Preface

With the developments of communication technology, measurement technology, computer technology, control theory, and applications of new primary and secondary devices (e.g., flexible alternating current transmission system devices, nonlinear optimization subduer (no power system stabilizers), dispersed reactive power compensator (distribution static synchronous compensator), filter, and phaser measurement units) in power systems, people have higher demands and expectations for modern and future power systems. Researchers around the world have proposed a series of concepts such as digital power system [1], smart power system [2–4], intelligent dispatching control center, advanced dispatching automation system, smart grid, and micro-grid to describe the possible forms of future power systems.

It has been a long time since these concepts have been proposed. Nonetheless, some issues still need to be clarified, for example, the relationships among the digital power system, smart power system and smart grid; definitions, principles, and objectives of these systems; and how these systems are implemented. In this book, the smart power system is defined as the initial stage of the digital power system. The concept of a smart power system is one of the subconcepts of the digital power system. We claim that the smart power system is a power system with a multi-index optimality-approximating capability. In other words, the power system with such capability is smart and intelligent. This book presents the relationships between smart power systems and smart grids proposed by former President Obama in terms of concepts, frameworks, principles, configurations, and project practice.

The book comprises nine chapters. Chapter 1 describes the basic concepts, structures, and significance of smart power systems. Meanwhile, it provides a brief introduction to the relevant researches. We hope to make it easier for a reader to comprehend the possible forms of future power systems.

Chapter 2 introduces the basic theory, namely power system hybrid control theory, to accomplish the objectives listed in Chapter 1. It should be noted that it is hard to achieve multi-index optimality-approximating power system operations with existing methods since the power system is a high-dimensional nonlinear system. The authors of this book offer an effective way to solve this problem. The Event-driven methodology is recommended to eliminate the unsatisfied state to achieve multi-index optimality-approximating operations. As a consequence, power system hybrid control theory is the theoretical basis for the smart power system (at least dispatching of the smart power system).

Chapters 3 and 4 introduce the infrastructure and basic platforms of smart power systems. In Chapter 3, the infrastructures of the smart power system are introduced, including digital substations, digital power plants, and digital transmission lines. On the one hand, they provide data sources for global information sharing. On the other hand, they provide means for coordinative control. They are indispensable components for information exchange in smart power systems.

Chapter 4 introduces the basic communication platform and data-sharing platform. The former is a physical transmission platform for the exchange of data. The requirements, architecture, and key technologies of the basic communication platform are illustrated in Chapter 4 in detail. A data-sharing platform is a logical transmission platform for the integration of data. It is composed of a universal data access interface, common information model, and data exchange platform. The independence between the data access method and the application is achieved through the universal data access interface during data exchange. The independence between data representation and application is achieved through a common information model. The independence between data processing and data locating is achieved by the data exchange platform. Data processing and data locating share a common data-sharing mechanism, thereby improving the consistency and validity of the data.

Chapters 5–7 describe the key technologies in smart power systems. In Chapter 5, a smart power system operation index system is proposed. It is used to evaluate whether the system is in multi-index optimality-approximating operation states. Key technologies (advanced state estimation algorithm and optimal power flow algorithm based on constraint transformation technology) for event processing and analysis in smart power systems are introduced in Chapter 6. Chapter 7 introduces the visualization techniques of a smart power system, a combination of machine intelligence and the artificial intelligence of system operators.

Chapter 8 presents the smart energy management system (SEMS). In this chapter, the definition, characteristics, fundamental algorithms, and structures of the SEMS are introduced.

Chapter 9 introduces some definitions, contents, and new technologies related to the smart grid which are of common concern to academia and industry at present, including distributed energy technology, large storage and long-life energy storage technology, new technology of grid interaction with users, and operation control of distribution network, especially new technology of network reconstruction (self-healing). The proposal and development of these new technologies enrich the regulation methods of distribution networks and users. It contributes to improving the reliability, economy, and quality of power supply, enhancing the interaction ability of users in the power supply, and developing the smart power system.

In sum, this book is intended to forecast future trends of development of power systems combining theory and practice, show the orientation of technical innovation in the field of dispatching automation of power systems, and offer an effective solution to the construction of smart power systems and smart grids in China.

This book summarizes the author's research on smart power systems and smart grids in recent years under the national 973 Project, the National Natural Science Foundation of China, the State Grid Corporation of China, and the South Grid Corporation of China.

Smart power systems and smart grids are emerging subjects and fields. It is still at a developmental stage. Further research efforts and innovations are required from researchers and practicing engineers worldwide.