

Preface

Energy harvesting and energy efficiency are two key topics for today's power community. In the development of modern society, one of the key factors is to save energy in order to become more independent of other resources. Two important approaches can be taken—one is to change behavior and thereby save energy and the second is to develop new technology which is able to save energy in different applications. Chapter 1 gives an overview of challenges and possibilities in terms of energy saving and also energy efficient use.

Initially, the first key topic—energy harvesting—becomes one of the most motivated fields of the multidisciplinary science due to the complicated features of the harvester materials, dependences on various mechanical, electrical, and magnetic parameters, rich responses on different external excitation frequencies and strength. Strictly speaking, vibrations stem from either man-made systems or natural processes can be used as an important electric resource for low-power-consuming electronic devices such as transducers and wireless sensors. That can contribute at the batteryless applications for much sustainable and renewable power generation, whereas some technical problems should be solved to achieve the expectations of the electronics society. Although conventional harvesters work on the basis of linear resonance, there exist certain parametrical limitations on their power generation. Indeed, excitation frequency, electrical load, manufacturing tolerance, and ambient temperature play important roles in order to determine the optimized energy generation. Besides, the nonlinear nature of the vibration phenomena contributes at the power, and these nonlinear effects cannot be neglected for an optimized harvester system. Thus, Part I of this book initially gives an outline to the reader on the electromagnetic and piezoelectric energy-harvesting systems and then focuses on the theoretical and experimental techniques by introducing different harvester systems.

In that context, Chap. 2 describes the harvesting sources with classical and novel types for the use of electromagnetic and piezoelectric hybrid structures. Various

experimental systems are described in detail in order to compare their output powers and their relation to the system parameters.

The batteryless applications of microscale harvesters have been explained in Chap. 3 for information technologies (IT). The importance of low-power harvesting systems for IT applications is particularly emphasized, and model systems have been discussed. One of the important practice areas of the harvesters is wireless sensor application. Therefore, a specific chapter (i.e., Chap. 4) is dedicated to the problems of electromagnetic and piezoelectric harvesters in wireless devices. This chapter gives both experimental and theoretical details on the matter. As the harvester systems have complicated equilibrium features for their time- and space-dependent nature, nonlinearity plays an important role to identify their dynamic behavior and power-generation strategy. Therefore, Chap. 5 is devoted to the nonlinear problems of the harvesters. Although the energy-harvesting issues mostly cover the systems related to the piezoelectric and electromagnetic ones in low power range, the most frequent energy-generation system—photovoltaics (PV) has been an important topic. Therefore, Chap. 6 focuses on the control phenomena of PV hybrid systems.

It can be emphasized that the chapters mentioned above provide a good background to the reader on the harvester systems and their applications. Both experimental and theoretical approaches to different harvesting problems help to understand the advanced problems and cutting-edge information, world widely, thereby the readers at different educational levels from undergraduate to the professionals can find interesting research topics in order to apply in their own studies.

Other main topic of this book is the energy efficiency. Due to the increasing population and industrial growth, energy efficiency has become a popular topic for every level of communities from ordinary to technical. There exist many attempts today that the energy efficiency itself can be counted as a new energy resource. Thus, interdisciplinary studies, which have been carried out in the fields of renewable energy, focus on different mechanisms that decrease the losses of the energy in methodological ways. In light of the present technology, the efficiency cannot be considered detached from the cost. Strictly speaking, the balance between the efficiency and system cost should be ascertained. With that respect, many energy systems such as solar, wind, and tidal can make use of good-quality materials or efficiency techniques if they are financially appropriate. Therefore, Chaps. 7–9 are devoted to the sun-tracking applications and maximal power point tracking (MPPT) techniques in PVs. In these chapters, both practices and theoretical backgrounds on the tracking mechanisms are presented including the case studies. Chapter 10 mentions the partial shading effect on the PV systems and clarifies the methodology on the solution of MPPT for those systems. The applications on solar cars are presented in Chap. 11. This chapter also sheds a light on the polymer composite materials in order to enhance the efficiency and gives some information on the charging stations.

The increasing demand for electricity supply along with higher requirements for power quality and system reliability, restrictions to use the available fossil fuels, and minimization of the environmental pollutants leads to the aggregation of clean

energy sources (renewable energy sources, fuel cell, etc.) in distributed generation systems and developing microgrids. Consequently, the energy efficiency of hybrid power system that integrates such clean energy sources must be improved through appropriate energy management strategies. Thus, the remaining parts of the book, namely II, III, and IV, analyze the energy efficiency based on fuel cell, PV, wind, and hybrid power systems.

The term “hybrid” means the use of other energy storage devices, or multiple input energy sources in hybrid power sources to sustain the load demand. Thus, the use of fuel cell system as energy source or energy storage devices in conjunction with an electrolyzer is analyzed in Chaps. 12 and 13. While Chap. 12 analyzes the possibility to use the extremum seeking control schemes for the reduction of hydrogen consumption in fuel cell hybrid power sources, Chap. 13 analyzes the efficiency of a fuel cell hybrid power source required for an automotive application. Chapter 14 proposes a stochastic model to analyze the microgrids with the goal of profit maximization and imbalance cost minimization. In this framework, a new method based on neural network theory is proposed for predicting wind speed and solar radiation. Other chapter (i.e., Chap. 15) analyzes the energy efficiency of a micro-combined cooling, heating, and power system driven by a solar dish stirling heat engine that is used for residential buildings. A novel methodology was introduced for short-term scheduling of small-scale trigeneration system, which can be used optimally and efficiently to provide cooling, heating, and power for residential applications, being environmentally friendliness, cost-cutting, and on-site applied.

The last part of this book is dedicated to some technical strategies, efficient methods, and applications in field of energy efficiency, so it will be of interest for all current researchers and specialists in that field as well as for technicians.

Chapter 16 presents wired and wireless communication systems in smart homes and buildings based on the recent developments proposed in applications. The basic principles of the smart homes and energy efficient buildings are introduced firstly in order to provide basic knowledge for readers and the chapter also gives an idea on the communication systems used for outdoor and indoor scenarios. Chapters 17 and 18 propose new flexible hybrid architecture for the power-conditioning unit for small satellites. Since the space agencies all over the world are interested today in very small satellites due to their advantages compared to heavier satellites, the advanced techniques are discussed including their converter and storage systems.

The batteries are unavoidable for any electricity system. Therefore, while making a discussion on the efficiency issues, one should also consider the storage techniques. Chapter 19 introduces a new method for determining the optimal model of batteries, puts a starting point in analyzing their discharge profiles, and employs a multicriteria analysis for processing the experimental data.

While considering the efficiency in solar, fuel cell and related hybrid systems, the energy efficiency in wind and water distribution systems should also be mentioned. In this manner, the optimal planning and operation of water distribution is presented in Chap. 20. This problem mainly involves the establishment of the operation schedule for all water hydrophore stations and uses a database of 85 urban

water hydrophore stations as a case study. Finally, the last chapter (i.e., Chap. 21) provides an overview about available knowledge, references, and investigations on the active and passive flow control devices, initially developed for aeronautical industry that are currently being investigated and introduced on wind turbines in order to improve their efficiency.

As a conclusion, a sustained research in the field of energy efficiency does not only give more chances to significant reduction of carbon dioxide, greenhouse gas emissions, and environmental pollution, but also increases the economic saving in fuel consumption and use of energy sources. Therefore, this book tries to highlight the difficulties of the basic methods on energy harvesting and energy efficiency and proposes advanced methods to solve these issues. All proposed methods were validated through simulation and experimental results. These “hot subjects” will be of interest for many decades and, at the same time, will be a challenge and hard task for the researchers all over the world, considering the new energy policies due to energy crisis.

We hope that this book will be very efficient for students and engineers who learn and wish to work in this field, because the chapters of this book cover all important and challenging subjects related to energy harvesting and energy efficiency. The book comprises the knowledgeable and up-to-date contents that present the state-of-the-art equipment and methods used for the energy harvesting and energy efficiency. Finally, the main arguments that may recommend this book to be read are the following: (1) It is the first comprehensive book on energy harvesting and energy efficiency of the power hybrid systems; (2) covers the operating principles, design methods, and real applications; (3) enables the low power for autonomous electronic system design; (4) introduces the high-power density technology and adiabatic concept to efficiently design the mission critical systems; (5) provides a much-needed system approach to hydrogen energy applications; (6) provides a comprehensive overview of the fundamentals of renewable power generation, conversion, and storage; and the last, but not the least, (7) can be used as a course text.

The editors and authors made all efforts to have a good book, and we hope interested readers to enjoy by reading this book and to be satisfied by its content.

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