
Liangzhong YAO
yaoliangzhong@epri.sgcc.com.cn
1. Tsinghua University, China, Beijing 100084, China.
2. China Electric Power Research Institute, Beijing, 100192, China

renewables as well as the temporal variation of the hydrology surrounding a PHS plant. Alfredo RAMIREZ-DIAZ, Francisco J. RAMOS-REAL, Gustavo A. MARRERO explore the complementarity of PHS and electric vehicles in small isolated energy systems, and introduce the potential application in the island of La Palma.

5) Market issues of ESS are also of great interest. Fei TENG and Goran STRBAC investigate the value that ESS may deliver to its owner over two specific business cases in UK power systems. Shi YOU, Junjie HU, Yi ZONG et al study the economic performance of MW-sized hydrogen system and the value of hydrogen-based ESS in the electricity spot market.

In summary, these papers comprehensively review current progresses and clearly reveal technical challenges in ESS research. We hope this section will serve as an introduction for future research aiming at promoting technical development and fostering practical utilization of ESS in power systems. We are grateful to the authors for sharing their new ideas and original researches to this special section. We also would like to express our appreciation to the reviewers for the thorough comments and constructive suggestions, which greatly helped us in the paper selection process and improved the overall quality of this special section. Finally, we would like to take this opportunity to thank the Editor-in-Chief, Prof. Yusheng XUE, Prof. Kit Po WONG and the handling editors of MPCE for their work enthusiasm and sharp awareness of the cutting-edge technology to initiate this special section and offer continual support.