

ENERGY

THE MASTER RESOURCE

*An Introduction to the History,
Technology, Economics,
and Public Policy of Energy*

ROBERT L. BRADLEY, JR.

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KENDALL/HUNT PUBLISHING COMPANY
4050 Westmark Drive Dubuque, Iowa 52002

Photos on pages 2, 16, 62, 80, 116, 142 and 176 from Corbis.
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ISBN 0-7575-1169-4

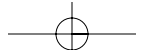
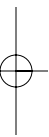
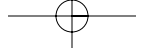
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Printed in the United States of America
10 9 8 7 6 5 4 3 2

To our next generation . . .

*Catherine and Robert Bradley III
Elizabeth, Katherine, James, and Marie Fulmer*



EPIGRAPHS

“Coal, in truth, stands not beside but entirely above all other commodities. It is the material energy of the country—the universal aid—the factor in everything we do. With coal almost any feat is possible or easy; without it we are thrown back in the laborious poverty of early times.”

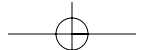
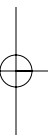
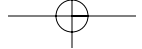
— William Stanley Jevons, *founder of mineral economics* (1865)

“Energy is the master resource, because energy enables us to convert one material into another. As natural scientists continue to learn more about the transformation of materials from one form to another with the aid of energy, energy will be even more important. . . . For example, low energy costs would enable people to create enormous quantities of useful land. . . . Reduction in energy cost would make water desalination feasible, and irrigated farming would follow in many areas that are now deserts. . . . Another example: If energy costs were low enough, all kinds of raw materials could be mined from the sea.”

— Julian Simon, *economist/optimist* (1996)

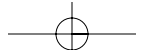
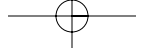
“Affordable energy in ample quantities is the lifeblood of the industrial societies and a prerequisite for the economic development of the others.”

— John Holdren, *environmentalist/pessimist* (2001)



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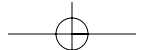
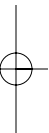
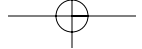


ACKNOWLEDGMENTS

The authors would like to thank the following readers for their review of the entire manuscript: Peter Grossman (Butler University), Gürcan Gülen (Institute for Energy, Law & Enterprise, University of Houston), Howard Hayden (University of Connecticut, emeritus), John Jennrich (Federal Energy Regulatory Commission), William Leffler (Shell Oil Company, retired), and Al Mayo (independent consultant).

Individuals who reviewed sections of the manuscript or provided important information include Gene Callahan (author, *Economics for Real People*), John Christy (University of Alabama at Huntsville), Indur Goklany (American Enterprise Institute), Ken Green (Fraser Institute), Joel Schwartz (American Enterprise Institute), and Christopher Namovicz and Tom Petersik (Energy Information Administration, U.S. Department of Energy).

The authors alone are responsible for any omissions or errors of fact or analysis.



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PREFACE

Energy is *the master resource*. It is essential for life and provides comfort and protection against the elements. People in developed countries can scarcely imagine living without lighting, conditioned air, indoor plumbing, electric ovens, mechanized transportation, medical devices, computers and all the other elements of the modern, energy-intensive world.

Yet energy is at the center of many concerns and controversies. Much of the world's oil supply is concentrated in the politically unstable Middle East. Oil, natural gas, and coal—the basis of today's economy—cannot be reproduced like most things we use. They are nonrenewable resources that can be consumed only until their reserves are depleted. Air pollution in our cities is an unwanted by-product of the fuels that power our cars and generate most of our electricity. Combustion of fossil fuels releases greenhouse gases that may alter the climate in undesirable ways. Oil spills around the world kill sea life and foul beaches.

Plentiful energy has enabled the great population growth of the past two hundred years. But can enough energy be produced cleanly enough to support the population rise—from six billion to nine billion people—that is predicted later this century? Is energy, or, more accurately, human ingenuity up to the challenge?

Energy and energy policy have provoked many emotional debates. A particularly vitriolic controversy sprang up between a Danish statistician, Bjørn Lomborg, and a group of natural scientists. Lomborg presented a mountain of facts in his book *The Skeptical Environmentalist* (Cambridge University Press, 2001) and concluded that alarm concerning energy supply and the climate is unwarranted. *The Scientific American* published a four-part rebuttal that claimed that Lomborg was not only wrong but also *incompetent*. To emphasize this point, the magazine subtitled the article, "Science defends itself against *The Skeptical Environmentalist*." The debate quickly escalated into an international brawl over issues of science, scholarship, professional ethics, and even censorship. Ideas and facts presented in our book will touch on many of these issues.



This primer on the history, technology, economics, and public policy of energy explains what energy is and how its use has evolved over the centuries.

It also discusses the “sustainability” of the modern energy economy from the standpoint of both available resources and energy’s effect on the environment. The book combines introductory information that might be found in an energy encyclopedia with the topics that have put energy at the forefront of the national consciousness. For the general reader, information is presented in a nontechnical way so that little prior knowledge of the field is required. For the more advanced reader, the leading writings on each side of the debate are referenced to facilitate further investigation.



The opening chapter presents the basics, including an historical overview to help the reader understand where we are and how we got here. Wind, solar, and biomass (wood, agricultural byproducts, etc.), which for centuries were the world’s primary sources of energy, no longer make significant contributions in the modern world. Carbon-based energies—the oil, coal, and natural gas that comprise approximately 85 percent of United States and world consumption¹—ended the renewable age because they were far more concentrated, portable, reliable, and cost-effective energy carriers.

Large central-station electricity plants replaced distributed generation (then called “isolated plants”) because of their greater efficiency and lower cost. Electric cars dominated the automobile market for a short time but were displaced by vehicles powered by internal combustion engines. Ethanol, an agricultural product, was a viable, even popular, fuel a century ago, but it was displaced by fossil fuels. The reasons for the switch to gasoline and diesel still remain relevant.

There are reasons to appreciate our energy past and to be optimistic about our energy future. As this book documents, carbon-related technologies are doing well in a two-front war against resource depletion and pollution. Economists believe that the fossil-fuel resource base will be adequate for many decades and probably centuries. Technological improvements and capital turnover (that is, replacement of older vehicles, machines, and power plants with newer, more efficient equipment) promise to continue to make our air and water cleaner in the decades ahead even as energy consumption increases.

The issue of energy sustainability now centers on the effects of fossil fuel extraction and usage on global warming—a subject that is central to this book. The science surrounding climate change in general and global warming in particular is complex, and many uncertainties remain. Crucial issues are still being hotly debated, including what the effects are on the climate after

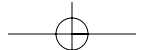
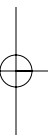
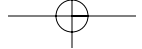
¹These percentages are based on *measured* energy use, which does not include such things as burning wood in a fireplace or using a window to capture sunlight.

150 years of rising atmospheric greenhouse gas concentrations and whether the risks of anthropogenic climate change are outweighed by the risks of climate change *policy*.

Of course, this book does not have all the answers—the science and economics of climate change are not advanced enough yet to provide them. But given the history of energy outlined in these pages, there can be confidence that any arising problems will inspire the human ingenuity and policy reform necessary to solve them. As the late resource economist Julian Simon emphasized, human ingenuity is the *ultimate resource* that, when applied to the *master resource* of energy, can enable people to enjoy longer, more comfortable, and more productive lives.



This book offers a basic, readable introduction to energy for advanced high school students, college and graduate students, policymakers, and the interested public. Far too much reporting on information about energy and environmental issues is simplistic, agenda-driven, and alarmist. Without historical context—and without appreciation for basic economic principles such as opportunity cost, cost/benefit analysis, and decision-making in the face of uncertainty—problems can be seen where none exist, and “solutions” can create real problems where none existed before. If this book can help to balance the debate in the classroom, the office, and at home, the authors will have achieved their goal.



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