



ENERGY TECHNOLOGY AND DIRECTIONS FOR THE FUTURE

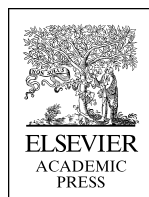


John R. Fanchi

Energy:
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By
John R. Fanchi



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***To the pioneers in the emerging energy
industry—for the benefit of future generations.***

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Preface

Energy: Technology and Directions for the Future presents the fundamentals of energy for scientists and engineers. It recognizes that society's dependence on fossil energy in the early twenty-first century is in a state of transition to a broader energy mix. Forecasts of the twenty-first-century energy mix show that a range of scenarios is possible. The more likely scenarios anticipate the use of several different energy sources. Energy professionals of the future will need to understand the origin and interactions of these energy sources to thrive in an energy industry that is evolving from an industry dominated by fossil fuels to an industry working with many energy sources.

Energy: Technology and Directions for the Future is a survey of energy sources that will be available this century. It is designed to help the reader understand and appreciate the role of alternative energy components in the energy mix. To achieve this objective, the reader will learn about the history and science of energy sources as well as energy technology. A familiarity with the material presented in the text will help the reader better assess the viability of emerging energy technologies and the role they will play in the future.

SCOPE OF TEXT

Energy: Technology and Directions for the Future begins by introducing the historical context of twenty-first-century energy, and then presents the concept of energy transformations. The modern system of distribution of energy in the form of electricity is then discussed, followed by a review of heat and thermodynamic concepts. This background sets the stage for the study of specific energy types.

The first energy type to be considered is geothermal energy. It allows us to introduce basic concepts of planetary formation and geology in anticipation of our study of fossil fuels. The discussion of planetary formation

and geology explains the source of geothermal energy and illustrates our approach to presenting an energy source in the broad context of the leading theories of several relevant sciences. Among these theories are Big Bang cosmology, the Kant-Laplace hypothesis, plate tectonics, the Oparin-Haldane hypothesis for the origin of life, and the synthetic theory of evolution. These theories provide a context that should help the reader understand existing mainstream ideas and be prepared to assess competing theories that may become significant over the course of a career.

Once geothermal energy has been studied, we consider fossil fuels, which provide the majority of energy consumed today. This is followed by a discussion of solar energy, nuclear energy, alternative energy (wind, water, biomass, synfuels), and then hydrogen. In several cases, such as the Battle of Currents, the development of the modern oil industry, and the discovery and development of nuclear energy, the historical context of the technology is used to put the technical material in a social context. The reader is exposed to the role of energy in society, including economic, ethical, and environmental considerations. The final topic is a discussion of energy forecasts and the trend toward a hydrogen economy.

THEMES AND STRANDS

Energy: Technology and Directions for the Future is presented as a set of thematic modules. Themes include electricity distribution, geothermal energy, fossil fuels, solar energy, nuclear energy, alternative energy, the hydrogen economy, energy and society, and energy forecasting. The technical level of presentation presumes that readers have completed college-level physics with calculus and mathematics through calculus of several variables. Given this level of preparation, it is possible to present a more sophisticated discussion of energy topics.

Technical strands run through the thematic modules to help prepare the reader for increasingly sophisticated concepts. For example, the Lagrangian is introduced in the review of energy transformations and then used to discuss the development and interpretation of quantum mechanics and relativistic quantum mechanics using path integrals. Quantum mechanics is used to help the reader understand tunneling (as in nuclear decay), and to explain the free electron theory of metals. The latter theory is useful for discussing the photoelectric effect and photovoltaics, which have applications in solar energy. Relativistic quantum mechanics is presented to help the reader understand the concept of mass–energy transformation

and develop a more sophisticated understanding of nucleosynthesis and nuclear energy (both fission and fusion). The use of technical strands lets the reader become familiar with mainstream scientific concepts and the technical themes demonstrate the significance of each energy option in a broad social context.

MATHEMATICS

The focus of *Energy: Technology and Directions for the Future* is on concepts, facts, and exercises that can be solved without advanced mathematics. Exercises are included in the book to complement the text and enhance its value as a textbook. The exercises range in difficulty from practice at converting units or verifying material in the text to analyses of multifaceted problems. Many of the exercises guide the reader through a detailed analysis of important aspects of contemporary energy issues. As a rule, energy statistics are included primarily in exercises and in the text for historical insight.

Energy: Technology and Directions for the Future contains sections that presume college-level calculus. When new mathematics is presented, such as the definition of conditional probability or the Einstein summation convention, it is presented at a level that is suitable for readers with a calculus background. For example, readers are exposed to differential equations, but are not expected to solve them. If a solution to a differential equation is needed to solve a problem, the solution will be provided. In some exercises, readers are asked to substitute the solution into the equation to verify its validity. As another example, integrals are used to show how to obtain the fundamental equations of quantum mechanics. Solutions to the integrals are provided.

The level of mathematics used in *Energy: Technology and Directions for the Future* facilitates a sophisticated exposure to many topics without exceeding the level of preparation of readers majoring in technical subjects. Indeed, the mathematics can be used to refresh a reader's mathematical knowledge. If readers would like more mathematical preparation, they can refer to standard mathematics textbooks or the book *Math Refresher for Scientists and Engineers*, 2nd Edition, written by the author and published by Wiley-Interscience in 2000.