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Alternative Energy Sources

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*To the memory of my parents
Emmanuel and Eleni*

Preface

In the beginning of the twenty-first century, our society is faced with an *energy challenge*: as highly populous, developing countries become more affluent and as the developed nations continue to increase their energy consumption, the energy demand in the entire world has reached levels that cannot be sustained in the future. At the same time, fossil fuels, which are currently providing more than 85% of the total global energy supply, are limited and, in addition, their widespread use has significant adverse environmental consequences. The combustion of fossil fuels produces carbon dioxide, which is one of the causes of global warming as well as of other environmental effects, such as acid rain; higher ozone concentration in urban areas; particulates; and aerosols that are detrimental to air quality. The limited supply of the fossil fuels and their effects on the global environment indicate the only long-term solution of the *energy challenge*: a significant increase in the use of alternative energy sources for the production of electricity as well as for meeting other energy needs of the industrial and post-industrial human society.

This book on *Alternative Energy Sources* is designed to give the reader, a clear view of the role each form of alternative energy may play in supplying the energy needs of the human society in the near and intermediate future (20–50 years). The book is aimed at two types of audience:

- a. The student of science and engineering who may take an elective course on one of the subjects of “alternative energy,” “renewable energy,” “sustainability,” etc. For this purpose, the students will review and expand on several concepts taught in the traditional disciplines of Thermodynamics, Fluid Dynamics and Heat Transfer. If “repetition is the mother of learning,” students in the engineering disciplines will learn a great deal of the material taught in the Thermal Sciences courses by studying this book.
- b. The educated reader, who has a basic knowledge of mathematics and science (e.g. algebra, elementary physics and elementary chemistry). The book assumes minimum prior knowledge on behalf of the reader and imparts some of the

pre-requisite knowledge by including chapters on basic thermodynamics, and elementary financial accounting (investment appraisal methods).

A unique aspect of this book is that it includes two chapters on nuclear fission and one on fusion energy. The reason for this is that nuclear energy does not contribute to the greenhouse effect and is currently viewed by many decision makers as an excellent alternative option for the production of electricity in the twenty-first century. As a result, and despite the recent accident at Fukushima Daiichi, the licensing process for additional nuclear power plants has accelerated in several countries and the debate for the future of nuclear energy has been recently renewed. Nuclear energy, a perennial pariah of environmental groups, may actually become one of the solutions to the global climate change.

The two first chapters on *energy demand and supply* and *environmental effects*, set the tone as to why the widespread use of alternative energy is essential for the future. The third chapter exposes the reader to the laws of energy conversion processes, as well as the limitations of converting one energy form to another. The sections on *exergy* give a succinct, quantitative background on the capability/potential of each energy source to produce power on a global scale. The fourth, fifth and sixth chapters are expositions of *fission and fusion nuclear energy*. The following five chapters (seventh to eleventh) include detailed descriptions of the most common renewable energy sources—*wind, solar, geothermal, biomass, hydroelectric*—and some of the less common sources, such as *tidal and wave* energy. The emphasis of these chapters is on the global potential of each source; the engineering/technical systems that are currently used in harnessing the potential of each one of these energy sources; the technological developments that will contribute to wider utilization of the sources; and the environmental effects associated with their current and their wider use. The last three chapters are: *energy storage*, which is the main limitation of the wider use of solar and wind power and will become an important issue if renewable energy sources are to be used widely; *energy conservation*, which appears to be everyone's favorite issue, but by itself is not a solution to our *energy challenge*; and *energy economics*, a necessary consideration in market-driven economies.

A number of individuals have helped in the writing of this book: first among them are the students who took my course on *Alternative Energy*. I have learned from them and their questions more than they have learned in my classes. Two of these students contributed significantly to the writing of the book: Maria Andersson reviewed several chapters and gave me valuable suggestions. Eric Stewart drew some of the figures. I am very thankful to my colleagues at the University of Texas at San Antonio and at Texas Christian University, for several fruitful discussions on energy and the great challenge our society is facing. I am also very indebted to my own family, not only for their constant support, but also for lending a hand whenever it was needed. My wife, Laura, has been a constant source of inspiration and help. My father-in-law, Dionisio Garcia proofread some

of the chapters and gave me valuable comments. My son Dimitri, who decided to become a student of nuclear energy, devoted a good part of his vacation time to proof-read the entire manuscript and gave me many excellent suggestions. Emmanuel and Eleni were always there and ready to help. I owe to all my sincere gratitude.

Fort Worth, TX, September 2011

Efstathios E. (Stathis) Michaelides

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