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GUEST EDITORIAL

Guest editorial: Application of cloud energy storage systems in power systems

1 | INTRODUCTION

Cloud energy storage system (CESS) technology is a novel idea to eliminate the distributed energy storage systems from the consumers into a cloud service centre, where CESS acts as a virtual energy storage capacity instead of the actual devices. The power and energy of several distributed energy storages are combined using a CESS to assure providing storage services for small consumers. A CESS is a shared pool of grid-scale energy storage systems to reduce the cost of energy storage services in the power system which can increase the penetration level of onsite distributed renewable energy sources, reduce the electricity bills of consumers, and provide flexibility to the power grid by reducing the peak loads.

The current Special Issue aims to explore technologies, methodologies, and solutions to develop CESSs with an efficient, secure, and stable operation of power systems.

2 | PAPERS IN THE SPECIAL ISSUE

In this Special Issue, we have received seventeen papers, all of which underwent peer review. Of the seventeen originally submitted papers, eleven have been accepted, two have been "Reject—unsuitable for referral", and four have been "Rejected with referral", that is, they did not meet the IET Generation, Transmission, and Distribution criteria for publication, yet they were of sufficient quality to be suggested for possible publication in other journals. Thus, the overall submissions were of high quality, which marks the success of this Special Issue.

The eventually accepted papers can be clustered into three main categories, namely review, optimal planning, and control of CESS in power systems.

Khezri et al.[1] present an overview on the main concept and fundamentals of CESS for the power systems, and their roles to support the consumers and the distribution network. The flow of information in a CESS is discussed, and the roles of operator, consumers, and facilities, as the main sectors of CESS, are explained. The existing studies are classified and discussed regarding different applications of the CESS in the power systems and their drawbacks are highlighted. Some technical challenges are described and finally, future directions are suggested for potential researchers to continue the studies on CESS integration and application.

Khanal et al.[2] explore an optimization framework to achieve the optimal capacity of solar photovoltaic (PV) and energy storage system (ESS) for a grid-connected house based on an energy-sharing mechanism. The grid-connected house shares electricity with other houses under a mutually agreed fixed energy price. The objective is to minimize the cost of electricity for the house with PV and ESS while decreasing the electricity cost of other houses. The developed methodology is examined by taking the actual load data of two houses in South Australia. Different scenarios of contract years between the houses are investigated to make it more practical in real life.

Wang et al. present a robust optimal configuration model of CESS based on a cooperative game theory. The CESS model on the generation side is developed to describe the formation mechanism of ESS supply and demand. The proposed model aims at maximizing the revenue of renewable energy power plants as the participants of the coalition. By taking the renewable power uncertainty into consideration, the novel nested column-and-constraint generation method is utilized to solve the proposed model based on the min–max–min form. A Shapley-value method is used to distribute the benefits to each member of the grand coalition.

Access full paper using the following link: https://ietresearch.onlinelibrary.wiley.com/doi/full/10.1049/gtd2.12473

Jalilpoor et al. present a novel preventive-corrective resilient energy management strategy for cyber–physical systems (CPSs) in two stages, exploiting the network reconfiguration (NR) and ESSs' capacity. The first stage of the proposed method follows preventive actions based on contingency faults. The second stage applies corrective measures for improving the CPS resilience to cope with natural physical disasters. The first stage of preparing the CPS for predictable faults focuses on prescheduled ESSs and preventive NR to minimise the expected

[2] This paper has been handled by independent Editors, i.e. outside the organisers of the Special Issue.

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energy curtailment cost. The second stage involves the network recovery in real-time through corrective NR to minimise energy curtailment cost after the faults. Three resistance, recovery, and resilience indices are introduced for evaluating the effectiveness of the model. The proposed model is examined by performing multiple simulations on the 33 and 118-bus radial test systems.

Access full paper using the following link: https://ietresearch.onlinelibrary.wiley.com/doi/full/10.1049/gtd2.12478

Khoshniyyat et al. explore residential microgrids which not only deploy smart algorithms and energy management strategies for appliances scheduling but also benefit insulated wall structures and modern windows ending to smart buildings with sustainable architecture. The proposed model adopts the most recent concept of CESS unit to provide a public access to charge/discharge capacity for smart home owners. Accordingly, a simple but applicable capacity sharing strategy of CESS is developed for the energy exchanges of smart homes in the microgrid. By establishing such an access to CESS, the proposed model allocates optimal shares of charge/discharge capacities for home owners, minimizes the daily operation cost of each home and grants an optimal operation of household appliances.

Access full paper using the following link: https://ietresearch.onlinelibrary.wiley.com/doi/full/10.1049/gtd2.12459

Jiang et al. propose the concept of the cloud-based location sharing ESS to satisfy the small and medium-scale timely storage requirement from localized users. The modular mobile ESS is flexibly deployed and configured at different sites to fulfil the long-term seasonally dynamic transformer capacity increment and short-term daily energy arbitrage based on economic values. To optimize the overall incomes of the energy storage investment, a two-step user potential identification algorithm is proposed to discover the most valuable users at different time scales from the regional power usage profile. Then, the optimal planning algorithm is proposed to optimally share the mobile ESS among users seasonally. Finally, the dispatching strategy of the cloud-based location sharing ESS is illustrated.

Mohiti et al. propose a novel energy and reserve scheduling model for power systems with high penetration of wind turbines. The objective of the proposed model is to minimize the total operational cost of the system while static and dynamic security is guaranteed by preserving the frequency nadir, RoCoF, and quasi-steady-state frequency in the predefined range. Likewise, a supervisory control and data acquisition system is developed which allows Vanadium Redox Flow Batteries to continuously communicate and participate in the primary frequency response. To cope with the uncertainties, adaptive information gap decision theory is used that ensures a target operating cost for the risk-averse operator of the power system.

Access full paper using the following link: https://ietresearch.onlinelibrary.wiley.com/doi/full/10.1049/gtd2.12592

Abadi et al. present an adaptive control framework for the flexible and effective management and control of clustered DC nano-grids (NGs) in an islanded DC microgrid system. It is assumed that each NG contains a PV, an ESS, local loads, and a gateway module. Each NG has a hierarchical control system consisting of a decision-making module and low-level controllers. The decision-making module ensures various desirable features including plug-and-play operation of NGs, maximum utilization of PV power generations, and avoiding state of charge (SoC) violation of ESSs. A smart switching consensus-based control strategy is designed that provides flexible power sharing among the NGs to balance the SoC of ESSs.

Access full paper using the following link: https://ietresearch.onlinelibrary.wiley.com/doi/full/10.1049/gtd2.12556

Ebrahimi et al. present the employment of CESS with synchronverter grid connections to create a suitable opportunity for improving the transient stability of the network by providing higher inertia. They have shown the fault current contribution of the synchronverter-based CESS imperils protection constraints in these networks. Therefore, a proper protection coordination index is considered in the conducted study to identify the optimal size of the synchronverter-based CESS through a two-stage optimization algorithm that preserves the protection constraints among protective devices. Finally, the transient stability of the network with synchronverter-based CESS is assayed by calculation of the critical clearing time for faults.

Access full paper using the following link: https://ietresearch.onlinelibrary.wiley.com/doi/full/10.1049/gtd2.12539

Yazdaninejadi et al. present the effects of contribution of synchronverter-based CESS and also fault resistance on recloser-fuse protection are explored and then, a new algorithm is proposed for tackling these bottlenecks. To overcome these hurdles, the conventional recloser-fuse scheme is applied at first. Then, by using the obtained schemes for fast and slow operations of the recloser, a specific part of them is set in a manner that the fuse-saving task is performed properly even when the synchronverter-based CESS is deployed. On the other hand, the other part of the recloser scheme is altered in a way that the maloperation of the recloser-fuse pair owing to the fault resistance is alleviated. Adequate numerical analyses are conducted to evaluate the proposed scheme.

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Abadi et al. develop the idea of using a community supercapacitor (SC) in an islanded DC multiple NG system. The proposed community SC operates in tandem with the CESS of the DC multiple NGs. This combination forms a grid-forming battery-supercapacitor cloud hybrid energy storage system (CHESS) which is responsible for maintaining the voltage stability and power balance at the common DC bus of the multiple NG system. They also propose a modified control structure for each DC nano-grid enabling the local battery units to coordinate with the community SC. By using the proposed grid-forming CHESS technology, the output power of all the local and community battery units has significantly smoother power variations leading to a higher battery lifetime.

AUTHOR CONTRIBUTIONS

Amin Mahmoudi (GE): Project administration; Supervision; Writing - review & editing. Ali Bidram: Writing - review & editing. Mohammad Hassan Khooban (GE): Writing - review and editing. Hirohisa Aki (GE): Writing - review and editing. Kaveh Khalilpour: Writing - review and editing. Hussein Abdeltawab: Writing - review and editing. Rahmatollah Khezri: Writing the first draft as well as Writing - review & editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

None.

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[Correction added on 15 February-2023, after first online publication: author contribution section has been updated in this version]

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