Preface

The electrical grid in the twenty-first century is experiencing major changes all over the world in order to become smarter, cleaner, more efficient, and reliable. Among different sources of renewable energy, wind and solar energy are gaining popularity in most countries. Due to the variable nature of renewable energy sources, in terms of power including real and reactive power, output voltage, and frequency, it is a major challenging issue for the current power industry to integrate large-scale wind and solar photovoltaic (PV) energy into the grid. There are over 69.68 GW of PV and 250 GW of wind power generation installed worldwide. More than 200 PV power plants have already been installed in the world, each of them generating an output of more than 10 MW. In these plants, 34 are located in Spain and 26 in Germany. The number of PV power plants will continue to rise. More than 250 PV power plants will be installed for the next few years. The output power of today's wind generators has exceeded 7 MW. For example, since 2011 ENERCON has been producing wind turbine E-126/7500 with a power capacity of 7.5 MW. Currently, Sway Turbine and Windtec Solutions are developing 10 MW wind turbine generators, which are expected to be commercially available by 2015.

This book is intended to cover the technical and regulatory issues related to the large-scale renewable power generation, transmission and distribution, storage, and protection to form a smart grid with sustainable environment. A main objective of the book is to show the relevance of large-scale renewable power generation and the role that this emerging field of technology can play for the transition toward a sustainable world. The latest developments and advances in technology, materials, systems, and processes in energy generation, transmission and distribution, energy storage, and protection are highlighted in this book.

The book is focused on different issues, such as generation, transmission and distribution, storage, and protection. It presents the critical issues related to large-scale renewable power generation, such as uncertainty modeling techniques, statistical characteristics of renewable sources, energy conversion efficiency, and compact and lightweight generation systems. It also contains the development of medium voltage converters for step-up-transformer-less direct grid integration of renewable generation units, grid codes, and resiliency analysis for large-scale renewable power generation, active power and frequency control, and HVDC transmission. The emerging SMES technology for controlling and integrating large-scale renewable power systems is also discussed. As the protection issues with large-scale distributed renewable power systems will be different compared to the existing protection system for one-way power flow, this book will provide new protection technique for renewable generators.

"Taxonomy of Uncertainty Modeling Techniques in Renewable Energy System Studies" of this book discusses different uncertainty modeling tools used for renewable energy system studies and then the appropriate ones for renewable energies are identified. The probabilistic modeling and statistical characteristics of aggregated wind power in large electrical systems are discussed in "Probabilistic Modeling and Statistical Characteristics of Aggregate Wind Power" and the conversion efficiency improvement methodology for GaAs solar cells are presented in "Conversion Efficiency Improvement in GaAs Solar Cells." "Emerging SMES Technology into Energy Storage Systems and Smart Grid Applications" presents the application of superconducting magnetic energy storage (SMES) in the energy storage systems and the future smart grids. Different multilevel converter topologies with switching and control issues analyzed for their medium voltage applications are provided in "Multilevel Converters for Step-Up-Transformer-Less Direct Integration of Renewable Generation Units with Medium Voltage Smart Microgrids." "A Review of Interconnection Rules for Large-Scale Renewable Power Generation" presents a comprehensive study of the grid interconnection rules set by various transmission system operators and regulators for large renewable-based power plants. A complex network framework-based network resiliency (percolation) analysis, for the future grid with large-scale renewable energy, is presented in "Resiliency Analysis of Large-Scale Renewable Enriched Power Grid: A Network Percolation-Based Approach." The aims of "Frequency Control and Inertial Response Schemes for the Future Power Networks" and "Active Power and Frequency Control Considering Large-Scale RES" are to present the fundamental aspects about system frequency and active power control for the power networks with low inertia renewable.

One of the important aspects of renewable energy integration is to analyze its impact on power system reliability which is discussed in "Impact of Large Penetration of Correlated Wind Generation on Power System Reliability" and "HVDC Transmission for Offshore Wind Farm" present an overview of different topologies for grid integration of offshore wind farms. The protection schemes, technical challenges, and difficulties for different wind generators are given in "Wind Farm Protection" and its impact on distance relay is discussed in "Wind Power Plants and FACTS Devices Influence in the Performance of Distance Relays." Next the protection scheme of high voltage direct current (HVDC) transmission systems for large-scale offshore wind farms is presented in "Protection Schemes for Meshed VSC-HVDC Transmission Systems for Large-Scale Offshore Wind Farms."

As brushless doubly-fed reluctance generator (BDFRG) for large-scale grid-connected wind turbines is a promising technology, its operation and control strategy are addressed in "Control of Emerging Brushless Doubly-Fed Reluctance Wind Turbine Generators" and an optimal energy management in energy hub for intermittent wind power is presented in "Energy Hub Management with

Intermittent Wind Power." Finally, "Adopting the IEC Common Information Model to Enable Smart Grid Interoperability and Knowledge Representation Processes" discusses the philosophy and processes underpinning smart grid information interoperability to enable power utilities to build and control the emerging smart grid and it elaborates upon how the common information model fits within a standardized power system interoperability framework.

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