Volume 2

SMART GRID HANDBOOK

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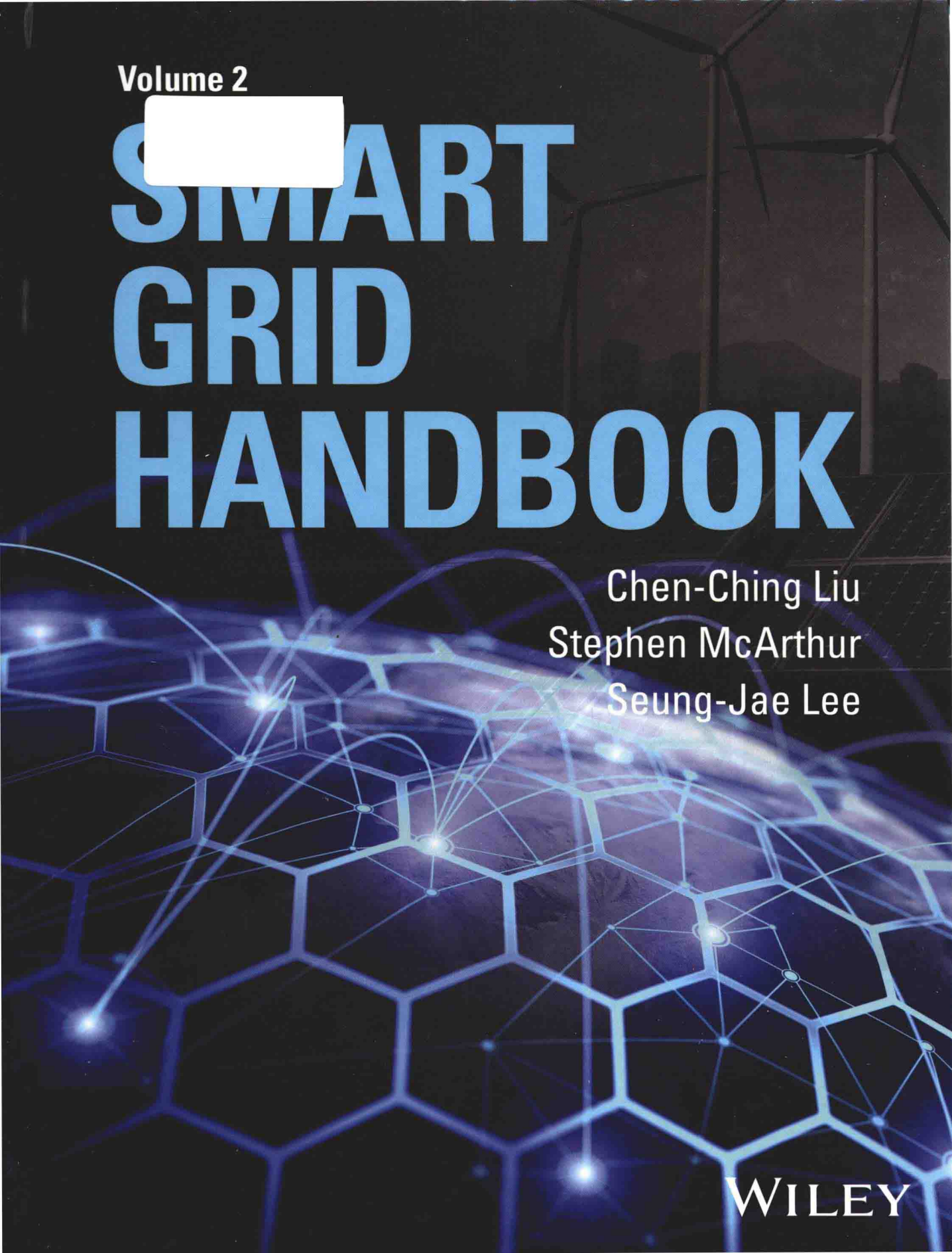

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SMART GRID HANDBOOK

VOLUME 2

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SMART GRID HANDBOOK

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Preface

Over the last several years, the development of smart grids has become a global trend for electric power grids. Although there is not a unique and widely adopted definition of the term, "Smart Grid," the development is driven by the sea change that is taking place in the power and energy industry. Renewable energy, particularly wind and solar, increases dramatically and represents a significant portion of the power generation capacity. Distributed generation, energy storage, and microgrids are moving power systems towards a de-centralized operational environment. Demand side response is evolving into a market mechanism where customers participate by managing their utilization of electric energy. Smart meters serve as the enabling technology that connects millions of customers with the power grid. The fundamental shift in the paradigm is driven by the international concern over energy and its environmental impact on climate change.

The smart grid concept is also motivated by the need to enhance the reliability of electric power systems. Widespread catastrophic outages caused by cascading events call for new technologies to enhance the monitoring, control, protection, and restoration of the power grids. In the last decade, a large number of Phasor Measurement Units (PMUs) have been installed on the grids in several countries to allow power system dynamics to be sampled much more frequently compared to what was possible with traditional supervisory control and data acquisition systems. The level of automation in the distribution level is greatly improved by the installation of numerous remote-controlled switches and voltage/var controllers. The smart grid depends on the underlying information and communications technology to provide the extensive connectivity among the enormous number of devices and systems on the grid. To a great extent, the "smart" nature of the emerging power grid depends on the massive amount of information brought through this connectivity.

This Handbook is focused on smart grid issues and, as a result, it is not intended to be a comprehensive reference for other related subjects such as renewable energy. Due to the global nature of smart grid development, we have made a great effort to represent a broad range of international perspectives. A total of 83 articles in the three volumes of the Handbook are organized into Sections based on the most relevant subjects on the smart grid: Vision and Drivers, Transmission, Distribution, Smart Meters and Customers, Information and Communications Technology, and Socio-Economic Issues:

- The first section, Vision and Drivers, includes articles that are concerned with the vision, definitions, evolution, and global development of the smart grid as well as new technologies and standards. The roles of renewable energy, demand response, and energy storage are discussed.
- The section on Transmission begins with a set of articles on the deployment of PMUs and their applications; for example, wide area monitoring, monitoring of power system dynamics, testing and standards of PMUs, and future energy management systems. The background of the technology deployment is provided by an article about cascading events causing catastrophic outages in power grids. This section then covers smart grid technologies including remedial control and defense systems, Flexible AC Transmission Systems (FACTS), High Voltage DC (HVDC), dynamic state estimation, dynamic security assessment, power system restoration, load modeling, and reliability evaluation. The coverage is completed through discussions of the industry practice, operational experience, standards, cyber security, and grid codes.

- The Distribution section starts with an introduction to distribution systems and the system configurations in different countries and different load areas served by the grid. Following the introduction are articles describing elements of smart grid in the distribution systems, i.e., control architecture, communications, distributed energy resources, electric vehicles as a distributed resource for energy storage, microgrids, renewable energy devices, power electronics, advanced protection systems, distribution PMUs, cyber security, and distribution/substation automation technologies. A set of articles provides the state-of-the-art in smart grid applications, e.g., feeder automation, Distribution Management System, Voltage/Var control, Conservation Voltage Reduction (CVR), active network management, power quality, condition monitoring and asset management, and reliability evaluation. Similar to the Transmission section, articles also address issues of industry practice, operational experience, and the international perspectives on the topics.
- The section on Smart Meters and Customers is concerned with smart meters and how they enable the customers to interact with the power grid. The industry perspective is provided by articles about drivers for smart meters, their functions, data collection and management and implementations as well as standards and security of smart meters. The section has articles detailing how research and development concerning smart meters has addressed issues around customer choices, customer behaviors, demand response, and home energy management. This section also includes an article that examines the issue of health effects of smart meters based on research.
- On the subject on Information and Communications Technology (ICT), the section includes articles that discuss the elements of ICT required for smart grid development, which includes interoperability and relevant standards, hardware-in-the-loop modeling and simulation, and system level simulation. Other articles are concerned with their application, such as distributed intelligence, transactive energy systems, and data analytics. Industry practice and operational experience are also covered.
- Smart grid development is not simply a matter of technology development and deployment. There are critical Socio-Economic Issues that must be addressed in order to gain public acceptance. The final section deals with these socio-economic issues. The section starts with an introduction to these issues, followed by articles concerning markets, regulation, cost-benefit analysis, organizational models, privacy, and social acceptance.

The development of this Handbook has been a major project that required a large international team of experts representing smart grid R&D, technology deployment, standards, industry practice, and socio-economic aspects. This major outcome cannot be achieved without the tremendous contributions and efforts from the team of Section Editors: Dan Ton, Xiaoxin Zhou, Kevin Tomsovic, Vladimir Terzija, Kevin Schneider, Seongil Lim, Diane Cook, Ron Ambrosio, and Michael Pollitt. They should be proud of the accomplishment of the Handbook and its contribution to the field of smart grid. Needless to say, the authors of all articles deserve special recognition. Smart grid is a dynamic field that is evolving over time and on a global basis. The vast experience of the invited authors brings an authoritative view of the state-of-the art. With Wiley's vision and strong support, we are privileged to have worked with the distinguished team of authors and section editors on this important project as we enter a new era of electric power systems.

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