RENEWABLE ENERGY INTEGRATION

PRACTICAL MANAGEMENT OF VARIABILITY, UNCERTAINTY, AND FLEXIBILITY IN POWER GRIDS

Editor
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Renewable Energy Integration

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Renewable Energy Integration

Praise for Renewable Energy Integration

In order to double the share of renewable energy in the global energy mix – one of the three goals of the UN Sustainable Energy for All initiative - there will need to be tools and methods for integrating high levels of variable renewable electricity into power systems and markets worldwide. This book makes an important contribution to the regulatory, operations, economic and technical aspects of that challenge. By bringing together cutting edge approaches, Dr. Jones has done much of the hard work for us. It is an extraordinary snapshot of the state-of-the-art, and I am very glad to recommend it to decision-makers in both industrialized and emerging economies alike.

Dr. Kandeh Yumkella, Under Secretary of the United Nations, Special Representative to the United Nations Secretary General, and CEO for UN Sustainable Energy for All (SE4All) Initiative General of the United Nations, Special Representative of the United Nations Secretary Sustainable Energy for All (SE4All)

With the demand for water, food and energy growing beyond all measure and with the supply of these inextricably linked 'resource spheres' under increasing threat, we are facing what many experts predict will be a 'perfect storm'. The threat to human life, as well as to whole sectors of the economy, is very real. Renewable energy can be a vital part of the solution and if this comprehensive and authoritative set of essays can help to accelerate both the generation and integration of renewable energy supplies then it will have served an invaluable purpose.

Paul Polman, Chief Executive Officer of Unilever, and Chairman, World Business Council for Sustainable Development

A typically outstanding effort by Dr. Jones and his assembled expert authors. A timely, "must read" for managing the energy trifecta of addressing climate concerns and energy poverty while maintaining economic viability and promoting more secure, reliable and sustainable fuel choices. The chapters deal head on with the key issues of the day (VER, storage, distributed energy, etc.) and suggest that while we should enjoy the success of the unconventionals revolution, we need to use the breathing space this moment provides to seriously move on to more sustainable energy forms.

Frank Verrastro, Senior Vice President and James Schlesinger Chair for Energy & Geopolitics, Center for Strategic and International Studies

Bravo! This book is an important resource. As renewable energy plays an increasingly important role in electric grids in the years ahead, this rich volume will help policymakers, utility executives, technology providers and many more.

David Sandalow, Inaugural Fellow, Center on Global Energy Policy, Columbia University

The efficient integration of renewable energy is one of the most important challenges posed by the move towards sustainable energy systems. Renewable energy challenges the norms and traditions accumulated over the last century, and it requires new dynamic approaches that match the needs

and requirements of a modern, sustainable power system. Many of these issues are considered in this publication, which gives new insights into how power systems can move forward and provide society with clean, reliable and affordable electricity.

Christian Pilgaard Zinglersen, Deputy Permanent Secretary,
Danish Ministry of Climate, Energy and Building

The use of renewable energy in modern power systems has accelerated rapidly in recent years – beyond what some skeptics thought possible. There could not be a more timely topic than the practical integration of these resources into large-scale grids. This collection of expert guidance is not only valuable now, but surely will need a fresh edition on an annual basis for the foreseeable future as technology continues to evolve.

Reid Detchon, Vice President, United Nations Foundation, and Executive Director,
Energy Futures Coalition

Dr. Lawrence Jones has assembled an exceptional team of experts to provide deep insights into the challenges of fully leveraging renewable generation across the globe. This book will serve as a great reference source for interested readers from all levels of knowledge regardless of their area of interest. From policy to engineering to operations, it has insights for all. Innovation in the electric energy sector offers great promise for clean, reliable, resilient and affordable power across the globe, however this same innovation is increasing the complexity of an already complex system. This book gives the reader an introduction into this promise as well as into the complexity that it will bring.

Becky Harrison, Chief Executive Officer, GridWise Alliance

Transitioning our power system to clean, renewable energy is one of the most important challenges of our lifetime. In many ways the task is familiar, as since the days of Edison and Westinghouse grid operators have accommodated fluctuating electricity demand and abrupt power plant failures to keep electricity supply and demand in balance. From remote Pacific islands to mainland Europe, Jones insightfully spans the globe to distill the success stories of grid operators who now reliably obtain more than a quarter of their electricity from wind and solar energy. The path forward for integrating even higher levels of renewable energy is clear, and we have the technology to do it today.

Rob Gramlich, Senior Vice President, American Wind Energy Association

Electrical systems around the world are undergoing radical change due to the rapid growth of solar and wind energy. We must modernize the grid to make it compatible with these critically important energy sources. This collection provides real-world examples of how the power sector, and society's leaders generally, can achieve this goal, which is key to energy security, environmental protection, and economic progress.

Andrew L. Shapiro, Founder & Partner, Broadscale Group

As the world searches for pathways towards a sustainable and inclusive energy future, one of the fundamental opportunities lies in ensuring that renewable energy technologies meet their vast potential. To that end, it has become evident that we need to urgently address the tools, regulations, and operational and institutional issues that will serve to elegantly integrate

renewable energy generation into the wider power system. Through rigorous analysis and sensitively designed contributions, Dr. Jones has brought us a book on just the right topic at just the right time. It clearly and coherently presents the state-of-the-art on this complex set of issues, and provides us with the confidence that these challenges can be addressed.

Dr. Morgan Bazilian, Adjunct Professor, Sustainable Engineering Lab, Columbia University

To simultaneously address climate change and meet the needs of the global poor for clean energy, renewable energy on a very large scale will have to play a central role. This book provides a detailed response to the central challenge in making this dream a reality: how to integrate clean but intermittent energy sources within utility systems that require a high degree of central planning and coordination.

Alan Miller, Principal Climate Change Specialist, International Finance Corporation (retired)

Solar and wind power is growing around the globe. Merits are obvious; fuel free electricity production is advantageous in terms of climate footprint and absence of other pollutants. However, integration of these variable power sources is challenging. This book is a comprehensive collection of contributions ranging from very technical challenges to market models and policies for this new era of electricity. Read and you will broaden and deepen your expertise in how to best integrate renewables in our power systems.

Dr. Magnus Olofsson, President, Elforsk—Swedish Electrical Utilities' Research & Development Company

Great book! Lawrence Jones has managed to capture the most important renewable energy topics in a single volume, and he has done so through the contributions of working experts in each topic. If you are interested in renewable energy integration, this book captures the current state-of-the-art for the entire field.

Mark Ahlstrom, CEO WindLogics

Renewable generation is becoming ever more prolific. The timing of this book is perfect. It combines practical examples with theory and will guide decision makers dealing with today's issues as well as those seeking ways to deal with tomorrow's challenges. The lessons learned will help avoid pitfalls and provide insight and inspiration. The topics covered are relevant to both developed and developing countries, those countries starting from a low renewables base as well as those with high proportions of renewables.

Eric Pyle, Chief Executive New Zealand Wind Energy Association

The timing of the publication is just perfect. Renewable energy has gone mainstream globally i.e. 45 GW of new wind installations in 2013. The content and focus of this remarkable book is both unique and demanding. It's all about integration: of markets, physical infrastructure, policies. This integrated approach is as often lacking in current debates as it is needed for progress. And the design both of the modern electricity markets and a modern grid are crucial for a transition to safer, cleaner energy world of the future. No transition without transmission, and no communication without electrification. Reading this book you might learn how integration can accelerate the transition.

Dr. Klaus Rave, Chairman Global Wind Energy Council

With wind and solar energy expanding at an ever-quickening pace, the time is right for a thorough and cross-disciplinary assessment of the integration challenge. This book hits the mark, with the industry's leading experts addressing a wide assortment of topics that are central to managing higher shares of variable generation.

Dr. Ryan H. Wiser, Staff Scientist, Lawrence Berkeley National Laboratory

Renewable Energy Integration is a critically needed and wonderfully comprehensive book that highlights the next frontier; not how much renewable energy potential exists, but how to most effectively and seamlessly merge this new power system with the old one.

Daniel Kammen, Class of 1935 Distinguished Professor of Energy, University of California, Berkeley

Understanding the intricacies discussed in Renewable Energy Integration is a predicate for achieving universal access to affordable, sustainable, reliable energy across a diverse portfolio of fuel sources. Towards this end, we must be able to maintain the balance and resilience of the power grid using technology, regulatory, and market forces. Dr. Lawrence Jones' outstanding compendium, based on an in-depth array of insights from an unique cast of renowned thought leaders, demonstrates that he clearly understands how critical this subject is for quality of life, continued economic growth and prosperity around the globe.

Hon. Vicky A. Bailey, former Assistant Secretary, International Affairs and Domestic Policy, Department of Energy and Former Commissioner, Federal Energy Regulatory Commission

There are many that have made a convincing case that we could move to 80% renewable electricity generation by 2030. As we unlock the greatest wealth creation opportunity since the mobile phone revolution, I am sure this resource from Dr. Jones and his assembled dreamteam will find its way onto the desks of every major grid operator and electricity policymaker in the World.

Jigar Shah, Founder SunEdison and Author of Creating Climate Wealth

The future of the energy landscape cannot be envisioned without taking into account renewable energy. It is a secret for no one however that the integration of renewable energy into the grid is an important challenge that will need to be overcome if we want to ensure its deployment to full capacity. Dr. Lawrence Jones brings together critical contributions from experts across the globe to address precisely these issues in a must-read, unique publication. It is an invaluable resource for anyone in the industry who wants a comprehensive overview of one of today and tomorrow's hottest topics.

Pierre Bernard, Founder and Managing Partner, Bernard Energy Advocacy

This book is dedicated to my parents, Emmanuel E. W. Jones, Jr. and Comfort H. Jones, who taught me many valuable lessons in life, two of which guided me especially on this journey: to always value and respect humanity and nature; and to work with people from different backgrounds toward a higher purpose.

This book honors the operators of power grids around the world. They are the unsung heroes and heroines who work around the clock, ensuring that we have electricity to light up our nights and fuel our lives.

About the Contributors

V.K. Agrawal is Executive Director at Power System Operation Corporation Ltd (POSOCO), in charge of the National Load Dispatch Centre of India. He has an M. Tech in 'Power Apparatus and Systems' from Indian Institute of Technology, Delhi and more than 33 years of experience in the power sector. Mr Agrawal has worked on the expansion and synchronization of large regional grids and development of power markets in India.

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Anders N. Andersen holds a master's degree in Mathematics and Physics, and a bachelor's degree in Economics from Aarhus University. He is Head of the Energy Systems Department at EMD International A/S and is Extension Associate Professor in energy planning at Aalborg University. He has more than 25 years of experience in the energy industry.

Göran Andersson obtained his M.S. (1975) and Ph.D. (1980) degrees from the University of Lund, Sweden. Since 2000 he is full professor in electric power systems at ETH Zürich, where he also heads the powers system laboratory. His research interests include power systems dynamics and control, power markets, and future energy systems.

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Ken Dragoon has more than 30 years in the power industry with responsibilities including power system planning, renewable resource acquisition and integration, and risk analysis. He is currently a Managing Consultant for Ecofys, a sustainable energy consulting firm. He authored a wind integration book: Valuing Wind Energy on Integrated Power Systems published by Elsevier in 2010.

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