

Preface

This is a book about **energy**. The resources that supply energy are essential to human survival. The intense exploitation of these resources has enabled the development of highly technological societies in the world's wealthier countries. But with the benefits of energy comes a dilemma. How can we keep providing humankind with energy-derived advantages without damaging the environment, affecting societal stability, or threatening the well-being of future generations? The resolution of this dilemma involves finding sustainable energy sources. Many experts view our energy use pathways as unsustainable for the long-term future, if present growth trends continue. A better future might depend strongly on how individuals and institutions choose amongst diverse and potentially contradictory technical, sociological, geopolitical, and environmental options, and how we set priorities for changing our present courses.

This book presents an overview of the development of energy technology, energy resources, and energy technologies available today, and of some emerging technologies for the future. But the issues surrounding the future role of energy extend far beyond technology, since energy use is integral to many activities, including our quality of life, our commerce, our mobility, and the stability of our social institutions. Our energy use impacts the environment in ways that may be irreversible—especially as the human footprint on the planet expands due to population increases. Population growth and economic growth lead to increased demands on natural resources and greater individual energy consumption. Moreover, the uneven geographic distribution of primary resources creates significant geopolitical consequences. Taken together, these factors pose substantial challenges to achieving a sustainable future.

The goals of this book are to clearly present the tradeoffs inherent in defining sustainability, to study technology and technology-intensive policy options, and to provide a framework for assessing solution options. The approach is quantitative, though not encyclopedic. We examine available and future technologies in the context of their environmental strengths and weaknesses, their technical and economic viability, and their ability to keep pace with evolving public and regulatory expectations for the sustainable use of the planet's resources.

About a decade ago, the authors of this book came together from a varied set of technological disciplines and experiences to develop a graduate-level course that would examine energy from a broad perspective and provide quantitative approaches for

evaluating future tradeoffs in a context of "sustainability." We developed and taught the course as an interactive team and brought in guest lecturers to cover aspects of environmental and societal issues that were outside of our immediate expertise. The students also came from diverse technical (engineering, natural science, political science, and public policy) and cultural backgrounds (both US and international). These students participated actively in class discussions and in the examination of case studies.

This book evolved from this experience. It is organized as a text, with illustrative examples, homework problems, references for further reading, and links to some interesting Web sites. Our presentation is structured to be helpful to both energy experts and to inquisitive non-specialists—in government, industry, foundations, other non-profit organizations, and the public. The value of this book lies beyond the course work, and we believe that anyone seeking a better understanding of energy in a framework of enduring social and environmental stewardship will find this book of interest and use.

The first six chapters of the book examine the broader aspects of energy use from viewpoints of sustainability, resource availability, technical performance, environmental effects, economics, and a systems perspective. These chapters provide essential "tools" for making informed energy choices. Chapters 7 through 15 review the technology, environmental impacts, and economics of each of the main energy sources that are likely to be part of a future energy portfolio. Chapter 16 addresses the important topic of energy storage, transmission, and distribution. Chapter 17 examines the electric power sector. The next three chapters present an overview of the role of energy in the three main end use sectors—transportation, industry, and buildings. Chapter 21 looks at the challenges of integrating all the pieces of the energy puzzle into a framework that will promote understanding of present and future pathways, as well as the role of uncertainties and vested interests. The final chapter returns to the dilemma, and challenges us to act in an informed manner.

The difficulty of implementing major change must not be lightly dismissed. Energy-intensive services and "luxuries" are largely taken as entitlements in the wealthier countries. People in poorer countries need and aspire to the improved socioeconomic conditions that energy can facilitate. Further, many aspects of environmental protection require energy for their implementation. Most nations jealously guard their right to ignite, invigorate, or revitalize economic prosperity by all suitable means, including use of low-cost energy if appropriate. As populous poorer countries industrialize to promote a better life for their people and achieve a semblance of parity with the wealthier countries, the demand for increased energy services will be enormous, even with moderate rates of growth, increasing the adverse impacts of global energy use. Moreover, these developments increase the difficulty of making sound energy decisions in the face of great uncertainty.

Overlying these factors, however, is a welcome and growing awareness around the world that energy and its social and environmental consequences affect the whole planet. More and more, people are realizing that nations and individuals must discover,

implement, and share the means to provide energy-related benefits more efficiently while preserving the earth's resources and ecosystems for future generations. This process of discovery, implementation, and cooperation can be considered the quest for sustainable energy.

But what is the end product of this quest? An objective of this book is to provide readers with the background and methodologies to answer this question for themselves—to develop their own conceptualizations of sustainable energy. To launch our thinking, we have chosen this operational definition:

Sustainable energy: a living harmony between the equitable availability of energy services to all people and the preservation of the earth for future generations.

In our view, pursuit of this harmony is worthwhile, but the journey will be long and arduous, with challenges, uncertainties, and some mistakes that, we hope, will teach valuable lessons and not be repeated. This book provides some navigational aids to those who wish to be active participants in the journey. Our hope is that it will give readers a better understanding of the strengths and weaknesses of different technology and technology-intensive policy options for transitioning to a more sustainable future—and that it will better equip readers to think critically and find their own sustainable energy pathways, while promoting local, regional, national, and global responsibility for a sustainable future.

Readers interested in learning more about the topics discussed in this book should visit our Web site:

<http://web.mit.edu/10.391j/www>

This site features supplementary material, updates, and errata.