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Editorial on Special Section: Invited Papers on Emerging Topics in the Power and Energy Society

TO KEEP up with the trend toward open access in science and technology publications, IEEE has created a number of open access journals including the IEEE Open Access Journal of Power and Energy (OAJPE). At present, due to the great number of emerging technologies in power and energy systems, our research and industrial communities are undergoing an unprecedented paradigm change.

To promote the dissemination of technological information and encourage open access publications, OAJPE initiated this Editor-In-Chief (EIC)-invited special section in early 2020 to cover a wide range of topics from eminent researchers in the field of power and energy. This section covers resilience, reliability, control, uncertainty, lower inertia, economics, measurement, quality, forecast, and testbeds of electric power systems. It should be noted that, although these were invited papers, all of them have been subject to a very rigorous peer review process to ensure the highest quality possible.

In the paper titled "The evolution of research in microgrids control," the authors provide an overview of the various hierarchical levels of microgrid control, and then discuss and compare selected popular control methods such as model predictive control and reinforcement learning-based control. The authors also point out the challenges that stem from the unique characteristics of microgrid control and future research directions.

In the paper titled "Complementarity, not optimization, is the language of markets," a tutorial overview of bi-level optimization and equilibrium models for power markets is provided based on different perspectives from different market agents. The bi-level model consists of an upper-level profit maximization problem and a lower level one representing market clearing. The solution techniques for the resulting mathematical program with equilibrium constraints (MPEC) and equilibrium problem with equilibrium constraints (EPEC) are discussed. To conclude the paper, future research needs are highlighted.

In the paper titled "Recent development of frequency estimation methods for future smart grid," three methods of frequency estimation via Phasor Measurement Units (PMUs) have been reviewed to address challenges from low-inertia power systems. These three methods, namely, an enhanced zero-crossing algorithm, a fault-tolerating algorithm, and a high reporting rate algorithm, are then implemented in hardware and compared with classic frequency estimation methods.

In the paper titled "Wildfire risk mitigation: A paradigm shift in power systems planning and operation," the authors first provide a summary of recent notable wildfires believed to be powerline-induced with possible causes related to power grids. Then, a number of possible prevention approaches, fire response strategies, and impact mitigation methods are discussed, followed by a detailed discussion of future research directions.

In the paper titled "Energy forecasting: A review and outlook," a brief review of influential energy forecasting works has been summarized from thousands of research papers in energy forecasting. Then, research frontiers and true challenges are suggested for both current and future researchers and practitioners. The authors also recommend several key aspects to consider in publishing reproducible research and quality papers in energy forecasting.

In the paper titled "Decentralized intrusion prevention (DIP) against coordinated cyberattacks on distribution automation systems," a new, holistic approach to providing cybersecurity for distribution automation systems has been proposed based on a multiagent system. The proposed approach is then demonstrated on the IEEE 13-node test feeder and compared with existing methods to validate the performance.

In the paper titled "Composite system reliability evaluation with essential reliability services assessment of wind power integrated power systems," the authors propose a probabilistic approach based on sequential Monte Carlo simulation to evaluate the composite system reliability that integrates both adequacy and dynamic security under high renewable penetration. New reliability indices are proposed. Case studies were performed on a synthetic system to illustrate the necessity and the efficiency of the proposed approach.

In the paper titled "System-level design for reliability and maintenance scheduling in modern power electronic-based power systems," a reliability and maintenance scheduling approach is proposed for power electronic-based power systems (PEPSs). The reliability model of converters has been incorporated into the overall model-based system-level design, which yields a reliable and economic planning of PEPSs. The paper is concluded with a case study on a PEPS.

In the paper titled "Energy quality: A definition," the authors propose a new technical framework, Energy Quality, in response to the high penetration of renewables causing a 39% cost increase in the U.K.'s balancing markets.

A definition and measures of energy quality are proposed in this paper. Also discussed are approaches to improving energy quality. Finally, promising future research directions are presented.

In the paper titled "Technical and economic impact of the inertia constraints on power plant unit commitment," a frequency stability constrained unit commitment method is proposed to address the low-inertia challenge. A multiple-criteria decision-making approach is proposed to find the best-compromised solution based on weighting factors. The method was then tested on a future scenario from a real case from the Italian transmission system.

In the paper titled "A stochastic two-stage model for the integrated scheduling of the electric and natural gas systems," a stochastic two-stage formulation for an electricity-gas integrated system is proposed to address the uncertainties at both the electrical and the gas sides. Three linearization techniques have been incorporated into the model. The proposed stochastic model was evaluated using real-world electrical and gas systems from Greece.

In the paper titled "Asynchronous economic dispatch for combined heat and power systems," the authors propose an asynchronous economic dispatch method to address the different time scales for the electric system dispatch and the heating system dispatch. A hybrid model and an identical model are proposed to implement the asynchronous dispatch. The comparisons in case studies demonstrate that the asynchronous dispatch can improve system efficiency and ensure reliable operation if compared with existing synchronous dispatch methods.

In the paper titled "Building highly detailed synthetic electric grid data sets for combined transmission and distribution systems," an effective methodology is proposed to build synthetic, combined transmission, and distribution systems based on data sets geographically located on an actual North America footprint. The details of process, challenges, and validations are discussed to ensure that the synthetical system is realistic.

In the paper titled "Reconfigurable real-time power grid emulator for systems with high penetration of renewables," the authors provide an overview of a power electronics-based hardware testbed (HTB) developed at the CURENT research center. The HTB emulates the North American grid with high penetration renewables and an HVDC overlay. Case studies were carried out to demonstrate the capability of the HTB as a test platform for research in electric power grids.

We hope that readers of this journal find this special section with 14 papers interesting and useful, and we also hope that these papers serve as significant references for future research.

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