Preface

Energy and the supply of energy sources have played a central role in the development of modern society. The technological revolution of the last century would not have been achieved without the invention and rapid expansion of systems for electricity distribution.

Up until the energy crises of the 1970s and early 1980s, satisfying energy demand was basically a question of the availability of resources and the best technology on hand. The last 20–30 years, however, have seen a change in the way of interpreting the idea of availability and of energy supply.

The main factor that triggered this change is tied to the sharp rise in the price of energy caused by the first oil crisis in the 1970s. In the West, that era heralded the collapse of the myth of cheap, plentiful and easily available energy and raised in its place concerns about the imminent exhaustion of natural resources. At the same time, the worries linked to the environmental consequences deriving from an increasingly greater use of hydrocarbons led to the search for energy technologies that were environmentally compatible.

In recent years the concept of energy has been revised and a new model based on the principle of sustainability has become more and more pervasive. The idea of *sustainable energy* is founded on three main principles: *production* pertaining to technologies for generating energy particularly those using renewable sources, *use* which encompasses the different classes of energy efficiency and saving, and *environmental impact* in terms of pollution and the use of natural resources, which should be minimised. This broad-based model does not embrace merely energy production but also its utilization, both of which are inserted within a bigger and more complex picture, i.e. sustainable development. In order to tackle the problem of sustainable energy effectively, it requires that energy-related economic, technological and ecological issues are no longer approached separately but are dealt with as a single integrated concern.

In its recent report *Energy Technology Perspectives* (2012), the International Energy Agency (IEA) underlines that to achieve sustainability it is essential to make a determined effort to activate the development and propagation of technologies for the decarbonization of the energy system. Unfortunately, it is more than evident that current schemes for technological innovations are proceeding at a rather slow pace and presumably will not be able to guarantee any real change in the energy system in the short term, a key factor to meet environmental sustainability targets.

The IEA gives unequivocal warning of the unsustainability over the medium–long term of the current balance between economic growth, energy demand and environmental impact. Based on a scenario which does not include any additional measures or policies to tackle the energy issue, it forecasts that by 2050 emissions of pollutants will have doubled compared to the figures for 2009. The Agency also stresses that the majority of technologies that could play a leading role in the shift towards low-carbon energy systems are still progressing very slowly.

The European Union, conscious of the risks linked to climate change, has taken an active interest in the issues related to sustainable energy. Indeed, in late 2007, the European Commission launched the Strategic Energy Technology (SET) Plan to promote the development and deployment of low carbon technologies that are capable of demonstrating good cost/benefit ratios. The SET Plan highlights the key role that energy technologies have to play in order to meet the European targets for 2020 (and the longer term ones for 2050) to fight climate change.

In this context, the scientific procedure of *assessment* has a vital role in that it can supply the right tools to evaluate the actual situation and make realistic forecasts of the effects and outcomes of any actions undertaken. The results of an accurate and effective assessment are undoubtedly a valid aid and guide not only for decision makers as a whole, but also for entrepreneurs, managers, designers and scientists. In brief, for anyone who wishes to measure or simulate the propagation and effect of an action (i.e. a plan, a project, a research study, etc.).

This book aims to offer readers a review of the main methods and approaches that can be used for assessment and simulation in the field of sustainable energy systems. The volume is divided into three parts. The first is dedicated to the analysis of the theoretical foundations and applications of multicriteria decision making and contains the following chapters. Chapter 1 is dedicated to sustainability assessment of solar technologies based on linguistic information. In this chapter a modified multicriteria method (PROMETHEE) that uses fuzzy sets is proposed to handle linguistic information for the assessment and appraisal of solar energy technologies. Chapter 2 focuses on outranking approaches and the difficulties underlying choices in Multiple Criteria Decision Analysis (MCDA). In particular, the authors propose the RUBIS method and the RUBIS D3 web server to select photovoltaic plants for the insular grid on the French island of Corsica. In Chap. 3 the Analytical Network Process (ANP) is used in order to evaluate and select the main green energy alternatives for the country of Turkey. The conflicting criteria used in the evaluation process are classified using the Benefits, Opportunities, Costs and Risks (BOCR) framework. Chapter 4 deals with the study and evaluation of decision criteria that influence the location of solar photovoltaic and thermoelectric plants, in order to obtain their weights or importance coefficients to which Analytic Hierarchy Process (AHP) methodology is to be applied. In Chap. 5 a multi-attribute decision-making method combining cloud and utility theory is described in order to evaluate different locations for a wind farm in Northern Spain. Chapter 6 illustrates how geographical areas have diverse green energy resources and different levels of energy consumption. The aim of this chapter is to group geographic areas in such a way that energy demand in a geographic cluster matches the available green energy potential in the same cluster. In Chap. 7 a methodology based on a cumulative belief degree approach is suggested for the prioritization of energy sources. The approach enables the use of all types of evaluations, without the loss of any information. In Chap. 8 the ranking of different scenarios for wind farm configurations is computed and discussed. The TIMED approach and the methodological framework for robustness analysis are described. Finally, Chap. 9 focuses on the technological assessment of heat pump water heaters using a tool based on a hierarchical decision model.

The second part concentrates on the theory and practice of fuzzy inference, neural net and algorithm genetics and comprises the following chapters. Chapter 10 sets out a model providing a general mechanism to measure the sustainability of energy sectors. The model, based on the Sustainability Assessment by Fuzzy Evaluation (SAFE) approach, is applied to a large number of countries, ranked according to their sustainable energy development. Chapter 11 explains how Artificial Neural Networks (ANN) and Genetic Algorithms (GA) operate by presenting a number of problems regarding different applications of solar energy systems. Chapter 12 focuses on the theoretical background of ANN methodologies applicable to the field of wind speed and discusses the implementation issues in a region with complex terrain, namely Chania on the Greek island of Crete. In Chap. 13 a new approach is proposed to deal with the "allocation procedure" in Life Cycle Inventory (LCI). The approach used is based on GAs to resolve multi-output systems and it is applied to a case study related to a cogeneration process. The second part concludes with Chap. 14 which explains the design and implementation of the maximum power point (MPP) tracking algorithm for a photovoltaic module using fuzzy logic and genetic algorithm.

The third and final part of the volume is dedicated to simulation methods such as Monte Carlo analysis, Mathematical Programming (MP), Value Stream Mapping (VSM), Particle Smarm Optimization (PSO) and Discrete-Event Simulation (DES). Chapter 15 introduces the main simulation techniques for sustainable energy systems, i.e. Monte Carlo, Dynamic Systems (DS), DES and Agent Based Simulation (ABS). In Chap. 16 the authors propose a combination of Mathematical Programming and Monte Carlo simulation in order to deal with project portfolio optimization. A case study using real data from the Clean Development Mechanism (CDM) projects' database is developed to illustrate the method. Chapter 17 offers a future-oriented Energy Value Stream Mapping approach designed to enhance energy efficiency in small- and medium-sized manufacturing companies. In Chap. 18 a simulation-based generic framework is described for the assessment of energy efficiency in Lean Manufacturing (LM) systems with the aim of contributing to theoretical and practical studies addressing both sustainable energy and performance in manufacturing systems. Finally, Chap. 19 focuses on the socio-effective value of bio-diesel production. An approach based on PSO and Self-Organizing Maps (SOMs) is implemented to obtain appropriate solutions of the model.

I hope that readers will find this volume a useful tool for energy assessment tasks. I also wish it to be a source of new ideas for further advancements in soft computing and simulation issues for sustainable energy.

Italy, December 2012 Fausto Cavallaro

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