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Qiuye Sun

# Energy Internet and We-Energy

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# Preface

*Background of This Book* Energy is the driving force of social and economic development, and it is the important material basis for human survival. The use of energy varied over time, from the age of firewood to the coal age of fossil energy, the age of the oil and gas, the electrical age, and by now the era of clean energy represented by wind, solar energy, water energy, and biomass energy. The change of utilization of energy is accompanied by great progress of human civilization and a great leap in the productive forces of society and economy. Social development and scientific and technological progress increase human's dependence on energy. Thus taking the third industrial revolution as an opportunity, establishing a safe, efficient, economic and environmental new energy supply model has become a great challenge in the process of sustainable development of human society.

On the basis of the idea of free transmission and open sharing of Internet information, the practitioners of the energy industry propose to build a new environmental-friendly energy network, with the characteristics of open interconnection, interactive sharing, and economic-information-energy integration, to achieve low carbon production and consumption of energy and ensure the sustainable development of energy. Therefore, the Energy Internet comes into being and attracts widespread attention from energy and correlated industries worldwide within a short time. People try to interpret it from many aspects such as society, environment, economy, technology. However, what is the definition of Energy Internet? Is the energy network with various types of energy sources connected the Energy Internet? Is it a combination of energy and the Internet? Or is it a network just so-called smart grid 2.0? Perhaps all of opinions mentioned above depict features of Energy Internet partially, but not all characteristics of Energy Internet. The authors believe that the Energy Internet is a network with high complexity where information and energy are integrated in depth and share equal access to multiple types of energy resources through a variety of energy transmission media. What's more, it is a novel energy production, transmission, and consumption network which can realize the open sharing of information and energy internally and achieve efficient and environmental-friendly utilization of energy.

Since the Internet and the Energy Internet are inextricably linked, does the Energy Internet inherit all the characteristics of the Internet? Can information at any point of Energy Internet be obtained by the whole network? Can information be duplicated and restored infinitely in Energy Internet? Can any user in Energy Internet be the publisher and receiver of information at the same time? In order to answer these questions better, this book presents the concept of We-Energy, a novel energy interaction mode based on a cyber-physical-economy-energy model. On the basis of this concept, we will interpret the Energy Internet and its energy conversion process.

We-Energy is a combination of energy producers, energy storage devices, and consumers, it is capable to transform various types of energy such as electricity, district heat, and natural gas into desired energy types. It can exchange with others using advanced communication, electronic conversion, and automatic control technology. We-Energy is located at the bottom of the information network and energy network; it can absorb energy from the energy bus and can also provide energy for it. Unlike traditional energy suppliers, We-Energy adopts a structure which allows bottom-to-top power interaction from users. What's more, it holds a concept of point-to-point energy transmission. We-Energy has some important characteristics such as source and load coordination, multi-energy complementarity, peer-to-peer access, energy-information-economic coupling, and plug-and-play. We-Energy promotes the efficient use of energy and achieves the transformation from traditional vertical power dispatch pattern to a distributed and coordinated power dispatch pattern. Furthermore, it completes the transition from fossil energy to renewable energy and ultimately brings human society into the era of zero marginal energy costs.

Unwittingly, Energy Internet has attracted great attention worldwide; from being rarely known, various related technologies have sprung up. However, it still calls for great effort of all aspects from technology and economy to national policy to achieve the landing of Energy Internet down to earth. What is worth of mentioning, how to make more researchers and energy users to know Energy Internet and realize their positions in Energy Internet, and how to promote the generation and connection to grid of We-Energies have become the key factors during the smooth landing of Energy Internet. Over the past few years, the authors have been promoting related academic work through Energy Internet forums, reports, and conferences. Therefore, in this book, rather than present intricate formula deduction and complex system analysis, the authors strive to present Energy Internet to readers in an intuitive way by using straightaway sentences and diagrams.

This book is divided into two parts. The first part including Chaps. 1–4 mainly makes an overall introduction of Energy Internet and its integrated applications. In this part, the authors briefly introduce the origin of the concept of We-Energy and depict the structural features of the Energy Internet. Analysis on the network characteristics and security of information physics technologies have been done as well. The second part including Chaps. 5–10 focuses on specific research on Energy Internet. Coordinated control strategies for power management of hybrid micro-grid and distributed coordination control of multi-agent have been proposed. Research

on energy router has also been done including its control strategy and stability analysis. What's more, the modeling and dual control strategies of energy hubs have been presented in this book. The energy flow calculation of the multi-energy system has been carried out including power flow calculation under steady state and reinforcement learning-based distributed energy flow calculation. Additionally, issues on optimal operation of Energy Internet have been done and consist of distributed cooperative management and reinforcement learning-based multi-WE-energy management.

As a complex network with energy, device, information, and economic coupling, Energy Internet needs to be viewed from a new perspective. The book tries to depict the characteristics of Energy Internet from multiple aspects, such as electrical, thermal, and information, for the first time. The authors hope to provide a helpful reference for readers.

The authors would like to acknowledge all of the help and encouragement received in the development of this book. Many of our graduate students and colleagues have contributed to the materials of this book. They are Jianguo Zhou, Fei Teng, Yushuai Li, Bingyu Wang, Yuyang Li, Rui Wang, Jingwei Hu, Lingxiao Yang, Ning Zhang, Danlu Wang, Yi Zhang, Xiaoting Yu, Qianyu Dong, Qian Sun, Dehao Qin. Finally, Qiuye Sun has checked the whole book carefully. At the same time, I want to thank the researchers for their efforts on Energy Internet so that I can successfully complete the book.

Shenyang, China

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