Guest Editorial

Energy storage for green transition of electrical grids

Bayati, Navid; Ebel, Thomas; Savaghebi, Mehdi; Lin, Zhengyu; Zhao, Haoran; Marzband, Mousa; Dehghanian, Payman

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GUEST EDITORIAL

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1 | INTRODUCTION

Energy storage systems (ESSs) are needed in the smart grids both at the generation, transmission, and distribution levels, and different types of ESSs have widely different characteristics and are suitable for different tasks and situations. In recent years, the smart grid concept has been dramatically developed in different applications, such as islands, shipboards, aircraft, microgrids and grid integration of renewables. With the wide application of ESS in smart grids, significant technical challenges remain along with the enhancement of smart grid operations and services. These challenges can be categorised as control of ESS, optimal operation, and energy management systems, optimal design of hybrid ESS, protection of ESS, and power electronics for ESS connections. This necessitates suitable design and control of the interfaces between ESSs in smart grids, as well as consideration of different applications of smart grid systems. This special issue of IET smart grid is focused on research ideas, articles, and experimental studies related to 'Energy Storage for Green Transition of Electrical Grids' from contributors in universities, industries, and research laboratories to develop and propose novel solutions on applications of ESS in smart grids.

2 | PAPERS IN THE SPECIAL ISSUE

This special issue presents six papers providing some methodologies within the field of ongoing research and development, all of which were selected after undergoing a thorough peer-review process. Below, we expand the publications on this special issue. Some common themes within the papers on this special issue include control of hybrid storage systems, energy management of electric vehicles (EVs), photovoltaics (PV), and ESS, and voltage regulation of storage systems. All of these attributes are vitally important to the integration of energy storage for the green transition of power grids. Moreover, the overall submissions have high quality, which marks the success of this special issue.

In the paper 'Moth-Flame-Optimization Based Parameter Estimation for Model-Predictive-Controlled SMES-Battery Hybrid Energy Storage System' by Liu et al., the authors propose an improved model-predictive-control (MPC) approach for superconducting magnetic energy storage (SMES)-battery hybrid energy storage system (HESS) by using the moth-flame-optimisation (MFO) algorithm to determine the circuit parameters in real-time. The actual parameters are updated by MFO and then sent to the MPC to minimise the model mismatches. The advantages of the proposed method, in terms of accuracy and convergence speed, are verified by comparison with Grey Wolf optimization (GWO) and particle swarm optimization (PSO). The simulation results prove that by taking the proposed strategy, DC bus voltage is more stable and the SMES can maintain more than 95% of capacity utilisation and avoid over-discharge even if the model parameters are inconsistent with the actual ones under circumstances of AC grid fault and fluctuation of new energy output.

In the paper 'A Novel Snow Conditions-Compatible Computational Intelligence-Based PV Power Forecasting Approach for Microgrids in Snow Prone Regions' by Hashemi et al., the authors suggest a novel snow conditions-compatible computational intelligence-based short-term PV power forecasting (PVPF) technique that is independent of exogenous weather forecasts. The proposed approach consists of a snow-cover-detection stage, a snow-cover-forecasting stage, and a PV power forecasting stage. This approach is then validated for an MPC-based energy management system (EMS) of a PV energy-based grid-connected microgrid located in a snow-prone area. The PVPF method together with a computational intelligence-based short-term load demand forecasting model constitutes the forecasting block of the EMS. The forecasting block generates day-ahead hourly forecasts based on the local measurements of the meteorological–electrical parameters and sends them to the optimisation block, where a two-stage control method, corresponding to the tertiary and secondary control levels, is developed based on mixed-integer linear and quadratic programming. The developed EMS is applied to a test microgrid simulated in MATLAB/Simulink and compared with a heuristic control method. The results show that the proposed approach can reduce the overall operation cost of the microgrid by 8%, 15%, and 13% on sunny, cloudy, and snowy days under study, respectively, compared to the heuristic controller.

In the paper 'Energy Management Strategies of Hybrid Electric Vehicles: a Comparative Review' by Azim Mohseni et. al., the authors have a comprehensive overview of existing power management strategies and energy storage technologies for HEVs. Also, the major challenges in this issue, including battery durability, battery ageing, computational load, and multi-energy sources, have been described and reviewed. While rule-based methods have low computational complexity and are simpler to implement, they suffer from a lack of adaptiveness in time-varying driving cycles, and traditional rule-based methods have weak optimisation solutions. In contrast, optimization-based methods provide better optimisation effects, but they are mostly difficult for real-time implementation due to the use of many mathematical operations for finding global optimal solutions.

In the paper 'Two-Stage Self-Adaption Security and Low-Carbon Dispatch Strategy of ESS in DNs with High Proportion PVs' by Chen et al., the authors suggest a two-stage self-adaptive dispatch strategy of ESS that considers the temporal characteristics of slack nodal carbon emission intensity to minimise carbon emissions while maintaining voltage stability in distribution networks (DNs) with high access to PVs. First, the framework of the proposed two-stage self-adaptive dispatch strategy of ESS is established by taking into account the effects of ESS on adjusting voltages and reducing carbon emissions, respectively, with the two-stage switch principle of two operation modes being determined. On this basis, an optimisation dispatch model is established to improve voltages and carbon emissions, and the optimal day-ahead dispatch strategy of ESS can be obtained by solving the model using the genetic algorithm (GA). Case studies of the modified 10 kV IEEE 33-node distribution network and IEEE 123-node distribution network verify the feasibility and superiority of the proposed two-stage self-adaptive security and low-carbon day-ahead dispatch strategy for ESS, showing that the voltage stabilisation and lower carbon emissions of DNs are both improved.

In the paper 'Voltage Regulation in Low Voltage Distribution Networks with Unbalanced Penetrations of Photovoltaics and Battery Storage Systems' by Micallef et al., the authors evaluate how self-consumption strategies with distributed battery energy storage systems can contribute to the voltage regulation in low voltage (LV) networks and the reduction of reverse power flows. The batteries are controlled to absorb the reverse power flow at the dwellings' point of common coupling before this is injected into the LV network. Simulations show that uncoordinated strategies are not suitable to address the distribution network challenges during reverse power flows and evening peak demands. On the other hand, self-consumption coordinated by a time-varying feed-in tariff can provide higher profitability to the prosumers while providing added benefit to the utility. The net-billing profitability for the prosumers in a self-consumption scenario with a time-varying feed-in tariff is transformed from the downward trend of the uncoordinated scenario to an upward trend against the increasing values of storage capacity.

In the paper 'The charge-discharge compensation pricing strategy of electric vehicle aggregator considering users response willingness from the perspective of Stackelberg game' by Dong et al., to reasonably guide EV charging/discharging to participate in Demand Response (DR) and help the power grid achieve peak cutting and valley filling, the charge–discharge compensation pricing strategy of EV Aggregator (EVA) considering user response willingness from the perspective of the Stackelberg game is proposed. Firstly, EVA, as the leader, provides a charge–discharge compensation price to maximise its income within a day, considering user satisfaction constraints. Secondly, a user response willingness model is established. User engagement is used to describe the change in the number of EV responses with the change of the charge–discharge compensation price by EVA and select the random EV set that accepts EVA charge–discharge guidance. Finally, the EV, as a follower, conducts charging/discharging behaviour to minimise the charging cost. By using the Karush–Kuhn–Tucker (KKT) condition, strong duality theory, and iterative method, the strategy equilibrium solution is solved. The results show that considering the user response, willingness can effectively reduce the decision risk when EVA participates in bidding. Although EVA income slightly decreases considering the response willingness, the average user satisfaction increases by 0.1.

3 | SUMMARY

The published papers in this special issue show energy storage systems in different forms, accelerate and contribute to the green transition. Different control and power management of energy storage systems in various applications like PV, grid, EVs, etc. will remain a source of inspiration for new designs and developments in the upcoming years.

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Navid Bayati[1]
Thomas Ebel[1]
Mehdi Savaghebi[2]
Zhengyu Lin[3]
Haoran Zhao[4]
Mousa Marzband[5]
Payman Dehghanian[6]

[1]*Centre for Industrial Electronics, Institute of Mechanical and Electrical Engineering, University of Southern Denmark, Odense, Denmark*
[2]*Department of Engineering Technology, Technical University of Denmark, Ballerup, Denmark*

[3]*Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, UK*
[4]*School of Electrical Engineering, Shandong University, Jinan, China*
[5]*Net Zero Industry Innovation Centre, Campus Masterplan, Teesside University, Middlesbrough, UK*
[6]*George Washington University, Washington, District of Columbia, USA*

Correspondence
Navid Bayati.
Email: navib@sdu.dk

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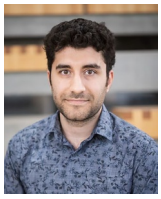
ORCID

Navid Bayati https://orcid.org/0000-0001-9247-0840
Zhengyu Lin https://orcid.org/0000-0001-7733-2431
Mousa Marzband https://orcid.org/0000-0003-3482-609X

AUTHOR BIOGRAPHIES



Navid Bayati received the M.Sc. degree in electrical engineering from the Amirkabir University of Technology, Tehran, Iran, in 2017 and the Ph.D. degree in electrical engineering from Aalborg University, Aalborg, Denmark, in November 2020. He was a visiting researcher at Loughborough University, UK, in 2019. In 2021, he was a postdoctoral researcher with the University of Southern Denmark, Odense, Denmark, where since 2022, he has been an assistant professor on power system protection. His research interests include power system protection, DC microgrids, and fault detection as well as hardware-in-the-loop simulations by dSPACE and OPAL-RT.

Thomas Ebel received the Dipl.-Chem. degree (M.Sc. equivalent) in chemistry from Münster University, in 1992, and the Ph.D. degree (Dr.rer.nat.) from the Institute of Inorganic Chemistry, Münster University, in 1995. In 1995, he has spent three months, as a guest researcher with CNRS, Institute des Matériaux de Nantes, France, with Prof. J. Rouxel. From August 1995 to September 2001, he was a research and development engineer, and later the Research and Development Director of Siemens Matsushita Components, Siemens AG PR. Since October 1999, he has been with EPCOS AG; and since October 2008, he has been with TDK, Business Unit of Aluminum Electrolytic Capacitors, Heidenheim, Germany. From October 2001 to July 2008, he was the research and development director, later the technical director (a CTO), and a member of the Board of Directors of Becromal Norway (Becromal S.p.A., since October 2008, Epcos, now TDK Foil), Milano, Italy. From September 2008 to July 2018, he was the managing director and a shareholder with FTCAP GmbH (Husum Manufacturer of Aluminum Electrolytic and Film Capacitors), Germany. Since August 2018, he has been the Head of the Section of Electrical Engineering and the Centre for Industrial Electronics (CIE), University of Southern Denmark (SDU), Odense, Sønderborg. Since January 2022, he has been a full professor.

Mehdi Savaghebi received the B.Sc. degree from the University of Tehran, Iran, in 2004 and the M.Sc. and Ph.D. degrees from Iran University of Science and Technology, Tehran, Iran in 2006 and 2012, respectively, all in Electrical Engineering. From 2014 to 2017, he was a Postdoc Fellow at the Department of Energy, Aalborg University where he was an associate professor for 2017–2018. For the next four years, he served as an associate professor and research team leader at the University of Southern Denmark, Odense, Denmark. Since June 2022, he has been the Head of Electric Energy Section at the Department of Engineering Technology, Technical University of Denmark (DTU), Ballerup, Denmark, where he is currently a professor in Power Electronic-Enabled Power Systems. His main research interests include renewable energy systems, microgrids, power quality and protection of electrical systems.

Zhengyu Lin received the B.Sc. and M.Sc. degrees from the College of Electrical Engineering, Zhejiang University, Hangzhou, China, in 1998 and 2001, respectively, and the Ph.D. degree from Herio-Watt University, Edinburgh, U.K., in 2005. He is currently a reader with the Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, U.K. His research interests include power electronics and its applications in renewable energy, energy storage, motor drives, microgrids, and multi-energy systems.

Haoran Zhao received the B.E. degree from Shandong University, Jinan, China, in 2005, the M.E. degree from the Technical University of Berlin, Berlin, Germany, in 2009, and the Ph.D. degree from the Technical University of Denmark, Kongens Lyngby, Denmark, in 2014. He is currently a professor with the School of Electrical Engineering, Shandong University. He was an electrical engineer with the State Grid Corporation of China, Beijing, China, in 2005. From 2010 to 2011, he worked as an application developer with

DIgSILENT GmbH, Gomaringen, Germany. His research interests include modelling and integration study of wind power, control of energy storage system, and integrated energy systems.

Mousa Marzband is currently an associate professor (Reader) with the Net Zero Industry Innovation Centre, Teesside University, U.K. One of his previous projects (funded by the British Council, £186k involves the design of power electronic topologies and smart controllers for energy storage and electric vehicles in the home microgrids. He also received the QNRF-National Priority Research Program (NPRP13S-108-200028), entitled 'Impact Assessment of EV Charging Stations and Regulation Policies for Upcoming Active Distribution Network of Qatar Utility Grid' (2021–2024), funded to the tune of ≈$600k. His proposal 'Electric Vehicles pOint Location optimization via VEhicular communications (EVOLVE)' has been funded by Marie Skłodowska-Curie Actions Staff Exchange (2022–2026) to the tune of £620k. He is a PI on the 'Optimal Scheduling of Electric Vehicle-Integrated Multi-Energy System With High Renewable Generation' funded by EPSRC through DTE Network+. He is also a PI on 'Bi-Directional MIMO DC/DC Converter for V2G/X Infrastructures' (in collaboration with Otaski ES), funded by Innovative U.K. (≈$300k).

Payman Dehghanian received the B.Sc. degree in electrical engineering from the University of Tehran, Tehran, Iran, in 2009, the M.Sc. degree in electrical engineering from the Sharif University of Technology, Tehran, in 2011, and the Ph. D. degree in electrical engineering from Texas A&M University, College Station, TX, USA, in 2017. He joined the Department of Electrical and Computer Engineering, George Washington University, Washington, DC, USA, in 2018, where he is currently an associate professor. His research interests include power system reliability and resilience assessment, data-informed decision-making for maintenance and asset management in electrical systems and smart electricity grid applications. Dr. Dehghanian was the recipient of the 2014 and 2015 IEEE Region 5 Outstanding Professional Achievement Awards, 2015 IEEE-HKN Outstanding Young Professional Award, 2021 Early Career Award from the Washington Academy of Sciences, 2022 George Washington University's Early Career Researcher Award, 2022 IEEE IAS Electric Safety Committee's Young Professional Achievement Award, and 2022 IEEE IAS Outstanding Young Member Service Award. In 2015 and 2016, Dr. Dehghanian was selected among the World's Top 20 Young Scholars for Next Generation of Researchers in electric power systems.