

NEW REVISED THIRD EDITION

ENERGY FUTURE

REPORT OF
THE ENERGY PROJECT
AT THE
HARVARD BUSINESS SCHOOL

EDITED BY ROBERT STOBAUGH
& DANIEL YERGIN

"No one who is seriously concerned about the energy crisis can afford not to read it."—Business Week

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Report of the Energy Project at the
Harvard Business School

ROBERT STOBAUGH | DANIEL YERGIN
editors

**I. C. BUPP | MEL HORWITCH | SERGIO KOREISHA
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new revised third edition



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In the course of researching and writing this book, we two communicated with over three hundred business executives, government officials, labor union leaders, analysts, academics, and other specialists. With some, it was a matter of only a small point. Others gave enormously of their time and attention. Our coauthors had similar exchanges with many hundreds more. Obviously, because of the space required to list a thousand or so names, but also because some spoke to us candidly on condition of anonymity, we do not thank them by name. But we do express our deepest appreciation to all of them. Our undertaking would not have been possible without such assistance.

Fortunately, there are also those we can thank by name. We start not with a person, but with an institution, the Harvard Business School, and in particular its Division of Research and its Associates, which made this entire effort possible in a way that few other institutions could—or would—have. It provided the resources so that we had ample time to explore these complex matters critically and pragmatically. It was Dean Lawrence Foulger who asked Robert Stobaugh to organize the Energy Project in 1972, and then gave it his continued support; and it was Elmer N. Funkhouser, Jr., the Dean's special assistant, who played a major role in encouraging the research and in raising funds for the

Division of Research. Professor Richard Walton, formerly head of the Division of Research, provided the necessary funding and encouragement for its launching. His successor, former Associate Dean Richard Rosenbloom, supported and encouraged us in a manifold of ways as the research project took shape as a book, and to him all of us have a special and lasting gratitude. Our colleagues in the Production and Operations Management Area at the school were willing to be in the classroom, enabling us to carry on with the required research and writing. For this, we thank them, as well as former Associate Dean Walter Salmon and former Associate Dean (and now Dean) John McArthur, Area Chairmen Wickham Skinner, Robert Hayes, James Healy, and Philip Thurston, all of whom handled the difficult task of working out faculty schedules. We also appreciate the encouragement and support that we have received from John McArthur in his role as Dean, Professor Raymond Corey in his role as Director of Research, and Joanne Segal, in her role as Assistant Dean and Director of Administration for the Division of Research.

As the title of the book suggests, this is a report of a project located at the Harvard Business School, and not a report of the school. And, of course, the conclusions and opinions are those of the authors, for, as the school's policy statement says: "Neither the Harvard Business School [nor] its faculty as a whole . . . reach conclusions or make recommendations as results of faculty research."

We would also like to thank the Center for International Affairs at Harvard, and its directors, Raymond Vernon, Benjamin Brown, and Samuel Huntington, for it was in the Center's International Energy Seminar that important parts of this book took shape. We also appreciate the support of the Energy and Environmental Policy Center at the Kennedy School of Government at Harvard, and its director, William Hogan, and its executive director, Henry Lee.

Nancy Estes served as combination administrative aide and secretary for the Project. Whether scheduling meetings at chaotic moments or typing at the oddest hours, she kept the Project running. Her efforts and skills, plus her kind nature, were invaluable. Nancy Armstrong also kept the project working and was a

pleasure to work with. Stacy Miller, as she has for other publications of the Energy Project, spent many hours in the library helping us to find information that did not want to be found. Gay Auerbach and Carmen Vaubel helped a great deal. Leslie Sterling stepped in to maintain order in the Project, and this she did with great skill and patience. Jane Shorall provided the essential administrative and editorial assistance for the second edition. Catherine Judson ably stepped into the role of administrative aide and secretary for this third edition. She organized and coordinated the work with a rare combination of efficiency and pleasantness. Jean Twomey was also very helpful on this revision, and also a pleasure to work with. We thank them all.

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We speak often in this book of the transition from imported oil to a more balanced energy system. There is also the transition from raw research to a finished book, for what value are years spent researching if the fruits remain unknown? Jason Epstein, editorial director at Random House, saw merit in what we were trying to do, chose to take us on as his authors, encouraged us, but also challenged us many times with tough and blunt questions. His colleague Grant Ujifusa also brought great dedication to this book, and gave it much more time and concern than the rules of publishing allow. As has been written about him when he edited Dan Yergin's *Shattered Peace*, Grant "brought insight, commitment, and patience to this project." Cheryl Merser's dedication and superb abilities made a major contribution to the life of the book. Carolyn Lumsden worked diligently as copy editor. Helen Brann believed that this was an important book that should be published, and made that possible. We thank her deeply for her continuing support, and also express great appreciation to her colleague, John Hartnett.

We twice had the invaluable experience of working with William Bundy, editor of *Foreign Affairs*, who has been editor of some of the truly significant energy articles of the 1970's and early 1980's. We express our appreciation to him and to his thoughtful colleague, James Chace.

Three other people must be mentioned: Sidney Robbins, this time not a coauthor with Robert Stobaugh, provided a careful reading of the entire manuscript. Max Hall provided editorial guidance in the early phases for a number of us. Herbert Hollo-man, director of MIT's Center for Policy Alternatives, provided financial support for our earlier studies of nuclear power, a careful reading of several chapters, and moral support for the entire undertaking. In addition, we thank the members of the Resources for the Future Project, "Energy: The Next Twenty Years" (of which Robert Stobaugh was a member), for discussion of our manuscript.

Only those who have participated in this kind of research project know the costs exacted on family life. Taking one away night after night, weekend after weekend, vacation after vacation, the work never ends. Our families deserve special medals for understanding.

As editors, we were extremely fortunate to be working with an unusual group of colleagues, who put aside many other obligations in pursuit of that intangible goal, a first-rate chapter. Strong-willed and determined, they have worked closely with us and with each other, not only on their chapters, but on ours, and never surrendered their independence of judgment. For such a group to be so harmonious throughout this demanding project is a tribute to their abilities and scholarly commitments, and also to their understandings of the frailties of the editors.

Events moved rapidly after the first edition of *Energy Future* was completed, and we and our colleagues subsequently had the opportunity to learn from many more people across the energy spectrum. Thus, when it came time to do a revised edition just a year after the publication of the first, we found ourselves doing a much more extensive revision than we had anticipated.

That has been no less true for this third edition, completed three years after the first. Many factors have changed, many as-

sumptions have shifted, and many energy relationships have been altered. Experience has begun to accumulate about life with \$30-plus a barrel oil—a condition that, as late as 1978, was generally not expected until the year 2000. Upheaval has persisted in the Middle East, the breadbasket of world oil production, with the revolution in Iran followed by a protracted war between Iran and Iraq. Mexico has quickly emerged as a major factor in the world oil market; France is the one western nation that has pushed ahead successfully with a major nuclear program. OPEC has faced its own oil crisis—falling demand for its product.

Despite the changes, many basic themes are as pertinent or even more pertinent today than they were at the time of the first edition: the instability surrounding world oil supplies, the uncertainty about the reserves base and the depletion rate of U.S. oil and gas reserves, the immobilization of nuclear energy in the United States, the challenge of building up an expanded coal infrastructure, the potential for conservation. We have sought to integrate the changes with the continuities in order to identify, understand, and explicate the fundamental questions that will be central to the energy future, both for the United States and the entire world, in the rest of this decade and into the next. In other words, our goal is to provide a framework for thinking about the energy future.

As we look through this manuscript, we are reminded of what has occurred to us so often before: The “energy problem” is so fragmented, in so many different pieces. We never doubted the importance of trying to make sense out of those pieces; sometimes we doubted the feasibility. We were willing to forgo much in order to try, for we regarded it as extraordinarily exciting to have the opportunity to try to make sense out of the pieces. It was also a great responsibility. We approached this work in that double spirit.

Robert Stobaugh
Daniel Yergin
Soldiers Field
1982

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|CONTENTS

1	 The End of Easy Oil	3
2	 After the Peak: The Threat of Hostile Oil	17
3	 Natural Gas: Conflicts and Compromise	69
4	 Coal: Constrained Abundance	100
5	 Nuclear Power: The Promise Melts Away	134
6	 Conservation: The Key Energy Source	173
7	 Solar America	238
8	 Energy Wars	272
9	 Conclusion: Toward a Balanced Energy Program	291
	Appendix: Limits to Models	309
	References	343
	Index	435
	About the Authors	

ENERGY FUTURE

1 | THE END OF EASY OIL

ROBERT STOBAUGH
DANIEL YERGIN

In 1968, the State Department sent the word to foreign governments—American oil production would soon reach the limits of its capacity. Friendly governments needed to know that the cushion of the U.S.'s extra capacity, which could be called into production during an emergency, was about to disappear. The end of an era was at hand.

But few people anywhere thought seriously about the implications of losing the cushion, for the industrial world had grown increasingly comfortable using oil to fuel the unprecedented economic growth of the 1950's and 1960's. Western Europe and Japan relied mainly on the Middle East, and the United States also was beginning to import from that region. Middle Eastern oil was the world's favorite fuel—easy to produce in very large volumes (a dime or two a barrel), easy to transport, and easy to burn—certainly easier than coal.

In 1970, some 111 years after the birth of the American oil industry, domestic production peaked and began to decline. But the demand for oil continued to surge, and that demand could be met only by more and more oil from the Middle East, which meant increasing dependence—and increasing vulnerability. The idea that there was something threatening in the growing dependence was an idea better ignored. Even if one recognized a poten-

tial problem, what to do about it was hardly clear when the general momentum to use more oil was regarded as unstoppable.

The first oil shock, in late 1973 and early 1974, definitely marked the end of secure and cheap oil. Arab oil producers embargoed the United States and reduced overall output and shipments to other nations. For the first time, OPEC countries stopped negotiating a price with the oil companies; they instead unilaterally set the price on a take-it-or-leave-it basis. The oil buyers had no choice, and they took it, paying the higher price, eight times higher by the end of 1974 than five years earlier.¹ And so the petroleum exporting countries defined a new age for the rest of the world—one of insecure supplies of expensive oil.

The oil crisis of 1973–74 constituted a turning point in postwar history, delivering a powerful economic and political jolt to the entire world. It interrupted or perhaps even permanently slowed postwar economic growth. And it set in motion a drastic shift in world power, in the very substance of international politics. Curiously, however, in the aftermath it became fashionable to discuss the crisis as though it were a unique event, a freak storm that had been weathered.

We have consistently disagreed, viewing it instead as a warning of a fundamental and dangerous disorder, for the basic conditions that allowed the first shock, and then the second, which occurred in 1979–1980 after the fall of the Shah of Iran, have continued to prevail. Indeed notwithstanding the so-called “oil glut” that existed in 1982, higher real oil prices seemed assured over the long run. But as of 1983, no one knows the timing of any price rise. Many expect level or slightly falling real prices for some years prior to a real rise; others expect the real rise to come sooner. Until the recession in the industrialized world ends, it is impossible to sort out how much of the decline in oil consumption has been due to recession and how much to conservation.

Any price increase has immediate, undesirable effects on all oil-importing nations, causing a direct loss in national income. If the price rise is very gradual over a period of many years, thereby allowing the oil-importing nations a gradual adjustment, the direct effects might then be the main ones.

A large, sudden increase in oil prices would have serious

indirect effects. It would exacerbate inflation, place further strains on the international monetary system, and sharply contract the demand for goods and services, further reducing national income. In short, the economic consequences would likely be a major recession, or possibly even a depression.

The political consequences are potentially no less serious. Slower economic growth and high inflation intensify conflicts not only within Western nations, but also among them. As the world's largest oil importer, the United States would bear much of the blame for higher oil prices. A bitter competition for oil could ensue, damaging the Western security and trading systems. Putting aside American relations with the industrialized nations, greater reliance on Middle East imports would certainly mean that U.S. foreign policy would be increasingly constrained by its oil suppliers.

Political instability in the Middle East, supply interruptions, the extension of Soviet influence—highlighted by the brutal invasion of Afghanistan—such factors only make a very bad situation much worse. *This point must be underlined.* For the industrial nations to continue to depend on Middle Eastern oil in the way current trends indicate means heavy reliance on a region of high political tension and risk. In the last three decades, the Middle East has been subjected to a dozen wars, a dozen revolutions, and innumerable assassinations and territorial disputes. Dependence reinforces the twin vulnerabilities—interruption of supplies and major price increases.

In 1975, economic activity, responding to the strains of the first shock, slowed down, tempering for a time the demand for oil, and thus postponing the reemergence of a tight petroleum market. But political and psychological factors were left out of many of the most prominent forecasts of the international energy scene, for they could not easily be integrated into economists' equations. It became quite fashionable to talk complacently of a glut on the world market.

Beginning in 1977, such factors did begin to make their influence felt, underscoring how crisis-prone is the current energy system. Increases in U.S. oil imports helped trigger the sharp decline of the dollar, which began in 1977 and reached almost

panic proportions by the end of 1978, spilling over into the U.S. stock markets.²

Then, in the latter part of 1978 and in early 1979, Iran exploded in revolution, throwing that country—the supplier of 10 percent of the world's oil—into chaos that choked off production and drove the Shah from the Peacock Throne. The interruption in the flow of oil onto the world market helped set the stage for the price leaps of 1979—from \$12 to \$13 a barrel in late 1978, to the \$32–\$40 range in 1981. In other words, the world price of oil had about tripled. These increases were fifteen times greater in dollar value than was the price of oil in 1970. The instability produced anxiety nearly everywhere; for one thing, it helped drive the price of gold from \$200 to \$850 an ounce. With the second oil shock, twenty years of anticipated change had been telescoped into one. The price of oil had risen to levels that many predictions made in 1978 had not anticipated until the year 2000.

Meanwhile, political threats to the world's oil supply that had been discussed as potentially serious five to ten years hence had become realities in 1979.

America's dependence on imported oil poses not only a host of old problems in graver form but at least one new one, the problem of "hostile oil"—potentially decisive proportions of Middle Eastern oil under the actual or prospective control of governments that are politically antagonistic to the United States. Also, the present outlook forces us to consider how, in the 1980's, our country can maintain economic growth with zero energy growth. Moreover, the fact that time had been telescoped means that the difficulty of meeting the challenge is much greater than would have been the case had its gravity become apparent after the first shock. Responses that might have been sufficient between 1974 and 1979 no longer suffice. Indeed, contrary to popular opinion in 1983, the United States—as well as Western Europe, Japan, and all the world's oil importers—are facing a protracted energy problem, now measured in the chilling statistics of the unemployed—an average of 9 million unemployed annually in the industrialized countries prior to the first oil shock, 18 million during the years between the two shocks, and 32 million after the second shock.

Fortunately, the United States has taken some steps to slow oil imports, including the decontrol of oil prices and the partial decontrol of natural gas prices. But, overall, the response still appears insufficient when measured against the scale and urgency of the problem.

Of course, one would hardly expect that it would be easy, even under the most favorable circumstances, to frame a program that could stop the growth of oil imports in a fashion that would not disrupt the economy and society. After all, a wide range of complex engineering and other technical problems is involved, from the difficulties of offshore drilling operations to the way in which electricity is priced. Beyond the technical problems, there is a host of competing economic, political, and regional interests, all of them warring over the allocation of vast resources. To put it bluntly, serious talk about energy involves a very great deal of money. There may never have been so rich a sweepstakes in American history, for the OPEC price revolution of 1973 and 1974 increased the world market value of proved U.S. reserves of oil and gas alone by \$800 billion. The second shock increased their value by another trillion dollars.³ And then, there are uncertainties, which stretch from the revolutionary dreams of some now-unknown Saudi Arabian colonel to the musings of a specialist in photovoltaic technology.

Given these complexities, it is no wonder that people prefer to dream of some simple solution. First it was nuclear power. Then coal. Then fusion. Then Mexican oil. Then shale oil. And then the opening up of public lands. And so on. But none of these is a singular remedy. An easy fix is unlikely to offer itself, and a prudent society does not count on one happening. And the task of policy formation is made even more difficult by the vocal and sometimes quite bitter debates that now becloud the American political process.

The disagreements can be striking. A news article in the *New York Times* was headlined "Oil Report Optimistic"; it reported that a global shortage before the late 1980's was unlikely, and that one before the twenty-first century was only a possibility, "not a probability." Yet elsewhere in the same newspaper on the same day a story warned that the Western world could "face a damaging