Editorial for the Special Issue on Distributed Energy Resources

TRANSFORMATION of the existing electric power systems into modern smart grids is gaining momentum as mostjurisdictions are seeking ways to lower their energy consumptions, life cycle costs and greenhouse gas (GHG) emissions. The transformation requires the integration of significant renewable energy into the existing power systems, which has posed tremendous technical and operational challenges involving the issues of voltage and frequency stability, insufficient energy storage, resources for system balancing and dispatch, renewable energy intermittency, and much more. During a recent research trip of mine to an island country, I got the first-hand experience in how the fast down-ramping events of a large central photovoltaic (PV) plant could cause load shedding and PV generation curtailment. Innovative solutions are needed to support this power system transformation, as the need for additional system resources can no longer be met by building more central generation plants.

As an integral part of modern power systems, distributed energy resources (DER) have been rapidly deployed throughout the world, initially as an effective means of clean generation to displace fossil fuels and subsequently as resources to provide power system functions such as ancillary services and peak load reduction. DERs include distributed generation systems such as wind, solar and CHP systems, energy storage units including electric vehicles, controllable loads, and associated power conversion and control systems, all in power distribution networks. The innovative solutions to facilitate the seamless integration of DERs into electric grids and the creation of new power systems resources have never been more important than today. These solutions are critical to enabling maximum penetration of renewable energy, while allowing utilities to maintain high standards of grid stability, reliability, flexibility, and economy. The purpose of this Special Issue is to review the state-of-the-arts in the DER fields and to disseminate the recent technological advancement in DERs, pertinent to analysis, design, conversion, control, performance, and application.

The Special Issue on Distributed Energy Resources collected 5 papers on diverse topics, ranging from the state-of-the-art reviews to the focused new discoveries. The first paper entitled "Optimal Design and Operation of a Remote Hybrid Microgrid" as written by Dr. Farzam Nejabatkhah and his colleagues at the University of Albert (Canada) presented the design, operation, and dispatch strategies for an isolated hybrid microgrid containing photovoltaic (PV) systems, battery energy storage systems (BESS) and diesel generators. A Northern remote off-grid community in Canada was used for the case study. Custom models to accurately represent all components of the hybrid microgrid in the Northern climate were developed. Optimization algorithm that minimizes the annual system cost were developed to size the PV and BESS. The paper demonstrated both cost saving and power quality improvement with the installation of PV and BESS systems, which may present guidelines for achieving similar benefits in other isolated hybrid microgrids.

The second paper contributed by Dr. Meiqin Mao and her colleagues at Hefei University of Technology (China) has a title of "Decentralized Coordination Power Control for Islanding Microgrid Based on PV/BES-VSG". The paper proposed a decentralized virtual synchronous generator (VSG)-based adaptive coordinated control strategy for islanded microgrids consisting of photovoltaic generators combined with battery energy storage (BES) on the DC side (PV/BES-VSG). With the proposed method, the droop characteristics of VSGs could be adaptively adjusted according to the DC bus voltage. The local controllers of PV/BES-VSG units could switch between the operating modes automatically without the need of a central controller. In this way, the power sharing among PV/BES-VSG units was achieved according to the maximum output power of PVs and the limit of charging/discharging power of BES, leading to the maximum utilization of renewable energy resources.

The third paper on "Power System Support Functions Provided by Smart Inverters–A Review" was contributed by Dr. Xin Zhao and his colleagues at the University of New Brunswick (Canada). The paper reviewed the new development in international standards relevant to "smart inverters" for distributed energy resources, particularly for the provision of grid support functions, such as reactive power control, harmonic compensation, voltage and frequency fault ride-through, which is key to achieving higher utilization of renewable energy based distribution generation systems in the distribution power networks. Experimental results from smart inverters were given in the paper to demonstrate the implementation of these power system support functions in contributing to reduced cost of energy and additional system resources.

The fourth paper is on an interesting topic of "Integration of Distributed Energy Resources into Offshore and Subsea Grids", and was submitted by Ms. Razieh Nejati Fard and Dr. Elisabetta Tedeschi of the Norwegian University of Science and Technology (Norway). This paper reviewed the recent developments in offshore and subsea electric distribution grids, particularly in case of high penetration of distributed and intermittent renewable energy sources. The paper provided an overview of electric loads operating in the ocean environment, their power and energy demands, and their main operational characteristics and corresponding maturity of technologies.

This paper presented the emerging trends in the electrification of the ocean space through the development of "offshore smart grids", a fascinating area where most of us would have not been exposed to yet.

The fifth paper entitled "Reconfiguration of NPC Multilevel Inverters to Mitigate Short Circuit Faults Using Back-to-Back Switches" was composed by Mr. Weiqiang Chen and his colleagues at University of Connecticut. This paper proposed a new reconfiguration method to mitigate short circuit faults in any devices and at any voltage levels in neutral point clamped (NPC) multilevel inverters which have been widely used as power conversion apparatuses for distributed energy resources. Simulation was conducted on a five-level NPC inverter with non-idealities to verify the proposed reconfiguration method. A five-level NPC inverter was built and tested to experimentally demonstrate that the proposed method could lead to a quick and effective recovery of the NPC inverter from faulty conditions.

I would like to express my deep gratitude to the industrious and thorough work of the guest associate editors of this Special Issue in selecting these high quality papers from a pool of manuscripts submitted for consideration for publication. I wish to thank the tremendous efforts of the expert reviewers who have provided invaluable, in-depth comments and suggestions in assessing and recommending the submitted manuscripts.

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Dr. Chang was the recipient of CanWEA R.J. Templin Award in 2010 for his contributions in the development of wind energy technologies, and the Innovation Award for Excellence in Applied Research in New Brunswick in 2016 for his contributions in renewable energy conversion. He is a fellow of Canadian Academy of Engineering (FCAE). He has published more than 350 refereed papers in journals and conference proceedings. Dr. Chang has focused on research, development, demonstration and deployment of grid-connected power converters, renewable energy based distributed generation systems and direct load control systems.