SMART ELECTRICITY DISTRIBUTION NETWORKS

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Smart Electricity Distribution Networks

PREFACE

Smart grid involves modernizing electric power networks and changing the way they are planned and operated. It empowers energy consumers, provides new services and supports the transition to a sustainable low-carbon economy. Although the driving forces and the objectives of smart grid development are different in different countries, smart distribution networks are always one of the key research and development topics.

The use of distributed energy resources (DERs), e.g. distributed generation, flexible loads and energy storage, is increasing rapidly in many countries and this can lead to operational difficulties in distribution networks. The changes that are already occurring in distribution networks include a dramatic increase in intermittent distributed generation while new home energy management and electric vehicle charging systems are introducing new patterns of load. Power flows in the distribution network are becoming more volatile and unpredictable as new types of generation and loads are connected, and customers gain greater understanding and control of their loads. In response to these changes, sophisticated measurement, control and ICT systems are being deployed throughout the network, and new incentives and market arrangements are emerging.

These changes to the distribution system will accelerate over the coming decades and the behaviour of distribution networks will become increasingly uncertain as new smart grid and smart energy interventions are introduced. Hence, there is a growing need for academia, industry and policymakers to move towards new planning and operation approaches to electricity distribution networks considering emerging technologies and uncertainties.

The aim of this book is to provide a fundamental discussion of smart distribution networks and the new technologies associated with them. The topics that are covered include an introduction to the new technologies in electricity distribution, which include various kinds of generation connected at the distribution level. Different concepts to manage a high penetration of DERs are discussed, including demand-side integration,

microgrids, CELLs and virtual power plants. From the perspective of distribution network development, information and communication infrastructure and new devices are addressed. Methods to analyse smart distribution systems are then described, including both steady state and transient analysis. The operation and planning of smart distribution networks are reviewed and DC distribution networks discussed.

This book will be valuable to all those who want to understand the key enabling technologies and performance of smart electricity distribution networks. It will allow readers to engage with the immediate development of electricity distribution networks and take part in the wider debate over the future smart grid.

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Specific sections of the book arose from several other collaborative projects and case studies, which include the European Commission Horizon 2020 project 'Peer to Peer Smart Energy Distribution Networks', EPSRC projects 'MISTRAL: Multi-Scale Infrastructure Systems Analytics' and 'Increasing the Observability of Electrical Distribution Systems using Smart Meters', the NIC project ANGLE-DC, the National 863 Program of China 'Research and Development of Self-Healing Control Technologies of Smart Distribution System', the NFSC project 'Protection and Control of Active Electrical Distribution Network' and the NRC (Sri Lanka) project 'DC networks for Energy Efficiency and Renewable Additions'.

We have learnt from collaborations and conversations with a number of industrial and public sector partners, including the State Grid of China, China Southern Power Grid, National Grid of the United Kingdom, Scottish Power Energy Networks, Toshiba Europe TRL, Electric Corby and others.

We acknowledge contributions from colleagues and individuals. We thank Dr. Xialin Li, Dr. Hao Yu, Dr. Chongbo Sun, Dr. Bingqi Jiao, Yixin Liu at Tianjin University and Dr. Meng Cheng at Cardiff University, who helped in numerous ways.

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