Atmospheric and environmental pollution as a result of extensive fossil fuel exploitation in almost all human activities has led to some undesirable phenomena that have not been experienced before in known human history. They are varied and include global warming, the greenhouse affect, climate change, ozone layer depletion, and acid rain. Since 1970 it has been understood scientifically by experiments and research that these phenomena are closely related to fossil fuel uses because they emit greenhouse gases such as carbon dioxide (CO$_2$) and methane (CH$_4$) which hinder the long-wave terrestrial radiation from escaping into space and, consequently, the earth troposphere becomes warmer. In order to avoid further impacts of these phenomena, the two main alternatives are either to improve the fossil fuel quality thus reducing their harmful emissions into the atmosphere or, more significantly, to replace fossil fuel usage as much as possible with environmentally friendly, clean, and renewable energy sources. Among these sources, solar energy comes at the top of the list due to its abundance and more even distribution in nature than other types of renewable energy such as wind, geothermal, hydropower, biomass, wave, and tidal energy sources. It must be the main and common purpose of humanity to develop a sustainable environment for future generations. In the long run, the known limits of fossil fuels compel the societies of the world to work jointly for their replacement gradually by renewable energies rather than by improving the quality of fossil sources.

Solar radiation is an integral part of different renewable energy resources, in general, and, in particular, it is the main and continuous input variable from the practically inexhaustible sun. Solar energy is expected to play a very significant role in the future especially in developing countries, but it also has potential in developed countries. The material presented in this book has been chosen to provide a comprehensive account of solar energy modeling methods. For this purpose, explanatory background material has been introduced with the intention that engineers and scientists can benefit from introductory preliminaries on the subject both from application and research points of view.

The main purpose of Chapter 1 is to present the relationship of energy sources to various human activities on social, economic and other aspects. The atmospheric
environment and renewable energy aspects are covered in Chapter 2. Chapter 3 provides the basic astronomical variables, their definitions and uses in the calculation of the solar radiation (energy) assessment. These basic concepts, definitions, and derived astronomical equations furnish the foundations of the solar energy evaluation at any given location. Chapter 4 provides first the fundamental assumptions in the classic linear models with several modern alternatives. After the general review of available classic non-linear models, additional innovative non-linear models are presented in Chapter 5 with fundamental differences and distinctions. Fuzzy logic and genetic algorithm approaches are presented for the non-linear modeling of solar radiation from sunshine duration data. The main purpose of Chapter 6 is to present and develop regional models for any desired location from solar radiation measurement sites. The use of the geometric functions, inverse distance, inverse distance square, semivariogram, and cumulative semivariogram techniques are presented for solar radiation spatial estimation. Finally, Chapter 7 gives a summary of solar energy devices.

Applications of solar energy in terms of low- and high-temperature collectors are given with future research directions. Furthermore, photovoltaic devices are discussed for future electricity generation based on solar power site-exploitation and transmission by different means over long distances, such as fiber-optic cables. Another future use of solar energy is its combination with water and, as a consequence, electrolytic generation of hydrogen gas is expected to be another source of clean energy. The combination of solar energy and water for hydrogen gas production is called solar-hydrogen energy. Necessary research potentials and application possibilities are presented with sufficient background. New methodologies that are bound to be used in the future are mentioned and, finally, recommendations and suggestions for future research and application are presented, all with relevant literature reviews. I could not have completed this work without the support, patience, and assistance of my wife Fatma Şen.

İstanbul, Çubuklu

15 October 2007
Solar Energy Fundamentals and Modeling Techniques
Atmosphere, Environment, Climate Change and Renewable Energy
Sen, Z.
2008, XII, 276 p., Hardcover
ISBN: 978-1-84800-133-6