Kasthurirangan Gopalakrishnan, Siddhartha Kumar Khaitan,
and Soteris Kalogirou (Eds.)

Soft Computing in Green and Renewable Energy Systems

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Springer

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Preface

Renewable energy and energy efficient technologies have been attracting much attention in recent years due to the soaring energy crisis and environmental problems associated with the depletion of natural resources. Electricity generation from burning of fossil fuels is a major source of greenhouse gas (GHG) emissions leading to global warming. Renewable energy resources such as solar, wind, biomass, hydrogen, geothermal, ocean and hydropower not only help conserve fossil resources for future generations, but are also considered clean sources of energy that are constantly replenished. The growth of renewable energy sources and their integration into the grid necessitate proper characterization of these systems and components for optimal performance under economic, environmental, and operational constraints.

However, the highly variable and site-specific nature of renewable energy sources has also increased the level of uncertainty in the operation of power systems and the unpredictability of load situations. Soft computing (SC) techniques offer an effective solution for studying and modeling the stochastic behavior of renewable energy generation, operation of grid-connected renewable energy systems, and sustainable decision-making among alternatives. The tolerance of SC techniques to imprecision, uncertainty, partial truth and approximation make them useful alternatives to conventional techniques.

This carefully edited book covers the application of SC in diverse area of renewable energy studies. Application areas include characterization of photovoltaic (PV) systems and grid-connected PV plants, study of operational characteristics of various renewable sources in multi-criteria decision-making, study of thermal energy systems and absorption cooling systems, probabilistic load flow problems, diagnosis and prediction of desert dust transport episodes for improved operation of renewable energy systems utilizing solar radiation, short-term wind forecasting based on time series analysis, and renewable energy hydrogen hybrid systems. A brief description of each chapter follows.

The chapter entitled “Soft Computing Applications in Thermal Energy Systems” presents a comprehensive review of applications of NNs, genetic algorithms (GAs), fuzzy logic (FL), and cluster analysis (CA) in thermal energy systems. The usefulness of such SC applications is demonstrated for modeling, prediction, and control of a range of energy systems which may be difficult or even impossible to do by conventional techniques.

The chapter entitled “Use of Soft Computing Techniques in Renewable Energy Hydrogen Hybrid Systems” reviews the application of soft computing techniques to renewable energy hybrid systems that consists of different technologies (photovoltaic and wind, electrolyzers, fuel cells, hydrogen storage, piping, thermal and

electrical/electronic control systems) capable as a whole of converting solar energy, storing it as chemical energy (in the form of hydrogen) and turning it back into electrical and thermal energy. Single or mixed implementation of a range of SC applications, including FL decision-making methodologies, NNs, GAs, and particle swarm optimization (PSO), are discussed.

The chapter entitled "Soft Computing in Absorption Cooling Systems" presents a wide overview of SC techniques in system modeling, control, optimization and determination of working fluids properties of absorption cooling systems which uses thermal energy to operate its compressor in place of a conventional system's compressor, which uses electricity.

The chapter entitled "A Comprehensive Overview of Short Term Wind Forecasting Models based on Time Series Analysis" presents several different approaches to short term wind forecasting and re-examines them with an eye towards setting automated procedures to clarify "grey" areas in their application. In addition, some recent applications of localized linear models and clustering algorithms coupled with linear and nonlinear models and the development of a customized regime model which captures the impact of changing synoptic weather characteristics are presented.

The chapter entitled "Load Flow with Uncertain Loading and Generation in Future Smart Grids" covers a variety of approaches to solve stochastic load flow problems, ranging from currently deployed state-of-the-art procedures to the newest advances in probabilistic load flow calculation and determination. The robustness and real-time issues of the proposed algorithms to deal with highly dynamic Smart Grid scenarios resulting from power feed-in from renewable sources are discussed.

The chapter entitled "Evaluation of Green and Renewable Energy System Alternatives Using a Multiple Attribute Utility Model: The Case of Turkey" discusses the use of multi-attribute utility theory (MUAT) to determine the most appropriate renewable energy alternative among solar, wind, hydropower, biomass, and geothermal. Based on utilities of criteria, the proposed MUAT methodology determines the most appropriate renewable energy alternative for Turkey.

The chapter entitled "A Novel Fuzzy-based Methodology for Biogas Fuelled Hybrid Energy Systems Decision Making" discusses the use of fuzzy multi-rules and fuzzy multi-sets to evaluate the main operational characteristics of five types of renewable sources fuelled by biogas. Using several criteria, including, costs, efficiency, cogeneration, life-cycle, technical maturity, power application range, and environmental impacts, the chapter illustrates the use of fuzzy-based methodology for biogas fuelled hybrid energy systems sustainable decision making.

The chapter entitled "Two New Applications of Artificial Neural Networks: Estimation of Instantaneous Performance Ratio and of the Energy Produced by PV Generators" discusses the application of NNs for estimating the instantaneous performance ratio, a fundamental parameter in the characterization of PV systems; and compare the results of conventional as well as NN-based methods for estimating the annual energy produced by a PV generator with different setting and types of modules.

The chapter entitled "Optimization of Fuzzy Logic Controller Design for Maximum Power Point Tracking in Photovoltaic Systems" presents the design and optimization of a FL controller (FLC) with a minimum rule base for maximum power point tracking in PV systems. The use of GAs is proposed for automated design and optimization of the FLC.

The chapter entitled "Application of Artificial Neural Networks for the Prediction of a 20-kWp Grid-connected Photovoltaic Plant Power Output" describes a simplified NN configuration used for estimating the power produced by a 20-kWp grid-connected PV (GCPV) plants. The development of four multilayer-perceptron (MLP) NN models using a database of experimentally measured climate (irradiance and air temperature) and electrical data (power delivered to the grid) for nine months are discussed.

The chapter entitled "Artificial Neural Networks for the Diagnosis and Prediction of Desert Dust Transport Episodes" discusses the practical applications of NNs in the study of atmospheric pollution by particulate matter due to desert dust transport episodes which profoundly affect the use of renewable energy systems utilizing solar radiation.

Researchers, educators, practitioners and students interested in the study of renewable energy systems will find this book very useful. This book will also serve as an excellent state-of-the-art reference material for graduate and postgraduate students with an interest in soft computing in green and renewable energy systems.

Kasthurirangan (Rangan) Gopalakrishnan
Siddhartha Kumar Khaitan
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