

# Preface

The importance of power and energy in modern society is well established and it is impossible to create a modern society and country without the existence of reliable power and energy systems. The continued development of reliable systems has been the main focus of power and energy system engineers for over a century. Reliability issues are integral elements in the planning and economics associated with any engineering system, and are embedded in basic project planning and appraisal techniques. As the complexities of modern power and energy systems grow, new approaches, techniques, and methods will be proposed for the evaluation and analysis of these systems. While rapid developments in the field of computational technologies have solved many issues related to the analysis of complex systems, the incorporation of new constraints arising from the use of particular technologies will dictate the solution techniques to be more creative and require considerable time to remodel, system test, and validate.

This Book Series entitled, “Reliable and Sustainable Electric Power and Energy Systems Management”, is intended to provide a platform for researchers, planners and policy makers to share their research outputs, ideas and opinions on the critical issue of sustainable and reliable power and energy systems. It also aims to provide impetus for critical research in this highly important area for modern society in the context of a meshed and complex environment that is affected by events taking place throughout the world. This book series is intended to be produced in separate volumes. The present book is the first volume of the Book Series. This volume is focused on new innovative research from academia and industry on understanding, quantifying and managing the risks associated with the uncertainty in wind variability. These are important issues in planning and operating electric power systems with acceptable levels of reliability and high proportions of wind power generation.

Five of the eight chapters in this book are extended versions of papers presented at the PMAPS-2012 Conference, June 10–14, 2012 in Istanbul, Turkey. The biennial Probability Methods Applied to Power Systems conferences are highly focused gatherings of international experts. Reliability analysis of renewable energy sources in electric power systems has been a major presentation and discussion topic in recent years and this activity is expected to continue in the future. All of the chapter authors

in this book are actively involved in PMAPS and many of them actively participated in the recent conference in Istanbul.

Wind power behaves quite differently from conventional electric power generating units due to its intermittent and diffuse nature. An important requirement in planning a wind integrated power system is to ascertain the capacity credit that can be assigned to both existing and planned wind power facilities. [Chapter 1](#) illustrates the procedures used by a large Regional Transmission Organization and Independent System Operator to determine the capacity value of the wind resources in their jurisdiction. This chapter demonstrates the method developed to calculate the system-wide capacity value of wind resources and illustrates how the capacity credit is designated to the individual wind sites.

The increasing trend towards renewable forms of generation, and in particular wind, is creating new operating challenges. The uncertainty associated with the wind is an issue which must be considered in order for wind power to be successfully integrated into an existing electric power system. This uncertainty may be managed through the use of suitable wind forecasting methodologies. The error inherent in forecasting will impact system reliability and cost as will inaccuracies in assumptions about the forecast error. [Chapter 2](#) presents a methodology adopted for use in a Scenario Tree Tool constructed to allow for closer examination of the effect of forecast error assumptions and properties in unit commitment scheduling models.

[Chapter 3](#) presents a new approach to the critical problem of detecting or forecasting ramping events in the context of wind power prediction. The novelty of the model relies on departing from the probability density function estimated for the wind power and building a probabilistic representation of encountering, at each time step, a ramp event according to some definition. The model allows the assignment of a probability value to each possible magnitude of a predicted ramp and its worth is assessed by several metrics including receiver operating characteristic curves which show the relationship between true positive and false positive ramp rates.

The increasing wind power penetration in electric power systems creates growing operational difficulties in maintaining system reliability due to the uncertain nature of wind power. An appreciation of the available wind power in the next few hours can assist the system operator to optimize the required regulating margin. [Chapter 4](#) illustrates a process in which time series Auto Regressive Moving Average (ARMA) models have been used to quantify the uncertainty associated with wind power commitment in a short future time such as 1–4 h using a conditional probability approach. Knowledge of available wind power a day ahead or even longer is also required by system operators to schedule the conventional generating units in the system. This chapter extends the future time of interest up to 24 h to examine the impact of initial wind speed/wind power conditions and to evaluate the wind power commitment based on a probabilistic wind power commitment risk.

[Chapter 5](#) proposes a novel framework for designing an N-1 secure generation day-ahead dispatch for power systems with a high penetration of fluctuating power sources, e.g., wind or PV power. This is achieved by integrating the security constraints in a DC optimal power flow optimization and formulating a stochastic program with chance constraints, which encode the probability of satisfying

the transmission capacity constraints of the lines. The resulting problem is solved numerically by transforming the initial problem into a tractable one using the so-called scenario approach, which is based on sampling the uncertain parameter (in this case the wind power) while keeping the desired probabilistic guarantees. A Markov chain-based model is employed to generate the wind power scenarios. The effectiveness of the proposed technique is illustrated by application to the IEEE 30-bus network, and comparing it with the solution of a deterministic variant of the problem, where the operator determines a secure generation dispatch based only on the available wind power forecast. A Monte Carlo simulation study is applied to collect statistical results regarding the performance of the method.

Substantial integration of intermittent renewable energy resources such as wind generation in an electric power system can have significant impacts on the system reliability. [Chapter 6](#) illustrates the application of system well-being analysis to address both generation system adequacy and security concerns. Sequential Monte Carlo simulation is utilized in the system well-being analysis to capture the characteristics associated with adequacy and security. A deterministic criterion of the loss of the largest generating unit is utilized as the security measure. The expected values and probability distributions of the system well-being indices associated with different generation scenarios are investigated and compared. The study results are demonstrated using the two test systems designated as the RBTS and IEEE-RTS.

[Chapter 7](#) presents an approach which can be used to represent the correlation between any number of time series in a reliability evaluation based on non-sequential Monte Carlo simulation. The technique is illustrated in this chapter by application to generating capacity adequacy assessment with correlation between wind time series related to wind generation located at different sites and/or the system time-varying load. The developed model can be applied in a reliability study (generating system, composite system, etc.) where several time series are present. The calculated generating system adequacy indices are compared to those obtained by sequential Monte Carlo simulation and show that the model captures the dependence between correlated random variables.

Methodologies based on probability concepts are extremely useful in assessing the reliability performance of electric power systems and have been successfully applied to many areas including generating capacity planning, operating reserve assessment, distribution systems, etc. Many studies in these areas have been conducted in the last few years in order to evaluate the behavior of electric power systems due to the volatility of renewable sources. New methods and models to assess the reliability of power networks with a high penetration of these sources have been proposed in the literature. Most of these methods, however, utilize simplified models, considering only generation reliability or the representation of energy constraints through clustered data models. [Chapter 8](#) presents an application of a flexible non-sequential Monte Carlo simulation approach to evaluate the main reliability indices of composite generation and transmission systems, considering renewable energy, comprising mainly hydro, mini-hydro, wind, co-generation (e.g. biomass), and solar power sources. The renewable capacity is calculated based on

monthly (hydro and mini-hydro) or hourly (wind, co-generation, and solar) series of primary energy. Case studies using variations of the IEEE RTS-96 are presented and discussed. The feasibility of the proposed method is demonstrated by application to an existing large electric power system.

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