

# Preface

To address the grand challenge of a sustainable energy future, there has been a surge of interest in renewable energy resources, including wind, solar, and bio-fuels. A very recent study by National Renewable Energy Lab (NREL), namely Western Wind and Solar Integration Study Phase 2, determined that up to 33 % wind and solar energy production in the Western grid of the United States would avoid dramatic reduction of carbon dioxide and nitrogen oxides emission. This level of greenhouse gas (GHG) emission reduction points to a bright future for renewable energy resources, provided that advancements are made to adequately integrate these resources in electric grid operations by developing tools and techniques to account for their inherent variability. The high penetration of wind energy generation, with their non-stationary and variable generation characteristics, however, introduces difficult-to-control dynamics and challenges for power system operation.

Building on the insight that massive data collected at wind farms contain rich statistical information, we devise data analytics based stochastic models to significantly improve the forecast accuracy of wind generation and aim to address the controllability and reliability of renewable generation integration. Specifically, in Chap. 1, we give an overview of the state-of-the-art wind power forecast. Chaps. 2 and 3 focus on the development of short-term wind power forecast using a spatio-temporal analysis approach. In Chap. 2, we investigate short-term forecast of wind farm generation by applying spatio-temporal analysis to extensive measurement data collected from a large wind farm and develop finite-state Markov-chain-based forecast models. In Chap. 3, we enhance the finite-state Markov models developed in Chap. 2 by incorporating the wind ramp forecast using support vector machines. In Chap. 4, we investigate stochastic optimization of economic dispatch using the proposed short-term wind power forecast. Finally, we draw conclusions and outline future research directions in Chap. 5. We hope this brief could be a useful reference for graduate students and professionals who are interested in data analytics for wind energy integration in smart grid.

We would like to thank National Renewable Energy Laboratory (NREL) and Xcel Energy for providing the data used in this study. We also would like to thank the Springer editors and staff for their great help in getting this brief published. This research work was supported in part by the US National Science Foundation under

Grant CPS-1035906, in part by the DTRA grant HDTRA1-13-1-0029, and in part by the Power System Engineering Research Center.

Tempe, AZ, USA  
Lubbock, TX, USA  
Tempe, AZ, USA  
Tempe, AZ, USA

Lei Yang  
Miao He  
Junshan Zhang  
Vijay Vittal

Spatio-Temporal Data Analytics for Wind Energy  
Integration

Yang, L.; He, M.; Zhang, J.; Vittal, V.

2014, VIII, 80 p. 34 illus., Softcover

ISBN: 978-3-319-12318-9