DOCUMENT RESUME

ED 193 101		SO 012 723
AUTHOR	Newman, Dorothy K.; And Others	
TITLE	Energy and the Way We Live. Article Booklet for the Twelfth Course by Newspaper.	
INSTITUTION	California Univ., San Diego. Univ. Extension.	
SPONS AGENCY	National Endowment for the Humanities (NFAH), Washington, D.C.; National Science Foundation, Washington, D.C.	
PUB DATE	80	
NOTE	51p.; For related documents, see SO 012 722 and SO 012 724.	
AVAILABLE FROM	Boyd & Fraser Publishing Company, 3627 Sacramento Street, San Francisco, CA 94118 ($2.95, quality discounts available)	
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.	
DESCRIPTORS	Adult Education; *Energy; Energy Conservation; *Environmental Education; Higher Education; *Newspapers; Nuclear Energy; Postsecondary Education; Resource Materials; Social Studies; Solar Radiation; United States History; World Problems	
IDENTIFIERS	Courses by Newspaper; *Energy Consumption; Energy Crisis	

ABSTRACT

The 15 articles in this booklet were written for the twelfth Course by Newspaper, "Energy and the Way We Live." Courses by Newspaper is a program presenting college-level courses to the public through the cooperation of newspapers and participating colleges. Other components of this course are the Reader/Study Guide (SO 012 724) and the Source Book (SO 012 722). The 1250-word articles, written by experts in the field and published in newspapers beginning in January 1980, focus on the nature and dimensions of our current energy dilemma, place it in historical perspective, and consider its implications for our way of life as individuals and as a nation. They also examine the potentials and limitations of alternative energy sources as well as moral, social, political, and economic issues involved in our energy choices. Specific topics are our energetic lifestyle, the nature of the energy crisis, ways energy was generated in the past, 19th and 20th century developments, waste, use of energy in other countries, international politics relating to energy, energy and the third world, conventional fuels in transition, nuclear and solar energy, synthetic fuels, effective energy use, and future choices and trade-offs. Authors include Dorothy K. Newman, S. David Freeman, Lynn White, Jr., John G. Burke, Daniel Bell, Norman Metzger, Joel Darmstadter, John K. Cooley, Kenneth E. Boulding, Don E. Kash, and others. (CK)

Article Booklet
for the
Twelfth Course by Newspaper

Energy and the Way We Live

Dorothy K. Newman
S. David Freeman
Lynn White, jr.
John G. Burke
Daniel Bell
Norman Metzger
Joel Darmstadter
John K. Cooley
Kenneth E. Boulding
Don E. Kash
Alvin M. Weinberg
Wilson Clark
John H. Gibbons
William Upton Chandler
Denis Hayes
Melvin Kranzberg

Courses by Newspaper is a project of
University Extension, University of California, San Diego
Funded by the National Endowment for the Humanities
with supplemental funding for this course from the National Science Foundation
Distributed by United Press International

Boyd & Fraser Publishing Company
San Francisco

Courses by Newspaper
Energy and the Way We Live

Dorothy K. Newman, et al.

ARTICLE BOOKLET FOR THE TWELFTH COURSE BY NEWSPAPER
ENERGY AND THE WAY WE LIVE

A Courses by Newspaper Publication

Distributed by United Press International

Published by Boyd & Fraser Publishing Company
3627 Sacramento Street, San Francisco, CA 94118

ISBN 0-87835-090-X

1 2 3 4 5 · 4 3 2 1 0

Preface

Despite a consensus that the era of abundant, cheap energy is over and that continued dependence on foreign energy sources can be a threat to our national security, there is still no agreement on solutions to America's energy problems. The fifteen articles in this booklet explore the nature and dimensions of our current energy dilemma, place it in historical perspective, and consider its implications for our way of life as individuals and as a nation. The potentials and limitations of alternative energy sources—such as fossil fuels, nuclear, and solar—are examined, along with the moral, social, political, and economic issues involved in our energy choices.

These articles were originally written for the twelfth Course by Newspaper, ENERGY AND THE WAY WE LIVE, offered in newspapers throughout the country for the first time in winter/spring, 1980. Melvin Kranzberg, Callaway Professor of the History of Technology at the Georgia Institute of Technology, was academic coordinator for this course.

Courses by Newspaper (CbN), a national program originated and administered by University Extension, University of California, San Diego, develops newspaper articles and related educational materials that are used as the basis of college-level courses. Hundreds of newspapers and participating colleges and universities throughout the country cooperate in presenting these courses to the general public.

Each course features a series of weekly newspaper articles, written by distinguished university scholars and other experts. Supplementary materials include a book of readings and a study guide for interested readers, audio cassettes, and a Source Book for community discussion leaders and instructors.

Colleges within the circulation area of participating newspapers offer the opportunity for readers to meet with local professors and earn college credit. If no local college or university is participating, credit arrangements can be made with the Department of Independent Study, University of Minnesota, Minneapolis, Minnesota 55455.

This particular course was prepared in conjunction with a nationwide dialogue, "Energy and the Way We Live: A National Issues Forum," coordinated by the American Association of Community and Junior Colleges with funding by the National Endowment for the Humanities and the U.S. Department of Energy. A series of National Public Radio broadcasts and cable television programs, along with hundreds of community forums across the nation, are part of this major effort to engage the nation in a thoughtful discussion of energy issues.

The first Course by Newspaper, *America and the Future of Man,* was offered in the fall of 1974. Subsequent courses have included:

In Search of the American Dream
Two segments of *The American Issues Forum*
Oceans: Our Continuing Frontier
Moral Choices in Contemporary Society
Crime and Justice in America
Popular Culture: Mirror of American Life
Taxation: Myths and Realities
Death and Dying: Challenge and Change
Connections: Technology and Change

To date, approximately 1300 newspapers and 900 colleges and universities have presented these courses. Approximately fifteen million people read the articles for each course, and almost fifty-five thousand persons have earned credit through Courses by Newspaper.

Courses by Newspaper has been funded since its inception in 1973 by the National Endowment for the Humanities, a federal agency created in 1965 to support education, research, and public activity in the humanities. Supplemental funding for this course has been contributed by the Public Understanding in Science program of the National Science Foundation, which has as its primary purpose the improvement of the content and process of communication between the scientific and nonscientific communities. We gratefully acknowledge their support.

We also wish to thank United Press International, which has cooperated with CbN since 1975 in distributing the articles to participating newspapers across the country.

The views presented in these articles, however, are those of the authors only and do not necessarily reflect the views of the University of California or of the funding and distributing agencies.

Contents

1. Our Energetic Lifestyle

DOROTHY K. NEWMAN

Americans are the world's most gluttonous energy consumers. With about 5 percent of the world's population, we gobble up one-third of all energy used in the world.

We self-righteously chide Third World countries for too rapid population growth, while if we add our cars to our human population, the total is increasing much faster than are Third World populations.

Adding cars to people for assessing growth may seem outrageous. But cars use far more nonrenewable organic materials per year than people do. Besides, cars are extensions of Americans; adding them to people is merely giving cars their rightful place in our culture.

Furthermore, this arithmetic emphasizes that our energy use is directly tied to our lifestyles. Public policies to save energy must therefore take into account whether or how to change lifestyles, for the evidence indicates that those Americans who use the most energy are unwilling to make voluntary sacrifices for conservation. Conservation has been effective only when backed by law.

How Much We Use

The things we buy, use, and repair, and the services we demand for our communities, consume huge amounts of energy that do not appear on household utility bills or on gas pump meters, which measure direct energy use. But we use four times as much indirect energy to maintain our lifestyle.

You can figure out your own energy consumption by using a Lifestyle Index, developed by Albert J. Fritsch of the Center for Science in the Public Interest, which provides an energy factor for every item one uses, each activity engaged in, and each service provided.

For instance, clothing involves energy costs in making the fabric, and designing, sewing, and shipping the garment. If you charge it instead of paying cash, the costs in billing machine usage, paper, and postage must be added. Or take government services: we must assume our share of energy use in keeping offices running, roads repaired, police on the beat, and trash removed.

Food and grocery packaging is especially energy intensive. We must account not just for soda pop, but for the bottle and everything that led up to the final product, including the ads and neon signs that say it's refreshing. And it's not just running an automobile that we must consider, but the steel, chrome, rubber, plastics, glass, upholstering, and the energy used to make all the other parts and extras.

Who Uses Most

Secondary energy use—what goes into making and maintaining our goods and services—matches the pattern of primary or direct energy use in our homes and in running our cars.

Several recent surveys show that primary energy use varies according to income and location. The better off you are, the more energy you use both inside and outside the home, especially in transportation.

In 1975, after the Arab oil embargo, the well-off ($25,000 or more income) used 73 percent more natural gas than low-income families ($6,000 or less for a family of four), more than twice the electricity, and over four times the gasoline.

Households differ widely in the kind of house and the number and kind of conveniences they have. The well-off live in big homes, exposed on four sides to the weather, with large windows, more than one bathroom, and central air conditioning. Such homes use large amounts of energy for heating space and water, and for cooling—the most energy-intensive requirements in a house.

The well-to-do also have many more electrical appliances than lower-income households, including such large energy-intensive kinds as frost-free refrigerators, color TVs, and self-cleaning ovens.

In contrast, most low-income households live in small homes or apartments with one bath. Many have only a black and white TV; their refrigerators are not automatically defrosted, their ovens are hand-cleaned, and they are usually without air conditioning.

Using an appliance index that weights household appliances according to their average energy use, we find that two-thirds of the low-income households had very low appliance index scores in 1972-73, and two-thirds of well-off households had very high scores.

Obviously, those with less income are not just using less energy, but doing without many work-saving features others enjoy. All appliances together, however, use only 15 percent of the energy Americans consume directly.

The not so obvious significance of the appliance index is its almost perfect correlation with total energy use by the household. It is a symbol of lifestyle. The high appliance index household tends to be an energy gobbler; the low appliance user is an energy conserver.

Such a conserver, however, uses energy sparingly, not with the goal of energy conservation, but because the household cannot afford the cost of energy—even of enough energy for health and minimal comfort.

Conservation Problems

This is a critical distinction. It is evident in the paradox that the rich conserve the most energy by adding insulating features to their homes, but they also use the most energy. Low-income households, on the other hand—called "nonconservers" by some—are most often renters; they have no opportunity for such conservation measures, or they cannot afford the initial expense of even fundamental weatherizing in anticipation of future savings.

7

A comparison of households before and after the oil embargo shows those most likely to have reduced their heating and cooling loss made energy-consuming additions simultaneously, thereby cancelling their energy savings. These are the very households where conservation can make the most difference, but their voluntary energy saving appears inextricably mixed with the appeal of greater comfort and ostentation in living standards.

The automobile is a good example. About half of all energy households consume is for transportation, mostly by auto. Half of all low-income households have no car: those who have, use it chiefly to get to work. Jobs have spread out, making it more evident than ever that public transit systems have earned the jibe, "You can't get there from here."

Upper-middle and high-income households have two or more cars, use several times the amount of gasoline others do, drive larger and newer cars more miles, and take more long trips, by air as well as by automobile. The energy intensive transportation lifestyle of the well-off did not decline after the oil embargo.

Only those with few resources use energy sparingly. They cannot conserve very much on their own, and they need help to protect them from energy disadvantage.

Policy Implications

So far, major changes in energy policy stress making everything more costly, but high prices alone do not deter the American high energy consumer, who has the most leeway for spending or saving both energy and money. Such policies only perpetuate our current energy lifestyle.

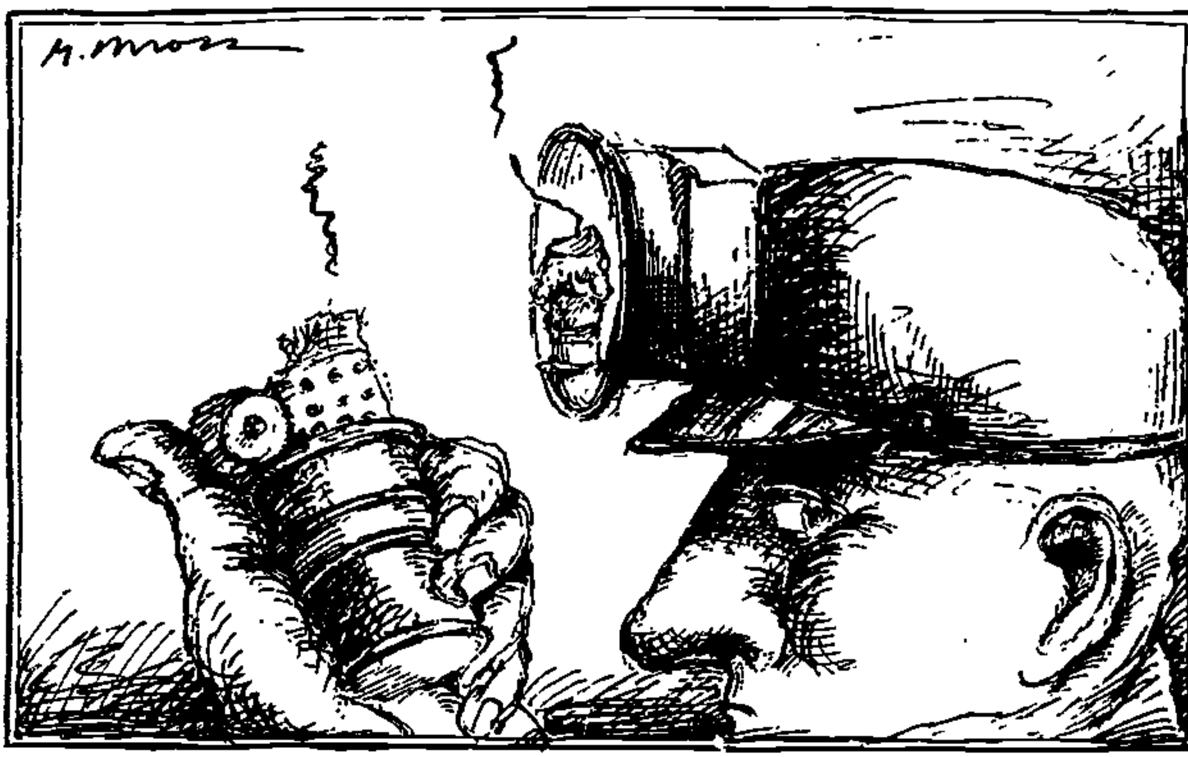
How, then, can lifestyles be changed? Conservation must begin where lifestyle is shaped — where wrappings become fancier, car styles more numerous and ever changing, apartments and houses advertised for their "luxury" features, and new buildings constructed and furnished to impress us with their opulence.

Energy-saving is a hard sell to Americans. Such a hard sell requires hard-nosed policies that are clear and fair, including gasoline rationing; a federal tax on inefficient and nonessential vehicles, with proceeds to be used for developing community-connecting transit systems, tax advantages for building or retrofitting structures according to energy conserving standards; and mandatory building codes. Additionally, more federal funds are needed for research and technological development in the energy field.

In this "moral equivalent of war," our first priority is to create and save energy. The dollar cost is high, the benefits higher.

ABOUT THE AUTHOR

DOROTHY K. NEWMAN is a consultant and lecturer in socio-economics whose recent work has included research for the U.S. Department of Labor. She received a Ph.D. in sociology from Yale University and is the author of *Let Them Freeze in the Dark* and coauthor of several books and reports including *Protest, Politics, and Prosperity: Black Americans and White Institutions; The American Energy Consumer;* and *Gasoline Usage and the Poor.*



2. "Cry Havoc" or "Cry Wolf": The Nature of the "Energy Crisis"

S. DAVID FREEMAN

In 1859 Edwin Drake started producing oil from a well in Pennsylvania, and the world has been running out of oil ever since.

Oil is a "nonrenewable" energy source; there's only a certain amount of it on earth. The same goes for natural gas, coal and uranium.

In 1978, these four finite sources supplied about 96 percent of U.S. energy consumption. Almost half came from oil and a fourth from natural gas. Coal accounted for 18 percent and nuclear, 4 percent. Hydro (water) power and other renewable resources supplied only about 4 percent of U.S. energy and 6 percent of the world's energy.

The current energy shortage, however, is not the result of the limited supply of nonrenewable fuels. Rather, it results from the failure of production to keep up with growing demand because of economic, environmental, and political constraints.

These constraints make it impossible for the United States to produce its way out of the energy shortage unless we curb our demand.

Productive Capacity

Energy supply is usually discussed in terms of the quantities of discovered fuel remaining in the ground, called "reserves," or the ultimate size of the energy sources, called "resources."

However, it is productive capacity—the amount that can be delivered to each home or car or industry each day—that is the key figure. Oil in the ground might just as well be mud if the capacity and incentive to produce and sell it don't exist.

The pace at which wells, mines, refineries, and other links in the energy chain are developed depends partly on the price paid by consumers. As long as Middle Eastern oil was selling at low prices that reflected its low production costs and was readily available, there was little incentive to develop domestic alternatives.

Now that imported oil is priced much higher by OPEC and its availability is unreliable, it is necessary for us to use less and to produce more costly domestic energy. But since no one guarantees future prices, investments by private companies for higher-priced sources will lag.

Price alone doesn't govern the rate of oil production. Environmental laws and impacts on nearby communities rightly place constraints on the rate of energy production. The world's proven reserves of crude oil total about 650 billion barrels, enough to last about 30 years at current rates of consumption. "Estimated reserves," those thought to exist but not yet discovered, may total roughly three times as much.

Yet, even if we created an energy company's dream world—high prices, no environmental laws, and lenient government policies—the rate of growth in energy production, especially petroleum, would still be constrained because existing fields are being depleted; new ones will be smaller, and more difficult to locate.

The most severe constraint, however, is that the OPEC nations have learned that holding back on oil production enables them to keep increasing prices as consuming nations bid ever higher for limited supplies.

But domestic production can't grow fast enough to meet growing demands. The United States now imports almost half its oil; if we are to cut back on imports from an oil-short world market, we must practice conservation and develop substitutes for oil.

Most of the problems of oil production also apply to natural gas, except relatively little natural gas is imported. The "easy to find" reservoirs have been discovered and are rapidly being depleted. Even without price controls, which dampen the incentive to explore for new sources, it will be difficult to find the remaining gas as rapidly as existing reservoirs are depleted.

The world's proven reserve of natural gas is about 2,200 trillion cubic feet; its estimated resource, about 8,150 trillion cubic feet. Proven reserves of gas in the United States are about 200 trillion cubic feet, enough to last only 10 years at present consumption levels. Even if the most optimistic estimates of undiscovered gas reserves prove true, U.S. production of natural gas will be severely curtailed in 30 to 50 years.

Coal and Nuclear Energy

Coal also illustrates our frustrating energy dilemma. Coal resources are large, compared to petroleum. The proven U.S. reserves could last about 700 years at present consumption rates. But obstacles to mining it and burning it in a socially acceptable manner have limited its use, and new technologies to convert coal to electricity and synthetic fuels need perfecting. If we can solve these environmental and technical efficiency problems, coal could supply a growing share of our needs well into the future.

Nuclear energy is a question mark, largely because the public fears it, especially after the Three Mile Island incident. In the next two decades the amount of uranium in the ground isn't likely to be a limiting factor. But, if more efficient nuclear plants cannot be perfected, nuclear fission is a relatively small source of energy, no larger than our oil and natural gas resources.

The United States could get energy from nonrenewable sources yet to be developed, such as shale oil or tar sands. It is estimated that we have 2,000 billion barrels of oil in shale, more than all the crude oil in the Mideast. But the shale oil poses awesome environmental problems, and other sources are untested and likely to be very expensive.

Renewable Sources

Obviously, our nonrenewable energy sources are going to run out some day. The problem then is to develop renewable or superabundant sources and use our fossil fuels and uranium wisely to bridge the gap in the meantime.

There are four potentially major sources of "durable energy" that should be pursued: the nuclear breeder, fusion, geothermal power, and solar energy.

The nuclear breeder holds promise of energy abundance. A breeder reactor is fueled by plutonium-239 instead of the uranium-235 used in today's reactors. While a breeder reactor operates, it "breeds" more of this plutonium fuel from uranium-238, which is abundant. This "breeding" of fuel could allow the known reserves of uranium to fuel breeder reactors for many centuries. But development of the breeder is clouded by concerns over safety, proliferation of atomic bombs from its fuel, and escalating costs.

Fusion power is, in a sense, an energy source as powerful as the sun in a reactor here on earth. Fusion could supply an almost unlimited amount of energy. But after 30 years of intensive effort, the scientific feasibility of fusion has yet to be established. For now, it's a long shot.

Geothermal power, using geyser steam, seems more diffuse and difficult to harness than the sun. Geothermal sites in the United States are scattered, and harnessing them presents major engineering and environmental problems.

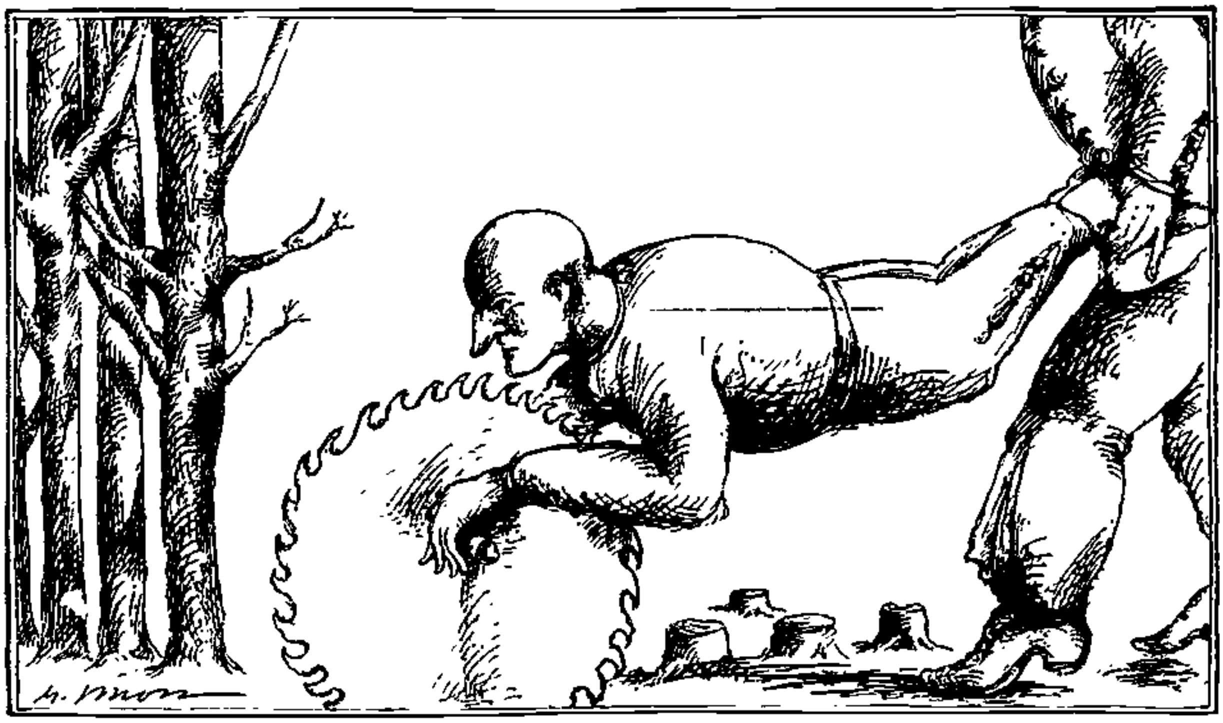
Solar energy offers the best possibility for our high-energy civilization to continue. Using the sun to heat buildings is practical today, but harnessing the sun to generate electricity on a large scale will require all our ingenuity. Whether the nation rises to that challenge may well determine our fate in the next century.

For the moment we are short of energy and new sources are many years away. And the shortages will grow if we don't curb our wasteful appetite for energy. Any policy not rooted in programs to conserve energy by making the American economy more energy-efficient is doomed to failure.

Conservation is our quickest and cheapest source of supply.

ABOUT THE AUTHOR

S. DAVID FREEMAN has been chairman of the Board of Directors of the Tennessee Valley Authority since 1977. He previously served on the White House energy staff and as an energy and resources consultant to the Senate Commerce Committee. From 1971 to 1974, he headed the Ford Foundation's Energy Policy Project. He is the author of *Energy: The New Era*.



3. Substitutes for Human Muscle: Past Crises

LYNN WHITE, JR.

The words "energy crisis" imply that what the world is now experiencing is an unpleasantness that will be fairly brief and will be solved by some sort of technological fix.

Don't hold your breath until that happens. It may take centuries.

There have been past societies—the Periclean Age, for example—that had very limited, even dwindling, sources of energy but didn't worry greatly about the situation or do much to remedy it.

Rome was a magistral civilization that got a lot of its energy from plain human muscle, especially the muscles of slaves. But the poor were scarcely better off than slaves. It seems never to have occurred to an educated Roman that slavery kept the wages of free labor at abysmal levels by its competition.

And since so high a proportion of the population lived in great poverty, it was doubtless politically rash to develop other sources of energy or labor-saving devices that would put people out of work. When, in the first century, an engineer offered Emperor Vespasian a novel machine that could hoist the great columns of a new temple at reduced labor costs, the Emperor rewarded him but refused to use his device, saying, "I must feed the little people."

This attitude may account for Roman indifference toward the water-mill, which was invented in the first century before Christ. One early mention of it is in a lovely Greek poem that urges the slave women to sleep late because the water nymphs have taken over their former task at su -up of grinding by hand the flour for the meals of the day. No doubt it is bad social strategy to let slaves sleep late. The water-mill was not spread rapidly, or its uses diversified, until after the collapse of the Western Roman Empire and the general conversion of Europe to Christianity.

Decline of Muscle Power

I should be happy to connect the spread of water power with Christian opposition to slavery; for slavery declined notably in this period. There is, however, no evidence that Christians in either Antiquity or the Middle Ages condemned slavery. The withering of slavery was probably caused by failure of slaves to reproduce themselves even at the rate the free population did, which was low. Moreover, the decay of Rome's military power, and less frequent conquests, resulted in a short supply of new slaves.

The Romans thus faced an increasing shortage of workers. Muscle-power was giving out. Yet they did amazingly little to find substitutes for muscles. Perhaps the chief reason why the Roman world went to pieces was failure to recognize and grapple with this problem.

It was not until about the year 840 that waterpower was applied in Europe to industrial tasks other than milling grain. The first signal of a new era came at the abbey of Saint Gall in Switzerland: water-powered trip-hammers were pounding the mash for beer. Then we discover the same device felting cloth. Soon such automatic machines were helping to tan leather, crush ore, pump bellows of forges, prepare the pulp for paper, and do the laundry. In 1204 the first water-powered saw appeared in Normandy, and in 1384 the first powered blast furnace in Belgium.

The Medieval Mentality

All this reflects a mentality worlds apart from that of the Romans. Medieval Europe first developed what we think of as the "modern" ideal of a capital-intensive, labor-saving technology. In the 1180s, for example, the European type of windmill was invented on the flat lands of Eastern England, and it spread as fast as moving pictures did in the early 20th cent ry. The Romans scarcely cared about improving energy resources: the Middle Ages were filled with enthusiasm for natural power and new uses of it.

Inevitably there was ecological backlash In the later 13th century water-powered saws were prohibited in one valley of the French Alps because their new productivity of lumber had devastated the forests In 1322 an English observer credited the deforestation of England in part to the search for long spars to make the vanes of windmills.

New technologies had contributed in other ways to a shortage of wood. Beginning in the 10th century, improved agricultural methods had begun to produce much more food, and population had skyrocketed. This meant increased needs for fuel, which then meant wood. Application of power machines to metallurgical processes reduced costs, increased demand, and put further strains on the wood supply for props in mines, for smelting, and for forging. Wooden ships, wagons, and houses increased in number and size.

To make matters wor - Europe's climate began getting colder so more wood was needed for domestic heating. By the late 13th century a wood famine was descending on Europe.

In England the poor, unable to buy wood, turned to coal, which was more accessible than elsewhere and cheaper than wood. Consequently, by 1300 London had a severe smog problem.

Wood Famine

Thus the rapidly advancing technology of the Middle Ages, having first produced a higher standard of living than ever before, and a larger population, at last brought about an energy crisis, pollution, and much human misery.

The wood crisis was temporarily solved not by a technological fix but by a vast human tragedy that had little to do with the state of engineering: the Black Death of 1347–1350. In its first sweep the plague killed probably one-third of Europe's population. By 1400 Europe contained only about half as many people as in 1347. Production fell because half of the market had vanished. Pressure on woodlands declined, and forests gradually restored themselves.

Population generally remained fairly static until the 16th century, when it rose again. By about 1575 England was once more suffering from a wood famine. People turned quickly to coal again, not only for domestic purposes but also for manufacturing bricks, glass, soap, sugar, salt and the like. But for a long time coal could not be used in many industrial processes, notably the metallurgical. It was not until 1709—almost 200 years after the wood famine had once more become acute—that coke was first used to smelt iron.

From Coal to Steam

The prolonged effort to replace wood with coal led to a steady increase in coal production. Mines went deeper, and the risk of their flooding rose. This led English inventors to try new kinds of pumps to rid the mines of water.

The breakthrough was Thomas Newcomen's steam pump of 1712. Late in the 1700s James Watt so greatly improved the steam engine that steam produced by coal became the typical energy used in 19th-century industry.

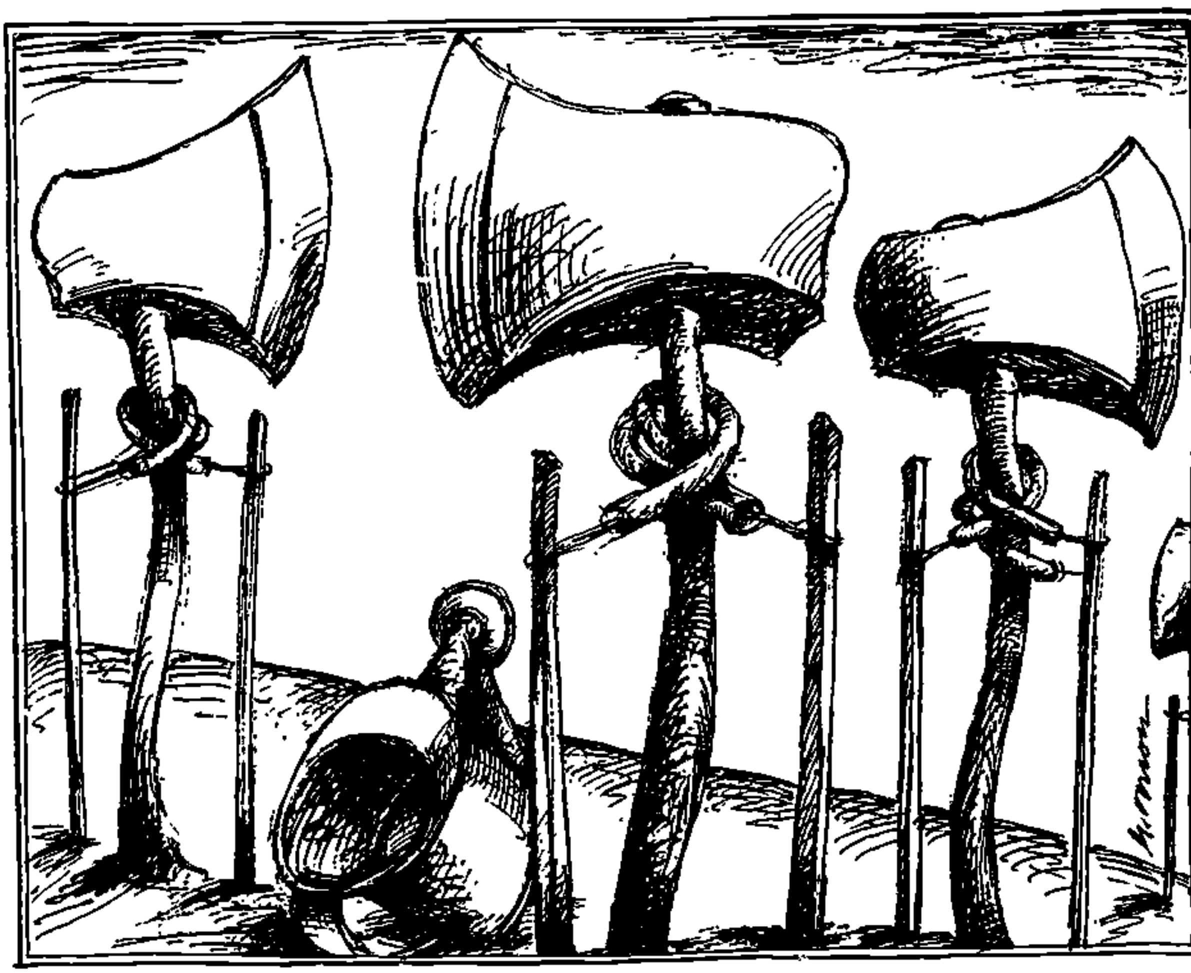
It was the first new source of power discovered since the invention of the windmill 600 years earlier. It grew out of the effort to substitute coal for wood as the primary fuel and thus meet the energy problem that had begun to afflict Europe severely 500 years earlier, and which, after the catastrophic "solution" of the Black Death, had returned as a threat in the 16th century.

Perhaps the Romans—or at least their prosperous decision-makers—would not have been bothered by any of these developments, as they were not greatly bothered by the growing muscle famine of their own period. But people in the Middle Ages took the ideal of a power-based technology seriously, as we, their descendants, do today.

Finding a fix for the present petroleum famine is becoming the chief goal of our society, because that is the way our minds work. But it may be found more slowly than we expect. The interim may call for social discipline on our part as well as for inventiveness.

ABOUT THE AUTHOR

LYNN WHITE, JR. is University Professor of History Emeritus at the University of California, Los Angeles, where he joined the faculty in 1958. From 1943 to 1958, he was president of Mills College, having previously taught at Princeton and Stanford universities. He is the author of *Medieval Religion and Technology* and *Medieval Technology and Social Change*. Since 1970, he has been editor of *Viator: Medieval and Renaissance Studies.*



4. Multiplying Energy: 19th and 20th Century Developments

JOHN G. BURKE

In 1952 President Truman's Materials Policy Commission clearly warned that in the 1970s the United States would be dependent on Middle East oil, and that unstable political conditions there could result in a serious energy shortage in America.

The Commission's prediction, which turned out to be surprisingly accurate, was based on the fact that after World War II oil production in the United States no longer met domestic demand, and we became a net importer of crude oil.

But few people heeded the Commission's report or its plea for energy conservation. After all, America had always had abundant energy resources. The Commission's bleak outlook was, for most Americans, just another example of how wrong-headed "experts" can be.

It is true that the increasing availability of cheap and flexible sources of energy was one of the most important factors in the transformation of America from a predominantly agricultural nation in 1850 to an industrial giant a century later. In 1950, in fact, the United States consumed about fifteen times more energy than it had in 1850.

What most people failed to realize, however, was that in the process of industrialization, our economic and social organization, our jobs and our daily routines had become increasingly reliant on the availability of petroleum products. The Materials Policy Commission clearly perceived the true state of affairs.

Wood, Water and Wind

Until about 1880 America depended on wood, water, and wind for its energy needs. The primeval forests were a hindrance to people seeking land to farm, but when they fell to the axe they provided huge quantities of wood. Wood was practically free, and it was consumed in the roaring open fireplaces of the pioneers, in the fireboxes of locomotives and steamboats, and in iron blast furnaces and other industrial processes requiring heat. In 1850 about 100 million cords—over four cords per capita—of wood were burned annually, a very large amount when one realizes that a cord of wood is four feet wide by four feet high by eight feet long.

For local manufacturing, water power, provided by huge water wheels or primitive turbines, was plentiful. The Pawtucket Falls of the Merrimack River powered the textile mills of Lowell, Massachusetts, and the Great Falls of the Passaic River provided Paterson, New Jersey, with the energy for its silk, jute, gun, and locomotive factories. As the 19th century progressed, water turbines became more common and more efficient, foreshadowing the large hydroelectric plants of modern times.

Windmills dotted the eastern seaboard and accompanied the westward expansion. The Halladay windmill, used to grind flour, pump water, and saw wood, was a familiar fixture on most farms and ranches of the great plains. Windmills rapidly disappeared from the landscape, however, after the Rural Electrification Administration brought electricity to rural areas beginning in the 1930s.

Much earlier, however, in the period 1855 to 1885, four developments stimulated massive industrialization and caused a drastic shift from wood, water, and wind to other energy sources. The first was the discovery and employment of the Bessemer and open hearth processes for manufacturing steel inexpensively. The second was the appearance of a new science—thermodynamics, whose application enabled engineers to design more efficiently steam and other engines that converted heat into mechanical work. The third was the drilling of the Drake well in 1859 at Titusville, Pennsylvania, which ushered in the era of petroleum. The fourth was the founding in the early 1880s of the electric generating industry.

Age of Coal

Cheap steel rails made possible the nationwide expansion of the railway network. Shipbuilders constructed steel ships, steel girders were used in bridges and later in skyscrapers, and steel wire fenced the cattle ranches of the west. Wood, however, was no longer a suitable fuel for the rapidly expanding steel mills. Steelmakers turned to coal and built their plants near the extensive coal reserves of Pennsylvania, West Virginia, and Ohio.

Coal was also found to be a cheaper, more convenient fuel both for railway locomotives and for urban buildings and residences. By the mid-1880s coal had become the nation's chief energy source.

The age of coal and steel demanded more powerful engines for mining, for the manufacture and fabrication of steel, for transoceanic steamships and transcontinental locomotives, and for driving electric generators. Using the laws of thermodynamics, engineers learned how to employ steam efficiently at very high temperatures and pressures, and their efforts culminated in the development of high-speed steam turbines.

Electricity Revolution

Initially, electricity provided power for arc lighting, street railways, and electric illumination of buildings. Electric motors, however, introduced about 1900, produced a revolution in industry and the home. Large electric motors were attached directly to the massive rolls fabricating thick steel plates or girders, while tiny motors powered vacuum cleaners and washing machines.

In providing an efficient power source for each individual machine, the motor caused the redesign of factories and the reorganization of industrial work. Similarly, it transformed household work. The electric generating industry exploded, expanding its capacity more than 650 times between 1900 and 1950. In the process, generating costs were dramatically reduced, and the price of electricity was progressively lowered.

Urbanization

A gradual but drastic change in the organization of society accompanied the process of industrialization. An increasingly dwindling proportion of our population engaged in agriculture or was needed to provide our food. Mass production industries employed armies of workers, causing massive urban growth, which, in turn, stimulated the expansion of service establishments—hospitals, hotels, department stores, groceries, and restaurants.

City dwellers needed cheap and dependable transportation, energy to heat and light their homes, cook food, and run vacuum cleaners, washing machines, and the new electric refrigerators. The city began to resemble a complicated machine, in which energy in its various forms was dispensed to consumers through complex networks.

Industries became concentrated and were dominated by such giant corporations as Standard Oil, U.S. Steel, American Telephone & Telegraph, General Electric, and Du Pont. In turn, governmental bureaucracy burgeoned in order to regulate trade and industry practices and to check monopolies, and political power became increasingly centralized in the federal government.

Gasoline and Diesel Engines

In the late 19th century, three German engineers—Nicholas Otto, Eugen Langen, and Rudolf Diesel—became convinced that centralized, expensive energy sources gave an overwhelming advantage to industrial barons. They determined to design and manufacture inexpensive power sources which would enable small entrepreneurs to compete successfully with the giants. The eventual products were the gasoline and diesel internal combustion engines, which, ironically, gave birth to the greatest mass production enterprises of the 20th century—the automobile and truck industry.

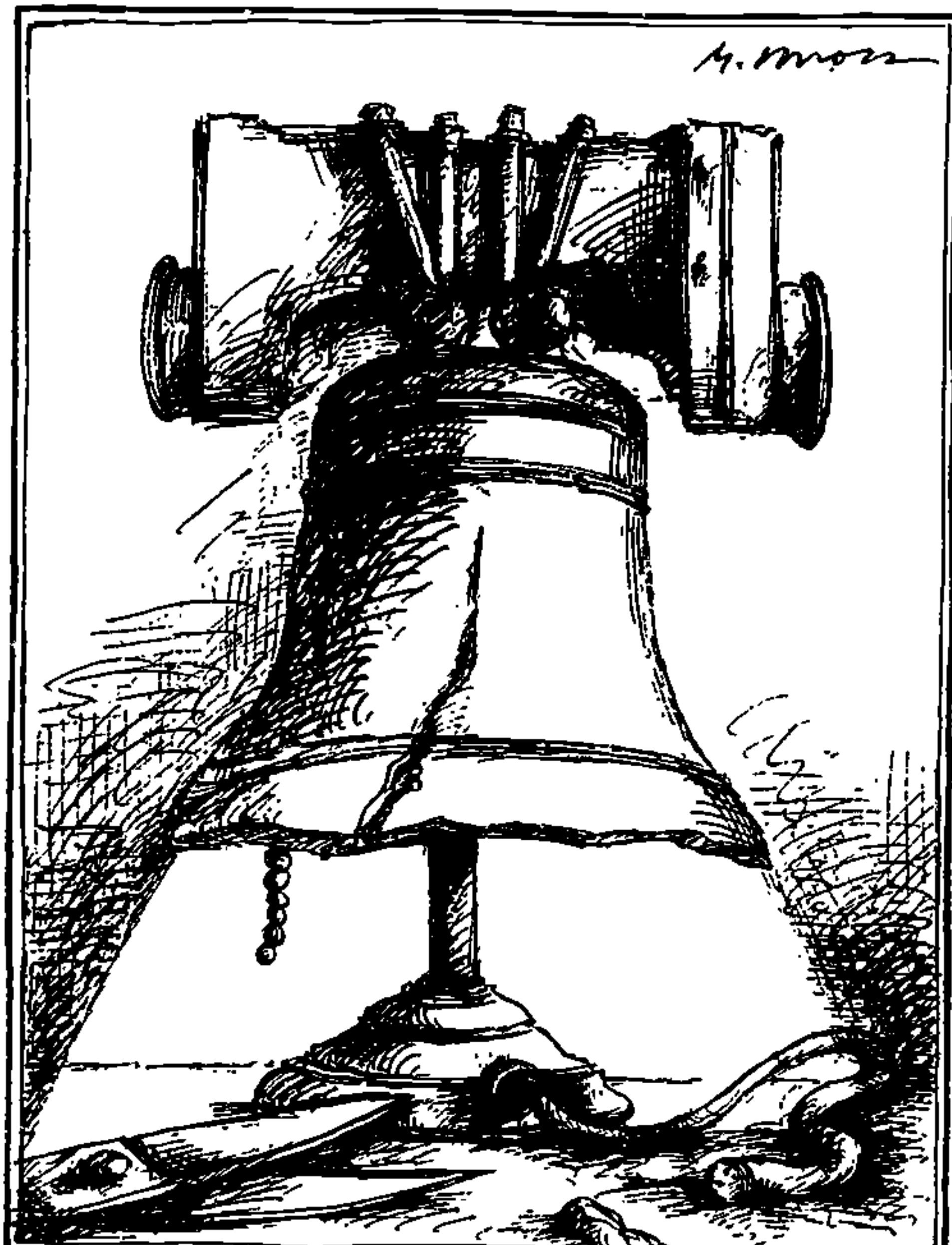
As petroleum production increased in response to the demand for gasoline, many electric generating plants and other industries took advantage of the availability of the cleaner liquid fuel oil or of natural gas to fire their boilers. The role of coal as an energy source declined sharply, while the consumption of oil multiplied twenty-five times between 1900 and 1950.

In 1952, when the Materials Policy Commission report was published, few government leaders thought about supporting research to enable the ailing coal industry to exploit deep deposits profitably or to process successfully coal having a high sulfur content.

Future energy requirements apart from transportation, it was thought, would come from a new energy source—the atom, which gave promise of clean, dependable power for the foreseeable future.

ABOUT THE AUTHOR

JOHN G. BURKE is Professor of History at the University of California, Los Angeles and was course coordinator for the eleventh Course by Newspaper, "Connections: Technology and Change." Holding degrees in both history and metallurgy, he joined the University of California faculty in 1962. He is the author of *Origins of the Science of Crystals*, coauthor of *The Science of Minerals in the Age of Jefferson*, and editor of *The New Technology and Human Values* and of *Technology and Change*.



5. Plenty and Profligacy: Energy and Growth in America

DANIEL BELL

Twenty-five years ago, a distinguished American historian, David M. Potter, wrote an influential book entitled *People of Plenty*. It was a convincing demonstration of the effects of economic abundance on the distinctive American character.

Only in America could such a book have been written. America was promises, and it seemed then as if those promises has been fulfilled—in part because of bountiful energy.

But do those promises still hold true? Now that energy has become more expensive, can we still be a people of plenty?

American Bounty

One of the earliest English descriptions of American bounty appeared in *Eastward Ho*, a comedy written in 1605 by George Chapman and John Marston. Virginia, one of the characters declares, is as pleasant a country "as ever the sun shined on; temperate and full of all sorts of viands; wild boar there is as common as our tamest bacon here. . . ."

And in the 1780s, in one of the most famous observations by an early traveler, Hector St. John de Crevecoeur wrote: "There is room for everybody in America. . . . Does he want uncultivated lands? Thousands of acres present themselves, which he may purchase cheap. Whatever be his talents or inclinations, if they are moderate, he may satisfy them. I do not mean, that everyone who comes will grow rich in a little time; no, but he may procure an easy and decent maintenance by his industry."

But it was not just the fertile soil, the large forests, the vast seams of coal, the large veins of iron ore and the Great Lakes and river system that tied these together, that made us a people of plenty—though all these were essential. America's primary bounty was the ingenuity, energy, and character of its people.

Long before industrialization began in the 1840s, visitors remarked on the kinds of production and social organization that permitted the United States to take the lead in manufactured goods. There was that largely home-taught genius Eli Whitney who, in setting up a factory to make muskets, in 1779 helped establish the principles of mass production: quantity, standardization, and interchangeability of parts. And Oliver Evans in the late 18th century invented a continuous flour-milling system which showed the way for the coordinated packing-house slaughter of animals, and later for the assembly line of Henry Ford.

What made the American outpouring of goods possible, of course, was bountiful energy—water power from the turbulent rivers, wood from the abundant forests, coal from the mines of Appalachia and southern Illinois, oil from western Pennsylvania and later from Texas and Oklahoma. Between 1820 and 1930, by exploiting new sources of power, America increased 40-fold the supply of energy that it could command per capita.

Electricity and oil changed our lives. Through electricity we could transform the night with light, provide power to drive machines, supply energy to lift elevators, run the home appliances that we take for granted and the electronic devices whose physics we can only dimly grasp. With oil, we heat our homes, fuel our autos, trucks and planes, and grow our food through petrochemicals that provide feedstock and fertilizer. These developments demanded increasing amounts of energy, particularly oil.

But the days of cheap oil and cheap energy are gone. We are living—and will live—in a very different era.

Early Warnings

There were warnings long ago. In 1893, in "The Significance of the Frontier in American History," the historian Frederick Jackson Turner signaled that land—for centuries our most abundant resource—was becoming limited in supply.

In the early 1900s, President Theodore Roosevelt and Gifford Pinchot of the U.S. Forest Service led a conservation movement to husband and develop our natural resources. The Newlands Reclamation Act of 1902 proposed irrigation for desert lands, flood control for rampaging rivers, and deepening of shallow rivers for navigation.

Yet strikingly, all these programs collapsed as special interest groups—such as the lumber, cattle, and power industries—obtained special advantages from Congress. Equally striking is our sense of prodigality that so affected our view of the past that most of the U.S. history textbooks give scant attention to the history of conservation.

It was not until the 1960s that we became concerned about our natural resources. By then, the United States, self-sufficient in energy throughout most of its history, had begun importing oil. And by 1973—when the OPEC cartel imposed its embargo and tripled and then quadrupled the price of oil—our dependence on foreign oil had risen to about 30 percent of our total oil usage.

Energy Independence

The United States is now trying to regain its energy independence. This is necessary for political reasons so we will not be blackmailed by foreign powers. It is useful for economic reasons so that we know the true market costs of energy.

We have been told, however—not by responsible economists, but by headline-hunting politicians or simple-minded moralists—that we will have to change our way of life totally and acquire new values.

I think—and the evidence shows—that such statements wildly exaggerate the facts and hinder the formulation ol a rational policy.

Let us focus on the most visible symbol of our way ot life, the automobile. The automobile accounts for 76 percent of the energy used for transportation, or slightly under 20 percent of all the energy we consume in the United States. (Since foreign oil accounts for 23.5 percent of our total energy, we can say, for dramatic sake, that the automobile consumes almost all the foreign oil we import.)

We are told that Americans are prodigal—that we consume four times as much gasoline per head as Western Europeans. But such comparisons ignore the greater size of the United States and its lower population density.

Given the distances in our country and the dispersal of homes and jobs, the automobile is a necessity for us. Before World War II, when existing mass transit systems were laid out, people traveled to the city to work.

Today, jobs are dispersed—for example, along Route 128 that rings Boston; or in "silicon valley" from San Francisco to San Jose, where high technology firms are strung out in a line; or in the corporate headquarters that fan out around New York City. A study of automobile use in Portland, Oregon, showed that only 4 percent of driving is for recreation.

Solving the Problem

The answer to our energy dilemma is not necessarily to drive less, but to drive more economically. Germans get 70 percent more mileage per gallon of gas than do Americans; the English, almost twice as much.

The basic, and cheapest, mode of becoming energy independent is thus conservation. Studies by the American Physical Society and by the National Academy of Sciences, using 1973 figures, showed that by reducing heat losses from buildings, improving automobile efficiency and the like, the same U.S. living standard could theoretically have been maintained with 40 percent less energy.

Is the idea of such conservation realistic? Following the oil embargo of 1973, Los Angeles instituted an energy curtailment plan with mandatory targets for reducing the use of electricity, but with consumers themselves implementing specific cuts. The response was gratifying: residential use decreased 18 percent; commercial, 28 percent; industrial, 11 percent.

The program brought dramatic savings with a minimum of sacrifice or change in lifestyles and with little investment.

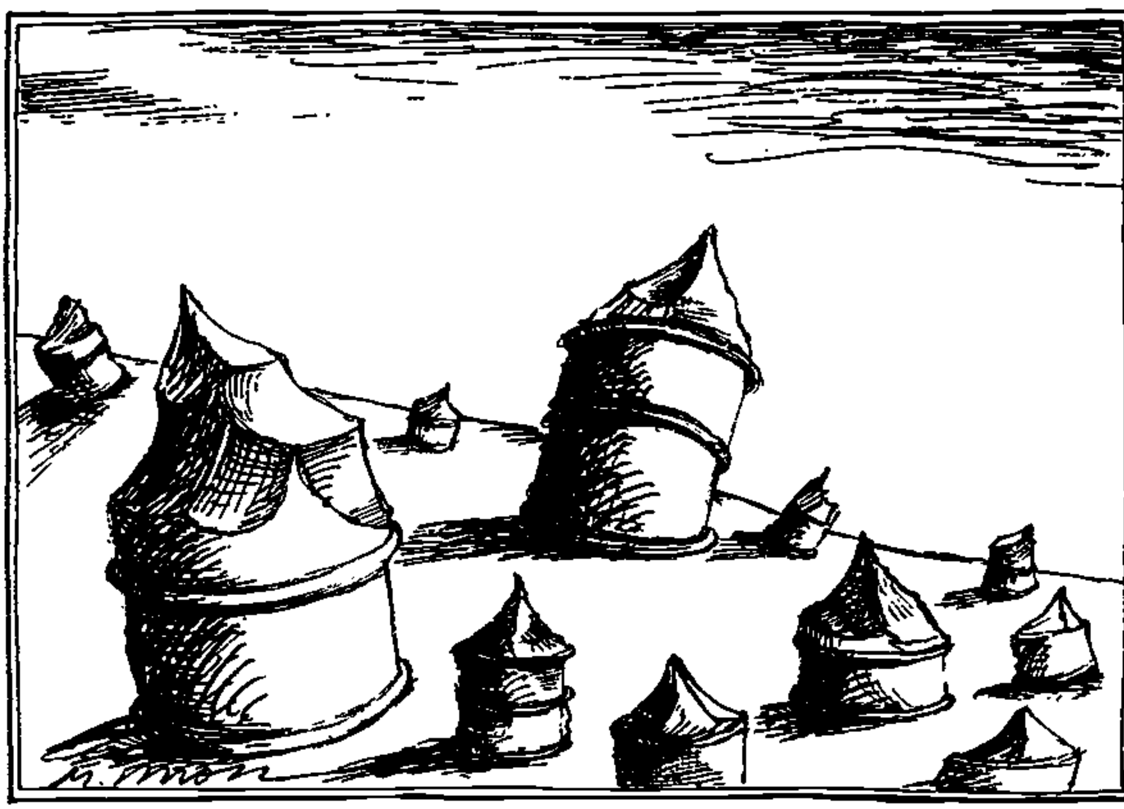
Could such a system work in the nation at large?

We would have to apply some practical engineering, some practical economics, and some practical commonsense.

Whether we will do so is a test of our national will.

ABOUT THE AUTHOR

DANIEL BELL has been Professor of Sociology at Harvard University since 1969. Prior to receiving his Ph.D. from Columbia University, he was staff writer and managing editor of *The New Leader* and later became managing editor of *Common Sense*. He cofounded *The Public Interest* in 1965 and served as coeditor from 1965 to 1973. His books include *Teletext: The New Networks of Information and Knowledge in Computer Society; The Cultural Contradictions of Capitalism; The Coming of Post-Industrial Society*; and *The Reforming of General Education*.



6. Prelude to Crisis

NORMAN METZGER

The energy crisis is really a crisis of oil and secondarily one of natural gas. These two fuels—which are clean-burning, easy to transport, and adaptable to many uses—provide three-quarters of our energy needs today.

To understand our present predicament we must understand how we came to be so heavily dependent on oil and natural gas.

Both are 20th-century fuels. Oil rose from barely measurable use around 1900 to a quarter share of total U.S. energy consumption in 1930 and almost half in 1970. Natural gas consumption quadrupled between 1930 and 1970.

Their spectacular growth has technological, political, and social roots. Repeating the 19th-century pattern for coal, we created new technologies that could take advantage of the unique properties of these fuels. The internal combustion engine is the most spectacular example.

We also found ways to move local fuels across the nation. Natural gas began to flow from the Southwest to the Midwest and East as the "Big Inch," "Little Inch" and other World War II pipelines built to transport petroleum across the country were turned over to the natural gas industry. Improved seamless welded pipelines made transporting gas under high pressure possible, creating new markets and greater demand.

Political and Social Changes

Technological changes moved in tandem with political and social transformations that assumed energy would be available everywhere, in the form needed, and cheaply—as indeed it was.

Political changes included the passage of the Rural Electrification Act and the creation of the Tennessee Valley Authority to deliver electrical power to the nation's farms and to the seven states drained by the Tennessee River and its tributaries.

Low cost loans and mortgages through the GI Bill of Rights encouraged Americans to marry, have children, and buy their own homes, beginning the baby and suburban booms. The Interstate Highway program started in the 1950s, its mission to enable us to drive coast-to-coast without stopping for a traffic light.

These political markers were evidence of deeper social trends. Urbanization continued, the proportion of the metropolitan population doubling between 1900 and 1960. More people bought cars, by 1970, 80 percent of all families had at least one. More women went to work, with a third in the labor force in 1950 and about half by 1977.

New Energy Demands

Common to all these changes was a heightened demand for energy. In the post-war decades, the amount of energy used by each person in the United States rose steadily, indicating the increasingly higher energy content of the goods and services produced.

These exuberant needs for energy were met by oil and gas, indeed, these two fuels were vital to the growth of the American economy, where Gross National Product almost quintupled between 1930 and 1977. The enormous self-confidence that growth engendered, and vast discoveries in Texas, Louisiana, even Alaska, eased any anxieties about wedding ourselves almost exclusively to two finite fuels.

The internal combustion engine developed further, with horsepower a better sales lure than gas mileage; the interstate highway system was built on the premise of cheap, ubiquitous gasoline. Air traffic, prop to jet, grew spectacularly even though it is a fuel-wasting way to travel short to medium distances, compared to railroads, whose passenger role gradually eroded.

And there were all those appliances: refrigerators replaced the ice box; washing machines, the washboard; air conditioners, the fan. New industrial processes, such as the electric arc furnace of the steel industry, appeared. Production of plastics grew prodigiously, particularly after World War II, further raising the demand for petroleum.

Only the benighted would argue that these events, which formed the setting for the energy crisis of the 1970s, were a mistake. A home of one's own, a car and the highways to drive it on, clean heat in winter and air conditioning in summer—all enriched American life.

And energy *was* cheap; its prices as a proportion of both Gross National Product and of personal incomes fell steadily for several decades. New oil fields were discovered; natural gas was so cheap and plentiful that its market price was set at a level to encourage its use.

Danger Signs

But there were some ominous signs, including the very fact that the United States depended largely on two fuels. Nuclear energy was not even up to the level of hydropower—about 4 percent—until the 1970s, and coal's share shrank and was increasingly restricted to electrical power plants. The level of oil imports rose from about 12 percent in 1950 to half in the 1970s. And the rate of oil and gas discovery per foot drilled was falling, as easily found fields had already been tapped

But only the politician wishing early retirement would have denied that more was better or would have pressed to conserve energy or to widen the array of fuel supplies

Moreover, while we were raising our energy consumption, almost solely through the growth of oil and natural gas, we were foreclosing other options. For example, there was a post-war effort, through the Synthetic Fuels Act, to improve on the horrendously costly conversion processes that the Nazis had used to liquefy coal for fueling tanks and planes.

That effort withered as cheap petroleum became more widely available, as natural gas found national markets, and as the petroleum industry continued its opposition to government support of alternative energy sources. The result was to impoverish coal research, and t. .ut coal's role as an alternative to increasing imports of ever more costly oil.

And there was a seemingly unlimited supply of oil to import. In the 1950s, new geophysical techniques led to the discovery of large oil deposits in Kuwait, Abu Dhabi, the United Arab Emirates, Saudi Arabia, and Iran. Productions costs from these new wells were only five to forty cents per barrel compared to two to six dollars in the United States. American oil companies pressed for an oil import program, which by "protecting" the nation from cheaper foreign oil accelerated the depletion of domestic supplies.

The environmental movement, which began in the 1960s, gained strength as the true price of energy became more apparent—air polluted by fossil-fueled power plants and automobiles; water heated as it coursed through nuclear power plants before spilling into rivers and lakes; oil slicks on Santa Barbara Bay and the English Channel.

The attack was well justified, but the immediate response led to other problems. For example, believing that sulfur dioxide from smoke stacks caused air pollution, the government restricted the burning of high-sulfur coals. But the effects of suddenly depriving utilities of high-sulfur coals—for which they had built plants, structured their rates, arranged transportation, intensively sought customers—were not thought out. Many utilities switched to low sulfur oil rather than compete in a seller's market for low sulfur coal, raising the demand for petroleum and refinery capacity beyond anything anticipated by the petroleum industry.

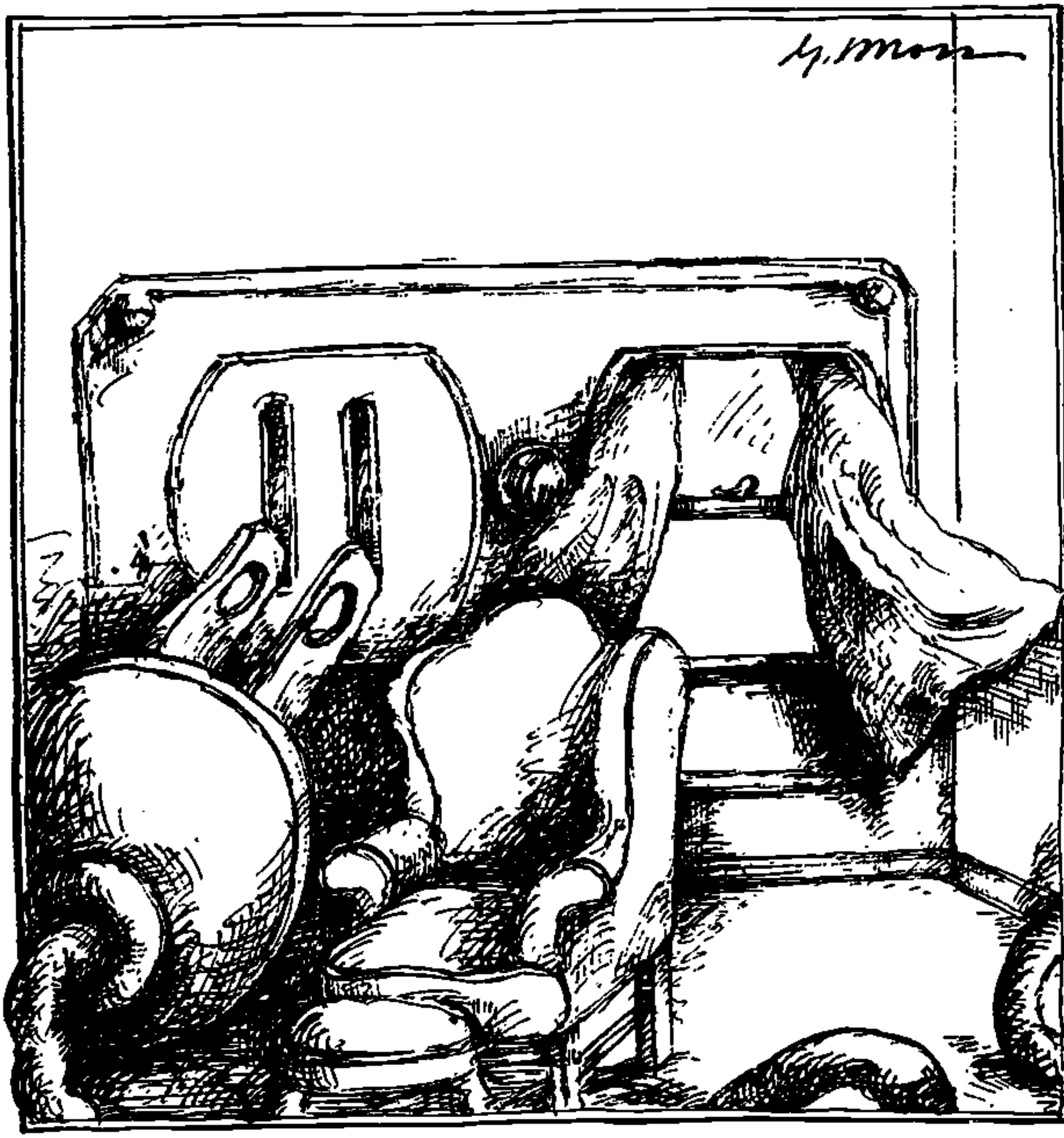
Also, the problems of coal raised the already high and, in retrospect, deceptive, attractions of nuclear fission for producing electricity.

The fortunes of oil and gas were thus deeply woven into transformations that occurred in American society beginning in the 1930s. These energy choices reflected what American society valued. It wanted oil and gas partly because of their convenience compared to coal. In turn, the changes that oil and gas made possible—from the automobile age to "clean heat"—entered our definition of a reasonable standard of life. And in time, the environmental movement signaled that clean rivers and air were sometimes of more value than an economy premised on ever more goods.

When the price of OPEC oil quintupled in the 1970s, the situation was ripe for an energy crisis.

ABOUT THE AUTHOR

NORMAN METZGER is senior editor in the Office of Information of the National Academy of Sciences. He is the author of *Energy: The Continuing Crisis* and *Men and Molecules* and has written on energy for *New Scientist*, *Popular Science*, *The Sciences*, and *Smithsonian*. He also wrote and produced an audioseries entitled *Energy: A Dialogue* for the American Association for the Advancement of Science.



7. Other People, Other Patterns of Energy Use

JOEL DARMSTADTER

Energy is a means toward a desired end.

It is valued because it helps provide us with amenities that contribute to our sense of well-being. Gasoline gives us mobility; heating fuels furnish comfort and warmth; mechanized factory operations produce the diversity of goods that we like to consume.

The statistics for other industrial nations, which consume less energy per capita than the United States, would seem to indicate that it is possible to achieve these amenities with a more economical use of energy than now prevails in this country.

But how relevant are foreign examples?

One faction contends we're misguided for having failed to do what Germany and some other countries have demonstrated *can* be done with effective public policies, skillful industrial management, and prudent consumption practices.

Another faction deplores our naiveté in not recognizing the distinctive conditions of American society and is convinced that ill-advised efforts to transplant foreign experience could choke our economy.

There is an element of truth in both arguments.

Energy and GDP

In a purely statistical sense, those arguing that we should apply foreign energy-consumption practices to the United States are persuasive. If we look at per capita Gross Domestic Product (GDP)—the value of goods and services produced domestically per person, which is roughly proportional to per capita income—we find that in several other countries this measure is similar to that of the United States, yet per capita consumption of energy is markedly below ours.

A concise way of depicting this is to measure the amount of energy consumption associated with each $10,000 of GDP in selected countries and express it in equivalent barrels of oil. The 1976 standings for nine countries are as follows:

Barrels-of-Oil Equivalent per $10 thousand GDP (1976)

Canada	115 barrels
U.S.	100
Netherlands	88
Sweden	85
West Germany	74
Britain	72
Italy	70
Japan	60
France	54

The ratio of energy to GDP in Germany is more than 25 percent below ours, in Sweden, 15 percent lower. Yet both are affluent societies. In this list, only Canada uses more energy than we do to produce a similar amount of goods.

However, before concluding from the German and Swedish examples that the United States could drastically reduce its level of energy use without affecting our living standards and our economic activity, we must look at the complex factors that affect the differences among countries in energy/GDP ratios.

Structural Factors

One set of factors concerns differences in the geographic make-up and industrial structure of countries. In a study published several years ago, Resources for the Future, a nonprofit research organization, found that about 40 percent of the difference between the high energy/GDP ratio in the United States and the lower European ratios is due to such U.S. characteristics as the large size of the country and dispersed population, which require goods and people to move over long distances. Another example is the U.S. preference for large, single-family homes.

It is debatable whether such features can simply be dismissed as "energy-inefficient" attributes of American life. Certainly cheap energy, particularly where governmental policy has kept it artificially cheap, facilitated these evolving patterns. However, these deeply rooted aspects of American society cannot be turned around easily—certainly not in less than the decades it would take substantially to replace our existing housing and alter settlement patterns.

The Resources for the Future research disclosed other findings as well. For example, our high energy use is not—as some may think—a consequence of a top-heavy industrial orientation. If the industrial sector in the United States played as important a role within our economy as it does in Western Europe, we would consume even more energy than we do now.

Nor does climate explain our high usage. On the contrary, Europe has a lower energy/GDP ratio than ours despite proportionately greater heating and air conditioning requirements.

So, while some structural features such as distance and housing can be cited in "extenuation" of high U.S. energy/GDP ratios, other factors, when standardized for comparability with Europe, would push our energy use even higher.

The importance of structure in determining a country's energy consumption can be illustrated by noting that Canada (even when allowance is made for the cold climate) uses more energy relative to income than we do. This high energy usage is the result of historically cheap hydropower and abundant natural resources, which, in turn, resulted in Canada's specialization in such energy-intensive activities as metallurgy, pulp and paper manufacturing, and chemicals production.

Energy Intensity

In addition to these structural factors, there is a second set of factors that affect differences in the amount of energy used: the energy intensity—that is, energy consumed for the same activity in various countries. These factors account for roughly 60 percent of the differences in energy/GDP ratios between the United States and Western Europe.

For example, the fuel economy of American cars has historically been very much poorer, and the energy consumption per unit of output in a wide range of American manufacturing enterprises is distinctly higher, than in Europe.

These differences in energy intensities can be attributed partly to the higher prices of foreign energy—particularly for motor fuel. And differences in price, in turn, arise partly because European prices have been held above the market level through taxation of energy and energy-using equipment, while in the United States, through controls, they have been held below market level. In both cases, social policy has helped shape energy patterns—deterring use in Europe, encouraging it in the United States.

When one takes account of these cost differences, high U.S. energy intensities are not necessarily economically inefficient or wasteful from the standpoint of a household or industrial plant, though the economy as a whole may be worse off because of misguided pricing for energy.

Room for Improvement

Even where the data indicate that one country's energy use is more effective than another's, however, it does not mean that it cannot be improved. For example, U.S. freight transportation is, overall, less energy-intensive than Western Europe's. But the energy intensity would be still lower if Interstate Commerce Commission regulations would not dictate that a trucker shipping Georgia pecans northward, for instance, has to return with an empty truck.

Similarly, economical heating practices in Sweden could be still further enhanced if occupants of unmetered apartments served by steam from district heating plants did not use their windows to regulate their heat!

The differences among countries in energy use are not frozen into place. Between 1972, the year before the Arab oil embargo, and 1976, for example, the gap between Sweden's energy/GDP ratio and ours narrowed from 28 percent to 15 percent. The U.S. ratio has been declining while Sweden's has been rising. A narrowing of the gap with other countries seems likely as well.

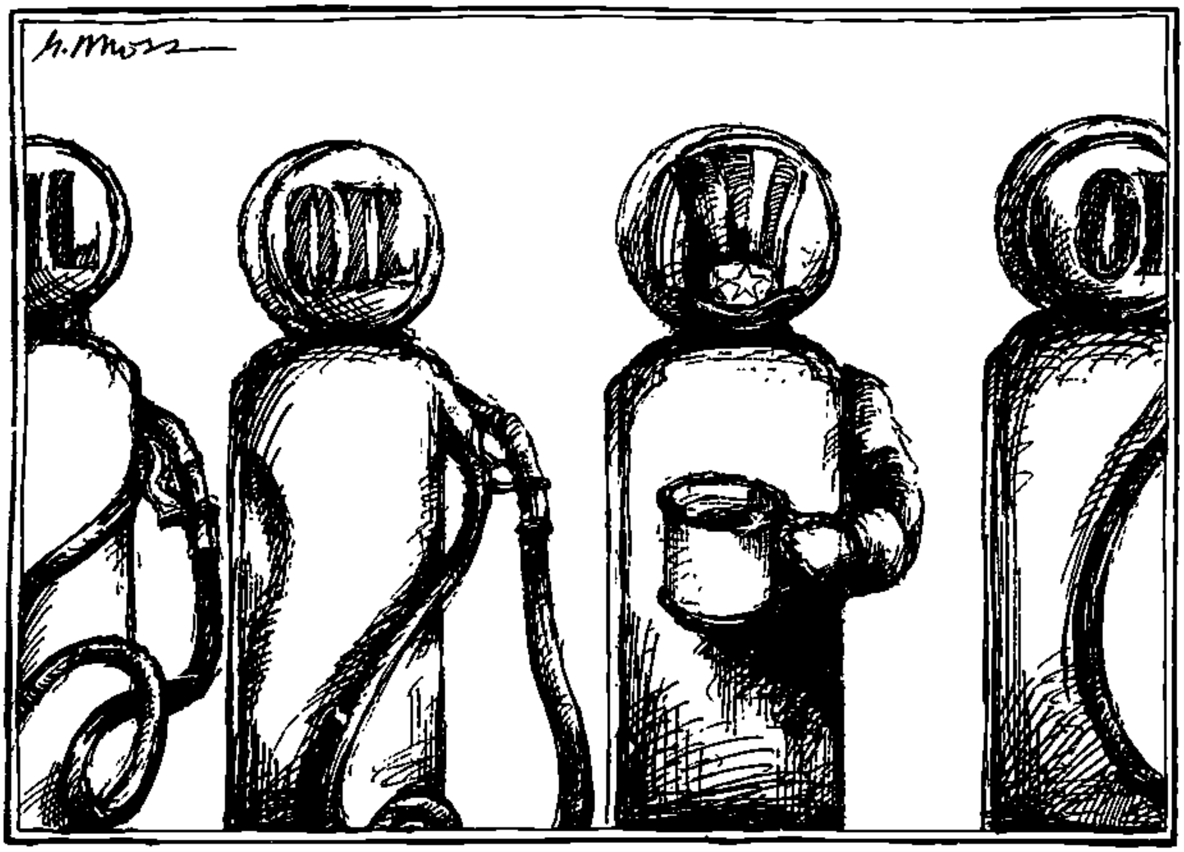
There is little doubt that a conservation momentum is gradually taking hold in this country, in part because of public policies, such as regulations for improved fuel economy in new cars.

Do international comparisons, then, point to the potential for significantly reduced energy consumption without sacrifice of economic welfare? It would be cavalier to conclude that we have nothing to learn from foreign energy-using practices—especially where these represent a technological and behavioral adaptation to high energy costs, which are now beginning to confront us, too.

At the same time, we would delude ourselves if we were to conclude that the lower ratio of energy use to GDP in some other countries provides a formula for painlessly lowering energy consumption in the United States.

ABOUT THE AUTHOR

JOEL DARMSTADTER has been a senior fellow at the Resources for the Future Center for Energy Policy Research in Washington, D.C., since 1975. From 1966 to 1975, he was senior research associate at Resources for the Future and from 1957 to 1966 was an economist with the National Planning Association. He is the author of *Conserving Energy: Prospects and Opportunities in the New York Region* and a coauthor of *How Industrial Societies Use Energy; Energy in the World Economy; Middle Eastern Oil and the Western World*; and, in 1979, *Energy in America's Future: The Choices Before Us*.



8. The International Politics of Energy

JOHN K. COOLEY

In early 1979, Iran's oil workers joined the revolution that hounded out their hated ruler, Shah Mohammed Reza Pahlavi.

By the year's end, seizure of American hostages in the U.S. Embassy in Tehran by the revolutionaries had escalated the situation beyond the mere loss of energy supplies from Iran into a major international crisis.

Cutbacks in Iran's oil exports, and leapfrogging price hikes inside and outside the 13-nation Organization of Petroleum Exporting Countries (OPEC) were giant new steps toward world power by the developing nations.

The process by which energy-rich states gained control of their own resources and also political leverage over their Western customers was far more, however, than just an exercise in current Muslim or Arab geopolitics. Its roots lie much deeper.

The Seven Sisters

In 1901, Muzzafereddin Shah of Iran granted gold prospector William Knox d'Arcy what was to become the first traditional Mideast oil concession. By the 1930s, seven big Western firms had come to dominate the world energy market.

In rough order of size, the majors, or "Seven Sisters," have been Exxon, the Royal Dutch Shell group, Texaco, Standard Oil of California (known as Socal, marketing as Chevron), Mobil, Gulf, and British Petroleum. In some areas a smaller, "eighth sister" has been France's Compagnie Française des Petroles.

Under the old concession system, the companies ran huge oil-bearing territories almost like colonies. Host governments had little control and shared minimally in profits.

Venezuela was the first to break with this pattern. After its first free elections in 1948, a nationalistic government passed an income tax law giving the government 50 percent of the oil companies' profits—at that time a truly revolutionary step.

The 50-50 system spread quickly to the Mideast, where Saudi Arabia took the lead in demanding half the profits of the Arabian-American Oil Company (ARAMCO), owned then by four of the seven sisters: Exxon, Texaco, Socal and Mobil. "Profit," calculated by deducting production cost from the crude oil price "posted" by the company, was split equally between company and producer government. Kuwait, Iraq and others soon followed.

Iran's efforts in the 1950s under Prime Minister Mohammed Mossadeq to break the concession system altogether and nationalize oil, brought confrontation between Mossadeq and a coalition of the Shah, the British, and the U.S. CIA—which brought the Shah back from temporary exile in 1953 in a military coup.

Before the 1950s, the seven sisters acted together to establish a single world price for oil, based on the Gulf of Mexico oil price set by U.S. oil companies. Since Mideast oil was vastly cheaper to produce than Gulf of Mexico oil, the major companies made enormous profits in the Middle East.

By the 1950s, however, Saudi Arabian Light oil had replaced Gulf of Mexico oil as the world's pricing yardstick. When the Suez War of 1956 between President Nasser's Egypt and an Anglo-French-Israeli coalition temporarily closed the Suez Canal to tankers, the price of Saudi Arabian Light rose to a then unprecedented height of $2.12 per barrel (compared to $32 for some OPEC spot transactions in the late 1970s).

Mideast oil-producing countries briefly tasted wealth, so when the foreign-owned companies unilaterally cut prices drastically again in 1959–60 without consulting producer governments, the shock was rude.

Creation of OPEC

The offspring of this shock, fathered chiefly by two oil ministers, Abdallah Tariki of Saudi Arabia and Pérez Alfonso of Venezuela, was OPEC. It was conceived at the first Arab Petroleum Congress of April 1959, and born at a crisis meeting of Iran, Iraq, Saudi Arabia, and Kuwait in Baghdad in 1960.

Eventually, the five charter members were joined by Qatar, Libya, Indonesia, Abu Dhabi (now the United Arab Emirates), Algeria, Nigeria, Ecuador and Gabon.

To force prices up to fair levels, OPEC in the 1960s regulated production. Its members also sought equity participation for host governments in decisions regarding production, distribution, and pricing, first urged upon ARAMCO by Saudi Arabia in 1964. When a world sellers' market for oil appeared in 1971, OPEC members were able to elbow major companies, little by little, toward granting participation.

Revolutions in Iraq (1958), Algeria (1962), and Libya (1969) led those three Arab states to nationalize production and related operations like distribution and marketing. Gradually they gained full control of Western oil operations on their soil. Other OPEC members branched out into creating their own petrochemical, natural gas, and tanker industries.

By February 1973, a devaluing U.S. dollar led OPEC to begin drastic price hikes to protect members' income. Then, as U.S. import demand rose, the Arab oil embargo exploded upon the West, to support Egypt and Syria in their 1973 war against Israel.

World oil prices quadrupled, and supplies drastically tightened in the 1973-74 period, bringing world recession. Despite such Western countermeasures as formation of the International Energy Agency to share scarce supplies, a series of OPEC conferences—not without inter-OPEC wrangling—moved prices upward again and again.

OPEC's Power

Thus, in the twenty years of OPEC's life, the oil-rich lands of Africa, Asia and Latin America have risen from total subservience to the industrial world outside the Soviet bloc to potential economic mastery over that world.

In 1960 the United States, Western Europe, and Japan were almost sole owners of the non-communist world's energy sources and distribution system. By 1979, they had become dependent for energy on about a dozen oil-producing states. Drawing about half its oil from OPEC, the U.S. found that OPEC was increasingly able to influence its foreign policy.

True, the economic interdependence of the world has mitigated this situation somewhat. Oil giants like Saudi Arabia depend on the West for everything from wheat to weapons, including the Western technology they need if they are to end this dependence.

Nonetheless, by 1979, Nigeria, black Africa's major OPEC member, had begun to exert pressure on the U.S. to favor the political solution it sought in Rhodesia, and Arab and Muslim OPEC members and their allies were influencing policies of West Europe and Japan to favor the Arab and Palestinian cause in the Mideast.

By combining skillful use of the oil weapon with extreme political acumen, President Sadat broke the stalemate with Israel in 1973.

First, with Syria, he waged limited war against Israel. Then with U.S. President Jimmy Carter, Sadat pursued a policy that they both termed "waging peace"—leading to the Egypt-Israel peace treaty signed in Washington March 26, 1979, the first which an Arab government ever signed with the Jewish state.

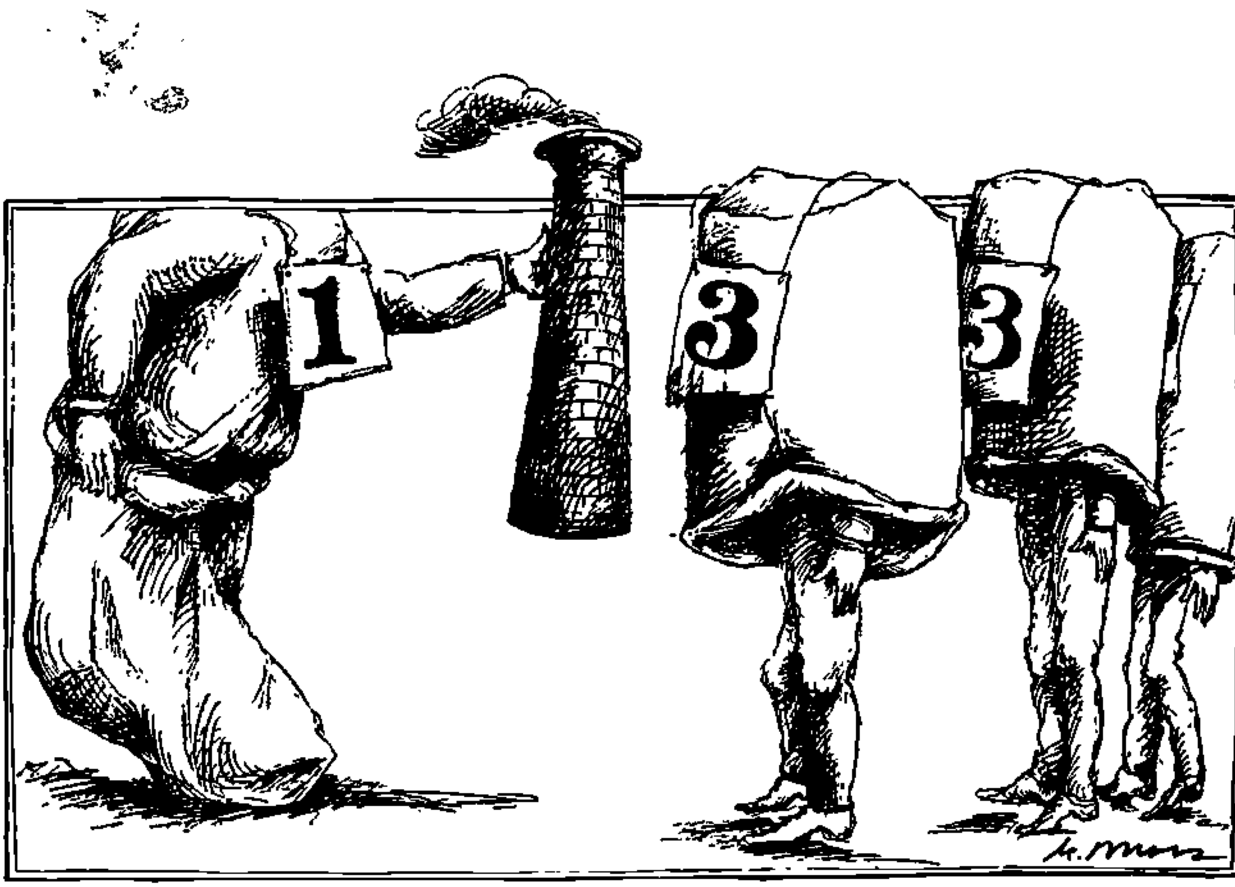
Today, the U.S. struggles toward a coherent energy policy. President Carter since 1977 has been seeking to allow U.S.-produced energy to rise toward world price levels, thus encouraging U.S. domestic production while the North Sea, Alaska and other non-OPEC sources are developed, and research goes forward on alternatives.

Meanwhile, OPEC's constantly growing leverage faces the U.S. with hard choices. Should it consider seizing oilfields or breaking blockades by use of military force? Or should it consider reshaping US. foreign policy to please OPEC members?

Or, finally, should the U.S. government try to curb, through legislation and mass education, America's insatiable appetite for OPEC oil? These questions are certain to engage the attention of Americans well into the 1980s and beyond.

ABOUT THE AUTHOR

JOHN K. COOLEY has been defense and national security affairs correspondent for *The Christian Science Monitor*, Washington, D.C., since October, 1978, having previously served for more than a dozen years as their Middle East correspondent. A free-lance reporter in North Africa from 1957 to 1964, he has been a radio commentator for ABC Radio News and has served with the U.S. Embassy in Vienna and Casablanca. His books include *Baal, Christ and Mohammed: Religion and Revolution in North Africa; East Wind Over Africa;* and *Green March, Black September: The Story of the Palestinian Arabs.*



9. The Global Lifeboat: Energy and the Third World

KENNETH E. BOULDING

At least half the world's population lives in poverty in rural areas in the tropical belt (and in China).

Their lives have been largely untouched by science-based technology or by use of fossil fuel resources, which elsewhere have led to the luxuries of our "modern" world.

Now that these resources are becoming increasingly scarce and expensive, are these so-called "Third World" countries condemned forever to stay in prescientific poverty? Have they come too late to the feast of geologically stored energy and materials?

The probability is uncomfortably high. Reducing this probability, through action and moral persuasion, must be one of our highest priorities.

Energy and Technology

The last 200 years have seen perhaps the greatest change in human history. This change has resulted from two closely related processes. One is the rise of science, which led to a great expansion of knowledge and its application in science-based technology.

The other is the discovery of fossil fuels—coal, oil and natural gas—and of uranium. Without either of these developments, the world of today would be strikingly different.

Without science-based technology, we would not have steel-framed skyscrapers, automobiles, fertilizers, artificial fibers and plastics, airplanes—much of what we think of as the "modern world." But even with the rise of science, if there had been no coal, oil, or natural gas, there would probably be no automobiles or airplanes, though there might be electricity, radios, and television on a small scale with a few wood-burning power stations.

And without science, we could not have utilized oil and natural gas, though we might have had primitive coal-burning steam engines. The issues of energy and science are thus intertwined.

Rich Get Richer

One byproduct of the change brought about by science and energy is that the world has become much more unequal in riches because of the unequal spread of the change itself. The change to a science-based technology took place quite rapidly in most areas of North America, Europe, and Japan between 1860 and the 1930s, with the rise of the electrical and chemical industries and of science-based agriculture.

In the tropics, however, the change took place very slowly and is still largely confined to bigger cities. The rural people there have been affected only slightly by the great revolution of science-based technology, which means they are still very poor. Even worse, where such technology has affected them, it may have made the poor poorer by cheapening the few commodities they have to sell and by disrupting the "folk" cultures in which they live, making them desire expensive goods and destroying native craft industries.

Grim Prospects

What then of the future? Will a science-based technology spread throughout the tropical countries, releasing hundreds of millions of people from agriculture to produce the conveniences of the modern world?

The spread of scientific knowledge and know-how is not too difficult, if political and cultural obstacles do not bar the way. The crucial questions concern energy and materials, which are the limiting factors in getting richer.

Even discounting inflation, it seems highly probable that energy and materials will become constantly more expensive in the next 100 or 200 years. Cheap oil and natural gas will be gone, certainly in 100 years, probably in 50. Coal will last somewhat longer, but it has great disadvantages, including damage to health and the environment.

Uranium and the breeder reactor can provide electricity for the world for centuries, and with our present knowledge, nuclear energy may be the main long-run hope of the poor countries. But it, too, has many disadvantages: it requires a high technology and an elite group to administer it; it entails small probabilities of large disasters (and even small probabilities do come to pass); and it poses grave danger of being used destructively.

New knowledge, especially of how to utilize solar energy, may make nuclear energy unnecessary, but we cannot be sure. At the moment, solar electricity is very expensive. Furthermore, electricity is not fuel; it will not drive airplanes and is not much good for automobiles.

Possible Solutions

Unless, therefore, there is continued expansion and useful application of scientific knowledge, the chances of Third World nations remaining permanently disadvantaged are all too high.

The first essential for reducing this likelihood is applied research in population control. With the 4½ billion people now on earth, the problem of finding adequate resources is extremely difficult. With the 8 or 10 billion people projected for the mid-21st century, the problem may be impossible. Every dollar devoted to the military lessens the amount available to balance production with population needs.

Grants from the rich nations to the poor should be encouraged, but they alone cannot solve the problem. The only hope is a growing sense of world community, based on two competing moral arguments. One is the notion that the world product is a "static pie," and it tries to make those who have created riches ashamed of them so they will give the poor a "fair share."

The other argument states that all humans must work together to solve the world's problems and to develop the technical competency of the poorer peoples—and that is quite a different problem.

This picture, of course, is enormously oversimplified. There is no "Third World," but a great variety of countries and regions with different resources and problems. The oil-rich but technologically poor countries may invest in technological change, giving them a permanent advantage over resource-poor countries.

Meantime, many of the really poor countries seem headed for disaster through population expansion on a very limited resource base. For them, the major energy crisis at present is not oil or gas, but firewood. In the mountainous tropics, especially, from Nepal to East Africa and to the Andes, forests are being cut down for firewood to supply the barest needs of an ever-expanding population. The result is a loss of fertile land as tropical rains wash off the unprotected soils, the mountains become irretrievably barren, the plains are silted up.

Local Competence

As one flies across Hispaniola today, one sees the boundary between Haiti, in the west, and Santo Domingo as a long straight line across the island, with trees on the west side and dry barrenness on the east. This is a symbol of a depressing principle—that it is hard to help those who do not help themselves. Only competence and realism at the local level can save people from catastrophe, or push them over the subtle social watershed that leads to betterment rather than worsening.

Tragically, however, the very impact of the modern world in technology, trade, even in aid, and still more in the psychological and political remnants of imperialism, both capitalist and socialist, often impairs local competence and capacity.

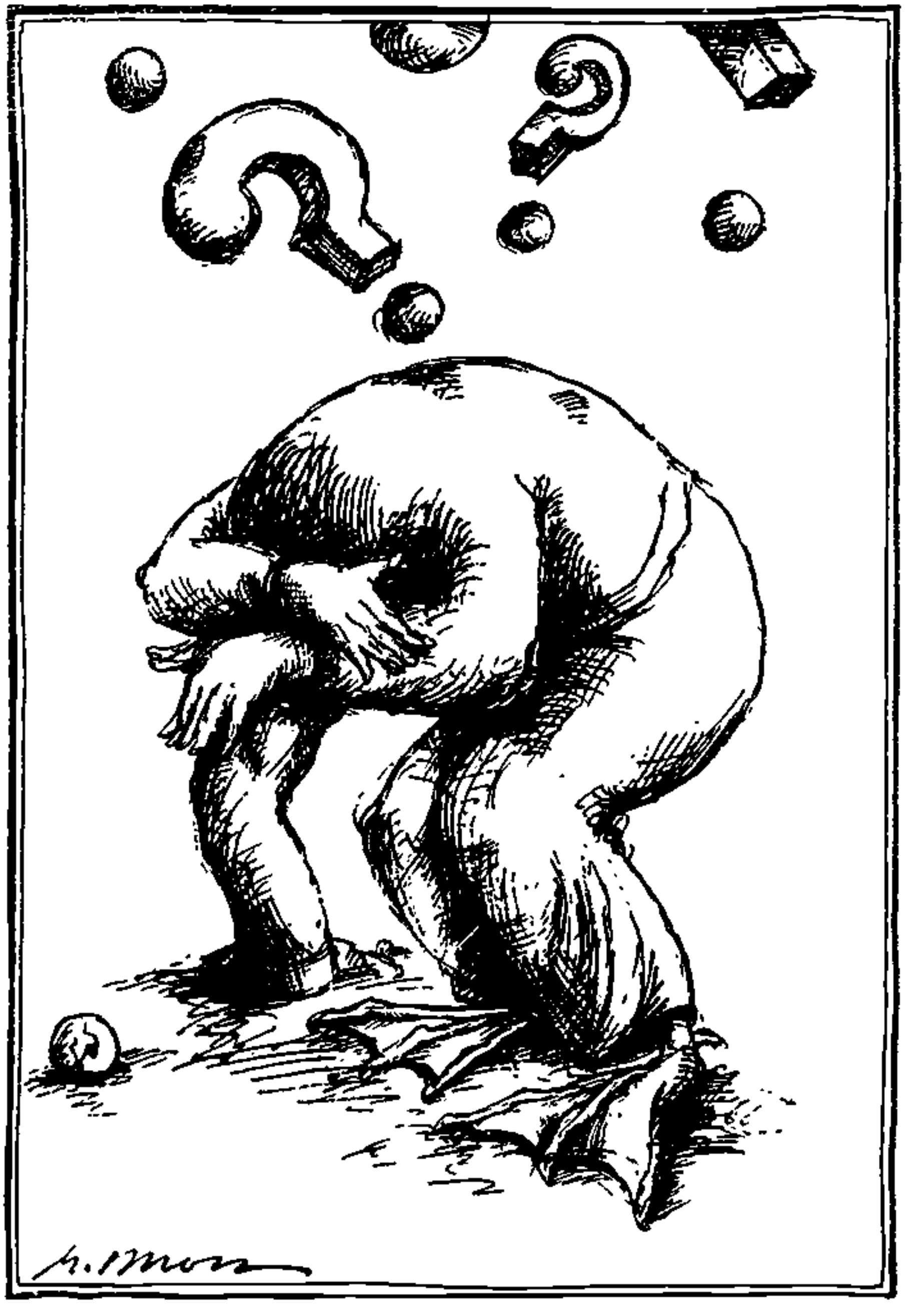
The improvement of local competence must therefore be of highest priority. Just as there are environmental impact statements, there should be competence impact statements on the impact of the modern world—through governments or corporations or international agencies or churches or traders—on the capacity of local societies to handle their own affairs.

The great tragedy occurs when an old traditional competence is destroyed, and modern competence has not been created to fill the gap. The catastrophic impact of the European settlers on the culture of the American Indians is a case in point. This is rarely discussed, for we tend to think only in terms of material transfers or exchange.

Yet underlying all human problems is the quality and the competence, and especially the organizational skill, of human beings themselves. Without them, all measures directed towards human betterment will fail.

ABOUT THE AUTHOR

KENNETH E. BOULDING is Distinguished Professor of Economics at the University of Colorado at Boulder and director of the Program of Research on General Social and Economic Dynamics in the university's Institute of Behavioral Science. He taught at the University of Michigan for several years before joining the University of Colorado faculty in 1968. His books include *The Social System of the Planet Earth*, *The Meaning of the Twentieth Century*, *The Image*, and *A Primer on Social Dynamics*.



10. Conventional Fuels in Transition

DON E. KASH

America is in a period of transition into its fourth energy era—a transition from oil and gas to other energy sources.

New energy technologies, however, are decades away from becoming full-scale substitutes for oil and gas. It is therefore virtually certain that we will have to muddle through a long transition period, requiring major changes in our lives.

Previous energy eras in the United States were wood (1850s), coal (1880s), and oil and natural gas (1950s to the present). Earlier transitions between eras were propelled by the twin engines of an expanding industrializing economy and the magnet of an attractive new energy source. Coal was cheaper and easier to use than wood, and so it was when oil and gas replaced coal.

Quite different and more painful forces propel the present transition: shortages, high costs, and unstable oil supplies. Nor is it clear what the energy sources of the future will be.

Without question, the nation has inadequate domestic supplies of oil and gas to support its present level of economic activity, let alone continued rapid growth. That was the message of the 1973 Arab oil boycott, a message repeated with cessation of Iranian exports in 1979.

Many Americans indict both government and industry for the failure to develop alternative sources of energy in the years between the 1973 and 1979 oil shortages. This indictment reflects the belief that alternative energy sources weren't developed because shortages allow energy companies to make excess profits.

Unfortunately, the answer is not so simple when there are no agreed upon substitute energy sources. In the long term, the nation must move to limitless or renewable energy sources such as nuclear fusion or solar power.

While these are being developed, our transition policy will rely on some combination of conservation, finding new oil and gas, and increased use of coal. Each of these options involves painful choices.

Conservation

Energy conservation can be achieved in two ways. First, and most attractive, is more efficient use of oil and gas. In many areas, technology offers the opportunity to save energy. These technological advances range from insulated houses, to diesel cars, to more efficient manufacturing processes.

This relatively painless approach to conservation, however, will not be adequate to meet the nation's conservation needs. Americans must also change their lifestyles.

To date, our willingness to live in 65 degree houses, drive 55 miles an hour, use fewer processed foods, and stop applying synthetic products to our lawns has not been encouraging. Rather, energy shortages have contributed more to inflation than conservation as we have sought to maintain present lifestyles in the face of shortage-driven escalating energy prices.

Simply stated, the need to conserve oil and gas has triggered a struggle over who has to conserve, the middle class or the poor, homeowners or industry The need to conserve is certain to create continuing social stresses during the transition from the oil and gas era, and those stresses are likely to be greater if we have to use rationing.

Domestic Oil and Gas

Industry advertisements note that the easily obtained oil and gas have already been found. Already discovered domestic oil would last us just over four years if it supplied all our needs at the present consumption rate of 6½ billion barrels a year.

That more oil is there to be found is agreed upon. What it will cost to find it and produce it, both economically and environmentally, is a source of disagreement.

Alaska and the offshore areas of the continental United States are believed to offer the best prospects for new oil and gas, with estimates ranging from two to five times the oil to be found in the inland 48 states. But development of these prospects will be expensive, take years, and continue to be a source of controversy. Furthermore, it must be emphasized that domestic prospects offer no hope of being a full substitute for oil imports, which now make up nearly half of our daily consumption of 18 million barrels.

Foreign Supplies

To the contrary, continued imports are critical to a stable transition period. We, however, can have little confidence in the long-term reliability of oil imports As events in Iran in 1978–1979 emphasized, the total world's production capability is probably only 3 million barrels a day more than present consumption (approximately 60 to 65 million barrels)—or less than the prerevolutionary export level of Iran of roughly 5 million barrels a day.

Some observers hope that both the production problem and the threat of instability posed by Middle Eastern politics will be mitigated by new discoveries in Mexico and potential discoveries in China. However, the Mexican and Chinese prospects are shaky sources of hope for a stable transition to a new energy era.

Mexican reserves, presently estimated at 25 billion barrels, are being added to every year By c parison, U.S. reserves, presently estimated at 28 billion barrels, are declining. Mexican production, however, is still only 1 to 2 million barrels a day, and it will be years before Mexican exports can achieve a level equal to that of prerevolutionary Iran. Further, Mexico, for political reasons, may not follow a policy of large-scale exports.

Chinese oil exploration and development is still in the talking stage. Even if large reserves are found, there is no assurance that China, any more than Mexico, will follow a policy of major exports.

On one point there is no major disagreement. Even with the most favorable situation in terms of both domestic discoveries and imports, the price of oil and gas will be high.

Limits of Coal

Coal offers the nation its clearest opportunity for an assured energy source through the transition. Domestic coal resources are huge, easily sufficient to carry us to our solar and/or nuclear future.

But coal poses a seemingly endless number of problems and challenges. We are still developing techniques and standards for mining coal in ways that minimize the damage to the nation's land and water—and to the miners' health.

Direct burning of coal raises serious pollution problems. Because of the impacts of air pollution on the environment and human health, the government requires the use of cleanup technologies by electric utilities and large-scale users before much of the nation's coal can be burned. Major differences exist over the adequacy and need for such cleanup technologies as the stack gas scrubbers, which take sulfur dioxide out of power plant smoke. No one, however, disagrees that scrubbers increase the cost of energy.

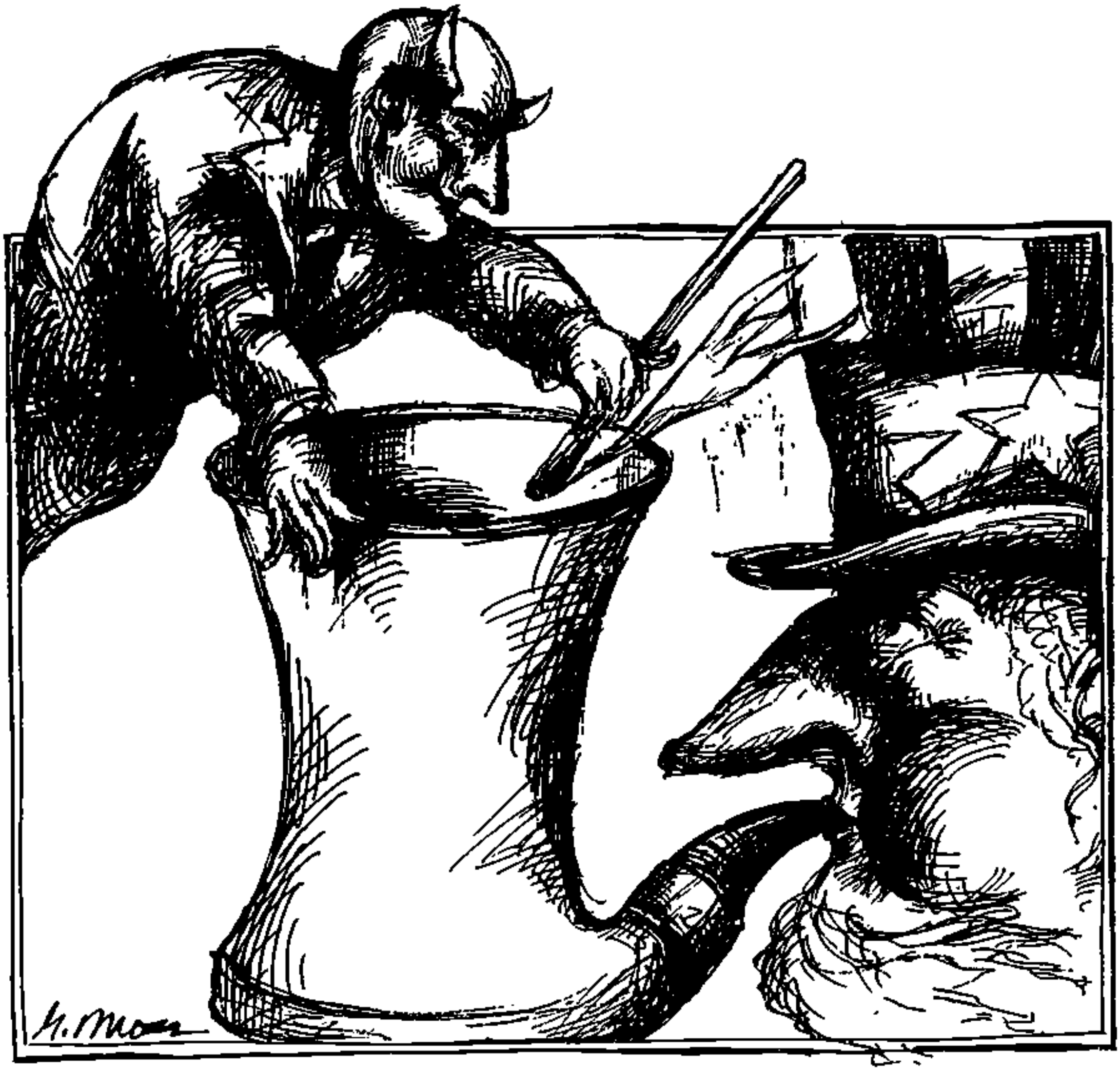
Management of pollution is only one of the barriers to substituting coal for oil and gas. Better than half the homes in America have gas furnaces. With minuscule exceptions, our whole transportation system requires gasoline or fuel oil. Coal can hope to meet these needs only if it is converted to gaseous or liquid energy forms. Although they exist in other countries, not a single commercial coal conversion facility is operating in the United States.

In his TV address to the nation following the Camp David policy review in July 1979, President Carter proposed a major coal synthetics program. Even were it to lead to the proposed production of 2½ million barrels of synthetic oil by 1990—at a capital cost of over $100 billion—this massive effort would meet less than 15 percent of our present daily use of oil.

The transition period we are entering will thus require major changes in individual as well as social and economic behavior. We are clearly faced with the kinds of difficult choices all societies would rather duck, but ducking is no longer an available option.

ABOUT THE AUTHOR

DON E. KASH is George Lynn Cross Professor of Political Science and director of the Science and Public Policy Program at the University of Oklahoma, where he joined the faculty in 1970 after teaching at Purdue University. He is the author of *The Politics of Space Cooperation* and coauthor of *Our Energy Future: The Role of Research, Development, and Demonstration in Reaching a National Consensus on Energy Supply; Energy Alternatives: A Comparative Analysis; North Sea Oil and Gas;* and *Energy Under the Oceans.*



11. Nuclear Energy: A Faustian Bargain?

ALVIN M. WEINBERG

It is now almost 40 years since the first nuclear chain reactor was created by Enrico Fermi in Chicago.

If we judge from the statistics—68 nuclear reactors supplying 12.5 percent of our electricity in 1978, 200 commercial power reactors in the rest of the world, and more than 200 reactors powering British, French, Soviet, and American naval vessels—nuclear power is now a great success.

But nuclear power is embroiled in a bitter debate that pits those who believe nuclear power is too dangerous against those who insist it can be safely controlled.

I have referred to nuclear power as a "Faustian bargain." Like the legendary Faust, who bargained for magical powers, we must pay a price for our power. Nuclear power, produced by the so-called breeder reactor that creates more fuel than it uses, confers on mankind an inexhaustible energy source. In return, however, mankind must exert continuing vigilance and attention to detail in handling the nuclear system so as to avoid harm.

Each 1000 megawatt nuclear plant can replace an oil-fired plant that burns 8 million barrels of oil per year or a coal-fired plant that burns 2.5 million tons of coal per year. Were we to replace the 300 nuclear plants originally planned for operation by 2000 A.D. with coal-powered plants, we might have to dig an additional 750 million tons of coal annually; if with oil, we would have to import an additional 2500 million barrels of oil each year.

With the world in an energy crisis, there is the strongest incentive to use and to expand nuclear energy.

Secure Sites

But there are potential problems that center on the dangers of intense radioactivity generated in a nuclear power plant, and on the possibility that plutonium produced in a reactor can be used to make nuclear bombs—the proliferation issue.

The possibility of terrorist attack on a nuclear plant or of clandestine diversion of nuclear material must be guarded against. This means that nuclear facilities will always require heavy security.

Such security can best be provided by clustering our nuclear plants in perhaps 100 heavily guarded, expertly manned centers throughout the nation rather than dispersing them as we have for fossil fuel power stations. Most of the existing nuclear sites could grow into such centers. They would be large, permanent, and largely self-contained.

The security demanded at such sites is a small price to pay for an enormous, new energy source. Moreover, if the sites are permanently dedicated to nuclear activities, both the low-level radioactive wastes and the reactors themselves, after 40 years of operation—the predicted period for which they would be serviceable—could be kept where they are until most of their radioactivity has decayed. The hazards associated with our current practice of transporting radioactive materials away from the site would thus be greatly reduced.

Radioactive Wastes

The other concern regards radioactivity in a reactor. A typical, one million kilowatt plant contains about 15 billion curies of radioactivity—about equal to the radioactivity due to the uranium naturally dissolved in all the oceans of the world. After a reactor is shut down, this radioactivity continues to generate heat that dies away gradually over several weeks, the reactor must therefore still be cooled. Eventually the remaining radioactivity must be isolated permanently.

Only about 50 cubic feet of high-level radioactive wastes are created each year by a large reactor if the wastes are chemically reprocessed—somewhat more if the spent uranium-bearing fuel is isolated unprocessed. Because the volume is small, most experts who have studied the matter believe that foolproof schemes for disposing of these wastes deep in the earth can be devised.

Yet, it is hard to convince people that even the experts can know much about containing man-made materials inside the earth for periods of 1000 years or more. By that time the wastes would be no more hazardous than the uranium originally dug out of the ground.

In seeking foolproof schemes, we are not asking the impossible. President Carter's task force on radioactive wastes concluded, "Successful isolation of radioactive wastes from the biosphere appears technically feasible for periods of thousands of years. . . ."

The technical arguments are reinforced by a study of ancient man-made artifacts. In the Ekain caves near San Sebastian, Spain, there are paintings of horses, many in superb condition, made by Cro-Magnons 12,000 years ago. If the artifacts of Cro-Magnon man could survive inadvertently in the earth this long, is it not reasonable to suppose that our geologists and ceramists and chemical engineers can do at least as well with radioactive wastes?

In Gabon, Africa, there is a uranium mine in which natural nuclear reactors operated 2 billion years ago. Several tons of plutonium and billions of curies of radioactivity were formed. Yet the plutonium, and much, though not all, of the radioactivity remained immobilized. If the earth can locally contain radioactivity so well by chance, cannot modern technologists do better?

To be sure, the isolated wastes will require surveillance—but the surveillance would be minimal, a few people checking on the closed repository periodically to make certain the site is undisturbed.

Reactor Accidents

Properly operating reactors pose a smaller insult to the environment than do coal-fired boilers. They emit no carbon dioxide and therefore create no long-range threat to the earth's climate.

On the other hand, as the Three Mile Island accident demonstrated, should a reactor lose its coolant, it could overheat and release some of its radioactivity to the environment. In this respect a nuclear reactor is like a large dam: a dam, when properly operating, is a benign source of energy. Should the dam fail, land is flooded and people are drowned.

Until the Three Mile Island accident, we in the nuclear community were confident that the probability of such an accident was very small. After all, the world's pressurized water reactors had operated for 500 reactor years without an accident that harmed the public. To this one must add more than 1000 reactor years of operation by the nuclear navy.

Three Mile Island has shaken this belief. Although no one was hurt, if the probability of such accidents is no lower than 1 in 500 reactor years, the public will probably not accept nuclear energy. The future, indeed the survival, of nuclear power requires us to do better. As the Kemeny Commission that investigated Three Mile Island put it, "The legacy of TMI is the need for change."

An Acceptable Nuclear Future

Can we design an acceptable nuclear future, one in which the accident probability is much lower than this? Of course we must, and will, correct the technical deficiencies revealed by the accident.

But equally important, and as suggested by Kemeny, we must have more expert operation and isolated sites. We should confine all reactors to relatively few permanent sites, which would be operated by an elite corps of professionals, each as highly selected and trained as pilots of sophisticated jet aircraft.

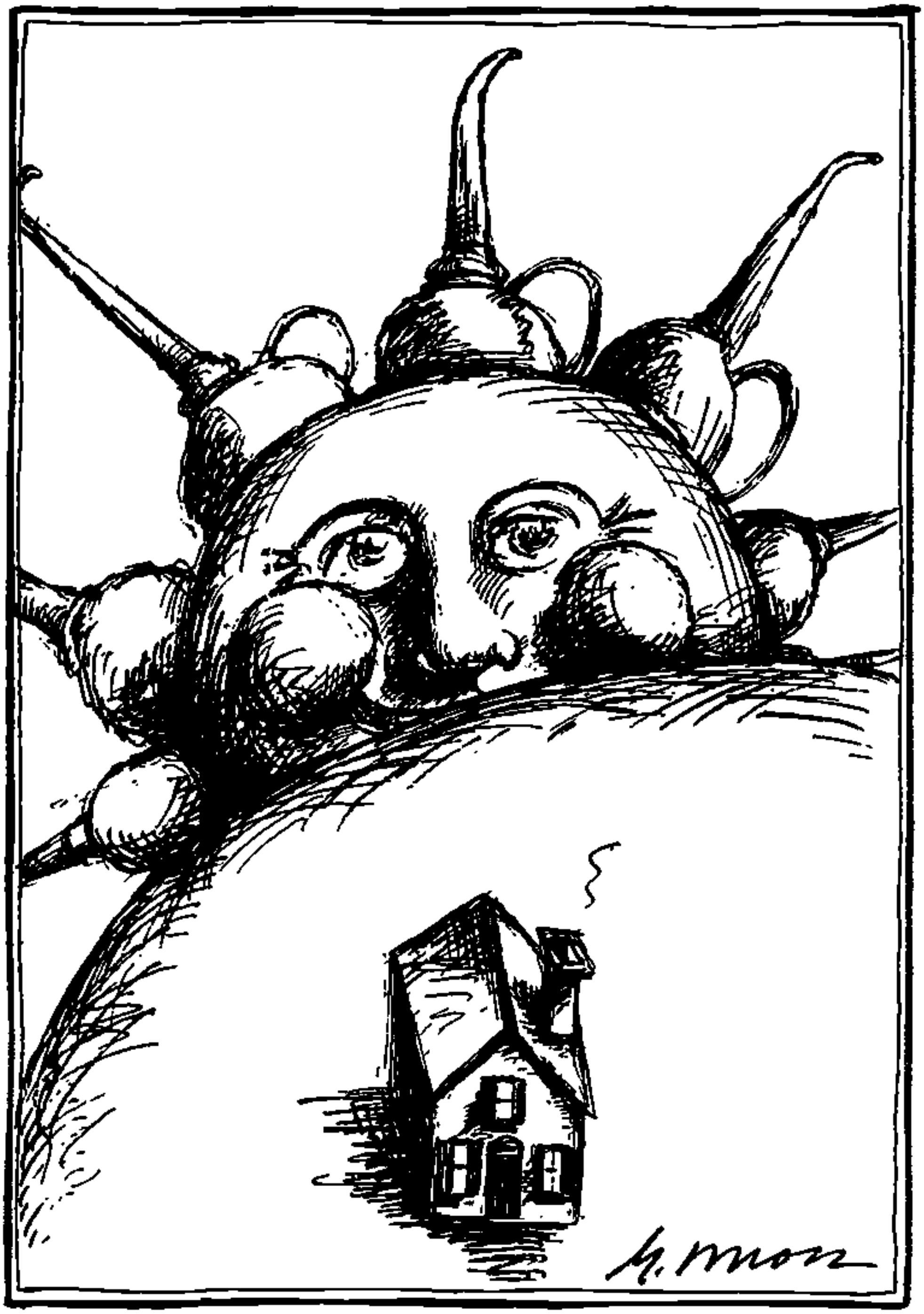
Beyond this the public will have to place the radiation hazard in better perspective. We must realize that we are bathed in a perpetual sea of radiation to which life has adapted. Unless the public (and the media) accepts exposure to radiation—even the remote possibility of exposure to dangerous levels—in the same spirit that it accepts exposure to other industrial pollutants, there is little chance of our enjoying the benefits of plentiful nuclear energy over the long run.

Can we redeem the Faustian bargain, even as did Goethe's Faust, whose soul was finally saved?

It was human fallibility that got us into trouble at Three Mile Island, but it was human ingenuity that limited the damage. An acceptable nuclear future is therefore possible. Three Mile Island may have given us the incentive to reexamine the terms of the bargain, and to make the changes necessary for an acceptable nuclear future.

ABOUT THE AUTHOR

ALVIN M. WEINBERG has been director of Oak Ridge Associated Universities' Institute for Energy Analysis, which he helped to establish, since 1975. Following his retirement in 1973 as director of Oak Ridge National Laboratory, a position he held for more than a quarter century, he served for one year as director of the Federal Energy Administration's Office of Energy Research and Development. The originator of the nuclear pressurized water reactor, he proposed its use for submarine propulsion in 1944. He has received many awards for his contributions to the theory and development of nuclear reactors, including the 1960 Atoms for Peace Award and the Atomic Energy Commission's E. O. Lawrence Memorial Award.



12. Solar Energy and "Appropriate Technologies"

WILSON CLARK

The international oil crisis is worsening, and safety and environmental problems plague the development of such energy sources as nuclear fission and coal. The rapid development of renewable, efficient energy supplies through harnessing the sun is therefore quickly becoming an important national priority.

Unlike the centralized energy sources of today, the development of clean, more localized energies based on the sun offers the potential of a society free from terrorist threats at nuclear plants, environmental degradation from the exploration and development of the earth's fossil fuels, and the Damocles' sword of nuclear power development.

With a major national commitment, we can build towards a new solar age while making the energy facilities and use patterns of today more efficient. Conservation of energy is important, but we must accelerate the use of renewable energy.

Today, the only major renewable energy source is hydroelectric power, triggered by the sun's effect on the world's water cycles. Hydroelectric dams supply 4 percent of the nation's energy, but finding new sites will limit the potential of this resource. Looming in the future, however, are other more direct uses of the sun's energy.

There are two basic ways to utilize solar energy in buildings: through the installation of "active" solar collectors, which trap and store heat, and through the "passive" design of buildings to maximize the use of natural sunlight and other climate-related energy factors.

Passive Solar Design

Harnessing the sun's energy through passive designs has been the hallmark of good architecture for centuries. Greek and Roman buildings faced the sun to gather heat; medieval castles were often built to store heat in great masses of stone; tropical structures are built with thatch and airy breezeways to deflect solar heat; barns in northerly climes are built with sloping, south-facing roofs to catch solar heat and deflect winter snows.

Today, the lessons of passive solar design—neglected since the introduction of cheap energy, home air-conditioners and compact central heating systems—are once again being learned. Proven passive solar techniques for new homes and buildings utilize the mass of thick walls, rocks, and storage devices to store solar heat captured by a building and its windows for later use. New structures may be specifically designed to incorporate large south-facing windows, as well as special ventilation techniques to cool structures in summer.

One award-winning builder, Jess Savell, has used five-inch walls of concrete and foam insulation to provide excellent cooling qualities in hot climates. His insulating cocoon has reduced energy requirements by 60 percent in test homes. Such superinsulation will undoubtedly prove popular as consumers recognize substantial energy savings at low cost.

Active Collectors

The active approach to solar energy, which uses special collectors to trap heat and storage devices to save it for later use, is also rapidly growing.

Early in this century, a sub..antial market for solar collectors developed in California and Florida, but the advent of cheap fossil fuels and electricity curtailed the solar demand. As late as 1951, however, there were 50,000 solar water heaters in Miami.

Today, solar water heating is catching on again, and nationally, the industry may reach $20 billion by the end of the 1980s. Solar space heating and air-conditioning technologies are also being developed and marketed for homes, commercial buildings, and industry.

The most familiar type of solar collector consists of a dark metal surface covered with copper tubes for transferring a liquid, enclosed in a glass-covered box. Until recently, this was the only widely available commercial solar technology. Now, more than 100 U.S. manufacturers produce a dazzling variety of designs, such as flat plate collectors covered with plastic glazing; collectors that have tracking devices to "follow" the sun; and evacuated tube collectors that trap heat in glass vacuum tubes.

For many household uses, simple flat-plate collectors can provide hot water and space heating, but for more sophisticated applications—such as providing heat over 200°F for the operation of refrigeration or industrial heating equipment—concentrating and tracking collectors are preferred.

Today's solar hot water heaters cost from $1,500 to $4,000 for household installations, and upwards of $10,000 for more sophisticated systems. As technologies improve in the 1980s, costs—discounting inflation—are expected to decline.

Photovoltaics

A currently expensive, yet very promising, solar technology that is utilized on spacecraft involves photovoltaics, whereby tiny cells (similar to the silicon semiconductor chips used in pocket calculators) convert 10–20 percent of the sunlight striking their surface into direct-current electricity.

The most common type of photovoltaic cell, the silicon cell, now costs $8–$10 per watt of generating capacity, when arranged in special power-generating arrays. Yet a reduction in cost to $1–$2 per "peak" watt is expected within the next few years, as modern manufacturing techniques and new technologies for producing the silicon raw materials are introduced.

Photovoltaics today are used mostly for remote power applications, such as Coast Guard navigational markers. However, some producers report t' at village sized power systems around the world that now use diesel generators are finding photovoltaic systems an economic replacement.

Other large-scale solar technologies include "power towers." Special reflector mirrors, called heliostats, concentrate sunlight a thousand-fold to generate steam in a tower-mounted boiler, which in turn is connected to a conventional electric turbogenerator.

The "solar pond," another large-scale technology, makes use of special brine ponds, which trap heat at high temperatures that can be used for electricity conversion. Developed in Israel, it is now being considered for California's man-made Salton Sea, south of Los Angeles. The Salton Sea project would be the world's largest single solar project, producing over 600,000 kilowatts of economic, pollution-free solar electricity, enough to supply a half-million people.

Wind Power

Another solar-derived technology that promises widespread application as well as low cost is wind power. Wind electricity is the least expensive form of solar energy today, and a recent study by SRI International, a technology consulting firm, indicates that wind power could supply 80,000 megawatts of electricity, equivalent to 80 large nuclear or coal plants, by the turn of the century.

To date, several large wind generators have been built by the federal government, and at least one electric utility, the Southern California Edison Co., has initiated a private test program. Until recently, the government's efforts have focused on gargantuan machines—each having rotor blades up to 300 feet in spread. Recent research shows, however, that smaller machines (1,000 kilowatt, 100–200 foot blades) linked together in favorable areas may be the best, most economic answer to the energy problem.

Since wind generators are relatively simple, they can be manufactured in large quantities at low cost and installed at favorable sites. The World Meteorological Organization estimates that 20 million megawatts of wind electricity can be harnessed on a global basis.

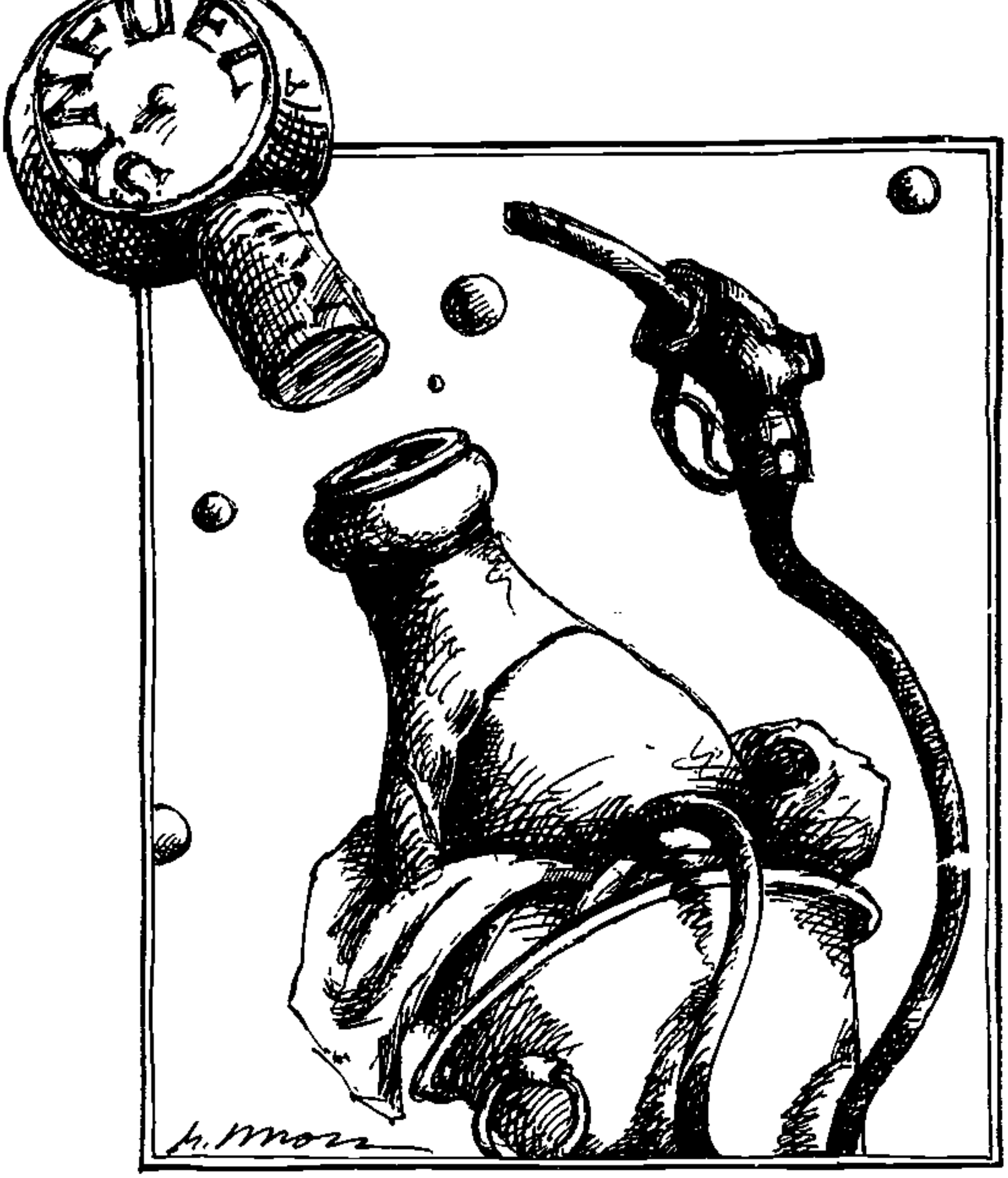
Solar energy is also stored in biomass, or plant matter, that can be converted into liquid and gaseous fuels to replace petroleum and natural gas. The goal is tantalizing—the energy stored in biomass is estimated to be 10 to 40 times the current annual human use of fossil fuels.

The conservation economy and the solar transition are not radical, impossible steps for our civilization. Using energy efficiently and increasing the use of solar energy will have dramatic, positive effects on the U.S. economy. Decentralized, community approaches to solving energy problems encourage the development of new jobs, and solar energy will reduce the need for inflationary imports of non-renewable fuels.

What is needed is a major national commitment to this goal. The full cooperation of industry, labor unions, citizens and government can make the dream of an energy-efficient solar age into a reality.

ABOUT THE AUTHOR

WILSON CLARK has been on the staff of California Governor Edmund G. Brown, Jr., since 1976. He is Assistant to the Governor for Issues and Planning and advisor on energy, economics, and the environment. He is also codirector of the Environmental Policy Institute and energy-policy coordinator for the Environmental Policy Center in Washington, D.C. He is the author of *American Land and Rural Resources; Energy for Survival: The Alternative to Extinction;* and *U.S. Energy Policy: Selected Environmental and Social Policy Issues.*



13. Making Our Own: Synthetic Fuels

JOHN H. GIBBONS and WILLIAM UPTON CHANDLER

Gasohol—ten percent alcohol and ninety percent gasoline—is one of the synthetic fuels that have intoxicated the imagination of some who worry about energy. Substituting alcohol and other synthetic fuels for gasoline could help relieve the problems of dwindling domestic and uncertain imported oil supplies.

To promote "synfuels," the U.S. government may spend tens of billions of dollars. But to do so without considering the enormous economic and environmental costs would be a mistake. Indeed, the cost of synfuels may be so high that conservation, including government subsidies for retooling industry, will be a far better investment for at least the next decade.

The excitement surrounding synfuels is understandable. Seventy-five percent of the energy we use today is derived from crude oil and natural gas, and the fuels we use are mostly liquids and gases.

Solid fuels like coal will be restricted in usefulness unless they can be liquefied or gasified, especially for transportation uses. Even increasing the use of solid fuels in making electricity will not solve our problems—unless, of course, the electric car can be perfected—because only ten percent of the energy used by consumers is in the form of electricity.

Thus, with the oil and gas shortage, many persons have become convinced that we must have synthetic fuels *now* at any price.

The Methane Scenario

Creating fuels from biomass—plant matter and animal wastes—could be the cheapest option for making synthetic fuels. Wood and crop residues, for example, can be converted to either liquid alcohol or methane gas, the principal component of natural gas.

Like all of our commonly used fuels, natural gas consists of hydrogen and carbon atoms. Naturally-occurring methane gas was produced by the pressure and heat of the earth breaking down the complex molecules of buried plants and animals. This process, destructive distillation, can be replicated in gasification plants in which wood or any suitable hydrogen-carbon compound is subjected to heat and pressure.

Gas can also be produced by using certain bacteria to "digest" biomass in the absence of air. In either case, large-scale production of synthetic gas from biomass currently costs several times as much as natural gas.

Alcohol liquids may be produced from biomass using common distillation techniques. Biological materials are fermented by the addition of yeast, and then ethyl alcohol is distilled from the "soup."

Pure alcohol cannot be used in cars without major engine alterations, but alcohol (up to about 15 percent) blended with gasoline can be burned without any engine modification. Some gasohol is being produced and marketed today. The alcohol fraction is subsidized by the government to about $ .40 per gallon, and is competitive for this reason.

Synthetic gas is also being marketed today in very small quantities. In the Midwest, gas made from stockyard manure is delivered through natural gas pipelines to Chicago consumers. The cost is low because the resource is free, though limited.

In terms of the environment, biomass-derived fuels could be either benign or catastrophic because removing wood and crop residues from soil reduces its fertility. The amount of residue which may be removed safely varies by soil type and must be studied carefully.

Oil Shale

Oil shale is another possible source of fuel. Enormous quantities of liquid kerogen, a substance similar to oil, are trapped in the pores of shale rock in Utah and Colorado. Retorting, or heating, shale frees the kerogen, which may be converted into substitutes for gasoline, diesel, fuel oil, and the like.

The problems of producing oil from shale, however, make us question its feasibility. One problem is that oil shale is more shale than oil. Mining and retorting each *ton* of shale rock produces only 25 to 35 gallons of oil.

A second problem is that up to 5 barrels of water are required to produce and refine a barrel of shale oil The already grim shortage of water in the oil shale regions of arid Utah and Colorado may strictly limit shale oil production.

Still another difficulty is that the technology of producing oil from shale is not well advanced, and only a few small plants have been constructed. There is also the potential for polluting water and air with the poisonous and cancer-causing materials that are present in shale.

Coal Gasification

Coal, like biomass, can be converted readily to a liquid or to methane gas. But even under the best circumstances, coal conservion "wastes" about one-third of the potential energy in the coal. This fuel loss, coupled with the high price of conversion equipment, makes the price of synfuels high.

Coal liquids can be produced by a number of processes, including the Fischer-Tropsch process used in Nazi Germany to produce synthetic fuel from coal. The process produces gasoline and many other compounds by first gasifying coal and then synthesizing the gases into liquids.

Alternatively, methyl alcohol may be produced from coal. Whatever fuel is made, however, the cost is high. Oil from coal may cost $50 or more per barrel, compared with an average $22 per barrel for oil in 1979

Coal production already demands a high price in human terms, as well. Families who live near strip mines suffer thousands of dollars of damages to their homes from blasting, landslides, and flooding. The agony suffered by underground miners who get lung disease is reflected in the cost of health care and benefits to ameliorate this problem. *one billion dollars each year.* And two hundred miners *die* in the mines each year. These human costs conceivably could be doubled by a major coal-based synthetic fuels program.

Costs of Synfuels

The U.S. government may spend approximately $90 billion—the amount requested by President Carter—over the next few years to develop synthetic fuels. The hoped-for benefits would be about 1.5 million barrels of synthetic oil per day by 1955, or about 10 tanks of gasoline per car per year if all the product went into automobile fuel production. The synthetic gasoline would cost at least $2 per gallon in addition to the $400 per person needed for the $90 billion start-up cost.

How would synfuels compare with conservation in solving our energy problems? Cars can be built to save half the fuel they use at little extra total cost. The amount of energy that could be "produced" by doubling the mileage obtained by all American cars by 1990 would amount to 2.5 million barrels per day, about 15 tanks of gasoline per car per year.

Even greater savings are possible without reductions in safety or comfort. But achieving this conservation goal for automobiles would require government subsidies to accelerate retooling our auto industry. Such an investment, however, would be more effective than a far more expensive investment in synfuels.

At some point we will need a large synthetic fuels industry: "When" is largely a matter of the cost of synfuels relative to conventional fuels. A logical energy plan might begin by immediately developing and adding to our gas supply the unconventional natural gas that is too expensive to produce under price controls. Later, gas from biomass and coal could be added. The existing gas pipeline system can serve three-fourths of all Americans, and gas can be put to almost any use, including operating vehicles.

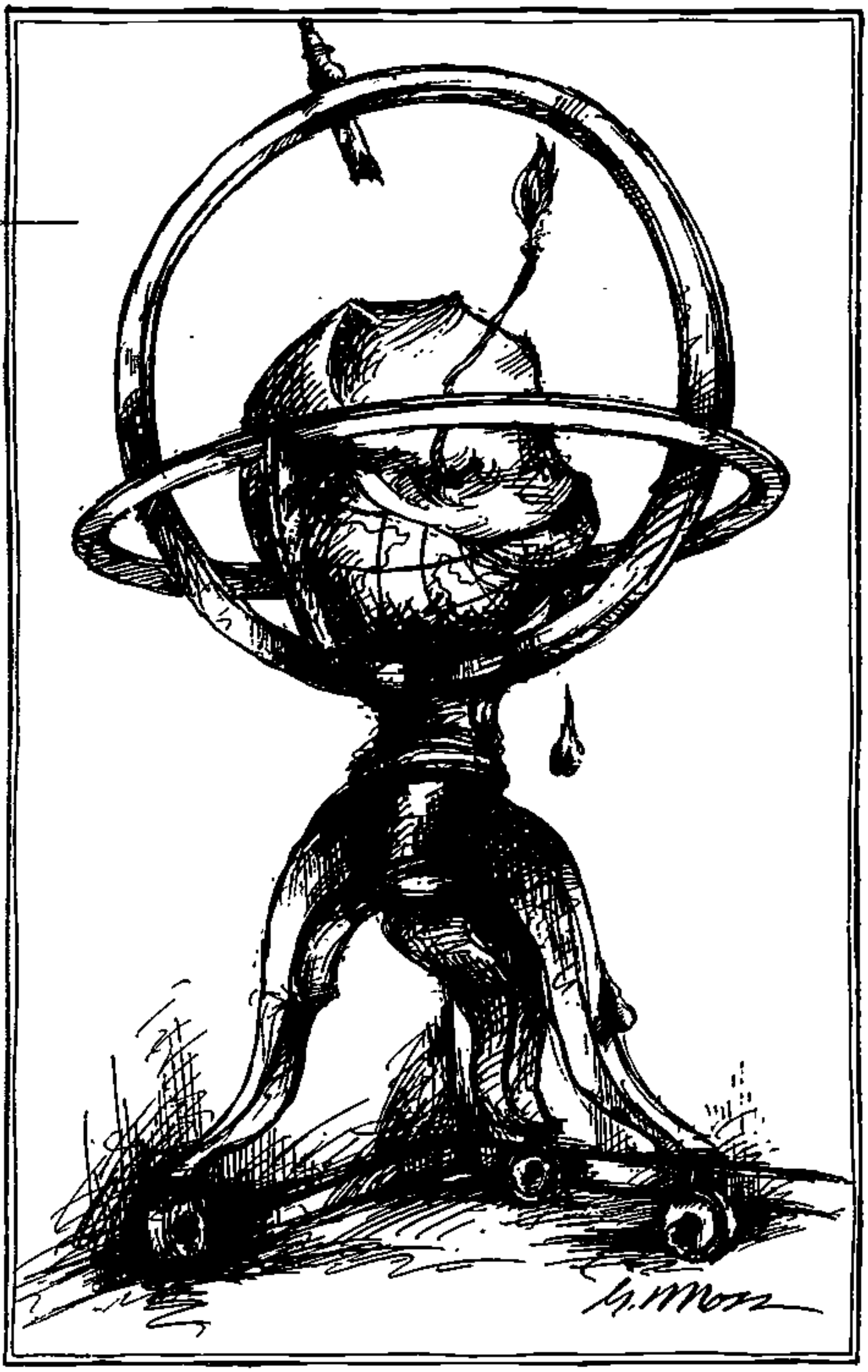
Liquid synfuel production then could be started in a few years by building a few full-scale plants to gain practical experience with processes using various hydrocarbon resources. Major production commitments should await the experience of these "pioneer plants."

Such an energy future might be the least costly in terms of *total* costs, and could be reached in an orderly fashion.

ABOUT THE AUTHORS

JOHN H. GIBBONS is Director of the Office of Technology Assessment. From 1974 to 1979, he was professor of physics and director of the University of Tennessee Environment Center. From 1954 to 1973, he was at Oak Ridge National Laboratory, and in 1973 he became director of the Office of Energy Conservation for the Federal Energy Administration.

WILLIAM UPTON CHANDLER is a consultant to the energy program of the Office of Technology Assessment. He previously was a senior research associate at the University of Tennessee Energy, Environment, and Resources Center.



14. More Through Less: Effective Energy Use

DENIS HAYES

The oil we Americans now devour at the rate of one million barrels every ninety minutes was formed over millions of years and is composed of the leftover food of that prime example of immoderate growth—the dinosaur. Rather than learning from history's mistakes, we have been burning the evidence.

In 1975, Americans *wasted* more fossil fuel than was *used* by two-thirds of the world's population. We annually consume twice as much fuel as we need to maintain our standard of living.

We could lead lives as rich, healthy, and fulfilling—with as much comfort, and with more employment—using half the energy now used. Continuation of our current wasteful course is spherically senseless: it doesn't make sense no matter how you look at it.

Resources are frequently estimated in terms of years left until world production will "peak" and begin to decline. Despite recent oil discoveries in Mexico, many authorities believe that worldwide oil production will peak within the next decade.

Since 1973, growth in world oil output has not kept pace with growth in world population. Per capita oil production has fallen from 5.34 barrels per person in 1973 to 5.20 barrels per person in 1978. If the government of Saudi Arabia were to decide it would rather have oil in the ground than paper money in the bank, per capita world oil production might never again reach the 1973 level.

Barriers to Growth

Growth in energy usage is constrained by factors other than the scarcity of certain principal fuels. Long before all the earth's coal has been burned, for example, the burning of coal could be halted due to climatic changes caused by rising carbon dioxide levels in the atmosphere.

In several states, nuclear power has already been effectively stopped by mounting public concern over safety, waste disposal, weapons proliferation, and construction costs of nuclear plants. The dramatic reactor accident in March, 1979 at Three Mile Island in Pennsylvania strengthened the anti-nuclear tide.

Such barriers to endless energy growth cause great consternation among those who believe that economic well-being requires continual growth in energy usage. Political exhortations for energy conservation have thus often taken the form of calls for sacrifice, as though thrifty energy use were oppressive. Nothing could be further from the truth.

Benefits from Conservation

A comprehensive program of energy conservation initiated today will yield vast benefits. It will enable our descendants to share in the earth's finite stock of fossil fuels. It will allow a portion of the world's petroleum to be used for drugs, lubricants, and other non-energy purposes.

An enlightened program of energy conservation will substantially bolster employment levels. Capital diverted from nuclear, coal gasification plants, and new petroleum refineries to investments in conservation will save more energy per dollar than the production facilities could produce, and create more jobs.

A strong energy conservation program will allow us to minimize the environmental degradation associated with all current energy conversion technologies. And the security of a modest energy budget is more easily assured than that of an enormous one that depends upon a far-flung network of sources.

But what will energy conservation mean for that touchstone of public policy: the economy? Is it true, as is apparently believed by some economists and many members of the public at large, that a reining-in of our energy growth—however attractive it might be from an environmental, consumer, or labor perspective—would damage the economy?

Energy and the Economy

Comparisons between countries and between different facilities in the same country demonstrate that reducing fuel consumption need not reduce economic output. Consumption can be cut back by using more fuel-efficient industrial machinery.

A recent study by the Mellon Energy Institute concluded that an investment of more than $200 billion in increasing the energy efficiency of U.S. buildings, industries, and transportation would save more energy than the same expenditure on new energy facilities would produce.

For the past several decades, the amount of fuel consumed per dollar's worth of goods and services has fallen—despite declining real energy prices. With rising energy prices a near-certainty in the future, this trend could accelerate dramatically.

A recent exhaustive study, *A Low Energy Strategy for the United Kingdom*, concluded that Great Britain could triple her Gross National Product during the next 50 years and still require less energy in 2025 than that country uses today.

Opportunities for energy savings in the United States are much greater than in Britain. Per capita energy consumption in the U.K. is only 45 percent as high as in America, and only 75 percent as much energy is used there per dollar of Gross National Product. If the British are wastrels, we Americans are downright gluttons.

Industrial Savings

Industry currently consumes about 40 percent of U S energy, and the opportunities for increased efficiency abound. Many companies have accomplished major energy savings simply by eliminating waste—f.. example, by repairing broken windows and closing factory doors during the winter.

The largest future opportunities for fuel savings, however, will require more sophistication. Devices such as recuperators, regenerators, and heat pipes, for example, help conserve the heat generated in industrial plants—heat that would otherwise be used once and discharged, or removed directly with the flue gases without naving been used at all.

At present, electricity purchased mainly from large, centralized power plants, fulfills much of industry's energy demand. The average efficiency of American power plants is about 30 percent: 70 percent of the energy originally contained in the fuel they use is discharged into the environment as low-grade heat. But factories have ...any needs for low-grade heat, needs they now meet by burning high-grade fuels. If electrical generation took place inside factories instead of at remote power plants, the waste heat could be efficiently cascaded through multiple uses.

Investments for such "industrial co-generation" require far less capital and fuel per unit of electricity produced than do investments in new centralized power plants.

Transportation Policy

Transportation ranks second, after industry, in energy consumption. It accounts for about 25 percent of U.S. energy end-use. Shifting goods wherever possible from trucks and airplanes to trains, ships, and pipelines could significantly increase the energy efficiency of transport.

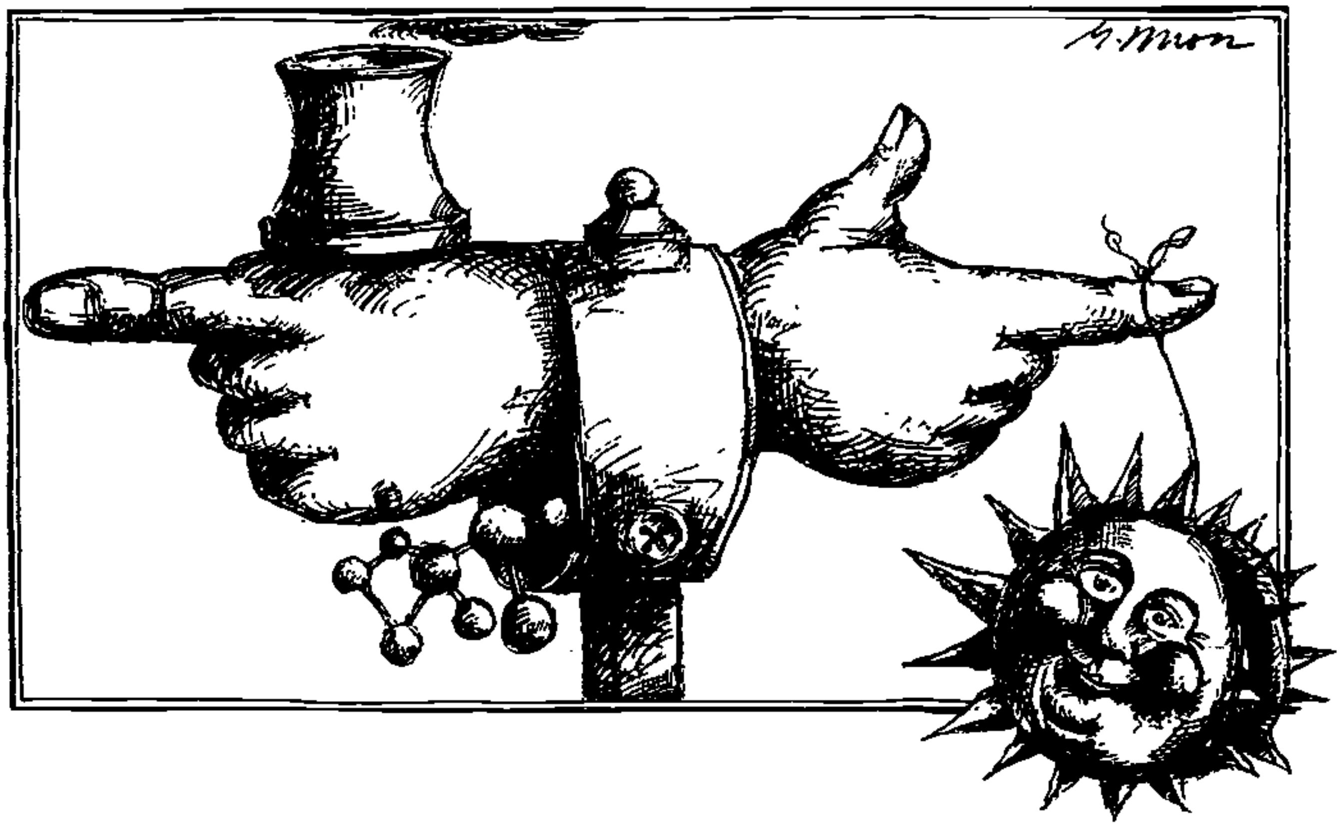
At the center of any sensible transportation policy must be a new approach to personal mobility. Current legislation requires a fleet average of 27.5 miles per gallon for new automobiles by 1985. This is a step in the right direction. The next steps include much greater mileage increases, the design of post-petroleum vehicles, and the establishment of land use patterns that diminish the need for personal transportation.

Enormous opportunities for energy conservation also exist in both old and new buildings. Weatherstripping, insulation, storm doors, thermopane windows, sensible use of curtains and overhangs, time-of-day thermostats, more efficient furnaces, solar collectors—to name a few—can lower conventional fuel requirements for space conditioning and water heating by 50 percent or more. No new building permits should be issued for structures that don't incorporate at least passive solar design features, such as windows properly placed for heating and cooling efficiency.

The President's Council on Environmental Quality noted in 1979 that, "Achieving low energy growth will not be easy or cheap, but it will be easier and less costly than achieving high energy growth." It is not too late to retrace our steps before we collide with inevitable boundaries on energy growth and consumption. But the longer we wait to begin a true national commitment to energy conservation, the more tumultuous the eventual turnaround is likely to be.

ABOUT THE AUTHOR

DENIS HAYES became Executive Director of the Solar Energy Research Institute (Golden, Colorado), which provides information for the Department of Energy and serves as an informational clearinghouse on solar energy, in 1979. He previously was a Senior Researcher with Worldwatch Institute in Washington, D.C., a private, nonprofit research organization devoted to the analysis of global issues. Chairman of the national Sun Day observance in 1978, Hayes was founder and head of Environmental Action, a public-interest lobby. He is author of *Rays of Hope: The Transition to a Post-Petroleum World*, and of numerous papers for Worldwatch and for such publications as *Saturday Review* and *The New York Times*.



15. Choosing Our Future: Choices and Tradeoffs

MELVIN KRANZBERG

Technology's the answer—but that's not the question.

The question is which technology (or technologies) will resolve our energy dilemma. And underlying that are more basic questions. What do we want our lives to be like in the future? What do we owe to future generations? What are our responsibilities to our fellow inhabitants on Spaceship Earth?

The energy choices we make today will affect not only our own lives, values, and institutions, but also the natural environment, the resources and lifestyles of generations to come, and ultimately all the earth's people.

Understandably, we don't want to change our lifestyles. Most Americans are happy with the material goods that industrial technology has brought, and we fear a decline in our living standards. Yet the cheap energy that fueled America's material growth in the past will no longer be available. What can—or should—we do about it?

In the short run—for the next decade or so—we will rely chiefly on conservation to fill the gap between energy supply and demand; in the longer run we will count on a "technological fix" to provide us with abundant (if not necessarily cheap) energy. Both of these solutions hold forth promises—and problems.

Conservation and Its Limits

Conservation would be commonsensical from an economic and ethical perspective even if we had no energy crisis. We Americans waste too much of everything, from food to fuel.

For individuals, conservation offers savings on fuel bills, and, if we walk rather than drive, better health. For the nation, conservation would lessen our dependence on costly foreign oil, which contributes to inflation.

Although some conservation might be a "good thing," too much might wreak economic and social disaster. While the loss of Iranian oil imports in 1979 inconvenienced some drivers, there was little decline in our living standards.

But suppose additional millions of barrels of imported oil were cut off [illegible] mployment would rise as factories shut down because of lack of fuel or a transportation breakdown, agricultural production would dip, affecting food supplies, public health would suffer from inadequate home heating, and the economy would gradually grind to a halt as vital services shut down.

New Energy Sources

In brief, conservation by itself—however desirable and necessary—is not enough to maintain our socioeconomic order and ensure the future. We must also develop new energy sources through a "technological fix," that is, the application of more and better technology. Because these technologies take time to develop, they represent longer-range solutions to our energy problem.

How do we choose among the technologies that will "fix" our situation? What benefits do they offer and what risks are involved? What tradeoffs must be made in the way we live in order to obtain or retain other things which we value? For values are implicit in our choices of our energy future.

For example, we might get more oil from offshore wells, but offshore drilling risks oil spills and environmental damage. We have plenty of coal, but mining it imposes danger to the miners and degradation to the environment, and burning it creates pollution.

Synthetic fuels—oil and gas made from coal, tar sands, and shale—present the same problems as mining coal. In addition, they release more carbon dioxide into the atmosphere than the direct burning of coal, and thus increase the possibility of a "greenhouse effect"—warming the earth's climate through absorbed infrared radiation.

Nuclear energy once promised unlimited, cheap energy. But there are doubts about reactor safety, radiation, and nuclear waste disposal. The Three Mile Island accident and the subsequent investigation set back the nuclear cause. Yet further nuclear development might be necessary if we want sufficient energy to maintain our lifestyles.

Solar energy has many attractions but technical problems hinder its large-scale production and storage. despite its suitability for hot water and home heating, it could not be expected to power America's industrial plant.

Even ardent proponents of solar energy project its supplying us with only 20 percent of our energy by the year 2000. The other "soft paths"—geothermal and wind—could provide only a minuscule portion of our energy needs.

Difficult Choices

Even if we try many different energy paths, we must still decide which will make the most effective use of our scientific research dollars and talent. And those decisions must be based not only on technical feasibility but also upon how and where we want to live.

Thus, solar energy proponents claim it would get us "back to the land," and they exalt a simpler lifestyle, others equate the "simple life" with a lower living standard. Americans tired of the rural life over a century ago; moving to the cities, they created today's urbanized, industrial society.

Are we willing to do without our wealth of material goods and go back to the "simple" life of the farm? Might not many Americans prefer the risks of, say, nuclear energy rather than forgo the amenities and excitement of the big city?

All energy paths have disbenefits as well as benefits, which are often difficult to assess. Even the "experts" can't always measure the risks precisely. Besides, the risks might be assigned to one group, such as Appalachian coal-miners, while others, such as Eastern urban dwellers who use the energy produced by coal, derive the benefits.

There is also the question of voluntary versus involuntary risk. The National Academy of Sciences estimates that radiation from nuclear plants might cause a total of 2,000 cancer deaths by the year 2000, whereas almost 50,000 people a year die on our highways. Yet we voluntarily drive our cars and risk a fatal accident.

We don't always have a choice in the case of energy sources. True, we decide whether or not to switch on the electric light, but others decide just how that electricity will be generated. Up till now, such decisions have usually been left to the marketplace, but increasingly society, through the political process, will be determining our energy future.

The Role of the Citizen

Because energy is so crucial to the nation's economy and well-being, the government must be concerned about it. In most places, the generation and distribution of electricity and natural gas are a monopoly, so these public utilities must be regulated for the public good. And our petroleum supply increasingly depends upon the government's conduct of foreign relations.

Furthermore, future energy resources will depend heavily on the government for research dollars, pilot plants, and tax incentives—and will be constrained by governmental action to protect the environment and the public's health. Thus, it is within our power as citizens to determine where the government should apply its efforts to bring us the energy future we want.

Throughout our history, concerned citizens have brought about major transformations of American policy. In energy matters, determined citizens have halted or delayed the construction of nuclear plants, oil refineries, and pipelines.

In the last analysis, therefore, our energy future is up to each of us.

Do we have the courage to make some difficult choices? Or, have we become a nation of materialistic hedonists, as some critics say, unwilling to forgo our material comforts regardless of the effects upon others?

Is this a crisis of the national will?

If so, there are some grounds for confidence. Despite recent strains, we remain the world's strongest democracy, and we shall retain our scientific preeminence. If we put our will to the test, we should be able to surmount the current energy crisis just as have overcome previous national crises.

ABOUT THE AUTHOR

MELVIN KRANZBERG is academic coordinator for "Energy and the Way We Live." Since 1972, he has been Callaway Professor of the History of Technology at the Georgia Institute of Technology. He previously taught for twenty years at Case Institute of Technology (now Case Western Reserve University). The principal founder of the Society for the History of Technology, he edits its quarterly journal, *Technology and Culture*. He is the coauthor of *By the Sweat of Thy Brow* and coeditor of *Technology in Western Civilization; Technology and Culture: An Anthology;* and *Technological Innovation: A Critical Review of Current Knowledge.*